VERMONT
ENVIRONMENTAL CONSERVATION

Berry Brook, Godin Brook & Samsonville Brook

Watershed Description

This bacteria TMDL summary applies to a 2.6-mile reach of Berry Brook, a 4.4-mile reach of Godin Brook, and a 4.5-mile stretch of Samsonville Brook. All three streams are tributaries of the Missisquoi River (Figure 1) which flows to Missisquoi Bay, a shallow eutrophic embayment at the north end of Lake Champlain on the Vermont/Quebec border (MBIAC, 2003). Berry Brook and its North Branch originate in Quebec, flow south-easterly through Berkshire and into Richford where Berry Brook joins the Missisquoi River. Samsonville and Godin Brooks originate in Berkshire and flow south/southeasterly to the Missisquoi River.

Though forest land is the dominant land use in each of the three watersheds, agricultural land represents a significant portion of the watershed area (Figure 2), with dairy as the predominant agricultural activity in the watersheds of these three streams. The Godin Brook watershed (5.5 sq mi) is the largest of the three watersheds, and also has the largest contribution of agricultural land (~ 45%), followed by Berry Brook watershed (4.3 sq mi) with 35% of the land in agriculture. Samsonsville Brook is the smallest of the three watersheds (~ 3 sq mi) and contains the least amount of agriculture (31%) and the highest percentage of forestland (66%).

The Berry Brook watershed (Figure 1) is located in the towns of Berkshire and Richmond, and in the province of Quebec, Canada. Overall land use in the watershed is 55% forested, 35% agricultural, 2% wetland, and 1% developed. No data is available for approximately 7% of the land area in the watershed as shown in Figure 2 (2006 Land Cover Analysis by NOAA-CSC).

Waterbody Facts (VT06-04)

- **Towns:** Berkshire, Richford, Enosburg and Quebec, CANADA
- **Berry Brook Impaired Segment Length:** From mouth upstream 2.6 miles including north branch
- **Godin Brook Impaired Segment Length:** From mouth upstream 4.4 miles
- **Samsonville Brook Impaired Segment Location:** From mouth upstream 4.5 miles
- **Classification:** Class B
- **Watershed Area:** 12.8 square miles
- **Planning Basin:** 6 – Missisquoi River Basin

