Office of Water Quality
Total Maximum Daily Load Program

Total Maximum Daily Load (TMDL)
for *Escherichia coli* (*E. coli*)
For the Upper Mill Creek Watershed, Hendricks, Putnam, Morgan, and Owen Counties

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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 waterbodies that are listed on the state's section 303(d) list of impaired waterbodies because they are not meeting state Water Quality Standards (WQS). 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 sources and determine the allowable levels of *E. coli* bacteria that will result in the attainment of the applicable WQS in the Upper Mill Creek watershed in Hendricks, Putnam, Morgan, and Daviess Counties, Indiana.

Background

In 1998 and 2002, Indiana's section 303(d) list cites Mill Creek as being impaired for *E. coli* upstream of US Highway 40 in Hendricks County. In 2004, Indiana's section 303(d) list cites, in addition to Mill Creek upstream of US Highway 40, Crittenden Creek, East Fork Mill Creek, Sallust Branch, Mud Creek, Mill Creek upstream of Cagles Mill Lake, and Doe Creek – Ferguson Branch. This TMDL address approximately 88 miles of Upper Mill Creek watershed in Hendricks, Putnam, Morgan, and Owen Counties, in western Indiana, where recreational uses are impaired by elevated levels of *E. coli* during the recreational season (Figure 1). All of the eleven (11) segments of the listed streams for this TMDL are located in the West Fork White River Basin in hydrologic unit code 05120203060. The description of the study area, its topography, and other particulars is as follows:

Waterbody Name	303(d) List ID	Segment ID number(s)	Length (miles)	Impairment
Mill Creek	134	INW0361_T1010, INW0362_T1011, INW0365_T1012	12.0	*E. coli*
Crittenden Creek	134	INW0362_00	8.0	*E. coli*
East Fork Mill Creek	134	INW0363_00, INW0364_00	11.0	*E. coli*
Sallust Branch and Other Tributaries	134	INW0365_00	21.0	*E. coli*
Mud Creek	134	INW0366_00, INW0367_00	13.0	*E. coli*
Mill Creek upstream of Cagles Mill Lake	134	INW036F_00	6.0	*E. coli*
Doe Creek – Ferguson Branch and other Tributaries	504	INW036G_00	17.0	*E. coli*

Historical data collected by IDEM documented elevated levels of *E. coli* in Mill Creek in 1996. This data was the basis for the listing of Mill Creek on the 1998 303(d) list. IDEM completed an intensive survey of the watershed upstream of US Highway 40 in Hendricks County in 2001. IDEM sampled fourteen sites five times, with the samples evenly spaced over a 30-day period from June 6, 2001, to July 5, 2001 and IDEM sampled three sites five times, with the samples evenly spaced over a 30-day period from July 31, 2001 to August 28, 2001. Both of these periods fall within Indiana's recreational season (April 1st through October 31st) (Figure 2). Sixteen of the seventeen sites violated the single sample maximum standard at least once during these sampling events. Of the sixteen sites that violated the single sample maximum standard, all sixteen sites violated the geometric mean standard. Based on this intensive study in 2001, IDEM determined that an *E. coli* TMDL would need to be completed on the Upper Mill Creek watershed (Attachment A).

The TMDL development schedule corresponds with IDEM's basin-rotation water quality monitoring schedule. To take advantage of all available resources for TMDL development, impaired waters are scheduled for TMDL development according to the basin-rotation schedule unless there is a significant reason to deviate from this schedule. Waterbodies could be scheduled based on the following:

1) Waterbodies may be given a high or low priority for TMDL development depending on the specific designated uses that are not being met, or in relation to the magnitude of the impairment.
2) TMDL development of waterbodies where other interested parties, such as local watershed groups, are working on alleviating the water quality problem may be delayed to give these other actions time to have a positive impact on the waterbody. If water quality standards still are not met, then the TMDL process will be initiated.
3) TMDLs that are required due to water quality violations relating to pollutant parameters where no EPA guidance is available, may be delayed to give EPA time to develop guidance.

This TMDL was scheduled based on the data available from the basin-rotation schedule, which represents the most accurate and current information on water quality within waterbodies covered by this TMDL.

Water quality *E. coli* load duration curves were created by using IDEM's data. A flow duration interval is defined as a percentage. Zero percent corresponds to the highest stream discharge (flood condition) and 100 percent corresponds to the lowest discharge (drought condition). The *E. coli* values at three of the sites were plotted with the corresponding flow duration interval to show the *E. coli* violations of the single-sample maximum standard and geometric mean standard during both the recreational and non-recreational seasons. These three sites are representative of the hydrodynamics of the Upper Mill Creek watershed (Attachment B).

Numeric Targets

The impaired designated use for the waterbodies in the Upper Mill Creek watershed is for total body contact recreational use during the recreational season, April 1st through October 31st.

327 IAC 2-1-6(d) establishes the total body contact recreational use *E. coli* Water Quality Standard (WQS[1]) for all waters in the non-Great Lakes system as follows:

[1] *E.coli* WQS = 125 cfu/100ml or 235 cfu/100ml; 1 cfu (colony forming units)= 1 mpn (most probable number)

> *E. coli* bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period.

The sanitary wastewater *E. coli* effluent limits from point sources in the non-Great Lakes system during the recreational season, April 1st through October 31st, are also covered under 327 IAC 2-1-6(d).

For the Upper Mill Creek watershed during the recreational season (April 1st through October 31st) the target level is set at the *E. coli* WQS of 125 per one hundred milliliters as a 30-day geometric mean based on not less than five samples equally spaced over a thirty day period.

Source Assessment

Watershed Characterization

Mill Creek begins in Hendricks County, Indiana, where it flows south into Putnam and Morgan Counties, then southwest into Cagles Mill Lake in Owen County. The major tributaries of this waterbody include Crittenden Creek, East Fork Mill Creek, Mud Creek, Sallust Branch, Lake Ditch, Rhodes Creek, and Doe Creek-Ferguson Branch. There are also several unnamed tributaries that flow into these major tributaries, as well as into Mill Creek.

The tributaries of Crittenden Creek, East Fork Mill Creek, and Doe Creek-Ferguson Branch are listed on the 2004 303(d) list for *E. coli*. Based on sampling completed in 2001, each of these tributaries is contributing to the impairment of Mill Creek. Cagles Mill Lake is not listed on the 2004 303(d) list for *E. coli* and the sampling completed in 2001 confirms that it is not contributing to the impairment on Mill Creek.

The landuse information, which was gathered from the mid-1970s for the Upper Mill Creek watershed, consisted of approximately 84% agriculture and 1.7% developed. The remaining 14.3% includes forested, wetlands, strip mines, and water. Landuse information was also assembled in 1992 using the Gap Analysis Program (GAP). In 1992, approximately 77% of the landuse in the Upper Mill Creek watershed is agriculture. The remaining landuse consists of approximately 1% developed, 1% palustrine, 20% terrestrial, and 1% water (Figure 3). A comparison of the mid-1970s landuse with the 1992 landuse information shows that no substantial changes to the Upper Mill Creek watershed have occurred.

Wildlife is a known source of *E. coli* impairments in waterbodies. Many animals spend time in or around waterbodies. Deer, geese, ducks, raccoons, turkeys, and other animals all create potential sources of *E. coli*. Wildlife contributes to the potential impact of contaminated runoff from animal habitats, such as urban park areas, forest, and cropland.

Most of the homes within the Upper Mill Creek watershed are on septics. Failing septic tanks are known sources of *E. coli* impairment in waterbodies. According to the Hendricks County Health Department, the townships located in the Upper Mill Creek watershed have improved residential properties with lack of adequate sewage disposal (Grindstaff, C., 2004). In Owen County, the Health Department has found a 70% to 80% failure rate for homes in the Cataract Lake area in

Jackson and Jennings Townships (Personal Communication, 2004). Septic systems are also a known problem in Warren and Washington Townships in Putnam County (Personal Communication, 2004).

National Pollutant Discharge Elimination System (NPDES) Permitted Dischargers

There are seven permitted dischargers in the Upper Mill Creek TMDL watershed (Figure 4, Table 1). One of these seven dischargers (Cloverdale Water Department IN0059846) does not have a sanitary component to its discharge and therefore, *E. coli* limits do not apply to its permit. This permitted discharger is not contributing to the source of *E. coli* in the Upper Mill Creek watershed.

Permit IN005996 is for the Town of Stilesville Wastewater Treatment Plant (WWTP). Prior to 2003, the Town of Stilesville WWTP permit did not contain *E. coli* limits because it was believed that an extended retention time of sanitary wastewater was sufficient to provide a natural attrition of *E. coli* that would be in compliance with Indiana's *E. coli* Water Quality Standards. However, recent studies completed by Ron Turco from Purdue University have indicated that *E. coli* may live longer in this environment than originally believed. Therefore, *E. coli* monitoring requirements were added to this permit in April 2003.

Since the additional of the *E. coli* monitoring, the Town of Stilesville WWTP has reported end-of-pipe *E. coli* data for only the months of September and October 2003 and April and June of 2004. The *E. coli* values have ranged from 20 cfu/100mL to 63 cfu/100mL for the daily maximum. Based on these limited reported *E. coli* values, the Town of Stilesville WWTP will be considered as a potential source of *E. coli*. If the WWTP monitors as per the NPDES permit requirements the assumption that the permitted facility is a potential source of the *E. coli* impairment may be revised on that information.

