DRAFT

Michigan Department of Environmental Quality
Water Bureau
June 2008

Total Maximum Daily Load for *E. coli* for Farmers Creek Berrien County

INTRODUCTION

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations, Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting water quality standards (WQS). The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the allowable levels of *E. coli* that will result in the attainment of the applicable WQS in Farmers Creek, a tributary of the St. Joseph River, located in Berrien County, Michigan.

PROBLEM STATEMENT

The TMDL reach for Farmers Creek appears on the 2008 Section 303(d) list as:

Water body name: **Eau Claire Village Drain and Farmers Creek**
AUID: 040500012604-02, 040500012604-03, 040500012604-04
Impaired designated use: Partial Body and Total Body Contact Recreation
Cause: *E. coli*
Size: 2, 4.9, 6.18 miles = Total 13.08 miles
Location Description: Tributary to St. Joseph River near Village of Eau Claire, Berrien County
TMDL Year(s): 2008

Farmers Creek was first placed on the Section 303(d) list in 2000 for the impairment of recreational uses due to the likely discharge of untreated sewage from an unknown source as evidenced by the odor of raw sewage. These impairments were actually noted in the Eau Claire Village Drain (a tributary to Farmers Creek), which should have been the original listed water body. Following the listing of Farmers Creek, monitoring data was collected in 2006 in the Farmers Creek watershed by the Michigan Department of Environmental Quality (MDEQ). These data documented exceedances of the total body contact and partial body contact WQS for *E. coli* at all sampling locations during the recreational season of May 1 through October 31 (Table 1). Data collected during 2006 indicates that the TMDL reach needs to be extended to the entire main branch of Farmers Creek from the confluence with the St. Joseph River upstream to the headwaters and to the main branch of the Eau Claire Village Drain from its confluence with Farmers Creek upstream to the headwaters, for a total distance of 13.08 miles. This TMDL addresses the entire 13.08-mile reach.

NUMERIC TARGET

The impaired designated uses addressed by this TMDL are total body contact and partial body contact recreation. The designated use rule (Rule 100 [R 323.1100] of the Part 4 rules, WQS, promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended) states that this water body be protected for total body contact recreation from May 1 through October 31 and partial body

contact recreation year-round. The target levels for these designated uses are the ambient *E. coli* standards established in Rule 62 of the WQS as follows:

> R 323.1062 Microorganisms.
> Rule 62. (1) All waters of the state protected for total body contact recreation shall not contain more than 130 *E. coli* per 100 milliliters (mL), as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken during five or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of three or more samples taken at representative locations within a defined sampling area. At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 mL. Compliance shall be based on the geometric mean of three or more samples taken during the same sampling event at representative locations within a defined sampling area.
>
> (2) All surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 *E. coli* per 100 mL. Compliance shall be based on the geometric mean of 3 or more samples, taken during the same sampling event, at representative locations within a defined sampling area.

The target for sanitary wastewater discharges is:

> Rule 62. (3) Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 mL, based on the geometric mean of all of five or more samples taken over a 30-day period, nor more than 400 fecal coliform bacteria per 100 mL, based on the geometric mean of all of three or more samples taken during any period of discharge not to exceed seven days. Other indicators of adequate disinfection may be utilized where approved by the Department.

Sanitary wastewater discharges are considered in compliance with the WQS of 130 *E. coli* per 100 mL if their National Pollutant Discharge Elimination System (NPDES) permit limit of 200 fecal coliform per 100 mL as a monthly average is met. This is assumed because *E. coli* are a subset of fecal coliform (American Public Health Association, 1995). Fecal coliform concentrations are substantially higher than *E. coli* concentrations when the wastewater of concern is sewage (Whitman, 2001). Therefore, typically it can be assumed that there are less than 130 *E. coli* per 100 mL in the effluent when the point source discharge is meeting its limit of 200 fecal coliform per 100 mL.

For this TMDL, the WQS of 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum to protect the total body contact designated use are the target levels for the TMDL reach from May 1 through October 31, and 1000 *E. coli* per 100 ml as a daily maximum year-round to protect the partial body contact designated use.

DATA DISCUSSION

Farmers Creek and the Eau Claire Village Drain were sampled for *E. coli* weekly at five stations from May through September 2006 (Figure 1). Thirty-day geometric mean *E. coli* concentrations ranged from 212 *E. coli* per 100 ml in August in Farmers Creek at Hipps Hollow Road (Station 5) to 2261 *E. coli* per 100 ml in June in Farmers Creek at Old Pipestone Road (Station 1; Table 1, Figure 1). The 30-day geometric mean total body contact recreation WQS was exceeded throughout the entire sampling season at all five stations (Figure 2). Daily maximum concentrations ranged from 86 *E. coli* per 100 ml in May in Farmers Creek at Hochberger Road to 16,761 *E. coli* per 100 ml in July at Station 1 (Table 1, Figure 3). Daily maximum concentrations exceeded the 300 *E. coli* per 100 ml total body contact recreation

WQS, for 75 of the 110 samples, and exceeded the 1000 *E. coli* per 100 ml partial body contact recreation WQS for 29 of 110 samples taken from all stations throughout the sampling season.

As part of an additional effort to identify possible sources of *E. coli* to the TMDL watershed, the MDEQ collected one sample for fecal *Bacteriodes* DNA analysis in the Eau Claire Village Drain downstream of the village of Eau Claire (Station 3). The results of the DNA analysis indicate that on the day of sampling (August 6, 2006) Station 3 contained fecal bacteria of human origin.

Further *E. coli* samples were taken on April 15, 2008, by the MDEQ as part of an inspection of the Eau Claire Waste Water Sewage Lagoon (WWSL) and village lift stations (Table 2, Figure 1). Daily maximum concentrations met WQS at all stations sampled.

SOURCE ASSESSMENT

The TMDL reach is primarily within Pipestone Township with a portion of the Eau Claire Village Drain within Berrien Township and the village of Eau Claire. The entire watershed is within Berrien County (Figure 1; Table 3).

The MDEQ, Water Bureau's NPDES permit Management System (NMS) indicated there are 4 NPDES permitted discharges in the Farmers Creek watershed (Tables 4 and 5) including 1 individual permit for a treated groundwater discharge (Alcoa Inc.), 1 certificate of coverage (COC) under a general industrial stormwater permit (Hoffman Ind.), 1 COC for the Eau Claire WWSL under a wastewater stabilization lagoon general permit, and the Michigan Department of Transportation (MDOT) statewide Municipal Separate Storm Sewer System (MS4) permit. There is also 1 notice of coverage (NOC) for earthwork under 1 permit-by-rule. The storm water and ground water cleanup permittees noted in this TMDL are not likely sources of *E. coli.* The MDOT MS4 permit prohibits the discharge of storm water that may cause or contribute to a violation of WQS, and is not expected to be a source of *E. coli*. The permit-by-rule (MIR100000) NOC involves earthwork and is not considered to be a source of *E. coli*. There are no Concentrated Animal Feeding Operation permitted discharges in the Farmers Creek watershed.

