

**Michigan Department of Environmental Quality**  
**Water Division**  
**January 2004**

**Total Maximum Daily Load for *Escherichia coli* for**  
**Kintz Creek and Hunter's Creek (Metamora)**  
**Lapeer County, Michigan**

**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 (NPS) 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 Kintz Creek and Hunter's Creek, tributaries to the south branch of the Flint River, located in Lapeer County, Michigan.

**PROBLEM STATEMENT**

The TMDL listing addressed approximately one mile of streams in the vicinity of Metamora. The TMDL reach is on the 2002 Section 303(d) list as:

**UNNAMED DRAINS (METAMORA)**

County: Lapeer

HUC: 4080204

WBID#: **210413I**

Size: 1 M

Location: All of Metamora drains eventually flow to the south branch Flint River.

Problem: **Untreated sewage discharge, pathogens (Rule 100).**

**TMDL YEAR(s): 2004**

**RF3RchID: 4080204 742 0.00**

It should be noted that the unnamed drains in Metamora were open ditches where historically, untreated sewage was discharged by area homes. This problem was resolved with the construction of a treatment system by the village of Metamora, and with the exception of Kintz Creek and Hunter's Creek, these drains no longer contain free-flowing water. Sampling conducted by the Michigan Department of Environmental Quality (MDEQ) in 2002, indicated two streams (Hunter's Creek and Kintz Creek) were exceeding WQS for *E. coli*. The focus of this TMDL is on approximately three miles of Hunter's Creek and four miles of Kintz Creek. Both of these tributaries flow to the south branch of the Flint River. The Section 303(d) list will be revised to reflect these updates.

The unnamed drains in the vicinity of Metamora (Figure 1) 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* (Creal and Wuycheck, 2002). Historical information dating back to 1968, document partially treated sewage in open ditches in the village of Metamora. Ten years later, in 1978,

approximately 80% of the septic systems in the village limits were estimated to be failing (Cosens, 1992). Subsequent sampling in 1990, performed by the Michigan Department of Natural Resources (MDNR), again documented raw sewage in open ditches in the village of Metamora (Morris, 1990). This data prompted the village of Metamora to construct a lagoon treatment system in 1997, with residential hook-ups complete in 1998.

Monitoring data collected by the MDEQ in 2002, documented exceedances of the WQS for *E. coli* at all sampling locations during the total body contact recreational season (Tables 1 and 2). In general, *E. coli* concentrations in Kintz Creek (Figure 2) were higher relative to Hunter's Creek (Figure 3). Thirty-day geometric mean concentrations in Kintz Creek ranged from 109 *E. coli* per 100 milliliters (ml) in June at Hunter's Creek Road, to 4,609 *E. coli* per 100 ml in August at Hunter's Creek Road. Daily geometric mean concentrations in Kintz Creek were consistently above 2,000 *E. coli* per 100 ml with one daily geometric mean of nearly 30,000 *E. coli* per 100 ml at Hunter's Creek Road.

The 30-day geometric mean *E. coli* concentrations were lower in Hunter's Creek, ranging from 104 *E. coli* per 100 ml in July at Hunter's Creek Road to 797 *E. coli* per 100 ml in July at Clark Road. Daily geometric mean concentrations were typically less than 1,000 *E. coli* per 100 ml, with one isolated event of greater than 12,000 *E. coli* per 100 ml in May at Hunter's Creek Road.

## 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 *Escherichia coli* (*E. coli*) per 100 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 ml if their National Pollutant Discharge Elimination System (NPDES) permit limit of 200 fecal coliforms 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). When the

wastewater of concern is sewage, fecal coliform are substantially higher than *E. coli* (Whitman, 2001). When the point source discharge is meeting its limit of 200 fecal coliform per 100 ml, it can reasonably be assumed that there are less than 130 *E. coli* per 100 ml in the effluent.

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 2002 monitoring data indicated exceedances of WQS. Stations with the highest concentrations are located in Kintz Creek.

## **SOURCE ASSESSMENT**

As discussed earlier, this TMDL will cover approximately three miles of Hunter's Creek and four miles of Kintz Creek, two tributaries of the south branch of the Flint River. Both streams have relatively low flows in this area (Tables 3 and 4). The TMDL watershed is located in Metamora and Lapeer Townships in Lapeer County. The municipalities in the TMDL reach include the village of Metamora, Metamora Township, and Lapeer Township (Figure 4). Table 5 shows the distribution of land for each municipality.

