Sewer System Modeling to Predict Water Quality: Examples from Wayne County's Rouge River Project

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INTRODUCTION

The Rouge River National Wet Weather Demonstration Project (Rouge Project) has developed a suite of modeling tools which are being used for watershed management planning in the highly urbanized Rouge River watershed. The Rouge Project, which began in 1992, is sponsored by the U.S. Environmental Protection Agency (USEPA) and is charged with developing a watershed plan to manage wet weather pollution to the Rouge River. The project is a cooperative regional effort involving three counties, 48 communities including the City of Detroit, the USEPA, the Michigan Department of Environmental Quality (MDEQ) and a number of other private and government agencies. The Rouge Project is being lead by the Wayne County Department of Environment with assistance from a team of consultants.

This paper presents an overview of the Rouge Project modeling approach and a brief description of the various models being used by the Rouge Project, which include sewer system models. Three examples are then described to illustrate how the models are used as analysis tools and predictive tools for decision-making. One example shows how the models are used to predict future combined sewer overflow (CSO) basin performance. A second illustrates how the models are used to evaluate instream impacts for two different levels of CSO control. The third example involves the use of models to develop a preliminary subwatershed plan for the Lower Rouge River and how the findings of the plan were conveyed to a wider audience.

THE ROUGE WATERSHED

The Rouge Watershed, shown in Figure 1, encompasses 467 square miles in Southeast Michigan and is home to 1.5 million residents. The Rouge River flows into the Detroit River several miles downstream of downtown Detroit and is a source of pollution to the Great Lakes system . The Lower, Middle, Upper and Main Rouge River branches total 126 miles in length, and comprise one of the state's most publicly accessible rivers.

Although the Rouge Watershed is predominantly of urban land use, there are remaining rural areas in the west and northwest areas of the watershed. The most dense urban areas in the watershed are the older communities in the southeast portion of the watershed. Approximately 20 percent of the watershed is served by combined sewers, 50 percent by separate storm sewers and the remaining areas having natural surface drainage. As can be seen in Figure 1, the sewer systems in the older communities have eliminated virtually all the natural tributaries in the southeast portion of the watershed.

Some of the major uses of the Rouge River include (MDNR, 1988 and MDNR, 1994):

- Fish and Wildlife Habitat
- Water Contact Recreation
- Recreational Fishing
- Canoeing
- Commercial Navigation (in the lower Main Rouge only)
- General Aesthetics
- Industrial and Agricultural Water Supply

Several major pollution sources have led to the gradual degradation of water quality and habitat and impaired the above uses in many reaches of the Rouge River. Over 160 combined sewer overflows frequently discharge a mixture of storm water and untreated sewage into the Rouge River. Storm water runoff from urban areas with separate storm sewers is also contributing pollutants to the Rouge. Increased flow variability also has a significant impact in the Rouge as the increased flows and runoff volumes have accelerated bank erosion, increased wet weather solids loadings and impaired fish habitat. Finally, raw sewage is entering the river from failing septic systems and illicit connections from sanitary leads or sewers to storm drain systems.

THE ROUGE PROJECT MODELING APPROACH

There are three primary objectives of the Rouge Project modeling effort. First, to develop models capable of predicting river water quality and quantity in response to wet weather events (existing and future) under various CSO and non-point source (NPS) control alternatives. Second, to simulate the pollutant loads and concentrations (existing and future) under various CSO and NPS control alternatives. Finally, to provide modeling tools, documentation and training which are transferable to future watershed planning nationwide.

The modeling effort is using a three-tiered approach as shown in Figure 2. Tier 1 consists of several small area models used to simulate flows and pollutant loads and concentrations from specific pilot projects or localized areas of study such as wetlands, swales, wet detention ponds and individual CSO basins. The models used include various blocks of the USEPA Storm Water Management Model (SWMM) (Huber et. al., 1992) a modified version (TRTSTORM) of the U.S. Army Corps of Engineers Storage, Treatment, Overflow, Runoff Model (STORM) (HEC, 1976), and the P8 Urban Catchment Model (Palmstrom, 1990). The results of the Tier 1 models are, in some cases, used to extrapolate to the watershed-wide Tier 2 models.

The Tier 2 models consist of a simple pollutant loading model and a detailed sewer system model which both simulate pollutant generation by subarea for the entire watershed. The Watershed Management Model developed by Camp, Dresser and McKee, Inc. (CDM, May 1994) is the pollutant loading model which is used to generate annual pollutant loading estimates and can be used to perform load allocation analyses. The detailed sewer system model has two components as follows.

A SWMM RUNOFF storm water model was developed to simulate flow routing and pollutant generation from all the major separate storm sewers and natural channels which convey storm water to the Rouge River. This model simulates runoff from the 181 unshaded storm water subareas in Figure 3, which have an average size of 2.1 square miles. A previously developed SWMM RUNOFF and TRANSPORT sanitary and combined sewer system model is used to simulate the flow and pollutants which enter the Rouge from CSOs. The sanitary and combined sewer quantity model is the Greater Detroit Regional Sewer System (GDRSS) model developed by the Detroit Water and Sewerage Department (DWSD) (CDM, June 1994), with water quality simulation added by the Rouge Project. This model simulates CSOs induced by runoff from the 154 shaded combined sewer subareas in Figure 3. Together the stormwater and CSO models are used to develop loads and flows for input to the Tier 3 river model.

The Tier 3 models are the river models which simulate instream flows and concentrations based on the inputs from the detailed sewer system models. The SWMM TRANSPORT block is used to simulate the river hydraulics and the USEPA Water Quality Analysis Simulation Program (WASP) (Ambrose et. al., 1993) is used to simulate water quality. The four main branches of the Rouge River are simulated with the Tier 3 models, with the total extent of the river system covered by these four submodels as shown in
Figure 4.

An extensive watershed monitoring program has been part of the Rouge Project since its inception, and has provided the required data for model calibration. The monitoring program included rain gages, stream flow measurements, continuous dissolved oxygen and temperature recording stations, and water quality sampling stations. Calibration of the TRANSPORT river quantity model (with its associated Tier 2 model inputs) is complete while the river quality model (with its associated Tier 2 model inputs) has undergone a preliminary calibration. A final calibration of the river quality model will be completed in the Spring of 1996.

MODEL PREDICTIONS OF CSO BASIN PERFORMANCE

There are 11 demonstration CSO projects, ten basins and one tunnel (collectively referred to herein as basins), in various stages of construction within the Rouge Watershed. While these basins were in the early design stages a Rouge Project model was developed and used to provide some early predictions as to how these basins would perform (Kluitenberg et. al., 1994). The model projected how the basins would measure up to the USEPA CSO policy issued in April 1994. Specifically, percent treated, as defined in the CSO policy, and the number of overflow events per year were calculated on an average annual basis using model simulations with 33 years of hourly rainfall data.

The 11 demonstration CSO basins in the Rouge Watershed were designed according to several different criteria, depending on the basin. The basis of design for each of the facilities is given in Table 1. Hydraulic/hydrologic specifications for the demonstration CSO basins were obtained from the basin designers and are summarized in Table 2. All the facilities are designed to provide settling, skimming, and disinfection to overflows. These 11 facilities, along with several sewer separation projects, will control more than one-third of the combined sewer drainage area in the Rouge Watershed. The remaining combined sewer areas are all required to be controlled by additional projects implemented by the year 2005.

In general, there are two types of CSO basins under construction. The three DWSD CSO basins and the Wayne County - Redford Township basin are being designed with a shunt channel, as shown schematically in Figure 5, which will allow the facility operator to route a portion of the combined sewer overflow around the basin during certain peak flow conditions. The main purpose of the shunt channel is to prevent resuspension of settled solids in the basins during peak flow conditions by "shaving the peak" off of the influent hydrograph. The portion of flow diverted through the shunt channel will receive skimming and disinfection, but no settling.

A shunt channel is not included in the design of the other seven CSO basins as shown schematically in Figure 6. All combined sewer overflows at these seven facilities will receive settling, skimming and disinfection. However, during certain peak flow conditions, velocities in the basin may be high enough to prevent complete settling or cause resuspension of previously settled solids.

The USEPA CSO Policy issued in 1994 (USEPA, 1994) allows for a demonstration approach or a presumption approach to CSO control. The presumption approach specifies that a CSO control facility must meet any one of three criteria. One of these criteria is to provide treatment to 85 percent of all combined sewer flows during wet weather events. Another is to allow no more than four overflow events per year which don't receive the equivalent of primary clarification.

The Tier 1 model used in the CSO basin analysis uses a mass balance approach to represent a combined sewer system, regulator, and basin as is used in the STORM model. However, a modified version of the program, named TRTSTORM (developed by the Rouge Project), was used to account for several operational options of the proposed CSO basins. Each CSO basin was analyzed on an individual basis and assumed that all overflows receiving at least two hours of hydraulic detention time have received the equivalent of primary clarification.

The predicted percent treated and number of overflow events per year for each CSO basin is shown as Scenario 3 in Figures 7 and 8, respectively. In each figure the Scenario 3 results are compared to the existing combined sewer capture for the same tributary combined sewer areas, which is labeled Scenario 1. The results indicate that all of the basins except the Hubbell-Southfield (whose size was limited due to site constraints) will meet the 85 percent treated criterion in the USEPA presumption approach and that seven of the basins should also meet the 4 overflows per year criterion.

The model simulations gave assurances to the various stakeholders that the performance of the Rouge Watershed CSO demonstration basins would exceed the presumption approach requirements in the national CSO policy, except for the Hubbell-Southfield basin. The results also gave some early indication of the differences in basin performance which could be expected for the various basin sizing criteria reflected among the demonstration basin designs.

INSTREAM IMPACTS OF VARIOUS CSO BASIN SIZES

For many years there has been much debate in Michigan as to what is a reasonable design criteria for sizing CSO basins. An early unofficial criterion (Criterion A) used by the MDEQ required that a basin be sized to provide complete capture of a 1 year, 1 hour design storm and provide at least 30 minutes of detention for a 10 year, 1 hour design storm. A number of the demonstration projects in the Rouge Watershed were sized to a smaller criterion (Criterion B) of providing 20 or 30 minutes of detention for the 1 year, 1 hour storm. Depending on the particular site, a basin designed to Criterion A could be more than double the size of a basin designed to Criterion B.

The Rouge Project Tier 2 sewer system models and the Tier 3 river model are currently being used to shed light on the CSO basin sizing debate by evaluating the instream impacts of the two different basin sizing criteria. The simulations are being conducted on the Main Rouge north of 8 Mile Road, referred to as the Main-1 Subwatershed. The model simulations are based on six months (May through October of 1994) of measured rainfall at multiple rain gages in the watershed.

