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Restoration of the Cuyahoga River in Ohio, 1968-present

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Abstract

The Cuyahoga River of northeastern Ohio has long been notorious for its low water quality, especially for having caught fire at least three times between 1936 and 1969.

The Upper Cuyahoga River has long been in better condition than the lower river. It is plagued by low dissolved oxygen as a result of its many drinking water reservoirs and its naturally low gradient, however its problems are dwarfed by those of the Lower Cuyahoga River. The lower Cuyahoga River has historically been heavily polluted by fecal matter and other discharge from sewage treatment plants, as well as by chemicals discharged by steel and coke refineries. The navigation channel at the mouth of the river robs the extreme lower portion of the river of oxygen. All these factors combined make the habitat value of the river very low. Restoration efforts began in the early1970’s and the Cuyahoga River today is in better condition, though much room for improvement remains.

Introduction

The Cuyahoga River is a U-shaped 100-mile (160 km) long low-gradient river located in Northeastern Ohio, beginning near the Lake Erie plain, heading south, then making a sharp turn to the north, passing through the major cities of Akron and Cleveland. The river moves slowly through a 813 square mile (2081 square km) watershed which is largely split between agricultural land use, urban uses, and second-growth forest.

Akron is the fifth-largest city in Ohio, with 217,000 inhabitants and Cleveland is the largest city in Ohio, with a city population of 505,000 and a metropolitan area population of 2.9 million (City of Akron 2001). Both are major cities in the American "Rust Belt" region, a region in the northeastern and north-central United States stretching from northern New York State to Wisconsin, and characterized by heavy-manufacturing activity and an outflow of jobs and industry during the 1970’s and 1980’s (Infoplease.com).

In 1969, the fire which burned on the surface of the Cuyahoga River for almost two hours was widely covered by the American news media and became a symbol of the poor quality of the United States’ waterways and American abuse of the natural environment (Case Western Reserve University 2001). The fire catalyzed a movement to restore degraded rivers and was essential in helping pass the Federal Clean Water Act of 1972, a piece of legislation which has been important in restoring the Cuyahoga and many other degraded waterways (Schneider 1997). Since the passage of the Federal Clean Water Act, the cities of Akron and Cleveland have modified their sewage treatment system to include tertiary treatment of wastewater, and most heavy manufacturers on the Cuyahoga have closed or have drastically reduced their toxic discharges into the system. The shipping channel from the mouth of the river to the 6-mile (9.6

km) point remains unaltered, but several plans have been forwarded to ameliorate the conditions causing the lack of dissolved oxygen.

As a result, the Lower Cuyahoga River, which had been almost entirely devoid of aquatic life and which had contributed large amounts of toxic waste to Lake Erie in 1968 is now home to several relatively sensitive fish species and is used by humans for "full-contact" recreation, such as wading and boating. Restaurants and entertainment centers are located along the once foul-smelling Cleveland shipping channel (Hun 1999). A large portion of the Cuyahoga's catchment basin between the cities of Akron and Cleveland is now designated "the Cuyahoga National Recreational Area", and a portion of the Recreational Area was designated "Cuyahoga Valley National Park" in October 2000 (National Park Service 2001). Boating and swimming are allowed at all times, except following a storm event, during which Akron's sewage treatment system still tends to overflow into the storm sewer, dramatically raising the level of fecal coliform bacteria in the river (Hun 1999). While the quality of water has improved, there is still a considerable amount of work to be done if the Cuyahoga is to be returned to the condition specified by the Cuyahoga river Remedial Action Plan (RAP).

