

## **FROM THEORY TO IMPLEMENTATION - FINDING ILLICIT CONNECTIONS**

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The Rouge River National Wet Weather Demonstration Project (Rouge Project) began in 1992 by the Department of the Environment, Wayne County, Michigan. The Project is a United States Environmental Protection Agency (USEPA) grant funded comprehensive program to manage wet weather pollution to restore the water quality of the Rouge River, an urbanized tributary of the Detroit River in Southeast Michigan. The Rouge River has been designated as a significant source of pollution to the Great Lakes system.

The Rouge Project is designed to identify the most efficient and cost effective controls of wet weather pollution, while assuring maximum use of the resource. Combined sewer overflow (CSO) controls are being implemented in phases. Under Phase 1, six communities are separating their sewers and eight communities are constructing 10 retention treatment basins. A two-year evaluation study of the CSO control basins began on June 1, 1997. These results coupled with efforts to control storm water and other pollution sources in the watershed will provide the basis for the Phase 2 CSO control program on the remaining CSO sources in the watershed. The information gained from the evaluation of design storms and control technologies will be useful nationwide in determining cost effective CSO controls to meet water quality standards.

Innovative storm water control technologies are also being evaluated under the Rouge Project. A total of 60 pilot storm water management projects are being implemented throughout the watershed by 25 different communities and agencies. Categories of pilot storm water management projects currently underway include wetlands creation and restoration, structural practices such as grassed swales and detention ponds, illicit discharge elimination, erosion controls, stream bank stabilization and habitat restoration to name a few.

Innovative, readily transferable tools have been developed, employed by the Project, and are being shared with other cities and state agencies. These include a suite of computer models to simulate the water quality and quantity response of the Rouge River in response to wet weather events for existing and future conditions under various CSO and storm water runoff management alternatives; a comprehensive geographic information system (GIS); relational databases were designed and implemented to manage the wealth of data collected under the Project (DataView and Rouge Information Manager); and the use of a holistic watershed approach.

The Rouge Project in southeastern Michigan is a working demonstration of a watershed-wide approach to restoring and protecting an urban river system by using a cooperative locally based approach to pollution control. Innovative, readily transferable tools have been developed and employed by the Project. The environmental results of the Project are already very evident.

## **ABSTRACT**

The Rouge River Watershed located in southeastern Michigan encompasses approximately 438 square miles. A primary objective of the Rouge Project is to demonstrate how to address and correct urban wet weather pollution problems. However, water quality objectives in the Rouge River Watershed will not be achieved unless illicit discharges are eliminated. The Rouge Project illicit connection program has utilized several methods to identify sources of illicit discharges, but first, a method to prioritize areas for detailed evaluations had to be developed. A GIS database was established to assist in this area.

Several methods were explored to identify illicit connections, however, this paper discusses five of those methods used to provide information to prioritize areas of the watershed for detailed investigation. Those include: *dye testing of plumbing and on-site sewage disposal systems*; *visual observations of manholes, outfalls and on-site sewage disposal systems*; *aerial photography*; *televising of storm sewers*; and *testing for ammonia, surfactants, E. coli and isotopes of hydrogen and oxygen*. Data collected suggested that there are 5,260 illicit discharges and at least 3,600 failing on-site sewage systems in the watershed. This data has been helpful in convincing municipalities to include an illicit discharge investigation and an on-site sewage maintenance program in their application for a storm water discharge permit.

## **KEYWORDS**

Illicit discharges, on-site sewage, dye test, illicit connections

## **INTRODUCTION**

Sampling and modeling of CSOs to the Rouge River in southeast Michigan indicates that when the CSOs are treated or eliminated, the river will not meet water quality standards. Investigations by municipalities have identified illicit connection problems. These sources of non-storm water pollutants into storm drainage systems are required to be investigated and eliminated as part of the voluntary National Pollutant Discharge Elimination System (NPDES) storm water permits for communities and as part of NPDES permits for storm water associated with industrial activities.

