Michigan Department of Environmental Quality
Water Bureau
May 2005

Total Maximum Daily Load for *Escherichia coli* for The Coldwater River and Bear Creek (Tyler Creek) Kent, Ionia, and Barry 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 (CFR), 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 *Escherichia coli* (*E. coli*) that will result in the attainment of the applicable WQS in the Coldwater River and Bear Creek (Tyler Creek), both tributaries of the Thornapple River, which are located in Kent, Ionia, and Barry Counties, Michigan. It should be noted that Bear Creek (Kent County) and Tyler Creek (Ionia County) are the same water body and will be referred to as Bear Creek for the remainder of this document.

PROBLEM STATEMENT

This TMDL addresses two listings: The Coldwater River and Bear Creek, both located in Kent, Ionia, and Barry Counties. The TMDL reach for the Coldwater River and Bear Creek appears on the Section 303(d) list as:

COLDWATER RIVER WBID#: 082811F
County: Kent Size: 6 M
Location: Morse Lake Avenue (Kent County) crossing u/s to Brown Road (Barry County) in the vicinity of Freeport.
HUC: 4050007 RF3RchID: 4050007 23
Problem: Pathogens (Rule 100).
TMDL YEAR(s): 2005

BEAR CREEK (TYLER CREEK) WBID#: 082811E
County: Kent Size: 7.6 M
Location: Coldwater River confluence u/s to Kent Co./Ionia Co. line.
HUC: 4050007 RF3RchID: 4050007 27
Problem: Pathogens (Rule 100).
TMDL YEAR(s): 2006

The Coldwater River and Bear Creek were placed on the Section 303(d) list due to impairment of recreational uses as indicated by the presence of elevated levels of *E. coli* (Figure 1) (Wolf and Wuycheck, 2004). Monitoring data collected by the Michigan Department of Environmental Quality (MDEQ) in 2004, documented exceedances of the WQS for *E. coli* at all sampling locations during the total body contact recreational season of May 1 and October 31 (Tables 1-4).

NUMERIC TARGET

The impaired designated use addressed by this TMDL is total body contact recreation. Rule 100 of the Michigan WQS requires that this water body be protected for total body contact recreation from May 1 to October 31. The target levels for this designated use 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.

In addition, sanitary wastewater discharges have an additional target:

> 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 milliliters (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 are substantially higher than *E. coli* when the wastewater of concern is sewage (Whitman, 2001). Therefore, it can reasonably 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 are the target levels for the TMDL reach from May 1 to October 31. As previously stated, the 2004 monitoring data indicated exceedances of WQS at all locations sampled.

DATA DISCUSSION

The Coldwater River was sampled at seven locations (Figure 2). Thirty-day geometric mean *E. coli* concentrations ranged from 56 *E. coli* per 100 ml in August at Brown Road to 547 *E. coli* per 100 ml in September at Messer Road (Table 1, Figures 2 and 3). Daily geometric mean concentrations ranged from 3 *E. coli* per 100 ml in October at M-43/Carleton Road to 3,727 *E. coli* per 100 ml in August at Messer Road. Overall, all stations exceeded the thirty-day geometric mean from early July to mid-August. Three stations, Morse Lake, Messer, and M-43/Carleton, exceeded WQS from early July through the remainder of the sampling season. The M-43/Carleton Road station had the highest consistent *E. coli* concentrations of those sampled on the Coldwater River. The Messer Road station exhibited similar exceedances to those noted upstream at M-43/Carleton Road until the end of August. For several weeks, *E. coli*

concentrations at Messer Road exceeded upstream concentrations, suggesting a localized source. It should be noted that this station is located downstream of the Messer Brook Creek confluence. Exceedances found in this tributary generally do not appear to correspond to exceedances found at Messer Road with the exception of sample results from August 30th. Particularly high exceedances were noted at the M-43/Carleton Road and Messer Road stations on August 30th as indicated by concentrations greater than 2,000 *E. coli* per 100 ml as a daily geometric mean (Table 1).

Two small tributaries of the Coldwater River, Messer Brook Creek and Duck Creek, were also sampled. In general, *E. coli* concentrations in Messer Brook Creek were higher relative to Duck Creek. Thirty-day geometric mean *E. coli* concentrations ranged from 46 *E. coli* per 100 ml in August in Duck Creek to 1,294 *E. coli* per 100 ml in September in Messer Brook Creek (Table 2, Figures 2 and 4). Daily geometric means ranged from 10 *E. coli* per 100 ml in August in Duck Creek to 4,081 *E. coli* per 100 ml in September at Messer Brook Creek (Table 2). Several daily geometric mean exceedances greater than 1,000 *E. coli* per 100 ml were found in Messer Brook Creek.

The second portion of this TMDL listing includes Bear Creek, a large tributary of the Coldwater River (Figure 5). Bear Creek was sampled at seven locations. Thirty-day geometric mean *E. coli* concentrations ranged from 69 *E. coli* per 100 ml in August at 92nd Street to 814 *E. coli* per 100 ml in July at 84th Street (Table 3, Figure 6). Daily geometric means ranged from 63 *E. coli* per 100 ml in October at Nash Road to 1,869 *E. coli* per 100 ml in May at 76th Street (Table 3). With exception of Bear Creek at 92nd Street, all stations exceeded WQS the entire sampling season. Generally, the highest concentrations were found at the 84th Street station. It should be noted that *E. coli* concentrations at 100th Street were considerably higher relative to the upstream station at 92nd Street. The station at 100th Street is in close proximity to Walton Drain, a small tributary that may be a source of *E. coli*.

Pratt Lake Creek, tributary to Bear Creek, indicated exceedances at all three locations sampled. Similar patterns of increasing and decreasing concentrations can be noted over the sampling period. Overall, the furthest downstream station, 84th Street, exhibited the highest concentrations. Thirty-day geometric mean *E. coli* concentrations ranged from 25 *E. coli* per 100 ml in August at 60th Street to 517 *E. coli* per 100 ml in October at 84th Street (Table 4, Figure 7). Daily geometric means ranged from 2 *E. coli* per 100 ml in August at 60th Street to 2,700 *E. coli* per 100 ml in September at 64th Street (Table 4).

SOURCE ASSESSMENT

The official listed reach for the Coldwater River and Bear Creek are approximately 6 miles from Morse Lake Avenue in Kent County, upstream to Brown Road in Berry County; and approximately 7.6 miles from the Coldwater River confluence upstream to the Kent and Ionia County line. The municipalities making up the largest portion of the TMDL watershed include Bowne Township, Odessa Township, Campbell Township, and Carlton Township (Figure 1). Table 5 shows the distribution of land for each municipality.

The primary pathogen sources for these water bodies are agricultural and to a lesser degree, suburban land uses. Specific sources include agricultural runoff, failing septic systems, and urban runoff. Historical data collected by the Kent County Health Department from 1999 to 2002 in the Coldwater River at Freeport and Morse Lake Roads indicate *E. coli* concentrations were routinely above the WQS (Kent County Health Department, 2002). Additional health department sampling conducted on Bear Creek at 92nd Street also indicate elevated levels of *E. coli* from 1999 to 2002.

Agriculture accounts for approximately 70% of the land use in the TMDL watershed (Grand Valley, 2003). *E. coli* has been shown to enter water bodies from land application sites via field drainage systems, such as tiles. Other possible sources of *E. coli* from agriculture include production area runoff and runoff from pasture land. Field tiles have shown significant transport of enteric bacteria through tile drainage systems under all manure application protocols and environmental conditions (Jamieson, et al., 2002). A citation for illegal discharges of agricultural runoff to a tributary of the Coldwater River was issued by the MDEQ to an agricultural operation on May 21, 2004 (Tompkins, 2004).

Local watershed activities have identified 290 nonpoint sources of sediment resulting from streambank erosion, overland stormwater runoff, and livestock generated erosion. Erosion is another pathway for *E. coli* to enter a water body (Grand Valley, 2003).

One sample on Bear Creek was collected for Deoxyribonucleic acid (DNA) ribotyping analysis. This is a relatively new technology that extracts DNA from *E. coli* isolates and compares the DNA to a library of known source isolates. The sample was collected at Bell Road on July 15, 2004. The results from this sample indicate all isolates were of nonhuman origin (Table 6).

Currently, there are 23 NPDES permitted discharges to the Coldwater River, Bear Creek, or their tributaries in the TMDL reach (Table 7, Figure 8): two individual permits, three Concentrated Animal Feeding Operations (CAFO) permits, five general and/or industrial storm water permits, and thirteen Notice of Coverage (NOC) permits. The Bowne Township Wastewater Treatment Plant (WWTP) (MI0055697) and the Lakewood Wastewater Authority WWTP (MI0042978) are permitted to discharge treated human waste. The CAFO permits allow a discharge from process/production area wastewater, and/or manure overflow, silage leachate, and runoff from precipitation events providing that the discharge does not cause or contribute to a violation of Michigan's WQS. The general and/or industrial storm water discharges are not considered to contain treated or untreated human sewage or animal waste; therefore, they are not deemed a significant source of *E. coli* to the Coldwater River and Bear Creek TMDL watershed. The NOC permits involve earthwork in the TMDL watershed, which is not considered a considerable source of *E. coli*.

LINKAGE ANALYSIS

Determining the link between the *E. coli* concentrations in the Coldwater River and Bear Creek and the potential sources are necessary to develop the TMDL. This link provides the basis for estimating the total assimilative capacity of the water bodies and any needed load reductions. For this TMDL, the loadings of pathogens appear to enter the Coldwater River and Bear Creek during all weather conditions (i.e., wet and dry weather events). Potential sources include agricultural runoff, failing septic systems, and urban runoff.

To further investigate the potential sources mentioned above, a load duration curve analysis was developed for each sampling station, as outlined in a paper by Cleland (2002). A load duration curve is a relatively new method utilized in TMDL development and considers how flow conditions relate to a variety of pollutant sources (point and nonpoint sources).

The load duration curves for each station sampled on the Coldwater River and Bear Creek are included in Appendix A. Flows for ungaged watersheds were estimated using a gaged stream from a nearby watershed of similar size and land use characteristics. The United States Geological Survey gage used to estimate the flows discussed here is located on the Thornapple River near Hastings (gage number 04117500). The data indicate that exceedances of the WQS are observed during wet weather events (noted by dots above the curve on the far left side of the figure); however, dry weather contributions also cause exceedances of WQS to both water bodies (noted by the dots above the curve on middle to right side of the figure). One particular

station, Bear Creek at Bell Road, is an example of *E. coli* input causing WQS exceedances during low- to mid-flow conditions rather than wet weather events.

The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in the Coldwater River and Bear Creek depends on the control of *E. coli* from wet and dry weather sources, as indicated by the flow duration curves in Appendix A. If the *E. coli* inputs can be controlled to meet the numeric standards, then total body contact recreation in the Coldwater River and Bear Creek will be restored and protected.

TMDL DEVELOPMENT

The TMDL 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 thirty-day geometric mean WQS of 130 *E. coli* per 100 ml and daily geometric mean of 300 *E. coli* per 100 ml. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the environmental conditions that will be used when defining allowable levels. Many TMDLs are designed around the concept of a "critical condition." The "critical condition" is defined as the set of environmental conditions that, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical conditions for the control of point sources in Michigan are given in R 323.1082 and R 323.1090. In general, the lowest monthly 95% exceedance flow for streams is used as a design condition for point source discharges. However, for pathogens in point source discharges of treated or untreated human sewage, levels are restricted to a monthly average limit of 200 fecal coliform per 100 ml regardless of stream flow. Therefore, the design stream flow is not a critical condition for determining the allowable loading of pathogen for WWTPs. In addition, sources of pathogens to the Coldwater River and Bear Creek arise from a mixture of wet and dry weather-driven nonpoint sources. For these sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

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) (USEPA, 2001). Therefore, this pathogen TMDL is concentration-based consistent with R 323.1062, and the TMDL is equal to the target concentration of 130 *E. coli* per 100 ml as a 30-day geometric mean and daily geometric mean of 300 *E. coli* per 100 ml in all portions of the TMDL reach for each month of the recreational season (May through October). 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.

ALLOCATIONS

TMDLs are comprised of 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 TMDL 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:

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

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. This pathogen TMDL will not be expressed on a mass loading basis and is concentration-based consistent with USEPA regulations in 40 CFR, Section 130.2(i).

WLAs

There are a total of 23 permitted point source discharges to the listed reach of the Coldwater River and Bear Creek: two individual permits, three CAFO permits, five general and/or industrial storm water permits, and thirteen NOC permits for earthwork. Each individual permit authorizes discharges of treated human waste in the TMDL reach and contains a fecal coliform limit. The permit for the Bowne Township WWTP authorizes discharge to an unnamed wetland tributary of Clark and Bunker Drain, and the Lakewood Wastewater Authority WWTP discharges to the Little Thornapple River, both tributaries of the Coldwater River. Both WWTPs will be considered in compliance with the WQS of 130 *E. coli* per 100 ml if their NPDES permit limit of 200 fecal coliform per 100 ml as a monthly average is met. Two of the three CAFO permits are permitted to discharge to Duck Creek, a tributary of the Coldwater River. The remaining CAFO permit discharges to Pratt Lake Creek, a tributary to Bear Creek. The facilities are authorized to discharge process wastewater and production area wastewater and/or manure, silage leachate and runoff, and runoff from precipitation events from land application areas of the CAFO, where such applications areas are managed in accordance with an approved Comprehensive Nutrient Management Plan (CNMP). A discharge may not cause or contribute to a violation of WQS and all structures must be properly designed, constructed, and maintained. These facilities may be a source of *E. coli* to the TMDL reach.

The WLA for the Bowne Township WWTP, Lakewood WW Authority WWTP, CAFO permits, and general and/or industrial storm water permits is equal to 130 *E. coli* per 100 ml during the recreational season between May 1 and October 31. The CAFO permits are not authorized to discharge except as described above. Details on prohibited discharges and manure and wastewater storage structures are included in Appendix B. The storm water permitted discharges are not considered significant sources of *E. coli* to the Coldwater River and Bear Creek due to Best Management Practices required in the permit. These permits do not authorize the discharge of non-storm water and require a certified storm water operator for the facility. The NOC permits involves earthwork in the watershed and, due to the nature of the permit, is not considered a significant source of *E. coli* to the TMDL watershed.

LAs

Because this TMDL is concentration-based, the LA is equal to 130 *E. coli* per 100 ml. This 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. This TMDL reach is located in 16 municipalities (Table 5). The townships making up the largest portion are Bowne Township (17.6%), Odessa Township (17.6%), Campbell Township (17.3%), and Carlton Township (15%).

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. Ordinarily, pathogen organisms 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 in order to provide for a greater protection of water quality. The MDEQ has determined that the use of the WQS of 130 *E. coli* per 100 ml for the WLA and LA is a more conservative approach than developing an explicit MOS and 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

Seasonality in the TMDL is addressed by expressing the TMDL in terms of a total body contact recreation season that is defined as May 1 through October 31 by R 323.1100 of the WQS. There is no total body contact during the remainder of the year primarily due to cold weather. In addition, because this is a concentration-based TMDL, WQS will be met regardless of flow conditions in the applicable season.

MONITORING

In 2004, pathogens were monitored weekly at a total of 19 stations on the Coldwater River and tributaries from May through September. Future monitoring will take place as part of the five-year rotating basin monitoring. When these results indicate that the water body may be meeting WQS, sampling will be conducted at the appropriate frequency (as defined in the numeric target section) to determine if the 30-day geometric mean value of 130 *E. coli* per 100 ml and 300 *E. coli* per 100 ml as a daily maximum are being met.

REASONABLE ASSURANCE ACTIVITIES

The Bowne Township WWTP and Lakewood WW Authority WWTP are presently meeting their NPDES permit limits for fecal coliform. Compliance is based on monthly review of discharge monitoring report data by the MDEQ. All three CAFOs, Freeport Dairy, Swisslane Farms, and Van Elst Brothers, are required to develop a CNMP, which describes production practices, equipment, and structures that the owner/operator uses. The objectives of the CNMP apply to both production areas and land application areas and include protecting water quality, obtaining beneficial use from animal manure and organic by-products of the operation, and minimizing impacts to the environment and public health from animal feeding operations. This plan must be reviewed annually by the permittee and submitted to the MDEQ. Other required activities include manure, wastewater, silage and silage leachate/runoff storage structures monitoring and inspection, sampling of waste/wastewater, soil inspections at land application sites, and inspection during land application activities.

A Section 319 Grant was awarded to the Grand Valley Metro Council. A product of the grant included a *Lower Grand River Watershed Project Information and Education Guidebook*, which was developed to motivate stakeholders and decision makers in the watershed to protect water quality. The guidebook includes a summary of activities and products for improving water quality, how to start a successful outreach program, investigating strategy targets, how to make things happen, and how to evaluate the strategy. The following Web site offers helpful information and important links to other groups and information on the Lower Grand River: http://www.gvsu.edu/wri/isc/lower-grand-river-watershed-management-plan-312.htm.

Using information generated by the Section 319 project, a Watershed Interactive Tool (WIT), was also developed for the Lower Grand River Watershed (LGRW) by the Grand Valley Metro Council and their partners. The WIT is a watershed-based interactive tool for local decision makers, educators, students, and residents of the LGRW. The tool includes information on the natural history of the LGRW, interactive maps of the LGRW, general watershed concepts, lesson plans for watershed education, and information on how everyday activities can affect water quality in the LGRW. The WIT can also help local units of government and nonprofit entities in writing their own nonpoint source management plan. Additional information can be found at the following Web site: https://www.gvsu.edu/wri/isc/lower-grand-watershed-interactive-tool-wit-57.htm.

In addition, the Coldwater River Watershed Council recently completed a Watershed Management Plan for the Coldwater River. The plan includes the development of a Web site, a monitoring program, public education program, erosion inventory, a recovery and restoration section, and a hydrology study. This group identified 290 nonpoint sources of sediment resulting from streambank erosion, overland stormwater runoff, and livestock generated erosion. Identifying and correcting critical erosion areas will reduce both sediment input and the amount of *E. coli* entering the water bodies from runoff or livestock. Benefits of public education and volunteer monitoring efforts are essential toward watershed restoration and protection.

