COMMUNICATING RIVER QUALITY INFORMATION TO THE PUBLIC USING A GRAPHICAL INDICATOR APPROACH

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ABSTRACT

Staff of the Rouge River National Wet Weather Demonstration Project (Wayne County, Michigan) have developed a graphical indicator approach for reporting river quality information to the public. The information consists of measurement data and observations of chemical, biological and physical indicators collected during 1994-1996. The quality indicators include three factors (dissolved oxygen, flow and bacteria) and two indexes or factor composites (aquatic life and stream habitat).

Indicator results for sites throughout the Rouge watershed are represented by color-coded icons linked to sites on subwatershed maps. Icon colors indicate three ranges of condition quality -- good, fair and poor. The reports also rate four common categories of public use: fishing; canoeing & boating; wading & swimming; aesthetics (other enjoyment). Similar color codings along the river lines indicate three ranges of use quality. The reports include brief descriptions of the indicators and the rating system used. Interpretations of condition and use quality are specific for each subwatershed. Nine of the 12-page reports were prepared for the whole Rouge watershed. In addition, 2-page summaries of water quality data were compiled for all monitoring sites in the subwatersheds.

Draft versions of all nine reports are now available for public review. As intended, local communities have become involved in refining these evaluations of condition and use quality, and in selecting management options to improve river quality.

KEY WORDS

indicators, indexes, watersheds, water quality, outreach

INTRODUCTION

The Rouge River and its urban watershed near Detroit are primary sources of pollution to the Great Lakes. The Rouge River Wet Weather Demonstration Project, conducted by Wayne County, Michigan, and funded by grants from U. S. EPA, is designed to restore Rouge water quality and public use. The Project mission also includes demonstrating solutions to water quality problems facing urban watersheds which are highly impacted by wet weather loadings of pollution. The Rouge Project is expected to provide other municipalities with potentially useful approaches and methods for dealing with similar problems of combined sewer overflows (CSOs), stormwater and other nonpoint sources of pollution. This includes demonstrating creative public involvement and education programs.

One of the main public issues concerning the Rouge River is how water quality conditions affect its recreational and aesthetic uses. Throughout the past three years, Rouge Project staff have produced an abundance of technical information on river and watershed quality. Project staff have gained some practical insights which can be expressed in fairly simple terms. Recently staff have explored the “quality indicator” approach as a tool for reporting technical information on river quality to the interested public. Such indicators represent only selected features of the whole database, but, ideally, they are key markers of river quality. Another premise of the indicator approach is that *condition* quality affects *use* quality. An important goal of Rouge reporting is to make the public aware of the linkage between river conditions and uses.

Project staff have developed a graphical report format using a few indicators to identify and rate the quality of river conditions which affect public uses of the Rouge. This form of public outreach has several advantages.

- Residents of the Rouge Watershed deserve to be informed of progress made toward improved river quality and public use through clear non-technical reporting.
- Problems that impact river use in specific subwatersheds should involve consensus and active participation of citizens at the local level.
- Upon completion of the Rouge Project, consistent methods should be established for reporting results of future monitoring programs.
- Public outreach encourages local feedback on any other problems which may impact river quality and uses.

Public involvement is a vital component of the indicator approach. Community input is necessary to make the reporting process more informative and useful.

METHODOLOGY

The indicator approach used in the Rouge Project evolved from many discussions among staff of the Rouge Project, the Michigan Department of Environmental Quality (MDEQ) and the Environmental Protection Agency (USEPA). It also borrowed from indicator approaches developed by USEPA (1995a & b, 1996). The latter have three general purposes:

- To characterize the quality of U. S. waterways;
- To chart progress toward meeting water quality goals;
- To help determine if programs designed to solve water quality problems are working.