The Eau Claire WWSL is located northwest of the village of Eau Claire. The WWSL has a permit to discharge treated sanitary wastewater to Farmers Creek north of the lagoon during the spring and fall of each year. The WWSL was not reported to be discharging during the MDEQ sampling period noted in this TMDL. On October 26, 2007, the MDEQ issued a notice of violation to the village of Eau Claire for the unpermitted discharge of sanitary sewage effluent to groundwater. Groundwater sampling data indicated that there is a connection between the lagoon and the upper aquifer. The village was instructed to investigate the integrity of the lagoon liner and to repair the damage to the lagoon caused by animals and vegetation. If contaminated groundwater is venting to surface waters it could be venting south of the lagoon to a tributary to the Eau Claire Village Drain downstream of Station 3, or north of the lagoon to Farmers Creek upstream of Station 2, and could be a source of *E. coli*.

The village of Eau Claire has two lift stations within the sanitary sewer infrastructure. The west station is located near Main Street and Hochberger Road and the east station is located near Main Street and 2nd Street. Both lift stations have overflow pipes which can lead to sanitary sewer overflows (SSOs) to the Eau Claire Village Drain upstream of Station 3. On April 15, 2008, evidence of a recent unreported SSO was discovered by the MDEQ at the east lift station, and there are reports in the MDEQ files of SSOs occurring at the lift stations on occasion since 1977. There was also a letter sent to the Berrien County Health Department by the MDEQ in 1982 regarding a septic field suspected to be discharging to the Eau Claire Village Drain in the village of Eau Claire; however, the location of this discharge is not clear and it is not clear if the issue has been remedied.

Potential sources of *E. coli* to the Eau Claire Village Drain are SSOs associated with two lift stations in the village of Eau Claire, possible issues with the Eau Claire WWSL leaking, possible failing septic systems located in close proximity to the drain, illicit connections to the storm drains within the village of Eau Claire, pet and wildlife waste, and livestock kept in close proximity to the stream. The primary *E. coli* sources to Farmers Creek upstream of the confluence of the Eau Claire Village Drain are most likely due to failing septic systems, illicit overflow pipes from septic systems draining to surface waters, agriculture sources, and pet and wildlife waste.

To assist in determining potential sources of *E. coli* to the Farmers Creek watershed, a load duration curve analysis was developed for each sampling station as outlined in a paper by Cleland (2002). A load duration curve considers how flow conditions relate to a variety of pollutant sources (point and nonpoint sources). The load duration curves for each station sampled on Farmers Creek are included in Figures 4-8. Farmers Creek does not have a stream flow gage; therefore, the flows of a gage from a stream with similar geological characteristics were used to develop load duration curves. The United States Geological Survey gage used to determine the load duration curves is located on the Dowagiac River near Sumnerville, Michigan (Gage #04101800). A ratio of the drainage area of Farmers Creek to the drainage area of the Dowagiac River at the stream gage (defined as the drainage area ratio), was calculated for each of the five sample locations on Farmers Creek. The curves were generated by applying these drainage area ratios to Dowagiac River flows for the period of record, which includes all historical flows available for the Dowagiac River gage.

The data indicate that exceedances of the daily maximum WQS are observed during wet and dry weather events (Table 1). Note that dots above the curve on the left side of the figure are indicative of *E. coli* WQS exceedances during wet weather conditions (higher flows) and dots above the curve to the right side of the figure indicate *E. coli* WQS exceedances during dry weather conditions (lower flows). The most likely source of *E. coli* during dry weather is a constant source unrelated to precipitation, such as residential failing septic systems, septic systems located near field drainage tiles, septic systems with overflow pipes discharging to surface waters, possible lift station failures, contaminated groundwater venting near the village WWSL, and livestock with direct access to the creek. It should be noted that exceedances of the daily maximum *E. coli* standard occurred not only in the Eau Claire Village Drain and Farmers Creek downstream of the village of Eau Claire, but in the upstream portions of Farmers Creek as well (Figure 1).

The type of bacteria (fecal *Bacteriodes*) used in the DNA analysis in the Eau Claire Village Drain downstream of the village of Eau Claire, is one that is considered a good indicator of recent fecal pollution because the bacteria are strict anaerobes and thus do not survive long outside of the host organism (i.e., humans) (Source Molecular, 2008). On-site septic systems serve many homes in the Farmers Creek watershed. In Berrien County, it is estimated that there are between 30-45 septic systems per square mile (*E. coli* Work Group, 2008 draft). The Berrien County Health Department does not maintain point-of-sale septic inspection records. Thus, we have no indication of the on-site septic system failure rate for the Farmers Creek watershed. Based on information obtained from other county health departments statewide, the on-site septic system failure rate across Michigan is about ten percent (*E. coli* Work Group, 2008 draft). The incidence of failure is variable depending on geology, age of the community, proportion of year-round homes, and stringency of local regulations. It was noted by the Berrien County Health Department that the soils in Pipestone and Berrien Township is dominated by heavy clay soils and in many areas is not well suited for septic systems.

Exceedances of the daily maximum *E. coli* WQS at all five stations also occurred during wet weather events. Precipitation data for the two days prior to each MDEQ sampling event were obtained from a weather station located approximately six miles northwest of Eau Claire

Michigan (MAWN, 2006). All of the above noted possible dry weather sources, agriculture runoff, and pet or wildlife wastes are possible sources of *E. coli* during wet weather. Agriculture, including grass and pasture land, accounts for approximately 60 percent of the land use in the TMDL watershed. The remaining land use includes 18 percent forest, 10 percent urban, 8 percent rangeland, 2 percent water, and 2 percent wetland (Enslin, 2005). *E. coli* have been shown to enter water bodies from pastureland runoff and land applications of manure via field drainage systems, such as tiles and direct runoff (Jamieson et al., 2002; Oliver et al., 2005).

LOADING CAPACITY (LC) DEVELOPMENT

The LC represents the maximum loading that can be assimilated by the water body while still achieving WQS. As indicated in the Numeric Target section, the targets for this pathogen TMDL are the total body contact 30-day geometric mean WQS of 130 *E. coli* per 100 mL, and daily maximum of 300 *E. coli* per 100 mL and the partial body contact daily maximum WQS of 1000 *E. coli* per 100 ml. Concurrent with the selection of a numeric concentration endpoint, development of the LC requires identification of the critical condition. The “critical condition” is defined as the set of environmental conditions (e.g., flow) used in development of the TMDL that results in attaining WQS and has an acceptably low frequency of occurrence.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). For *E. coli*, however, mass is not an appropriate measure, and the USEPA allows pathogen TMDLs to be expressed in terms of organism counts (or resulting concentration). Therefore, this pathogen TMDL is concentration-based, consistent with R 323.1062, and the TMDL is equal to the total body contact target concentrations of 130 *E. coli* per 100 mL as a 30-day geometric mean and daily maximum of 300 *E. coli* per 100 mL in all portions of the TMDL reach for each month of the recreational season (May through October) and partial body contact target concentration of 1000 *E. coli* per 100 mL as a daily maximum year-round. Expressing the TMDL as a concentration equal to the WQS ensures that the WQS will be met under all flow and loading conditions; therefore, a critical condition is not applicable for this TMDL.