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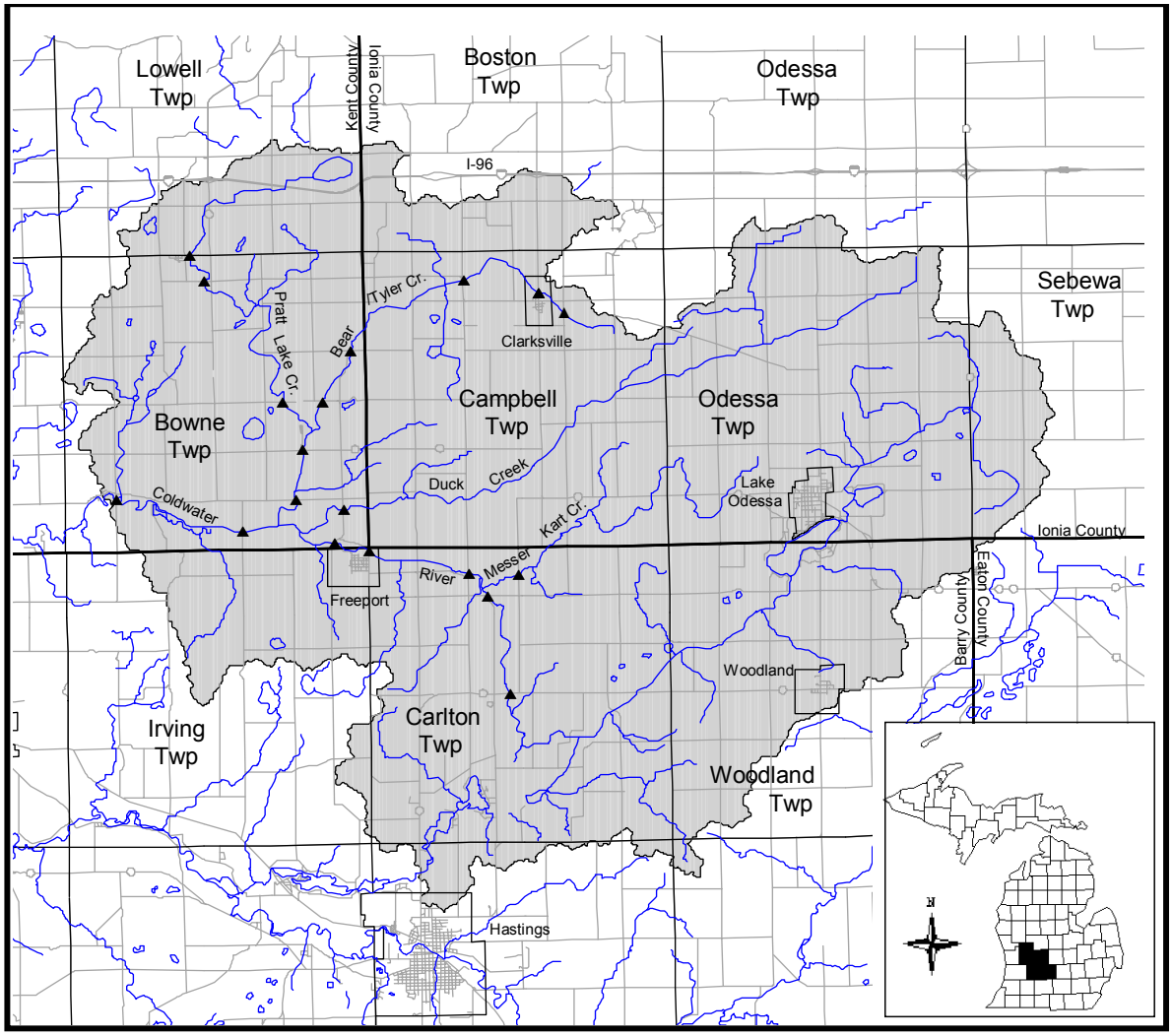

Figure 1. The Coldwater River and Bear Creek *E. coli* sampling locations, vicinity of Freeport, Michigan, 2004. Shaded areas represent the TMDL watershed.

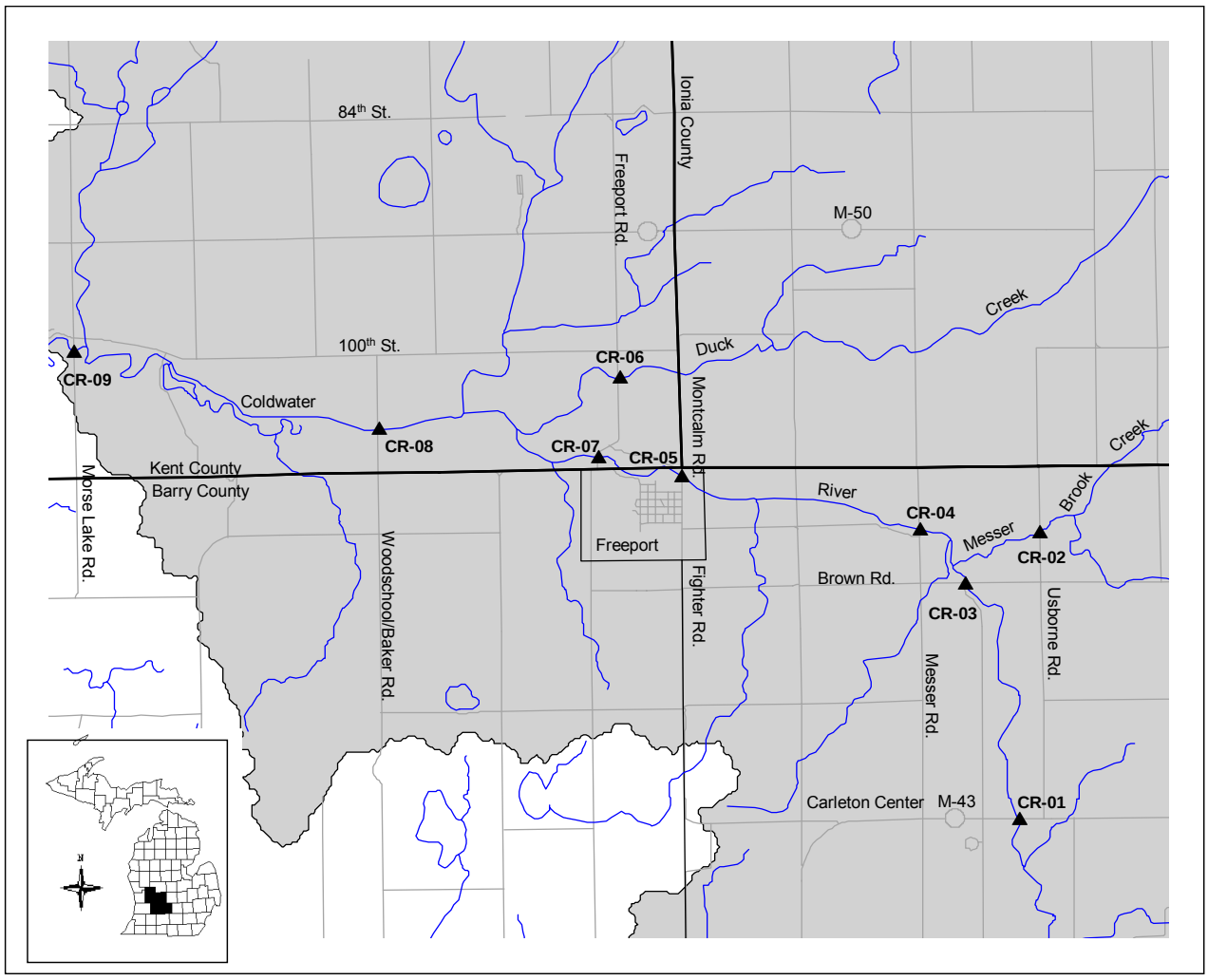

Figure 2. The Coldwater River *E. coli* sampling locations, vicinity of Freeport, Barry, and Kent Counties, Michigan, 2004.

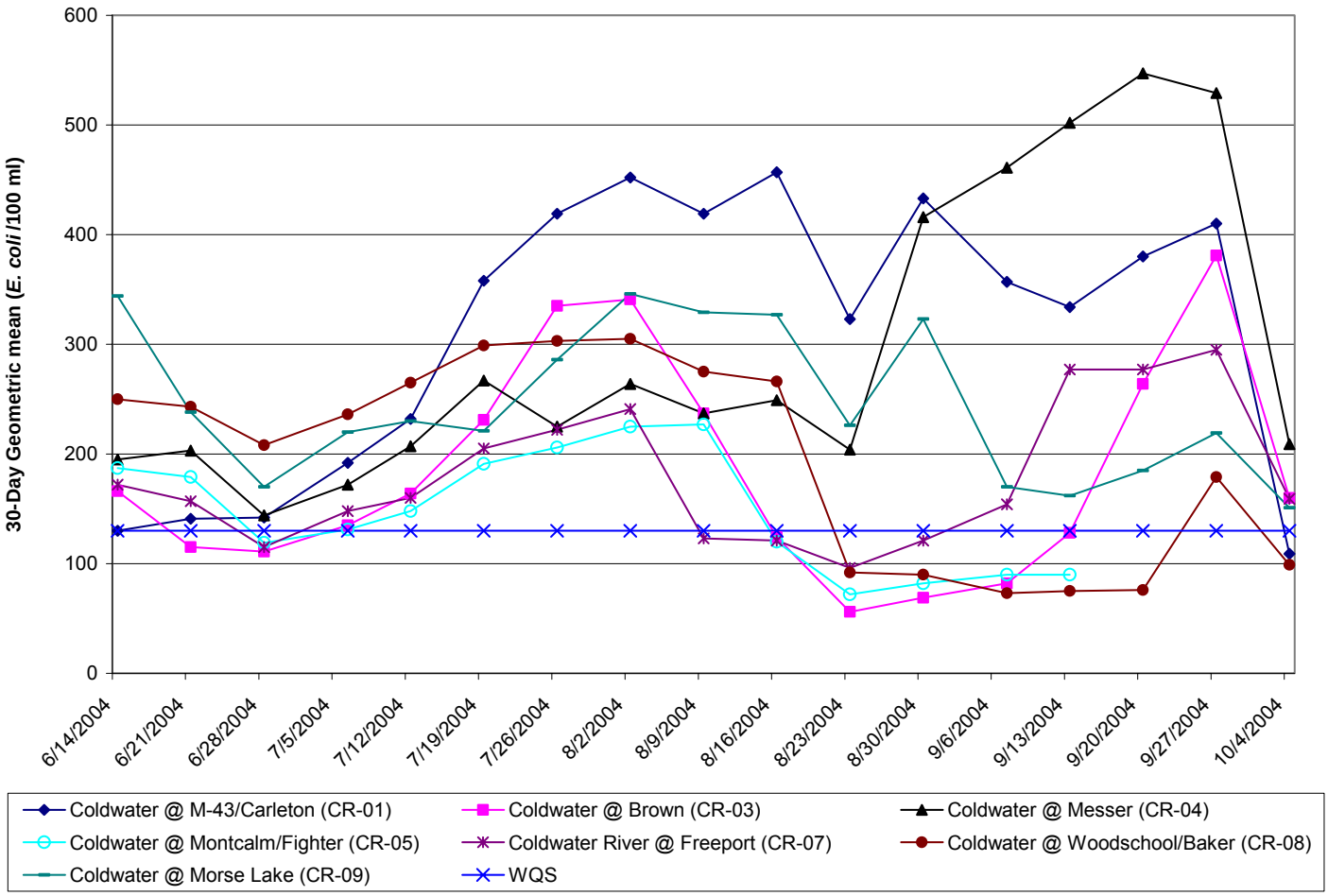

Figure 3. Thirty-day geometric mean for *E. coli* in the Coldwater River in the vicinity of Freeport, Kent County, Michigan, 2004.

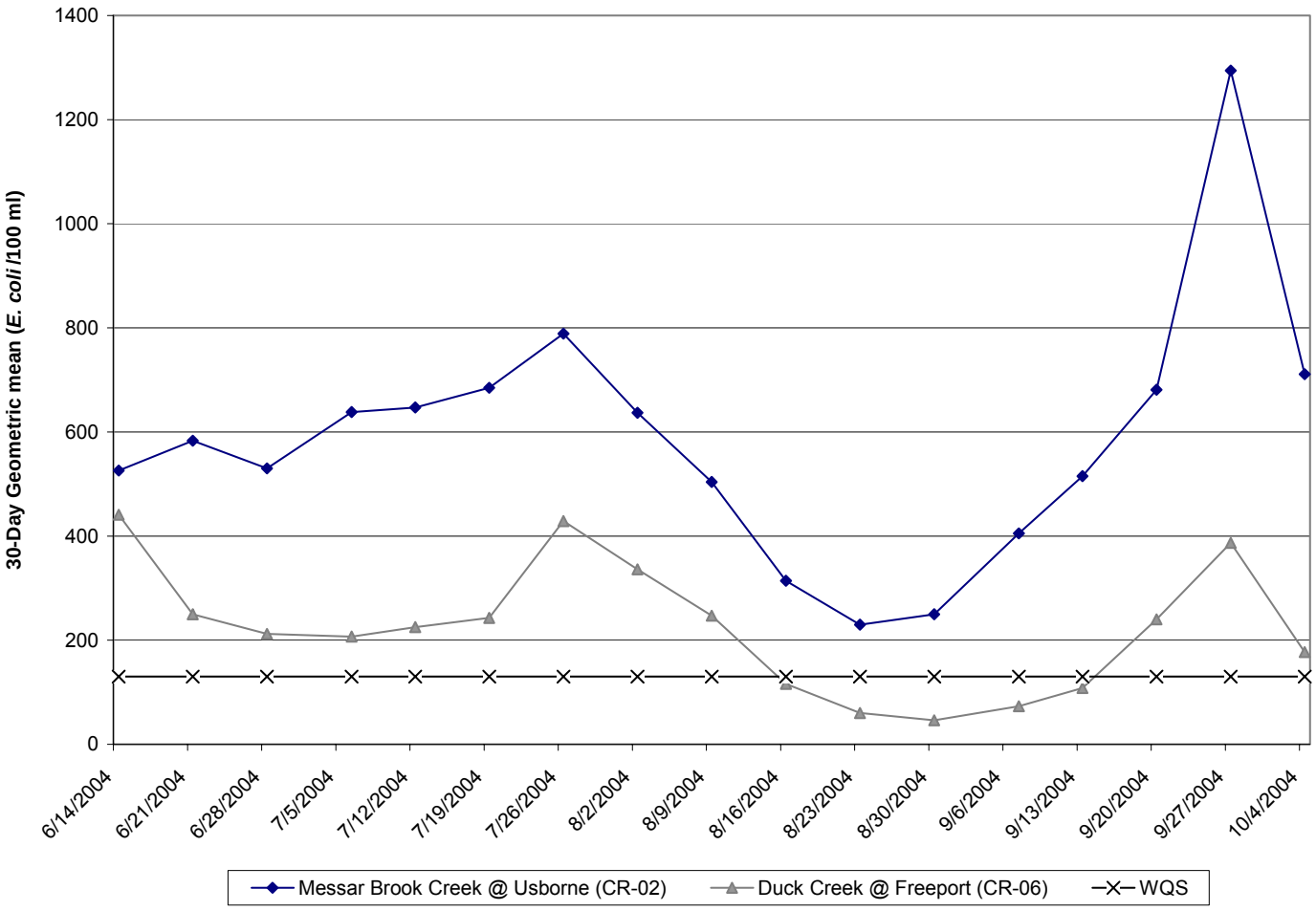

Figure 4. Thirty-day geometric mean for *E. coli* in Coldwater River tributaries, Kent County, Michigan, 2004.

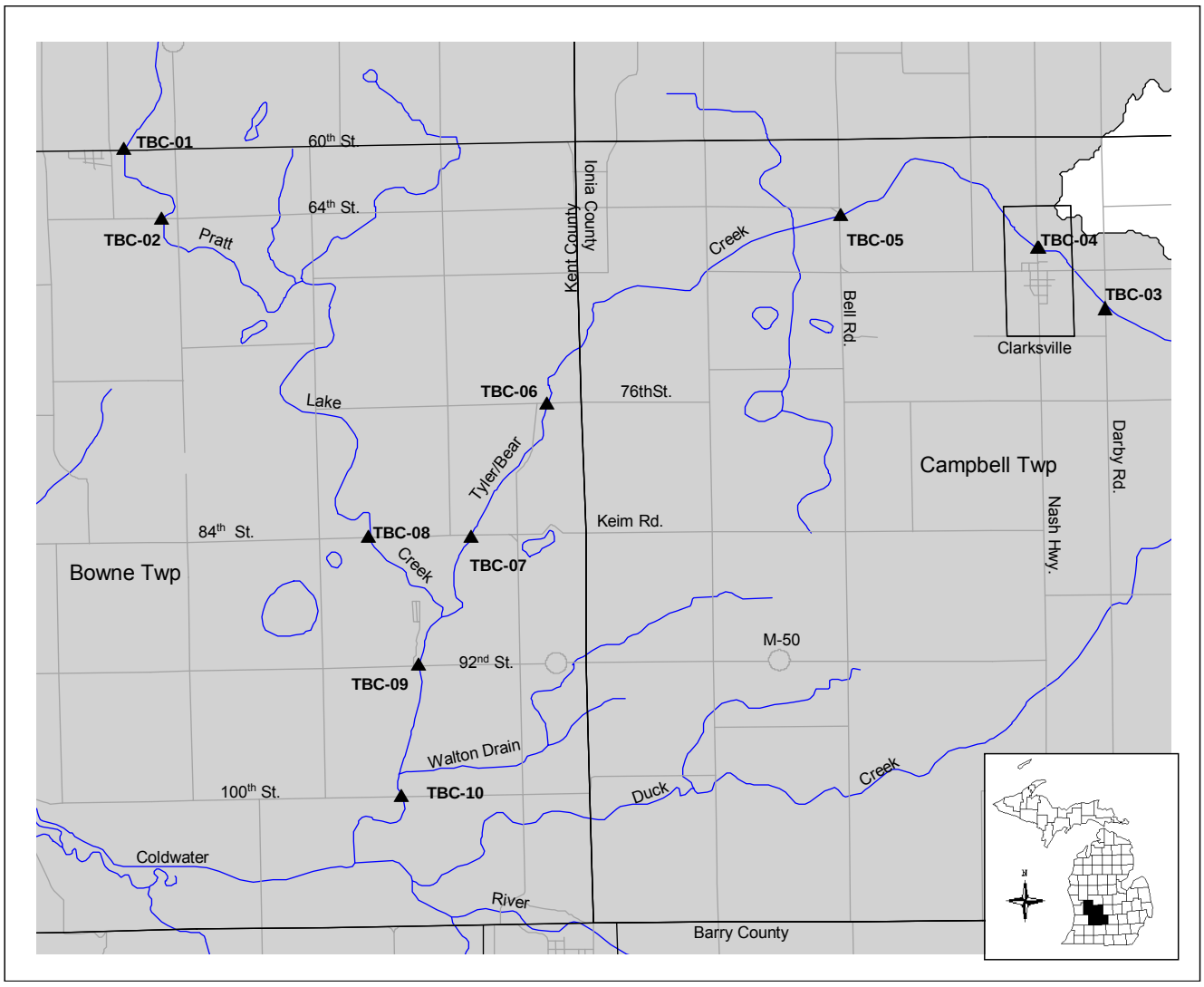

Figure 5. Bear Creek *E. coli* sampling locations, Ionia and Kent Counties, Michigan, 2004.