In late 1995 the Rouge Project staff began to consider an indicator approach for reporting to local communities. By then a sizable database was available. The Project needed some way to simplify and condense the data for public consumption. Several considerations were important:

- *Historical concerns;* the indicators selected should relate to known impairments of river quality, as already defined in the Rouge River Remedial Action Plan or RAP (MDEQ, 1989, 1994);
- *Condition - Use Linkage;* the condition indicators should have a clearly defined relationship to use quality, as perceived by the general public;
- *Available data;* indicators should be selected or developed from the suite of river quality factors already being monitored in the Rouge Project; quality ratings should be defined in terms of available measurements and observations;
- *Graphical presentation;* results should be expressed by simple graphical means as much as possible, in order to appeal to the broadest audience.

Over a year's time the Rouge indicator approach developed through a number of iterations until the present method and format of reporting were adopted in early 1997. Draft reports were subsequently produced for public review. Based on initial responses from some communities, the reports are now being customized somewhat to reflect local concerns and initiatives.

RESULTS

RPO staff have produced a series of nine river quality reports for Rouge subwatersheds. These 12-page reports describe the average quality of river conditions and public use categories during both wet and dry weather, based upon 1994-1996 data. The report contents and layout are designed to summarize river quality conditions based on selected indicator results. The results for each site and indicator are represented on maps by icons, which are color-coded to express ranges of quality. Secondly, the probable impacts of these conditions on public uses are represented on the same maps by color-coded

river lines expressing ranges of use quality. The reports also contain other supporting information as described below and illustrated in Figures 1-5.

Since the reporting format relies greatly on color graphics, publishing it by conventional means can be relatively expensive. However, electronic means are available for publishing and distributing it at little cost, For example, a digital version of one of these subwatershed reports can be downloaded from the Rouge Project Office internet site at ***www.great-lakes.net/partners/rouge/rpo.html***.

Report definitions

The report cover provides a map of the Rouge watershed and defines the subwatershed names and boundaries. Within the report (Fig. 1) condition and use icons are defined, as follows.

River conditions:

- Dissolved Oxygen. Adequate oxygen concentrations (over 5 parts-per-million) in the Rouge are essential for healthy fish and other aquatic life. Even brief declines in oxygen concentrations can have a detrimental effect on aquatic organisms, especially when the condition is widespread and frequent.
- River Flow. Moderate, stable flows are generally best for aquatic life and stream habitats. Extreme variations of flow rate and volume can cause disruptions and scouring of the stream bed, as well as bank erosion. A procedure for rating flow impacts on aquatic communities is currently under development.
- Bacteria. Elevated concentrations of coliform bacteria, especially *E. coli* from human waste, pose a threat to human health through contact with contaminated water. Michigan law prescribes safe levels for "total body contact" (over 130 *E. coli* per 100 milliliters). The highest levels tend to occur in wet weather. Risk increases with the frequency of contact.
- Aquatic Life. The health of Rouge River fish communities has been evaluated and scored by a technique called the Index of Biotic Integrity (IBI). The IBI takes into account the condition of both populations and individual fish (Karr, 1981). The State of Michigan applied the IBI method at 31 Rouge sites during July-August, 1995.
- Stream Habitat. Important features of health stream habitats include streamside cover, bottom structures, sedimentation and flow. These features are important to bottom organisms which are food sources for fish. The State has used a field method called GLEAS Procedure 51 (MDNR, 1991) to rate the quality of stream bottom habitats at 32 sites in the Rouge.

Public uses:

- Fishing. Sport fishing is a limited but important recreational use of the Rouge River. Due to contamination problems in certain areas, fish consumption advisories may apply. Improvements in water quality and fish habitats should lead directly to better fishing and fish quality.
- Wading & Swimming. Wading is feasible in much of the shallow Rouge, but swimming is mainly limited to impoundments (over 2 ft. water depth). However, health and safety concerns include bacteria (*E. coli*) and streambed debris in many areas. With respect to health guidelines for bacterial exposure, wading is considered "partial body contact," and swimming represents "total body contact" (MDEQ, 1996).
- Canoeing & Boating. Recreational canoeing and boating is a under-developed use of the Rouge River. Currently, opportunities are limited due to bacterial contamination, shallow water, log jams, and limited public access. Restoration efforts should result in more favorable conditions for canoeing and boating.
- Aesthetics. Potential for aesthetic enjoyment is high, given that more than 50 miles of parkland border the Rouge River. Popular activities include walking, biking picnicking, and explorations of nature. Water quality and streamside restoration efforts can only add to public enjoyment of Rouge scenic areas. The Rouge Project aesthetic rating system is described by Heidtke (1996).

