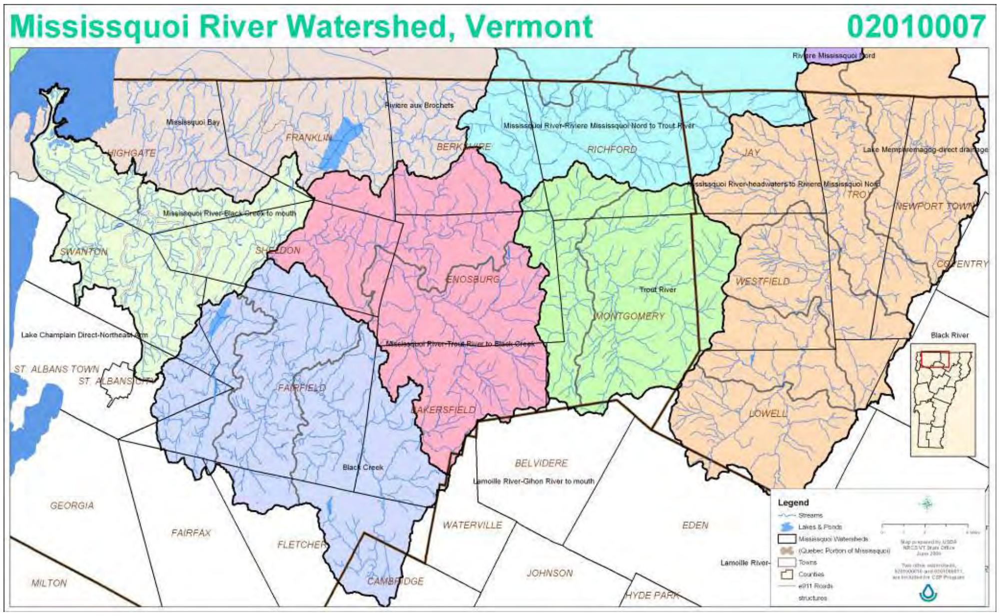
The Missisquoi Areawide Plan

MISSISQUOI RIVER BASIN – VERMONT: A WATERSHED APPROACH TO IMPROVING WATER QUALITY IN LAKE CHAMPLAIN



An NRCS-Led Partnership Project
to
Develop Strategies for Reducing
Agriculturally-Related
Phosphorus Pollution in Missisquoi Bay

January 22, 2008 Draft

Supported by an NRCS 2006
Cooperative Conservation Partnership Initiative Grant

Acknowledgements

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INTRODUCTION

Project Background - Lake Champlain and the Missisquoi Sub-basin

Lake Champlain is one of the largest bodies of freshwater in the world. Most of its 120 mile length and drainage basin is divided between Vermont and New York. The most northern end of the Lake extends into the province of Quebec in Canada. Due to the worsening water quality problems in Lake Champlain the Lake Champlain Special Designation Act (Public Law 101-596**)** was signed into law on November 16th, 1990. This Act has lead to an ongoing multi-jurisdictional effort comprised of the states of New York and Vermont, and the province of Quebec to address water quality and other concerns in the Lake Basin.

Known for its scenic beauty, Lake Champlain attracts millions of tourists each year. It is also the drinking water source for over 200,000 people in Vermont and New York. Unfortunately, it is also a water body with significant water quality problems, particularly in Missisquoi Bay. This Bay is shallow and eutrophic; it experiences severe, and sometimes toxic, algae blooms that typically occur each summer. The Missisquoi Bay watershed covers about 720 square miles in Vermont. Most of it occupies an 8-digit sub-basin (02010007) under the Natural Resources Conservation Service (NRCS) Hydrologic Unit Code (HUC) system. About 20 percent of the Sub-basin lies in Canada. The Canadian portion of the Sub-basin is not considered in this report unless it is otherwise specifically mentioned.

The Missisquoi Bay Sub-basin is a very rural area located in the northwest corner of Vermont adjacent to the Canadian border. It is dominated by forests and agricultural lands which comprise 68 and 21 percent of the land cover, respectively. Urban and other built-up uses comprise only about 5 percent of the land cover in the watershed[1]. Due to the extent of agriculture in the watershed most of the pollutant primarily responsible for the eutrophic conditions in the Bay, specifically phosphorus (P), is from agricultural sources. An estimated 70% of the non-point phosphorus load in the Sub-basin originates from agricultural sources[1].

Agriculture in the Missisquoi Sub-basin is dominated by dairy operations. The phosphorus runoff from animal waste handling facilities and land application of manure and fertilizer are the principal management concerns. Erosion resulting from cropping practices, stream channel instability, and forestry practices also contribute phosphorus-laden sediment to the

[1] Troy A., Wang D. and Capen D., The Rubenstein School of Environment and Natural Resources University of Vermont, Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading. LCBP Technical Report #54, 2007, 121p.

Bay. There is an extensive legacy of phosphorus applications to fields during the early history of farming in the Sub-basin. As a result, some of the alluvial soils along the stream network have accumulated phosphorus throughout the profile. Because of the intensity of agriculture in this area, many of the stream reaches in the Missisquoi Sub-basin are included on the Vermont State 303(d) list as "Impaired Waters" due to agriculture[2]. The Phosphorus Total Maximum Daily Load (TMDL) for Lake Champlain identifies a phosphorus reduction goal of 40 metric tons per year[3]. This is the largest required phosphorus reduction of any lake segment in the Lake Champlain Basin.

Led by efforts under the Lake Champlain Basin Program (LCBP) a plan was developed in 1990, "Opportunities for Action"[4], that provided guidance for addressing water quality and other concerns in the Basin. More recently, Vermont Governor Jim Douglas designated a state Clean & Clear Initiative[5] to improve water quality. This initiative has provided additional State funds to implement targeted water quality improvement and protection programs in the Lake Champlain Basin. Since the most severe water quality problems in the Lake occur in the Missisquoi Bay and nearby St. Albans Bay, a new "Northern Waters" initiative is also underway. This "Northern Waters" effort focuses the State's conservation efforts and funds on Missisquoi and St. Albans Bay, essentially designating these as the highest priorities for water quality remediation in the State.

This Areawide Plan consists of a series of water quality improvement strategies that target efforts to specific priority areas. They have been developed in close consultation with local stakeholders and representatives of various state and federal agencies. These strategies represent a first initial attempt to target conservation efforts in the Sub-basin. NRCS and other co-operating agencies and organizations will continue to refine priorities and targeting methods in the forthcoming years. Most of the methods and procedures developed in this plan for the Missisquoi Sub-basin could be employed in other priority watersheds in Vermont and elsewhere.

Scope of Project

The Missisquoi River Sub-basin (hydrologic unit code 02010007) is large, about 862 sq. mi. (Figure 1). It spans the border between Quebec, Canada and Vermont. Eighty three percent of the Sub-basin is in Vermont. Vermont portions of the Rock and Pike River Sub-watersheds (Lake Champlain Direct Sub-basin, code 02010008), comprising about 148 square miles, will be included in the project area because these sub-watersheds also drain to Missisquoi Bay and make for a more sensible project area. The Rock and Pike River Sub-watersheds are of particular conservation concern for both partners and the NRCS due to

[2] Vermont Department of Environmental Conservation, State of Vermont 2006 303(d) List of waters Water, March 1, 2007, 10p.
[3] Vermont Agency of Natural Resources, Department of Environmental Conservation, Lake Champlain Phosphorus TMDL, September 25, 2002, 130p.
[4] Lake Champlain Basin Program, Opportunities for Action Lake Champlain Management Plan, April 2003, 138p.
[5] Vermont Agency of Natural Resources, Center for Clean and Clear DRAFT Work Plan, August 29, 2007, 86p.

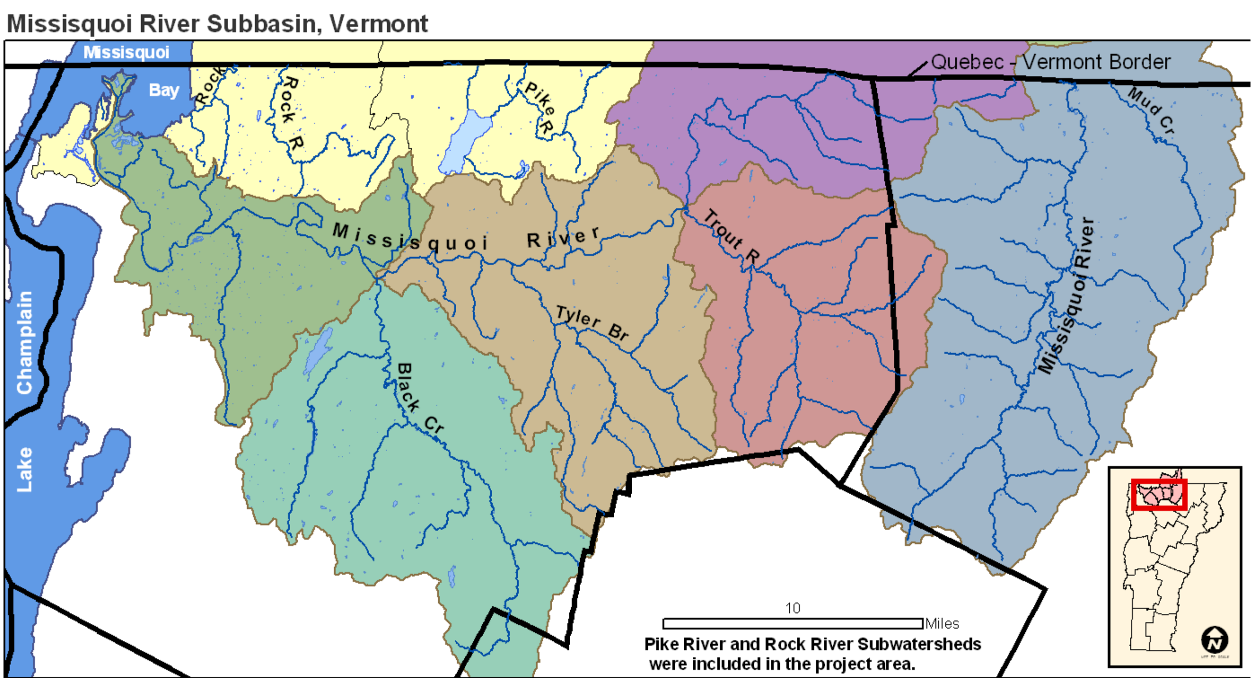
their large contributions of phosphorus to the Bay. All of these collective watersheds are referred to as the Missisquoi Sub-basin throughout this report.

Need for an Area-wide Plan

Conservation measures to remediate water quality problems in Missisquoi Bay have been conducted for several decades. NRCS, the Farm Service Agency (FSA) and the Vermont Agency of Agriculture, Food and Markets (VAAFM) have targeted this area for conservation programs since the early 1980's. More recently, the State of Vermont has also undertaken efforts to reduce phosphorus discharges from point sources such as sewage treatment plants and urban stormwater outlets. To date, millions of dollars of conservation funds have been spent in the Sub-basin with as yet no observable improvement in water quality.

At this point in time no formal plan has been developed for conservation efforts in the Missisquoi Sub-basin. Conservation implementation actions are largely conducted on a first come, first served basis working primarily with farmers who apply for conservation program cost-share funds. In addition, there has been no comprehensive database, including geospatial information, to help compile, integrate, and analyze the various resource needs in the Sub-basin. The development of this comprehensive database, in conjunction with a well thought out plan, will enable the effective targeting of restoration efforts. In the future, this data will also be used to help evaluate the effectiveness and success of conservation efforts in the Missisquoi Sub-basin and direct watersheds

Figure 1 - Map of the Missisquoi Sub-basin and Sub-watersheds.



Annual expenditures of conservation funds in the Missisquoi Sub-basin total several million dollars. The total annual expenditures by NRCS for all of its conservation programs is estimated to be between 1 - 2 million dollars per year. The State of Vermont also has several well funded conservation programs with expenditures of less than 1 million dollars per year in the Sub-basin. In addition, the U.S. Environmental Protection Agency and the International Joint Commission, through the LCBP, expects to allocate more than $400,000 for monitoring and phosphorus reduction in the Missisquoi Sub-basin. However, these funds appear to be insufficient when compared to the total conservation need.

In the agricultural sector alone, initial anticipated conservation systems needed for all Sub-basin farms include over 200 waste storage facilities, 185 barnyard runoff control systems, conservation crop rotation on 2,550 acres, 180 comprehensive nutrient management plans, 800 acres of filter strips, and over 300 acres of forested riparian buffer[6]. Based on these NRCS estimates, the total estimated implementation need in the Missisquoi Sub-basin is approximately $30,804,500 (Table 1). Obviously, the total conservation needs far exceed the funds available to address these needs. In order to achieve significant improvements in water quality, these limited conservation funds must be spent as effectively as possible.

Project Objectives

NRCS and its partners will develop tools which compile existing data with new data inventories to characterize resource problems, target land-based implementation efforts, and leverage NRCS programs with state and local partner programs. This framework will be refined throughout the project to improve its application in future priority sub-basins. The implementation phase will utilize Farm Bill programs with other available federal, state and local programs to implement targeted conservation practices that optimize environmental benefits.

This project will develop a watershed-based Area-wide plan that will reduce the Phosphorus load delivered to Missisquoi Bay. The plan is structured to inform and help partner agencies and cooperating farmers schedule their work in the Missisquoi to complement each others' efforts, addressing the most pressing resource concerns first. The Missisquoi Sub-basin is a Conservation Security Program (CSP) Priority Watershed and this plan will provide extensive information to guide CSP program delivery.

Geospatial analysis and simple hydrologic modeling are used in a watershed approach, to examine where conservation interventions are likely to have the greatest impact. This includes assessing which sub-basins and farm/field locations are the greatest pollution source areas, which stream reaches are transporting the largest amounts of sediment and phosphorus downstream, and where conservation practices, channel modifications, wetland enhancements, and other actions will have the greatest potential for phosphorus reduction.

[6] USDA-NRCS, personal communication with Kathryn Hakey, 2007.

Table 1 - Missisquoi Sub-basin, Vermont - Conservation Needs (60% participation), with Costs.

			Completed		Obligated		Remaining	
Practice Name	**Unit**	**Ave. Unit Cost**	**#**	**Est. Dollars FA**	**#**	**Est. Dollars FA**	**~#**	**Est. Dollars FA**
Waste Storage Facility	each	70,000	**19**	**1,330,000**	**41**	**2,870,000**	**205**	**14,350,000**
Manure Transfer	each	20,000	**28**	**560,000**	**37**	**740,000**	**185**	**3,700,000**
Heavy Use Area Protection	each	40,000	**12**	**480,000**	**37**	**1,480,000**	**185**	**7,400,000**
Composting Facility	each	20,000	**4**	**80,000**	**8**	**160,000**	**40**	**800,000**
Roof runoff Structure	each	7,500	**15**	**112,500**	**37**	**277,500**	**185**	**1,387,500**
CNMP	each	500	**24**	**12,000**	**36**	**18,000**	**180**	**90,000**
Nutrient Management	acre	18	**5700**	**102,600**	**9900**	**178,200**	**49500**	**891,000**
Conservation Crop Rotation	acre	250	**150**	**37,500**	**510**	**127,500**	**2550**	**637,500**
Residue Management	acre	45	**0**	**0**	**260**	**11,700**	**1300**	**58,500**
Streambank/Shoreline Protection (bio)	linear foot	50	**1100**	**55,000**	**1300**	**65,000**	**10000**	**500,000**
Cover Crop	acre	25	**225**	**5,625**	**800**	**20,000**	**4000**	**100,000**
Riparian Forest Buffer	acre	2,500	**18**	**45,000**	**28**	**70,000**	**308**	**770,000**
Filter Strip	acre	150	**50**	**7,500**	**160**	**24,000**	**800**	**120,000**
	Totals			**2,827,725**		**6,041,900**		**30,804,500**

This Missisquoi Areawide Plan pulls together data collected to date and provides a newly developed framework for incorporating geomorphic and geospatial information into the VT Department of Environmental Conservation (DEC) Missisquoi Basin Plan and the Clean and Clear Work Plan. This planning framework may then be used in future Basin Plans being developed for the State's 16 other priority sub-basins. The Geographic Information System (GIS) inventories and analyses will drive and target land-based implementation efforts planned for the Sub-basin by willing partners who will leverage NRCS programs with state and local programs to optimize environmental results.

Specific objectives of the Missisquoi Areawide Plan include:
i. Integrate existing and newly developed databases for the Sub-basin, and collect missing information needed to identify major sources of P.
ii. Use stream geomorphic data to highlight priority reaches, and improve access to the

data by all partner agencies.
iii. Describe P transport and sequestration mechanisms within the Sub-basin, and develop a model to analyze P transport, sedimentation and delivery.
iv. Incorporate farmer resource concerns into the planning process and relate to target areas.
v. Collaboratively determine conservation priorities, using GIS to analyze compiled data to more efficiently and effectively develop solutions to address those priorities.
vi. Develop a coordinated, spatially-enabled approach to implementation; optimize and foster strategies by agencies, local organizations, and farmers.

The newly developed framework for incorporating geomorphic and geospatial information into the Missisquoi Bay and future watershed plans will be achieved through active collaboration. NRCS and its partners will use tools developed for this Areawide Plan which compile existing data, and develop new data inventories to characterize resource problems, target land-based implementation efforts, and leverage NRCS programs with state and local partner programs to optimize environmental results. This framework will be refined as necessary to improve its application in future priority sub-basins.

Project Partnerships

NRCS provided overall management and support, as well as data collection, organization, and GIS analysis as part of this project. Funds were used to support NRCS staff, for development of a web-based planning tool by DEC, and to support graduate research work at the University of Vermont (UVM). Other partners included the Vermont DEC, Water Quality Division (VTDEC); the Franklin County and Orleans County Conservation Districts; the USDA FSA; the Lake Champlain Basin Program (LCBP); the U.S. Fish and Wildlife Service (USFWS); the Missisquoi River Basin Association; the Northwest Regional Planning Commission (NRPC); the UVM Rubenstein School of Environment and Natural Resources, the UVM Extension System; and the VAAFM.

The LCBP has been working in the Lake Champlain Basin since the initiation of the Lake Champlain Designation Act. Their efforts have focused research and implementation funds to address critical issues throughout the Basin. These ongoing efforts were coordinated with the Missisquoi Areawide Plan. Priorities identified in this plan will help further focus research and conservation efforts not only in the Missisquoi Sub-basin, but throughout the Basin as a whole.

The VTDEC has ongoing programs associated with the Missisquoi Sub-basin that will be coordinated with this area-wide plan. The VTDEC has initiated targeted water quality implementation programs through its Clean and Clear Program as well as the new Northern Waters Initiative. These efforts will benefit directly from the area-wide plan. They are also in the process of developing a watershed plan for the Missisquoi Sub-basin that has focused on developing priorities based on the input of local stakeholders.

Several ministries and organizations in the Canadian Province of Quebec are also actively addressing agricultural runoff issues in their portion of the watershed. In addition, farmers in the Sub-basin have formed a Watershed Alliance in the past year, with the purpose of assisting their peers with technology, farm planning, and environmental goal-setting.

One project partially funded by the Missisquoi CCPI grant is the software development of a GIS web-based planning tool. The tool is designed to gather disparate records from VTDEC's Stream Geomorphic Assessment databases, summarize and deliver information within a GIS interface. It has been specifically designed for partners' planning and decision making needs. It will be used to assist with decision-making for applications in programs such as CREP, Partners for Wildlife, WHIP, EQIP, and AMA.

Another project was partially funded through the UVM Rubenstein School of Environment and Natural Resources. The CCPI funds were leveraged with UVM funds to support a full time graduate student who performed data collection and analysis of phosphorus from water samples collected during storm events at stream confluences in the Hungerford Brook Sub-watershed. Additionally, UVM provided laboratory phosphorus analysis of soil samples collected throughout the watershed. These data will be used to develop a conceptual model to better characterize P transport dynamics in Hungerford Brook Sub-watershed.

Anticipated Results and Benefits

NRCS and the conservation partnership will: 1) use the newly developed framework for incorporating geomorphic and geospatial information into the Missisquoi Basin Plan to target implementation efforts; 2) prioritize and leverage NRCS programs with state and local partner programs to optimize environmental results; 3) help solve water quality problems in Missisquoi Bay and remove identified stream segments from the state's 303(d) list; and 4) establish a methodology for addressing water quality resource concerns in other, future priority watersheds in Vermont. This suite of changes will help the partnership reduce the total cost for effective conservation implementation in the project area by as much as 50%.

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.

[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.

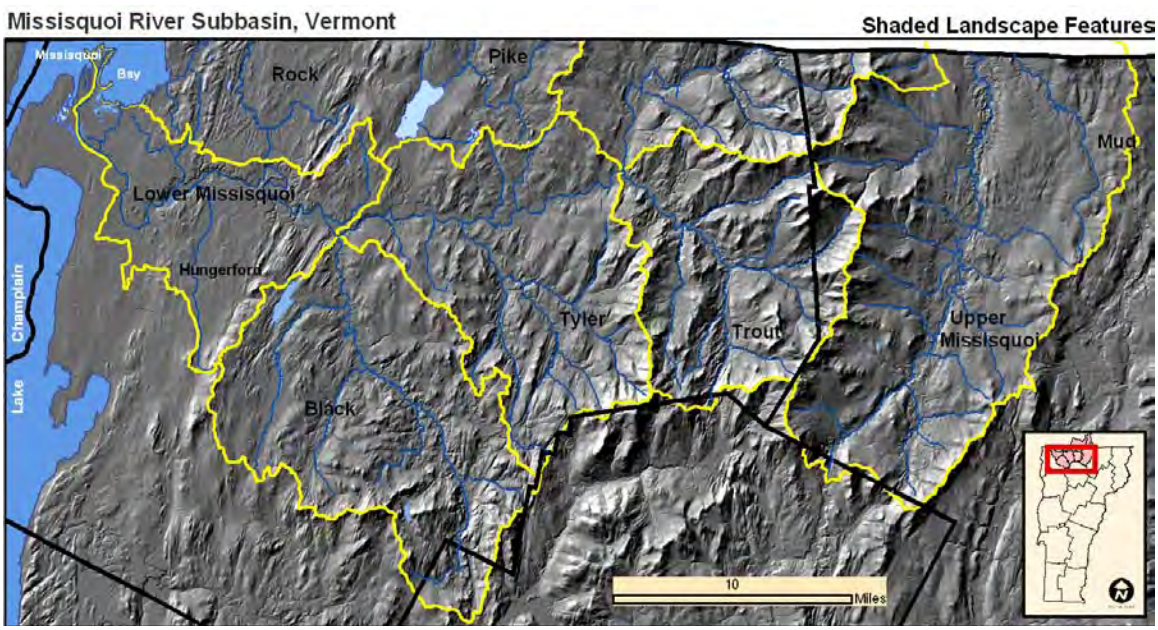


Table 2 - Slope Classes in the Sub-basin by Acres and Percent of Total.

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].

<u>Champlain Valley:</u> 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.

<u>Northern Vermont Piedmont:</u> 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.

<u>Northern Green Mountains</u>: 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

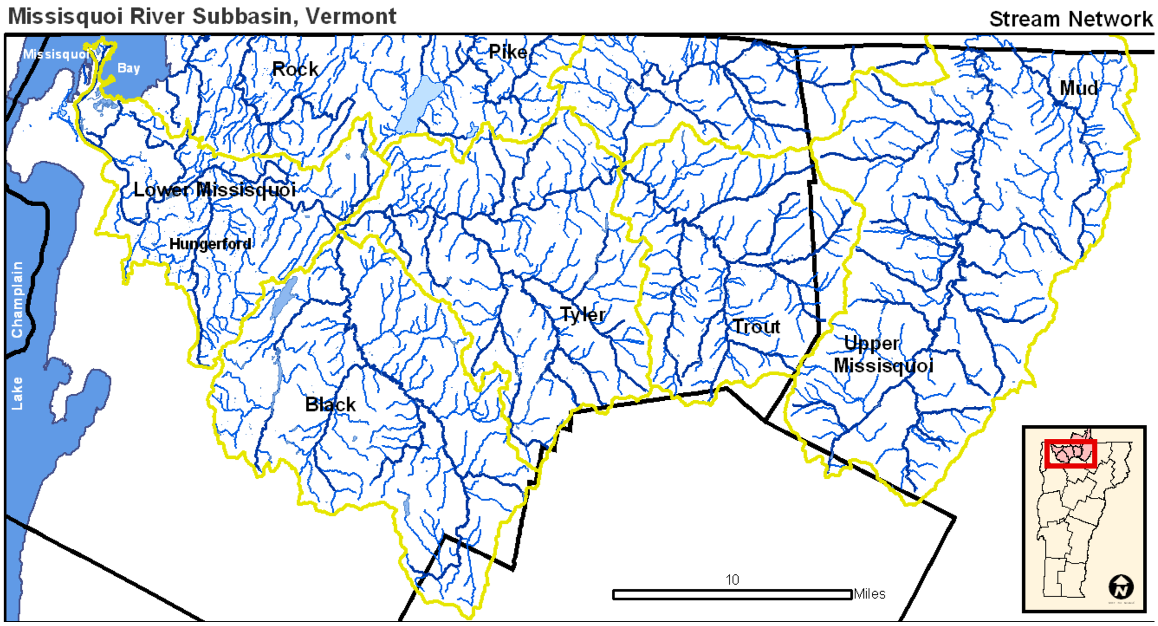
Trends in Land Use and Land Cover for the Missisquoi Sub-basin

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%
  - Forest – 69%
  - Developed – 4%
  - Other Land – 1%
  - Water – 1%

- 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.

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[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).

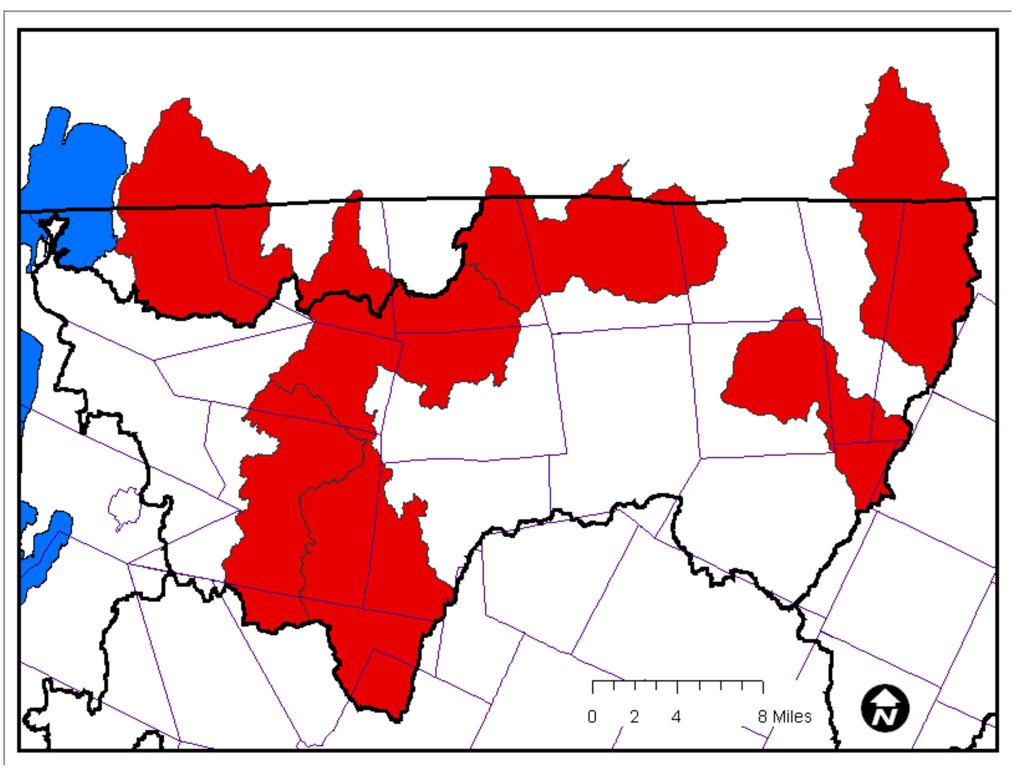
Table 5 - Land-Use/Land-Cover as Percentage of Sub-Watershed.

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.

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[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.

COMPONENTS OF THE AREA-WIDE PLAN

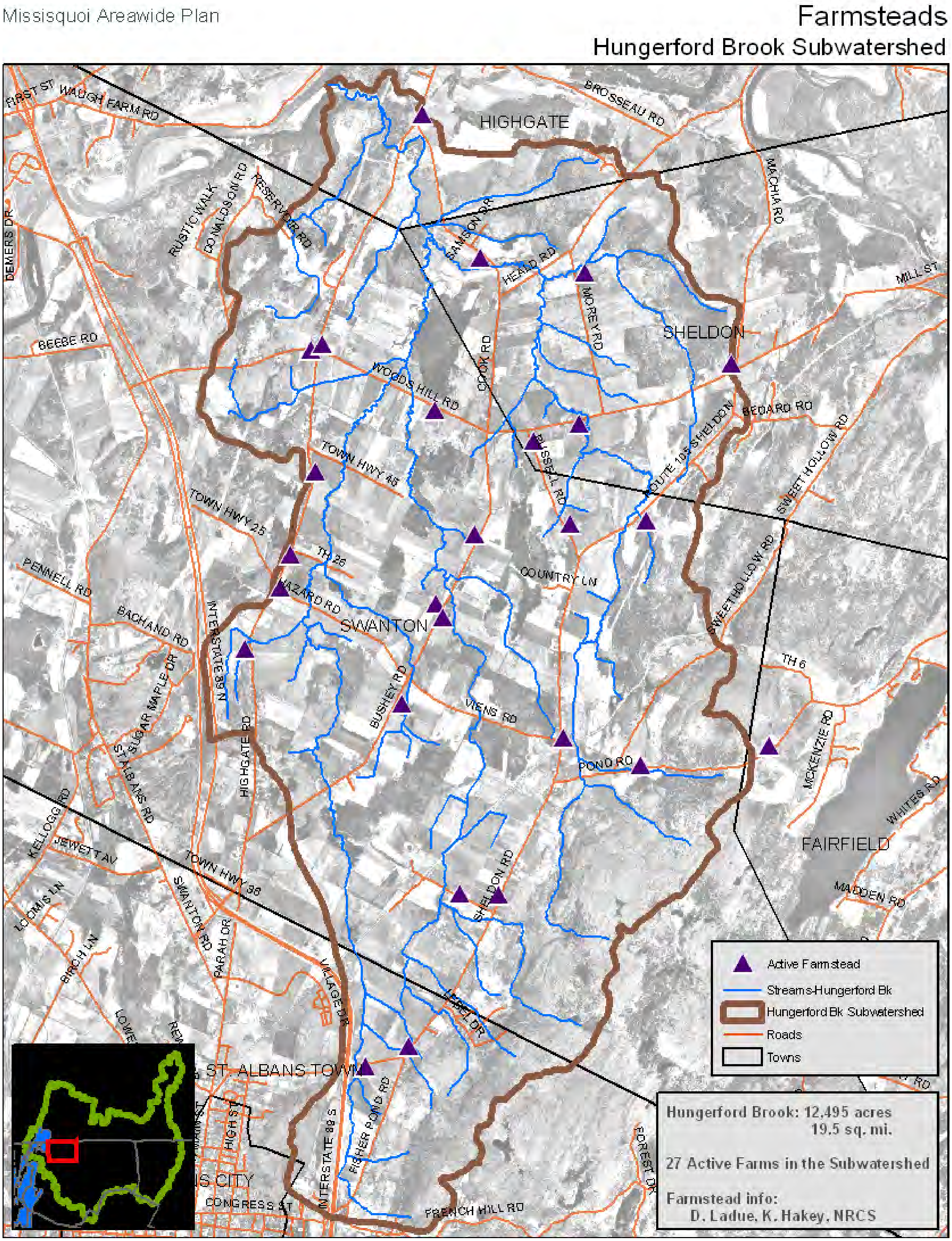
The major components of the Area-wide Plan focus on agricultural land, streams and stream corridors. The collected and analyzed data will be used to identify priority treatments for the Sub-basin and to spatially target conservation measures throughout the Sub-basin and the sub-watersheds.

