South Branch Yellow Medicine River Fecal Coliform Total Maximum Daily Load Report

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Minnesota Pollution Control Agency

Submitted by:

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Executive Summary

The Minnesota Pollution Control Agency (MPCA) has listed a stream reach in the South Branch of the Yellow Medicine River Watershed as impaired for swimming designated use (primary contact recreation) under Section 303(d) of the Clean Water Act. The 2004 303(d) list identifies the impaired reach as the "Yellow Medicine River, South Branch; Headwaters to Yellow Medicine River", Hydrological Unit Code (HUC) 07020004-503. The South Branch of the Yellow Medicine River is referred to as sub-watershed in this document. The main cause contributing to impairment is excessive fecal coliform bacteria load. This Total Maximum Daily Load (TMDL) document assesses the fecal coliform current concentrations and the load reductions needed for this reach of the Yellow Medicine River to comply with Minnesota water quality standards. The specific problems and recommended approach and actions to control fecal coliform loads are highlighted below.

The area of concern is a sub-watershed of the Yellow Medicine River located along the south branch of the river's five main branches, and, in particular, the downstream section of the South Branch. The land use is dominated by agricultural cropping and animal production. The single urban center is the City of Minneota. The 79,731 acre sub-watershed was divided into 30 monitoring areas, each with a monitoring station to pinpoint pollution sources. The focus and primary intent of this project is to better characterize fecal levels, probable sources, and estimated reduction needs to meet the TMDL water quality goal. The TMDL approach was undertaken to quantify the individual point and non-point sources of fecal coliform bacteria. Sub-watershed wide bacterial loading allocation methods were employed to assess the magnitude of point and non-point sources and establish a cause-effect linkage of loading sources and subsequent stream concentrations. The maximum daily load was also calculated for spring, summer, and fall conditions, based on the results of the monitoring.

Samples were collected during 1999 by the Minnesota Pollution Control Agency staff and again in 2001 by Yellow Medicine River Watershed District staff. The 1999 study sampled eleven stations covering all of the drainage of the South Branch of the Yellow Medicine River, and the 2001 study sampled 25 stations in the downstream half of the South Branch. Six of these stations were common to both sampling efforts. Analysis of the data showed that although impaired status was relatively rare during the spring and fall seasons, all of the 30 sites showed impairment during at least one of the summer months of June - August.

The TMDL report includes:

- Problem Statement
- Applicable Water Quality Standards and Water Quality Numeric Targets
- Pollutant Assessment
- Linkage Analysis
- TMDL and Allocations
- Follow-Up Monitoring Plan
- Implementation Plan
- Public Participation

The TMDL implementation plan is composed of three parts: 1) the first part calls for an 78 percent reduction in fecal coliform, applied sub-watershed wide, to bring the geometric monthly mean, during wet conditions, of all sampling stations from 794 organisms/100ml to less than 180 organisms/100ml during wet conditions; the water quality goal that includes a 10 percent margin of safety. 2) The second part of the plan calls for high implementation activities, and 3) the third part calls for an intensive monitoring effort to determine the success of the plan and the performance of specific implementation activities.

1. Introduction

Section 303(d) of the Clean Water Act (CWA) provides authority for completing Total Maximum Daily Loads (TMDL's) to achieve state water quality standards and/or designated uses.

A TMDL is a calculation of the maximum amount of pollutant that a water body can receive while still meeting water quality standards and/or designated uses. It is the sum of the loads of a single pollutant from all contributing point and non-point sources. TMDL reports must include the following eight elements to be approved by the U.S. Environmental Protection Agency (EPA):

The TMDL report must:

1. Be designed to implement applicable water quality criteria;
2. Include a total allowable load, as well as individual waste load allocations;
3. Consider the impacts of background pollutant contributions;
4. Consider critical environmental conditions;
5. Consider seasonal environmental variations;
6. Include a margin of safety;
7. Provide opportunity for public participation;
8. Have a reasonable assurance that the TMDL can be met.

In general, the TMDL is developed according to the following relationship:

$$TMDL = WLA + LA + MOS$$

Where:

TMDL = Total Maximum Daily Load (may be seasonal, for critical conditions, or other constraints).

WLA = Waste Load Allocation (point source).
LA = Load Allocation (non-point source)
MOS = Margin of Safety (may be implicit and factored into conservative WLA or LA, or explicit).

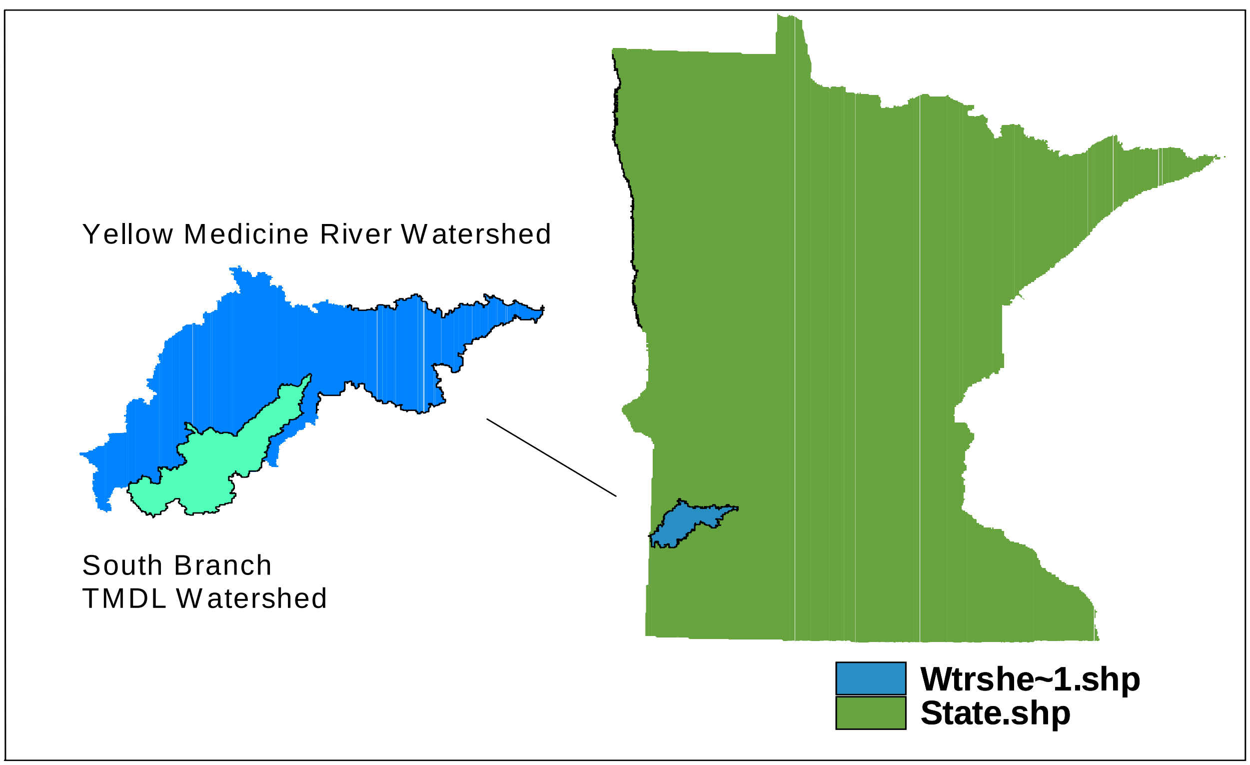
2. Problem Statement

- Waterbody name and location
- Map
- Waterbody 303(d) list status and priority ranking
- Sub-watershed description (land use, geology, and hydrology)

The South Branch TMDL sub-watershed represents a specific activity within a larger project addressing water quality improvements within the Yellow Medicine River Watershed. The larger project goals are to relate monitoring data to land use in a cause-effect manner.

During the period October 22, 1990 to May 17,1999, 64 fecal coliform observations were conducted from a milestone site, YMS-10.1, South Branch of the Yellow Medicine River at CSAH-10 near the city of Minneota. Of these samples, 42 observations were greater than 200 organisms/100ml. There were 56 observations in this time period within the months that the fecal coliform standard was in effect. There were 5 months that had more than 5 observations per month (across all years), and for each of these 5 months, the geometric mean was greater that 200 organisms/100ml. This leads to a preliminary assessment of non-support, and a TMDL listing. The 2004 303(d) list identifies the impaired reach as the "Yellow Medicine River, South Branch; Headwaters to Yellow Medicine River", HUC 07020004-503.

Figure 2.1: Location of the South Branch Subwatershed of the Yellow Medincine River Watershed in Minnesota



Background Information:

History of the watershed

Some 12,000 years ago the Yellow Medicine River was formed as part of an extensive drainage system for the retreating glaciers of the Pleistocene age. As the massive glaciers paused from their southward advance, the Coteau de Prairie was formed from rock and soil aggregates carried by the glaciers from places far north and deposited along a present day ridge extending from west central Minnesota to Iowa. As the aggregates deposited and formed the Coteau, also called "Buffalo Ridge", finer richer soils washed in an eastern direction forming the flood plain extending from the Coteau to the Minnesota River.

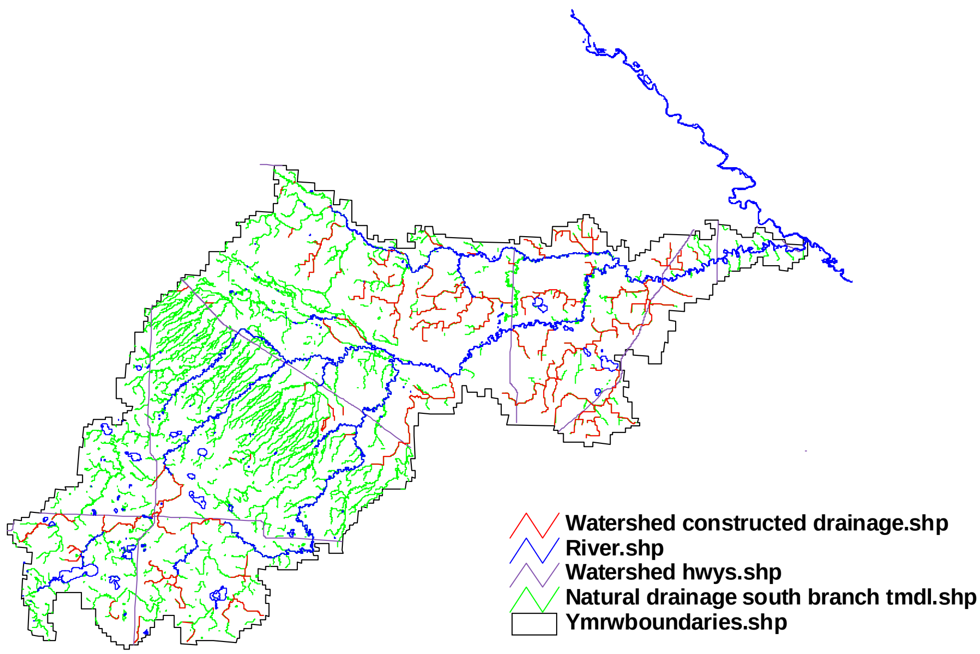
Humans have inhabited the area during the "Ice Age" and continuously thereafter in a succession from ancient peoples crossing the Bering Straits to hunter gathering tribes to Dakota tribes hunting buffalo with horses. European settlers arrived in the area as early as the 17^{th} century trapping for furs and later in the 19^{th} century as farmers as part of the westward expansion of American settlement. The effect on the land was enormous with the opening of the soil and the beginnings of the change in soil rainfall-runoff patterns. The initial changes were minor, but with the mechanized era beginning in the 20^{th} century the retention characteristics were abruptly changed.

This pattern continued to accelerate to the present day and was exacerbated by further drainage modifications such as wetland drainage, ditch construction, and the installation of drain tile. Local catchment and infiltration processes were changed to downstream discharges, and through the construction of ditch systems, continuous flow from the extended reaches of the watershed to the mouth were established. Flow is present now where they previously were limited to extreme rainfall events. Prior to these modifications prairie potholes would have to fill to capacity to flow downstream and tributaries would outflow to swollen flood plains. With these changes soils loss was greatly enhanced washing from the row crops and plowed fields into the river channels. The cutting of the river banks and stream bottoms was also accelerated as the flows from each rainfall increased and the channels were filled to capacity more frequently.

The GIS maps on the following two pages illustrate the role and extent of the ditch system created in the last century. Figure 2.2 shows the main river flow formed by the glacial drainage and sustained by rainfall events over thousands of years, and also shows the constructed drainage system in relation to the natural drainage. Note that the Yellow Medicine River and the associated watershed is a major tributary of the Minnesota River. The primary conduit of this system originates in Lincoln County, located in western Minnesota bordering South Dakota. Lake Shaokatan is considered the start of the river with North and South branches joining several miles upstream, along with the Mud Creek from the west; flowing generally northeast after running down the eastern slope of the Coteau Des Prairies or Buffalo Ridge. Spring Creek flows at a much gentler slope and joins the main stem several miles downstream where the flow continues eastward to the Minnesota River.

The watershed lies in the Northern Glaciated Plains ecoregion and has land use patterns typical for this ecoregion. Extensive drainage networks are established within the flood plain on the eastern half of the watershed and in the far reaches above the Coteau in the southwestern portion (the Coteau is marked by the concentration of intermittent tributaries along a northwest to southeast line just left of center in the map). These zones of ditch networks were presumably areas where storage and infiltration took place during spring runoff, and following each storm event. These areas are now implicated as priority loading sources for nutrients, solids, and excessive rainfall runoff.

Figure 2.2: Yellow Medicine River Watershed



Past and current studies in the watershed include the Lake Shaokatan Clean Water Partnership (CWP) Diagnostic and Implementation phases, and the Greater Yellow Medicine River CWP Diagnostic and Implementation phases; this project is currently in a second phase of implementation.

Target Sub-watershed

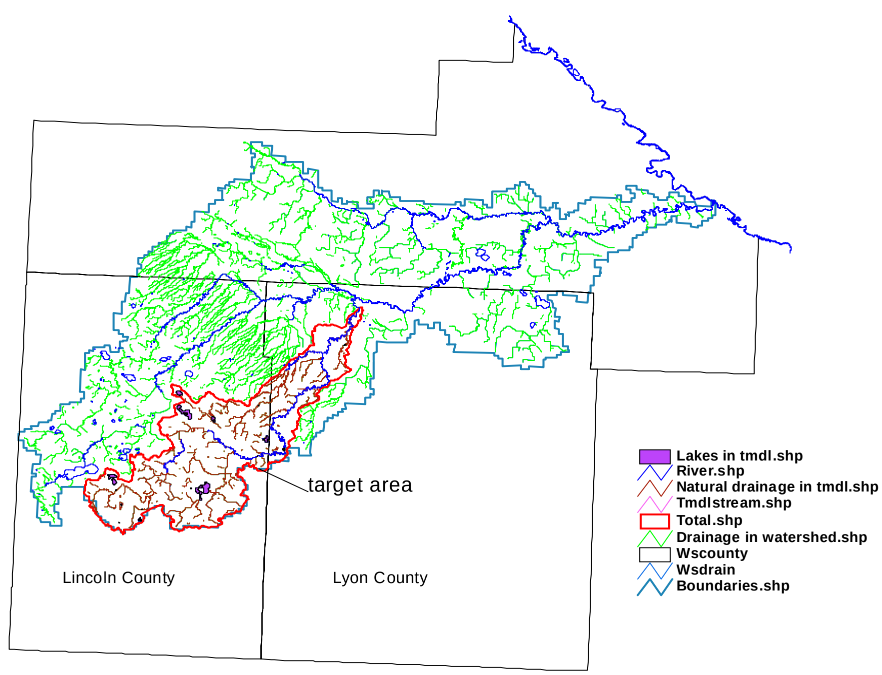
The project area is defined by the drainage area as shown in Figure 2.3. The sub-watershed is comprised of 124.6 square miles flowing mainly in a northeast direction down the Coteau de Prairies and out on the flood plain. The average slope of the sub-watershed is 22.6 feet/mile.

LOCAL UNITS OF GOVERNMENT IN THE PROJECT AREA:

COUNTIES	TOWNSHIPS	CITIES
Lincoln	8	1
Lyon	4	1

The studies indicate the river is subject to extreme water quality deterioration processes in the recent past that related to rainfall storage loss and subsequent increasing stream velocities. Nutrient and suspended solids data suggest the river is receiving excessive loadings of nutrient and solids from this sub-watershed. The state of the river is in very high profile within the surrounding communities and landowners due to the increasing downstream flooding, and crop loss due to flooding has particularly been the subject of growing debate.

Figure 2.3: South Branch of the Yellow Medicine River - TMDL Target Sub-watershed



The focus and primary intent of this project is to better characterize fecal levels, the probable sources, and estimate reductions required to meet the TMDL water quality goal. The scope of the project includes identifying and quantifying the point and non-point sources of fecal coliform, and linking these sources to the river concentrations. The project design attempts to:

- Assess the various sources of fecal coliform;
- Develop assumptions of the availability of each source;
- Develop assumptions on the delivery of each source to the river;
- Assess the central tendency and variability of the river's fecal coliform;

The data gathered during the diagnostic study enables the project managers and the steering committee to develop an information-based management plan to:

- Assess the magnitude of each pollution source;
- Design realistic control measures;
- Quantify the performance of the control measures implemented;
- Prognosticate the net effect on the river water quality and quantity;

The basic scope of the project is comprised of three components. The first is to access the magnitude and variability of the sub-watershed loading quantitatively at the most cost effective resolution. The second is to assemble a technical committee involving the Yellow Medicine River Watershed District (YMRWD), the Lincoln Soil and Water Conservation District, the Lyon County Soil and Water Conservation District, the Natural Resources Conservation District (NRCS), the Minnesota Pollution Control Agency (MPCA), and local cities and townships. This committee guides the project flow by interpreting the available information and setting goals and direction. The third component is to create and utilize a one-stop, “state of the art” information processing mechanism in the form of a GIS system. The requirements of this system include, but are not limited to, compatibility within and outside of the user group, usable spatial and numeric information systems, and dynamic communication protocols linking the project information to committee members and the land owners.

Land Use

Land use is a mixture of agriculture, pasture, urban, open/wetland, and forest, with most of the watershed dominated by cropland. The land use categories of wetland, agriculture, and forest are depicted in Table 2.2 below. The watershed is located within the Northern Glacial Plains Ecoregion in Western Minnesota. Lakes in this ecoregion range between total phosphorus levels of 130-250 ug/L[1] during the summer growing season, and chlorophyll-a levels range between 30-55 ug/L. Streams and rivers in this ecoregion typically have phosphorus concentrations in the 200-500 ug/L range and suspended solids that are indicative of excessive erosion processes. These erosion forces are partially due to the terrain and steep elevation changes associated

[1]Inter quartile ranges (25-75 percentile), Heiskary S.A. and C. B. Wilson, 1991)

with the Coteau de Prairie and are exacerbated by the cropping practices and the associated drainage throughout the sub-watershed. These drainage practices are extensive and involve mostly ditches and drain tiles. The net effect of the drainage and cropping is elevated runoff coefficient and increased discharge per unit rainfall.

The land use pattern for the entire 685 square mile Yellow Medicine River Watershed is shown below in Table 2.1. As indicated the dominant activity is agriculture with over 90% of the watershed in cropland and pasture. The scant forest regions are limited to the river and stream tributary valleys and farmsteads.

Table 2.1: Land Use for the Yellow Medicine River Watershed

Land Use Category	Acres	Percent
Cropland	350,000	82.8
Pasture/Range	35,400	8.4
Forest	3,600	0.9
Urban	3,000	0.7
Wetland/Open	30,600	7.2
Total	422,600	100

The South Branch TMDL sub-watershed reach has a similar land use pattern as the greater watershed, but has an even more intensive agriculture component with 99% cropland (Table 2.2).

Table 2.2: Land Use for the South Branch TMDL Sub-watershed

Land Use	Lincoln Count	Lyon County	Total
Other Total	0.00%	0.00%	0.00%
Urban and Industrial Total	0.03%	1.71%	0.04%
Farmsteads and Rural Residences Total	0.03%	1.39%	0.06%
Other Rural Developments Total	0.00%	0.57%	0.02%
Cultivated Land Total	99.41%	76.71%	98.86%
Transitional Agricultural Land Total	0.00%	0.17%	0.00%
Grassland Total	0.41%	12.63%	0.72%
Grassland-Shrub=Tree decidious Total	0.00%	0.14%	0.00%
Deciduous Forest Total	0.11%	5.97%	0.26%
Wetlands Total	0.01%	0.22%	0.02%
Gravel Pits And Open Mines Total	0.00%	0.35%	0.01%
Exposed Soil, Sandbars, and Sand Dunes To	0.00%	0.12%	0.00%
Total	100.00%	100.00%	100.00%

3. Applicable Water Quality Standards and Water Quality Numeric Targets

- Description of applicable WQ standards, designated uses affected by the pollutant of concern, and numeric criteria.

The TMDL evaluation is a method of addressing and assessing the fecal coliform bacteria exceedences of the state standard. All waters of Minnesota are assigned classes, based on their suitability for the following beneficial uses (Minn. R. ch 7050.0200):

Class 1 - Domestic consumption
Class 2 - Aquatic life and recreation
Class 3 - Industrial consumption
Class 4 - Agriculture and wildlife
Class 5 - Aesthetic enjoyment and navigation
Class 6 - Other uses
Class 7 - Limited resource value

The use classification assigned to the 303(d) South Branch impaired reach is Class 2B, 3B, 4A, 4B, 5 and 6 waters. The Minnesota Department of Natural Resources watershed and fisheries characteristics are shown in Table 3.1 below.

Table 3.1: Watershed and Fishery Characteristics

MNDNR ID	Trib#M-55-146-42
AREA (ac)	36,582
RIVER LENGTH (mi)	37.9
DNR CLASSIFICATON	Agricultural; class 3 warm water feeder stream
NUMBER OF TRIBUTARIES	
STREAMS	3
DITCHES	4
POINT SOURCES	1

3.1 Applicable Minnesota Water Quality Standards

According to Minn. R. ch. 7050.0430, the South Branch of the Yellow Medicine River is characterized as, ‘Unlisted Waters which are classified as 2B, 3B, 4A, 4B, 5, and 6 waters”. The Class 2B standards apply to the South Branch of the Yellow Medicine River because it is most restrictive. Class 2B waters support indigenous fish and associated aquatic communities, and recreation use. Minn. R. ch. 7050.0222 subp. 4 and 5, Fecal Coliform water quality standard for Class 2B, states that fecal coliform shall not exceed 200 organisms per 100 milliliters as a geometric mean of not less than five samples in any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 2,000 organisms per 100 milliliters. The standard applies only between April 1 and October 31.