The Main 1 Subwatershed shown in Figure 4 is 78 square miles in size and contains 7 square miles of combined sewer areas located in the center of the subwatershed. These combined sewer areas discharge to the Main Rouge River through more than 30 individual combined sewer overflow locations. All these CSOs will be controlled by 1997 by three CSO basins and one sewer separation project which are currently under construction. Each of these three basins was sized using Criterion B.

Simulations of the sewer system and river model within the Main-1 Subwatershed were conducted for three conditions listed below.

- Existing Conditions
- Alternative 1 - After Implementation of All CSO Controls as Designed to Criterion B
- Alternative 2 - Hypothetical Increase of CSO Basin Sizes to Criterion A

The total CSO basin storage volume provided under Alternative 1 is about 20 million gallons while the comparable storage volume provided under Alternative 2 is about 40 million gallons.

Although these simulations are still being refined, some preliminary results are available based solely on the capture provided by the basins, i.e. not accounting for the treatment ability of the basins. Alternative 1 will decrease CSO volumes discharged to the Main Rouge River from these combined sewer areas by at least 50 percent, and Total Suspended Solids (TSS) by at least 70 percent. By comparison, if Alternative 2 would have been implemented instead, it would have decreased CSO volumes discharged to the Main Rouge River from these combined sewer areas by 70 percent, and reduced TSS by 80 percent. Once the pollutant removal ability of the basins is accounted for, the TSS removal for each alternative should be even greater.

The preliminary model results have been used to generate predicted cumulative frequency of occurrence curves for wet weather conditions and time series plots for the Main Rouge River just downstream of the CSO areas. An example time series plot for flow is shown in Figure 9 for existing conditions and the two alternatives. The model results demonstrate the incremental instream impacts which result from the two different levels of CSO controls. Note that Alternative 2 shows no impact on the small storms since they were captured by the Alternative 1 basin sizing. Further refinement of these model simulations will serve as a useful tool in making decisions about the most appropriate sizing of future CSO basins designed in the watershed and around the state.

PREDICTIVE ANALYSIS OF LOWER ROUGE WATERSHED MANAGEMENT BUILDING BLOCKS

The Tier 2 sewer system models and Tier 3 river models are currently being used as a tool for analyzing the existing condition of the river and predicting the response of the river to various watershed management strategies. A good example of this model application is a recently conducted analysis on the Lower Rouge Subwatershed to demonstrate the general types of improvements and programs, and their expected impacts, which may be needed to restore uses of the Lower Rouge River. Specific recommended improvements and programs will eventually be presented in this same format.

The analysis was conducted by evaluating existing conditions and four progressive steps of watershed management activities, referred to herein as alternatives, as follows:

- Alternative 1 - After Onset of YCUA Discharge (Fall 1995)
- Alternative 2 - Full Implementation of CSO Control (2005)
- Alternative 3 - Implementation of Stormwater Controls
- Alternative 4 - Full Watershed Plan for Lower Rouge

The alternatives considered should be viewed as building blocks which stack up to a complete watershed plan for the Lower Rouge River. The alternatives are not a group of choices from which one can be chosen. In this analysis, each alternative is compared to the sum effect of all previous alternatives. The order of analysis is not important -- many of these watershed management activities could occur concurrently during implementation.

Although the analysis relied on the Rouge Project models, it also made use of monitoring data collected by the RPO, MDEQ and others and the Rouge River Indices. The indices are a simple tool developed by the RPO for analyzing and graphically displaying the condition of a river. The Rouge River Indices are in a development stage and currently include an Aesthetic, Biological, Chemistry and Health Index, each based on a number of criteria as shown on Figure 10. Each index has its own scoring and evaluation system for ranking the condition of the river. For purposes of this analysis, the index rankings were simplified to the point where each reach of the Lower Rouge River could be classified as being in good, fair or poor condition for existing conditions and for each of the four alternatives.

Existing Conditions (1994)

Figure 11 depicts the Lower Rouge Subwatershed and a summary of 1994 conditions on the Lower Rouge River. The Lower 1 subwatershed is the headwater area of the Lower Rouge which is one of the few predominantly rural areas left in the Rouge Watershed. The Lower 2 Subwatershed is highly urbanized and contains a number of combined sewer areas which discharge to the most downstream reaches of the Lower Rouge.

The 1994 monitoring showed the entire Lower Rouge has significant bacteria levels during dry and wet weather, and the more downstream reaches also have odor problems and unsightly debris. Sediment oxygen demand combined with low dry weather flow depths results in periods of low or zero dissolved oxygen (DO) levels in the dry summer periods, and these DO levels sometimes undergo even further transitory drops in response to wet weather events. Increased flow variability due to urbanization has accelerated bank erosion and caused increased wet weather solids loadings, increased velocities, impaired fish habitat, and increased the number of log jams from fallen trees. Fish consumption advisories exist on portions of the Lower Rouge due to the presence of PCBs in bottom sediment in several locations.

Alternative 1 - After Onset of YCUA Discharge (Fall 1995)

In the Fall of 1995, the Ypsilanti Community Utilities Authority (YCUA) Wastewater Treatment Plant began the permanent rerouting of its effluent to the Lower Rouge near Beck Rd. The plant discharges an annual average flow rate of 13.5 mgd at a point where the Lower Rouge's annual average flow is 3 mgd, and summer flows are much lower. The minimum allowable DO concentration of the effluent specified in the discharge permit is 6 mg/l, but the levels are typically higher.

As summarized in Figure 12, The YCUA discharge significantly increases base flows in the Lower Rouge and improve dissolved oxygen levels, which should allow for a wider diversity of aquatic life. Potential drawbacks of the discharge are surfactants in the effluent, which introduce foam at the point of discharge and at points of turbulence downstream, a slight odor created in the river, and increases in nutrient (nitrogen and phosphorus) loadings to the river. Selected model simulation results were used to generate predicted cumulative frequency of occurrence curves for existing conditions and Alternative 1. The model results graphically display the dramatic changes in dissolved oxygen levels expected as a result of Alternative 1.

Alternative 2 - Full Implementation of CSO Control (2005)

Figure 13 depicts the predicted impacts of full implementation of CSO control on the Lower Rouge River. This alternative includes all CSO control projects currently under construction on the Lower Rouge, and the assumption that all remaining CSOs are completely controlled by diversion to the Dearborn Tunnel CSO control project. This assumption is for analysis purposes only, and is not necessarily a future course of action.

The CSO control projects eliminate transitory DO drops and significantly reduce peak flows in the downstream reaches of the Lower Rouge. They also eliminate virtually all "raw sewage" which enters the Lower Rouge, causing significant reductions in wet weather bacteria levels in the downstream reaches. The model simulations predict, that in comparison to Alternative 1, Alternative 2 will eliminate 20 percent of the total wet weather runoff volume and 10 to 30 percent of the wet weather pollutant loads entering the Lower Rouge. A wet weather frequency of occurrence plot and time series plot for BOD_5 at the mouth of the Lower Rouge illustrate the expected instream impacts of complete CSO control.

Alternative 3 - Implementation of Stormwater Controls

The next building block in the watershed plan for the Lower Rouge is the implementation of a moderate stormwater control program and an aggressive illicit connection and septic system failure identification and remediation program. The benefits of this alternative over Alternative 2 are graphically depicted in Figure 14.

This alternative significantly reduces dry weather bacteria levels and reduces to a smaller amount, the wet weather bacteria levels. The alternative also further reduces wet weather loads to the Lower Rouge. The model simulations predict, that in comparison to Alternative 2, Alternative 3 will eliminate 10 to 20 percent of the wet weather pollutant loads entering the Lower Rouge. Wet weather frequency of occurrence plots and time series plots for BOD_5 at several locations along the Lower Rouge illustrate the model predictions of instream impacts of these controls.

Alternative 4 - Full Watershed Plan for the Lower Rouge

The last alternative analyzed consists of the various types of programs and measures which will most likely be required to implement a full watershed plan. One of these measures is the construction of regional stormwater impoundments at the outlets of several major tributaries to the Lower Rouge River. The Tier 2 models were used in an iterative fashion, sizing the impoundments to cut peak flows from these areas by 50 percent. This alterative could have smaller but more numerous impoundments that could act similarly. Pollutant removal rates due to the impoundments were assumed for each pollutant simulated. Alternative 4 also includes a number of other measures and programs as described in Figure 15 including stream bank stabilization, habitat restoration/creation, trash and debris removal, elimination of abandoned dumps, addition of a recreational corridor along selected reaches, and possibly some localized sediment remediation.

If all the above projects were implemented, most of the major uses of the Lower Rouge river could be restored due to significant improvements in aesthetics and fish and wildlife habitat, further reductions in peak flows and velocities, and further reductions of pollutant loads to the river. The model results indicate a 20 percent reduction in wet weather runoff volume and a 30 to 40 percent reduction in total wet weather loads can be expected in comparing Alternative 4 to Alternative 3. The models are also useful in demonstrating the expected instream peak flow impacts from the time series plots and wet weather frequency of occurrence curves for flow.

CONCLUSIONS

In summary the three tiers of models developed and used by the Rouge Project are proving to be a very useful tool in analyzing existing river conditions and predicting the expected impacts of future alternative CSO and NPS control strategies being considered. The models are useful in estimating expected pollutant load reductions, expected impacts on instream concentrations, and in generating frequency of occurrence statistics for various alternative watershed management strategies. The model results are an integral part of graphical tools being used to communicate to various audiences the problems and potential solutions to water quality problems in the Rouge Watershed. Lastly, the models are playing an important role as a decision-making tool in the process of reaching consensus as to what is a reasonable level of control for future CSO control projects.