LC

The LC is the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the LC must include a margin of safety (MOS), either implicitly within the WLA or LA, or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$LC = \sum WLAs + \sum LAs + MOS$$

The LC represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. Because this TMDL is concentration-based, the total loading for this TMDL is equal to the total body contact WQS of 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum during from May 1 to October 31 and partial body contact WQS of 1000 *E. coli* per 100 mL as a daily maximum year-round.

WLAs

Tables 4 and 5 outline the permitted point source discharges to the Farmers Creek watershed. The discharges include 2 individual permits, 1 industrial storm water COC, 1 WWSL COC, and 1 NOC under 1 permit-by-rule. The WLA for the permits in Table 4 is equal to 130 *E. coli* per 100 mL as a 30-day average and 300 *E. coli* per 100 mL as a daily maximum from May 1 through October 31, and 1000 *E. coli* per 100 mL as a daily maximum year-round.

LAs

Because this TMDL is concentration-based, the LA is also equal to 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum from May 1 to October 31 and 1000 *E. coli* per 100 mL as a daily maximum year-round. This LA is based on the assumption that all land, regardless of use, will be required to meet the WQS. Therefore, the relative responsibility for achieving the necessary reductions of bacteria and maintaining acceptable conditions will be determined by the amount of land under the jurisdiction of the local unit of government in the watershed (Table 3).

MOS

This section addresses the incorporation of an MOS in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality, including the pollutant decay rate, if applicable. The MOS can be either implicit (i.e., incorporated into the WLA or LA through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS because no rate of decay was used. Pathogen organisms ordinarily have a limited capability of surviving outside of their hosts and a rate of decay could be developed. However, applying a rate of decay could result in an allocation that would be greater than the WQS, thus no rate of decay is applied to provide for greater protection of water quality. The MDEQ has determined that the use of the total body contact WQS of 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum from May 1 to October 31, and the partial body contact WQS of 1000 *E. coli* per 100 mL as a daily maximum year-round, for the WLA and LA is a more conservative approach than developing an explicit MOS. This accounts for the uncertainty in the relationship between pollutant loading and water quality, based on available data and the assumption to not use a rate of decay. Applying the WQS to be met under all flow conditions also adds to the assurance that an explicit MOS is unnecessary.

SEASONALITY

The WQS for *E. coli* are expressed in terms of seasons, e.g., total body contact from May 1 through October 31 and partial body contact year-round. Allocations and controls developed for the more protective total body contact season are also expected to assure attainment of the daily maximum partial body contact WQS of 1000 *E. coli* per 100 mL, year-round. Because this is a concentration-based TMDL, WQS must be met at all flow conditions in the applicable season as described in R 323.1090, applicability of the WQS.

MONITORING

Pathogens were monitored bi-weekly at five stations on Farmers Creek. Monitoring occurred from May through September 2006. Future monitoring will take place as part of the five-year rotating basin monitoring, as resources allow, once actions have occurred to address sources of *E. coli.* When these results indicate that the water body may be meeting WQS, sampling will be conducted at the appropriate frequency to determine if the 30-day geometric mean value of 130 *E. coli* per 100 ml and daily maximum values of 300 *E. coli* per 100 ml and 1000 *E. coli* per 100 ml are being met.

REASONABLE ASSURANCE ACTIVITIES

On April 25, 2008, the MDEQ issued a notice of violation letter to the village of Eau Claire for the unreported SSO that was discovered near the village's east lift station. The MDEQ required the village to provide a schedule for the elimination of the lift station overflow pipes by May 23,

2008. If the overflow pipes can not be eliminated due to public health concerns associated with sewage backing up into homes, the village is to provide plans and specifications for alarms and telemetry packages at each lift station that will alert the village when overflows may occur, so that they can prevent them. The facility is currently reviewing possible causes of the overflow and possible sources of funding to remedy the problem.

As was required in the October 26, 2007, notice of violation letter issued by the MDEQ, the village of Eau Claire has repaired damage to the lagoons cause by muskrats. They have not yet completed an investigation of the lagoon liner. The village has very little funding available for maintenance of the sanitary system, and has been encouraged by the MDEQ to apply for state of Michigan Revolving Loan Funds.

The Friends of the St. Joe River Association was established in 1994. The organization is active in local communities with cleanup projects and volunteer monitoring programs. The major goal for the group is to link numerous activities and efforts in the St. Joseph River watershed together. The group has a Web site (www.stjoeriver.net) that provides contact information to the regulatory community, information on other activities in the watershed, and serves as a centralized source of information for this large watershed. The Friends of the St. Joe River Association was awarded a Clean Water Act Section 319 Grant from the MDEQ in 2002 to develop the St. Joseph River Watershed Management Plan (DeGraves, 2005). The Mission of the St. Joseph River Watershed Management Plan is to "unite a diverse group of stakeholders throughout the watershed in a collaborative effort to protect, restore, and foster stewardship of the St. Joseph River Watershed as a critical component of the Great Lakes Basin." The plan also "seeks to promote and facilitate coordinated, collaborative action among stakeholders in order that nonpoint source loads of sediment, nutrients, pathogens, and toxins in the St. Joseph River Watershed are reduced to levels sufficient to meet both states designated uses throughout the entire year..." (DeGraves, 2005). One specific goal of the watershed plan is to "eliminate/correct sources of disease causing organisms that are harmful to public health and that limit the use of rivers, creeks, and lakes." The plan notes that this goal could be met by educating property owners about maintaining and properly installing septic systems, developing storm water education programs, and increasing the development of certified manure management plans. The intention of the watershed plan is to provide goals for more localized watershed groups. Currently, there is no watershed group for the Farmer's Creek watershed.

Prepared by: Tamara Lipsey, Aquatic Biologist
Surface Water Assessment Section
Water Bureau
Michigan Department of Environmental Quality
June 23, 2008

REFERENCES

American Public Health Association. 1995. Standard Methods for the Examination of Water and Wastewater. 19th Edition.

Cleland, B. 2002. TMDL Development from the "Bottom Up" – Part II. Using Duration Curves to Connect the Pieces. America's Clean Water Foundation.

DeGraves, A. 2005. St. Joseph River Watershed Management Plan. Friends of the St. Joe River Association. Athens, Michigan.

