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The Rouge River Area of Concern - A multi-year, multi-level successful approach to restoration of Impaired Beneficial Uses

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Citizen outcry in the 1960s led to passage of the 1972 U.S. Clean Water Act. Expansion of industrial permitting and availability of federal grants to municipalities controlled industrial waste and untreated municipal sewage entering the Rouge River. However, many sources persisted – notably wet weather discharges, stormwater runoff, and contaminated sediments. This remaining pollution led state officials to cooperatively craft the Rouge River Remedial Action Plan in 1985. This plan addressed all pollution sources, but was not substantially implemented until 1993 when the federal government, encouraged by Congressmen Dingell and Knollenberg, committed to the Rouge River National Wet Weather Demonstration Project. The federal government ultimately delivered $350 million that was matched by $700 million in local funds. Efforts have been sustained through multi-year state and federal grants, with additional funding from local communities and other stakeholders. Early focus of the Rouge Project was on untreated sewage from combined sewer overflows, but quickly expanded to address other impairments from sanitary sewer overflows, stormwater runoff, illicit connections and failing septic systems. With major sewage discharges under control, efforts shifted to remediating contaminated sediments and improving in-stream water quality and habitat. In total, over 380 projects were completed by 75 communities and agencies at a cost of over $1 billion since 1988, resulting in improved water, sediment, and biological quality. Prior to the U.S. Clean Water Act, the Rouge River nearly continuously failed to meet water quality standards. After decades of effort and investment, it now rarely violates standards. This miraculous recovery was initiated by a small handful of citizens, facilitated by local municipal leaders, and supported by the federal government. The Rouge River is a model for how a holistic, ecosystem approach to water pollution can result in cost-effective and greater and faster achievement of restoration, while meeting local needs.

Keywords: Great Lakes, watershed, ecosystem approach

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/uaem.
Introduction

The Rouge River watershed in southeast Michigan includes a diversity of land uses from urbanized areas of Detroit, Livonia and Southfield to the developing areas of Troy, Canton Township and Novi to the rural areas of Salem, Superior and Van Buren townships. The watershed covers 1207 km² and is home to more than 1.3 million people living in 48 communities in parts of three counties. Like most urban rivers, the Rouge River has experienced more than a century of bad environmental practices (Ridgway, 2010). The International Joint Commission has long identified the Rouge River as a Great Lakes Area of Concern (AOC) and in 1985 the Michigan Department of Natural Resources, with support from U.S. Environmental Protection Agency, committed to working all communities and stakeholders to clean up the river and restore all impaired beneficial uses (International Joint Commission’s Great Lakes Water Quality Board, 1985). This article will: review the history of efforts to clean up the river using a holistic, ecosystem approach on a watershed scale; document progress; and share lessons learned.

Methods

To undertake a review and evaluation of what has been accomplished and learned over the last 32 years in the cleanup of the Rouge River, a survey was performed of key actions taken to restore impaired beneficial uses in the watershed and of the available, long-term, monitoring data and information. For the purposes of this review manuscript, summary data and information were used to evaluate changes over time and program effectiveness.

Rouge River dissolved oxygen concentrations were monitored continuously from May through October for 14 years between 1994 and 2008 by the U.S. Geologic Survey as part of the Rouge River National Wet Weather Demonstration Project. Concentrations were initially recorded every 15 minutes using a membrane-covered electrode as part of a water quality sonde (YSI 600OMS or equivalent). As remote sensing technology improved, optical sensors replaced the electrodes.

Historical background

The Rouge River has long been a working river with significant environmental degradation (Michigan Department of Natural Resources and Southeast Michigan Council of Governments, 1988; Rouge Remedial Action Plan Advisory Council, 1999) and includes the drainage area known as the “Arsenal of Democracy” as it provided many of the planes and vehicles that helped the Allies win World War II. The industrial infrastructure that remained after the war did not practice present-day pollution control practices resulting in a severely degraded Rouge River.

In the 21 October 1965 edition of the Dearborn Guide, the headline read: “Rouge Called State’s Most Polluted River” (Gnau, 1975). The article identified three sources of pollution: industrial waste from the Rouge Plant, stormwater and raw sewage from overflows, and garbage and trash thrown into (and washed into) the river. In fact, the downstream portions of the Rouge River were so polluted with oil and other petroleum products, that it even caught on fire in 1969 (Hartig, 2010).