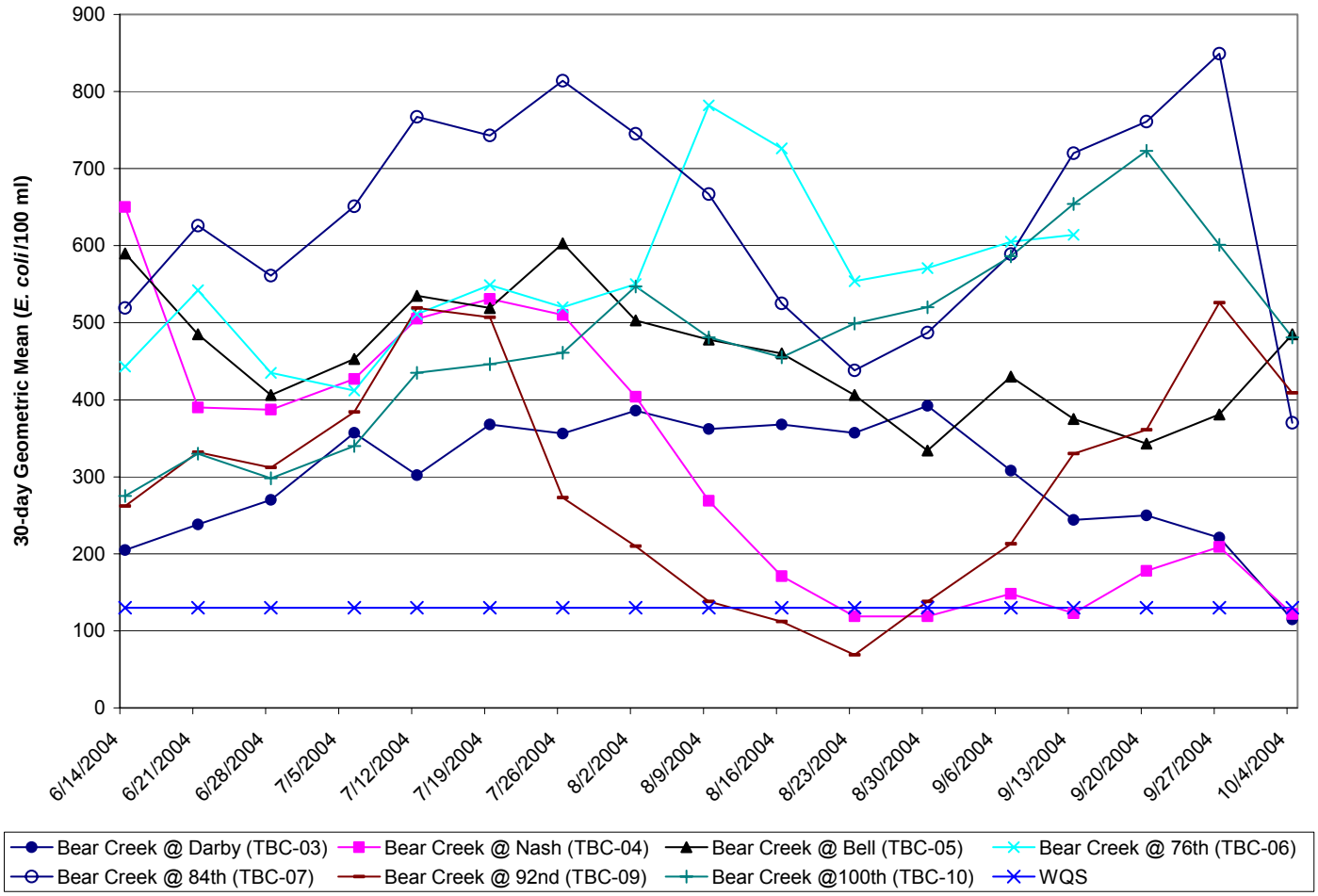

Figure 6. Thirty-day geometric mean for *E. coli* in Bear Creek, Kent County, Michigan, 2004.

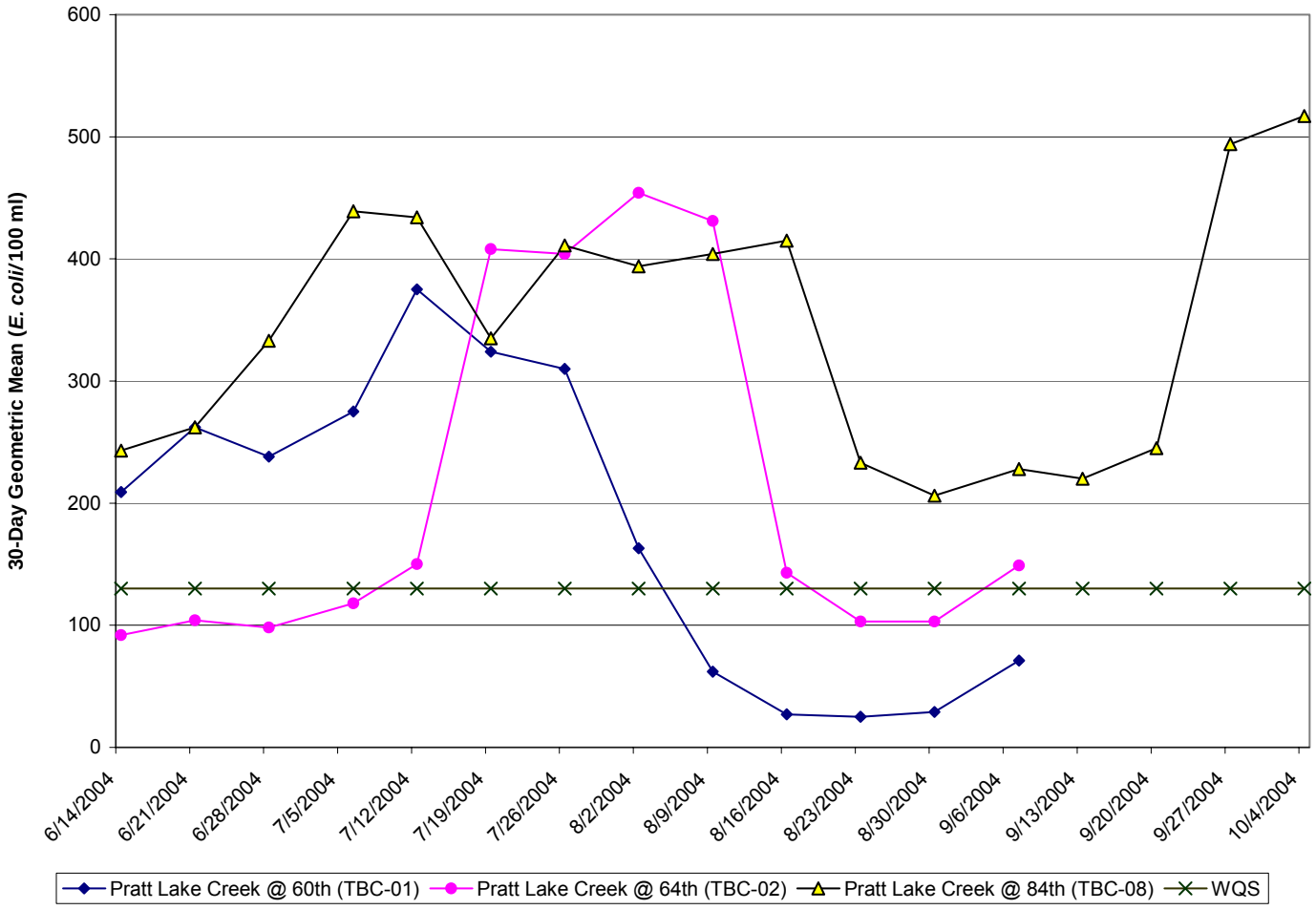

Figure 7. Thirty-day geometric mean for *E. coli* in Pratt Lake Creek, tributary of Bear Creek, Kent County, Michigan, 2004.

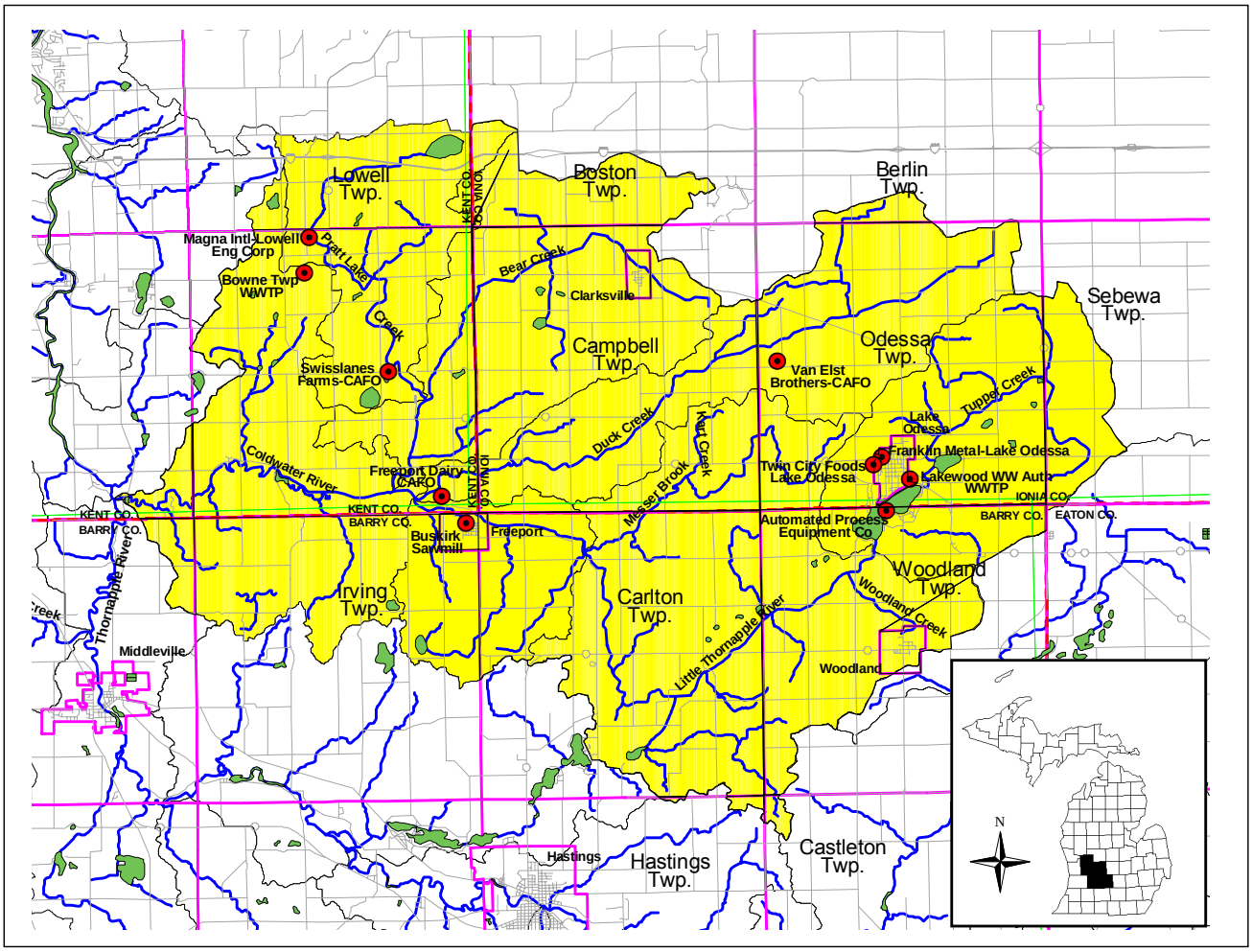

Figure 8. NPDES permitted discharges to the Coldwater River and Bear Creek TMDL reach, Kent, Ionia, and Barry Counties, Michigan, 2004. (Note: figure does not contain NOC permits).

Table 1. MDEQ 2004 *E. coli* monitoring data for the Coldwater River (*E. coli*/100 ml) in the vicinity of Freeport. Shaded areas indicate exceedances of the WQS. Data are presented upstream to downstream. Note: precipitation is noted for 24 hours preceding sampling. Gage located in Grand Rapids, Michigan.

	Coldwater River @ M-43/Carleton Center (CR-01)			Coldwater River @ Brown (CR-03)			Coldwater River @ Messer (CR-04)			
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**	**Weather data**
5/17/2004	140	160	---	340	288	---	220	199	---	59°, 0.6"
	140			370			240			
	210			190			150			
5/24/2004	140	201	---	260	237	---	670	613	---	59°, 0.4"
	200			300			530			
	290			170			650			
6/1/2004	97	87	---	110	127	---	130	129	---	63°, 0.3"
	83			110			150			
	83			170			110			
6/7/2004	110	94	---	82	77	---	90	81	---	65°, 0.0"
	76			87			66			
	100			64			88			
6/14/2004	120	137	130	230	191	166	280	223	195	67°, 0.0"
	180			160			220			
	120			190			180			
6/21/2004	240	247	141	2	46	115	230	243	203	68°, 1.1"
	250			320			250			
	250			150			250			
6/28/2004	240	210	142	200	199	111	240	112	144	70°, 0.0"
	160			180			70			
	240			220			83			
7/6/2004	350	392	192	460	335	135	450	312	172	71°, 0.0"
	430			240			260			
	400			340			260			
7/12/2004	220	244	232	220	203	164	210	199	207	70°, 0.0"
	220			190			210			
	300			200			180			

Table 1 continued (*E. coli*/100 ml).

	Coldwater River @ M-43/Carleton Center (CR-01)			Coldwater River @ Brown (CR-03)			Coldwater River @ Messer (CR-04)			
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**	**Weather data**
7/19/2004	1400	1195	358	1200	1071	231	870	802	267	72°, 0.0"
	870			930			770			
	1400			1100			770			
7/26/2004	700	539	419	480	290	335	10	104	225	72°, 0.0"
	400			230			230			
	560			220			490			
8/2/2004	370	307	452	220	220	341	240	244	264	71°, 0.0"
	340			180			210			
	230			270			290			
8/9/2004	360	267	419	300	53	237	170	182	237	71°, 0.0"
	240			170			210			
	220			3			170			
8/16/2004	280	379	457	130	8	124	290	255	249	70°, 0.0"
	330			2			190			
	590			2			300			
8/23/2004	260	211	323	2	20	56	250	296	204	68°, 0.0"
	190			68			220			
	190			60			470			
8/30/2004	2700	2319	433	800	800	69	2700	3727	416	67°, 0.2"
	4200			800			2700			
	1100			800			7100			
9/7/2004	10	117	357	330	544	82	380	409	461	64°, 0.4"
	540			670			390			
	300			730			460			

Table 1 continued (*E. coli*/100 ml).

	Coldwater River @ M-43/Carleton Center (CR-01)			Coldwater River @ Brown (CR-03)			Coldwater River @ Messer (CR-04)			
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**	**Weather data**
9/13/2004	33	191	334	330	426	125	250	277	502	62°, 0.0"
	450			350			250			
	470			670			340			
9/20/2004	830	726	380	300	299	257	390	393	547	60°, 0.0"
	870			370			380			
	530			240			410			
9/27/2004	220	308	410	320	144	381	230	250	529	58°, 0.0"
	310			200			310			
	430			47			220			
10/4/2004	3	3	109	3	11	160	3	36	209	55°, 0.0"
	3			3			130			
	3			130			120			

Table 1 continued (*E. coli*/100 ml).

	Coldwater River @ Montcalm/Fighter (CR-05)			Coldwater River @ Freeport (CR-07)			Coldwater River @ Woodschool/Baker (CR-08)			
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**	**Weather data**
5/17/2004	87	255	---	310	274	---	160	273	---	59°, 0.6"
	260			300			550			
	730			220			230			
5/24/2004	5967	951	---	510	425	---	300	329	---	59°, 0.4"
	400			1000			440			
	360			150			270			
6/1/2004	56	65	---	67	69	---	630	156	---	63°, 0.3"
	70			67			60			
	70			73			100			
6/7/2004	64	80	---	110	100	---	140	137	---	65°, 0.0"
	110			110			140			
	72			82			130			
6/14/2004	190	184	187	230	188	172	630	508	250	67°, 0.0"
	150			180			310			
	220			160			670			
6/21/2004	200	203	179	170	173	157	330	238	243	68°, 1.1"
	150			160			240			
	280			190			170			
6/28/2004	120	123	119	90	90	115	170	153	208	70°, 0.0"
	180			120			110			
	87			67			190			
7/6/2004	10	104	131	320	240	148	250	292	236	71°, 0.0"
	390			310			310			
	290			140			320			
7/12/2004	160	148	148	150	150	160	280	245	265	70°, 0.0"
	170			140			250			
	120			160			210			

Table 1 continued (*E. coli*/100 ml).

	Coldwater River @ Montcalm/Fighter (CR-05)			Coldwater River @ Freeport (CR-07)			Coldwater River @ Woodschool/Baker (CR-08)			
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	Weather data
7/19/2004	580	655	191	550	651	205	830	917	299	72°, 0.0"
	570			540			930			
	850			930			1000			
7/26/2004	230	295	206	220	255	222	300	255	303	72°, 0.0"
	350			420			220			
	320			180			250			
8/2/2004	160	193	225	220	136	241	200	159	305	71°, 0.0"
	160			87			87			
	280			130			230			
8/9/2004	80	109	227	2	8	123	67	174	275	71°, 0.0"
	210			140			280			
	77			2			280			
8/16/2004	60	6	120	140	142	121	190	206	266	70°, 0.0"
	2			300			220			
	2			68			210			
8/23/2004	2	51	72	240	207	96	3	4	92	68°, 0.0"
	180			160			10			
	370			230			3			
8/30/2004	800	555	82	800	800	121	20	234	90	67°, 0.20"
	800			800			800			
	267			800			800			
9/7/2004	690	312	90	400	447	154	2	56	73	64°, 0.40"
	260			620			290			
	170			360			300			

Table 1 continued (*E. coli*/100 ml).

	Coldwater River @ Montcalm/Fighter (CR-05)			Coldwater River @ Freeport (CR-07)			Coldwater River @ Woodschool/Baker (CR-08)			
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**	**Weather data**
9/13/2004	180	106	90	180	156	277	210	196	75	62°, 0.0"
	67			190			200			
	100			110			180			
9/20/2004	230	---	---	80	141	277	140	223	76	60°, 0.0"
	73			160			330			
	*			220			240			
9/27/2004	330	378	---	290	286	295	340	318	179	58°, 0.0"
	430			300			430			
	380			270			220			
10/4/2004	3	37	---	150	37	159	3	12	99	55°, 0.0"
	140			3			200			
	120			110			3			

*laboratory accident prevented count of colonies.

Table 1 continued (*E. coli*/100 ml).

	Coldwater River @ Morse Lake (CR-09)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
5/17/2004	700	594	---	59°, 0.6"
	250			
	1200			
5/24/2004	240	511	---	59°, 0.4"
	370			
	1500			
6/1/2004	76	87	---	63°, 0.3"
	73			
	118			
6/7/2004	130	153	---	65°, 0.0"
	130			
	210			
6/14/2004	950	1205	344	67°, 0.0"
	920			
	2000			
6/21/2004	260	94	238	68°, 1.1"
	10			
	320			
6/28/2004	40	96	170	70°, 0.0"
	110			
	200			
7/6/2004	260	311	220	71°, 0.0"
	320			
	360			
7/12/2004	200	189	230	70°, 0.0"
	200			
	170			

Table 1 continued (*E. coli*/100 ml).