Report content

Except for the final report page which describes the Rouge Project and cites references, the rest of the content is specific to each subwatershed. Page 3 of each report (Fig. 2) summarizes key environmental features of the subwatershed, and maps the type and location of monitoring sites on river branches.

For each public use category, such as Fishing, a pair of report pages (Figs. 3-4) summarizes the overall status of that use category in the subwatershed, and provides a graphical key to condition and use quality (Fig. 3). Two maps with color-coded icons and river lines indicate ratings of condition and use quality in both wet and dry weather situations (Fig. 4). For the aesthetic use category, no such icons are appropriate since aesthetic ratings for sites were based on a set of observations which are mostly non-quantitative.

Report supplements

As a technical supplement to each subwatershed report, Site Water Quality Summaries were prepared. Each of these two-page documents (Figs. 5-6) provides a map and photograph of one monitoring site with a brief site description (Fig. 5), a list of the parameters monitored there, and a statistical summary of water quality data for the period of record (Fig. 6).

DISCUSSION

Graphical format

These reports use graphics, as much as possible, to convey “best professional judgments” about river quality impacts on public use, along with some of the technical information supporting them. This approach succeeds to the degree that any literate person with an interest in the subject can quickly grasp the main conclusions about river status.

Condition quality

As noted above, two kinds of condition quality indicators were used: factors or direct measurements and observations of river quality features (dissolved oxygen, river flow and bacteria); and indexes (aquatic life and stream habitat) which represent certain combinations of factors. There are many precedents for using water quality indexes to simplify reporting of technical data. However, composite indexes can sometimes obscure the importance of factors which have a relatively great impact on river quality. Therefore, key factors, such as dissolved oxygen, were reported here separately rather than as part of an index. In general, indicators are useful to describe patterns and trends of water quality, particularly to a non-technical audience.

Use quality

The Rouge RAP (1989), originally described 16 different impairments of beneficial use, resulting from poor water quality conditions in the Rouge River. These impairments can be categorized in various ways, either from a wildlife or a human perspective. Currently, the Rouge Project condition quality is being evaluated for its impact on four categories of river use by the public. However, it is important to recognize that conditions which best support full public use and enjoyment of the river are generally most favorable to wildlife as well. As defined above, the four use categories are fishing, canoeing & boating, wading & swimming and aesthetics.

Quality ratings

Although condition quality in the Rouge is based largely on numerical data, Project staff concluded that

indicator results expressed with graphics rather than numbers would be a more effective way to reach a general audience. Many residents simply want to know whether river conditions and uses are good, fair, or poor, relative to common sense standards of quality. Indicator data in graphical form best provides this information in a user-friendly manner. Residents are also concerned with how these qualities change over time as pollution control methods are implemented in the watershed. Eventually this quality rating system will allow residents to judge the effectiveness of measures designed to improve Rouge River quality, for both conditions and uses.

For purposes of Rouge reporting, conditions and uses were rated for three levels of quality: good, fair or poor, and were color-coded green, yellow and red, accordingly. The differences in condition quality for DO, river flow and bacteria were based on the relative frequency with which certain reference conditions occurred. However, the aquatic life and stream habitat index ratings were based on established procedures used by the Michigan Department of Natural Resources (MDNR, 1991) for scoring ecosystem quality. The condition ratings (except for aesthetics) are expressed in the reports as color-coded icons linked to sites.

