LAKE EVALUATION AND ENHANCEMENT PLAN

LAKE TRUESDALE
LEWISBORO, NEW YORK

PREPARED FOR:
TRUESDALE LAKE ASSOCIATION

September 5, 2001

Land-Tech Consultants, Inc. has been retained by the Truesdale Lake Association to prepare a limnological evaluation of the 83± acre Truesdale Lake located in Lewisboro, New York and provide lake management recommendations.

As part of the evaluation, Land-Tech Consultants, Inc. conducted a bathymetric survey of the lake and collected sediment samples during a site visit on May 31, 2001. The findings presented in this report were prepared using the physical, chemical, and biological data collected by Allied Biological Inc., The Citizens Statewide Lake Assessment Program (CSLAP) and Land-Tech Consultants, Inc. This report also presents a series of recommendations, which are designed to enhance the aesthetics, recreational, function and wildlife habitat of the lake and the associated shoreline.

PHYSICAL FEATURES

The 83-acre lake is located within a residential area. The manmade lake was created in 1927. Lake Truesdale receives surface runoff from residentially developed and undeveloped portions of the watershed. A perennial watercourse discharges into the northeastern portion of the lake from Pumping Station Swamp, a drinking water wellfield located on the border of Fairfield County, Connecticut and Westchester County, New York. The watercourse is approximately 25 feet wide at the mouth of the lake. The substrate of the watercourse consists of silt and sand with some gravel. Boulders and deadfall are common. A smaller intermittent watercourse discharges into a cove located in the northeastern portion of the lake.

The lake discharges via a 200-foot wide concrete dam that is located at the northern tip of the lake. The dam was built in the early 1920s and contains an 18-foot spillway with removable springboards allowing the lake levels to be seasonally managed. A spillway height of 14 inches is maintained during the summer months. The lake water level has been raised and lowered seasonally to minimize damage from ice and to minimize encroachment of aquatic plants. The dam is listed by the New York State Department of Environmental Conservation as a low hazard, class “A” dam and is built to handle the 100-year storm event.

Eleven transects accompanied by random spot checks in the lake identified a maximum depth to soft sediment of approximately eleven feet. This maximum depth occurs in the middle of the northern end of the lake. The shoreline of the lake is vegetated with deciduous hardwoods and pines interrupted by maintained lawns.

Watershed/Hydrology

A watershed is a drainage area in which all land and water areas drain or flow toward a central collector, such as the lake. Precipitation falling on the watershed that does not infiltrate into the ground will flow over land to the central collector. The size of the contributing watershed largely determines the amount of water that enters the central collector, in this case, the lake.

This lake lies within the Waccabuc River Drainage Basin, which is a sub-basin of the Croton Regional Basin and the Hudson Major Basin.

The portion of this watershed contributing surface runoff to the lake is large (2,380± acres, 963 ha), relative to the size of the lake (83 acres, 33.6 ha) (Figure 1). The majority of this watershed is located to the east of the lake and contains the Pumping Station Swamp. The size of the watershed creates a watershed to lake ratio of 28.7:1. The amount of rainfall draining to the lake was calculated using a runoff value of approximately 55 percent of precipitation (CT DEP 1982), an annual precipitation value of 47.5 inches per year (Soil Survey of Putnam and Westchester Counties, New York, 1994), and 68.6 cm (27 inches) per year of surface lake evaporation. Therefore, the net amount of rainfall that drains to the lake is large, (1.6 billion gallons) annually or an average daily flow of 4 million gallons per day. Thus, on an annual basis, the lake, with a volume of approximately 99,150,000 gallons, shows a moderate turnover rate (hydraulic residence time) of 16.2 times per year or every 22 days.

However, since the perennial watercourse is in the northeast portion of the lake and the discharge is at the northern tip of the lake, it is reasonable to assume that much of the water entering the lake from the perennial watercourse exits the system with little mixing of water in the southern lake basin. Therefore, the actual hydraulic residence time in the southern portion of the lake is expected to be longer than that stated above.

The predominant composition of the Waccabuc River Drainage Basin surrounding the lake is a mixture of maintained lawn and small woodlots consistent with residential land uses. The dominant soil surrounding the lake is the well drained Paxton fine sandy loam. Other soils include the poorly drained and somewhat poorly drained Ridgebury loam, which is located in the northeast portion of the lake, and the moderately well drained Woodbridge loam, which is located along the southeastern shoreline. Sun loam soils are located adjacent to the perennial inlet and discharge stream. These are poorly drained or very poorly drained soils.

