OVERVIEW OF THE MISSISQUOI SUB-BASIN

Cultural Setting

The Missisquoi Sub-basin lies in the rural, predominantly agricultural area of northwest Vermont that includes nearly ¾ (69%) of Franklin County and 30 percent of Orleans County. It stretches from Lake Champlain on the west, over the Green Mountains to the Lake Memphremagog Watershed on the east. The Sub-basin contains several small villages, the largest of which are Swanton (population 2,600) and Enosburg (population 2,000). Franklin County had a population of approximately 48,187 in 2006[7].

There is a rich cultural heritage in the area dominated by French Canadians and Abenaki American Indians. In 2000, the racial makeup of the County was is 96% White, 2% Native American, and less than 1% each for African American, Asian or Pacific Islander, and Hispanic, and 2% other ethnicities. Over 94% of the residents of Franklin County speak English as a first language, while 5% speak French as a first language[8].

Principal industries in the Sub-basin include light manufacturing, agriculture and agricultural supplies and services, and other skilled services. Dairy agriculture is the single largest industry. Recreation and tourism are also important in supporting the local economy. The median income for a household in the county was $41,659 in 2000. About 7% of families and 9% of the population were below the poverty line, including 10% of those under age 18 and 10% of those age 65 or over[9].

Physiographic Characteristics

The Missisquoi Sub-basin is located in the northern part of the Lake Champlain Basin (Figure 1). This River empties into Missisquoi Bay, a fairly large and shallow body of water divided between Vermont and Quebec. The Vermont portion of two sub-watersheds, the Rock River and Pike River (the Pike is called Riviere aux Brochets in Quebec, where the river flows into Missisquoi Bay), are also included in the Plan.

Terrain

Elevation in the Sub-basin ranges from 95 feet at Missisquoi Bay in the west, to 3,858 feet at the summit of Jay Peak. The Sub-basin includes a broad Upper Missisquoi Valley in the eastern part where the river flows north into Canada. This valley is the primary agricultural region for Orleans County, Vermont.

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[7] U.S. Bureau, 2000 Demographic Data.
[8] Ibid.
[9] Ibid.

The central part of the Sub-basin constitutes the northernmost extent of the Green Mountains and its foothills, which extend into Canada. The Missisquoi flows north around this mountainous region, eventually turning west and then south, back into the United States and flowing into the Lower Missisquoi Valley in the greater Champlain Valley.

The Trout River Watershed, the headwaters of Black Creek and Tyler Branch Sub-watershed, are the most rugged areas of the Sub-basin. Hungerford Brook winds through a valley with gentler terrain. The Pike and Rock Rivers run through flat land north of the Missisquoi River. The Rock River flows in an incised channel with little access to its former floodplain before flowing into Missisquoi Bay. Figure 2 shows shaded relief for the Sub-basin which characterizes the watersheds, Table 2 provides total acres by slope class.

Figure 2 - Shaded Relief and Watershed Boundaries within the Missisquoi Subbasin, including the Rock and Pike River Watersheds.

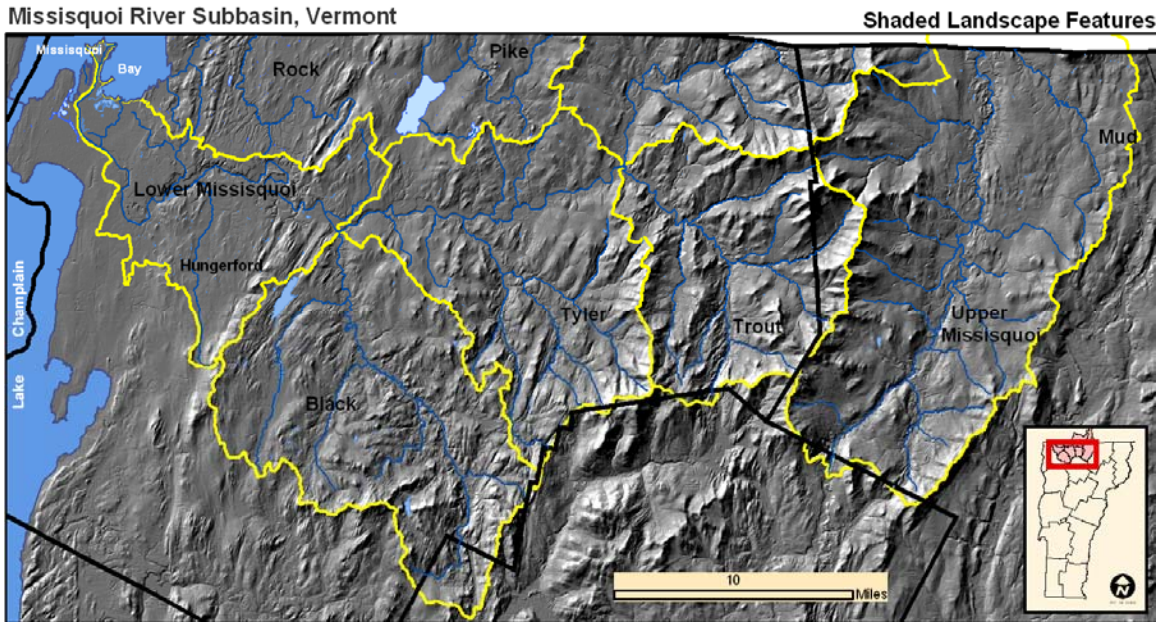

Table 2 - Slope Classes in the Sub-basin by Acres and Percent of Total.

