Rouge River National Wet Weather Demonstration Project
CSO Basin Evaluation Study

Carol L. Hufnagel, P.E.[1], Vyto P. Kaunelis, P.E.[2], Suresh K. Sangal, Ph.D., P.E.[3]

INTRODUCTION

The Rouge National Wet Weather Demonstration Project was initiated in 1992 to identify and implement measures to improve water quality in the Rouge River. The watershed approach included the construction of 10 CSO retention treatment basins to control a portion of the CSO discharges. An evaluation of the effectiveness of these facilities will assist in determining the design criteria for future CSO control projects. The evaluation will help to identify the relative impacts of CSO versus stormwater discharges, to further facilitate evaluation of various projects on a financial basis. Five CSO facilities are currently in operation as of July, 1997, and the remainder will be operational in late 1997 or in 1998. This paper is intended to describe the basin and supporting river monitoring studies and intended outcomes of the evaluation study.

CSO PROJECT DESCRIPTION

Project Background

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 basin and separation projects will control or partially control approximately one half of the service area and 83 of the outfalls.

The Michigan Department of Environmental Quality (MDEQ) established a definition of "adequate treatment" for CSOs as part of the National Pollutant Discharge Elimination System (NPDES) permitting program. Under this definition, CSOs must be eliminated through sewer separation or the construction of basins capable of completely capturing the 1-year/1-hour storm and detaining the 10-year/1-hour storm for 30 minutes. Among CSO communities, the level of required control was a major issue since the estimated costs ranged from roughly $1 billion to $3 billion. Believing that a smaller level of control would meet water quality objectives, the CSO communities contested the resultant proposed NPDES permits.

Negotiations were conducted by a U.S. District Court-appointed monitor in an attempt to identify a less costly first round CSO control program and avoid lengthy litigation over the permit requirements. The negotiations led to a settlement document that was incorporated as a formal modification to the disputed NPDES permits. The revised permits required each permittee, at selected CSOs, to construct and evaluate varying sizes of CSO demonstration basins. A two year time period was allotted to evaluate the performance of these Phase I CSO control basins. Evaluation findings will establish the level of control needed for the remaining CSOs. These controls will be implemented as Phase II of the project prior to 2005.

It is recognized that other sources are contributing to water quality problems in the river. Even with control basins in place for all CSO outfalls, the Rouge River still will not meet all water quality standards. Pollution sources include stormwater, septic systems, sediment, air deposition and others which need to be controlled to attain desired uses in the river. Thus, evaluation efforts will also need to improve the understanding of relative impacts caused by CSO versus other sources and what water quality can be expected following implementation of CSO control projects.

CSO Control Objectives

Primary CSO objectives of the Rouge Project include control of Phase I CSO outfalls and the determination of the level of control for remaining outfalls. A listing of these objectives follows:

1. Control or eliminate CSO discharges within the Rouge River watershed.
2. Test the performance of different CSO control technologies, including ten retention-treatment basins and six sewer separation projects
3. Utilize performance data from Phase I facilities to establish the level of control necessary for remaining uncontrolled CSOs in the watershed.
4. Identify how CSOs, urban stormwater, illicit discharges, septic systems and other sources can be managed to most effectively achieve water quality protection goals.

CSO Projects Implemented

The location of CSO projects implemented in Phase I is shown in Figure 1. The Rouge River divides into four branches, including the Lower, Middle, Upper and Main. Following the completion of Phase I facilities, all CSOs on the Upper Main and a section of the Upper Rouge will be controlled. Other segments of the river will be partially controlled.

Design criteria for CSO basin projects are identified in Table 1. 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.

MONITORING PROGRAMS

Basin Monitoring Objectives

The primary goal for the basin evaluation study is to identify the level of control required for future control projects. A series of objectives were developed to address this goal. These objectives are identified in Table 2, along with an indication of an initial hypothesis to be tested, and the data which will be collected for addressing the objective.