Sedimentation

The nature of the lake subjects it to natural and man-influenced sediment loads from the contributing watershed including adjacent roadways. As such, the lake receives suspended particles (sand and road salt) from upgradient sources. These particles settle out in the lake due to the lower velocity flows of the lake in comparison to the inlet stream.

Natural erosion from undisturbed watersheds equals approximately 4.1 metric tons (4 tons) per acre per year. Winter road sanding activities will contribute coarse to fine grained sediments annually. The volume of sand is dependent upon the severity of the winter and municipal and state sand application practices within the watershed.

Pond Sediment

At least two previous studies have measured sediment depths in the lake. The first survey was conducted in 1956. A second undated map was prepared by Allied Biological. Land-Tech Consultants, Inc. conducted a survey on May 31, 2001.

To obtain sediment depths during the May 2001 survey, water depth to soft sediment was measured throughout the lake using a 10 foot graduated rod. The depth of soft sediment was obtained by pushing the rod into the soft sediment and recording the depth to refusal.

According to the data collected in 2001, the maximum depth of the lake is over 11 feet. This depth was located in the northern portion of the lake (See Figure 2, Truesdale Lake Bathymetry Map). Zero to one and a half feet of soft sediment were recorded throughout the lake. Sediment depths appear to be uniformly distributed throughout the lake.

The bathymetry data collected in 2001 is consistent with data collected by Allied Biological. The bathymetry study conducted in 1956 indicated that seven inches of board were used in the spillway. The 2001 study was conducted using 12 inches of board in the spillway. Adjusting for this difference, since 1956 the southern tip of the lake shows a one-half foot to one foot increase in sediment, the center of the lake basin from the beach to the inlet stream has received approximately one foot of sediment while the northern basin appears to have received a half to one foot of sediment. Overall this equates to a range of approximately 0.1 – 0.3 inches per year (0.3 – 0.7 cm/year) of sediment accretion.

A composite sediment sample was obtained from the lake near the mouth of the perennial watercourse and sent to a laboratory to determine the grain size distribution. The results of this analysis are presented in Table 1 below. The copy of the laboratory sieve analysis report is presented in the Appendix of this report.

Table 1 Sieve Analysis

Sieve Size	Percent Passing	Percent Composition	Soil Classification
1_	100.0	0	Coarse Gravel
_”	97.7	2.8	Fine Gravel
_”	97.2		
#4	96.8	2.1	Coarse Sand
#10	95.1		
#40	73.3	65.8	Fine Sand
#100	29.3		
#200	14.6	29.3	Silt/Clay

Source – Special Testing Laboratories, Inc.

Sediments entering the lake basin from the primary inlet are characterized as gray sand (67.9%) and silt (29.3%) with a trace of gravel (2.8%). The high percentage of fine sand is consistent with deposition from fast to moderate flowing streams. The likely source of this sediment is primarily road sand along with particles from upgradient stream banks dislodged during storm events.

WATER QUALITY

According to the New York State Water Quality 2000 Report prepared by the New York State Department of Environmental Conservation, Truesdale Lake is classified as a Class B fresh surface water body. The recommended uses for Class B water bodies are primary and secondary contact recreation and fishing. Waterbodies within this classification are suitable for fish propagation and survival.

The Citizens Statewide Lake Assessment Program (CSLAP) has been monitoring the water quality of the Lake since 1999. Data collected includes: temperature (^{o}C), pH, conductivity corrected to 25 ^{o}C (µmho/cm), nitrate (mg/l), total phosphorous (mg/l), chlorophyll A (µg/l), true color (platinum color units), and Secchi disk transparency (m). In addition, three survey questions were asked of local residents.

CSLAP reported total phosphorous ranges of 0.018 to 0.084 mg/l between 1999 and 2000. Chlorophyll A ranged from 2.37 to 116 µg/l while Secchi Disk ranged from 0.55 to 2.35m in clarity. The CSLAP data has determined that Lake Truesdale is a clearwater and eutrophic lake (Table 2). CSLAP found that in general, Lake Truesdale was more productive (eutrophic) than other similar lakes in the drainage basin. The CSLAP assessment on water clarity determined that clarity is more influenced by algae than by depth, color or inorganic material.