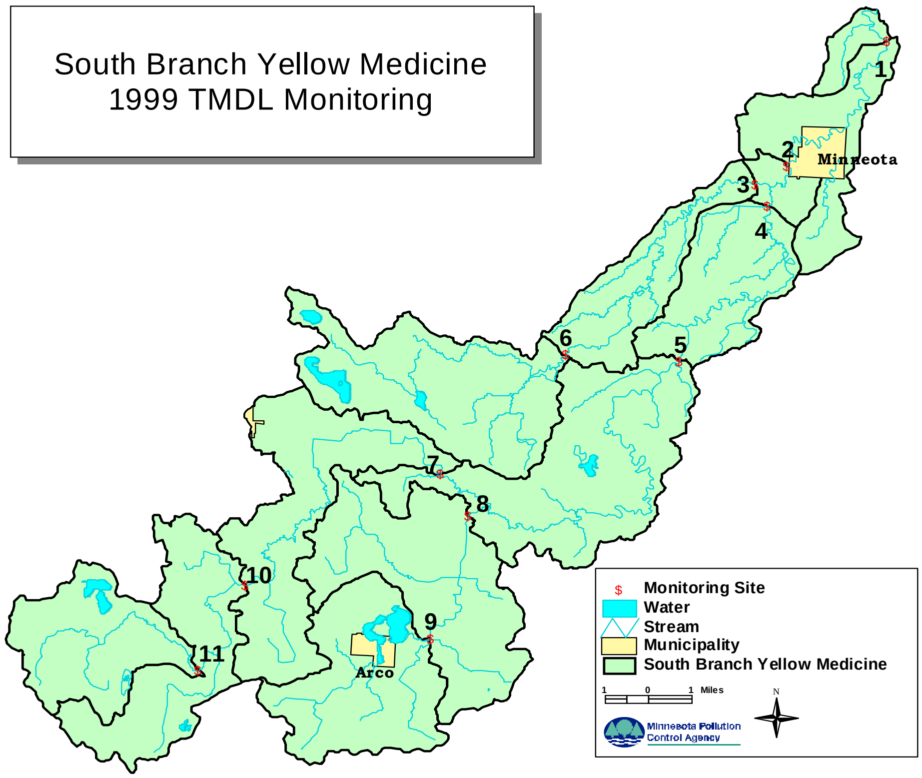
The final goal of the project is to reduce the current sub-watershed fecal coliform loading sources sufficiently to subsequently reduce the stream load to concentrations of less than 200 bacteria per 100 milliliters in all portions of the South Branch reach. These reductions will inhibit acute standard violations of 2,000 bacteria per 100 milliliters. The goal of the project will meet both parts of the standard. It is likely that if one part of the standard is exceeded then the other part of the standard will also be exceeded. The follow up monitoring will show the extent of these reductions, and if still in exceedance of the standard, will initiate further implementation activities targeting further reductions.

3.2 Impairment Assessment

During the period October 22, 1990 to May 17, 1999, 64 fecal coliform observations were conducted from a milestone site, YMS-10.1, South Branch of the Yellow Medicine River at CSAH-10 near the city of Minneota. Of these samples, 42 observations were greater than 200 organisms/100ml. There were 5 months that had more than 5 observations per month (across all years), and for each of these 5 months, the geometric mean was greater that 200 organisms/100ml. This leads to a preliminary assessment of non-support, and a TMDL listing. The South Branch reach was placed on the 1998 303(d) impaired waters list as the “Yellow Medicine River, South Branch; Headwaters to Yellow Medicine River”.

Data was collected at 11 locations within the South Branch reach during the period May thru September 1999 (Figure 3.1). Three to five samples were collected each month at the eleven stations. A single station was in exceedance of the standard in May, and all stations sampled were above the standard for the following three months with one exception. Roughly half of the stations sampled were in exceedance of the standard in September.

Figure 3.1: South Branch Yellow Medicine River 1999 Sampling Sites



The data is listed in Table 3.2 below.

Table 3.2: Summary of South Branch Fecal Coliform Assessment

South Branch Yellow Medicine - 1999 Fecal TMDL

	1999 TMDL Data										
1999 Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
May											
5/4/1999	24	20	130	36	8	12	24	52	120	4	4
5/11/1999	120	130	140	150	32	34	40	40	32	56	320
5/17/1999	150	350	120	120	40	8	150	32	56	32	4
5/27/1999	2100	460	1700	120	100	36	130	44	60	300	80
G Mean	174	143	247	94	32	19	66	41	60	38	25
June											
6/1/1999	200	260	310	200	110	68	130	960	370	260	80
6/8/1999	52000	9000	27500	9200	2900	3500	1700	4200	3400	710	990
6/15/1999	730	460	910	640	280	350	420	270	67	73	130
6/22/1999	860	1200	940	1300	440	200	840	300	180	220	180
6/29/1999	1450	1100	800	1300	320	150	1000	360	190	290	600
G Mean	1568	1073	1423	1148	417	302	600	652	310	244	257
July											
7/6/1999	1200	1100	1100	1200	450	100	760	680	210		
7/13/1999	560	505	600	660	180	300	350	270	300		305
7/20/1999	1200	740	2600	1200	340	500	690	1400	680		
G Mean	931	744	1197	983	302	247	568	636	350		305
August											
8/3/1999	960	490	1300	1200	490	640	150	240	2310		
8/10/1999	3000	1100	3200	740	1050	900	280	275			
8/24/1999	220	1200	6000	305	460	310	27	76	180		
8/31/1999	2500	3000	4400	2800	1500	700	500	910	1300		
G Mean	1122	1180	3237	933	772	595	154	260	815		
September											
9/7/1999	350	540	330	420	500	250	160	340	230		
9/20/1999	2400	1300	2800	640	405	180	300	200	250		
9/23/1999	405	330	18000	140	160	78	130	24	310		
9/27/1999	420	97	3200	230	140	76	64	20	91		
9/29/1999	500	24	1500	240	560	270	80	24	170		
G Mean	590	222	2401	291	303	148	126	60	194		

Data was collected at 25 locations within the downstream portion of the South Branch during the period of April thru September of 2001 (Figure 3.2). Five stations were in exceedence of the fecal coliform standard during the months of April and May, but nearly all of the stations were in exceedence at least one of the summer months. Five stations exceeded the standard during September.

Figure 3.2: Sites sampled during the 2001 season

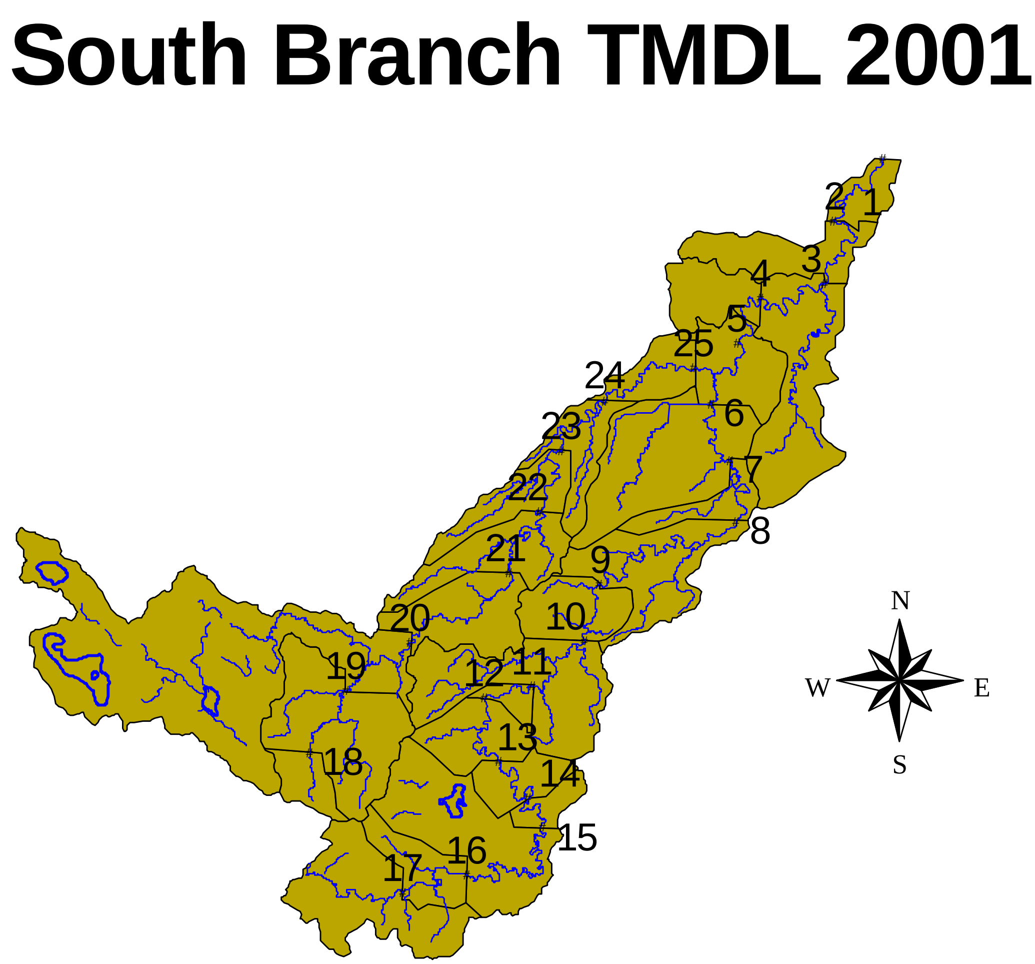


Table 3.3: Summary of the South Branch Fecal Coliform Assessment

South Branch Yellow Medicine = 2001 Fecal TMDL

Date	Fec Coli (cfu/100 mls)				Sites								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
4/3/2001	10	10	10	10	10	10	10	10	10	10	300	100	100
4/12/2001	3400	1100	1500	1800	1100	1000	3600	4100	3500	2700	2100	1600	2300
4/17/2001	20	25	10	4	20	5	5	5	5	30	5	5	5
4/24/2001	3000	3800	2600	2500	1900	2300	1800	1600	1200	1100	800	600	900
GEOMEAN	213	180	141	116	143	104	134	135	120	173	224	148	179
5/1/2001	40		70	65	25	85	48	10	25	30	25	35	20
5/14/2001	90	125	65	55	155	103	55	15	90	23	28	20	20
5/29/2001	98	140	220	109	200	116	88	74	16	4	16	20	20
GEOMEAN	71	132	100	73	92	101	61	22	33	14	22	24	20
6/11/2001	450	380	460	410	370	280	230	220	360	230	210	80	170
6/13/2001	670		3040	1050	1240	2040	325	810	610	675	255	95	338
6/14/2001	530	560	410	290	410	210	230	220	230	720	450	360	4300
6/25/2001	430	370	310	570	530	300	243	313	75	65	10	15	35
GEOMEAN	512	429	649	516	562	436	254	333	248	292	125	80	305
7/9/2001	193	143	120	45	128	85	20	25	25	5	25	5	10
7/20/2001	9900	1177	2880	990	1140	2630	3065	2025	1283	2975	2130	950	906
7/23/2001	3000		2600	3600	3000	3400	3100	3900	1760	1840	1480	1280	1000
GEOMEAN	1790	410	965	543	759	913	575	582	384	301	429	183	208
8/6/2001	860	338	155	100	253	425	215	55	50	180	20	28	20
8/20/2001	130	138	90	90	48	80	63	80	10	30	15	5	5
GEOMEAN	334	216	118	95	110	184	116	66	22	73	17	12	10
9/4/2001	498	95	255	15	50	45	30	85	20	55	45	10	18
9/18/2001	5			5	5	5	5	5	5	5	5	5	5
GEOMEAN	50	95	255	9	16	15	12	21	10	17	15	7	9

Date	Fec Coli (cfu/100 mls)				Sites							
	14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
4/3/2001	5	100	200	135		125	230		200	100	135	
4/12/2001	10	2700	900	1600	30	280	900	400	350	190	240	200
4/17/2001	5	6	4	2	2	5	5	10	20	65	45	50
4/24/2001	15	800	700	500	10	450	6800	3500	1600	400	800	300
GEOMEAN	8	190	150	121	8	94	290	241	218	149	185	144
5/1/2001	10	40	35	45	5	10	20	15	15	90	25	45
5/14/2001	35	65	30	15	5	5	15	20	40	40	130	240
5/29/2001	123	36	89	121	2	74	2	40	126	51	530	205
GEOMEAN	35	45	45	43	4	15	8	23	42	57	120	130
6/11/2001	100	530	188	370	18	103	730	175	153	140	570	380
6/13/2001												
6/14/2001	205	3700	6000	6600	10	320	330	340	173	490	50	15
6/25/2001	15	203	405	175	4300	123	10	90	55	158	123	201
GEOMEAN	67	736	770	753	92	159	134	175	113	221	152	105
7/9/2001	1700	65	40	75			1400	80	75	10	80	30
7/20/2001	40	2190	8400	547	9800	12200	5310	8400	4340	1870	7800	10800
7/23/2001	5	860	1240	1440	890	840	230	250	400	430	640	780
GEOMEAN	70	497	747	389	2953	3201	1196	552	507	200	736	632
8/6/2001	1257	140	65	175			330	80	30	120	170	820
8/20/2001	1000	60	35	25			430	115	30			123
GEOMEAN	1121	92	48	66			377	96	30	120	170	318
9/4/2001	2300	155	215	23			213					296
9/18/2001	3200	5	5	5			205	10	5	5	5	5
GEOMEAN	2713	28	33	11			209	10	5	5	5	38

3.3 Combined Fecal Coliform TMDL

The combined two year data set, 1999 and 2001, represents 30 stations across the South Branch sub-watershed. Six sites were common to both years (MPCA 1999 sites 1-6). The pattern was similar to the individual data for each of 1999 and 2001. Six stations exceeded the fecal coliform standard during the spring months of April and May, and only a single station did not exceed the standard during at least one of the summer months. Four stations exceeded the standard during September.

The 30 stations are shown below in Figure 3.3. The numbering system uses the 25 sites from 2001 plus an additional 5 sites (26-30) representing the upper sub-watershed sites (7-11) of the 1999 study.

Figure 3.3: South Branch Yellow Medicine River 1999 & 2001 Monitoring Sites

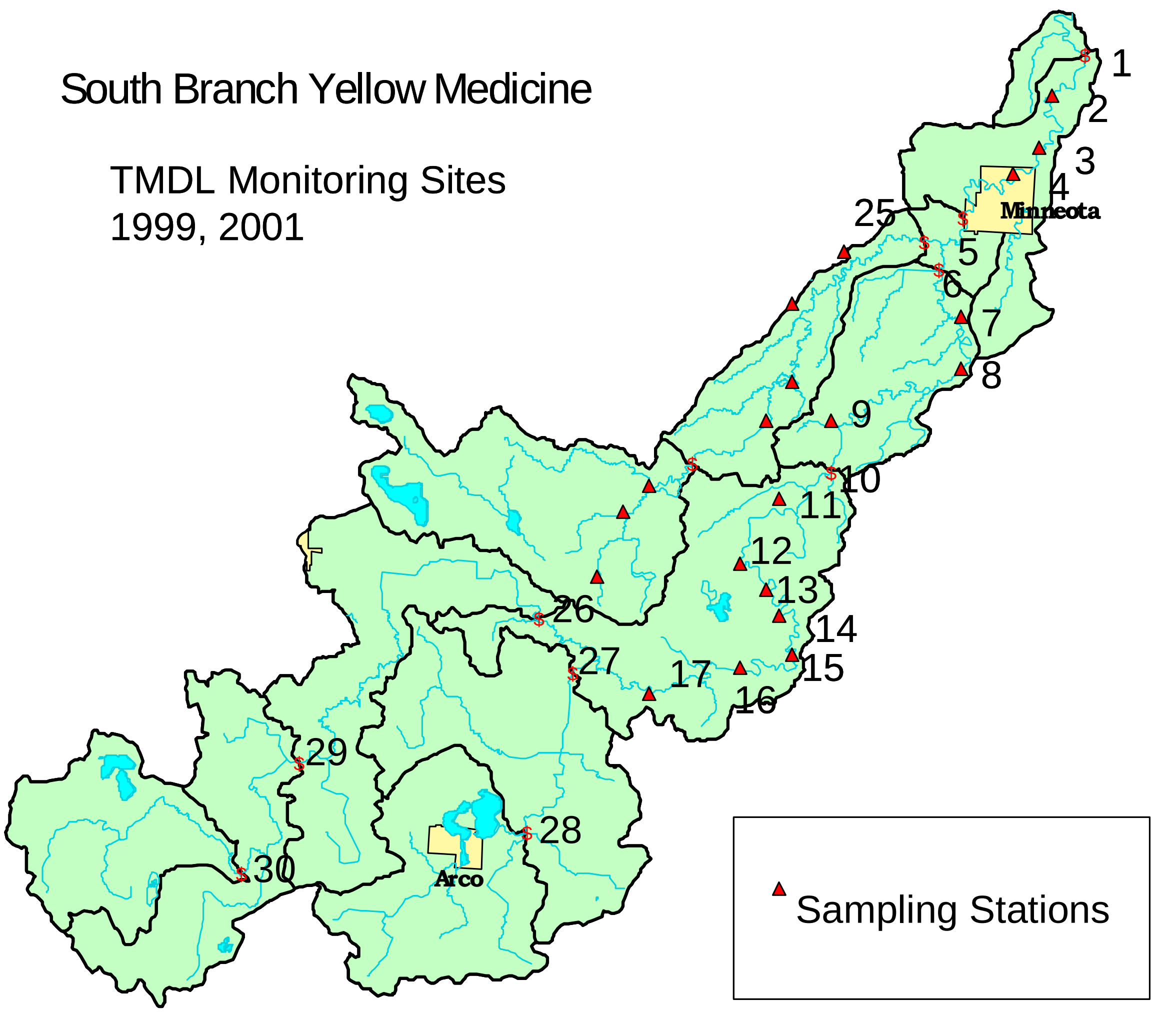


Table 3.4: South Branch Yellow Medicine River 1999 & 2001 Fecal Coliform Data

South Branch Yellow Medicine - 1999 and 2001 Fecal TMDL

Date	Fecal Coliform (cfu/100 mls)												Sites		
1999 Sites	*1*				*2*	*4*				*5*					
2001 Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
4/3/01	10	10	10	10	10	10	10	10	10	10	300	100	100	5	100
4/12/01	3400	1100	1500	1800	1100	1000	3600	4100	3500	2700	2100	1600	2300	10	2700
4/17/01	20	25	10	4	20	5	5	5	5	30	5	5	5	5	6
4/24/01	3000	3800	2600	2500	1900	2300	1800	1600	1200	1100	800	600	900	15	800
GEOMEAN	213	180	141	116	143	104	134	135	120	173	224	148	179	8	190
5/4/99	24				20	12				36					
5/11/99	120				130	34				150					
5/17/99	150				350	8				120					
5/27/99	2100				460	36				120					
5/1/01	40		70	65	25	85	48	10	25	30	25	35	20	10	40
5/14/01	90	125	65	55	155	103	55	15	90	23	28	20	20	35	65
5/29/01	98	140	220	109	200	116	88	74	16	4	16	20	20	123	36
GEOMEAN	118	132	100	73	118	38	61	22	33	42	22	24	20	35	45
6/1/99	200				260	68				200					
6/8/99	52000				9000	3500				9200					
6/15/99	730				460	350				640					
6/22/99	860				1200	200				1300					
6/29/99	1450				1100	150				1300					
6/11/01	450	380	460	410	370	280	230	220	360	230	210	80	170	100	530
6/13/01	670		3040	1050	1240	2040	325	810	610	675	255	95	338		
6/14/01	530	560	410	290	410	210	230	220	230	720	450	360	4300	205	3700
6/25/01	430	370	310	570	530	300	243	313	75	65	10	15	35	15	203
GEOMEAN	953	429	649	516	805	355	254	333	248	625	125	80	305	67	736
7/6/99	1200				1100	100				1200					
7/13/99	560				505	300				660					
7/20/99	1200				740	500				1200					
7/9/01	193	143	120	45	128	85	20	25	25	5	25	5	10	1700	65
7/20/01	9900	1177	2880	990	1140	2630	3065	2025	1283	2975	2130	950	906	40	2190
7/23/01	3000		2600	3600	3000	3400	3100	3900	1760	1840	1480	1280	1000	5	860
GEOMEAN	1291	410	965	543	751	474	575	582	384	544	429	183	208	70	497
8/3/99	960				490	640				1200					
8/10/99	3000				1100	900				740					
8/24/99	220				1200	310				305					
8/31/99	2500				3000	700				2800					
8/6/01	860	338	155	100	253	425	215	55	50	180	20	28	20	1257	140
8/20/01	130	138	90	90	48	80	63	80	10	30	15	5	5	1000	60
GEOMEAN	749	216	118	95	535	402	116	66	22	400	17	12	10	1121	92
9/7/99	350				540	250				420					
9/20/99	2400				1300	180				640					
9/23/99	405				330	78				140					
9/27/99	420				97	76				230					
9/29/99	500				24	270				240					
9/4/01	498	95 `		15	50	45	30	85	20	55	45	10	18	2300	155
9/18/01	5			5	5	5	5	5	5	5	5	5	5	3200	5
GEOMEAN	291	95		9	104	77	12	21	10	128	15	7	9	2713	28

Table 3.4 (continued)

South Branch Yellow Medicine - 1999 and 2001 Fecal TMDL

Date															
1999 Sites			***6***					***3***			***7***	***8***	***9***	***10***	***11***
2001 Sites	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
4/3/01	200	135		125	230		200	100	135						4
4/12/01	900	1600	30	280	900	400	350	190	240	200					320
4/17/01	4	2	2	5	5	10	20	65	45	50					4
4/24/01	700	500	10	450	6800	3500	1600	400	800	300					80
GEOMEAN	150	121	8	94	290	241	218	149	185	144					25
5/4/99					8					130	24	4	52	120	80
5/11/99					32					140	40	56	40	32	990
5/17/99					40					120	150	32	32	56	130
5/27/99					100					1700	130	300	44	60	180
5/1/01	35	45	5	10	20	15	15	90	25	45					600
5/14/01	30	15	5	5	15	20	40	40	130	240					
5/29/01	89	121	2	74	2	40	126	51	530	205					305
GEOMEAN	45	43	4	15	18	23	42	57	120	188	66	38	41	60	264
6/1/99					110					310	130	260	960	370	80
6/8/99					2900					27500	1700	710	4200	3400	990
6/15/99					280					910	420	73	270	67	130
6/22/99					440					940	840	220	300	180	180
6/29/99					320					800	1000	290	360	190	600
6/11/01	188	370	18	103	730	175	153	140	570	380					
6/13/01															
6/14/01	6000	6600	10	320	330	340	173	490	50	15					
6/25/01	405	175	4300	123	10	90	55	158	123	201					
GEOMEAN	770	753	92	159	272	175	113	221	152	535	600	244	652	310	257
7/6/99					450					1100	760		680	210	
7/13/99					180					600	350		270	300	
7/20/99					340					2600	690		1400	680	
7/9/01	40	75			1400	80	75	10	80	30					
7/20/01	8400	547	9800	12200	5310	8400	4340	1870	7800	10800					
7/23/01	1240	1440	890	840	230	250	400	430	640	780					
GEOMEAN	747	389	2953	3201	601	552	507	200	736	870	568		636	350	
8/3/99					490					1300	150		240	2310	
8/10/99					1050					3200	280		275		
8/24/99					460					6000	27		76	180	
8/31/99					1500					4400	500		910	1300	
8/6/01	65	175			330	80	30	120	170	820					
8/20/01	35	25			430	115	30			123					
GEOMEAN	48	66			608	96	30	120	170	1493	154		260	815	
9/7/99					500					330	160		340	230	
9/20/99					405					2800	300		200	250	
9/23/99					160					18000	130		24	310	
9/27/99					140					3200	64		20	91	
9/29/99					560					1500	80		24	170	
9/4/01	215	23			213					296					
9/18/01	5	5			205	10	5	5	5	5					
GEOMEAN	33	11			272	10	5	5	5	737	126		60	194	

4. Pollutant Assessment

- Source inventory, including magnitude and location of
    - Background
    - Point sources
    - Non-point sources
- Supporting documentation for the analysis of pollutant loads from each source.