Farmstead Mapping

Most agricultural operations, including dairy operations, exhibit an area of concentrated use and activity. These farmstead areas are typically comprised of animal housing (barn), a milking center, an outside livestock concentration area, manure storage and feed storage areas. Because of the intensity of use, there is often the potential for significant discharges of manure and nutrients such as phosphorus from farmsteads. There are no readily available, up to date GIS layers depicting the location and describing the characteristics of these farmsteads. The Missisquoi Plan began the process of farmstead data collection with a pilot project in the Hungerford Brook Sub-watershed. The procedures developed to map farmsteads in the Hungerford Sub-watershed are found in Appendix B.

The resulting map allows USDA conservation planners and partners to identify potential sources of contaminants, estimate workloads, and better track past practice implementation. The maps will be primarily used by NRCS internally. Figure 5 provides an example farmstead location map developed for the Hungerford Brook Sub-watershed.

Figure 5 - Example Farmstead Location Map for the Hungerford Brook Sub-watershed



Annual Crop and Hay Lands Mapping

Background

The US Department of Agriculture, Farm Service Agency maintains an agricultural lands polygon data layer for their work with farmers that participate in USDA programs. It is maintained as the Common Land Unit layer, or CLU. The CLU layer, depicting cropland and other areas on a farmer's tract, was used as the basis to develop a corn and hay data layer for the Missisquoi Areawide Plan. Corn and hay fields in production in 2003, but not included in the CLU, were added to the layer by digitizing on-screen using 2003 natural color photography from the National Aerial Photography (NAIP) and ESRI's ArcMap software. These polygons were independently verified as cropland by the University of Vermont Spatial Analysis Lab (SAL), and by the Areawide Plan team. Detailed procedures developed to identify types of agricultural land are located in Appendix C.

The resulting layer can be differentiated within a GIS by attributing corn, hay, and other agricultural fields. NRCS had planned to map pasture lands as part of the Areawide Plan; but determined that available aerial orthophotography to be insufficient for accurately identifying and mapping pasture lands, especially grazed pasture. The digital pixel resolution for NAIP is 1.0 meter. It is simply too coarse to conduct accurate mapping for grazed pasture and idle land.

The distinction between grazed pasture, idle pasture, and other herbaceous areas is important to assess impacts of grazing animals on water quality, especially with respect to streams and streambanks. Pasture mapping, considered to be of value in conservation planning, needs to be conducted with higher resolution photography. The agency partnership, fostered by the Areawide Plan and Vermont's Clean and Clear Initiative, is working to find funding sources for the purchase of high resolution photography.

Extent of Corn and Hay

In 2003 the Missisquoi Sub-basin contained 71,939 acres of cropland, 17,114 of these acres were planted to corn (see Table 8). Hay was managed on 50,009 acres. Only 4,816 acres were planted to other unidentified crops. It is not known how many of the corn and hay acres are continuously planted to the same crop. Most of the crop fields in the Missisquoi Sub-basin are managed in a corn and hay rotation of varying length. Figure 6 shows the geographical location of corn and hayland in the entire Missisquoi Sub-basin in the year 2003. Cropland is concentrated in the western half of the Sub-basin and the far eastern sub-watersheds. The higher concentration of corn acreage in the far western sub-watersheds is also obvious.

The extent of corn and hay acreage varies considerably between the sub-watersheds. The Rock River Sub-watershed had the highest acreage of corn at 3,296 acres, while the Trout River Sub-watershed only had 393 acres. This variation is partially due to the size of the Sub-watershed, as well as the extent of available good agricultural land. The Black Creek Sub-watershed had 8,652 acres of hay, while the Trout River only had 1,406 acres of hay.

Figures 7 and 8 show the high concentration of total cropland and corn acres in the Rock River and Hungerford Brook Sub-watersheds.

Cropland Slope Analysis

Terrain of the cropped landscape in the Missisquoi Sub-basin varies considerably. Even in the relatively flat areas of the Lower Missisquoi, glacial and fluvial activity have resulted in rolling terrain, such that 40% of the cropland occurs on slopes exceeding 8% (Table 8).

Figure 9 provides an example of mapped cropland slope classes for the Rock River Sub-watershed. Two thirds of the total cropland (47,146 ac, or 66%) is on slopes steeper than 8%. Corn is generally on the lower slopes throughout the Sub-basin. Forty-four percent of the corn acres are on slopes of 0-3%, and 40% are on slopes of 3% to 8%. Hay, conversely, is generally on steeper slopes, with 74% of the acres on slopes of 3% to greater than 8%.

There is considerable variation in slope of cropland between the sub-watersheds. In headwaters areas of the Trout River, the landscape consists of steeper mountain valleys. Croplands are sparse and 58% of the fields have areas of steep slopes (more than 8%). In the Hungerford Brook to mouth Sub-watershed only 18% of the cropland is on slopes steeper than 8%. In the "Trout River to Canada" Sub-watershed upwards of 38% of the corn acres are on slopes greater than 8%. In other watersheds, such as the Hungerford Brook to mouth Sub-watershed, most of the corn (81% for the Hungerford Brook to mouth Sub-watershed) is on slopes of 0% to 3%. Hay fields generally tend to be on steeper slopes. The Tyler Branch Sub-watershed has one of the highest percentages of hay on steep slopes with 58% of the hay acres on slopes greater than 8%.

Table 8 - Extent of Water Quality Concerns by Watershed, with Important Sub-watersheds Noted.

10-digit Watershed Name (data for specific subwatersheds indented)	Land Area in Watershed	Cropland, all types	Land in Corn, 2003	Land in Hay, 2003	Cropland on Steeper Slopes (>=8%)	Cropland Adjacent to Steep Slopes (>25%)	Land in Corn, 2003, 0-3% Slopes	Land in Corn, 2003, 3.01-8% Slopes	Land in Corn, 2003, 8.01+% Slopes	Land in Hay, 2003, 0-3% Slopes	Land in Hay, 2003, 3.01-8% Slopes	Land in Hay, 2003, 8.01+% Slopes	Crop Fields with Good No-Till Potential	Restorable Wetlands	Streambank (left & right considered separately)	Streambank with Riparian Buffer Gaps
(data for Subwatersheds indented)	----------acres in USA----------														----------miles in USA----------	
Missisquoi Bay	38,870	10,490	3,519	6,612	6,268	1,999	1,273	1,644	602	2,401	2,766	1,341	1,584	1,989	201	99
Rock River (subwatershed)	36,196	8,678	3,296	5,198	5,656	1,968	1,105	1,590	601	1,634	2,326	1,197	1,209	1,151	195	97
Riviere aux Brochets	25,133	6,037	1,263	4,587	4,609	743	288	637	338	806	2,096	1,662	1,726	329	179	
Pike River (subwatershed)	27,614	3,467	756	2,617	2,649	498	193	408	155	408	1,158	1,039	1,006	291	94	
Missisquoi River - Black Creek to mouth	44,638	11,332	5,226	5,907	4,340	1,779	3,164	1,710	352	3,027	2,240	590	4,721	2,592	347	165
Missisquoi River - Hungerford Brook to mouth (subwatershed)	16,147	3,559	1,735	1,786	656	484	1,397	315	23	1,149	539	61	852	1,820	107	48
Hungerford Brook (subwatershed)	12,495	5,014	2,080	2,777	2,024	290	1,176	830	74	1,417	1,183	168	2,393	603	112	64
Black Creek	76,855	10,812	1,777	8,652	7,749	2,858	854	528	395	1,753	3,351	3,537	1,933	735	491	156
Missisquoi River - Trout River to Black Creek	68,679	13,430	3,494	9,602	9,591	4,121	1,336	1,401	757	1,921	3,444	4,181	4,240	352	444	190
Tyler Branch (subwatershed)	37,100	4,022	608	3,342	3,202	1,562	172	249	187	516	890	1,899	1,161	63	227	68
Trout River	53,493	1,916	393	1,406	1,114	942	318	40	35	357	444	595	717	50	330	45
Missisquoi River-Riviere Missisquoi North to Trout River (aka "*Trout River to Canada"*)	36,376	4,358	840	3,358	3,114	1,195	356	219	265	604	1,434	1,316	975	160	200	71
Missisquoi River-headwaters to Riviere Missisquoi Nord (aka "*Upper Missisquoi River" - 4 subwatersheds*)	111,880	7,356	582	6,364	5,140	1,071	208	281	93	1,571	3,491	1,274	3,153	304	514	128
Mud Creek (subwatershed)	36,703	6,208	657	5,297	5,221	683	21	516	120	634	3,663	921	509	124	153	78
Totals for Plan Project Area*	492,627	71,939	17,114	50,009	45,648	15,391	7,583	6,794	2,737	12,818	22,159	15,032	19,558	6,635	3,594	1,209

Figure 6- Mapped Corn, Hay and Other Cropland Acres in the Missisquoi Sub-basin.

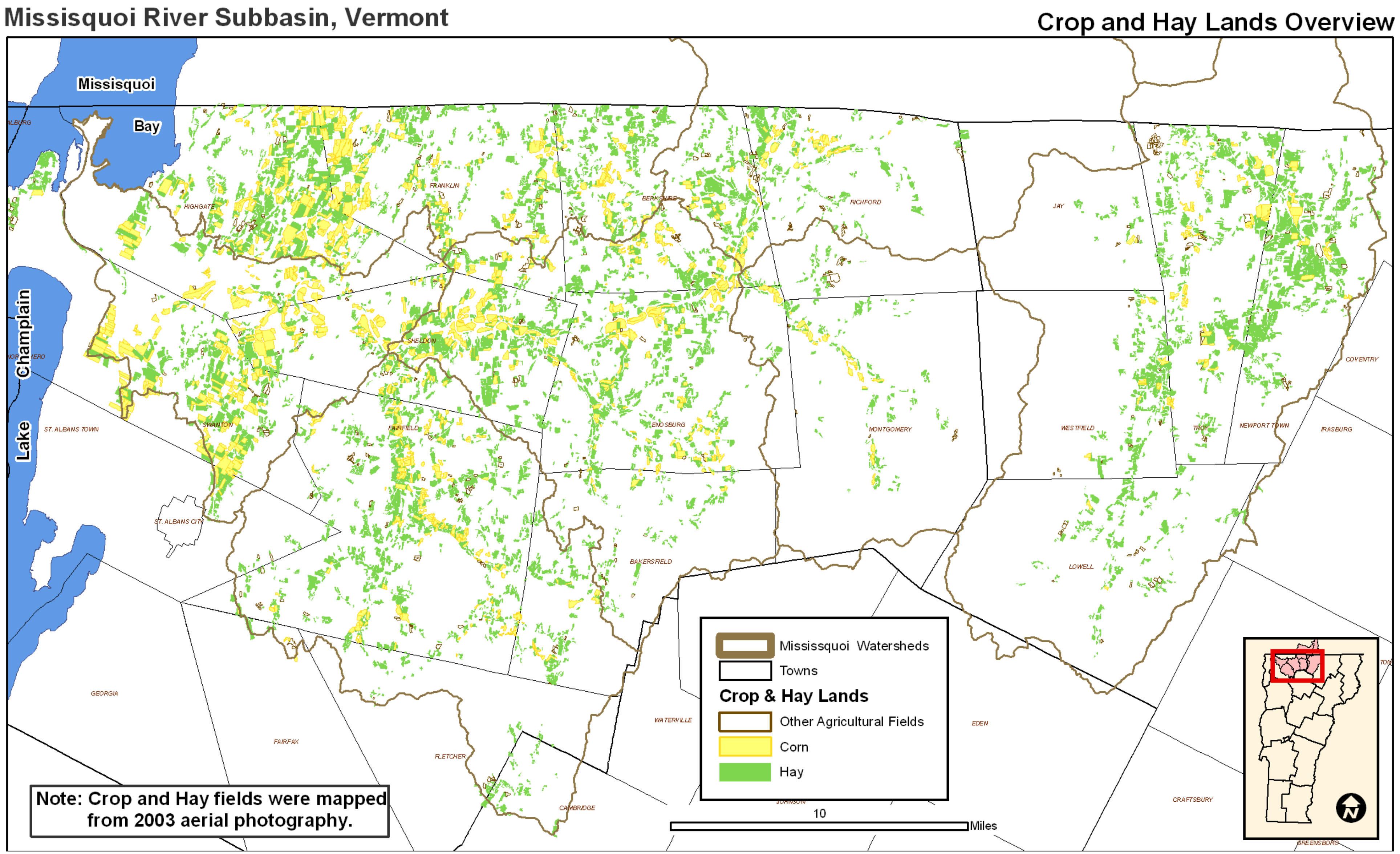


Figure 7 - Mapped Corn, Hay and Other Cropland Acres in the Rock River Sub-watershed.

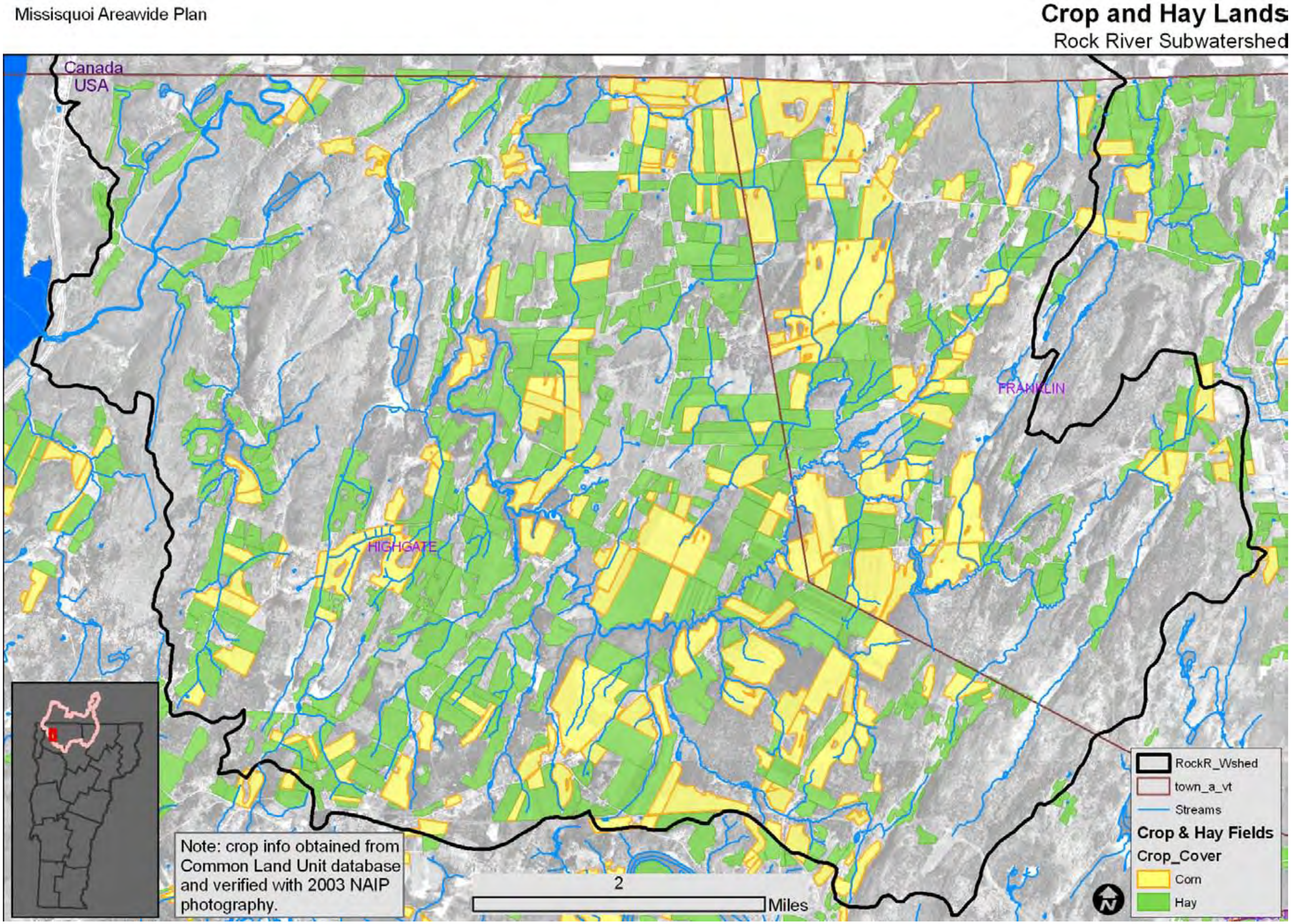


Figure 8- Mapped Corn, Hay and Other Cropland Acres in the Hungerford Brook Sub-watershed.

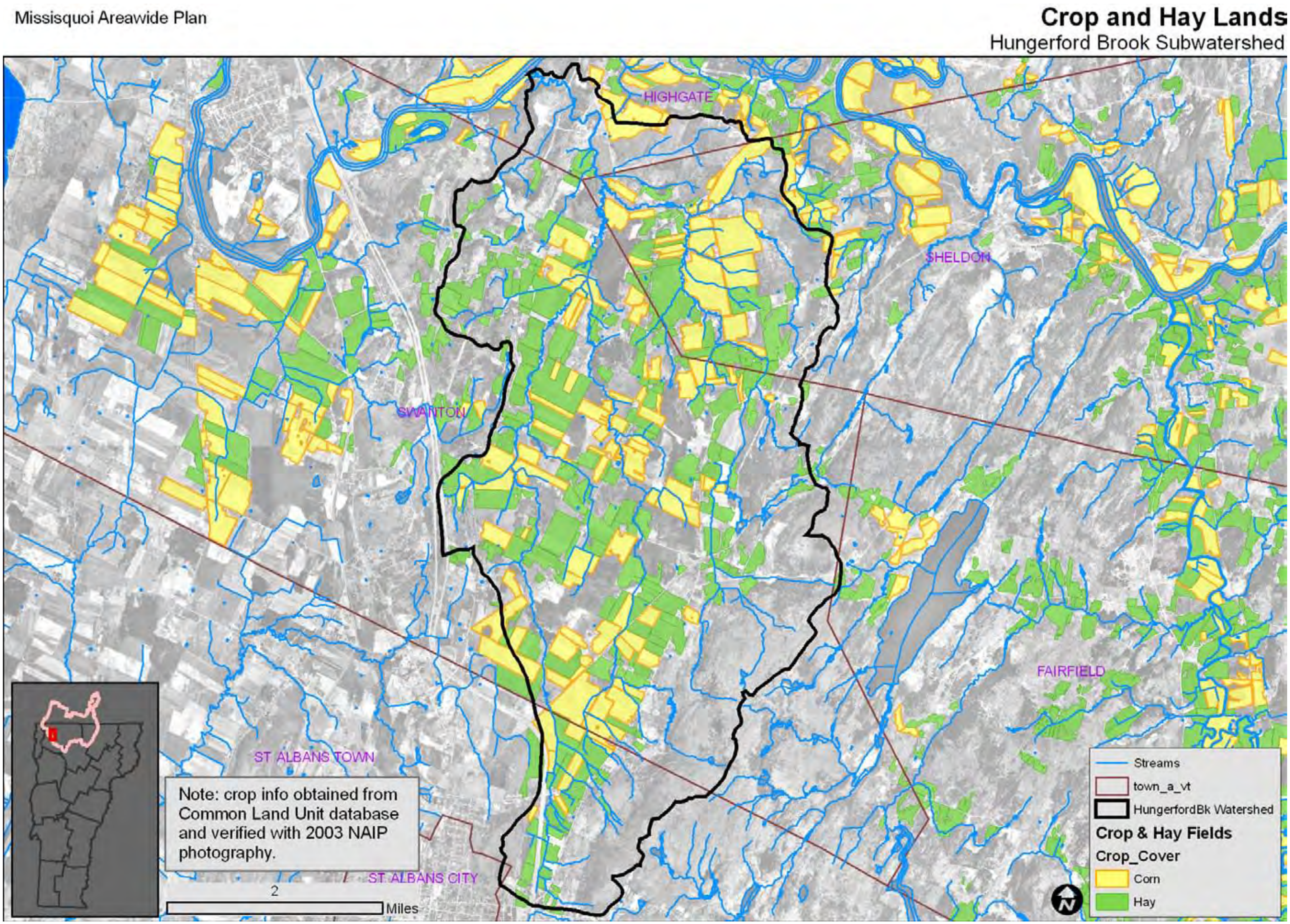
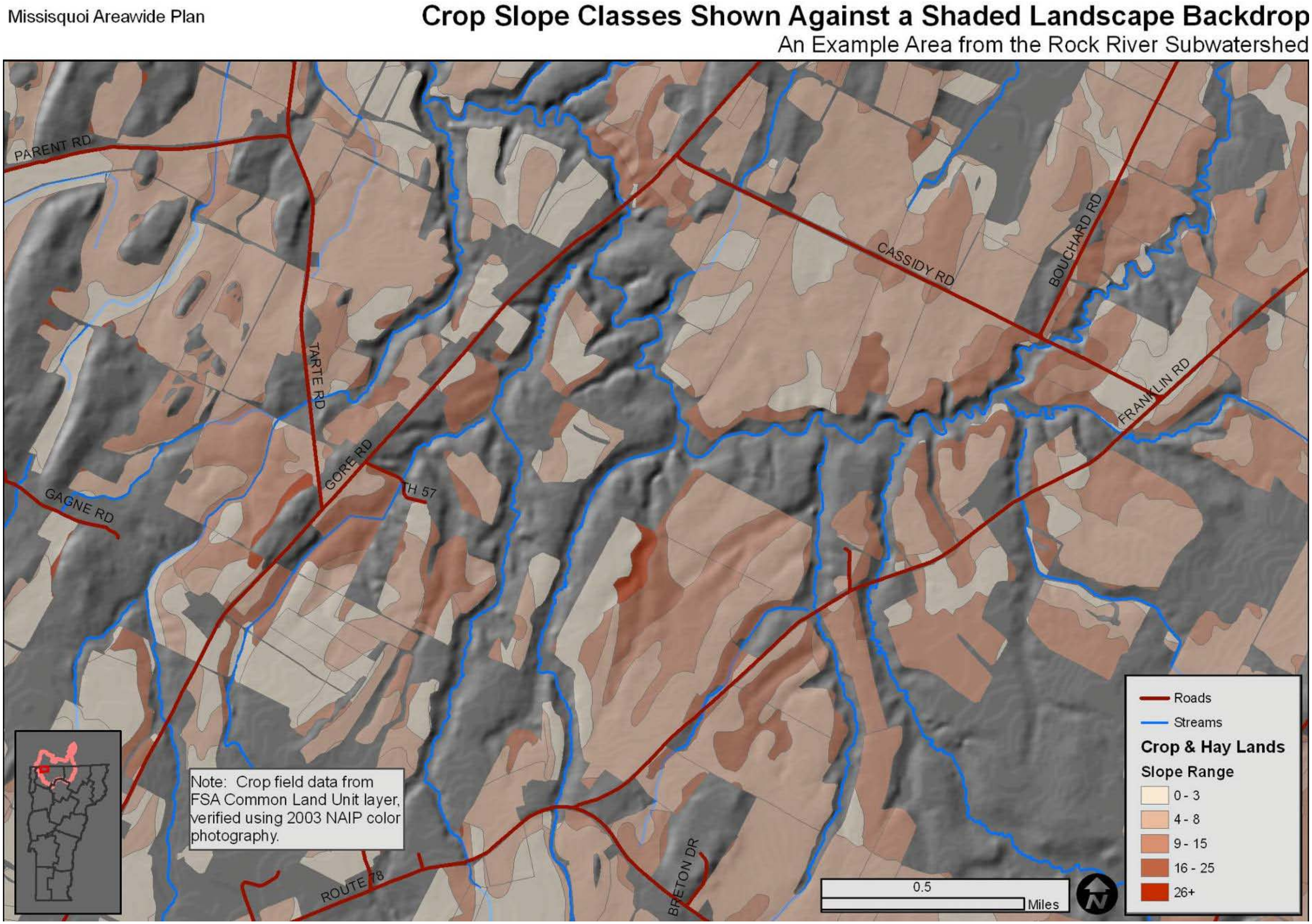


Figure 9 - Cropland Slope Classes for the Rock River Sub-watershed.



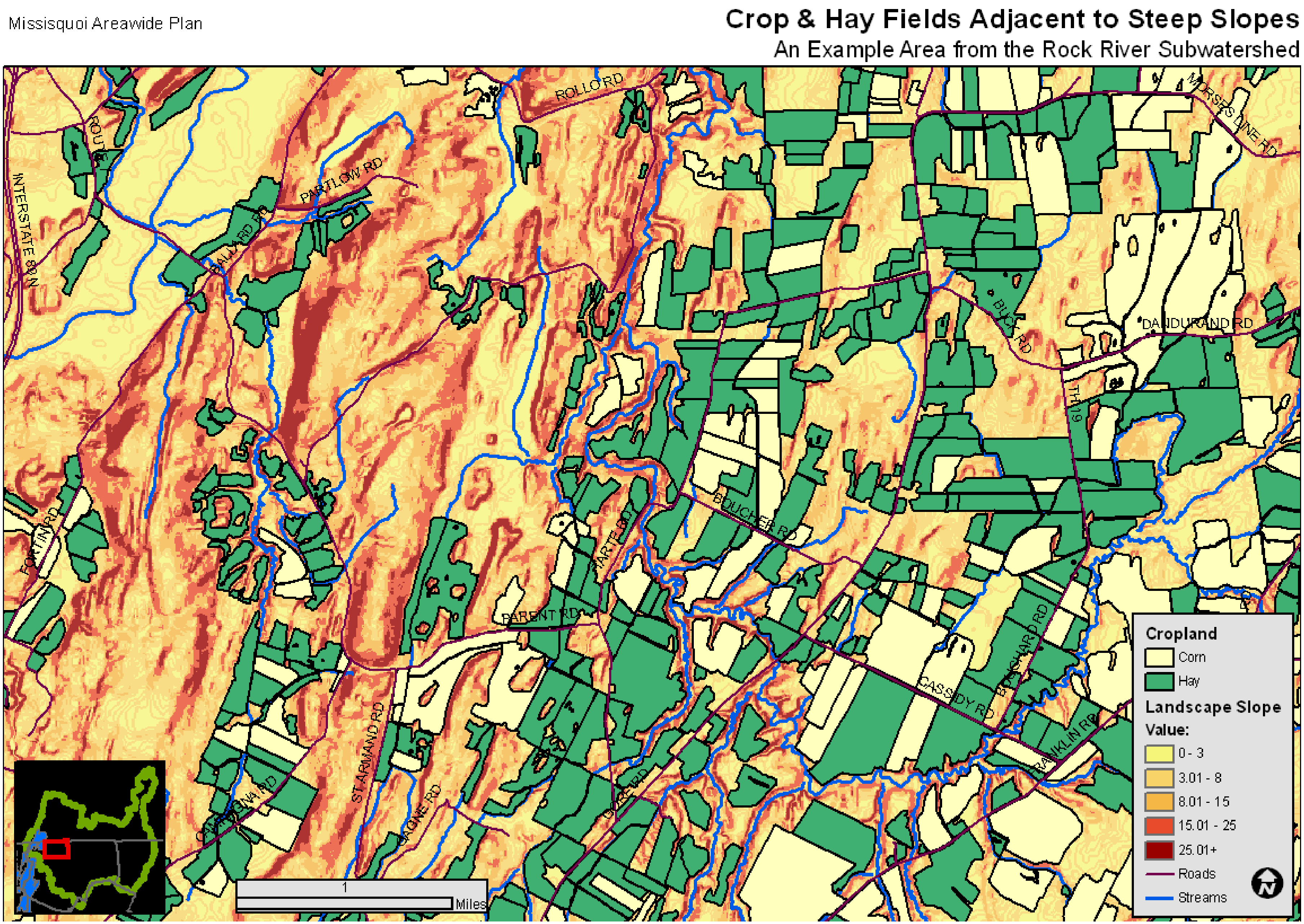
Cropland and Steep Slope Adjacency

Cornfields with adjacent steep areas are a common land feature in certain watersheds of the Sub-basin. These landforms are typified by relatively flat plateaus with deeply incised stream valleys. Erosion and subsequent delivery of sediment and phosphorus to waterways is at a heightened risk for these fields. An analysis of this erosion risk was undertaken using a subset of slope polygons derived from existing elevation data (Vermont Center for Geographic Information's HydroDEM raster layer) to identify these areas in one pilot sub-watershed.