Four of the seven permitted dischargers (Cloverdale STP IN0022616, Lieber State Recreation Area IN0030279, Camp Otto IN0059765, and Cascade Junior/Senior High School IN0037401) have total residual chlorine limits in their permits (Figure 5, Table 1). These dischargers do have possible sanitary components in their discharge. Previously, facilities with design flows under 1 MGD (typically minor municipals and semipublics) were not required to have *E. coli* effluent limits or conduct monitoring for *E. coli* bacteria, provided they maintained specific total residual chlorine levels in the chlorine contact tank. The assumption was that as long as chlorine levels were adequate in the chlorine contact tank, the *E. coli* bacteria would be deactivated and compliance with the *E. coli* WQS would be met by default. The original basis for allowing chlorine contact tank requirements to replace bacteria limits was based on fecal coliform, not *E. coli*. No direct correlation between the total residual chlorine levels and *E. coli* bacteria can be conclusively drawn. Further, it has been shown that exceedances of *E. coli* bacteria limits may still occur when the chlorine contact tank requirements are met. Due to the complications of comparing total residual chlorine to *E. coli*, it is difficult to determine to what extent, if any, these four dischargers could be a source of *E. coli* in the Upper Mill Creek watershed.

One of the seven permitted dischargers (Amo-Coatesville STP IN0043877) has *E. coli* and total residual chlorine limits in its permit (Figure 5, Table 1). This discharger has not violated their *E. coli* limits for at least the past 3 years. Therefore, this permitted discharger is considered to be in compliance and is not considered a significant source of the *E. coli* impairment in the Upper Mill Creek watershed.

Confined Feeding Operations and Confined Animal Feeding Operations

The removal and disposal of the manure, litter, or processed waste water that is generated as the result of confined feeding operations fall under the regulations for confined feeding operations (CFO) and confined animal feeding operations (CAFO). There are twelve (12) CFOs in the Upper Mill Creek watershed. Of the 12 CFOs, only one is considered a CAFO and has a general permit (Table 2, Figure 5). The CFO and CAFO regulations (327 IAC 16, 327 IAC 15) require operations "not to cause or contribute to an impairment of surface waters of the state". The currently operational CFOs and CAFO in the Upper Mill Creek watershed have no open enforcement actions at this time. Therefore, these operations are not considered a significant source of *E. coli* for the Upper Mill Creek TMDL.

There are also many small livestock operations in the watershed. These operations, due to their small size, are not regulated under the CFO or CAFO regulations. These operations may still have an impact on the water quality and the *E. coli* impairment. No specific information on these small livestock operations is currently available however; it is believed that these small livestock operations may be a source of the *E. coli* impairment.

Linkage Analysis and *E. coli* Load Duration Curves

The linkage between the *E. coli* concentrations in the Upper Mill Creek watershed and the potential sources provides the basis for the development of this TMDL. The linkage is defined as the cause and effect relationship between the selected indicators and the sources. Analysis of this relationship allows for estimating the total assimilative capacity of the stream and any needed load reductions. Analysis of the data for the Upper Mill Creek watershed indicates that *E. coli* load enters the Upper Mill Creek watershed through both wet (nonpoint) and dry (point) weather sources.

To investigate further the potential sources mentioned above, an *E. coli* load duration curve analysis, as outlined in an unpublished paper by Cleland (2002), was developed for each sampling site in the Upper Mill Creek watershed. The load duration curve analysis is a relatively new method utilized in TMDL development. The method considers how stream flow conditions relate to a variety of pollutant loadings and their sources (point and nonpoint).

In order to develop a load duration curve, continuous flow data is required. Two USGS gages, Mill Creek (03359000) located near Manhattan, Indiana and Mill Creek (03358000) located near Cataract, Indiana, were used for the development of the E. coli load duration curve analysis for the Upper Mill Creek watershed TMDL. USGS gage 03359000 is located downstream from the mouth of Doe Creek-Ferguson Branch on Mill Creek; therefore, the drainage area for Doe Creek – Ferguson Branch is accounted for in the drainage area for this gage. In order to obtain an estimated flow for Doe Creek – Ferguson Branch, the drainage area was calculated at the mouth of Doe Creek – Ferguson Branch (22 square miles) and compared to the drainage areas of the USGS gage 03359000 (294 square miles). The flow for the gage was then multiplied by the percent of drainage area that is accounted for in the total drainage area at the USGS gage. The calculated flow number and drainage area for the Upper Mill Creek watershed were then used to create a load duration curve for Doe Creek – Ferguson Branch. The USGS gage 03358000 (245 square miles) is located downstream of from the impaired segments of Mill Creek on Mill Creek; therefore, the drainage area for Mill Creek, Sallust Branch and Tributaries, Crittenden Creek, East

Fork Mill Creek, and Mud Creek is the drainage area for this gage. The flow for the gage is the flow used for the load duration curves on Mill Creek.

The flow data is used to create flow duration curves that display the cumulative frequency of distribution of the daily flow for the period of record. The flow duration curve relates flow values measured at the monitoring station to the percent of time those values are met or exceeded. Flows are ranked from extremely low flows, which are exceeded nearly 100 percent of the time, to extremely high flows, which are rarely exceeded. Flow duration curves are then transformed into load duration curves by multiplying the flow values along the curve by applicable water quality criteria values for *E. coli* and appropriate conversion factors. The load duration curves are conceptually similar to the flow duration curves in that the x-axis represents the flow recurrence interval and the y-axis represents the allowable load of the water quality parameter. The curve representing the allowable load of *E. coli* was calculated using the daily and geometric mean standards of 235 *E. coli* per 100 ml and 125 *E. coli* per 100 ml, respectively. The final step in the development of a load duration curve is to add the water quality pollutant data to the curves. Pollutant loads are estimated from the data as the product of the pollutant concentrations, instantaneous flows measured at the time of sample collection, and appropriate conversion factors. In order to identify the plotting position of each calculated load, the recurrence interval of each instantaneous flow measurement was defined. Water quality pollutant monitoring data are plotted on the same graph as the load duration curve and provides a graphical display of the water quality conditions in the waterbody. The pollutant monitoring data points that are above the target line exceed the Water Quality Standards (WQS); those that fall below the target line meet WQS (Mississippi DEQ, 2002).

Load duration curves were created for all the sampling sites in the Upper Mill Creek watershed. However, the sampling sites of US Highway 40 on Mill Creek and US Highway 231 & SR 43 also on Mill Creek provide the best description of the sources of *E. coli* to the Upper Mill Creek watershed (Figure 2, Attachment C). This is because these two sites have monitoring data from 1996 through 2001. The data indicate that the largest exceedances of the *E. coli* WQS are prevalent during wet weather events (noted by diamonds above the curve on the far left side of the figure in Attachment C). Dry weather contributions are also a source of *E. coli* to the Upper Mill Creek watershed (noted by diamonds above the curve on far right side of the figure in Attachment C).

While there are point source contributions, compliance with the numeric *E. coli* WQS in the Upper Mill Creek watershed most critically depends on the control of nonpoint sources using best management plans (BMPs). If the *E. coli* inputs can be controlled, then the total body contact recreation use in the Upper Mill Creek watershed will be protected.

TMDL Development

The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving the Water Quality Standard (WQS). As indicated in the Numeric Targets section of this document, the target for this *E. coli* TMDL is 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1 through October 31. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the critical conditions that will be used when defining allowable levels. Many TMDLs are designed as the set of critical conditions that, when addressed by appropriate controls, will ensure attainment of the WQS for the pollutant. For example, the critical conditions

for the control of point sources in Indiana are given in 327 IAC 5-2-11.1(b). In general, the 7-day average low flow in 10 years (Q7, 10) for a stream is used as the design condition for point source dischargers. However, *E. coli* sources to the Upper Mill Creek watershed arise from a mixture of dry and wet weather-driven conditions, and there is no single critical condition that would achieve the *E. coli* WQS. For the Upper Mill Creek watershed and the contributing 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* indicators, however, mass is not an appropriate measure because *E. coli* is expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). The geometric mean *E. coli* WQS allows for the best characterization of the watershed. Therefore, this *E. coli* TMDL is concentration-based consistent with 327 IAC 5-2-11.1(b) and 40 CFR, Section 130.2 (i) and the TMDL is equal to the geometric mean *E. coli* WQS for each month of the recreational season (April 1 through October 31).

Allocations

TMDLs are comprised of the sum of individual wasteload 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 or explicitly, that accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. 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. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for nonpoint sources, and the MOS. This *E. coli* TMDL is concentration-based consistent with USEPA regulations at 40 CFR, Section 130.2(i).

Wasteload Allocations

As mentioned previously, there are seven permitted point source dischargers located in the Upper Mill Creek watershed. Four dischargers (Cloverdale STP IN0022616, Lieber State Recreation Area IN0030279, Camp Otto IN0059765, and Cascade Junior/Senior High School IN0037401) have a sanitary component to their discharge and will likely get *E. coli* limits the next time their permits come up for renewal. One of the seven dischargers, The Town of Stilesville WWTP (IN0059986), since April of 2003 has been required to monitor for *E. coli*. Based on the limited *E. coli* values that have been reported from the Town of Stilesville WWTP, IDEM's TMDL program recommends the addition of *E. coli* limits to IN0059986 during their next permit renewal.

