WATER QUALITY TRENDS IN THE ROUGE RIVER WATERSHED

Colleen Hughes, Joe Rathbun, Edward Kluitenberg, Kelly Cave, Chris Catalfio
CDM
One Woodward Avenue, Suite 1500
Detroit, Michigan 48226

ABSTRACT

The Rouge River basin is an urban/suburban watershed of 48 communities that drains 466 square miles of southeastern Michigan and discharges into the Detroit River. The Rouge suffers from typical urban watershed stressors including discharges from combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), non-point sources, limited industrial discharges, contaminated sediments and high flow variability. These factors have resulted in public health advisories for fish consumption and water recreation, poor biotic communities, impoundment eutrophication, and damage to the stream channel morphology.

The Rouge River National Wet Weather Demonstration Project (Rouge Project), funded by the United States Environmental Protection Agency (USEPA) through Wayne County's Department of Environment, was initiated in 1992 to address these impairments. The project implemented an intensive monitoring program to assess existing conditions, identify primary pollution sources, and track long-term trends. Components of the program include continuous monitoring of dissolved oxygen (DO), water temperature, stream flow, and rainfall; intermittent dry and wet weather water quality sampling; and periodic assessments of the trophic status of major impoundments, stream geomorphology, sediment quality, and macro-invertebrate populations. After ten years, the sampling program has generated over 15 million records of data.

Sampling conducted during the first few years of the project showed that *E. coli* bacteria concentrations were well above the Michigan Department of Environmental Quality (MDEQ) water quality standards for both full and partial body contact recreation. DO deficiencies were prevalent particularly downstream of CSO areas and in river reaches with low stream flow. Nutrient concentrations were high particularly in impoundments, and one of the impoundments was contaminated by Poly-chlorinated biphenyls (PCBs).

The Rouge Project implemented several watershed management activities to address these concerns, including construction of ten CSO retention treatment basins, sewer separation in six communities, participation of all 48 communities in a watershed-wide storm water management permit program, and several local remediation projects including the dredging of the PCB-contaminated impoundment, reconnection of an oxbow to a channelized portion of the river, and community illicit discharge detection programs.

To evaluate the effectiveness of watershed management activities, DO and *E. coli* bacteria data collected from 1994 to 2002 were assessed using two different trend analysis techniques, linear regression and Seasonal Kendall analysis. At all locations with representative data substantial improvements in DO have been observed during both wet and dry weather conditions. In 2002, seven of the eight continuously monitored DO locations met the State DO standard more than 80 percent of the time.

E. coli bacteria concentrations are also improving, particularly downstream of now controlled CSO outfalls. However, most locations are still not meeting State water quality standards and a number of locations in the headwaters and downstream of still uncontrolled CSO outfalls are showing potentially degrading trends. Although these results clearly demonstrate that implemented watershed management activities have been successful, it is evident that continued diligence in addressing remaining water quality pollution sources is necessary and should lead to continued improvement.

KEYWORDS

Monitoring, trend analysis, watershed management, dissolved oxygen, *E.coli* bacteria

INTRODUCTION

The Rouge River basin is an urban/suburban watershed of 48 communities that drains 466 square miles of southeastern Michigan and discharges into the Detroit River. The Rouge suffers from typical urban watershed stressors including discharges from combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), non-point sources, limited industrial discharges, contaminated sediments and high flow variability. These factors have resulted in public health advisories for fish consumption and water recreation, poor biotic communities, impoundment eutrophication, and damage to the stream channel morphology.

The Rouge River National Wet Weather Demonstration Project (Rouge Project), funded by the USEPA through Wayne County's Department of Environment, was initiated in 1992 to address these impairments. The project implemented an intensive monitoring program to assess existing conditions, identify primary pollution sources, and track long-term trends. Components of the program include continuous monitoring of dissolved oxygen (DO), water temperature, stream flow, and rainfall (15 minute intervals); intermittent dry and wet weather water quality sampling, and periodic assessments of the trophic status of major impoundments, stream geomorphology, sediment quality, and macro-invertebrate populations.

Pollution from CSOs was identified as a major priority, with non-point source pollutants such as storm water runoff, discharges from illicit connections, discharges from failed on-site septic systems, and other sources further impeding attainment of water quality standards. CSO control activities included the construction of ten retention treatment basins (RTB) and six sewer separation projects, most of which were completed by early

1999 and have resulted in a 51 percent reduction in CSO impacted stream miles. Watershed management activities to address non-point sources included:

- the elimination of on-site sewage disposal systems,
- illicit discharge elimination programs,
- stormwater management BMPs,
- downspout disconnection programs,
- pollution prevention and good housekeeping practices,
- reduction of pollutants to the separated storm system,
- reduction of the use of pesticides, herbicides, and fertilizers, and
- public information and education programs.

Since a primary objective of the Rouge Project monitoring program is to evaluate the effectiveness of implemented watershed management activities by assessing water quality improvements, two different trend analysis techniques have been applied to evaluate long term changes in dissolved oxygen (DO) and *E.coli* bacteria concentrations using data collected from 1994 through 2002.

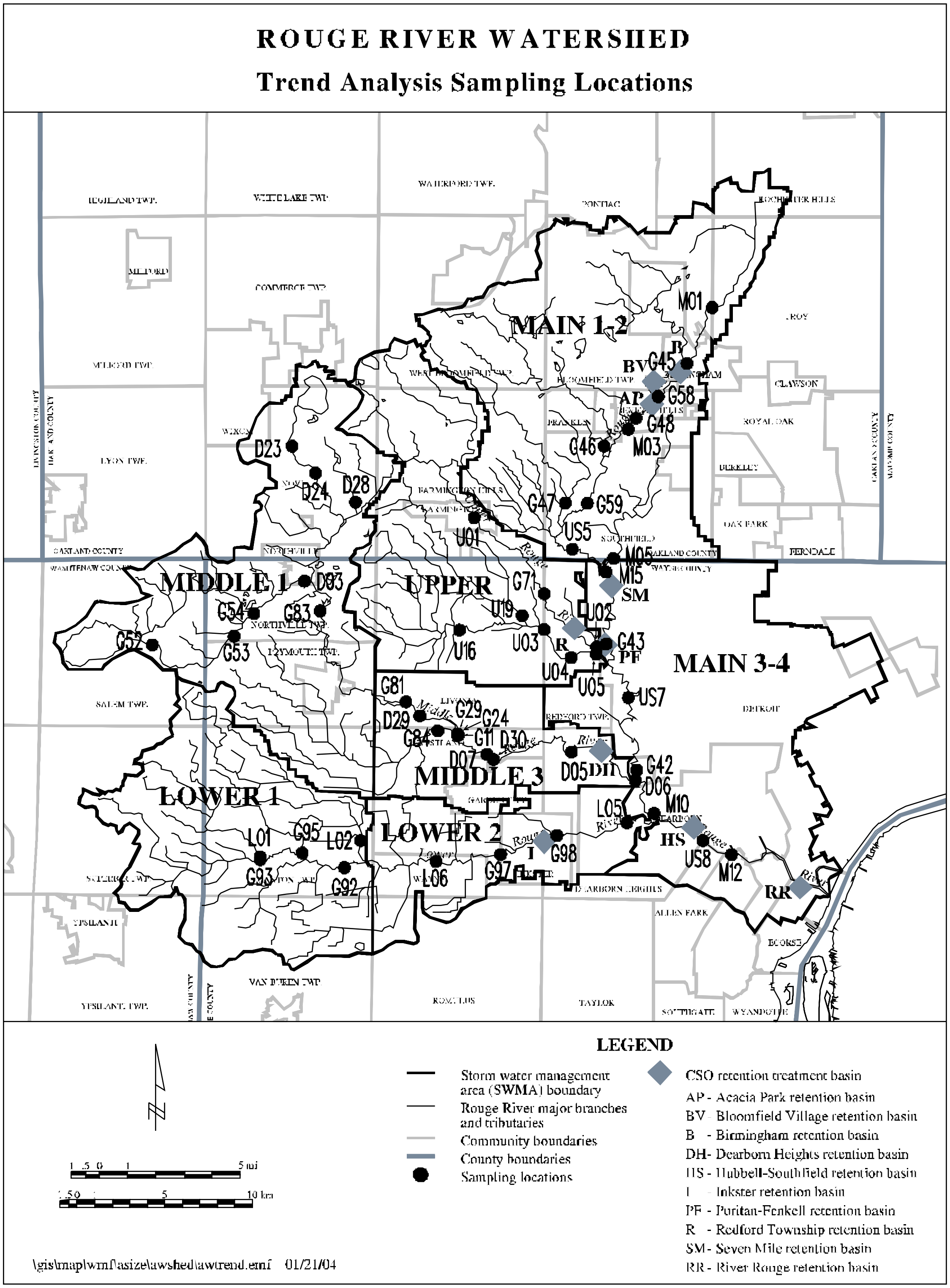
METHODOLOGY

The Rouge River sub-watershed or storm water management area (SWMA) map in Figure 1 shows the water quality monitoring locations included in trend analysis and the location of the ten CSO RTBs that were constructed. The trend tests included linear regression of water quality concentration over time and the Seasonal Kendall test, which extracts seasonality factors contributing to water quality conditions by evaluating yearly changes in monthly average concentrations. Both tests were run for wet and dry weather data collectively and independently, using average concentrations and the percent greater than 5 mg/L for DO and the percent less than 1000 cfu/100 ml for *E. coli* (Michigan's partial body contact standard).

The linear regression method calculated a trend line using a least squares fit through the time series data points as shown in Figures 2 through 6. Since *E. coli* concentrations are more log normal, an exponential fit was applied using a semi-log scale. DO trend analysis included all locations where representative continuously monitored data were available and included any grab DO sampling records that were available for those locations. Regression plots were generated for daily average DO (Figure 2), monthly May through October wet and dry weather daily average DO (Figures 3-4) and the percent of the daily DO measurements greater than or equal to 5 mg/L for all, dry, and wet weather samples (Figure 5). *E.coli* regression plots (Figure 6) were generated for all representative grab sampling locations and included trend tests for the geometric mean for all weather samples and wet and dry weather independently as well as a test for change in the percent less than or equal to 1000 cfu/100mL.

A trend is defined as an increasing or decreasing change over time. Both tests calculate an average trend statistic, indicating the magnitude of the change and a probability statistic (P), indicating the certainty of the trend. A P-value of 0.01, for example, indicates a 99 percent probability that the true trend differs from 0 or no trend. The regression trend statistic is in the form of a slope, reported in mg/L per year for DO and as a percent improvement per year for *E. coli*. The Seasonal Kendall analysis reports the Kendall Tau statistic, indicating the strength of the trend and ranges from –1 to +1. A –1 indicates a strong decreasing trend whereas a +1 indicates a strong increasing trend.

Figure 1 - Trend Analysis Sampling Locations



For assessment purposes, the trend analysis results were ranked as increasing, potentially increasing, none (no statistically significant trend), potentially decreasing, and decreasing based on the following criteria:

- Increasing = increasing trend with P <= 0.05,
- Potentially increasing = increasing trend with P>0.05 and <=0.20,
- No statistically significant trend = P>0.20,
- Potentially decreasing = decreasing trend with P>0.05 and <=0.20, and
- Decreasing = decreasing trend with P <= 0.05.

For average DO, percent DO greater than or equal to 5 mg/L, and *E. coli* less than or equal to 1,000 cfu/100ml an increasing trend equates to an improvement in water quality. For the *E.coli* geometric mean an increasing trend equates to degrading water quality.

Since all locations were not sampled all years during both dry and wet conditions, many locations have inadequate data for detecting statistically valid trends over the time period when watershed management activities were implemented. It should also be noted that the magnitude of the trend statistic is relative to the baseline condition for each site. For example, a site that had good water quality to begin with is unlikely to show much of an improving trend as water quality approaches pristine conditions. Similarly, it is important to recognize that the average trend statistic is representative of the period of available data and not necessarily a prediction that water quality will continue to change at the same rate in the future.