Fecal coliform bacteria represent a group of several genera associated with the intestines of warm-blooded animals. The group is always associated with fecal matter and the sources are various as the existing warm blooded animal species. Fecal coliform is used in public health as an indicator of the presence of pathogens, due to their similar characteristics and habitat. Fecal coliform are used widely in the water works industry as indicators of possible pathogens, and "boil water" orders and violations can be issued as a result of a single positive test. Certain strains of Escherichia Coli (E.Coli), members of the Fecal Coliform bacteria group, have been shown to be extremely pathogenic. For these reasons, excessive fecal coliform stream concentrations pose a public health threat.

The assessment of fecal coliform sources within a watershed, and establishing the cause-effect relationship between the watershed sources, the transport mechanisms, and the subsequent stream loading is very complex and difficult to quantify. The problem is further exacerbated by the nature of the fecal coliform bacteria. Their survival rate in the terrestrial and aquatic environments is poorly understood, and confounds efforts to track their sources.

The methodology presented here is adapted from the Lower Mississippi River Regional TMDL. The sequence of assumptions and calculations consist of four steps: 1) inventory of point and non point potential sources; 2) assumptions of the fractions of fecal coliform mass that are available for transport from each of the sources; 3) assumptions of the mass fraction that is delivered to the stream from the available mass fraction; and 4) the resulting stream concentration of fecal coliform from the delivered mass.

CAUSE – EFFECT
Fecal Coliform Stream Loading Sequence:

Potential Sources → Availability of Sources → Delivery Fraction → Resulting Stream Concentration

4.1 Inventory of Fecal Coliform Sources

Table 4.1 summarizes the major potential sources of fecal coliform in the South Branch reach. The livestock records originate from the MPCA permitted facility database and the YMRWD feedlot survey[2]. In the winter of 2000, the YMRWD and SWCD personnel from Lyon and Lincoln Counties assisted with a level 2 feedlot survey. In Lincoln County, through the services of the Lincoln SWCD, a survey program was developed where townships were paid $20.00 for each feedlot survey submitted from their township. Total participation was achieved, with every township. In Lyon County, participating townships were similarly paid for submission of feedlot surveys.

The human sources were addressed largely by population census for urban and rural areas. The total population for the sub-watershed is 2730, with an urban population of 1550 and a rural population of 1180. The urban populations are in the city of Minneota and the city of Arco. The septic coverage was provided by the Lincoln County Environmental Services[3], and also from the Lyon County Soil Water Conservation District[4]. The septic systems within the TMDL sub-watershed were assumed to be 77% non-compliant[5]. The single point source, the Minneota municipal waste water treatment facility, provided discharge reports.

The deer estimates of 2.6-9.4 per square mile were adapted from deer densities in the near-by Chippewa Watershed[6]. The high end of a reported range of deer densities, 2.6-9.4 deer per square mile,was selected and slightly inflated to 10 deer per square mile to account for other wildlife contributions of fecal coliform.

The dog and cat populations were estimated from the population statistics. Urban and rural households were assumed to have 2.5 members on average, and 0.58 dogs and 0.73 cats per household[7].

[2] Yellow Medicine River Feed Lot Survey, 2000, Appendiz 5
[3] Robert Olson, Lincoln County Environmental Services.
[4] Chris Winter, GIS Specialist Lyon County.
[5] Yellow Medicine River Watershed District ISTS survey, 2001.
[6] Bob Osborn, MNDNR Farmland Research Group, spring 2001.
[7] Minnesota Department of Animal Health

Table 4.1: Inventory of Fecal Coliform Producers in the South Branch TMDL Sub-watershed

Category	Sub-Category		Animal Units	Number
Livestock	The basin contains an estimated 93 livestock facilities ranging in size from 1 animal units to 733 animal units	Dairy	1757	
		Beef	4916	
		Swine	1737	
		Sheep	567	
		Chicken	31	
		Horse	45	
Human	Rural Population with Inadequate Wastewater Treatment*			909
	Rural Population with Adequate Wastewater Treatment			271
	Municipal Waterwater Treatment Facilities			1
Wildlife	Deer (average 10 per mile)			1218
	Other It was not possible to obtain estimates for other wildlife. This sub-category was estimated using an equivalency to deer in the basin.			
Pets	Dogs and Cats in Urban Areas**			812
	Dogs and Cats in Rural Areas***			618

* 77% non compliant
** 1550 people / 2.5 people/household, 0.58 dogs/household, .73 cats/household
*** 1180 people / 2.5 people/household, 0.58 dogs/household, .73 cats/household

The values in Table 4.1 are expressed as “Animal Units” or “Number”. Animal units represent the equivalent of a 1000 pound animal. The feedlot survey was tabulated as animal number. The animal numbers were converted to animal units by multiplying the animal numbers by the representative weights: Dairy 1400 lbs, Beef 1000 lbs, Swine 140 lbs, Sheep 100 lbs, Chicken 4 lbs, and Horse 1000 lbs[8]. The product was divided by 1000 lbs to get animal units (see appendix 2).

4.2 Assumptions and Current Load Contributions

In order to assess potential contributions of fecal coliform from different sources a number of assumptions were made regarding where the fecal coliform bacteria “start out’, i.e., where they are deposited or otherwise reside on the landscape (Table 4.2). These assumptions translate livestock type and numbers into different settings or situations, e.g., overgrazed pasture, and indicate how much of the fecal coliform from a given source might ultimately end up in a stream or river. The assumptions are very gross and are intended to represent “average” conditions in the sub-watershed. The assumptions were adopted from available information from the following sources, Generic Environmental Impact Statement on Animal Agriculture (e.g. Mulla et.al. 2001), and professional judgment from MPCA and YMRWD staffs.

[8] ASAE D384.1 Feb, 2003 Manure Production and Characteristics

Table 4.2: Assumptions Used to Estimate the Amount of Daily Fecal Coliform Production Available for Potential Discharge into the Streams and Rivers of the South Branch TMDL Sub-watershed.

Category	Source	Assumptions
Livestock	Overgrazed Pasture near Streams or Waterways	1% of Dairy, Beef, Sheep, and Horse Manure
	Feedlots or Stockpiles without Runoff Controls	1% of Dairy and Chicken manure, 5% of Beef and Swine Manure
	Surface Applied Manure	49% of Dairy Manure, 47% of Beef Manure, 47.5% of Swine Manure, 49.5% of Chicken Manure, 49.5% Horse and Sheep Manure
	Incorporated Manure	49% of Dairy Manure, 47% of Beef Manure, 47.5% of Swine Manure, 49.5% of Chicken Manure, 49.5% Horse and Sheep Manure
Human	Failing Septic Systems	100% of all Failing Septic Systems
	Municipal Wastewater Treatment Facilities	One facility discharging at a fecal coliform concentration of 200 organisms/100ml
Wildlife	Deer Other Wildlife	100% of all Deer in the sub-watershed The equivalent of all fecal matter produced by Deer in the sub watershed
Pets	Improperly Managed Waste from Dogs and Cats	10% of waste produced by estimated number of dogs and cats in the basin

The assumptions in Table 4.2 are used to estimate daily fecal coliform availability by source, and are an attempt to account for all of the fecal material produced in the rural and urban areas of the sub-watershed. The sources represent the major pathways to stream loading of fecal coliform. For example, 1% of dairy cow manure is on over grazed pasture, 1% is in feedlots and stockpiles without controls, and 98% is split between surface and incorporated soil application. The majority of the fecal coliform available is associated with the land application of stored manure. Well managed pastures, feedlots, and stockpiles with runoff controls are assumed to be negligible sources of fecal coliform. The availability of Fecal Coliform from this source varies greatly with seasonal conditions and subsequent manure application cycles.

4.3 Discussion of loading sources

1. Overgrazed Pasture
There is much evidence within the TMDL sub-watershed of stream bank erosion due to cattle. Cattle are present in the streams at three locations in the sub-watershed. Dairy, beef, sheep, and horses are assumed to be on overgrazed pasture 1% of the time (available source assumption). A delivery assumption is 4% of the fecal coliform is used to estimate the delivery fraction from these sources during wet periods. An assumption of 1% delivery is used for dry periods due to direct access of animals to the streams

2. Feedlots and Stockpiles
Several feedlots and manure storage practices within the TMDL sub-watershed are lacking proper controls and presumably deliver fecal coliform directly to the streams. The degree of loading ranges from mild to severe. 1% of the dairy and chickens are

assumed to have poor feedlots and stockpiles, and 5% of beef and swine. The delivery from this source during wet periods is 4% and no discharge from this source is assumed during dry periods.

3. Manure application

The vast majority of the fecal coliform loading is assumed to be from manure application. This is a result of manure and subsequent fecal coliform production calculations based on animal number and type in the sub-watershed.[9] The fate of fecal coliform bacteria in the surface applied and incorporated soil applications is poorly understood, however. Additionally, the application rates and locations are not closely tracked. A 50/50 split is used between surface applied and incorporated manure for dairy, beef, swine, chickens, and horses, for the remaining portions of the total manure production. The delivery rate during wet periods is considered to be 0.5% for the surface applied manure and 0.1% for incorporated manure applications. The delivery rate for surface applied manure is considered to be 10 times that of incorporated manure applications, but applications drop off during the summer and fall seasons. A 0.5% discharge is used to simulate surface manure applications for half the growing season. Zero discharge is assumed for dry periods for both surface and incorporated manure applications.

4. Municipal Sources

4a. Storm Water Discharge:

The two municipalities within the TMDL sub-watershed are the city of Minneota and the city of Arco. These cities have a combined a population of 1550 people and encompasses approximately 90 acres of land. The fecal coliform delivery from this source is expressed as the urban portion of the pet source.

4b. Waste Water Treatment Discharge:

The municipal sewage facility in Minneota, NPDES permit # MNG580033, discharged three times during 2001 totaling 13.2 million gallons with the highest fecal coliform concentration of 90 organisms/100ml. The annual discharge divided into daily discharges results in a bacterial load of 1.2×10^{8} organisms per day. The largest acute discharge from this source would be 1.48×10^{10} organisms or about a 0.2% of the river fecal coliform load during wet conditions and about 7% of the river load during dry conditions. The discharge from the facility is within permit limits, and no reductions are needed from this source. This source is optimized and negligible when compared to the other loading sources, and is not considered in Table 4.5.

5. Septic Systems

The septic systems within the sub-watershed range from very good condition to very poor. There are many failing systems that are within 500 feet of the river and its tributaries. The availability assumption for this source is considered 100%. The

[9] Manure Production and Characteristics, American Society of Agricultural Engineers ASAE D384.1, February, 2003.

assumed 8% delivery is adapted from the Lower Minnesota TMDL and is considered to deliver at this rate independent of rainfall conditions.

6. Domestic Animals

The relatively low population of the TMDL sub watershed suggests a subsequent low pet population, and subsequent minor fecal coliform load from this source. 10% of the dog and cat waste is assumed to be available in storm-water runoff; 90% is assumed to be properly disposed of. The delivery during wet periods is assumed to be 4%, the same as the wildlife and domestic animals. This source is considered to be exclusively rainfall driven and no delivery is assumed during dry periods.

7. Wildlife

The wildlife population estimates are from a deer survey in 2001 that was conducted in the near by Chippewa River watershed[10]. The deer population range was estimated to be 2.6-9.4 deer per square mile. An inflated value of 10 deer per square mile was adopted to allow for other wildlife as well as the fecal coliform input from deer. This availability assumption is 100% for this source. The wildlife populations are assumed to deliver 4% during wet periods and 1% during dry conditions; the animals are assumed to use the streams for a water source.

The daily mass production of fecal coliform from each animal and human source is estimated using data results of several studies involving the measurement of fecal coliform mass per animal type and size. The daily estimates of fecal coliform production are shown in Table 4.3.

Table 4.3: Estimated Daily Fecal Coliform Production for Each Available Source

	FC orgs/animal/day			Weight	
	Source 1*	Source 2	Average	lbs.†	FC orgs/AU/day
Dairy		1.00E+11	1.00E+11	1400	7.14E+10
Beef		1.00E+11	1.00E+11	1000	1.00E+11
Swine	8.90E+09	1.10E+10	9.95E+09	140	7.11E+10
Chickens	2.40E+08	1.40E+08	1.90E+08	4	4.75E+10
Turkeys	1.30E+08	9.50E+07	1.13E+08	18	6.25E+09
Horses		4.20E+08	4.20E+08	1000	4.20E+08
Sheep	1.80E+10	1.20E+10	1.50E+10	100	1.50E+11
Deer**	5.00E+08		5.00E+08		
People	2.00E+09		2.00E+09		
Dogs/cats***	5.00E+09		5.00E+09		

* Source 1: Metcalf and Eddy, 1991; source 2: ASAE, 1998 (according to EPA, 2001)
** interpolated from Metcalf and Eddy, 1991 (in Dry Creek Watershed TMDL, Alabama, 2001)
*** from Horsley and Witten, 1996
† Assumed weights from GEIS (Impacts of animal agriculure on water quality: technical work paper: Animal agricululture's economic impact in Minnesota, April 3, 2001), except for sheep (from SE FC TMDL)

[10] Deer Densities in the Chippewa Watershed, Bob Osborn MN DNR Farmland Research Group, 2001.

The delivery is defined as the fraction of the available fecal coliform sources that are actually transported to the stream. The concept for the qualitative and quantitative fecal coliform delivery potentials shown in Table 4.4 was adapted from Mulla et.al. (2001), which describes water quality risk associated with different types of livestock, animal housing operations, and land application practices on a 1-5 scale (1 = very low risk, 5 = very high risk). For this evaluation, a similar scale (very low to very high)

Table 4.4 Estimated Deliveries for Each Available Source

Source	Estimated Delivery Potential	
	(Wet)	(Dry)
Overgrazed Pasture near Streams or Waterways	High (4%)	Low (1%)
Feedlots or Manure Stockpiles without Runoff Controls	High (4%)	
Surface Applied Manure	Low (0.5%)	
Incorporated Manure	Very Low (0.1%)	
Failing Septic Systems and Unsewered Communities	Very High (8%)	Very High (8%)
Municipal Wastewater Treatment Facilities	Contribution estimated directly on discharge reports	
Wildlife	High (4%)	Low (1%)
Pets	High (4%)	

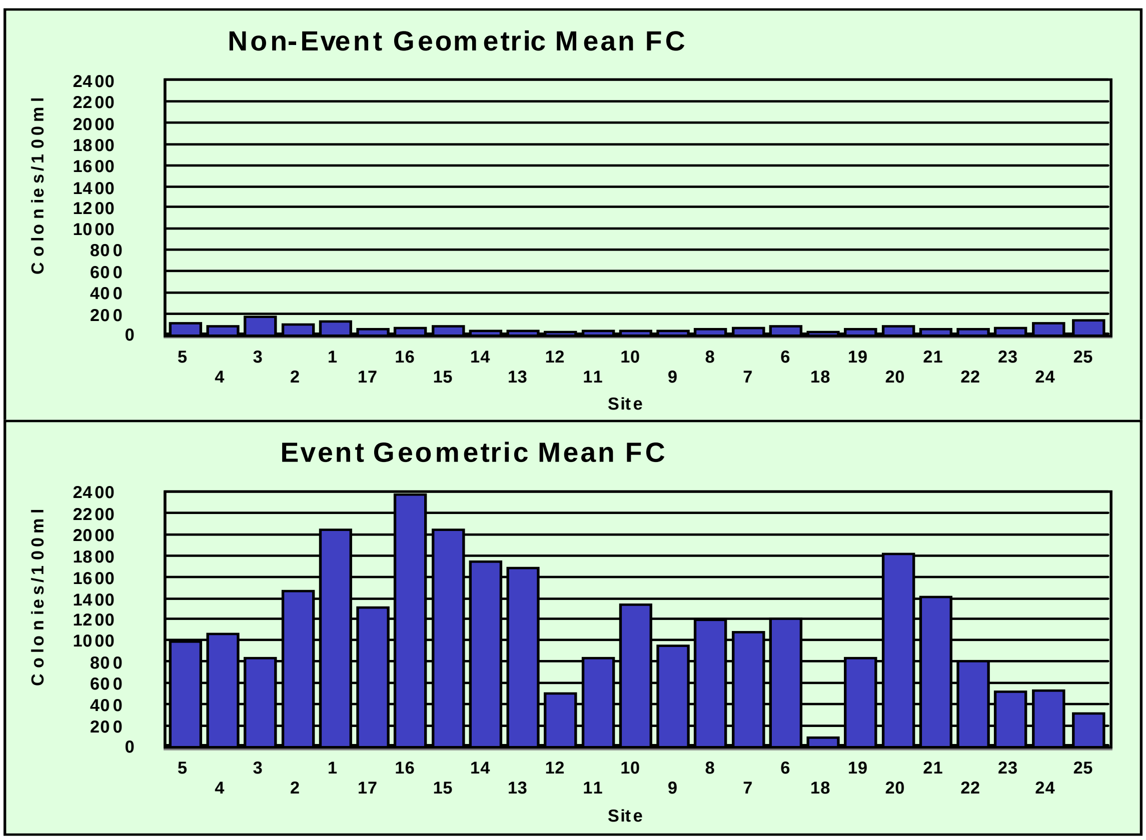
was used to describe fecal coliform delivery potential. In order to satisfy the requirement for a numeric load allocation, these qualitative rankings were translated into delivery percentages. One percent is considered a low delivery percentage, and is doubled for each step up the scale (moderate = 2 percent, high = 4 percent, very high = 8 percent). The only source assigned a very low delivery is incorporated manure. It was assigned a delivery percentage of 0.1 percent, based on the suggestion that delivery potential from incorporated manure is at least as order of magnitude below that of surface applied manure.

The delivery fractions assume that rainfall events are the driver for transporting bacteria from the available sources to the river, and delivery during dry periods would have to be via direct stream input.

The delivery of fecal coliform from pastures, feedlots, wildlife and pets is 4% during rainfall events. During quiescent periods deliveries from pastures are assumed to be 1% from cattle wading in the streams. The feedlot and stockpile delivery is assumed to be 4% during wet periods and zero during dry periods. The assumption is made that surface applied manure is delivered at a rate of 0.5%, five times that of incorporated manure, and delivery of fecal coliform from stockpiles is twice the rate in spring as the summer and fall seasons. Failing septic systems are assumed to be delivered at very high rates (8%) during all conditions and wildlife are assumed to have a 4% delivery during wet periods and a 1% delivery during dry periods by direct stream input due to daily water needs. Domestic pet fecal runoff occurs only during storm events at a delivery of 4%. The rate of decay of fecal coliform is not accounted for in the spreadsheet approach used in this TMDL. The decay of fecal coliform is accounted for through the estimated delivery potentials assigned to the fecal sources.

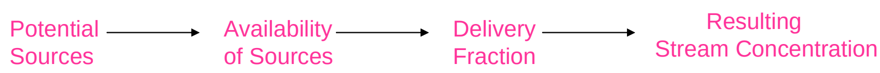
The driving force for fecal coliform delivery to the stream is rainfall events and the runoff produced during and following a rainfall event. The 2001 data from the 25 sites were queried into storm event and quiescent stream conditions. The results of the query showed huge increases in stream concentrations during storm events and dramatically lower concentrations during non-event flow regimes. The results are shown in Figure 4.1 below. As can be seen, all 25 stations are below the TMDL limit of 200 organisms/100ml during quiescent periods, the highest at 161 organisms/100ml, and conversely, all stations with single exception show impairment during storm events. This suggests readily available fecal coliform sources throughout the sub-watershed, and storm event driven runoff as the primary delivery mechanism.

Figure 4.1: Storm Event Effect on Fecal Coliform Stream Concentrations



The contributions from point and non-point sources are summarized in Table 4.5. The table illustrates the series of calculations relating the "potential" inventory of sources to the "available sources" to the "deliveries" from each of the available sources in a stepwise fashion.

CAUSE – EFFECT
Fecal Coliform Stream Loading Sequence:



The assumed percentage of available fecal sources is expressed as animal units and human numbers (from Table 4.1); the assumed percentages of the fecal coliform from these sources are shown in the second column. The "Fecal Coliform Organisms per Unit per Day" column is derived from Table 4.3, and the "Total Fecal Coliform Available" column is the product of the "AU" column and the "Fecal Coliform Organisms Produced per Unit per Day" column. The "Total Fecal Coliform Available by Source" column is the sum of each "Source". The "Total Fecal Coliform Delivered Wet and Dry" columns are the product of the "Total Fecal Coliform Available by Source" column and the percent delivery assumptions (shown in parentheses). The resulting fecal coliform loads to the river are expressed as both fecal coliform numbers and percents of the total load for each source ("Percent of Total Wet and Dry").

Table 4.5: Estimated Daily Fecal Coliform Available for Potential Runoff or Discharge into the South Branch TMDL basin.

Category	Source	Animal Units or Individuals Derived from Tables 4.10 and 4.20*	AU and Count	Assumption	Fecal Coliform Organisms Produced Per Unit Per Day**	Total Fecal Coliform Available	Total Fecal Coliform Available by Source	Percent of Total FC Available by Source	Total Fecal Coliform Delivered (Wet)	Percent of Total (Wet)	Total Fecal Coliform Delivered (Dry)	Percent of Total (Dry)
Livestock	Overgrazed Pasture near Streams or Waterways	Dairy Animal Units	18	1%	7.14E+10	1.25E+12						
		Beef Animal Units	49	1%	1.00E+11	4.92E+12			(4%)		(1%)	
		Horse Animal Units	0.5	1%	4.20E+08	1.89E+08						
		Sheep Animal Units	6	1%	1.50E+11	8.51E+11	7.02E+12	0.4%	2.81E+11	3.9%	7.02E+10	31.7%
	Feedlots or Stockpiles without Runoff Controls	Dairy Animal Units	18	1%	7.14E+10	1.25E+12						
		Beef Animal Units	246	5%	1.00E+11	2.46E+13			(4%)		(0%)	
		Swine Animal Units	87	5%	7.11E+10	6.18E+12						
		Chicken Animal Units	0	1%	4.75E+10	1.47E+10	3.20E+13	1.7%	1.28E+12	17.6%		
	Surface Applied Manure***	Dairy Animal Units	861	49%	7.14E+10	6.15E+13						
		Beef Animal Units	2311	47%	1.00E+11	2.31E+14			(0.5%)		(0%)	
		Swine Animal Units	825	48%	7.11E+11	5.87E+14						
		Horse Animal Units	22	50%	4.20E+08	9.36E+09						
		Sheep Animal Units	281	50%	1.50E+11	4.21E+13						
		Chicken Animal Units	15	50%	4.75E+10	7.29E+11	9.22E+14	48.9%	4.61E+12	63.2%		
	Incorporated Manure	Dairy Animal Units	861	49%	7.14E+10	6.15E+13						
		Beef Animal Units	2311	47%	1.00E+11	2.31E+14			(0.1%)		(0%)	
		Swine Animal Units	825	48%	7.11E+11	5.87E+14						
		Horse Animal Units	22	50%	4.20E+08	9.36E+09						
		Sheep Animal Units	281	50%	1.50E+11	4.21E+13						
		Chicken Animal Units	15	50%	4.75E+10	7.29E+11	9.22E+14	48.9%	9.22E+11	12.6%		
Human	Failing Septic Systems and Unsewered Communities	People	909	100%	2.00E+09	1.82E+12	1.82E+12	0.1%	(8%) 1.45E+11	2.0%	(8%) 1.45E+11	65.6%
Wildlife	Wildlife	Deer	1218	100%	5.00E+08	6.09E+11	6.09E+11	0.03%	(4%) 2.44E+10	0.3%	(1%) 6.09E+09	2.7%
Pets	Pets	Dogs and cats ****	143	10%	5.00E+09	7.15E+11	7.15E+11	0.0%	(4%) 2.86E+10	0.4%	(0%)	
Total						1.89E+15	1.89E+15	100.0%	7.29E+12	100%	2.22E+11	100%

* example - 1757 Dairy Animal Units in Basin X 1% on Overgrazed Pasture in Riparian Areas = 17.6 Animal Units
** Derived from literature values in Mulla et. Al (2001), USEPA (2001), and Alderisio and DeLuca (1999)
*** Total fecal coliform available reduced by a factor of 10 for summer calculations to reflect that only a small subset of facilities (daily or weekly scrape and haul) are applying manure in summer
**** Horsley and Witten, 1996

The total daily fecal coliform available by all sources in the sub-watershed is **1.89 x 10^15^** colony forming units and the total delivered to the stream in wet and dry conditions is **7.29 x 10^12^** and **2.22 x 10^11^** using this model. The surface applied manure dominates the source loading during wet periods and the source loading is dominated by two sources during the dry period, including overgrazed pasture and failing septic systems.