Potential pathogen sources for this TMDL watershed were historically from illicit discharges to open ditches in the vicinity of Metamora, a problem that was resolved with the 1998 sewerage of the village. Particularly high exceedances of *E. coli* in Kintz Creek at Hunter's Creek Road indicate continued sources of *E. coli* could be from illicit connections from residential areas downstream of the village of Metamora. Sources of *E. coli* could also be agricultural in origin, given that land use in the Flint River watershed is approximately 49% agriculture (Leonardi and Gruhn, 2001). Data indicate particularly high concentrations in Kintz Creek between Sutton Road and Hunter's Creek Road. In addition, localized problems in Kintz Creek in the Clark Road area (immediately downstream of Station MD-2A) may be due to poor land use practices as noted by unrestricted cattle access.

Currently, there is one permitted point source discharge to the Kintz Creek TMDL reach, the Metmora Wastewater Sewage Lagoon (WWSL) (MIG580056). In addition, there is one Notice of Coverage construction permit (MIR104946) in the TMDL watershed. This permit was issued to an individual and will terminate in November 2003.

In an effort to determine possible sources of *E. coli* to the Kintz Creek, the MDEQ collected one sample for Deoxyribonucleic acid (DNA) ribotyping analysis on October 3, 2002. This is a relatively new technology that extracts DNA from *E. coli* isolates. The DNA is compared to a library of known source isolates. The results of the ribotyping analysis indicate that Kintz Creek at Hunter's Creek Road (Station MD-2A) contains a higher percentage (three of five isolates) of *E. coli* of human origin than nonhuman origin – further indicating the likelihood of illicit connections in the watershed (Table 6).

## **LINKAGE ANALYSIS**

Determining the link between the *E. coli* concentration in Kintz Creek and Hunter's Creek and the potential sources is necessary to develop the TMDL. This link provides the basis for estimating the total assimilative capacity of the creeks and any needed load reductions. For this TMDL, the major loadings of pathogens likely enter both creeks by both wet and dry weather sources such as agricultural run-off and illicit connections.

The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in Kintz Creek and Hunter's Creek depends on the

control of *E. coli* from illicit connections and agricultural run-off. If the *E. coli* inputs can be controlled, then total body contact recreation in both creeks will be protected.

## **TMDL DEVELOPMENT**

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 concentrations of 130 *E. coli* per 100 ml as a 30-day geometric mean and 300 *E. coli* per 100 ml as a daily maximum in all portions of the TMDL reach for each month of the recreational season (May through October).

## **ALLOCATIONS**

TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for NPS and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly within the WLA and/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:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

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 is one permitted point source discharge of treated human sewage to the TMDL reach, the Metamora WWSL (MIG580056). The WWSL is only permitted to discharge during the months of March through May and October through December. The discharge period overlaps the recreational season in May and October only and 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. As previously mentioned, when the WWSL is meeting their fecal coliform permit limit, it is assumed the WQS will be met in the discharge. Therefore, the WLA is equal to 130 *E. coli* per 100 ml.

### LAs

Because this TMDL is concentration-based, the LA is equal to 130 *E. coli* per 100 ml. The determination of individual LAs will be based on the assumption of equal bacteria concentration for all lands in the watershed. 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 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 designated use in Hunter's Creek and Kintz Creek. This TMDL reach is located in the village of Metamora, as well as in Metamora and Lapeer Townships (Table 5).

## 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 TMDL WLA and LA analysis 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 is used. The MDEQ has determined that the use of the WQS of 130 *E. coli* per 100 ml is a more conservative approach, although pathogen organisms have a limited capability of surviving outside of their hosts and a rate of decay would normally be used. Applying a rate of decay could result in a discharge limit 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. Applying the WQS to be met under all flow conditions also adds to the assurance of the MOS.

## **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 2002, pathogens were monitored weekly at a total of four stations from May through September. Of the stations sampled, two were on Kintz Creek and two were on Hunter's Creek. Future monitoring will take place during 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 as a 30-day geometric mean and 300 *E. coli* per 100 ml as a daily maximum are being met.

## **REASONABLE ASSURANCE ACTIVITIES**

The village of Metamora is utilizing a relatively new, clay-lined lagoon as a method of treatment for sanitary wastes. The WWSL is considered in compliance with their NPDES permit and is not a likely source of *E. coli* to Kintz Creek. The WWSL is only permitted to discharge during the months of March through May and October through December, an overlap of the recreational season of two months. The lowest concentrations of *E. coli* were found in Kintz Creek during the month of May, with the highest exceedances found later in the summer.