Considerable effort has been made since 1994 in the Rouge Watershed to locate and eliminate illicit connections. Published material suggested many possible ways to trace the sources of illicit connections. As part of the Rouge Project, methods to locate illicit connections have been evaluated. This paper presents the approaches used to locate areas with illicit discharges, and methods to locate illicit connections and results.

## **DISCUSSION**

The Rouge River Watershed has a population of over 1.5 million people and has 43,520 businesses. Because of the size of the area, it was necessary to develop criteria to prioritize areas for investigation. One screening was done to eliminate businesses that were on combined sewer systems. This reduced the number of businesses to 22,467. Once developed, the criteria used was to identify areas of known water quality problems, to review complaints related to water quality, and to review water quality data and land use. Land use was of particular interest because the data were used to identify areas in communities that

were used for business operations. Businesses were a priority based on findings in Washtenaw County (Schmidt, 1986). These findings indicated that 38 percent of the businesses tested were improperly connected to the storm sewer system. The highest percentage of illicit storm drain connections were detected at automobile-related facilities.

Water sample results were given more weight in residential areas in selecting areas for investigation because it is more convincing to the public and municipal employees that there is a problem. *E. coli* bacteria was found to be the most significant water quality problem in the residential areas. This could have resulted from on-site sewage disposal systems (OSDS), sanitary sewers, pet waste, wildlife, and illegal dumping. Census data from 1990 reported that there were over 18,000 OSDS in the Rouge Watershed. It was suspected that failing OSDS could be contributing to the bacterial problem in the watershed. This encouraged the development of a program to investigate non-residential operations, and OSDS in areas with high *E. coli* results and storm sewers. The data collected has been used to project illicit connections and their impact on water quality in each subwatershed in the Rouge River Watershed.

## **METHODOLOGY**

First, dye testing was used to locate illicit connections in businesses. A method to prioritize the investigation was developed based on the Standard Industrial Classification (SIC) of businesses. Businesses were surveyed in the target areas and dye was placed into the plumbing fixtures to observe discharge locations. Storm and sanitary sewers in the business target areas were observed after dye was placed in the fixture.

Dye testing was also used to evaluate OSDS. Dye was placed in the septic tank and the surface water downstream from the property was checked for visual observation of the dye. If no dye was seen, a charcoal packet was placed in the stream to collect dye that was not visible. The charcoal packets were collected and taken to the laboratory for analysis.

In residential areas, a second and third method was used to help isolate sources of bacteria; water testing and visual observations. Visual observations were conducted on manholes, outfalls, and on-site disposal systems. Manholes and outfalls in areas that had reported high *E. coli* bacteria were also tested for ammonia, surfactants and *E. coli*. The manhole or outfall was photographed and the following were recorded: water color, staining on the structure, debris and odor.

A fourth method, consisted of television cameras in storm sewers which were used to show staining on the pipe, debris in the sewer, and the sewer lead location of a suspicious discharge. The fifth method was the use of aerial photography. It was believed that infrared photography could identify warm water discharges in the winter. These warm discharges would then be investigated for the source of the water. An analysis of the same area in the warm months might also allow concentrations of chlorophyll to be identified. The source of the nutrients that stimulated the chlorophyll might identify an illicit discharge.

## RESULTS

### *Dye Testing*

From 1987 through December of 1997, Wayne County dye tested approximately 3,340 businesses and industries for illicit connections to the storm sewer system. Approximately 8 percent of the 3,340 facilities inspected were found to have illicit connections and the elimination of these improper discharges has diverted raw sewage and other pollutants from the river to the wastewater treatment plant. If one illicit connection was found at a business, it usually resulted in finding others. An average of 2.5 improper connections were found at businesses that had an illicit connection.

