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# REMEDIATION OF PCB-CONTAINING SEDIMENTS USING SURFACE WATER DIVERSION "DRY EXCAVATION": A CASE STUDY

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## ABSTRACT

Remediation of contaminated sediments presents an on-going challenge in the efforts toward improved water quality and environmental restoration. Faced with this challenge, Mercury Marine recently selected a remedial alternative that included diverting creek flow and removing approximately 5,900 in-situ cubic meters of sediments containing PCBs from an impoundment in Cedar Creek. The regulatory objective was to remove all sediment containing PCBs "to the extent practicable" from an 180-meter stretch of the impoundment.

A remedial investigation was conducted to collect the data necessary to characterize the site and prepare a remedial design. Technical issues involved with dry excavation that were critical to implementing this alternative included: channel diversion, sediment characterization, pond dewatering, wastewater treatment, groundwater infiltration, surface water run-off, and sediment removal, handling and disposal.

Mercury Marine and its engineering staff found sediment removal by dry excavation to be a labor intensive and costly means of remediating the PCB-affected sediments at this site. Before implementing dry excavation at any site, owners, consultants, and regulatory agencies must realize the many limitations of this alternative and give special consideration to site conditions, engineering, and planning. Copyright © 1996 IAWQ. Published by Elsevier Science Ltd

## KEYWORDS

characterization; dredging; dry excavation; polychlorinated biphenyls (PCBs); remediation; resuspension; sediment; siphon; stabilization.

## INTRODUCTION

Studies conducted by the Wisconsin Department of Natural Resources (WDNR) indicated that polychlorinated biphenyls (PCBs) concentrations were as high as 150,000 parts per million (ppm) in Ruck Pond, an impoundment of Cedar Creek in Cedarburg, Wisconsin. The WDNR identified Mercury Marine Plant 2, a former die-casting facility, as one of several potential sources of PCBs to the pond's 180-meter reach of concern.

In June 1994, Mercury Marine entered into an agreement with the WDNR to remediate PCBs in a portion of the pond. Specifically, the agreement included the removal of an estimated 5,900 cubic meters of sediment from a 180-meter reach of Ruck Pond, remediation of affected creek banks, and remediation of the storm sewer line, which was identified as the conduit from the plant to the creek via which PCBs entered the creek system. The WDNR agreed that upon successful completion of the remediation activities, the Department would not sue Mercury Marine or request that additional remediation be completed. This agreement was one of the first of its kind in Wisconsin.

The regulatory goal was to "remove" all sediment containing PCBs from the 180-meter stretch of the impoundment. Dredging effectiveness data collected at other sites containing PCBs indicated that the regulatory goal would be difficult and costly to achieve using mechanical or hydraulic dredging techniques. Concern also existed regarding the potential for PCB resuspension and transport during implementation. In an attempt to alleviate these concerns, a sediment removal strategy was implemented, which consisted of surface water diversion, pond dewatering, and subsequent dry excavation of sediments.

## SITE BACKGROUND

The Ruck Pond Site (site) is located in southeast Wisconsin in the downtown central business district of Cedarburg. The site was small, congested, and bordered by both commercial and residential neighborhoods.

As an impoundment formed by the Ruck Dam, Ruck Pond spills over the dam and continues as Cedar Creek, which flows on for approximately 10 kilometers until it flows into the Milwaukee River. The Milwaukee River discharges into Lake Michigan. The pond is approximately 500 meters long and has a width that varies from 21 to 24 meters, with an average depth of 2 meters. The surface area of the entire pond is an estimated 1.6 hectares. The area of concern extended from the storm sewer outfall, downstream to Ruck Dam. Ruck Dam was built in the late 19th century to provide power to an adjacent mill that operated until 1934. With a masonry face and backfilled with rock and earth, the dam is 35 meters long, 4.6 meters high, and has a raceway to the mill. The pond flows from north to south in this reach of the creek.

## PROJECT DEVELOPMENT

Prior to the implementation of the project design and removal action, project teams from Mercury Marine and the WDNR worked on defining the scope of the project. As the project developed, six project goals were identified:

1. Remove all sediments containing PCBs from the 180-meter reach of concern using a volume approach. No cleanup concentration levels were established for this project. Rather, the agreement stated that the sediment was to be "removed to the underlying material to the extent practicable using conventional earth-moving equipment (i.e., front-end loaders, backhoes, bulldozers, cranes)."

2. Minimize resuspension and transport of PCBs. Transport of sediments during the remedial action was a concern of all parties because of the relatively high PCB concentrations in the sediments. A technology to minimize the resuspension and transport of PCBs during removal needed to be employed.

3. Identify and remediate other sources of PCBs to Ruck Pond. The WDNR was concerned that other sources of PCBs were entering the creek system. Potential sources noted by the regulator were bank soils containing PCBs and the storm sewer connecting the pond to Plant 2. The project approach would need to include the identification and any subsequent remediation of other sources.