Slope class (percent)	Acres in Plan area	Percentage of Plan area
0-3	70,083	16
3-8	121,369	27
8-15	124,534	27
15-25	80,906	18
25-50	60,039	13
50+	4,620	1
Total area	472,015	100

Substrate
Soils in the Sub-basin are mostly derived from glacial till (mountains and foothills), lake terraces and lacustrine sediments from an ancient sea filling the valley. Along the streams in the lower watershed, soils are alluvial and recent, as thick as 6 feet in some places, and on top of limestone bedrock and glacial till. Organic soils can be found in and near numerous wetlands throughout the Sub-basin,

Two of the largest wetland systems in Vermont occur at the mouths of the Rock and Missisquoi River. Other large wetland systems are associated with Lake Carmi and Fairfield Pond. Based on the Vermont Wetlands Inventory, there are 2,577 wetlands in the Sub-basin, comprising some 28,271 acres.

Biophysical Regions
The Missisquoi Sub-basin is divided fairly equally between the three Biophysical Regions described below[10,11,12].

Champlain Valley: The Champlain Valley has a warm and comparatively dry climate and abundant fertile farmland. The Valley contains both northern hardwood forest comprised of beech, birch and maple, and various species of oaks and hickory. The Valley also includes some of the State's most significant natural diversity and densely populated areas. Extensive wetlands bordering Lake Champlain provide outstanding habitat for waterfowl, marsh and aquatic species. Large areas of existing and former agricultural grasslands provide habitat for declining species such as Bobolink, Eastern meadowlark and Upland sandpiper.

Northern Vermont Piedmont: Calcium-rich soils combine with a cool climate to support mixed forests and Northern White Cedar Swamps, Fen, Rich Northern Hardwoods and other natural communities in this region. The uplands have good agricultural soils, but a short growing season. Moose are common in this region. The greatest concentration of nesting loons is found here.

Northern Green Mountains: This area has a cool climate and high elevations and is mostly forested. Northern hardwoods of beech, birch and maple dominate the side slopes and broad areas of the region. Areas with high elevations have spruce and fir tree species and alpine meadow habitat. The dominant bedrock is acidic and non-calcareous. The region provides extensive forested habitat for many wildlife species. Typical mammals include black bear, white-tailed deer, bobcat, fisher, beaver and red squirrel. There are also several species of birds that characteristically nest in high elevation forests, especially Blackpoll warblers, Swainson's thrush, and the rare Bicknell's thrush.

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[10] Johnson, C.W. 1998. The Nature of Vermont, Introduction and Guide to a New England Environment. University Press of New England. Hanover, New Hampshire.
[11] Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. www.vtfishandwildlife.com
[12] Thompson, E.H., and E.R. Sorenson. 2000. Wetland, Woodland, Wildland, A Guide to the Natural Communities of Vermont. University Press of New England. Hanover, New Hampshire. http://www.vtfishandwildlife.com/books.cfm?libbase_=Wetland,Woodland,Wildland

Climate
Because of wide variations in elevation, precipitation and temperature follow typical orographic gradients, from the west at Lake Champlain to the east in the Green Mountains. Precipitation ranges from 36 inches in the vicinity of the Lake to over 70 inches per year in the higher peaks. Precipitation generally falls year-round, but severe rainstorms associated with tropical storms, hurricane remnants, or Nor'easters, periodically cause flooding in the Sub-basin, especially when combined with winter thaws.

The growing season in the Champlain Valley portion of the Sub-basin averages about 130 days. A shorter growing season (100-120 days) occurs in Piedmont areas such as the Black Creek and Tyler Branch Watersheds. Higher elevations and the eastern piedmont in Orleans County have a growing season of less than 90 days or less.

Hydrography
There are nearly 3,000 (2,915) miles of streams in the Watershed. The drainage network is representative of a classic dendritic (fan shaped) drainage pattern (Figure 3). A dam at mile 8 of the Missisquoi River in Swanton prevents fish passage. There are also several other dams along the main stem of the River. To date, about 1,800 stream miles have been assessed for geomorphic characteristics by the Vermont Department of Environmental Conservation and its partners. The Phase 2 Stream Geomorphic Assessment of the Rock River Watershed gives extensive descriptions of Glacial Lake Vermont and the Champlain Sea, and the stream network that developed in place as these waters receded. These data also indicate that the Rock River has incised within its channel and has much-reduced access to former floodplains. This is probably the case for many other tributary systems in the Sub-basin, such as the upper reaches of Hungerford Brook