Many crop fields in the Rock River Sub-watershed are adjacent to areas with slopes of more than 25%. Adjacency is defined as a 1-meter separation in this study. For example, in the Rock River Sub-watershed, 23% (1,968 acres) of cropland acres are within a meter of steep slopes. These breaks are commonly found along edge of historically incised river valleys. The darker orange and brown areas depicted in Figure 10 displays these steep areas located adjacent to crop fields.

In many cases these fields have no buffer between the cropped areas and the steep slopes. As such, these areas are susceptible to the formation of classic gullies which can then head cut into the crop fields, if left untreated. NRCS and its conservation planning partners will use this information to promote practices to control gully erosion in those fields identified as being at risk. This includes practices such as grade stabilization structure, permanent seeding to grass, reduced tillage, cover crops, grassed filter strips and riparian forest buffers.

Figure 10 - Crop and hay Fields Adjacent to Steep Slopes



Stream Geomorphic Assessment Data Viewer

The Stream Geomorphic Assessment Data Viewer provides a new, user friendly method for land managers and planners to gain access to the growing database of assessed streams across Vermont. Development of this viewer by the Vermont DEC River Management Program was partially funded by NRCS through the Missisquoi Area-wide Plan CCPI grant.

In the past, gaining information about the geomorphic condition of a stream required working with a river scientist to determine the proper reach number and then pursue a cumbersome search of the SGA Data Management System to find reports. Now, any user familiar with basic GIS can use the online viewer to zoom to a stream in Vermont and be able to view aerial photographs, topographic maps and various vector GIS layers such as roads, surface water, and buildings. Where the streams have been assessed, there is much more information.

Phase 1 Stream Geomorphic Assessment Data

Where Phase 1 assessments have been completed, the user can view the approximate river corridor as well as the complete Phase 1 report for a reach within a watershed. The river corridor, as defined by DEC River Management, includes lands defined by the lateral extent of a stream's meanders necessary to maintain the dimension, pattern, profile, and sediment regime of the stream in equilibrium. This is an important piece of information for NRCS planners and partners in the state for stream restoration projects and buffer establishment, particularly on straightened or unstable streams. The Conservation Reserve Enhancement Program (CREP) uses the "River Corridor Approach" as planning guidance to help determine the extent of planned buffers on unstable reaches where the area and configuration of buffer is expected to change over time as the river moves toward equilibrium. This information is also important for landowners along Vermont's rivers. These corridors visually highlight potential areas of flood and or erosion hazard and would be areas to limit or preclude investments such as roads and buildings.

The Stream Geomorphic Assessment Data Viewer can be used to display a variety of information from the Phase 1 database. Figure 11 provides an example map from the data viewer showing a river corridor (in yellow) defined for a section of the Tyler Branch. The Phase 1 report provides general information about the watershed and selected reaches, which is the first level of assessment. This information is gathered primarily by remote sensing as well as windshield surveys. Figure 12 shows the type of data included in a Phase I Reach Summary Report.

Figure 11 - Example of a River Corridor (in yellow) Displayed through the Stream Geomorphic Assessment Data Viewer.

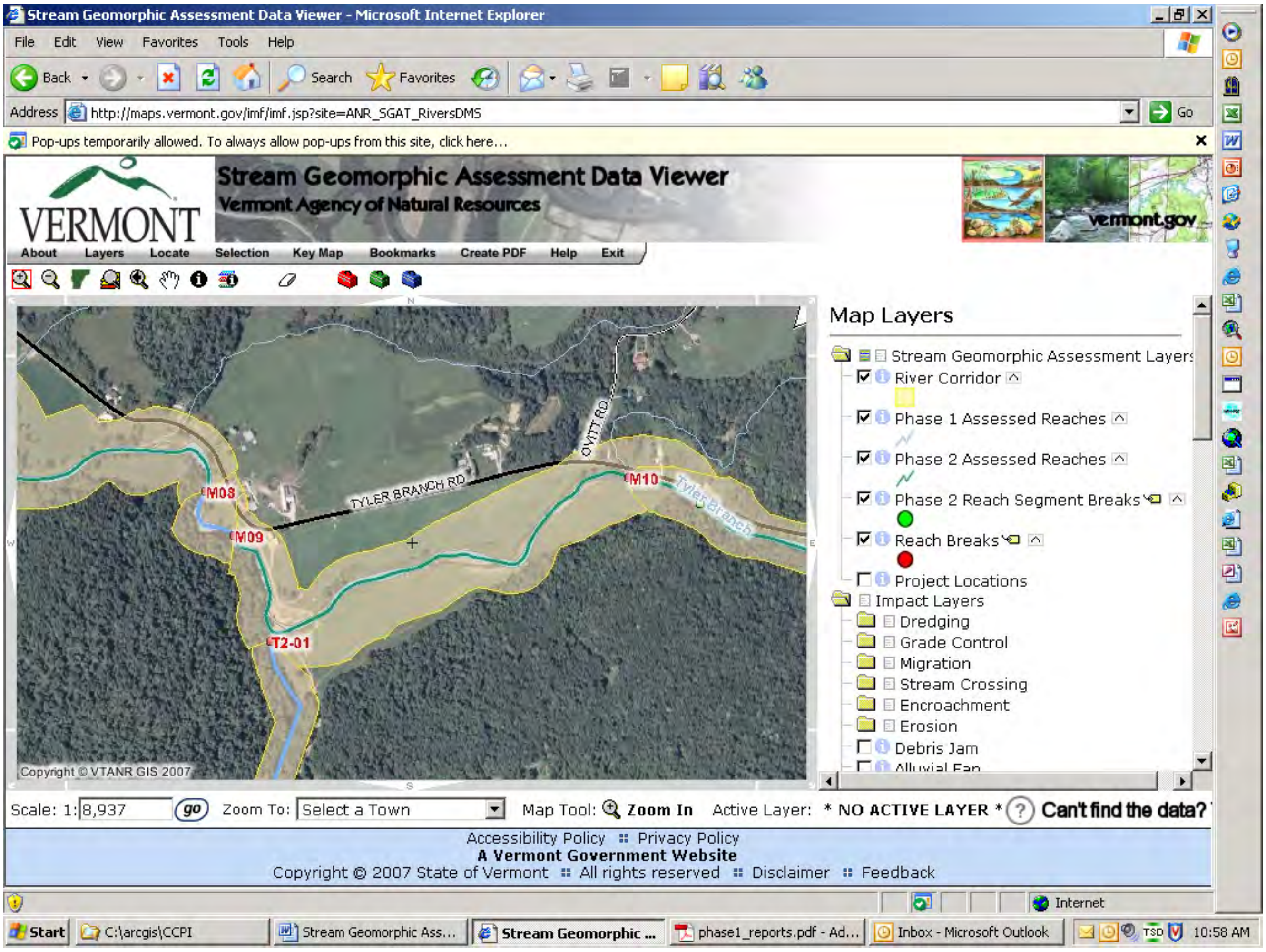


Figure 12 - Example Phase 1 Reach Summary Report Viewed through the Stream Geomorphic Assessment Data Viewer.

Black Creek Mouth — Phase 1 - Reach Summary Report

Basin: Missisquoi
Stream Name: Unnamed-2 to Wanzer — Reach T3.3S1.02
Topo Maps: Bakersfield
Date Last Edited:
Watershed: Missisquoi River
Sub-watershed: Black Creek (Missisquoi drainage)
Is Reach an Impoundment? No — Quality Control Status: Step 2 done

Step 1. Reach Location
1.1 Reach Description: ---
1.2 Towns: Fairfield
1.3 Downstream Latitude: 44.84
1.3 Downstream Longitude: -72.87

Step 2. Stream Type
2.1 Elevation Upstream: 744
2.1 Elevation Downstream: 647
2.1 Is Gradient Gentle? No
2.2 Valley Length: 2847 feet. 0.54 Miles.
2.3 Valley Slope: 3.41 %
2.4.Channel Length: 3048 feet. Miles.
2.5 Channel Slope: 3.18 %
2.6 Sinuosity: 1.07
2.7 Watershed Area: 1 Square Miles
2.8 Channel Width: 12 feet.
2.9 Valley Width: feet.
2.10 Confinement Ratio: 0
2.10 Confinement Type: Semi-confined
2.11 Reference Stream Type: B
Bedform: ---
Sub-class Slope:
Bed Material: No Data

Step 3. Basin Characteristics:
3.1 Alluvial Fan: None
3.2 Grade Control: None
3.3 Dominant Geologic Mat.: Till 79.7 %
3.3 Sub-dominant Geological Mat.: Alluvial
3.4 Left Valley Side Steep
3.4 Right Valley Side Steep
3.5 Soils
Hydrologic Group: D 71.0 %
Flooding: None/Rare 87.8 %
Water Table Deep: 2.0 71.0 %
Water Table Shallow: 0.0 83.2 %
Erodibility: High - 86.9 %

7.4 Comments:

Step 4. Land Cover - Reach Hydrology
4.1 Watershed
Historic Land Cover: Not Evaluated
Current Dominant land Cover: Forest 58.4 %
Current Sub-Dominant Land Cover: Field
4.2 Corridor
Historic Land Cover: Not Evaluated
Current Dominant land Cover: Forest 50.0 %
Current Sub-Dominant Land Cover: Urban
4.3 Riparian Buffer — Left Bank / Right Bank
Dominant: 0-25 / 0-25
Sub-dominant: >100 / >100
Length w/ less than 25 ft.: 1493 / 1493
4.4 Ground Water Inputs: Abundant

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old): No Data
Type: None
Use:
5.2 Bridges and Culverts: 1 1 %
5.3 Bank Armoring: 0.0
Left Right
5.4 Channel Straightening: 0.0
5.5 Dredging History: No Data

Step 6. Floodplain Modifications
6.1 Berms and Roads old 0.0 ft. 0.0
One Side / Both Sides
Road: ft. ft.
Railroad: ft. ft.
Berm: ft. ft.
Improved Path: ft. ft.
6.2 Development: 121.0 ft. 0.0 ft.
6.3 Channel Bars: No Data
6.4 Meander Migration: No Data
6.5 Meander Width: Ratio: 0.0
6.6 Wavelength: Ratio: 0.0

Step 7. Windshield Survey
7.2 Bank Erosion: 30.00 ft.
7.2 Bank Height: 1.00 ft.
7.3 Ice/Debris Jam Potential: Culvert

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	1 Low	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	5

Phase 2 Stream Geomorphic Assessment Data

Where a Phase 2 assessment has been completed, more site specific information can be attained through the data viewer and database reports. NRCS and other resource professionals can use the data viewer to help determine what the geomorphic condition of the stream is in their planning area, whether it is in equilibrium or in a state of adjustment. A number of 'Impact Layers' are included in the legend which display a variety of impacts or resource concerns such as dredging, stream crossings, erosion, encroachments, gullies, headcuts, armoring, straightening, buffers less than 25 feet, etc. Examples of 'Impact Layer" data is displayed in Figure 13. A link to the Phase 2 reports and more in depth information is provided by clicking on the phase 2 assessed reaches layer. This is critical information both for planning conservation practices as well as for farm or land management along rivers.

For instance, streambank stabilization using rip-rap has historically been a common practice to arrest streambank erosion along Vermont's streams. However, when this is used on a stream that is midway through the channel evolution (adjustment) process, it may be prone to failure and may not provide a net environmental benefit to the river system. This information may also raise a red flag for other common practices such as riparian forest buffers. It is probably not a good investment to plant trees at the top of a bank in a highly sensitive river reach experiencing significant lateral adjustment. These are some of the examples of the information that is now at the planners' fingertips with the data viewer. The Phase 2 reach reports can be accessed through the 'Identify Results' pop up window as shown in Figure 14. The Phase 2 reach reports will provide much of the information discussed above, as shown in Figure 15.

Figure 13 - Example Phase 2 Data, Viewer Impact Layers - Armoring in Blue and Straightening in Black, Viewed through the Stream Geomorphic Assessment Data Viewer.

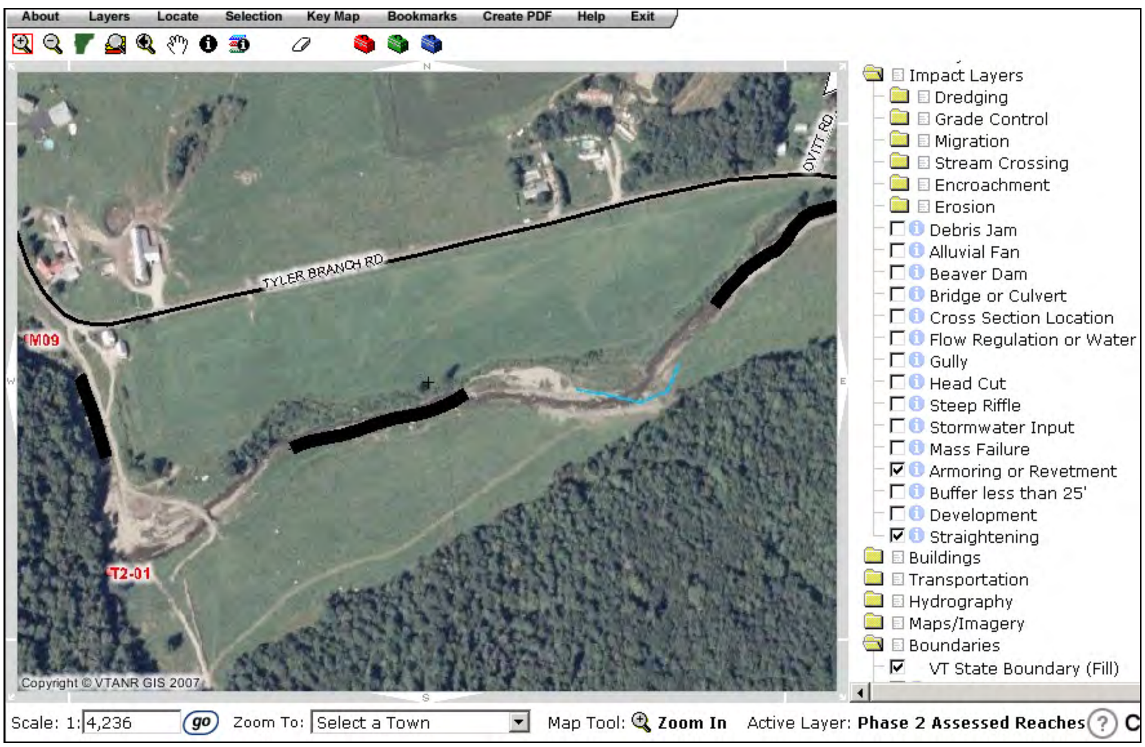


Figure 14 - Example of Data Viewer 'Identify Results' Pop Up Window and Link to Phase 2 Reports.

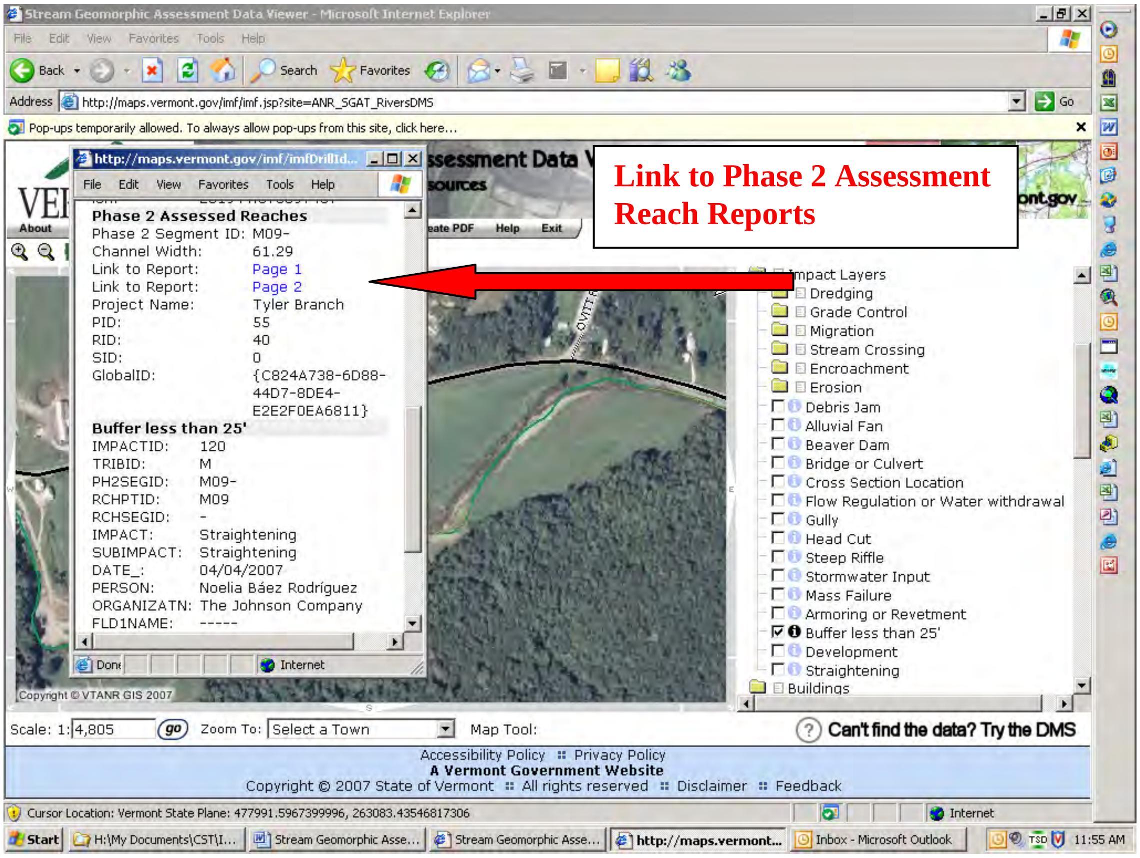


Figure 15 - Excerpts from the Phase 2 Assessment Reach Reports.

Bank Erosion	Left	Right
Erosion Length (ft)	0	55
Erosion Height (ft)	0.00	5.00
Revetmt. Type	Rip-Rap	None
Revetmt. Length (ft)	364	0
Near Bank Veg. Type	Left	Right
Dominant	Pasture	Shrubs/Saplin
Sub-dominant	Herbaceous	Pasture
Bank Canopy	Left	Right
Canopy %	0	1-25
Mid-Channel Canopy	Open	
3.2 Riparian Buffer		
Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	None	0-25
W less than 25	0	0
Buffer Veg. Type	Left	Right
Dominant	Herbaceous	Shrubs/Saplin
Sub-dominant		Herbaceous
3.3 Riparian Corridor		
Corridor Land	Left	Right
Dominant	Crop	Pasture
Sub-dominant	Pasture	Forest
Mass Failures	0	0
Height	0	0
Gullies	0	0
Height	0	0

(old) Upstrm Flow Reg None

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	0	Tile Drain	0
Overland Flow	0	Urb Strm Wtr Pipe	0

4.9 # of Beaver Dams 0
Affected Length (ft) 0

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
1	2	2
Diagonal	Delta	Island
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
1	0	0	1

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
1	0	No

5.4 Stream Ford or Animal Yes
5.5 Straightening Straightening
Straightening Length: 1,235
5.5 Dredging Dredging, Gravel Mining, Gravel Mining

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Figure 15 (cont.) - Excerpts from the Phase 2 Assessment Reach Reports.

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	15	None	Yes
7.2 Channel Aggradation	14	None	No
7.3 Widening Channel	15		No
7.4 Change in Planform	15		No
Total Score	59		
Geomorphic Rating	0.7375		
Channel Evolution Model	F		
Channel Evolution Stage	III		
Geomorphic Condition	Good		
Stream Sensitivity	High		

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	8
6.2 Embeddedness	11
6.3 Velocity/Depth Patterns	10
6.4 Sediment Deposition	13
6.5 Channel Flow Status	11
6.6 Channel Alteration	14
6.7 Frequency of Riffles/Steps	14
6.8 Bank Stability	Left: 9 Right: 7
6.9 Bank Vegetation Protection	Left: 5 Right: 2
6.10 Riparian Vegetation Zone Width	Left: 0 Right: 2
Total Score	106
Habitat Rating	0.53
Habitat Stream Condition	Fair

This is a brief summary of the functionality and uses of this tool. As the tool begins to be adopted and used for everyday planning activities it is hoped that users will be able to provide input for future improvements. For this tool to be fully used across the state, it is critical that the geomorphic assessment process continue to evaluate additional watersheds and streams. For additional information about the specific functions and tools in this tool see Appendix D for VTDEC River Management's *"MapServe" NRCS Training Document.* This tool and document were introduced to the Vermont NRCS Planning and Engineering Staff on November 5, 2007 by the VT DEC River Management Program.

Access to the Stream Geomorphic Assessment Data Viewer can be obtained on the VTDEC website at the following web address:

http://maps.vermont.gov/imf/sites/ANR_SGAT_RiversDMS/jsp/launch.jsp?popup_blocked=true

Riparian Forest Buffer Gap Mapping

Background

Conservationists in the federal, state, municipal and volunteer citizen sectors all agree that effective riparian forest buffers are an important component of stream ecosystems and water quality. In many parts of the study area, particularly in intensively used agricultural areas, buffers are insufficient or nonexistent. Thus, there are known resource concerns but there has been no clear way to quantify the extent of the problem in the Missisquoi Sub-basin. This lack of objective data has made it difficult to decide where to target limited conservation funds. Newly developed riparian buffer gap data will help agencies and partners target outreach and available funds in programs such as Conservation Reserve Enhancement Program (CREP) to riparian buffer projects that will have the greatest positive impact.

Methods

As part of this Plan a method was developed to identify and digitize gaps in riparian forest buffers along streams and rivers. The photobase used for this work was the 2003 NAIP. Variable-width buffer evaluation areas were created along the streams using channel width as the formula basis for calculation. A 25-foot buffer from the top of bank was evaluated. This width was chosen based on water quality concerns, the primary focus of the Missisquoi Areawide Plan. Twenty-five feet is the minimum buffer width required under the NRCS standard for Filter Strips and as such is considered the minimum needed for any effective treatment of surface runoff.

Presence or absence of woody riparian vegetation was noted within these buffer polygons, which were split to represent beginning and ending points along the stream, on each side separately. Left and Right sides were determined looking downstream. Notations were also made regarding whether the vegetation was at least 50% woody or not. A small amount of ground truth investigation was performed in areas where the aerial photo interpretation was uncertain.

Results

Although presence or absence interpretation exposed actual gaps, the functional quality of areas showing adequate vegetation cover was not assessed. For instance, there may be channels cut through the buffer by rapid crop field runoff which circumvent the nutrient attenuation and velocity reduction functions buffers should provide. High resolution slope data, such as that derived from LiDAR, can be used to locate likely areas of concentrated flow from crop fields. Identifying the presence or absence of riparian buffers can help with conservation practice decision making. This ability to visualize the buffer gap situations across a large planning area has drawn comments from experienced conservationists like, “We already knew there was a problem, but seeing it and understanding the scale of the problem is really valuable.”

Figure 16 shows the fragmented condition of riparian forest buffers in the Missisquoi Sub-basin. Agricultural fields are the primary encroachments on the 25-foot buffer zone. Road crossings were also noted throughout the Sub-basin. Of the 2,815 streambank miles assessed, 919 appear to have inadequate riparian buffers. The problem is more pronounced in the lower watersheds where agriculture dominates land use. There are also positional differences in gaps among the watersheds: the Rock River’s buffer gaps (Figure 17) are prevalent in headwater streams and tributaries, whereas for Hungerford Brook (Figure 18), the headwaters are generally forested areas, and it is the mainstem which is impacted by gaps. Knowledge of these differences will help NRCS and partners tailor conservation practice promotion, design and implementation to the particular needs of a watershed. NRCS and partnering agencies will evaluate buffer gap locations with cropping intensity, slope percent, and streambank susceptibility to scour erosion, to target CREP and other conservation program funds wisely. Ranking criteria have begun to include the results of GIS analysis now that we have information from which to draw conclusions.

Figure 16 - Riparian Forest Buffer Gaps in the Missisquoi Sub-basin.

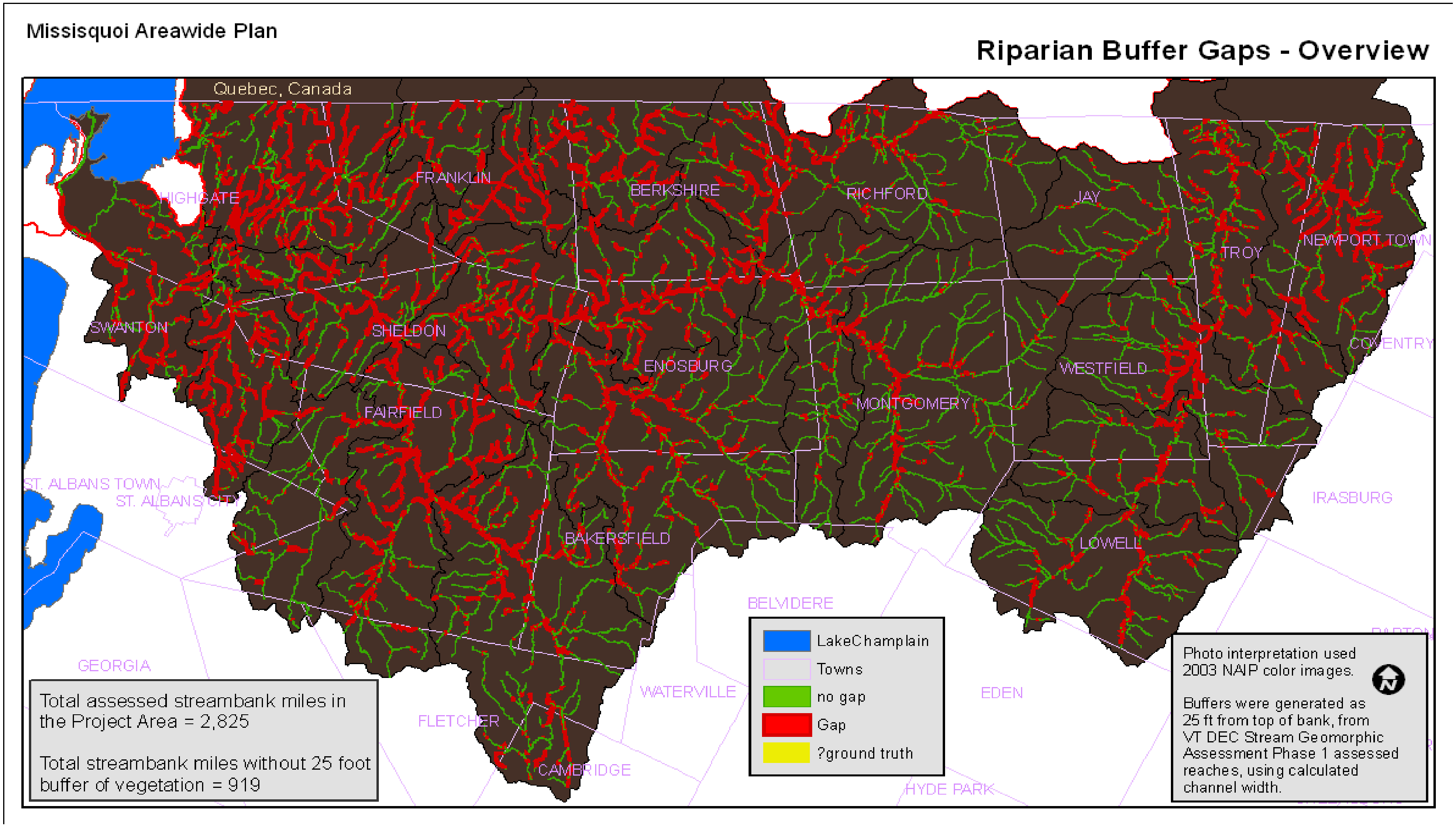


Figure 17 - Riparian Forest Buffer Gaps in the Rock River Sub-watershed.

