DRAFT

Michigan Department of Environmental Quality
Water Bureau
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Total Maximum Daily Load for *E. coli* for Pine Creek and Mill Creek Berrien and Van Buren Counties

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 Pine Creek and Mill Creek, tributaries of the Paw Paw River, located in Berrien and Van Buren Counties, Michigan.

PROBLEM STATEMENT

The TMDL reach for Pine Creek appears on the 2008 Section 303(d) list (LeSage and Smith, 2008) as:

Water body name: **Pine Creek**
AUID: 040500012507-02, 040500012507-03
Impaired designated use: Partial Body and Total Body Contact Recreation
Cause: *E. coli*
Size: 4.17, 5.81 miles = Total 9.98 miles
Location Description: Pine Creek from the Paw Paw River confluence upstream to 66th Avenue, Pine Creek from 66th Avenue upstream to headwaters
TMDL Year(s): 2009

The TMDL reach for Mill Creek appears on the 2008 Section 303(d) list (LeSage and Smith, 2008) as:

Water body name: **Mill Creek**
AUID: 040500012506-01
Impaired designated use: Partial Body and Total Body Contact Recreation
Cause: *E. coli*
Size: 12.77 miles
Location Description: Mill Creek
TMDL Year(s): 2009

Pine Creek and Mill Creek were first placed on the Section 303(d) list in 2006 for the impairment of recreational uses due to exceedances of the *E. coli* WQS. Data collected by the Michigan Department of Environmental Quality (MDEQ) documented exceedances of the total body contact and partial body contact WQS for *E. coli* at all sampling locations for both Pine Creek

and Mill Creek during the months of July through September 2005 (Tables 1 and 2). This TMDL addresses impaired reaches in the Pine Creek and Mill Creek watersheds (Figures 1 and 2).

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 5 or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of 3 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.

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

Pine Creek was sampled for *E. coli* weekly at five stations from July through September 2005 (Figure 1). Thirty-day geometric mean *E. coli* concentrations ranged from 386 *E. coli* per 100 ml in September in Pine Creek at 64th Street to 6,635 *E. coli* per 100 ml in September at Red Arrow Highway (Table 1). The 30-day geometric mean total body contact recreation WQS was exceeded throughout the entire sampling season at all five stations (Figure 3). Daily maximum concentrations ranged from 290 *E. coli* per 100 ml in September in Pine Creek at 64th Street to 3,787,266 *E. coli* per 100 ml in September at Red Arrow Highway (Table 1, Figure 4). With exception of 64th Street on September 8, the daily maximum *E. coli* concentrations exceeded the daily geometric mean total body contact recreation WQS on every sampling event, often by several orders of magnitude. In fact, concentrations were greater than 100,000 *E. coli* per 100 ml at multiple stations in response to rain events.

Mill Creek and a tributary were sampled for *E. coli* weekly at three stations from July through September 2005 (Figure 2). The 30-day geometric mean total body contact recreation WQS was exceeded throughout the entire sampling season at all three stations (Table 2). Thirty-day geometric mean *E. coli* concentrations in Mill Creek ranged from 845 *E. coli* per 100 ml to 2,696 *E. coli* per 100 ml in September (Figure 5). Daily maximum concentrations ranged from

576 *E. coli* per 100 ml in August to 14,428 *E. coli* per 100 ml in September (Figure 6). Thirty-day geometric mean *E. coli* concentrations in the tributary ranged from 1,041 *E. coli* per 100 ml at 67th Avenue to 4,480 *E. coli* per 100 ml at 77th Avenue in September (Figure 5). Daily maximum concentrations ranged from 654 *E. coli* per 100 ml at 77th Avenue in July to 17,676 *E. coli* per 100 ml at 67th Avenue in September (Figure 6). *E. coli* concentrations were greater than 9,000 *E. coli* per 100 ml at all three stations for the last two sampling events, likely in response to rain events.

SOURCE ASSESSMENT

Pine Creek and Mill Creek, both coldwater tributaries to the Paw Paw River, are located in Berrien and Van Buren Counties. The headwaters (i.e., upstream areas) of both creeks have been dredged to facilitate drainage resulting in flashy flow regimes in these agricultural watersheds (Walterhouse, 2006). United States Geological Survey 2000 land cover data indicate that the Pine Creek watershed is largely cultivated (row) crops (51 percent) while the Mill Creek watershed is approximately 61 percent cultivated (row) crops (USGS, 2001b). A watershed breakdown by municipality can be found in Tables 3 and 4 (MICGI, 2005).

Possible sources of *E. coli* in Pine Creek and Mill Creek include runoff from land application of manure, pastureland runoff, failing septic systems, illicit connections to storm sewers and drains, and inputs from wildlife.

There are two National Pollutant Discharge Elimination System Permits (NPDES) in the Pine Creek watershed: the Michigan Department of Transportation (MDOT) Municipal Separate Storm Sewer System (MS4) (MI0057364), and the Hartford Dairy Concentrated Animal Feeding Operation (CAFO) (MI0057562) (Figure 7). 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* in this watershed. The Hartford Dairy CAFO, under certain weather conditions, is a likely source of *E. coli* to Pine Creek.

