# WHAT PERFORMANCE MONITORING TELLS US ABOUT HOW TO IMPROVE THE DESIGN OF CSO STORAGE / TREATMENT BASINS

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## ABSTRACT

The Wayne County Rouge Program Office has collected and analyzed data from six CSO demonstration facilities in the Rouge River watershed from June 1997 through September 1998. As part of this monitoring and evaluation effort, a number of design and operational considerations have been identified. These results indicate ways in which additional pollutant load can be conveyed to a POTW for an equivalent capital outlay. Operational experience with the facilities has also provided insight on design of facilities from an operational perspective and other measures that can improve facility performance.

The amount of pollutant load reduction is in excess of the CSO volume reduction. This is due to a number of factors including the higher pollutant concentration found in flow contained in the collection system and within the CSO basins. Treatment of that portion of the flow stream that is discharged from CSO facilities accounts for a further reduction in pollutant loading. Overall, the effluent quality from the CSO facilities was very good. Typical CBOD values have been less than 30 mg/l for most events.

Management of system flows. A significant number of the events that formerly caused discharge to the river can now be contained within the headworks of the CSO treatment facilities. This operational capability is improved by monitoring systems within the downstream interceptor, which allow the facility operator to pump back to the interceptor system when capacity is available. Approximately one half of the CSO events can be contained in this manner.

**KEYWORDS**

CSO, system flow management, CSO quality

## INTRODUCTION

The Rouge River watershed is located in southeast Michigan within Wayne, Oakland and Washtenaw Counties. The City of Detroit and 47 other communities are located wholly or partially within the watershed. Combined sewer systems are prevalent in much of the tributary area. Prior to implementation of the Rouge Project there were approximately 59,300 acres of CSO service area, with 157 outfalls. The initial series of 10 CSO basin and a number of separation projects will control or partially control approximately one half of the service area and 83 of the outfalls.

The Rouge National Wet Weather Demonstration Project includes the implementation of CSO controls in a number of communities within the river's watershed. A total of 10 CSO basins are included as part of the CSO controls being implemented. The facilities were intended to meet demonstrative criteria, rather than presumptive criteria. A range in sizing criteria was established as part of the permit negotiations. The range of sizing criteria results in basin sizing from 0.06@ to 0.29@ (in inches over the tributary area). Facilities also incorporate a variety of additional features or variations in compartment sizing and sequencing in an effort to improve their effectiveness. These basins and their design criteria are listed in Table 1. At this time six of the ten facilities are operational, and data has been collected at the facilities following their start-up periods. The basin facilities are currently being evaluated to assess whether they meet the demonstration goals.

**Table 1**
**Rouge River CSO Detention Projects Summary Data**

| Basin Name & Location | Volume | Combined Drainage Area (acres) | Design Storm | Detention Time | Inches Over Drainage Area |
|---|---|---|---|---|---|
| Inkster, MI | 3.1 MG | 833 | one year - one hour storm | 20 | 0.14' |
| Dearborn Heights, MI | 2.7 MG | 340 | ten year - one hour storm | 30 | 0.29" |
| Redford, MI | 1.9 MG | 551 | one year - one hour storm | 20 | 0.13" |
| Acacia Park | 4 MG | 816 | one year - one hour storm | 30 | 0.18" |
| Bloomfield Village | 10 MG | 2325 | one year - one hour storm | 30 | 0.16" |
| Birmingham | 5.5 MG | 1175 | one year - one hour storm | 30 | 0.17" |
| Hubbell-Southfield | 22 MG | 14,400 | Built within site constraints | NA | 0.06" |
| Puritan-Fenkell | 2.8 MG | 649 | one year - one hour storm | 20 | 0.16" |
| Seven Mile | 2.2 MG | 463 | one year - one hour storm | 30 | 0.18" |
| River Rouge | 2 MG | 929 | ten year - one hour storm | 30 | 0.21" |

Objectives of the Rouge National Wet Weather Demonstration Project include the goal of adding to the knowledge base for CSO characteristics and control options. Specifically, the Rouge Project aims to provide insight on design of CSO facilities so that they can achieve better pollutant removal and a greater beneficial impact on the receiving stream. Secondly, the experience gleaned from the operation of the Rouge CSO facilities provides an opportunity for information sharing of operations and maintenance issues which may assist in future designs or in operations of other facilities. Third, the Rouge CSO evaluation will help to assess the need for

CSO control within the Rouge watershed, and will assess the necessary level of control to meet water quality goals.