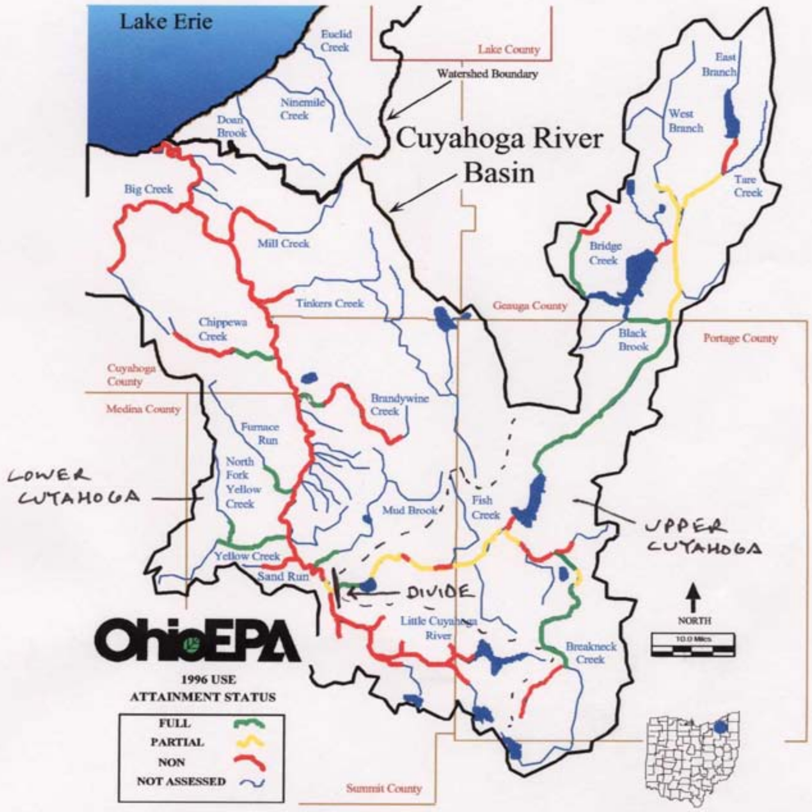

Fig. 1. Cuyahoga River Watershed

Source: Ohio Environmental Protection Agency. 1999. Biological and Water Quality Study of the Cuyahoga River and Selected Tributaries. Ohio EPA, Columbus OH.

The Cuyahoga River RAP board was created in 1988 by the EPA and the Northeast Ohio Areawide Coordinating Agency to monitor water quality in the Cuyahoga River and plan its future. The RAP began by listing the impairment factors on the river, which include:

- Restrictions on fish and wildlife consumption
- Degradation of fish and wildlife populations
- Fish tumors or other deformities
- Degradation of benthos
- Restrictions on dredging activities
- Eutrophication or undesirable algae
- Beach closings
- Degradation of aesthetics

- Degradation of phytoplankton, and zooplankton populations
- Loss of fish and wildlife habitat

The long term goals of the RAP are to:

- Have the river meet all biological and water quality standards
- Not have any fish consumption advisories or impacts on human health
- Have adequate public access and recreation opportunies
- Have enough suitable protected habitat to maintain
- Protect aquatic and terrestrial wildlife.

The RAP has chosen *Ardea herodius* (Great Blue Heron) and *Haliaetus leucocephalus* (Bald Eagle) as indicator species and has as an additional goal maintaining sustainable *Pandion haliaetus* (Osprey) and *Lutra canadensis* (River otter) populations in the Cuyahoga. Kelvin Rogers of the RAP states, "We feel that we now have the improved water quality, fish populations, habitat and protected areas needed to support these species...they just have not returned to the area although there are populations very close by" (Rogers 2001).

The Cuyahoga River RAP board has so far focused its efforts on fundraising, education, and reports on water quality. It has also studied methods of restoring portions of the river, and has several feasibility studies in progress. Its greatest concrete achievement so far has been reduction of point source pollution in the lower Cuyahoga river, by helping to enforce the Federal Clean Water Act requirements for point-source industrial polluters and sewage discharge sites. Active restoration activity has yet to take place on the river (Cuyahoga RAP 2001).

