Michigan Department of Environmental Quality
Water Division
January 2003

Total Maximum Daily Load for *Escherichia coli* for Rio Grande Creek, Muskegon and Ottawa Counties

INTRODUCTION

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations (CFR), Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for 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 Rio Grande Creek, a small waterbody in the Grand River Watershed, located in Muskegon and Ottawa Counties, Michigan.

PROBLEM STATEMENT

Rio Grande Creek was first placed on the Section 303(d) list in 1998. This TMDL addresses approximately one-half mile of stream. The TMDL reach is on the Section 303(d) list as:

RIO GRANDE CREEK WBID#: **082803F**
County: Ottawa HUC: 4050006 Size: 0.5 M
Location: Crockery Creek confluence u/s to Chester Twp.
Problem: **Untreated sewage discharge, pathogens (Rule 100).**
TMDL YEAR(s): 2003 RF3RchID: 4050006 60

Rio Grande Creek (Figures 1 and 2) 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*. Historical information cites problems with on-site sanitary treatment in the unincorporated village of Conklin since 1966. A subsequent sanitary survey performed by the Michigan Department of Natural Resources documented evidence of human waste at five of six stations sampled in 1987 (Turek, 1987). Recent monitoring data (Table 1) collected by the Michigan Department of Environmental Quality (MDEQ) for the 2002 monitoring season documented exceedances of the WQS for *E. coli* at all stations sampled during the full body contact recreational season (Table 1 and Figure 3). *E. coli* counts increased from a low in May to peak levels in July and August. Thirty-day geometric mean *E. coli* concentrations in 2002 in Rio Grande Creek ranged from 68 *E. coli* per 100 milliliters (ml) in May at 32nd and 40th Avenues to 1,064 *E. coli* per 100 ml in July at 40th Avenue. Daily geometric means in Rio Grande Creek in 2002 ranged from 2 *E. coli* per 100 ml in May at 40th Avenue to 3,649 *E. coli* per 100 ml in July at the Musketawa Trail Bridge at 40th Avenue.

Monthly geometric means in two small tributaries of Rio Grande Creek followed the same general pattern and ranged from 107 *E. coli* per 100 ml in May at the Jackson-Gilbert Drain at 40th Avenue to 1,076 *E. coli* per 100 ml in August at the Fryer-Dinkle Drain at 40th Avenue (Table 1).

The official Section 303(d) listing for Rio Grande Creek was 0.5 miles from the Crockery Creek confluence upstream to Chester Township in Ottawa County. Based on a review of the listing and the 2002 monitoring data, the listed TMDL reach would more appropriately be described as Rio Grande Creek from the Crockery Creek confluence upstream eight miles to 32nd Avenue. This updated reach is located in both Ottawa and Muskegon Counties. Rio Grande Creek has relatively low flows in this area (Table 2).

NUMERIC TARGET

The impaired designated use for Rio Grande Creek 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.

In addition, permitted 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 milliliters, based on the geometric mean of all of 5 or more samples taken over a 30-day period, nor more than 400 fecal coliform bacteria per 100 milliliters, based on the geometric mean of all of 3 or more samples taken during any period of discharge not to exceed 7 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 is substantially higher than *E. coli* (Whitman, 2001). When the point source dischargers are meeting their 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 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 at all stations sampled. Stations with the highest concentrations are located near 40th Avenue, particularly the Fryer-Dinkle Drain.

SOURCE ASSESSMENT

The official listed reach of Rio Grande Creek is the Crockery Creek confluence upstream to Chester Township (Figure 1), located in Ottawa County. However, based on the 2002 sampling data, a more accurate description of the listed reach is the Crockery Creek confluence upstream eight miles to 32nd Avenue. The updated reach is located in both Ottawa and Muskegon Counties.