The ratings for use quality, while based in part on condition quality, depend on other public use considerations as well. For example, Rouge staff felt that uses involving water contact should always be limited by poor bacterial conditions; otherwise, stream access or water depth would govern use. The use quality ratings as applied here to whole sections of the river were average ratings based on data and best professional judgments. The use ratings are expressed in the reports as color-coded zones along the river lines.

Site Summaries

Altogether, the Site Summaries for each subwatershed represent much of the technical basis for the graphical report. As brief descriptions of the monitoring sites and the water quality data collected there, they provide the more technical user with a summary of findings at an intermediate level of detail. The Site Summaries furnish an overview of the Rouge database itself. They are available on request.

Technical Memorandum

A more detailed discussion of the approach and results is contained in a Technical Memorandum (Smith, 1997), available from the Rouge Project Office, 220 Bagley, Suite 920, Detroit, MI 48226.

CONCLUSIONS

The following comments apply to this demonstrated use of river quality indicators to report on river quality in the Rouge.

- The graphical approach proved useful to distill a large variety and quantity of data into simple expressions of condition and use quality for subwatersheds. The map symbols, icons and color codes indicated where quality ratings were best supported by data.
- Quality interpretations based on indicators is always arguable, but there are good precedents for using these particular indicators in an urban watershed context.
- Clear linkage of condition and use quality is important in conveying river quality data to the public; however, cause and effect relationships may only be implied.
- Long term consistency is necessary when using indicators to report on status and trends; the same approach would be useful to predict river quality for future management scenarios.
- Some version of the Site Summary document is desirable as a data supplement to the indicator reports. This provides a bridge to the database for semi-technical users.
- Public user input is essential to judge the effectiveness of quality indicator reports. While the basic structure of reports should be maintained for long term consistency, subwatershed communities should have a role in customizing them to track the progress of local initiatives.

ACKNOWLEDGMENTS

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Figure 1

Rouge River Watershed

Public Uses

Fishing

Sport fishing is a limited but important recreational use of the Rouge River. Due to contamination problems in certain areas, fish consumption advisories may apply. Improvements in water quality and fish habitats should lead directly to better fishing and fish quality.

Wading / Swimming

Wading is feasible in much of the shallow Rouge, but swimming is mainly limited to impoundments (over 2 ft. water depth). Health and safety concerns include bacteria (*E. coli*) and streambed debris in some areas. With respect to health guidelines for bacterial exposure, wading is considered "partial body contact," and swimming represents "total body contact."

Canoeing / Boating

Recreational canoeing and boating is an under-developed use of the Rouge River. Currently, opportunities are limited due to bacterial contamination, shallow water, log jams, and limited public access. Restoration efforts should result in more favorable conditions for canoeing and boating.

Aesthetics

Potential for aesthetic enjoyment is high, given that more than 50 miles of parkland border the Rouge River. Popular activities include walking, biking, picnicking, and explorations of nature. Water quality and streamside restoration efforts can only add to public enjoyment of scenic areas.

River Conditions

Dissolved Oxygen

Adequate oxygen concentrations (over 5 parts-per-million) in the Rouge are essential for healthy fish and other aquatic life. Even brief declines in oxygen concentrations can have a detrimental effect on aquatic organisms, especially when the condition is widespread and frequent.

River Flow

Moderate, stable flows are generally best for aquatic life and stream habitats. Extreme variation of flow rate and volume can cause disruptions and scouring of the stream bed, as well as bank erosion. A procedure for scoring flow impacts on aquatic communities is currently under development.

Bacteria

Elevated concentrations of coliform bacteria, especially *E. coli* from human waste, pose a threat to human health through contact with contaminated water. Michigan law prescribes safe levels for "total body contact" (<130 *E. coli*/100 ml·). The highest levels tend to occur in wet weather. Risk increases with the frequency of contact.

Aquatic Life

The health of Rouge River fish communities has been evaluated and scored by a technique called the Index of Biotic Integrity (IBI). The IBI takes into account the condition of both populations and individual fish. The State of Michigan applied the IBI method at 31 Rouge sites during July-August, 1995.