	Coldwater River @ Morse Lake (CR-09)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
7/19/2004	760	986	221	72°, 0.0"
	1300			
	970			
7/26/2004	290	347	286	72°, 0.0"
	370			
	390			
8/2/2004	160	248	346	71°, 0.0"
	340			
	280			
8/9/2004	240	240	329	71°, 0.0"
	250			
	230			
8/16/2004	200	183	327	70°, 0.0"
	280			
	110			
8/23/2004	150	155	226	68°, 0.0"
	100			
	250			
8/30/2004	2700	2060	323	67°, 0.2"
	1200			
	2700			
9/7/2004	10	10	170	64°, 0.4"
	10			
	10			

Table 1 continued (*E. coli*/100 ml).

	Coldwater River @ Morse Lake (CR-09)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
9/13/2004	130	189	162	62°, 0.0"
	200			
	260			
9/20/2004	440	360	185	60°, 0.0"
	330			
	320			
9/27/2004	250	361	219	58°, 0.0"
	410			
	460			
10/4/2004	290	317	151	55°, 0.0"
	500			
	220			

Table 2. MDEQ 2004 *E. coli* monitoring data for Coldwater River tributaries (*E. coli*/100 ml) in the vicinity of Freeport. Shaded areas indicate exceedances of the WQS. Data are presented upstream to downstream.

	Messer Brook Creek @ Usborne (CR-02)			Duck Creek @ Freeport (CR-06)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
5/17/2004	260	387	---	450	544	---	59°, 0.6"
	240			510			
	930			700			
5/24/2004	1300	892	---	160	225	---	59°, 0.4"
	260			230			
	2100			310			
6/1/2004	250	277	---	350	386	---	63°, 0.3"
	230			400			
	370			410			
6/7/2004	870	720	---	380	294	---	65°, 0.0"
	1100			210			
	390			320			
6/14/2004	670	584	526	770	1206	441	67°, 0.0"
	550			2300			
	540			990			
6/21/2004	480	646	583	10	32	250	68°, 1.1"
	770			10			
	730			320			
6/28/2004	630	556	530	100	97	212	70°, 0.0"
	580			120			
	470			77			
7/6/2004	430	701	638	620	348	207	71°, 0.0"
	1000			93			
	800			730			
7/12/2004	670	769	647	310	440	225	70°, 0.0"
	930			520			
	730			530			

Table 2 continued (*E. coli*/100 ml).

	Messer Brook Creek @ Usborne (CR-02)			Duck Creek @ Freeport (CR-06)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
7/19/2004	560	780	685	3600	1777	243	72°, 0.0"
	770			1300			
	1100			1200			
7/26/2004	780	1307	789	800	546	429	72°, 0.0"
	1100			700			
	2600			290			
8/2/2004	10	191	637	10	29	336	71°, 0.0"
	1400			10			
	500			240			
8/9/2004	1400	217	504	240	74	247	71°, 0.0"
	10			570			
	730			3			
8/16/2004	260	72	314	3	10	116	70°, 0.0"
	480			3			
	3			120			
8/23/2004	30	165	230	7	65	60	68°, 0.0"
	1500			360			
	100			110			
8/30/2004	800	1961	250	6	150	46	67°, 0.2"
	4100			800			
	2300			710			
9/7/2004	2700	2150	405	420	287	73	64°, 0.4"
	1600			110			
	2300			510			

Table 2 continued (*E. coli*/100 ml).

	Messer Brook Creek @ Usborne (CR-02)			Duck Creek @ Freeport (CR-06)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
9/13/2004	650	721	515	600	505	108	62°, 0.0"
	670			370			
	860			580			
9/20/2004	1900	293	681	670	563	240	60°, 0.0"
	110			700			
	120			380			
9/27/2004	6400	4081	1294	1200	709	387	58°, 0.0"
	1800			430			
	5900			690			
10/4/2004	3	98	711	3	3	177	55°, 0.0"
	410			3			
	770			3			

Table 3. MDEQ 2004 *E. coli* monitoring data for the Bear Creek (*E. coli*/100 ml), Kent County, Michigan. Shaded areas indicate exceedances of the WQS. Data are presented upstream to downstream.

	Bear Creek @ Darby (TBC-03)			Bear Creek @ Nash (TBC-04)			Bear Creek @ Bell (TBC-05)			
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**	**Weather data**
5/17/2004	260	153	---	1000	1292	---	670	512	---	59°, 0.6"
	51			770			770			
	270			2800			260			
5/24/2004	280	296	---	940	766	---	2200	1694	---	59°, 0.4"
	320			770			1700			
	290			620			1300			
6/1/2004	110	107	---	500	402	---	330	356	---	63°, 0.3"
	100			360			310			
	110			360			440			
6/7/2004	610	764	---	510	530	---	340	335	---	65°, 0.0"
	830			470			410			
	880			620			270			
6/14/2004	140	98	205	390	551	650	490	689	590	67°, 0.0"
	17			430			710			
	390			1000			940			
6/21/2004	280	322	238	3	101	390	340	193	485	68°, 1.1"
	330			660			150			
	360			520			140			
6/28/2004	870	560	270	800	736	387	530	694	406	70°, 0.0"
	480			600			790			
	420			830			800			
7/6/2004	530	432	357	730	658	427	570	621	453	71°, 0.0"
	410			750			600			
	370			520			700			
7/12/2004	340	330	302	1400	1221	505	870	763	535	70°, 0.0"
	320			1300			730			
	330			1000			700			

Table 3 continued (*E. coli*/100 ml).

	Bear Creek @ Darby (TBC-03)			Bear Creek @ Nash (TBC-04)			Bear Creek @ Bell (TBC-05)			
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**	**Weather data**
7/19/2004	190	262	368	810	710	531	600	593	519	72°, 0.0"
	220			630			570			
	430			700			610			
7/26/2004	170	275	356	3	82	510	290	409	603	72°, 0.0"
	330			390			420			
	370			470			560			
8/2/2004	1000	839	386	240	230	404	330	279	503	71°, 0.0"
	680			210			200			
	870			240			330			
8/9/2004	370	310	362	3	86	269	510	486	478	71°, 0.0"
	260			280			340			
	310			760			660			
8/16/2004	240	361	368	510	126	171	610	628	460	70°, 0.0"
	400			230			830			
	490			17			490			
8/23/2004	250	226	357	73	116	119	280	315	406	68°, 0.0"
	220			930			620			
	210			23			180			
8/30/2004	680	434	392	3	82	119	140	154	334	67°, 0.2"
	400			930			270			
	300			200			97			
9/7/2004	290	251	308	970	684	148	970	990	430	64°, 0.4"
	210			600			770			
	260			550			1300			

Table 3 continued (*E. coli*/100 ml).

	Bear Creek @ Darby (TBC-03)			Bear Creek @ Nash (TBC-04)			Bear Creek @ Bell (TBC-05)			
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**	**Weather data**
9/13/2004	160	98	244	3	35	123	30	245	375	62°, 0.0"
	290			10			690			
	20			1400			710			
9/20/2004	370	404	250	550	782	178	370	404	343	60°, 0.0"
	480			870			480			
	370			1000			370			
9/27/2004	180	124	221	300	259	209	470	533	381	58°, 0.0"
	170			340			480			
	62			170			670			
10/4/2004	33	16	115	3	6	122	350	516	485	55°, 0.0"
	2			3			700			
	66			20			560			

Table 3 continued (*E. coli*/100 ml).

	Bear Creek @ 76th (TBC-06)			Bear Creek @ 84th (TBC-07)			Bear Creek @ 92nd (TBC-09)			
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**	**Weather data**
5/17/2004	93	232	---	260	246	---	170	120	---	59°, 0.6"
	750			240			110			
	180			240			93			
5/24/2004	1600	1869	---	610	907	---	290	376	---	59°, 0.4"
	2400			2600			400			
	1700			470			460			
6/1/2004	160	161	---	290	279	---	220	222	---	63°, 0.3"
	130			250			200			
	200			300			250			
6/7/2004	290	408	---	370	568	---	150	151	---	65°, 0.0"
	600			740			190			
	390			670			120			
6/14/2004	380	600	443	470	1062	519	840	816	262	67°, 0.0"
	740			1500			810			
	770			1700			800			
6/21/2004	670	636	542	670	629	626	400	393	332	68°, 1.1"
	620			700			380			
	620			530			400			
6/28/2004	1250	620	435	790	524	561	340	273	312	70°, 0.0"
	490			250			300			
	390			730			200			
7/6/2004	3	122	412	400	587	651	430	628	384	71°, 0.0"
	730			830			720			
	830			610			800			
7/12/2004	1100	1207	511	1200	1293	767	660	683	519	70°, 0.0"
	1600			1500			660			
	1000			1200			730			

Table 3 continued (*E. coli*/100 ml).

	Bear Creek @ 76th (TBC-06)			Bear Creek @ 84th (TBC-07)			Bear Creek @ 92nd (TBC-09)			
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**	**Weather data**
7/19/2004	1300	860	549	1000	907	743	760	729	507	72°, 0.0"
	700			830			810			
	700			900			630			
7/26/2004	470	485	520	800	986	814	3	18	273	72°, 0.0"
	550			1000			610			
	440			1200			3			
8/2/2004	800	822	550	570	337	745	3	74	210	71°, 0.0"
	770			480			490			
	900			140			280			
8/9/2004	770	709	782	620	339	667	3	78	138	71°, 0.0"
	600			350			630			
	770			180			250			
8/16/2004	840	830	726	350	389	525	43	111	96	70°, 0.0"
	1000			330			230			
	680			510			140			
8/23/2004	410	223	554	210	366	438	3	64	59	68°, 0.0"
	100			180			300			
	270			1300			290			
8/30/2004	520	566	571	1500	1678	487	510	572	119	67°, 0.20"
	830			2100			490			
	420			1500			750			
9/7/2004	1200	1097	605	900	876	589	630	641	183	64°, 0.40"
	1100			970			580			
	1000			770			720			

Table 3 continued (*E. coli*/100 ml).

	Bear Creek @ 76th (TBC-06)			Bear Creek @ 84th (TBC-07)			Bear Creek @ 92nd (TBC-09)			
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**	**Weather data**
9/13/2004	600	759	614	780	921	720	520	692	283	62°, 0.0"
	1000			1000			740			
	730			1000			860			
9/20/2004	400	---	---	360	515	761	480	381	361	60°, 0.0"
	510			520			280			
	540			730			410			
9/27/2004	740	867	---	830	632	849	510	419	526	58°, 0.0"
	800			800			450			
	1100			380			320			
10/4/2004	270	347	---	3	27	370	200	163	409	55°, 0.0"
	430			190			90			
	360			33			240			

Table 3 continued (*E. coli*/100 ml).

	Bear Creek @ 100th (TBC-10)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
5/17/2004	230	218	---	59°, 0.6"
	250			
	180			
5/24/2004	630	451	---	59°, 0.4"
	330			
	440			
6/1/2004	210	232	---	63°, 0.3"
	270			
	220			
6/7/2004	100	132	---	65°, 0.0"
	190			
	120			
6/14/2004	240	527	275	67°, 0.0"
	770			
	790			
6/21/2004	380	544	330	68°, 1.1"
	650			
	650			
6/28/2004	480	268	298	70°, 0.0"
	190			
	210			
7/6/2004	450	450	340	71°, 0.0"
	520			
	390			
7/12/2004	540	449	435	70°, 0.0"
	480			
	350			

Table 3 continued (*E. coli*/100 ml).

	Bear Creek @ 100th (TBC-10)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
7/19/2004	630	597	446	72°, 0.0"
	750			
	450			
7/26/2004	960	645	461	72°, 0.0"
	570			
	490			
8/2/2004	320	629	547	71°, 0.0"
	410			
	1900			
8/9/2004	220	236	481	71°, 0.0"
	240			
	250			
8/16/2004	160	339	455	70°, 0.0"
	290			
	840			
8/23/2004	1200	950	499	68°, 0.0"
	340			
	2100			
8/30/2004	590	796	520	67°, 0.2"
	610			
	1400			
9/7/2004	1500	1145	586	64°, 0.4"
	1300			
	770			

Table 3 continued (*E. coli*/100 ml).

	Bear Creek @ 100th (TBC-10)			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
9/13/2004	390	406	654	62°, 0.0"
	410			
	420			
9/20/2004	520	561	723	60°, 0.0"
	1000			
	340			
9/27/2004	420	379	601	58°, 0.0"
	340			
	380			
10/4/2004	230	259	481	55°, 0.0"
	360			
	210			

Table 4. DEQ 2004 *E. coli* monitoring data for Bear Creek tributaries (*E. coli*/100 ml), Kent and Ionia Counties, Michigan. Shaded areas indicate exceedances of the WQS. Data are presented upstream to downstream.

	Pratt Lake Creek @ 60th (TBC-01)			Pratt Lake Creek @ 64th (TBC-02)			Pratt Lake Creek @ 84th (TBC-08)			
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**	**Weather data**
5/17/2004	50	89	---	210	232	---	70	159	---	59°, 0.6"
	53			260			250			
	267			230			230			
5/24/2004	360	336	---	370	319	---	140	143	---	59°, 0.4"
	340			230			130			
	310			380			160			
6/1/2004	130	123	---	170	169	---	110	120	---	63°, 0.3"
	130			190			130			
	110			150			120			
6/7/2004	130	134	---	290	262	---	410	341	---	65°, 0.0"
	170			230			440			
	110			270			220			
6/14/2004	800	800	209	2	2	92	800	904	243	67°, 0.0"
	800			2			840			
	800			2			1100			
6/21/2004	120	278	262	350	432	104	170	234	262	68°, 1.1"
	380			490			290			
	470			470			260			
6/28/2004	190	206	238	230	240	98	400	476	333	70°, 0.0"
	210			250			370			
	220			240			730			
7/6/2004	160	256	275	480	425	118	400	476	439	71°, 0.0"
	300			400			270			
	350			400			1000			
7/12/2004	750	633	375	820	859	150	290	319	434	70°, 0.0"
	450			930			330			
	750			830			340			

Table 4 continued (*E. coli*/100 ml).

	Pratt Lake Creek @ 60th (TBC-01)			Pratt Lake Creek @ 64th (TBC-02)			Pratt Lake Creek @ 84th (TBC-08)			
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**	**Weather data**
7/19/2004	350	386	324	230	299	408	150	247	335	72°, 0.0"
	410			400			240			
	400			290			420			
7/26/2004	70	221	310	120	412	404	330	654	411	72°, 0.0"
	140			870			470			
	1100			670			1800			
8/2/2004	3	8	163	97	427	454	230	386	394	71°, 0.0"
	3			670			390			
	63			1200			640			
8/9/2004	2	2	62	3	328	431	300	539	404	71°, 0.0"
	2			2500			790			
	2			4700			660			
8/16/2004	2	10	27	2	3	143	340	365	415	70°, 0.0"
	2			2			570			
	270			10			250			
8/23/2004	270	270	25	20	60	103	3	14	233	68°, 0.0"
	270			44			3			
	270			240			290			
8/30/2004	510	419	29	320	401	103	230	355	206	67°, 0.2"
	390			480			300			
	370			420			650			
9/7/2004	800	800	71	2700	2700	149	660	641	228	64°, 0.4"
	800			2700			570			
	800			2700			700			

Table 4 continued (*E. coli*/100 ml).

	Pratt Lake Creek @ 60th (TBC-01)			Pratt Lake Creek @ 64th (TBC-02)			Pratt Lake Creek @ 84th (TBC-08)			
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**	**Weather data**
9/13/2004	*	---	---	*	---	---	470	450	220	62°, 0.0"
	*			*			380			
	*			*			510			
9/20/2004	*	---	---	*	---	---	660	619	245	60°, 0.0"
	*			*			800			
	*			*			450			
9/27/2004	*	---	---	*	---	---	730	464	494	58°, 0.0"
	*			*			390			
	*			*			350			
10/4/2004	*	---	---	*	---	---	780	448	517	55°, 0.0"
	*			*			240			
	*			*			480			

Table 5. Distribution of land for each municipality in the Coldwater River and Bear Creek TMDL reach.

Municipality	County	Square Miles	Percent
Bowne Township	Kent	33.5	17.6
Odessa Township	Ionia	33.4	17.5
Campbell Township	Ionia	33.1	17.3
Carlton Township	Barry	28.7	15.0
Woodland Township	Barry	19.7	10.3
Irving Township	Barry	15.7	8.2
Lowell Township	Kent	8.8	4.6
Boston Township	Ionia	6.6	3.4
Sebewa Township	Ionia	5.3	2.8
Hastings Township	Barry	2.0	1.0
Berlin Township	Ionia	1.0	0.5
Woodland	Barry	0.9	0.5
Lake Odessa	Ionia	0.8	0.4
Freeport	Barry	0.8	0.4
Clarksville	Ionia	0.5	0.3
Castleton Township	Barry	0.4	0.2
TOTAL		**191.2**	**100**

Table 6. Discriminant Analysis of Ribotype Profiles of *E. coli* isolates from water sample collected from Bear Creek at Bell Road (TBC-05) on July 15, 2004.

Fecal coliform mpn*/100 ml	*E. coli* isolate number (5 colonies of cultured *E. coli* were analyzed)	Probable Source
=1,100	1	Non-human
	2	Non-human
	3	Non-human
	4	Non-human
	5	Non-human

*mpn = most probable number of fecal coliforms in 100 mL of sample after 20 hrs of cultivation at 44.5 degrees Celcius.

Table 7. Permitted outfalls to the Coldwater River and the Bear Creek TMDL watershed. Source: MDEQ, Water Bureau's NPDES Permit Management System.

Facility	Permit Number	Receiving Water	Latitude	Longitude
Bowne Township WWTP	MI0055697	Wetland continuous to Clark and Bunker Dr.	42.84333	-85.38111
Lakewood WW Authority WWTP	MI0042978	Little Thornapple River	42.77861	-85.13083
Freeport Dairy - CAFO	MIG440008	Duck Creek	42.77500	-85.32500
Swissland Farms – CAFO	**MIG440024**	**Pratt Lake Creek**	**42.81486**	**-85.33766**
Van Elst Brothers – CAFO	MIG440031	Duck Creek	42.81523	-85.18558
Automated Process Equipment Co.	MIS510055	Jordan Lake	42.76940	-85.14080
Buskirk Sawmill – Freeport	MIS510341	Coldwater River	42.76667	-85.31500
Franklin Metal – Lake Odessa	MIS510425	Jordan Lake	42.78560	-85.14250
Magna International – Lowell Eng Group	MIS110517	Tyler Creek	42.85417	-85.37917
Twin City Foods – Lake Odessa	MIS510415	Jordan Lake	42.78330	-85.14580
Dykema – Stoneridge Apts	MIR105071		42.93453	-85.37868
Dykema – Whispering Hills 2 & 3	MIR106563		42.93453	-85.37868
Dykema – Whispering Hills Sub	MIR105810		42.93453	-85.37868
Kent County – Grand River Drive	MIR105063		42.91998	-85.39823
Kent County – Grand River Drive	MIR106507		42.92015	-85.33894
Kent County – Timpson Avenue	MIR105061		42.91998	-85.39823
Lettings – Hunters Run Phase I	MIR106283		42.84694	-85.37758

Table 7 continued.