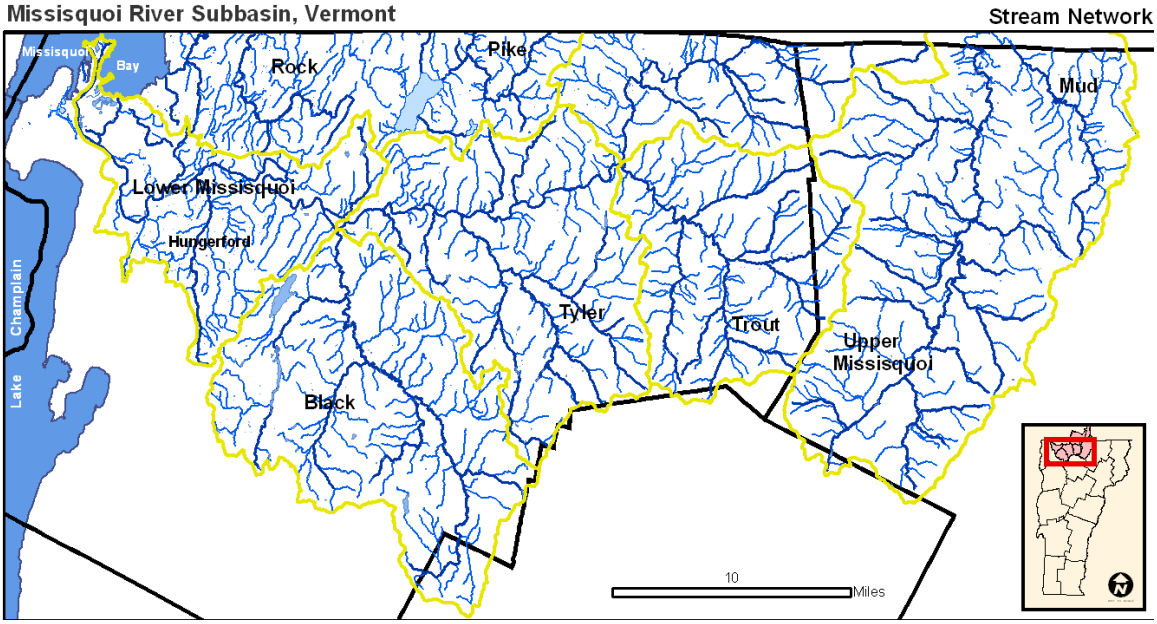
Trends in Land Use and Land Cover for the Missisquoi Sub-basin

The following discussion on land use/cover is based on two data sources: the National Resources Inventory (NRI)[13], conducted by NRCS, and the Census of Agriculture[14], conducted by the National Agricultural Statistics Service (NASS).

The NRI data used in the analysis is for the Missisquoi Hydrologic Unit Area (HUA) Sub-basin. This data does not include the Pike and Rock River Sub-watersheds. It has very high statistical margins of error (45-50%), because NRI data is most reliable at the state level or sub-state levels larger than the Missisquoi. And while the margins of error are very high, and are considered to be unreliable when this high, they are relatively consistent for each five-year period between 1982 and 1997. As such, they are useful for suggesting some broad trends, especially when coupled with other data. Data for 1997 is the most recent available NRI data.

[13] USDA, Natural Resources Conservation Service, Natural Resource Inventory, unpublished data, 1982, 1987, 1992, and 1997.
[14] USDA, National Agricultural Statistics Service, Census of Agriculture, 1974, 1979, 1982, 1987, 1992, 1997, 2002.

Figure 3 - Drainage Network in the Missisquoi Sub-basin.



Census of Agriculture data is available on a county basis every 5 years. The most recent data available is for 2002. It provides information on a wide variety of agricultural statistics, including number of farms, crop acreage, and animal numbers. The Missisquoi Sub-basin is located in three Vermont Counties: Franklin, Orleans and Lamoille. About 69% of Franklin is in the Missisquoi, followed by Orleans and Lamoille at 29% and 1.4%, respectively. It is assumed that the number of animals, acres and trends in Franklin County are reflective of what is happening in the Missisquoi.

The Ag Census information (Table 3) shows a relatively stable number of farms since 1992 in both Orleans and Franklin Counties. There were 770 farms in Franklin County in 2002; however, 20% (157) of those farms had gross sales of less than $1,000, more than 1/3 (283 farms, 37%) had gross sales of less than $5,000, and nearly 44% had sales of less than $10,000. The numbers do not express a likely reduction in the number of, but indicate a trend toward larger dairy operations, and an increase in the number of smaller, more diversified farms. In general, dairy farms in these counties are increasing in size, both in cropland acres and in livestock numbers, while the overall number of dairy operations has decreased.

Table 3 - Summary Ag Census and U.S. Census Data for Franklin and Orleans Counties[15]

Data Obtained From **Census of Agriculture** ***National Agricultural Statistics Service***

	Franklin County			Orleans County		
	1992	1997	2002	1992	1997	2002
Number of Farms:	728	835	770	549	649	583
Land in Farms (acres):	203,503	192,790	190,115	149,503	142,252	132,240
Average Size of Farms (acres):	280	231	247	272	219	227
Milk Cows (# of Farms)	41,090 (483)	39,343 (378)	40,492 (315)	27,642 (418)	24,349 (261)	22,794 (212)
Cattle and Calves Inventory (# of Farms)	65,838 (605)	65,942 (569)	67,371 (459)	43,862 (426)	43,192 (395)	40,081 (313)
Beef Cows (# of Farms)	702 (84)	938 (113)	998 (116)	448 (76)	820 (100)	634 (80)
Cropland Used Only For Pasture or Grazing (# of Farms)	25,414 (467)	21,391 (440)	12,587 (316)	21,617 (365)	16,327 (327)	9,554 (261)
Harvested Cropland- Hay & Annual Crops (# of Farms)	77,393 (654)	75,548 (659)	80,958 (539)	58,154 (485)	54,529 (508)	53,761 (421)
Total Woodland (# of Farms)	71,035 (562)	69,488 (627)	68,821 (627)	56,859 (454)	56,139 (496)	52,962 (486)
Corn for Grain (# of Farms)	894 (23)	2,113 (29)	1,565 (16)	109 (5)	137 (3)	170 (5)
Corn for Silage (# of Farms)	21,532 (311)	23,843 (258)	25,328 (198)	6,992 (80)	8,710 (72)	10,193 (71)