The assumptions in Table 4.2, the fecal coliform numbers per animal type in Table 4.3 and the estimated delivery in Table 4.4 are combined to produce Table 4.5. Table 4.6 summarized the contributions of fecal coliform from each source expressed as percentages, and is taken from Table 4.5.

Table 4.6: Contributions from Point and Non-Point Sources

Category	Source	Contribution Wet	Contribution Dry
Livestock	Overgrazed Pasture near Streams or Waterways	4%	32%
	Feedlots or Stockpiles without Runoff Controls	18%	
	Surface Applied Manure***	63%	
	Incorporated Manure	13%	
Human	Failing Septic Systems and Unsewered Communities	2%	66%
Wildlife	Deer	0.3%	3%
Pets	Dogs and Cats	0.4%	
Total		100.00%	100.00%

The arithmetic mean of the sum of the monthly geomeans was used to calculate the means for both the wet/dry and seasonal conditions. Taking the mean of geomeans is an appropriate methodology to partition wet/dry and seasonal conditions from a monthly standard stated as a geomean according to the best professional judgment of MPCA staff. Average flows for spring, summer and fall were used to determine loads. Because the reductions are provided in terms of percent in this spreadsheet method they are not effected by the flows. The required reductions would not change had other than average flows , e.g., high flows, been used. This approach is thought to be robust due to the fact that, with a single exception, all stations sampled during the years 1999 and 2001 exceeded the standard, and all stations exceeded the standard during wet conditions. The flows used were from site 1, which is the outflow of the TMDL target area and represents the total drainage of the sub-watershed.

5. Linkage Analysis

- Rationale for the analytical method used to establish the cause-effect relationship between the numeric target and the identified pollutant sources.
- Supporting documentation for the analysis (e.g., basis for assumptions, strengths and weaknesses in the analytical process, results from the water quality modeling).

5.1 Allocation and Reductions Needed to Satisfy the TMDL

A "Bacteria Matrix" spreadsheet matrix approach[11] (Table 5.1) was used to simulate the existing loading contributions in two scenarios: 1) wet conditions; and 2) during spring, summer, and fall seasons. The contributions from each of seven sources are derived from Table 4.6. The "assumed shares" for each season and for each source contribution is calculated using the geometric mean fecal coliform concentration at all sites for spring (April-May), summer (June-August), and fall (September), and the average flows at site 1 for each season. The combined 1999 and 2001 data sets were used in the calculations:

Month	Ave MGD	Geomean FC
April-May	257	75
June-Aug	54	364
Sept	7	85

The total stream load is calculated as the product of flow and concentration (MGD org/100ml). The contributions from each source are calculated as bacterial loads (organisms/day), and concentrations (organisms/100ml) by multiplying the total stream load by the percent shares.

Table 5.1: Source Contribution Matrix from Seasonal Loading Conditions for the South Branch TMDL Sub-watershed

Bacteria TMDL process: South Branch TMDL Basin									
				Existing	Existing	Existing	Existing	Existing	Existing
	[assumed shares]			Loading	Concen.	Loading	Concen.	Loading	Concen.
	Spring	Summer	Fall	Spring	Spring	Summer	Summer	Fall	Fall
Sources:				(orgms/day)	(orgms/100mL)	(orgms/day)	(orgms/100mL)	(orgms/day)	(orgms/100mL)
Overgrazed Pasture	4%	4%	4%	2.84E+10	3	2.89E+10	14	9.30E+08	3
Feedlots/Stockpiles	18%	18%	18%	1.28E+11	13	1.30E+11	64	4.20E+09	15
Surface Applied Manure	63%	63%	63%	4.59E+11	47	4.69E+11	230	1.51E+10	54
Incorporated Manure	13%	13%	13%	9.16E+10	9	9.34E+10	46	3.00E+09	11
Failing Septic Systems	2%	2%	2%	1.45E+10	2	1.48E+10	7	4.77E+08	2
Wildlife**	0.3%	0.3%	0.3%	2.18E+09	0	2.22E+09	1	7.15E+07	0
Pets	0.4%	0.4%	0.4%	2.91E+09	0	2.97E+09	1	9.54E+07	0
	100.00%	100.00%	100.00%						
Total #s=				7.27E+11		7.41E+11		2.38E+10	
"Concentration"=	75	364	85	75	75	364	364	85	85
Flow(mgd)=				257		54		7	
WQ Goal =				180		180		180	
WQG #s=				1.74E+12		3.67E+11		5.05E+10	
** background; assume no reduction									
TMDL Standard	200								
Margin of Safety	20								

The source contributions are shown in blue, and the flow and fecal coliform concentrations are shown in green. The water quality goal of 180 organisms per 100 milliliters is shown in the lower left corner and is based on a 10% margin of safety[12].

[11] Spreadsheet Matrix Approach Memo from the MPCA to the EPA, 1999.
[12] See section 6.1 Method of Calculation Margin of Safety.

The simulation indicates that the TMDL water quality goal of 180 organisms/100ml is satisfied in the spring and fall, but fails to meet the standard during the summer season. The model shows that the vast majority of the bacterial loading to the stream is from the manure application and feedlots; urban, point, and wildlife bacterial loads are insignificant in comparison.

Table 5.2 illustrates a simulation showing the existing loading contributions during wet and dry conditions. The contributions from each of seven sources are derived from Table 4.6. The wet and dry fecal coliform concentrations are calculated using the geometric mean fecal coliform concentration of all sites and all years. The "wet" fecal coliform concentration is the average of samples collected during storm events, and the "dry" concentration is the average of samples collected between storm events. The average flows (MGD, million gallons per day) are calculated for the same "wet" and "dry" conditions at site 1. The flows during wet conditions are nearly double the dry, but the concentrations are over eight times larger during wet conditions; the dry concentrations are about half the water quality goal of 180 org/100ml.

Table 5.2: Source Contribution Matrix from Wet and Dry Loading Conditions for the South Branch TMDL Sub-watershed

Bacteria TMDL process: South Branch TMDL Basin						
Sources:	Wet [assumed	Dry shares]	Existing Loading Wet (orgms/day)	Existing Concen. Wet (orgms/100mL)	Existing Loading Dry (orgms/day)	Existing Concen. Dry (orgms/100mL)
Overgrazed Pasture	4%	32%	1.69E+11	31	9.82E+10	30
Feedlots/Stockpiles	18%	0%	7.64E+11	140	0.00E+00	0
Surface Applied Manure	63%	0%	2.74E+12	502	0.00E+00	0
Incorporated Manure	13%	0%	5.47E+11	100	0.00E+00	0
Failing Septic Systems	2%	66%	8.68E+10	16	2.03E+11	62
Wildlife**	0.3%	3%	1.30E+10	2	8.36E+09	3
Pets	0.4%	0.0%	1.74E+10	3	0.00E+00	0
	100%	100%				
Total #s=			4.34E+12		3.10E+11	
"Concentration"=	794	95	794	794	95	95
Flow(mgd)=			145		86	
WQ Goal =			180		180	
WQG #s=			9.84E+11		5.87E+11	
** background; assume no reduction						
TMDL Standard	200					
Margin of Safety	20					
Water Quality Goal	180					

Table 5.3 shows stream fecal coliform concentrations as a function of equivalent reductions from each source. The assumed reductions would be 78% inhibition of fecal coliform delivery to the stream from each source, and are shown as allocations (1-% reduction). The resulting "wet" stream concentration would be 176 organisms/100ml and would meet the water quality goal.

Table 5.3: Percent Reductions from Current Fecal Coliform Bacteria Load Necessary to Meet Total Maximum Daily Load Allocation for the South Branch Sub-watershed; All Sources Reduced Equally

			All sources reduce equally				
			RS1	RS1	RS1	RS1	Reduction
	Wet	Dry	Wet	Wet	Dry	Dry	GOALS
Sources:	[assumed	shares]	x	Concen.	x	Concen.	(1-x)
Overgrazed Pasture	4%	32%	22%	7	20%	6	78%
Feedlots/Stockpiles	18%	63%	22%	31	100%	60	78%
Surface Applied Manure	63%	0%	22%	110	20%	0	78%
Incorporated Manure	13%	0%	22%	22	100%	0	78%
Failing Septic Systems	2%	66%	22%	3	20%	12	78%
Wildlife**	0.3%	3%	100%	2	100%	3	0%
Pets	0.4%	0.0%	22%	1	100%	0	78%
	100%	100%					
			Conc	177		81	
			goal	180		180	
			WQG	200		200	

These spreadsheet models indicate that, based on 1999-2001 fecal coliform concentrations and average flow conditions for the South Branch TMDL sub-watershed, the daily fecal coliform loads are **Summer: 7.41×10^{11}.** To meet water quality goals the allowable daily fecal coliform loads in the sub-watershed are **Summer: 3.67×10^{11}.** In terms of wet and dry conditions, as defined above, the fecal coliform loads are **Wet: 4.34×10^{12}.** To meet water quality goals the allowable daily fecal coliform loads in the sub-watershed are **Wet: 9.84×10^{11}.**

From a seasonal point of view, a 51% reduction is required to bring the summer fecal concentrations to the water quality goal, and from a wet and dry condition point of view, a 78% reduction is required to meet the WQG during wet conditions. The wet weather reduction of 78% is applied to all seasons. Meeting the load reductions under wet conditions will meet the standard under all conditions.

6. TMDL and Allocations

- Total Maximum Daily Load (TMDL)
  - The TMDL is expressed as the sum of the WLAs, the LAs, and the MOS (if an explicit MOS is included).
  - If the TMDL is expressed in terms other than mass per time, explain the selection of the other appropriate measure.
- Wasteload Allocations (WLAs)
  - Loads allocated to existing and future point sources.

  - An explanation of any WLAs based on the assumption that loads from a nonpoint source will be reduced.
  - If no point sources are present, list the WLA as zero.
- Load Allocations (LAs)
  - Loads allocated to existing and future nonpoint sources.
  - Loads allocated to natural background (where possible to separate from nonpoint sources).
  - If there are no nonpoint sources and/or natural background, the LA should be listed as zero.
- Seasonal Variation
  - Description of the method chosen to take into account seasonal and inter-annual variation.
- Margin of Safety
  - An implicit MOS is accounted for through conservative assumptions in the analysis. To justify this type of margin of safety, an explanation of the conservative assumptions used is needed.
  - An explicit MOS is incorporated by setting aside a portion of the TMDL as the MOS.
- Critical Conditions
  - Critical conditions associated with flow, loading, designated use impacts, and other water quality factors.

The TMDL requires the components of the following equation to balance in order to reduce fecal coliform enough to meet the fecal coliform water quality standard:

TMDL = WLA + LA + MOS

TMDL, as loads (numbers of fecal coliform colony organisms):

- 9.84 E+11 = 0 + 9.84 E+11
- 10.94 E+11 = 0 + 9.84 E+11 + 1.09 E+11

TMDL, as concentrations (colony forming units [cfu]/100 ml):

- 180 = 0 + 180
- 200 = 0 + 180 + 20

6.1 Method for Calculating Margin of Safety

The TMDL process provides for two primary means of dealing with uncertainty[13]:

1. Incorporating a margin of safety (MOS) in calculating pollutant load reduction requirements.
2. Using a phased approach when developing and implementing the TMDL study.

[13] U.S EPA "Protocol for Developing Pathogen TMDLS" , 1[ST] edition, EPA 841-R-00-002; January 2001.

Under the phased approach, load allocation and waste load allocations are based on the best available information, and monitoring is planned to generate additional data to determine if the load reductions required by the TMDL are being achieved following a prescribed period of implementation. The MOS accounts for scientific uncertainties and other factors to help ensure that water quality standards are achieved and maintained. The MOS can be expressed in the calculation of the WLA and LA, or can be expressed as a separate value. For the South Branch TMDL, uncertainty is dealt with both ways as follows:

- The load-reduction goals listed in Table 5.2 and Table 5.3 include a margin of safety (MOS). The MOS is set at 10% of the impaired stream level, or 20 organisms/100ml. This essentially lowers the impaired level to 180 organisms/100ml. This margin of safety addresses the uncertainty of the TMDL method due to sampling and modeling errors, both in estimating the Fecal Coliform concentrations and the flow regimes. The MOS also addresses errors in delivery estimates from overgrazed pasture, feedlots or manure stockpiles, surface-applied and incorporated manure, failing septic systems and un-sewered communities, and urban storm water runoff. Much uncertainty exists in the fate of fecal coliform in the terrestrial and aqueous environment. The seasonal effect and inter-year variation is also poorly understood in terms of the carry-over effect of bacteria from season to season and year to year. Alterations in land use practices also confound the TMDL process and the uncertainty is addressed by the MOS.
- The MOS provides a degree of safety in estimating the tendency and extent of the fecal coliform loading and the assumptions associated with implementation plan performance. The results of the extensive stream monitoring have highlighted top loading sub-watersheds and have provided a level of priority to the implementation plan. Through targeted implementation of source-reduction programs, the highest-contributing sources of fecal coliform will be addressed first. This will result in a higher degree of source reduction than that calculated by the spreadsheet model, which assumes spatially uniform (untargeted) implementation.
- The phased TMDL approach is expressly designed to account for uncertainties in the measurement of fecal coliform concentrations in streams throughout the sub-watershed, in current knowledge regarding sources, and the effectiveness of strategies to reduce specific sources. The phased TMDL approach provides built-in opportunities to revise source-reduction estimates over time, based on continued monitoring information, reducing the uncertainty that load allocations and waste load allocations will achieve water quality standards.

6.2 Rationale for the Margin of Safety

Methods used to calculate the WLA, a very small part of the allocation, are based on known data (discharge and concentration from wastewater treatment facility). The vast majority of the allocation is thus attributed to the LA for non-point sources, and to a large degree, focused on feedlots and manure application. There is considerable uncertainty about the individual contributions of specific non-point source categories, but there is much less uncertainty about the allocation for non-point sources associated with livestock activities in the TMDL sub-watershed. The uncertainty of the specific performance of individual implementation activities in reducing the fecal coliform delivery to the stream is the chief concern.

The needed reductions called for in this TMDL are based on wet weather fecal coliform loading, i.e., the worst-case scenario. The rate of decay of fecal coliform in surface water is not accounted for in the spreadsheet matrix used in this TMDL. The decay of fecal coliform is accounted for through the estimated delivery potentials assigned to the fecal sources. Therefore, a relatively modest MOS (10%) should be adequately protective and account for uncertainties in the assumptions and data used in this TMDL. Given the reliance on professional judgment inherent in the methodology used in this TMDL a rigorous calculation to determine MOS is not appropriate.

7. Seasonal Variation

Fecal coliform samples and flow measurements were conducted over the spring, summer, and fall months (April-September). The results indicated a wide range of flows and fecal coliform concentrations. The large flows associated with snow melt events in the early spring did not exceed the impaired levels, however. The fall period represented low end of the flow regime, but the fecal coliform concentrations were above the impaired level. The summer period from June and July are the critical periods when fecal coliform levels vastly exceed the level of impairment. Furthermore, the exceedences are limited to storm event periods. This is also the peak season of cattle grazing and agriculture. The manure soil applications are finished by summer and the soil is presumably at peak seasonal load of fecal coliform and is most sensitive to rainfall driven transport mechanisms.

It is uncertain how long fecal coliform exist in the soil conditions, but if their survival is significant, it is reasonable to assume the bacteria counts are at their highest during the period following application. The critical period will be the summer rain events and the effectiveness of the controls implemented.

The variability of stream fecal coliform concentrations and flows are shown in Table 7.1 below for each of the three seasons.

Table 7.1: Seasonal Variation of Fecal Coliform and Flows

month	Ave MGD	Geomean
April-May	172	75
June-Aug	135	364
Sept	99	85

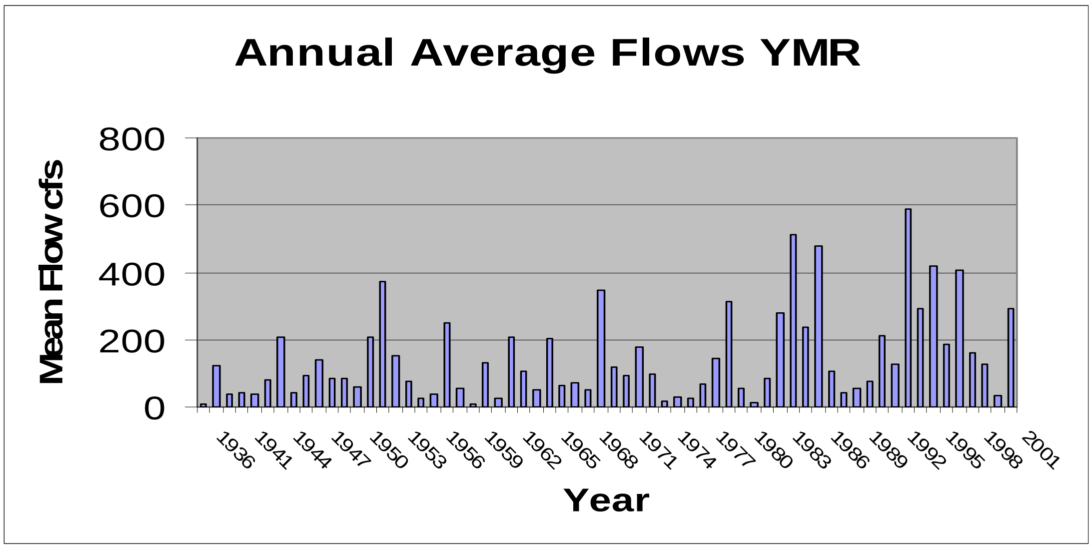
The water quality standard (WQS) applies to the seasonal period April thru October of each year. The loads and allocations that were developed in the South Branch

TMDL were developed for wet/dry conditions, and address all open water season conditions as well.

Inter-Year Variation

The inter-year variability in flows is depicted by the USGS historical data at the mouth of the Yellow Medicine River (Figure 7.1). The flows for 2001 are in the 87th percentile of the 66 year record, and the flows for 1999 are well above the average flow for the period.

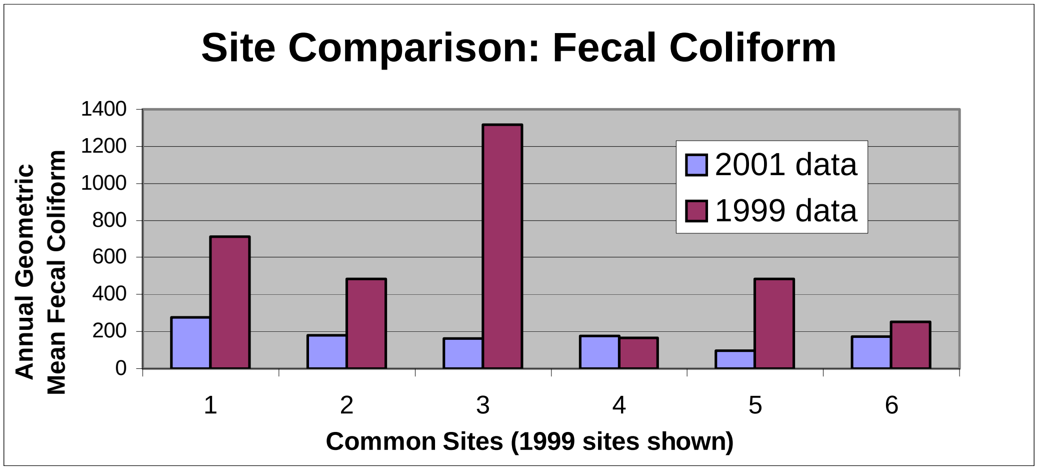
Figure7.1: Annual Average Flows at the mouth of the Yellow Medicine River



Sites 1-6 of the 1999 sampling sites were common to both the 1999 and 2001 sampling seasons. Figure 7.2 illustrates the average fecal coliform data for each of the six common sites between the years 1999 and 2001. The fecal coliform concentrations are significantly higher during the 1999 season at the confluence of the sub-watershed (PCA sites 3 &4) and downstream (PCA sites 1& 2). The upstream sites were nearly identical at PCA site 5, and were much lower at PCA site 6 during the 1999 season. TMDL standard exceedences were rare in the spring months of both 1999 and 2001, and nearly all the sites exceeded the TMDL standard during the summer months in both years.

Figure 7.2
Site Comparison: 2001 vs 1999 data

Site YMR	Site PCA	2001 Results	1999 Results
1	1	275	711
5	2	181	485
25	3	164	1317
6	4	175	166
10	5	98	483
20	6	173	254



8. Follow-Up Monitoring Plan

The goals of this monitoring plan are to assess the effectiveness of the Source Reduction Strategies for attaining water quality standards and designated uses. The impaired reaches will remain listed until water quality standards for fecal coliform are met. The approach will be similar to the initial 2001 sampling design using 25 sampling stations. Flow measurements and fecal coliform concentrations will be measured at a frequency that will allow for statistical significance in estimates of implementation performance, as well as subsequent stream concentrations. This level of sampling will give the level of resolution needed to determine the effectiveness of the specific implementation activities, especially high priority. The effectiveness of implementation activities can be assessed on a sub-watershed basis offering a higher level of control and evaluation in implementation. This level of resolution will also help assess the survival of fecal coliform in the streams. The sampling design will also address inter-year variation.

The monitoring effort will commence after two years of significant implementation activities have been installed. The monitoring results will be used to access the effectiveness of the implementation activities installed, and will be the basis for accessing the future implementation requirements needed to reach the water quality goal. Monitoring will resume after each two years of significant implementation until the water quality goal is satisfied.