There are presently no 319 Grants for the Hunter's Creek and Kintz Creek sub-watersheds. Local stakeholders are exploring the possibility of a 319 Grant Application for this watershed using an active grant in the neighboring Swartz Creek watershed as a reference project. The 319 Grant process could be beneficial here because local stakeholders are able to develop a watershed plan specific to the needs of their watershed. Goals typically found in 319 Grants target the identification of NPS of pollution and recommend Best Management Practices to remedy them.

There is an active watershed group, the Flint River Watershed Coalition, that conducts volunteer monitoring throughout the watershed, with one sampling station on Hunter's Creek just

downstream from the TMDL reach. This group was formed in 1996, and has a web site at [www.flintriver.org](http://www.flintriver.org) for interested citizens.

DNA ribotyping indicates a substantial source of *E. coli* is entering Kintz Creek in the vicinity of Hunter's Creek Road. This information, along with the high probability that the *E. coli* are of human origin, warrant further investigation. It is recommended that the Lapeer County Health Department coordinate with the MDEQ for appropriate actions to identify and eliminate the sources of *E. coli* to Kintz Creek. To this end, the local health department, Drain Commissioner, and townships will be investigating Kintz Creek in the vicinity of Hunter's Creek Road for illicit connections to the stream.

Prepared by: Christine Alexander, Aquatic Biologist  
Surface Water Quality Assessment Section  
Water Division  
Michigan Department of Environmental Quality  
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## REFERENCES

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- Leonardi, J.M., and W. J. Gruhn. 2001. Flint River Assessment. Michigan Department of Natural Resources, Fisheries Division. Special Report 27, Ann Arbor, Michigan.
- Morris, B. 1990. MDNR correspondence to Village of Metamora President Robert Klauka.
- USEPA. 2001. Protocol for Developing Pathogen TMDLs. USEPA, 841-R-00-002.