The Hartford Dairy farm is a CAFO with approximately 4,900 animal units, the majority of which are dairy cattle. This facility is capable of generating approximately 32.2 million gallons per year of liquid dairy waste and wastewater and regularly applies manure to lands in the Pine Creek watershed (Walterhouse, 2006). The facility's NPDES permit requires development of a Comprehensive Nutrient Management Plan (CNMP) to address soil nutrients. While the CNMP does not address *E. coli*, the information provided indicates that Hartford Dairy has approximately 4,500 acres available for land application of manure. Facility records show that manure was applied to many fields in the Pine Creek watershed between March and September 2005. MDEQ records indicate no direct discharges of manure to Pine Creek between 2004 and 2005; however, it appears that under certain conditions (e.g., wet weather), runoff from the land application of manure is likely a substantial source of *E. coli* to Pine Creek. For instance, the second highest daily geometric mean *E. coli* concentration observed in 2005 – 910,640 *E. coli* per 100 ml at Station 3 – was in response to 0.84 inches of rainfall and was located downstream of manure application sites (Michigan Automated Weather Network [MAWN], 2005; Walterhouse, 2006). Extensive field reconnaissance by MDEQ staff confirmed numerous field tile outlets to Pine Creek. Elevated *E. coli* concentrations collected under wet weather conditions and high stream flow conditions (e.g., July 21, September 14, and September 16, 2005) are consistent with numerous literature studies noting that field tiles are a significant pathway for pathogens (i.e., *E. coli*) to enter surface waters from manure-treated fields, especially during periods of wet weather (Roger and Haines, 2005; Dean and Foran, 1992; Geohring et al., 1999; Hunter et al., 2000; and Monaghan et al., 2004). Statistical analysis of the rainfall event samples collected on July 21, 2005, showed that *E. coli* levels at Station 1 were significantly less than Station 2 ($\alpha = 0.007$) and Station 4 ($\alpha = 0.06$). The watershed upstream of Station 1 did not receive manure application in 2005 (Walterhouse, 2006).

On-site septic systems serve many homes in the Pine Creek and Mill Creek watersheds. In Berrien and Van Buren Counties, it is estimated that there are 30 to 45 septic systems per square mile (*E. coli* Work Group, 2008 draft). When they are not functioning properly, or are poorly designed, they can be another potential source of *E. coli* contamination. Neither county maintains point-of-sale septic inspection records, thus, we have no indication of the on-site septic system failure rate for the impaired watersheds. However, based on information obtained from other county health departments statewide, the on-site septic system failure rate across Michigan reportedly averages 5 to 10 percent (*E. coli* Work Group, 2008 draft). The incidence of failure is variable depending on geology, age of the septic system, and stringency of local regulations. Officials from the Van Buren County Health Department indicate they have not performed septic system inspections, nor are they aware of specific failures, in the Pine or Mill Creek watersheds.

The city of Hartford is located at the lower end of the Pine Creek watershed, in the vicinity of Station 5. This community is not under an MS4 permit and it is not known if illicit connections to the storm sewer system are a potential source of *E. coli* to Pine Creek. Illicit connections to storm sewers can result in the discharge of untreated sanitary wastewater to separated sewer systems and surface waters. In some cases, an illicit discharge may be a direct discharge of sanitary wastewater from a sanitary sewer improperly discharging to a water body. In other cases wastewater may infiltrate to a storm sewer from a dilapidated sanitary sewer. It is worth noting that the highest daily geometric mean *E. coli* concentration – 3,787,266 *E. coli* per 100 ml, occurred at Station 5 on September 16, 2005.

Wildlife contributions are also a potential source of *E. coli* to Pine Creek. MDEQ site reviews in the watershed noted open water ponds where waterfowl may be present as well as the presence of deer. In addition, the state of Michigan manages property for wildlife upstream of Station 1.

There are three NPDES permits in the Mill Creek watershed: the MDOT MS4, and two certificates of coverage (COCs) under a general industrial storm water permit: Orchard Hill LF – Watervliet, and Norm and Sons Auto Salvage (Table 5, Figure 7). 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* in this watershed. The COCs for industrial storm water, due to the nature of their discharge, are not expected to be sources of *E. coli.* There are no CAFO permitted facilities in the Mill Creek watershed; however, the Hartford Dairy CAFO (MI0057562) does apply manure to some fields in the watershed.

As discussed in the Data Discussion section, the daily and monthly geometric mean WQS were exceeded in the upstream portions of Mill Creek on every sampling event. The *E. coli* concentrations in Mill Creek, and its tributaries, showed no obvious differences between stations; however, dry weather WQS exceedances appear to be higher in Mill Creek relative to Pine Creek. Field reconnaissance indicates that the watershed upstream of Station 6 is predominately agricultural land, with some wood lots, suggesting that wildlife contributions may be one potential source of *E. coli*. The watershed in the vicinity of Stations 7 and 8 are devoted to row crop agriculture and residential use. These stations are both located adjacent to fields that received manure application in 2005. Small animal pastures were also noted in the watershed.

Mill Creek, like Pine Creek, expressed similar peaks in *E. coli* concentrations in response to precipitation events (e.g., July 21, September 14, and September 16, 2005); however, wet weather *E. coli* concentrations appear to be several-fold lower relative to Pine Creek. The highest observed daily geometric mean in the Mill Creek watershed was 17,676 *E. coli* per 100 ml versus 3,787,266 *E. coli* per 100 ml in Pine Creek under the same precipitation event.

Differences in the magnitude of *E. coli* concentrations between Mill Creek and Pine Creek in wet weather could be the result of fewer manure application sites in the Mill Creek watershed.

LOADING CAPACITY (LC) DEVELOPMENT

The LC represents the maximum loading of a pollutant 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 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

Table 5 outlines the NPDES permitted point source discharges to the Pine Creek and Mill Creek watersheds. There are two permitted discharges in the Pine Creek watershed - Hartford Dairy CAFO (MI0057562) and the statewide storm water permit for MDOT. There are three permitted discharges to the Mill Creek watershed - two industrial storm water COCs, and the statewide storm water permit for MDOT. The WLA for the permits in Table 5 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 (Tables 3 and 4).

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 WQS.

MONITORING

Pathogens were monitored weekly at five stations on Pine Creek and three stations in the upper watershed of Mill Creek from July through September 2005. 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

The statewide MDOT MS4 permit requires the permittee to reduce the discharge of pollutants to the maximum extent practicable and employ Best Management Practices to comply with TMDL requirements. The general industrial storm water permits (i.e., MIS310115 and MIS310349) require that if there is a TMDL established by the MDEQ for the receiving water that restricts a

material that could impair or degrade water quality, then the required storm water pollution prevention plan shall identify the level of control for those materials necessary to comply with the TMDL and estimate the current annual load of those materials via storm water discharges to the receiving stream.