The intense urbanization of the Rouge River watershed placed additional stresses on the river, including stormwater runoff and other diffuse sources. Chief among these were sanitary sewer overflows and combined sewer overflows (CSOs) that discharged untreated sanitary waste into the river during wet weather conditions. A study of the Rouge River in the early-1970s (Jackson, 1975) reported that approximately 64 km of the Rouge River were characterized by very poor water quality as evidenced by a macroinvertebrate community dominated by animals tolerant of severely polluted waters. The principal contaminants at that time were raw sewage and inorganic sediment entering the river via combined and/or storm sewers.

The 1972 U.S. Clean Water Act called for watershed-wide planning throughout the U.S. and for all waters to be “fishable and swimmable” within 20 years. Under Section 208 of the Clean Water Act, municipalities were encouraged to experiment with best management practices to address stormwater challenges, but no broad-based implementation funding was provided.
Then in 1983 a “tipping point” for the Rouge River occurred when residents of Melvindale and Dearborn could no longer keep their windows open at night because of the putrid smell of hydrogen sulfide off gassing from the river (Hartig, 2010). Residents quickly learned that the Rouge River had become so polluted with raw sewage that all the oxygen was being depleted in the river generating the hydrogen sulfide — a putrid and toxic gas. The oxygen was being consumed by bottom sediments that were the result of raw sewage from sanitary sewer overflows, CSOs, and illegal discharges. Even the most pollution tolerant fish, like carp, could not survive in a river with no oxygen.

The putrid smell was the beginning of a well-educated public that recognized that raw sewage and industrial pollution was causing a public health threat in their own backyard. Public awareness of the pollution was growing and these agencies were forced to take notice. Concerned citizens from Melvindale and Dearborn started a petition drive in 1984 and gathered nearly 1000 signatures. The petition was sent to the Regional Administrator of U.S. Environmental Protection Agency and the Michigan Department of Natural Resources and its Water Resources Commission. It demanded that something be done immediately to stop the illegal, raw-sewage discharges to the Rouge River and to eliminate the water quality standards’ violations occurring in the river.

In 1985 a tragic accident occurred when a 23-year old man fell into the Rouge River, swallowed water, and died of an infection from a rare parasitic, waterborne disease called leptospirosis or rat fever (Diebolt, 1985). While the local health department news release stated that there was no evidence that the man’s illness and death were directly linked to the polluted water of the Rouge River, most people simply assumed that the probable route of exposure was the river (Bean et al., 2003). The event became the compelling evidence that the polluted Rouge River was the source of the waterborne pathogen that caused one man’s death and was a public health risk to 1.3 million watershed residents. In response, the health department warned the public to avoid contact with the river. The Michigan Department of Natural Resources and its Michigan Water Resources Commission chose to comprehensively address this public health problem.

From 1985 tipping point to ecosystem-based, watershed management

All levels of governments had long recognized that the Rouge River was the most polluted river in Michigan. However, the problem seemed insurmountable. It was still viewed as a working river that facilitated industry, commerce, and technological progress. That changed in 1985.

The widespread recognition of the pollution of the Rouge River and the water quality and public health threat led to a coordinated, basin-wide, ecosystem approach that included all 48 Rouge River communities and resulted in a technically-sound and politically-supported restoration (Hartig and Thomas, 1988; Vallentyne and Beetton, 1988; Hartig and Vallentyne, 1989; Slocombe, 1993).

Clearly, no one community’s actions could restore the Rouge River. If CSO controls were implemented in the city of Detroit alone in the lower reaches, there would be no improvement in water quality because of the substantial number of upstream CSOs (Giffels/Black and Veatch, 1980). On 1 October 1985, the Michigan Water Resources Commission (the state agency responsible at that time for protecting waters of the state, establishing rules, and issuing permits) passed a resolution implementing the Rouge River Basin Strategy, and action plan, and a public participation process (Schrameck et al., 1992). This culminated in the comprehensive and systematic Rouge River Remedial Action Plan (RAP) to restore all impaired beneficial uses throughout the watershed. As a result, the Rouge River became the leader in the efforts to clean up the 42 Great Lakes Areas of Concern through the U.S.-Canada Great Lakes Water Quality Agreement (International Joint Commission’s Great Lakes Water Quality Board, 1985). This gave international attention to the Rouge problems and legitimacy the Rouge River RAP.