Eutrophication is an aging process where water quality and biological productivity go through stages of succession. A pond or lake naturally “evolves” from one trophic state to another. This is a natural process involving the addition of nutrients, including nitrogen and phosphate. However, it is very common for this process to be accelerated (cultural eutrophication) by introducing higher concentrations of nutrients to the pond through erosion, agricultural runoff, residential fertilizer use and inefficient septic systems.

Plants, both phytoplankton (algae) and vascular plants, require nutrients such as metals, nitrogen and phosphorous to grow. Growth of plants is typically limited by the growth factor, which is present in the least quantity relative to the growth demands of the plant. The limiting factors of interest are generally plant nutrients, usually nitrogen and/or phosphorus. These two elements are usually the least available. If the limiting nutrient becomes depleted, growth stops despite the fact that other nutrients might still be available. In most eastern New York ponds and lakes, phosphorus is the nutrient that limits algal growth.

Typically during cultural eutrophication, these additional sources of limiting nutrients are provided, removing the growth limitation. This in turn allows for algal blooms and the establishment of aquatic weeds. This process speeds up the natural succession of the pond and can lower water quality.

The high concentration of total phosphorous indicates that phosphorous is abundant in the lake (not limiting) allowing algal growth to prosper. Limiting the introduction of phosphorus in this system is very important and is a major focus of the enhancement plan.

Table 2 New York State Trophic Status Criteria

Parameter	Oligotrophic	Mesotrophic	Eutrophic
Transparency (m)	>5	2 - 5	<2
Total Phosphorous (mg/l)	<.010	0.010 – 0.020	>0.020
Chlorophyll a (µg/l)	<0.002	0.002 – 0.008	>0.008

Phosphorous binds to sediment allowing the sediment to act as a reservoir for phosphorous. This storage of phosphorous can be tapped by rooted aquatic emergents or re-suspended by storm events due to the shallow nature of the lake. To determine the levels of phosphorous stored in the sediment, an indication of phosphorous loading, a composite sediment sample was obtained from the lake on May 31, 2001. This sample was sent to a State approved contract laboratory (Certification #PH-0574) for analysis. Total phosphorous levels for the lake sediment were reported as 410 mg/kg.

Phosphorus is often transported in aquatic systems by adsorbing to fine sediments. As such, a significant fraction of the total annual phosphorous load to the lake probably occurs during storm events. Potential sources of phosphorus include fertilizers, inadequately renovated septic effluent and exposed soil. The partially wooded buffer surrounding the lake functions to filter or uptake nutrients reducing the amount of nutrients entering the water. Fertilizer and droppings from Canada geese and other waterfowl are also contributors to the total phosphorous levels observed in regional lakes.

Based on data collected in 1999 and 2000, CSLAP reported that the lake becomes more productive during the summer months. This was based on increasing nutrient and algae levels increasing and water clarity decreasing. The short monitoring period, two years, limits the ability to determine how much of this productivity is due to nutrient loading from the watershed.

The water quality information provided in this report is a summary of the data reported by CSLAP. The reader will find a detailed assessment of the water quality in Truesdale Lake presented in the CSLAP Annual Report.

AQUATIC BIOLOGY

Aquatic plants are a vital part of lake ecosystems; they provide cover for juvenile fish and essential habitat to many groups of aquatic invertebrates that serve as food for fish. Macrophytes (aquatic plants) also provide a direct food source for wildlife (particularly waterfowl and muskrats). Too many macrophytes can limit swimming, fishing, boating, and aesthetic appreciation.

Algae (phytoplankton). Excessive algae can also alter the ecosystem. The amount of algae in small lakes and ponds of the region tends to be highest in late summer. The seasonal increase in water temperature and light availability (longer days) allows the algae to reproduce faster. If nutrient levels are too high, some algae can form dense blooms or even floating scums on the surface, reducing water transparency to less than one foot. Algal productivity is usually low in the winter because of low water temperature and low light availability.

Aquatic vascular plants and algae are a major problem in Lake Truesdale. The physical removal of weeds goes back to 1950 using weed cutters and harvesting. Chemical treatment was initiated in 1957 under the direction of Cornell University's State School of Agriculture, Conservation Department. The weed control program has been continued ever since under the advice of professional aquatic biologists. Allied Biological has been performing aquatic plant surveys and conducting chemical weed control using Aquathol K since the mid 1980s.

