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RESTORATION OF AN URBAN LAKE: THE NEWBURGH LAKE PROJECT

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ABSTRACT

Newburgh Lake is an impoundment located on the Middle Rouge River in Wayne County, Michigan. Newburgh Lake had the potential of being one of the valuable recreational areas in the urban metropolitan Detroit area. The history of the lake encompasses over 65 years of sediment accumulation, some contaminated with PCBs, which over time, degraded the lake water quality. Shallow water depths resulting from the sediment accumulation and nutrient-rich water led to excessive growth of aquatic plants and the presence of organic contaminants such as PCBs that tend to bioaccumulate, as they pass up through the food chain, resulted in a potential human health hazard.

The construction to remediate and restore Newburgh Lake, thereby returning this valuable resource to the citizens of the region, began in April 1997 after initial studies and design had been completed. The most challenging phase of the project was the excavation and removal of 558,000 tons of sediments, much of which was contaminated with PCBs. Sediments were excavated by use of dredges, draglines and conventional equipment. Complicating the process was the varying nature of the sediments in the lake bottom, the urban setting, various storm events and an interceptor sewer that runs along the lake bottom.

Beyond sediment removal, 7 acres of fish spawning beds and habitat structures were built throughout the lake bottom; 10 acres of beneficial aquatic vegetation were planted

in constructed shoal areas; 28,000 pounds of PCB contaminated fish were eradicated and removed from the lake and its adjacent waterways; over 30,000 fish of various species were restocked; and numerous shoreline and infrastructure upgrades were made to enhance the recreational use of the surrounding park area. The total cost for the project including the cost of excavation, restoration, disposal, engineering design and construction management was \$11.8 million dollars.

KEY WORDS

Lake restoration, sediment, aquatic plants, fish kill

INTRODUCTION

Lake sedimentation occurs naturally in a lake, filling with silts and sands, over a period of years. This is also true for impoundments. By their very nature, they begin to fill with sediments as soon as they are built. The pooling of the water created by the dam decreases water velocities in the now dammed stream causing sediments that once were carried through the river to settle onto the floor of the impoundment behind the dam.

These sediments, both inorganic and organic in nature, consist of the upstream sediment load from the river, sediments carried by overland runoff from the area immediately surrounding the impoundment, sediments from the erosion of the impoundment shoreline, and other organic matter. Often the sediments that accumulate in impoundments will contain toxic contaminants such as heavy metals, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and so on. This is particularly true of impoundments downstream of, or surrounded by, industrial or urban areas.

Nutrients do not directly contribute to sediment volume; however, additional nutrients from fertilizers carried in runoff, septic tank leachate, and wildlife do lead to excessive aquatic plant growth (eutrophication). These plants then die and sink to the bottom where they contribute to the sediments accumulating in the impoundment.

Newburgh Lake is an impoundment in which all of these processes and the problems associated with these processes were occurring. Sediments had accumulated in Newburgh Lake since it was created in the early 1900s. These sediments, some contaminated with pollutants, had significantly degraded the recreational quality of Newburgh Lake. Shallow water depths resulting from the sediment accumulation and nutrient-rich water led to excessive growth of aquatic plants. Moreover, sediments

sometimes contain toxic organic contaminants such as PCBs that tend to bioaccumulate as they pass through the food chain. This bioaccumulation results in a potential human health hazard associated with fish consumption. To eliminate this possible hazard it was necessary to remove the contaminated sediments.

SETTING AND HISTORY

Newburgh Lake is an impoundment in the Rouge River Watershed, Figure 1. The lake is located on the Middle Rouge River in the City of Livonia located in Wayne County, Michigan. The lake is part of the Wayne County Park System's Edward Hines Parkway.

The lake was developed in the 1930s as part of Henry Ford's "Village Industries" on the Rouge River. Ford's Village Industries were part of a project in which Mr. Ford tried to blend industry, rural life, and ecology. To counteract the migration of rural residents to the city for jobs in the car plants, Ford began establishing small water-powered factories on old mill sites, such as the one at Newburgh. With the cooperation of the Wayne County Road Commission (WCRC), the mill and dam at Newburgh were rebuilt. In exchange for their assistance Ford deeded Newburgh Lake to the WCRC for inclusion in a park. Recreational activities have been a part of Newburgh Lake's existence ever since.