Figure 2 - Military Rd. (L05) DO Daily Averages - All Weather Samples, 1994-2002

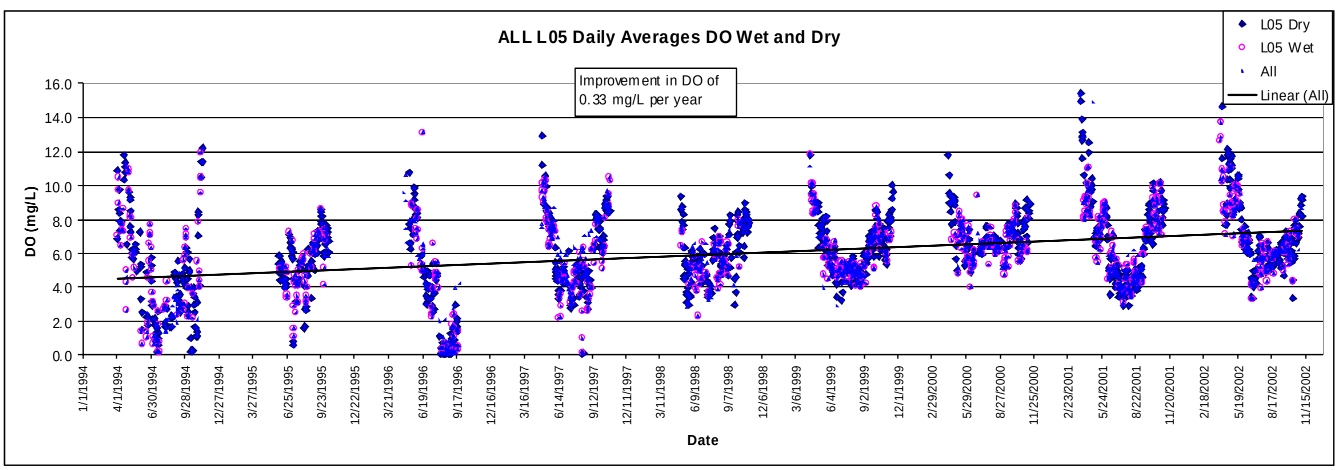
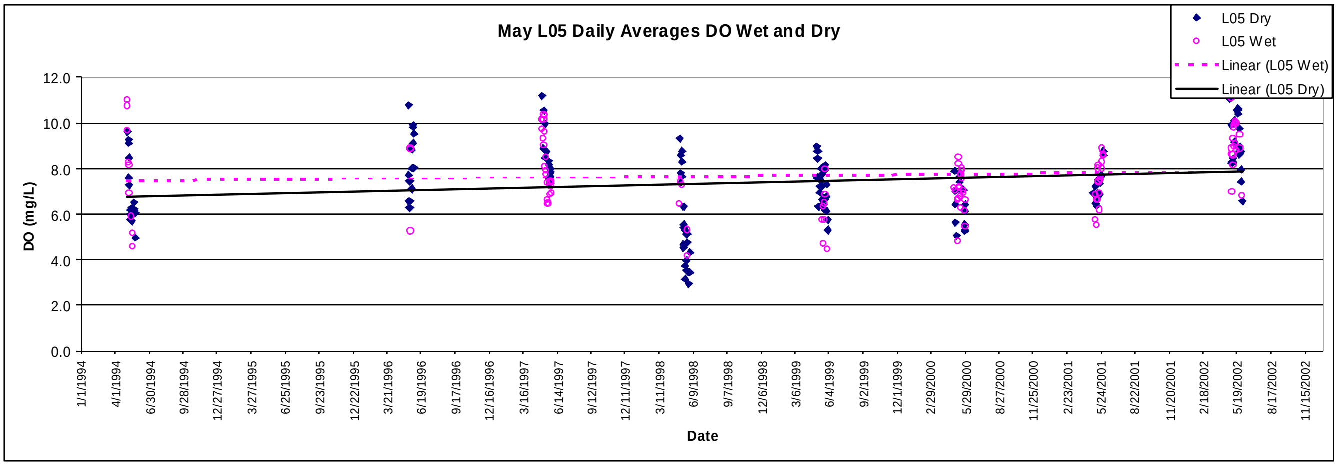
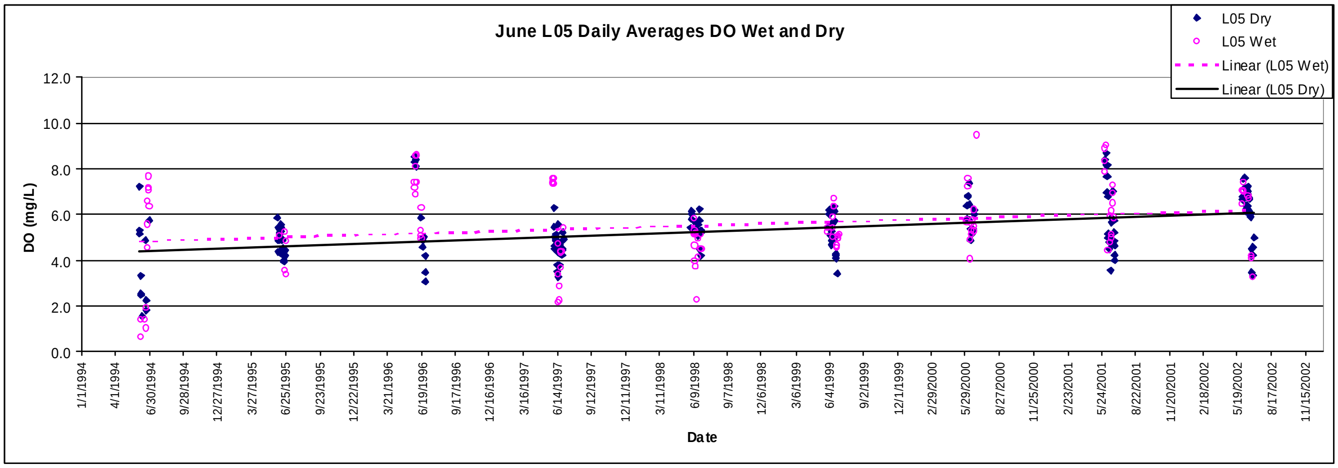


Figure 3 - Military Rd. (L05) DO Daily Averages - Wet and Dry Weather Samples, May-July 1994-2002





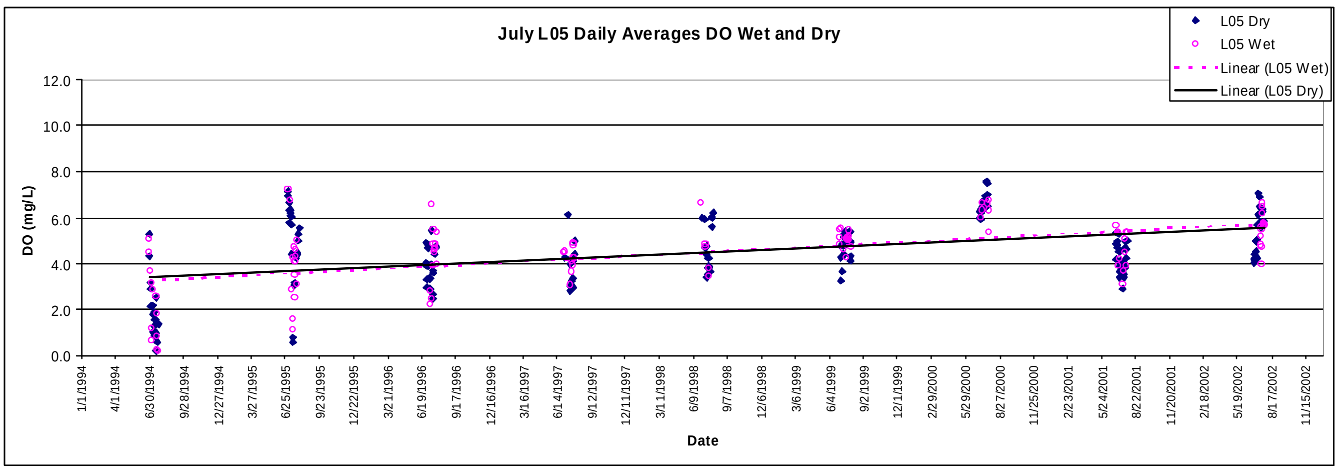
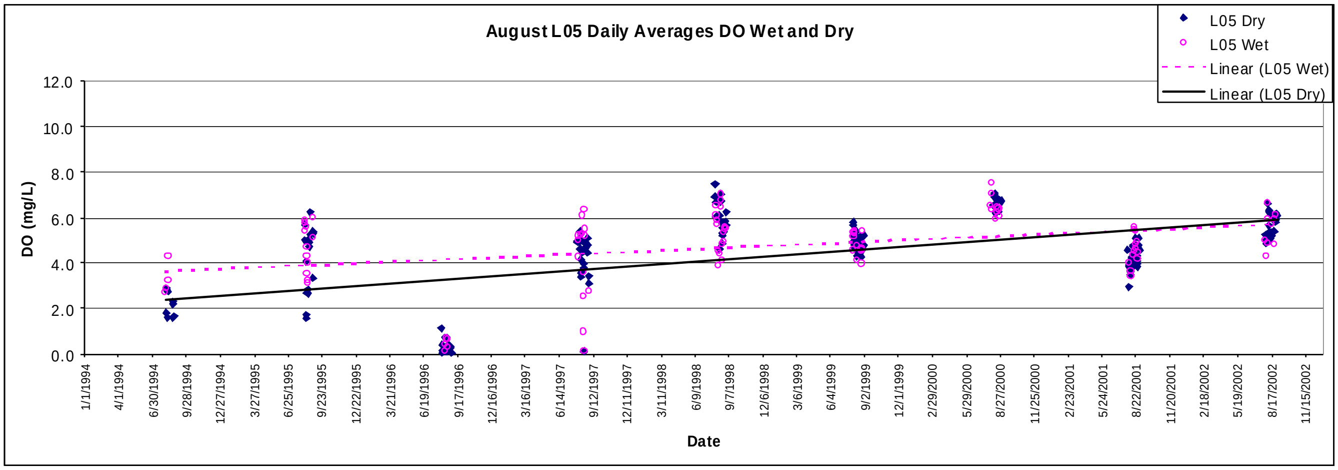
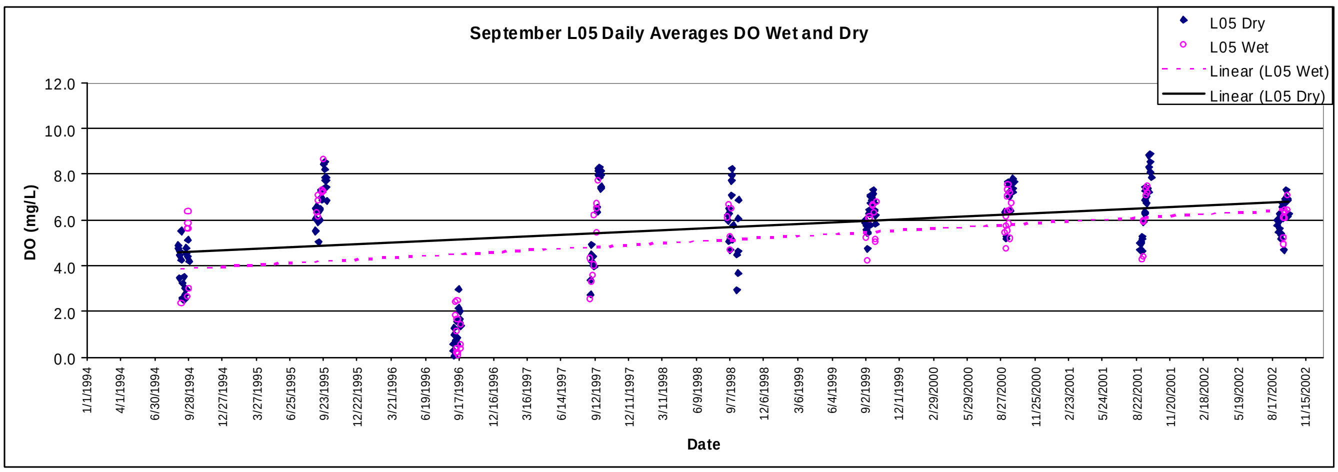


Figure 4 - Military Rd. (L05) DO Daily Averages - Wet and Dry Weather Samples, August-October 1994-2002