It was decided early on to build on the strengths of the Michigan Department of Natural Resources, the U.S. Environmental Protection Agency, Southeast Michigan Council of Governments, and others, yet achieve local ownership among the 48 communities within the watershed. It was recognized that the river could be studied ad infinitum with little improvement.

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The RAP process was envisioned to implement concurrently both necessary studies and remedial and preventive actions (Schrameck et al., 1992). To facilitate public participation, a Rouge River Basin Committee was established with representation of all 48 watershed communities and all major stakeholder groups, and an Executive Steering Committee was established with representation from both state and federal agencies. During this same period, small-scale trash removal projects were being staged by local officials. These visionaries recognized the recreational benefits that had been lost to pollution. One of the first Rouge River cleanups was led by Steve Marshall, a Southfields Parks employee. When these early cleanups were initiated, the prospect of cleaning the river seemed impossible – yet these visionary leaders persisted. In 1986, the first basin-wide Rouge Rescue was held to clean up debris and log jams. That same year of 1986, the Friends of the Rouge was established as a nonprofit organization to help coordinate Rouge Rescue, foster environmental education, and encourage citizen stewardship. This organization has continued its grass-roots stewardship and advocacy work to this day (Friends of the Rouge, 2015).

In 1988, the Rouge River RAP was completed and submitted to the Michigan Water Resources Commission for adoption in 1989 (Michigan Department of Natural Resources and Southeast Michigan Council of Governments, 1988). The RAP had the goal of restoring all of impaired uses within 20 years. There was also an intentional attitude that remedial projects that were ready to be implemented should not be delayed by additional studies. All wanted an aggressive, “move-ahead” attitude toward action. The initial Rouge River RAP focused heavily removing sewage – notably the approximately 29.5 million m³ of combined sewage was being discharged into the Rouge River during rain events annually. While the 1988 RAP recommendations focused on sanitary sewer capacity and CSO control, it also recognized polluted stormwater from separated storm sewers as a significant problem across the entire watershed. In support of continuous improvement, the Rouge River RAP was updated in 1994 (Rouge RAP Advisory Council, 1994), 1999 (Rouge RAP Advisory Council, 1999), and 2004 (Rouge RAP Advisory Council, 2004).

In 1992, the representatives of the Rouge River Basin Committee were reorganized into the Rouge RAP Advisory Council and in 1993 the Rouge River National Wet Weather Demonstration Project (Rouge Project) was established with over $350 million to help implement CSO controls and innovative stormwater management techniques called for in the Rouge River RAP (Murray, 1994). This funding was provided from U.S. Environmental Protection Agency to Wayne County's Department of Environment to implement cost-effective, control programs in a collaborative fashion with local governments. These substantial funds clearly were essential to moving forward on cleanup.

Stakeholders recognized that to be cost-effective, pollution problems in the river must be addressed collaboratively by all of the local governments, with flexibility across the regulatory programs. Effective policy, programs, and institutional arrangements were consistently emphasized through the Rouge Project (Ridgway and McCormack, 1994). For practical reasons, the Rouge River watershed was divided into seven sub-watersheds, with distinct watershed advisory groups and sub-watershed management plans. Over 380 cleanup, restoration, and preservation projects have been implemented by 75 communities and agencies under the Rouge Project (Table 1). Other major accomplishments of the Rouge Project include the

Table 1. A summary of projects implemented to help restore the Rouge River with financial support from the Rouge River National Wet Weather Demonstration Project, 1993–2006.

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State of Michigan’s Watershed-Based Stormwater Permit (the first of its kind in the nation), passage of the Watershed Alliance legislation Public Act 517 of 2004, the establishment of the Alliance of Rouge Communities in 2003, and the implementation of a comprehensive monitoring program for the Rouge River watershed (Ridgway et al., 1996). The Alliance of Rouge Communities has been particularly effective in facilitating communication among watershed stakeholders and in coordinating subwatershed planning in order to implement stormwater plans mandated under the Michigan Stormwater General Permit. The Alliance of Rouge Communities has an annual budget of over $600,000 to support watershed monitoring, data analysis, and report writing, and coordination of public education and involvement activities under their Stormwater General Permit and habitat restoration projects through the AOC program.