Potential pathogen sources for this waterbody have historically been noted from illicit discharges in the area of Conklin. However, this has been sewered since 1997. Other potential inputs are likely agricultural given the land uses in the watershed. Predominant land use in the subwatershed includes row crops and small scale dairy operations. Monitoring data indicate the highest exceedances at all stations sampled at 40th Avenue. The data seem to indicate continued dry weather sources. Potential sources in the 40th Avenue area include illicit discharges, the Chester Township Wastewater Sewage Lagoon (WWSL), as well as agricultural runoff. In-stream levels of *E. coli* in Rio Grande Creek at 32nd Avenue, the furthest upstream station, were the lowest sampled (Table 1 and Figure 3).

There are two permitted point source discharges to tributaries of Rio Grande Creek, the Ottawa County Road Commission - Chester Township WWSL (Chester Township WWSL) (MIG580295) and the Ravenna WWSL (MIG580126). The Chester Township WWSL discharges to the Fryer-Dinkle Drain in Ottawa County and the Ravenna WWSL discharges to Dry Drain in Muskegon County. The WWSLs 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 per previous discussion. Based on Discharge Monitoring Reports (DMRs), the WWSLs are in compliance with their fecal coliform limits during the period the discharge is monitored.

In an attempt to identify possible sources of *E. coli* to the TMDL watershed, 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 are compared to a library of known source isolates. The results of the ribotyping analysis indicate that Rio Grande Creek at 40th Avenue (station RG-4) contain *E. coli* of both human and nonhuman origin (Table 3).

LINKAGE ANALYSIS

The link between the *E. coli* concentration in Rio Grande 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, a significant amount of the pathogen load likely enters the Rio Grande Creek in the vicinity of 40th Avenue, likely by ongoing dry weather sources such as illicit connections.

The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in Rio Grande Creek depends on the control of *E. coli* from illicit connections, agriculture, and the permitted point source discharges. If the *E. coli* inputs can be controlled, then total body contact recreation in Rio Grand 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% exceedance flow for streams is used as a design condition for point source discharges. However, for pathogens in point source discharges of treated or untreated human sewage, levels are restricted to a monthly average limit of 200 per 100 ml for fecal coliform regardless of stream flow. Therefore, the design stream flow is not a critical condition for determining the allowable loading of pathogens for WWTPs. In addition, other *E. coli* sources to Rio Grande 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 at Blackmer Road is equal to the target concentration of 130 *E. coli* per 100 ml 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:

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

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. 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

The Chester Township WWSL (MIG580295) and the Ravenna WWSL (MIG580126) are the only permitted point source discharges that contain treated or untreated human sewage to tributaries of Rio Grande Creek. Both facilities are 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. Therefore, the WLA will be 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 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 various units of local government in the subwatershed.

The Rio Grande Subwatershed has a total area of 19.5 square miles. The two governmental entities in the subwatershed are Ravenna Township and Chester Township. Ravenna Township makes up 56% of the subwatershed while Chester Township makes up the remaining 44% (note that the total subwatershed area in Chester Township is 11.7 square miles; however, a portion of the subwatershed lies outside of the TMDL project area and was not used in the percent calculation). These percentages give 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 uses to Rio Grande Creek.

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 thorough 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 at seven locations, five on Rio Grande Creek and two on small tributaries, from May through August. Future monitoring will take place as resources allow. Monitoring is anticipated to begin in 2004 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

Under the NPDES permit program, the Chester Township WWSL and the Ravenna WWSL are responsible for meeting their effluent limits for fecal coliform. Compliance is determined based on a review of DMR data by the MDEQ. Existing DMR data reviewed by the MDEQ indicates these facilities are meeting their permit limits for fecal coliform.