The questions to be answered from this effort include “What is the required CSO basin size to achieve pollutant reduction goals?” and “What size facility is required to meet instream water quality objectives?” Data analysis for the first question will measure facility performance against EPA’s CSO Control Policy. This comparison will assist others in identifying the size requirement for proposed facilities.

This paper is intended to share preliminary data and observations, which have been made in the course of the evaluation program.

**DATA COLLECTION**

The Wayne County Rouge Program Office has collected and analyzed CSO data from six demonstration facilities in the Rouge River watershed from June 1997 through fall 1998. The data compiled for this study includes flow and sampling data for over 160 CSO events, as shown in Table 2. Data has been collected and compiled at six facilities with the focus of the data collection intended to quantify volume and load reduction, and the relative performance of facilities with variable design sizing and process configurations. As part of this monitoring and evaluation effort, a number of design and operational considerations have been identified. These results indicate ways which facility design and operation could result in the conveyance of additional pollutant load to a POTW for an equivalent capital outlay. Operational experience with the facilities has also provided insight on design of facilities from an operational perspective and other measures that can improve facility performance.

**Table 2**
**Number of Sampled Events, By Facility**

| Facility | Influent Events Monitored | Influent Events Sampled | Effluent Events Monitored | Effluent Events Sampled |
|---|---|---|---|---|
| Inkster CSO Facility | 59 | 27 | 11 | 9 |
| Redford CSO Facility | 38 | 19 | 9 | 7 |
| Dearborn Heights CSO Facility | 18 | 10 | 5 | 4 |
| Acacia CSO Facility | 15 | 15 | 6 | 5 |
| Bloomfield Village CSO Facility | 19 | 19 | 3 | 3 |
| Birmingham CSO Facility | 3 | 3 | 1 | 1 |

Events through August 1998

**FINDINGS**

**Influent Quality**

Influent quality observed at the different CSO facilities has been considerably different from site to site. All CSO basins are located in predominately residential areas, yet the concentration of monitored parameters, particularly for nutrients, can vary considerably between sites. This difference cannot be directly explained by the characteristics of the drainage area or the interceptor capture. However, the following unique characteristics of the following tributary areas have been identified. The Redford CSO tributary area includes a significant number of gravel streets. In addition, there is a separated sewer area tributary to the same regulator structure.

The separated area is approximately three times the size of the combined area. The Acacia CSO tributary area has larger lots than either Redford or Inkster and has a less efficient drainage system. CSO influent and effluent quality characteristics are shown in Figures 1 through 4.

(Insert figures 1 – 4, influent quality by parameter)