E. coli Work Group, draft. Evaluation of *E. coli* in Surface Waters. January 2008 Draft Report. MDEQ.

Jamieson, R.C., R.J. Gordon, K.E. Sharples, G.W. Stratton, and A. Madani. 2002. Movement and Persistence of Fecal Bacteria in Agricultural Soils and Subsurface Drainage Water: A Review. Canadian Biosystems Engineering, Volume 44.

Enslin, B. 2005. MapImage Viewer Version 5.0. Remote Sensing and GIS Research and Outreach Services. Michigan State University. East Lansing, Michigan.

MAWN, 2006. Michigan State University, Michigan Automated Weather Network. Scottdale Station.

Oliver, D.M., L. Heathwaite, P.M. Haygarth, and C.D. Clegg. 2005. Transfer of *Escherichia coli* to Water from Drained and Undrained Grassland after Grazing. Journal of Environmental Quality 34: 918-925.

Source Molecular, 2008. Human Bacteroidetes ID™ http://www.sourcemolecular.com/humanbacteroidetes.html

Whitman, R. Personal Communication. United States Geological Survey, October 2001.

Table 1. MDEQ 2006 *E. coli* monitoring data (*E. coli per* 100 ml) for Farmers Creek. Shaded results are those that exceed WQS.

	Farmers Creek @ Old Pipestone Road (Station 1)			Farmers Creek @ Hochberger Road (Station 2)			Eau Claire Village Drain @ Hochberger Road (Station 3)			Farmers Creek @ Pipestone Road (Station 4)			Farmers Creek @ Hipps Hollow Road (Station 5)			Prior 24 hour Precipitation in inches
DATE	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	
5/4/2006	200	221	---	80	86	---	200	104	---	<20	110	---	60	134	---	0.01
	180			80			40			100			100			
	300			100			140			120			400			
5/10/2006	200	221	---	800	386	---	260	225	---	240	175	---	300	610	---	0
	180			400			220			160			840			
	300			180			200			140			900			
5/17/2006	2,200	170	---	3,400	1030	---	200	230	---	300	287	---	200	137	---	0.16
	160			1,340			160			180			160			
	14			240			380			440			80			
5/22/2006	400	543	---	200	164	---	240	296	---	820	516	---	240	115	---	0.02
	400			220			360			600			160			
	1,000			100			300			280			40			
5/31/2006	1,600	511	297	580	817	341	2,400	1936	315	1,200	1104	341	660	633	241	0
	260			940			1,260			1,400			600			
	320			1,000			2,400			800			640			
6/7/2006	740	1625	442	6,800	5615	786	4,600	4375	665	5,600	6447	714	2,400	5572	508	0.41
	1,000			6,200			2,600			9,200			10,600			
	5,800			4,200			7,000			5,200			6,800			
6/15/2006	15,400	16761	1051	1,200	1065	962	1,400	1330	948	1,200	596	911	140	146	382	0
	16,800			560			1,200			400			140			
	18,200			1,800			1,400			440			160			
6/21/2006	600	763	1419	600	626	871	840	1578	1394	820	702	1090	140	247	430	0
	1,000			660			1,800			440			360			
	740			620			2,600			960			300			
6/28/2006	3,200	5572	2261	800	377	1029	120	386	1470	900	928	1225	160	178	469	0.01
	1,200			840			800			1,140			160			
	800			80			600			780			220			
7/5/2006	340	146	1761	740	414	899	400	2320	1524	960	785	1145	180	240	386	0
	560			160			6,000			720			320			
	620			600			5,200			700			240			
7/12/2006	2,800	247	1209	1,600	1064	644	1,200	2496	1362	1,400	952	781	800	862	266	0.58
	1,460			940			2,400			540			1,000			
	1,400			800			5,400			1,140			800			
7/19/2006	440	178	487	1,000	438	539	820	1119	1316	1,000	621	787	420	476	337	0.97
	400			600			1,400			600			640			
	400			140			1,220			400			400			

Table 1 continued.

	Farmers Creek @ Old Pipestone Road (Station 1)			Farmers Creek @ Hochberger Road (Station 2)			Eau Claire Village Drain @ Hochberger Road (Station 3)			Farmers Creek @ Pipestone Road (Station 4)			Farmers Creek @ Hipps Hollow Road (Station 5)			Prior 2-Day Precipitation in inches
DATE	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	SAMPLE RESULTS	DAILY MAX	30-day G. MEAN	
7/26/2006	260	280	682	400	292	463	600	711	1122	320	221	625	200	173	314	0.15
	140			260			1,000			280			100			
	600			240			600			120			260			
8/2/2006	1,600	613	574	300	288	439	5,200	6746	1988	500	391	526	80	159	307	1.15
	400			80			7,200			600			180			
	360			1,000			8,200			200			280			
8/9/2006	1,200	896	647	200	323	417	400	400	1399	600	796	527	120	145	277	0
	600			600			400			1,400			180			
	1,000			280			400			600			140			
8/16/2006	200	186	412	160	234	308	800	589	1048	400	416	447	400	271	220	0
	180			200			1,600			180			80			
	180			400			160			1,000			620			
8/23/2006	800	783	468	200	288	284	400	512	897	400	824	473	400	400	212	0.92
	600			600			1,200			1,000			200			
	1,000			200			280			1,400			800			
8/31/2006	1,200	783	575	1,400	2752	444	7,600	6688	1404	1,000	1423	686	1,200	916	296	0.12
	1,000			2,400			4,800			1,200			800			
	400			6,200			8,200			2,400			800			
9/6/2006	600	493	550	120	256	434	1,200	1512	1041	260	292	647	1,200	1166	441	0
	200			1,000			1,200			160			600			
	1,000			140			2,400			600			2,200			
9/13/2006	5,000	3932	740	7,400	2666	662	1,200	1572	1369	2,400	2194	793	800	543	575	0
	3,800			1,600			1,800			4,400			1,000			
	3,200			1,600			1,800			1,000			200			
9/20/2006	1,000	1189	1072	600	832	853	1,400	1038	1533	1,600	1592	1037	1,000	928	735	0.21
	1,400			800			1,000			1,800			800			
	1,200			1,200			800			1,400			1,000			
9/27/2006	2,400	1592	1235	400	400	910	1,400	695	1629	400	458	922	200	543	782	0.01
	1,200			400			400			600			1,000			
	1,400			400			600			400			800			

Table 2: MDEQ 2008 Sample *E. coli* Sample Results (*E. coli per* 100 ml) for Farmers Creek Watershed.

	Station 3 Eau Claire Village Drain @ Hochberger Road		Station 6 Unnamed Tributary @ South of Lagoon		Station 7 Unnamed Tributary @ North of Lagoon		Station 8 Eau Claire Village Drain @ West of 2nd		Station 9 Eau Claire Village Drain @ Downstream Eau Claire Rd.		Station 10 Unnamed Tributary @ North of Grace St.		
DATE	**SAMPLE RESULTS**	**DAILY MAX**	**SAMPLE RESULTS**	**DAILY MAX**	**SAMPLE RESULTS**	**DAILY MAX**	**SAMPLE RESULTS**	**DAILY MAX**	**SAMPLE RESULTS**	**DAILY MAX**	**SAMPLE RESULTS**	**DAILY MAX**	**Prior 2 day Precipitation**
4/15/2008	**150**	190	**10**	10	**20**	13	**150**	185	**50**	31	**210**	213	0
	200		**10**		**10**		**150**		**20**		**230**		
	230		<10		**10**		**280**		**30**		**200**		

Table 3: Percent of land area in Farmers Creek watershed located within each municipality.