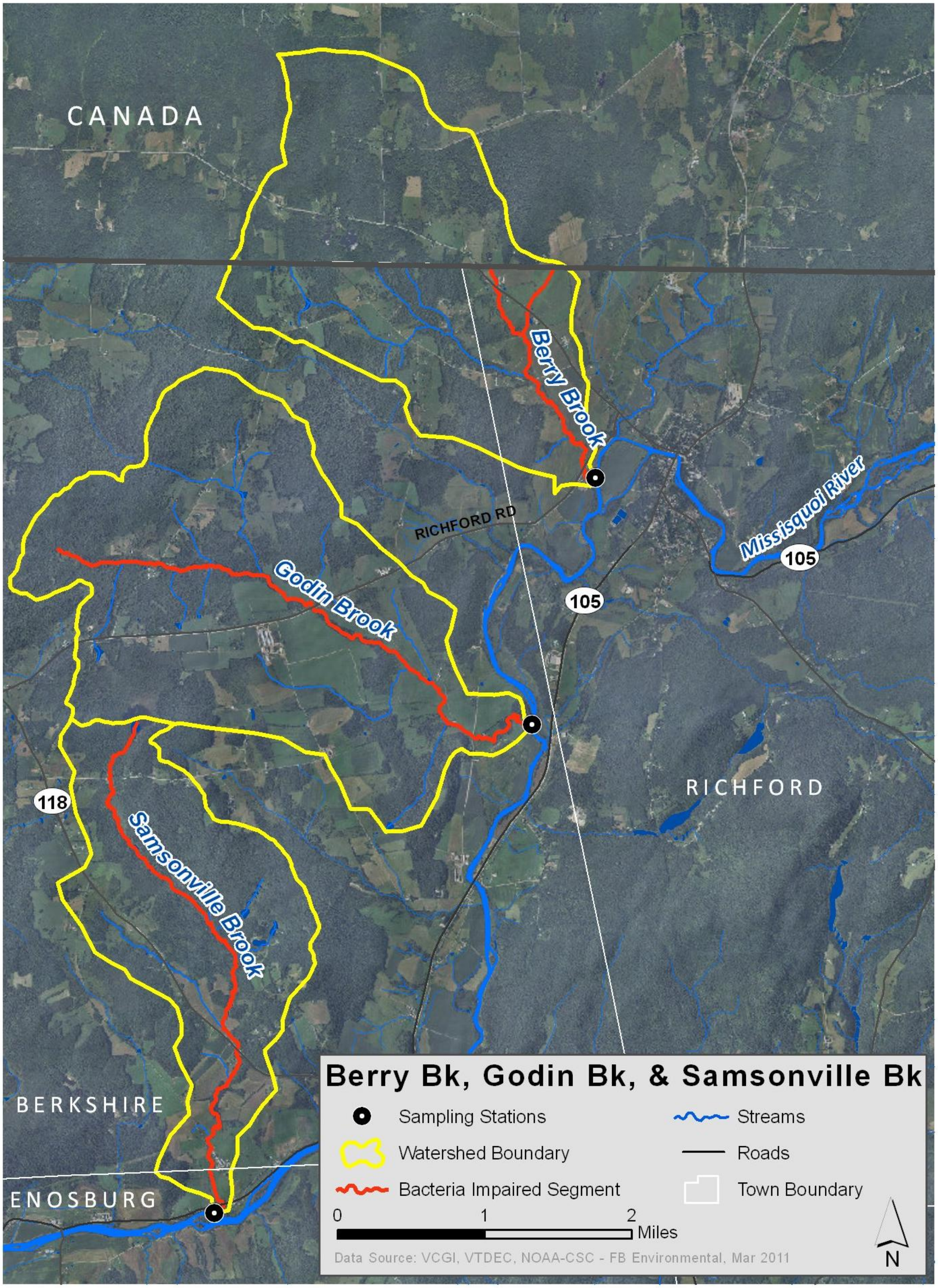

Figure 1: ***Map of the Berry, Godin and Samsonville watersheds with impaired segment and sampling stations indicated.***