Data Obtained From ***US Census Bureau***

	Franklin County		Orleans County	
	2000	2006	2000	2006
Population	45,417	48,187	26,277	27,718

Key Points from the NRI and Census Data

- Based on the NRI, the broad land cover/use of the Missisquoi Sub-basin in 1997 was as follows.

  Agricultural – 25% Other Land – 1%
  Forest – 69% Water – 1%
  Developed – 4%

- Total cropland and pasture acreage in the Missisquoi declined by about 10% from 1982-1997.

- In 1997, there was approximately 34,000 acres of pasture-type land in the Sub-basin, with perhaps 15-20,000 acres of it being grazed at that time.

- The acreage of harvested cropland (hay and corn) in Franklin County was fairly steady from 1974-2002, moving up and down between 75,000 and 81,000 acres.

- Both the NRI and Census data suggest a significant increase in corn acreage in Franklin County over 15 and 28-year time frames from 1974-2002.

- **Corn acreage grew by 73% over the 28-year period**, jumping by more than 11,000 acres, from about 15,500 to 26,900 acres.

[15] USDA, National Agricultural Statistics Service, Census of Agriculture, 1992, 1997, 2002.

- Nearly two-thirds of the corn acreage increase in the Missisquoi came out of hay land, nearly ¼ came out of pasture, and about 1/6 came out of forestland.

- The Missisquoi Sub-basin has some of the highest concentration of farmland and dairy cows in Vermont. An estimated 29.5% of the Franklin County area is in agricultural use/cover and it houses ¼ or more of the State's cows.

- Franklin County is the only Vermont county where the number of dairy cows increased from 1974-2002. The number increased by 8.4 percent from 37,400 to about 40,500 animals over that time.

- Compared to other counties, Franklin has the least amount of cropland per head of cattle. In 2002, there were 1.2 acres of harvested cropland for each head of cattle in Franklin County. This compares with a state average of 1.6 ac/head, and suggests that the concentration of cattle per cropland unit is higher in Franklin.

- Developed land increased by about 25% in the Missisquoi Sub-basin from 1982-1997, growing from about 13,800 to 17,200 acres over that time.

- About 1,500 acres (40%) of the new built-up land came from cropland and pasture, and about 2,200 acres (58%) came out of forestland.

See Appendix D for a further explanation of the NRI and Census data as well as further detail concerning the bulleted items above.

Lake Champlain Basin Land Use/ Land Cover (LULC) Study

The LULC data is from an updated digital land use/land-cover layer for the Lake Champlain Basin (LCB 2001) generated from publicly-available 2001 National Land Cover Database (NLCD) with circa 2001 Landsat satellite imagery and additional Geographic Information System (GIS) datasets[16]. The data for this analysis was taken directly from Appendix D of the report '*Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading*'[17].

The geographic area included for the land-use/land-cover (LULC) summary includes the Missisquoi Sub-basin as well as five 12 digit sub-watersheds that enter Missisquoi Bay: the Pike River, Lake Carmi, Riviere Aux Brochets, the Rock River and Lakeshore-Goose Bay to Riviere Aux Brochets. This includes twenty-three 12-digit Hydrologic Unit Codes (HUC) sub-watersheds. This GIS layer is available from the Vermont Center for Geographic Information as 'VT Sub-watershed boundaries (HUC12).' The entire watersheds, including the areas within Canada, were included in this summary.

[16] Troy et al. 2007, Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading,
[17] Ibid.

Sub-basin and Sub-watershed Summary
The entire area of the basin and additional sub-watersheds, as detailed above, includes 565,552 acres. The area consists of 67.7% forest, 21.1% agriculture, 5.0% urban, 2.2% brush, 1.7% urban open, 1.4% wetland, 0.8% water and 0.2% barren. For a description of these LULC see Table 4 below. This overall landuse/land cover data agrees well with the NRI data provided in the previous section. One advantage of the LULC data is that acreages and percentages can be expressed at the sub-watershed level with a fairly high level of confidence.

Table 4 - LULC Classification Scheme from Troy et al. 2007.

Class	Code	Description
Urban	1	Areas dominated entirely by constructed materials or a mix of constructed materials and vegetation. Impervious surfaces generally constitute >20% of total land cover.
Agriculture	2	Land use dominated by the production of crops or for the grazing of livestock.
Brush/Shrub	3	Areas in transition where early-successional species dominate.
Forest	4	Areas dominated by tree canopy.
Water	5	Open water.
Wetland	6	Areas dominated by wetland vegetation, often with saturated soils and standing water.
Barren	7	Exposed soil or bare rock.
Urban-Open	8	Areas dominated by vegetation, typically lawn grass, where the use is anthropogenic. This includes many suburban and exurban properties with large lawns on former farm fields

Individual Sub-watershed Summary
Between the sub-watersheds there is quite a bit of variability in the composition of land cover/use. In general, there is more development and agriculture in the West near the lake and more forest land to the East in the headwaters. For example, Riviere Missisquoi-Riviere Missisquoi Nord to Lucas Brook (020100070302), in the Northern Green Mountains of Franklin and Orleans County of Vermont and into Canada, consists of 91.3% forest, 3.6% urban, and 2.7% agriculture. While closer to the lake, primarily in the town of Swanton, Hungerford Brook (020100070702) consists of 51.9% agriculture, 36% forest, and 6.4% urban. For a full list of the twenty three sub-watersheds and their percent of the different land-use/land-cover types (see Table 5).