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Figure 1

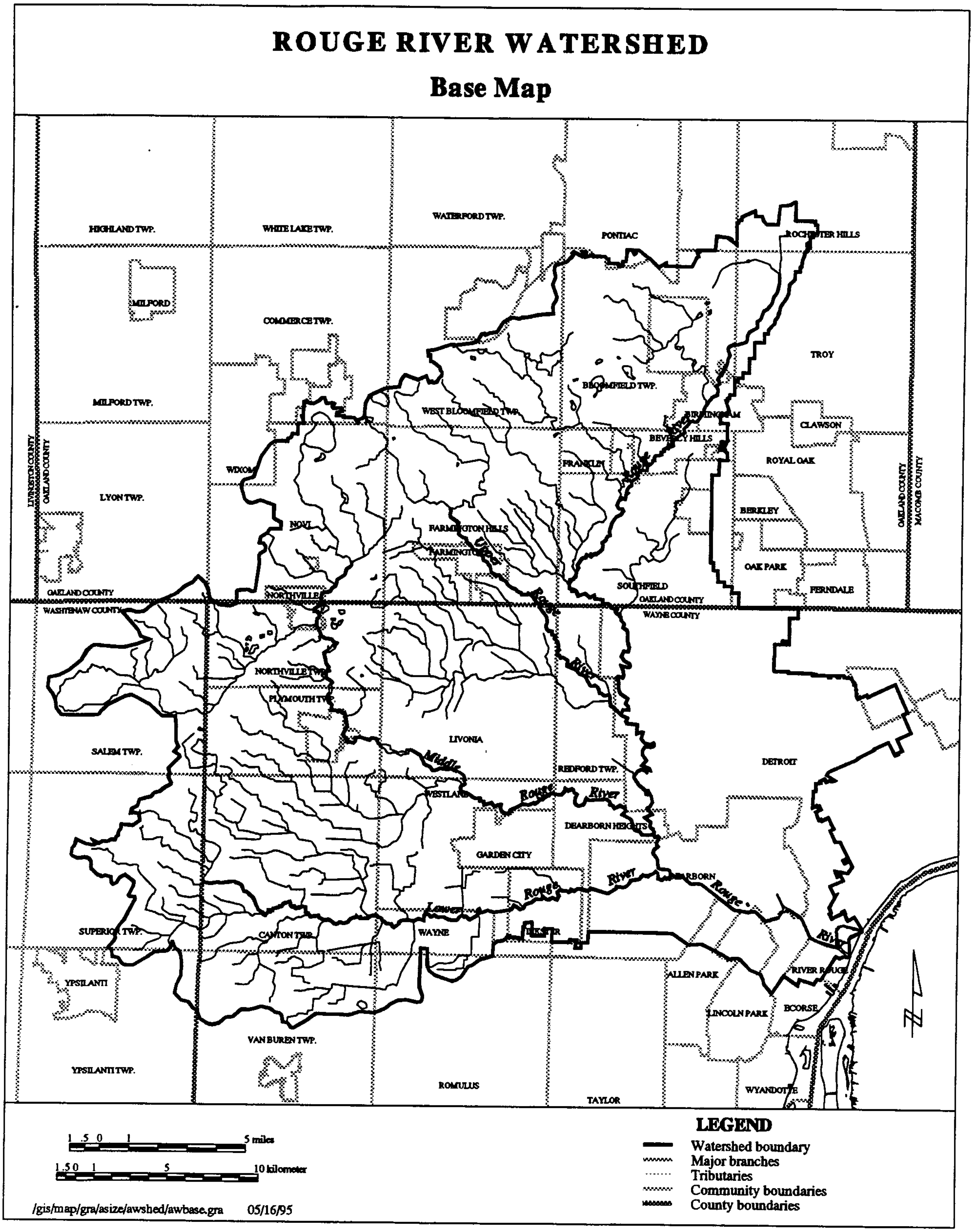
ROUGE RIVER WATERSHED
Base Map
HIGHLAND TWP.
WHITE LAKE TWP.
WATERFORD TWP.
PONTIAC
ROCHESTER HILLS
MILFORD
COMMERCE TWP.
TROY
MILFORD TWP.
WEST BLOOMFIELD TWP.
BLOOMFIELD TWP.
BIRMINGHAM
BEVERLY HILLS
CLAWSON
ROYAL OAK
FRANKLIN
WIXOM
LYON TWP.
NOVI
FARMINGTON HILLS
FARMINGTON
BERKLEY
OAK PARK
SOUTHFIELD
FERNDALE
OAKLAND COUNTY
WASHTENAW COUNTY
NORTHVILLE
WAYNE COUNTY
LIVINGSTON COUNTY
MACOMB COUNTY
NORTHVILLE TWP.
PLYMOUTH TWP.
LIVONIA
SALEM TWP.
REDFORD TWP.
DETROIT
WESTLAND
Middle Rouge River
DEARBORN HEIGHTS
GARDEN CITY
Lower Rouge River
DEARBORN
SUPERIOR TWP.
CANTON TWP.
WAYNE
INKSTER
YPSILANTI
ALLEN PARK
RIVER ROUGE
LINCOLN PARK
ECORSE
VAN BUREN TWP.
YPSILANTI TWP.
ROMULUS
TAYLOR
WYANDOTTE
1 .5 0 1 5 miles
1.5 0 1 5 10 kilometer
LEGEND
Watershed boundary
Major branches
Tributaries
Community boundaries
County boundaries
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Figure 2
ROUGE WATERSHED ANALYSIS APPROACH