4. Educate and obtain community support. Since the project site was located in the center of the city, implementation would be very difficult to perform without the cooperation of the community. An extensive program focused on educating the community about the project. Also, community input was requested on various aspects of the project to minimize disruptions to daily activities and major community social events.

5. Obtain the "Covenant Not to Sue." Obtaining the "Covenant Not To Sue" was important to Mercury Marine. This covenant meant that Mercury would not have to perform further remediation activities for the WDNR once it successfully removed the sediment, to the extent practicable, in the 180-meter reach of concern.

6. Complete removal in 1994. Given the concern over the potential for movement of PCBs from Ruck Pond, the WDNR emphasized the importance of completing the removal action in 1994.

To achieve the six project goals, Mercury Marine evaluated the following three remedial alternatives:

1. Mechanical dredging;

2. Hydraulic dredging; and

3. Surface water diversion, or "dry excavation.

After completing a detailed evaluation of the three alternatives, surface water diversion was selected as the remedial alternative to be employed. The removal of sediments in-the-dry was perceived by all parties to be the most effective remedial option for the removal of sediment containing PCBs and the minimization of PCB resuspension and transport. One key factor in selecting the surface water diversion alternative was the WDNR's offer to issue a covenant not to sue. A second key factor in selecting this alternative was the preliminary cost estimates that indicated that surface water diversion would be the most cost-effective technique.

## SITE CHARACTERIZATION

During the project development and design phases, Mercury Marine initiated a characterization of the creek sediments. The objective of this characterization was to:

Determine in-situ sediment volumes;

2. Characterize sediment for disposal;

3. Identify other sources of PCBs to the pond; and

4. Collect pertinent design data.

To characterize the pond, the removal area was sectioned into 14 transects, approximately 15 meters apart along the centerline of the creek. Depth probing was undertaken at approximately 3-meter intervals along each transect to determine sediment depth, and 52 sediment core samples, 0.6 meters in depth, were collected and analyzed for PCBs. In addition to PCBs, the landfills required that a select number of sediment samples be analyzed for oil and grease, reactive sulfides, total cyanide, chlorine, volatile organics, semivolatile organics, pesticides, herbicides, and metals.

The sediment probing data indicated that approximately 5,700 cubic meters of sediment were present. PCBs were found to be the primary analyte of concern. The highest concentration of PCBs determined from the 0.6 meter core sampling, was 2,500 ppm. Material containing PCBs at a concentration of 50 ppm or greater is regulated by the Toxic Substances Control Act (TSCA), requiring special handling and disposal. Sediment in an area extending approximately 107 meters along the west bank, starting north of the storm sewer outfall and going south, was defined as TSCA material. Additionally, other samples were collected on the creek banks and in storm sewers to confirm the limits of PCB-containing soils and sediments.

To collect pertinent design data, three soil borings were drilled along the banks of the creek. Unconsolidated soil samples were collected and submitted for analysis to determine moisture content, grain-size distribution, and specific gravity. Packer testing of the bedrock was also performed at each bore hole location. This information was used to investigate the rock quality and hydraulic conductivity. The resulting data was used to estimate groundwater infiltration rates along the banks and beneath the temporary dam into the dewatered area of the pond. The soil boring results indicated an average hydraulic conductivity of 4.4 x $10^{-3}$ centimeters per second, with a resulting anticipated groundwater infiltration rate to the reach of concern from 20 to 120 liters per minute.

## PROJECT IMPLEMENTATION

### Overview

The implementation involved the construction of a temporary dam up stream of the removal area and a siphon system to divert creek flow. Since the lowest flow of the creek is historically in August, the goal was to remove sediments during this month. The normal flow of the creek during August was 0.7 cubic meters per second. The siphon had a design capacity of 5.7 cubic meters per second, which was to accommodate a 10-year storm event. While the creek flow for this storm event was 5.0 cubic meters per second, surface water that was diverted into the siphon for this same storm event had a flow of 0.7 cubic meters per second. All surface waters were prevented from entering this area of the pond during the removal period. Following diversion, the pond was dewatered and sediments were excavated and transported for stabilization and disposal.

### Site Preparation

To implement the project, extensive site preparation was first required, including clearing and grubbing, installation of security fencing, installation of temporary utilities, temporary shoring, and extensive excavation along the siphon alignment. While the execution of these activities was complicated by the site's location in a congested, historic, urban area, these constraints were overcome by an effective community relations program.

### Siphon Erection

The erection of the siphon required the installation of a supporting structure, which consisted of 20.3 centimeter diameter steel pipe piling, wide flanged beams, knee bracing, and pipe cradles. Providing support to the structure, knee braces were located underwater and required the pond to be lowered by drawing water through the existing mill raceway to accommodate the extensive welding required for their erection.

