

Michigan Department of Environmental Quality
Water Division
April 2003

Total Maximum Daily Load for *Escherichia coli* for
Mickles Creek (Shiawassee River),
Saginaw 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 waterbodies that are not meeting Water Quality Standards (WQS). The TMDL process establishes the allowable loadings of pollutants for a waterbody 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 Mickles Creek, a tributary to the Shiawassee River, located in Saginaw County, Michigan.

PROBLEM STATEMENT

This waterbody was first placed on the Section 303(d) list in 1998. This TMDL listing addressed approximately one-half mile of stream in the vicinity of Oakley. The TMDL reach is on the Section 303(d) list as:

SHIAWASSEE RIVER

County: Saginaw

HUC: 4080203

WBID#: **210415B**

Size: 0.5 M

Location: Vicinity of Oakley d/s

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

TMDL YEAR(s): 2003

RF3RchID: 4080203 9

The Shiawassee River (Figure 1) was placed on the Section 303(d) list (Creal and Wuycheck, 2002) due to impairment of recreational uses as indicated by the presence of elevated levels of *E. coli*. Saginaw County Health Department records dating back to the late 1970s document the discharge of raw sewage to Mickles Creek, a tributary of the Shiawassee River, from the village of Oakley (Datte, 1997). Sanitary surveys done in 1997 and 1999 by the Michigan Department of Environmental Quality (MDEQ) also confirm the presence of raw sewage and elevated *E. coli* concentrations at all sampling locations in the village limits (Bauer, 2001).

Monitoring data collected by the MDEQ in 2002 documented exceedances of the WQS for *E. coli* at various sampling locations during the total body contact recreational season (Tables 1 and 2). In general, *E. coli* concentrations in Mickles Creek were highest at the most downstream station sampled (SH-5A) in the village of Oakley (Table 2 and Figure 3). Thirty-day geometric mean concentrations ranged from 57 *E. coli* per 100 milliliters (ml) in September at Woodard Road, to 1,073 *E. coli* per 100 ml in June at M-52. The highest daily geometric mean in Mickles Creek coincided with a rain event in August 2002. Daily geometric means for this

rain event in August ranged from 3,577 *E. coli* per 100 ml at Woodard Road to 8,538 *E. coli* per 100 ml at Johnstone Road.

The 30-day geometric mean *E. coli* concentrations in the Shiawassee River ranged from 20 *E. coli* per 100 ml in July at 6 Mile Creek Road to 83 *E. coli* per 100 ml in June 2002 at Ditch Road. Overall, sampling in the Shiawassee River documented only one exceedance of the total body contact standard in May 2002. Except for this single exceedance, the Shiawassee River met total body contact recreational standards for the remainder of the sampling season (Figure 2).

The official Section 303(d) listing for the Shiawassee River was 0.5 mile downstream in the vicinity of Oakley. Based on a review of the listing and the 2002 monitoring data, the listed TMDL reach would more appropriately be described as Mickles Creek from the confluence with the Shiawassee River, upstream 1.0 miles to Johnstone Road. Mickles Creek has little flow in this area during the recreational season (Table 3).

NUMERIC TARGET

The impaired designated use addressed by this TMDL is total body contact recreation. Rule 100 of the Michigan WQS requires that this waterbody 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 milliliters, as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken during 5 or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of 3 or more samples taken at representative locations within a defined sampling area. At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples taken during the same sampling event at representative locations within a defined sampling area.

For this TMDL, the WQS of 130 per 100 ml as a 30-day geometric mean is the target level 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 Mickles Creek, particularly in the village of Oakley.

SOURCE ASSESSMENT

The official listed reach of the Shiawassee River was 0.5 miles in the vicinity of Oakley. Based on a review of the 2002 data, the modified listed reach covered by this TMDL is Mickles Creek, from the confluence with the Shiawassee River, upstream 1.0 miles to Johnstone Road. The TMDL reach is located in Brady Township in Saginaw County and Rush Township in Shiawassee County. The municipalities in the modified reach for Mickles Creek include the village of Oakley, Brady Township, and Rush Township (Figure 4). Table 4 shows the distribution of land for each municipality.