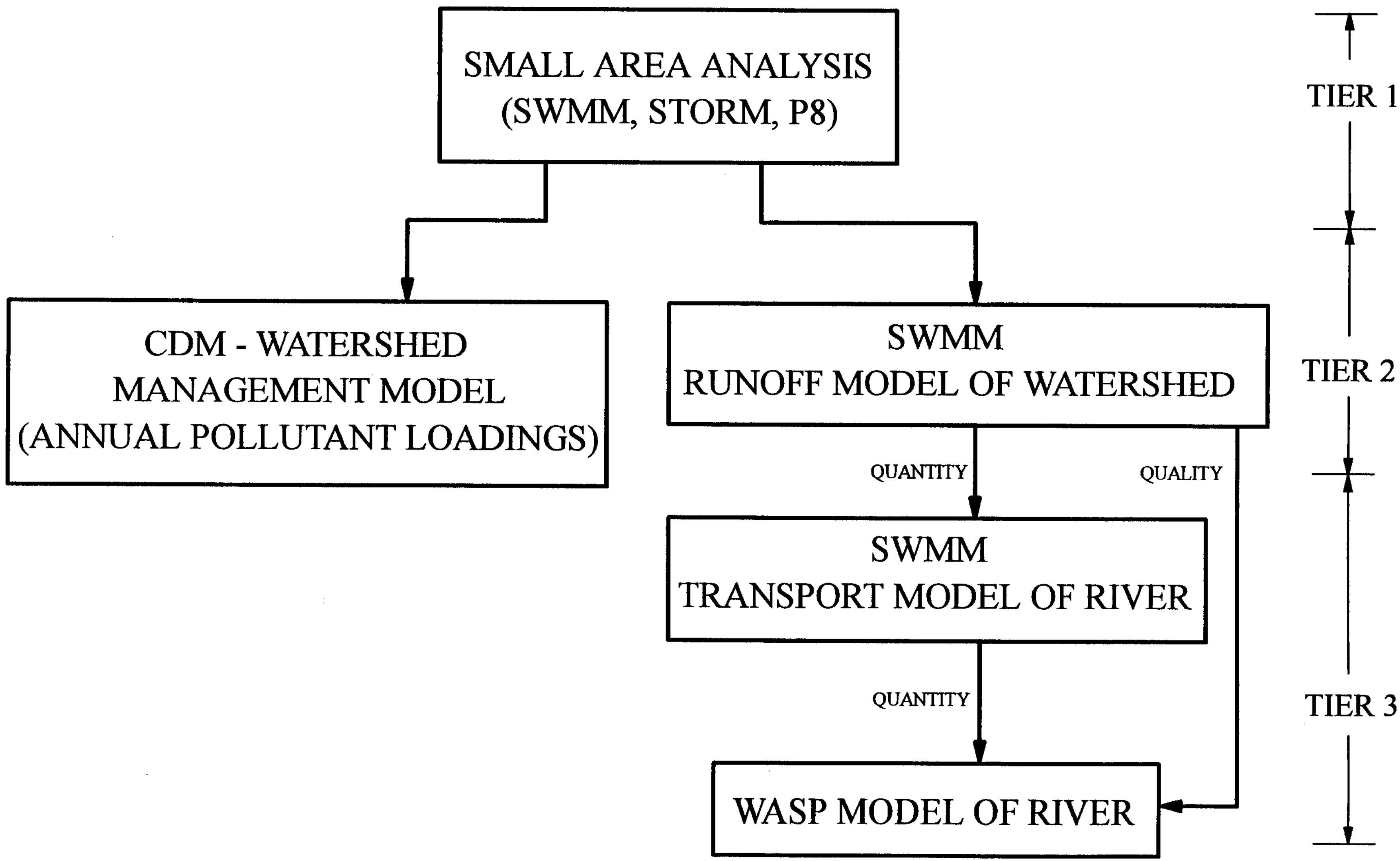


Figure 3

ROUGE RIVER WATERSHED
Drainage Subareas

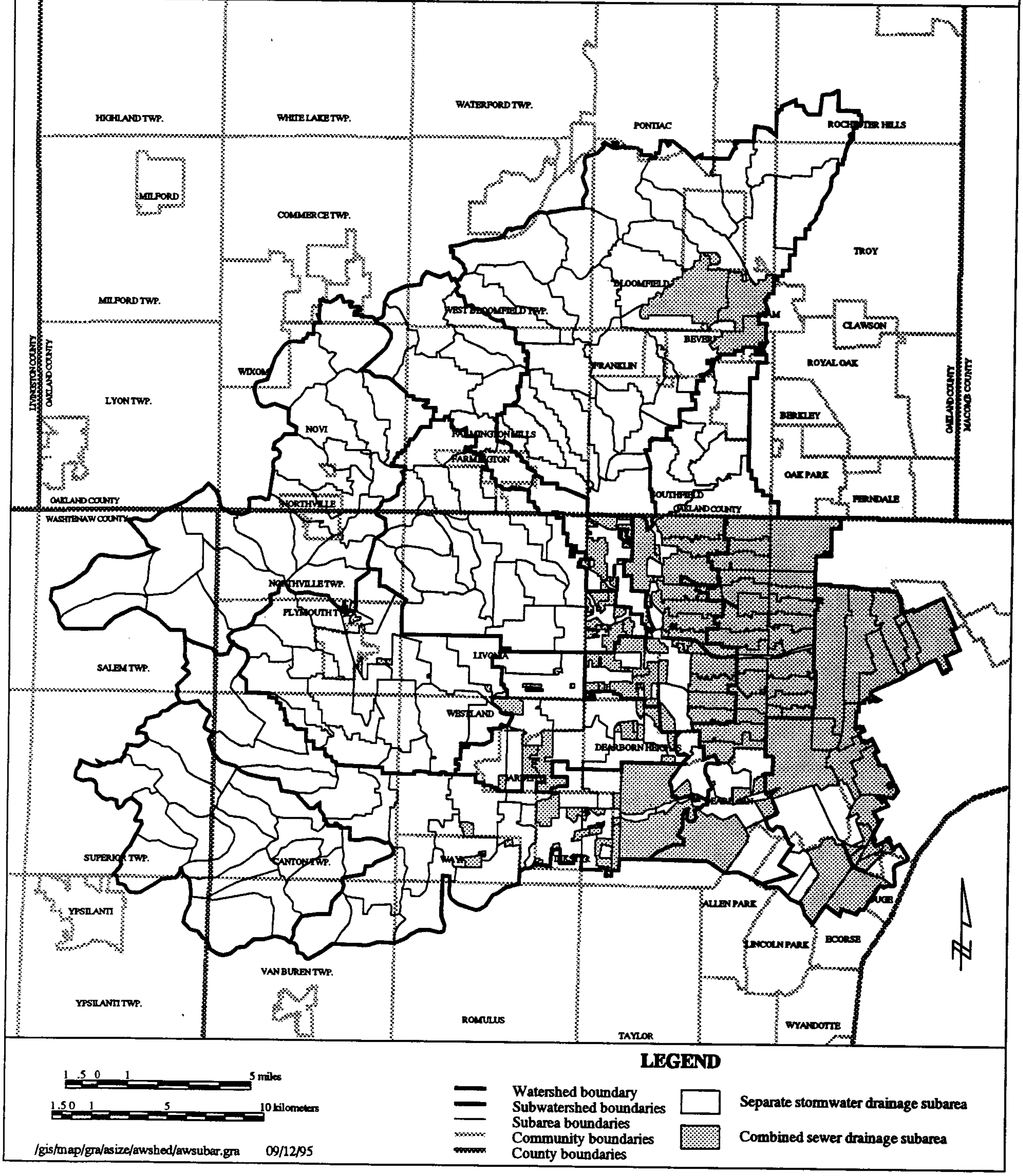


Figure 4

ROUGE RIVER WATERSHED

Extent of Water Quantity / Quality Submodels

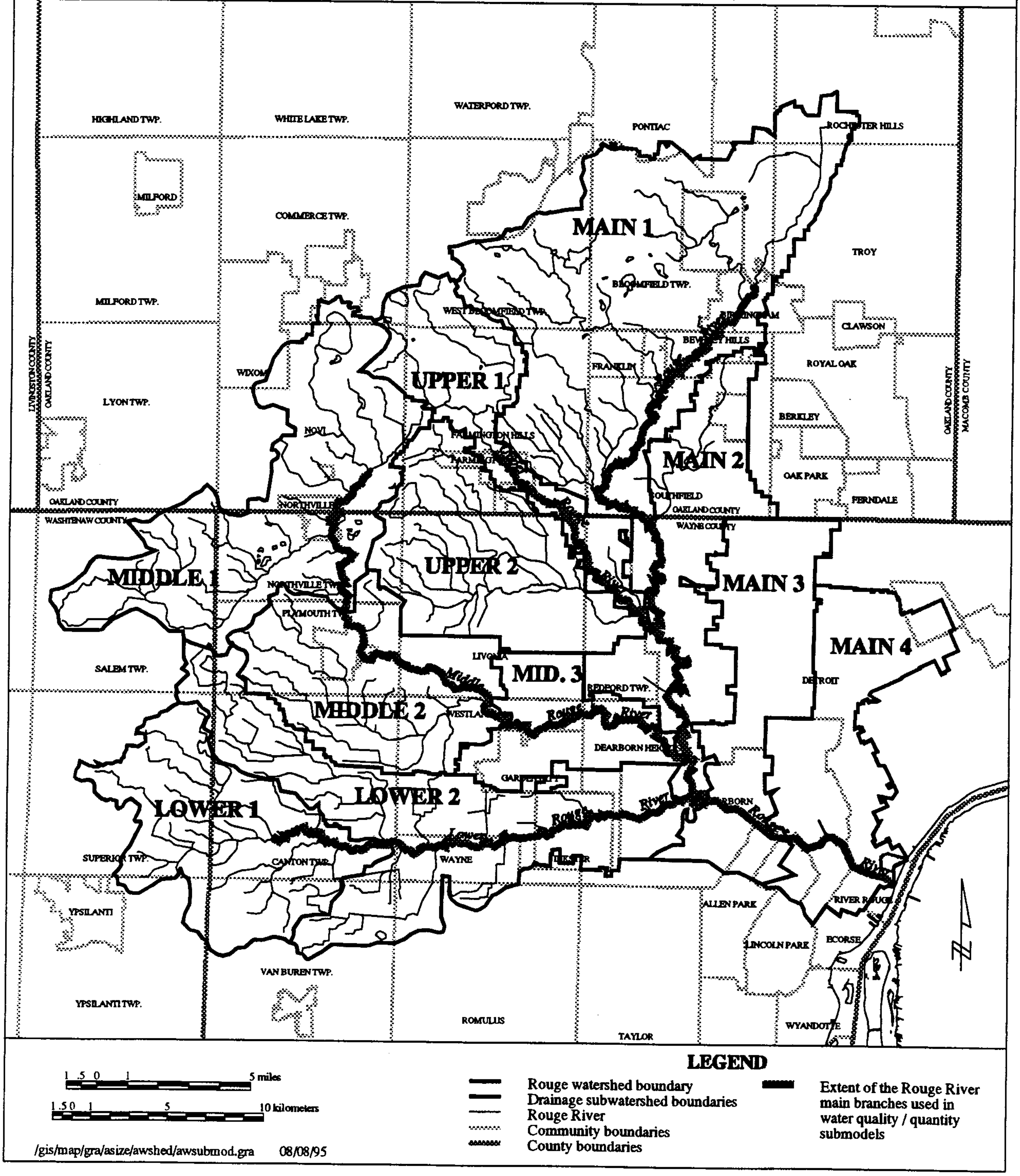


Table 1
BASIS OF DESIGN FOR
DEMONSTRATION CSO CONTROL FACILITIES

Basin Name	Design Storm(s)*				
	1 yr, 1 hr w/ 20 min. Detention	1 yr, 1 hr w/ 30 min. Detention	1 yr, 1 hr w/ Full Retention	10 yr, 1 hr w/ 30 min. Detention	Size Limited By Site
River Rouge			X	X	
Wayne Co. - Dearborn Heights				X	
Wayne Co. - Redford Twp.	X				
Wayne Co. - Inkster	X				
DWSD - Hubbell-Southfield					X
DWSD - Seven Mile		X			
DWSD - Puritan/Fenkell	X				
Dearborn - Tunnel			X	X	
Oakland Co. - Acacia Park		X			
Oakland Co. - Birmingham		X			
Oakland Co. - Bloomfield Village		X			

* The 1 year, 1 hour storm is 1 inch of rain.
The 10 year, 1 hour storm is 1.7 inches of rain.

Table 2
SPECIFICATIONS OF
DEMONSTRATION CSO CONTROL FACILITIES

Basin Name	Shunt Channel	Drainage Area (acres)	Basin Volume (mg)	Basin Volume (in)	Dewatering Time (hours)
River Rouge	N	929	5.2	0.21	23.5
Wayne Co. - Dearborn Heights	N	340	2.7	0.29	12.2
Wayne Co. - Redford Twp.	Y	551	1.9	0.13	4.9
Wayne Co. - Inkster	N	833	3.1	0.14	8.8
DWSD - Hubbell-Southfield	Y	14,431	22.0	0.06	17.3
DWSD - Seven Mile	Y	463	2.2	0.17	8.6
DWSD - Puritan/Fenkell	Y	649	2.8	0.16	5.5
Dearborn - Tunnel	N	2,057	28.5	0.51	42.5
Oakland Co. - Acacia Park	N	816	4.0	0.18	14
Oakland Co. - Birmingham	N	1,185	5.5	0.17	45
Oakland Co. - Bloomfield Village	N	2,326	10.0	0.16	24