The weed population is treated with Aquathol K in the spring. A program that applies algaecide (copper sulfate) to the lake is employed during July to August.

Copper sulfate is effective in controlling many species of aquatic plants, however, it may cause increased copper concentrations in the lake sediments and negatively impact the benthic invertebrates living in the sediment. There is also the concern that copper could affect invertebrates in the water column such as zooplankton.

The results of the 2000 Allied Biological treatment program found that the earlier part of the season (May) was dominated by curly-leaf pondweed (*Potamogeton crispus*). Other species identified were leafy pondweed (*Potamogeton foliosus*) and filamentous algae. The only plant identified by CSLAP during the May through October 2000 field events was *Najas flexilis* (bushy pondweed). This plant was found in the northeast cove in approximately 0.24 meters of water. The plants identified in these two reports are in drastic contrast to each other. This discrepancy should be resolved.

Applications in May of both Aquathol K and copper sulfate controlled the curly-leaf pondweed and algae allowing leafy pondweed (*Potamogeton foliosus*) to become dominant by mid summer. Additional applications of copper sulfate were used to control the leafy pondweed. Algae (*Nitella sp.)* was identified in the southern cove and was treated with copper sulfate. Algal blooms of blue-green algae and filamentous algae appeared in June and were treated in July and August with copper sulfate.

These data collected by Allied Biological showed an increased pondweed growth and a slight reduction in planktonic algae growth in comparison to 1999. The weed and algal control program employed Lake Truesdale is effective in controlling the seasonal weed population.

Copper sulfate bound sediments

Copper binds to particulate matter in the water and sediment and as an element will persist indefinitely in the soil. Copper is strongly bioaccumulated and is typically stored in the liver and brain. Fish especially trout and carp are very susceptible in soft or acid water. This toxicity decreases as water hardness increases (Extension Toxicology Network). Copper sulfate is toxic to aquatic invertebrates such as worms, pond snails and clams.

Copper sulfate is highly water soluble, but also easily binds to particulate matter and sediment. To determine the levels of copper in the sediment, a composite sediment sample was obtained from the lake on May 31, 2001, and analyzed for total copper to determine the retention of copper in the sediments introduced from the application of copper sulfate. These samples were sent to a State approved contract laboratory (Certification #PH-0574) for analysis. Total copper levels in Lake Truesdale were reported as 34 mg/kg. The average copper levels for the region is around 20 mg/kg.

Although the application of copper sulfate has been done by professionals under strict guidelines, the long period of application (44 years) warrants the monitoring of copper concentrations in the lake water. Comparing the results with known toxicological thresholds (LD 50) will help determine if any impacts have been caused by the long period of copper sulfate application.

Additional Observations. The area around the lake has a high wildlife support capacity (songbirds, game birds, mammals). Sources of water, food, and cover are common. The diversity of structural vegetative types surrounding the lake includes turf grass, mixed deciduous hardwoods, and riparian (stream corridor) habitat.

Fisheries were not investigated, however, several species of fish likely occupy the lake. Potential fish species populating the lake include sunfish, perch, small mouth bass, large mouth bass, minnows and darters. Although continuous application of chemical treatments to a water body has the potential to harm fish and other aquatic species, reports from local residents state that the lake continues to support a healthy fish population. A routine fish monitoring program should be initiated to document the health and species diversity of the fish population in Lake Truesdale.

SUMMARY OF EXISTING CONDITIONS

The lake currently has high landscape, scenic, and recreational values. The lake receives flow from overland flow and from a perennial watercourse discharging into the northeastern shoreline. The lake has accumulated approximately one foot of sediment since 1965. This is not an excessive accretion rate. Some of this sediment is entering the lake from the perennial watercourse, altering the bathymetry of this lake, and decreasing its depth. The sediment load to the lake is probably the major contributor to the high total phosphorous and nitrogen in the system. The lake contains high phosphorous and chlorophyll A levels resulting in abundant aquatic plants and seasonal algal blooms.

These blooms are effectively controlled by a continuous weed control program using Aquathol K and copper sulfate. This program has been in effect since 1956 and has contributed to the high concentrations of copper in the sediment.