Agricultural runoff, as well as the potential for failed septic systems, exists in this subwatershed. The unincorporated village of Conklin was hooked up to a collection system in 1997, likely eliminating a majority of the problems coming from the village. Current data indicate the Fryer-Dinkle Drain may be a substantial source of *E. coli* to Rio Grande Creek perhaps by illicit connections. The MDEQ will further evaluate options to identify and eliminate illicit connections. These actions may be carried out through Clean Michigan Initiative grants or programs focusing on best management practices for agricultural watersheds. The MDEQ will also encourage both Muskegon and Ottawa Counties to evaluate the option of funding an illicit connection elimination program in the Fryer-Dinkle Drain Watershed. The MDEQ believes future sampling should concentrate on the Fryer-Dinkle Drain both upstream and downstream of the Chester Township WWSL discharge to determine potential sources.

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REFERENCES

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Whitman, R. Personal Communication. United States Geological Survey, October 2001.

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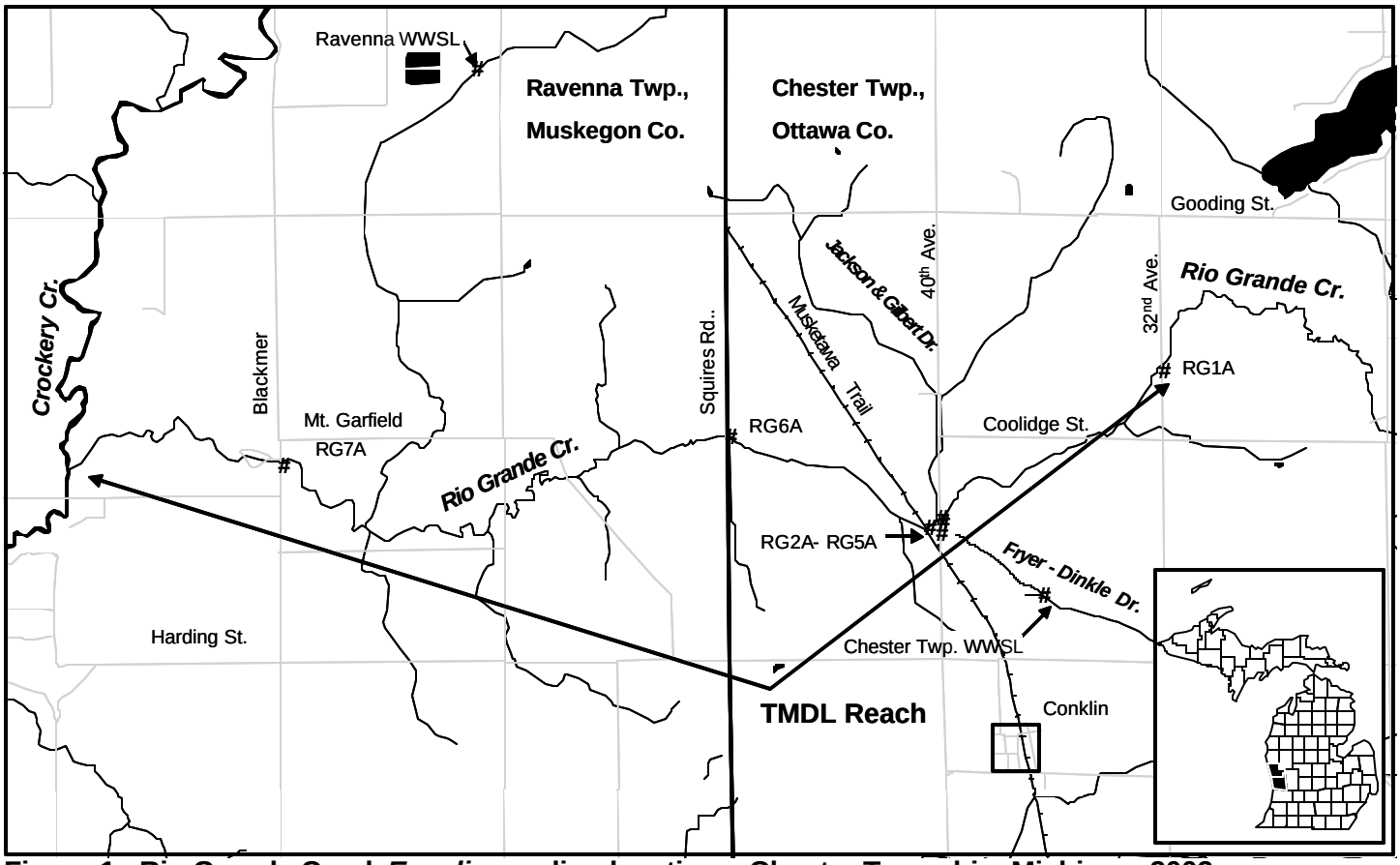