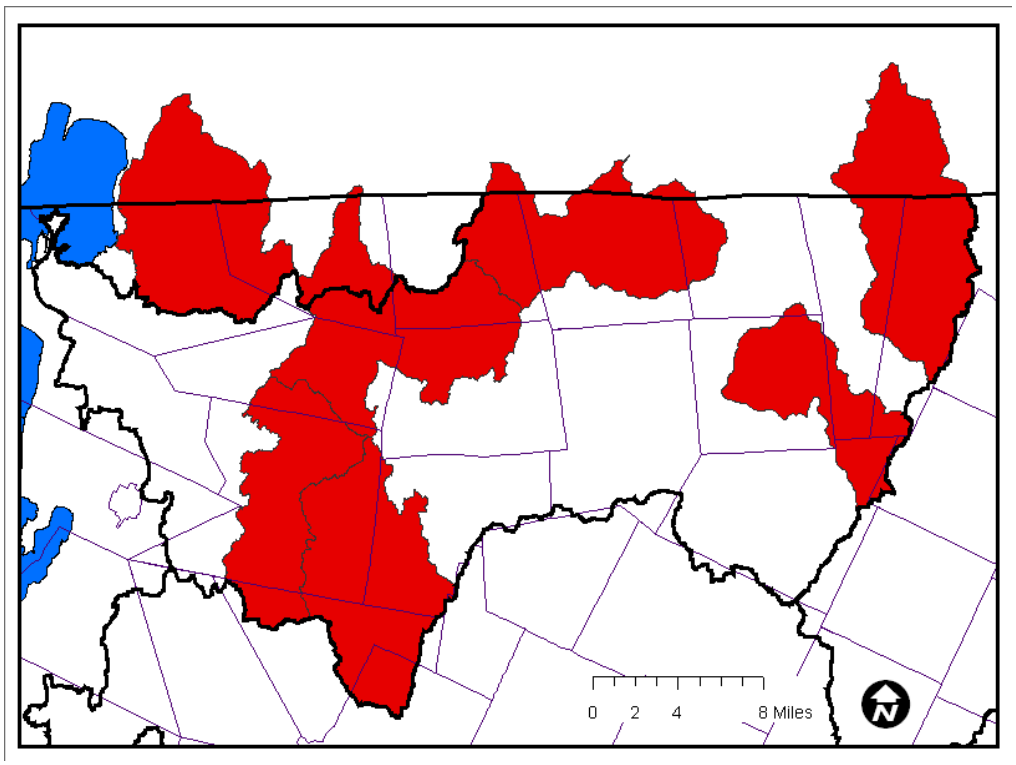
Table 5 - Land-Use/Land-Cover as Percentage of Sub-Watershed.

12 Digit Sub-Watershed	Sub-Watershed Name	Urban	Agricult.	Brush	Forest	Water	Wetland	Barren	Urban Open
020100070303	Riviere Sutton	5.8%	8.4%	3.4%	82.1%	0.2%	0.1%	0.0%	0.0%
020100070302	Riviere Missisquoi-Riviere Missisquoi Nord to Lucas Brook	3.6%	2.7%	1.7%	91.3%	0.1%	0.5%	0.0%	0.0%
020100070104	Mud Creek	4.2%	28.8%	3.6%	61.4%	0.1%	1.0%	0.1%	1.0%
020100070304	Missisquoi River mainstem-Canada to Trout River	4.7%	17.5%	1.8%	73.1%	0.3%	0.5%	0.1%	1.9%
020100070105	Missisquoi River-Beetle Brook to Mud Creek	4.9%	18.2%	2.7%	71.2%	0.1%	1.6%	0.1%	1.3%
020100070703	Missisquoi River-Hungerford Brook to mouth	12.4%	23.6%	1.8%	30.4%	6.8%	16.5%	1.3%	7.2%
020100070502	Missisquoi mainstem-Trout River to Black Creek	5.4%	45.6%	1.9%	43.9%	0.9%	0.4%	0.2%	1.5%
020100070701	Missisquoi River-Black Creek to Hungerford Brook	6.5%	23.6%	3.3%	58.8%	3.1%	1.5%	0.1%	3.2%
020100070402	Trout River-West Hill Brook to mouth	4.2%	10.4%	1.4%	82.4%	0.1%	0.2%	0.0%	1.2%
020100070401	Trout River-headwaters to West Hill Brook	2.8%	3.7%	1.0%	91.3%	0.0%	0.2%	0.0%	1.0%
020100070103	Missisquoi River-Mineral Spring Brook to Beetle Brook	3.6%	11.9%	3.2%	79.6%	0.0%	0.6%	0.0%	0.9%
020100070702	Hungerford Brook	6.4%	51.9%	2.2%	36.0%	0.0%	0.9%	0.0%	2.5%
020100070501	Tyler Branch	4.1%	16.9%	1.2%	75.6%	0.1%	0.3%	0.0%	1.8%
020100070603	Black Creek-Fairfield River to mouth	4.7%	38.3%	1.8%	52.8%	0.1%	0.4%	0.0%	2.0%
020100070602	Fairfield Pond-Dead Creek	4.4%	17.5%	2.8%	65.1%	3.3%	3.8%	0.0%	3.2%
020100070102	Missisquoi River-McAllister Pond Brook to Mineral Spring Brk.	3.6%	11.4%	1.5%	81.8%	0.2%	0.6%	0.1%	0.8%
020100070601	Black Creek-headwaters to Fairfield River	4.0%	17.0%	1.5%	75.0%	0.4%	0.9%	0.0%	1.1%
020100070101	Missisquoi River-headwaters to McAllister Pond Brook	3.3%	4.7%	1.5%	86.7%	0.2%	0.4%	1.9%	1.2%
020100081102	Lakeshore-Goose Bay to Riviere Aux Brochets	13.7%	18.6%	1.8%	51.6%	0.3%	10.7%	0.1%	3.2%
020100081101	Rock River	5.8%	42.5%	2.0%	44.6%	0.3%	2.2%	0.1%	2.5%
020100081005	Riviere Aux Brochets-Riviere Aux Brochets Nord to Ruiss Coslett	6.2%	24.1%	3.4%	64.1%	0.1%	0.6%	0.3%	1.2%
020100081001	Lake Carmi	5.5%	29.8%	1.9%	40.6%	19.8%	1.2%	0.1%	1.0%
020100081002	Pike River	5.4%	29.4%	3.1%	56.3%	0.1%	1.3%	0.1%	4.2%