Township or Municipality	Percent of Watershed in Municipal Boundary
Pipestone	68
Berrien	23
Sodus	<1
Village of Eau Claire	8

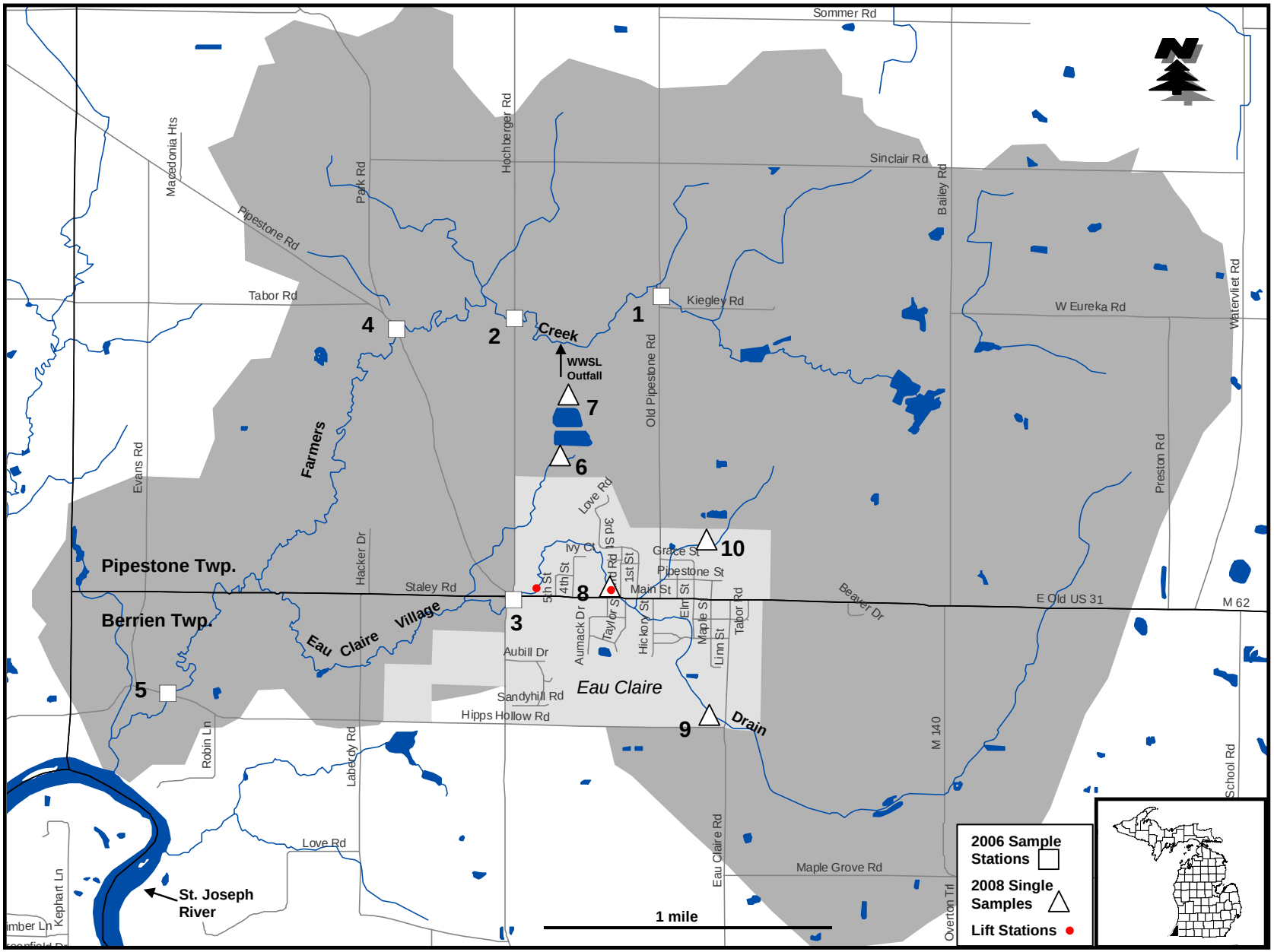
Table 4: NPDES individual permits and COCs with receiving waters in the Farmers Creek watershed.

Designated Name	Permit No.	County	Latitude	Longitude	Receiving Water
Individual Permits					
Alcoa Inc	MI0056626	Berrien	41.98500	-86.29972	Eau Claire Village Drain
Michigan Department of Transportation MS4	MI0057364	Statewide			
Wastewater Sewage Lagoon COC	**General Permit MIG580000 Wastewater Stabilization Lagoon**				
Eau Claire WWSL	MIG580386	Berrien	41.98611	-86.29720	Farmers Creek
Industrial Storm Water COCs	**General Permit MIS319000 Storm Water from Industrial Activities**				
Hofmann Ind-Mich Tube Div	MIS310391	Berrien	41.98778	-86.30440	Eau Claire Village Drain

Table 5: NOCs covered under permit-by-rule MIR100000 potentially in the Farmers Creek watershed.

Designated Name	Permit No.	County	Township
2006 WW System Improvements	MIR109333	Berrien	Berrien

Figure 1. Farmers Creek watershed and *E. coli* sampling locations, Berrien and Pipestone Township, Berrien County, Michigan, 2006.