There is also one CAFO in the Upper Mill Creek watershed that has a general NPDES permit. Under the NPDES permit, the CAFO must not violate water quality standards. The WLA is set at the WQS of 125 per one hundred milliliters, as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1st through October 31st.

Load Allocations

The LA is equal to the WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1st through October 31st. The assumption used in this load allocation strategy is that there are equal bacterial loads per unit area for all lands within the watershed. Therefore, the relative responsibility for achieving the necessary reductions of bacteria and maintaining acceptable conditions is determined by the amount of land under the jurisdiction of the various local units of government within the watershed. This gives a clear indication of the relative amount of effort that will be required by each entity to restore and maintain the total body contact recreational use of the Upper Mill Creek watershed.

The Hendricks County government and their corresponding portions of the land area in the Upper Mill Creek watershed are as follows: Franklin Township (9.0%); Liberty Township (8.6%); Clay Township (8.48%); Marion Township (3.54%); Center Township (2.45%); and the city of Danville (0.24%). The Putnam County government and their corresponding portions of the land area in the Upper Mill Creek watershed are as follows: Cloverdale Township (14.5%); Jefferson Township (10.67%); Marion Township (2.03%); Washington Township (0.94%); and Warren Township (0.32%). The Morgan County government and their corresponding portions of the land area in the Upper Mill Creek watershed are as follows: Adams Township (10.12%); Ashland Township (8.0%); Monroe Township (2.99%); and Gregg Township (2.74%). The Owen County government and their corresponding portions of the land area in the Upper Mill Creek watershed are as follows: Taylor Township (5.24%); Jennings Township (4.92%); Harrison Township (3.4%); and Jackson Township (1.82%). (ESRI, 2004) (Table 3 and Figure 6.)

Load allocations may be affected by subsequent work in the watershed. There are currently no watershed projects or plans in the Upper Mill Creek watershed, however, there are several in the surrounding areas of the watershed. IDEM plans to work with these watershed coordinators along with local government agencies to try and create some watershed projects. It is anticipated that watershed projects will be useful in further defining the nonpoint sources of *E. coli* in the Upper Mill Creek watershed.

Margin of Safety

A Margin of Safety (MOS) was incorporated into this TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be either implicit (i.e., incorporated into TMDL analysis thorough conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS by applying a couple of conservative assumptions. First, no rate of decay for *E. coli* was applied. *E. coli* bacteria have a limited capability of surviving outside of their hosts and therefore, a rate of decay normally would be applied. However, applying a rate of decay could result in a discharge limit that would be greater than the *E. coli* WQS, thus no rate of decay was applied. Second, the *E. coli* WQS was applied to all flow conditions. This adds to the MOS for this TMDL. IDEM determined that applying the *E. coli* WQS of 125 per one hundred milliliters to all flow conditions and with no rate of decay for *E. coli* is a conservative approach that provides for greater protection of the water quality.

Seasonality

Seasonality in the TMDL is addressed by expressing the TMDL in terms of the *E. coli* WQS for total body contact during the recreational season (April 1st through October 31st) as defined by 327 IAC 2-1-6(d). There is no applicable total body contact *E. coli* WQS during the remainder of the year in Indiana. Because this is a concentration-based TMDL, *E. coli* WQS will be met regardless of flow conditions in the applicable season.

Monitoring

Future monitoring of the Upper Mill Creek watershed will take place during IDEM's five-year rotating basin schedule and/or once TMDL implementation methods are in place. During the five-year rotating basin schedule, IDEM will monitor the Upper Mill Creek watershed for *E. coli*. Monitoring will be adjusted as needed to assist in continued source identification and elimination. When these results indicate that the waterbody is meeting the *E. coli* WQS, IDEM will monitor at an appropriate frequency to determine if Indiana's 30-day geometric mean value of 125 *E. coli* per one hundred milliliters is being met.

Reasonable Assurance Activities

Reasonable assurance activities are programs that are in place or will be in place that assist in meeting the Upper Mill Creek watershed TMDL allocations and the *E. coli* Water Quality Standard (WQS).

Confined Feeding Operations and Confined Animal Feeding Operations

CFOs and CAFOs are required to manage manure, litter, and processed wastewater pollutants in a manner that does not cause or contribute to the impairment of *E. coli* WQS.

National Pollutant Discharge Elimination Systems

327 IAC 5-2-11.1(h) requires effluent limits to be included in NPDES permits for pollutants discharged at levels that have the reasonable potential to cause an exceedance of water quality standards. Since the Town of Stilesville Wastewater Treatment Plant (IN0059986) has limited reported *E. coli* values, they will be required at some point in the future to report their *E. coli* monitoring, according to their permit, to comply with Indiana's *E. coli* Water Quality Standards.

MS4 permits are being issued in the state of Indiana. Once these permits have been issued and implemented, they will improve the water quality in the Upper Mill Creek watershed. Guidelines for MS4 permits and timelines are outlined in Indiana's Municipal Separate Storm Sewer System (MS4) Rule 13 (327 IAC 15-13-10 and 327 IAC 15-13-11). These permits will be used to address storm water impacts to the Upper Mill Creek watershed.

Watershed Projects

There are watershed projects in the surrounding areas of the Upper Mill Creek watershed. IDEM plans to work with these watershed coordinators along with local government agencies to try and create some watershed projects in the Upper Mill Creek watershed. It is believed that watershed

projects will help to further identify and reduce the nonpoint sources that are contributing to the *E. coli* impairment in the Upper Mill Creek watershed.

In addition, IDEM has recently hired a Watershed Specialist for this area of the state. The Watershed Specialist will be available to assist stakeholders with starting a watershed group, facilitating planning activities, and serving as a liaison between watershed planning and TMDL activities in the Upper Mill Creek watershed.

Potential Future Activities:

Nonpoint source pollution, which is the primary cause of *E. coli* impairment in this watershed, can be reduced by the implementation of "best management practices" (BMPs). BMPs are practices used in agriculture, forestry, urban land development, and industry to reduce the potential for damage to natural resources from human activities. A BMP may be structural, that is, something that is built or involves changes in landforms or equipment, or it may be managerial, that is, a specific way of using or handling infrastructure or resources. BMPs should be selected based on the goals of a watershed management plan. Livestock owners, farmers, and urban planners, can implement BMPs outside of a watershed management plan, but the success of BMPs would be enhanced if coordinated as part of a watershed management plan. Following are examples of BMPs that may be used to reduce *E. coli* runoff:

Riparian Area Management - Management of riparian areas protects streambanks and river banks with a buffer zone of vegetation, either grasses, legumes, or trees.

Manure Collection and Storage - Collecting, storing, and handling manure in such a way that nutrients or bacteria do not run off into surface waters or leach down into ground water.

Contour Row Crops - Farming with row patterns and field operations aligned at or nearly perpendicular to the slope of the land.

No-Till Farming - No-till is a year-round conservation farming system. In its pure form, no-till does not include any tillage operations either before or after planting. The practice reduces wind and water erosion, catches snow, conserves soil and water, protects water quality, and provides wildlife habitat. No-till helps control soil erosion and improve water quality by maintaining maximum residue plant levels on the soil surface. These plant residues: 1) protect soil particles and applied nutrients and pesticides from detachment by wind and water; 2) increase infiltration; and 3) reduce the speed at which wind and water move over the soil surface.

Manure Nutrient-Testing - If manure application is desired, sampling and chemical analysis of manure should be performed to determine nutrient content for establishing the proper manure application rate in order to avoid overapplication and run-off.

Drift Fences - Drift fences (short fences or barriers) can be installed to direct livestock movement. A drift fence parallel to a stream keep animals out and prevents direct input of *E. coli* to the stream.

Pet Clean-up / Education - Education programs for pet owners can improve water quality of runoff from urban areas.

Septic Management/Public Education - Programs for management of septic systems can provide a systematic approach to reducing septic system pollution. Education on proper maintenance of septic systems as well as the need to remove illicit discharges could alleviate some anthropogenic sources of *E. coli*.

Conclusion

The sources of *E. coli* to the Upper Mill Creek watershed include both point and non-point sources. In order for the Upper Mill Creek watershed to achieve Indiana's *E. coli* WQS, the wasteload and load allocations for the Upper Mill Creek watershed in Indiana have been set to the *E. coli* WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty day period from April 1st through October 31st. Achieving the wasteload and load allocations for the Upper Mill Creek watershed depends on:

1) permitted facilities meeting their permit limits;
2) CFOs and CAFOs not violating their permits; and
3) nonpoint sources of *E. coli* being controlled by implementing best management practices in the watershed.

The next phase of this TMDL is to identify and support the implementation of activities that will bring the Upper Mill Creek watershed in compliance with the *E. coli* WQS. IDEM will continue to work with its existing programs on implementation. In the event that designated uses and associated water quality criteria applicable to the Upper Mill Creek watershed are revised in accordance with applicable requirements of state and federal law, the TMDL implementation activities may be revised to be consistent with such revisions. Additionally, IDEM will work with local stakeholder groups to pursue best management practices that will result in improvement of the water quality in the Upper Mill Creek watershed.