The Hartford Dairy CAFO is required to submit a CNMP as part of their NPDES permit obligation, which requires a plan for the storage and disposal (land application) of animal waste. This facility has submitted a complete CNMP. CAFO permits also require the facility to employ a certified operator to manage animal waste, possess waste storage structures with a minimum of six months storage capacity, and limit the spreading of manure on frozen ground. These actions are intended to prevent *E. coli* from entering the impaired water bodies.

Pine Creek and Mill Creek are tributaries of the Paw Paw River and located within a network of knowledgeable citizens and organizations (e.g. the Southwestern Michigan Planning Commission) interested in water quality protection. These groups organized to produce the Paw Paw River Watershed Management Plan (PPRWMP) (MDEQ grant tracking number 2005-0115) in August 2008. This watershed was identified as a priority for protection and preservation among southern Michigan watersheds because a relatively high percentage of its natural land cover remains in spite of increasing development pressure throughout the region.

The Pine Creek and Mill Creek watersheds have been identified as high priority agricultural management areas based on significant water body impairments (i.e., known *E. coli* WQS exceedances), estimated pollutant loadings, amount of agriculture land cover, and problems identified by local/state officials and volunteer information. The PPRWMP implementation activities identify actions in high and medium priority agricultural areas to be completed within the next five years, some of which may substantially decrease *E. coli* concentrations in Pine and Mill Creeks. Some activities include: restore riparian buffers, restore and protect wetlands (preventing overland runoff), prevent/limit livestock access, and installing agricultural best management practices (e.g., filter strips, no-till, cover crops, grassed waterways). Future activities include the development of manure management plans and improved and/or enforcement of septage waste disposal regulations. The PPRWMP also places a high priority on enacting a septic system time-of-sale inspection ordinance in the watershed. This could greatly benefit water quality in the Pine Creek and Mill Creek watersheds by locating and potentially correcting failing or poorly operating on-site septic systems thereby reducing *E. coli* contributions to the watersheds.

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Table 1. MDEQ 2005 *E. coli* monitoring data (*E. coli per* 100 ml) for Pine Creek.

	Pine Creek @ 72nd Ave.			Pine Creek @ 64th St.			Pine Creek @ Private Rd.			Pine Creek @ 66th Ave.			Pine Creek @ Red Arrow Hwy.		
	1			2			3			4			5		
DATE	Sample Results	Daily G. Mean	30-day G. Mean	Sample Results	Daily G. Mean	30-day G. Mean	Sample Results	Daily G. Mean	30-day G. Mean	Sample Results	Daily G. Mean	30-day G. Mean	Sample Results	Daily G. Mean	30-day G. Mean
7/7/2005	3100	2745	---	1100	1283	---	1800	1485	---	1500	1452	---	1100	1464	---
	2900			1200			1400			1200			1500		
	2300			1600			1300			1700			1900		
7/14/2005	1100	1382	---	2600	1673	---	2400	1715	---	2100	2262	---	2900	2919	---
	1500			1000			1500			2900			3300		
	1600			1800			1400			1900			2600		
7/21/2005	3100	1502	---	210000	211105	---	230000	140272	---	150000	194694	---	25000	35088	---
	840			140000			120000			410000			72000		
	1300			320000			100000			120000			24000		
7/28/2005	1200	621	---	1500	1182	---	1900	2349	---	2500	1847	---	5600	3482	---
	400			1100			2200			1800			2900		
	500			1000			3100			1400			2600		
8/4/2005	2700	2756	1577	4100	4459	4738	1000	1281	4039	1400	1361	4377	800	796	3340
	2500			4600			1500			1500			700		
	3100			4700			1400			1200			900		
8/11/2005	1100	851	1248	340	303	3549	450	440	3166	1300	1013	4073	1100	1018	3106
	700			340			510			1000			600		
	800			240			370			800			1600		
8/18/2005	2300	2776	1434	440	453	2733	510	493	2467	800	1018	3472	900	965	2489
	3100			450			490			1200			1000		
	3000			470			480			1100			1000		
8/25/2005	1700	1736	1477	600	513	820	380	361	749	1000	928	1192	1000	1080	1241
	1400			500			400			800			1400		
	2200			450			310			1000			900		
9/1/2005	460	456	1388	360	420	667	1200	1161	650	1000	1419	1131	780	864	939
	420			480			1500			2200			950		
	490			430			870			1300			870		
9/8/2005	1700	1764	1270	280	290	386	350	360	505	2800	2274	1253	1000	928	968
	1700			290			360			2000			800		
	1900			300			370			2100			1000		
9/14/2005	5300	4935	1804	21000	20856	900	4000	4516	804	25000	22942	2339	3600	3919	1268
	4200			24000			4900			23000			4400		
	5400			18000			4700			21000			3800		
9/16/2005	2110	1980	1686	660000	674236	3880	790000	910640	3619	700000	---	---	3760000	3787266	6635
	2150			860000			1210000			1430000			3980000		
	1710			540000			790000			*			3630000		

Table 2. MDEQ 2005 *E. coli* monitoring data (*E. coli per* 100 ml) for Mill Creek and Tributary.

	Mill Creek Tributary @ 77th Ave.			Mill Creek Tributary @ 67th Ave.			Mill Creek @ Hill Rd.			
	6			7			8			
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	Precip. (inches) preceding 24 hours
7/7/2005	3500	2940	---	2300	1902	---	1000	1054	---	0
	3300			2300			1300			
	2200			1300			900			
7/14/2005	2500	2887	---	3200	2057	---	970	895	---	0.1
	2600			1700			840			
	3700			1600			880			
7/21/2005	2100	1788	---	2200	2454	---	5200	3560	---	0.47
	1600			2400			2800			
	1700			2800			3100			
7/28/2005	900	654	---	1800	2175	---	5000	6910	---	0
	610			2200			6000			
	510			2600			11000			
8/4/2005	1900	1992	1816	670	1040	1851	1400	1472	2026	0.05
	1600			1200			1900			
	2600			1400			1200			
8/11/2005	1600	1806	1648	1400	1322	1721	1000	896	1962	0.01
	1600			1500			900			
	2300			1100			800			
8/18/2005	800	958	1322	1200	1104	1520	600	632	1830	0.14
	1000			1400			600			
	1100			800			700			
8/25/2005	2000	2605	1425	1000	1528	1382	600	576	1271	0
	3400			1700			490			
	2600			2100			650			
9/1/2005	3400	3473	1990	810	752	1118	1500	1281	907	0
	2800			640			1400			
	4400			820			1000			
9/8/2005	1500	1328	1835	770	729	1041	1000	1032	845	0
	1300			800			1000			
	1200			630			1100			
9/14/2005	15000	16619	2860	16000	17673	1749	8000	12958	1442	0.34
	18000			23000			16000			
	17000			15000			17000			
9/16/2005	11900	9036	4480	9200	10695	2754	14800	14428	2696	0.84
	15500			10900			13900			
	4000			12200			14600			

Table 3: Percent of land area in Pine Creek watershed located within each municipality (Southwestern Michigan Planning Commission, 2008).