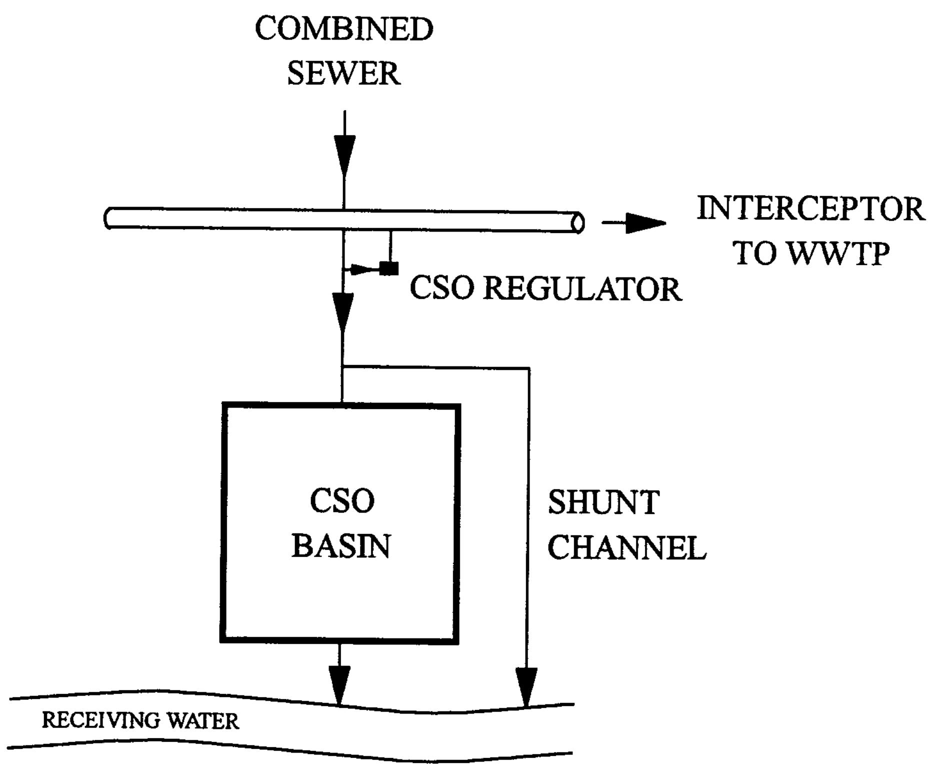


FIGURE 5: TYPICAL CSO BASIN WITH SHUNT CHANNEL

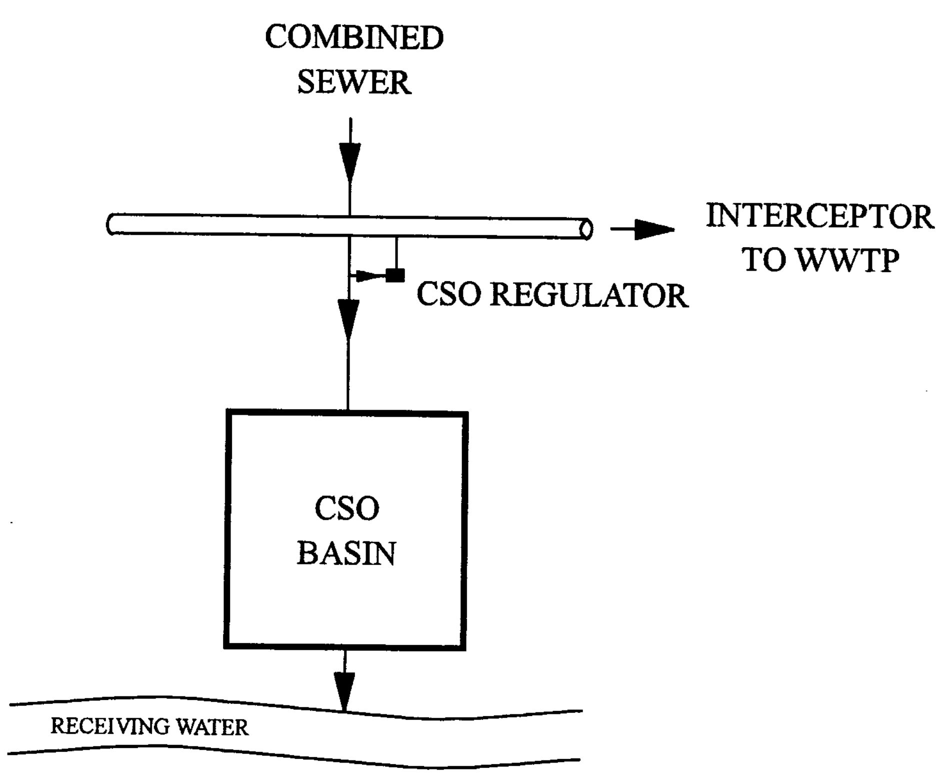


FIGURE 6: TYPICAL CSO BASIN WITHOUT SHUNT CHANNEL

Figure 7
Percentage of CSO Treated

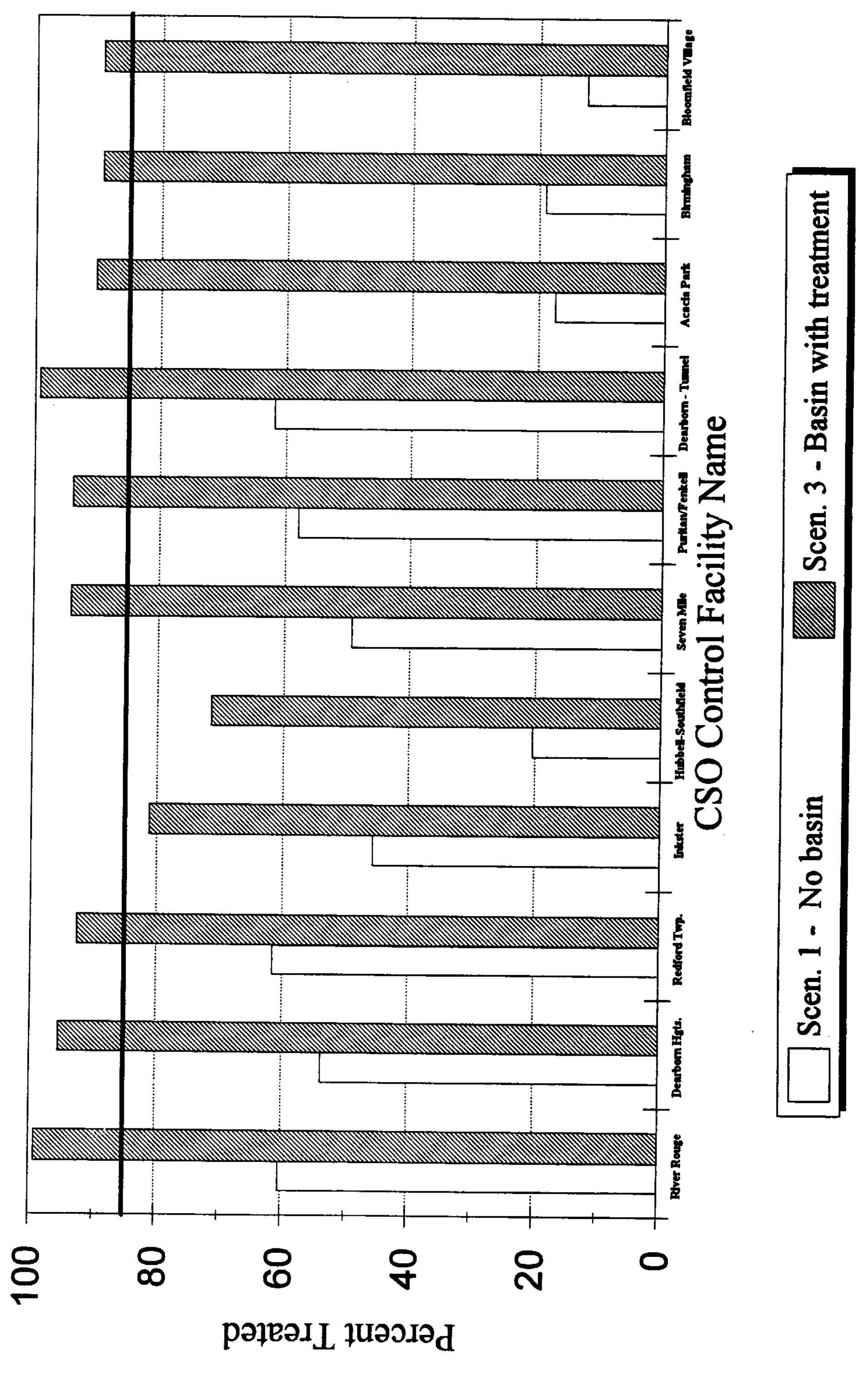
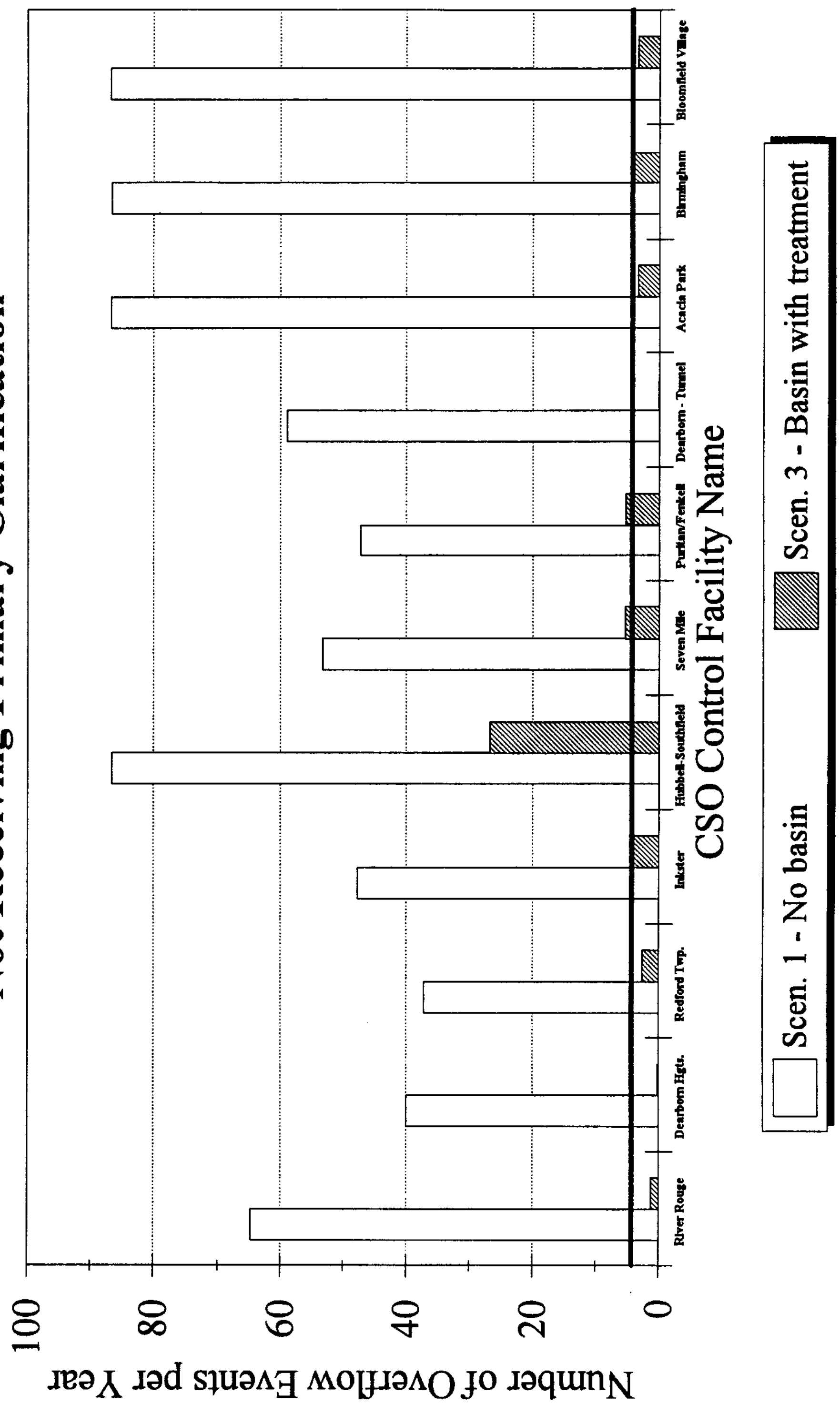