The majority of illicit connections found in non-residential facilities were drains connected to storm sewers. Drains include floor drains, trench drains, interior catch basins, oil separators, machine process water and sump pumps. The categories of illicit connections found were: floor drains (46 percent), sinks (20 percent), horse washing-washing machines (15 percent), toilets (11 percent), and a variety of others (8 percent). **Figure 1** is a chart of these findings.

Another study, funded in the Oakland County portion of the Rouge Watershed included stream sampling for fecal coliform, *E. coli* bacteria, and benthic macroinvertebrates, along with dye testing of septic tanks.

- a. Of the 49 surface water sampling sites, 43 percent had a daily geometric mean for *E. coli* bacteria of 1000 or more per 100 mL. of sample.
- b. The macroinvertebrate study was done to indicate water quality of the streams in the survey area. A scale has been developed to rate macroinvertebrate and water quality. The results in the study area ranged from 7 which indicates poor water quality, to 20 which is considered good water quality.
- c. Dye testing in 1994 found 52.3 percent of the homes tested had discharges to the river.
- d. An optical brightener test was done at the river sites where dye was collected. These were all negative. The brightener test has been used to detect laundry waste in coastal areas.
- f. Dye testing in 1995 found a 39.3 percent failure rate for OSDS in the communities surveyed.

### *Water Testing and Visual Observations*

Hundreds of manholes and outfalls were tested for ammonia and photographic documentation and field data sheets were recorded at each manhole and outfall. Over 150 manhole locations and outfalls were identified to have over 1 ppm ammonia or visual evidence of suspicious discharges. Follow up sampling was done to relate *E. coli* levels with ammonia and surfactants at each manhole and outfall. Over 200 manholes and outfalls have been checked for ammonia, anionic surfactants and *E. coli*. Nineteen of these had *E. coli* counts over 5000 per 100 mL.

A grant was funded by the Rouge Program Office to Wayne County to survey OSDS serving homes in one of the tributaries that drain to an area that was planned to be used for canoeing. Canoeing has been discouraged in most of the Rouge River due to the high *E. coli* bacteria counts. Through December 31, 1997, 427 homes have been visited and a visual survey of the property has been done to identify signs of OSDS problems. Ninety-three of the systems have been described as failing or potentially failing for a

failure rate of 21 percent. Typical descriptions from the field notes are:

- Sewage backup in the home
- Gray water discharging to the ground surface
- Standing water on top of gravel seepage field
- Mushy area, associated with back end of apparent seepage field
- Illicit connection and undersized septic tank (100 gallons) drained by a trench type (long single perforated pipe) seepage field.
- Black sludge residue and toilet paper debris around surface of the septic tank covering
- Growth of cattails, wet marsh on the face of the downward sloping hill.

Visual observations from field crews and the public have identified significant improper discharges to the river. Two examples that field crews found and reported were:

- C a team doing a habitat study found a combined sewer discharging during dry weather. The sewer maintenance personnel investigated this, corrected the problem and reported that the discharge gate had stuck in the open position.
- C a team sampling outfalls noticed signs of sewage in the outfall. Tracing the flow upstream they found that a sewer contractor was by-passing the sanitary waste to the storm sewer so he could work on the sanitary.

Stable isotopes of oxygen and hydrogen have been used to determine the existence of illicit connections in a discharge. The study funded under this project found that the isotope signatures of groundwater, sanitary sewer water and tap water were significantly different. This signature allowed the discharges to be identified as having come from groundwater, precipitation or sanitary sewage. For further details of methods and findings refer to the paper "Identification of Illicit Connections in Storm Sewers: An Innovative Approach Using Stable Isotopes," by Suresh Sangal et. al.

#### *Aerial, Infrared and Thermal Photography*

The use of aerial, infrared and thermal photography to find illicit discharges is in the experimental phase. An examination of the aerial photo of a site with a known illicit discharge revealed thermal conditions that were too similar to other warm conditions to make it distinguishable.