Figure 1. Rio Grande Creek *E. coli* sampling locations, Chester Township, Michigan, 2002.

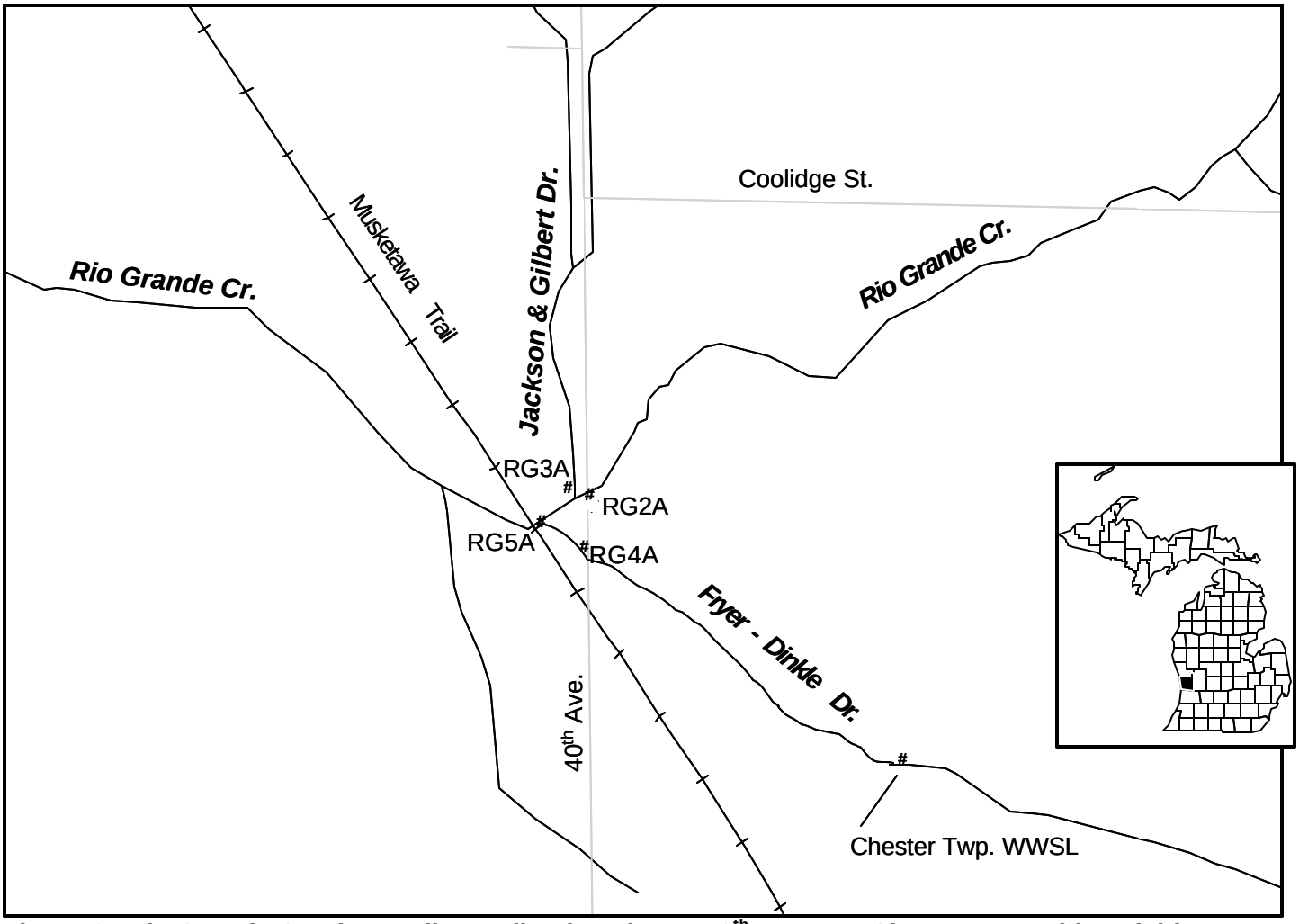

Figure 2. Rio Grande Creek *E. coli* sampling location at 40th Avenue, Chester Township, Michigan, 2002.