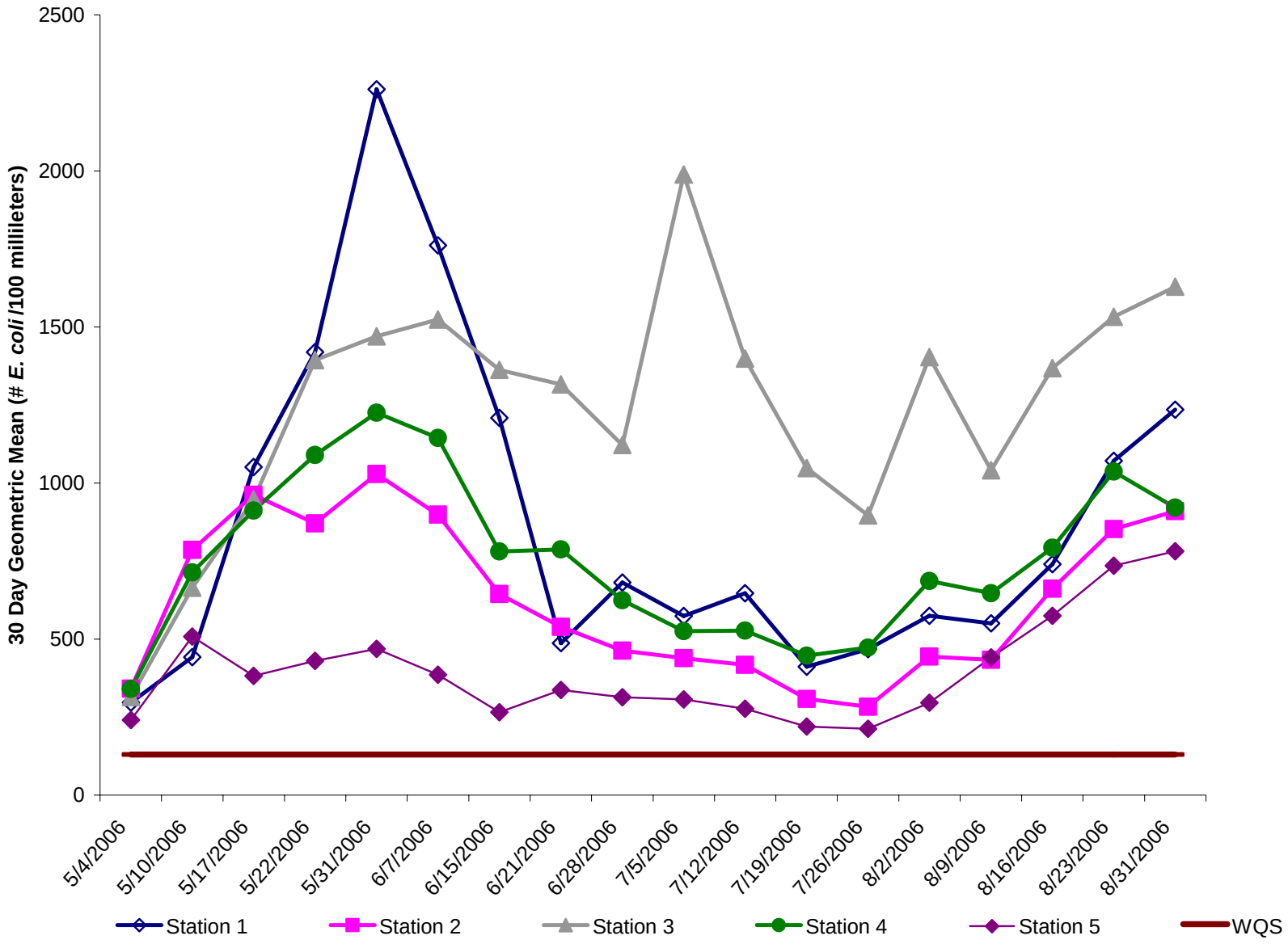


Figure 2. Thirty-day geometric mean values for *E. coli* in Farmers Creek, Berrien County, Michigan, 2006.

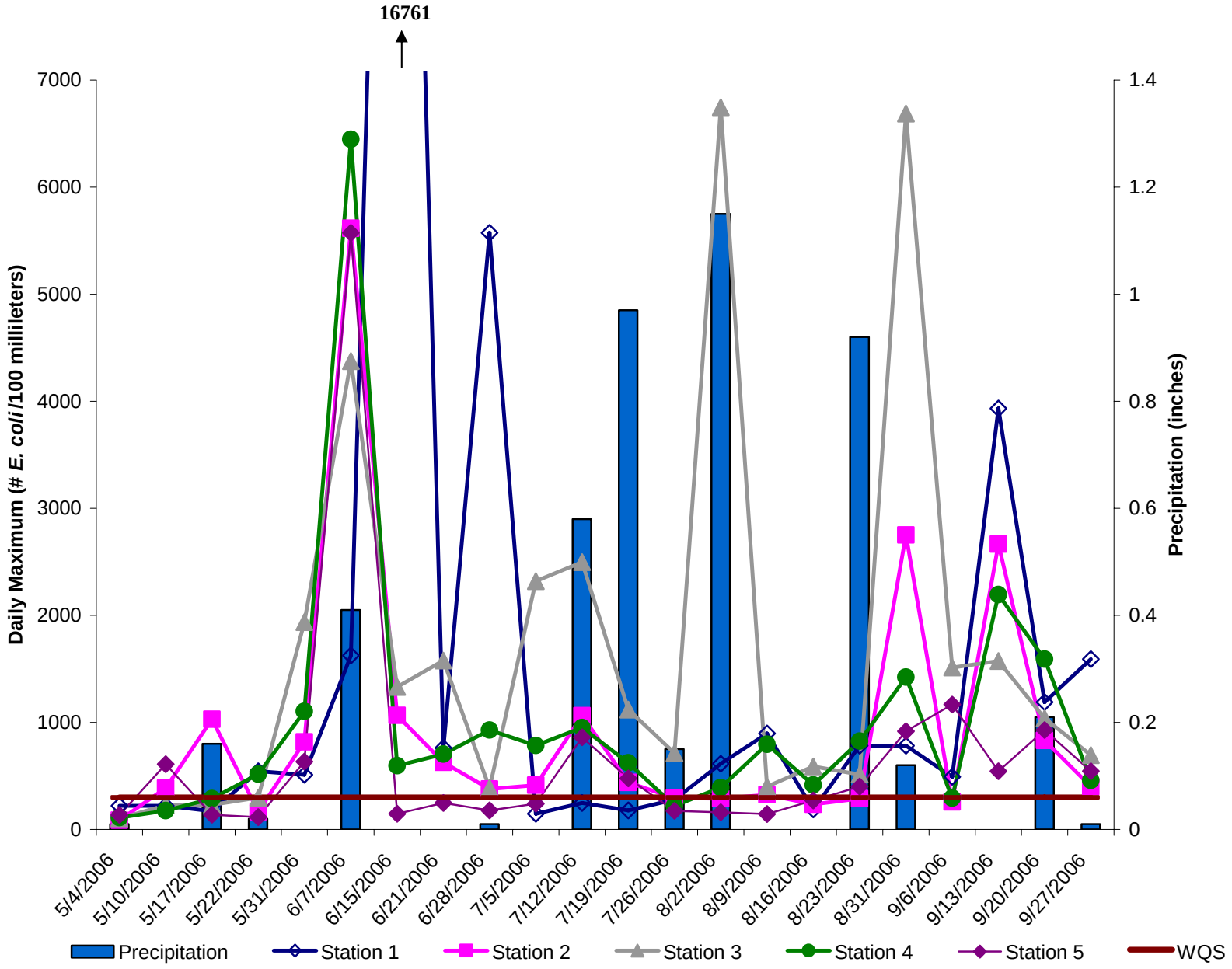


Figure 3. Daily maximum values for *E. coli* with prior 24-hour precipitation values in Farmers Creek, Berrien County, Michigan, 2006.