State Of The Cuyahoga River In 1968

A special symposium on the Cuyahoga River watershed held at Kent State University in Kent Ohio in 1968 (Orr 1968, Rau 1968, Simpson et al., 1968) helped to form a baseline for later analysis of water quality in the Cuyahoga River system. The symposium featured several speakers from Ohio as well as neighboring states to discuss the quality of the Cuyahoga River, as well as broader issues of watershed management. The proceedings show the Cuyahoga River to have been in a state of severe degradation in 1968, the result of large inputs of fecal matter and industrial waste, and a severe lack of dissolved oxygen. Few plant and animal species were able to survive under these conditions. The upper portion of the river, while burdened with low dissolved oxygen, was shown to be in a much less degraded state than the lower portion.

Upper River

The Upper Cuyahoga River differs significantly from the lower river in two ways. While the entire Lower Cuyahoga river is a low-gradient stream, with vertical drops of 1 to 6 feet (.3 to 1.8 meters) per mile (1.6 km), the Upper Cuyahoga has a significant "gorge" area, a 5.5 mile (8.8 km) stretch with an average drop of 42 feet (13.5 m) per mile (1.6 km). The rest of the river has vertical drops similar to the lower Cuyahoga. The upper river also differs in having a mostly rural watershed, while the lower river has a mostly urban watershed. As a result, the Upper Cuyahoga River had better water quality.

The greatest stressor on the Upper Cuyahoga River in 1968 was shown to be the dams and drinking water reservoirs for the city of Akron . These reservoirs caused water to stagnate and dissolved oxygen to plummet (Simpson et al. 1968). These pools, some as deep as 80 feet, often created anoxic conditions downstream during the summer months. The pool at the Ohio Edison Dam was shown to have an average dissolved oxygen level of 2 mg/L year-round. (Simpson et al. 1968). This "pool effect" left only rough, benthos-feeding fish in the river, and effectively segmented the available habitat for higher-quality fish with higher oxygen requirements.

A sewage treatment plant in Kent Ohio, at the 56 mile point, discharged sewage into the river, but not at the levels found in the lower river. 125,000 mg/L of fecal coliform bacteria were present at the sampling site just downstream from the plant. The Kent plant had just recently installed secondary treatment at the time of the printing, and significant improvements were beginning to be seen (Simpson et al. 1968). Previously the Kent plant had had only primary treatment which involved passing the effluent through a screen to remove large pieces of solid waste, allowing the waste to settle briefly before it was discharged into the river. (Lima OH wastewater 2001)

Orr (1968) found thirty-one fish species in the Upper Cuyahoga. These included *Minytrema melanops* (spotted sucker) a species which requires relatively high quality habitat, and *Micropterus salmoides* (Largemouth bass) a popular gamefish which requires relatively high habitat quality, but which can endure low dissolved oxygen. *Minytrema* were found only in the headwaters area, but *Micropterus* appeared to be abundant throughout the Upper Cuyahoga. Other fish were "rough"fish, minnows, and fish which could tolerate low levels of oxygen (Simpson et al. 1968).

Lower River

The Lower Cuyahoga River is a low gradient river throughout, with average vertical drops of 1 to 6 feet (.3 to 1.8 m) per mile (1.6 km). It begins at the entrance of the Little Cuyahoga River into the main stem of the Cuyahoga, at approximately the 44 mile (70.4 km) mark. The transition from the Upper to Lower Cuyahoga River is dramatic. The river abruptly begins to flow north, after flowing south for the entirety of the Upper Cuyahoga's run. It also marks the transition to a highly polluted state. The Little Cuyahoga River tributary deposited waste from Akron's rubber manuifacturing plants at this juncture (Simpson et al. 1968) and the Akron sewage treatment plant is located only five miles downstream from this transition area. This is where the Cuyahoga River begins to have concerted water quality problems.

While most of the national attention on the Cuyahoga River after the fire of 1969 was focused on industrial petrochemical waste, Simpson et al. (1968) found that the greatest threat to water quality in the lower river came from three sewage treatment plants in the lower half of the Cuyahoga's run. These plants contributed levels of fecal coliform bacteria which rendered the river unuseable to recreationists and near anoxic during the summer months.