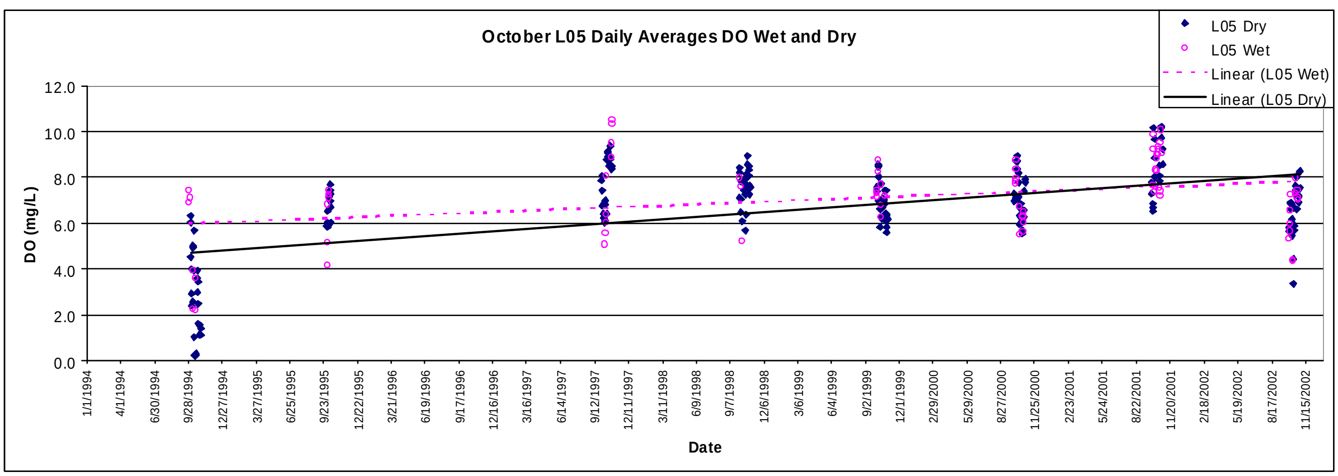
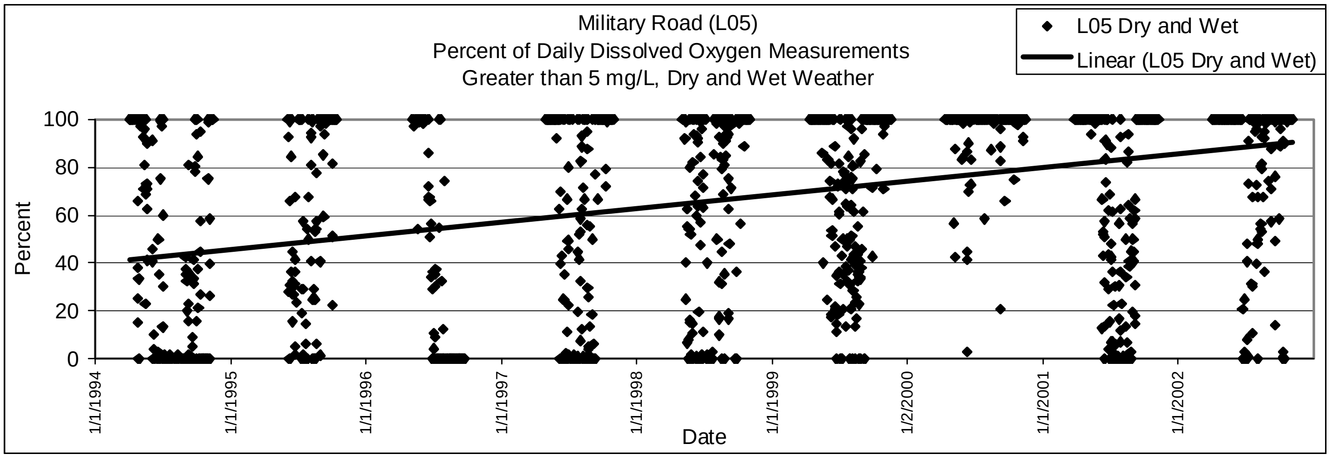
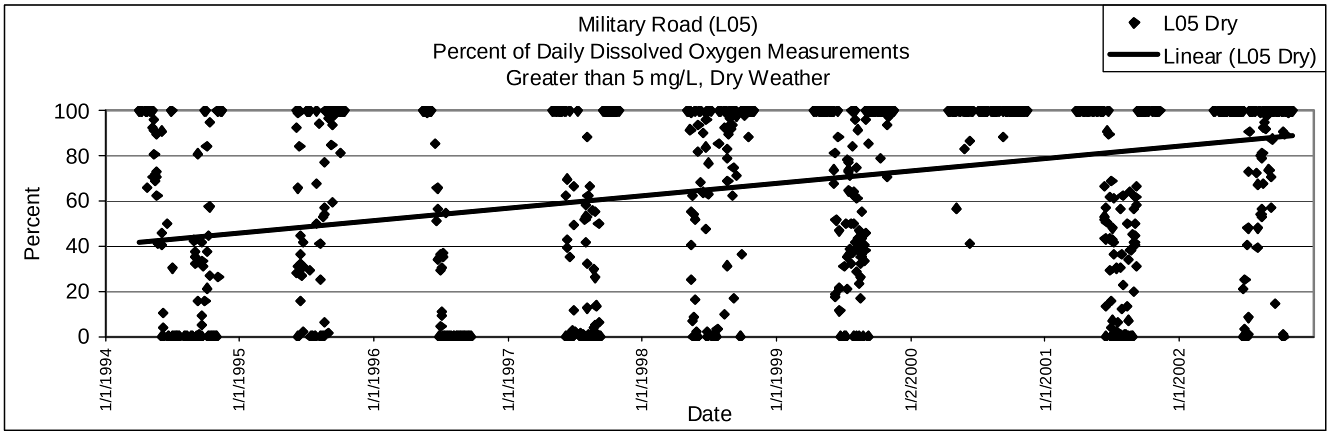


Figure 5 - Military Rd. (L05) Percent of Daily DO >= 5 mg/L 1994-2002





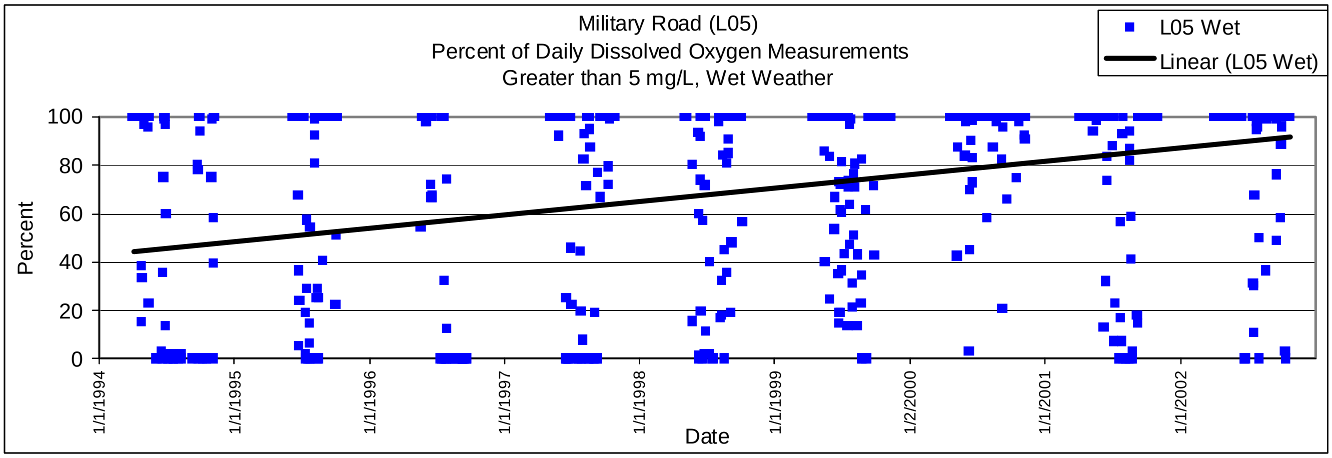
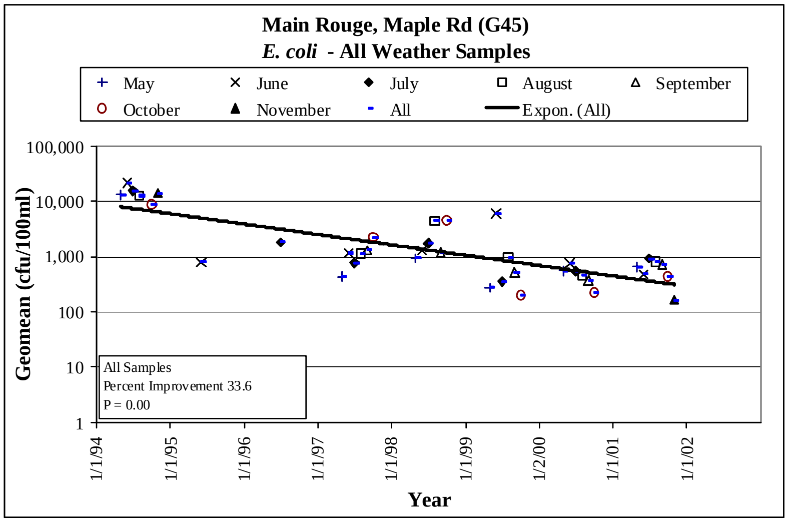
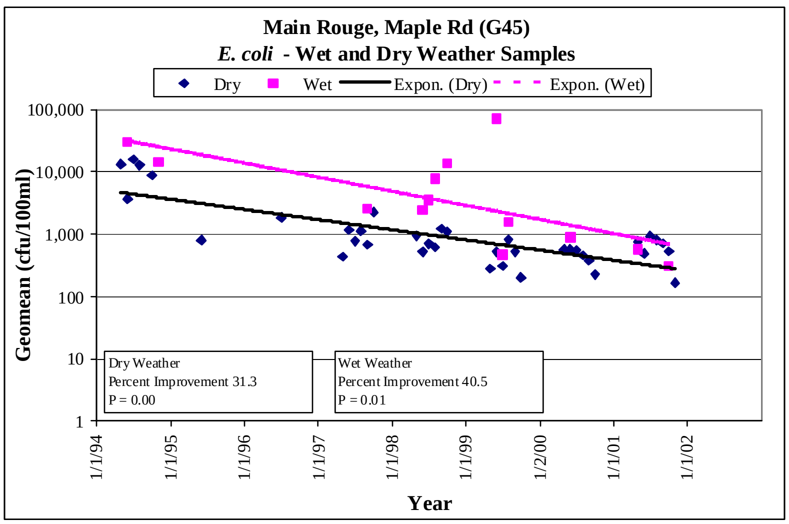
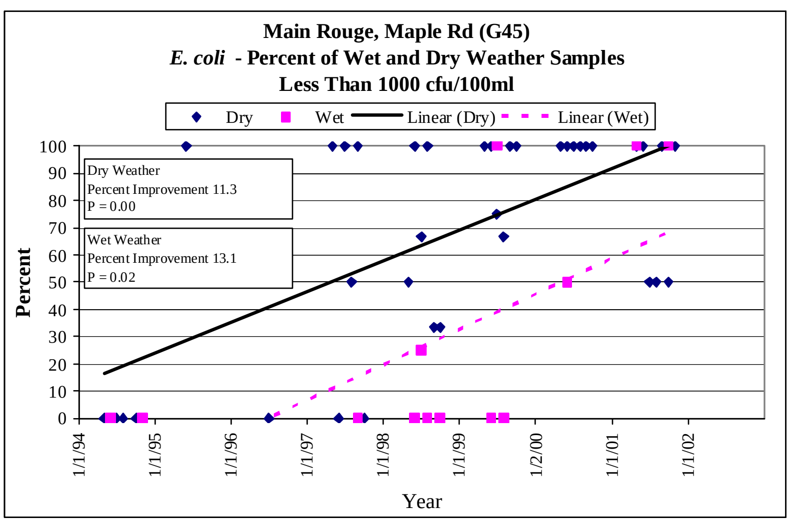


Figure 6 - *E. coli* - Dry and Wet Weather Samples, 1994-2002







DISSOLVED OXYGEN TREND ANALYSIS RESULTS

Trend analysis results clearly demonstrate that DO concentrations are improving in the Rouge River Watershed during both wet and dry weather conditions. Tables 1 through 4 summarize the results of the regression and Seasonal Kendall analyses for daily average DO and the percent of daily values greater than the State water quality standard of 5 mg/L during wet and dry weather conditions, independently and collectively. Eight of nine locations show a statistically significant improving trend for the mean DO with the average annual improvement ranging from 0.07 to 0.53 mg/L per year. The ninth location, US8, has only been monitored for the past two years and not surprisingly reported no statistically significant trend. This location is also the most downstream DO monitoring location in the watershed and is influenced by many uncontrolled CSO outfalls.

Average DO trend results are summarized in Figures 7 and 8 for the linear regression and Seasonal Kendall tests showing the proximity to CSO basins and now controlled CSO outfalls. Locations with no statistically significant trend are not shown on the maps. In general, the Seasonal Kendall test appears to be more sensitive to statistical significance, most likely due to the fact that the Seasonal Kendall analysis was conducted using monthly average DO, whereas the linear regression test used daily average DO. Analysis of monthly DO plots similar to those shown in Figures 3 and 4, indicate that most locations are improving during all seasons with the possible exception of U05 and US5 where improvement is more pronounced in cooler months.

Trend analysis results for the percent of daily DO measurements greater than the State water quality standard of 5 mg/L also shows that conditions are improving, particularly in the Lower Rouge River. In 2002, seven of the eight continuously monitored locations met the State standard more than 80 percent of the time. Analysis of regression plots similar to Figure 5 show that the DO at US5 is typically above the 5 mg/L standard, making the no trend result an indication that water quality does not appear to be threatened at this location. The potentially degrading trend at G45 is similarly misleading. DO is typically above the water quality standard at this location and continuous monitoring was discontinued in 1999. Only grab samples were collected in recent years with one grab sample taken during an upstream lake restoration project involving dredging, resulting in one measurement below the standard and skewing the trend analysis result. This situation emphasizes the importance of designing a consistent and systematic monitoring program including a critical review of supporting time series plots when conducting trend analysis studies.

Figure 9 shows a summary of the DO trend analysis results for each Rouge SWMA. This bar chart represents the average improvement in DO per year for wet and dry weather conditions over the period of available data. The Middle 1 and Lower 1 SWMAs are not represented in the chart because available DO data in these SWMAs was not suitable for trend analysis. DO concentrations have improved substantially at all locations evaluated, with the Lower 2 showing the most improvement of over 0.3 mg/L per year for both wet and dry weather conditions.