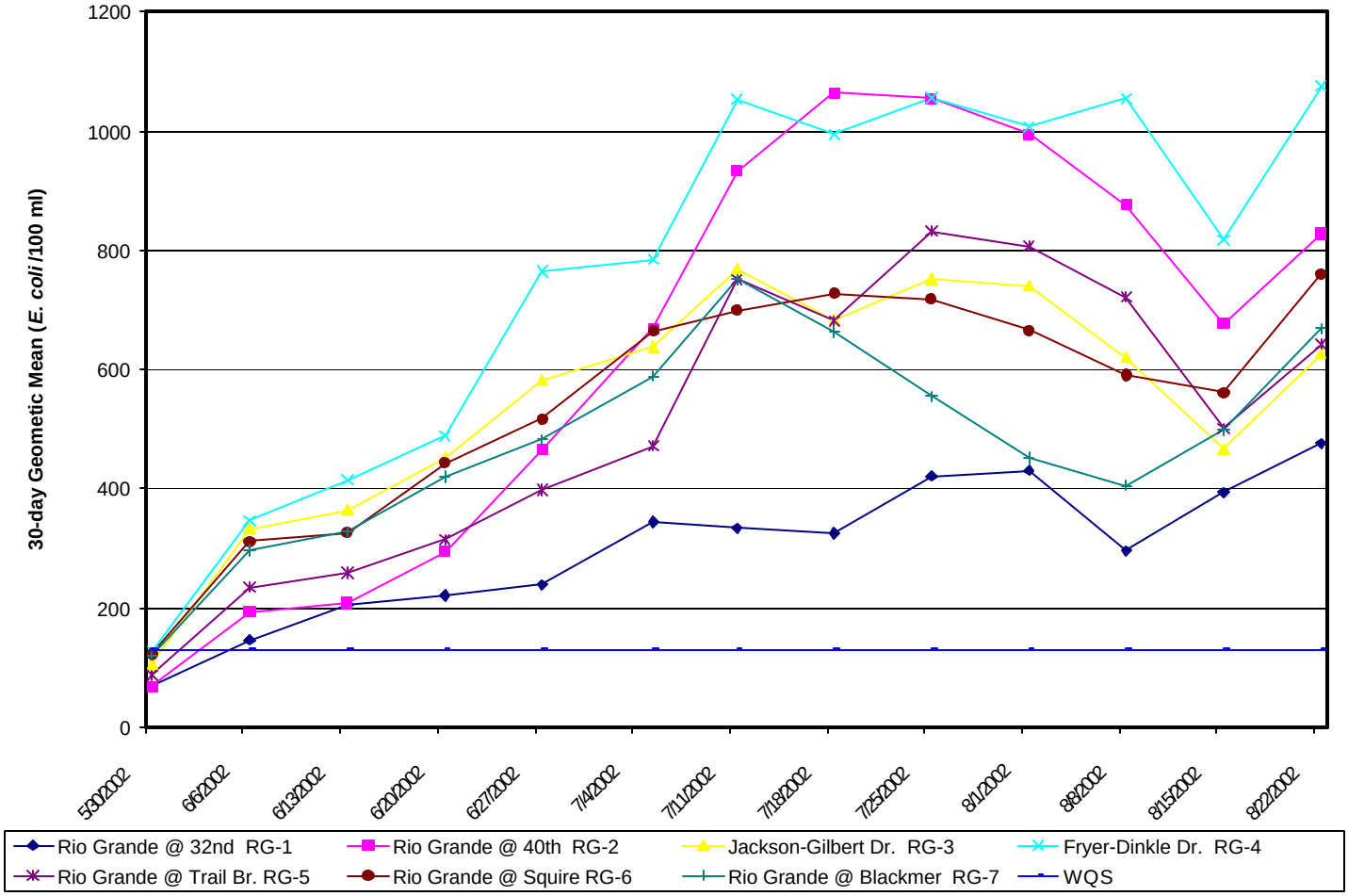

Figure 3. Thirty-day Geometric mean for *E. coli* in Rio Grande Creek and tributaries for 2002.

Table 1. MDEQ 2002 *E. coli* monitoring data for Rio Grande Creek (*E. coli*/100 ml). Shaded areas indicate exceedances of the Water Quality Standard.

	Rio Grande @ 32nd RG-1A			Rio Grande @ 40th RG-2A			Jackson/Gilbert Dr. @ 40th RG-3A			
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
5/3/2002	4	5	---	2	2	---	2	3	---	sunny, 50°
	2			2			2			
	14			2			4			
5/9/2002	120	76	---	360	272	---	400	397	---	rain, 60°
	65			140			400			
	57			400			390			
5/15/2002	99	115	---	79	116	---	120	120	---	sunny, cool
	110			210			120			
	140			95			120			
5/23/2002	110	126	---	100	97	---	200	186	---	cloudy, 65°
	150			150			230			
	120			60			140			
5/30/2002	290	279	68	290	235	68	540	633	107	sunny, 75°
	250			150			770			
	300			300			610			
6/6/2002	200	213	146	450	371	193	660	728	333	overcast, 60°
	180			390			680			
	270			290			860			
6/13/2002	400	427	206	410	396	208	600	619	364	cloudy, 65°
	500			360			670			
	390			420			590			
6/20/2002	170	165	221	660	653	294	500	356	452	humid, 80°