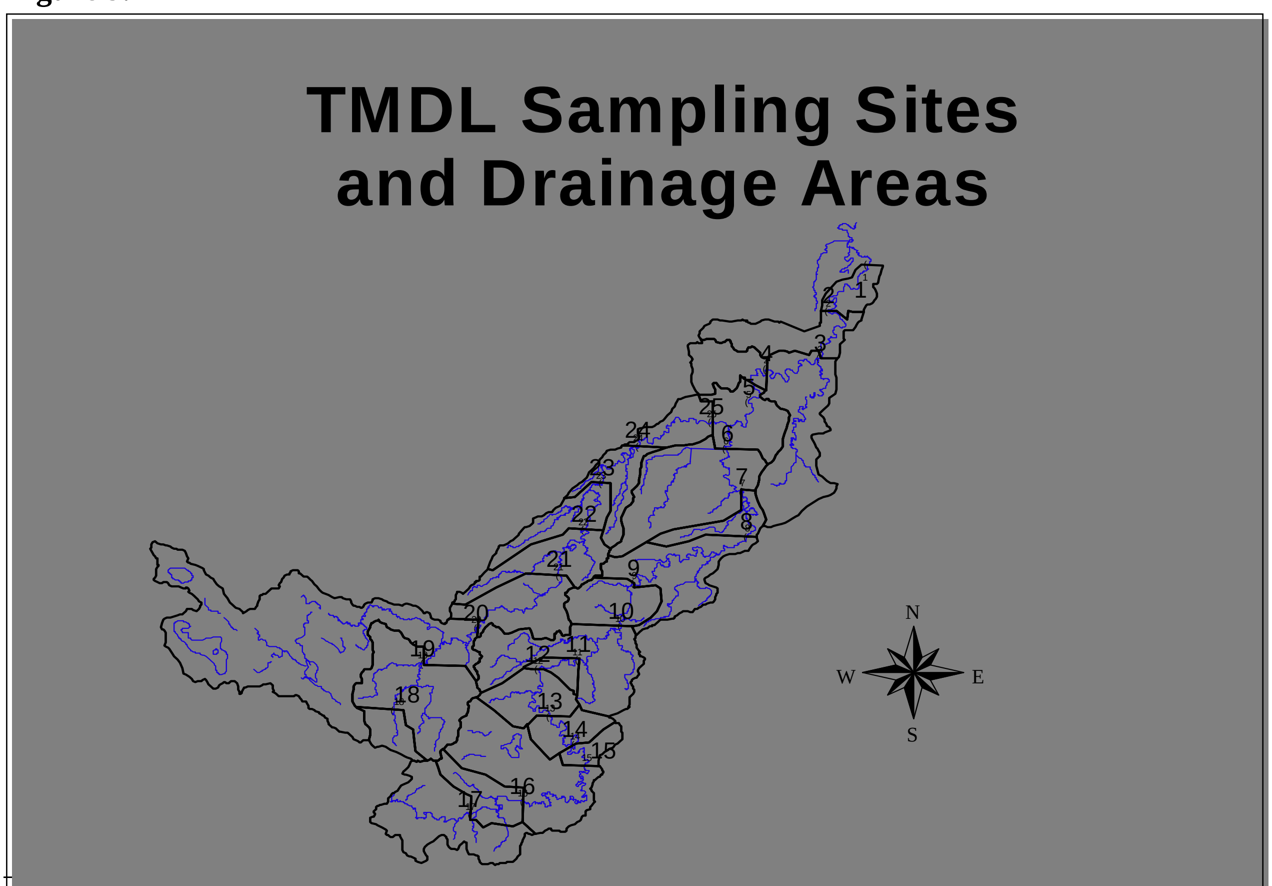
9. Implementation

9.1 Implementation through Source Reduction Strategies

The YMRWD has embraced a watershed-wide goal of achieving water quality standards for fecal coliform bacteria within ten years, the same time frame as the TMDL. The final implementation plan will be developed within a year of the final approval of the TMDL Report by the EPA. It will spell out specifically what and where BMPs will be applied in the sub-watershed, and identify the cost and funding sources for their application. To achieve the water quality goal (WQG) of 180 organisms/100ml, a 78% reduction in fecal coliform loading is required. The TMDL results suggest that it is crucial to get this level of reduction in the areas of animal production and manure handling, including the animal confinement, manure containment, and manure soil application aspects. The Minneota WWTP is optimized and is a very small loading source. The remaining point and non-point sources are minor loading sources and reductions of any extent in these sources will not achieve the WQG. They are sources and will be addressed in the implementation plan; however, the main focus will be on the major sources.

The strategy of the sampling design was to divide the study area into sub-watersheds (Figure 9.1) in an attempt to determine the locations of large discharges of water and pollutants, and prioritize the sub-watersheds. The South Branch sub-watershed becomes

Figure 9.1



thirty sub-watersheds ranging in drainage areas from 150 acres to nearly 7,000 acres, but the average is about 1,400 acres with a standard deviation of about 1,300 acres.

Manure production estimates of nitrogen and phosphorus were generated for feedlots, septic systems, and municipal discharges and compared to the downstream site loads in an effort to account for all mass sources of bacteria, phosphorus, and ammonia nitrogen. Data interpretations were used to identify contamination sources within the sub-watershed and estimate specific contributions to the total mass measured at each site. A prioritized list of sources has been developed and is the basis for the implementation plan.

The intent of the diagnostic, feasibility, and implementation is:

1) Assess the magnitude of each pollution source.
2) Design realistic control measures.
3) Prognosticate the net effect on the river water quality

However the mass-balance approach is somewhat limited in a TMDL project due to the concentration standard. The initial phase of implementation will focus on the larger contributing sub-watersheds, but each impaired sub-watershed (nearly all) will need to be examined individually, and a specific fecal coliform reduction strategy employed. All point and non-point fecal coliform source assessment completed in this report has been detailed for each sub watershed using GIS delineation methods. This will allow for the analysis of source contributions on an individual sub-watershed basis.

9.2 Locally Targeted Implementation

The goals of any water quality project should be based on practical considerations. Two important considerations are the potential for improvement for the specific sub-watershed and how feasible the implementation is. An agricultural landscape is never going to be as pristine as its former pre-settled state, and realistic goals should reflect the constraints of the local economy and subsequent land use practices. The implementation controls have to be contiguous with the local culture, in that a great degree of local “buy in” is necessary for the general success of the project.

The project staff, partners, and technical committee feel the goals are realistic and obtainable, and that the initial success of the implementation plan is crucial to the long term management of the water quality. The availability of programs, funding, local technical expertise and experience, and public acceptance are considered optimal with the project goals and strategies. Incentives were considered by the group to stimulate public interest in the plan and create the initial momentum for the project.

Informational brochures have been sent to all area land owners within the target sub-watershed introducing the project and objectives in the spring of 2001. Based on the results of the data analysis, specific correspondence was made with targeted land owners that are suspected loading contributors. These land owners were selected based on the data results, feedlot and septic surveys, production rates, application rates, and geographical features that promote the discharge of fecal material to the river. This correspondence will be the basis for a successful implementation plan that will require a cooperative effort from the affected parties. A partnership will be formed with the YMRWD office, land owners, and the technical committee that will review implementation scenarios and available funding for project suitability. Following the final TMDL report, several meetings with the “stakeholders” will be conducted presenting the draft implementation plan for public comment and input. The final implementation plan will be modified by the input and approval of the stakeholders.

Implementation strategies under consideration for fecal coliform control include terraces, grass waterways, sediment control, CREP/ CRP, sewer systems, tillage practices, buffer strips, filter strips, replace open intakes with blind intakes, nutrient and pest management, the EQIP program, French intakes, crop residue, riverbank restoration, wetland restoration, and feedlot control methods.

<u>Manure Management Planning Soil Application</u>

This source is considered to be the vast majority of the loading to the river and will subsequently require the most attention. The YMRWD has an agronomist on staff as part of the Phase II CWP implementation plan. This staff person is used to access the fertility of soils and recommend application rates. The MN P index[14] can be used to guide phosphorus applications. The P index gives a relative risk of P loss to surface waters. Operations located in P impaired waters areas can use the P index in attempts to lower the risk of loss. The MN P index takes into account erosion, soil test P, runoff, snowmelt, and other factors. The factors are put into an equation and results in a number that can be evaluated and then management practices put in to lower the number. The relationship between soluble phosphorus and fecal coliform was studied during the South Branch TMDL diagnostic. A fair correlation was found when predicting fecal coliform concentrations using soluble phosphorus as an independent variable (see Part II Diagnostic Report).

[14] Minnesota Phosphorus Site Risk Index, A Final Report to The Minnesota Environmental Quality Board
Generic Environmental Impact Statement, June 30, 2002. Department of Soil, Water, and Climate, University of Minnesota.

<u>Manure Management Planning and Feedlot Management</u>

New feedlot rules require that manure management plans be developed for any feedlots that need a permit. These include the following categories of feedlots:

- Those with more than 300 animal units that are planning new construction or expansion;
- There is a pollution hazard that has not been corrected through the Open Lot Agreement;
- Feedlot has been designated as a CAFO (>1000 animal units or direct man-made conveyance to waters);
- Feedlot has more than 300 animal units and is applying manure in sensitive areas; or
- slopes exceeding 6 percent grade within 300 feet of waters.

Funding to support technical assistance and to provide produce incentives will be sought to maximize produce adoption of manure management plans. Buffer strips, immediate incorporation, and maintenance of surface residue have been demonstrated to reduce manure and pathogen runoff (Environmental Quality Board, General Environmental Impact Statement for Feedlots). The new state feedlots rules (Minn. R. ch. 7020) require manure application record-keeping and manure management planning, with the exact requirements differing according to size of operation and pollution risk of application, based on method, time and place of application.

<u>Feedlot Runoff Reduction:.</u>

All feedlots will be brought into compliance. For feedlots of 300 animal units or less the rule consists mainly of maximizing participation in the new Open Lot Agreement. This feature of the state feedlot rules provides a framework for eligible producers to phase into compliance by October 2005, achieve a 50 percent reduction and achieve full compliance with runoff rules by October 2010.

<u>Stream Buffer Initiative:</u>

This is considered to be the best alternative for controlling the bacterial runoff to the streams. The diagnostic study has shown that rainfall events drive stream fecal coliform levels to exceedence levels at 24 of 25 sites. Through the use of programs such as CREP and CRP, coupled with incentives, the YMRWD intends to implement stream buffers throughout the TMDL sub-watershed.

<u>Drain Tile Initiative:</u>

Drain tiles with surface intakes are considered a significant fecal coliform delivery mechanism. Funding programs coupled with YMRWD incentives will be used to convert surface drain tiles that drain directly to streams and tributaries to sub surface drain systems.

Accelerated Adoption of Rotational Grazing:
Sovell, et al. (2000) demonstrated that rotational grazing, in contrast to conventional grazing, significantly reduces both sedimentation and fecal coliform concentrations in water downstream of study sites in southeastern Minnesota.

Conservation Tillage Strategy:
Conservation tillage and riparian buffer strips have been demonstrated to be effective in reducing sediment delivery to streams. Since embedded sediment can serve as a substrate for fecal coliform survival, reduction of sediment sources is considered an effective measure for controlling fecal coliform bacteria in streams.

Urban Storm Water:
Practices such as runoff detention, infiltration, and street sweeping have been shown to be effective in reducing urban runoff and associated pollutants. Minneota is the single urban source of fecal coliform to the river and is considered a minor source.

Municipal Wastewater Treatment:
The single municipal source, the Minneota WWTP, is optimized. Municipal Wastewater Disinfection with chlorine or ultraviolet radiation is required of all NPDES permitted facilities.

Residential Wastewater Treatment
Individual Sewage Treatment Systems – ISTS with proper drain fields provide virtually complete treatment of fecal coliform bacteria, acceptable designs are described in Minn. R. ch. 7020. The two counties in the South Branch sub-watershed, Lincoln and Lyon Counties, are delegated to implement these rules, which require conformance with state standards for new construction and disclosure of the state of the ISTS when property transfers ownership.

The incentives adopted from the current Greater Yellow Medicine River CWP include:

(1) CREP/CRP 1st year concentrate on 1 mile corridor tributaries and main stream
2nd year concentrate on 2 mile corridor tributaries and main stream
CREP Incentive additional $100.00 per acre if permanent, 50.00 per acre if limited, Continuous CRP Incentive additional $50.00 per acre,

(2) Sewer/ Septic systems: ISTS loans at low interest; can finance through property taxes,

(3) Minimum Tillage- $14.00 acre (Ridge/no-till),

(4) Buffer Strips through CRP to allow landowner to harvest hay crop

(5) Filter Strip around intakes (CRP) plus $100/acre incentive

(6) Replace Open intakes with Blind Intakes 50%

(7) Nutrient and Pest Management $14.00 or if EQIP $7.00 plus $7.00/acre CWP Incentive maximum acreage per landowner.

10. Reasonable Assurance

10.1 Evidence of BMP Implementability

The source-reduction strategies listed above have been shown to be efficacious in reducing pathogen transport and survival, and to be capable of widespread adoption by land owners and local resource managers.

- Feedlot runoff controls – these are evaluated by professional engineers through the Feedlot Evaluation Model referenced in Minn. R. ch. 7080. These rules are implemented by the MPCA staff and by local staff of counties via a delegation agreement with the Agency. Lincoln County is a designated feedlot county; Lyon County is not.
- Individual Sewage Treatment Systems – ISTS with proper drain fields provide virtually complete treatment of fecal coliform bacteria. Acceptable designs are described in Minn. R. ch. 7020. All counties in the watershed are delegated to implement these rules, which require conformance with state standards for new construction and disclosure of the state of the ISTS when property transfers ownership.
- Municipal Wastewater Disinfection – Disinfection with chlorine or ultraviolet radiation is required of all NPDES permits.
- Land Application of Manure – Buffer strips, immediate incorporation, and maintenance of surface residue have been demonstrated to reduce manure and pathogen runoff (Environmental Quality Board, Ceneral Environmental Impact Statement for Feedlots). The new state feedlots rules (Minn. R. ch. 7080) require manure application record-keeping and manure management planning, with the exact requirements differing according to size of operation and pollution risk of application, based on method, time and place of application.
- Erosion Control and Sediment Reduction – Conservation tillage and riparian buffer strips have been demonstrated to be effective in reducing sediment delivery to streams. Since embedded sediment can serve as a substrate for fecal coliform survival, reduction of sediment sources is considered an effective measure for controlling fecal coliform bacteria in streams.
- Planned Rotational Grazing: Sovell, et al. 2000, demonstrated that rotational grazing, in contrast to conventional grazing, significantly reduces both sedimentation and fecal coliform concentrations in water downstream of study sites in southeastern Minnesota.

- Urban Stormwater Management: Practices such as runoff detention, infiltration, and street sweeping have been shown to be effective in reducing urban runoff and associated pollutants. Minneota is the single urban source of fecal coliform to the river and is considered a minor source.

10.2 Non-Regulatory, Regulatory, and Incentive-Based Approaches

The leadership of the Implementation will be sponsored by the Yellow Medicine River Watershed District Managers. They will have the responsibility to direct the staff consisting of Project Manager and Project Technician. This will be accomplished informally with daily interaction with the project elements and formally with monthly Watershed District Board meetings to keep current on the progress. They will also conduct quarterly meetings with the Project Partners, which will consist of representatives from the three Soil and Water Conservation Districts, Water Planners, Natural Conservation Service, Board of Soil and Water Resources Department of Natural Resources, and the Minnesota Pollution Control Agency. The Project Partners will advise the Managers on technical matters and priorities concerning implementation progress.

The YMRWD successfully completed the Lake Shaokatan CWP Diagnostic and Implementation phases in 1991-96, and is currently implementing a Phase II Clean Water Partnership program in the Yellow Medicine River watershed. These programs have successfully implemented watershed based nutrient control measures, and the intent is to use a similar approach in the South Branch TMDL sub watershed.

11. Public Participation

Public participation has been the hallmark of the South Branch TMDL from the beginning. The YMRWD conducted two public meetings, June 24 and October 24, 2003 respectively, following the diagnostic phase of the TMDL. Invitations to the meeting, in the form of a brochure explaining the TMDL process, were mailed to the residents within the TMDL sub-watershed.

The draft TMDL report is available to the public via the MPCA web site at http://www.pca.mn.us/water/tmdl.html. A public meeting was held 1-3 p.m., Wednesday, July 28, 2004 at the Minnesota Pollution Control Agency Southwest Regional Office, Marshall. A public notice was posted in the State Register and the public comment period extended from July 6 – August 6, 2004. No written comments were received during this period.

A feedlot survey was conducted using the Lincoln and Lyon SWCD staff to complete the survey. Landowners were approach on a one-to-one basis to obtain the feedlot data. Throughout the current Phase II CWP implementation plan, landowners have been involved in planning and implementing nutrient control strategies. The YMRWD has also offered the services of their agronomist in determining optimized fertilizer and manure application rates based on soil fertility analysis and subsequent application plans.

Many local, state, and federal agencies have been involved in the public participation process including, but not limited to the Lincoln and Lyon Soil and Water Conservation Districts, the Lincoln County Environmental Services, the Lincoln and Lyon County Boards, the MN Department of Natural Resources, the MN Board of Soil and Water Resources, the MN Pollution Control Agency, the US Natural Resources Conservation Service, the MN Fish and Wildlife Service, and the Yellow Medicine River Watershed District. These agencies, in cooperation with the local residents, landowners, and farm operators, have contributed to the understanding of the political, economic, and natural resource aspects of the TMDL and the ultimate implementation plan.

12. References

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Appendix: South Branch Yellow Medicine River Fecal Coliform Total Maximum Daily Load Report

12. Appendix

Appendix 1: Fecal Coliform Database 1987-1999.

YELLOW MEDICINE WATERSHED FECAL TMDL											
Station Name	Station ID										
S BR YELLOW MEDICINE R AT CSAH-10, AT MINNEOTA	*S001-156*										
Sample Date	Sample Type	BOD5	Chlorophyll A µ g/l	DO mg/L	Kjeldahl Nitrogen mg/L	N03 & No2, Total mg/L	Pheophytin-A (H2O) µ g/l	Phosphorus mg/L	Suspended Solids mg/L	Temperature degrees C	Fecal Coliforn #/100ml
29-Sep-99	*RS/O*										*24*
27-Sep-99	*FR/D*										*54*
27-Sep-99	*RS/O*										*140*
23-Sep-99	*RS/O*										*330*
20-Sep-99	*RS/O*										*1300*
7-Sep-99	*RS/O*										*540*
31-Aug-99	*RS/O*										*3000*
24-Aug-99	*RS/O*										*1200*
10-Aug-99	*RS/O*										*1100*
20-Jul-99	*RS/O*										*740*
13-Jul-99	*FR/D*										*620*
13-Jul-99	*RS/O*										*390*
6-Jul-99	*RS/O*										*1100*
29-Jun-99	*RS/O*										*1100*
22-Jun-99	*RS/O*										*1200*
15-Jun-99	*RS/O*										*460*
8-Jun-99	*RS/O*										*9000*
1-Jun-99	*RS/O*										*260*
27-May-99	*RS/O*										*460*
17-May-99	*RS/O*										*350*
11-May-99	*RS/O*										*130*
4-May-99	*RS/O*										*20*
28-Jul-98	*RS/O*	*1.3*	*13.8*		*0.58*		*3.34*	*0.072*	*22*		*350*
21-Jul-98	*RS/O*										*2700*
14-Jul-98	*RS/O*	*1.1*	*5.83*				*1.53*	*0.065*	*18*		*820*
7-Jul-98	*RS/O*										*600*
30-Jun-98	*RS/O*										*400*
23-Jun-98	*RS/O*										*390*
16-Jun-98	*RS/O*										*1000*
8-Jun-98	*RS/O*										*390*
2-Jun-98	*RS/O*										*530*
28-May-98	*RS/O*										*440*
26-May-98	*RS/O*										*440*
19-May-98	*RS/O*										*410*
12-May-98	*RS/O*										*310*

Appendix 1: Fecal Coliform Database 1987-1999 (continued)

YELLOW MEDICINE WATERSHED FECAL TMDL											
Station Name	Station ID										
S BR YELLOW MEDICINE R AT CSAH-10, AT MINNEOTA	*S001-156*										
Sample Date	Sample Type	BOD5	Chlorophyll A µ g/l	DO mg/L	Kjeldahl Nitrogen mg/L	N03 & No2, Total mg/L	Pheophytin-A (H2O) µ g/l	Phosphorus mg/L	Suspended Solids mg/L	Temperature degrees C	Fecal Coliforn #/100ml
5-May-98	*RS/O*										*300*
30-Sep-97	*RS/O*										*290*
24-Sep-97	*RS/O*									*14*	*260*
17-Sep-97	*RS/O*										*300*
9-Sep-97	*RS/O*										*460*
3-Sep-97	*RS/O*										*820*
27-Aug-97	*RS/O*										*540*
20-Aug-97	*RS/O*										*1500*
13-Aug-97	*RS/O*										*380*
4-Aug-97	*RS/O*									*24.5*	*1600*
22-Jul-97	*RS/O*									*24*	*700*
19-Sep-94	*RS/O*	*1.2*		*8.5*	*0.56*	*0.86*		*0.044*	*6.8*	*18*	*370*
31-Aug-94	*RS/O*	*1.2*		*8.9*	*0.58*	*0.79*		*0.064*	*11*	*17.5*	*470*
12-Jul-94	*RS/O*	*2.3*		*7.1*	*1.09*	*1.7*		*0.164*	*60*	*20.5*	*740*
27-Jun-94	*RS/O*	*2.7*		*7.8*	*1.98*	*2*		*0.296*	*170*	*22*	*900*
22-May-94	*RS/O*	*2.7*		*7.8*	*0.79*	*1.6*		*0.057*	*32*	*22*	*72*
2-May-94	*RS/O*	*2.5*		*10*	*1.4*	*3.1*		*0.158*	*130*	*11.5*	*480*
7-Mar-94	*RS/O*	*4.7*		*13*	*1.92*	*2*		*0.264*	*86*	*0*	*72*
3-Jan-94	*RS/O*	*0.9*		*12*	*0.78*	*1.9*		*0.03*	*4.2*	*0*	*44*
26-Oct-93	*RS/O*	*1.8*		*11*	*0.72*	*2.4*		*0.029*	*2.6*	*7.5*	*110*
27-Sep-93	*RS/O*	*1.9*		*10*	*1.08*	*2.7*		*0.125*	*41*	*11*	*310*
16-Aug-93	*RS/O*	*3.2*		*7*	*2.38*	*1*		*0.544*	*280*	*23.5*	*3000*
30-Jul-93	*RS/O*	*2.9*			*2*	*2.6*		*0.196*	*85*	*21*	*1000*
28-Jun-93	*RS/O*	*2.3*		*7.9*	*1.72*	*2.5*		*0.292*	*48*	*19.5*	*450*
12-May-93	*RS/O*	*2.7*		*8.4*	*1.99*	*2.2*		*0.308*	*140*	*16*	*180*
7-Apr-93	*RS/O*	*2.9*		*11*	*1.59*	*3.2*		*0.173*	*110*	*5*	*84*
8-Mar-93	*RS/O*	*11*		*12*	*1.47*	*1.9*		*0.348*	*76*	*0*	*1500*
18-Jan-93	*RS/O*	*3.1*		*12*	*1.62*	*1.7*		*0.121*	*71*	*0*	*18*
12-Oct-92	*RS/O*	*0.8*		*9.4*	*0.73*	*0.4*		*0.042*	*8.2*	*10.5*	*72*
14-Sep-92	*RS/O*	*1.4*		*8.8*	*1.09*	*0.4*		*0.045*	*7*	*19.5*	*120*
24-Aug-92	*RS/O*	*2.2*		*7.7*	*1.2*	*0.38*		*0.104*	*25*	*18*	*3400*
27-Jul-92	*RS/O*	*2.6*		*8*	*1.35 Q*	*3.2*		*.184 Q*	*63*	*21*	*1000*
1-Jul-92	*RS/O*	*2.5*		*8*	*1.77*	*2*		*.191 Q*	*110*	*19.5*	*1000*
20-May-92	*RS/O*	*1.7*		*8.3*	*0.54*	*1.1*		*0.157*	*25*	*22*	*200*
13-Apr-92	*RS/O*	*1.7*		*14*	*0.81*	*2.3*		*0.046*	*3.8*	*3.5*	*32*

Appendix 1: Fecal Coliform Database 1987-1999 (continued)