Table 1 - Dissolved Oxygen All, Dry, and Wet Weather Samples - Regression Analysis of Daily Average Dissolved Oxygen (mg/L) - (Sites are ordered upstream to downstream)

			All				Dry				Wet			
SWMA	Field ID	Location	Number of Samples	Improvement per Year (mg/L)	P-value	Trend	Number of Samples	Improvement per Year (mg/L)	P-value	Trend	Number of Samples	Improvement per Year (mg/L)	P-value	Trend
Main 1-2	G45	Main Rouge River	23,402	0.34	<0.01	I	19,251	0.35	<0.01	I	3,747	0.75	<0.01	I
Main 1-2	M03	Main Rouge River	76,728	0.17	<0.01	I	51,095	0.19	<0.01	I	16,408	0.10	0.03	I
Main 1-2	US5	Main Rouge River	70,041	0.21	<0.01	I	51,652	0.19	<0.01	I	18,160	0.30	<0.01	I
Main 3-4	US7	Main Rouge River	129,923	0.17	<0.01	I	81,125	0.19	<0.01	I	47,416	0.18	<0.01	I
Main 3-4	US8	Main Rouge River	30,370	-0.11	0.49	none	17,078	0.02	0.93	none	12,513	-0.14	0.55	none
Upper	U05	Upper Rouge River	125,449	0.11	<0.01	I	81,496	0.09	<0.01	I	36,195	0.15	<0.01	I
Middle 3	D06	Middle Rouge River	126,815	0.07	<0.01	I	70,354	0.07	<0.01	I	40,830	0.10	<0.01	I
Lower 2	L06	Lower Rouge River	33,717	0.53	<0.01	I	21,759	0.45	<0.01	I	6,777	0.56	<0.01	I
Lower 2	L05	Lower Rouge River	130,026	0.33	<0.01	I	87,890	0.32	<0.01	I	38,395	0.30	<0.01	I

Note: In Trend column, D = decreasing trend, PD = potentially decreasing trend, I = increasing trend, PI = potentially increasing trend, ID = insufficient data, none = no statistically significant trend

Table 2 - Dissolved Oxygen All, Dry, and Wet Weather Samples - Regression Analysis of the Percent of Values Greater Than 5 (mg/L) - (Sites are ordered upstream to downstream)

			All				Dry				Wet			
SWMA	Field ID	Location	Number of Samples	% Improvement	P-value	Trend	Number of Samples	% Improvement	P-value	Trend	Number of Samples	% Improvement	P-value	Trend
Main 1-2	G45	Main Rouge River	23,402	-0.6	0.17	PD	19,251	-0.7	0.19	PD	3,747	0.3	0.36	none
Main 1-2	M03	Main Rouge River	76,728	2.1	<0.01	I	51,095	2.1	<0.01	I	16,408	2.1	<0.01	I
Main 1-2	US5	Main Rouge River	70,041	0.0	0.25	none	51,652	0.0	0.27	none	18,160	0.0	0.53	none
Main 3-4	US7	Main Rouge River	129,923	2.8	<0.01	I	81,125	2.9	<0.01	I	47,416	3.3	<0.01	I
Main 3-4	US8	Main Rouge River	30,370	2.9	0.21	none	17,078	5.2	0.12	PI	12,513	-1.0	0.75	none
Upper	U05	Upper Rouge River	125,449	0.2	0.48	none	81,496	-0.3	0.47	none	36,195	1.2	<0.01	I
Middle 3	D06	Middle Rouge River	126,815	1.1	<0.01	I	70,354	0.7	<0.01	I	40,830	2.0	<0.01	I
Lower 2	L06	Lower Rouge River	33,717	12.8	<0.01	I	21,759	12.3	<0.01	I	6,777	8.8	<0.01	I
Lower 2	L05	Lower Rouge River	130,026	5.7	<0.01	I	87,890	5.5	<0.01	I	38,395	5.5	<0.01	I

Note: In Trend column, D = decreasing trend, PD = potentially decreasing trend, I = increasing trend, PI = potentially increasing trend, ID = insufficient data, none = no statistically significant trend

Table 3 - Dissolved Oxygen All, Dry, and Wet Weather Samples - Seasonal Kendall Analysis of the Monthly Average Dissolved Oxygen (mg/L) - (Sites are ordered upstream to downstream)

			All				Dry				Wet			
SWMA	Field ID	Location	Number of Samples	TAU	Probability	Trend	Number of Samples	TAU	Probability	Trend	Number of Samples	TAU	Probability	Trend
Main 1-2	G45	Main Rouge River	23,402	-0.20	0.27	None	19,251	-0.17	0.37	None	3,747	0.64	0.10	PI
Main 1-2	M03	Main Rouge River	76,728	0.35	<0.01	I	51,095	0.28	0.02	I	16,408	0.40	0.01	I
Main 1-2	US5	Main Rouge River	70,041	0.33	0.06	PI	51,652	0.13	0.48	None	18,160	0.35	0.06	PI
Main 3-4	US7	Main Rouge River	129,923	0.18	0.11	PI	81,125	0.21	0.06	PI	47,416	0.07	0.57	None
Main 3-4	US8	Main Rouge River	30,370	-0.33	0.68	None	17,078	-0.60	0.37	None	12,513	-0.33	0.68	None
Upper	U05	Upper Rouge River	125,449	0.01	0.93	None	81,496	-0.04	0.75	None	36,195	0.02	0.90	None
Middle 3	D06	Middle Rouge River	126,815	0.09	0.43	None	70,354	0.09	0.45	None	40,830	0.08	0.51	None
Lower 2	L06	Lower Rouge River	33,717	0.42	<0.01	I	21,759	0.41	<0.01	I	6,777	0.58	0.04	I
Lower 2	L05	Lower Rouge River	130,026	0.40	<0.01	I	87,890	0.41	<0.01	I	38,395	0.40	<0.01	I

Note: In Trend column, D = decreasing trend, PD = potentially decreasing trend, I = increasing trend, PI = potentially increasing trend, ID = insufficient data, none = no statistically significant trend

Table 4 - Dissolved Oxygen All, Dry, and Wet Weather Samples - Seasonal Kendall Analysis of the Percent of Values Greater Than 5 (mg/L) - (Sites are ordered upstream to downstream)

			All				Dry				Wet			
SWMA	Field ID	Location	Number of Samples	TAU	Probability	Trend	Number of Samples	TAU	Probability	Trend	Number of Samples	TAU	Probability	Trend
Main 1-2	G45	Main Rouge River	23,402	-0.02	1.00	None	19,251	-0.02	1.00	None	3,747	0.09	1.00	None
Main 1-2	M03	Main Rouge River	76,728	0.48	<0.01	I	51,095	0.40	<0.01	None	16,408	0.40	<0.01	I
Main 1-2	US5	Main Rouge River	70,041	-0.07	0.65	None	51,652	0.00	1.00	None	18,160	-0.06	0.67	None
Main 3-4	US7	Main Rouge River	129,923	0.23	0.04	I	81,125	0.18	0.10	PI	47,416	0.18	0.11	PI
Main 3-4	US8	Main Rouge River	30,370	0.17	1.00	None	17,078	0.20	1.00	None	12,513	-0.17	1.00	None
Upper	U05	Upper Rouge River	125,449	-0.09	0.43	None	81,496	-0.15	0.19	PD	36,195	-0.06	0.60	None
Middle 3	D06	Middle Rouge River	126,815	0.19	0.09	PI	70,354	0.08	0.46	None	40,830	0.15	0.21	None
Lower 2	L06	Lower Rouge River	33,717	0.55	<0.01	I	21,759	0.54	<0.01	I	6,777	0.74	0.01	I
Lower 2	L05	Lower Rouge River	130,026	0.45	<0.01	I	87,890	0.42	<0.01	I	38,395	0.42	<0.01	I

Note: In Trend column, D = decreasing trend, PD = potentially decreasing trend, I = increasing trend, PI = potentially increasing trend, ID = insufficient data, none = no statistically significant trend

Figure 7 - Dissolved Oxygen All Weather Samples - Regression Analysis of the Daily Average Dissolved Oxygen (mg/L)

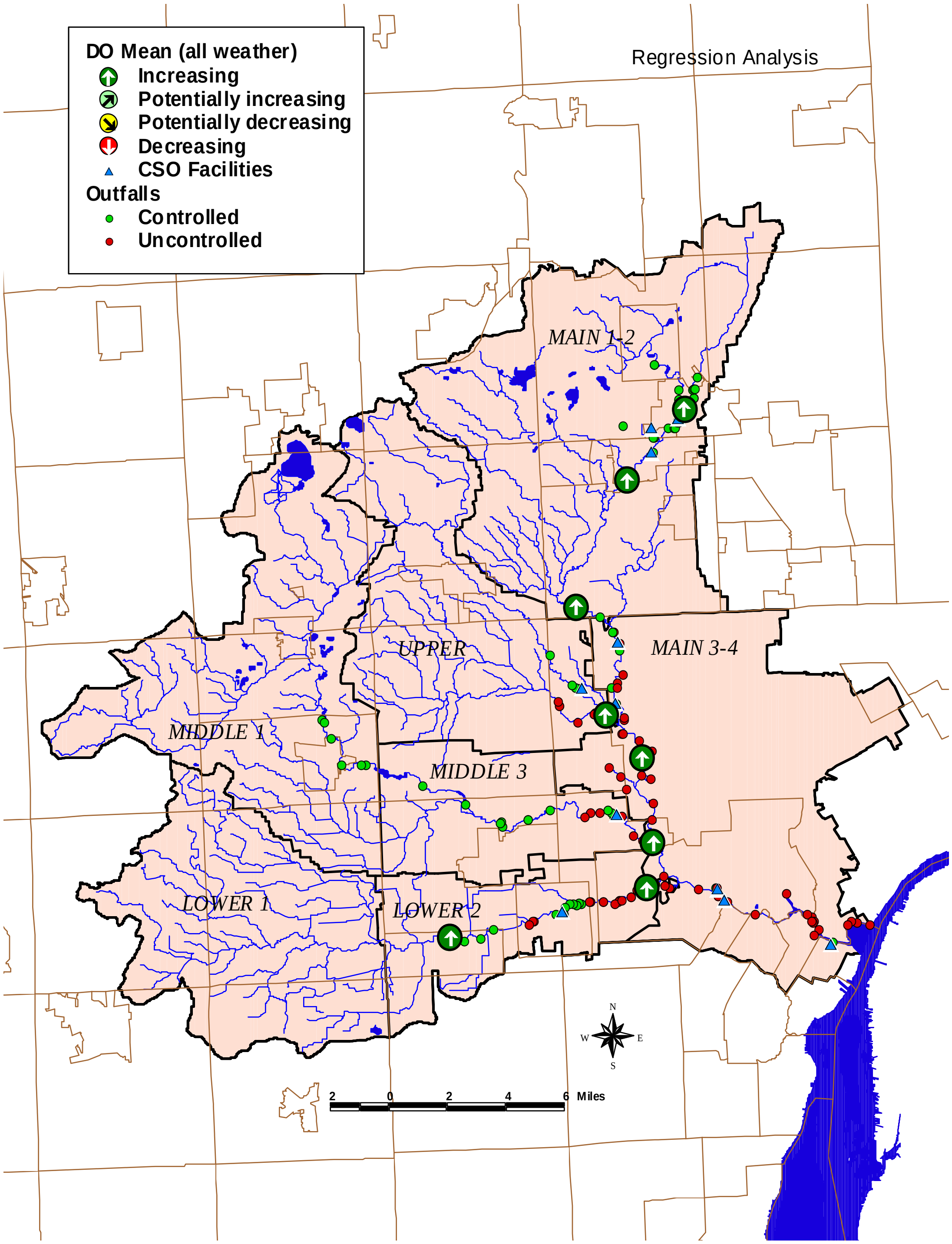


Figure 8 - Dissolved Oxygen All Weather Samples - Seasonal Kendall Analysis of the Monthly Average Dissolved Oxygen (mg/L)