Facility	Permit Number	Receiving Water	Latitude	Longitude
Sundry Corp – Highland Hill Site	MIR107215		42.93483	-85.31925
Stedfast – Nash Hwy Business Park	MIR105500		42.87705	-85.24036
T & M Riverside Woods	MIR108159		42.92756	-85.29465
Wal-Mart – Ionia	MIR107417		42.93500	-85.08218
Dan Valley Southeast Village 2	MIR105282		42.63012	-85.27816
Georgetown – N Ridge Estate # 3	MIR106988		42.65905	-85.27839

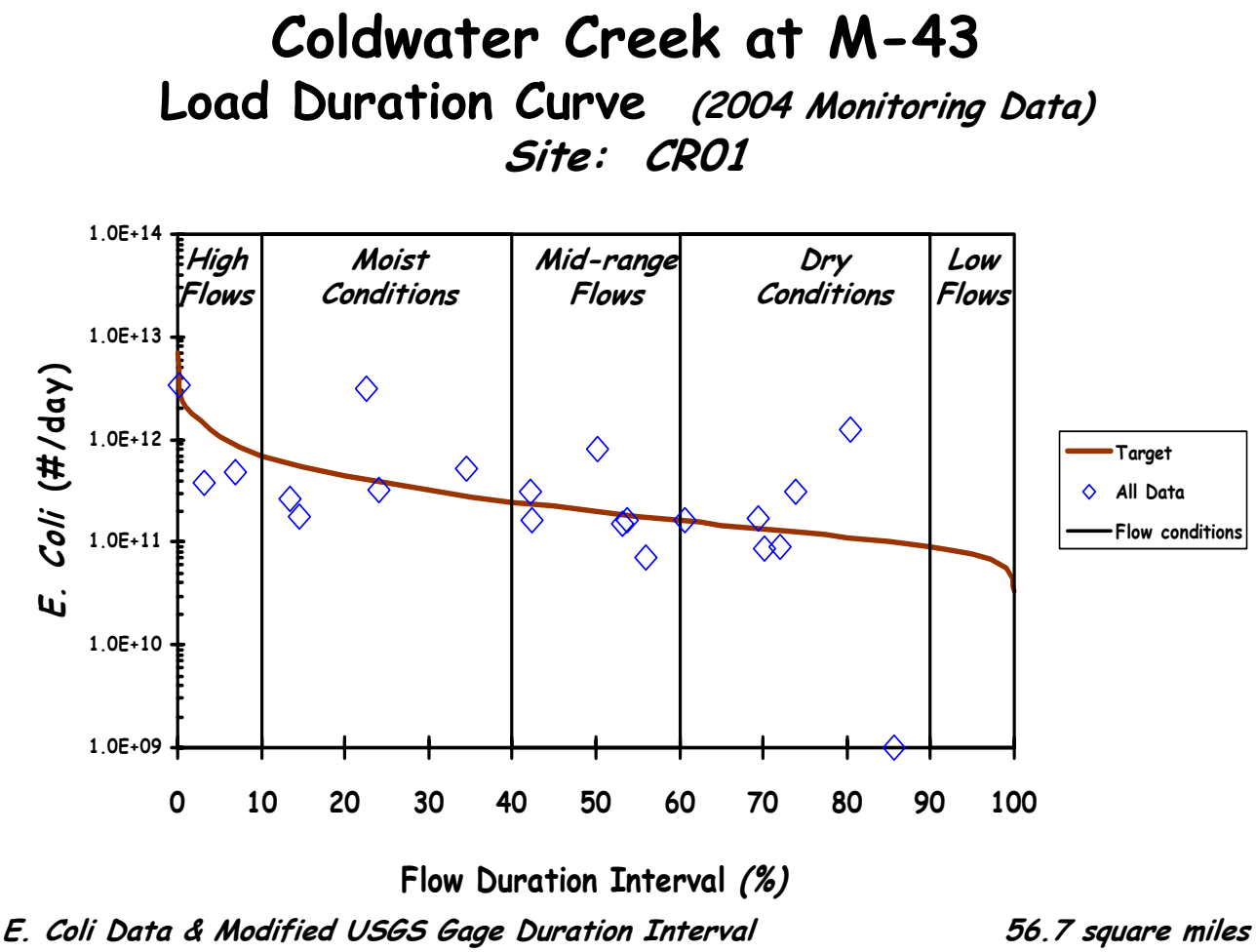

Figure A-1. Coldwater River at M-43/Carleton. Load duration curve based on daily geometric mean. Site: CR-01.

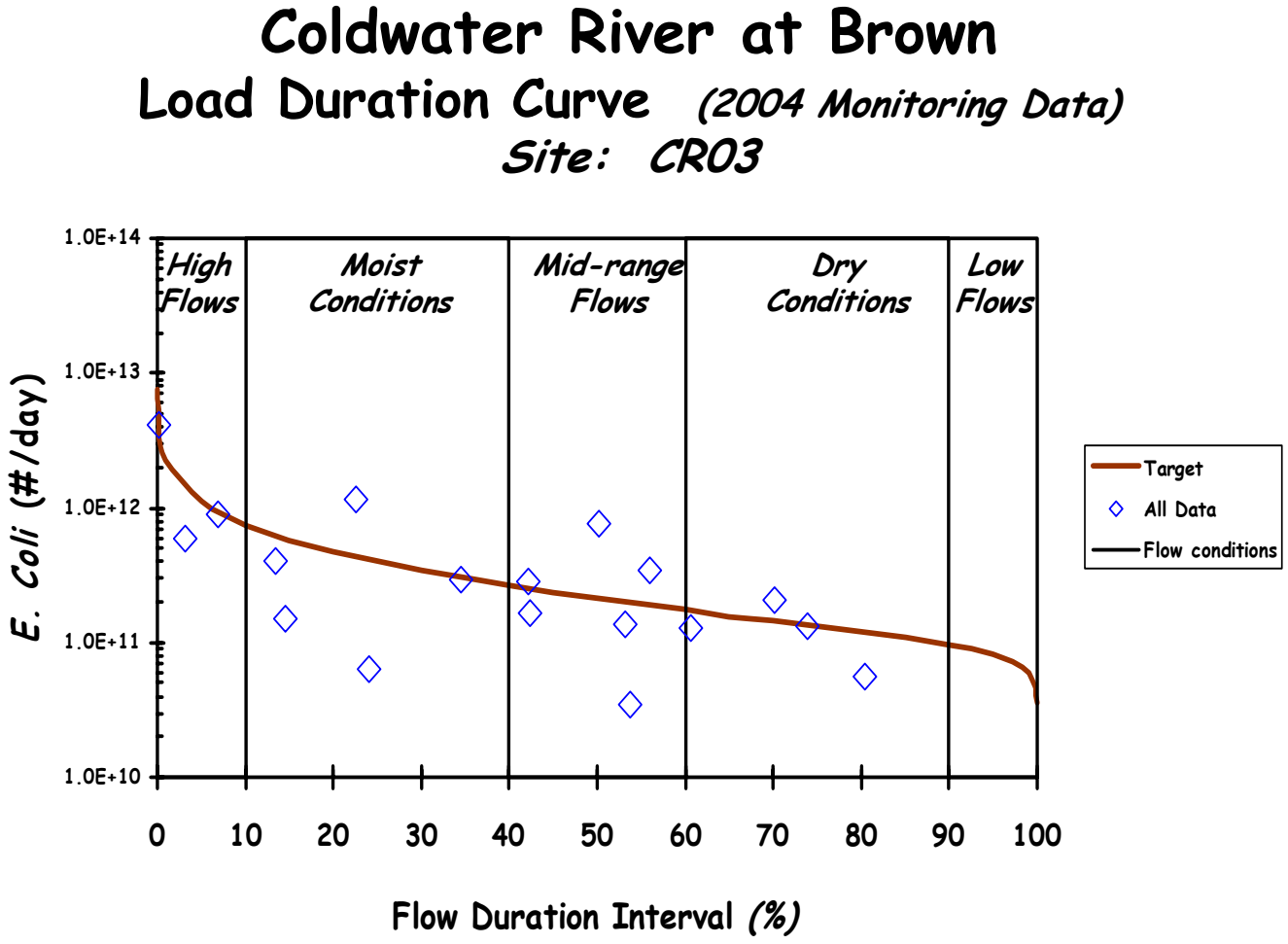

Figure A-2. Coldwater River at Brown Road. Load duration curve based on daily geometric mean. Site: CR-03.

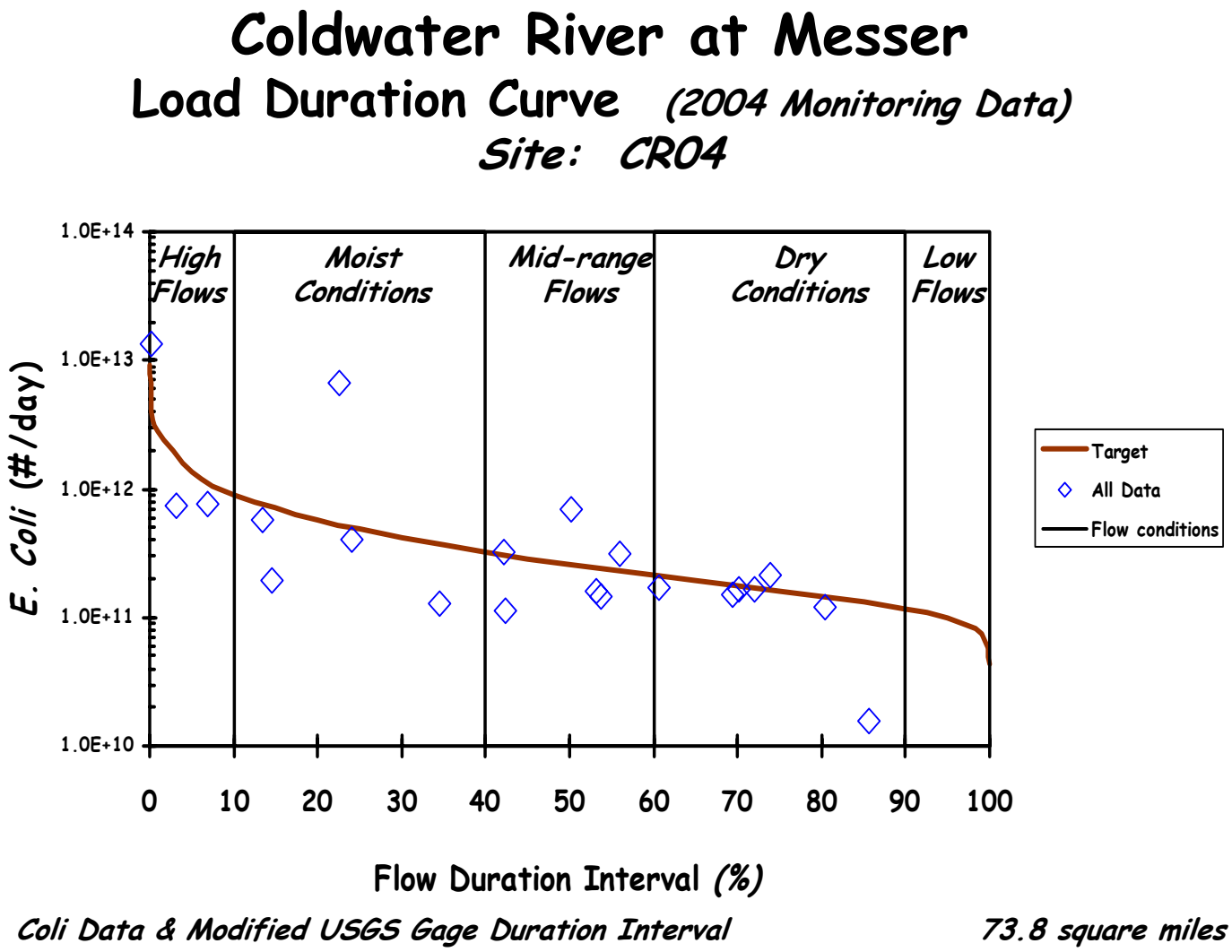

Figure A-3. Coldwater River at Messer Road. Load duration curve based on daily geometric mean. Site: CR-04.

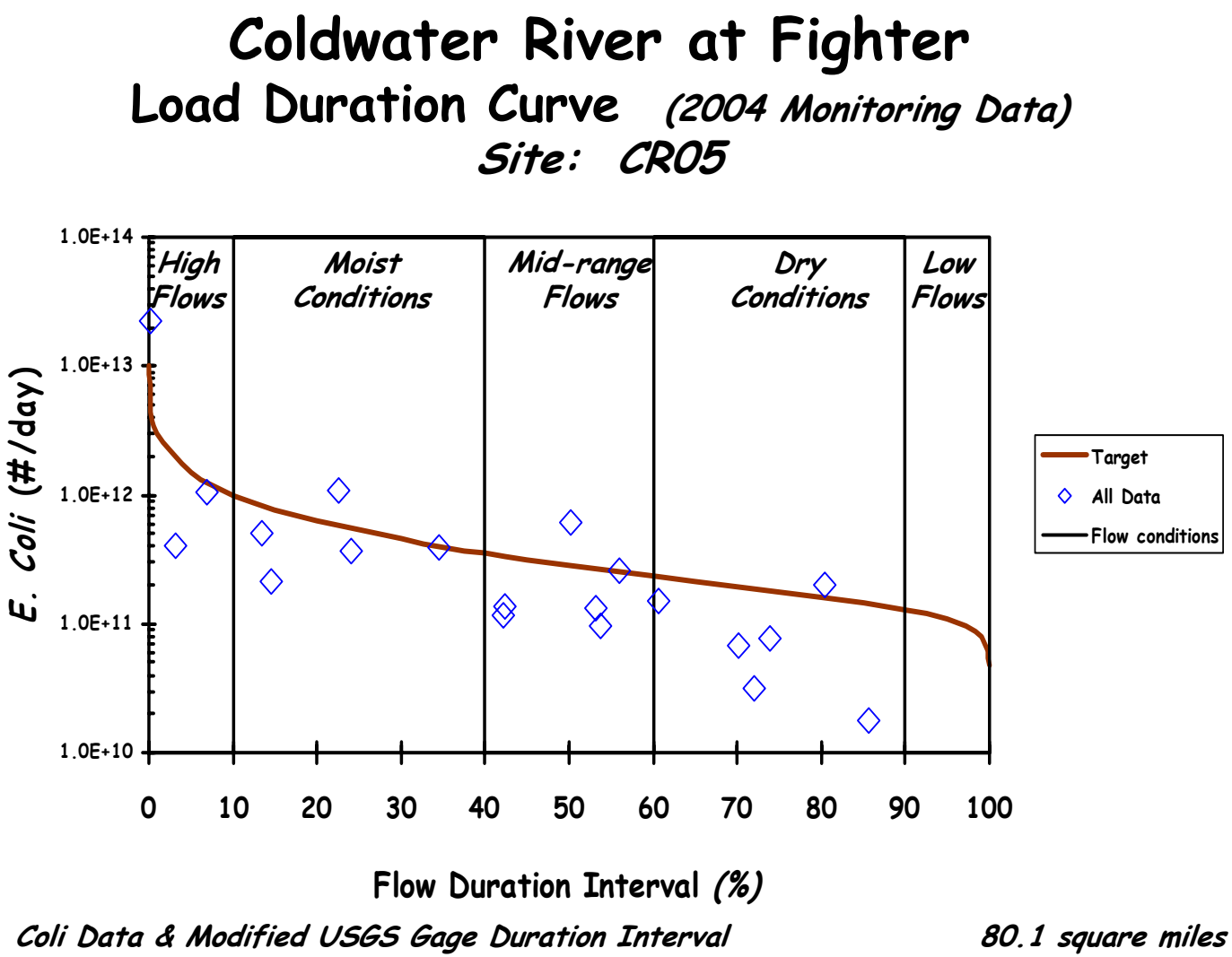

Figure A-4. Coldwater River at Fighter Road. Load duration curve based on daily geometric mean. Site: CR-05.

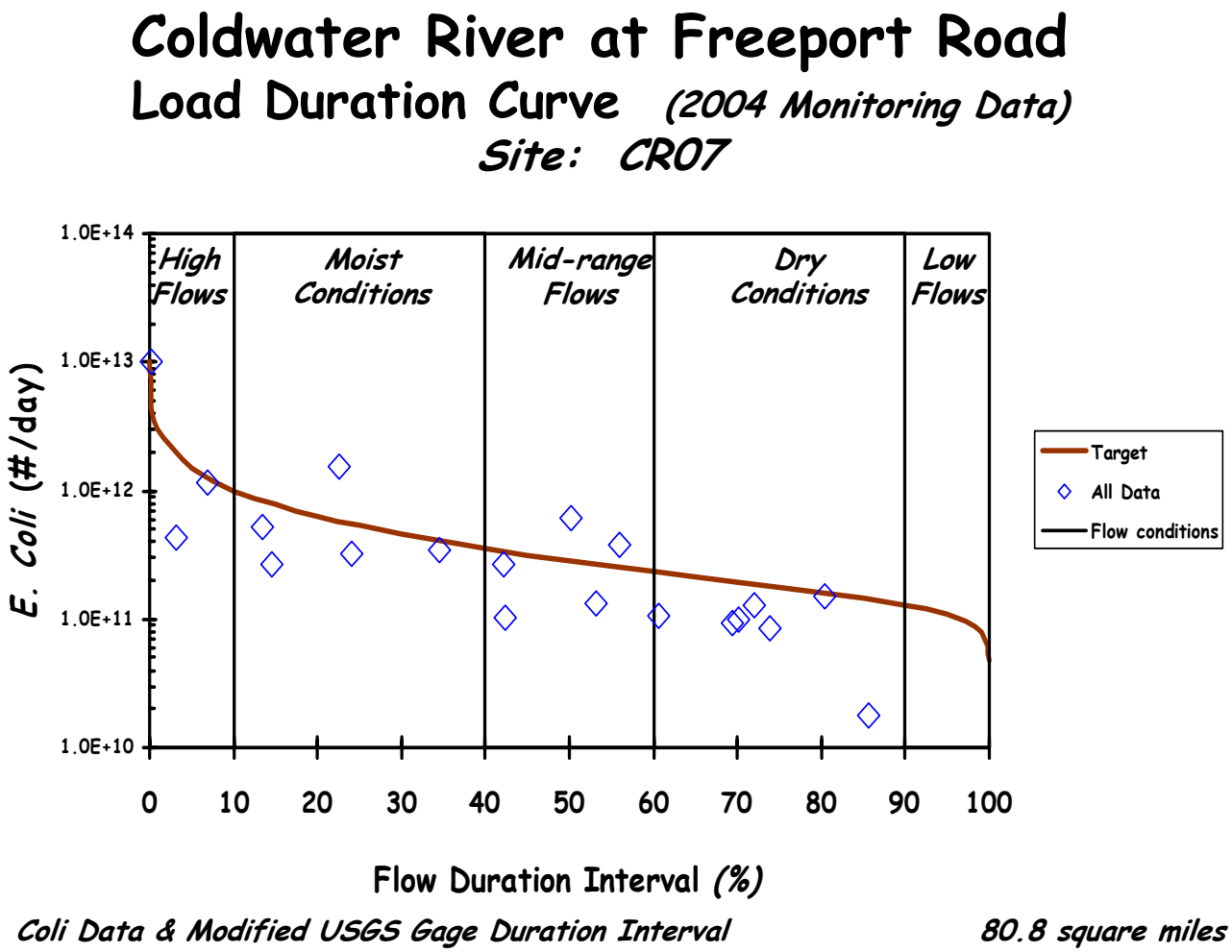

Figure A-5. Coldwater River at Freeport Road. Load duration curve based on daily geometric mean. Site: CR-07.