#### *Televising of Sewers*

Several television tapes of storm sewers were reviewed. The tapes did not show the characteristic staining or debris that is seen when an illicit discharge has been occurring for some time. The storm sewer televised was newly constructed a year ago. The failure to observe sewage debris or detect an odor during the field work also helped support that there was no illicit discharge occurring when the sewer was being televised.

#### *Results of One Detailed Investigation*

A storm sewer relief drain was investigated to locate a pollution source. This 11 foot diameter storm sewer had been under suspicion for several years. In 1997, samples from manholes were taken upstream from

the discharge point of the sewer. These samples were taken from the main pipe of the sewer and in laterals that connected to the sewer. One of the laterals that connects to the sewer had *E. coli* results of 8160 per 100 mL of sample. A confirmation sample a few days later showed 9600 *E. coli*. When the results were found at that level, additional samples were taken 5 days after the confirmed sample (9600) had been taken. The sample results going upstream in the storm sewer where the 8160 and the 9600 *E. coli* were found were: 12,560, 24,000, 160,000 and 9600 per 100 mL. These results indicate an increase and then a decrease as you move upstream. The manhole where the 160,000 result was the “hot spot.” **Figure 2** shows a representation of the sewer and the test results.

The results were shared with the city which had the sewer televised. The television tapes did not show any suspicious connections. Plans were made to begin dye testing the homes next to the storm sewer. Before beginning the process of dye testing, a sample was taken to show current information. The results of that sample indicated less than 8 *E. coli* per 100 mL in the sample. After discussion with the city, it was agreed to postpone the dye testing and instead inform the residents of the results of the sampling on their street. At this point it was felt that the high *E. coli* may have been due to dumping of waste into the sewer. A letter was prepared to ask residents to inform the city or county personnel of anything they may have knowledge about which would have resulted in the high *E. coli* counts. As a result of this investigation, dry weather sampling continues on a monthly basis at this location.

*Other findings have included:*

- The prioritization method for businesses was successful in locating illicit connections; it was not helpful in locating illicit discharges of *E. coli*.
- There was no definite correlation to date between field tests for ammonia, anionic surfactants (a test to detect detergents) and *E. coli*.
- Projections have been made of illicit connections for the Rouge Watershed based on these findings. The estimated number of potential illicit connections in the entire watershed is 5260. It is estimated that 51 million gallons of liquid would be discharged from these illicit connections. (Boerma, 1997)
- Eighteen percent (77) of the residences contacted indicated that they did not have an OSDS. They indicated that they were connected to the sewer. In most cases, the municipality had no record of the sewer connection and were not charging them.

## CONCLUSION

Future areas to be checked will be developed based on complaints, a review of manhole and outfall sampling to determine contributing conveyances, and instream/in-sewer sampling to localize the sources. Results of the manhole sampling have found several that have *E. coli* results over 10,000 per 100 mL. Utilizing the Rouge Project GIS, maps have been prepared for tracking sampling of manholes and outfalls, and other data to illustrate results, and to help prioritize further investigations. These will be helpful in showing municipalities the areas that need to be investigated.

The future direction of illicit connection/discharges is to have each community in the Rouge Watershed commit to actively exploring illicit connections/discharges within their community. Grants and assistance from county agencies are available for communities. As part of an application for a general storm water

permit from the State of Michigan under the NPDES program, a community is required to develop an Illicit Discharge Elimination Plan. The Rouge Project is assisting communities in the preparation of these applications. Elements of the Illicit Discharge Elimination Plan that are recommended to be included are: a legal basis for the program, how problem areas will be identified, how the sources will be pinpointed, and how to achieve correction and evaluation and reporting. **Figure 3** was developed to describe these elements to communities and suggest options for them to consider. Education is very important when developing an illicit discharge elimination plan. Reference is made to education development in the boxes below each element.