YELLOW MEDICINE WATERSHED FECAL TMDL											
Station Name	Station ID										
S BR YELLOW MEDICINE R AT CSAH-10, AT MINNEOTA	*S001-156*										
Sample Date	Sample Type	BOD5	Chlorophyll A µ g/l	DO mg/L	Kjeldahl Nitrogen mg/L	N03 & No2, Total mg/L	Pheophytin-A (H2O) µ g/l	Phosphorus mg/L	Suspended Solids mg/L	Temperature degrees C	Fecal Coliforn #/100ml
30-Mar-92	*RS/O*	*1*		*13*	*0.73*	*2.8*		*0.107*	*12*	*8*	*< 4*
6-Jan-92	*RS/O*	*1.1*		*13*	*0.59*	*1*		*< .01*	*3.6*	*0*	*32*
8-Oct-91	*RS/O*	*2.3*		*9.1*	*0.48*	*0.15*		*0.046*	*3*	*12*	*18*
24-Sep-91	*RS/O*	*2.7*		*11*	*0.51*	*0.26*		*0.069*	*6.4*	*11.5*	*540*
12-Aug-91	*RS/O*	*1.8*		*8.3*	*0.99*	*2.3*		*0.038*	*22*	*22*	*570*
23-Jul-91	*RS/O*	*2.8*		*9.4*	*1.63*	*0.72*		*0.097*	*25*	*22.5*	*570*
10-Jun-91	*RS/O*	*2.6*		*6.6*	*1.86*	*2.9*		*0.325*	*150*	*21.5*	*1100*
21-May-91	*RS/O*	*1.3*		*8.1*	*1.07*	*1.7*		*0.1*	*32*	*20*	*190*
8-Apr-91	*RS/O*	*3.4*		*12*	*0.81*	*0.02*		*0.08*	*9.6*	*10*	*4*
25-Mar-91	*RS/O*	*3.4*		*15*	*0.85*	*0.49*		*< .01*	*5.8*	*0*	*44*
14-Jan-91	*RS/O*	*5.1*		*4.9*	*3.63*	*0.19*		*0.57*	*350*	*0*	*54*
22-Oct-90	*RS/O*	*2.4*		*9*	*0.31*	*< .01*		*0.083*	*2*	*7*	*< 4*
3-Aug-89	*RS/O*	*4.3*		*5.6*	*1.02*	*< .01*		*0.144*	*23*	*28*	*48*
7-Jun-89	*RS/O*	*2.2*		*9.7*	*1.33*	*0.01*		*0.317*	*77*	*24*	*36*
3-May-89	*RS/O*	*0.5*		*12*	*0.49*	*< .01*		*0.033*	*3.8*	*12*	*28*
5-Apr-89	*RS/O*	*1.4*		*11*	*0.89*	*1*		*0.099*	*11*	*6*	*24*
8-Mar-89	*RS/O*	*4.1*		*14*	*3.19*	*0.54*		*0.748*	*270*	*0*	*9*
6-Jul-88	*RS/O*	*3.7*		*7.7*	*1.28*	*0.02*		*0.161*	*34*	*32*	*120*
9-Jun-88	*RS/O*	*1.8*		*6.7*	*1*	*0.39*		*0.153*	*51*	*18*	*720*
26-May-88	*RS/O*	*2*		*7.4*	*1.13*	*0.58*		*0.122*	*52*	*19*	*150*
6-Apr-88	*RS/O*	*0.9*		*11*	*0.85*	*1.2*		*0.117*	*28*	*9*	*8*
10-Mar-88	*RS/O*	*1.4*		*11*	*1.01*	*1.8*		*0.139*	*4.6*	*1*	*72*
7-Jan-88	*RS/O*	*1.2*		*7.8*	*0.71*	*0.46*		*0.068*	*22*	*0*	*12*
7-Oct-87	*RS/O*	*3.4*		*6.5*	*0.59*	*< .01*		*0.1*	*6.8*	*10*	*44*
RS/O = Routine Sampling/Observation											
FR/D = Field Replicate/Duplicate											

Appendix 2: Feedlot Survey Database

Dairy	Beef	Swine	Sheep	Foul	Horses	UNIQUE_ID
50	24	100	0	350	1	53
200	70	454	0	654	0	65
0	0	0	0	0	0	52
0	95	0	0	0	0	66
0	0	0	0	0	0	54
19	41	0	0	19	0	35
41	50	0	0	41	0	49
84	20	0	0	334	0	43
0	0	0	0	380	0	61
0	60	0	0	0	0	56
0	30	0	0	0	0	62
0	43	0	145	145	0	38
0	25	0	0	0	0	46
15	160	0	0	15	0	58
0	75	0	0	0	0	47
0	30	0	0	0	0	45
0	92	0	0	0	0	36
30	0	322	0	352	0	34
0	0	0	0	0	0	87
0	0	1300	0	1300	0	88
0	98	0	0	0	0	78
0	100	0	0	0	0	77
0	0	0	0	0	0	71
30	0	0	0	30	0	72
0	0	0	0	0	0	90
0	20	0	0	0	0	44
0	925	0	0	0	0	67
0	15	0	0	0	0	200
0	0	0	0	0	0	197
0	0	210	0	210	0	211
0	6	90	0	90	0	188
0	4	25	0	25	4	203
0	20	0	150	200	0	201
0	0	0	0	0	0	204
0	525	0	0	0	0	199
0	0	0	0	0	0	202
1	13	0	0	1	0	193
0	0	0	0	0	0	213
0	0	0	0	0	0	189
0	0	0	0	0	6	194
5	98	0	0	5	4	198
0	6	0	0	0	0	186
3	4	0	0	3	8	187
0	0	0	1300	1305	0	205
0	0	0	0	0	0	217
0	0	198	65	263	0	34
0	0	198	65	263	0	206

Appendix 2: Feedlot Survey Database (continued)

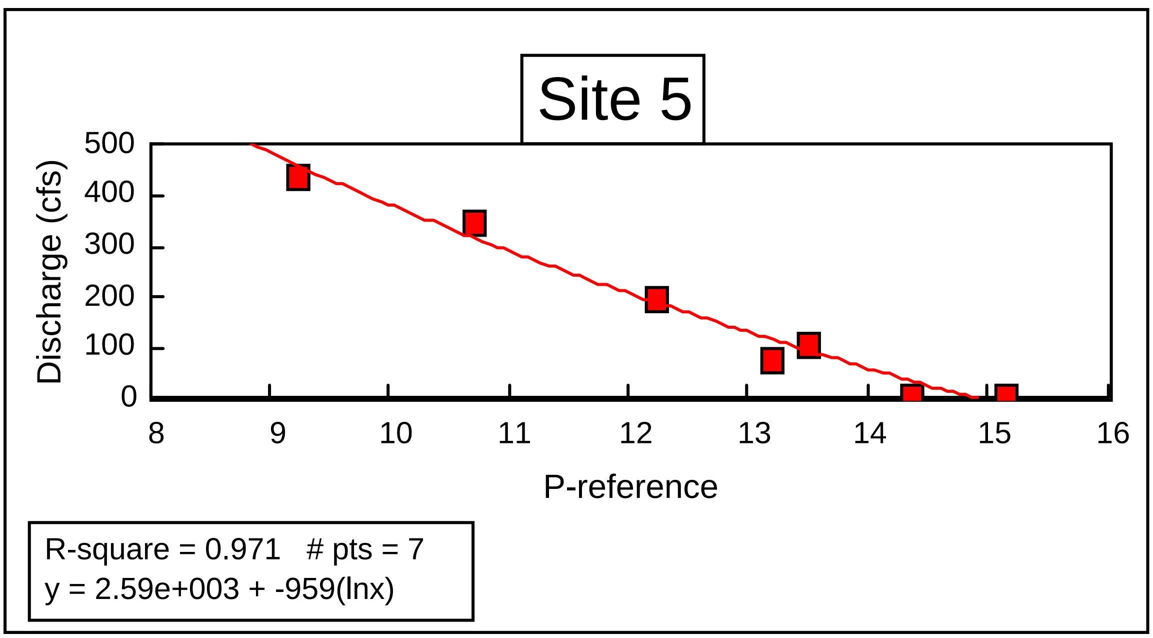
	Dairy	Beef	Swine	Sheep	Foul	Horses	UNIQUE_ID
	5	98	0	0	5	4	196
	0	290	0	0	0	0	190
	0	0	0	0	0	0	210
	0	30	0	0	0	10	245
	0	48	0	0	0	0	247
	0	225	820	0	820	0	321
	0	0	500	150	650	0	324
	0	42	0	0	0	0	301
	0	150	0	0	0	0	322
	0	25	0	100	100	0	347
	50	63	0	0	50	0	387
	20	1	0	0	20	0	380
	0	29	0	0	0	0	133
	80	50	0	0	0	0	100089000
	36	82	0	0	0	0	100152000
	0	0	830	0	0	0	90053000
	0	90	0	0	0	0	90065000
	0	0	0	0	0	0	100101000
	0	0	750	0	0	0	103
	0	55	660	0	0	1	116
	0	33	0	0	0	0	132
	0	0	0	2500	0	0	**100123000**
	0	0	618	0	0	0	130115000
	0	67	0	0	0	0	**130121000**
	0	55	0	0	0	0	90003000
	0	0	0	0	0	0	90051000
	0	0	2112	0	0	0	100052000
	0	170	0	0	0	0	135
	0	160	0	0	0	0	134
	0	60	0	0	0	0	130060000
	0	0	220	0	0	0	100083000
	200	0	0	0	0	0	100111010
	110	30	0	40	0	0	117
	0	36	0	0	0	0	101
	0	0	300	550	0	0	104
	200	20	845	26	0	6	130120000
	0	50	0	0	0	0	90066000
	0	0	0	0	0	0	122
	0	0	154	578	0	0	100133000
	0	0	0	0	0	0	100115000
	0	40	200	0	0	0	100145000
	0	80	0	0	0	0	100094000
	0	120	0	0	0	0	100113000
	0	68	0	0	0	1	130068000
	0	0	1500	0	0	0	100114000
	76	0	0	0	0	0	100149000
Total Animals:	**1255**	**4916**	**12406**	**5669**	**7630**	**45**	
Ave Mass(lbs):	**1400**	**1000**	**140**	**100**	**4**	**1000**	
Animal Units (AU):	**1757**	**4916**	**1737**	**567**	**31**	**45**	

Appendix 3: Discharge and Stream Ratings

The stream ratings for the Yellow Medicine River hydrologic stations were established by the US Geological Survey (sites 2-8) and the Yellow Medicine River Watershed District (sites 9-15). Site 5 represents the final station, or the outflow, of the South Branch TMDL basin; site 1 in the TMDL study.

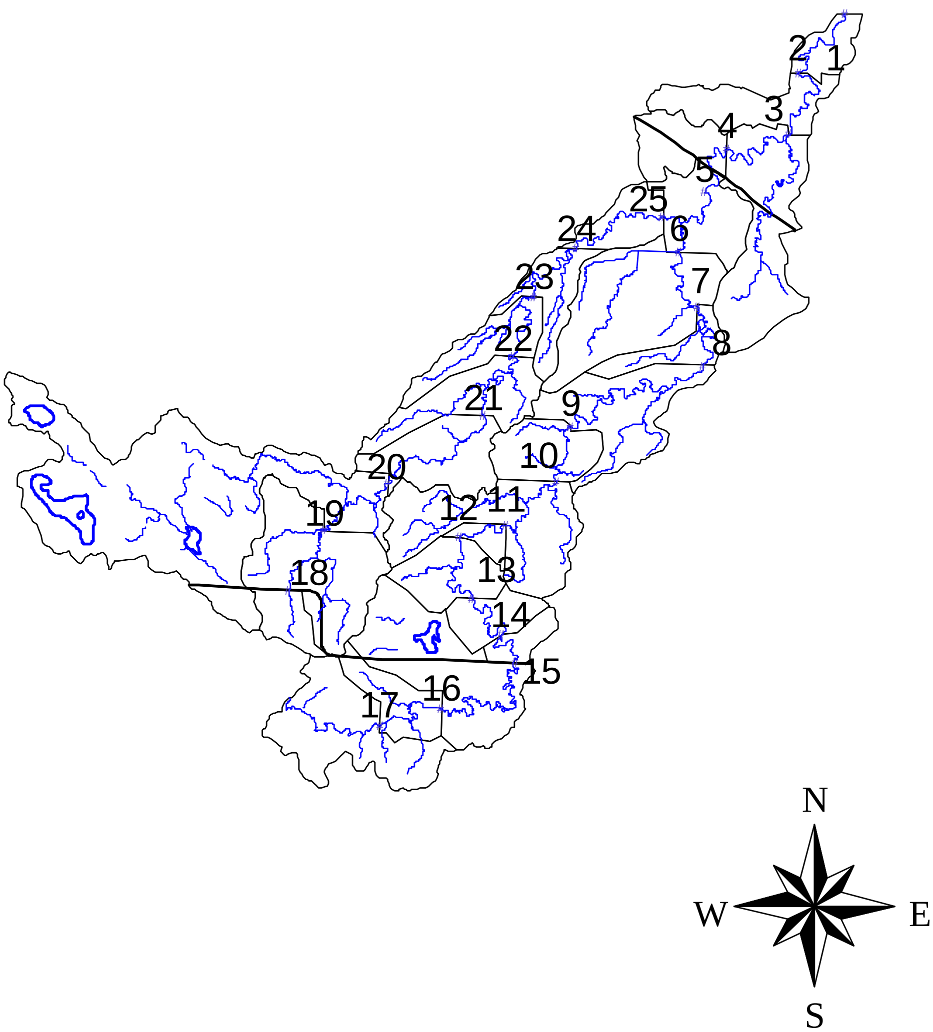
YMRWD Site Ratings

Site	Equation	r2	Type	B.H.	USGS B.H.	Offset	
2	8050-2750lnP	0.977	*logarithmic*	21	24	1.7	Transducer
3	3190-1020lnP	0.992	*logarithmic*	26	26	1.35	Transducer
4	2200-855lnP	0.987	*logarithmic*	16	16	1	Transducer
5	**2590-959lnP**	**0.971**	***logarithmic***	**19**	**20**	**2.7**	**Transducer**
6	934-371lnP	0.993	*logarithmic*	15	15	1.3	Transducer
7	520-268lnP	0.99	*logarithmic*	16	16	4.55	Transducer
8	1110-600lnP	0.994	*logarithmic*	11	11	2.05	Potentiometer
9	1270-642lnP	0.99	*logarithmic*	9	*na*	*na*	Potentiometer
10	4230-1740lnP	0.995	*logarithmic*	13	*na*	*na*	Potentiometer
11	730-311lnP	0.97	*logarithmic*	11	*na*	*na*	Transducer
12	243P^(-1.22)	0.98	*Power*	10	*na*	*na*	Potentiometer
13	48400e(-105P)	0.978	*exponential*	12	*na*	*na*	Potentiometer
15	409-188lnP		*exponential*	10	*na*	*na*	Transducer

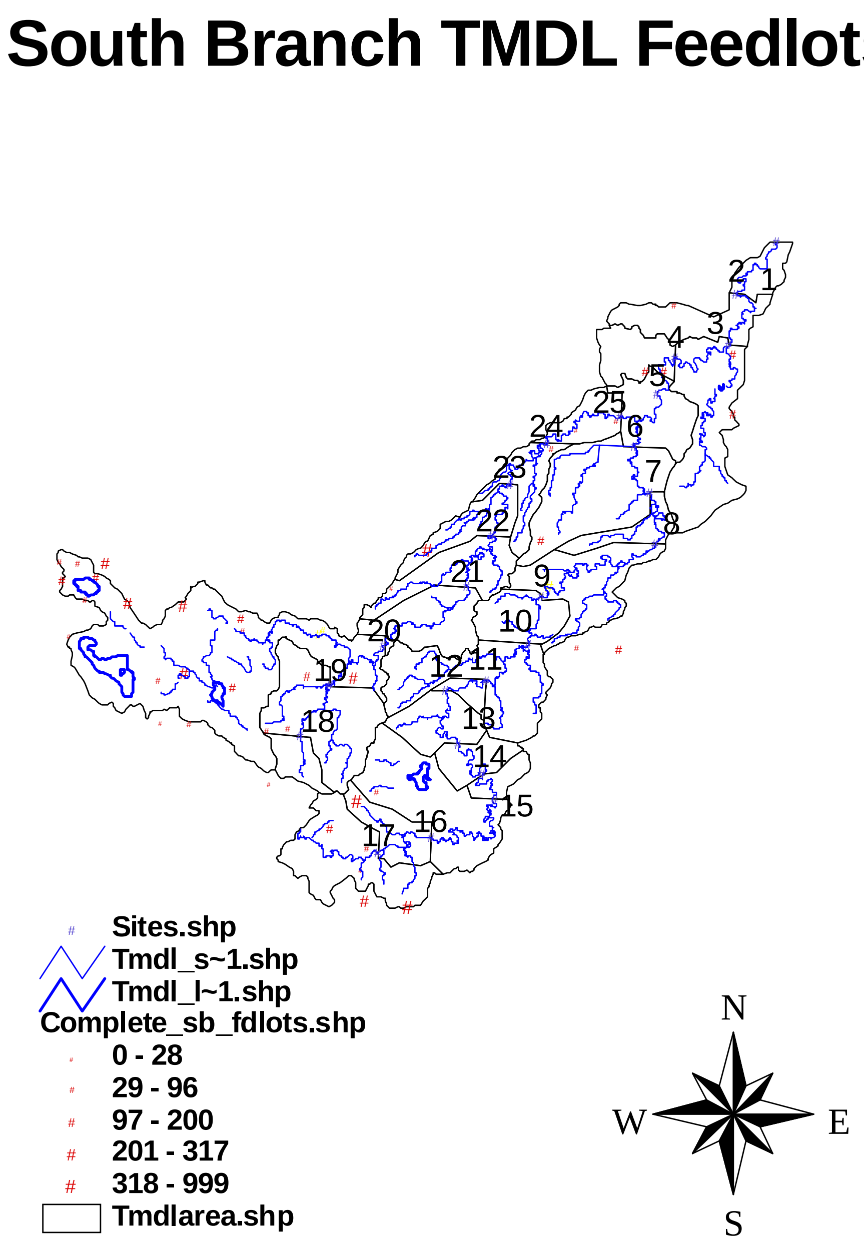


Appendix 4: Map of theSouth Branch TMDL

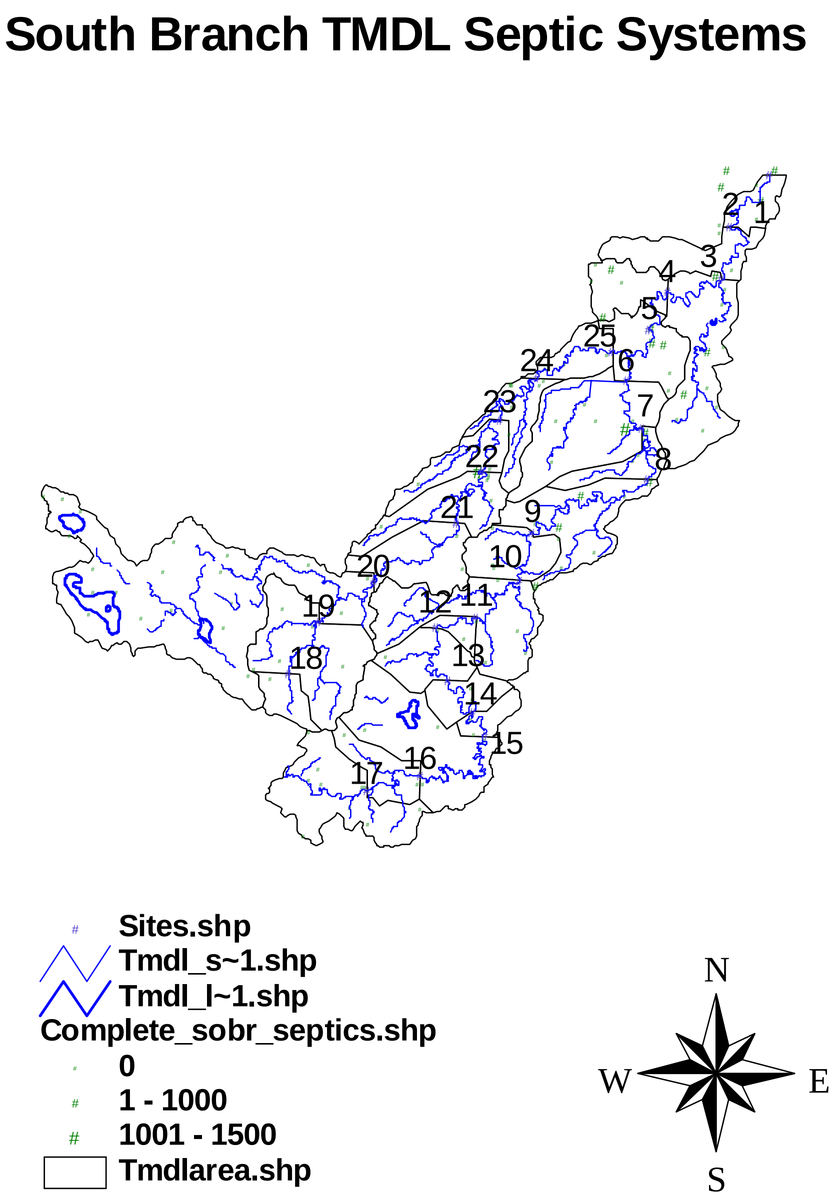
South Branch TMDL Sampling Stations



Appendix 5: Map of the South Branch TMDL Feedlots

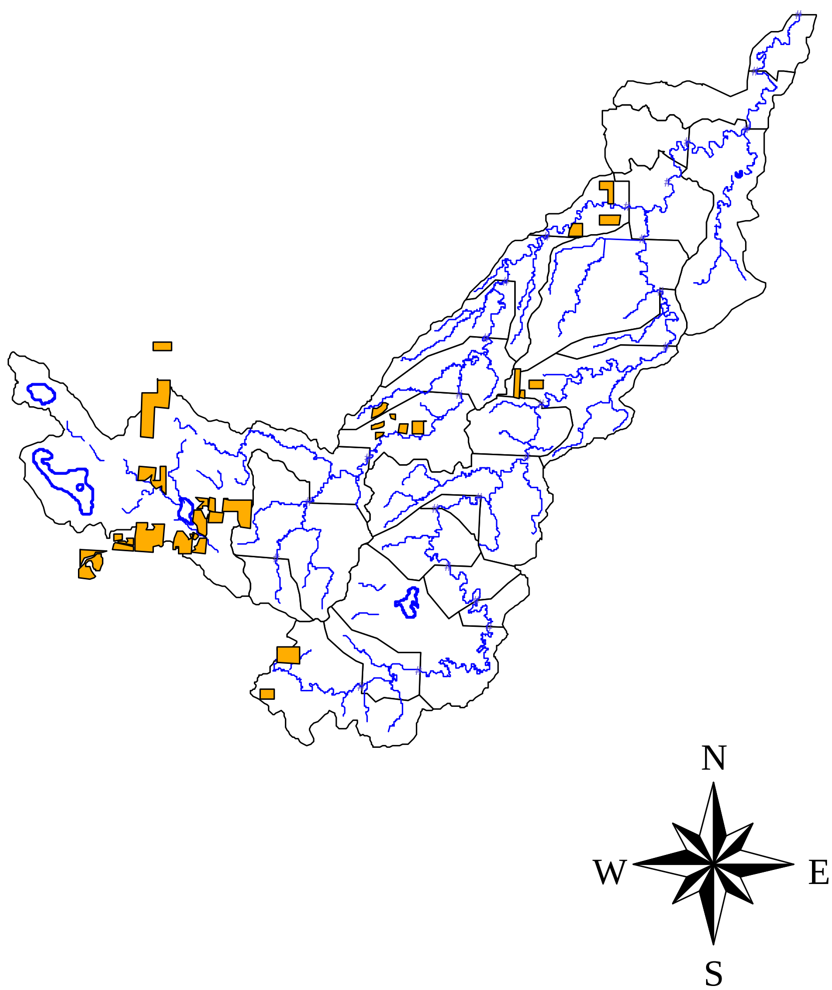


Appendix 6: Map of the South Branch TMDL Septic Systems



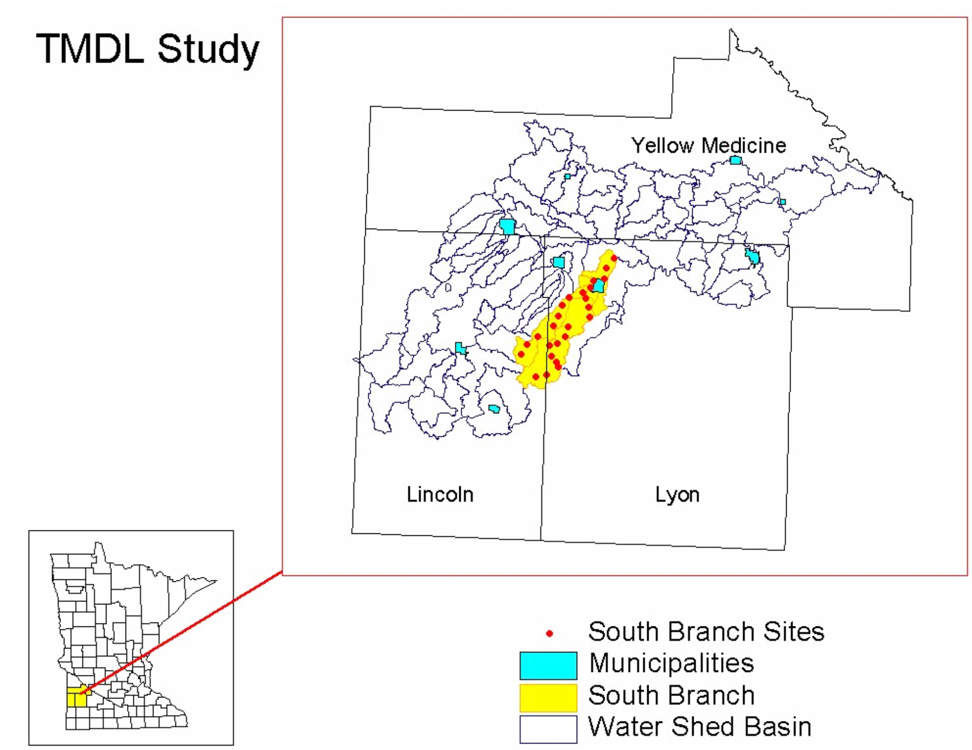
Appcndix 7: Map of the South Branch TMDL Manure Applications (surveyed)