Figure 1 CBOD5 Range

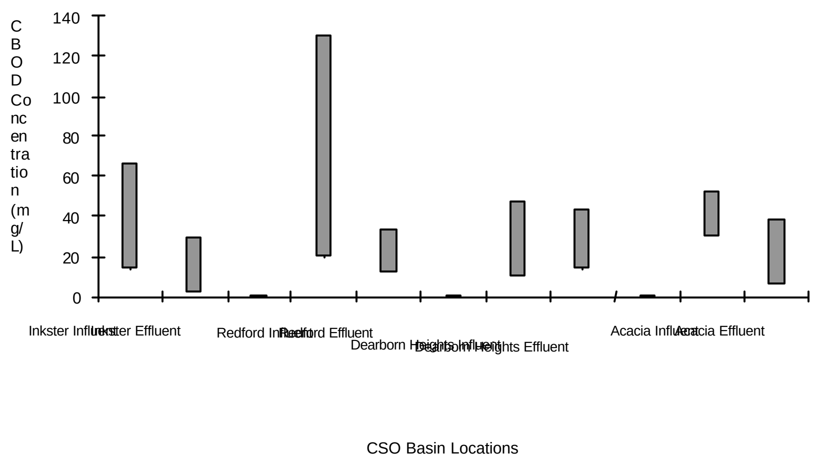



Figure 2 TSS Range

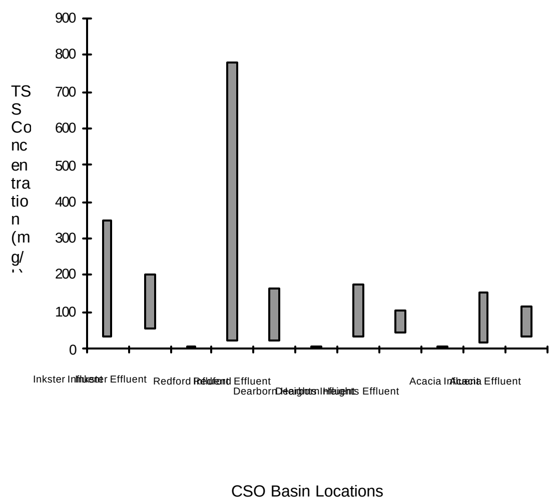


Figure 3 NH3 Range

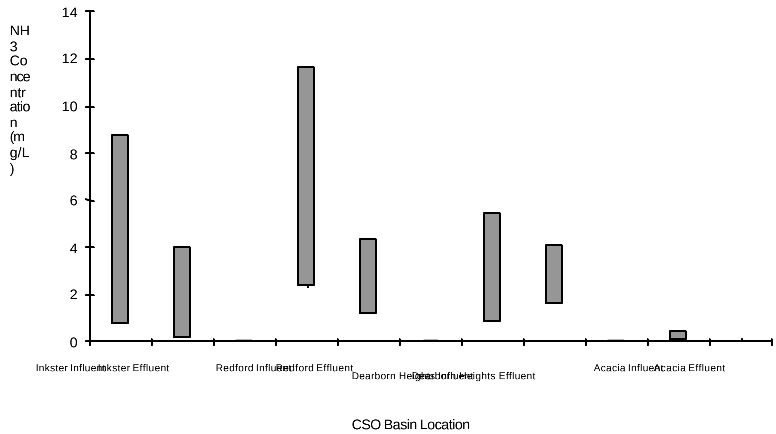
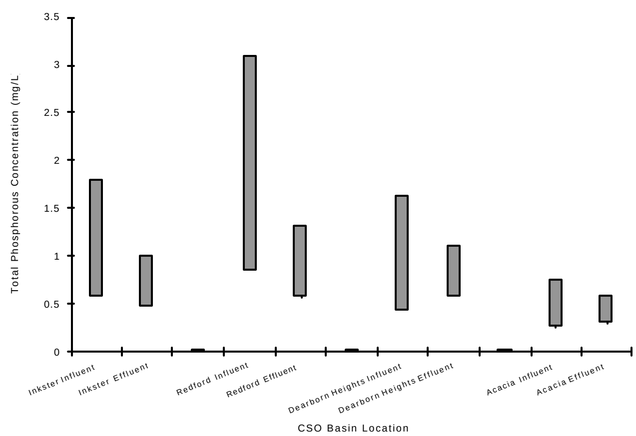



Figure 4 Total Phosphorous Range



**Treatment Effectiveness**

The data analysis to date has indicated that the pollutant reduction is significantly in excess of the CSO volume reduced, as shown in Table 3. Flow contained in the collection system was shown to have the highest concentration of pollutant load, this flow stream may represent a large portion of the annual flow. A number of small events are contained within the CSO basins, accounting for additional pollutant load reduction. Treatment of that portion of the flow stream that is discharged from CSO facilities accounts for a further reduction in pollutant loading. The overall impact is that the pollutant load reduction may be several times greater than the flow volume captured.

**Table 3**
**Pollutant and Volume Removal at CSO Facilities**

| Facility | Volume Reduction | CBOD Reduction | TSS Reduction | Ammonia Reduction |
|---|---|---|---|---|
| Inkster CSO Facility | 55% | 76% | 74% | 84% |
| Redford CSO Facility | 45% | 71% | 67% | 59% |
| Dearborn Heights CSO Facility | 33% | 47% | 61% | 36% |
| Acacia CSO Facility | 62% | 94% | 74% | 89% |

Volume and Pollutant load reduction through June 1998

Data analyzed to date have shown that these facilities are removing a significant quantity of pollutant load. With 50 % of the volume contained approximately 76% of the CBOD load has been captured for treatment at the POTW (total for all facilities through June 1998). The majority of the load reduction has been due to capture of pollutants in the more concentrated first portion of the events, but has also been achieved by treatment removals during the course of the event.