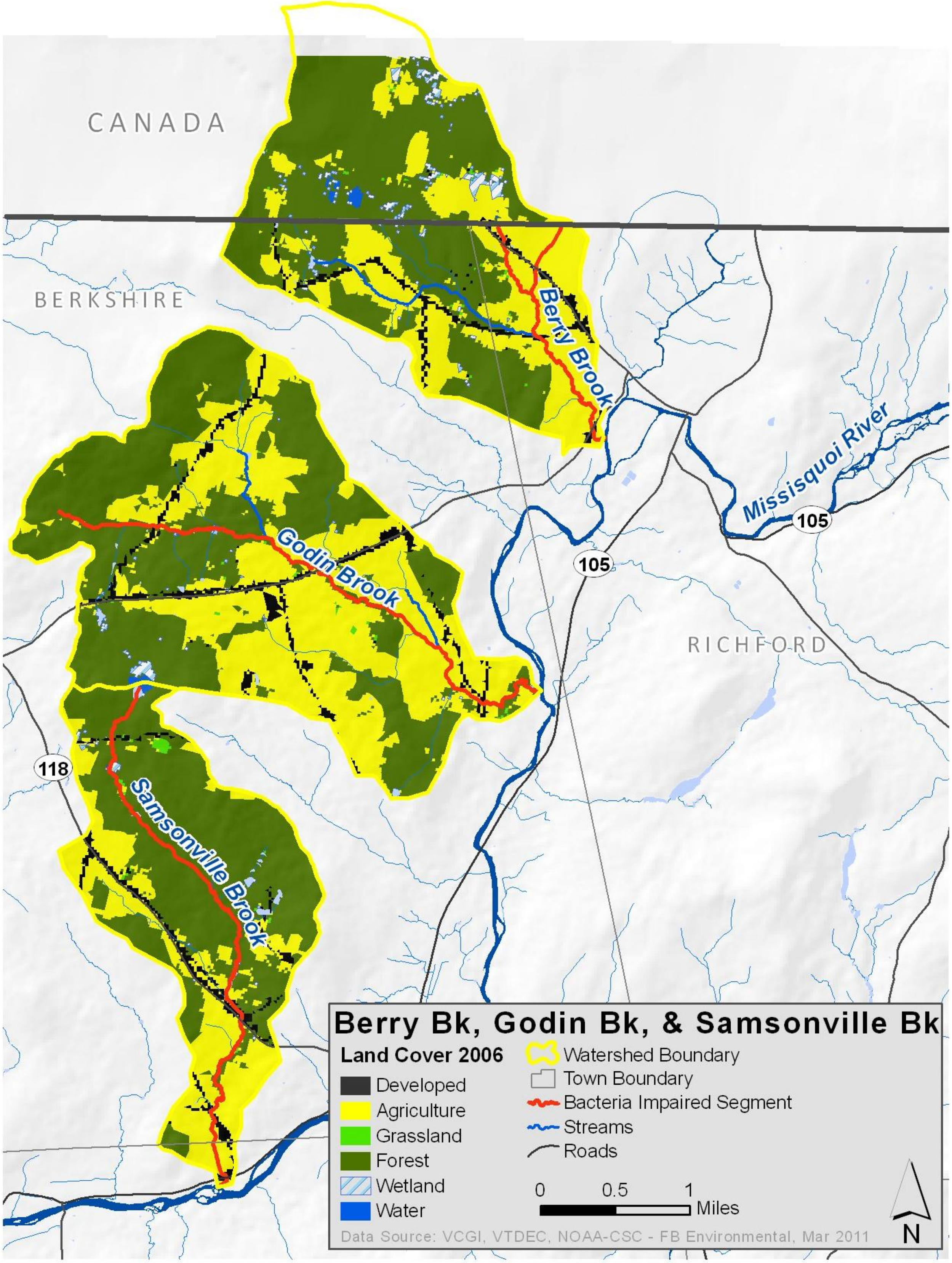

Figure 2: ***Map of the Berry, Godin and Samsonville watersheds with impaired segment and land cover indicated.***

Aerial view of Berry Brook and its confluence with the Missisquoi River. (Source: Google Earth)

The Godin Brook watershed is located entirely in the Town of Berkshire (Figure 1). Overall, land use in the watershed is 52% forested, 45% agricultural, 1% wetland, and 1% developed. The remaining 1% is categorized as grassland and water (Figure 2).

The Samsonville Brook watershed is located primarily in the Town of Berkshire, with a small amount of land in the southern portion of the watershed located in the Town of Enosville. Overall, land use in the watershed is 66% forested, 31% agricultural, 1% grassland, and 1% developed. The remaining 1% of the land is either wetland or water (Figure 2).

These three streams flow to the Missisquoi River, which is known to contribute the greatest share of nonpoint source phosphorus to Lake Champlain, and is itself impacted by phosphorus, bacteria and organic matter from agricultural sources, primarily animal wastes from dairies, cropland, and livestock activity within streams and riparian areas (Lombardo et al., 2000). Average bacteria counts in tributary streams of the Missisquoi including Berry, Godin and Samsonville brooks often exceed Vermont water quality standards. Phosphorus and nitrogen levels provide evidence of significant nutrient enrichment, while fish and macroinvertebrate data suggest moderate to severe impacts due to nutrients and organic matter.

Between 1994 and 2000, Samsonville, Godin, and Berry brooks watersheds (including the North Branch of Berry) were part of the federal Clean Water Act Section 319 National Monitoring Program to evaluate the effectiveness of livestock exclusion, streambank protection and riparian zone restoration in reducing nutrients, sediments and bacteria from agricultural sources in these watersheds (Meals, 2001). Treatment effectiveness was evaluated through intensive water quality monitoring at watershed outlets (Figure 1) using a paired-watershed design and through detailed land use and agricultural activity tracking over a seven-year period between 1994 and 2000. Agricultural Best Management Practices (BMPs) or "treatments" were implemented in both the Samsonsville and Godin brooks watersheds, while the Berry Brook watershed was selected as the reference watershed for the study and did not receive any treatment. Agricultural activity was stable over the study period with slow population growth and consolidation of dairy agriculture into fewer, but larger farms. The total livestock population in the three watersheds increased by 20% over the project (Meals, 2001).