South Branch TMDL Manure Applications (survey results)



Appendix 8: Letter to Feedlot Owners (Manure Application Survey)

The Yellow Medicine River Watershed District (YMRWD) is conducting a study of a section of the South Branch of the Yellow Medicine River roughly stretching from Hwy 19, on the southern border, to the City of Minneota, on the northern border. The study is part of the Environmental Protection Agency's Total Maximum Daily Load program (TMDL) that is administrated by the Minnesota Pollution Control Agency (MPCA). The study is in response to the "Impaired" status of this portion of the river as defined by the MPCA. The intent of the study is to measure the concentrations of Fecal Coliform bacteria within this reach of the river and determine the sources of these bacteria. Fecal Coliform are bacteria associated with the feces of warm blooded animals and pose a health threat to humans.



The TMDL program has **<u>No Regulatory Language</u>** and your participation in the project is purely voluntary. **No regulatory action can or will be used against you as a result of your participation or non participation in this project.** The YMRWD has studied the river section for the past two years and have began public meetings to relay the results of the study. A final report will be submitted to the Pollution Control Agency this fall and an application for implementation funds will follow. The funds will be directed to landowners as incentives for manure handling improvements and protective barriers for the river.

We would like to identify the areas of your land, if any, that has been used for manure application in the past three years. Please identify the areas on the parcel maps provided and return in the self addressed envelope. The data will be used to understand the causes of the river concentrations of Fecal Coliform bacteria. Our intent is to obtain funding and direct these monies to local landowners to make improvements to manure handling processes and provide barriers to river pollution. Any current or future participation by you will be at your complete discretion. However, your input will be valuable to the study and will have a great influence on our ability to obtain implementation funding.

If you have any questions or concerns, please feel free to contact us at 507-872-6720 or ymrw@starpoint.net.

Sincerely,

Appendix 9: Geometric Means for Wet and Dry Conditions

South Branch Yellow Medicine - 1999 and 2001 Fecal TMDL

	Date	Fecal Coliform (cfu/100 mls)																													
	1999 Sites	***1***				***2***	***4***				***5***										***6***					***3***	***7***	***8***	***9***	***10***	***11***
Conditions	**2001 Sites**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
wet	04/12/2001	3400	1100	1500	1800	1100	1000	3600	4100	3500	2700	2100	1600	2300	10	2700	900	1600	30	280	900	400	350	190	240	200					320
wet	04/24/2001	3000	3800	2600	2500	1900	2300	1800	1600	1200	1100	800	600	900	15	800	700	500	10	450	6800	3500	1600	400	800	300					80
wet	05/11/1999	120				130	34				150										32					140	40	56	40	32	990
wet	06/08/1999	52000				9000	3500				9200										2900					27500	1700	710	4200	3400	990
wet	06/29/1999	1450				1100	150				1300										320					800	1000	290	360	190	600
wet	06/13/2001	670		3040	1050	1240	2040	325	810	610	675	255	95	338																	
wet	06/14/2001	530	560	410	290	410	210	230	220	230	720	450	360	4300	205	3700	6000	6600	10	320	330	340	173	490	50	15					
wet	07/20/1999	1200				740	500				1200										340					2600	690		1400	680	
wet	07/20/2001	9900	1177	2880	990	1140	2630	3065	2025	1283	2975	2130	950	906	40	2190	8400	547	9800	12200	5310	8400	4340	1870	7800	10800					
wet	08/31/1999	2500				3000	700				2800										1500					4400	500		910	1300	
wet	09/20/1999	2400				1300	180				640										405					2800	300		200	250	
	Wet Geomean	**794**																													
dry	04/03/2001	10	10	10	10	10	10	10	10	10	10	300	100	100	5	100	200	135		125	230		200	100	135						4
dry	04/17/2001	20	25	10	4	20	5	5	5	5	30	5	5	5	5	6	4	2	2	5	5	10	20	65	45	50					4
dry	05/04/1999	24				20	12				36										8					130	24	4	52	120	80
dry	05/17/1999	150				350	8				120										40					120	150	32	32	56	130
dry	05/27/1999	2100				460	36				120										100					1700	130	300	44	60	180
dry	05/01/2001	40		70	65	25	85	48	10	25	30	25	35	20	10	40	35	45	5	10	20	15	15	90	25	45					600
dry	05/14/2001	90	125	65	55	155	103	55	15	90	23	28	20	20	35	65	30	15	5	5	15	20	40	40	130	240					
dry	05/29/2001	98	140	220	109	200	116	88	74	16	4	16	20	20	123	36	89	121	2	74	2	40	126	51	530	205					305
dry	06/01/1999	200				260	68				200										110					310	130	260	960	370	80
dry	06/15/1999	730				460	350				640										280					910	420	73	270	67	130
dry	06/22/1999	860				1200	200				1300										440					940	840	220	300	180	180
dry	06/11/2001	450	380	460	410	370	280	230	220	360	230	210	80	170	100	530	188	370	18	103	730	175	153	140	570	380					
dry	06/25/2001	430	370	310	570	530	300	243	313	75	65	10	15	35	15	203	405	175	4300	123	10	90	55	158	123	201					
dry	07/06/1999	1200				1100	100				1200										450					1100	760		680	210	
dry	07/13/1999	560				505	300				660										180					600	350		270	300	
dry	07/09/2001	193	143	120	45	128	85	20	25	25	5	25	5	10	1700	65	40	75			1400	80	75	10	80	30					
dry	07/23/2001	3000		2600	3600	3000	3400	3100	3900	1760	1840	1480	1280	1000	5	860	1240	1440	890	840	230	250	400	430	640	780					
dry	08/03/1999	960				490	640				1200										490					1300	150		240	2310	
dry	08/10/1999	3000				1100	900				740										1050					3200	280		275		
dry	08/24/1999	220				1200	310				305										460					6000	27		76	180	
dry	08/06/2001	860	338	155	100	253	425	215	55	50	180	20	28	20	1257	140	65	175			330	80	30	120	170	820					
dry	08/20/2001	130	138	90	90	48	80	63	80	10	30	15	5	5	1000	60	35	25			430	115	30			123					
dry	09/07/1999	350				540	250				420										500					330	160		340	230	
dry	09/23/1999	405				330	78				140										160					18000	130		24	310	
dry	09/27/1999	420				97	76				230										140					3200	64		20	91	
dry	09/29/1999	500				24	270				240										560					1500	80		24	170	
dry	09/04/2001	498	95		15	50	45	30	85	20	55	45	10	18	2300	155	215	23			213					296					
dry	09/18/2001	5			5	5	5	5	5	5	5	5	5	5	3200	5	5	5			205	10	5	5	5	5					
	Dry Geomean	**95**																													

Appendix 10: Geometric Means for Spring, Summer, and Fall

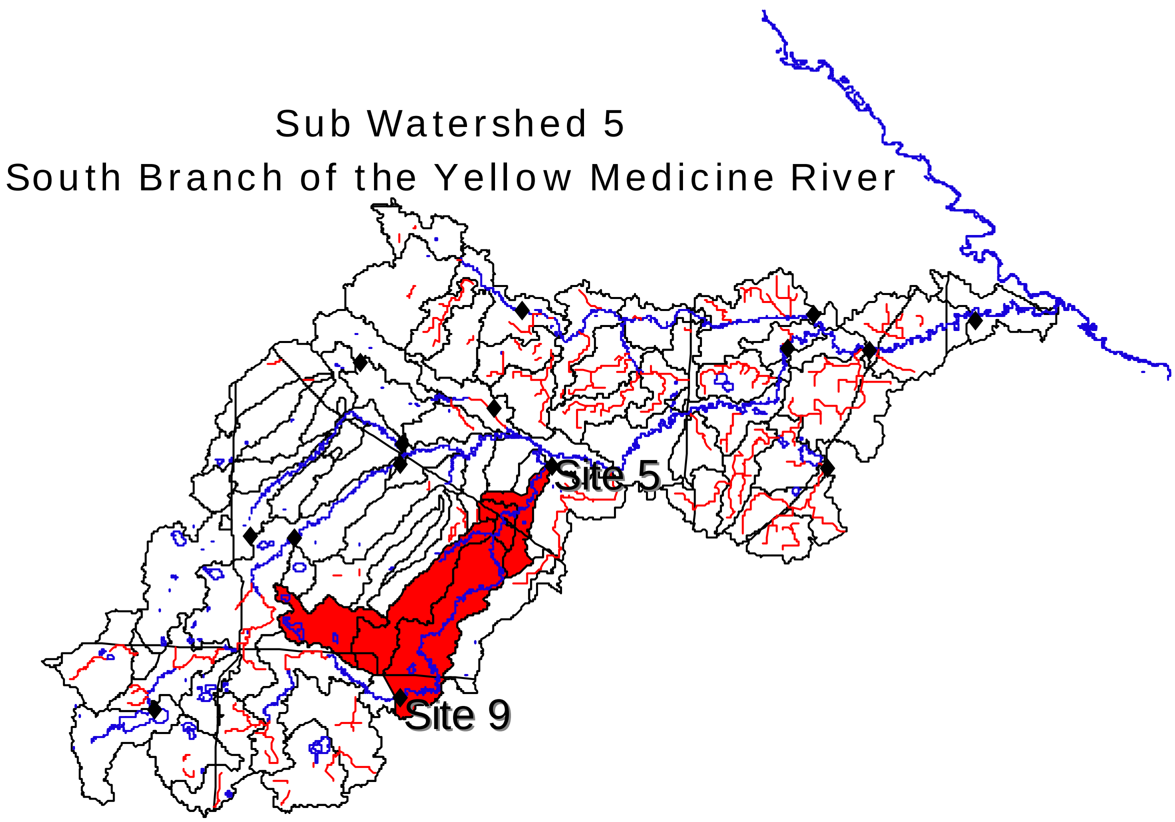
South Branch Yellow Medicine - 1999 and 2001 Fecal TMDL

Date	Fecal Coliform (cfu/100 mls)																													
1999 Sites	*1*				*2*	*4*				*5*								*6*					*3*			*7*	*8*	*9*	*10*	*11*
2001 Sites	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
04/03/2001	10	10	10	10	10	10	10	10	10	10	300	100	100	5	100	200	135		125	230		200	100	135						4
04/12/2001	3400	1100	1500	1800	1100	1000	3600	4100	3500	2700	2100	1600	2300	10	2700	900	1600	30	280	900	400	350	190	240	200					320
04/17/2001	20	25	10	4	20	5	5	5	5	30	5	5	5	5	6	4	2	2	5	5	10	20	65	45	50					4
04/24/2001	3000	3800	2600	2500	1900	2300	1800	1600	1200	1100	800	600	900	15	800	700	500	10	450	6800	3500	1600	400	800	300					80
05/04/1999	24				20	12				36										8					130	24	4	52	120	80
05/11/1999	120				130	34				150										32					140	40	56	40	32	990
05/17/1999	150				350	8				120										40					120	150	32	32	56	130
05/27/1999	2100				460	36				120										100					1700	130	300	44	60	180
05/01/2001	40		70	65	25	85	48	10	25	30	25	35	20	10	40	35	45	5	10	20	15	15	90	25	45					600
05/14/2001	90	125	65	55	155	103	55	15	90	23	28	20	20	35	65	30	15	5	5	15	20	40	40	130	240					
05/29/2001	98	140	220	109	200	116	88	74	16	4	16	20	20	123	36	89	121	2	74	2	40	126	51	530	205					305
Spring Geomean	75																													
06/01/1999	200				260	68				200										110					310	130	260	960	370	80
06/08/1999	52000				9000	3500				9200										2900					27500	1700	710	4200	3400	990
06/15/1999	730				460	350				640										280					910	420	73	270	67	130
06/22/1999	860				1200	200				1300										440					940	840	220	300	180	180
06/29/1999	1450				1100	150				1300										320					800	1000	290	360	190	600
06/11/2001	450	380	460	410	370	280	230	220	360	230	210	80	170	100	530	188	370	18	103	730	175	153	140	570	380					
06/13/2001	670		3040	1050	1240	2040	325	810	610	675	255	95	338																	
06/14/2001	530	560	410	290	410	210	230	220	230	720	450	360	4300	205	3700	6000	6600	10	320	330	340	173	490	50	15					
06/25/2001	430	370	310	570	530	300	243	313	75	65	10	15	35	15	203	405	175	4300	123	10	90	55	158	123	201					
07/06/1999	1200				1100	100				1200										450					1100	760		680	210	
07/13/1999	560				505	300				660										180					600	350		270	300	
07/20/1999	1200				740	500				1200										340					2600	690		1400	680	
07/09/2001	193	143	120	45	128	85	20	25	25	5	25	5	10	1700	65	40	75			1400	80	75	10	80	30					
07/20/2001	9900	1177	2880	990	1140	2630	3065	2025	1283	2975	2130	950	906	40	2190	8400	547	9800	12200	5310	8400	4340	1870	7800	10800					
07/23/2001	3000		2600	3600	3000	3400	3100	3900	1760	1840	1480	1280	1000	5	860	1240	1440	890	840	230	250	400	430	640	780					
08/03/1999	960				490	640				1200										490					1300	150		240	2310	
08/10/1999	3000				1100	900				740										1050					3200	280		275		
08/24/1999	220				1200	310				305										460					6000	27		76	180	
08/31/1999	2500				3000	700				2800										1500					4400	500		910	1300	
08/06/2001	860	338	155	100	253	425	215	55	50	180	20	28	20	1257	140	65	175			330	80	30	120	170	820					
08/20/2001	130	138	90	90	48	80	63	80	10	30	15	5	5	1000	60	35	25			430	115	30			123					
Summer Geomean	364																													
09/07/1999	350				540	250				420										500					330	160		340	230	
09/20/1999	2400				1300	180				640										405					2800	300		200	250	
09/23/1999	405				330	78				140										160					18000	130		24	310	
09/27/1999	420				97	76				230										140					3200	64		20	91	
09/29/1999	500				24	270				240										560					1500	80		24	170	
09/04/2001	498	95		15	50	45	30	85	20	55	45	10	18	2300	155	215	23			213					296					
09/18/2001	5			5	5	5	5	5	5	5	5	5	5	3200	5	5	5			205	10	5	5	5	5					
Fall Geomean	85																													

Appendix 11: 2001 Fecal Coliform Diagnostic Report

Introduction
The area of concern is a sub watershed of the Yellow Medicine River located along the south branch of the rivers five main branches, and in particular, the downstream section of this sub watershed. This sub watershed was identified as sub watershed 5 (Figure 1) during the Greater Yellow Medicine River Clean Water Partnership[1] and extends from monitoring site 9 to site 5 near the city of Minneota. The 36,582 acre watershed was divided into 25 sub watersheds defined by monitoring stations. Stage-flow ratings were developed at each station using stream velocity measurements various stream flows and curve fitting methods. Two of the stations were fully automatic with data loggers and pressure transducers and provided a continuous 15 minute recording of flow through the sampling period. The remaining sites were equipped with staff gages and were read weekly on a routing basis and during storm events.

Figure 1



The focus and primary intent of this project is to advance the current understanding of the cause-effect mechanisms relating the watershed land use practices to river sanitary quality. A mass balance approach was undertaken quantifying the individual sub watershed discharges of water, bacteria, ortho phosphate, and ammonia nitrogen.

[1] CWP Diagnostic and Feasibility Report, 2000

Geographic and survey data was used to identify and characterize possible source locations and their specific contributions. The sampling design addressed the questions:

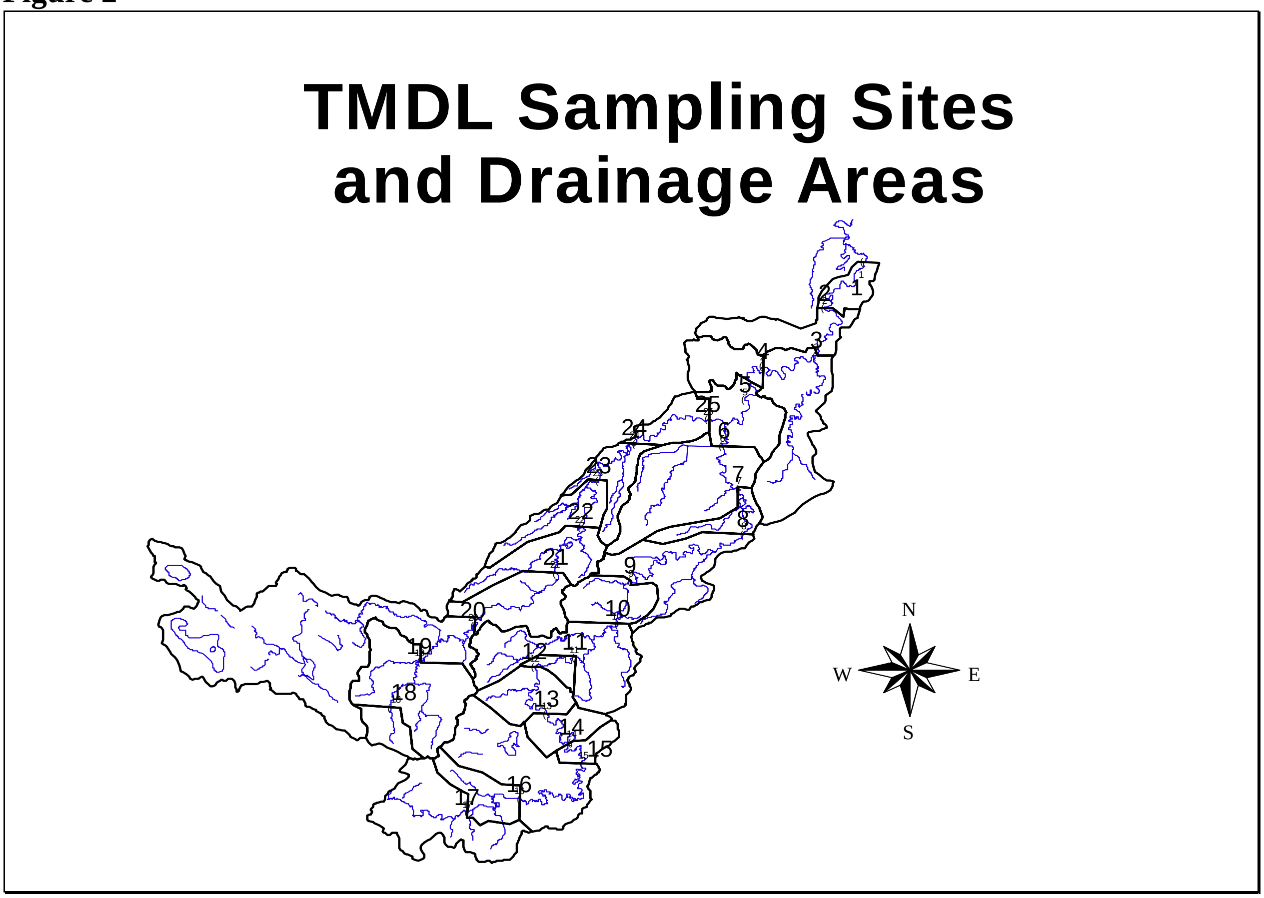
- v 1) What is the Coliform mass entering the river?
- v 2) Where is it coming from?
- v 3) What can be done?

Project summary

Activity #1. Data collection:

Each of the sites were sampled for flow discharge, Fecal Coliform, ortho phosphorus, and ammonia nitrogen concentrations. The 25 sites are shown in Figure 2. These sites represent all of the road bridges that cross the river branches and additional sites that provide access to the water.