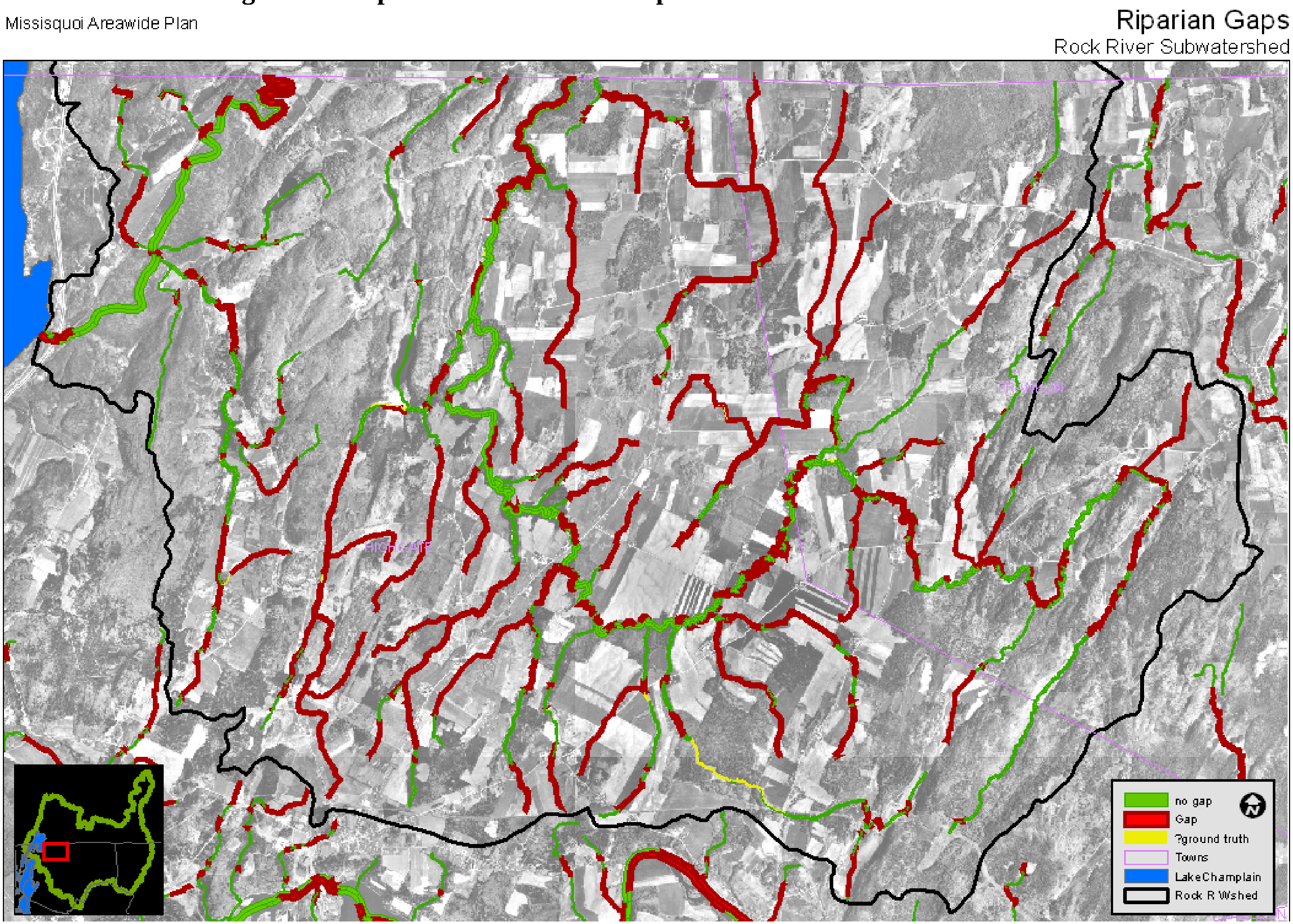
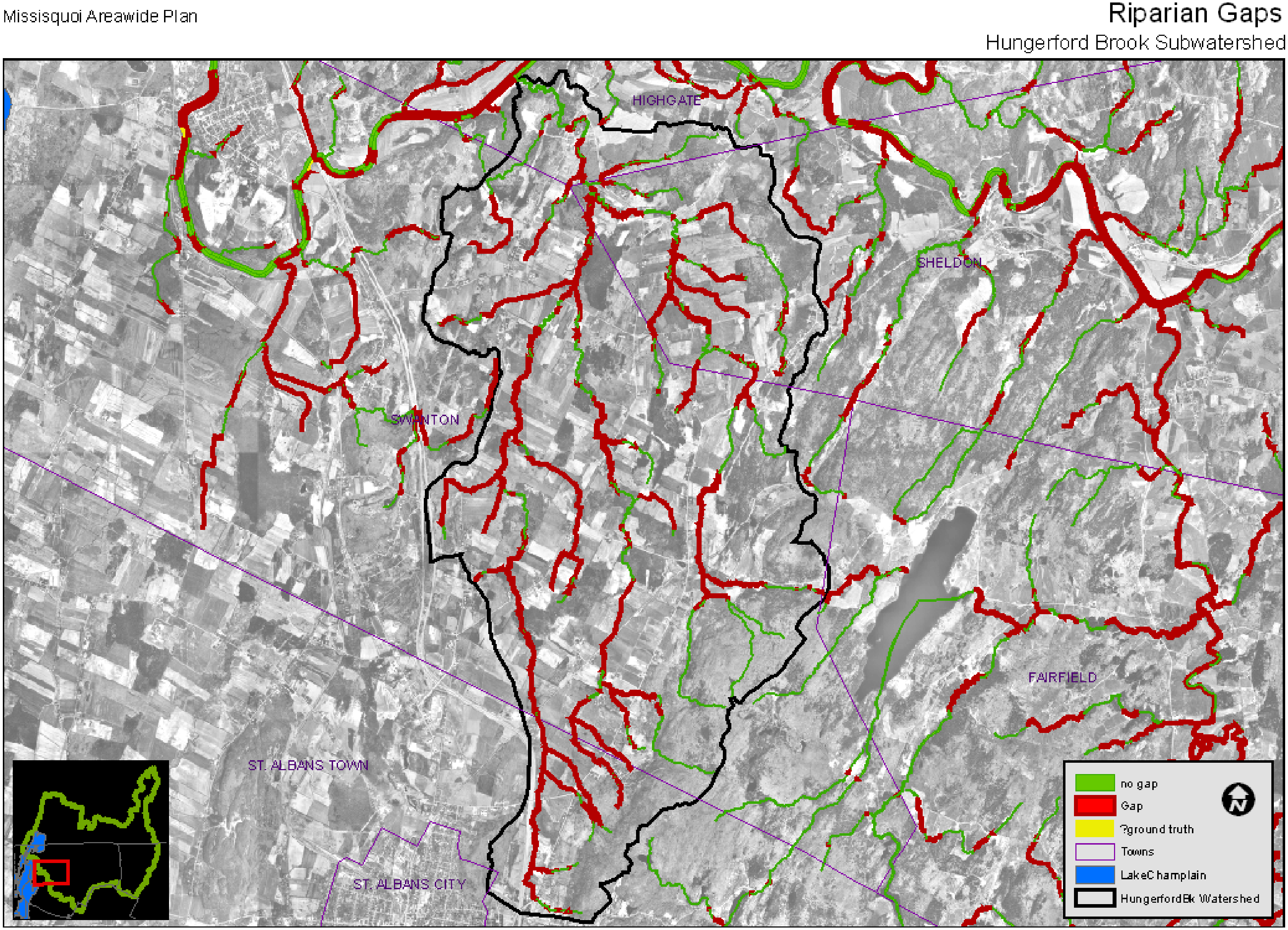


Figure 18 - Riparian Forest Buffer Gaps in the Hungerford Brook Sub-watershed.



Streambank Scour Erosion Susceptibility

Background

Soil characteristics can be used to predict the susceptibility that streambanks have to scour erosion by floodwaters. Friction from swift flowing water can cause substantial erosion and undercutting of the subsoils in areas where the stream has cut down through deep soils to form a channel with steep or vertical banks. The texture, method of soil formation, and organic matter content of a soil in this position will affect how easily water, and the sediment and debris it carries during flood events, can dislodge soil particles. As part of the Missisquoi Areawide Plan, NRCS refined a soil interpretation process developed 7 years ago by the NRCS for the adjacent sub-basin to the south, the Lamoille.

During the mid-1800's up to 70% of the Sub-basin's land was cleared of trees for either cropping, grazing or for the potash industry. The VTDEC River Management Group and the NRCS Cultural Resources Specialist report that anywhere from 3 to 6 feet of new soil eroded from upstream was laid down during that period of intensive land clearing. In the latter part of the 20th Century, forests reclaimed the upper elevations of the Sub-basin, and sediment load was reduced to more normal natural levels. However, the process of down-cutting and channel evolution is still continuing in the lower river channels. Because of the soils' characteristics in certain areas, the stream banks in these areas are more susceptible to erosion and mass wasting, and should be protected from flood waters.

Methods

Detailed digital soil map unit information (SSURGO data) has been certified for the entire Plan project area. The standard "cutbanks cave" soil interpretation used nationally by NRCS to select map units that are susceptible to bank cave-in did not seem to capture all of the possibilities for scour susceptibility. We expanded that interpretation, and used this to query the agency's NASIS soils database to arrive at our set of susceptible soils map units. A representative value between 0 and 1.0 is assigned to each soil map unit after weighing its characteristics against the criteria; the result is a fuzzy rating from which we can infer susceptibility. The criteria we finalized for this interpretation query are shown in Table 9.

Results and Data Usage

Soils susceptible to bank scour erosion were identified and mapped in the Missisquoi Sub-basin. The most susceptible soils are alluvial soils laid down by the streams themselves, but other soils found along streams also are moderately to highly susceptible (see criteria table above). An example analysis was conducted for the Rock River Sub-watershed. The most susceptible soils (fuzzy rating of 0.85 or higher) were intersected with the layer of known riparian gaps. Documented bank erosion and mass wasting sites in another layer from Vermont DEC's Stream Geomorphic Assessments were also used to refine the analysis. Thus, susceptible soils within the 25 foot buffer zone which are already eroding, were mapped as target areas for conservation efforts. The resulting map for the Rock River Sub-watershed from this analysis is shown in Figure 19.

Table 9 - Streambank Scour Erosion Susceptibility Ratings for Soils.

	fuzzy rating	soil types
Most Susceptible	1.000	alluvial parent material EXCEPT very poorly drained OR poorly drained
	0.850	particle size class = sandy or sandy-skeletal OR loamy-skeletal OR anything over sandy-skeletal
	0.600	particle size class = coarse-silty OR sandy over loamy OR loamy over clayey
	0.500	E slope with densic contact OR E slope with clay soils
	0.400	particle size class = coarse-loamy NOT alluvial parent material NOT with a densic contact
	0.400	densic contact OR clay soils, NOT E slope
	0.200	shallow OR moderately deep to bedrock (would include moderately deep to deep)
	0.050	very poorly drained mineral or organic soil OR very shallow to bedrock
Most A[illegible]d / Least Susceptible	0.000	rock outcrop (water would get 0.000, too)

In the Rock River Sub-watershed, there are 44 riparian gaps noted from 2003 color aerial photography, of varying length from 0.02 to 0.75 miles which occur in soils with susceptibility of 0.85 or higher. Of these, 5 gaps are within stream reaches where erosion has been observed during Stream Geomorphic Phase 2 Assessments by Vermont DEC and its' partners. These 5 stretches of riparian buffer gap are areas we may be able to target for further investigation and conservation practice implementation. While there is known erosion in these gaps, another way to look at targeting is to protect those gaps at high risk which have not yet begun eroding severely. The 39 other high-risk gaps thus may be targeted for protection using USDA or partners' funds.

An alternative way to look at and use the data is shown in Figure 20**.** This map is of the Hungerford Brook Sub-watershed. The map shows the range of susceptibility for soils within the riparian zone of streams that have been assessed for Phase 1 SGA.

Figure 19 - Soils Near Streambanks Susceptible to Scour Erosion in the Rock River Sub-watershed.

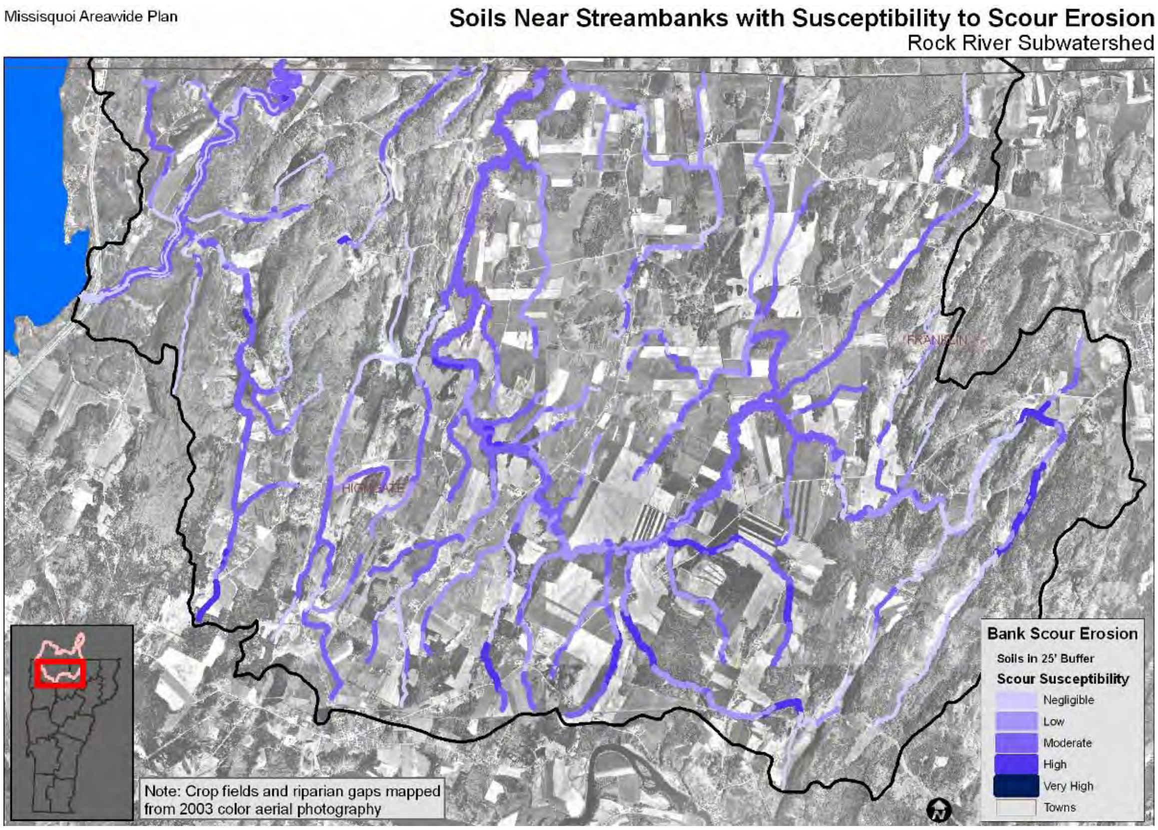
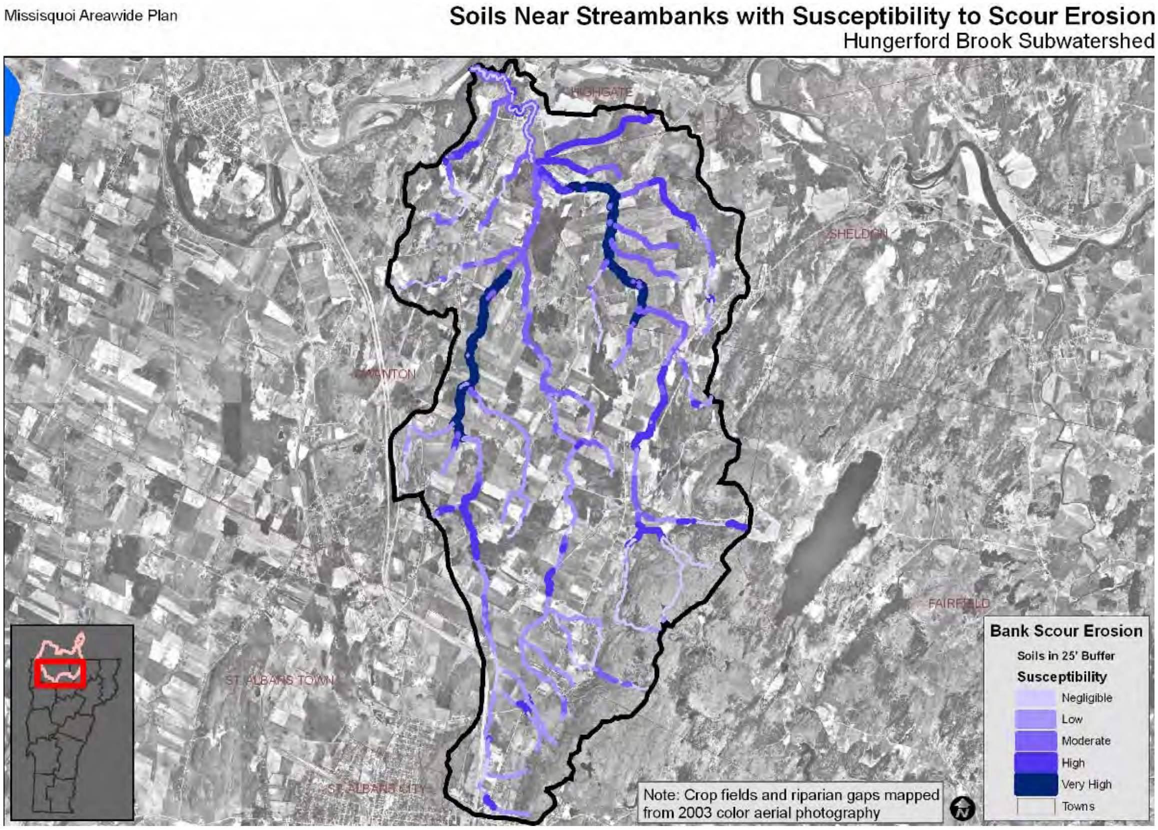


Figure 20 - Soils Near Streambanks Susceptible to Scour Erosion in the Hungerford Brook Sub-watershed.



Lake Champlain Basin Wetland Restoration Plan

Background

Wetlands provide a variety of functions and values that include high quality fish and wildlife habitat, storing floodwaters, groundwater recharge and discharge, and improving water quality. Wetlands improve water quality by a variety of means including capturing, filtering and retaining sediments and nutrients from source waters and upland areas. Of particular interest in the Lake Champlain Basin of Vermont is the need to prioritize potential wetland restoration sites based on which sites are most likely to retain significant amounts of phosphorous. The Lake Champlain Clean and Clear Action Plan – Lake Champlain Basin Wetland Restoration Plan has presented a framework and results of priority areas that are best suited for this purpose.

The goal for the Wetland Restoration Plan is to meet applicable portions of the Phosphorous Total Maximum Daily Load (TMDL) requirements for Lake Champlain on the Vermont side of the lake. The Wetland Restoration Plan presents a basin-wide identification and prioritization model for reducing phosphorous (P) loading in Lake Champlain. The plan targets lands that have met specific criteria and that will have the greatest potential for phosphorus removal. The plan was developed for use by resource managers involved in planning and implementing wetland restoration projects in the Basin.

A Geographic Information System (GIS) model was developed to assess former wetlands for restoration. Non-forest agricultural and urban sites were evaluated using a variety of criteria including hydric soils, slopes $\leq$ 5%, National Wetlands Inventory (NWI) data, and size $\geq$3 acres. The resulting preliminary list of sites was prioritized using a model with eleven variables to rank potential to capture phosphorus. The variables included the following elements of site function:

- soil texture,
- erosion risk,
- size class,
- flood class,
- proximity to surface waters,

and a number of elements related to the watershed, including:

- upslope drainage area,
- slope,
- erosion risk,
- estimated phosphorus load,
- hydrologic soil group,
- land cover,
- and drainage area to wetland ratio.

The result of this analysis was a numeric value that ranked the potential sites from lowest to highest. One of the products of this plan was a siterank_final.shp' (siterank) shapefile that contains the wetland polygon features as well as twenty-three attributes including the total restoration score. A feasibility component of the plan and restoration alternatives was also developed following the GIS model.

Using the siterank shapefile, we determined the acreage of wetland restoration sites by the four score ranges highlighted in the draft plan for the entire Missisquoi Project Area (Table 10). ArcView 3.3 was used for the GIS processes and analysis. The siterank shapefile was clipped by the sub-basin and merged with the remaining siterank polygons within the Missisquoi Sub-basin.

Figure 21 shows the results in the form of a map of restoration sites for the Sub-basin. For each sub-watershed, all siterank polygons were selected within the sub-watershed and acreage was calculated from the siterank polygons. There are about 16,000 acres of potential wetland restoration sites within the Missisquoi Sub-basin that could help lower phosphorus loads to Lake Champlain (Table 10). For comparison at the sub-watershed level, there are about 1,050 and 3,160 acres of potential restoration sites identified within the Hungerford and Rock River Sub-watersheds, respectively (Figures 22 and 23).

The Clean and Clear Wetland Restoration Plan highlights the Otter Creek sub-basin for initial wetland restoration efforts due to the highest mean restoration scores. However, there is also great opportunity to restore wetlands in the Missisquoi Sub-basin. The data table and maps show this graphically and visually. Additionally, there are significant areas for potential restoration; including many with ‘highest’ potential just outside the project area, in and around Maquam and St. Albans Bays.

The siterank GIS layer will be a useful planning and prioritization tool for conservationists in the Lake Basin. The siterank shapefile can easily be viewed and used within a GIS to help determine potential sites, acreages and proximity to other projects, important habitats (e.g. Vermont Significant Wetland Inventory, etc.) and protected lands. This flexibility of the GIS will help with strategically targeting restoration areas as phosphorous sources are better isolated. While the plan and shapefile were intended to highlight areas to target for water quality purposes, they can also be used to help highlight areas that can serve multiple purposes such as terrestrial-wetland-aquatic habitat improvement, storing floodwaters, etc. Finally, the layer/maps and plan can be used by program administrators to determine priority areas and also to direct funding. Conservationists in the Lake Basin are fortunate to have this set of tools that will help them direct outreach, funds and restoration to the most important areas.

Table 10 - Extent of Potential Wetland Restorations Sites by Rank.

Potential Wetland Restoration Sites - CCPI Project Area

Potential for Restoration	Restoration Score Range	Acres
Low	91-204	2,277.1
Moderate	204-275	8,224.4
High	275-336	4,974.1
Highest	336-460	532.4
Total in Project Area		**16,008.0**

Potential Wetland Restoration Sites - Hungerford Brook Sub-watershed

Potential for Restoration	Restoration Score Range	Acres
Low	91-204	110.7
Moderate	204-275	474.7
High	275-336	458.8
Highest	336-460	0.0
Total in Sub-watershed		**1,044.2**

Potential Wetland Restoration Sites - Rock River Sub-watershed

Potential for Restoration	Restoration Score Range	Acres
Low	91-204	96.6
Moderate	204-275	1,928.9
High	275-336	1,120.8
Highest	336-460	9.2
Total in Sub-watershed		**3,155.5**

Figure 21 - Potential Wetland Restoration Sites in the Missisquoi Sub-basin, by Rank.

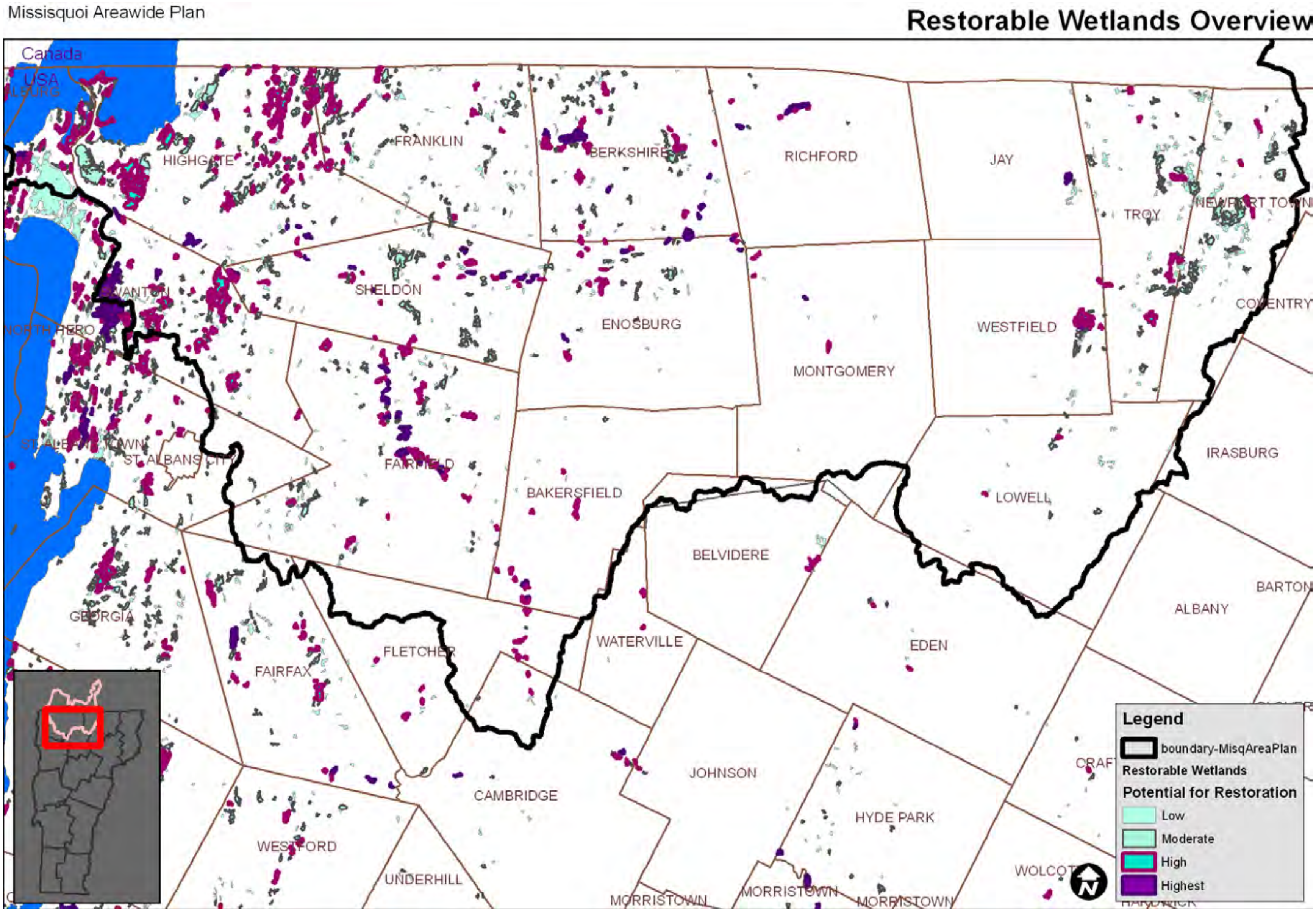


Figure 22 - Potential Wetland Restoration Sites in the Rock River Sub-watershed, by Rank.

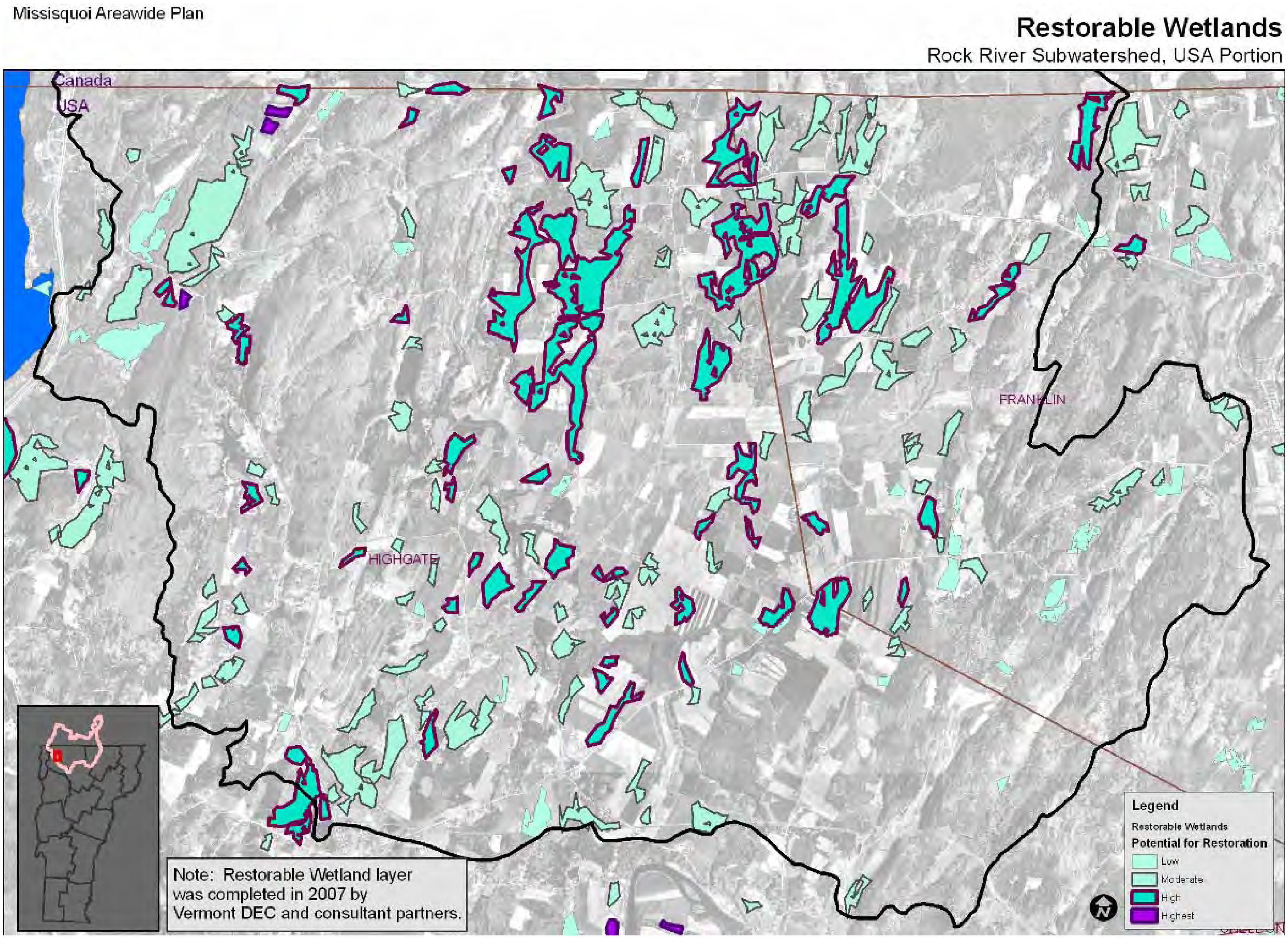
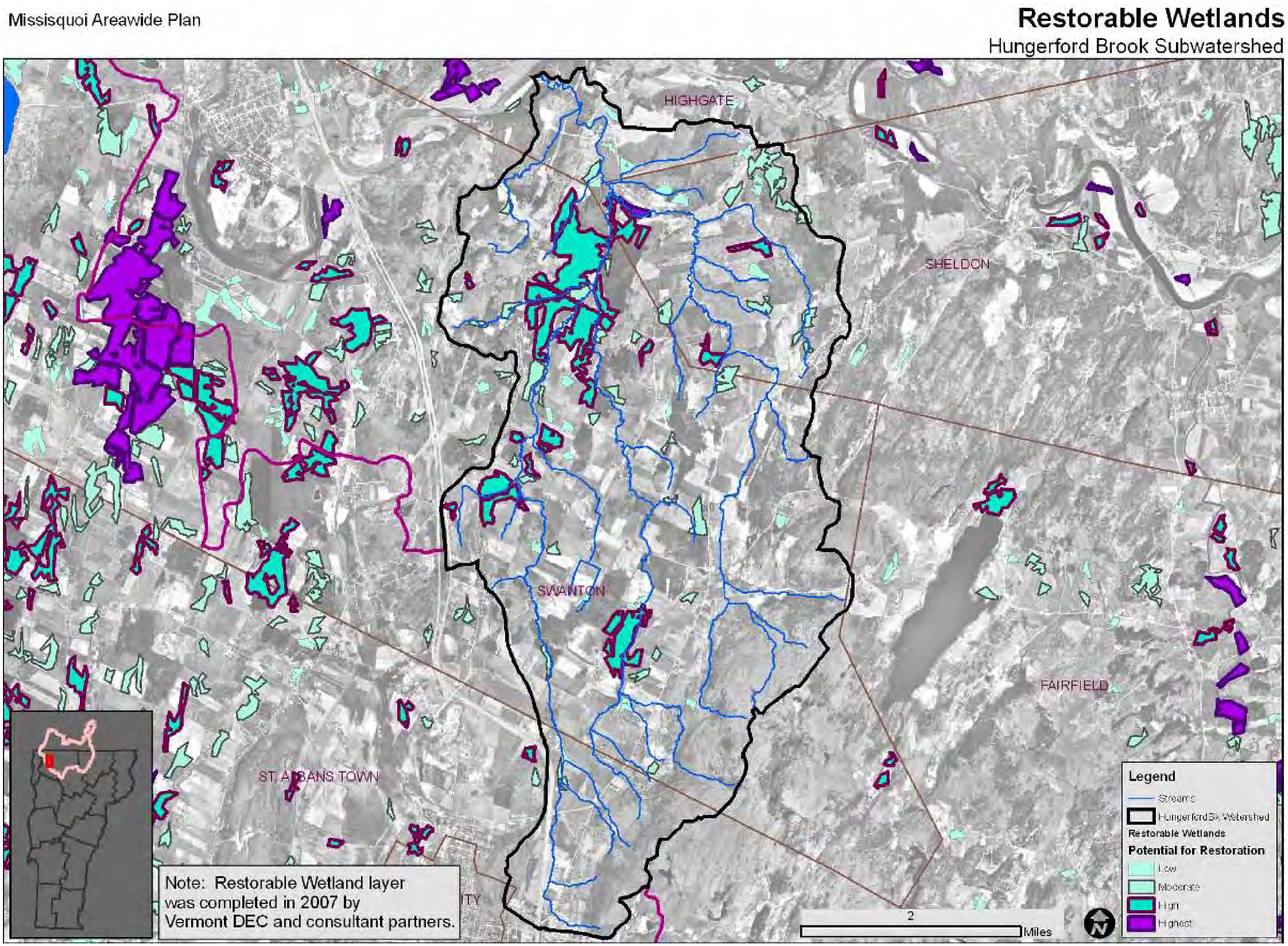


Figure 23 - Potential Wetland Restoration Sites in the Hungerford Brook Sub-watershed, by Rank.