The logistics to erect the siphon demanded careful scheduling to incorporate the long lead times and extensive construction tasks. Several difficulties were encountered during erection of the siphon that led to project delays. These constrains included unknown obstructions and not receiving right-of-way access that caused changes in the siphon alignment. Changes in alignment required that the structural integrity and flow hydraulics of the siphon be recalculated.

All piping was first sent to the contractor's fabrication shop where it was prepared for welding and erection. This allowed scheduled deliveries of pipe on a "just-in-time" basis so trucks could be unloaded directly onto a transportation barge which was necessary since no space was available for staging materials on site. One crane was land based and dedicated to material handling, while five sectional barges were used to gain access to the siphon alignment and temporary dam. These barges were typically used for the staging of two cranes, for material transport, and for welding.

Once erected, the siphon had an overall length of 244 meters and consisted of four 91.4 centimeter diameter pipes and one 61 centimeter diameter pipe. A fifth pipe was located on the siphon to handle storm water diversion. Water flow through the siphon was controlled by butterfly valves located both at the intake and discharge ends of the siphon. All valves were interlocked with control wiring and operated from a control building. The intake valves were located in concrete structures, which also served as part of the temporary dam installation. A tailwater dam was also installed at the discharge end of the siphon to keep the discharge valves covered with water to maintain a vacuum on the siphon during its operation.

Temporary Dam

The original plans for the temporary dam included an earthen dam beneath the siphon intake structures and a water structure across the remaining channel width. The water structure consisted of two geomembrane tubes filled with water sitting adjacent to each other and both wrapped together by an outer geomembrane. A few hours after installation of the water structure, it became dislodged and floated down stream. The next day the temporary dam was rebuilt using steel sectional barges that were at the site. The barges were sunk into place, covered with a PVC membrane, and ballasted with sand and concrete. The membrane was installed to reduce water infiltration. A dewatering trench was installed down stream of the temporary dam to collect any water infiltrating beneath this dam after the pond was dewatered.

Pond Draw Down

After the temporary dam was in place and the siphon was bypassing the entire creek flow, draw down was initiated in a three-step process. First, the pond was drained by gravity via the mill raceway. Since the raceway floor elevation was above the creek bed, a large pool of dead water storage remained in the pond. Next, dead water storage was pumped over the dam to a depth of approximately 0.6 meters, the minimal depth that could be safely pumped without concern for sediment scouring. Once this depth was reached, all remaining water was pumped directly to the wastewater treatment plant via two sumps located in low points of the streambed. The initial draw down period lasted approximately two weeks.

Once the pond draw down was completed, an access ramp was constructed and heavy equipment was mobilized into the pond. The project team quickly realized that substantial volumes of pore water remained and groundwater infiltration was not being adequately captured. Testing undertaken during the design phase did not indicate that pore water and groundwater would be an issue. Dewatering became an ongoing battle throughout the sediment removal process, causing construction delays and increased costs. To increase dewatering capabilities, sumps were installed in pits cut into the bed rock.

To expedite the dewatering process, trenches were cut into the sediments to allow the pore water to move more easily to the sumps. Smaller sumps were also installed to leap frog pockets of water back to the two main sumps or the trenches. In the process of sediment trenching, a sediment slurry was created, which clogged the sumps. This problem was addressed by dedicating one worker approximately 18 hours a day, seven days a week, to constantly clean and maintain all sumps.

Wastewater Treatment

A wastewater treatment plant was temporary staged on site to treat the dead water storage and to continually treat water collected from sediment removal. The wastewater treatment plant had a capacity of approximately 13 liters per second and consisted of an oil water separator, bag filters, sand filters, carbon units, and canister filters. The influent water to the plant was collected in the dewatering sumps as described above, while the effluent water from the plant discharged below the dam. Effluent sampling was taken on a flow proportional basis. In general, the wastewater treatment plant was effective in meeting the WDNR's discharge requirements.

Sediment Removal

Effective implementation of the dry excavation technique required that the pond be sufficiently dewatered to allow earth-moving equipment to enter and maneuver in the pond. Because standing water was continuously present in the pond due to groundwater infiltration, the earth-moving equipment experienced difficulties maneuvering around the impoundment, and segregating and removing the sediments. As a result, TSCA sediments could not be easily segregated from non-TSCA sediments. If the sediments were not completely dewatered, they were oily, muddy and difficult to excavate requiring the mobilization of additional equipment in an attempt to counter the delays. To overcome this problem, improved dewatering of the sediments was achieved by cutting drainage channels and segregating and stockpiling the dryer sediments.

Once the stockpiled sediments were moved to the loading area, they were screened to remove debris through a grizzly equipped hopper and loaded onto a conveyor to be transported to the transport trucks. This step became a bottleneck of the load-out operation. Sediments that were too dry or too wet would create problems passing through the grizzly and up the conveyor. Therefore, the material had to be blended as it was processed.