Potential pathogen sources for this waterbody are primarily due to illicit connections discharging to the creek. Since the 1970s, monitoring has documented ongoing problems regarding the discharge of raw sewage to Mickles Creek or its tributaries. Currently, the

construction of a stabilization lagoon is under review by the village of Oakley and MDEQ. Until a collection system is constructed, this situation will continue to cause problems as indicated by data collected in 2002. Currently, there are no National Pollutant Discharge Elimination System (NPDES) permitted discharges, including storm water permits, in the TMDL reach.

To verify suspected human contributions to Mickles Creek, the MDEQ collected one sample for Deoxyribonucleic acid (DNA) ribotyping analysis on October 3, 2002. This is the latest available technology that extracts DNA from *E. coli* isolates. After a complex process, the DNA is compared to a library of known source isolates. The results of the ribotyping analysis indicate that Mickles Creek at M-52 (station SH-5A) contain a higher percentage (three of five isolates) of *E. coli* of human origin than nonhuman origin (Table 5).

LINKAGE ANALYSIS

The link between the *E. coli* concentrations in Mickles Creek and the potential sources is the basis for the development of the TMDL. The linkage is defined as the cause and effect relationship between the selected indicators and the sources. This provides the basis for estimating the total assimilative capacity of the river and any needed load reductions. For this TMDL, the primary loading of pathogens likely enters Mickles Creek by illicit connections and raw sewage inputs from the village of Oakley.

The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in Mickles Creek depends on the control of *E. coli* from illicit connections and raw sewage inputs from the village of Oakley. If the *E. coli* inputs can be controlled, then total body contact recreation in the Shiawassee River and Mickles Creek will be protected.

TMDL DEVELOPMENT

The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving WQS. As indicated in the Numeric Target section, the target for this pathogen TMDL is the WQS of 130 *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 percent (%) exceedance flow for streams is used as a design condition for point source discharges. However, *E. coli* sources to Mickles Creek arise from a mixture of wet and dry weather-driven nonpoint sources, and there is no single critical condition that is protective for all other conditions. 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 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 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 relation between pollutant loads and the quality of the receiving waterbody. 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. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for nonpoint sources, and the MOS. As previously indicated, 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

At this time, there are no known permitted point source discharges to Mickles Creek. Therefore, the WLA is equal to zero.

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 loads per unit area 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 TMDL reach is located in the village of Oakley, as well as in Rush and Brady Townships.

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. The MOS can be either implicit (i.e., incorporated into the TMDL 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 was used.

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 six stations from May through September. Of the stations sampled, three were on Mickles Creek and three were on the Shiawassee River. Future monitoring will take place after the village of Oakley has been sewerred and as part of the five-year basin monitoring. When these results indicate that the

waterbody may be meeting WQS, sampling will be conducted at the appropriate frequency to determine if the 30-day geometric mean value of 130 *E. coli* per 100 ml is being met.

REASONABLE ASSURANCE ACTIVITIES

The three stations sampled on the Shiawassee River, with one exception to one sampling event in May, meet total body contact recreation standards for *E. coli*. Pathogen inputs to the Shiawassee River appear to be from illicit discharges originating in the village of Oakley and discharging to Mickles Creek. The village of Oakley has attempted to address the problem without success in the past. To address the situation in the village of Oakley, the MDEQ has initiated escalated enforcement action. This will result in an order with an enforceable compliance schedule.

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April 23, 2003

REFERENCES

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- Creal, W. and J. Wuycheck. 2002. Federal Clean Water Act Section 303(d) List – Michigan's Submittal for Year 2002. Michigan Department of Environmental Quality, Surface Water Quality Division, Report Number MI/DEQ/SWQ-02/013.
- Datte, K. 1997. Correspondence to Tom Kamppinen, Michigan Department of Environmental Quality.
- USEPA. 2001. Protocol for Developing Pathogen TMDLs. United States Environmental Protection Agency, 841-R-00-002.