Table 1
Rouge River CSO Detention Projects Summary Data

Basin Name & Location	Compartmental	Basin Configuration	Combined Drainage Area	Basin Dimensions	Design Storm	Detention Time	Inches Over Drainage Area
Birmingham	2 compartments Total volume=5.5 MG	2 compartments in series with 11' tunnel	1175	140'x120'x20' each compartment	one year - one hour storm	30	0.17"
Hubbell-Southfield	1st basin - 10 MG 2nd basin - 12 MG Total =22 MG	2 tanks in series with the capability of running the 1st basin as 1st flush capture tank	14400	900'x240'x16.5' Overall Basin	Built within site constraints		0.06"
Puritan-Fenkell	2 compartments each = 1.4 MG Total = 2.8 MG	2 tanks operating in parallel	649	236'x99.5'x8' each compartment	one year - one hour storm	20	0.16"
Seven Mile	2 compartments each = 1.1 MG Total = 2.2 MG	2 tanks operating in parallel	463	200'x91.5'x8' each compartment	one year - one hour storm	30	0.18"
River Rouge	2 compartments upper and lower Total = 2	2 compartments in series lower compartment fills first then the upper	929	lower 135'dia. 46.2' deep upper 135' dia. 21.8 deep	ten year - one hour storm	30	0.21"
Redford, MI	2 parallel compartments each 0.9 MG Total = 1.9 MG	2 parallel compartments preceded by a swirl concentrator	551	180'x66'x11.2' Each compartment	one year - one hour storm	20	0.13"

Table 1
Rouge River CSO Detention Projects Summary Data
(continued)

Basin Name & Location	Compartmental	Basin Configuration	Combined Drainage Area	Basin Dimensions	Design Storm	Detention Time	Inches Over Drainage Area
Inkster, MI	1st flush compartment - 1.1 MG 2 detention compartments each = 1 MG Total = 3.1 MG	1 first flush tank followed by 2 detention tanks operating in parallel	833	186'x60'x11.75' each detention tank	one year - one hour storm	20	0.14'
Dearborn Heights, MI	3 compartments, each -0.9 MG Total = 2.7 MG	3 detention tanks in parallel with the capability of using the 1st tank for a 1st flush capture	340	175'x60'x11.6' each compartment	ten year - one hour storm	30	0.29"
Acacia Park	2 compartments Total Volume = 4 MG	2 compartments in series	816	160'x80'x20' each compartment	one year - one hour storm	30	0.18"
Bloomfield Village	3 compartments Total volume = 10 MG	3 compartments filling series through different elevation weir	2325	157.5'x128.5'x20' each compartment 1	one year - one hour storm	30	0.16"

Table 2
Goals and Data Requirements for the CSO Demonstration

Goal	Hypothesis is to be Tested	Date Required
1. Establish sizing criteria/design criteria for later facilities	Basins smaller than current state criteria can provide pollutant load reductions necessary to achieve water quality goals. Identification of "best" basin size will need to be determined relative to total flow generated, quality of flow, and other influent factors. A range in sizes may be recommended dependent on flow and load based characteristics.	Influent/effluent flow (event totals); influent and effluent load of key parameters; number of events; rainfall data to identify what triggers event; river loads
2. Quantify changes in loading to the Rouge (i.e., before and after control CSO control projects)	Basins as designed/constructed will result in significant annual reductions in CSO loads to the river. Separation may result in increased loads to the river in areas where the collection system previously had good capacity.	Influent load for all wet weather events which result in flow to basins; effluent loads for all discharge events; corresponding precipitation data; in separation areas, selective monitoring of new stormwater outfalls to collect flow volume and quality data
3. Following implementation of CSO controls, identify remaining instream water quality impairment which can be attributed to CSO discharge.	Temporal dissolved oxygen sags will no longer occur where CSOs are controlled. Bacterial levels will improve. Long term dissolved oxygen will still be impaired.	Instream water quality monitoring data at selected locations (i.e., dissolved oxygen, other key parameters); model results (calibrated)
4. Identify "better design" methodology. (i.e., should basins be equipped with first flush tanks, swirl concentrators, shunt channels?). Provide recommendation on how to configure a CSO basin. Identify "treatment" capability of flow throughbasin operation.	Improved retention facility design may result in improved load reduction over storage volume alone, and may provide equivalent removals to larger facilities. Basin effectiveness (% removal during flow through) will be quantifiable.	Compare effluent quality of basins with swirls, first flush tanks or shunt channels to those without; compare similar events at basins which can operate in different modes; prepare evaluation plan Samples sufficient to determine basin influent and effluent loadings for a range of storms and operating conditions; discrete samples
5. Identify distribution of CSO load entering containment/treatment structure (pollutograph, etc.).	Load will be more concentrated at the beginning of storm event. "Small" events (i.e., those completely captured) account for significant loads.	Collect discrete samples over portions of the influent event (this could likely be either time or flow paced, but would need to be evaluated at each facility); samples need to be able to define the pollutograph shape (load distribution)
Goal	**Hypothesis is to be Tested**	**Date Required**