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Personal Communication. Representative of Morgan County Health Department. August 2004.

USEPA. 2001. Protocol for Developing Pathogen TMDLs. United States Environmental Protection Agency, 841-R-00-002.

Table 1: NPDES Permits in Upper Mill Creek Watershed

Permitted Dischargers with *E. coli* Limits

Permit No.	Facility Name	Receiving Waters
IN0043877	Amo-Coatesville Municipal STP	Crittenden Creek
IN0022616	Cloverdale Municipal STP	Rabbit Run
IN0059765	Camp Otto	Unnamed Tributary to Doe Creek
IN0030279	Lieber State Recreation Area	Cagles Mill Lake
IN0037401	Cascade Junior/Senior High School	Mud Creek
IN0059986	Town of Stilesville WWTP	Mill Creek
IN0059846	Cloverdale Water Department	Higgins Branch

Table 2: Permitted Confined Feeding Operations and Confined Animal Feeding Operations in the Upper Mill Creek Watershed

			Approved Animals								
Log Number	**Name**	**NPDES Permits**	**Nursery Pig**	**Grower/Finishers**	**Sows/Boars**	**Beef**	**Dairy**	**Dairy Calves**	**Veal**	**Layers**	**Turkeys**
836	Martin Farms		2,690	1,630	347						
2735	Mark & Phyllis Legan		600	950	22						
2776	William Brewer		275	740	132						
3241	Gilly Farm						165				
3573	Hannah Family		960	210	632						
5002	Hannah Family			1,300							
924	White Oak Farms	ING800924	1,800	6,000							
1996	Mike Arnold		440	120	100						
2448	Mike Mann Family Farms, LLC				1,214						
3031	White Oak Farms Partnership		120	400	76						
3534	Arthur & Bryan Scott			1,000	150						
4192	Ed Samsel Farms, Inc.		368	1,160	246						

Table 3: Land Area Distribution for the Upper Mill Creek Watershed

Municipality	Square Mile	Percent
Gregg Township	8.07	2.74
Adams Township	29.81	10.12
Ashland Township	23.58	8.0
Monroe Township	13.33	2.99
Franklin Township	26.46	9.0
Liberty Township	24.0	8.6
Center Township	13.46	2.45
Clay Township	23.77	8.48
Marion Township	18.37	3.54
City of Danville	0.70	0.24
Cloverdale Township	42.7	14.5
Jefferson Township	31.44	10.67
Marion Township	6.01	2.03
Washington Township	2.78	0.94
Warren Township	0.93	0.32
Taylor Township	15.44	5.24
Jennings Township	14.48	4.92
Harrison Township	10.0	3.4
Jackson Township	5.39	1.82
Total	**310.72**	**100**