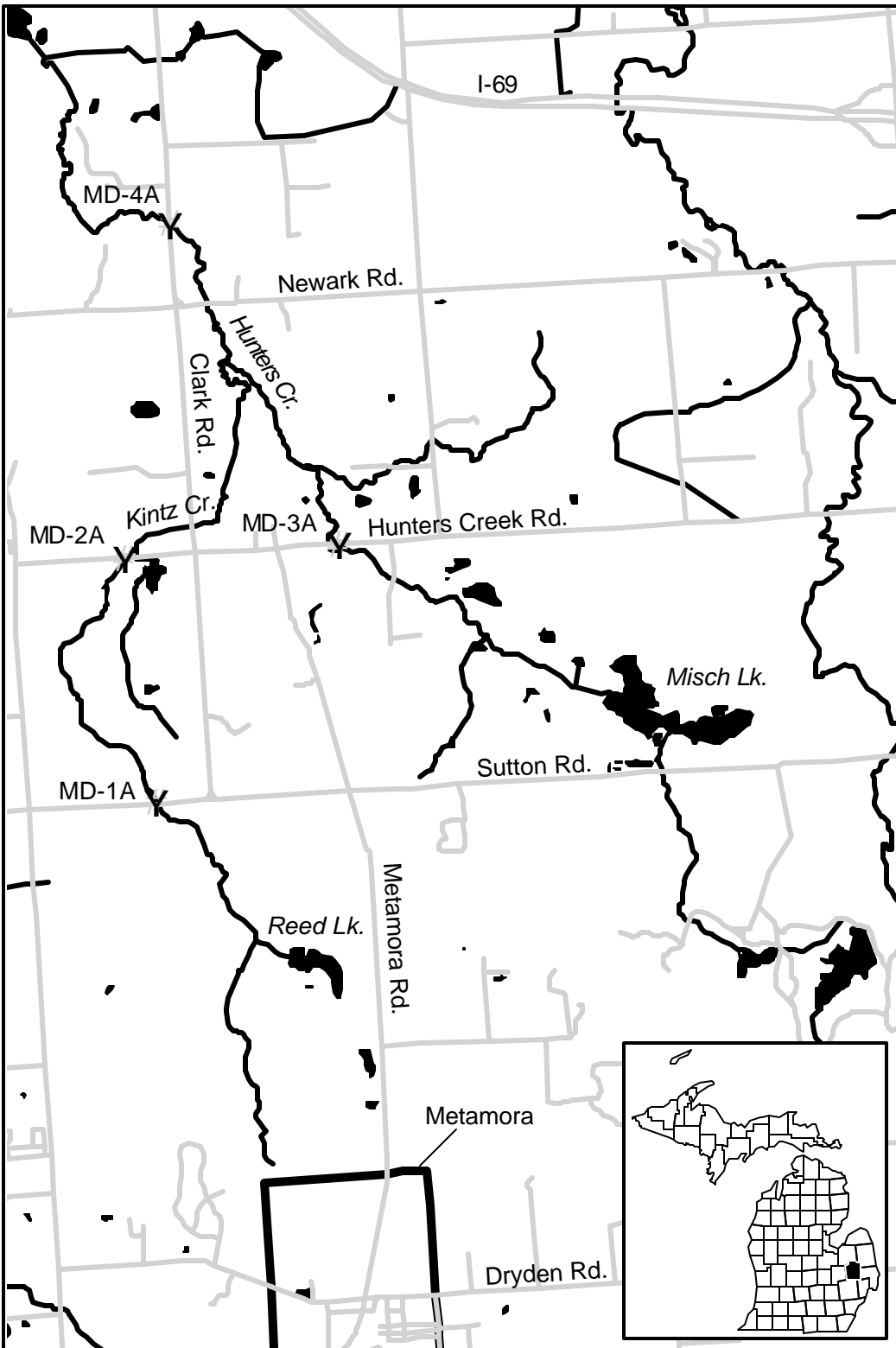


Figure 1. Kintz Creek and Hunter's Creek *E. coli* sampling locations, vicinity of Metamora, Michigan, 2002.