The lake is lacking a diversity of habitat. The lake is shallow with gentle slopes offering little variation in depth for fish habitat.

Limiting excessive phosphorous and nitrogen concentrations is essential to the balance of this system. The high nutrient content in the lake will continue until changes in the watershed are made to reduce sediment and nutrient loads. The following section provides recommendations on a watershed approach to improve the conditions in the lake.

BEST MANAGEMENT PRACTICES SYSTEM

Non-point source pollutants in stormwater runoff may originate from a variety of sources (Table 3). The data collected from Lake Truesdale during this evaluation indicated that phosphorus-laden sediments are a major concern in stormwater runoff. The Best Management Practice systems proposed for the Lake Truesdale watershed were selected following a thorough review of their effectiveness at reducing non-point sources of pollution (primarily sediment and secondary phosphorus), associated costs, and site constraints.

Table 3 - Potential Sources of Urban Runoff Pollutants

Source	Pollutants of Concern
Soil Erosion	Sediment and attached soil nutrients, organic matter, and other absorbed pollutants.
Atmospheric deposition	Hydrocarbons emitted from automobiles, dust, aromatic hydrocarbons, metals, and other chemicals released from industrial and commercial activities.
Construction materials	Metals from flashing and shingles, gutters and downspouts, galvanized pipes and metal plating, paint, and wood.
Manufactured products	Heavy metals, halogenated aliphatics, phthalate esters, PAHs, other volatiles, and pesticides and phenols from automobile use, pesticide use, industrial use, and other uses.
Plants and animals	Plant debris and animal excrement
Non-storm water connections	Inadvertent or deliberate discharges of sanitary sewage and industrial wastewater to storm drainage systems.
Onsite disposal systems	Nutrients and pathogens from failing and improperly sited systems.

From U.S. EPA Publication 840-B-92-002, 1990.

BMPs vary in their effectiveness in removing pollutants (Watershed Protection Techniques, Technical Note 95, 1997). In addition, consistency within comparative studies of the effectiveness of various BMPs is highly variable, and therefore the removal capacities provided should be considered guidelines that will most likely differ depending on the storm event, site conditions, etc.

The estimated average removal rates for total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN), nitrate (N03) and other pollutants (bacteria, metals) of selected Best Management Practice systems are presented in Table 4.

Table 4 - Estimated Average Pollutant Removal Capacity of Different Stormwater Filter Systems

	Removal Efficiency (%)				
Management Practice	*TSS*	*TP*	*TN*	*$N0^3$*	*Other pollutants*
Drainage Channel[1]	30	10	zero	zero	Bacteria - negative
Grass Channel[1]	65	25	15	neg.	Hydrocarbons - 65% Metals - 80-90% Bacteria - negative
Dry Swale[1]	90	65	50	80	Metals - 80-90%
Wet Swale[1]	80	20	40	50	Metals - 40-70%
Filter Strip[1]	70	10	30	zero	Metals - 40-50%
Gravel Filter[1]	80	80	65	75	Hydrocarbons - 85% Metals - 50-75%
Catch Basin with Sump (Water Quality Inlet)[2]	35	5	20	no data	Lead - 15% Zinc - 5%
Oil/Grit Separator[2]	15	5	5	no data	Lead - 15% Zinc - 5%

[1] From Claytor and Schueler 1996.
[2] From Environmental Protection Agency 1990.

The following section contains a brief summary of some of the advantages and disadvantages associated with selected BMPs.

TABLE 5A - CATCH BASINS WITH HOODS AND SUMPS

Advantages	Provide high degree of removal efficiencies for larger particles and debris as pretreatment	Require minimal land area	Flexibility to retrofit existing small drainage areas and applicable to most urban areas	Biannual cleaning of sumps can reduce TSS levels by 10-25% and phosphorus levels by 10-20%*.
Disadvantages	Not feasible for drainage area greater than one acre	Marginal removal of small particles, heavy metals, and organic pollutants	Not effective as water quality control for intense storms, require frequent sediment removal.	Minimal nutrient removal
Factors	Maintenance	Sedimentation storage		
Costs	□ $1,500/unit			

* Carrying Capacity of Public Water Supply Watersheds, CT DEP Bulletin No. 11.