Figure 4. Farmers Creek at Old Pipestone Road (Station 1). Load duration curve based on daily maximum concentration values.

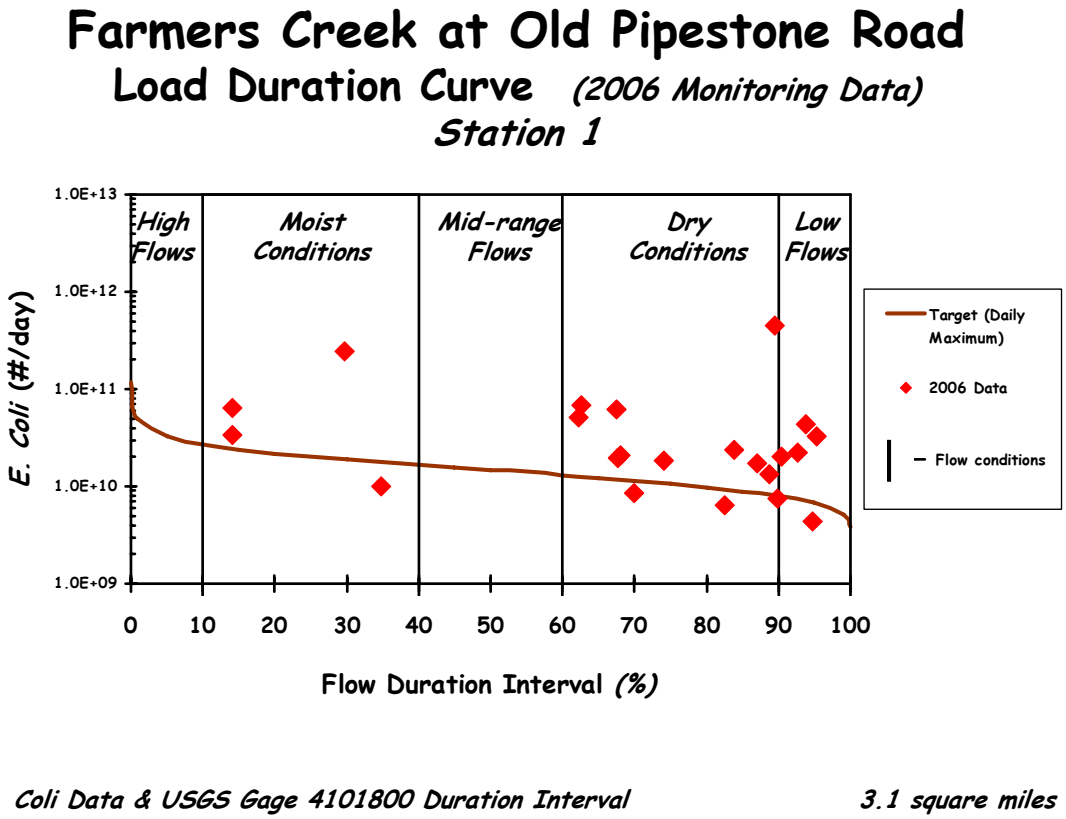


Figure 5. Farmers Creek at Hochberger Road (Station 2). Load duration curve based on daily maximum concentration values.

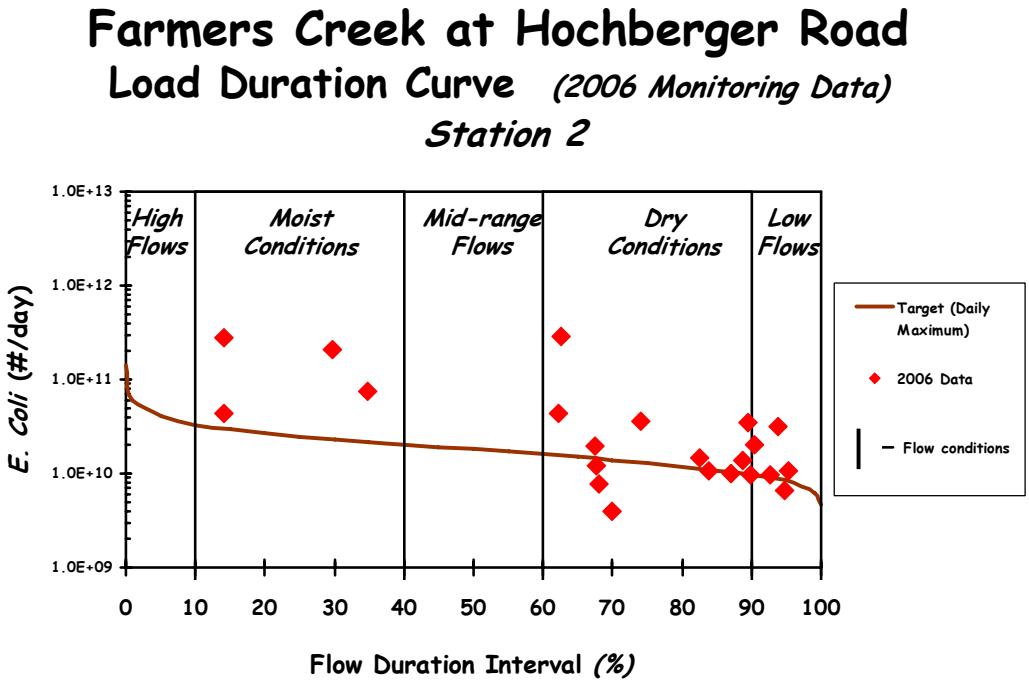


Figure 6. Eau Claire Village Drain at Hochberger Road (Station 3). Load duration curve based on daily maximum concentration values.