Impaired Waters in the Missisquoi Sub-basin

State listed impaired waters are identified in Vermont's Department of Environmental Conservation (VTDEC), Water Quality Division's 2006 303(d) List of Impaired Waters[18]. This report was reviewed for water quality impairments and stream reaches with impairments in the Missisquoi Sub-basin were included in Figure 4 and Table 5. The segments from this list (Part A) are scheduled for total maximum daily load (TMDL) development. The map does not show the actual impaired reach but highlights 12 digit Hydrologic Unit Code (HUC) sub-watersheds that contain impaired reaches. Thus, the map highlights major geographic areas where impaired reaches are found, which may seem to exaggerate the extent of the impaired reaches. The intent is to provide the 12 digit HUCs as a way to reference where the impaired reaches are found in the watershed. While it may be desirable to show a map of the actual impaired reaches, this shows an apparent level of precision that is not recommended by the Agency of Natural Resources. This map of impaired sub-watersheds is used by Vermont NRCS in Farm Bill Program ranking tools to prioritize projects that will improve water quality in these sub-watersheds.

Figure 4 - Missisquoi Sub-watersheds with Impaired Stream Reaches.



[18]Vermont Department of Environmental Conservation, State of Vermont 2006 303(d) List of Impaired Waters, March 1, 2007, 10p.

Table 6 has been compiled from the 303(d) list; it identifies all of the impaired reaches within the project area. All of the impaired stream segments within the Sub-basin have water quality problems due to agriculture or phosphorus (which is also probably from agricultural sources). These impairments include sediment, nutrients, E. coli and undefined. The surface water quality problems are agricultural runoff, nutrient enrichment, aquatic habitat impacts, and excessive algal growth.

Although outside the scope of Clean Water Act Section 303(d), there are numerous surface waters within the project area that are assessed as "stressed" and have been identified as needing further assessment to confirm the presence of a violation of one or more criteria of the Vermont Water Quality Standards. These waters are identified in Part C of the State of Vermont's 2006 List of Priority Surface Waters. A violation has not been documented by sufficient data (i.e. there is an insufficient weight of evidence) for these waters, but they are considered high priority for assessment and monitoring.

The Missisquoi River from Lake Champlain upstream to Richford has been identified as 'stressed'. This includes the lower Trout River, lower Black Creek, the Tyler Branch and the Jay Branch. The primary (possible) pollutants include sediment, nutrients, and E. coli. The possible problems include agricultural runoff, streambank erosion, morphological instability and loss of riparian vegetation. While this list (Table 7) has not been validated with sufficient data it further emphasizes the extent of water quality concerns within the Sub-basin.

Priority Resource Concerns Identified in the Missisquoi Sub-basin

There are two primary resource concerns in the Sub-basin: (1) agriculture and its impact on water quality; and (2) the geomorphic condition of rivers and streams.

The water quality concerns related to agriculture are generally associated with three components of agricultural operations: farmsteads, cropland and associated cropping systems, and pasture. In addition, the geomorphic instability of the streams and rivers due to historic land uses and past manipulations is likely a contributing factor to the phosphorus load in the lake and is in itself a priority resource concern.

Farmsteads

Dairy farms comprise the majority of agricultural operations in the Watershed. Animals, manure, and feed are usually concentrated at the farmstead, posing serious water quality problems when they and surface water are not managed properly. Problems may include surface water runoff that carry sediment, manure, milkhouse waste, and silage leachate off-site. To prevent these discharges, clean surface water and waste products must be properly managed, stored, spread or otherwise disposed of. When discharges from farmsteads do occur, they can cause severe problems to the natural environment, contributing significant loads of phosphorus and other pollutants to streams and water bodies.