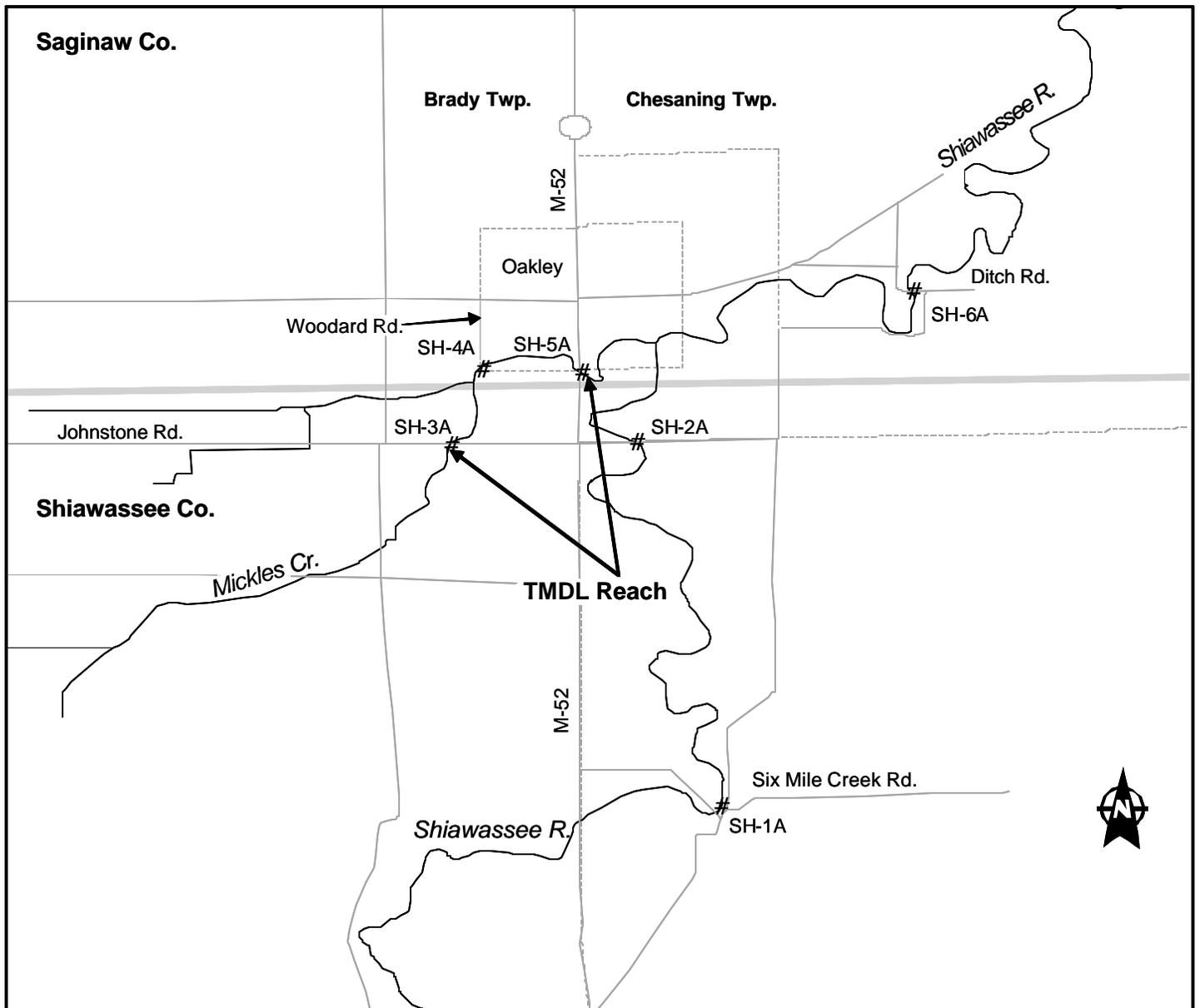


Figure 1. Shiawassee River and Mickles Creek *E. coli* sampling locations, vicinity of Oakley, Michigan, 2002.