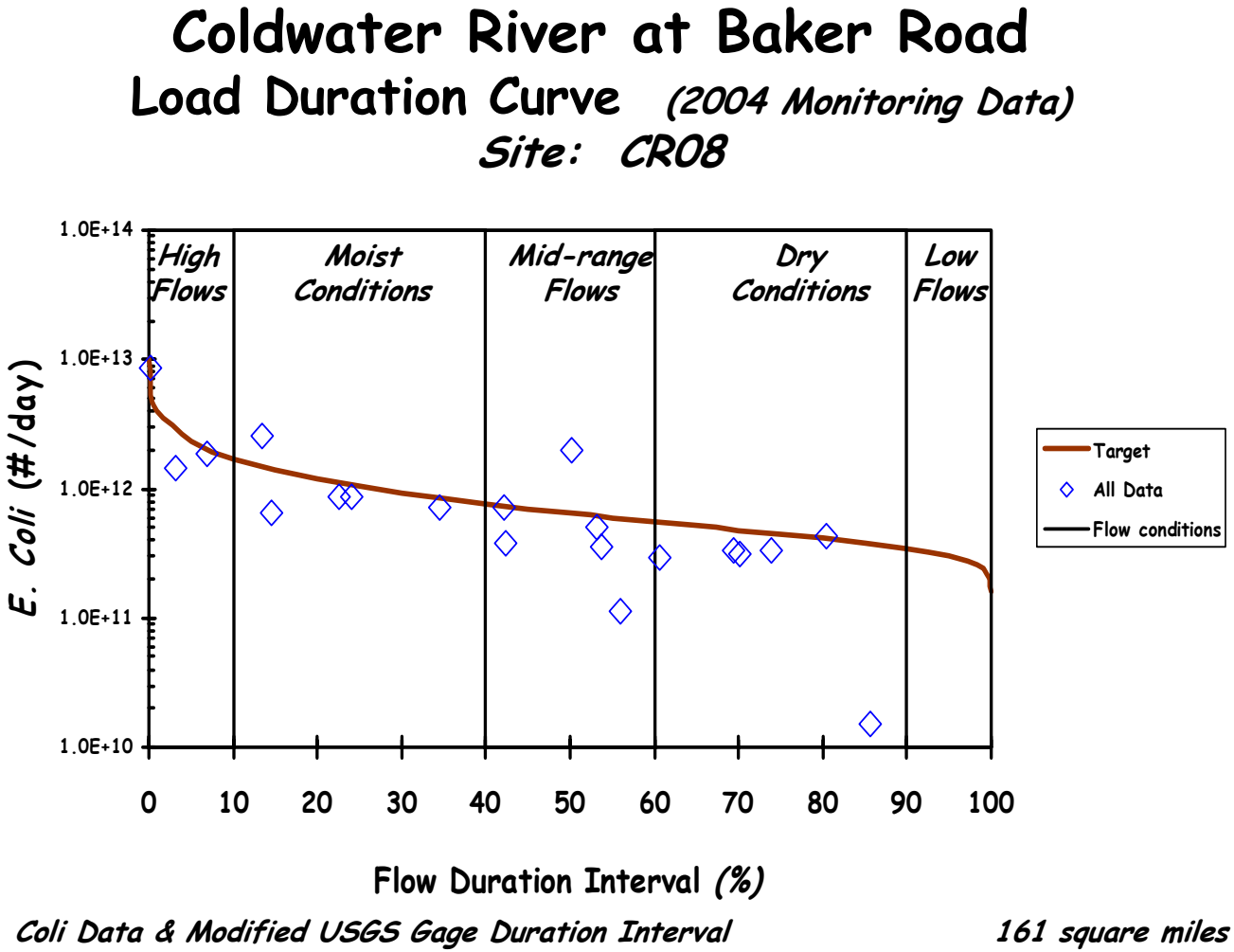

Figure A-6. Coldwater River at Baker Road. Load duration curve based on daily geometric mean. Site: CR-08.

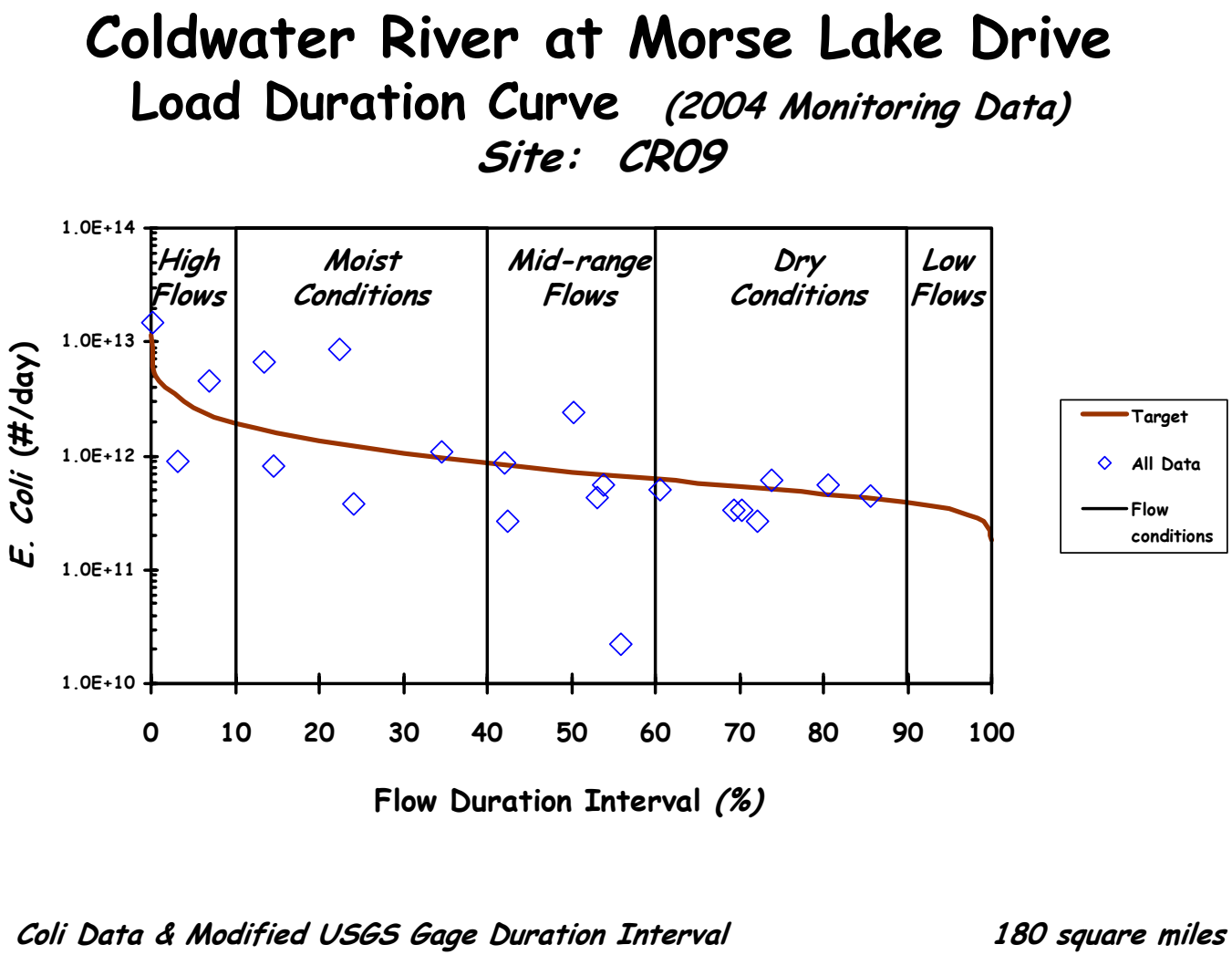

Figure A-7. Coldwater River at Morse Lake Drive. Load duration curve based on daily geometric mean. Site: CR-09.

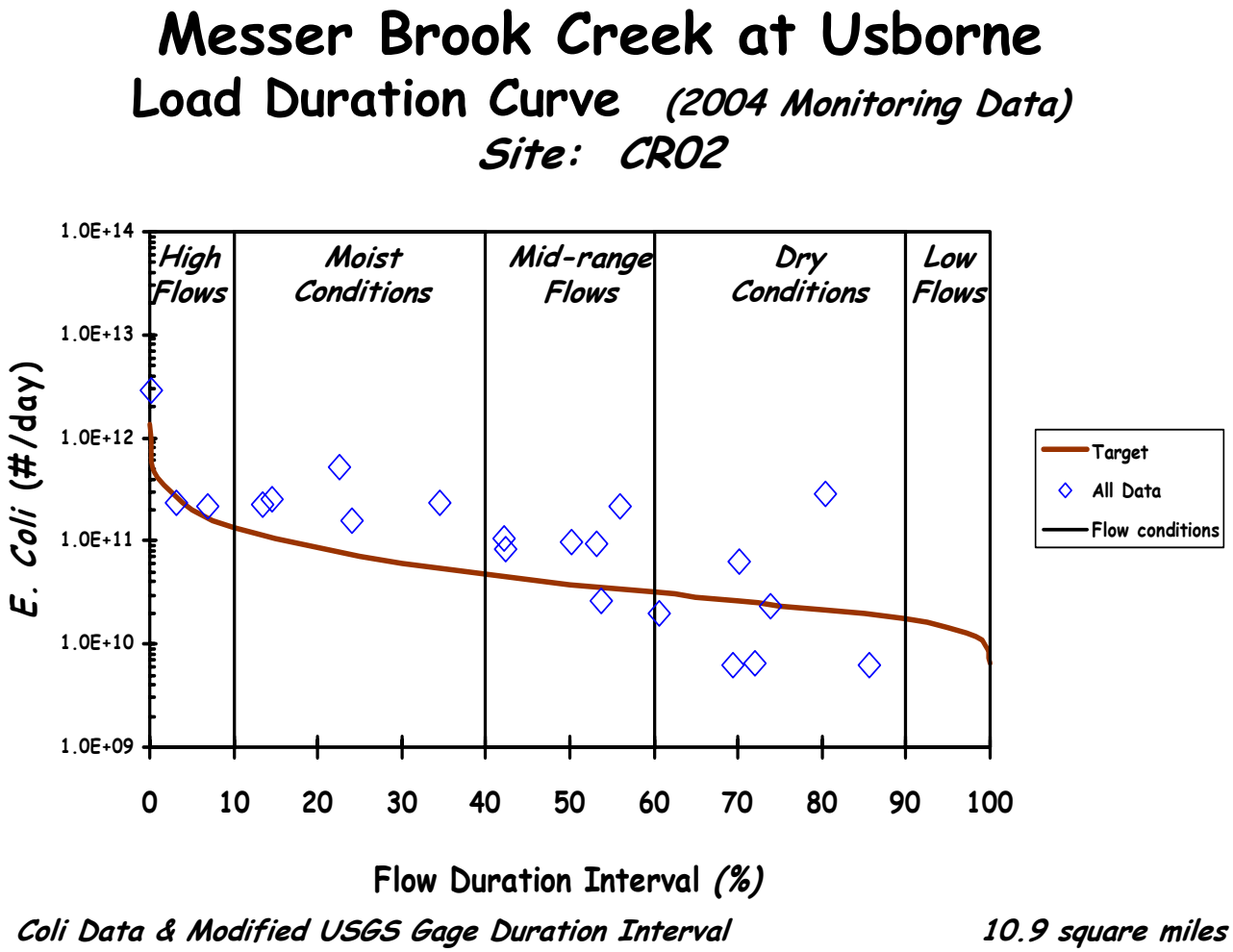

Figure A-8. Messer Brook Creek at Usborne. Load duration curve based on daily geometric mean. Site: CR-02.

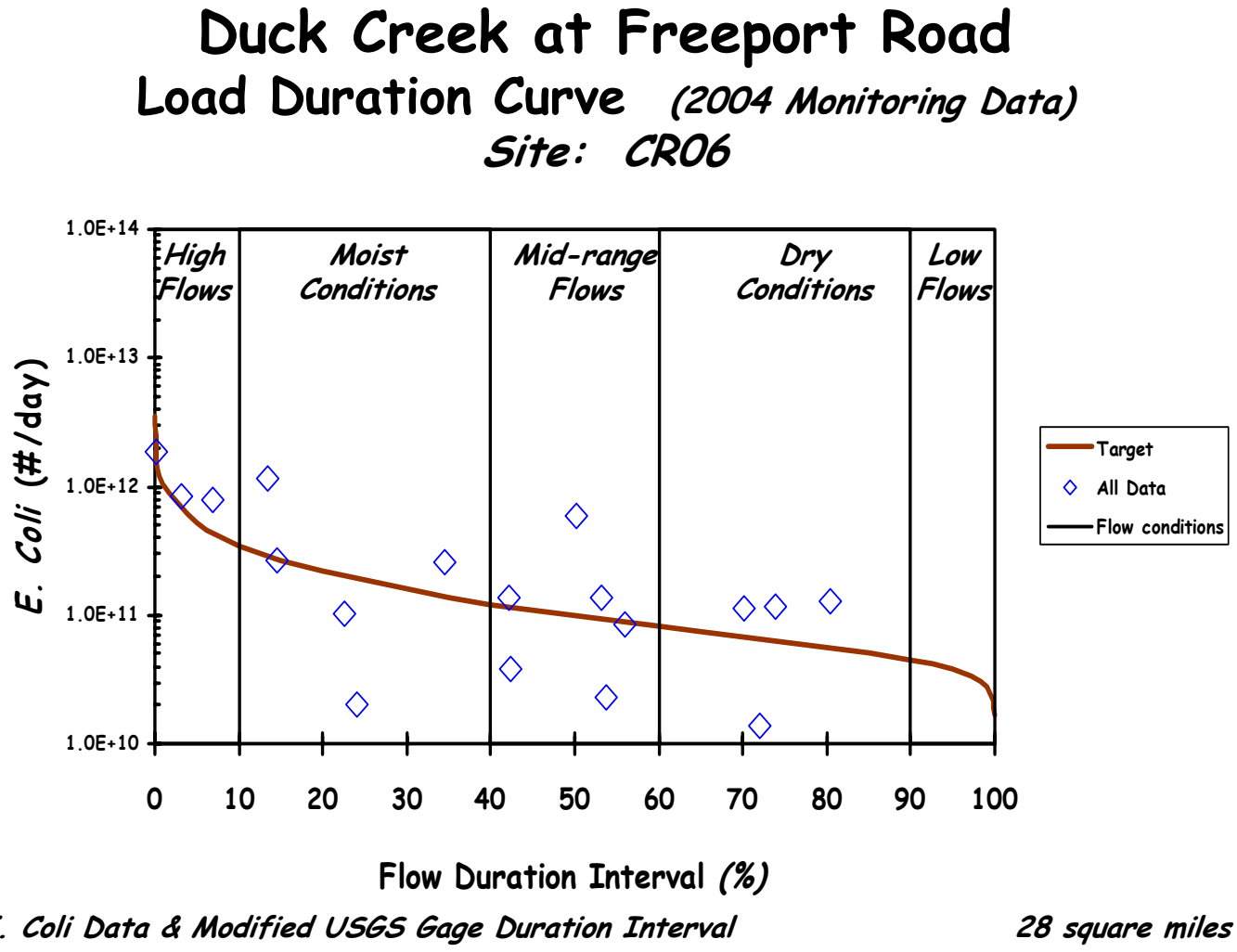

Figure A-9. **Duck Creek at Freeport Road. Load duration curve based on daily geometric mean. Site: CR-06.**

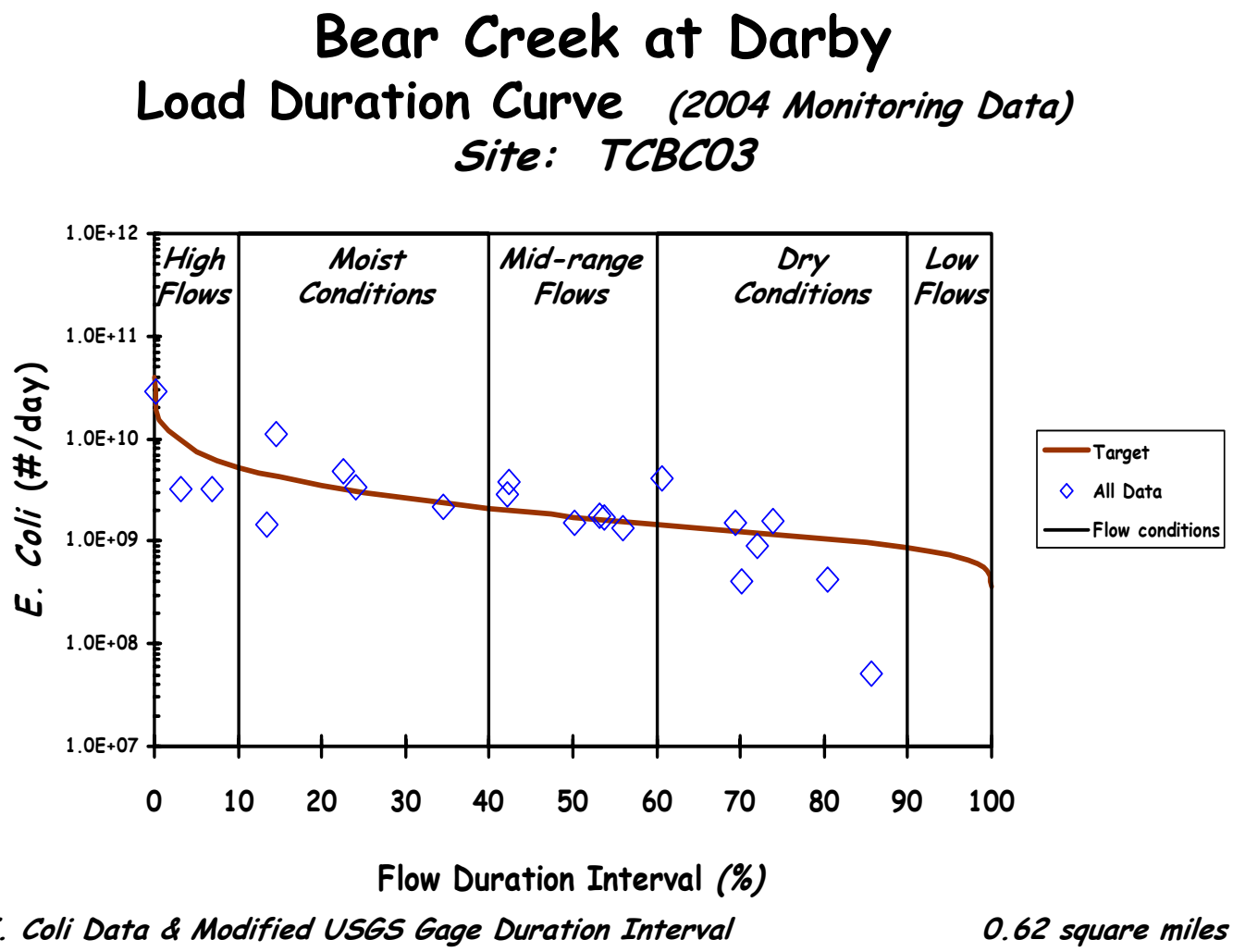

Figure A-10. Bear Creek at Darby Road. Load duration curve based on daily geometric mean. Site: TBC-03.