Links Between Geomorphic Condition, Streamside Land Use, and Phosphorus Loading in Hungerford Brook

This study was conducted by Mary C. Watzin and Dani Newcomb of the Rubenstein School of Environment and Natural Resources. It was partially funded by NRCS through the Missisquoi CCPI project. Most of the text below was copied from the project report written by Watzin and Newcomb[20].

Transport of phosphorus and sediment within the watershed is a critical determinant in understanding loading. It has been observed in other studies that nutrient concentration and load increases from the headwaters to the outlet of the watershed[21,22,23,24.] However, processes of deposition and re-suspension can lead to discontinuous transport of phosphorus loads that do not always increase downstream[25]. Understanding the different transport mechanisms can be extremely important in trying to determine critical source areas, sinks, and areas that may act as both under different conditions.

The overall objectives of this study were to: (1) determine if rapid geomorphic assessment (RGA) scores are linked to phosphorus concentrations and loads during typical storm events using water total phosphorus concentrations and water soluble reactive phosphorus (SRP) concentrations. (2) Determine if watershed land use or near stream land use has a greater impact on phosphorus loads and if soil phosphorus is a covariate in the relationship. (3) Develop a model to look for the associations between soil phosphorus levels, soil type, RGA scores, land use, and phosphorus concentrations and load using data collected from tributary junctures and the mouth of Hungerford Brook. The model will also be used to look for locations and conditions in the watershed where conservation practice implementation or stream restoration would likely have the greatest impact in reducing phosphorus load at the mouth of Hungerford Brook. By systematically breaking a small watershed into its component sub-watersheds and collecting data at the sub-watershed and whole watershed scale, we explored the effect of assessment scale and thresholds of land use alteration and geomorphic condition on the overall sediment and phosphorus load.

The study was conducted in the Hungerford Brook Sub-watershed in northwestern Vermont.

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[20]Mary C. Watzin and Dani Newcomb, 2007, Links between geomorphic condition, streamside land use, and phosphorus loading in Hungerford Brook, unpublished report, Rubenstein School of Environment and Natural Resources, University of Vermont, 45 p.

[21] Allan, J.D. 2001. Stream ecology: structure and function of running waters. Kluwer Academic Publishers, Dordrecht, The Netherlands.

[22] Castillo, M.M., J.D. Allan, and S. Brunzell. 2000. Nutrient concentrations and discharges in a Midwestern agricultural catchment. J. Environ. Qual. 29:1142-1151.

[23] Sonoda, K., and J.A. Yeakley. 2007. Relative effects of land use and near-stream chemistry in an urban stream. J. Environ. Qual. 36:144-154.

[24] Harding, J.S., R.G. Young, J.W. Hayes, K.A. Shearer, and J.D. Stark. 1999. Changes in agricultural intensity and river health along a river continuum. Freshwater Biol. 42:245-357.

[25] Verhoff, F.H., D.A. Melfi, and S.M. Yaksich. 1982. An analysis of total phosphorus transport in river systems. Hydrobiologia. 91:241-252.

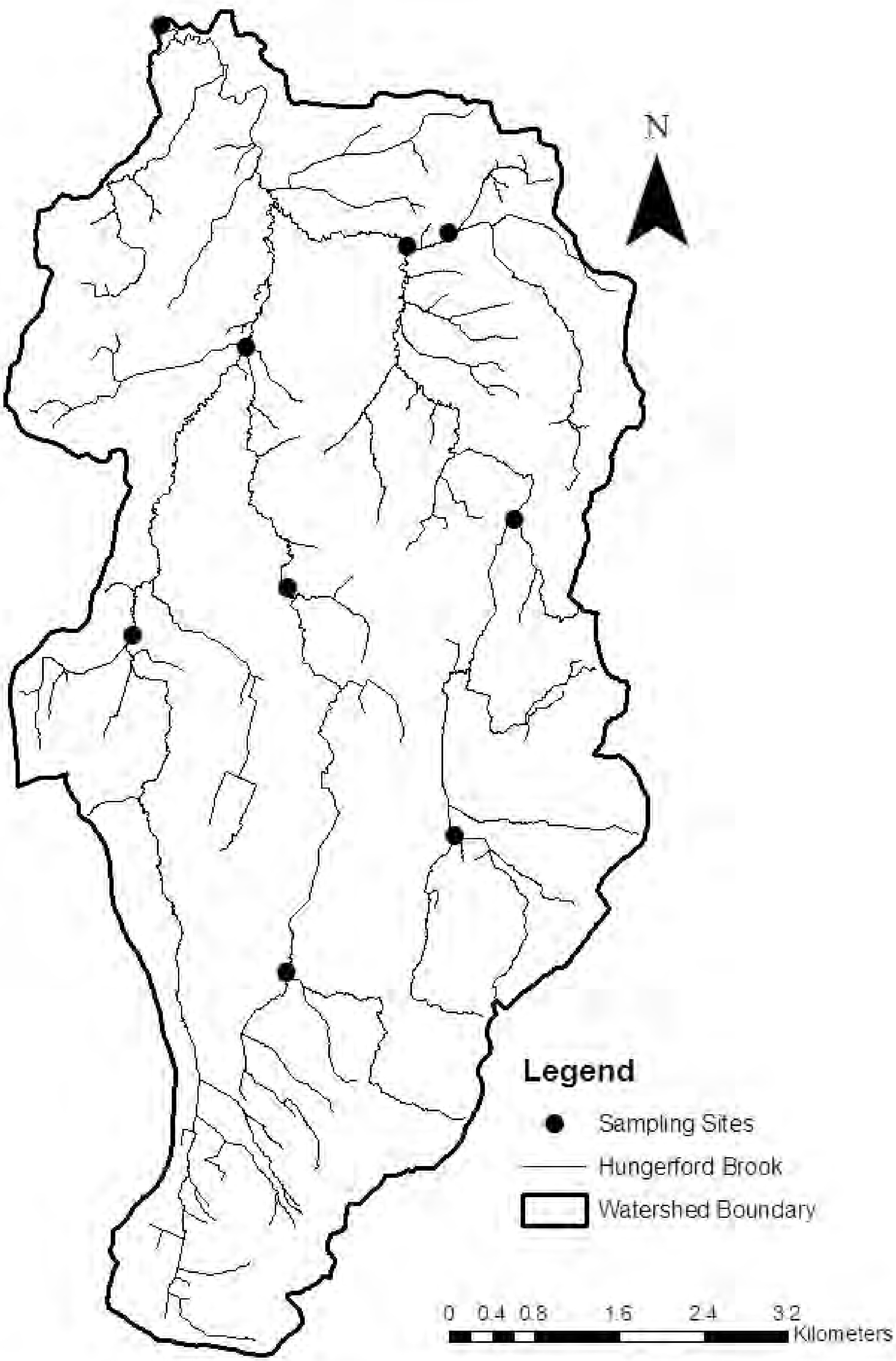
The Hungerford Brook Sub-watershed is part of the larger eight digit Missisquoi River Sub-basin (02010007). Hungerford Brook empties into the Missisquoi River which in turn empties into Missisquoi Bay in Lake Champlain (Figure 24). The mainstem of Hungerford Brook is approximately 16 km long with over 117 km of total stream length in the relatively flat watershed. The overall Sub-watershed is approximately 50 km2 in area and land use includes agriculture (53%), forest (28%), developed land (8%), and wetlands (11%) (from the National Land Cover Dataset (NLCD), 2001). Within the agricultural land use, 41% is hay, 25% pasture, and 32% corn.

This study shows that excess amounts of phosphorus and sediment are being transported throughout the Hungerford Brook Sub-watershed and may be accumulating at the mouth of the river. Phosphorus concentrations in the water leaving Hungerford Brook are above the 25 μg/L target for Missisquoi Bay. The Total Phosphorous (TP) and Soluble Reactive Phosphorus (SRP) concentrations exiting in Hungerford Brook are in excess of the water quality standards for Missisquoi Bay even under baseflow conditions.

In large storm events, accumulated phosphorus and sediment are transported downstream and exported in large amounts. SRP concentrations and loads in Hungerford Brook appear to be linked to near-stream agriculture, while TP and Total Suspended Sediments (TSS) are linked to agricultural land use in general. Additionally, it appears that agriculture in the riparian buffer area not only contributes to an increase in SRP, but also to a decrease in geomorphic condition, providing additional justification for the protection of riparian buffer areas. Management practices that result in lower phosphorus concentrations in the soil and that provide significant stabilization and nutrient removal in the riparian corridor should help reduce the phosphorus load leaving Hungerford Brook.

Future studies could greatly increase our understanding of the general dynamics of runoff and should focus on determining the relative contributions of sediment from overland flow and in-stream processes. This study design could also be replicated in a watershed without a high correlation between near-stream and whole watershed land use to further examine the relative importance of interventions in the watershed as a whole, and interventions focused on the riparian corridor.

Figure 24 - Map of the Hungerford Brook Sub-watershed and Location of Water Quality Sampling Sites.



The results of this study also suggest that targeted management in Hungerford Brook could be appropriate. Tributary data indicates that particular problems exist in the Pratt, Sholan, and Morey tributaries. Both Pratt and Sholan have higher sediment and total phosphorus loads and concentrations than other sub-watersheds, indicating that these areas are transporting sediment that is highly enriched with phosphorus. Management practices targeting sediment reductions should be focused in tributary watersheds. The Morey tributary has the highest SRP concentrations in the Hungerford Brook Sub-watershed. While sediment and phosphorus problems in Sholan and Pratt appear to be watershed-wide, most of the excess SRP levels in the Morey tributary can be attributed to a single large dairy farm with a barnyard very near to the stream. Following the completion of this study, a biodigester and manure composting system were installed on this farm. It would be worthwhile to examine the impacts of this installation before designing additional interventions. In the larger Hungerford Brook Sub-watershed, management should focus on two key areas: (1) nutrient management to reduce soil phosphorus concentrations, and (2) stream riparian buffers, especially focusing stream bank restoration in areas of high degradation.

No-Till Practice Application Analysis

Background

Some conservation practices can be successfully implemented on fields with particular soil and landscape characteristics. No-till (NRCS practice standard, Residue Management, No-till, #329) is one of these practices. No-till is commonly acknowledged as an effective practice to reduce soil erosion, nutrient loss and increase soil organic matter. However, the application of no-till in northern Vermont appeared to have limitations due to the presence of heavy soils and short growing seasons.

The Vermont NRCS Soils Staff recently developed a No-till soil interpretation which accounts for maximum slope, rock content, and other factors as quoted below. GIS was then used to find crop fields where at least half the field was rated Good or Excellent for this practice. The GIS procedure is included in Appendix D.

Here, quoted from the State Soils Staff, is the reasoning behind the interpretation of soil map units for No-Till potential: "Soils are classified for their suitability for No-Till conservation practices. These practices include planting methods commonly referred to as no-till, strip till, direct seed, zero till, slot till or zone till. Soils that are classified as excellent, good or fair are considered to be suitable for No-Till practices.

The soil properties and qualities considered in developing these classifications are those that affect tillage operation, crop growth, and other necessary mechanical operations. The soil properties that affect No-Till practice establishment and continuance are

1. soil drainage
2. surface gravel, cobbles and stones
3. flooding
4. ponding
5. depth to water table

6. slope
7. depth of soil

Flooding, ponding, high water table and soil depth also affect crop establishment, growth, and productivity.”

Sub-basin Summary

The analysis showed that there is widespread potential for this practice throughout the Sub-basin. A total of 19,558 acres of crop or hay fields have potential for no-till (see Figure 25). Fifty percent or more of the soils in these fields are rated either Good or Excellent. The Rock River and Hungerford Sub-watersheds have 1,131 acres and 2,393 acres, respectively, of fields with Good or Excellent potential for no-till (see Figures 26 and 27). The practice may be especially helpful in curtailing erosion on fields that contain steep areas under corn production. We will use the resulting GIS layers maps to target the promotion and application of this practice.

Figure 25 - Crop and Hay Fields with Good or Excellent Potential for No-till in the Rock River Sub-watershed.

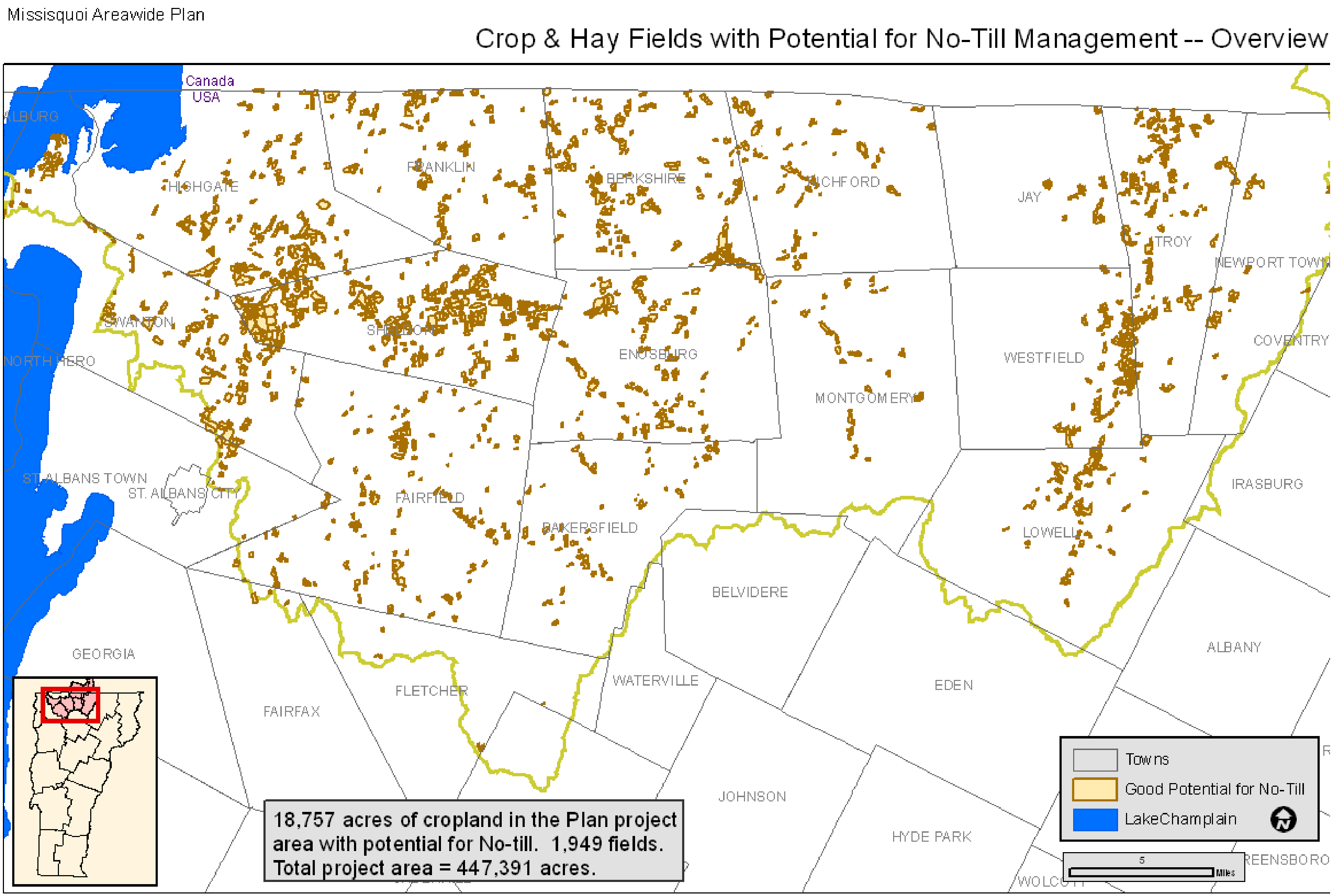


Figure 26 - Crop and Hay Fields with Good or Excellent Potential for No-till in the Rock River Sub-watershed.

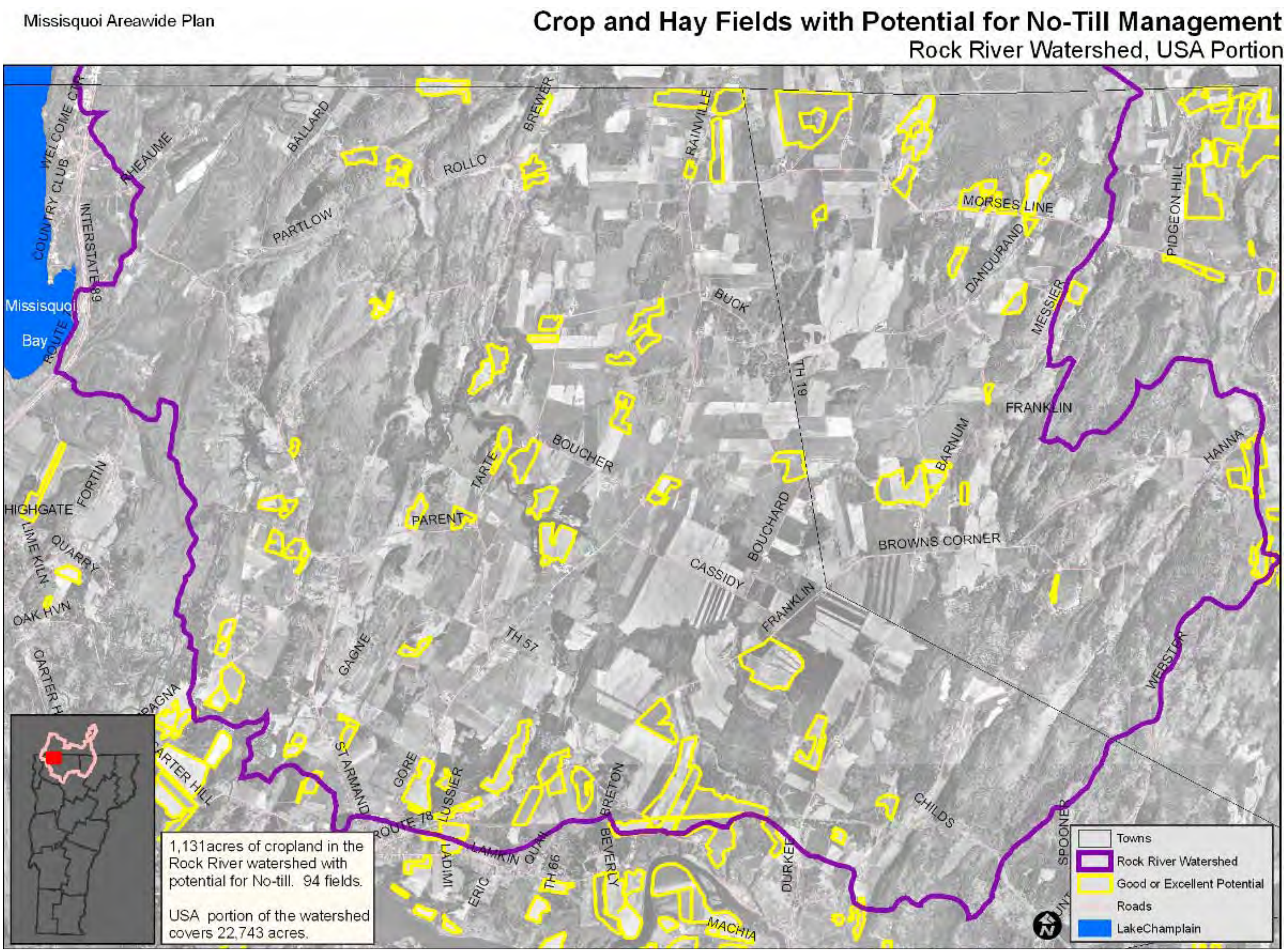
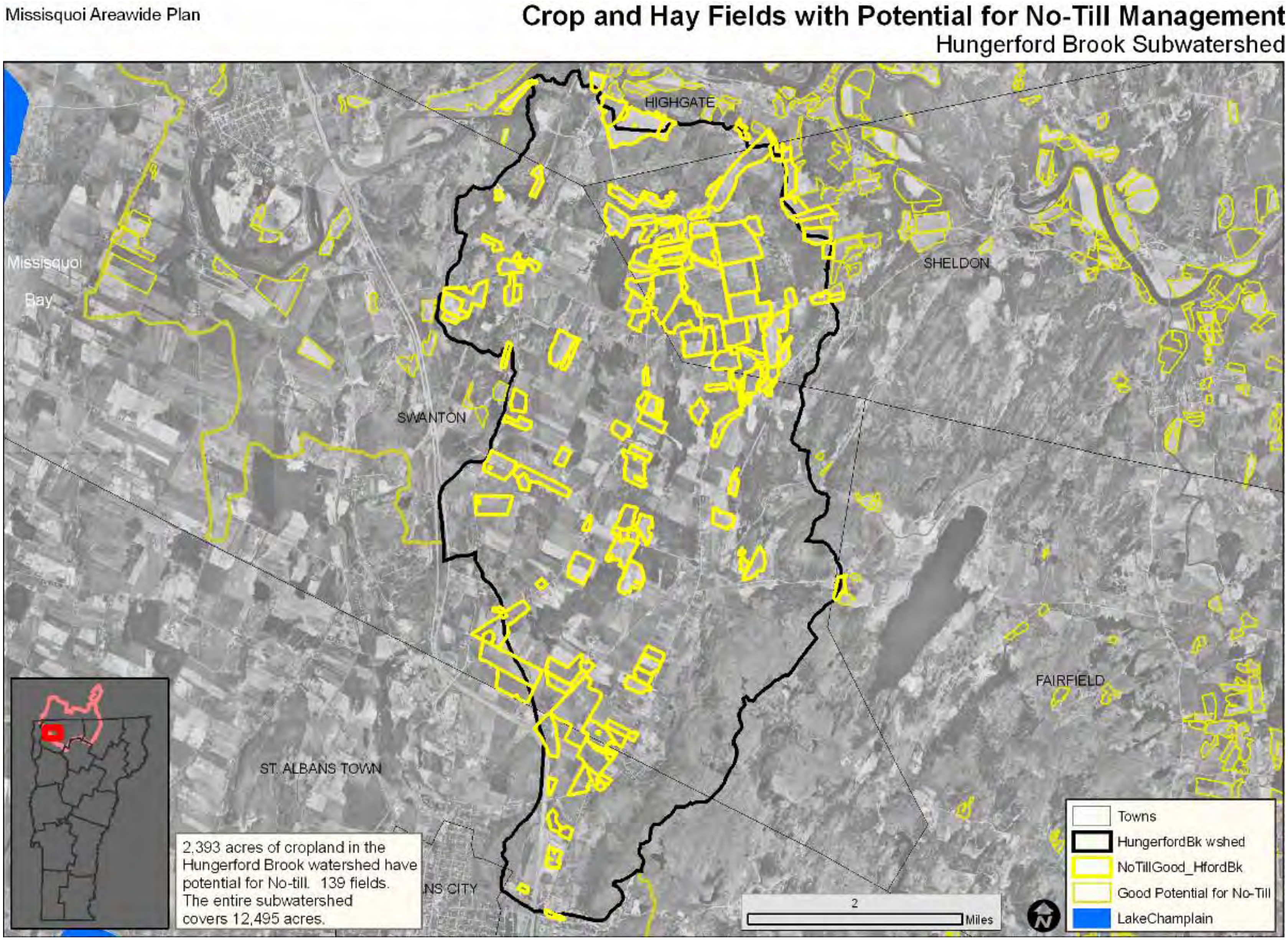


Figure 27 - Crop and Hay Fields with Good or Excellent Potential for No-till in the Hungerford Brook Sub-watershed.



Examination of 10 BMP Scenarios on Cropland

Ten Best Management Practice (BMP) scenarios to improve water quality were developed for cropland in the sub-basin. The purpose of the scenarios is to compare the relative effectiveness of different conservation practices on estimated phosphorus export from the edge of fields. These scenarios were evaluated using a combination of RUSLE2, Vermont P Index and estimated cost data. RUSLE2 is a method developed by NRCS to estimate sheet and rill soil erosion on cropland. The Vermont P Index is a tool developed by UVM Extension to estimate the relative magnitude of phosphorus runoff from cropland.

The ten scenarios are described below. They were developed to represent actual conditions in the sub-basin and to include reasonable applications of accepted conservation practices. For each scenario the assumptions employed to develop the conditions for its application are described. **The phosphorus estimates resulting from this analysis should not be interpreted as absolute numbers.** They do not represent actual contributions of phosphorus to the lake or even to the edge of the field. However, the phosphorus estimates can be used to compare the relative magnitude of phosphorus reduction associated with each scenario.

BMP Scenarios Used in this Analysis

A "base" scenario was developed that was comprised of continuous corn on 3 different slope classes of fields. These slope classes included 0 – 3%, 4 – 8%, and greater than 8%. No BMPs were assumed to be present on these fields. For the RUSLE2 analysis we used a Georgia Stony Loam as the typical soil. This soil was used in all scenarios. An average slope of 2%, 6% and 11% were used to represent fields in each of the respective slope classes. A slope length of 200 ft. was used in the low slope class, 170 ft. in the medium slope class, and 100 ft. in the high slope class. Total cropland (71,939 ac), land in corn (17,114 ac) and land in hay (50,009 ac) were estimated from an interpretation of the 2003 NAIP photography (Table 8). The number of acres in corn production for this year was assumed to represent the amount of corn production in any given year in the Sub-basin, even though the actual fields in corn production change from year to year since many of the fields are in crop rotations. The acres in corn production for each of three slope classes were estimated from the cropland slope analysis, the results of which are reported in Table 8.

The P-Index analysis for this "base" scenario included spring and fall dairy manure applications, spring plowing and no incorporation of manure in the fall. The scenario also included 30 lb P_20_5 fertilizer per acre, incorporated on silage corn with very little residue. A 10 ft wide buffer was assumed on all fields.

All analyzes were conducted for the Sub-basin as a whole. Differences at the Sub-watershed level were not considered.

<u>Scenario #1 – Permanent seeding on fields with steeper slopes</u>

Under this scenario it was assumed that 50% of all the corn acreage in the steeper slope class would be seeded down to permanent grass. Thus the number of acres of corn in this slope class was reduced from 2,737 to 1,369. All other variables were held constant.

Scenario #2 – Implementation of no-till on a broad basis
It was determined that there were a total of about 19,558 ac. of soils in the sub-basin that were suitable for no-till. This was based on an analysis of the soil interpretations for soil map units in the sub-basin. It was assumed that 50% of field acreage with soils suitable for no-till in each of the 3 slope classes would be converted from continuous corn to no-till. All other variables were held constant.

Scenario #3 – Implementation of cover crops on a broad basis
Cover crops were assumed to be planted on 50% of the corn acreage in the high and medium slope classes. All other variables were held constant.

Scenario #4 – Use Manure Injection on Permanent Hay
Using 2003 as the base year, there are 51,100 acres of fields managed as hay in the sub-basin. This scenario assumed that manure injection would be used on 50% of this acreage.

A "base" hay scenario was also developed that used the same 3 slope classes and soils as the corn "base" scenario. Under the hay "base" dairy manure was surface applied twice during the summer, at a rate of 30 P_2O_5 lbs P per acre.

Scenario #5 – Reduce soil phosphorus in fields with test results of 'exceeds' to 'optimum' phosphorus levels
It was assumed that 10% of the fields in each slope class had soil phosphorus test levels of exceeds. Soil test results generally indicate that less than 10% of the fields have soil phosphorus levels of 'exceeds'. For the P Index we used soil test values of 7 to represent optimum phosphorus levels and 30 to represent exceeds. The scenario assumed 100% of the fields with exceeds levels of phosphorus were reduced to optimum levels.

Scenario #6 – Use of no-till and manure injection in combination
The same test conditions were used as in Scenario #2. In addition, manure injection was assumed to be used on all of the no-till fields to apply manure in both the spring and fall.

Scenario #7 – Manure injection used in combination with cover crops on corn
The same test conditions were used as in Scenario #3. In addition, manure injection was used in combination with the cover crops. In the fall, manure is often surface applied to corn fields with cover crops and not incorporated.

Scenario #8 – Addition of a filter strip of 50ft to fields at 'T'
It was assumed that 50% of all corn fields in each slope class had a 50 ft. wide filter strip installed. All other variables were held constant.