In addition to the wet conditions, the irregular bedrock surface of the pond also complicated the removal of the last several centimeters of sediments. To remove these sediments, sections of a rubber conveyor belt were bolted to a bulldozer blade in an attempt to "squeegee" the bedrock. The placement of pebble-lime chips to absorb water and stabilize the sediment, and the use of a super sucker vacuum truck to remove residual sediments also were employed. While these efforts allowed some additional sediment to be removed, they were not successful in removing all of the sediment slurry. Although the bedrock did provide a good working surface for the earth-moving equipment, a residual layer of sediment was left in the pond.

The sediments that were being transported were wet; therefore, all trucks were equipped with gasketed tailgates to prevent leakage. Bentonite was placed in the dump box along the tailgate to soak any liquids if they appeared during transport. All dump boxes were tarpped and all trucks were washed prior to leaving the hot zone. The trucks averaged a payload of 21 metric tons. The final activity was the removal of all debris that would not pass the grizzly hopper or be able to be processed in the mixing plant. This debris was very typical of river sediments. The rocks were washed and used for erosion control. The remaining debris was loaded into trucks with a crane equipped with a clam shell and shipped unstabilized to the appropriate landfill.

<u>Sediment Stabilization</u>

All sediments that required stabilization were shipped to Mercury Marine's Hartford facility, which was approximately 40 kilometers west of Ruck Pond. TSCA material was stabilized and then shipped by rail to a TSCA landfill in Utah, approximately 3,200 kilometers west of Hartford. Non-TSCA material was stabilized and then shipped by truck to a solid waste landfill in Mayville, approximately 24 kilometers northwest of Hartford.

When material arrived at the Hartford facility, it was placed into a below-grade storage pit. A backhoe loaded the feed hopper on the mixing plant, and an inclined conveyor then transported the sediments into the pugmill for mixing with the stabilizing agent. Lime kiln dust was used to stabilize TSCA material and fly ash was used to stabilize non-TSCA material. Both arrived by bulk tanker and were stored in a horizontal storage bin that was adjacent to the mixing plant. From the storage bin, the stabilizing agent was transported via piping to a storage silo mounted on the mixing plant. This silo gravity fed a screw conveyor that fed the pugmill. After the sediments were mixed in the pugmill, they were loaded into rail cars or trucks by a stacker conveyor equipped with a belt scale. The mixing plant could process approximately 180 metric tons of stabilized sediments per hour.

The mixing plant was very effective in stabilizing wet sediments. The wet sediments that required stabilization had an approximate moisture content of 58% and were stabilized by weight through the addition of approximately 15-20% stabilization agent. Sediments that did not require stabilization had moisture contents typically in the low 20s. Due to the unusually dry weather, a large volume of non-TSCA materials was shipped to the landfill without being stabilized.

<u>Site Restoration</u>

Currently being implemented, the restoration phase of the removal action involves repairing damaged retaining walls, removing surplus construction materials, construction of a river walkway, and landscaping.

## SUMMARY AND CONCLUSIONS

Implementation of the Ruck Pond removal action lasted approximately 19 weeks, extending from June 9, with the preconstruction meeting, to October 19, with the filling of the pond. The sediment tonnage removed was 3,758.4 metric tons of TSCA material and 7,461.1 metric tons of non-TSCA material, for a grand total of 11,219.5 metric tons of sediment. Probing conducted during the investigation phase was very effective in defining in-situ sediment volumes. Post-removal residual sediment PCB concentrations were reported to be up to 300 ppm. The approximate all inclusive removal cost was $1,200 per cubic meter.

Technological limitations must be considered when establishing sediment cleanup objectives, goals, and selecting sediment remedial techniques. As it was learned from Ruck Pond, site constraints may make it difficult to achieve project goals.

Three alternate approaches that may prove to be more effective than sediment removal in meeting the goals of protecting water quality are:

* Natural recovery, which involves the natural deposition of cleaner sediments over the contaminated sediments through time.

* Engineered armoring, which involves the engineered placement of natural and/or manmade materials over contaminated sediments to eliminate migration and exposure of the contaminants.

* In-situ treatments such as solidification/stabilization and biodegradation.

Ruck pond was only a 180-meter cleanup of an approximate 10 kilometer waterway that is to be investigated in the future. Ruck Pond appeared to present ideal conditions for dry excavation, yet the cleanup efficiency in the pond was no better than that of other currently used removal technologies. Given the problems encountered, the high cost for this type of removal, and the short time window available for implementation, dry excavation would not only be cost prohibitive, but may be technically infeasible for the rest of the creek system. Realizing the limitations of removal technologies, serious consideration must be given to alternative approaches to contaminated sediment management.