6. Identify proportion of CSO flow captured by collection system / basins.	Flow captured by the collection system will be significant, and may equal or exceed the amount captured in basins. Total flow captured will be approximately 80 percent or greater on an annual basis (except for Hubbell - Southfield).	Assess flows in collection system (at connection to interceptor or other suitable location) with available monitoring capabilities (may not be possible at all facilities); monitor basin flows (continuous record
7. Identify ability to add additional CSO tributary area to existing CSO basins as an interim/final control measure.	Ties closely with goal #1 regarding basin sizing.	Same data as identified in #1
8. Develop cost versus benefit comparisons for constructed facilities.	Per gallon cost of facilities is greater in smaller facilities. The benefit provided by smaller, as opposed to larger facilities, in terms of load reduction, number of discharge events or frequency of water quality criteria exceedences is also less. A "most cost effective" size will need to assess the relative costs and benefits of various options.	Cost data; data developed and analyzed in other sections
9. Address other issues, e.g.: a. *Decanting.* Define quality of decant water. define best timing to discharge decant water, i.e., river conditions. b. ***Dewatering.*** Identify ability to dewater facilities. c. *Chlorination/dechlorination.* Define chlorine plume (if any). Define biological river impacts.	a. Decanting can be performed under some conditions which will not cause detrimental river impacts. b. Dewatering can generally be performed prior to the next event. Dewatering will result in continued high flows in the downstream system. c. Chlorine impacts on the stream are minimal or localized. Residual plume may be quantifiable and measurable downstream of the basin (during discharge). NAOCl dosing can be planned prior to events to minimize residual impacts.	a. Monitor ability to dewater, including WWTP flow conditions and local flow conditions; hourly sampling of basin contents for a period of 4-5 hours once influent has stopped b. Monitor ability to dewater, including WWTP flow conditions and local flow conditions c. Instream sampling at 3 or more locations (such as bridge crossings) for minimum of four storm events; record of NaOCl usage, influent chlorine demand and effluent coliform (minimum four events resulting in discharge)

Table 2
Goals and Data Requirements for the CSO Demonstration
(continued)

Goal	Hypothesis to be Tested	Data Required
10. Review volumetric sizing issues, to determine if the basins were sized consistent with their design objective, or rather if they are larger or smaller than required for the design criteria.	Basins are likely sized conservatively. Volume as provided is sufficient to provide design detention time required for the design storm.	compare basin CSO volume versus rainfall
11. Identify impacts of separation versus retention in terms of annual and event impacts.	Separation results in increased loads; however, impact of these loads on the receiving stream is limited. Separation results in no sanitary bypass if properly implemented, and sanitary flows fall within predicted post separation flow range.	data (or model study) of pre-/post-flow volumes in newly separated areas; monitoring of flow and sampling at selected stormwater discharge locations; flow monitoring of upstream portions of the collection system
12. Other items.	Basement flooding is not worsened by the basin/separation project. Basins will successfully remove floatables. Innovative features contribute to the effectiveness of the facility.	basement flooding complaint records; visual inspection by operators; oil and grease samples of basin effluent; data regarding innovative features

Basin Monitoring Data Sets

The data collected as part of the basin monitoring efforts are summarized in Table 3:

Table 3
Basin Monitoring Data Set

Data Set Objective	Data Collected
Number and description of events	Volume, duration and frequency of influent and effluent
Pollutant load quantification	Determination of influent load for a majority of events, including captured events; determination of effluent load for all events. Primarily for CBOD, TSS, NH3, TP. Secondary interest includes metals, alkalinity, hardness, soluble CBOD and bacteria.
Pollutant concentration variability	Identification of pollutant concentration variability at influent and effluent for a minimum of 10 events, with additional events monitored if required. The parameters sampled at a frequency to determine variability include: CBOD, TSS, NH3, TP.
Evaluation of varying operational plans	Comparison of efficiency of varying operational modes, e.g. first flush versus flow through, swirl concentrator followed by basin versus basin only.
Evaluation of dewatering, decanting	Identification of duration to dewater (to the treatment plant), quality of decant (potential discharge of settled basin contents to river).
Effectiveness of disinfection and presence of residual chlorine	Effluent and instream monitoring for bacteria and residual chlorine.

River Monitoring

River monitoring is intended to address issues regarding the impact of CSO capture and treated basin discharge. It will also show the stormwater impact on sections of the river upstream of the CSO areas. As part of the river monitoring program, weekly monitoring of dissolved oxygen and bacteria in areas where CSO controls are being implemented is being conducted. During CSO discharge events, and during events where CSO basins fill but do not discharge, river monitoring will be conducted to provide a picture of the river response to stormwater only discharges, and stormwater/treated CSO discharges. Samples will be collected upstream and downstream of the CSO facilities before, during and after the events. Additional efforts will include identification of the total residual chlorine (TRC) plume at instream sites during and following basin discharge.