Figure 2

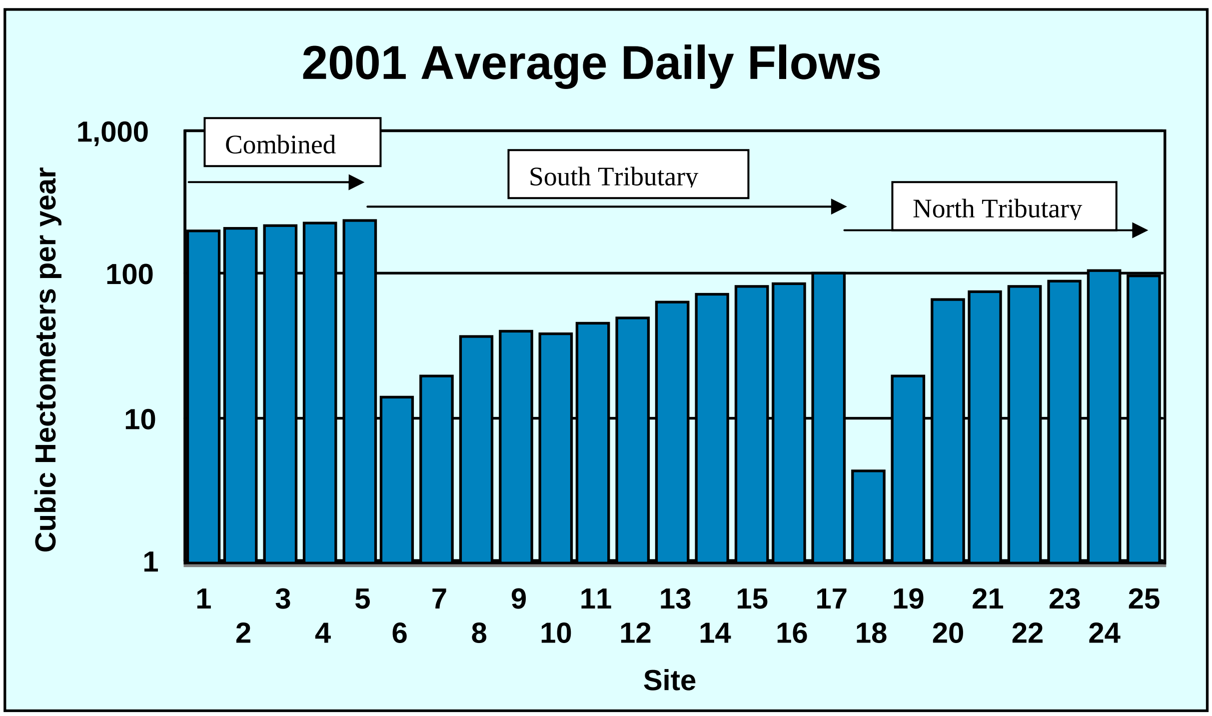


Results
The study area lends itself to be divided into three river sections based on the river tributaries: 1) the North Tributary consisting of sites 18 through 25 flowing downstream; 2) the South Tributary consisting of sites 17 through 6 flowing downstream; and 3) the Combined Section consisting of site 5 through 1 flowing downstream; site 5 marks the confluence of the North and South Tributaries. The average daily flows from all sites are shown in Figure 3. These estimates are based on the stream ratings and flow measurements from site 1 near the city of Minneota that is equipped with an automated data-logger and a stream rating[2]. Flows at the remaining 24 sampling sites within the TMDL basin were estimated using the contributing watershed at each station, the total basin area, and the total annual flow at site one using the expression:

Contributing acres/Total basin acres x total basin discharge = Sub watershed discharge

Stream flows were calculated for each site for each sampling event. The volumes are expressed as cubic hectometers per year or millions of cubic meters per year (HM^3/yr). The data is arranged by each of the three river sections flowing downstream from left to right (west to east).

Figure 3



[2] The results of the individual stream ratings at each site were discarded due to overestimates of flow at certain stations where beaver dams were built and/or significant sedimentation occurred during the coarse of the study.

Figure 4

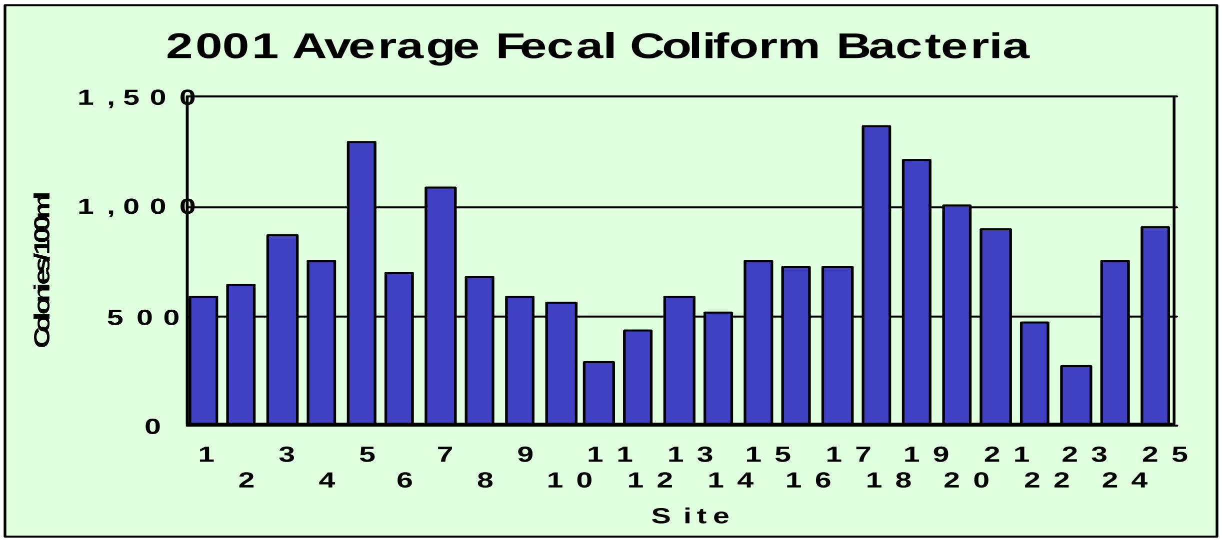
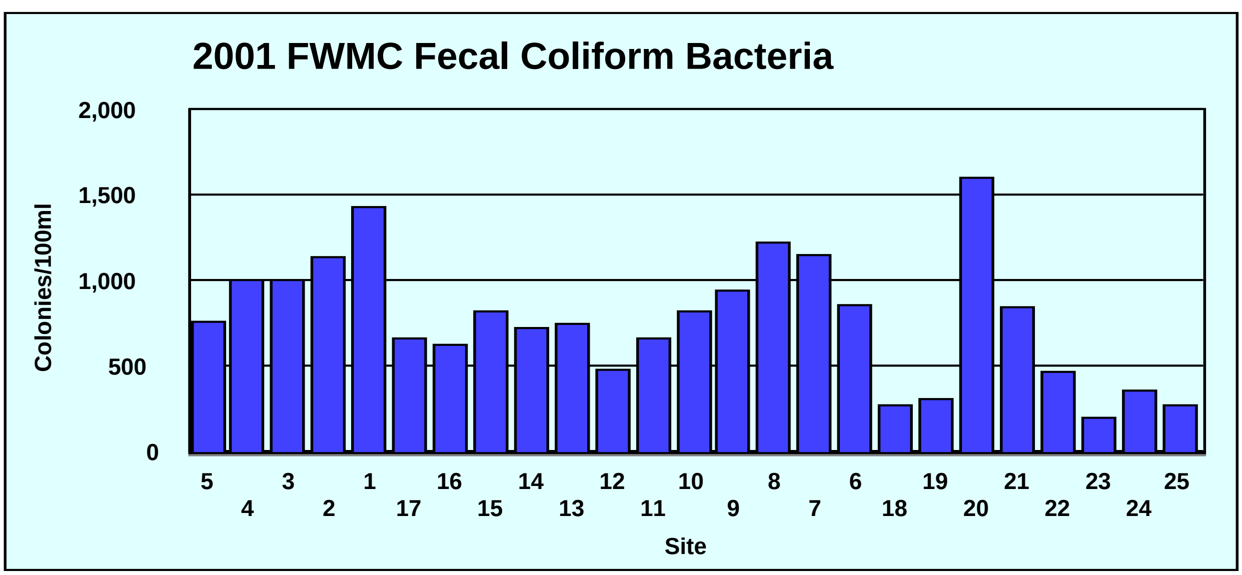


Figure 4 displays the arithmetic averages of Fecal Coliform concentrations collected at each site. These values are independent of the highly variable flow regime at each of the sites. As a result the calculations do not address the mass loading, but rather ambient concentrations at the sites or "snapshots" of the dynamic river. Elevated concentrations are apparent at sites 21-18 and sites 24-25 in the northern tributary, site 7 in the southern tributary, and sites 3 and 5 in the combined section of the TMDL basin.

The flow weighted mean Fecal Coliform concentrations (FWMC's) are shown in Figure 5. The calculations consider the flow conditions during the sampling event and reflect the mass loading of Fecal Coliform bacteria and provide further resolution in the sub watershed loading patterns. The pattern is somewhat different viewing the FWMC's. Site 20 appear to be a significant loading source in the northern tributary, sites 8-7 in the southern tributary, and sites 4-1 in the combined section.

Figure 5



The individual sub watershed contribution of Fecal Coliform are shown in Figure 6. The individual contributions of each sub watershed are calculated as the difference between the load at each station and the upstream contribution(s). This technique brings further resolution to locating the source of the Fecal Coliforms. The graphic shows significant source loading again from site 20 in the northern tributary, and large contributions from sites 5-4 and 2-1 in the combined section; the southern tributary sub watershed contributions are much less in comparison.

Figure 6

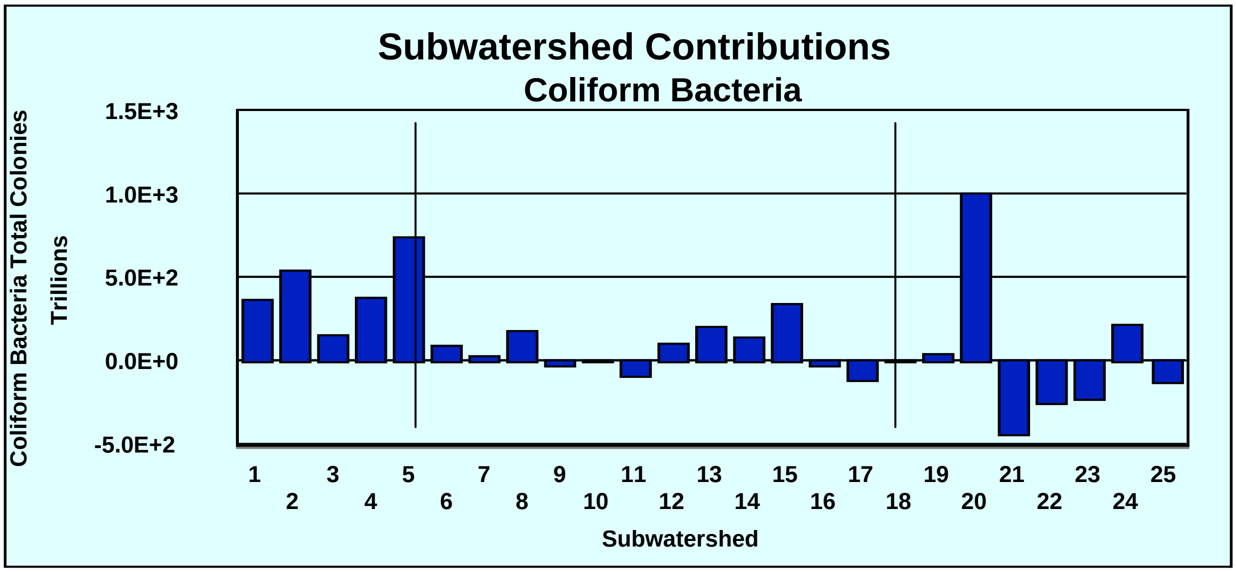
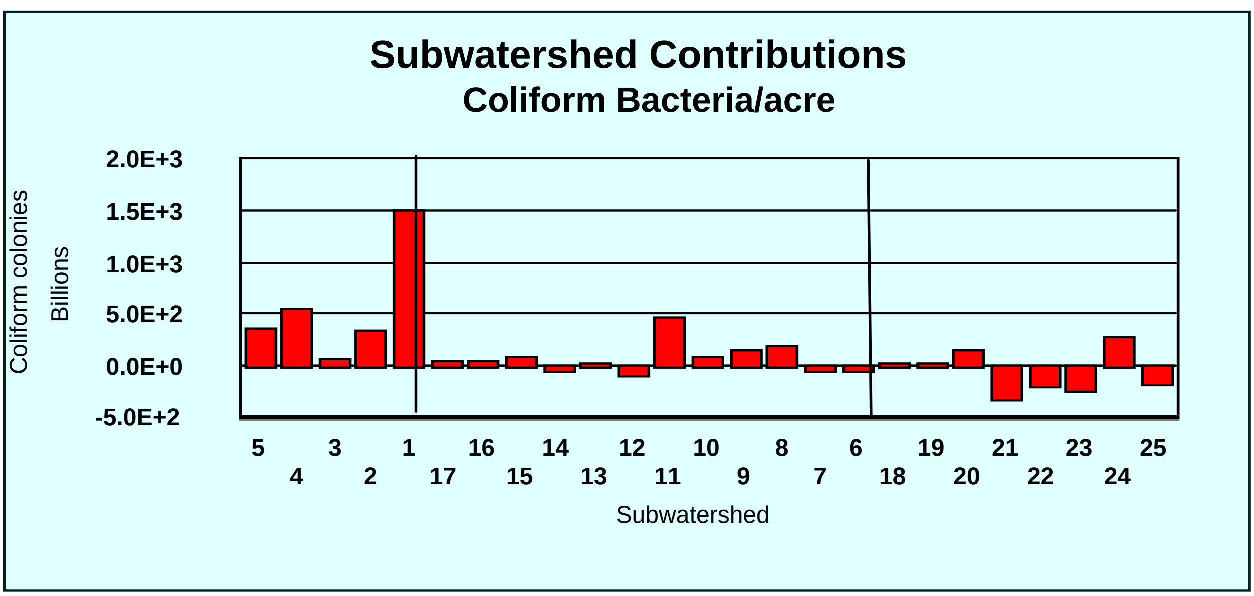


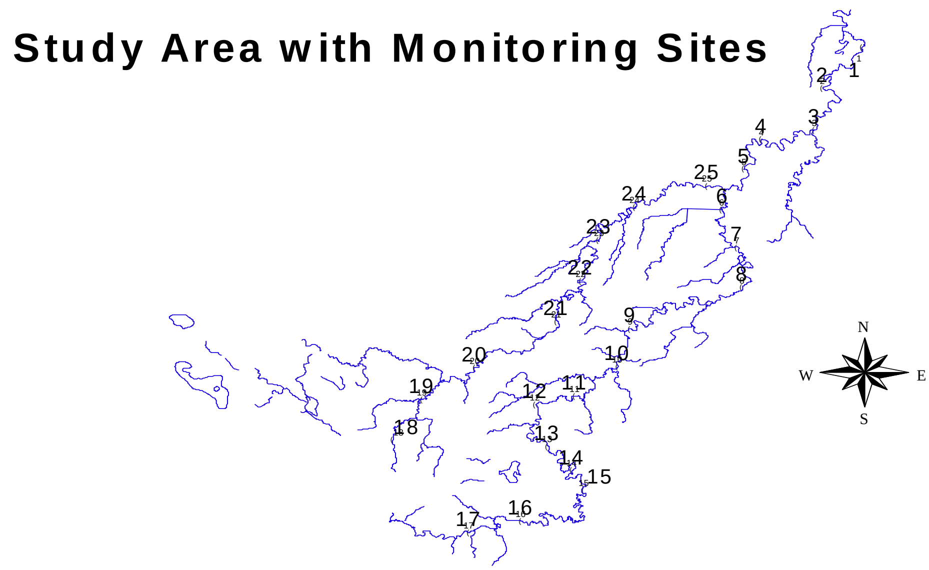
Figure 7 illustrates the loading patterns from each of the sub watersheds expressed as loading per unit area or number of organisms/acre. The graphic shows significant loading on a unit basis at sites 11 in the southern tributary and sites 5-4 and especially site 1 in the combined section of the river.

Figure 7



This analysis does not necessarily reveal the largest loading sources, but rather the most concentrated loading sources and opportunities to realize the most benefit per dollar spent in implementation activities.

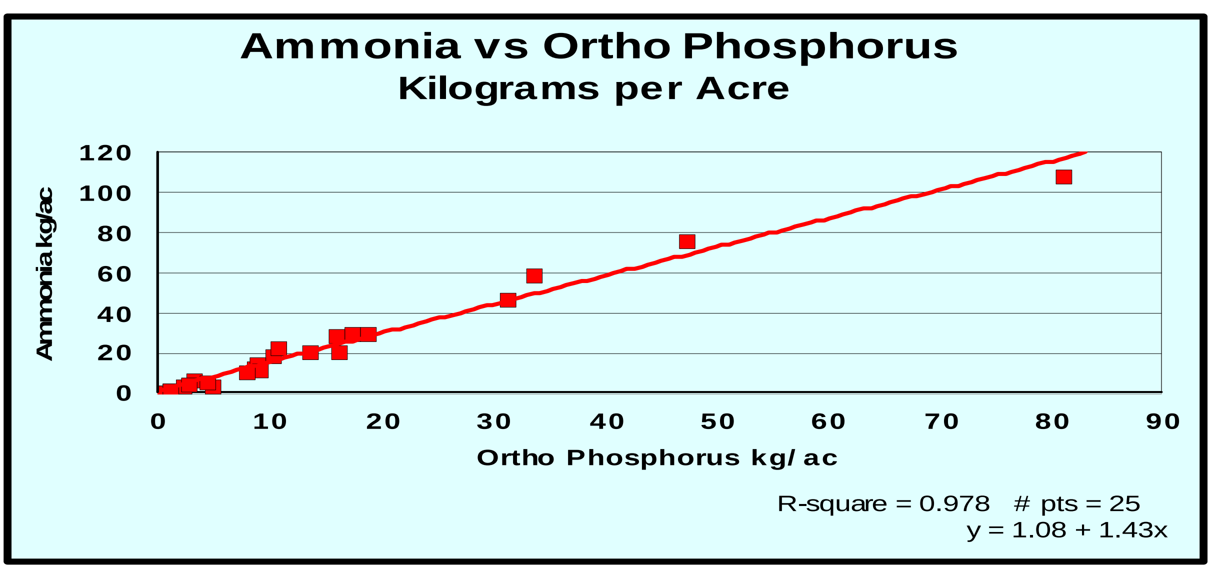
Figure 8



Fecal Coliform Markers

Ortho Phosphorus and ammonia nitrogen analysis were performed along with Fecal Coliform with each sample collected during the study period. The intent was to determine if these soluble nutrient forms would act as a marker for Fecal Coliform presence. These species do not persist in the environment and therefore signify recent contamination, and manure and feces contain large amounts of phosphorus and nitrogen.

Figure 9



A very good relationship exists between ortho phosphorus and ammonia nitrogen loading per acre (r^2 = 0.98) as would be expected (Figure 9). The relationship between ortho phosphorus and Coliform bacteria was much less with an r^2 of only 0.77 (Figure 10). Ammonia loading per acre was a better predictor of Coliform loading with an r^2 of 0.81 (Figure 11).

Figure 10

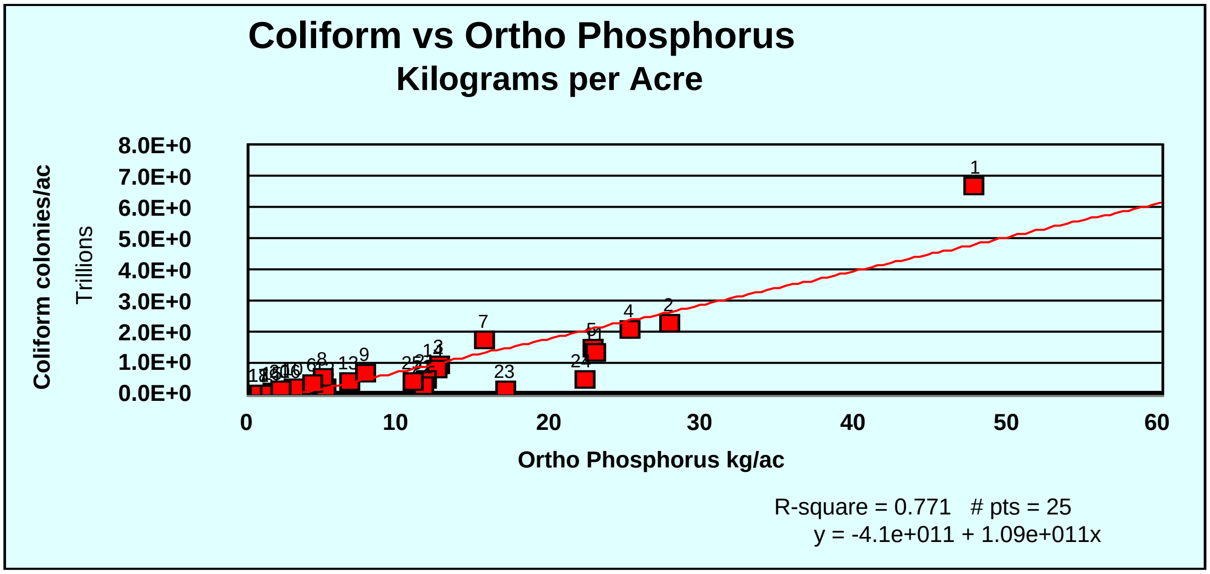
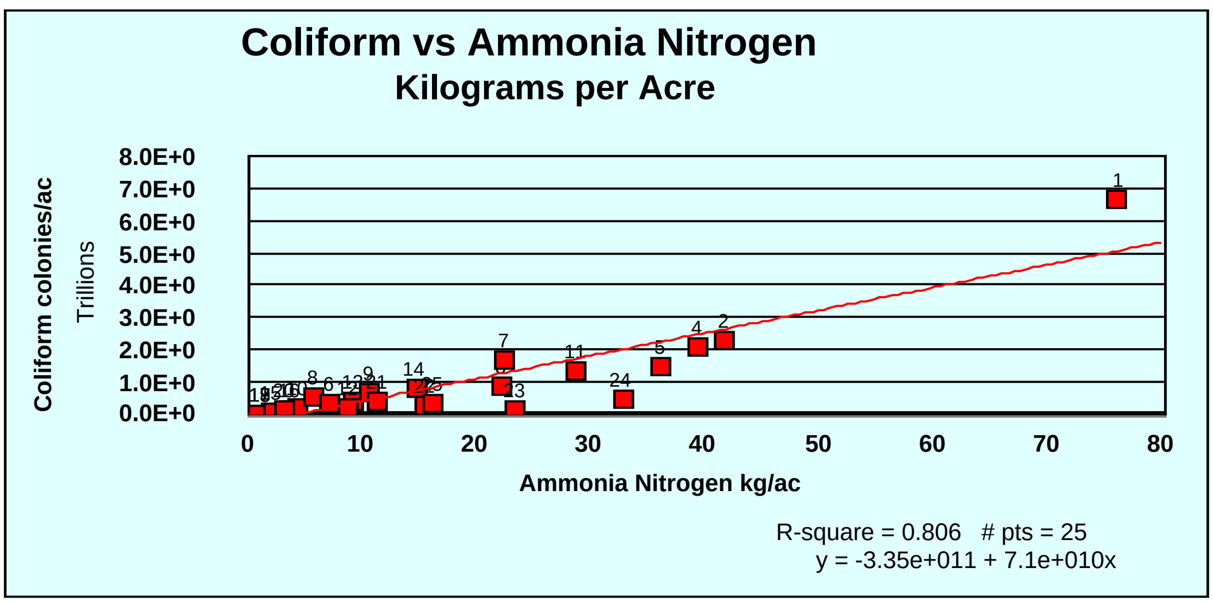


Figure11



Conclusions

1. Sub watersheds 1-4, 7-8, and 20 were the largest loading sources of Fecal Coliform in terms of a flow weighted mean concentration.

2. Sub watersheds 1-2, 4-5, and 20 were the largest loading sources of Fecal Coliform in terms of individual sub watershed contribution.

3. Sub watersheds 1, 4, 5, and 11 were the largest loading sources of Fecal Coliform on a per unit area basis (kg/acre).

4. Ammonia and ortho phosphorus were strong predictors of each other on a kg/acre basis, but were poorer predictors of Fecal Coliform (colonies/100ml-acre).