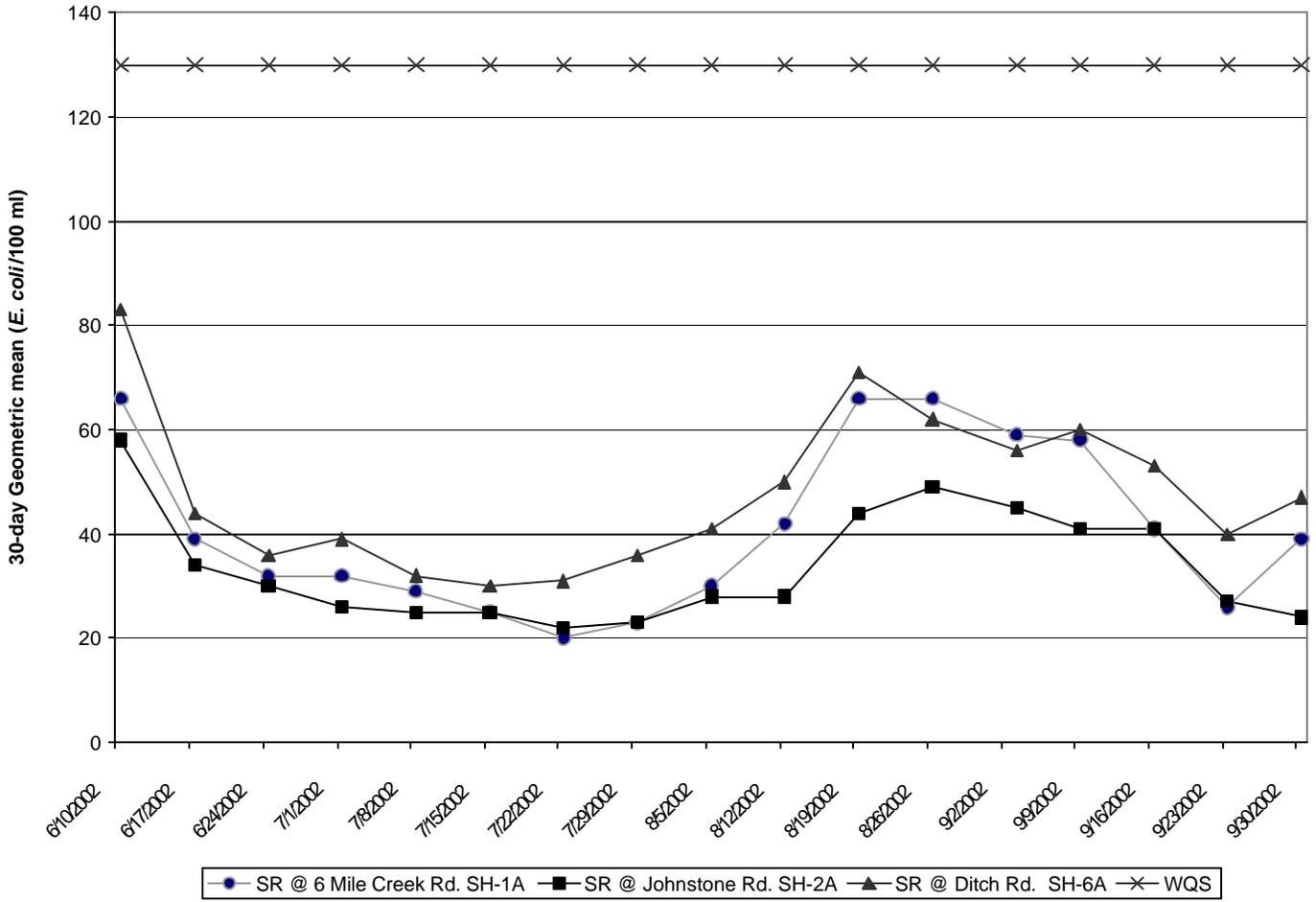


Figure 2. Thirty-day Geometric mean for *E. coli* in the Shiawassee River, vicinity of Oakley, 2002.