**Progress in combined sewer overflow controls and stormwater management**

As industrial point sources of pollution were being addressed during the 1960s and 1970s through both federal and state regulations, it became abundantly clear that considerably more effort would have to be targeted on addressing nonpoint sources of pollution – i.e. pollution which cannot be traced back to a single origin or source such as stormwater runoff, water runoff from urban and agricultural areas, and failing septic systems (Ridgway and McCormack, 1994). The Rouge River was still highly polluted through the mid-1980s as a result of raw sewage being discharged to the river from CSOs and sanitary sewer overflows. CSOs and polluted stormwater runoff result in many water quality problems, including extreme flow variations, streambank erosion, flooding, loss of habitat, high bacteria levels, and low dissolved oxygen. Polluted stormwater runoff contains bacteria, heavy metals, nutrients, oil, and pesticides. Minimizing impacts from both CSOs and polluted stormwater became a top priority.

The amount of sewage entering the Rouge River was dramatically reduced and, as a result, dissolved oxygen levels improved to the point that they rarely violate water quality standards (5 mg l⁻¹) (Ridgway, 2010). Over $1 billion (i.e. $350 million in federal funds with an additional $700 million in local funds) has been spent since 1988 on sewer capacity projects and CSO controls. CSO pollutant loads to the Rouge River have been cut by 90% during most wet weather events, with all CSOs being fully controlled in Oakland County and continued control efforts being implemented in Detroit and Wayne County. As more sewer capacity projects and CSO controls were implemented, and more stormwater management initiatives were undertaken, the Rouge River began to respond with improved dissolved oxygen conditions.

Dissolved oxygen is an important indicator of river quality. When dissolved oxygen concentrations are below 4.0 mg l⁻¹, there are adverse impacts on aquatic life. To protect aquatic life, State of Michigan water quality standards specify that dissolved oxygen must be greater than 7
mg l$^{-1}$ at all times for streams designated as cold-water fisheries and must be greater than 5 mg l$^{-1}$ at all times for streams designated as warm water fisheries. All of the Rouge River and its tributaries are designated as warm water streams, with the exception of Johnson Creek that is designated as a cold-water fishery (Bean et al., 2003).

Not only are dissolved oxygen levels a key indicator of river quality, but they are a good measure of the effectiveness of water pollution control programs. A 1973 study performed by the Michigan Department of Natural Resources (Jackson, 1975) found the 5 mg l$^{-1}$ standard was only met approximately 20% of the time. In the 1980s and early-1990s, dissolved oxygen concentrations in the lower Rouge River were routinely zero. Today, it rarely goes below 5 mg l$^{-1}$.

Figure 1 shows that dissolved oxygen regularly went to zero in 1994 in the Lower Rouge at Military Road. By 2008 more than 99% of the dissolved oxygen measurements at Station L05 exceeded the water quality standard of 5 mg l$^{-1}$ as compared to 30% in 1994 (Catalfio, 2008).

### Health advisories and legacy toxic substances contamination

Today, a high priority is being placed on control of contaminants at their source through National Pollutant Discharge Elimination Permits by Michigan Department of Environmental Quality and on pollution prevention programs like “Design for Environment,” ISO 14000, and others. However, the Rouge River’s long history of industrial activity resulted in legacy, toxic substances’ contamination, including health advisories on fish, degradation of benthos, and loss of fish and wildlife habitat. Health advisories on fish are in effect for specific river segments where consumption limitations are recommended for certain species and size classes of fish.

Contaminated sediment remediation has been a major priority of the Rouge River RAP (Schrameck et al., 1992). In 1986, sediments in the lower Rouge River were found to be contaminated with elevated levels of zinc (up to 2500 mg kg$^{-1}$), which was discharged from Double Eagle Steel Coating Company (Schrameck et al., 1992). A Consent Decree was signed with Double Eagle Steel requiring cleanup costs, damages, and penalties. Improvements were made to the industrial treatment process that resulted in a 99% reduction in effluent zinc concentration and loading. In addition, approximately 30,600 m$^3$ of zinc-contaminated sediment were removed from a 1.5 km stretch of the lower Rouge River at a cost of about $1 million. These sediments were disposed of in the Pointe Mouillee Confined Disposal Facility on western Lake Erie. Further, the company also paid $875,000 in fines and penalties (Schrameck et al., 1992).