The water in the stream directly downstream from Akron's treatment plant contained on average 150,000 mg of fecal coliform bacteria per liter of water. 15 miles downstream was the Brecksville sewage treatment plant which raised the fecal coliform levels to 190,000 mg/L. Eight miles later, immediately downstream from Cleveland's Southerly treatment plant, fecal coliform levels of 375,000 mg/L were measured (Simpson et al. 1968). In contrast, the areas in the far upper river contained between 0 and 1,000 mg/l. All treatment plants in 1968 lacked the tertiary treatment capacity necessary to reduce the nutrients entering the river to a less harmful level. (Simpson et al. 1968) Tertiary treatment reduces the nitrogen compounds which are discharged, disinfects the waste with liquid chlorine, then removes the chlorine from the wastewater before discharging it into the stream (Lima OH wastewater 2001).

Orr (1968) found *Lepomis macrochirus* (bluegill) *Carassius auratus auratus* (goldfish) *Pimephales notatus* (Blunt-nosed minnow) and 11 invertebrate species at sampling station 24, immediately upstream from the Akron treatment plant. At sampling station 23, approximately 2 miles (3.2 km) downstream from the Akron plant, he found no fish species, and only four invertebrate species. This was potent evidence that the sewage plant was rendering the river unsuitable for fish species of any kind.

Simpson et al. (1968) measured dissolved oxygen at 36 locations, most in the lower river, and found in many areas that oxygen levels were high enough to support relatively tolerant fish species, however, the species were not present in these areas. Orr (1968) suggested that the apparent disparity may have been the result of intermittent pulses of high toxicity which caused stresses on the system which many animal communities never recovered. During periods of low flow, the wastewater from the Akron sewage plant often accounted for over 2/3 of the total river flow (Orr 1968)

The Shipping Channel

In order to facilitate barge transport to mills on the banks of the Cuyahoga River, the Army Corps of Engineers channelized the last 5.6 miles of the Lower Cuyahoga with metal riprap, forming a relatively straight and sterile channel. The Corps also dredged the river each year to a depth of 24 feet (7.3 m). As a result, the Cuyahoga, which throughout most of its run is 2 to 8 feet (.6 to 2.5 m) deep, slows down dramatically and drops sediment and other suspended substances (Simpson et al. 1968). An informal estimate puts the time of transport of a drop of water from Akron to Cleveland-- approximately 30 miles/48 km-- as taking 10 hours, and the transport time from the beginning to the end of the shipping channel (6 miles/9.6 km.) as being 10 days (Hun 1999).

The shipping channel area was also the location for most of Cleveland's heavy industry in 1968. Organic and inorganic chemical waste products were discharged regularly into the river by coke refineries, steel mills and rubber manufacturers. According to Simpson et al. (1968) "(the river is) covered with a brown oily film observed upstream as far as the (Southerly Cleveland sewage treatment plant). In addition, large quantities of black heavy oil floating in slicks, sometimes several inches thick are observed frequently. Debris and trash are commonly caught up in these slicks, forming an unsightly floating mess." High levels of sulfate (260-300 mg/L) and low dissolved oxygen (0-3 mg/L) were noted by Simpson et al. (1968) in the period from 1964 to 1967.

Along with floating petrochemicals and solid waste, the heavy industries along the Lower Cuyahoga River also contributed heavy metals and thermal pollution. Steel plants using river water for cooling raised the temperature in the channel from 18 to 27 degrees Fahrenheit (10-15 degrees Celsius) (Simpson et al. 1968). Thermal inputs made the channel completely inhospitable to coldwater fish and invertebrates and also lowered levels of dissolved oxygen and increased plant mortality.

The industrial waste, low dissolved oxygen and high temperatures in the shipping channel prevented any movement between the Cuyahoga River and Lake Erie by fish that may have otherwise moved between the two aquatic systems, presenting an almost impermeable barrier. While there may have been suitable habitat for species such as *Ictalurus* in Lake Erie and in parts of the Cuyahoga River above the shipping channel, any movement between the lake and the river was prevented.