Figure 8
No. of Overflow Events per Year
Not Receiving Primary Clarification



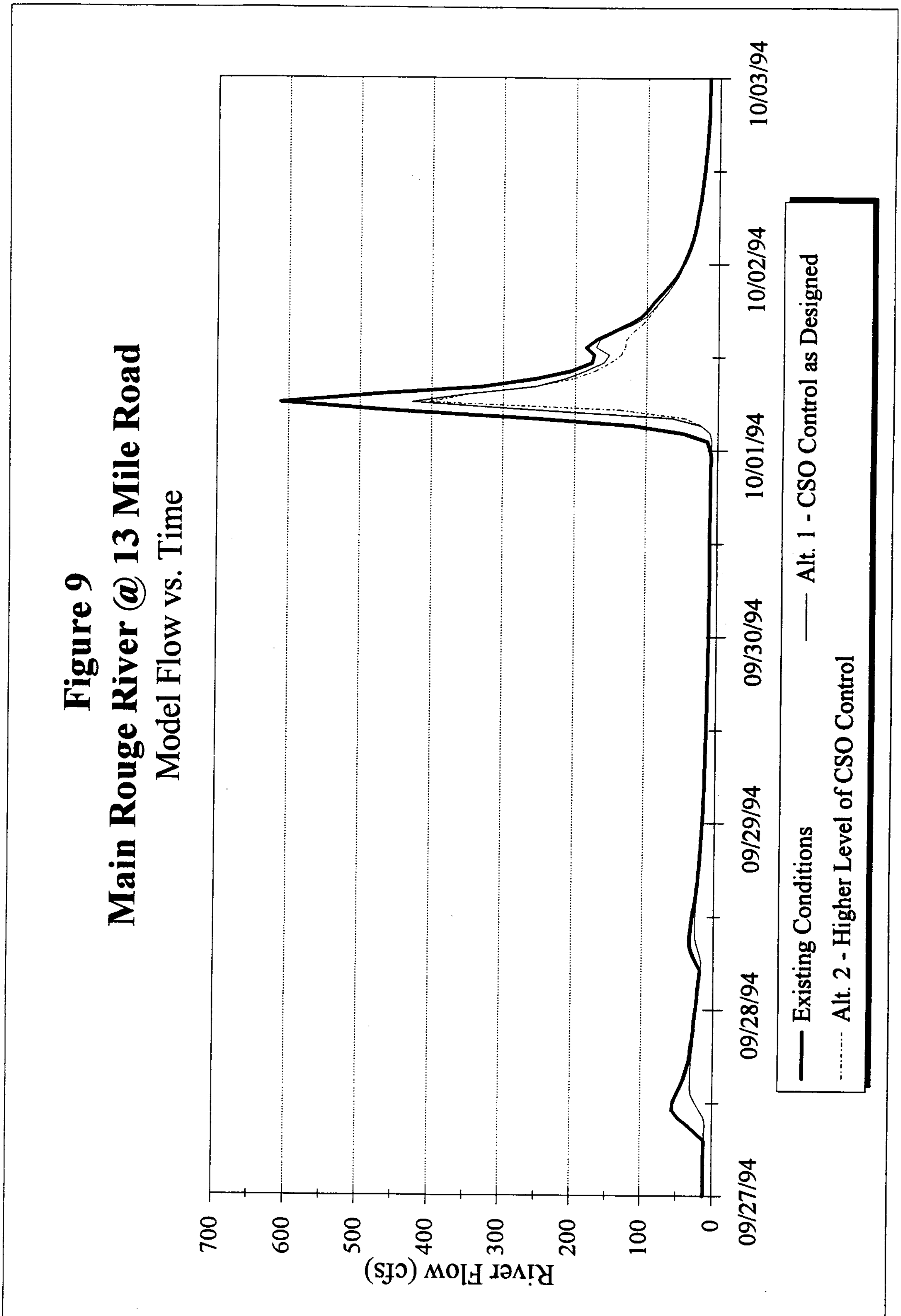


Figure 9
Main Rouge River @ 13 Mile Road
Model Flow vs. Time
River Flow (cfs)
700
600
500
400
300
200
100
0
09/27/94
09/28/94
09/29/94
09/30/94
10/01/94
10/02/94
10/03/94
Existing Conditions
Alt. 1 - CSO Control as Designed
Alt. 2 - Higher Level of CSO Control

Figure 10
Rouge River Indices Criteria and Weighting

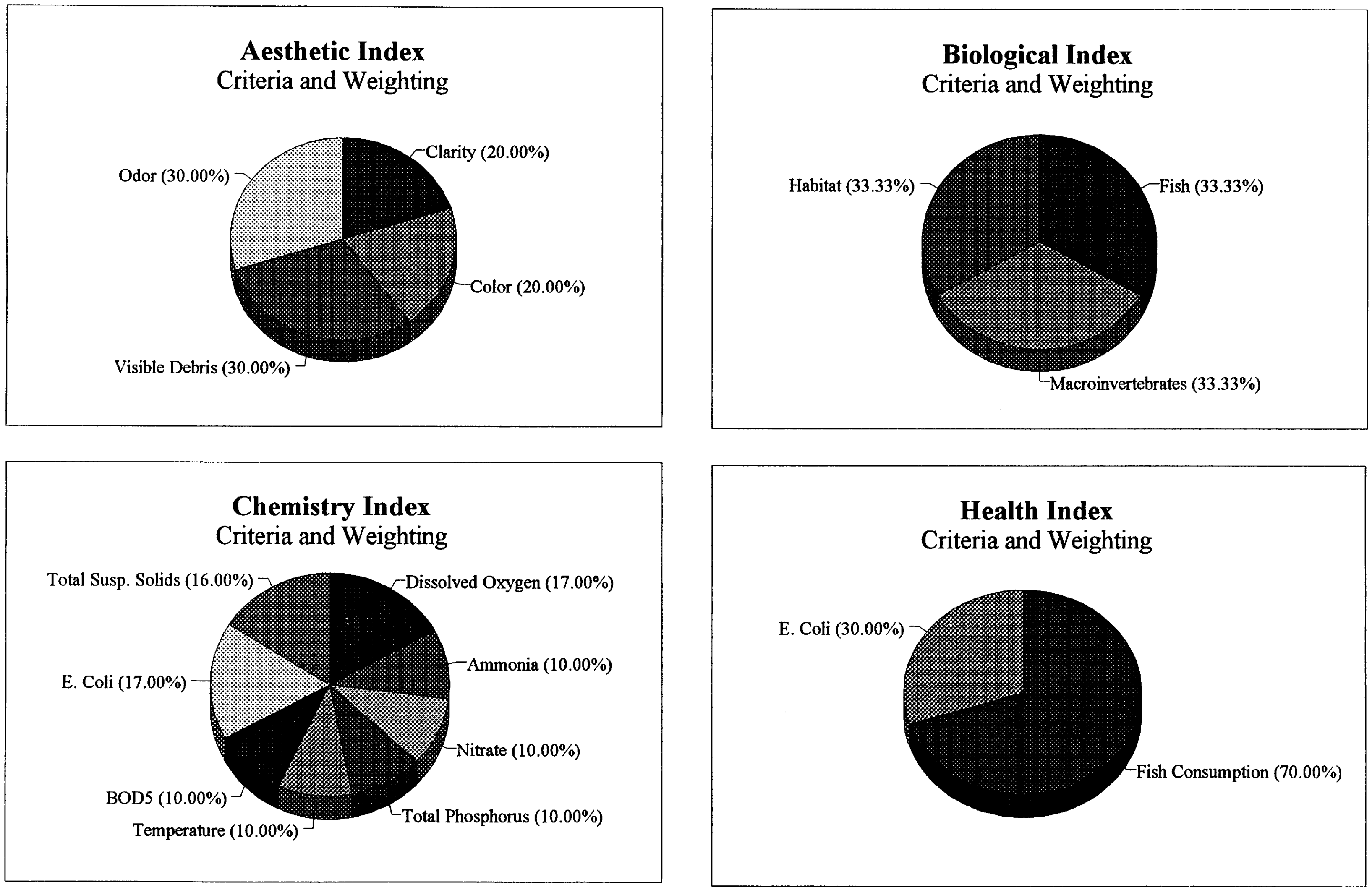
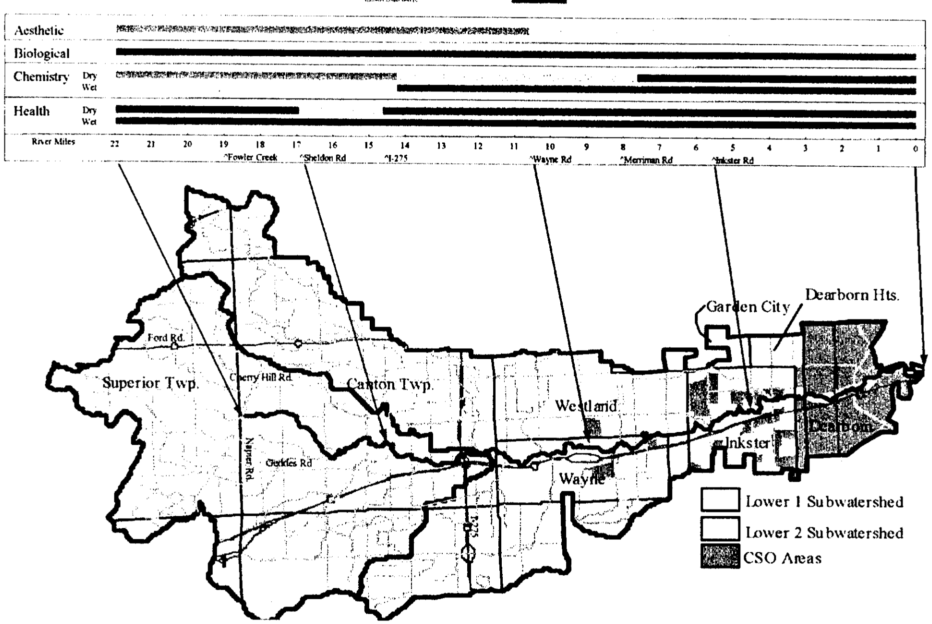


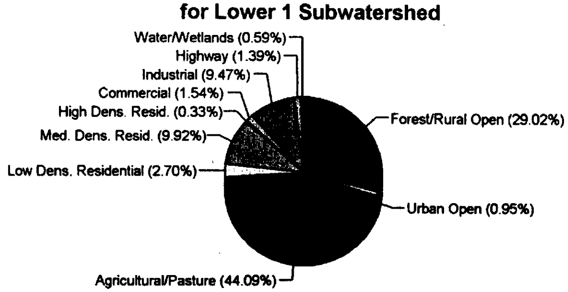
Figure 11

Lower Rouge Watershed
Existing Conditions (1994)

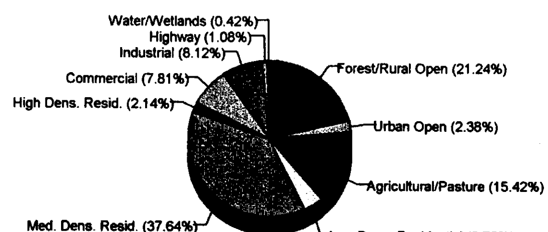


Index	Strengths	Weaknesses
Aesthetic	· Headwaters are in good condition with no significant odors or debris and clear water.	· Significant odor and clarity problems in middle reaches. · Significant odor, clarity and debris problems in lower reaches.
Biological	· Supports limited aquatic life.	· The combination of low dry weather flows and high peak flows prevents the river from supporting a wide diversity of aquatic life.
Chemistry	· Nutrient loadings are relatively low.	· Low dissolved oxygen in summer months. · High suspended solids during wet weather.
Health		· High bacteria levels, even in headwaters. · Fish consumption advisories exist on the Lower Rouge River due to the presence of PCBs.
Other		· Fallen trees and log jams which result in part from bank erosion interfere with use of the stream for canoeing.