Newburgh Lake is a 42-hectare reservoir on the Rouge River in Wayne County. It was long recognized as one of the most contaminated reaches of the Rouge River. The cleanup was initiated with addressing the primary source of the PCBs – Evans Products. In 1997, 7300 m$^3$ of PCB-contaminated sediment were dredged and disposed from the Evans Products Ditch site at a cost of $750,000, removing 8000 kg of PCBs (Zarull et al., 2001). The Newburgh Lake Restoration Project was undertaken in late-1997 and 1998. This project targeted remediation of PCB-contaminated sediment and restoration of habitat. In total, approximately 317,450 tonnes of PCB-contaminated sediment were removed and placed in a Type II landfill at a cost of $11 million (Zarull et al., 2001). In addition, 13,636 kg of contaminated rough fish were eradicated and removed. These measures helped in eliminating existing fish populations exhibiting high levels of PCB contamination, while at the same time eliminating contaminated sediments that were posing a risk to newly-stocked game fish. Follow-up assessments for Newburgh Lake indicated that all fish species stocked in the lake adapted well and were in good health. Post-remediation monitoring of PCBs in fish in 2001 showed nearly an order of magnitude decline from pre-remediation levels. In 2003, improved sediment and water quality in Newburgh Lake allowed Michigan Department of Community Health to lift the fish consumption advisory ban for some species of fish caught in Newburgh Lake, although river-wide advisories remain in effect (Selzer, 2008).

In 2018, a voluntary Great Lakes Legacy Act cleanup will begin on the Lower Rouge River Old Channel. The Michigan Department of Environmental Quality has also identified the lower Rouge River from the turning basin...
to the mouth as requiring additional sediment remediation.

Progress in conserving and rehabilitating habitats

With substantial reductions in pollutant loadings of all types, further restoration of the river could begin. Before habitat could be restored, the flow regimes had to be moderated – that is, the peak flows needed to be reduced and the low flows had to increase.

Loss of fish and wildlife habitat is considered an impaired beneficial use in all branches and tributaries of the Rouge River (Rouge RAP Advisory Council, 1994). Based on 1995 land use cover data, 23.1% of the Rouge River watershed has been transformed into impervious surface that causes both significant runoff problems and loss of habitat (Rouge RAP Advisory Council, 2004). Research has shown that watershed health begins to decline when impervious surfaces coverage exceeds 10% and becomes severely impaired if this number climbs beyond 30% of the total watershed area (Arnold and Gibbons, 1996). Clearly, the Rouge River watershed has too much impervious surface and much needs to be done to moderate flows, while conserving, rehabilitating, and restoring wetland and upland habitat that represents pervious surface.

All seven Subwatershed Management Plans under the voluntary watershed-based General Stormwater Permit identify habitat restoration/preservation as a goal (Rouge RAP Advisory Council, 2004). During the Rouge Project the understanding of green infrastructure matured, resulting in many projects being implemented in many communities. This reflected the evolution of management priorities from point sources and CSOs to urban nonpoint sources, green infrastructure, and habitat, representing a fundamental change to land use planning in the watershed. Good examples of green infrastructure projects implemented include: over 24 ha of native plant grow zones were installed throughout the watershed; over 15,000 native herbaceous plants and 3500 trees/shrubs were planted; over 8,600 tree seedlings were distributed for planting; and over 7646 m³ of invasive plants removed.

The Rouge River Oxbow restoration at Greenfield Village is particularly noteworthy. This project was led by Wayne County, The Henry Ford, and the State of Michigan, with funding from the Rouge River National Wet Weather Demonstration Project and the Clean Michigan Initiative. A 671-meter oxbow in the lower Rouge River that was historically removed to straighten the river channel was re-established in 2003 for wildlife habitat. It has become a model for habitat rehabilitation for the watershed.

In recent years, Rouge River projects have been funded by Great Lakes Restoration Initiative (GLRI). GLRI has placed a priority on the cleanup of AOCs and is essential to meeting long-term watershed goals and reaping its many benefits.

Alliance of Rouge Communities and the future

The Alliance of Rouge Communities (ARC) is a voluntary public watershed entity currently comprised of 36 municipal governments (i.e. cities, townships and villages), three counties (Oakland, Wayne and Washtenaw) and the Wayne County Airport Authority and is authorized by Part 312 (Watershed Alliances) of the Michigan Natural Resources and Environmental Protection Act (MCL 324.101 to 324.90106) as amended by Act No. 517, Public Acts of 2004. The ARC was established to provide an institutional mechanism to encourage watershed-wide cooperation and mutual support to meet water quality permit requirements for the municipal members while restoring beneficial uses of the river for area residents.