OBJECTIVES FOR NEWBURGH LAKE RESTORATION

The Newburgh Lake Restoration Project set out specific objectives in order to meet and address the needs and desires of Wayne County, the Michigan Department of Environmental Quality, and the public. These objectives were formulated to address the causes of each of the lake's problems with a specific remedy. These objectives with their associated issues and remedies were:

- *Restoration of water quality in Newburgh Lake.*

The contaminants in the sediment were providing a source of oxygen-demanding substances and toxics to the river. These sediments, coupled with the river influent, resulted in a high nutrient loading and a depletion of dissolved oxygen (DO) within the water column. The removal of the contaminated sediment and the proposed use of vegetative filters on storm water outfalls would help to reduce nutrient loadings to the lake as well as reduced oxygen demand and toxics.

- *Reduction of the human health risk by eliminating the PCBs and removal of the fish consumption advisory*

The PCBs in the sediment bioaccumulated in the food chain. Because of the resulting human health concern, the Michigan Department of Public Health issued a fish consumption advisory for Newburgh Lake. By conducting fish kills to remove all the PCB-contaminated fish, removing the contaminants in the sediment that bioaccumulate in the fish, and finally restocking the lake with new fish, the fish consumption advisory for PCBs would be eliminated.

- *Restoration of habitat for aquatic life and wildlife.*

There was very little habitat for sustaining a fish population within the lake. The establishment of habitat suitable for fish spawning and nursery and the restoration of water quality would allow for restoring the aquatic life and wildlife.

- *Increased recreational use of canoeing/boating and fishing.*

Newburgh Lake in its former state did not allow for fishing or boating. The fish were under a consumption advisory, vegetation choked off the lake preventing any surface activity, and the water quality was poor. By eliminating the fish advisory for PCBs and providing habitat to sustain a fish population, recreational fishing would be an acceptable activity in the future. Canoeing/boating will become a normal activity for Newburgh Lake with the reduction of the strangling vegetation that impedes recreational opportunities during potential high use periods.

- *Improved public perception of Newburgh Lake as a resource for both recreation and education.*

LAKE BACKGROUND

A number of investigations were conducted prior to the restoration design and construction in order to provide the required information. These investigations are summarized in the following sub-sections.

LAKE MORPHOLOGY

The existing morphology of Newburgh Lake was determined using existing detailed

survey maps and the results from a precision bathymetric survey conducted in April 1994. All of Newburgh Lake's morphometric parameters, their derivation, and significance are summarized in Figure 2. Newburgh Lake has a surface area of 4.56×10^6 square feet (ft²) or 105 acres at a lake elevation of 659.3 feet relative to the National Geodetic Vertical Datum of 1929 (ft-NGVD 29). The mean depth of the lake calculated by dividing the volume of the lake by the lake's surface area was 3.9 feet. Perhaps the most notable feature is that the eastern half is generally 6 feet or greater in depth; and the western half is considerably more shallow.

It was apparent from water depth versus surface area (hypographic) and depth versus volume data, that decreasing the surface area by 50 percent would require lowering the lake level by about 3 feet; the volume of the lake, however, would be decreased to 42 percent of the original volume. Lowering the lake by 2.5 feet would decrease the volume by 50 percent, however, the surface area would only be decreased to 57 percent of the original surface area of 105 acres (i.e., 60 acres).

SEDIMENTS

Initial sediment screening was conducted on Newburgh Lake during November 1993 and 1995. Cores ranging from 1.67 to 9.75 feet long were collected at 21 locations in Newburgh Lake in 1993. The average core length was 7.17 feet. Generally, the sediment stratigraphy was relatively simple with a 2- to 3-foot upper layer consisting of black silt and a second layer of non-oily, gray or brown silt usually several inches thick. Most cores had a third layer consisting of several feet of sand or sandy gravel which, in at least some cases, appeared to represent the terrestrial riparian soils present before Newburgh Lake was formed.

The cores were subdivided for analytical analysis for PCBs, Metals, and PAHs. The analysis was performed using screening methods of immunoassay and x-rf. The total solids concentration ranged from 14.3 to 86.8 percent; the mean concentration was 54.0 percent. Lower solids concentrations were typical for the uppermost portions of the cores, however, the top 30 inches of sediment still had a mean total solids content above 30 percent. These uppermost sediments were typically soft, dark, oily silts. Higher solids concentrations occurred in the deeper sediments. These sediments were mixtures of clay, silt, sand, and gravel.

The highest concentrations of PCBs were observed in samples taken from the west end of the lake and were found in or just below the uppermost sediment. The lowest concentrations of PCBs were found in the deeper layers of sediment cores from the west end and middle of the lake or from the cores collected from the east end of the lake. The mean PCB concentration was 2.4 mg/kg-DW. The highest concentrations of metals were observed in sediments in the vicinity of three outfalls; two along the

northern shore of the lake, and one on the southern shore. Though metals were not constituents of interest.