Township or Municipality	Percent of Watershed in Municipal Boundary
Hartford	64
Watervliet	16.4
Keeler	8.2
city of Hartford	5.7
Pokagon Band of Potawatomi Indians	4.6
city of Watervliet	1.1

Table 4. Percent of land area in Mill Creek watershed located within each municipality (MICGI, 2005; USGS, 2001a).

Township or Municipality	Percent of Watershed in Municipal Boundary
Bainbridge	35.1
Keeler	34.5
Watervliet	16.6
Hartford	10.8
city of Watervliet	2.1
Coloma	0.9

Table 5: NPDES individual permits and COCs with receiving waters in the Pine Creek and Mill Creek watersheds.

Designated Name	Permit No.	County	Latitude	Longitude	Receiving Water
Individual Permits					
Harford Dairy CAFO (Pine Creek)	MI0057562	VanBuren	42.16251	-86.18342	Pine Creek
Michigan Department of Transportation MS4 (Pine Creek and Mill Creek)	MI0057364	Statewide	---	---	---
Industrial Storm Water COCs	**General Permit MIS319000 Storm Water from Industrial Activities**				
Orchard Hill LF – Watervliet (Mill Creek)	MIS310115	Berrien	42.17083	-86.27917	Knapp Drain
Norm & Sons Auto Salvage (Mill Creek)	MIS310349	Berrien	42.16250	-86.22500	Brandywine Creek

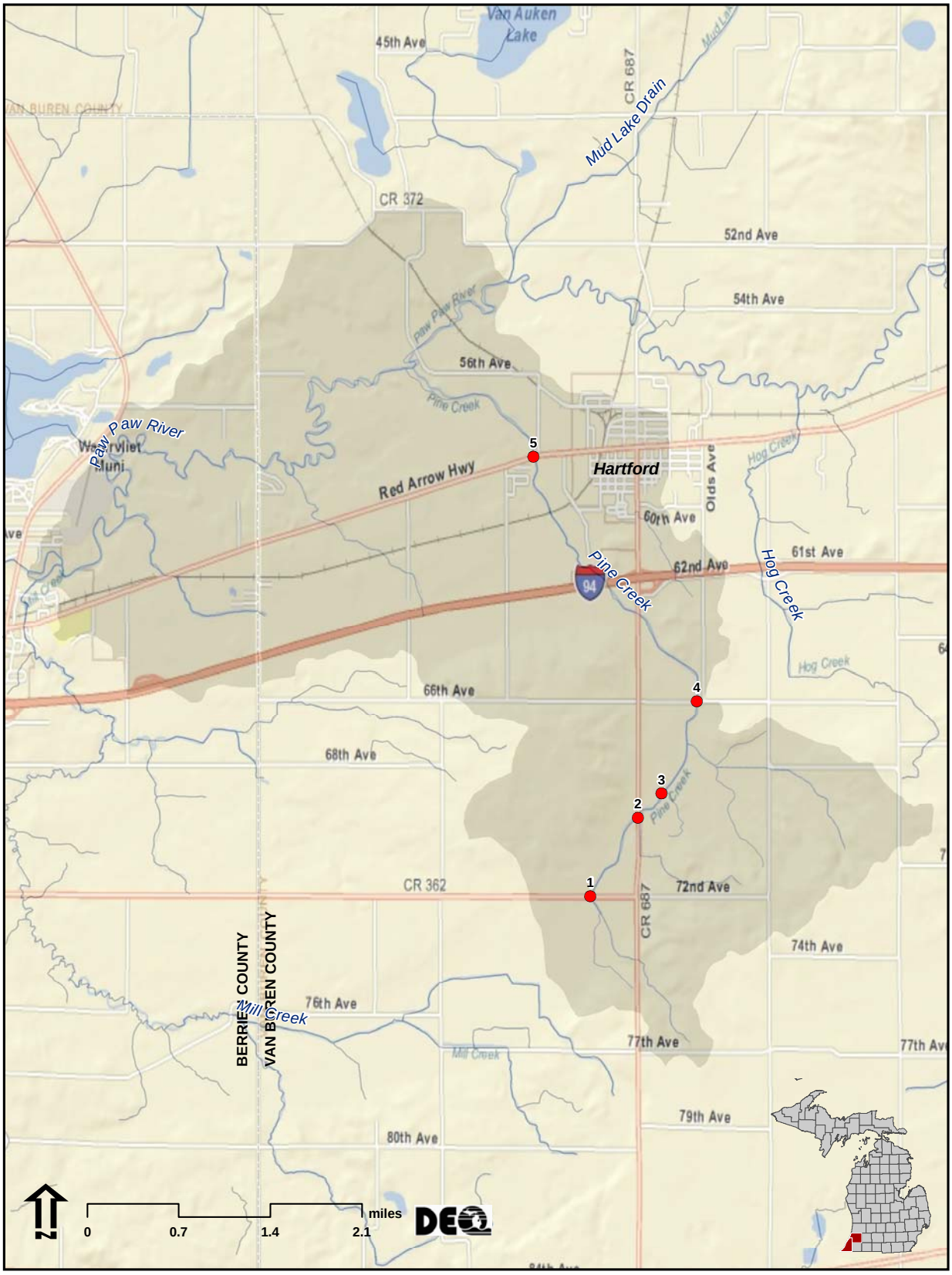

Figure 1. 2005 *E. coli* sampling locations in the Pine Creek watershed, Van Buren County, Michigan.