TABLE 5B - STONE FILTERS

Advantages	May provide ground water recharge	Requires minimal land area	May helps replicate pre-development hydrology, increase dry weather base flow
Disadvantages	Dependent upon in-situ soils	Requires maintenance, access is a problem.	
Factors	Treatment volume	Filtration media	Soil percolation rates

TABLE 5C - VEGETATED FILTER STRIP (VFS)					
Advantages	Low maintenance requirements. Can effectively reduce velocity	Can be used as part of the runoff conveyance system to provide pretreatment	Can effectively reduce particulate pollutant levels in areas where runoff velocity is low to moderate	Provides excellent urban wildlife habitat. Requires minimal land area	Economical
Disadvantages	Often concentrates water, which significantly reduces effectiveness	Ability to remove soluble pollutants highly variable	Limited feasibility in highly urbanized areas where runoff velocities are high and flow is concentrated	Requires periodic repair, re-grading, and sediment removal to prevent channelization	

TABLE 5D - STONE WATERFALL					
Advantages	Can effectively reduce velocity	Low maintenance requirements	Requires minimal land area		
Disadvantages	High Construction costs				
Factors	Storage volume	Detention time	Pool shape	Wetlands biota	Seasonal variation
Costs	$3,000/unit				

TABLE 5E - OIL/GRIT SEPARATOR					
Advantages	Captures coarse-grained sediments and some hydrocarbons	Requires minimal land area	Flexibility to retrofit existing small drainage areas and applicable to most urban areas	Shows some capacity to trap trash, debris, and other floatables	Can be adapted to all regions of the country
Disadvantages	Not feasible for drainage area greater than one acre	Minimal nutrient and organic matter removal	Not effective as water quality control for intense storms	Concern exists over the pollutant toxicity of trapped residuals	Requires high maintenance
Factors	Sedimentation storage volume	Outlet configurations			
Costs	$8,000 - $10,000				

MANAGEMENT RECOMMENDATIONS

Currently, Lake Truesdale's aquatic plants are heavily managed and ecologically out of balance. The management activities conducted on Lake Truesdale have been focused on treating the effects of the unbalanced nature of the lake and not on treating the cause. The highly eutrophic nature of the lake is most likely caused by excess nutrients entering the lake from the watershed. Sources in the watershed include roads (sand, salt, etc.), the use of fertilizers and herbicides on residential lawns, inefficient septic systems and other factors that are common today.

Currently there are two main problems with Lake Truesdale. These two problems are sediment accretion and high nutrient content. On paper, these factors can be separated, however, in an ecosystem they are very much related. The recommendations listed below were established to address the watershed as a whole and not just the lake. Although in today's society it is impossible to manage the entire watershed, several actions can be taken, to significantly reduce many of the problems addressed by this evaluation.

1. The accumulation of sediments is primarily due to the unrestricted flow from the two largest inlet streams discharging into the northeastern portion of the lake. Due to the size of the watershed, it would be impossible to eliminate sedimentation and the introduction of nutrients into the system. The large wetland system located to the east of the lake traps sediment and removes nutrients that enter the watershed upgradient of the wetland. However, many sources exist down gradient. Sediment sources in close proximity to the inlet are considered the principal sources of sediment loading. The most practical way to control these influences to the lake is near the

stream/lake interface. Remove the sediment at the mouth of the perennial stream and from the northeastern cove at the mouth of the intermittent stream. Install sediment forebays within both of the inlet streams. A sediment forebay would capture sediment before entering the lake, reducing sediment entering the lake. Once properly designed and installed, periodic maintenance (sediment removal) would be simple and relatively inexpensive.

2. The southern and northeastern coves could be dredged to provide greater depths and a more diverse habitat for wildlife including fish and turtles. Boulders or stumps could be placed in a limited area of the lake to provide basking areas for turtles and frogs and escape cover for small fish. These areas contain deep soft sediment deposits. Therefore, removing the sediment would remove some of the nutrients and plant seed contained within the sediment. Seeds and nutrients would eventually be replenished, however, with forebays installed their accumulation would be retarded. The dredging of these areas would be expensive, would require the development of a detailed dredging plan, and permits from the Town, State of New York and possibly the Army Corps of Engineers.