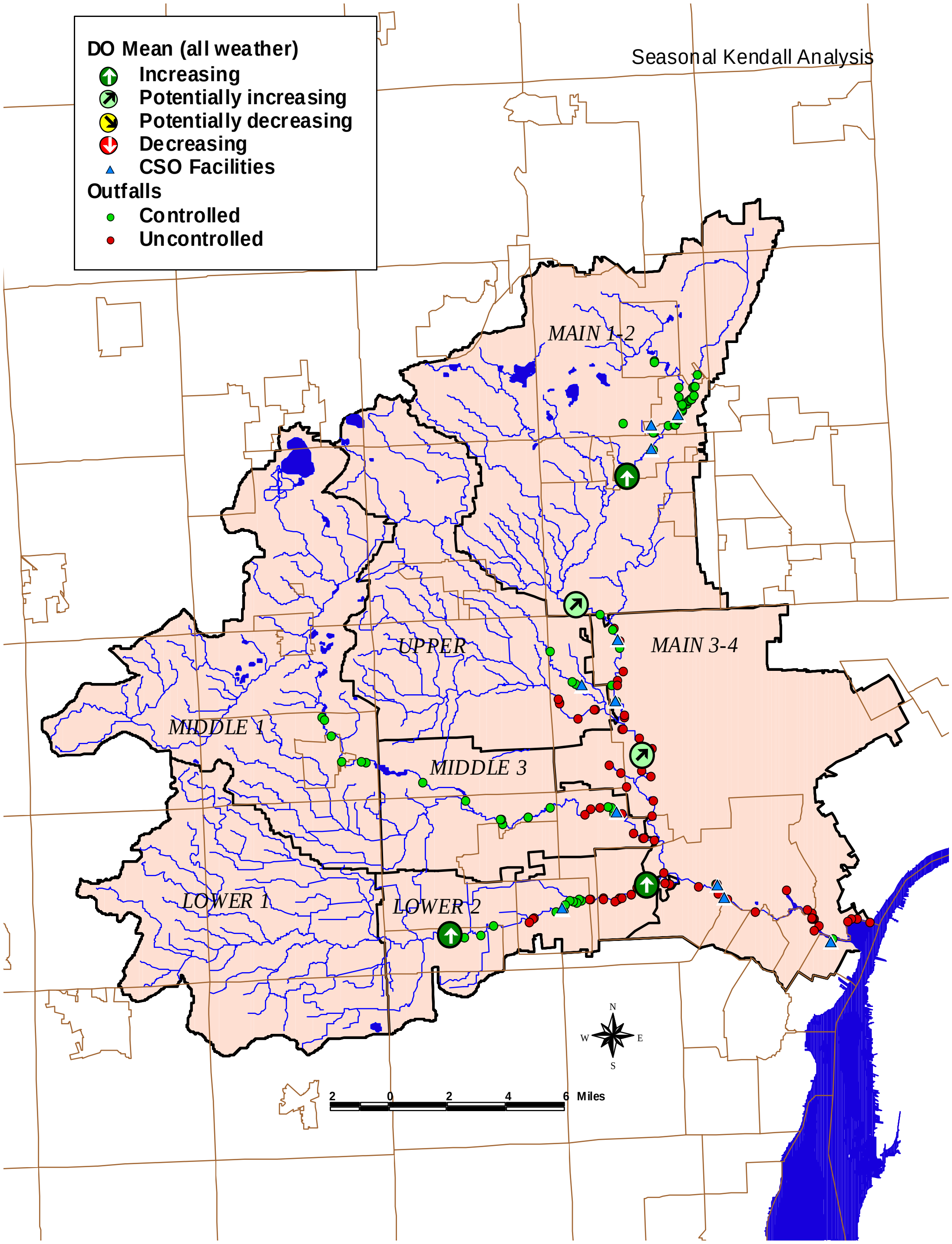
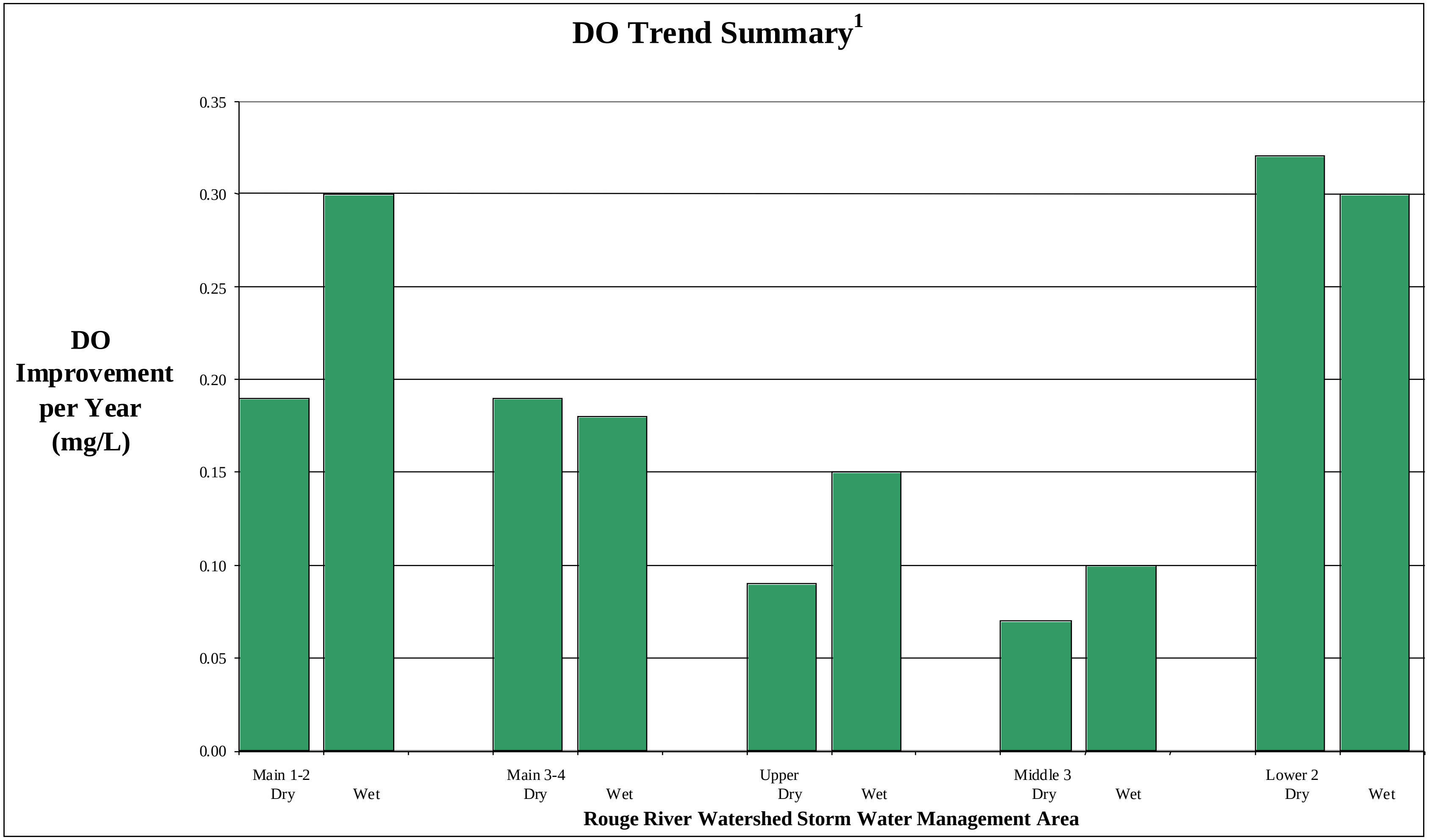


Figure 9: Average DO Improvement per Year by SWMA



[1]Based on Linear Regression Method

BACTERIA TREND ANALYSIS RESULTS

E. coli trend analysis results generally showed improvement directly downstream of most watershed management activities, particularly downstream of now controlled CSO outfalls during wet weather. Some locations were identified where *E. coli* concentrations may be increasing. These sites were generally located near the headwaters in areas still being developed or in areas still impacted by CSOs. Although improving, most locations are still not meeting State water quality standards for *E. coli* total or partial body contact recreation.

Tables 5 through 8 summarize the results of the regression and Seasonal Kendall analyses for the geometric mean and the percent less than or equal to the State partial body contact water quality standard of 1000 cfu/100mL during wet and dry weather conditions, independently and collectively. Substantial improvement is occurring at some locations, whereas many locations are showing little to no change and some locations may be getting worse. Figures 10 and 11 summarize the geometric mean results spatially and in relation to the CSO control activities performed within the watershed for dry and wet weather conditions, respectively. More improvement is clearly being observed during wet weather conditions, indicating that CSO control projects have resulted in substantial water quality improvements. Most of the potentially degrading conditions during dry weather appear to be in the headwaters where residential and commercial development are generally expanding or areas where CSO outfalls are still uncontrolled.

Figure 12 summarizes the percent of the *E. coli* measurements that were less than or equal to 1000 cfu/100 ml during wet weather conditions. Locations with no statistically significant trend are not shown on the map. This statistic resulted in fewer sites showing significant trends largely because even though water quality conditions are improving, concentrations are still typically above the State's partial body contact recreation standard. It is evident that State water quality bacteria standards will not likely be attained without continued efforts to identify and remedy sources of bacteria to the river.

Figure 13 summarizes the *E. coli* bacteria trend analysis results, by ranking improving trends as Good, degrading trends as Poor, and no statistically significant trend as No Change. The chart presents the percentage of locations in each SWMA that met these criteria as calculated in the linear regression trend analysis using the monthly geometric mean *E. coli* concentration. The Lower 2 and Main 1-2 are showing the most improvement with an average of 63 percent and 50 percent of the locations improving, respectively.

Table 5 - *E. coli* All, Dry, and Wet Weather Samples - Regression Analysis of the Geometric Mean (cfu/100ml) - (Sites are ordered upstream to downstream)

			All				Dry				Wet			
SWMA	Field ID	Location	Number of Samples	% Improvement	P-value	Trend	Number of Samples	% Improvement	P-value	Trend	Number of Samples	% Improvement	P-value	Trend
MAIN 1-2	M01	Main Rouge River	73	-1.0	0.86	none	64	1.0	0.86	none	9	-6.0	0.71	none
	G45	Main Rouge River	106	33.6	0.00	D	73	31.3	0.00	D	33	40.5	0.01	D
	G58	Impoundment	93	26.8	0.00	D	66	23.8	0.00	D	27	31.0	0.26	none
	G48	Main Rouge River	9	7.1	0.89	none	8	36.4	0.18	PD	1	ID	ID	ID
	M03	Main Rouge River	98	17.6	0.02	D	70	15.4	0.00	D	28	38.1	0.18	PD
	G46	Franklin Branch	105	2.7	0.73	none	75	-7.3	0.16	PI	30	29.8	0.05	D
	G59	Main Rouge River	60	13.3	0.20	PD	40	0.1	0.99	none	20	53.6	0.01	D
	G47	Pebble Creek	86	8.2	0.37	none	62	-7.2	0.13	PI	24	44.2	0.01	D
	US5	Main Rouge River	106	20.2	0.11	PD	74	-1.3	0.89	none	32	49.9	0.05	D
	M05	Evans Ditch	105	6.2	0.43	none	77	-5.7	0.28	none	28	36.2	0.01	D
MAIN 3-4	M15	Main Rouge River	10	12.3	0.31	none	9	12.6	0.33	none	1	ID	ID	ID
	G43	Main Rouge River	85	23.2	0.00	D	48	15.0	0.04	D	37	31.9	0.02	D
	US7	Main Rouge River	50	-11.1	0.37	none	37	-14.3	0.21	none	13	50.7	0.12	PD
	G42	Main Rouge River	56	19.2	0.05	D	37	-2.6	0.75	none	19	39.7	0.09	PD
	M10	Main Rouge River	35	-52.3	0.00	I	31	-48.0	0.00	I	4	ID	ID	ID
	US8	Main Rouge River	25	15.3	0.50	none	12	-9.9	0.57	none	13	ID	ID	ID
	M12	Main Rouge River	39	-34.4	0.00	I	35	-30.1	0.00	I	4	-40.2	0.85	none
UPPER	U01	Upper Rouge River	90	3.9	0.68	none	67	-7.9	0.42	none	23	45.9	0.00	D
	G71	Upper Rouge River	113	5.3	0.33	none	75	-3.9	0.45	none	38	13.9	0.21	none
	U02	Upper Rouge River	111	11.8	0.09	PD	71	-6.1	0.28	none	40	26.8	0.01	D
	U16	Bell Branch	43	0.6	0.92	none	39	0.7	0.91	none	4	-4.5	0.93	none
	U19	Tarabusi Creek	44	-17.6	0.05	I	39	-11.3	0.07	PI	5	-45.9	0.85	none
	U03	Bell Branch	16	-16.5	0.35	none	16	-16.5	0.35	none	0	ID	ID	ID
	U04	Bell Branch	65	9.7	0.12	PD	48	5.2	0.44	none	17	16.2	0.38	none
	U05	Upper Rouge River	85	3.8	0.68	none	46	-3.9	0.60	none	39	34.9	0.13	PD
MIDDLE 1	D28	Bishop Creek	18	9.4	0.59	none	16	3.8	0.80	none	2	ID	ID	ID
	D23	Walled Lake Branch	20	-8.6	0.62	none	18	-5.7	0.75	none	2	ID	ID	ID
	D24	Walled Lake Branch	49	12.4	0.17	PD	43	15.5	0.13	PD	6	-2.5	0.90	none
	G52	Johnson Creek	19	36.3	0.47	none	15	11.1	0.65	none	4	ID	ID	ID
	G53	Johnson Creek	49	-2.5	0.81	none	41	-18.5	0.09	PI	8	17.5	0.54	none
	G54	Johnson Creek	16	-18.0	0.27	none	14	-28.9	0.15	PI	2	ID	ID	ID
	D03	Johnson Creek	47	0.7	0.94	none	39	-1.5	0.88	none	8	11.0	0.73	none
	G83	Middle Rouge River	45	16.9	0.01	D	35	11.1	0.04	D	10	39.2	0.03	D
MIDDLE 3	D29	Middle Rouge River	107	-139.1	0.01	I	60	-115.7	0.10	PI	47	-117.3	0.07	PI
	G81	Middle Rouge River	45	-9.5	0.44	none	35	-17.2	0.21	none	10	23.1	0.30	none
	G29	Nankin Lake Spillway	36	-6.5	0.83	none	35	-8.9	0.79	none	1	ID	ID	ID
	G24	Nankin Lake Dam	52	-44.3	0.06	PI	51	-45.9	0.07	PI	1	ID	ID	ID
	G11	Nankin Mills Dam	51	-24.9	0.34	none	50	-15.3	0.57	none	1	ID	ID	ID
	G84	Tonquish Creek	78	-0.6	0.93	none	70	-6.3	0.34	none	8	34.8	0.23	none
	D07	Middle Rouge River	149	-7.8	0.33	none	114	-12.1	0.18	PI	35	18.9	0.04	D
	D30	Middle Rouge River	42	53.0	0.08	PD	37	19.3	0.59	none	5	ID	ID	ID
	D05	Middle Rouge River	85	12.3	0.16	PD	66	-1.7	0.79	none	19	49.2	0.01	D
	D06	Middle Rouge River	81	12.9	0.16	PD	67	11.9	0.19	PD	14	51.1	0.02	D
LOWER 1	L01	Lower Rouge River	44	-6.9	0.24	none	38	-9.1	0.12	PI	6	27.3	0.04	D
	G93	Fowler Creek	47	6.3	0.34	none	36	1.0	0.88	none	11	13.5	0.51	none
	G95	Lower Rouge River	24	14.0	0.39	none	12	-9.0	0.47	none	12	ID	ID	ID
	G92	Lower Rouge River	53	8.9	0.04	D	38	8.3	0.08	PD	15	6.8	0.58	none
	L02	Fellows Creek	39	-6.8	0.27	none	35	-4.5	0.40	none	4	-10.2	0.65	none
LOWER 2	L06	Lower Rouge River	69	14.7	0.01	D	47	8.2	0.13	PD	22	28.8	0.08	PD
	G97	Lower Rouge River	123	7.9	0.19	PD	82	-0.7	0.91	none	41	18.4	0.10	PD
	G98	Lower Rouge River	128	29.5	0.00	D	81	23.0	0.01	D	47	37.3	0.01	D
	L05	Lower Rouge River	114	-6.9	0.47	none	83	-13.7	0.26	none	31	8.2	0.54	none