DEPTH OF SEDIMENT IN SITU CONTAMINATION

The first step in the development of the conceptual restoration plan was to determine the quantity of in situ contaminated sediment in Newburgh Lake. This was accomplished using data collected from the sediment coring task and the bathymetric task. The deepest limit of a given interval (e.g., 20 inches for the 10- to 20-inch interval) at which the concentrations of PCBs exceeded the MDL (330 ppb) for the State of Michigan was considered the depth of contamination. Selecting the bottom of the interval represented a more conservative approach for estimating the depth of contamination.

GEOTECHNICAL

The information obtained during the geotechnical investigation, in which 25 borings were advanced 15 feet below the subsurface, revealed a somewhat variable subsurface condition. Typically, the subsurface consisted of very soft organic sediments underlined by silty sand and/or silty clay deposits. The thickness of the lake bottom sediments varied from 0.5 feet to 6.5 feet, with an average of 2.7 feet. At half the borings a soft silty clay was observed with a thickness from 0.5 to 5 feet. Below the organic sediments or the soft silty clay, granular deposits are present. The deposits consisted of silty sand generally, however, isolated layers of gravel were encountered. The granular deposits are generally loose below the soft sediments becoming more compact with depth.

SAMPLING

As part of the initial construction work, the engineer team collected additional in situ lake samples for analysis of PCBs. This was done after the lake had been lowered. The samples were collected to better define the distribution of PCBs and to aid in the determination of disposal classifications. Concentrations ranged from less than MDL to 31 ppm, Figure 3 & 4. As the project progressed the engineers collected additional samples to further aid in the definition (August and December 1997). The resulting Classification Distribution based on the sampling analysis is shown in Figure 5. In addition to the sediment in situ analysis, the engineers continually

collected samples from containment cells to verify that sediments were being characterized appropriately. The Classification system was defined as follows:

- Class A 2 to <50 ppm
- Class B 1 to < 2 ppm
- Class C 0.33 to < 1 ppm
- Class D < detection limit (0.33 ppm)

The classification used a conservative approach in that if PCBs were detected the entire depth removed was classified at the highest PCB concentration detected. This was used even if removal of lower concentrations or clean sediments below the PCBs was required.

To make sure that dredging, excavation, and dewatering activities were not creating an environmental concern to the surface waters, samples were taken from the dredging area, containment cells discharge, and the river.

CONSTRUCTION

Construction activities began in the winter of 1997 with the erection of a coffer dam at the dam face to repair the outlet structure. Once the inoperable outlet structure of the dam was removed, stop logs in the coffer dam were removed slowly to drain the lake at a rate of 3 feet every 3 days. This prevented the lake bank from becoming unstable. The lake was lowered until only a 3-acre pool remained. This pool was used for sedimentation control. Next, additional sediment sampling was conducted to verify the concentrations and more precisely define the distribution of the PCBs. This sampling also was required for disposal reasons, since different concentrations involved different disposal costs or uses.

The restoration contractor began sediment removal operations in April of 1997. The contractor spent the first few months mobilizing and establishing a learning curve for meeting the many challenges of restoring Newburgh Lake. Because Newburgh Lake is an impoundment of an urban river system, storm events have a direct and immediate effect on the lake level requiring the contractor to adapt to and work with rapidly fluctuating lake levels.

Removal of the sediment was accomplished using a variety of techniques including mechanical dredging with a dragline, hydraulic dredging with a cutterhead, and earth moving equipment. Each technique was used in different areas of the lake because of the differing conditions encountered. Earth moving equipment, however, was the most productive and was used for the majority of the lake. Being an urban lake, we also have

had to deal with considerable amounts of debris during the course of the excavation. Often this debris interfered with the operation of the dredges. During sediment removal, the river channel was excavated deeper than the final project depth to aid in flow control and dewatering of the sediments. The contractor constructed a network of haul roads on the lake surface and holding/loading cells in order to process the material. The contaminated sediment was removed and disposed of in a municipal landfill. There was no TSCA material on this project. Figure 6 shows the construction phase.

Two fish kills were conducted in June 1997 and August 1998 to remove all of the contaminated and rough fish from the Newburgh and Nankin lakes and the approximately 5 miles of river upstream and in between the two lakes. A total of approximately 30,000 pounds of fish were removed from the lake; 78 percent of this weight was represented by carp, goldfish, and their hybrids. Figure 7 depicts the fish kills.