Example of livestock exclusion- a new stream crossing on Godin Brook. (Source: Lombardo et al, 2000)

Two years of post-treatment data suggest that phosphorus, nitrogen, suspended solids, and indicator bacteria were all reduced in Godin and Samsonville brooks in response to implementation of livestock exclusion and riparian zone protection practices in these watersheds. Values for Samsonville Brook showed reductions in nutrient and suspended solid concentrations and exports, and reductions in bacteria concentrations as a response to the treatments. Mean bacteria (*E. coli*) counts in Samsonsville Brook decreased by 29% following treatment with reductions over nearly all seasonal conditions, including summer when highest bacteria counts are typically observed (Meals, 2001). Similarly, in Godin Brook, significant drops in post-treatment *E. coli* and Fecal coliform bacteria counts (45% reduction) were observed over the entire range/season following treatment (Meals, 2001). In addition, slight improvements were documented in fish and macroinvertebrate assemblages in both Samsonville and Godin brooks (Lombardo et al., 2000).

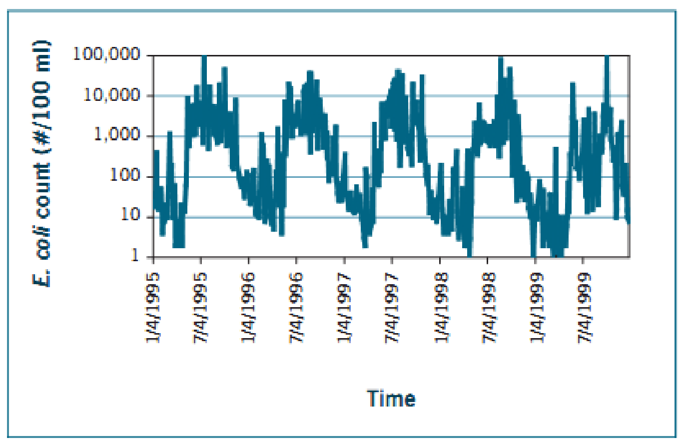

Figure 3. Time-Series plot showing seasonal cycles of indicator bacteria in Godin Brook, 1995-1999. *(Source: NNSMP 2005)*

The study also confirmed that indicator bacteria survive in stream sediments during the warmer months and can be resuspended by stream bed disturbance. Pronounced seasonal cycles of indicator bacteria counts were documented (Figure 3), where the counts were low during cold weather and very high during the growing season and the beginning of livestock pasturing in late May (NNSMP, 2005; Meals, 2001).

Overall, this study showed gains in reducing bacteria, nutrient and sediment loading to Godin and Samsonville brooks through implementation of agricultural BMPs when compared to Berry Brook (the reference stream). Overall, the study concluded that: BMPs that were implemented were simple and inexpensive; removal of land from grazing was not a significant issue; installation of pasture pumps was successful to supply water to the livestock following exclusion from the streams; riparian plantings including bioengineering worked well; and livestock exclusion fences worked well as did bridge and culvert crossings (Meals, 2001).

Why is a TMDL needed?

Berry, Godin and Samsonville brooks are Class B, cold water fisheries with designated uses including swimming and fishing (VTDEC, 2008). While intensive water quality sampling data was collected as part of the 319 National Monitoring Project (Meals, 2001), no additional monitoring data has been collected on these streams since 2000. Despite overall improvements in reducing bacteria counts in Godin and Samsonville brooks as a result of this project, the most recent bacteria data from 2000 exceed Vermont's water quality criteria for *E.coli* bacteria. Tables 1-3 (below) provide bacteria data collected at these sampling stations in 2000. Individual values represent the average of two samples collected each week. All three tables provide the water quality criteria for *E.coli* bacteria along with the individual sampling event bacteria results and geometric mean concentration statistics for each sampling station on Berry, Godin and Samsonville brooks.

The single current single sample water quality criterion is exceeded in the majority of sampling events, with the highest counts occurring in May through October during the growing/grazing season. Berry Brook exhibited the highest bacteria readings in 2000 (88,300 organisms/100 mL), followed by Godin Brook (16,500 organisms/100 mL), and Samsonville Brook (11,050 organisms/100 mL). The geometric mean concentration is also exceeded in both Berry and Godin brooks (Tables 1 and 2), but not in Samsonville Brook (Table 3) as a result of low bacteria counts with few exceedances over the period between January and early May.