Stream Habitat

Important features of healthy stream habitats include streamside cover, bottom structures, sedimentation and flow. These features are important to bottom organisms which are food sources for fish. The State has used a field method called GLEAS Procedure 51 to rate the quality of stream bottom habitats at 32 sites in the Rouge.

Figure 2

The Rouge Upper 2 Subwatershed

Overview

Sanitary Service

Combined Sewers - 4%
Separated Sewers - 84%
Septic Systems - 12%

Development

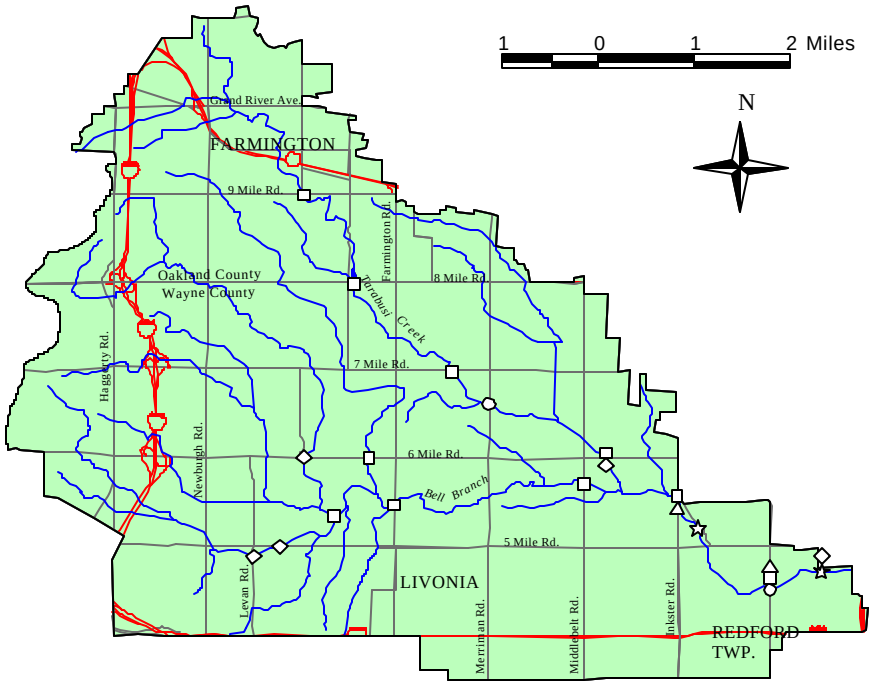
Population - 106,330
Size (Acres) - 24,315
Developed Area - 76.8%
Undeveloped Area - 23.2%
Impervious Area - 34%

Land Use

Residential 57.3%
Commercial/Industrial - 16.6%
Highways - 2.9%
Agriculture - 1.6%
Forest/Rural - 21.6%

Features

River Parkland (Miles) - 12
Abandoned Dumps - 4
Combined Sewer Outfalls - 6
Storm Sewer Outfalls - 3
Unclassified Outfalls - 0



Monitoring Stations

- Biological
- Bacterial
- Water Quality
- Combined Sewer Outfalls
- Sediments

Rouge River National Wet Weather Demonstration Project

Draft: November 1996

Figure 3

Fishing Quality

Fishing in the Upper 2

Fishing quality is generally poor in the Upper 2 subwatershed. Water quality factors such as dissolved oxygen, river flow, and stream habitat limit the resident populations of game fish in Tarabusi Creek and Bell Branch. Large variations in flow can occur, which creates unstable habitat conditions. Severe bank erosion and sediment resuspension may also occur during wet weather events. As a result, only limited numbers of small game fish are found in Bell Branch and Tarabusi Creek. No fish consumption advisory is in effect.