Note: In Trend column, D = decreasing trend, PD = potentially decreasing trend, I = increasing trend, PI = potentially increasing trend, ID = insufficient data, none = no statistically significant trend

Table 6 - *E. coli* All, Dry, and Wet Weather Samples - Regression Analysis of the Percent of Values Less Than 1,000 (cfu/100ml) - (Sites are ordered upstream to downstream)

			All				Dry				Wet			
SWMA	Field ID	Location	Number of Samples	% Improvement	P-value	Trend	Number of Samples	% Improvement	P-value	Trend	Number of Samples	% Improvement	P-value	Trend
MAIN 1-2	M01	Main Rouge River	73	-4.2	0.29	none	64	-2.5	0.54	none	9	-10.7	0.30	none
	G45	Main Rouge River	106	11.7	0.00	I	73	11.3	0.00	I	33	13.1	0.02	I
	G58	Impoundment	93	8.3	0.07	PI	66	11.6	0.02	I	27	-8.0	0.35	none
	G48	Main Rouge River	9	12.8	0.47	none	8	21.9	0.18	PI	1	ID	ID	ID
	M03	Main Rouge River	98	10.7	0.00	I	70	10.4	0.01	I	28	15.3	0.20	PI
	G46	Franklin Branch	105	2.9	0.27	none	75	0.4	0.88	none	30	11.2	0.04	I
	G59	Main Rouge River	60	5.5	0.31	none	40	3.4	0.55	none	20	13.2	0.20	PI
	G47	Pebble Creek	86	2.9	0.27	none	62	0.3	0.90	none	24	11.1	0.04	I
	US5	Main Rouge River	106	9.2	0.10	PI	74	4.9	0.37	none	32	12.9	0.30	none
	M05	Evans Ditch	105	-1.2	0.66	none	77	-2.8	0.33	none	28	3.7	0.52	none
MAIN 3-4	M15	Main Rouge River	10	2.4	0.79	none	9	2.9	0.76	none	1	ID	ID	ID
	G43	Main Rouge River	85	4.5	0.05	I	48	4.3	0.15	PI	37	3.5	0.31	none
	US7	Main Rouge River	50	-0.5	0.90	none	37	-2.1	0.58	none	13	32.1	0.03	I
	G42	Main Rouge River	56	1.9	0.51	none	37	-1.1	0.74	none	19	5.1	0.35	none
	M10	Main Rouge River	35	-11.9	0.00	D	31	-11.0	0.01	D	4	0.0	1.00	none
	US8	Main Rouge River	25	-8.8	0.19	PD	12	-14.0	0.07	PD	13	0.0	1.00	none
	M12	Main Rouge River	39	-12.5	0.00	D	35	-11.9	0.00	D	4	0.0	1.00	none
UPPER	U01	Upper Rouge River	90	3.0	0.43	none	67	-0.5	0.89	none	23	20.8	0.01	I
	G71	Upper Rouge River	113	0.8	0.72	none	75	-0.9	0.75	none	38	2.3	0.49	none
	U02	Upper Rouge River	111	-2.0	0.45	none	71	-4.5	0.19	PD	40	-1.3	0.15	PD
	U16	Bell Branch	43	0.1	0.98	none	39	1.5	0.72	none	4	0.0	1.00	none
	U19	Tarabusi Creek	44	-10.3	0.01	D	39	-9.4	0.04	D	5	0.0	1.00	none
	U03	Bell Branch	16	-9.0	0.47	none	16	-9.0	0.47	none	0	ID	ID	ID
	U04	Bell Branch	65	-2.3	0.31	none	48	-1.5	0.60	none	17	-5.0	0.36	none
	U05	Upper Rouge River	85	-2.7	0.37	none	46	-3.5	0.31	none	39	0.0	1.00	none
MIDDLE 1	D28	Bishop Creek	18	-3.8	0.56	none	16	-4.6	0.49	none	2	ID	ID	ID
	D23	Walled Lake Branch	20	-3.2	0.73	none	18	-2.1	0.83	none	2	ID	ID	ID
	D24	Walled Lake Branch	49	2.0	0.64	none	43	1.9	0.69	none	6	2.5	0.88	none
	G52	Johnson Creek	19	16.0	0.25	none	15	7.1	0.11	PI	4	8.3	0.95	none
	G53	Johnson Creek	49	0.4	0.92	none	41	-2.0	0.66	none	8	4.5	0.65	none
	G54	Johnson Creek	16	2.0	0.17	PI	14	3.0	0.08	PI	2	ID	ID	ID
	D03	Johnson Creek	47	3.1	0.34	none	39	3.8	0.17	PI	8	-0.9	0.94	none
	G83	Middle Rouge River	45	3.3	0.11	PI	35	1.7	0.43	none	10	10.8	0.10	PI
MIDDLE 3	D29	Middle Rouge River	107	-8.2	0.19	PD	60	-7.9	0.31	none	47	-1.0	0.91	none
	G81	Middle Rouge River	45	-0.6	0.74	none	35	-1.6	0.23	none	10	4.6	0.67	none
	G29	Nankin Lake Spillway	36	-4.8	0.51	none	35	-5.8	0.45	none	1	ID	ID	ID
	G24	Nankin Lake Dam	52	-9.3	0.05	D	51	-10.3	0.04	D	1	ID	ID	ID
	G11	Nankin Mills Dam	51	-7.0	0.29	none	50	-7.6	0.31	none	1	ID	ID	ID
	G84	Tonquish Creek	78	-3.7	0.14	PD	70	-4.8	0.07	PD	8	3.9	0.71	none
	D07	Middle Rouge River	149	-2.3	0.44	none	114	-4.4	0.17	PD	35	10.9	0.20	PI
	D30	Middle Rouge River	42	37.5	0.00	I	37	25.9	0.03	I	5	0.0	1.00	none
	D05	Middle Rouge River	85	1.1	0.72	none	66	-2.7	0.41	none	19	15.6	0.03	ID
	D06	Middle Rouge River	81	3.8	0.24	none	67	4.0	0.24	none	14	13.1	0.25	none
LOWER 1	L01	Lower Rouge River	44	-4.0	0.19	PD	38	-5.4	0.10	PD	6	8.1	0.61	none
	G93	Fowler Creek	47	1.1	0.66	none	36	1.0	0.76	none	11	1.1	0.84	none
	G95	Lower Rouge River	24	2.5	0.71	none	12	-3.6	0.62	none	12	0.0	1.00	none
	G92	Lower Rouge River	53	5.1	0.04	I	38	4.4	0.14	PI	15	4.9	0.39	none
	L02	Fellows Creek	39	-3.5	0.31	none	35	-3.6	0.34	none	4	0.0	1.00	none
LOWER 2	L06	Lower Rouge River	69	3.4	0.24	none	47	2.5	0.44	none	22	5.2	0.45	none
	G97	Lower Rouge River	123	0.2	0.92	none	82	-1.9	0.53	none	41	4.1	0.20	PI
	G98	Lower Rouge River	128	1.5	0.48	none	81	0.2	0.93	none	47	4.3	0.33	none
	L05	Lower Rouge River	114	-0.9	0.47	none	83	-1.4	0.43	none	31	0.0	1.00	none

Note: In Trend column, D = decreasing trend, PD = potentially decreasing trend, I = increasing trend, PI = potentially increasing trend, ID = insufficient data, none = no statistically significant trend

Table 7 - *E. coli* All, Dry, and Wet Weather Samples - Seasonal Kendall Analysis of the Geometric Mean (cfu/100ml) - (Sites are ordered upstream to downstream)

			All				Dry				Wet			
SWMA	Field ID	Location	Number of Samples	TAU	Probablility	Trend	Number of Samples	TAU	Probablility	Trend	Number of Samples	TAU	Probablility	Trend
MAIN 1-2	M01	Main Rouge River	73	0.21	0.20	None	64	0.18	0.27	None	9	-0.33	1.00	None
	G45	Main Rouge River	106	-0.48	0.00	D	73	-0.46	0.00	D	33	-0.56	0.24	None
	G58	Impoundment	93	-0.47	0.01	D	66	-0.50	0.00	D	27	-0.67	0.25	None
	G48	Main Rouge River	9	-1.00	0.09	PD	8	-1.00	0.09	PD	1	0.00	1.00	None
	M03	Main Rouge River	98	-0.24	0.15	PD	70	-0.34	0.03	D	28	-0.67	0.25	None
	G46	Franklin Branch	105	0.10	0.51	None	75	0.23	0.13	PI	30	-0.56	0.24	None
	G59	Main Rouge River	60	0.14	0.56	None	40	0.56	0.01	I	20	-1.00	0.25	None
	G47	Pebble Creek	86	-0.11	0.55	None	62	0.00	1.00	None	24	-0.56	0.24	None
	US5	Main Rouge River	106	-0.07	0.76	None	74	0.13	0.48	None	32	-0.67	0.25	None
	M05	Evans Ditch	105	0.15	0.31	None	77	0.15	0.31	None	28	-0.67	0.25	None
MAIN 3-4	M15	Main Rouge River	10	-0.71	0.17	PD	9	-0.67	0.27	None	1	0.00	1.00	None
	G43	Main Rouge River	85	-0.32	0.06	PD	48	-0.13	0.51	None	37	-0.33	0.70	None
	US7	Main Rouge River	50	0.32	0.14	PI	37	0.18	0.43	None	13	1.00	1.00	None
	G42	Main Rouge River	56	-0.32	0.16	PD	37	-0.21	0.40	None	19	-1.00	0.48	None
	M10	Main Rouge River	35	0.46	0.08	PI	31	0.38	0.15	PI	4	0.00	1.00	None
	US8	Main Rouge River	25	0.67	0.27	None	12	0.67	0.27	None	13	0.00	1.00	None
	M12	Main Rouge River	39	0.42	0.06	PI	35	0.42	0.06	PI	4	0.00	1.00	None
UPPER	U01	Upper Rouge River	90	-0.23	0.18	PD	67	0.06	0.79	None	23	0.00	1.00	None
	G71	Upper Rouge River	113	-0.02	0.94	None	75	0.14	0.39	None	38	-0.43	0.49	None
	U02	Upper Rouge River	111	-0.03	0.93	None	71	0.25	0.12	PI	40	-0.71	0.17	PD
	U16	Bell Branch	43	-0.17	0.54	None	39	-0.17	0.54	None	4	0.00	1.00	None
	U19	Tarabusi Creek	44	0.31	0.22	None	39	0.24	0.36	None	5	0.00	1.00	None
	U03	Bell Branch	16	-0.60	0.40	None	16	-0.60	0.40	None	0	NA	NA	NA
	U04	Bell Branch	65	-0.29	0.18	PD	48	-0.19	0.39	None	17	-1.00	1.00	None
	U05	Upper Rouge River	85	0.07	0.77	None	46	0.19	0.32	None	39	-0.20	1.00	None
MIDDLE 1	D28	Bishop Creek	18	-0.11	1.00	None	16	0.00	1.00	None	2	0.00	1.00	None
	D23	Walled Lake Branch	20	0.20	1.00	None	18	0.33	1.00	None	2	0.00	1.00	None
	D24	Walled Lake Branch	49	-0.12	0.68	None	43	-0.17	0.54	None	6	0.00	1.00	None
	G52	Johnson Creek	19	-0.14	1.00	None	15	0.00	1.00	None	4	0.00	1.00	None
	G53	Johnson Creek	49	0.18	0.49	None	41	0.33	0.20	None	8	0.00	1.00	None
	G54	Johnson Creek	16	0.20	1.00	None	14	1.00	0.25	None	2	0.00	1.00	None
	D03	Johnson Creek	47	0.26	0.28	None	39	0.35	0.15	PI	8	0.00	1.00	None
	G83	Middle Rouge River	45	-0.27	0.29	None	35	-0.33	0.18	PD	10	0.00	1.00	None
MIDDLE 3	D29	Middle Rouge River	107	1.00	0.13	PI	60	0.00	1.00	None	47	0.00	1.00	None
	G81	Middle Rouge River	45	-0.20	0.45	None	35	-0.13	0.65	None	10	0.00	1.00	None
	G29	Nankin Lake Spillway	36	0.41	0.20	PI	35	0.41	0.20	PI	1	0.00	1.00	None
	G24	Nankin Lake Dam	52	0.48	0.05	I	51	0.48	0.05	I	1	0.00	1.00	None
	G11	Nankin Mills Dam	51	0.18	0.58	None	50	0.18	0.58	None	1	0.00	1.00	None
	G84	Tonquish Creek	78	0.35	0.03	I	70	0.34	0.04	I	8	1.00	1.00	None
	D07	Middle Rouge River	149	0.10	0.63	None	114	0.13	0.50	None	35	0.00	1.00	None
	D30	Middle Rouge River	42	-0.50	0.31	None	37	-0.50	0.31	None	5	0.00	1.00	None
	D05	Middle Rouge River	85	0.11	0.52	None	66	0.26	0.10	PI	19	-1.00	0.48	None
	D06	Middle Rouge River	81	-0.14	0.40	None	67	-0.22	0.18	PD	14	-1.00	0.48	None
LOWER 1	L01	Lower Rouge River	44	0.31	0.23	None	38	0.31	0.23	None	6	0.00	1.00	None
	G93	Fowler Creek	47	0.11	0.70	None	36	0.21	0.37	None	11	-1.00	0.48	None
	G95	Lower Rouge River	24	-0.20	0.78	None	12	0.00	1.00	None	12	0.00	1.00	None
	G92	Lower Rouge River	53	-0.27	0.22	None	38	-0.27	0.22	None	15	-1.00	0.48	None
	L02	Fellows Creek	39	0.55	0.02	I	35	0.48	0.04	I	4	0.00	1.00	None
LOWER 2	L06	Lower Rouge River	69	-0.02	1.00	None	47	-0.09	0.68	None	22	1.00	0.25	None
	G97	Lower Rouge River	123	-0.15	0.33	None	82	0.11	0.50	None	41	-0.14	1.00	None
	G98	Lower Rouge River	128	-0.50	0.00	D	81	-0.41	0.01	D	47	-0.64	0.10	PD
	L05	Lower Rouge River	114	-0.07	0.70	None	83	-0.01	1.00	None	31	-0.33	0.70	None