Scenario #9 - Reducing erosion on corn fields from 2'T' to 'T'
Erosion on 50% of the corn fields in the medium and high slope classes was reduced from 2'T' to 'T'. This can be accomplished by employing a variety of practices such as cross slope tillage, diversions, strip tillage, etc. All other variables were held constant.

Scenario #10 - Convert fields in silage corn to grain corn

It was assumed that 50% of the corn fields in each slope class would be converted to grain corn production. This change in cropping system results in a significant increase in residue left on the ground surface. A few small farms in Vermont have already switched to growing high moisture grain corn instead of silage corn. Apparently there are benefits from growing grain corn to soil conditions and field management, as well as decreasing sediment and phosphorus loss. All other variables were held constant.

Overview of Results

The total acres of corn estimated in the sub-basin for 2003 was 17,114 ac. Of this corn, 7,583 acres occurred on slopes of 0 to 3 percent, 6,794 acres occurred on slopes between 3 and 8 percent, and 2,737 acres occurred on slopes greater than 8% (Table 11).

There were an estimated 50,009 acres of hay in the sub-basin in 2003. Of these acres, 12,818 occurred on slopes between 0 and 3 percent, 22,159 occurred on slopes between 3 and 8 percent and 15, 032 occurred on slopes greater than 8 percent (Table 11).

Using these acreages and the assumptions stated above, savings in soil erosion rates (t/ac/yr) and totals (t/yr) were calculated for each of the 10 scenarios. Reductions in phosphorus losses were also calculated as a rate (lbs/ac/yr) and as a total amount (lbs/yr).

The cost of reducing phosphorus loss was estimated using the amount saved per acre and the estimated per acre cost of implementing the BMP(s). Cost estimates were derived from the recently developed NRCS Payment Schedules which are used to set conservation practice payments for cost-share programs. Estimates of cost per pound of phosphorus were developed for the cost of implementing the practice and for the cost of lost crop production associated with implementing the practice.

The results from the scenarios (Table 11) produced a wide range of results for sediment and phosphorus savings, and cost of implementing the practice(s). Reductions in soil loss rates varied from no change for several scenarios that do not significantly affect cover, such as manure injection, to 12.4 t/ac/yr for Scenario #1, permanent seeding on steep slopes. By implementing no-till, Scenario #2 also produced a high reduction in soil loss rate, 5.8 t/ac/yr. Several scenarios showed no reduction in total soil loss, such as scenarios #4, 5, and 8. Scenarios #2 and 6, the no-till scenarios, produced the largest reduction in total soil loss, 36,911 t/yr. The large reductions in total soil loss with no-till was a result of a good rate of reduction coupled with a relatively large acreage (8,558 ac.) on which this practice was applied. The number of acres for which each scenario was applied had a significant impact on the total estimated reductions of both soil and phosphorus loss.

Table 11 - Summary of Soil Loss and Phosphorus Loss Reductions from 10 Selected BMP Scenarios.

Scenario	Total Acres Applied	Av. Soil Loss Reduction (tons/ac/yr)	Total Soil Loss Reduction (tons/yr)	P Loss Reduction (lbs/ac/yr)	Total P Loss Reduction (lbs/yr)	Practice Cost of P Reduction* ($/lb P)	Total Cost of P Reduction** ($/lb P)
#1 - Permanent Seeding on Steep Slopes	1,369	12. 4	17,003	2.7	3,696	31	307
#2 - No-till	8,558	5.8	36,911	1.2	8,122	40	40
#3 - Cover Crops	4766	2.7	12,366	0.8	3,550	49	49
#4 - Manure Injection on Hay	25,005	-	-	0.7	17,066	9	9
#5 - Reduce Soil P Levels	856	-	-	1.0	733	14	14
#6 - No-till and Manure Injection	8,558	5.8	36,911	2.4	18,359	47	47
#7 - Cover Crops and Manure Injection	4,776	2.7	12,366	1.0	5,177	79	79
#8 - Add Filter Strip	8,558 (428)***	-	-	0.6	4862	15	324
#9 - 2 'T' vs. 'T'	4766	1.5	4,968	0.5	3,312	0	1,074
#10 - Convert to Grain Corn	8,558	4.9	5,498	1.1	7,795	0	0

* This represents the estimated cost per pound of phosphorus based on the cost of implementing the practice.
** This represents the estimated total cost per pound of phosphorus. It includes both the cost of implementing the practice and any costs associated with lost crop production.
*** Estimated number of acres actually planted to filter strips.

There were also a wide range of results for the reductions in phosphorus loss between the various scenarios. The rate of estimated reduction varied from 0.5 lbs/ac/yr for Scenario #9, 2 'T' vs. 'T', to a high of 2.7 lbs/ac/yr for permanent seeding of steeper slopes. Total reductions in phosphorus loss ranged from 733 lbs/yr for Scenario #5, reducing soil P levels, to a high of 18,395 lbs/yr for implementing no-till in combination with manure injection. The highest total reductions were again achieved by those scenarios that expressed a combination of high rate reductions and large acres applied.

Clearly, well accepted and documented Practices such as no-till and cover crops are well accepted by the agricultural community throughout most of the U.S. Based on the results above they can potentially have a significant impact on both soil and phosphorus reduction in the Missisquoi Sub-basin. Another interesting result is the very significant reduction in total phosphorus loss by implementing manure injection. This practice produced a good rate of reduction, 0.7 lbs P/ac/yr, but really benefited from the relatively large acreage on which this practice could be applied. This is due to the fact that there is significantly more estimated hay in production, 50,009 ac., versus the estimated acreage in corn, 17,114 ac. Permanent seeding on steeper corn fields, Scenario #1, produced very high rates of phosphorus reduction, but because of the small number of acres of corn on steeper slopes produced relatively lower total phosphorus reductions. One much discussed BMP, reducing soil phosphorus levels on fields with excessive phosphorus, Scenario #5, produced very low reductions in total phosphorus loss. This is primarily due to the relatively small number of corn acres that were estimated to exhibit excessive soil phosphorus levels (assumed to be 10% of all corn fields). Finally, Scenario #10, changing from silage corn to grain corn, shows how changing cropping systems and crops can have significant benefits in reducing soil and phosphorus losses. The large reductions associated with this scenario resulted primarily from the benefit of increased residue on the ground surface under a grain corn cropping system.

The final two columns of data in Table 11 include estimates of the implementation and total costs associated with each BMP. Rough cost estimates were developed using recently developed NRCS Payment Schedules. Included in the practice cost column in Table 11 are the estimated costs associated only with implementing the practice. The final column includes the total costs of implementing the practice plus the costs of lost crop production. There were 2 scenarios #9 and #10 for which there was no cost associated with implementation. In these situations there might be additional costs to the farmer for a different type of equipment or feed storage; these costs were not included in the analysis. Manure injection on hay (Scenario #4) showed the highest cost $78/lb P. If the cost associated with a loss of crop production is included, conversion to grain corn (Scenario #10) still showed the best rate of return. Increasing the length of hay in crop rotations (Scenario #9, 2'T' vs. 'T') had the highest phosphorus savings cost, $1,074/lb P.

These 10 scenarios are examples of the type of data that can be generated from using RUSLE2 and P-Index information. This information should be useful in establishing priorities and goals for phosphorus reduction activities related to agricultural crop production. It can be used to determine the extent of a particular phosphorus loss problem and estimate the relative amount of reduction of phosphorus loss that is associated with different BMPs or systems of BMPs in order to assess when a phosphorus loss goal might be achieved. This information can also be used to evaluate the relative effectiveness of different BMPs and systems of BMPs in different cropping situations. Finally, relative cost information can provide insights as to the most cost effective methods in reducing phosphorus losses from cropping systems.

Chapter IV - Implementation of the Area-wide Plan

COORDINATING THE AREA-WIDE PLAN WITH PARTNERS AND ONGOING PROGRAMS

NRCS in Vermont administers and implements a variety of water quality related programs that are funded by the Conservation Title of the U.S. Farm Bill. For the last five years, NRCS has obligated approximately 10 million dollars per year to farmers and other rural landowners in Vermont. Most of these funds, such as for the Environmental Quality Incentives Program (EQIP) funds are targeted primarily to projects where water quality is a resource concern. Other programs, such as the Farm and Ranchland Protection Program (FRPP) have significant secondary benefits for water quality protection by helping ensure land does not go into development. Farm Bill funds associated with these programs are obligated in partnership with other on-going State programs and initiatives. This includes the VAAFM BMP program that provides funding for many of the same practices as EQIP.

A fundamental objective of the Missisquoi Area-wide Plan is to provide NRCS and its partners additional information to better target and coordinate these kinds of state and federal expenditures in the Missisquoi Sub-basin.

Prioritization of Resource Concerns and the Targeting of Conservation Practices

As discussed, intensive agriculture comprises a large part of the Missisquoi Sub-basin. Because of this, the highest priority resource concerns are related to agricultural; they include issues such as runoff of manure and feed wastes from farmsteads, nutrient and sediment rich runoff from cropland and erosion associated with streams and rivers. Other resource concerns, identified by the VTDEC Watershed Planning initiative include: forest and urban related issues such as erosion from logging activities and urban stormwater runoff. This Area-wide Plan addresses only the agricultural and stream related resource concerns. As such, the targeted efforts discussed in the Area-wide Plan need to be coordinated with those of other conservation agencies already underway in the Sub-basin.

The studies and data analyses are specific to several different resource concerns, such as erosion from cropland. The analyses provided here do not attempt to compare or prioritize between different resource concerns. For example, no effort was made to quantify and prioritize runoff from farmsteads with the runoff from cropland. Additionally, there are already established, ongoing federal and state programs that provide funding to address each of the resource concerns identified in this Plan.

It is not the purpose of this Plan to recommend changes in programs or funding levels currently directed at each of these concerns. Rather, this Plan has provided further data and analysis that can help target and direct conservation in each of these areas of concern. For example, conservation funds obligated to treat erosion on cropland may be more effective in reducing phosphorus runoff if additional funds are targeted to erosion control on a smaller number of corn acres, but only to those fields with slopes greater than eight percent.

Using Synoptic Water Sampling to Identify Problem Areas

Phosphorus and sediment loadings within a watershed can be highly variable and discontinuous. Phosphorus loads do not always increase proportionally downstream and may be due to specific problems associated with small areas. A study was discussed in Chapter 3 that collected water quality data on tributaries throughout the Hungerford Brook Watershed. A few tributaries were shown to have higher sediment and total phosphorus loads and concentrations than other tributaries, indicating that these areas are transporting sediment that is highly enriched with phosphorus. In one case the higher loading could be attributed to one specific farmstead and problems associated with it. In other tributaries the higher loading appears to be watershed wide.

This synoptic approach to water quality sampling can provide important information to help target conservation efforts within a watershed or region. It can provide information on tributaries with higher sediment and phosphorus loads and can help identify specific problem areas that need remediation. Further sampling of this type could be a valuable targeting tool in the Missisquoi Sub-basin.

Treating Resource Concerns on Farmsteads

Currently there is no comprehensive agricultural database for the Missisquoi Sub-basin that details farm numbers and type. NRCS maintains contract specific information for only those farmers who are active program participants. The type and extent of this information varies greatly depending on the program and the amount of land included in the program contract. The VAAFM maintains information on all Large Farm Operations (LFOs) and is in the process of compiling information on all Medium Farm Operations (MFOs) as is required by State Law. An attempt to collect information on small farms in the Missisquoi Sub-basin has been discontinued and there is no indication when or if it might resume. Under the LFO and MFO rules, all discharges from these farms have either already been addressed or will be in the next few years. However there are a large number of small farms with the potential for continued, undocumented farmstead discharges.

Chapter 3 discussed a method developed to identify and map all farmsteads in the Hungerford Brook Sub-watershed. This effort needs to be extended throughout the Sub-basin and expanded to include critical farmstead information that would include the presence and type of any discharges. This information could be compiled by combining data already collected by the VAAFM for LFOs and MFOs with data that would be collected through a small farm survey or some alternative procedure. One alternative is the identification of farmstead discharges using high resolution color photography. This photography has already been purchased for small "special project" areas in other parts of Vermont. The benefits associated with the use of this type of photography are further explained in Appendix C.

Interpretation of this photography could provide information for this Sub-basin wide farmstead database in lieu of other methods such as on-farm surveys.

NRCS and VAAFM cost-share programs for agricultural conservation practices are obligated through voluntary programs. These programs all use ranking procedures to ensure that funds are obligated to those farmers with the most significant resource concerns. These programs generally rely on the farmer to initiate an application for cost share. As such, these programs cannot be used to effectively target all significant water quality problems in the Sub-basin. A farmstead database would greatly aid the targeting of conservation cost-share funds to the most significant existing problems in the Sub-basin. Farmsteads with significant discharges could be identified and the farmers targeted for outreach efforts to participate in cost-share programs to eliminate the discharge. This process would help eliminate ongoing discharges that are not being adequately addressed. Critical farmsteads may become eligible for piggyback funding from other agencies to further lower barriers to conservation implementation. The Missisquoi Area-wide Plan was designed to foster such cooperation between agencies when critical needs are understood and agreed upon.

Treating Resource Concerns on Cropland

The Missisquoi Sub-basin has substantial acres dedicated to hay and corn production. As discussed in Chapter 2 the acreage of annually tilled corn has increased significantly over the last 25 years. Conservation programs such as EQIP and the VAAFM BMP program have continued to cost-share a wide variety of cropland practices. The location and type of practices implemented is often the decision of each farmer; this often does not address the more critical resource concerns. In addition, the relative effectiveness of some conservation practices is largely unknown for specific situations. The Area-wide Plan has identified several cropland situations where priorities should be established to reduce sediment and phosphorus loss in an efficient manner. For example, corn fields on slopes greater than eight percent have been shown to deliver much higher rates of sediment and phosphorus directly to surface waters than corn fields on flatter slopes.

Based on the analyses in this Plan, the following practices or combinations thereof appear to be most effective in reducing sediment and phosphorus losses from cropland:

- Corn fields with a predominance of slopes greater than eight percent, should be seeded down, and permanently maintained in hay.
- Implement no-till cropping systems on fields having a good potential for no-till.
- Convert silage corn cropping systems to grain corn cropping systems or other cropping systems with permanent vegetation or high residue levels.
- Inject manure on hay land instead of using surface applications,

These scenarios were discussed in detail in Chapter 3. The specific location of steep corn fields, hay fields and fields with no-till potential were provided as part of the analysis. Conservation planners can now use this information to target specific fields and farms for conservation practices. Federal and state programs will need to be modified to ensure that sufficient incentives are available to get farmer participation. Further spatial information was provided for one Sub-watershed, the Rock River, identifying areas with a high potential for gully erosion. This information should be used by planners to target areas for site visits to assess whether gully erosion is occurring. This could also be conducted as part of the overall resource inventory process when working with a farmer to develop a conservation plan.

Targeting the fields identified above with a new array of conservation practices will ultimately result in a much more significant and efficient reduction of sediment and phosphorus loss from cropland in the Missisquoi Sub-basin.

Treating Resource Concerns Associated with Stream and River Systems

Vermont landscapes have undergone significant historic modifications due to extensive land clearing and forest clear cutting over the past 150-175 years. In more recent times, our stream and river systems have suffered from a variety of impacts and encroachments including: gravel mining, straightening, man-made re-alignments and construction of bridges and other permanent structures. As a result, up to 75 percent of our stream and river reaches are currently undergoing adjustment due to geomorphic instability[26]. This instability creates conditions where accelerated rates of stream bed and stream bank erosion are common. These accelerated erosional processes have the potential to deliver significant amounts of sediment and phosphorus to Lake Champlain. The Missisquoi Sub-basin and its sub-watersheds are typified by many stream reaches in a state of geomorphic adjustment.

The data collected through the Phase I and Phase II stream geomorphic assessments is now readily available through the VTDEC Stream Geomorphic Assessment Data Viewer. Described in Chapter 3, this Data Viewer provides conservation planners with a variety of stream and river data as both map products and databases. The information can be used to assess various reaches of streams and rivers in the Missisquoi Sub-basin in order to target practices to areas with the greatest need. Several different conservation measures, such as channel re-alignment and floodplain restoration can be targeted to those sites where the greatest benefits will be realized. NRCS and its partners now need to develop a process to include these high priority areas in project application ranking for on-going programs such as WHIP and EQIP.

Historically all natural community types associated with riparian areas were dominated by woody vegetation (forested or scrub/shrub). The exceptions were beaver meadows, a successional stage of an alder swamp and some lake influenced streams dominated by sedges, rushes, and grasses. The geomorphic instability of rivers and streams can be accelerated or even created by the lack of natural boundary conditions associated with woody vegetation on streambanks. The removal of woody vegetation from stream and river banks has the potential to significantly alter these boundary conditions, resulting in accelerated erosion. This loss of woody riparian vegetation is often a result of agricultural activities, either from clearing for crop production or from the grazing by livestock. As a result, large

[26] Mike Kline, VTDEC River Management Group, Personnel Communication, 2008.

sections of most river and stream corridors are now devoid of woody vegetation. Livestock still have access to the stream banks in some areas, creating further instability and erosion. Forested riparian buffers can help to reduce sediment and phosphorus runoff associated with adjacent crop and pasture fields. Fencing livestock from stream access, combined with watering facility development, has been shown to be successful in substantially reducing phosphorus delivery to streams, by stabilizing stream banks.

As part of this Plan, a comprehensive interpretation of aerial photography was performed to identify stream and river reaches without woody vegetation. This analysis was discussed in some detail in Chapter 3. Of the 2,815 streambank miles assessed in the Missisquoi Sub-basin, 919 appear to have inadequate riparian buffers. A minimal buffer from a water quality perspective was considered to be 25 feet. The location of these "riparian buffer gaps" has been identified and included in a GIS database. This gap information can now be overlain with other information on the riparian corridor, such as stream bank erosion susceptibility data. This overlay identifies areas along the river corridor that have soils susceptible to erosion and without woody vegetation. These are areas where stream restoration and stabilization practices are likely a priority.

This riparian gap data can also be used in conjunction with erosion information available in the Stream Geomorphic Data Viewer to identify high priority areas for stabilization and tree planting and establishment. Further efforts are needed to coordinate the use of VTDEC programs and funds for restoring and protecting river corridors with USDA programs such as CREP to re-establish forest riparian buffers.

Treating Resource Concerns Associated with Degraded Wetlands

Vermont has lost approximately fifty percent of its natural wetlands since the time of European settlement.[27] Incremental loss of wetlands continues today due to both urban development and agricultural conversions. One important function of natural wetlands is sediment and nutrient retention. On a watershed wide basis there has been a significant reduction of this wetland function throughout Vermont, including the Missisquoi Sub-basin.

The Lake Champlain Wetland Restoration Plan discussed in Chapter 3 identified approximately 16,000 acres of degraded wetlands that could have restoration potential in the Missisquoi Sub-basin. Many of the potential restoration areas occur in landscape positions, such as floodplains, that could provide sediment and nutrient retention functions. In general, these areas received a higher priority ranking in the Wetland Restoration Plan.

Several wetland restoration programs operate in the State. NRCS administers the Wetland Reserve Program (WRP) and has been restoring 2-3 wetlands each year since 1998. WRP funds are available for protection of wetlands through easements and for restoration. The Partners for Fish and Wildlife program (PfW) of the USFWS also has funding to restore

[27] Wetlands and Agriculture: Private Interests and Public Benefits. Ralph E. Heimlich, Keith D. Wiebe, Roger Claassen, Dwight Gadsby, and Robert M. House. Resource Economics Division, Economic Research Service, U.S> Department of Agriculture. Agricultural Economic Report No. 765. p. 80.

wetlands. More recently, The VT DEC funded an initiative to restore wetlands under the Clean and Clear Program. Funds from this program can also be used to protect wetlands with easements and restore them to natural conditions.

To date, most applications for wetland restoration were submitted by interested landowners. Many of these voluntary applications, if approved for funding, would have provided marginal benefits to improving wetland functions. In order to maximize wetland restoration benefits, especially for water quality, a more targeted approach to wetland restoration is needed. The three agencies, NRCS, USFWS and VTANR, need to establish a targeted outreach program with a goal of restoring wetland sites that provide the greatest increase in wetland functions. The Lake Champlain Wetland Restoration Plan provides the basis for this targeted outreach program. Landowners with high priority wetland restoration sites can be contacted and the merits and benefits of restoring their sites can be discussed. Although still a voluntary program, this targeted effort will help ensure high priority sites will be the first to be restored.

Use of the Area-wide Plan by Partner Organizations

This Area-wide Plan was prepared for use by NRCS and its partner organizations. In most cases, NRCS will be an active partner in any initiatives relating to this Plan in the Missisquoi Sub-basin. NRCS will take the lead to develop any additional maps or other applications of the data submitted in this report. In some cases, partner organizations may undertake an initiative without NRCS involvement. In these situations it may become necessary to develop additional maps or displays of data not provided in this Plan.

The Plan provides data and examples of output that is now readily available for use by resource managers from any organization. In some cases, examples of compiled data are provided for specific watersheds, such as cropland data for the Rock River and Hungerford Brook sub-watersheds. When working in other watersheds, it may be necessary to develop GIS data and maps specific to these sub-watersheds. The methods to produce the more complex maps shown in this report are provided in the Appendix.

FUTURE DIRECTIONS AND NEEDS

The Missisquoi Area-wide Plan serves as a guide for future conservation efforts in the Missisquoi Sub-basin. Future initiatives in the Sub-basin should evolve and change over time as knowledge increases and new tools become available. Some possible initiatives and tools are described below that could help meet the goals of this Plan as well as the goals outlined in the LCBP's “Opportunities for Action” and the VTDEC Center for Clean and Clear Work Plan.

Use of Adaptive Management

Adaptive Management is defined as a structured, iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. In this way, decision making simultaneously maximizes one or more resource objectives and, either passively or actively, accrues information needed to improve future management. Adaptive Management is often characterized as "learning by doing."[28]

There are several key elements associated with adaptive management. These elements must be recognized and incorporated into the decision making and management process. For resource management in the Missisquoi Sub-basin, the following elements must be developed and incorporated into the long-term process of improving water quality in Missisquoi Bay.

1. Recognize our gaps in knowledge and the risk associated with implementing programs and practices in such uncertainty;
2. Develop a conceptual understanding of how sediment and phosphorus enter the Bay and the relative magnitude of those sources. This conceptual understanding can be adjusted over time based on new data and knowledge of how the system works;
3. Develop a water quality monitoring program to provide input to the decision making process and use the data as insight to adjust our conceptual understanding of how the system works; and;
4. Build iteration into the decision making process. Sufficient data needs to be collected in order to evaluate the results of our decisions and then make needed adjustments. The results from collecting data can then be used to further refine the monitoring program.

Additional Data and Tools Needed

During development of this Area-wide Plan it became clear to the authors that there is a need for additional data and tools to further evaluate resources.

Farmstead Database

The lack of a formal database for agricultural farmsteads has been described. As part of this Plan an initial farmstead database was created for the Hungerford Brook Sub-watershed. This example included farmstead locations and type of operation. A Sub-basin wide database is important in order to track existing resource concerns. It can also be used as a tool to estimate workload and funding needs, and can also be used to measure success. A farmstead database that includes all significant farming operations is an important first tool needed in the Sub-basin. The information included in the database should be expanded to include information on resource concerns associated with the operation.

[28] Wikipedia contributors, 'Adaptive management', *Wikipedia, The Free Encyclopedia,* 24 January 2008, 20:29 UTC, http://en.wikipedia.org/w/index.php?title=Adaptive_management&oldid=186658915

Crop Field Database
An initial cropland database for the Missisquoi Sub-basin was developed for this Plan. The location of cropland fields as of August, 2003 was determined, their slope was measured, and their use for corn or hay was identified. A more complete cropland database could be developed that would include a variety of additional useful data including active or idle pastureland. This database could include information on RUSLE2 erosion rates, cropping systems and rotation schedules, soil test results for phosphorus, and P Index values.

This additional information would prove valuable in targeting additional fields for specific conservation practices. It could also be used in the development of computer-based models in order to better understand sediment and phosphorus export on a watershed and field level basis and to help determine which conservation practices would be most effective in controlling it.

High Resolution Digital Photography
The most recent available digital imagery is the NAIP imagery. The imagery from 2003 has a pixel resolution of 1.0 meter, while the 2006 imagery has a resolution of 2 meters. This imagery is not generally suitable for developing accurate spatial agricultural use data, either alone or in conjunction with other data such as the CLU and crop report data. A detailed description of the NAIP imagery and its limitations is located in Appendix C.

Data collected for the NRI in 2001 and later with digital imagery with a pixel size of 1.0 foot (0.30 meter) has proven to be much more effective. Used in GIS, this imagery, coupled with the hard copy color diapositives, provides greater sharpness and resolution. The NRI photography is natural color, is flown at the height of the growing season, and is flown at a scale of 1:7,920.

Examples of uses of the high resolution photography include:
- Assess condition of farmsteads, farmland, residential land, and other built-up areas;
- Distinguish active versus inactive farmstead areas;
- Assess farmstead runoff and determine its proximity to drainage ditches, streams, and water bodies;
- Distinguish idle pasture land from pasture that is being grazed;
- Distinguish the presence or lack of fencing in pastures along streams;
- Assess pasture vegetative health, watering facility distribution, and overgrazed pastures;
- Identify and map built-up (developed) areas with high accuracy, including residential, commercial, industrial and recreational areas;
- Ability to assess these factors in regard to their proximity to streams and water bodies;
- Identify and map wetlands and other water features (where Color Infra-Red CIR is also available)
- Identify stream bank areas devoid of vegetation, stream bank erosion, and snags in streams; and
- Provide a permanent record of current growing season conditions.

This type of photography could prove invaluable. It would greatly aid in the targeting of specific problem areas, especially if on-site access is difficult to obtain. Additionally, it will assist in targeting where further on-site assessments and conservation activities are necessary.

LiDAR Data

Light Detection and Ranging (LiDAR) is a remote sensing system used to collect highly accurate elevation (topographic) data. These data are collected with aircraft-mounted lasers capable of recording elevation measurements that have a vertical precision of 15 centimeters (6 inches). The LiDAR data provides much greater resolution than the currently available 10 meter DEM data.

The LiDAR data could be used to more accurately determine the slope of crop fields. It could even be used to identify steep areas and areas of concentrated runoff within field areas. The data also provides sufficient resolution to identify classic gullies within fields or gullies that form in steep areas adjacent to fields. Annually tilled fields in floodplains often include areas that are susceptible to recurring scour erosion. LiDAR data would be an effective means of identifying scour erosion in floodplains. These identified problem areas could then be targeted for remediation with appropriate conservation practices.

Water Quality Impacts of Surface and Tile Drainage

The installation of drainage systems in cropland fields used to be a very common practice. In many instances, drainage systems installed years ago are still functioning. Field drainage installation is still done, but to a much lesser extent than 2-3 decades ago. There are many advantages to the removal of excess surface and ground water from fields in crop production. Improved drainage allows for crop production and extended periods of access for activities such as the application of manure, tilling and planting, and the harvesting of crops as well as for improved production. Both surface ditches and subsurface (tile) drainage are common agricultural practices in the Missisquoi Sub-basin due the prevalence of poorly and somewhat poorly drained soils.

The alteration of natural hydrologic conditions on farm fields impacts the export of sediment, manure, and phosphorus to surface waters. In some cases the improved crop field drainage may decrease contaminant export due to less surface runoff over the field. In other cases, the establishment of more direct hydrologic links between the field and surface waters may increase contaminant runoff. More research is needed to determine drainage effects on water quality with different soil types and with different cropping systems.

As part of this initiative more information is needed on the remediation of contaminants in ditch and tile water outflows with best management practices. This may require the development of new BMP’s that fit these particular situations.

Sediment and Phosphorus Contributions from Streambank Erosion

A high percentage of stream and river reaches in the Missisquoi Sub-basin are undergoing geomorphic adjustments due to historic changes in landuse and to more recent modifications of stream alignments. During the process of geomorphic adjustment, erosion and deposition are accelerated in these stream and river systems. These accelerated erosional processes have the potential to increase the amount of sediment and attached phosphorus moving into surface waters, and ultimately being deposited in Missisquoi Bay.

The accelerated rate of erosion has not been adequately quantified; nor has the amount of phosphorus associated with this increased load of sediment and resulting deposition. Further research is needed to quantify the effects of these processes resulting from geomorphically unstable rivers and streams. Research is also needed on the quantity of phosphorus associated with different soil types and strata within the active floodplain of these systems.

RECOMMENDATIONS

Below are 13 recommendations that are the highest priority for consideration in implementing the Missisquoi Area-wide Plan. These recommendations were developed as a result of completing this Plan.

1. Complete farmstead identification and maps for the entire Sub-basin.
2. Create a farmstead GIS database for the entire Sub-basin.
3. Determine where discharges from farmsteads are occurring and their relative severity, either through on-farm surveys or through photo interpretation.
4. Target conservation practices to specific crop fields that have the greatest risk of sediment loss and phosphorus export.
5. Use cropland conservation practices that have the greatest anticipated impact on sediment and phosphorus loss reduction, including: no-till planting, permanent seeding for targeted annually tilled land, manure injection on hayland, and conversion from silage corn to grain corn or other cropping systems which provide increased crop residues on the soil surface.
6. Identify highest priority riparian buffer gaps for treatment through programs such as CREP and contact landowners about participation.
7. Identify high priority river and stream reaches in need of treatment.
8. Initiate an interagency effort to contact landowners with high priority wetland restoration sites for participation in federal and state programs.
9. Initiate synoptic water quality sampling in targeted areas.
10. Identify additional map and data products that need to be developed.
11. Implement a work plan based on the components of Adaptive Management that includes adequate monitoring.
12. Complete existing databases and develop new databases for use in the Missisquoi Sub-basin.
13. Develop new resource evaluation and inventory tools for use in the Missisquoi Sub-basin.

SUMMARY

The Missisquoi Area-wide Plan was developed by NRCS in conjunction with several partner agencies and organizations. The purpose of the Plan was to aid the parties in targeting high priority resource concerns associated with agriculture in specific geographic locations with conservation measures to reduce sediment and phosphorus export to the Missisquoi Bay. The identified high priority resource concerns included farmstead discharges, erosion, sediment loss and phosphorus export from annually tilled crop fields, manure and phosphorus loss from hayland, loss of riparian buffers, geomorphic instability in rivers and streams, and the loss of wetland function.