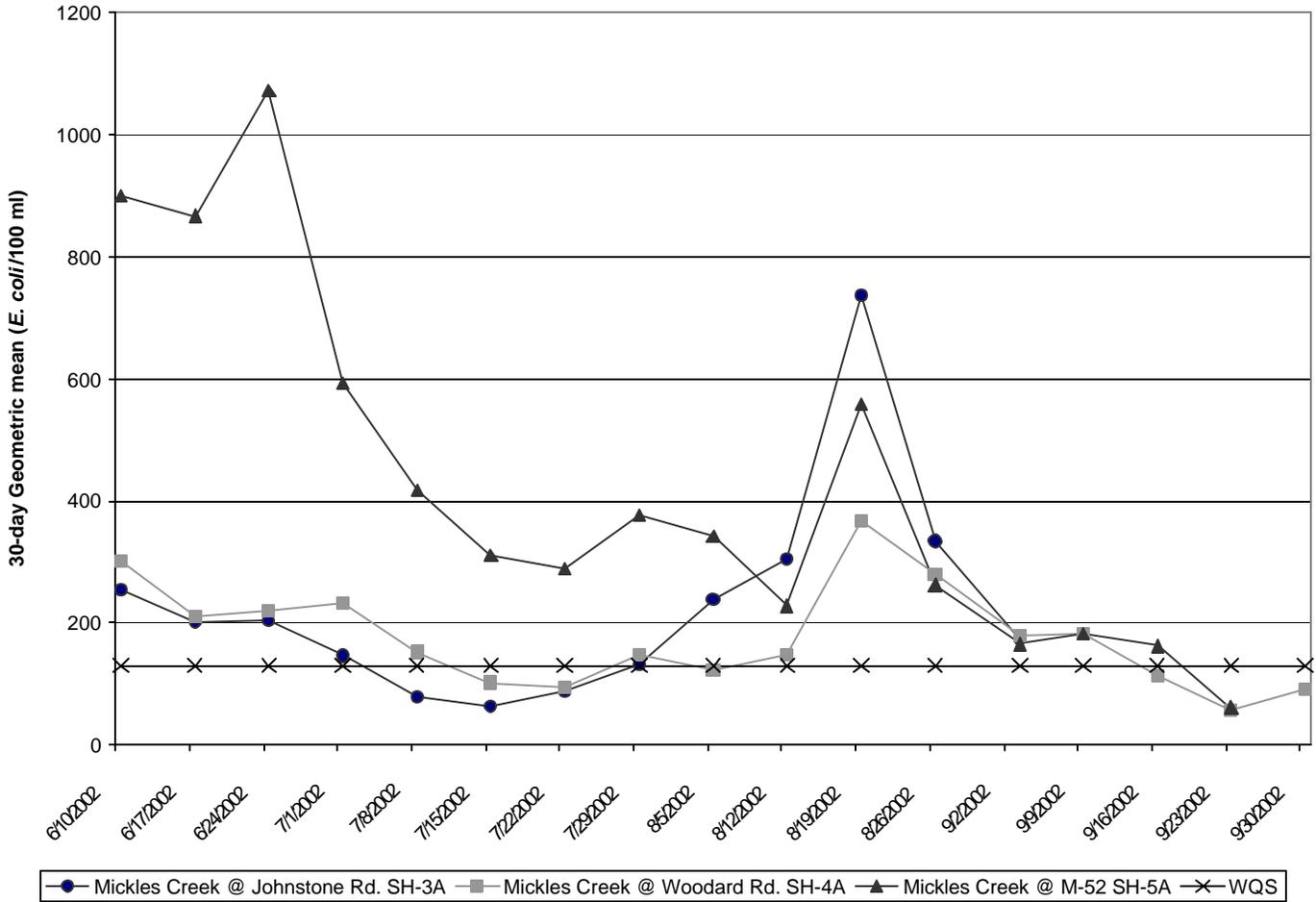


Figure 3. Thirty-day Geometric mean for *E. coli* in Mickles Creek, vicinity of Oakley, 2002.