Due to the elevated bacteria measurements presented in Tables 1-3, Berry, Godin and Samsonsville brooks did not meet Vermont's water quality standards, were identified as impaired, and placed on the 303(d) list (VTDEC, 2008). The 303(d) listing states that uses of Berry, Godin and Samsonville brooks for aquatic life support and contact recreation (i.e., swimming) are impaired due to agricultural runoff, and aquatic habitat impacts. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL assessment that describes the impairments and identifies the measures needed to restore water quality. The goal is for all waterbodies to comply with state water quality standards.

Potential Bacteria Sources

Erosion and runoff from agricultural land as a result of high manure application rates, concentrated overland flow, inadequate buffers along the streams, lack of livestock exclusion, and inadequate storage of manure all contribute to surface water pollution, and contribute the greatest sources of bacterial contamination to these streams. Other potential sources such as failing or malfunctioning onsite septic disposal systems or leaking sanitary sewer pipes may also be a contributing factor.

The paired watershed study (Meals, 2001) described above is evidence that proper design, installation, and maintenance of agricultural BMPs can significantly reduce sources of bacteria, nutrients and sediments in these streams.

Recommended Next Steps

Major efforts were made to educate agricultural landowners and operators about the effects that agricultural practices have on local water quality through hands on implementation of agricultural BMPs in these streams between 1994 and 2000. However, no follow-up activities (including monitoring) have occurred since the project was completed.

Additional bacteria monitoring data is crucial to evaluate the long-term effectiveness of the treatments that were implemented in the Godin and Samsonville brook watersheds. Ongoing efforts to reduce agricultural runoff, increase stream buffers, and limit livestock access will be critical components of stream restoration in these watersheds.

The Missisquoi River Basin Association (MRBA) is an active non-profit group of volunteers dedicated to the restoration of the river, its tributaries and Missisquoi Bay. Due to the high bacteria counts in Berry, Godin, and Samsonville brooks, and their effect on the Missisquoi, the MRBA would be a good fit for future restoration efforts. This group offers many free services to improve water quality in the Missisquoi Basin including cost-sharing for farmers, stream restoration projects, educational tools for local teachers, and leading a volunteer-led water sampling program (MRBA, 2011).

The following actions will support water quality goals in Berry, Godin and Samsonville brooks:

- Agricultural **-** Work with the USDA, NRCS and other agencies to assess the extent of agricultural waste application and potentially reduce applications through improved nutrient management planning. Implement land treatments that address grazing-related water quality problems. Educate farmers about the importance of conservation and water quality considerations, and the relatively low cost solutions to these problems. Encourage sustainable farming practices, such as those employed by farmers that participated in the paired watershed study. Encourage farmers to assess and repair all agricultural practices on an annual basis. Work with the Missisquoi River Basin Association to implement cost-share opportunities for farmers related to nutrient management.

- Riparian Corridor – Work with farmers to convert grazing land in the riparian area into permanent livestock exclusion areas. Utilize bioengineering applications such as planting willows, native riparian zone vegetation and brushrolls to trap sediment, support new vegetation growth and protect stream banks. Work with the Missisquoi River Basin Association to stabilize stream banks and improve riparian vegetation.

- Monitoring – Monitor bacteria concentrations in Berry, Godin and Samsonsville brooks on an annual basis with a focus on the growing season (May-October). Work with the MRBA to start a volunteer sampling program for Berry, Godin and Samsonville brooks.

Several of the steps outlined above are ongoing and should be continued and enhanced to focus on the goals of bacteria TMDL implementation. If implemented, these actions will provide a strong basis toward the goal of mitigating bacteria sources and meeting water quality standards in Berry, Godin and Samsonville brooks.

Bacteria Data

Vermont's current criteria for bacteria are more conservative than those recommended by EPA. For Class B waters, VTDEC currently utilizes an E. coli single sample criterion of 77 organisms/100ml. Although, Vermont is in the process of revising their bacteria WQS to better align with the National Recommended Water Quality Criteria (NRWQC) of a geometric mean of 126 organisms/100ml, and a single sample of 235 organisms/100ml. Therefore, in Table 1 below, bacteria data were compared to both the current VTWQS and the NRWQC for informational purposes.