Land Use Breakdown by RPO Category for Lower 1 Subwatershed



Land Use Breakdown by RPO Category for Lower 2 Subwatershed

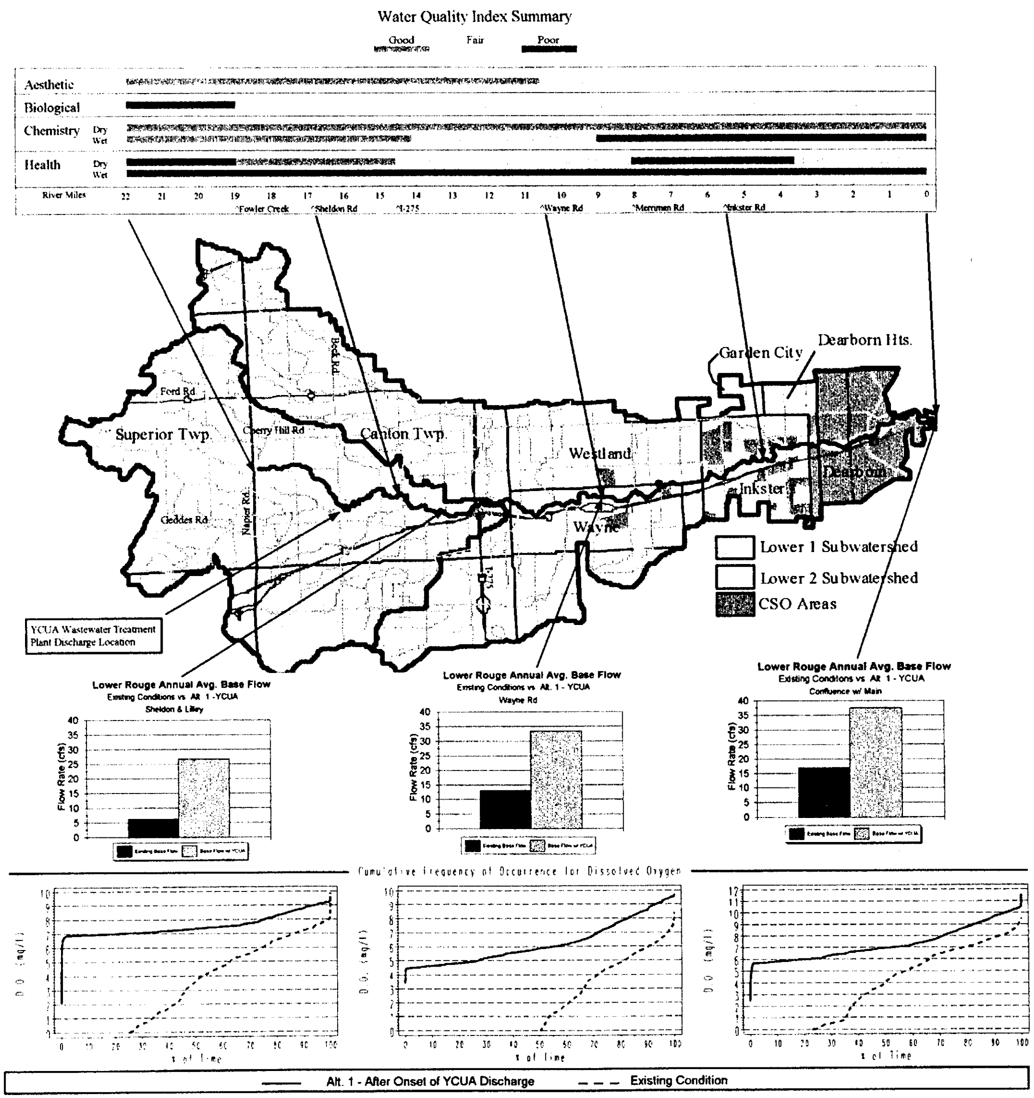


Lower Rouge River at Lilley Road

Figure 12

Lower Rouge Watershed

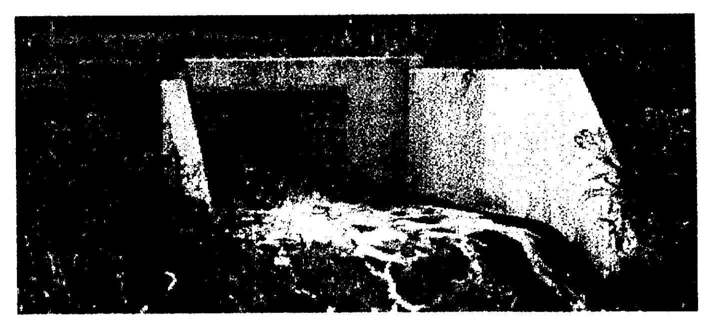
Alt. 1 - After Onset of YCUA Discharge (Fall 1995)



Index	Benefits	Drawbacks
Aesthetic	· Decrease in odor problems in middle and lower reaches for 1995 relative to 1994, but not a direct result of YCUA.	· Foam at point of discharge and at other points of turbulence downstream, caused by surfactants in YCUA effluent. · Slight odor to effluent at point of discharge
Biological	· Increased dry weather flow conditions and improved dissolved oxygen levels will allow for establishment of a wider diversity of aquatic life.	· Increased dry weather flows may increase stream bank erosion and increase suspended solids.
Chemistry	· Improved dry and wet weather dissolved oxygen levels.	· Significant increase in nutrient concentrations, but not necessarily problematic
Health	· Dry weather bacteria concentrations decreased due to dilution. · Improvement in bacteria levels from 1994 to 1995, but unrelated to YCUA discharge.	
Other	· Increased dry weather flow depths will enhance canoeing.	· Public knowledge that stream contains wastewater effluent may deter recreational use.

Description of Alternative 1

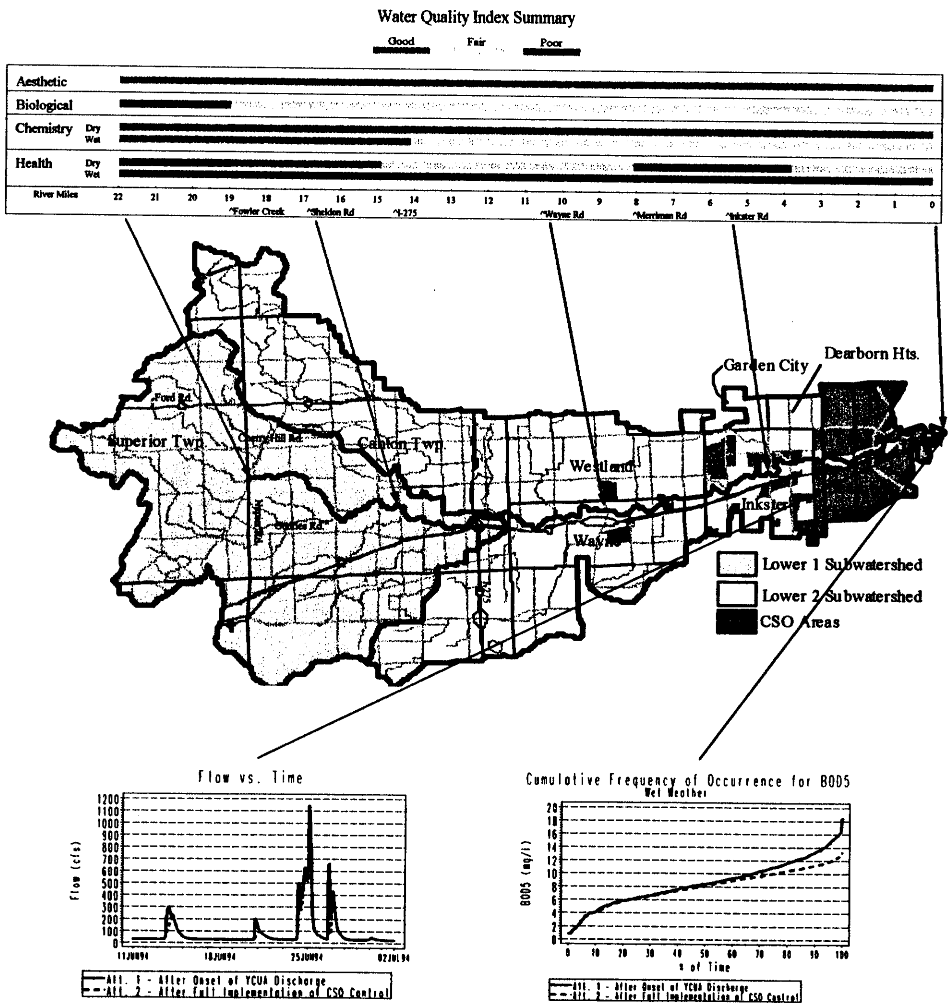
- Ypsilanti Community Utilities Authority (YCUA) Wastewater Treatment Plant effluent discharged into the Lower Rouge near Beck Rd. beginning Fall of 1995.
- Annual average flow rate of 13.5 mgd (≈21cfs).
- Minimum allowable dissolved oxygen concentration of effluent is 6 mg/l, but is typically higher.



Lower Rouge Watershed

Alt. 2 - Full Implementation of CSO Control (2005)

Figure 13



Index	Benefits	Drawbacks
Aesthetic	· Improvement in water clarity and debris in lower reaches.	
Biological	· Elimination of transitory dissolved oxygen drops and further reductions in peak flows will allow for establishment of a wider diversity of aquatic life in lower reaches.	· Potential localized threats to aquatic life near CSO basin outfalls due to residual chlorine in effluent.
Chemistry	· Reductions in instream concentrations of BOD, suspended solids and toxics in lower reaches. · Reductions in sediment oxygen demand in lower reaches.	
Health	· Reductions in wet weather bacteria levels in lower reaches, although wet weather bacteria levels will still exceed human health criterion.	
Other	· Improved public perception of river with all "raw sewage" removed.	