Figure 1: Upper Mill Creek Watershed TMDL

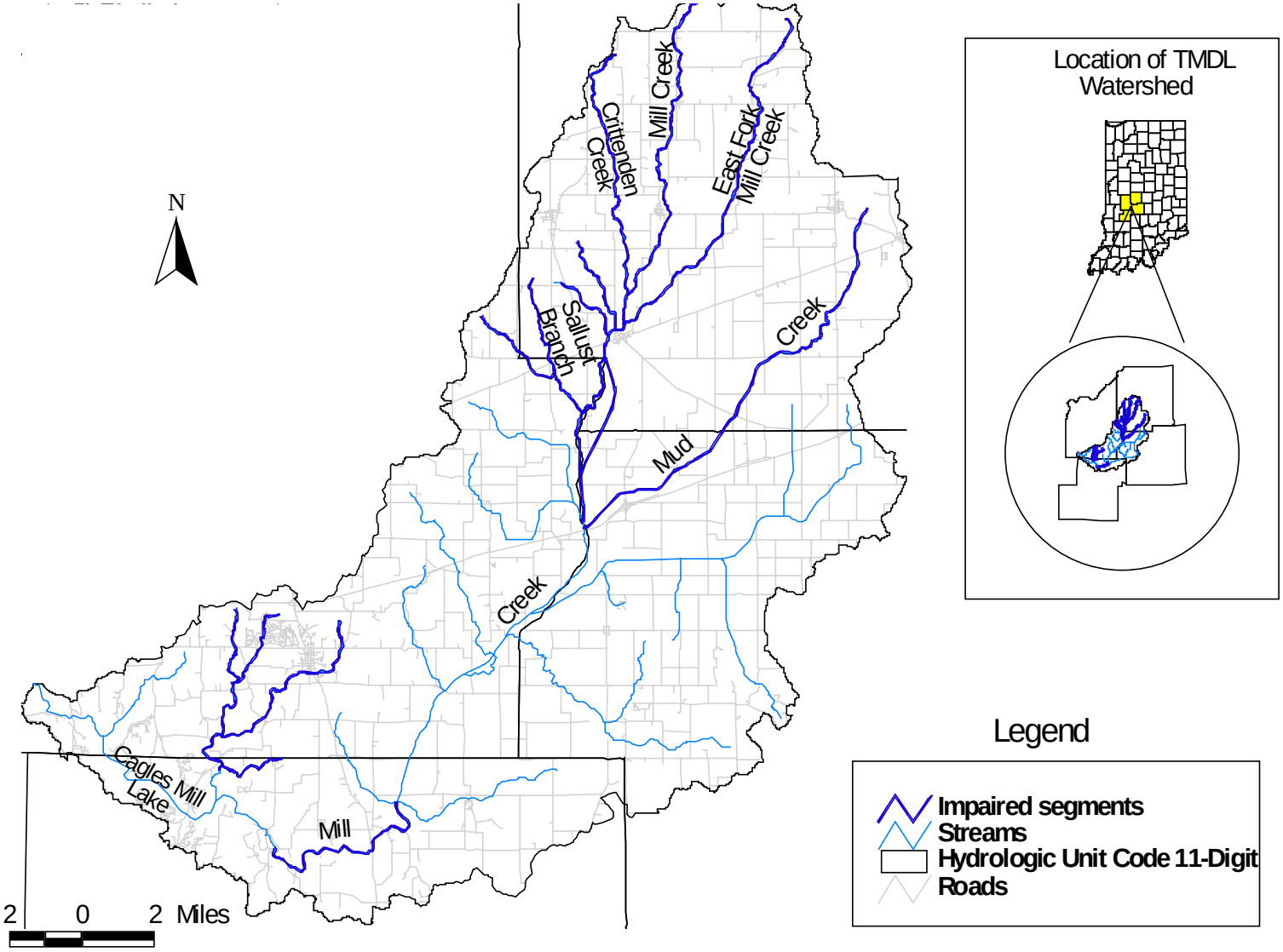

Figure 2: IDEM's E. coli Sampling Sites in Upper Mill Creek Watershed

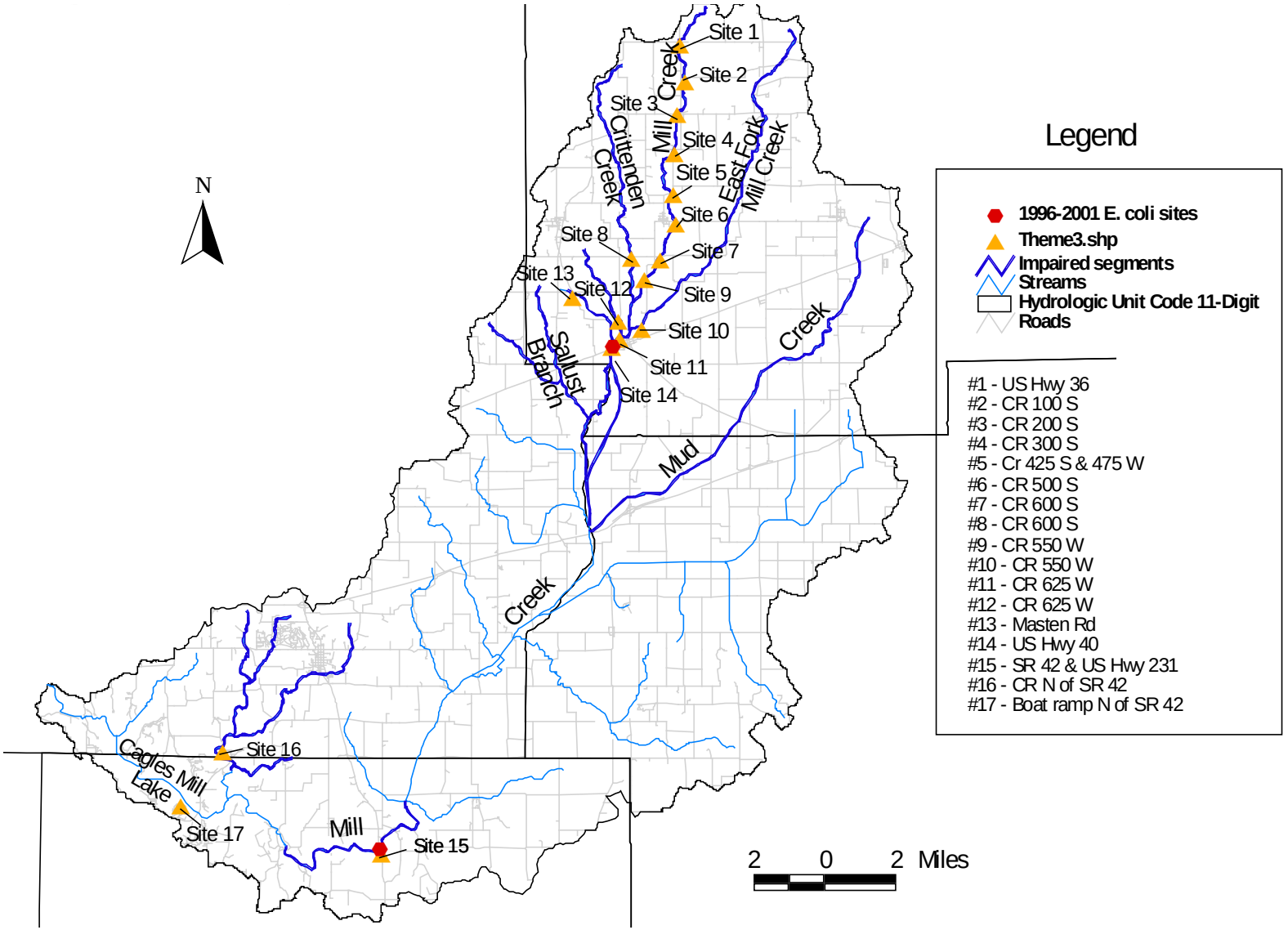

Figure 3: Landuse in Upper Mill Creek Watershed

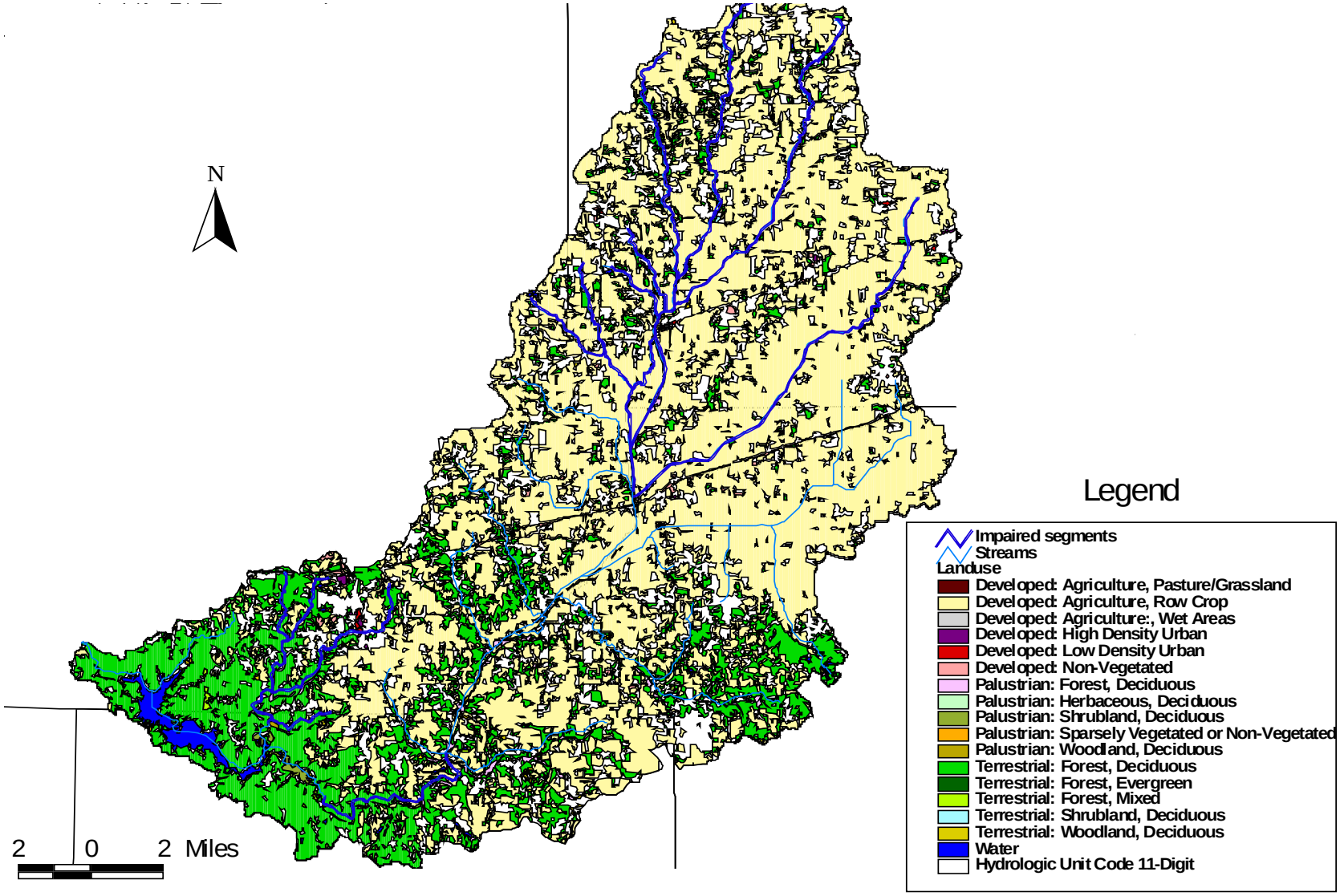

Figure 4: NPDES Permits in Upper Mill Creek Watershed

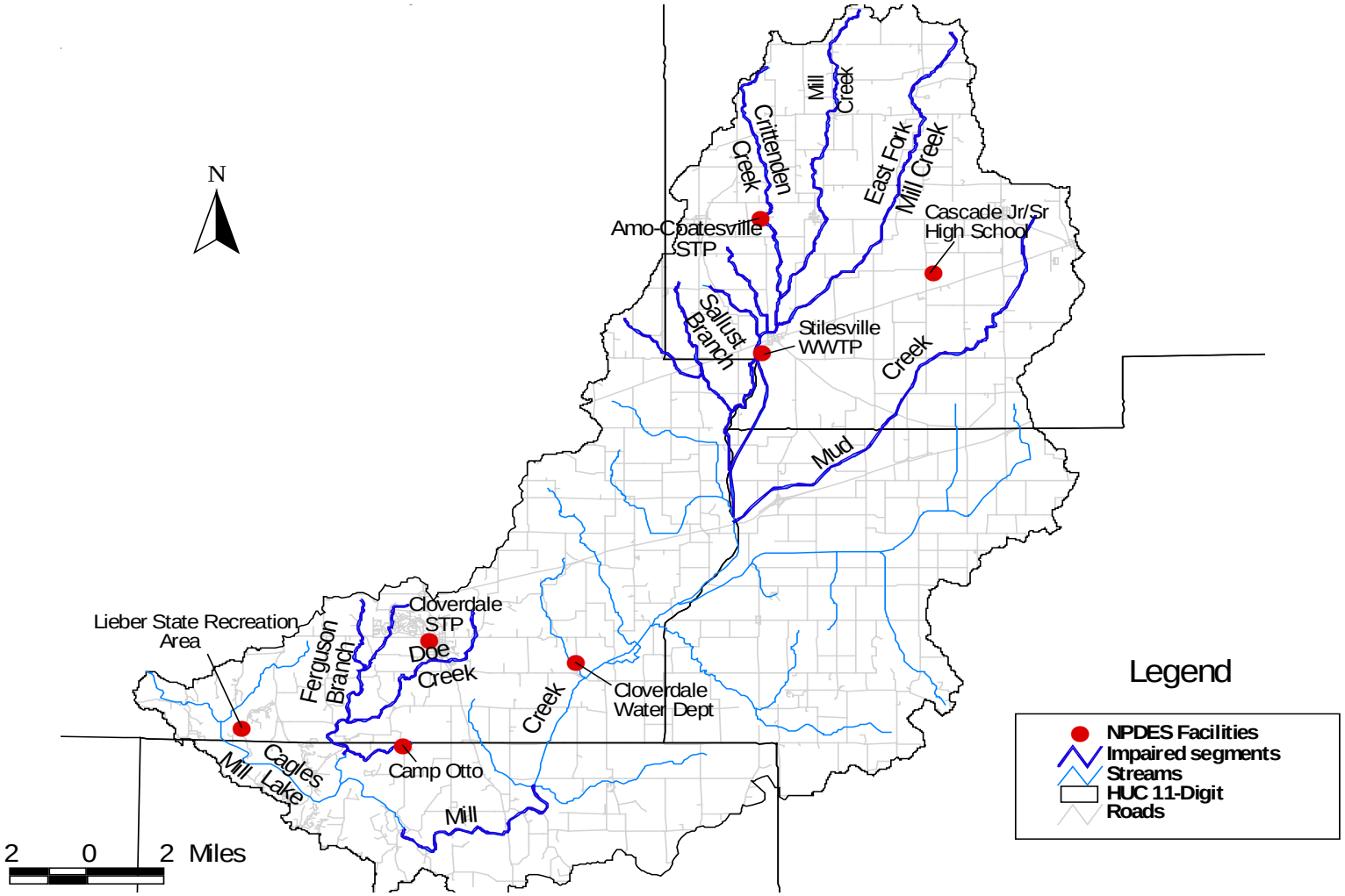

Figure 5: Confined Feeding Operations in Upper Mill Creek Watershed

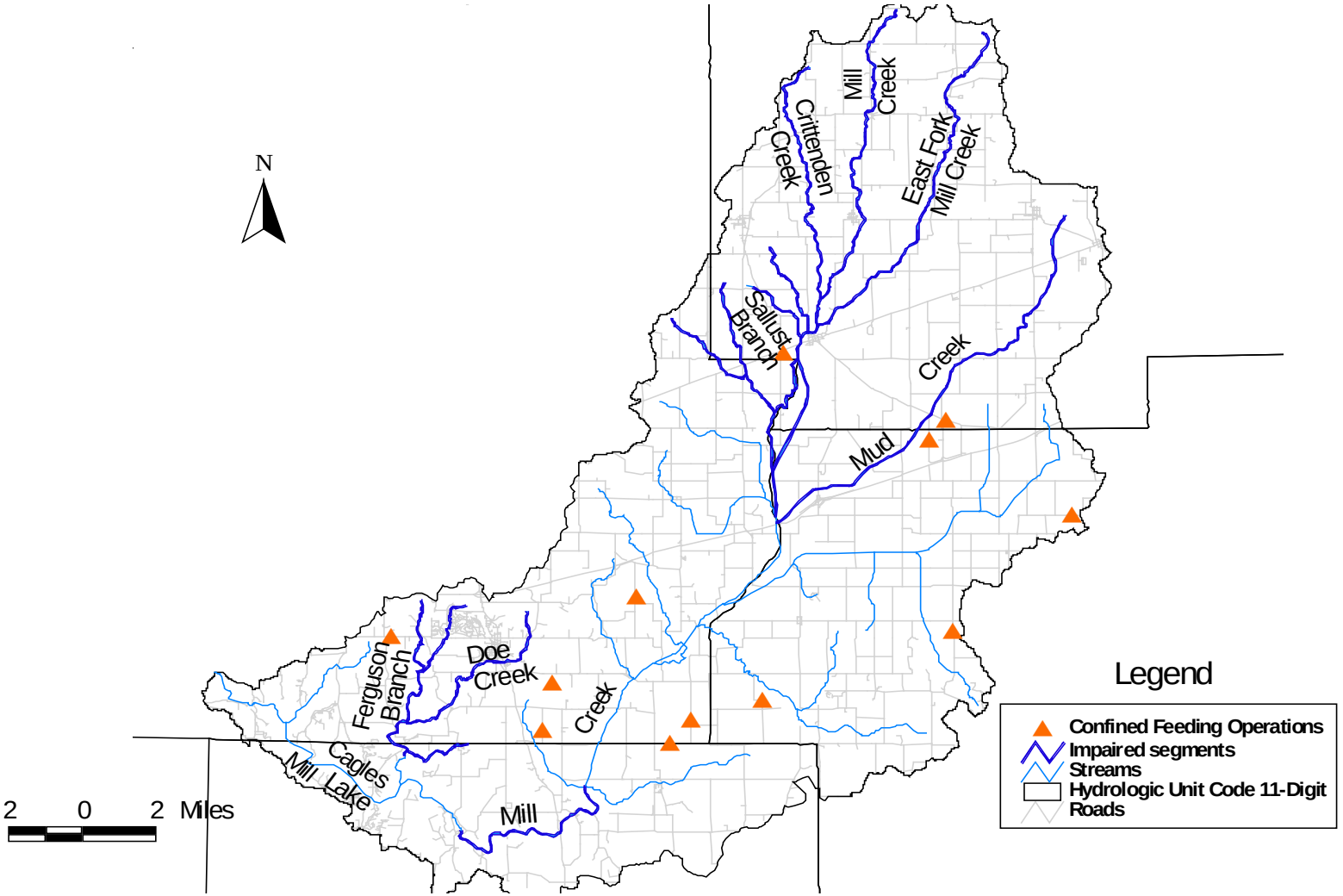

Figure 6: Land Area Distribution in Upper Mill Creek Watershed

Attachment A

Upper Mill Creek Watershed *E. coli* Data

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Attachment B

Water Quality Duration Curves for Upper Mill Creek Watershed TMDL

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Attachment C

Load Duration Curves for Upper Mill Creek Watershed TMDL

Attachment A: Upper Mill Creek Watershed *E. coli* Data

Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E. coli (MPN/100 mL)	Geometric Mean
1	2001 Mill Creek upstream of US 40 Assessment	WWE060-0015	Mill Creek	US Hwy 36	AA04462	06/06/01	>24000	>703
					AA04976	06/13/01	240	
					AA05329	06/20/01	170	
					AA05551	06/27/01	73	
					AA05726	07/05/01	>2419	
2	2001 Mill Creek upstream of US 40 Assessment	WWE060-0016	Mill Creek	CR 100 S	AA04464	06/06/01	6900	>915
					AA04978	06/13/01	370	
					AA05331	06/20/01	550	
					AA05554	06/27/01	190	
					AA05728	07/05/01	>2419	
3	2001 Mill Creek upstream of US 40 Assessment	WWE060-0017	Mill Creek	CR 200 S	AA04465	06/06/01	>24000	>3365
					AA04979	06/13/01	>2419	
					AA05332	06/20/01	>2419	
					AA05555	06/27/01	1300	
					AA05729	07/05/01	>2419	
4	2001 Mill Creek upstream of US 40 Assessment	WWE060-0018	Mill Creek	CR 300 S	AA04466	06/06/01	>24000	>3069
					AA04980	06/13/01	>2419	
					AA05333	06/20/01	>2419	
					AA05556	06/27/01	820	
					AA05730	07/05/01	>2419	
5	2001 Mill Creek upstream of US 40 Assessment	WWE060-0019	Mill Creek	CR 425 S and 475 W	AA04467	06/06/01	>24000	>2163
					AA04981	06/13/01	1100	
					AA05334	06/20/01	1700	
					AA05557	06/27/01	440	
					AA05731	07/05/01	>2419	

Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E. coli (MPN/100 mL)	Geometric Mean
6	2001 Mill Creek upstream of US 40 Assessment	WWE060-0020	Mill Creek	CR 500 S	AA04468	06/06/01	>24000	>1909
					AA04982	06/13/01	1100	
					AA05335	06/20/01	870	
					AA05558	06/27/01	460	