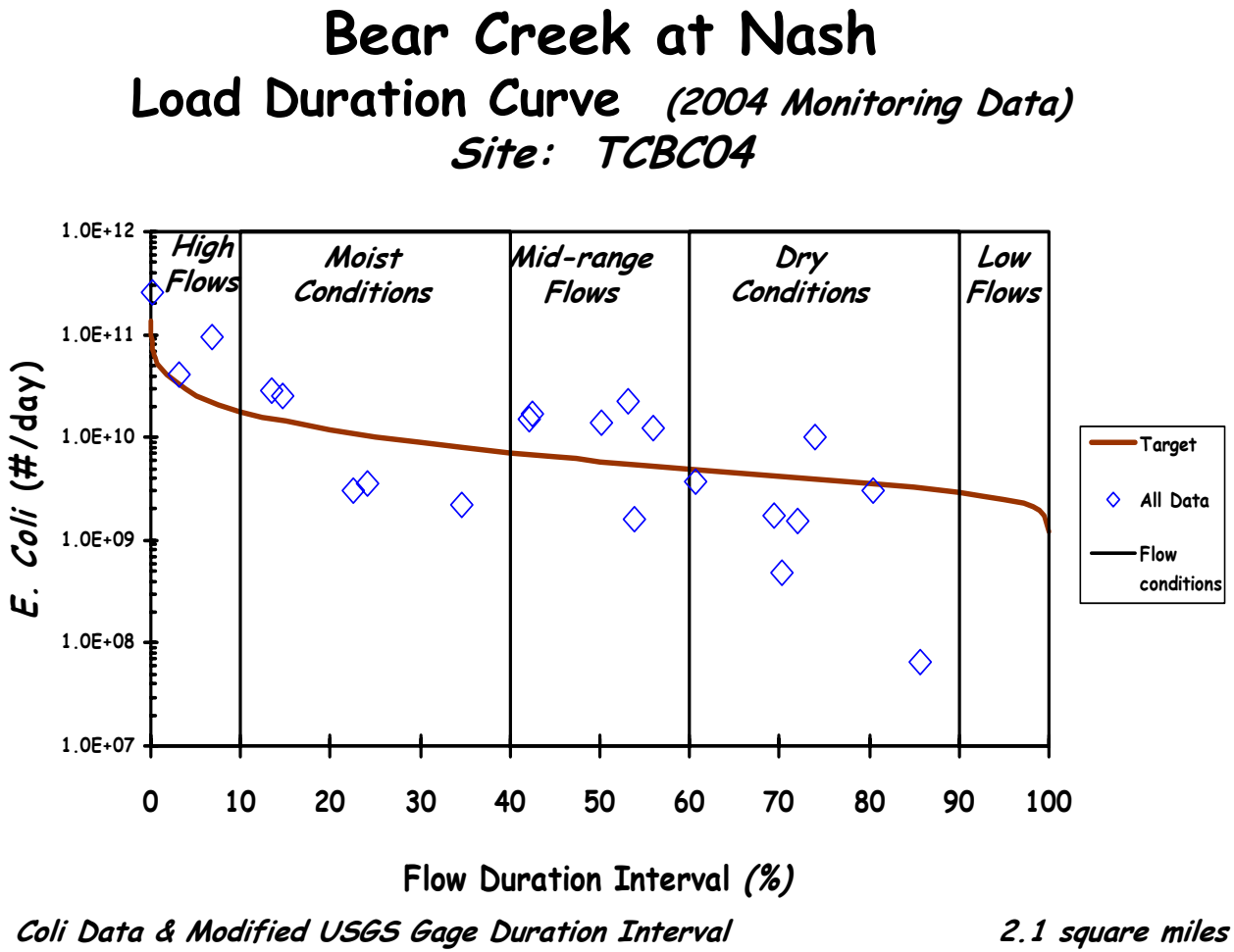

Figure A-11. Bear Creek at Nash Road. Load duration curve based on daily geometric mean. Site: TBC-04.

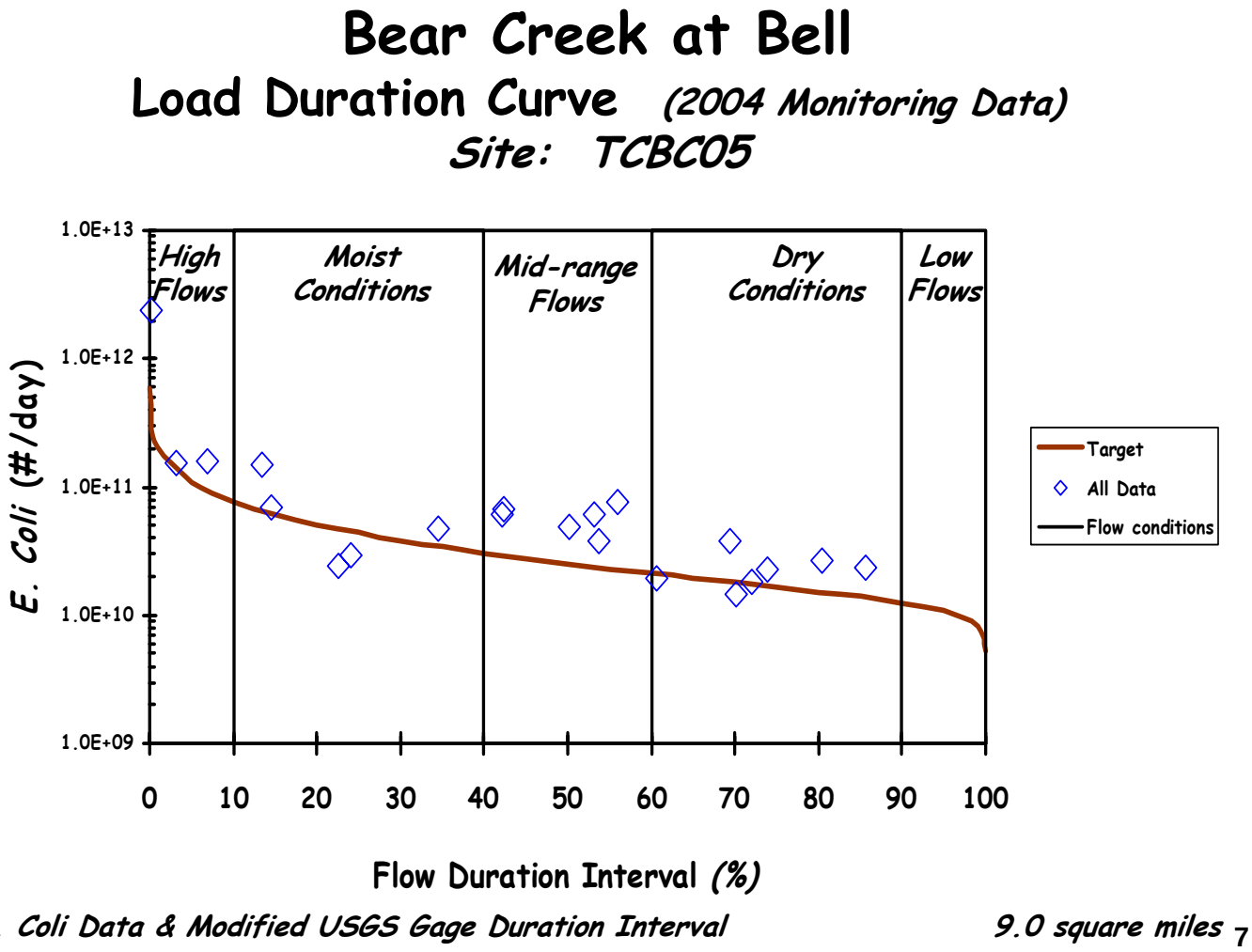

Figure A-12. Bear Creek at Bell Road. Load duration curve based on daily geometric mean. Site: TBC-05.

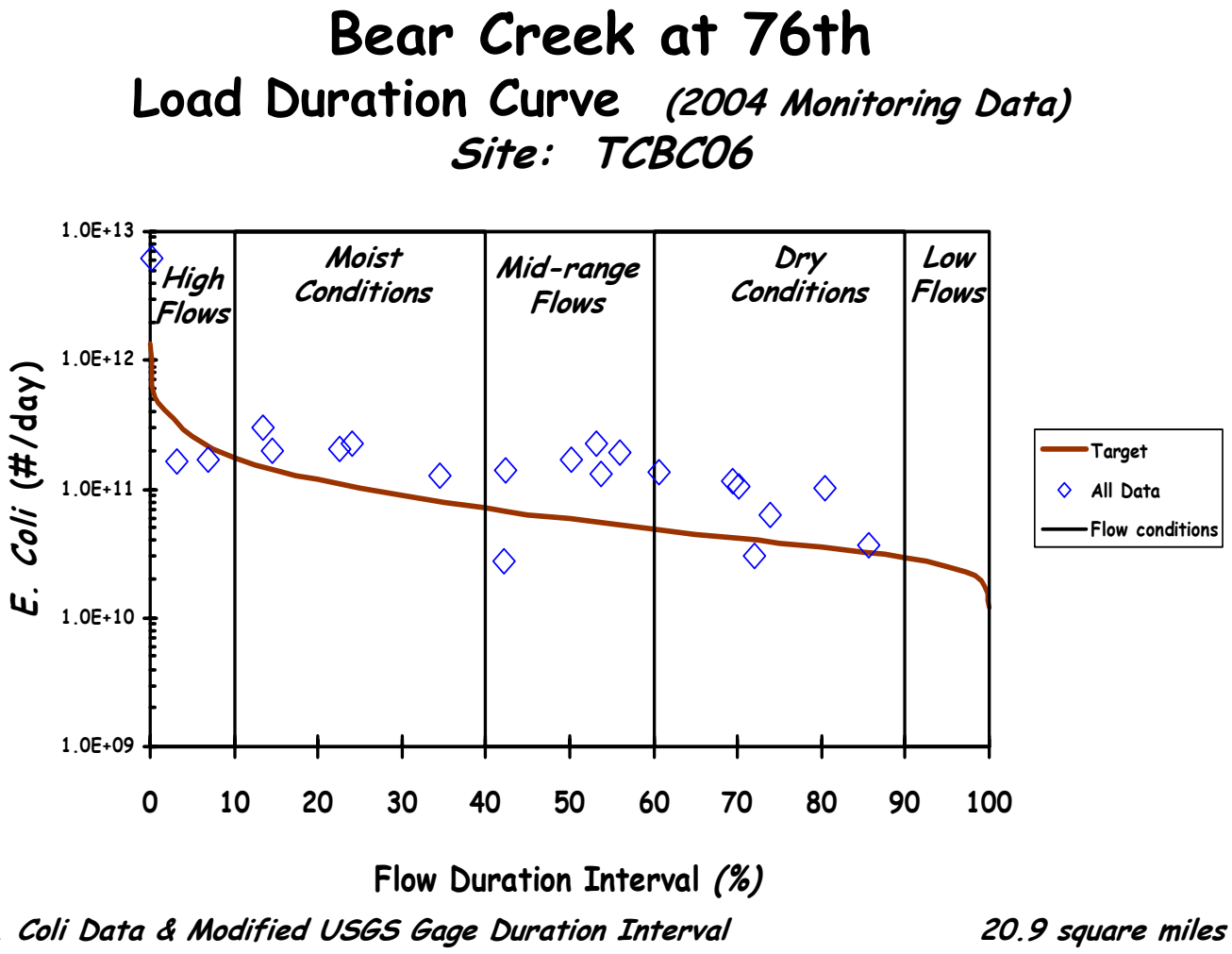

Figure A-13. Bear Creek at 76th Street. Load duration curve based on daily geometric mean. Site: TBC-06.

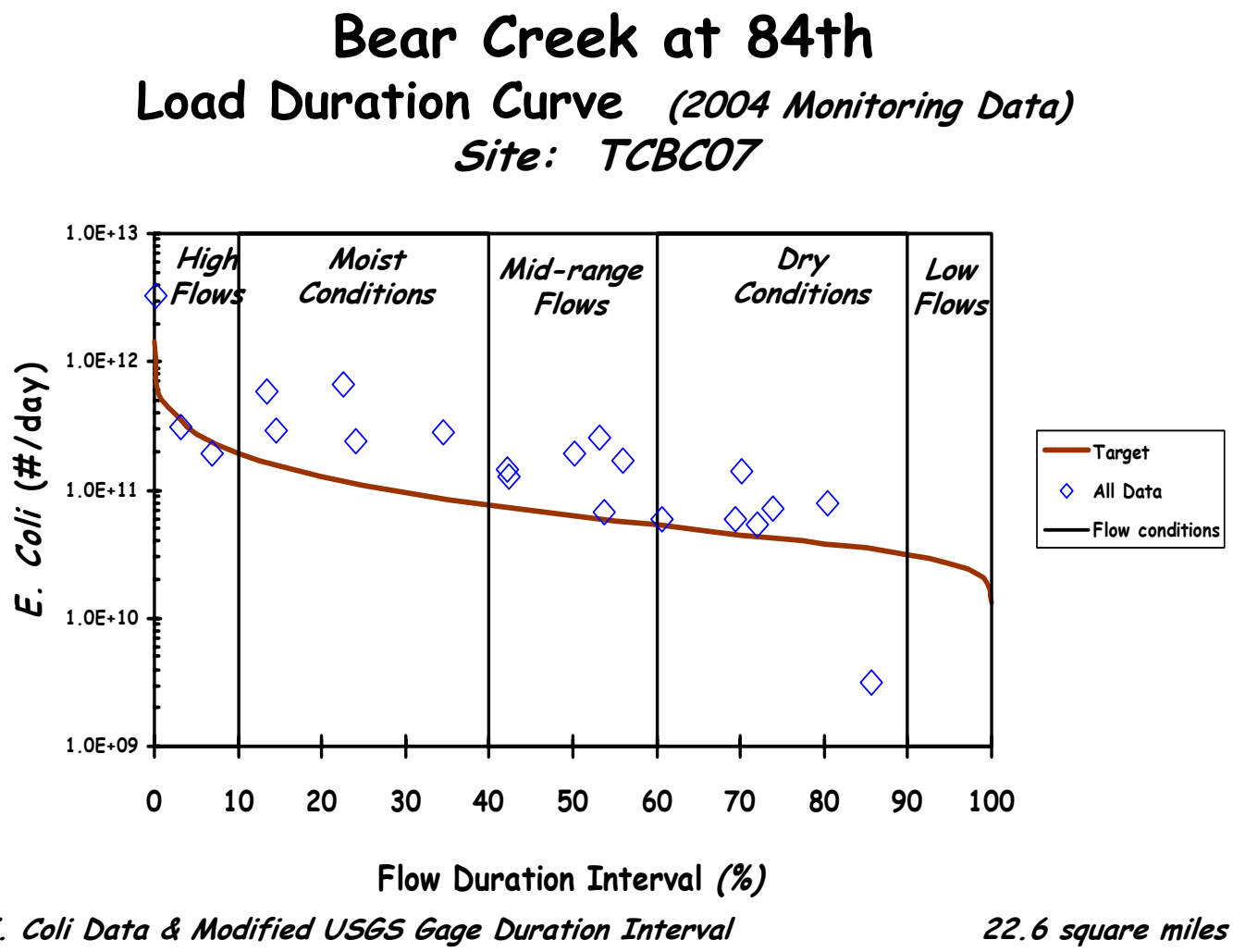

Figure A-14. Bear Creek at 84th Street. Load duration curve based on daily geometric mean. Site: TBC-07.