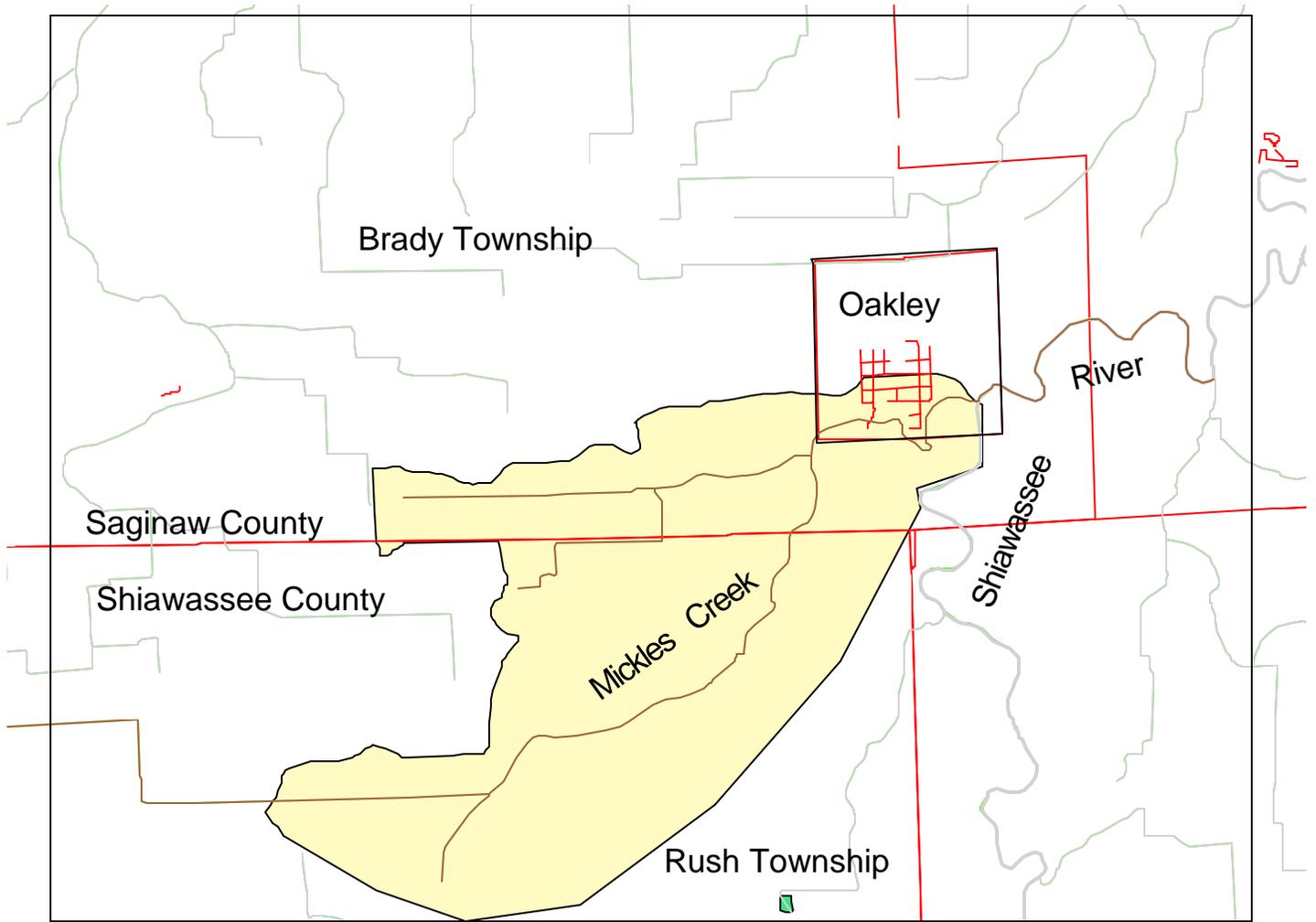


Figure 4. The shaded area indicates the municipalities in the Mickles Creek *E. coli* TMDL Watershed.