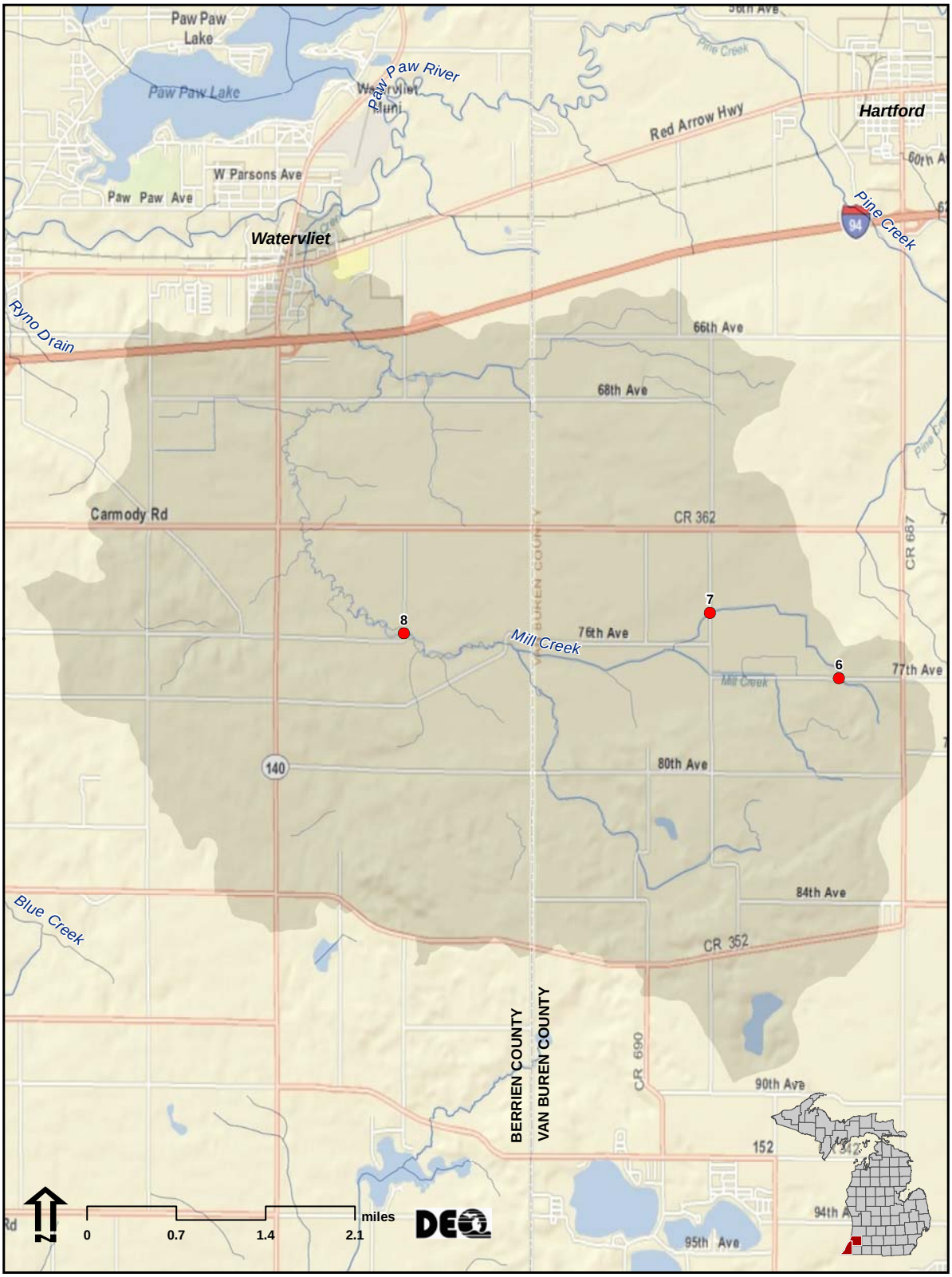

Figure 2. 2005 *E. coli* sampling locations in the Mill Creek watershed, Berrien and Van Buren Counties, Michigan.