Berry Brook (From mouth, 2.6 miles upstream)

***WB ID*:** VT06-4

Characteristics: Class B

Impairment: *E. coli* (organisms/100mL)

Current Water Quality Criteria for E. coli:

Single sample: 77 organisms/100 mL

NRWQC for E. coli:

Single sample: 235 organisms/100 mL

Geometric mean: 126 organisms/100 mL

Percent Reduction to meet TMDL (Current):

Single Sample: **99%+**

Percent Reduction to meet NRWQC:

Single sample: **99%+**

Geometric mean: **69%**

Data: 2000, VTDEC

Samsonville Brook (From mouth, 4.5 miles upstream)

***WB ID*:** VT06-4

Characteristics: Class B

Impairment: *E. coli* (organisms/100mL)

Current Water Quality Criteria for E. coli:

Single sample: 77 organisms/100 mL

NRWQC for E. coli:

Single sample: 235 organisms/100 mL

Geometric mean: 126 organisms/100 mL

Percent Reduction to meet TMDL (Current):

Single Sample: **99%**

Percent Reduction to meet NRWQC:

Single sample: **98%**

Geometric mean: **Complies**

Data: 2000, VTDEC

Godin Brook (From mouth, 4.4 miles upstream)

***WB ID*:** VT06-4

Characteristics: Class B

Impairment: *E. coli* (organisms/100mL)

Current Water Quality Criteria for E. coli:

Single sample: 77 organisms/100 mL

NRWQC for E. coli:

Single sample: 235 organisms/100 mL

Geometric mean: 126 organisms/100 mL

Percent Reduction to meet TMDL (Current):

Single Sample: **99%+**

Percent Reduction to meet NRWQC:

Single sample: **99%**

Geometric mean: **66%**

Data: 2000, VTDEC

Table 1: ***E.coli*** **(organisms/100 mL) Data for Berry Brook and Geometric Mean (organisms/100mL) for Calendar Year 2000.**

Station Name	Station Location	Date	Result	Geometric Mean**
Berry		10/5/2000	1760	408
Berry		9/28/2000	455	
Berry		9/21/2000	665	
Berry		9/14/2000	1690	
Berry		9/7/2000	800	
Berry		8/31/2000	8700	
Berry		8/24/2000	31750	
Berry		8/17/2000	1400	
Berry		8/10/2000	88300	
Berry		8/3/2000	44750	
Berry		7/27/2000	1030	
Berry		7/20/2000	3850	
Berry		7/13/2000	11850	
Berry		7/6/2000	3100	
Berry		6/29/2000	8950	
Berry		6/22/2000	8950	
Berry		6/15/2000	3750	
Berry		6/8/2000	4800	
Berry		6/1/2000	21400	
Berry		5/25/2000	19175	
Berry		5/18/2000	27	
Berry		5/11/2000	115	
Berry		5/4/2000	1	
Berry		4/27/2000	171	
Berry		4/20/2000	2	
Berry		4/13/2000	25	
Berry		4/6/2000	340	
Berry		3/30/2000	6	
Berry		3/23/2000	118	
Berry		3/16/2000	5	
Berry		3/9/2000	13	
Berry		3/2/2000	120	
Berry		2/24/2000	10	
Berry		2/17/2000	25	
Berry		2/10/2000	10	
Berry		2/3/2000	27	
Berry		1/27/2000	234	
Berry		1/20/2000	258	
Berry		1/13/2000	36	
Berry		1/6/2000	370	

*Yellow cells indicate readings above 2420, gray cells indicate the geometric mean used to calculate the percent reduction.
**Only geometric mean values calculated with 5 data points or more are used to determine percent reduction.