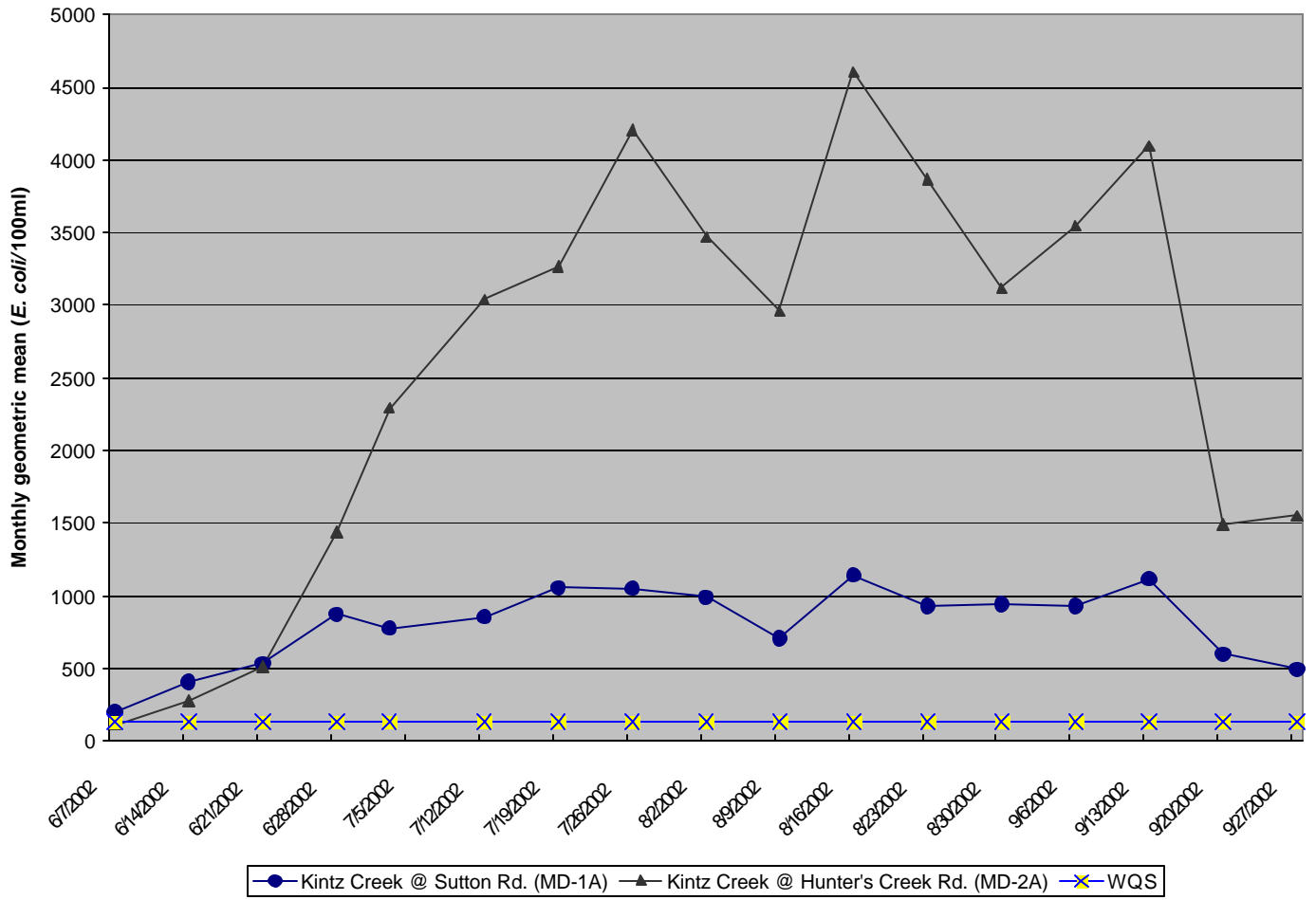


Figure 2. Thirty-day Geometric mean for *E. coli* in Kintz Creek, vicinity of Metamora, 2002.

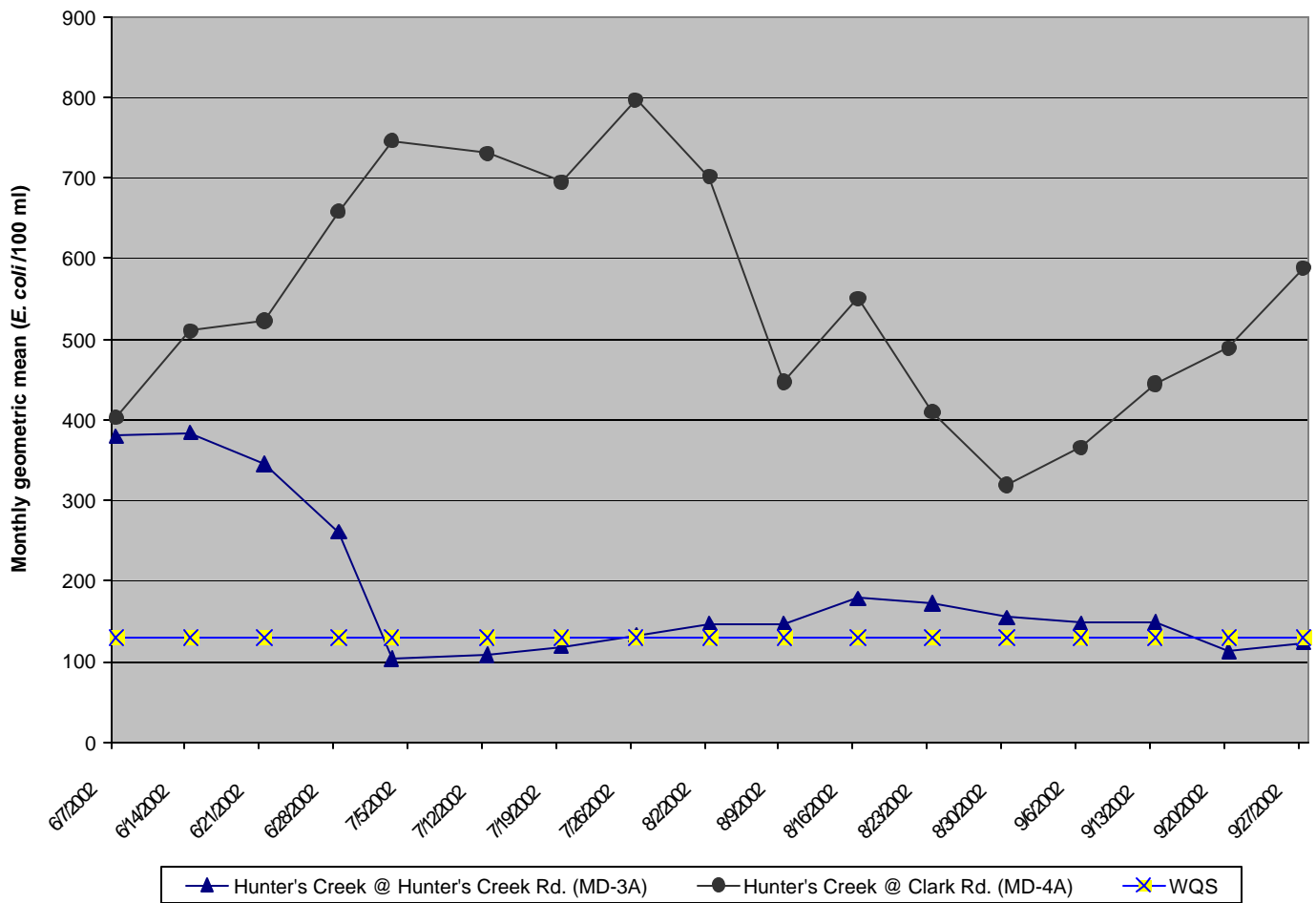


Figure 3. Thirty-day Geometric mean for *E. coli* in Hunter's Creek, vicinity of Metamora, 2002.