Condition Quality

Good Conditions

- O_2 Always greater than 5 ppm.
- Flows usually moderate and stable
- Good IBI fish community health rating
- Good GLEAS fish habitat rating

Fair Conditions

- O_2 Under 5 ppm. less than half the time
- Flows sometimes extreme and variable
- Fair IBI fish community health rating
- Fair GLEAS fish habitat rating

Poor Conditions

- O_2 Under 5 ppm. more than half the time
- Flows often extreme and variable
- Poor IBI fish community health rating
- Poor GLEAS fish habitat rating

Use Quality

Full Use

Good sport fishing conditions
No consumption advisories

Limited Use

Fair to poor conditions or
Consumption advisories

Restricted Use

Both poor conditions and
Consumption advisories

Not Evaluated

Figure 4

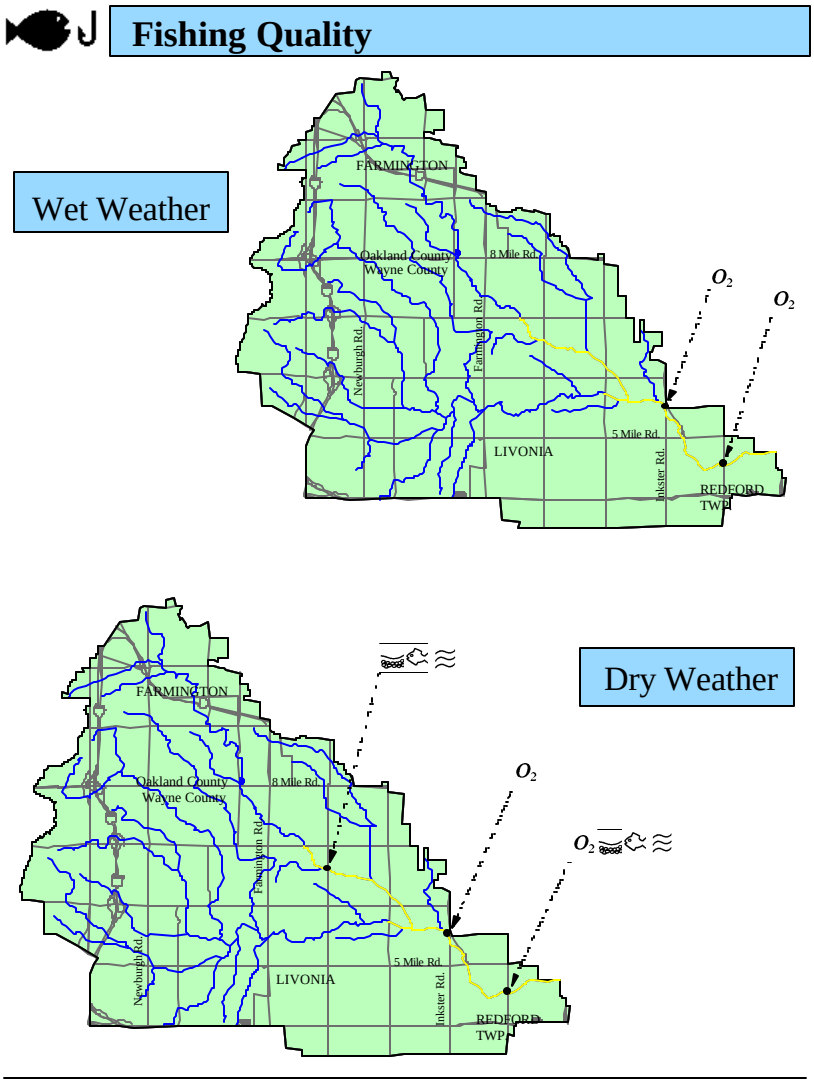

Fishing Quality
Wet Weather
FARMINGTON
Oakland County
Wayne County
8 Mile Rd.
Farmington Rd.
Newburgh Rd.
5 Mile Rd.
LIVONIA
Inkster Rd.
REDFORD TWP.
O2
O2
Dry Weather
FARMINGTON
Oakland County
Wayne County
8 Mile Rd.
Farmington Rd.
Newburgh Rd.
5 Mile Rd.
LIVONIA
Inkster Rd.
REDFORD TWP.
O2
O2