One major complication occurred during July 1997, when a facility that discharges its storm water to a storm sewer that enters the lake had an oil spill. Approximately 1,500 gallons of oils were spilled. Cleanup of this spill and sediment removal had to be conducted concurrently without either operation interfering with the other.

By the end of the excavation and removal process, over 14,000 truck loads removed approximately 558,000 tons of sediment, Figure 8. Of the total sediment removed 27% was Class A, 17% Class B, 20% Class C, and 36% Class D, Figure 9.

Additional restoration activities included construction of 10 acres of aquatic planting shoals to provide habitat for the wildlife and fish, in addition to helping with nutrient uptake. After the shoals were completed, fish habitat structures consisting of defective new sewer pipe and rip rap placed in piles at discrete locations in the lake and fish "moguls" (areas of uneven final contours) were constructed. To further provide for greater fish habitat, spawning beds were constructed using a stone and sand mix and spread in areas throughout the lake. In total, seven acres of spawning beds and habitat structures were constructed.

CONCLUSIONS

The Newburgh Lake Restoration Project set out as its overall objective to reduce to acceptable levels the risk at the lake associated with the sediment by removing and disposing of the sediment and restoring the lake to beneficial use. This main objective was accomplished. The project: 1) Repaired level controls in the dam structure, 2) Removed approximately 558,000 tons of sediment for the lake, approximately 350,000

tons of sediment removed contained PCBs based on the project's classification, 3) Disposed of all 558,000 tons in a Type II landfill, 4) Deepened the lake to a minimum of 8 feet, except where shoals were constructed, 5) Established 10 acres of aquatic vegetation on the shoals, 6) Eradicated, removed, and disposed of approximately 30,000 pounds of contaminated and rough fish, 7) Created structural and spawning bed fish habitat, 8) Restocked the lake with game fish, 9) Resurfaced 2 miles of roads through the park/lake area, 10) Provided a new boat ramp and docks, and 11) Cleared areas of park for more recreational use.

The Restoration Project, additionally, set out specific objectives to address the needs and desires of the public, Wayne County, Michigan Department of Environmental Quality (MDEQ), and the local communities. These specific objectives were fulfilled in the following ways:

- *Restoration of water quality in Newburgh Lake.* The removal of the contaminated sediment and the construction of the "vegetative filters" on the two largest storm water outfalls will greatly improve the water quality of the lake. The sediments contained near the outfall will limit the source of potential contaminants to the water column, contain the oxygen demanding material which would reduce the dissolved oxygen in the lake, and control the extreme suspension of particles which has caused a cloudy appearance. In addition, the work of the Rouge River Project should also enhance the water quality coming into the lake by implementing source controls in the upstream areas.
- *Reduction of the human health risk by eliminating the PCBs and removal of the fish consumption advisory.* The two fish eradications conducted in June 1997 and August 1998 removed the PCB contaminated fish from the river and lake. Since PCBs bioaccumulate in the food chain, the removal of the PCB contaminated sediments will prevent future fish contamination from PCBs. Additionally, new game fish were restocked in September 1998 with additional restocking in each of the next two years. The fish advisory will remain in effect for a least two years as the fingerlings that are stocked grow to catchable size. At that time the MDEQ will catch and test the fish. The project considers this objective to be well on its way to successful completion and is now turned over to the state.
- *Restoration of habitat for aquatic life and wildlife.* The construction of structural fish habitat and "fish moguls", spawning beds, and the building of over 10 acres of aquatic shoals has greatly increased the amount and diversity of habitat in and around the lake.
- *Improvement in the public's perception of Newburgh Lake as a recreational and educational resource.* The restoration of the lake has

helped to improve the public's perception of Newburgh Lake. The removal of the contaminated sediment increased the lake depth and removal of the choking vegetation allows for access to a greater surface area of the lake for canoeing and boating activities during the non-winter months. The public's access has been greatly increased by the inclusion of new docks, refurbished boat ramp, additional recreational use, resurfaced bike path, resurfaced roadway, paved parking areas. All these items have added to a greater appreciation of the lake. If any indication can be taken from the very favorable press coverage, attendance at the grand opening, and people's comments in general after the lake was reopened, the public has embraced the restored Newburgh Lake as a valuable resource that needs to be preserved. The public has been supportive throughout the project and continues to teach one another that simple actions can help maintain the health of Newburgh Lake.