Table 2: ***E.coli*** **(organisms/100 mL) Data for Godin Brook and Geometric Mean (organisms/100mL) for Calendar Year 2000.**

Station Name	Station Location	Date	Result	Geometric Mean**
Godin		10/5/00	6925	371
Godin		9/28/00	3900	
Godin		9/21/00	1660	
Godin		9/14/00	73450	
Godin		9/7/00	740	
Godin		8/31/00	7100	
Godin		8/24/00	10700	
Godin		8/17/00	760	
Godin		8/10/00	5000	
Godin		8/3/00	1235	
Godin		7/27/00	1295	
Godin		7/20/00	3800	
Godin		7/13/00	16500	
Godin		7/6/00	1100	
Godin		6/29/00	2200	
Godin		6/22/00	2950	
Godin		6/15/00	915	
Godin		6/8/00	260	
Godin		6/1/00	2830	
Godin		5/25/00	2795	
Godin		5/18/00	51	
Godin		5/11/00	15685	
Godin		5/4/00	68	
Godin		4/27/00	3235	
Godin		4/20/00	3	
Godin		4/13/00	20	
Godin		4/6/00	65	
Godin		3/30/00	15	
Godin		3/23/00	67	
Godin		3/16/00	2	
Godin		3/9/00	24	
Godin		3/2/00	400	
Godin		2/24/00	30	
Godin		2/17/00	2	
Godin		2/10/00	4	
Godin		2/3/00	5	
Godin		1/27/00	14	
Godin		1/20/00	104	
Godin		1/13/00	109	
Godin		1/6/00	2400	

*Yellow cells indicate readings above 2420, gray cells indicate the geometric mean used to calculate the percent reduction.
**Only geometric mean values calculated with 5 data points or more are used to determine percent reduction.

Table 3: *E.coli* (organisms/100 mL) Data for Samsonville Brook and Geometric Mean (organisms/100mL) for Calendar Year 2000.

Station Location	Date	Result	Geometric Mean**
	10/5/00	1895	44
	9/28/00	442	
	9/21/00	188	
	9/14/00	1071	
	9/7/00	66	
	8/31/00	340	
	8/24/00	51	
	8/17/00	70	
	8/10/00	2950	
	8/3/00	380	
	7/27/00	235	
	7/20/00	230	
	7/13/00	11050	
	7/6/00	1200	
	6/29/00	310	
	6/22/00	179	
	6/15/00	175	
	6/8/00	74	
	6/1/00	84	
	5/25/00	86	
	5/18/00	46	
	5/11/00	77	
	5/4/00	1	
	4/27/00	17	
	4/20/00	4	
	4/13/00	17	
	4/6/00	19	
	3/30/00	7	
	3/23/00	2	
	3/16/00	3	
	3/9/00	1	
	3/2/00	2	
	2/24/00	1	
	2/17/00	2	
	2/10/00	3	
	2/3/00	2	
	1/27/00	6	
	1/20/00	10	
	1/13/00	10	
	1/6/00	151	

*Yellow highlighted cells indicate readings above 2420 organisms/100mL.
**Only geometric mean values calculated with 5 data points or more are used to determine percent reduction.

References

Lombardo et al. (2001). Lombardo, L.A., G.L. Grabow, J. Spooner, D.E. Line, D.L. Osmond, and G.D. Jennings. 2000. Section 319 Nonpoint Source National Monitoring Program Successes and Recommendations. NCSU Water Quality Group, Biological and Agricultural Engineering Department, NC State University, Raleigh, North Carolina.

MBIAC (2003). Missisquoi Bay Phosphorus Reduction Action Plan 2003-2009. Missisquoi Bay Inter-Agency Advisory Committee-Monteregie. October 2003. Updated September 9, 2004.

MRBA (2011). Missisquoi River Basin Association website: http://www.troutrivernetwork.org/mrba/index.html. Accessed March 15, 2011.

Meals, D.W. (2001). Lake Champlain Basin Agricultural Watersheds Section 319 National Monitoring Program Project, Final Project Report: May 1994 – November 2000. Vermont Department of Environmental Conservation. Waterbury, VT.

NNSMP (2005). Monitoring Data: Exploring Your Data, The First Step. TechNOTES 1. National Nonpoint Source Monitoring Program. July 2005.

VTDEC (2004). Basin 6 Missisquoi River Watershed Water Quality and Aquatic Habitat Assessment Report. Vermont Agency of Natural Resources, Department of Environmental Conservation. Water Quality Division. November 2004.

VTDEC (2008). State of Vermont, 2008, 303(d) List of Waters, Part A – Impaired Surface Waters in Need of TMDL, October 2008 (Approved by USEPA September 24, 2008). Prepared by: Vermont Department of Environmental Conservation, Water Quality Division, Waterbury, VT.