Figure 5

THE ROUGE RIVER PROJECT
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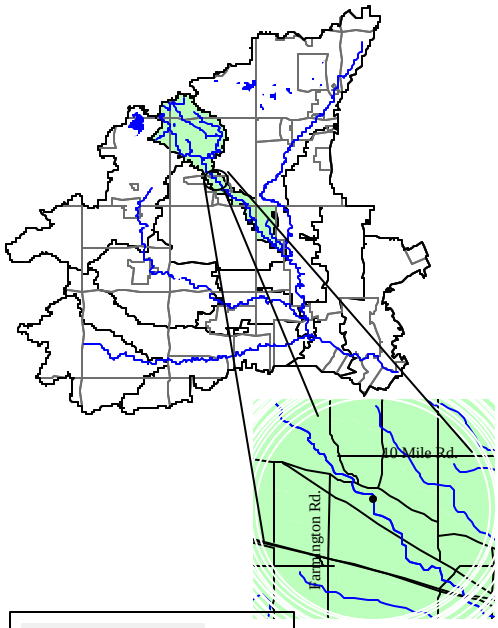
BRINGING OUR RIVER BACK TO LIFE

Water Quality Summary for Site: U01/US3 in Farmington



Parameters Monitored

- Alkalinity
- Hardness
- Heavy Metals
- Oxygen Demand
- Suspended Solids
- Bacteria
- Water Temperature
- Dissolved Oxygen
- Conductivity
- pH
- Nutrients

* Summary statistics on reverse

Site Summary

Site ID: U1003517
U1003042 (USGS)

Site Type: Instream

Site Description

Upper 1 Subwatershed

Upper Rouge River in Farmington

Powers Road, North of Grand River Avenue

Years Monitored

1993 1995
1994

THE ROUGE RIVER PROJECT
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Water Quality Summary for Site: U01/US3 in Farmington

Summary Statistics

Parameter	No. of Samples	Min.	Max.	Avg.	Units
Dissolved Oxygen	24507	4.6	17.7	8.7	mg/l
Water Temperature	26966	2.0	25.3	15.9	C
Conductivity	20991	44	3363	935	umho/cm
pH	22575	4.4	9.5	8.1	STU
E. Coli	2	52	308	127	#/100ml
F. Coli	2	104	1920	447	#/100ml
F. Strep	2	44	588	161	#/100ml
BOD(5-day)	61	2.0	73.3	5.1	mg/l
CBOD	56	2.0	56.4	5.5	mg/l
NBOD	43	2.0	16.9	2.3	mg/l
UBOD	10	2.5	11.2	6.0	mg/l
TSS	111	2	1500	93	mg/l
VSS	60	2	190	16	mg/l
Total Phosphorus	53	0.05	0.60	0.12	mg/l
Ortho Phosphorus	56	0.01	0.20	0.04	mg/l
TKN	53	0.24	5.10	1.09	mg/l
Ammonia	61	0.05	0.66	0.13	mg/l
Nitrate	59	0.05	0.76	0.37	mg/l
Nitrite	52	0.05	0.28	0.08	mg/l
Alkalinity	11	110	280	215	mg/l
Hardness	11	180	370	283	mg/l
Arsenic	12	1.0	5.0	2.1	ug/l
Cadmium	11	0.5	1.0	0.6	ug/l
Chromium	7	1.0	26.0	7.3	ug/l
Copper	9	3.0	10.0	5.8	ug/l
Mercury	3	0.2	0.3	0.3	ug/l
Nickel	12	1.0	22.0	5.8	ug/l
Lead	9	1.0	24.0	7.4	ug/l
Zinc	11	18.0	200.0	65.8	ug/l

** Below Detection Limit results are included in computations using the detection limit
*** Statistics for flow include 5% frequency of occurance for minimum and 95% frequency of occurance for maximum