The water in the shipping channel was shown to be unsuitable even for nitrifying bacteria and the ammonia that resulted was carried out into Lake Erie. Simpson et al. (1968) concluded that this stretch of the Cuyahoga River did not meet any criteria for any use. Davis (1968), in his report on Lake Erie's water quality, described the Cuyahoga River as a "cloaca"-- likening it to a birds' combined bladder and rectum-- collecting and concentrating urinary, fecal and reproductive wastes, and discharging them out of the system-- and into Lake Erie.

Measures Taken Since 1968 to Improve Water Quality

As a result of the passage of the Federal Clean Water Act of 1972, and the creation of the Cuyahoga Valley RAP, the water quality of the Cuyahoga River has markedly improved. Fecal matter and associated nutrients have decreased, as the result of tertiary treatment stages being installed at all sewage plants on the river, almost all sources of petrochemical input have been eliminated, however the reservoirs and shipping channel remain nearly anoxic much of the time.

Upper River

The installation of tertiary treatment capacity at the Kent sewage treatment plant reduced the level of fecal bacteria to 1000 mg/L at every point on the Upper Cuyahoga. Most of the river above the Edison reservoir is now considered to be in full or partial attainment by the EPA (1999). A section of river is considered to be in non-attainment by the EPA when all index values (index of dissolved oxygen, fecal coliform levels, other toxin levels) are in the "very poor" range. Partial attainment is achieved when at least one index is above "very poor", and full attainment is achieved when all index values are "poor" or better (EPA 1999).

There was no record of any alteration of the drinking water reservoirs. The reservoirs appear to remain unaltered in aerial photos taken in 1994 (Terraserver.com 2001). The dissolved oxygen in the reservoirs continues to be low. Measurements in 1996 showed oxygen levels to range from 3.30 to 4.48 mg/L in one reservoir and from 5.37 to 5.88 in another. Levels in other parts of the river ranged from 6 to 12 mg/L.

Brown and Olive (1995) found that the while species diversity increased over the last 20 years throughout the Cuyahoga river, the diversity of species continued to be 2 to 3 times greater in the Upper Cuyahoga River than in the Lower Cuyahoga. This is not surprising, given the historically highly degraded state of the lower river.

Lower River

The input of fecal matter into the Lower Cuyahoga River has been greatly reduced in the last three decades. In the 1970's the cities of Akron and Cleveland installed tertiary-treatment facilities at their sewage treatment plants, reducing the nutrients and other fecal byproducts entering the flow of the Cuyahoga at the Akron sewage plant to between 110 and 2400 mg/L (EPA 1999). However, pulses of fecal bacteria as high as 200,000 mg/L were still found upstream from the plant. This could be the result of combined sewer overflows from Akron's combined septic and storm sewer systems, which have been largely separated, but which still tend to overflow during rain events of as little as .1 inch (.25 cm) (EPA 1999).

Species diversity was shown to be greater in the areas downstream from the treatment plants in 1992 than it was in 1974. 10 fish species were found in a sample of the river immediately below the Akron sewage plant discharge, where none were found in 1968. However, all species were pollution-tolerant fish such as *Ictalurus* and *Lepomis cyanellus* (green sunfish). Meyers, Koltun and Francy (1999) found that the highest concentration of fecal bacteria in the Cuyahoga continued to be found just downstream from the Akron treatment plant.

The Shipping Channel

The Federal Clean Water Act of 1972 severely curtailed the point-source dumping of industrial waste that had rendered the shipping channel flammable in 1969. All of the coke refineries and all steel plants except one located on the lower Cuyahoga have since gone out of business or moved to new locations off of the Cuyahoga river. (Lin et al. 2001) As a result, the thick, oily discharges once common on the Cuyahoga are a thing of the past.