					AA05732	07/05/01	>2419	
7	2001 Mill Creek upstream of US 40 Assessment	WWE060-0021	Mill Creek	CR 600 S	AA04469	06/06/01	>24000	>2148
					AA04984	06/13/01	610	
					AA05337	06/20/01	1300	
					AA05559	06/27/01	1000	
					AA05733	07/05/01	>2419	
8	2001 Mill Creek upstream of US 40 Assessment	WWE060-0022	Crittenden Creek	CR 600 S	AA04543	06/06/01	>2400	>705
					AA04985	06/13/01	390	
					AA05338	06/20/01	580	
					AA05560	06/27/01	370	
					AA05735	07/05/01	870	
9	2001 Mill Creek upstream of US 40 Assessment	WWE060-0023	Mill Creek	CR 550 W	AA04545	06/06/01	>24000	>2049
					AA04987	06/13/01	450	
					AA05341	06/20/01	1700	
					AA05562	06/27/01	820	
					AA05737	07/05/01	>2419	
10	2001 Mill Creek upstream of US 40 Assessment	WWE060-0024	East Fork Mill Creek	CR 550 W	AA04546	06/06/01	24000	1423
					AA04988	06/13/01	690	
					AA05342	06/20/01	820	
					AA05563	06/27/01	390	
					AA05739	07/05/01	1100	
11	2001 Mill Creek upstream of US 40 Assessment	WWE060-0025	Mill Creek	CR 625 W	AA04547	06/06/01	>24000	>1849
					AA04989	06/13/01	690	
					AA05343	06/20/01	1600	
					AA05564	06/27/01	340	
					AA05740	07/05/01	>2419	

Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E. coli (MPN/100 mL)	Geometric Mean
12	2001 Mill Creek upstream of US 40 Assessment	WWE060-0026	Unnamed Tributary	CR 625 W	AA04548	06/06/01	4900	1330
					AA04991	06/13/01	550	
					AA05344	06/20/01	1700	
					AA05565	06/27/01	650	
					AA05741	07/05/01	1400	
13	2001 Mill Creek upstream of US 40 Assessment	WWE060-0027	Unnamed Tributary	Masten Rd	AA04549	06/06/01	10000	1465
					AA04992	06/13/01	980	
					AA05345	06/20/01	920	
					AA05566	06/27/01	1700	
					AA05742	07/05/01	440	
14	2001 Mill Creek upstream of US 40 Assessment	WWE060-0004	Mill Creek	US Hwy 40	AA04550	06/06/01	>24000	>871
					AA04993	06/13/01	440	
					AA05346	06/20/01	2000	
					AA05567	06/27/01	370	
					AA05743	07/05/01	64	
	1996 – 2001 Fixed Station				D121651	06/11/96	26000	N/A
					D122123	08/08/96	460	
					D123655	05/20/97	400	
					D124006	09/04/97	510	
					D127054	04/08/99	160	
					D127293	05/12/99	110	
					D127491	06/10/99	46	
					D127880	08/05/99	190	
					D128083	09/22/99	60	
					D128295	10/20/99	38	
					D129430	04/18/00	1400	
					D129677	05/23/00	410	
					D129871	06/20/00	1200	
					D130067	07/20/00	730	
					D130231	08/08/00	2000	
					D130446	09/21/00	1700	
					D130615	10/13/00	330	
					D132007	0523/201	330	