	110			640			300			
	240			660			300			

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

	Rio Grande @ 32nd RG-1A			Rio Grande @ 40th RG-2A			Jackson/Gilbert Dr. @ 40th RG-3A			
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**
6/27/2002	210	186	239	910	959	465	700	665	583	cloudy, 80°
	180			970			600			
	170			1000			700			
7/5/2002	1900	1725	344	1100	1455	669	970	989	638	sunny, 85°
	1800			2000			830			
	1500			1400			1200			
7/11/2002	230	183	334	1800	1963	933	2100	1855	769	sunny, 75°
	140			2100			1600			
	190			2000			1900			
7/18/2002	510	377	325	800	763	1064	290	346	684	cloudy, 80°
	350			760			420			
	300			730			340			
7/25/2002	660	597	421	600	627	1055	580	569	752	overcast, 65°
	670			760			530			
	480			540			600			
8/1/2002	190	209	431	740	713	995	520	615	740	humid, 85°
	240			830			620			
	200			590			720			
8/8/2002	380	266	296	730	777	877	510	411	621	clear, 75°
	290			740			290			
	170			870			470			
8/15/2002	840	765	394	590	535	677	590	448	467	cloudy, 75°
	730			520			610			
	730			500			250			
8/22/2002	870	965	476	2000	2098	828	1400	1498	627	rain, 70°
	940			2100			1600			
	1100			2200			1500			