Note: In Trend column, D = decreasing trend, PD = potentially decreasing trend, I = increasing trend, PI = potentially increasing trend, ID = insufficient data, none = no statistically significant trend, NA = no samples <=1,000cfu/100ml

Table 8 - *E. coli* All, Dry, and Wet Weather Samples - Seasonal Kendall Analysis of the Percent of Values Less Than 1,000 (cfu/100ml) - (Sites are ordered upstream to downstream)

			All				Dry				Wet			
SWMA	Field ID	Location	Number of Samples	TAU	Probablility	Trend	Number of Samples	TAU	Probablility	Trend	Number of Samples	TAU	Probablility	Trend
MAIN 1-2	M01	Main Rouge River	73	-0.21	0.25	None	64	-0.18	0.35	None	9	0.00	1.00	None
	G45	Main Rouge River	106	0.23	0.16	None	73	0.04	0.89	None	33	1.00	1.00	None
	G58	Impoundment	93	0.43	0.07	PI	66	0.23	0.35	None	27	0.00	1.00	None
	G48	Main Rouge River	9	0.00	1.00	None	8	0.00	1.00	None	1	NA	NA	NA
	M03	Main Rouge River	98	0.21	0.25	None	70	0.15	0.42	None	28	1.00	1.00	None
	G46	Franklin Branch	105	0.08	0.62	None	75	-0.17	0.13	None	30	1.00	1.00	None
	G59	Main Rouge River	60	0.06	1.00	None	40	0.13	0.79	None	20	0.00	1.00	None
	G47	Pebble Creek	86	0.18	0.24	None	62	0.12	0.28	None	24	-1.00	1.00	None
	US5	Main Rouge River	106	-0.14	0.43	None	74	-0.11	0.54	None	32	0.00	1.00	None
	M05	Evans Ditch	105	-0.14	0.37	None	77	-0.13	0.40	None	28	0.00	1.00	None
MAIN 3-4	M15	Main Rouge River	10	0.00	1.00	None	9	0.00	1.00	None	1	NA	NA	NA
	G43	Main Rouge River	85	-0.13	1.00	None	48	-0.13	1.00	None	37	1.00	1.00	None
	US7	Main Rouge River	50	-0.27	0.25	None	37	-0.08	0.81	None	13	0.00	1.00	None
	G42	Main Rouge River	56	-0.20	0.57	None	37	-0.20	0.57	None	19	0.00	1.00	None
	M10	Main Rouge River	35	-0.33	0.34	None	31	-0.08	1.00	None	4	NA	NA	NA
	US8	Main Rouge River	25	0.00	1.00	None	12	0.00	1.00	None	13	NA	NA	NA
	M12	Main Rouge River	39	-0.22	0.48	None	35	-0.22	0.48	None	4	NA	NA	NA
UPPER	U01	Upper Rouge River	90	0.34	0.05	None	67	0.08	0.74	None	23	0.00	1.00	None
	G71	Upper Rouge River	113	0.17	0.51	None	75	0.03	1.00	None	38	1.00	1.00	None
	U02	Upper Rouge River	111	0.00	1.00	None	71	0.03	1.00	None	40	0.00	1.00	None
	U16	Bell Branch	43	-0.67	0.48	None	39	-0.67	0.48	None	4	NA	NA	NA
	U19	Tarabusi Creek	44	0.00	1.00	None	39	0.25	1.00	None	5	NA	NA	NA
	U03	Bell Branch	16	1.00	0.48	None	16	1.00	0.48	None	0	NA	NA	NA
	U04	Bell Branch	65	0.00	1.00	None	48	0.00	1.00	None	17	0.00	1.00	None
	U05	Upper Rouge River	85	-0.67	0.48	None	46	-0.67	0.48	None	39	NA	NA	NA
MIDDLE 1	D28	Bishop Creek	18	0.20	1.00	None	16	0.20	1.00	None	2	0.00	1.00	None
	D23	Walled Lake Branch	20	0.60	0.30	None	18	0.67	0.48	None	2	0.00	1.00	None
	D24	Walled Lake Branch	49	0.17	0.64	None	43	0.15	0.76	None	6	0.00	1.00	None
	G52	Johnson Creek	19	0.33	0.54	None	15	0.00	1.00	None	4	0.00	1.00	None
	G53	Johnson Creek	49	-0.09	0.67	None	41	-0.05	1.00	None	8	0.00	1.00	None
	G54	Johnson Creek	16	0.20	1.00	None	14	0.33	1.00	None	2	0.00	1.00	None
	D03	Johnson Creek	47	-0.15	0.56	None	39	-0.04	1.00	None	8	0.00	1.00	None
	G83	Middle Rouge River	45	-0.15	0.53	None	35	-0.19	0.21	None	10	0.00	1.00	None
MIDDLE 3	D29	Middle Rouge River	107	-0.50	0.62	None	60	0.00	1.00	None	47	0.00	1.00	None
	G81	Middle Rouge River	45	-0.07	0.84	None	35	-0.20	0.19	None	10	0.00	1.00	None
	G29	Nankin Lake Spillway	36	0.00	1.00	None	35	0.00	1.00	None	1	0.00	1.00	None
	G24	Nankin Lake Dam	52	-0.05	1.00	None	51	-0.05	1.00	None	1	0.00	1.00	None
	G11	Nankin Mills Dam	51	0.00	1.00	None	50	0.00	1.00	None	1	0.00	1.00	None
	G84	Tonquish Creek	78	-0.35	0.05	D	70	-0.33	0.06	None	8	0.00	1.00	None
	D07	Middle Rouge River	149	0.30	0.18	PI	114	0.33	0.12	PI	35	1.00	1.00	None
	D30	Middle Rouge River	42	0.43	0.40	None	37	0.43	0.40	None	5	NA	NA	NA
	D05	Middle Rouge River	85	-0.08	0.67	None	66	-0.16	0.34	None	19	0.00	1.00	None
	D06	Middle Rouge River	81	0.09	0.70	None	67	0.09	0.68	None	14	0.00	1.00	None
LOWER 1	L01	Lower Rouge River	44	-0.16	0.69	None	38	-0.29	0.44	None	6	0.00	1.00	None
	G93	Fowler Creek	47	-0.05	1.00	None	36	-0.60	0.04	D	11	1.00	0.48	None
	G95	Lower Rouge River	24	0.60	0.30	None	12	0.20	1.00	None	12	NA	NA	NA
	G92	Lower Rouge River	53	0.03	1.00	None	38	-0.08	0.83	None	15	0.00	1.00	None
	L02	Fellows Creek	39	-0.43	0.47	None	35	-0.43	0.47	None	4	NA	NA	NA
LOWER 2	L06	Lower Rouge River	69	-0.06	1.00	None	47	-0.13	0.75	None	22	0.00	1.00	None
	G97	Lower Rouge River	123	0.00	1.00	None	82	-0.08	1.00	None	41	0.00	1.00	None
	G98	Lower Rouge River	128	-0.10	1.00	None	81	0.43	0.43	None	47	0.00	1.00	None
	L05	Lower Rouge River	114	-1.00	1.00	None	83	0.00	1.00	None	31	NA	NA	NA

Note: In Trend column, D = decreasing trend, PD = potentially decreasing trend, I = increasing trend, PI = potentially increasing trend, ID = insufficient data, none = no statistically significant trend, NA = no samples <=1,000cfu/100ml

Figure 10 - *E. coli* Dry Weather Samples - Regression Analysis of the Geometric Mean (cfu/100ml)

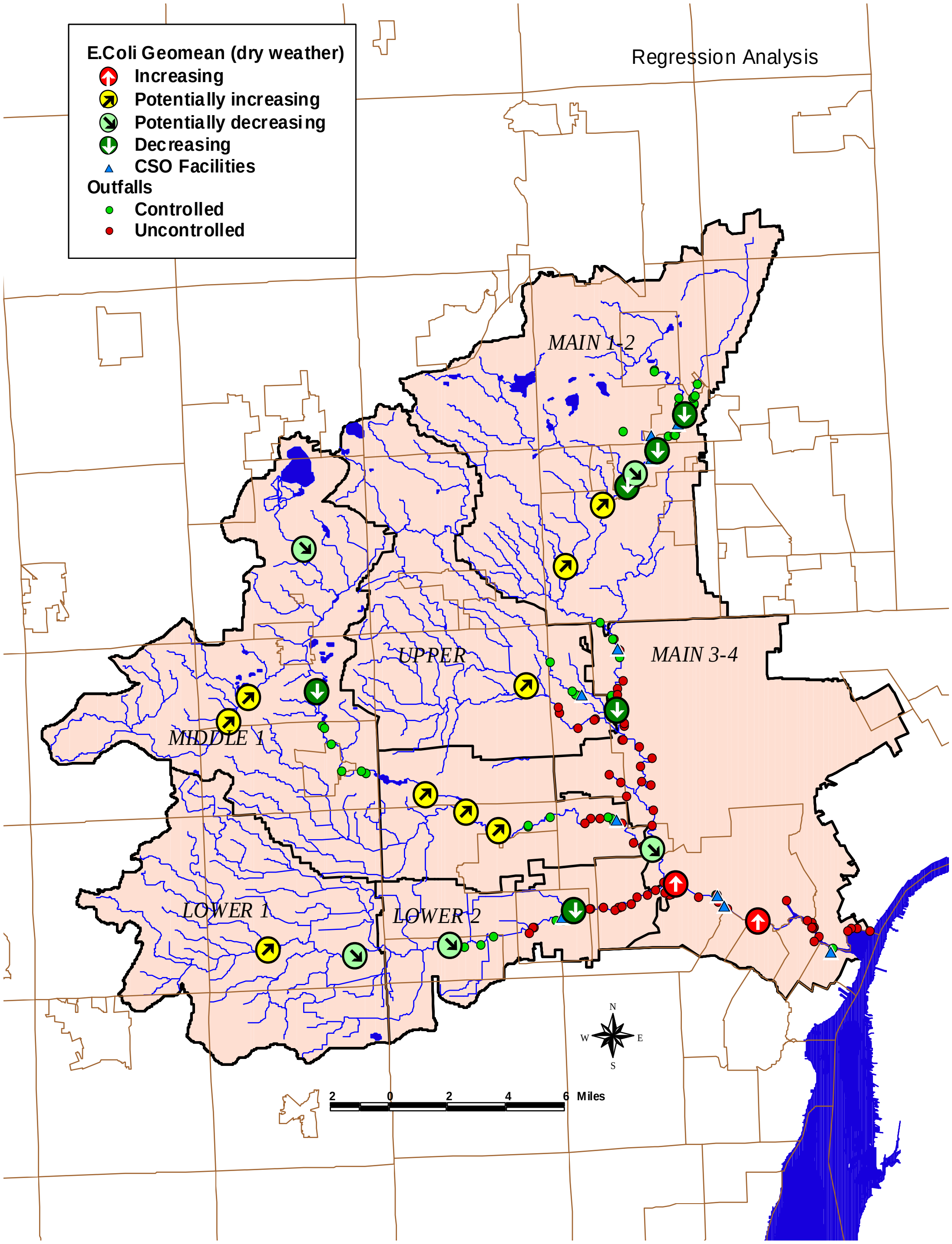


Figure 11 - *E. coli* Wet Weather Samples - Regression Analysis of the Geometric Mean (cfu/100ml)