On-site sewage disposal systems contribute to surface water pollution. With over 18,000 of these in the watershed and average failure rates between 17 and 39 percent, there are a substantial number impacting surface water. Using a 20 percent failure rate, there would be 3600 OSDS failing in the watershed. Two hundred gallons (200) per day per OSDS would result in 720,000 gallons per day of sewage being discharged to the ground surface or directly to surface water each day. The discharge of this waste can be prevented if there is regular inspection and maintenance of OSDS.

The liquid waste discharged from illicit discharges is estimated to be 51 million gallons per year. This is a significant amount. This waste includes human waste, oil, grease, detergents, chemical and solids.

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**Figure 1**  
**Types of Violations - Rouge River**  
**October 1987 - March 1998**

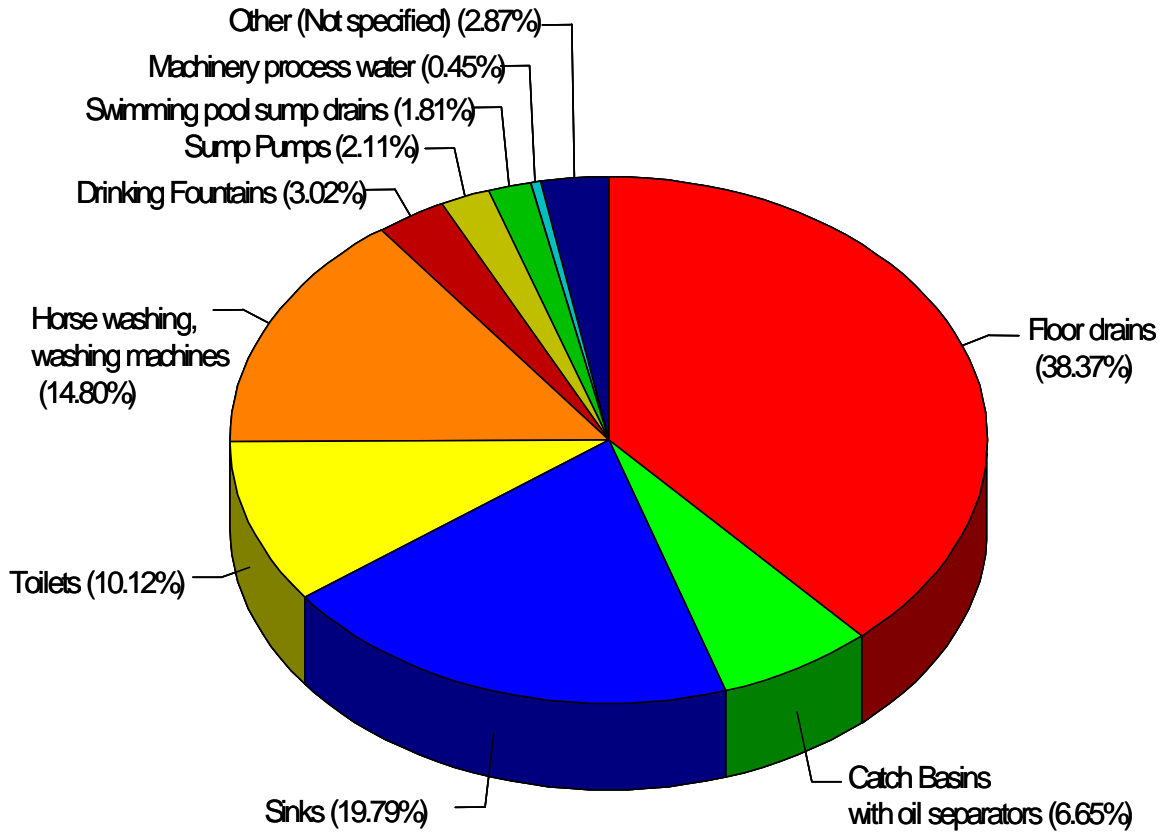
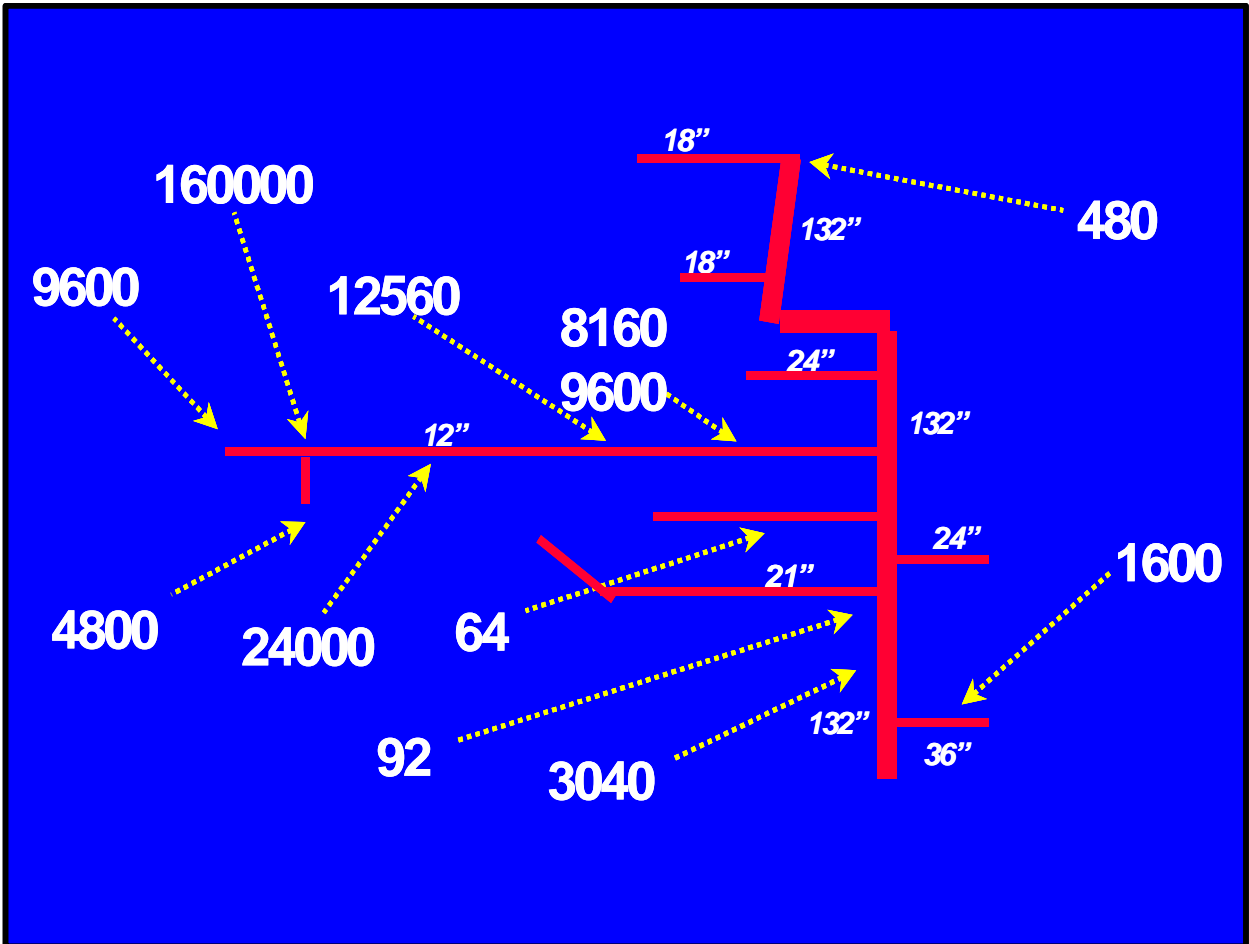


Figure 2  
 E. coli Results June 11-18, 1997  
 Farmington Relief Sewer



**Figure 3  
Eliminating Illicit Discharges**