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

	Fryer-Dinkle Dr. @ 40th RG-4A			Rio Grande @ Musketawa Trail Bridge @ 40th RG-5A			Rio Grande @ Squire Rd. RG-6A			Rio Grande @ Blackmer Rd. RG-7A			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
5/3/2002	2	4	---	2	3	---	8	4	---	2	4	---	sunny, 50°
	2			4			4			2			
	18			2			2			14			
5/9/2002	400	400	---	410	403	---	540	537	---	510	444	---	rain, 60°
	400			400			530			410			
	400			400			540			420			
5/15/2002	210	193	---	89	102	---	140	126	---	270	213	---	sunny, cool
	180			120			120			200			
	190			100			120			180			
5/23/2002	150	143	---	120	137	---	270	262	---	290	266	---	cloudy, 65°
	130			180			290			270			
	150			120			230			240			
5/30/2002	670	731	127	370	352	87	450	390	123	290	263	121	sunny, 75°
	870			420			280			300			
	670			280			470			210			
6/6/2002	770	622	347	410	357	235	310	429	312	310	346	297	overcast, 60°
	600			370			510			360			
	520			300			500			370			
6/13/2002	960	986	415	900	663	259	880	661	326	610	740	328	cloudy, 65°
	1000			690			420			1300			
	1000			470			780			510			
6/20/2002	300	438	489	200	271	315	600	597	444	1100	727	420	humid, 80°
	400			200			600			700			
	700			500			590			500			

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

	Fryer-Dinkle Dr. @ 40th RG-4A			Rio Grande @ Musketawa Trail Bridge @ 40th RG-5A			Rio Grande @ Squire Rd. RG-6A			Rio Grande @ Blackmer Rd. RG-7A			
DATE	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**SAMPLE RESULTS**	**DAILY G. MEAN**	**30-day G. MEAN**	**Weather data**
6/27/2002	1400	1333	765	440	443	398	600	561	517	570	536	483	cloudy, 80°
	1300			420			590			530			
	1300			470			500			510			
7/5/2002	1100	832	785	760	822	472	1400	1366	665	960	713	589	sunny, 85°
	570			960			1400			650			
	920			760			1300			580			
7/11/2002	3800	2717	1054	4800	3649	751	450	557	700	1300	1163	751	sunny, 75°
	2400			4400			630			1100			
	2200			2300			610			1100			
7/18/2002	770	739	995	420	406	681	950	801	728	520	399	664	cloudy, 80°
	680			420			730			370			
	770			380			740			330			
7/25/2002	540	589	1056	670	741	832	570	556	718	270	296	555	overcast, 65°
	540			690			530			300			
	700			880			570			320			
8/1/2002	1100	1055	1007	340	379	807	440	388	666	210	193	452	humid, 85°
	970			410			340			190			
	1100			390			390			180			
8/8/2002	1900	1050	1055	440	472	722	750	746	591	430	410	405	clear, 75°
	870			470			770			400			
	700			510			720			400			
8/15/2002	800	755	817	570	588	501	480	432	561	2500	3286	498	cloudy, 75°
	560			650			400			3300			
	960			550			420			4300			
8/22/2002	2500	2932	1076	1300	1395	642	4100	3654	760	2100	1750	669	rain, 70°
	2400			1100			3500			1500			
	4200			1900			3400			1700			

Table 2. Rio Grande Creek average flows (cfs) at Blackmer Road, Muskegon County, Michigan.

May	June	July	August	September	October
16	7.6	5.4	4.6	4.5	7.7

Table 3. Discriminant Analysis of Ribotype Profiles of *E. coli* isolates from water samples received on October 4, 2002.

Sample number Fecal coliform Mpn/100 ml[2]	*E. coli* isolate number	Probability value per source[*1]	
		non-human	human
RG-4A	1	0.00	1.00
Mpn = 210	2	0.00	1.00
	3	1.00	0.00
	4	1.00	0.00
	5	0.00	1.00

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

[1]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.

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