Databases were developed to include information on the extent and geographic location of these high priority resource concerns. These data were analyzed and displayed in GIS systems and maps. Other tools were also used, including conceptual modeling, RUSLE2 and the Vermont P Index. These efforts have culminated in a series of maps and databases that can be used together to target conservation measures for addressing each of these resource concerns with increased efficiency and effectiveness. These targeting efforts need to be incorporated into ongoing conservation programs of all involved agencies. This includes such programs as EQIP and the VAAFM BMP program. In some cases, new conservation initiatives will need to be developed to address these resource concerns in a targeted fashion.

This Plan does not provide a final, conclusive answer to addressing resource concerns in the Missisquoi Sub-basin. A process of Adaptive Management needs to be developed and used in the Sub-basin. This process will allow agencies to learn from their efforts and refine their conservation programs over time. In addition, several new tools and initiatives are described that could greatly aid in continued conservation efforts, including new high resolution digital photography and LiDAR derived elevation data.

As in the past, involved partners must continue to work closely together and coordinate their efforts. Hopefully, the establishment and implementation efforts of the Northern Waters Clean and Clear Center will greatly aid in this future coordination and in the implementation of more targeted conservation measures in the Missisquoi Sub-basin.

Appendices

Appendix A - Acronyms

AAPs – Accepted Agricultural Practices
AMA - Agricultural Management and Assistance Program
ANR – Vermont Agency of Natural Resources
BMPs – Best Management Practices
CCPI - Cooperative Conservation Partnership Initiative
CLU - FSA's Common Land Unit
CREP - Conservation Reserve Enhancement Program
CSP - Conservation Security Program
EPA – United States Environmental Protection Agency
EQIP – NRCS Environmental Quality Incentives Program
ESRI – Environmental Systems Research Institute
FSA - US Dept. of Agriculture, Farm Services Agency
FWA – Franklin-Grand Isle Farmers Watershed Alliance
GIS - Geographic Information System
HUC - Hydrologic Unit Code
LFO – Large Farm Operation, subject to LFO rules
LCBP – Lake Champlain Basin Program
LiDAR - Light Detection and Ranging
MFO – Medium Farm Operation, subject to MFO rules
NAIP - FSA's National Aerial Photography Imagery Program
NASIS - National Soil Information System
NASS - National Agricultural Statistics Service
NOFA - Northeast Organic Farming Association
NMP – Nutrient Management Plan
NRCDs - Natural Resources Conservation Districts
NRPC - Northwest Regional Planning Commission
NRI - NRCS's National Resource Inventory
NRCS - US Department of Agriculture, Natural Resources Conservation Service
RGA - Rapid Geomorphic Assessment
RUSLE2 - Revised Universal Soil Loss Equation, version 2
SGA - Stream Geomorphic Assessment
SSURGO - Soil Survey Geographic Database
TMDL - Total Maximum Daily Load
USFWS - US Fish and Wildlife Service
UVM - University of Vermont
VAAFM - Vermont Agency of Agriculture, Food, and Markets
VTDEC – Vermont Department of Environmental Conservation
WHIP - Wildlife Habitat Incentives Program

Appendix B - Farmstead Mapping Procedures

General Procedures:

1. Use aerial photography from 1995 (VT orthophotography 0.5m B&W) and 2003 (NAIP 1m color orthophotography) on-screen – zoom and pan to find likely-looking farmsteads.
2. Digitize each identified farmstead (point located at the barn door) into a farmsteads-<watershed>.shp point layer.
3. Print the point layer on a paper or .pdf-file map with other information such as roads and photo backdrop, and give this map to the NRCS Service Center staff for the county where the sub-watershed is located. Ask them to verify which of the digitized farmsteads are active, and if active, what is the main business of the farm (youngstock; dairy; beef, corn silage, etc.). Ask also that the staff mark locations of other known farmsteads that were missed.
4. When the edited map is sent back, digitize any new ones into the farmsteads-<watershed>.shp point layer, and add attributes to capture information the service center staff supplied.
5. Distribute or use the layer for analysis.

Notes from Hungerford Brook pilot project:

1. Some of the farmsteads digitized are active farms and others are abandoned.
2. Although few in number, any farmsteads constructed after 2003 were not identified in this pilot project.
3. The map was reviewed and any abandoned farmsteads were deleted from the layer while the primary function of operating farmsteads was identified (youngstock, milk production, beef, etc.). This information was entered in as attributes to the farmstead layer.
4. It does not take much time to find and digitize potential farmstead points. The layer for Hungerford Brook was digitized within about 3 hours. More time was required for the DC to designate and attribute the farmsteads on the map, but most of the information was obtained quickly from memory.
5. Collective knowledge in each field office should facilitate the future development of a farmstead layer that would cover the entire Lake Champlain Basin. These layers would be dynamic and would need at least semi-annual maintenance to remain useful.
6. By on-screen photo interpretation, 34 farmsteads were digitized within the Hungerford Brook sub-watershed. Of these, 27 were determined to be active farms known to the NRCS Service Center staff.

Appendix C - Agricultural Land Cover/Use Inventory Methods

The goal was to develop a GIS-based agricultural land use data layer that reflected current conditions. The identification of three agricultural land uses was important in this effort: corn, hay, and pasture. Additionally, it was important to distinguish grazed pasture from idle pasture, and vegetated land in transition to forest.

Materials

The conduct of the inventory relied on four data sources and ancillary materials: (1) USDA-FSA Common Land Unit (CLU) data; (2) FSA Crop Report data for 2003, (3) digital aerial orthophotographs (orthos) from the FSA's National Aerial Photography Imagery Program (NAIP); and VT Mapping Program digital orthos.

The CLU data was based on FSA's digitization of farm areas using FSA office records, including aerial photographs of compiled farm and field boundaries. Vermont digital orthos were used as the photo-base when digitizing CLU boundaries.

The VT orthos were black and white, leaf-off, spring-photos acquired in 1995. They have a pixel resolution of 0.5 meter. The NAIP imagery was natural color, leaf-on, summer-photos acquired in 2003. The imagery has a pixel resolution of 1.0 meter.

Methods

Being the most recent digital aerial photography, the NAIP imagery was used as the photo-base to reflect current conditions. The plan was two-fold: edit the CLU data using the 2003 imagery for visual inspection, and use the 2003 crop report data for verification of 2003 conditions.

Results

After much effort, areas of crop and hay were identified but pasture was not. Additionally, the accuracy of hay identification was not as good as it might have been. In short, the materials and methods proved inadequate to obtain the accuracy and detail needed. Limitations with the method are substantial as discussed below.

Limitations of Data and Photography

CLU Data – The CLU data has critical shortcomings when using it to derive spatially **accurate** agricultural land use data.

1. It contains some inaccuracies because digitization was done using 1995 imagery. Field boundaries that changed after 1995 and before the availability of the 2003 NAIP imagery were often not detected at the time of the CLU development. Some of these discrepancies were found and corrected upon inspection of the 2003 imagery. The extent to which other errors went undetected is not known.

2. Errors exist because some forested areas in 1995 were not forested in 2003. The CLU data usually missed these changes. Additionally, the opposite was true: some areas cropped in 1995 were no longer in crop use in 2003. Again, the CLU data often missed these changes.

3. The CLU data identifies crop areas or areas that were cropped at one time. Cropland, as used in this context, includes pasture. However, pasture in the cropland category is not identified as

pasture. It must be assumed that an area is tillable until known otherwise. 'Cropped at one time' is problematic because such areas may not be currently cropped, and may even be reverting to forest cover.

4. The CLU data includes a category called 'other agriculture'. It is essentially a catch-all category and may include farmsteads, land in transition, forest, built-up areas, hedgerows, field inclusions, and the like. In the mix, there are areas that may be used as cropland or pasture.

5. The CLU data does not capture all cropland in a given area. It may capture the majority, but rarely does it capture all.

It is clear that the CLU alone does not provide a spatially accurate nor precise view of what the agricultural land use is in a given area. This was not a new realization, and the thinking was that FSA crop report data would be extremely helpful in rectifying CLU shortcomings. Unfortunately, this was not the case.

<u>Crop Report Data</u> – The crop report data has different limitations that make it inadequate for rectifying CLU shortcomings. The most fundamental shortcoming is that there is no spatial link between it and the CLU. This was still not seen as a major hurdle because the report data could be put into a .dbf file for easy linking with the CLU attribute table. In application however, the linking surfaced immediate and insurmountable problems.

1. The CLU data contains many more polygons than there are entries in the crop report data. Without a spatial linkage, this causes one to cut and paste the crop report data many times to match it up correctly with the CLU attribute table. This process is very tedious time consuming and prone to error.

2. Some crop report entries are for one or more sub-fields, but comparable sub-fields do not exist in the CLU. In these instances, it is not possible to link the CLU data and crop report data.

3. Crop reporting is no longer required. The result is that the crop data does not include all crop fields from all farms.

4. In most cases, the crop report data does not include grazed pasture. This again results in little or no information on pasture, and in particular, grazed pasture.

These problems render crop report data unusable for developing spatial agricultural land use data. The data is not effective for updating the CLU data, and it is not useful for determining the location of pasture. In short, the time expended to truly use the data exceeds any benefits gained, and even then, there would be questionable data in many locations.

<u>NAIP Imagery</u> – The NAIP imagery with a pixel resolution of 1.0 meter is not suitable for developing accurate spatial agricultural use data, either alone or in conjunction with the CLU and crop report data noted above. Shortcomings of the imagery are as follows.

Of corn, hay, and pasture, row corn is the only use that can be identified with certainty most of the time using NAIP imagery. The resolution and sharpness is simply not there to consistently and accurately identify and distinguish hay from pasture. And in many and perhaps most instances, it is not at all possible to determine whether an area is grazed or simply idle land in grass cover.

This is a particular concern when developing an agricultural land use data set because preliminary NRI data collected from 2000-2003 suggested that upwards of 50 percent of Vermont's pasture may not be grazed. It is essential that grazed areas be identified and distinguished from hay or idle land so that its proximity to and its impact on surface waters can be assessed, and field checked where needed.

Impact of Cited Limitations

Using NAIP, an attempt was made to identify corn, hay, and pasture areas for those areas *where CLU data was known or likely to be deficient.* This work was done for Franklin County, a county with a total land area of about 407,000 acres (636 sq. mi.).

CLU areas identified as forestland were visually checked using NAIP imagery. This effort required 73 hours, and resulted in 2,173 acres in 510 polygons (av. of 4.3 ac/polygon) being identified as possible corn, hay, or pasture.

CLU areas identified as 'other agriculture' were also visually checked using NAIP imagery. This effort required between 80 and 90 hours, and resulted in 21,582 acres in 2,883 polygons (av. of 7.5 ac/polygon) being identified as possible corn, hay, or pasture. This acreage represents nearly 2/3 (65%) of the total CLU area tagged as 'other agriculture.

The NAIP was also visually inspected to identify possible corn, hay, and pasture areas that occurred outside the CLU data. This effort was completed for about 30 percent of the county, resulting in 1,705 acres in 279 polygons (av. of 6.1 ac/polygon) being identified as possible corn, hay, and pasture. Because the areas checked occurred in the least intensive agricultural areas, it is estimated that a complete review might result in as many as 5,000 acres being identified as possible corn, hay or pasture.

In total, more than 165 hours have been expended to identify corn, hay, and pasture in CLU forestland and other agriculture areas, and in areas outside CLU boundaries. It is estimated that an additional 35 hours, at least, will be needed to complete the inspection outside CLU boundaries. Once this is complete, it will probably require an additional 100-200 hours to assess each of the polygons and determine if they are in corn, pasture, or hay. In short, it is estimated that it will require an estimated 400 hours to do the work to identify corn, hay, and pasture in CLU forestland and other agriculture, and in areas outside CLU boundaries.

Once this work is done, there will still be significant acreage for which agricultural land use will not be known with precision or certainty. This is because of the limitations of CLU data and NAIP imagery noted above. Additionally, there will be few acres where pasture areas will be definitively identified as grazed pasture, a land use that is quite important in the broad effort to address problems related to water quality.

Needed Photography

It has been shown time and time again that traditional hard copy and digital aerial imagery does not provide the sharpness or resolution to identify and map agricultural land uses such as corn, hay, and pasture with consistent precision and accuracy. Additionally, it is especially difficult to distinguish idle versus grazed pasture.

This realization was learned over 15 years of data collection for the National Resources Inventory (NRI). In fact, digital imagery with a resolution of 0.7 meter was deemed inadequate for data collection in Vermont in 2000. Data collected in 2001 and later with digital imagery with a pixel size of 1.0 foot (0.30 meter) was much more effective. This imagery in GIS, coupled with the hard copy color diapositives, provides the sharpness and resolution needed to do the detail of identification and mapping discussed above. The NRI photography is natural color, is flown at the height of the growing season, and at a scale of 1:7,920.

It is this kind of photography that is needed to get the detail that is needed for this kind of inventory work. In addition, such imagery is invaluable in collecting additional data and in providing insights in overall watershed planning. Examples of such uses include the following.

- Assess condition of farmsteads, farmland, residential, and other built-up areas.

- Distinguish active versus inactive farmstead areas.

- Assess farmstead runoff and determine its proximity to drainage ditches, streams, and water bodies.

- Distinguish idle pasture land from pasture that is being grazed, and often times, the presence or lack of fencing along streams.

- Assess pasture vegetative health, watering facility distribution, and presence of overgrazing.

- Identify and map, with high accuracy, built-up (developed) areas, including residential, commercial, industrial and recreational areas.

- Ability to assess these factors in regard to their proximity to streams and water bodies.

- Identify stream bank areas devoid of vegetation, stream bank erosion, and snags in streams.

- Provide permanent record of current growing season conditions

- High-scale (1inch = 400 feet, even as fine as 1 inch = 200 feet) color aerial photos that can be used during land owner/operator discussions and for planning and implementation.

- Can do agricultural and developed land mapping accurately, and expeditiously.
In noting agricultural and developed land mapping, this photography can enable accurate delineation and measurement than is provided on the satellite-based imagery.

The photograph is what you see. Satellite data is based on data classification. Additionally, 30-meter satellite data will underestimate the true extent of built-up land.

Appendix D - Estimates of Cropland and Other Agricultural Statistics for the Missisquoi Sub-basin

Cropland and Pasture – The acreage of cropland and pasture, combined, declined by about 10 percent in the Missisquoi from 1982-1997. There was about a 13 percent loss in the Orleans County part and a 10 percent loss in the Franklin County part. The percent losses for the Sub-basin are similar to estimates for all of Franklin County (-10% from NRI; -16% from Census). The Census estimate is for acres of harvested cropland and cropland used for grazing only. The 1997 NRI cropland and pasture estimate for the Watershed was about 113,000 acres, with an 80:20 split between the counties (91,000 ac. in Franklin; 22,000 ac. in Orleans).

Pasture – Whether it is Census or NRI data, estimates for pasture are difficult to establish. First, the NRI and Census have differing definitions. Further, the Census has three categories of land that could be grazed: pasture, cropland used for grazing only, and woodland grazed. Additionally, more recent NRI preliminary data suggests that, statewide, upwards of 45-50 percent of the pasture is not grazed, and much of it could be well on its way to transitioning to forest cover.

The 1997 NRI estimated that Franklin County pasture decreased by more than 30 percent between 1987 and 1997, dropping from about 54,000 to 37,000 acres. Assuming that the grazing estimate is correct for the NRI, this would suggest that there were about 18,500 acres being grazed in 1997.

The Census estimates that there were about 13,700 acres of pasture in 1997. This is land that is 'grazable', and includes good to very marginal land. The Census also estimates that there were about 21,000 acres of 'cropland used only for grazing' in 1997, land that may have been identified as pasture during NRI data collection. The total of the two Census categories is 34,700 acres, fairly close to the NRI estimate of 37,000 acres. And while the two Census categories show a total of 34,700 acres, it offers no clarity regarding the extent of actual 'grazed' pasture.

In summation, both the NRI and Census data suggest that there were about 35-36,000 acres of Franklin County land that could have been grazed in 1997. The extent of grazing is not known, but it is likely that at least half of the total pasture-type acres, or about 18,000 acres were being grazed in 1997. Considering that about 69 percent of Franklin County falls in the Missisquoi, and assuming that the acreage was distributed equally across the County, it could be further assumed that there are about 12-13,000 acres of land that might be grazed at any one time in the Franklin County part of the Missisquoi.

The NRI puts the Missisquoi pasture estimate at about 29,000 acres with another estimated 5,000 acres in the Orleans County part of the Watershed. Thus, the NRI data suggests that there are about 34,000 acres of land that could be grazed in the Missisquoi. Considering the more recent preliminary NRI data, the extent of actual grazing is probably at least 17,000 acres. Until other more accurate data is available, and based on NRI and Census data for Franklin County and the Watershed, it is estimated that there were about 15–20,000 acres of land being grazed in the Missisquoi in 1997. Considering the trends of declining pasture over the past 20-30 years, the number of acres being grazed in 2007 was likely lower than 15-20,000 acres.

Cropland – With regard to cropland trends for Franklin County, the NRI and Census show conflicting data. The NRI indicates a cropland increase from 1982 – 1997 while the Census data show a fairly steady decline from 1974 – 2002. The exception for the Census data is for harvested cropland acres, which held fairly steady, moving up and down between about 75,000 to 81,000 acres over the 28-year period. The NRI cropland trend is suspect, and it would be prudent to assume that cropland has declined or stayed fairly level over the past 15-30 years.

Cropland in Corn – Both the NRI and Census data suggest a significant increase in corn acreage in Franklin County from 1982-1997. The 1982-'97 Census shows a dramatic increase, a jump of more than 9,300 acres (56%) from 16,640 to 25,960 acres. The Census also shows an even higher increase from 1974 to 2002, a jump of 11,359 acres and 73 percent. The Census also indicates that the Franklin corn acreage decreased by about 8 percent from 1978 – 1987, but from 1987 forward, it jumped by nearly 2/3 (64%, 10,500 ac.) from 16,400 to 26,900 acres.

The only other Vermont County with a similarly high percent increase in corn is Essex County, but that involves small acreage: 940 acres in 1974 and 1,500 acres in 2002. Orleans County experienced a 38 percent increase, going from about 7,500 acres in 1974 to 10,363 in 2002. The acreage dropped by about 20 percent between 1978 and 1982, but since 1982, the acreage has increased consistently from about 6,300 to 10,360 acres, a jump of more than 4,000 acres and nearly 65 percent.

If the Franklin County corn acreage was distributed equally over the County, then about 69 percent or 18,000 acres would have been in the in the Missisquoi in 1997, and 18,550 acres in 2002.

While the margins of error are very high, the NRI estimates suggest an increase of about 5,500 acres (53%) from about 10,300 to 15,800 acres in the Missisquoi. This percentage is consistent with Census data for Franklin County (56 vs. 53%). Most, if not all of this increase occurred in the Franklin County part of the Watershed. Considering Census data, the NRI may have underestimated corn acreage in Franklin County, and thus the Missisquoi as well. The acreage could have been closer to 18,000 acres in the Missisquoi in 1997.

Based on NRI data, the majority of the 5,500 acre corn increase in the Missisquoi came from existing cropland and pasture. Nearly 2/3 (7,000 ac, 63.6%) came from hay land, nearly ¼ (2,500 ac., 22.7%) came from pastureland, and 1/6 (1,800 ac, 16%) came from forestland. The estimated 7,000 acres that shifted from hay to corn from 1982 – 1997 was most likely a rotational shift from hay to corn because as this occurred, an estimated 6,500 acres went from corn to hay.

It has been suggested that some pasture areas converted to cropland were acres that were more susceptible to erosion. In a general, the NRI data seems to support this. The data suggests that the acres of cropland on capability class and subclass IIIe may have declined from 1982-1997. If true, this was a good trend, resulting in fewer cropland acres on more erodible land. However, the data also suggests that this change was more than offset by an increase of acres on IVe land. The estimates for these insights are pretty shaky, but are in the area of 2,000 – 3,600 acres. More reliable data is really needed to confirm or refute these suggestions.

Cropland and Livestock – Relative to the rest of Vermont, Franklin County and thus the Missisquoi Watershed, have the most intensive dairy agriculture in the State. This is evident upon analysis of both cattle numbers and the acres of cropland per head of cattle, and a look at the change in cattle numbers.

Franklin County has a large share of the State's 283,619 total cattle. Whether it is milk cows, milk and beef cows, or all cattle, Franklin County was the number one county in 2002 with 67,371 animals. It had nearly 24 percent of the State's total cattle, 25.5 percent of the milk and beef cattle, and 27 percent of the State's milk cows.

The County closest to this was Addison (64,602 cattle), which had 21-23 percent of the State's cattle in these categories. The third county was Orleans (40,081), where 14-15 percent of the State's cattle are located. The next highest counties were Orange (19,395) and Rutland (16,571) where just 6-7 and 5-6 percent of the State's cattle are, respectively. The remaining counties 10 counties had 1-5 percent of the State's cattle. With the exception of Addison and Orleans counties then, Franklin County had a multiple of 3.5 to 17 times more cattle than did the remaining 11 counties. It had 1.1 to 1.75 more cattle than Addison and Orleans, respectively.

Franklin County is the only VT county where the number of milk cows increased over the 28-year period from 1974 – 2002. Franklin saw a milk cow growth of 8.4 percent over that time frame, to 40,492 cows in 2002. Addison County was next with an estimated 1.8 percent ***loss*** over 28 years, to 32,797 cows. A couple other counties experienced a 9-10 percent loss while the remaining counties saw losses ranging from 28 to 51 percent.

Not only does Franklin County have a high percentage of the State's cattle, it also has the least amount of cropland or harvested cropland per head of cattle. This is true for total cattle, beef and milk cows, and milk cows only. These data suggest a higher concentration of animals per cropland unit in Franklin than in other counties. Considering total cattle and harvested cropland, the following relationships exist.

In 2002, there were 1.20 acres of harvested cropland in Franklin County for each head of cattle. Orleans ranked second, with 1.34 acres per head. All other counties had 1.63 or more acres of harvested cropland per head. Put into percentages, the data indicates that in 2002, Franklin had 10 percent less harvested cropland per head than Orleans County. Orleans is the only VT county where the concentration of animals approached that of Franklin.

Franklin had 26-31 % less land per head than six other counties, 37-42% less land per head than four counties, and 47-52% less land per head than the two remaining counties.

Developed Land

This includes land in roads and built-up land being used for residential, commercial, and industrial uses. It does ***not*** include farmsteads, greenhouses, or nurseries.

From 1982 to1997 developed land in the Missisquoi increased from about 13,800 to 17,200 acres, a growth of about 3,400 acres (25%). Of the total land going into built-up (3,400 ac.), about 1,500 acres (40%) came from cropland and pasture. About 2,200 acres (58%) came out of forestland. These change estimates are pretty consistent with estimates for other areas of Vermont, including statewide estimates. The 25 percent growth in the Missisquoi compares with an estimated statewide growth of 31 percent. A lower growth rate in the Missisquoi seems reasonable. Statistically speaking, NRI estimates for urban and built-up land have a lower margin of error and are generally considered to be the more reliable than are the estimates for pasture and cropland.

<u>Appendix E -</u>

NRCS TRAINING DOCUMENT

"MapServe"

River Management Stream Geomorphic Assessment Viewer (RMSGAV)

Commonly referred to as the "Mapserve"

Introduction:

The RMSGAV is a web-based geographic tool, designed to give our partners and the public, access to our river data for the entire state of Vermont. One can use the RMSGAV to create maps that can be viewed, saved, printed or emailed.

Our hope is that this tool will be used to make technically sound decisions relating to River Management and our partnerships and to serve as an education tool.

Acknowledgements:

We would like to thank all of you in the NRCS who provided the funding to get this project off the ground.

We would like to thank our "Geographical Information Systems IT Guy" Erik Engstrom for all his hard work in developing this tool.

Table of Contents

A quick tutorial

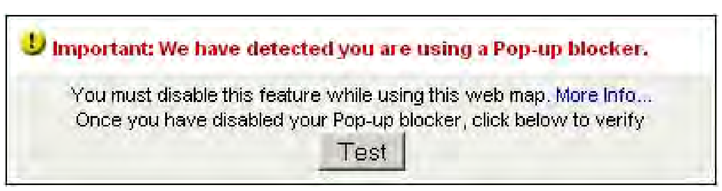
Please note: This pamphlet was designed as a quick tutorial guide and does not include directions for every function.

Getting Started
Use the link below to navigate to the RMSGAV

http://maps.vermont.gov/imf/sites/ANR_SGAT_RiversDMS/jsp/launch.jsp?popup_blocked=true

The first screen you will see is the disclaimer. Please read and make sure you understand the policies explained in this text.

The Map Viewer uses pop-up windows to display some of its information. Before you can get started with the Map Viewer you must disable your popup blocker. If you do not know whether this is on or not click the "Test" button.

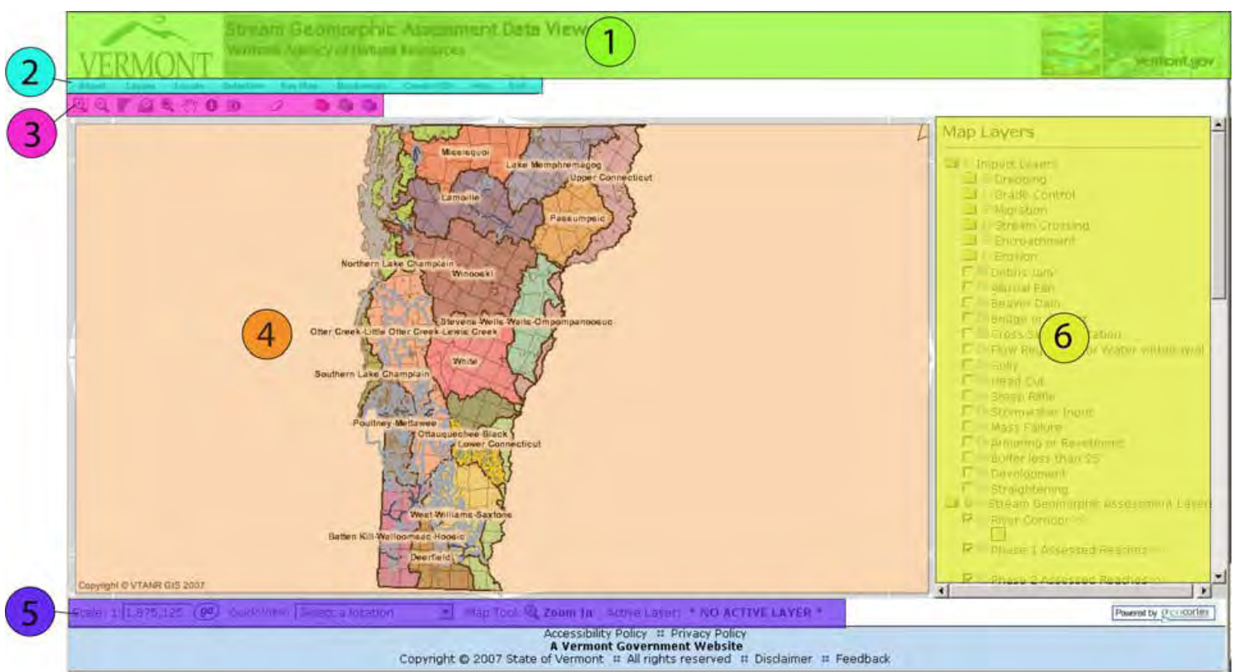


If you popup blocker is disabled you will see the window below

You will be able to toggle your pop-up blocker **on** or **off** by using the “Tools” button in the menu bar of your internet browser.

Now click the “Launch Map Viewer” to enter the mapserve

When the program first opens this is what you will see:
1 Banner
2 Menu Bar
3 Tool Bar
4 Main display A map of Vermont with all 17 planning basins Phase 1 assessed rivers in light blue Phase 2 assessed rivers in green blue
5 Active status Bar
6 Active menu Window (default “map layers”)



1) The Banner

This provides some basic information about the product. This banner contains two hyperlinks to other sites. The link on the left will take you to the Agency of Natural Resources page (http://www.anr.state.vt.us/index.cfm) and the link on the right will take you to the Vermont page (http://www.vermont.gov).

2) Menu Bar

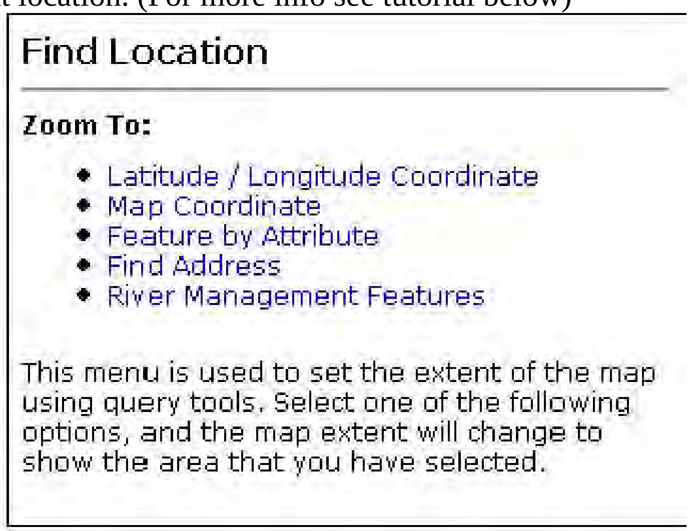
A 9 button menu is located just below the banner.

When you click on any of these buttons (except help and exit) the right hand side of your screen (Active menu window) will change.

Click the about button to learn about the geocortex program.