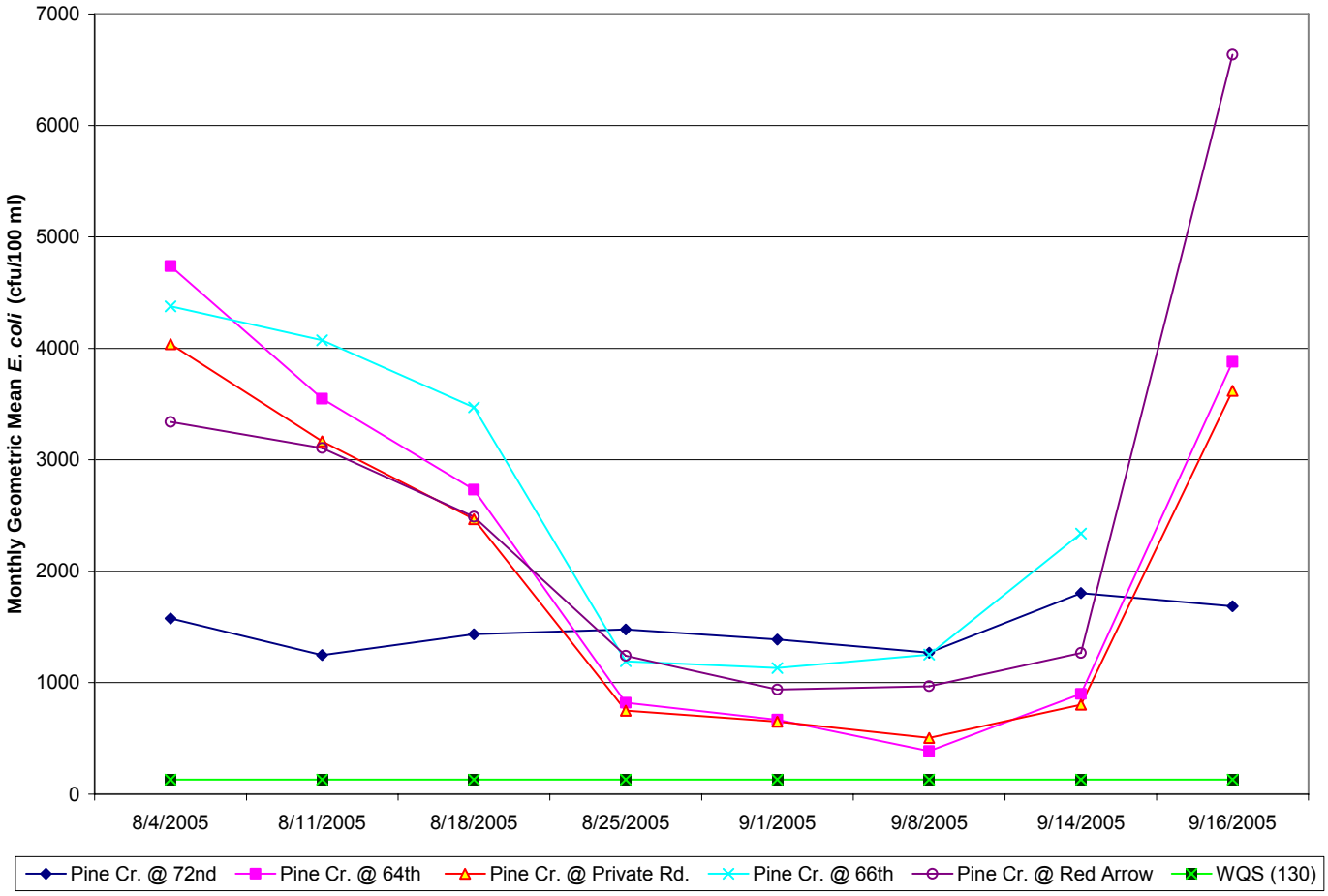

Figure 3. Monthly Geometric mean concentrations for *E. coli* in Pine Creek, Van Buren County, Michigan, 2005.

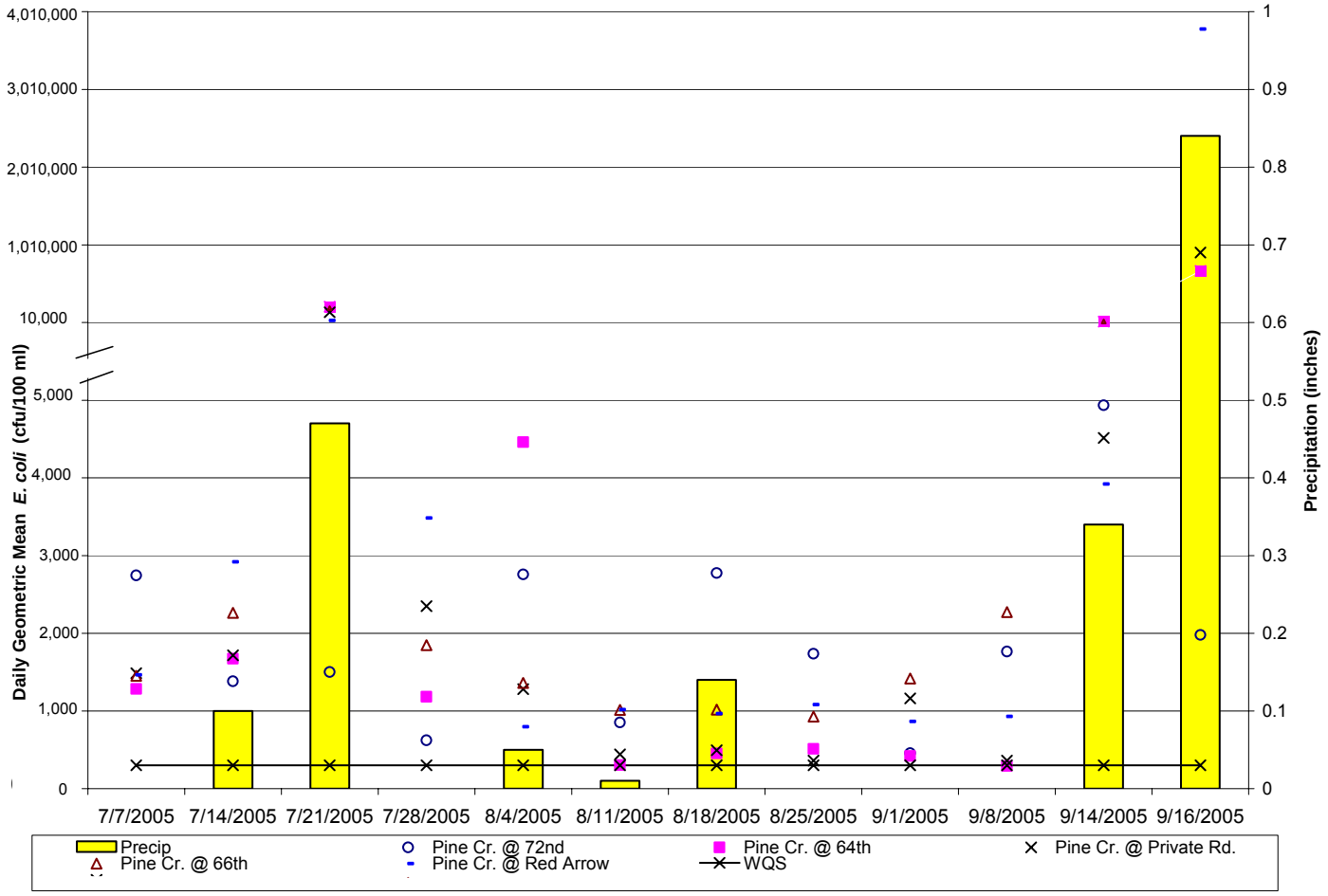

Figure 4. Daily maximum values for *E. coli* and precipitation within the prior 24 hours in Pine Creek, Van Buren County, Michigan, 2005.