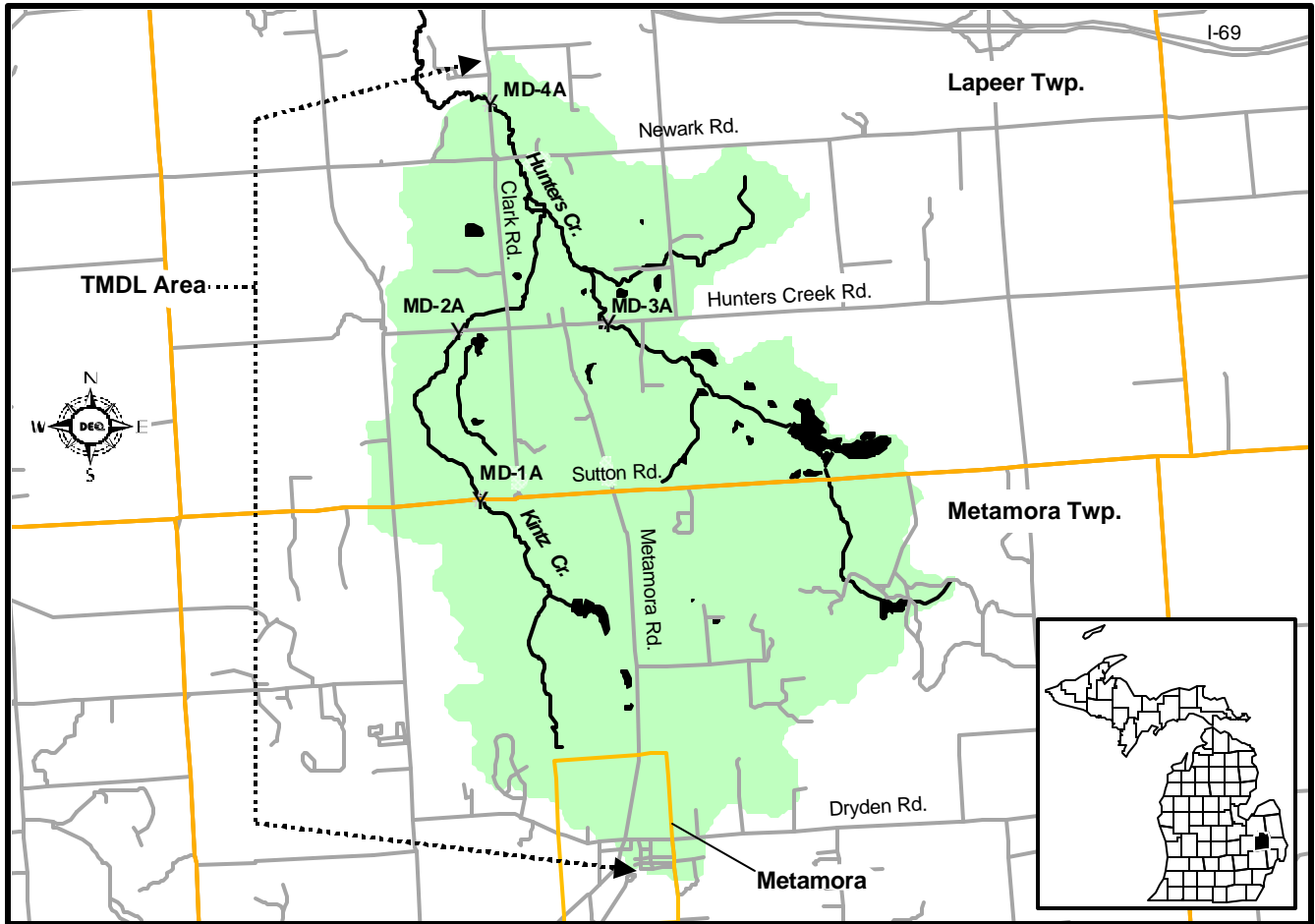


Figure 4. Municipalities in the TMDL watershed. The shaded area represents the Kintz Creek and Hunter's Creek *E. coli* TMDL watershed, Lapeer County.