Table 6 - 2006 List of Impaired Stream Segments in the Missisquoi Sub-basin.

12 Digit Sub-Watershed	Segment Name/Description	Pollutants	Use(s) Impaired	Surface Water Quality Problems
020100081101	Rock River - Mouth to VT/QUE Border (3.6 miles)	Undefined	Aesthetics	Algal Growth; Agricultural Runoff; Fish Kill
	Rock River, Upstream From QUE/VT Border (~13 miles)	Undefined	Aquatic Life Support	Agricultural Runoff; Nutrient Enrichment
	Saxe Brook (Trib to Rock River) From Mouth Upstream 1 Mile	Undefined	Aquatic Life Support	Agricultural Runoff
020100081001	Lake Carmi (Franklin)	Phosphorus	Aesthetics; Contact Recreation (swimming)	Algae Blooms
020100070304	Berry Brk Up To No. Trib (Mouth to 1 Mi Upstream)	Sediment, Nutrients, E. Coli	Aquatic Life Support; Contact Recreation	Agricultural Runoff, Aquatic Habitat Impacts
	Godin Brook	Sediment, Nutrients, E. Coli	Aquatic Life Support; Contact Recreation	Agricultural Runoff, Aquatic Habitat Impacts
020100070502	Samsonville Brook	Sediment, Nutrients, E. Coli	Aquatic Life Support; Contact Recreation	Agricultural Runoff, Aquatic Habitat Impacts
	Trout Brook, Upstream From Mouth For 2.3 Miles	Undefined	Aquatic Life Support	Agricultural Runoff
020100070603	Wanzer Brook (Mouth to RM 3.2)	Undefined	Aquatic Life Support	Agricultural Runoff
020100070601	Chester Brook	Undefined	Aquatic Life Support	Agricultural Runoff
020100070103	Coburn Brook (Mouth to RM 0.2)	Nutrients	Aquatic Life Support	Agricultural Activity and Runoff
020100070104	Mud Creek, From RM 6.5 Downstream To Que/VT Border	Undefined	Aquatic Life Support	Agricultural Runoff; Nutrient Enrichment

Table 7 - 2006 List of Surface Waters in the Missisquoi Sub-basin in Need of Further Assessment.

12 Digit Sub-Watershed	Segment Name/Description	Possible Pollutants	Possible Use(s) Impaired	Possible Surface Water Quality Problem Needing Assessment
020100070703 020100070502 020100070701	Missisquoi River, Lake to Tyler Branch	Sediment, Nutrients, E. Coli, Turbidity	Aesthetics, Aquatic Life Support and Contact Recreation (swimming)	Agricultural Runoff, Streambank Erosion, Loss of Riparian Vegetation
020100070304 020100070502	Missisquoi River, Tyler Branch to Richford	Sediment, Nutrients, E. Coli, Turbidity	Aesthetics, Aquatic Life Support and Contact Recreation	NPS Contributions From US and Quebec, Streambank Erosion, Agricultural Activity
020100070603 020100070601	Black Creek, Mouth to East Fairfield (12 Miles)	Sediment, Nutrients, E. Coli	Aesthetics, Aquatic Habitat and Contact Recreation	Agricultural Runoff
020100070501	Tyler Branch	Sediment, Nutrients, E. Coli	Aesthetics, Aquatic Life Support, Contact Recreation	Agricultural Runoff; Morphological Instability (West Enosburg To Cold Hollow Brook)
020100070401 020100070402	Trout River (Mouth to Montgomery Center)	Sediment	Aesthetics, Aquatic Life Support	Morphological Instability
020100070402	Trout River From Mouth to 6 Miles Upstream	Sediment, Nutrients, E. Coli	Aesthetics, Aquatic Life Support, Contact Recreation	Agricultural Runoff, Streambank Erosion
020100070105	Jay Branch, RM 8.3 to RM 5.6	Sediment, Stormwater	Aquatic Life Support, Aesthetics	Potential Impacts From Construction Erosion, Watershed Hydrology

Cropland
Most dairy farms in the Missisquoi include large acreages of cropland (both annual crops such as corn for silage, and permanent hay fields). Soil erosion from the annually tilled corn fields is a significant concern, especially when appropriate conservation practices are not employed. There can be significant loss of phosphorus associated with the soil erosion from these fields. Permanent hayfields have significantly less soil erosion, however manure and phosphorus losses can be significant because there are often multiple surface applications of manure throughout the growing season. The total load of phosphorus and other pollutants from corn and hay fields can be great due to the large extent of land associated with these cropping systems.

Pasture
A percentage of dairy farms in the Sub-basin still actively graze their cows on pasture. Water quality concerns associated with pasture systems often result from cows having unrestricted access to surface waters, erosion of streambanks from animal traffic, concentration of animals at watering or feeding areas, and sometimes, overgrazing pasture fields. Individual problem sites, especially when in close proximity to streams, can be significant sources of sediment and manure.