The ARC continues to focus on public education and involvement, monitoring and assessment, and planning, design, and construction of projects to benefit the Rouge River. Day-to-day activities are directed through committees of municipal officials – the Technical Committee, Public Involvement and Education Committee, Organization Committee, Finance Committee, and Executive Committee. The efforts are supported by cooperating partners. Most importantly, the ARC continues to demonstrate that pooling resources saves money and yields better results.
Table 2. Examples of improvements in the Rouge River watershed since 1985.

<table>
<thead>
<tr>
<th>Indicator</th>
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| **Combined sewer overflows (CSOs)** | • Construction of 10 CSO retention treatment basins and six sanitary and storm sewer separation projects  
• Approximately 144 of the 203 km of stream in the Rouge River watershed are now free of the adverse impacts of uncontrolled CSO discharges  
• CSO pollutant loads to the river have been reduced by 90 to 100 percent during most events |
| **Illicit discharges** | • Over 2,000 illicit discharges of wastewater to the Rouge River have been identified and have been/are being corrected  
• Over 727,270 kg of polluting materials and 1.764 billion l of polluted water are estimated to have been removed from the Rouge River as of 2013 through illicit discharge elimination efforts in the watershed |
| **Onsite sewage disposal systems** | • 898 failed onsite sewage disposal systems were found and corrected in the Rouge River areas of Wayne, Washtenaw and Oakland counties |
| **Green infrastructure** | • Over 24.3 ha of native plant grow zones were installed throughout the watershed  
• Over 15,000 native herbaceous plants and 3500 trees/shrubs were planted  
• Over 8600 tree seedlings were distributed  
• Over 7646 m³ of invasive plants removed |
| **Streambank stabilization** | • Over 5182 m of streambank stabilization, including restoration of the 671 m oxbow restoration at Greenfield Village to provide natural riverine habitat along the channelized portion of the main Rouge River |
| **Contaminated sediment remediation** | • Double Eagle Steel Coating Company – 30,600 m³ of zinc-contaminated sediment removed from the lower river in 1986 at a cost of $1 million  
• Evans Ditch – 7300 m³ of PCB-contaminated sediment removed and disposed in 1997 at a cost of $750,000  
• Newburgh Lake – 317,450 tonnes of PCB-contaminated sediment removed and placed in a Type II landfill in 1997–1998 at a cost of $11 million  
• Lower Rouge River Old Channel – voluntary Great Lakes Legacy Act cleanup projected for 2018 |
| **Dam removal** | • Two dams were removed from the Rouge River: Danvers Pond Dam along Pebble Creek, a tributary to the Main Rouge River, and the Wayne Road Dam along the Lower Rouge River (over 197 km of river and tributary streams have been reconnected to the Great Lakes for fish passage for the first time in over a century)  
• A fishway around the historic Henry Ford Estate Dam, the first dam on the Main Rouge River, will be built in 2018. Effectively reconnecting over 250 km of river and tributaries to the Great Lakes. |
| **Dissolved oxygen** | • In 1994, the dissolved oxygen was routinely zero  
• Today, dissolved oxygen never goes to zero and rarely goes below 5 mg l⁻¹  
• Dissolved oxygen improved 0.22 mg l⁻¹ per year for fifteen years starting in 1994 |

(Continued on next page)
From cleanup to restoration to revitalization

The cleanup of the Rouge River AOC has been an unqualified success, based on numerous indicators (Table 2). Major progress has been made in controlling pollutants being discharged to the Rouge River and evidence is mounting of ecological revival (Table 2). Perhaps the best indicator of success is that people are returning to the river and are benefitting from living, working and playing in the watershed.

Conclusions and lessons learned

The Rouge River AOC has shown that a concerted effort from a diverse group of stakeholders can, in fact, bring a river back to life. The Rouge River efforts – the AOC, the RAP, the watershed plans, the ARC and most importantly the investment – have proven that a holistic, ecosystem approach to water pollution can result in cost-effective and ultimately greater and faster achievement of water quality restoration. The challenge for the Rouge River (and other urban watersheds) was to develop innovative approach to addressing water quality problems that were cost-effective, implementable, and effective in meeting regulatory requirements and the needs of its citizens.