Table 1. MDEQ 2002 *E. coli* monitoring data for Kintz Creek (*E. coli*/100 ml) in the vicinity of Metamora. Shaded areas indicate exceedances of the WQS.

DATE	Kintz Creek @ Sutton Rd. MD-1A			Kintz Creek @ Hunter's Creek Rd. MD-2A			Weather data
	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
5/10/2002	20	20	---	20	20	---	sunny, 50 <sup>?</sup>
	20			20			
	20			20			
5/17/2002	300	262	---	140	112	---	sunny, 50 <sup>?</sup>
	300			100			
	200			100			
5/24/2002	100	62	---	60	29	---	overcast, 65 <sup>?</sup>
	120			20			
	20			20			
5/31/2002	9800	2696	---	120	298	---	sunny, 75 <sup>?</sup>
	400			100			
	5000			2200			
6/7/2002	340	332	196	880	797	109	sunny, 75 <sup>?</sup>
	360			640			
	300			900			
6/14/2002	560	756	406	2800	2060	275	rain, 65 <sup>?</sup>
	840			1200			
	920			2600			
6/21/2002	2000	1011	532	3200	2527	513	humid, 80 <sup>?</sup>
	680			1800			
	760			2800			
6/28/2002	500	734	872	5400	4989	1439	sunny, 80 <sup>?</sup>
	3600			4600			
	220			5000			

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

DATE	Kintz Creek @ Sutton Rd. MD-1A			Kintz Creek @ Hunter's Creek Rd. MD-2A			Weather data
	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
7/3/2002	1200	1512	776	2800	3045	2290	sunny, 85 <sup>?</sup>
	1600			3600			
	1800			2800			
7/12/2002	740	539	855	5800	3294	3042	sunny, 80 <sup>?</sup>
	480			2200			
	440			2800			
7/19/2002	5800	2156	1054	780	2942	3266	overcast, 75 <sup>?</sup>
	5400			4800			
	320			6800			
7/26/2002	740	991	1050	9600	8942	4206	thunderstorms, 90 <sup>?</sup>
	940			7600			
	1400			9800			
8/2/2002	400	547	990	1140	1911	3471	cloudy, 75 <sup>?</sup>
	820			3400			
	500			1800			
8/9/2002	600	276	705	2480	1382	2964	sunny, 75 <sup>?</sup>
	40			380			
	880			2800			
8/16/2002	6400	6048	1144	28000	29955	4609	rain, 75 <sup>?</sup>
	7200			32000			
	4800			30000			
8/23/2002	640	761	929	1800	1226	3869	rain, 70 <sup>?</sup>
	820			800			
	840			1280			

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

DATE	Kintz Creek @ Sutton Rd. MD-1A			Kintz Creek @ Hunter's Creek Rd. MD-2A			Weather data
	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
8/30/2002	600	1063	942	2600	3047	3120	sunny, 75 <sup>?</sup>
	1000			3200			
	2000			3400			
9/6/2002	1000	512	929	4200	3631	3547	sunny, 65 <sup>?</sup>
	240			3800			
	560			3000			
9/13/2002	580	686	1115	3800	2836	4096	sunny, 65 <sup>?</sup>
	820			3000			
	680			2000			
9/20/2002	560	272	599	1600	192	1491	overcast, 70 <sup>?</sup>
	20			220			
	1800			20			
9/27/2002	360	290	494	1400	1493	1551	overcast, 70 <sup>?</sup>
	260			2200			
	260			1080			

Table 2. MDEQ 2002 *E. coli* data for Hunter's Creek (*E. coli*/100 ml) in the vicinity of Metamora. Shaded areas indicated exceedances of the WQS.