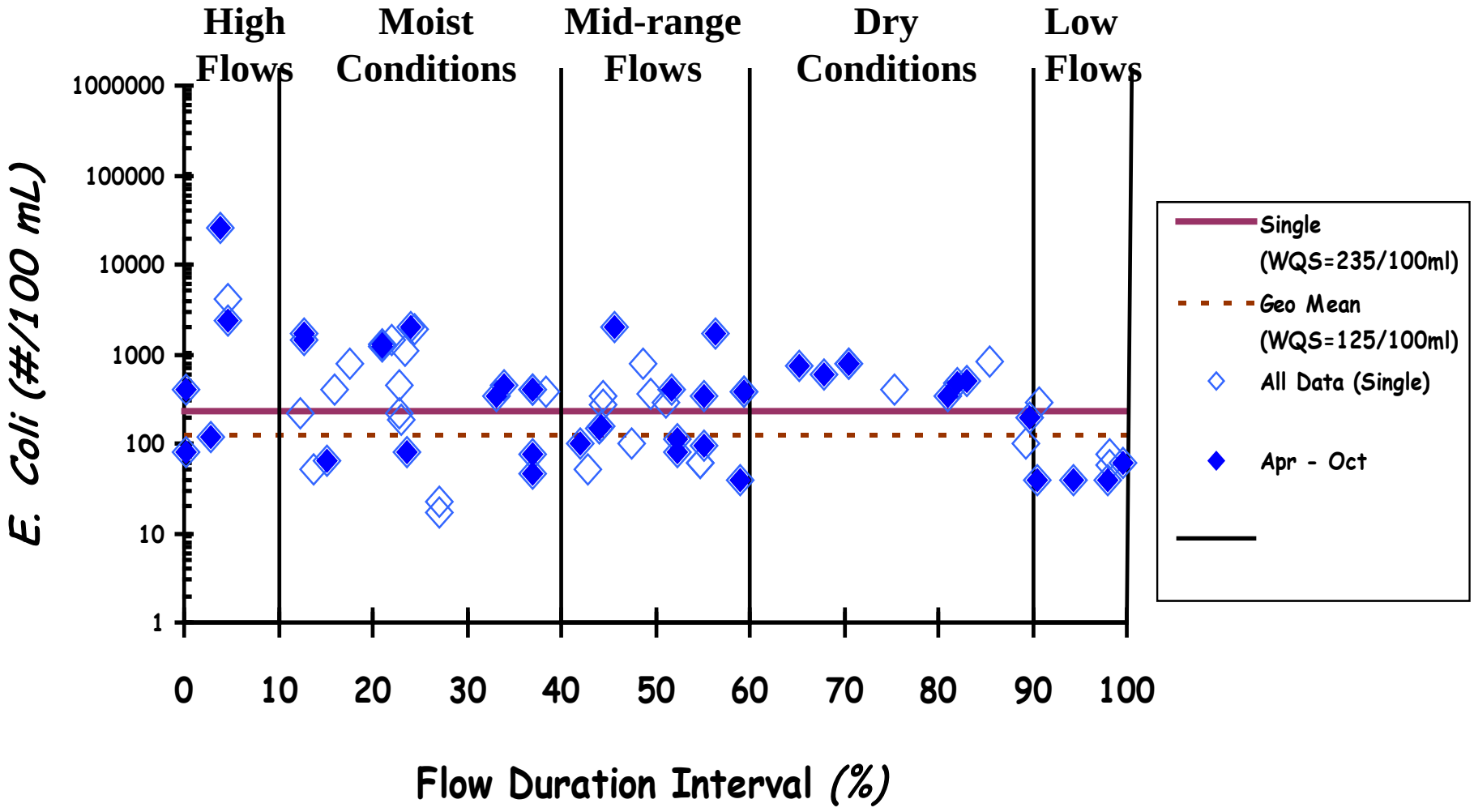
Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E. coli (MPN/100 mL)	Geometric Mean
	1996 Synoptic				D120933	04/30/96	400	N/A
					D121314	06/07/96	120	
					D121698	07/16/96	800	
					D122166	10/08/96	800	
15	2001 *E. coli*-Lower WFWR and Eel	WWE060-0002	Mill Creek	SR 43 and US Hwy 231	AA06591	07/31/01	1203	388
					AA06932	08/07/01	201	
					AA07088	08/14/01	96	
					AA07391	08/21/01	921	
					AA08137	08/28/01	411	
	1996 – 2001 Fixed Station				D120931	04/30/96	1200	N/A
					D121652	06/11/96	8700	
					D122124	08/08/96	80	
					D123656	05/20/97	40	
					D124007	09/04/97	100	
					D127055	04/08/99	230	
					D127294	05/12/99	210	
					D127492	06/10/99	400	
					D127881	08/05/99	90	
					D128084	09/22/99	30	
					D128296	10/20/99	34	
					D129431	04/18/00	6900	
					D129678	05/23/00	200	
					D129872	06/20/00	2400	
					D130232	08/08/200	1400	
					D130447	09/21/200	2400	
					D130316	10/13/00	170	
					D132008	05/23/01	1200	
	1996 Synoptic				D120931	04/30/96	1200	N/A
					D121312	06/07/96	3200	
					D121696	07/16/96	40	
					D122168	10/08/96	280	

Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E. coli (MPN/100 mL)	Geometric Mean
16	2001 *E. coli*-Lower WFWR and Eel	WWE060-0030	Doe Creek	CR N of SR 42	AA06595	07/31/01	1986	667
					AA06937	08/07/01	461	
					AA07089	08/14/01	140	
					AA07392	08/21/01	1414	
					AA08139	08/28/01	726	
17	2001 *E. coli*-Lower WFWR and Eel	WWE060-0029	Cagles Mill Lake	Boat ramp off of SR 42	AA06594	07/31/01	55	12
					AA06935	08/07/01	39	
					AA07090	08/14/01	1	
					AA07393	08/21/01	26	
					AA08140	08/28/01	4	