River monitoring locations are identified in Figure 2. A summary of river sampling and monitoring activities is provided in Table 4.

Table 4
River Monitoring Data Set

Data Set Objective	Data Collected
River recovery - long term dissolved oxygen	Routine monitoring of dissolved oxygen levels at instream locations upstream and downstream of CSO facilities and tributary areas. Continuous recording with dissolved oxygen/temperature probes. Continuous flow record. Sediment oxygen demand.
Public health conditions	Weekly sampling for bacteria in the vicinity of CSO basins. Sampling upstream and downstream of the facilities during dry and wet weather.
Wet weather river response	Water quality measurements upstream and downstream of CSO basins and outfalls before, during and following events. Some events will be sampled during basin overflow conditions. Other events which cause flow to reach the CSO basin facility will be sampled, as these represent events which would have previously resulted in CSO discharge to the river. Sampling will include CBOD, BOD, TSS, NH3, TP, dissolved oxygen, temperature and bacteria.
Total residual chlorine	Identification of TRC plume downstream of CSO basins during discharge. Intent is to identify extent, concentration and duration of TRC impact.

PROGRAM IMPLEMENTATION

Current Status of Monitoring Program

Three CSO basins were placed into operation in early 1997. These basins have been collecting limited data and addressing various start up issues with respect to accuracy and operation of metering and sampling equipment. Actual basin evaluation monitoring began on June 1, 1997 at the Inkster and Redford CSO basins. Acacia Park evaluation monitoring began on July 1, 1997. Routine river monitoring has been conducted since May 1, 1997. A significant wet weather event occurred on July 2 - 4, 1997. Basin and river monitoring was performed for the Inkster and Redford CSO facilities.

Implementation Challenges

Implementation of basin monitoring has been hampered by several metering and monitoring issues. Basin flow metering equipment has required numerous calibration efforts, which can only be assessed during a CSO event.

As a result, flow metering equipment has yet to achieve the desired accuracy. This has been partially addressed by the use of alternate flow quantification techniques which were allowed for in the monitoring plan. In addition, sampling equipment and the interface between the computerization system and the metering equipment has resulted in some difficulties. These facilities have incorporated sophisticated instrumentation, and significant flexibility in operational aspects of the basins. This has resulted in some unanticipated problems with logic for starting sampling pumps and other equipment.

Sampled Events

Samples were collected for a number of events prior to the evaluation monitoring period. The frequency of sample collection during these events was less often than during the evaluation period. The total number of events which have been monitored are provided in Table 5.

Table 5
Basin Monitoring through June, 1997

Facility	Prior to evaluation monitoring		During evaluation monitoring period	
	Influent events	Discharge events	Influent events	Discharge Events
Acacia Park	14	4	--	--
Redford	5	5	2	1
Inkster	6	6	2	1

DATA AVAILABILITY

Data from the evaluation basin monitoring and river monitoring are expected to be available for presentation in October, 1997. These data will primarily be from the Inkster, Redford and Acacia Park facilities. In addition, river monitoring conducted during basin overflow events and performed on a routine basis will be available.

Samples collected prior to the evaluation monitoring provide additional information regarding the range in concentrations. These data provide some insight into concentrations observed at the influent and effluent of CSO basins. These data are summarized in Table 6. As additional data are collected, they will be evaluated relative to basin monitoring objectives.

Table 6 Quality Concentration Data

Facility	BOD		TSS		NH3		Total P	
	Influent (mg/l)	Discharge (mg/l)	Influent (mg/l)	Discharge (mg/l)	Influent (mg/l)	Discharge (mg/l)	Influent (mg/l)	Discharge (mg/l)
Inkster	4 - 101	2 - 48	48 - 419	42 - 152	1.0 - 5.9	0.7 - 3.2	0.5 - 2.5	0.48 - 1.0
Redford	8 - 70	2 - 21	30 - 287	29 - 109	1.5 - 7.9	1.9 - 4.8	0.6 - 2.3	0.7 - 1.1
Acacia Park	10 - 103	8 - 104	15 - 214	19 - 132	0.04 - 1.01	0.05 - 0.23	0.3 - 1.2	0.15 - 0.8

Note: The majority of data collected was from events which resulted in influent and effluent samples being collected. However, some of the data presented above was collected during smaller events which were completely contained within the basins. The data includes values from the 10th percentile to the 90th percentile reading.