Percent Reduction in Total Wet Weather Loads to the Lower Rouge Based on Alt. 2

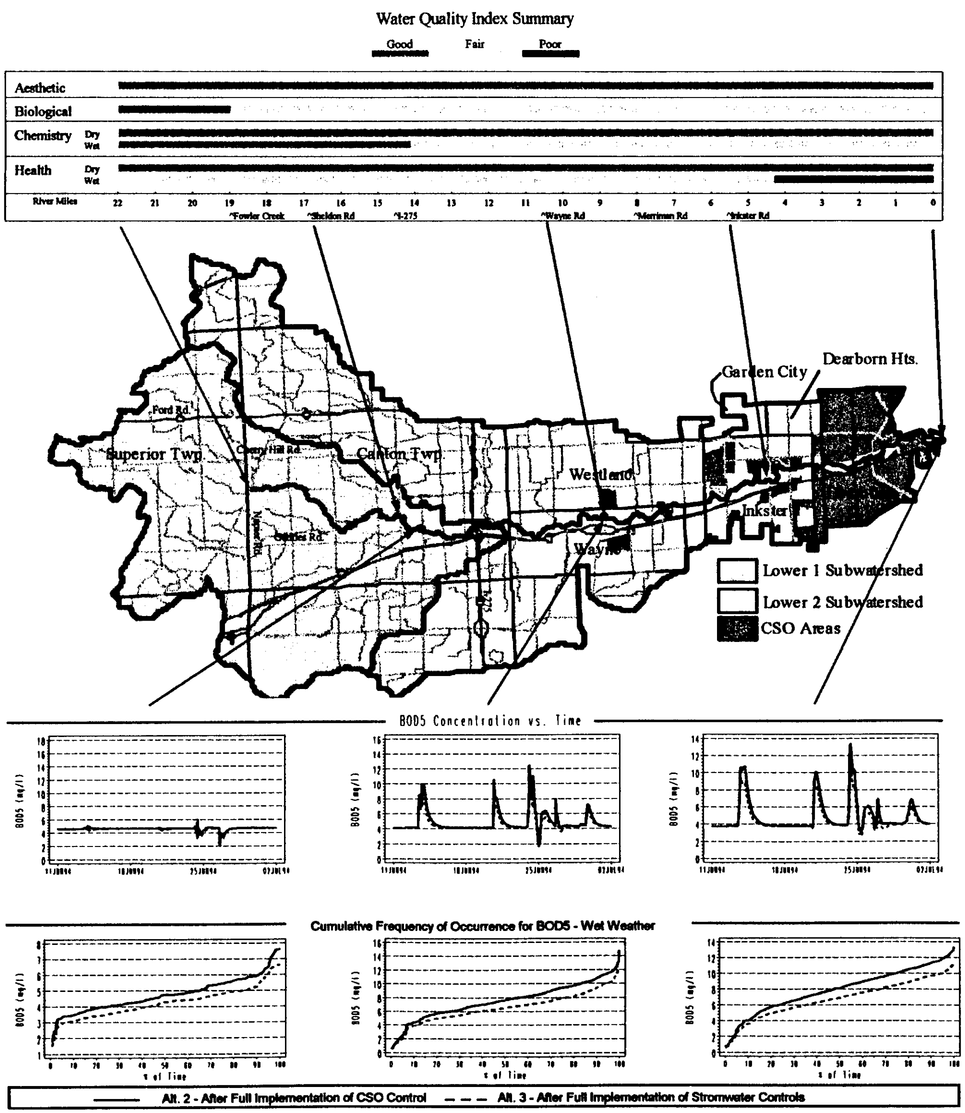
Parameter	% Reduction
Runoff Volume	21
BOD5	26
TSS	11
TKN	28
NO2+NO3	11
Phosphorus	28

Description of Alternative 2

- Controls all CSOs in the Lower Rouge Subwatershed by 2007.
- Includes Phase I CSO Contol projects: a sewer separation project in Westland and the Inkster CSO Basin to be in operation by 1997; and a sewer separation project in Wayne to be completed by 1999.
- Includes Phase II CSO Control projects: the Dearborn Tunnel extension, and the Inkster and Dearborn Heights CSO control projects. The type of Phase II CSO control to be implemented in Dearborn Heights and Inkster is not yet known. The control of these CSOs is assumed to be via the Dearborn Tunnel extension for purposes of this hypothetical analysis. These Phase II projects are scheduled to be operational by 2005.

Figure 14

Lower Rouge Watershed
Alt. 3 - Implementation of Stormwater Controls



Index	Benefits	Drawbacks
Aesthetic	· Small improvements in water clarity and debris.	
Biological	· Further reductions in suspended solids will increase the diversity of aquatic life which can be supported.	
Chemistry	· Small reductions in instream concentrations of suspended solids, BOD and other pollutants. · Marginal reductions in BOD.	
Health	· Significant reductions in dry weather bacteria levels. · Some reduction in wet weather bacteria levels, but still exceeding human health criterion.	
Other		

Percent Reduction in Total Wet Weather Loads to the Lower Rouge Based on Alt. 3

Parameter	% Reduction
BOD5	18
TSS	13
TKN	17
NO2+NO3	14
Phosphorus	18

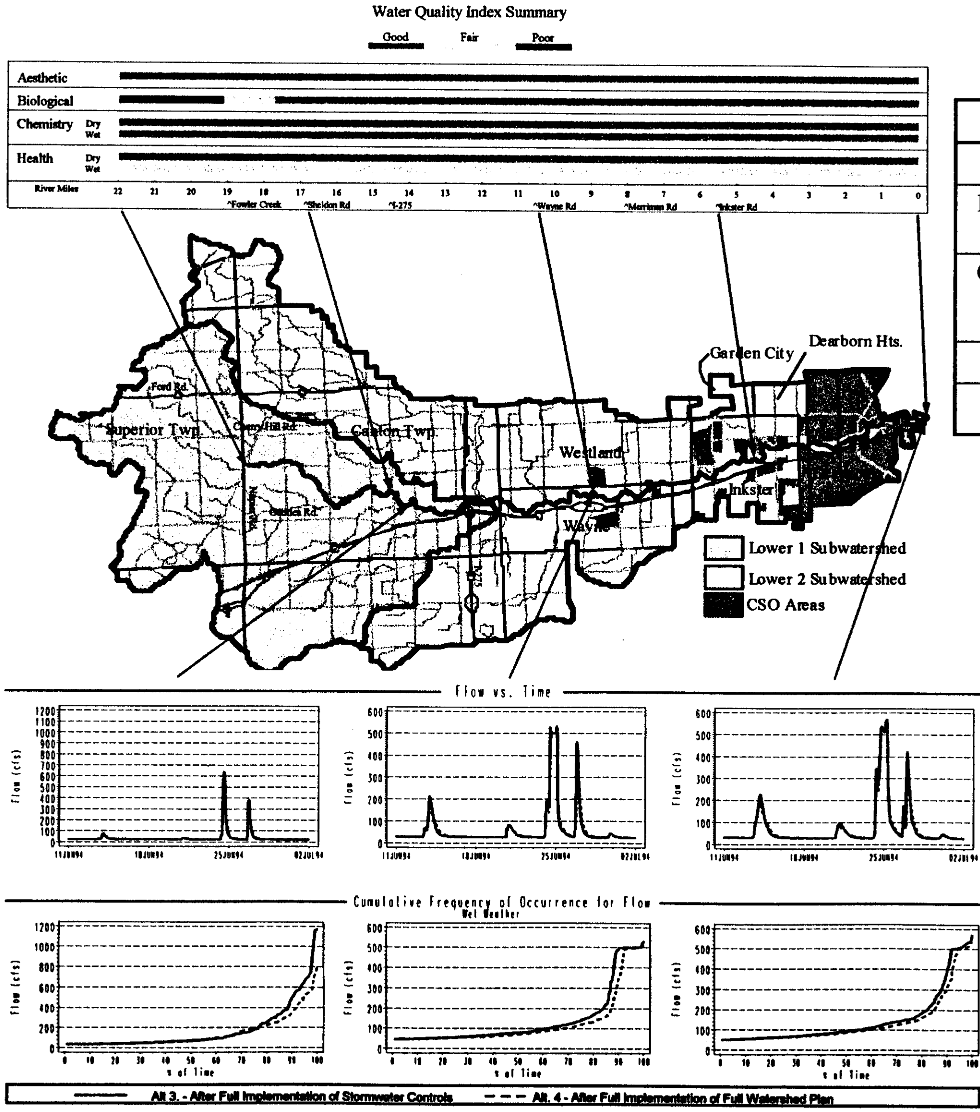
Description of Alternative 3

- Represents a moderate stormwater control program as follows:
  - Public education program.
  - Catch basin cleaning program.
  - BMPs required for new development, but not existing.
  - Street sweeping program.
- Includes an aggresive illicit connection and septic system failure identification and remediation program.
- Stormwater controls assumed to result in pollutant load reductions of 20%, which is a very optimistic projection.

Figure 15

Lower Rouge Watershed

Alt. 4 - Full Watershed Plan for Lower Rouge



Index	Benefits	Drawbacks
Aesthetic	· Improvement in water clarity.	
Biological	· Further reductions in peak flows and suspended solids, and restoration/creation of habitats will enhance biodiversity.	
Chemistry	· Further reductions in instream concentrations of suspended solids and other pollutants.	· Potential increase in water temperature downstream of the stormwater impoundments. · Potential eutrophication problems in stormwater impoundments.
Health		
Other	· Regional stormwater impoundments would be a recreational resource and aesthetic asset.	

Percent Reduction in Total Wet Weather Loads to the Lower Rouge Based on Alt. 4

Parameter	% Reduction
Runoff Volume	19
BOD5	28
TSS	40
TKN	32
NO2+NO3	38
Phosphorus	34

Description of Alternative 4

- Represents the final steps to a complete watershed plan for the Lower Rouge River
- Construct regional stormwater impoundments at the outlets of several major tributaries to the Lower Rouge River. For this analysis the impoundments were sized to cut peak flows from these areas by 50%. The impoundments were assumed to reduce BOD, TKN and NO_2+NO_3 by 30%, reduce total phosphorous by 50% and reduce TSS by 90%.
- Implement habitat restoration/creation projects along selected reaches.
- Stabilize stream banks along selected reaches to reduce bank erosion and reduce the number of fallen trees which contribute to debris.
- Create or enhance a trash and debris removal program (e.g. Adopt-a-Stream) to eliminate man-made and natural debris in and along the river channel.
- Eliminate other known point sources such as abandoned dumps.
- Increase accessibilty to and use of the Lower Rouge west of I-275 with a path system and/or recreational corridor along the river.
- Possibly conduct sediment remediation for a few selected reaches.
- Other.