Table 1. MDEQ 2002 *E. coli* monitoring data for Shiawassee River (*E. coli*/100 ml) in the vicinity of Oakley. Shaded areas indicate exceedances of the Water Quality Standard.

	Shiawassee River @ 6 Mile Creek Rd. SH-1A			Shiawassee River @ Johnstone Rd. SH-2A			Shiawassee River @ Ditch Rd. SH-6A			
DATE	SAMPLE	DAILY	30-day	SAMPLE	DAILY	30-day	SAMPLE	DAILY	30-day	Weather
	RESULTS	G. MEAN	G. MEAN	RESULTS	G. MEAN	G. MEAN	RESULTS	G. MEAN	G. MEAN	data
5/13/2002	780	844	---	460	623	---	780	750	---	overcast, 50°
	740			820			540			
	1040			640			1000			
5/20/2002	100	49	---	20	34	---	120	66	---	overcast, 45°
	60			100			40			
	20			20			60			
5/28/2002	20	20	---	20	43	---	20	20	---	sunny, 80°
	20			100			20			
	20			40			20			
6/3/2002	100	34	---	40	25	---	100	49	---	rain, 55°
	20			20			20			
	20			20			60			
6/10/2002	100	43	66	20	29	58	80	78	83	hazy, 80°
	20			20			100			
	40			60			60			
6/17/2002	140	61	39	80	40	34	40	32	44	sunny, 70°
	80			40			40			
	20			20			20			
6/24/2002	20	20	32	20	20	30	20	25	36	humid, 80°
	20			20			20			
	20			20			40			
7/1/2002	20	20	32	20	20	26	20	29	39	hazy, 80°
	20			20			60			
	20			20			20			

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

	Shiawassee River @ 6 Mile Creek Rd. SH-1A			Shiawassee River @ Johnstone Rd. SH-2A			Shiawassee River @ Ditch Rd. SH-6A			
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
7/8/2002	20 20 20	20	29	20 20 20	20	25	20 20 20	20	32	sunny, 80°
7/15/2002	20 20 20	20	25	20 20 60	29	25	20 50 120	49	30	humid, 85°
7/22/2002	20 20 20	20	20	20 20 20	20	22	140 20 20	38	31	humid, 85°
7/29/2002	20 200 20	43	23	20 20 60	29	23	20 140 60	55	36	thunderstorms 90°
8/5/2002	20 120 120	66	30	160 20 40	50	28	100 20 80	54	41	sunny, 85°
8/12/2002	20 320 240	115	42	20 20 20	20	28	20 60 140	55	50	hazy, 80°
8/19/2002	120 280 200	189	66	800 220 120	276	44	200 200 600	288	71	Thunderstorm 70°
8/26/2002	20 20 20	20	66	100 20 20	34	49	20 20 20	20	62	sunny, 70°

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

	Shiawassee River @ 6 Mile Creek Rd. SH-1A			Shiawassee River @ Johnstone Rd. SH-2A			Shiawassee River @ Ditch Rd. SH-6A			
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
9/3/2002	20	25	59	20	20	45	20	32	56	cloudy, 70°
	20			20			20			
	40			20			80			
9/9/2002	40	58	58	40	32	41	40	78	60	sunny, 70°
	60			40			100			
	80			20			120			
9/16/2002	20	20	41	20	20	41	60	29	53	sunny, 70°
	20			20			20			
	20			20			20			
9/23/2002	20	20	26	80	32	27	20	73	40	sunny, 60°
	20			20			120			
	20			20			160			
9/30/2002	100	159	39	20	20	24	220	44	47	partly sunny, 70°
	200			20			20			
	200			20			20			