Mill Creek at US Hwy 40

WQ Duration Curve *(1996 - 2001 Monitoring Data)*

Site: WWE060-0004



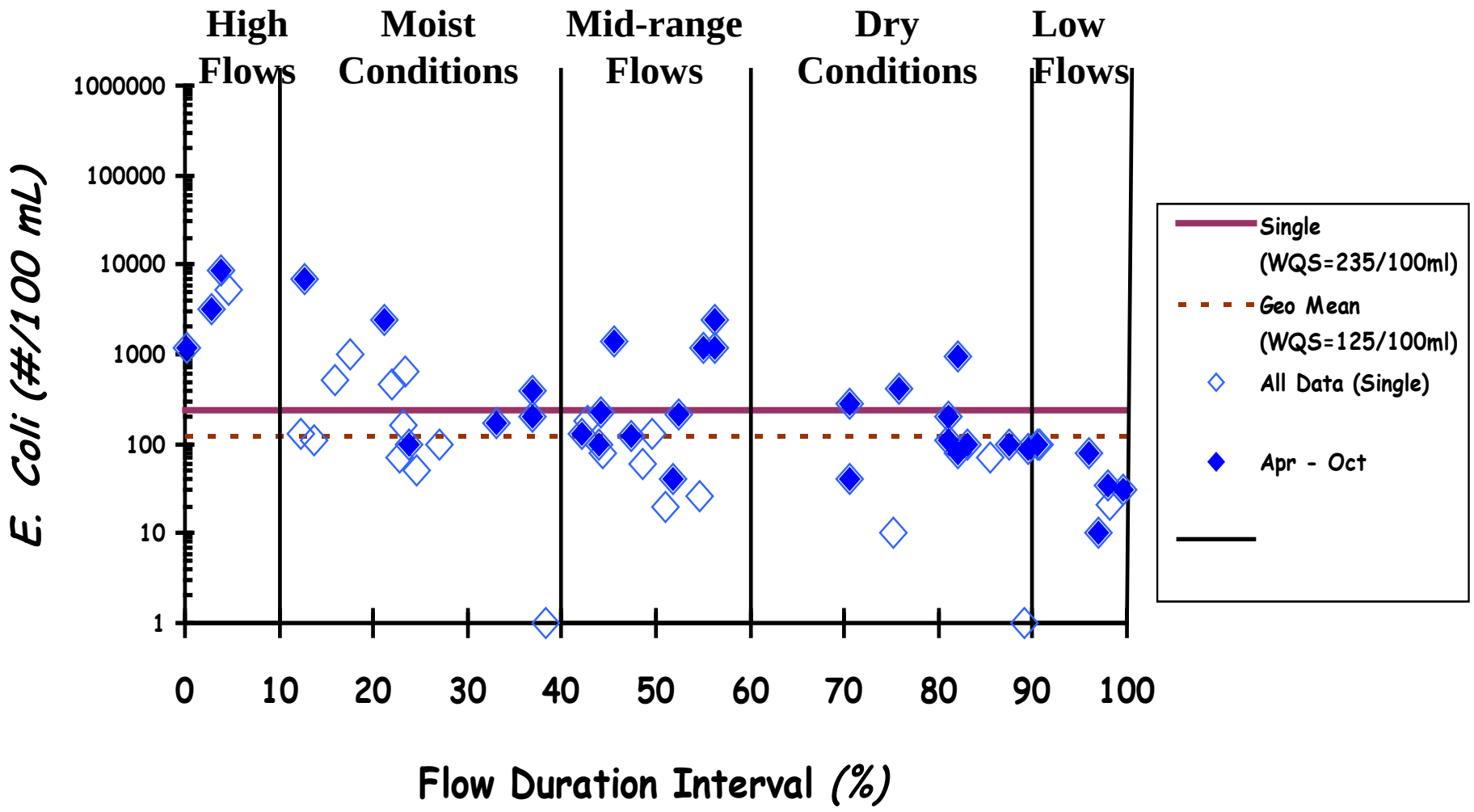
IDEM Data & USGS Gage Duration Interval

295 square miles

Mill Creek at US Hwy 231 & SR 42

WQ Duration Curve *(1996 - 2001 Monitoring Data)*

Site: WWE060-0002



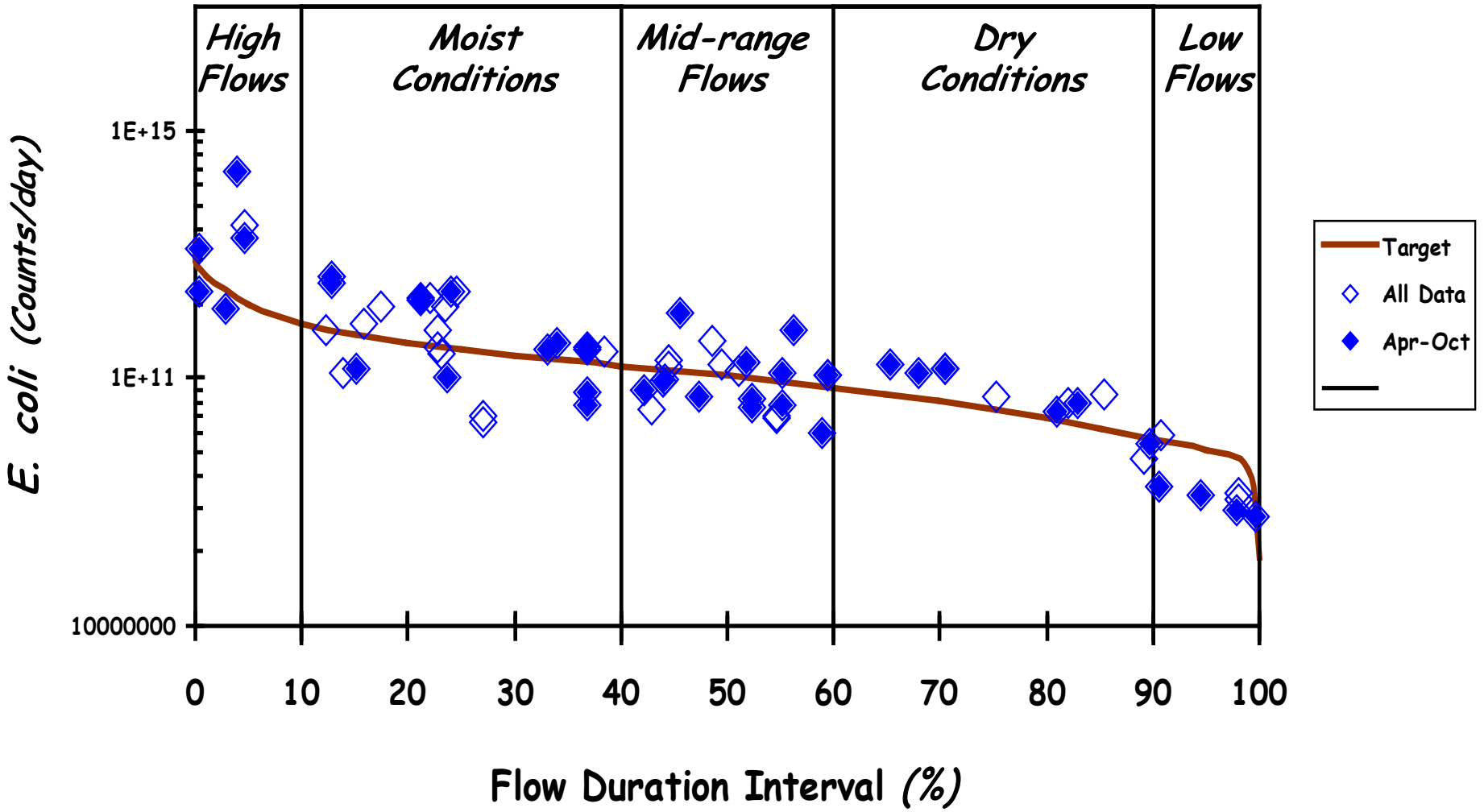
IDEM Data & USGS Gage Duration Interval

295 square miles

Mill Creek at US Hwy 40

Load Duration Curve *(1991-2001 Monitoring Data)*

Site: WWE060-0004



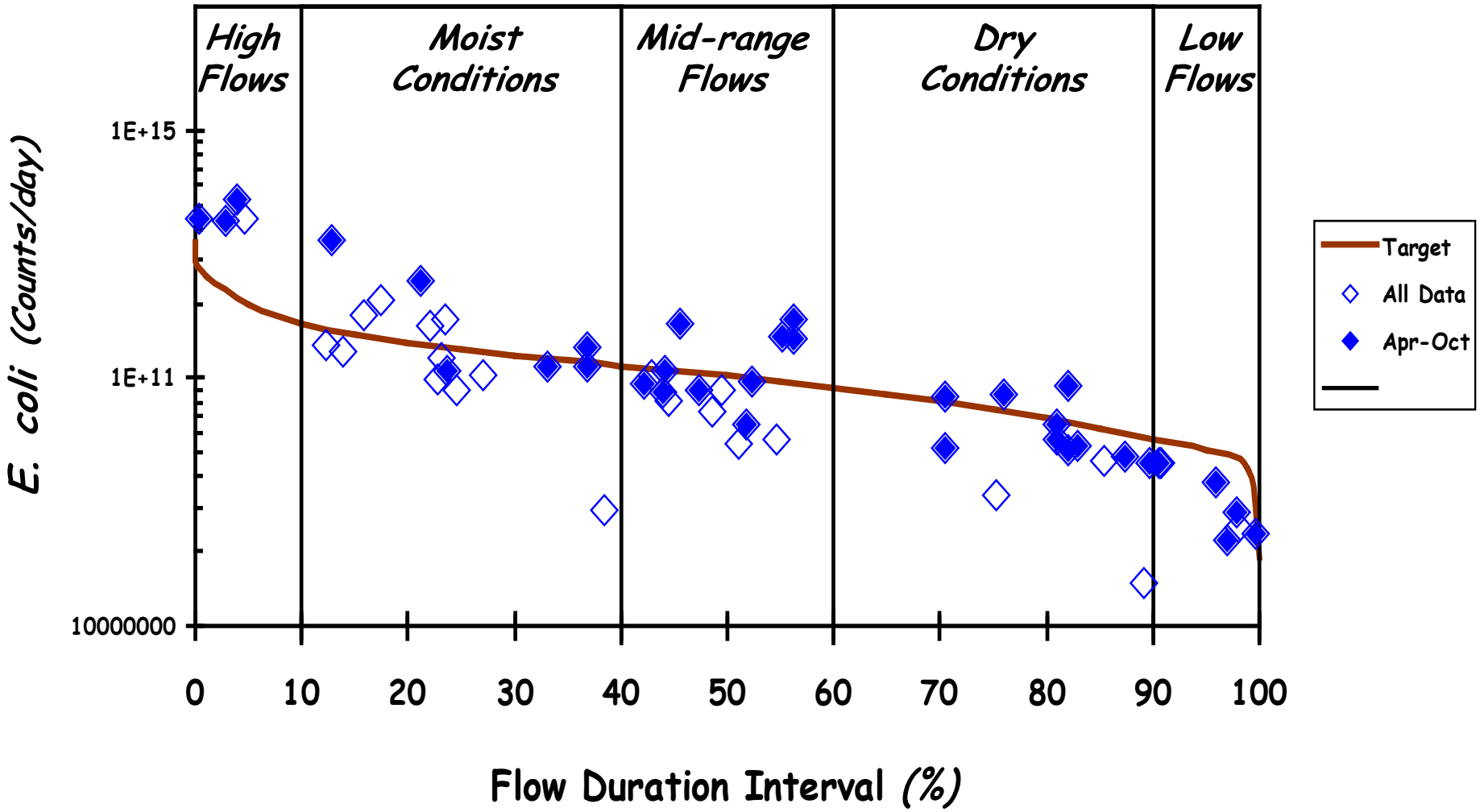
IDEM Data & USGS Gage Duration Interval

295 square miles

Mill Creek at US Hwy 231 & SR 43

Load Duration Curve *(1991-2001 Monitoring Data)*

Site: WWE060-0002



IDEM Data & USGS Gage Duration Interval

295 square miles