Geomorphic Condition
The geomorphic condition of rivers and streams is the other principal resource concern in the Sub-basin. A large percentage (up to 75%) of the Sub-basin's waterways are undergoing adjustment due to past modifications to watershed land cover and hydrology, and man-made channel re-alignments. Some of these modifications date back 150 years to when large areas of Vermont were cleared of forests for agriculture, lumber and the potash industry. This caused significant erosion, leaving a legacy of 1-2 meters of alluvium in some river valleys. In more recent decades, large extents of our river and stream network have been straightened, dredged, and armoured. These many modifications have resulted in geomorphic responses in our waterways such as down-cutting, widening, re-alignments and loss of floodplain access, an important geomorphic function. The overall effect of this instability is an accelerated rate of river erosion and deposition, producing a largely unknown load of sediment to the lake.

NRCS Listed Resource Concerns
NRCS maintains a list of Quality Criteria for Resources Concerns[19] in its Electronic Field Office Technical Guide. The list of concerns and criteria helps guide NRCS employees as they develop conservation plans for landowners and implement conservation programs. The priority resource concerns identified in the Missisquoi Sub-basin are all associated with soil erosion and water quality. These include:

Soil Erosion, Sheet and Rill - Detachment and transport of soil particles caused by rainfall splash and runoff degrade soil quality.

[19] USDA-NRCS, Electronic Field Office Technical Guide (eFOTG), http://www.nrcs.usda.gov/technical/efotg/

Soil Erosion, Ephemeral Gully - Small channels caused by surface water runoff degrades soil quality and tend to increase in size. On cropland, they can be obscured by heavy tillage.

Soil Erosion, Classic Gully - Deep, permanent channels caused by the convergence of surface runoff degrade soil quality. They enlarge progressively by headcutting and lateral widening.

Soil Erosion, Streambank - Accelerated loss of streambank soils restricts land and water use and management.

Water Quality, Excessive Nutrients and Organics in Surface Water - Pollution from natural or human induced nutrients such as N, P, and organics (including animal and other wastes) degrades surface water quality.

Water Quality, Excessive Suspended Sediment and Turbidity in Surface Water - Pollution from mineral or organic particles degrades surface water quality.

Water Quality, Harmful Temperatures of Surface Water - Undesired thermal conditions degrade surface water quality.

Water Quality, Harmful Levels of Pathogens in Surface Water - Kinds and numbers of viruses, protozoa, and bacteria are present at a level that degrades surface water quality.

NRCS conservation programs such as EQIP have been targeted to address these concerns through the ranking and review process. Most conservation plans developed under these programs typically include practices to address one or more of these concerns.

VTDEC Missisquoi Bay Watershed Action Plan

This draft plan for water quality protection and improvement in the Missisquoi Bay Watershed is being developed through discussions by the Missisquoi Bay Watershed Council. It is based on the ideas and concerns of local stakeholders in the Missisquoi Bay watershed. This group is led by Barry Gruessner of the Vermont Department of Environmental Conservation.

Overall Goal:
Water quality in Missisquoi Bay and all streams in its watershed will meet state standards, including phosphorus loading and in-lake concentration targets established in the Lake Champlain Phosphorus TMDL and all additional water-quality impaired stream segments. Of the 39 strategies identified in the VTDEC Plan the following 15 apply directly to actions proposed by the Missisquoi area-wide plan.

Missisquoi Bay Watershed Specific Strategies (Not Ranked)

1. Manage river corridors to increase river bank and channel stability, protecting water quality, land, and infrastructure.
2. Maintain an VAAFM position working with landowners to establish riparian buffers through state and federal programs.
3. Provide implementation funds directly to the Franklin/Grand Isle Farmers Watershed Alliance (FWA) to implement Best Management Practices (includes areas outside of Missisquoi Bay Watershed).
4. Establish a program that provides 100% cost share for low-cost ($10,000 or less), high-impact best management practices (proposed as a statewide program).
5. Continue enhanced assistance for Missisquoi Bay Watershed farmers in implementing Nutrient Management Plans.
6. Further increase the number of engineers and technical assistants available to implement approved agricultural projects in the Missisquoi Bay Watershed.
7. Maximize the potential of the Conservation Security Program for the Missisquoi Bay Watershed.
8. Educate farmers about funding sources to enable them to meet their portion of cost shared conservation practices in a timely manner in those years that milk prices do not fully support farm operations.
9. Assess all farm operations in the watershed to determine the need for water quality protection projects and to provide information on available financial and technical assistance.
10. Continue implementation of the revised Accepted Agricultural Practices on all farms in the watershed including an emphasis on education.
11. Implement Nutrient Management Plans and associated field practices for cropland and grazing land.
12. Eliminate discharges from the production area of farms.
13. Support the expanded use of technology to achieve P reduction while maintaining and enhancing agricultural economic viability including methane digestion, nutrient separation and compost.
14. Reestablish buffers along Vermont waterways with state and federal programs and other mechanisms.
15. Partner with the ANR/DEC River Management Program to seek and develop solutions which will result in water quality while maintaining the economic integrity of the agricultural land base in the basin.

The 39 strategies in the VTDEC Plan address a wide range of issues from residential septic systems to stormwater management. However, a large percent of them are related to agriculture. Of the 39 strategies identified in the Plan, almost half of them are directly related to resource concerns identified by NRCS as priorities for agricultural NPS pollution control. Other major strategies in the VTDEC Plan concern the geomorphic condition of rivers and streams, the restoration of degraded wetlands, erosion from backroads, and failing residential septic systems.