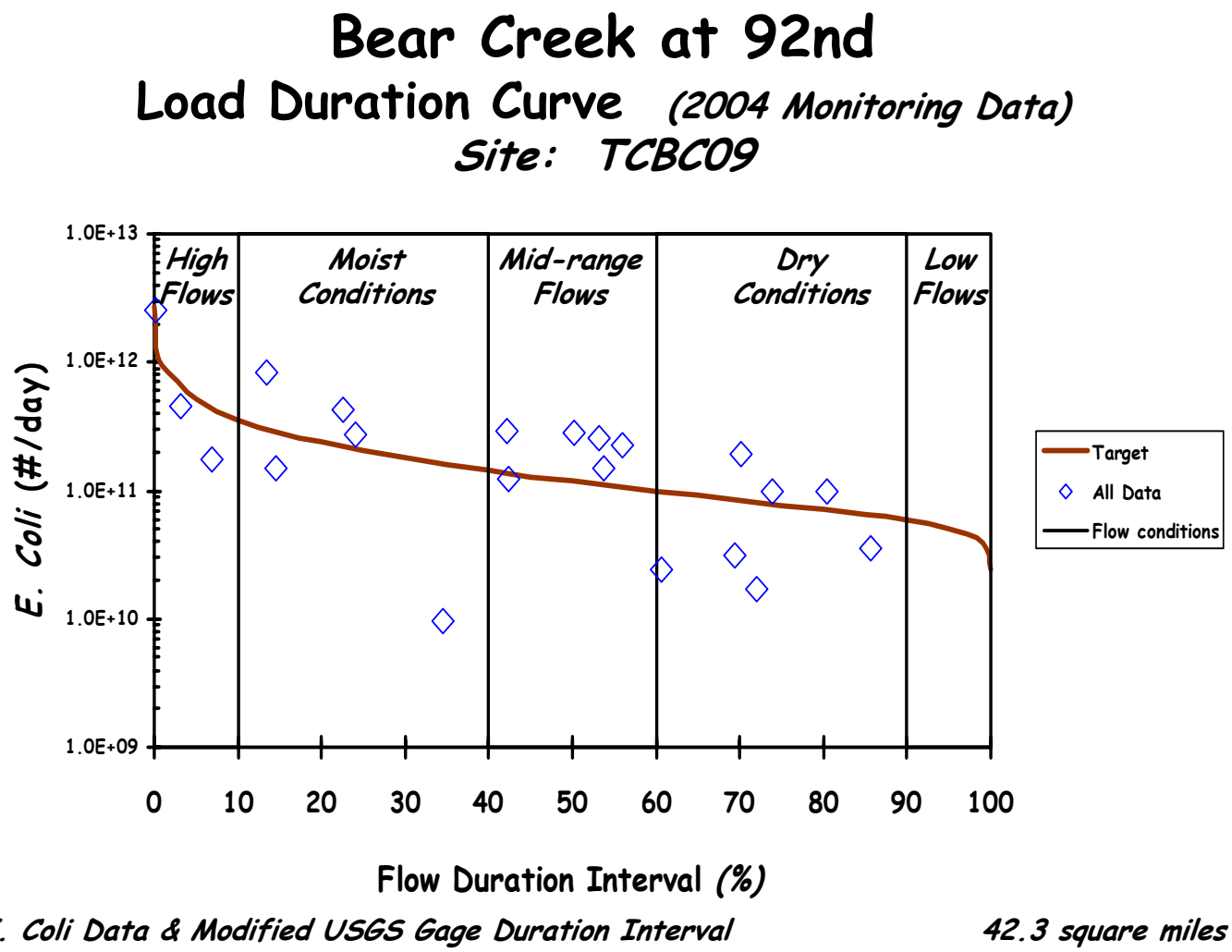

Figure A-15. Bear Creek at 92nd Street. Load duration curve based on daily geometric mean. Site: TBC-09.

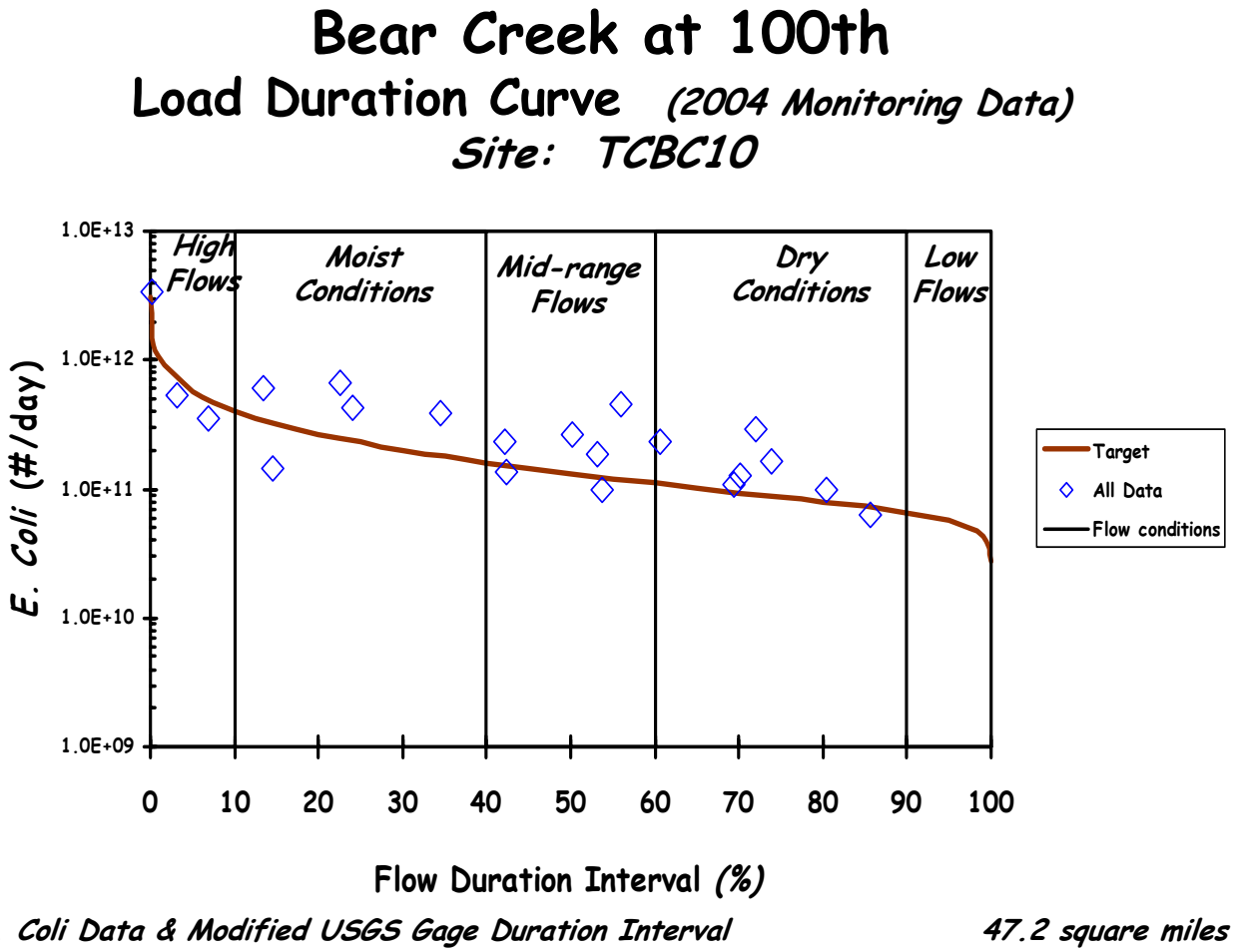

Figure A-16. Bear Creek at 100th Street. Load duration curve based on daily geometric mean. Site: TBC-10.

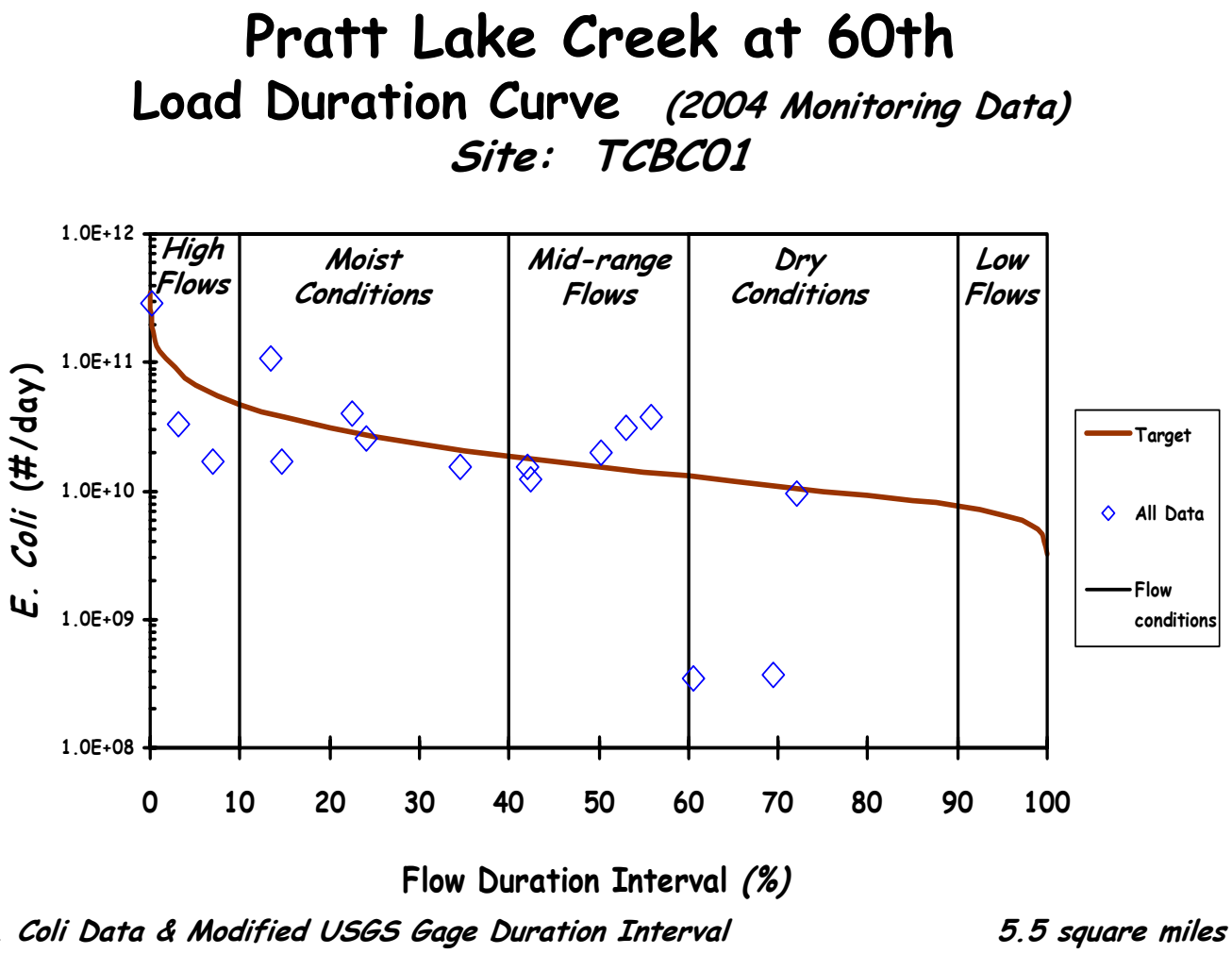

Figure A-17. Pratt Lake Creek at 60th Street. Load duration curve based on daily geometric mean. Site: TBC-01.

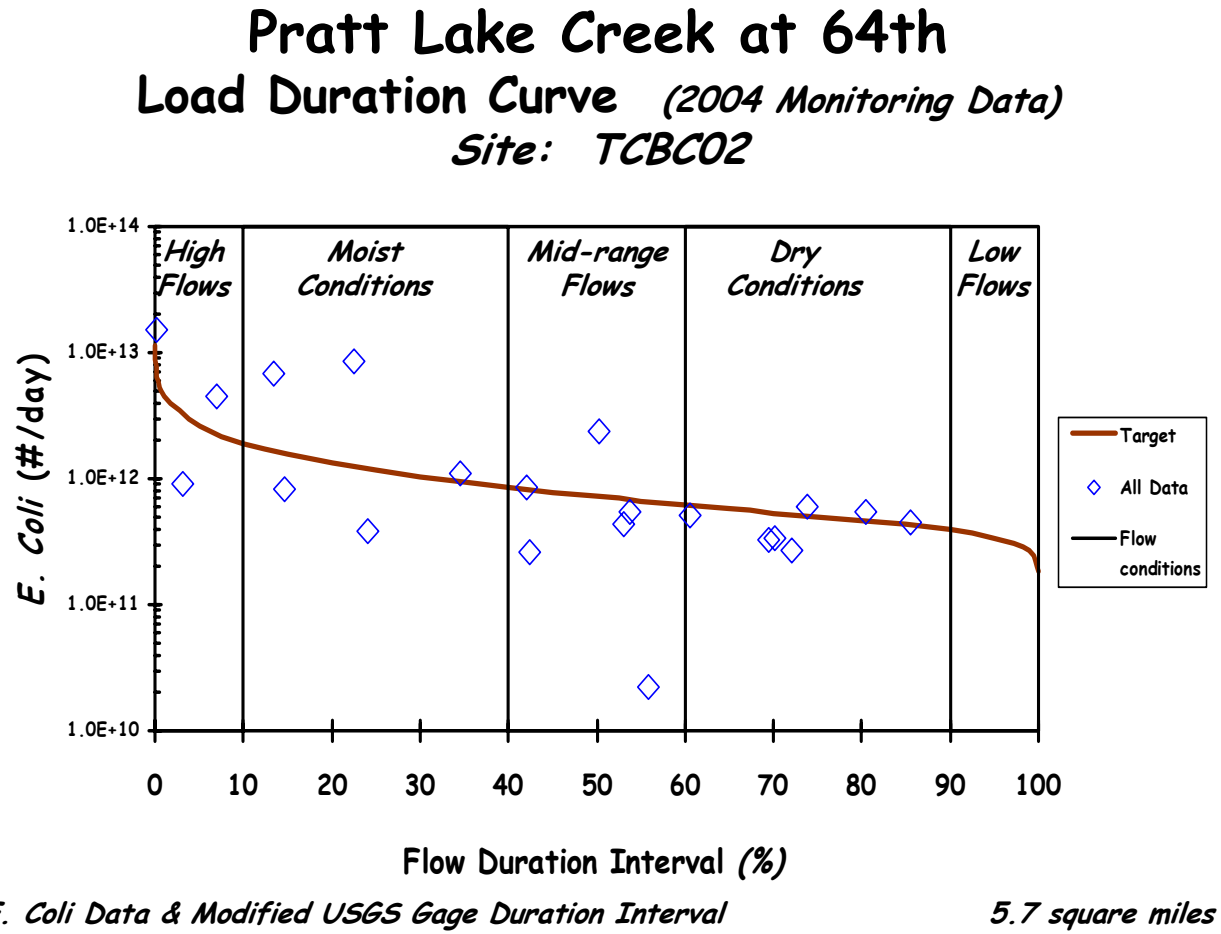

Figure A-18. Pratt Lake Creek at 64th Street. Load duration curve based on daily geometric mean. Site: TBC-02.

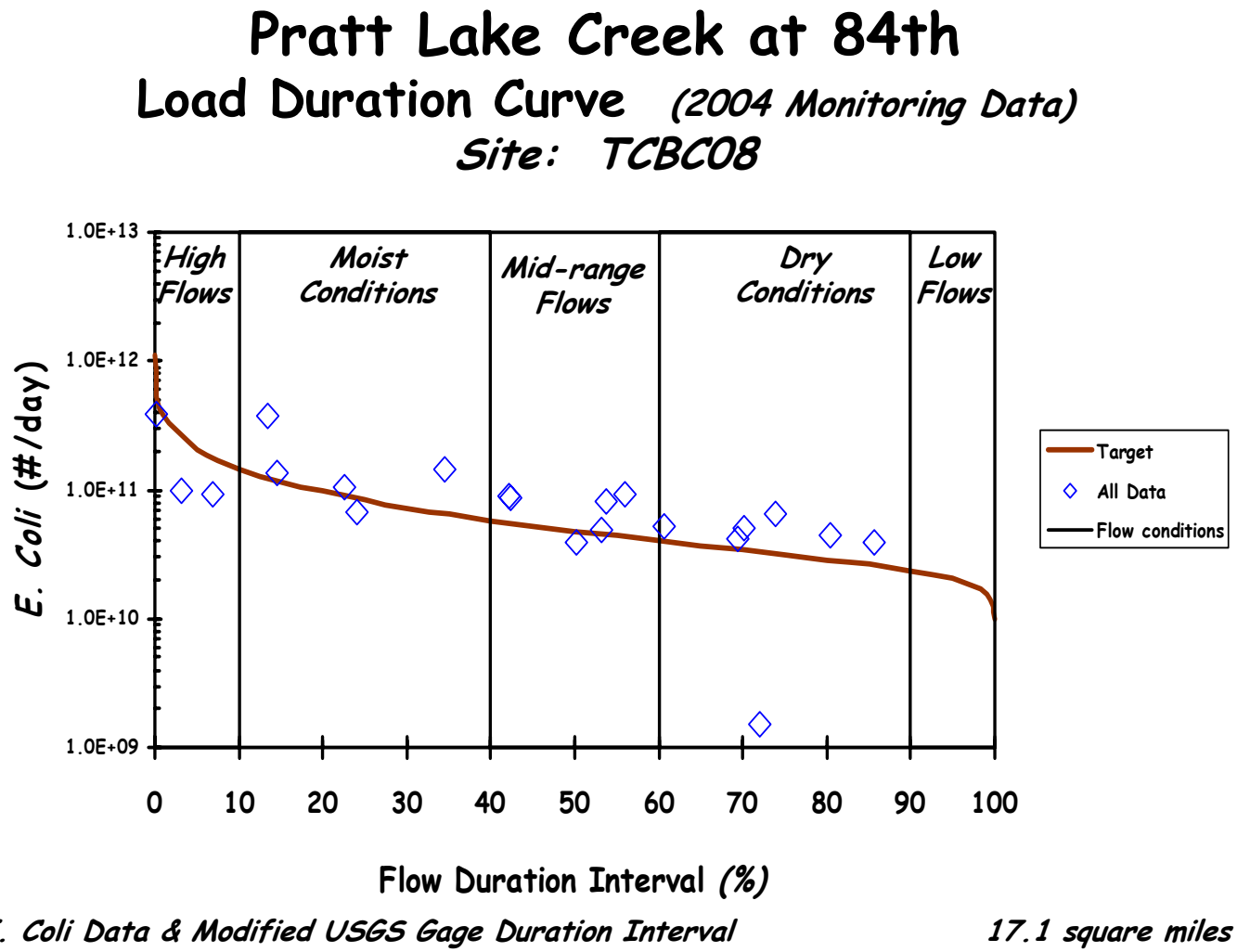

Figure A-19. Pratt Lake Creek at 84th Street. Load duration curve based on daily geometric mean. Site: TBC-08.

APPENDIX B

PERMIT NO. MIG440000

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
GENERAL PERMIT

CONCENTRATED ANIMAL FEEDING OPERATIONS

PART I

Section A. Water Pollution Control Requirements and Limitations

1. Authorized Discharges

During the period beginning on the effective date of a CAFO's certificate of coverage, and lasting until the expiration of this permit or termination of the certificate of coverage, the permittee is authorized to discharge the following, providing that the discharge does not cause or contribute to a violation of Michigan's Water Quality Standards:

a. Process wastewater and production area wastewater and/or manure in the overflow from the storage structures identified in Part I.A.3. below, when both of the following conditions are met:
   1) These structures are properly designed, constructed, operated and maintained, and
   2) Either chronic or catastrophic precipitation events cause an overflow of the storage structures to occur.

b. Silage leachate and runoff in the overflow from the facilities identified in Part I.A.4. below, when both of the following conditions are met:
   1) The facilities are properly designed, constructed, operated and maintained, and
   2) Either chronic or catastrophic precipitation events cause an overflow from the facilities

c. Runoff from precipitation events from land application areas of the CAFO where such land application areas are managed in accordance with the approved Comprehensive Nutrient Management Plan (CNMP)(see Part I.A.5. below).

2. Prohibited Discharges

During the period beginning on the effective date of a facility's certificate of coverage, and lasting until the expiration of this permit or termination of the certificate of coverage, the permittee is prohibited from having any dry weather discharge or discharging any process wastewater, production area wastewater, manure and/or silage leachate and/or runoff that doesn't meet the requirements of Part I.A.1. Discharges from land application activities that do not meet the requirements of Part I.A.1. are prohibited.