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

	Mickles Creek @ Johnstone Rd. SH-3A			Mickles Creek @ Woodard Rd. SH-4A			Mickles Creek @ M-52 SH-5A			
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
5/13/2002	560	701	---	760	726	---	1600	1566	---	overcast, 50°
	640			560			1000			
	960			900			2400			
5/20/2002	80	68	---	40	40	---	320	63	---	overcast, 45°
	40			80			20			
	100			20			40			
5/28/2002	80	105	---	420	420	---	7400	6313	---	sunny, 80°
	120			340			5000			
	120			520			6800			
6/3/2002	600	751	---	820	750	---	7600	2848	---	rain, 55°
	720			920			15200			
	980			560			200			
6/10/2002	240	282	254	440	276	302	480	333	901	hazy, 80°
	260			200			320			
	360			240			240			
6/17/2002	120	221	202	100	119	211	1600	1291	867	sunny, 70°
	280			140			1200			
	320			120			1120			
6/24/2002	900	71	203	20	49	220	520	184	1073	humid, 80°
	20			300			600			
	20			20			20			
7/1/2002	20	20	146	560	548	232	720	322	592	hazy, 80°
	20			460			580			
	20			640			80			

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

	Mickles Creek @ Johnstone Rd. SH-3A			Mickles Creek @ Woodard Rd. SH-4A			Mickles Creek @ M-52 SH-5A			
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
7/8/2002	100	34	79	80	92	152	680	493	417	sunny, 80°
	20			480			440			
	20			20			400			
7/15/2002	100	104	64	20	38	102	80	77	310	humid, 85°
	280			20			20			
	40			140			280			
7/22/2002	1080	1051	88	20	79	94	680	882	288	humid, 85°
	1120			1240			560			
	960			20			1800			
7/29/2002	620	522	131	280	446	147	1600	704	376	thunderstorms, 90°
	520			440			420			
	440			720			520			
8/5/2002	420	391	238	220	228	123	240	204	343	sunny, 85°
	340			300			220			
	420			180			160			
8/12/2002	260	118	305	80	229	148	20	63	228	hazy, 80°
	40			500			80			
	160			300			160			
8/19/2002	6800	8538	737	4000	3577	366	9600	6764	558	thunderstorms, 70°
	10400			2600			12400			
	8800			4400			2600			
8/26/2002	20	20	334	20	20	278	20	20	262	sunny, 70°
	20			20			20			
	20			20			20			

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

DATE	Mickles Creek @ Johnstone Rd. SH-3A			Mickles Creek @ Woodard Rd. SH-4A			Mickles Creek @ M-52 SH-5A			Weather data
	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	
9/3/2002	20	20	174	40	48	178	20	70	165	cloudy, 70°
	20			20			140			
	20			140			120			
9/9/2002	*	---	---	260	252	182	520	346	183	sunny, 70°
	*			220			400			
	*			280			200			
9/16/2002	*	---	---	20	20	112	20	34	162	sunny, 70°
	*			20			100			
	*			20			20			
9/23/2002	*	---	---	40	124	57	40	50	61	sunny, 60°
	*			160			20			
	*			300			160			
9/30/2002	*	---	---	60	192	90	*	---	---	Partly sunny, 70°
	*			220			*			
	*			540			*			

*sample not collected due to dry conditions.

Table 3. Mickles Creek average flows (cfs) at M-52, Saginaw County, Michigan.

May	June	July	August	September	October
0.9	0.4	0.1	0	0	0.1

Table 4. Distribution of land for each municipality in the Mickles Creek TMDL reach.

Municipality	Square Miles	Percent
Rush Township	4.0	67
Brady Township	1.7	28
Village of Oakley	0.3	5
TOTAL	6.0	100

Table 5. Discriminant Analysis of Ribotype Profiles of *E. coli* isolates from water samples received on October 3, 2002.

Sample number Fecal coliform mpn/100 ml ²	<i>E. coli</i> isolate number	Probability value per source ^{*1}	
		non-human	human
SH-5A mpn = 93	1	1.00	0.00
	2	0.00	1.00
	3	1.00	0.00
	4	0.00	1.00
	5	0.00	1.00

*100 times the probability value equals % probability of true sources

¹Ribotyping 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.

²Standard methods for the Examination of Water and Wastewater method 9223 (APAHA. 1998).