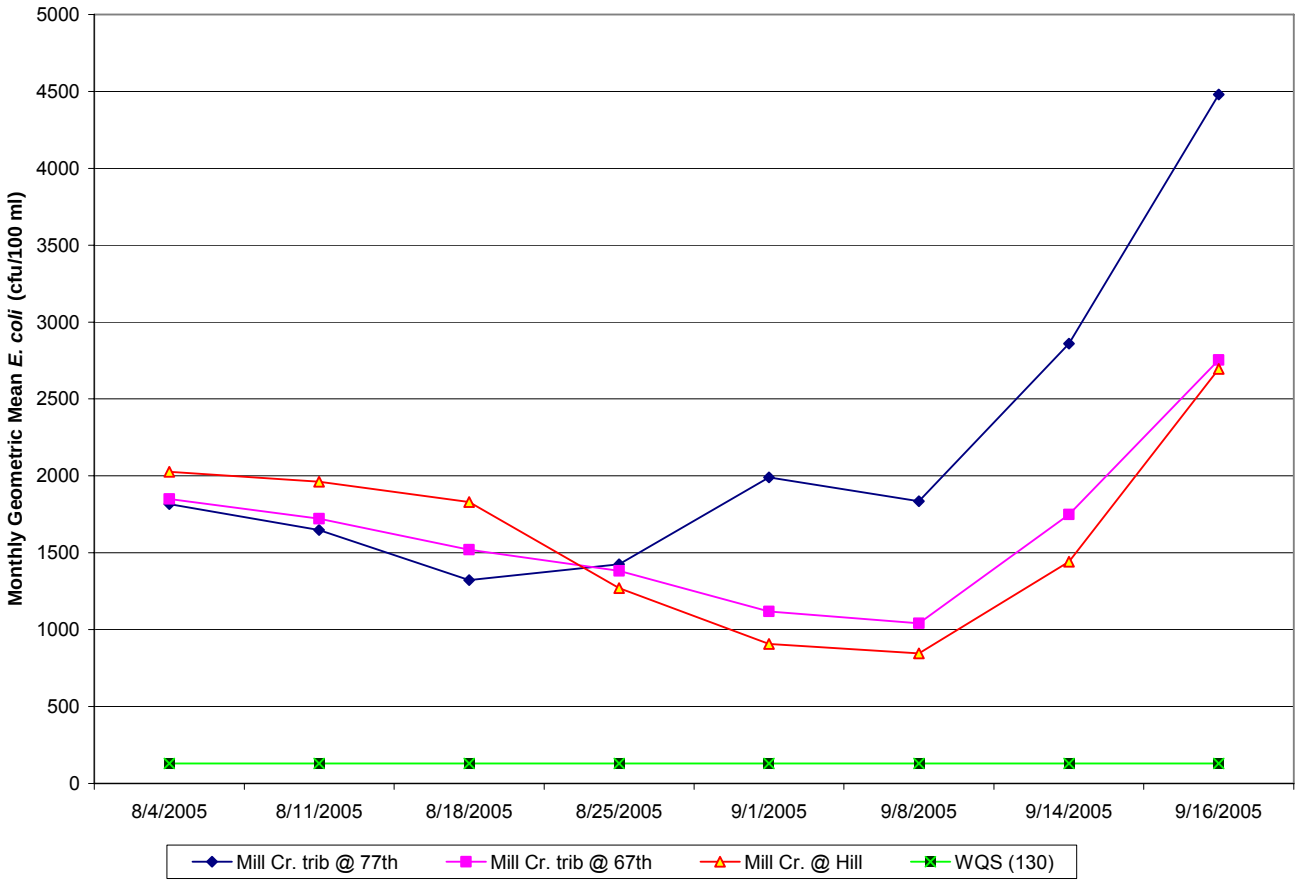

Figure 5. Monthly Geometric mean concentrations for *E. coli* in the Mill Creek watershed, Van Buren and Berrien Counties, Michigan, 2005.