The Rouge River cleanup process evolved with changes in the state and federal programs – from early planning under Section 208 of the 1972 Clean Water Act, to the Rouge River RAP initiated in 1985, to the Rouge River National Wet Weather Demonstration Project started in 1993 that delivered $350 million in federal funding, to the establishment of the Alliance of Rouge Communities in 2003 that continues this

Table 2. Examples of improvements in the Rouge River watershed since 1985. (Continued)

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| Benthos       | • Stonflies, a sensitive indicator of river health, were never found in the lower river in the 1970s and 1980s  
|               | • In 2017 Stonflies were found at 18 locations, suggesting that they are expanding their range as a result of improved water quality  
|               | • Several species of pollution-sensitive Dragonflies have been found in the watershed in recent years by University of Michigan-Dearborn biologists  
| Fish kills    | • Frequent fish kills, including pollution-tolerant Common Carp, that occurred in the lower river during the 1960s, 1970s and early-1980s because of dissolved oxygen depletion have been eliminated  
| Fishery       | • The fishery in headwater streams remains in good condition, including Johnson Creek that supports a Brown Trout fishery  
|               | • The fishery in the lower portions of the Rouge River is still degraded and appears limited by water quantity and quality  
|               | • Populations of gamefish have been restored in Newburgh Lake following sediment remediation and habitat rehabilitation  
|               | • Steelhead have returned to the lower river in limited numbers, indicative of improved water quality  
|               | • More Northern Pike are now found in the lower river  
| Beaver        | • Between the 1940s and 1970s Beaver could not have survived in the lower river because of the significant oil pollution (oiled fur becomes matted and they lose their ability to trap air and water to control body temperature)  
|               | • Today, they have been found in the river at University of Michigan-Dearborn and the headwaters, representing the first time that Beaver were reported in the area since 1877  

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restoration work with essential funding from communities and the GLRI. The cleanup process can best be described as evolving from top-down, command-and-control water pollution programs to bottom-up, ecosystem-based partnerships to restore impaired beneficial uses. Adaptive management was practiced where assessments are made, priorities set, and action taken in an iterative fashion for continuous improvement (Hartig, 1997). Institutional arrangements have been flexible and responsive to local needs – to achieve local ownership.

Urban water quality challenges of the Rouge River watershed were best addressed on a watershed scale. Indeed, Platt (2006) has shown that urban watershed management is part science and part art, and that it depends upon creative institutional arrangements, combinations of federal and state mandates, and incentives, regional partnerships, municipal awareness of externalities, and grassroots sense of community. Based on the experiences of the Rouge River watershed, a holistic, ecosystem approach to water pollution resulted in cost-effective and ultimately greater and faster achievement of water quality restoration. Stressors were best addressed on a watershed scale, with the largest pollution sources addressed first. Other lessons learned include:

- Prioritizing the control of those sources and the other stressors allows the citizens to see progress which is essential to get desired environmental protection;
- It will take a long time to correct problems and control pollution sources – focus on building a record of success and measuring and celebrating progress (Hartig, 1997);
- Prioritize control programs to get the maximum environmental improvement as soon as possible;
- Critically assess the cumulative watershed impacts to quantitatively assess the physical, chemical and biological processes before fashioning a watershed-based solution (this discourages treating the symptoms, rather than affecting a cure);
- Tailor the management plan and tools to address watershed specific problems;
- Long-term success demands that the program be locally-owned with financial and technical assistance from state and federal governments;
- Innovative solutions can arise out of community cooperation;
- Institutional arrangements should be flexible and should be allowed to evolve over time to meet future needs and build on growing knowledge of the problems;
- Measuring results in transparent fashion – this builds trust (Hartig et al., 1998); and
- The likelihood of success of a watershed approaches is greatly improved with a locally driven institutional mechanism like Alliance of Rouge Communities to ensure continuity and sustain partner support (Ridgway, 2010).

References
Diebolt, J., 1985. Bad Rouge water may have killed Novi man. Detroit Free Press. October 5 issue. Detroit, Michigan, USA.
Giffels/Black and Veatch, 1980. Quantity and quality of combined sewer overflows. Detroit, Michigan, USA.