Overall, the effluent quality from the CSO facilities was very good, as shown in Table 4. Typical CBOD values have been less than 30 mg/l for most events. This result has been due both to the observed decrease in CSO concentration as event proceeds, as well as additional removal which occurs during flow through conditions in the facilities. First flush capture also promotes improved effluent quality.

**Table 4**
**Typical Effluent Quality at CSO Facilities**

| Facility | CBOD (mg/l) | TSS (mg/l) | Ammonia (mg/l) | Phosphorus (mg/l) |
|---|---|---|---|---|
| Inkster CSO Facility | 14 | 110 | 0.7 | 0.7 |
| Redford CSO Facility | 19 | 86 | 2.4 | 0.7 |
| Dearborn Heights CSO Facility | 21 | 50 | 2.2 | 0.6 |
| Acacia CSO Facility | 10 | 29 | 0.04 | 0.15 |

Water Quality through June 1998

**Hydrologic Assessment**

Cool winters and warm summers characterize the climate in southeastern Michigan. Precipitation in the winter months is a mix of snow and rain. The snow pack typically does not reach a significant depth and snow generally does not remain on the ground for the duration of the winter. Significant rain events occur in the months of January through March. In some cases these can include ice storms. Summer rain events are more intense, of shorter duration and frequently occur as thunderstorms, although longer rainfall events can occur.

The impact of seasonal influences in the amount of precipitation which translates into runoff, and hence CSO volumes, was not quantified during the design of the facilities. As the primary design criteria related to an intense rainfall of one-hour duration ("one-year storm"), the design event was based on the summer condition.

The hydrological response, while not unexpected, has been surprising in magnitude. CSO volume response (expressed as inches of CSO Volume relative to the tributary combined area) has been significantly different between summer and winter events. The summer response for a design storm has generally been less than facility design allowed for, and the winter response has been greater than the facility design anticipated. These wide swings in volumetric response are due both to changes in the hydrologic condition of the tributary areas, and the changes in the interceptor behavior during the different scenarios. Hydrologic response, particularly in the winter, is increased by the apparent back up of flow from the interceptor into the facilities, due to a lack of transport capacity. In fact, the ratio of CSO volume to tributary area seen at Dearborn Heights in winter events is greater than one. As this is not physically possible, additional flow is clearly reaching the CSO facility from another source. The hydrologic response is shown in Figure 5.

**Figure 5**
**CSO Volume Response**
**Number of Discharge Events**
**(Varying monitoring duration 9 - 15 months)**

| Basin | Number of Events | Events Captured | Treated Discharge Events |
|---|---|---|---|
| Inkster | 57 | 46 | 11 |
| Redford | 34 | 25 | 9 |
| Dearborn Heights* | 19 | 14 | 5 |
| Acacia Park | 24 | 19 | 5 |
| Bloomfield Village | 19 | 16 | 3 |
| Birmingham | 3 | 2 | 1 |

*due in part to interceptor backup

**Operational Issues**

The primary operational issue that has been defined during the operation of the facilities has been the management of system flows. A significant number of the events that formerly caused discharge to the river can now be contained within the headworks of the CSO treatment facilities. This operational capability is improved by monitoring systems within the downstream interceptor, which allow the facility operator to pump back to the interceptor system when capacity is available. Approximately one half of the CSO events can be contained in this manner.

Other operational lessons involve experience gained with facilities that have a wide range in potential flow rates and irregular frequency of operation. For example, flow monitoring and sampling needs to be designed for both minimal flow rates as well as peak flow rates. Infrequent operation resulted in reduced potency of NaOCl. The concentration of the stored solution deteriorated below what manufacturers had indicated. This resulted in inadequate disinfection during some discharge events.

## CONCLUSIONS

CSO facility design can be improved by a better knowledge of the tributary characteristics. Greater achievements in CSO volume and pollutant load reduction can be achieved by a better understanding of the quality of the flow and the volumetric response from a particular tributary area. With this knowledge available, prioritization of levels of control for various outfalls could result in a greater reduction of CSO load to the receiving stream.

Maximum use of the interceptor system is one of the nine minimum controls. Even with additional CSO control in place, optimized use of the interceptor to transport flow can result in reduced CSO volumes and loads.

## ACKNOWLEDGEMENTS

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