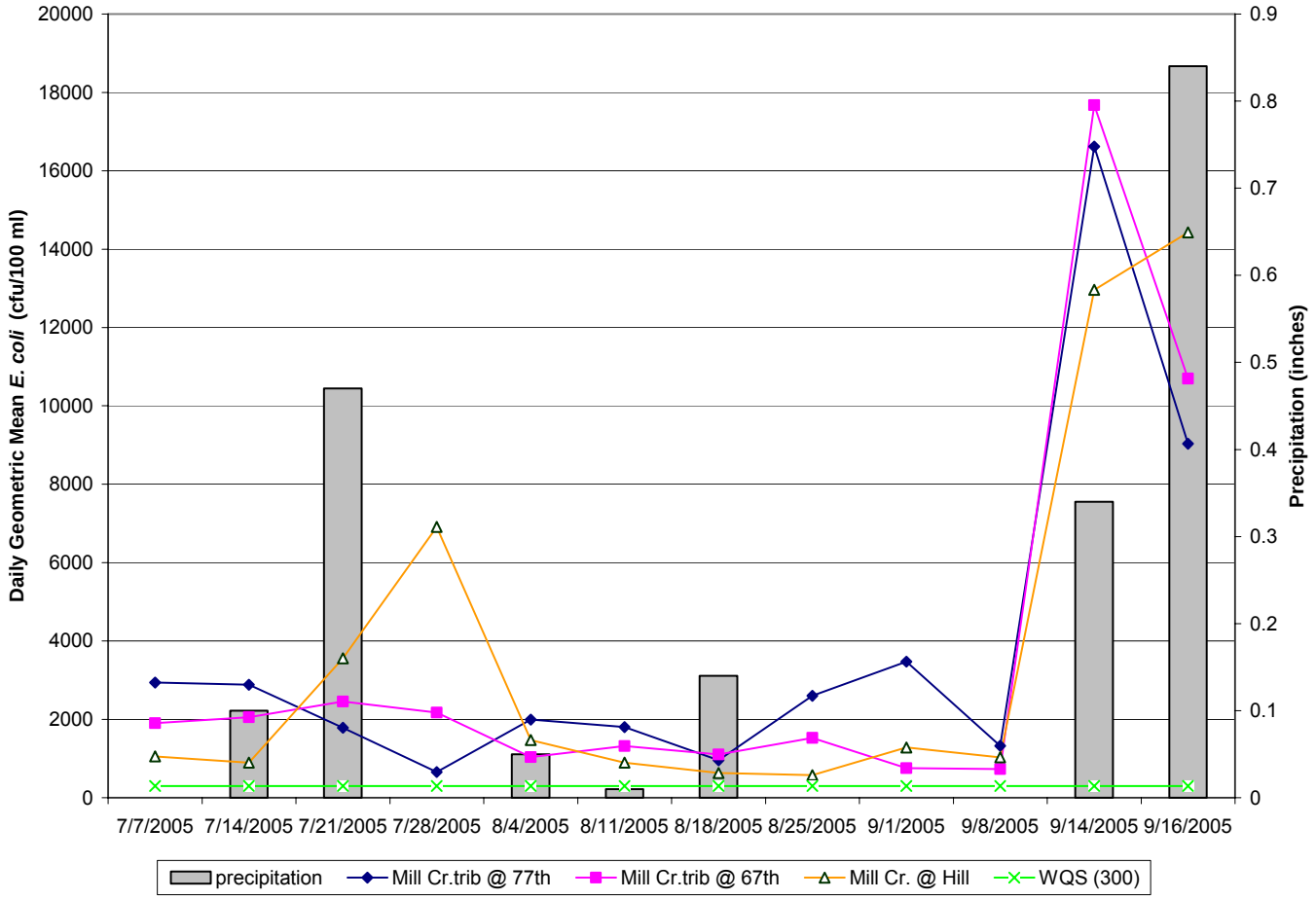

Figure 6. Daily maximum values for *E. coli* and precipitation within the prior 24 hours in the Mill Creek watershed, Van Buren and Berrien Counties, Michigan, 2005.

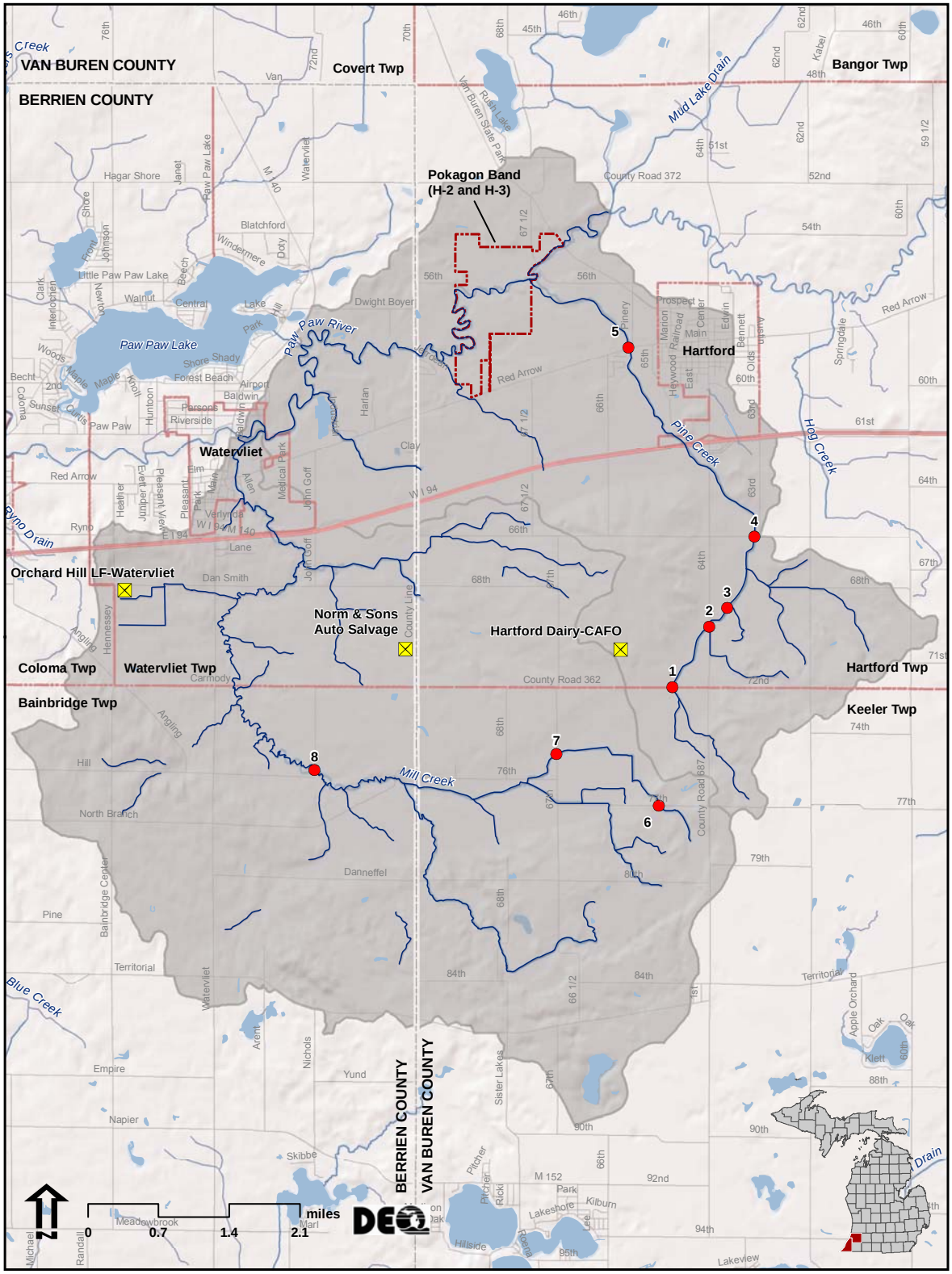

Figure 7. NPDES permit locations in the Pine Creek and Mill Creek watersheds, Berrien and Van Buren Counties, Michigan. (Pokagon Band of Potawatomi Indian property delineations obtained at http://www.pokagon.com/environmental.htm).