The heavy metals, Polychlorinated Biphenyls (PCBs) and Polyaromatic Hydrocarbons (PAH) discharged by the departed plants have remained in the sediment of the Cuyahoga, however. Lin et al. (2001) found that even 5 years after the last coking plant on the Lower Cuyahoga River had closed down, several toxic chemicals were still present in the sediments at levels of concern. Additionally, the toxic sediments were linked to tumors on*Ictalurus* that feed heavily on benthic invertebrates (Lin et al. 2001). Toxicity was highest in years when the channel was dredged and sediments resuspended, but toxin levels continued to be high the next year, when sediment was not dredged (Lin et al. 2001).

Sources show that nothing has been done to alter the shape and morphology of the shipping channel. Several alterations have been proposed by the Environmental Protection Agency, such as aerating the channel and/or creating a shallower habitat area and "soft"edge on one side of the channel (Hun 1999). One of the more creative, and less likely to be successful ideas proposed by a participant in the 1968 conference involved pumping water from Lake Erie to the headwaters of the Cuyahoga River to recharge reservoirs and increase flow during dry periods, (Rau 1968).

While the quality of the water in general in the channel has improved, dissolved oxygen levels continue to be lower than the rest of the Lower Cuyahoga, and temperatures in the channel continue to be high, though not as high as 1968. The EPA (1999) found in 1996 that dissolved oxygen levels in the first 5 miles (8 km) of the shipping channel ranged from 3.5 to 7.4 mg/L (high enough to support most fish) with levels being consistently higher further from the mouth of the river. Levels at the last sampling station, closest to Lake Erie ranged from 2.7 to 4.1 mg/L, (EPA 1999) which were unacceptably low levels for many fish.

Summer temperatures in the channel ranged from 72.5 to 84.2 F (22.5 C to 29.0 C) with a mean temperature of approximately 80.6 F (27 C). This was about 9 degrees F (5 C) higher than the rest of the lower Cuyahoga which had a mean temperature of approximately 71.6 F (22 C) (EPA 1999). While these temperatures are still high, they represent a significant improvement over the 18-27 F (10-15 C) increases seen in the shipping channel in 1968 (Simpson et al. 1968).

Dredging continues to resuspend sediment and the shipping channel causes the water to slow dramatically, almost to the point of stopping (Simpson et al.1968). The Environmental Protection Agency still considered the entire shipping channel to be in non-attainment in 1999 (EPA 2001).

Animal Species Recovery Since 1968

Upper River

The Upper Cuyahoga River in 1968 supported 31 species of fish, almost all being pollution tolerant species, i.e. *Ictalurus, Lepomis macrochirus, Carassius auratus, Catostomus* (White sucker) and *Esox americanus vermiculatus* (Mud pickerel). Between 8 and 20 invertebrate taxa were found at each sampling station. In 1996, however, the EPA found approximately 50 species of fish in the Upper Cuyahoga River, including relatively pollutant-sensitive species such as *Minytrama melanops* (Spotted sucker) *Micropterus salmoides* (Largemouth bass) *Ambloplites rupestris* (Rock bass), *Perca flavescens* (Yellow perch) and between 25 and 58 taxa of macroinvertebrates at sampling stations (EPA 1999).

Lower River

The Lower Cuyahoga River has recovered in a manner proportional to the Upper Cuyahoga. At its worst in 1968, the Lower Cuyahoga River supported only 2 species; *Carassius auratus* and *Lepomis macrochirus* at one sample site out of 23 and no fish at the other 22 sites. *Oscillatoria*algae were the only species of plant or animal found at some sites, (Simpson et al. 1968). In 1996, at least 7 species of fish were found at each sampling site. A single aberrant *Oncorhynchus mykiss* (Rainbow trout) was even found just outside of the Cleveland city limits. Most other species were rough, pollutant-tolerant fish. However, a few *Micropterus salmoides* and *Esox lucis* (Northern pike) were found in the lower river in 1996 (EPA 1999).