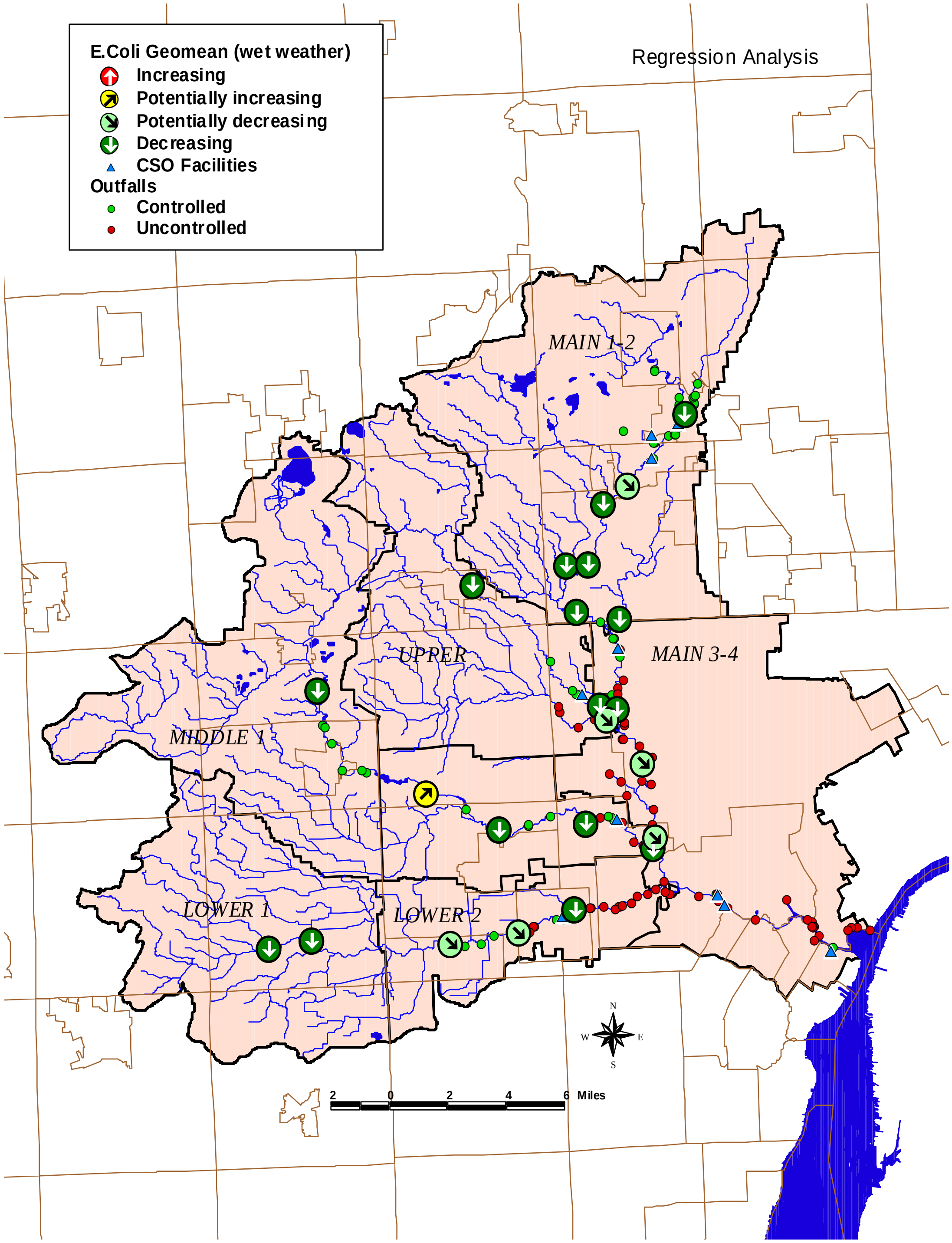


Figure 12 - *E.coli* Wet Weather Samples - Regression Analysis of the Percent of Values Less Than 1,000 (cfu/100ml)

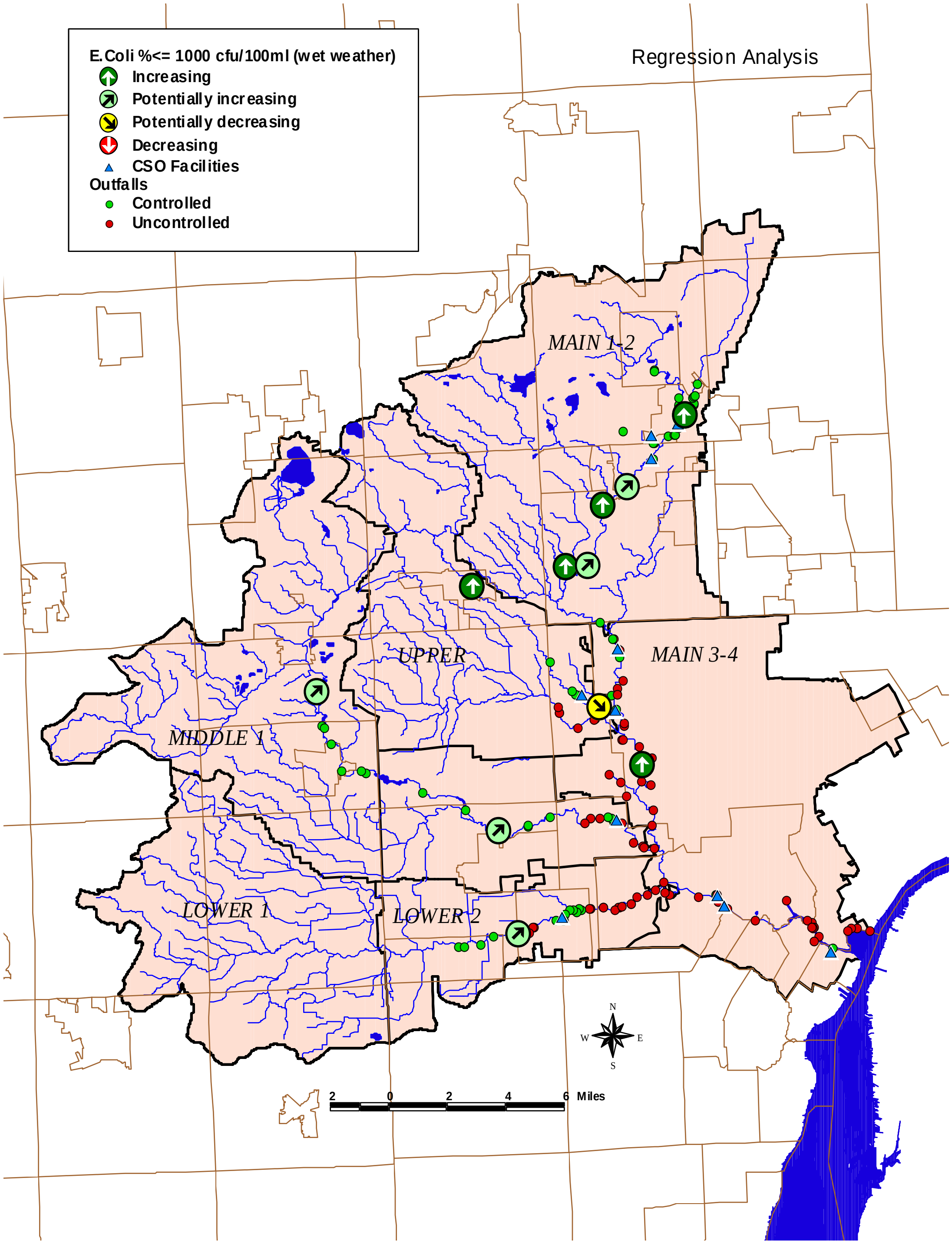
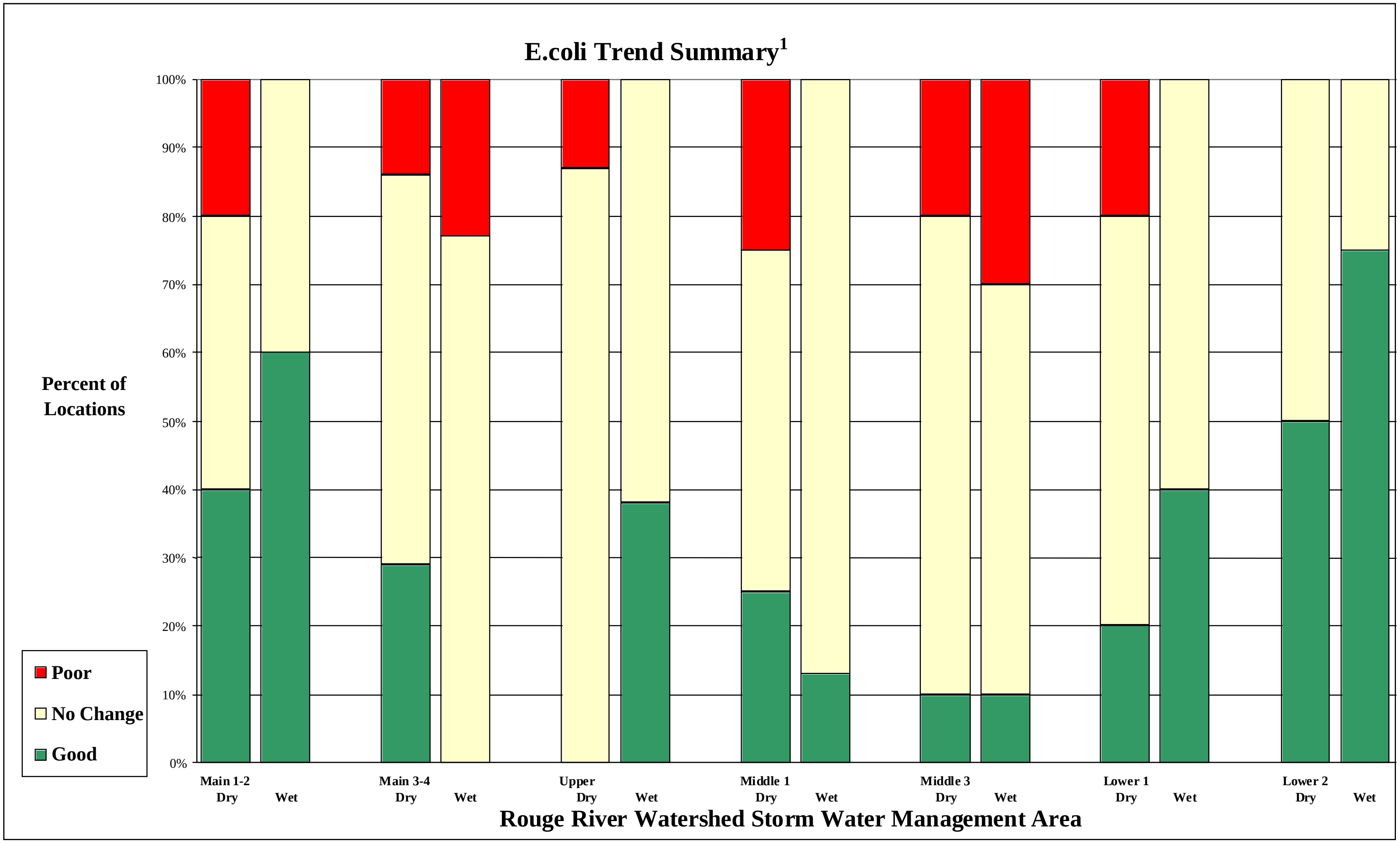


Figure 13: Summary of *E. coli* Trend Analysis Results by SWMA



[1] Based on Linear Regression Method

CONCLUSIONS

In an effort to evaluate the effectiveness of watershed management activities in the Rouge River Watershed, water quality trends were evaluated using two statistical analysis techniques. The linear regression and Seasonal Kendall trend tests were applied to DO and *E. coli* data collected from 1994 through 2002. In general, both statistical methods show that DO concentrations and the percent of values greater than the State standard of 5 mg/L have improved substantially throughout the watershed. In 2002, seven of the eight continuously monitored locations met the State standard more than 80 percent of the time.

E. coli results generally showed improvement directly downstream of most watershed management activities, particularly downstream of now controlled CSO outfalls during wet weather. Additionally, some locations have been identified where *E. coli* concentrations may be increasing. These sites are generally located near the headwaters where residential and commercial development is expanding or in areas still influenced by CSOs. Although improving, most locations are still not meeting State water quality standards for *E. coli* total or partial body contact recreation.

Overall, these results clearly demonstrate that the implemented watershed management activities have been successful and that continued diligence in addressing remaining water quality pollution sources should lead to continued improvement.