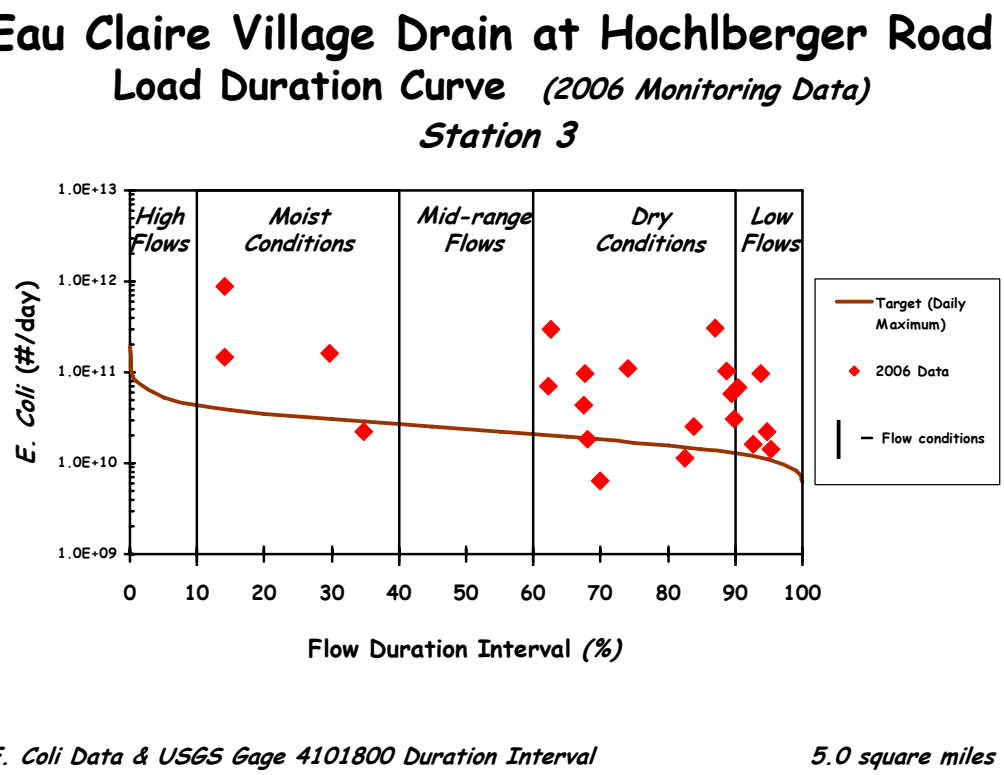


Figure 7. Farmers Creek at Pipestone Road (Station 4). Load duration curve based on daily maximum concentration values.

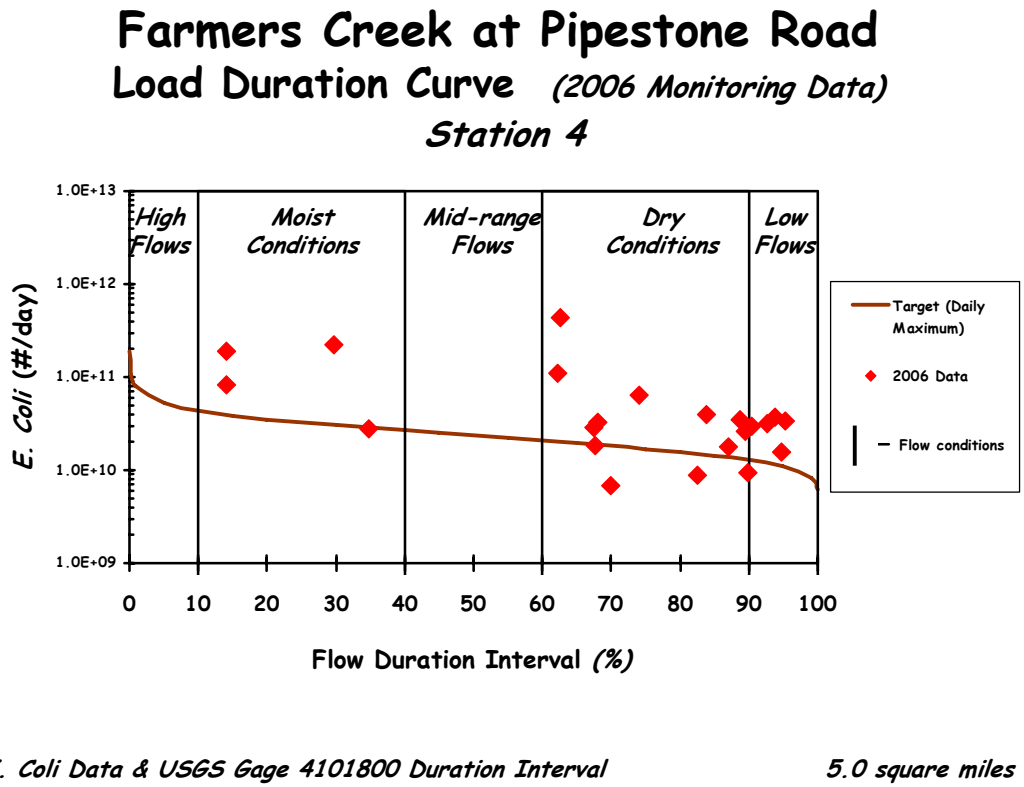
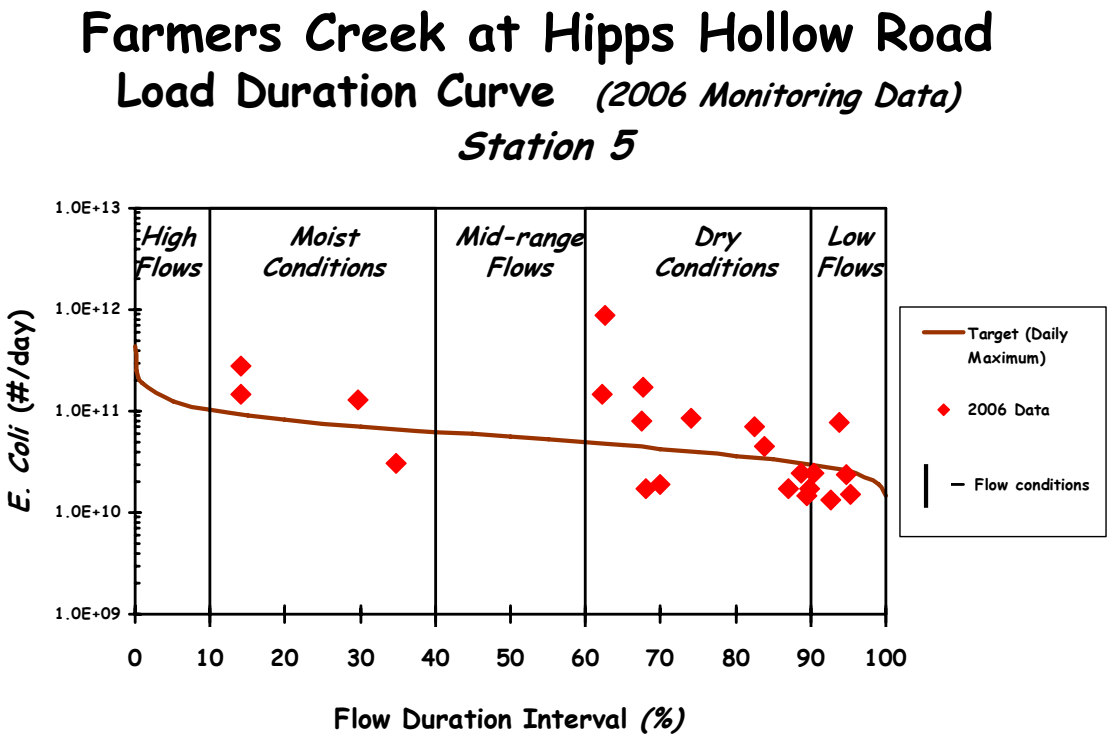


Figure 8. Farmers Creek at Hipps Hollow Road (Station 5). Load duration curve based on daily maximum concentration values.



E. Coli Data & USGS Gage 4101800 Duration Interval *11.7 square miles*