3. Ensure that the entire Lake contains adequate shoreline vegetative buffers. Vegetative buffers consisting of native shrubs and dense, tall grasses slow down overland flows allowing particulates to settle out. These plants also take up nutrients for their own metabolism reducing the amount of nutrients entering the pond. The buffer should be a minimum of 15 feet wide and preferably 25 feet wide around the lake to allow uptake of nutrients that would enter the lake via runoff. Turf environments should grade into coarse grass buffers and then to shrubs for maximum effectiveness. Depending on cover story vegetation, land use and soils, the woody (shrubs) buffer or herbaceous (grass) buffer may be used independently. For the points of access, i.e. beach along eastern shore, the already established grass buffer should be adequate. Grass buffers need to be mowed twice per year to remove accumulated nutrients.

4. Application of fertilizer to the maintained lawns adjacent to the lake should be based on the nutrient needs of the grasses, and the results of the soil nutrient analysis. Proper selection of turf grass species will also reduce the need for excessive nutrient application. At a minimum, insure that only enough fertilizer is applied to meet the needs of the lawn and plantings. Typically lawn fertilizers are water-soluble and their use should be minimized near open water. Soil samples can be analyzed to determine if phosphorus is needed. If not needed, no more phosphorus should be applied. Use of a mulching lawn mower to return grass clippings to the lawn would reduce the amount of fertilizer needed. If possible, discontinue fertilizer applications to trees, shrubs, flowerbeds, and turf grass in areas that drain to the pond. Applications of fertilizer should not be done immediately preceding heavy rain and only organic slow release fertilizers should be used when available. Fertilizer should not be applied more than once per year.

5. The recommendations outlined in #3 and #4 above are most effective when owners of the properties that drain to the lake follow the same recommendations around the inlet

streams. The property owners who abut the streams that drain to the lake should be informed of the potential impacts caused by excessive fertilization and the ways to reduce impacts to the pond such as vegetative buffers.

6. Lake residents should also be made aware that poorly functioning septic systems can introduce additional concentrations of phosphorous to the lake and therefore should be properly maintained.

7. Introduce rooted emergents along the shore of the lake. These plants would take up nutrients (including nitrogen and phosphorous) making lower concentrations available for algal species. The introduction of emergents would also increase the aesthetics of the pond, create escape cover for fish and provide attachment sites for amphibian egg masses and macroinvertebrates (aquatic insects).

8. Since waterfowl can contribute significant phosphorus to your pond, do everything you can to discourage them from visiting the lake and the surrounding lawns (e.g. vegetative buffers, nettings, or dogs). The buffer cited in # 3 above can be effective in minimizing the attractiveness of your pond to waterfowl.

9. During our May 15, 2001 lake inspection with Ray Morse and Sue Innis, we were shown six locations where stormwater entered the lake. All of these areas have noticeable sedimentation problems and are, therefore, probable nutrient sources. The following are brief descriptions of the six areas and possible ways to capture sediment and nutrients before they enter the lake. The locations of the six areas appear on Figure 2 (Truesdale Lake Bathymetry).

    - <u>#1 – South end of lake, where 18" pipe discharges stormwater directly to lake.</u> The outlet has a short rip rap area near the water, and a sand bar has developed in the water. In this area, it would be possible to reduce the deposition of sand within the lake:
        - Remove a section of the pipe, so its end is farther from the edge of the water.
        - Enlarge the outlet area between the end of the pipe and the edge of the water.
        - Create a plunge pool within the outlet area.
        - Create a semi-circular forebay in the water.
        - Plant the surrounding shallow water area with aquatic vegetation selected to compete with algae for nutrients.
        - Provide annual maintenance (sediment removal, erosion repair, etc.) for the sediment basin and as-needed maintenance for the forebay.

- <u>#2 – Near intersection of Truesdale Lake Drive and Lakeshore Drive, pipe crosses Truesdale Lake Drive and flows south to north.</u> There is a catch basin on the north side of Truesdale Lake Drive, and a 15" pipe leads from the catch basin north toward the lake. In this area, it would be possible to improve on sediment trapping by making two changes:
  - Remove a section of the pipe running north from the catch basin, and replace the pipe section with a vegetated channel. In a location where access for maintenance equipment is available, construct a small sediment basin. Extend the channel to the lake. Use rip rap to armor channel sections that are steep enough to be susceptible to erosion.
  - Provide annual maintenance (sediment removal, erosion repair, etc.) for the channel and sediment basin.