DATE	Hunter's Creek @ Hunter's Creek Rd. MD-3A			Hunter's Creek @ Clark Rd. MD-4A			Weather data
	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
5/10/2002	600	62	---	280	238	---	sunny, 50 <sup>?</sup>
	20			200			
	20			240			
5/17/2002	80	234	---	1200	945	---	sunny, 50 <sup>?</sup>
	400			880			
	400			800			
5/24/2002	600	375	---	800	109	---	overcast, 65 <sup>?</sup>
	880			20			
	100			80			
5/31/2002	5000	12186	---	2300	1016	---	sunny, 75 <sup>?</sup>
	15600			20			
	23200			22800			
6/7/2002	100	119	380	720	427	403	sunny, 75 <sup>?</sup>
	140			1080			
	120			100			
6/14/2002	60	66	384	960	778	510	rain, 65 <sup>?</sup>
	60			680			
	80			720			
6/21/2002	100	136	345	1600	1065	523	humid, 80 <sup>?</sup>
	140			840			
	180			900			
6/28/2002	220	93	261	260	345	659	sunny, 80 <sup>?</sup>
	20			440			
	180			360			

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

DATE	Hunter's Creek @ Hunter's Creek Rd. MD-3A			Hunter's Creek @ Clark Rd. MD-4A			Weather data
	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
7/3/2002	80	124	104	2000	1887	746	sunny, 85 <sup>?</sup>
	120			2400			
	200			1400			
7/12/2002	160	145	108	420	386	731	sunny, 80 <sup>?</sup>
	120			760			
	160			180			
7/19/2002	100	106	119	440	605	695	overcast, 75 <sup>?</sup>
	100			740			
	120			680			
7/26/2002	220	231	133	400	2118	797	thunderstorms, 90 <sup>?</sup>
	200		4400				
	280		5400				
8/2/2002	320	157	147	120	182	702	cloudy, 75 <sup>?</sup>
	100		140				
	120		360				
8/9/2002	160	121	147	240	198	447	sunny, 75 <sup>?</sup>
	140		180				
	80		180				
8/16/2002	400	395	179	420	1103	551	rain, 75 <sup>?</sup>
	480			4200			
	320			760			
8/23/2002	60	88	172	440	138	410	rain, 70 <sup>?</sup>
	80		300				
	140		20				



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

DATE	Hunter's Creek @ Hunter's Creek Rd. MD-3A			Hunter's Creek @ Clark Rd. MD-4A			Weather data
	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
8/30/2002	80	137	155	540	603	319	sunny, 75 <sup>?</sup>
	200			580			
	160			700			
9/6/2002	160	124	148	180	362	366	sunny, 65 <sup>?</sup>
	100			600			
	120			440			
9/13/2002	360	123	149	360	526	445	sunny, 65 <sup>?</sup>
	20			440			
	260			920			
9/20/2002	20	99	113	2200	1764	489	overcast, 70 <sup>?</sup>
	240			2400			
	200			1040			
9/27/2002	20	134	123	440	345	588	overcast, 70 <sup>?</sup>
	400			260			
	300			360			

Table 3. Kintz Creek average flows (cfs) at Sutton Road, Lapeer County, Michigan.

May	June	July	August	September	October
1.8	0.9	0.5	0.3	0.4	0.6

Table 4. Hunter's Creek average flows (cfs) at Hunter's Creek Road, Lapeer County, Michigan.

May	June	July	August	September	October
1.2	0.6	0.3	0.2	0.2	0.4

Table 5. Distribution of land for each municipality in the Kintz Creek and Hunter's Creek TMDL reach.

Municipality	Square Miles	Percent
Lapeer Township	5.0	50
Metamora Township	4.6	46
Village of Metamora	0.4	4
<b>TOTAL</b>	<b>10.0</b>	<b>100</b>

Table 6. Discriminant Analysis of Ribotype Profiles of *E. coli* isolates from water samples received on October 4, 2002.

Sample number Fecal coliform mpn/100 ml <sup>2</sup>	<i>E. coli</i> isolate number	Probability value per source <sup>*1</sup>	
		non-human	human
MD-2A mpn = 23	1	0	100
	2	100	0
	3	100	0
	4	0	100
	5	0	100

\*The probability value equals % probability of true source.

<sup>1</sup>Ribotyping analysis was performed by the method of Salina et al., 1998. Briefly, chromosomal DNA was extracted from *E. coli* isolates and digested with *Hind*III. Fragments were separated by agarose electrophoresis. The DNA was then transferred and fixed to a Zeta-probe membrane. A cDNA probe complimentary to the *E. coli* 16S and 23S rDNA was labeled with digoxigenin-dUTP and was used to probe the membranes. The resulting genetic fingerprint was translated to a binary code based on the presence and absence of predetermined bands. The resulting binary code was then analyzed by discriminate analysis using SAS (registered) software against a vast library of known source isolates.

<sup>2</sup>Standard methods for the Examination of Water and Wastewater Method 9223 A1 (APAHA. 1998).