Partial restoration of the fish and benthic invertebrate communities have been accomplished according to Arbuckle and Olive (1995) but impairments to the communities are still apparent in many areas. While species of *Micropterus* appear to be relatively abundant in the Upper Cuyahoga, upstream from the Akron sewage treatment plant, *Micropterus* disappear for two miles (3.2 km) after the plant's outflow, then only reappear in small numbers afterward. *Minytrema melanops* (Spotted sucker), a pollutant-sensitive species (Orr 1968) disappear altogether downstream from the Akron plant. However, the existence of any fish at all in the Lower Cuyahoga River is an improvement. Most encouraging is the unpublished data from the EPA's 2000 survey showing "for the first time several sites in the Cuyahoga mainstem between Akron and Cleveland meeting (RAP) criteria - in full or partial attainment" (Rogers 2001).

Shipping Channel

One of the most surprising developments is the relative abundance of fish now in the shipping channel. As mentioned previously, the shipping channel was too polluted to support any form of life other than *Oscillatoria*, being too toxic even for *Tubificids* (sludgeworms). (Simpson et al. 1968). However, in 1996 several species of *Micropterus* as well as 10 to 20 other species were found at sampling stations in the first three miles (5 km) of the shipping channel. Species abundance decreased to seven closer to the mouth of the river, and minnow species were dominant (EPA 1999).

Anecdotal evidence collected by the EPA suggests that *Ardea herodius* (Great blue herons) are again nesting in (an unspecified area within) the watershed and *Nycticorax nycticorax* (black-crowned night herons) have been seen in the shipping channel (EPA 2001). The Ohio EPA (1999) claims that "fish communities have recovered significantly in historically depleted segments of the Cuyahoga River, (but) pollution-tolerant species continue to dominate the population composition."

Possible Future Remediation Efforts

The restoration efforts on the Cuyahoga River to date have been very successful at eliminating or reducing point-source industrial pollutants, and the EPA and Cuyahoga River RAP board should be applauded for their help in reducing industrial waste and sewage input into the river. However, they seem to have neglected the issue of creating habitat or reintroducing native species which may have been eliminated from the river by toxins and low oxygen levels. None of the sources cited in this report showed evidence of any attempt to change stream morphology or attempt planting of native vegetation, or reintroduction of native fish species. The RAP is currently investigating streambank restoration options, but has not yet acted (Cuyahoga River RAP 2001).

Completely eliminating the sporadic sanitary sewer overflows which still take place in Akron and to a lesser extent in Cleveland would lead to a long-term improvements in water quality. The sporadic extreme reductions in oxygen levels which now kill off most life in the river at regular intervals would cease to be a controlling factor. Akron and Cleveland have done nothing since the 1970's to improve the quality of their wastewater discharge (EPA 1999) and regularly experience combined sewer overflows.

Though many of the heavy manufacturers which once depended on the shipping channel are gone, the shipping channel at the very end of the river continues to move almost 13 million tons of cargo in 800 vessels up the river each year (Rogers, personal communication). However, if industry continues to move away from the river, the shipping channel could possibly be decommissioned. (It should be noted that decommissioning of the channel is not being considered by the city of Cleveland or the Army Corps of Engineers at present.) (Rogers, personal communication) This would open up many restoration options, such as removal of riprap and regrading of streambanks to allow greater access to the river.

Conclusion

The Cuyahoga River, particularly the Lower Cuyahoga River, has made a surprising comeback from its highly degraded state in the late1960's. The reduction of inputs of insufficiently treated sewage, industrial chemical waste and thermal pollution has increased the quality of the water, and the habitat quality of the river. It is a slow-moving low-gradient river in a watershed with little vertical relief, and low levels of dissolved oxygen will continue to be a limiting factor in areas, no matter what is done. The Lower Cuyahoga, now almost surrounded by urban development, may never be restored to pre-European settlement conditions, but it could be restored to the high habitat and recreational standards that the Cuyahoga River RAP has set for it. It has proven to be a surprisingly resilient river, and with some more active management could someday be high-quality habitat for all wildlife species which once inhabited it, and a high-quality recreational river for the enjoyment of all the people and fish of Northeastern Ohio.

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