- <u>#3 – Area identified as Beach #2 owned by Truesdale Estates Association.</u> Along the south side of the beach, there is a silted-in channel draining from catch basins in the street directly to the lake. Further north, but south of the beach entry drive, two more catch basins in Truesdale Lake Drive collect road runoff and discharge it toward the lake. There are signs of erosion on the beach property near the road, a partially exposed 12" concrete pipe running roughly parallel to the road (destination unknown) and another pipe running north to another catch basin north of the beach driveway. Further north, a 12" metal pipe and a 24" concrete pipe discharge to an eroded channel. All these discharge to the lake. Options available in the beach #2 area include:
  - Clean out and re-vegetate the channel at the south end of the beach. Near the water's edge, build a small settling basin, then a forebay in the water.
  - Plant the surrounding shallow water area with aquatic vegetation selected to compete with algae for nutrients.
  - Sort out the drainage pipes associated with the two catch basins in Truesdale Lake Drive south of the driveway. Identify one outlet pipe and confirm that it leads to the catch basin north of the driveway. Block and remove all other pipes from this catch basin. Remove the 12" concrete pipe running north-south.
  - Construct one or more channels lined with rip rap leading from the area north of the driveway to the lake. Ensure that all pipes north of the driveway discharge to this channel. Construct a forebay in the water at the end of the channel.
  - Plant the surrounding shallow water area with aquatic vegetation selected to compete with algae for nutrients.
  - Repair eroded areas on the property.
  - Provide annual maintenance (sediment removal, erosion repair, etc.) for the channels and as-needed maintenance for the forebays.

- #4 – Channel leading from culvert passing under Boway Road near intersection of Truesdale Lake Drive southwest to lake. There are large sand bars and silt deposits along the channel. The channel discharges to a small manmade pond with a stone dam, then there is a rocky channel leading to the lake. It is our understanding that the Truesdale Lake Property Association has maintenance rights for the entire length of the channel, including the manmade pond. At a minimum, there should be an annual channel maintenance program that includes sediment removal and erosion repair along the channel each Fall. This channel is a major contributor of sediment to the lake, and therefore presents the opportunity to trap a substantial fraction of the sediment entering the lake. The following bear consideration for a more aggressive approach:
    - The channel has a flat slope and wide bed, both conducive to sedimentation. Restore the sediment-trapping capabilities of the channel by removing the large silt and sand deposits that exist between the road culvert and the manmade pond.
    - Construct one or more sediment basins within the channel at location(s) where access for maintenance would be available.
    - Reconstruct the channel to improve its aesthetics, increase its resistance to erosion and improve its sediment removal characteristics. This may involve creation of a series of riffles and pools, where the pools would provide a series of small sediment traps.
    - Provide annual maintenance (sediment removal, erosion repair, etc.) for the channel and sediment basin(s).

- #5 – Private property at end of Country Lane. A boulder-strewn watercourse leads from Hoyt Street to the lake, where deposition of silt and sand are evident. In this area, there is adequate room for improved sediment trapping:
    - Open up the area where the watercourse enters the lake. Construct a crescent-shaped forebay in the water. Deepen the forebay area and a short area of watercourse immediately upstream from the water's edge to provide for sediment storage.
    - Plant the surrounding shallow water area with aquatic vegetation selected to compete with algae for nutrients.
    - Provide annual maintenance (sediment removal, erosion repair, etc.) for sediment storage area and as-needed maintenance for the forebay.

- #6 – Area along west side of lake at north end of Lake Shore Drive and south end of Gilbert Street. The road drainage system (metal pipes) discharges runoff to a channel leading to the lake. The area between the road and the lake provides opportunities for sediment trapping as well as nutrient uptake:
    - Construct a rip rap channel from the road drainage pipe outlet for the length of the slope that is steep.

- Where the slope flattens approaching the water, excavate a sediment basin.
- Construct a forebay within the lake.
- Plant the surrounding shallow water area with aquatic vegetation selected to compete with algae for nutrients.
- Provide annual maintenance (sediment removal, erosion repair, etc.) for the sediment basin and as-needed maintenance for the forebay.

We believe the recommendations presented above adequately address the issues identified by this evaluation while enhancing the functions and aesthetics of the lake. If there are any questions concerning the evaluation of the existing conditions or regarding the proposed activities, please contact us to discuss them.

Sincerely,
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APPENDIX

Laboratory Results