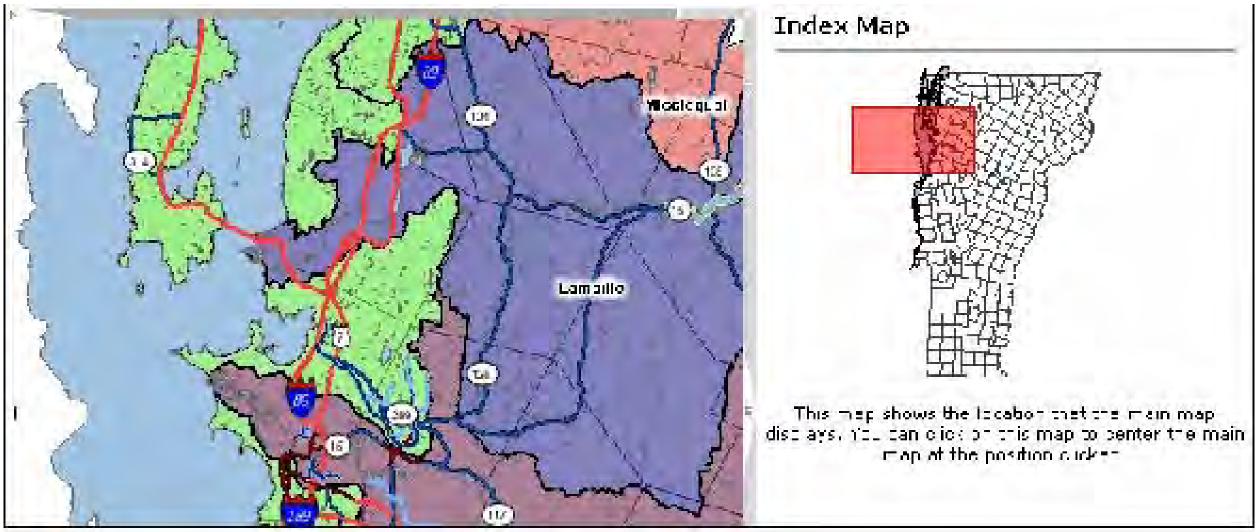
This is the default active menu for the mapserve and the menu option you should use **75%** of the time. This is similar to the table of contents in ArcMap or ArcView. Click to see the list of layers displayed on the map. All layers can be turned on and off.

This is an **important** menu option. This allows a user to navigate to a location in Vermont based on information about that location. (For more info see tutorial below)



At present this button has no relevant functionality, but in the future it will help us manage the data within the mapserve.

While using any mapping program it is easy to become geographically confused. The key map shows a full extent version of Vermont and your exact screen shot location shown within the red box. This key map can also be used for large navigational jumps. Click and drag the red box to another location in VT or just click on another location to re center the box.



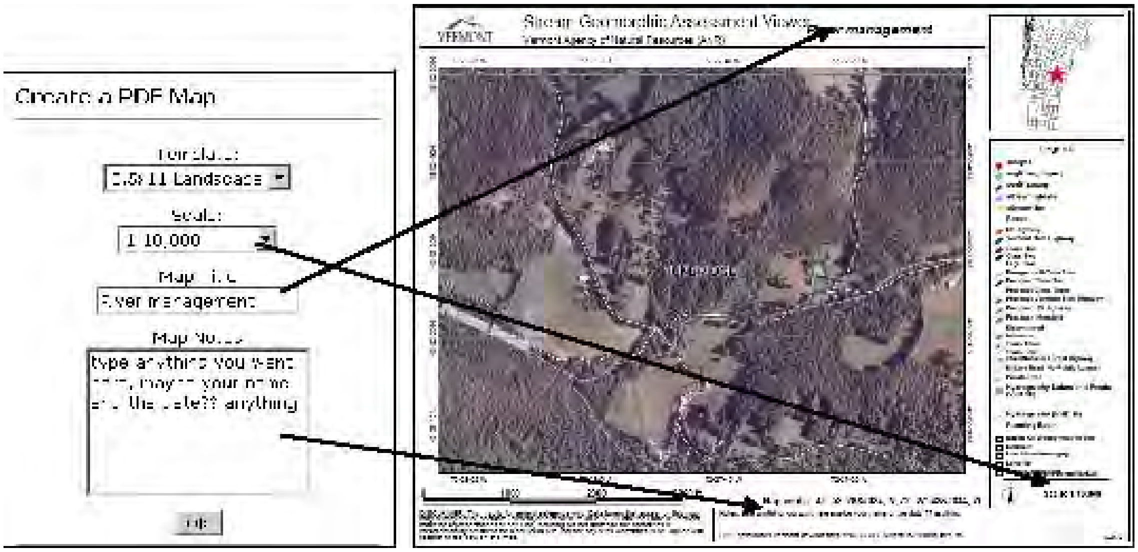
Bookmarks

You are able to set up and save various zoom scenarios. Whether you would like to navigated at the 1:100,000 scale between several rivers and have each one saved for easy navigating **or** if you want to have various views (1:200,000, 1:150,000, 1:50,000) of the same river, it is easy. These book marks are saved within your temporary internet files so they will be remembered the next time you log on.

Create PDF

A nifty little options allows you to save your map as a layout in 3 differently sized templates and 2 orientations -Select your template 8.5 x 11, 8.5 x 14, or 11 x 17 and orientation (landscape or portrait)

-Set your scale. Or use the current extent. -Choose your Title (up to 29 characters long) -Write some notes



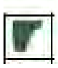
By default the PDF will have a north arrow, a legend, a location map, a scale, a grid, the date, and the lat/long coordinate for the center of the map.

What happens when you lose this user guide? Click on the help button to help explain what everything does.

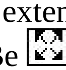
Click here to exist instead of closing the window with the “X” in the top right corner.

3) Tool Bar

Navigation, Editing, Acquiring data reports and general attribute data.

 Zoom in tool. Single click **<u>or</u>** draw a box around where you want to go in Vermont.

Single click on the map to zoom out.

Zoom to full extent (in ArcMap this is a Globe symbol, but in the mapserve our full extent is VT, so we have chosen an image of Vermont). Click this to see the furthest zoomed out view. Be  careful. As you navigate through the mapserve the icon may magically change, but its function remains the same.

 Zoom to Active layer button. If you have an active layer, this will zoom to the extent of that layer.

Zoom previous view (like the back button in you internet browser)

The pan button. Click and drag you map to where you want to be.

The active layer info button tells you information about (gives you attribute data for) the user set active layer (describe later in this document). **Bottom line:** Once the active layer has been set, this data acquisition method is fast and straight forward. [e.g. if you make "Phase 1 data" your active layer, and then click on that layer with the *active layer info* button the resulting data for that individual layer will appear with in a few seconds)

- The every layer info button tells you information about every layer that is in the geographic location that you clicked. You save time by not having to make a layer "active". However this is a time consuming calculation that brings up a lot of data (if you are unfamiliar with our data format the results of this process may be overwhelming). **Bottom line:** this is the easiest way to get **<u>all</u>** the information you want. [e.g. if you want to know all the information about the reach M02 of a specific layer and you click on that reach with the *every layer* info button, resulting data for phase 1, phase 2, corridor, VHD, Town, County, State, River Basin, Planning basin and NAIP orthos will appear after a few 10's of seconds.
- Erase all lines, polygons, labels, and selected (highlighted) features you have put on the map (this will make more sense once you learn about the "Markup tool box")

Tool boxes:
The tool bar has specialized tools that can be found within the red, green, and blue tool boxes.

Advanced tools. Click to open the toolbox.

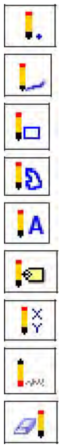
- - Measure a distance (in feet).
- - Measure an area that you draw yourself (in square feet).
- - Save a project (as a .ssn) to your computer.

-Open a project (.ssn).

- - Email a screen shot of the main display to one person or a group of people.
- - Extract data to be used in other applications -Shape file (this option will be available in the future) -XML (web browser code file) -KML (google earth file) -XLS (Excel file with lat/long coordinates) -Map image (screen shot of the main display) -Markup shape file (any point, line, polygon,

XY coordinate you have added to the map).

Mark up tools. Click to open the toolbox.

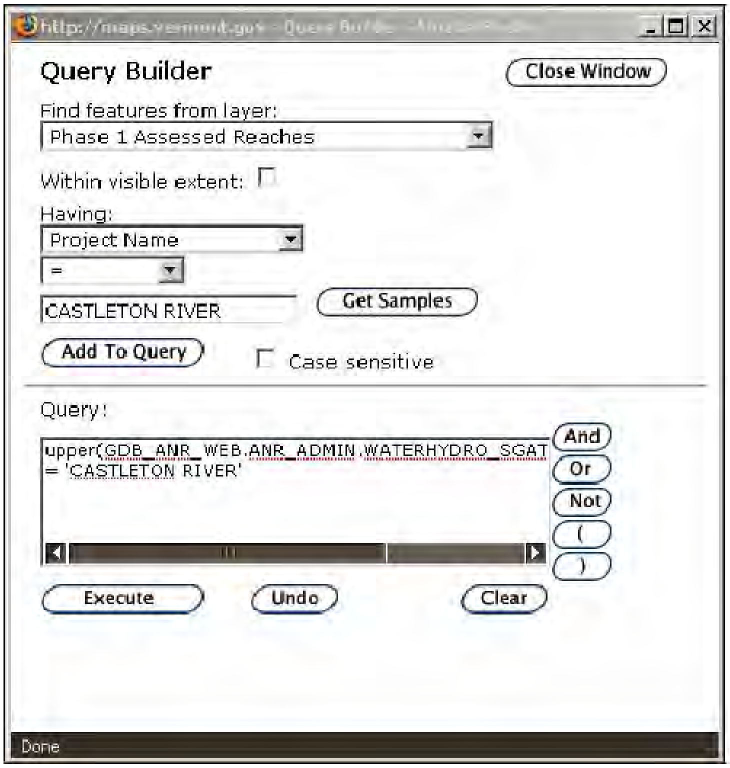


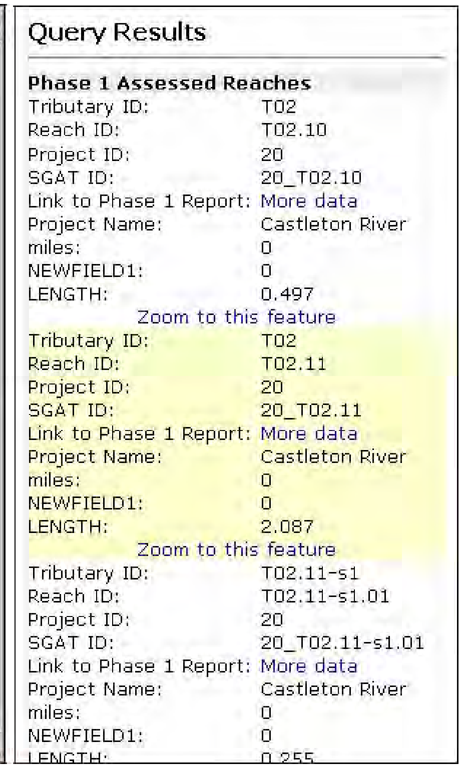
□ - Add a point to map
□ - Add a line to map
□ - Add a rectangle to map
□ - Add a polygon to map
□ - Add text to map
□ - Add a label to map (from attribute data)
□ - Add an X Y coordinate to map (lat / long)
□ - Erase markup (most recent)
□ - Erase all markup

 **Selection tools**. Click to open the toolbox.

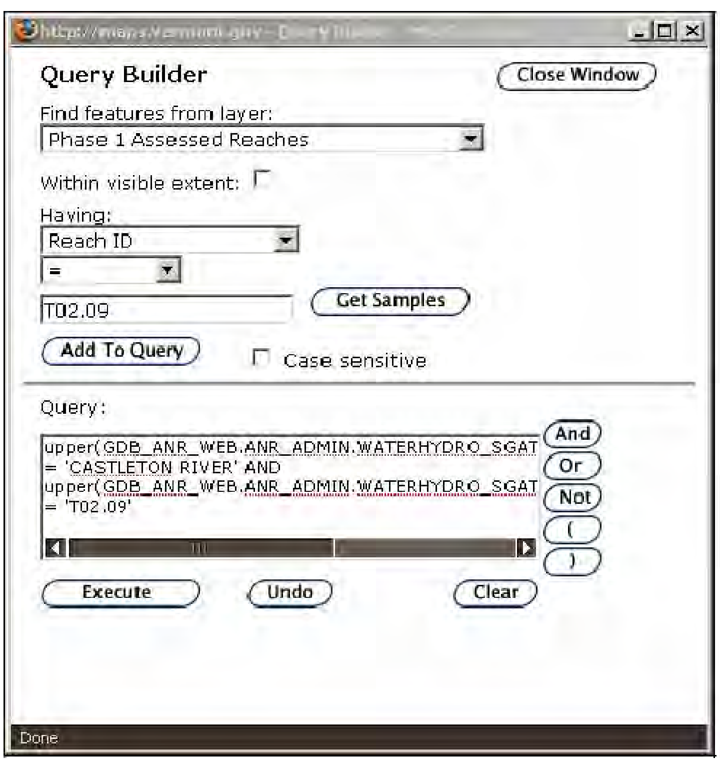
 -Generate query Just like in arcview or Arc Map, you have the ability to set-up a simple mathematical search, or a query.

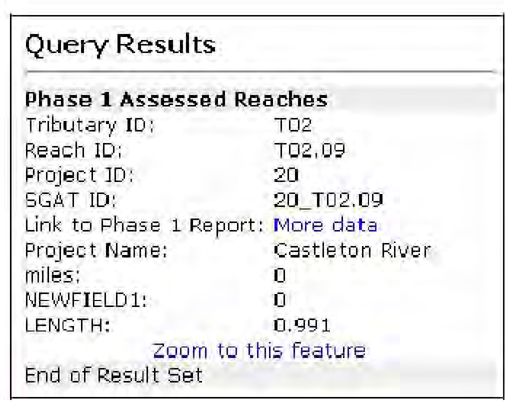
Single query
If you wanted to search for all **Phase 1 data** for the **Castleton River**. Select “Phase 1 Assessed Reaches” from the *Find features from layer:* drop-down menu. Select “Project name” from the *Having:* drop-down menu and then “=” Type “Castleton River” and click the “**Add to Query**” button followed by “**Execute**” This will highlight the phase 1 reaches in the main display and populated the active menu window with the attribute data for those reaches





<u>Or</u> *multiple*
If you are interested in navigating to a certain reach of a certain river you can build a query to look for separate items within the same layer.
i.e. From the "Phase 1 Assessed Reaches" one can show the *Castleton River* **<u>AND</u>** the reach *T02.09*





Active layer selection tools:

If there is a certain layer you are interested in, like phase 1 river segments, you must make that 

layer active layer by clicking on the blue “i” changing it to a black “i” in the “layers” window. Once you have made a layer active you will be able to:

 -Identify by radius. Click somewhere, set your radius (in feet, meters, miles or kilometers and click ok. This will select all the components of the active layer that are with in this radius. A translucent circle will appear in the main display and the attribute data will appear in the active menu window.

□ -Select by rectangle. Click and drag a rectangle around a an area of the map to select all features of the active layer in that portion of the map. The items will appear highlighted on the map and there attributes will be in the active layer window.

□ -Select by radius. This button works only slightly different than the identify by radius button, but produces the same results

□ -Select by buffer. (e.g. If a user selects roads and then sets a buffer of say 50 ft off all roads, looking for phase 1 assessed rivers (the active layer), the rivers within this road buffer will be highlighted in black).

Active status bar

data

selec
high

 .

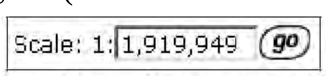
radiu

 .

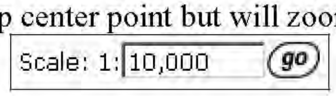
Located at the bottom of the screen, this tells you info about the current conditions of your map.

Scale

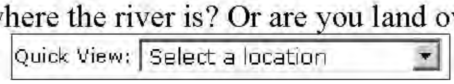
Current scale defaults to 1:1,919,949 (to see the entire view of the State)



-Click in the scale window and type the scale you want (like 1:10,000) then click “**go**”. The map will keep the same map center point but will zoom to this new scale



Quick View

Do you know the name of the town where the river is? Or are you land owner who wants to see what is going on in your town. 

Quick View

Do you know the name of the town where the river is? Or are you land owner who wants to see what is going on in your town.

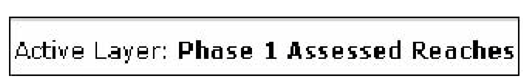
-Click the drop down arrow to reveal a list of all of the towns in Vermont -Select your town and the mapserve will zoom in to the full extent of that town.

Active tool
Often one cannot tell what their active tool is. A quick glace to the bottom right of your screen will solve that

Active Layer

This tells you what layer is active. layer is needed, when you want to zoom to a specific feature, like all the phase 2 assessed 
rivers in VT make the phase 2 the active layer and click the zoom to active layer button, **<u>or</u>** if you want to get a phase 1 report but not a phase two report, make the Phase 1 the active layer and use the identify button

Link to Data Management System
If there is an existing project that you are interested in and you do not see it on the “mapserve”, there is a good chance that you will find it in our online data management system. Click on the text “? Can’t find the data? Try the DMS”



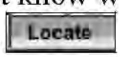
An active

TUTORIAL

Scenario:
You want to see a map of the entire Castleton River, with the reaches labeled. You Want to print this map as a whole but are also interest in the detail of the river near the college campus (T02.09, T02.08, and T02.08-S1.01). You would like to see the reports for these reaches as well as the physical location of debris jams on campus.

Part 1.
Finding a map location

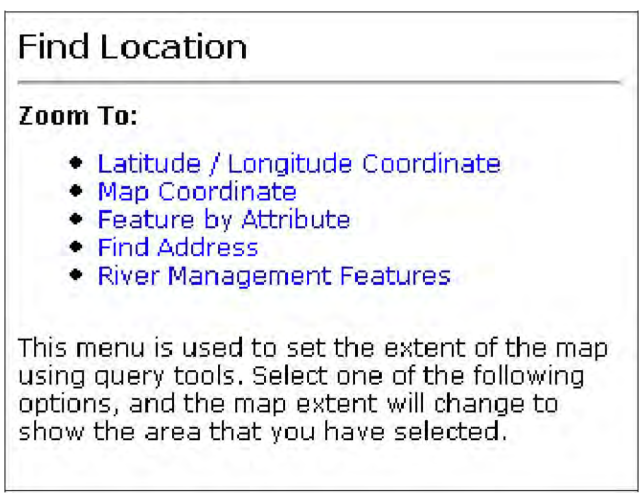
If you do not know where the Castleton river is located, so you cannot simply zoom in.

If you do not know w
-Choose the 

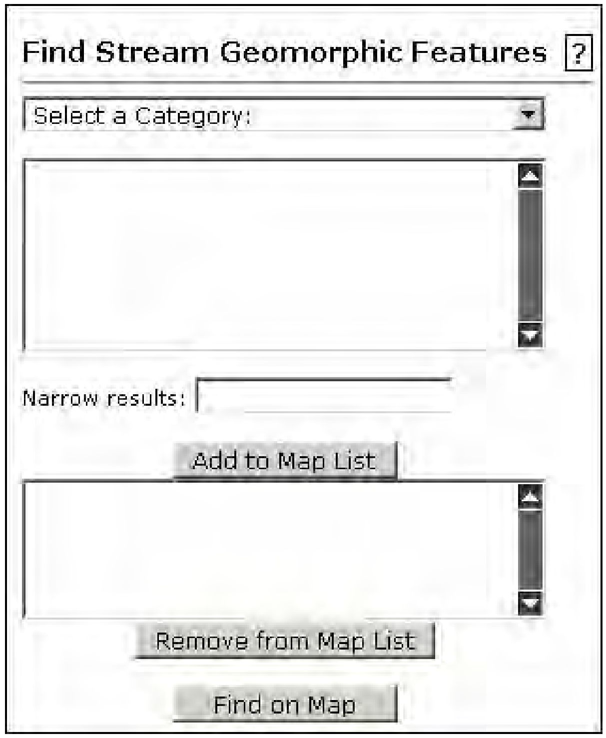
active menu window.

-Choose the

button from the menu bar. This will open the “Find a Location” “zoom to:”



-Select the 5th option down from the top “River Management Features”. This will prompt the “Find Stream Geomorphic Features” active menu window.



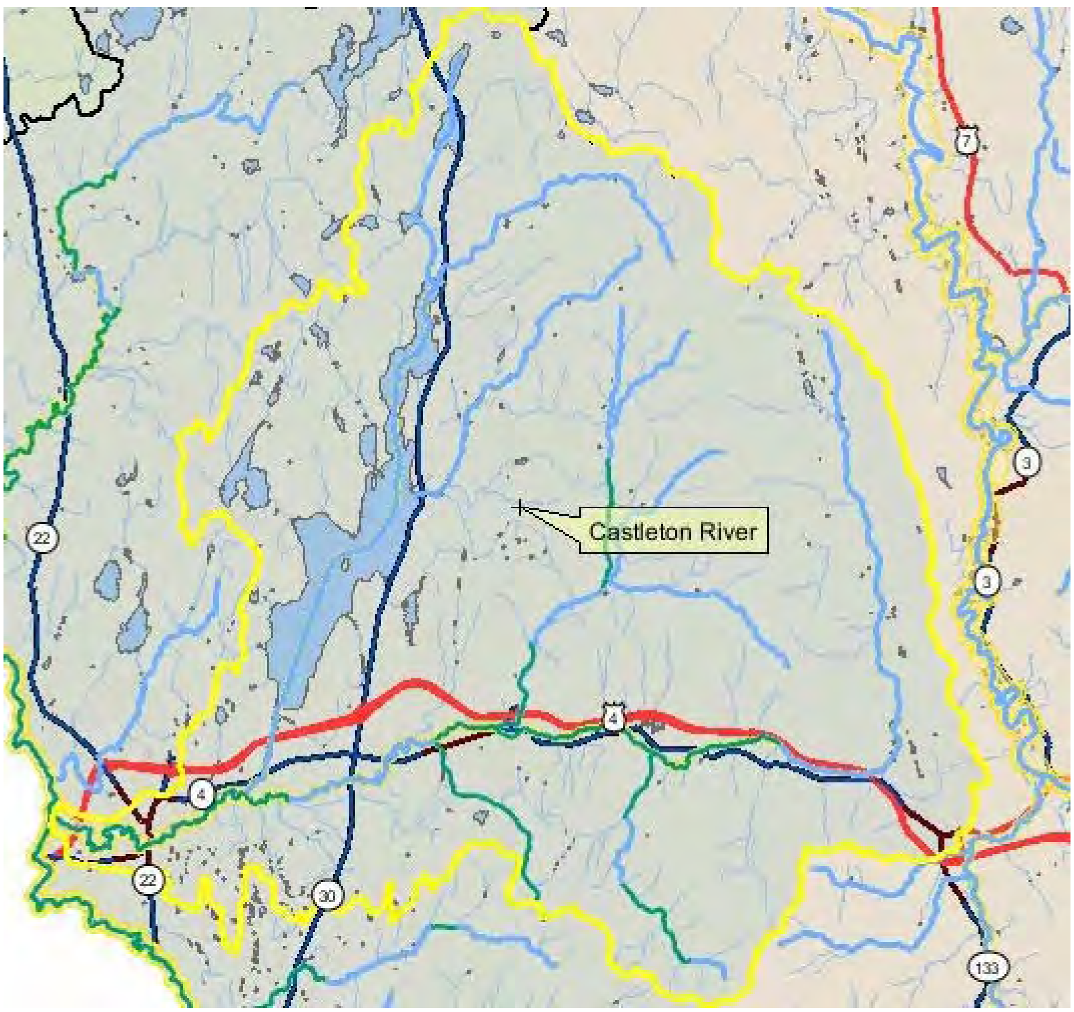
-Click on the drop down arrow to select the category you would like to search. We are not looking for specifically phase 1 or phase 2 data so we will generically search fro the project by selecting “Find SGAT Project by name”.

Once this is chosen, all the SGAT projects that are registered with in the mapserve will populate the box below the category (this is quirky and may take up to 3 tries to populate this box) -Choose the “Castleton River”

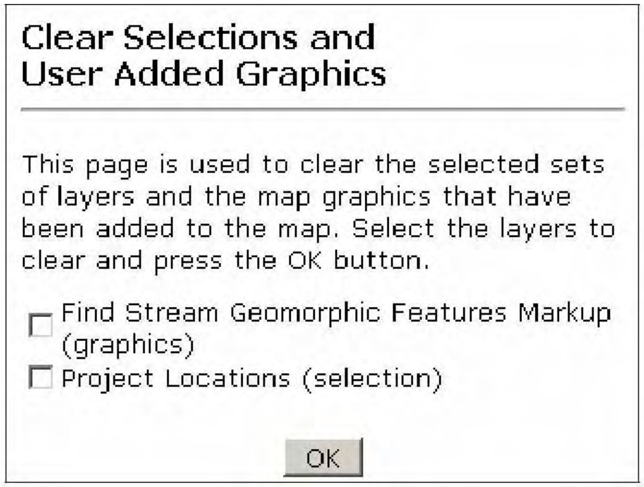
And click the

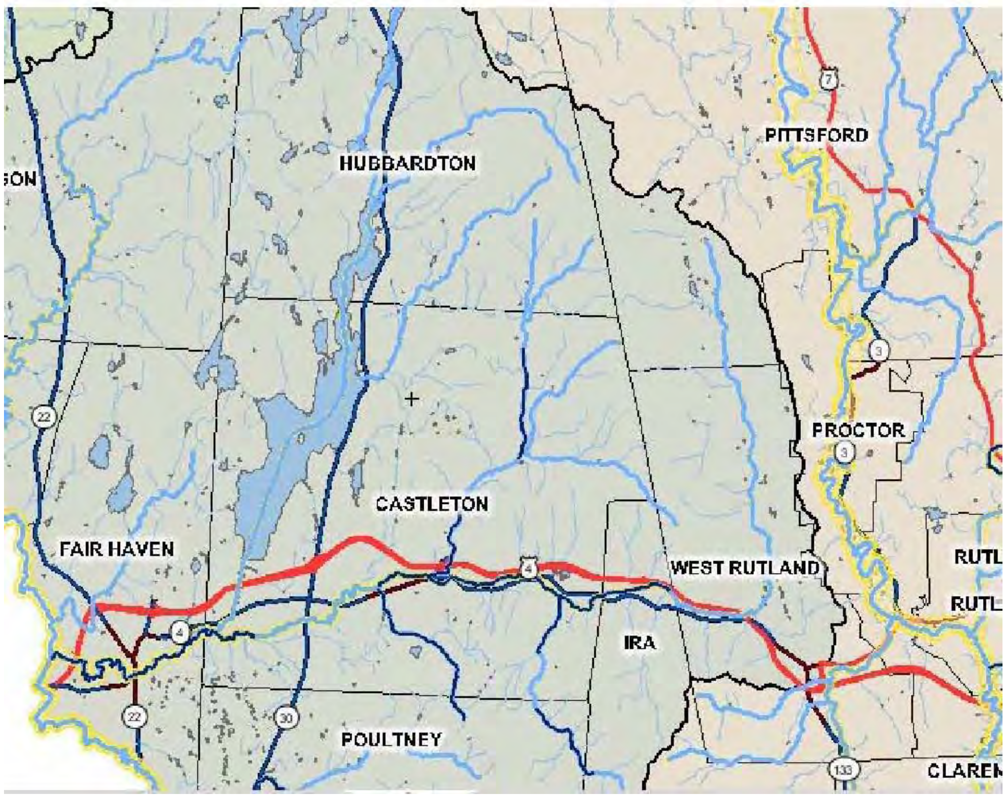
button. This will cause the “Castleton River” to populate the lower box.

-Now click the “**Find on Map**” button and the mapserve will navigate to the location of the Castleton River. Here you see the watershed highlighted in yellow with a label that says “Castleton River”

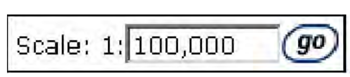


We don’t like the way this looks. To get rid of any user created graphic choose the eraser tool from the upper tool bar (if only one user modification exists, it will be erased instantly). If more than one modification exists the “Clear Selections and User Added Graphics” active menu window will appear. Here you can select anything you wan to delete. In our case we would like to get rid of both the label and the highlighted steams reaches, so we check both boxes and click the “**OK**” button.





Now we see the whole project but let's zoom in closer. In the active status bar we need to set the scale to 1:100,000

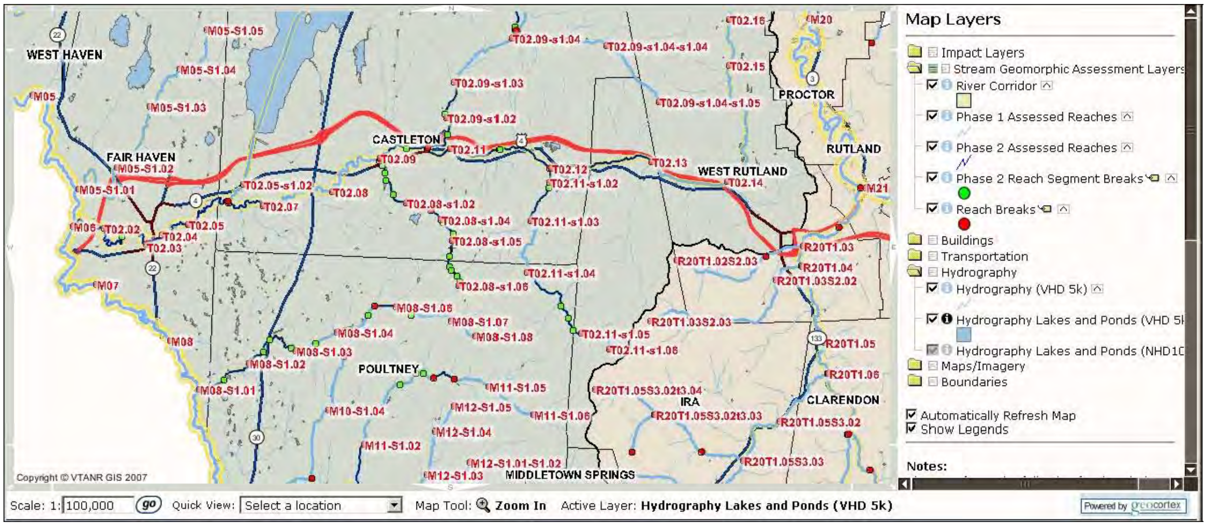


and click "go".

-You see, magically the reach points become labeled.

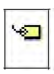
Note: 1:100,000 is the label threshold. (i.e. at 1:100,001 the reach point labels will not appear).

Labels



If you feel that the labels make the map too cluttered at this scale feel free to experiment turning the labels off.

-Click the yellow tag image

 next to the "Reach Breaks" layer in the Map Layers active menu window.

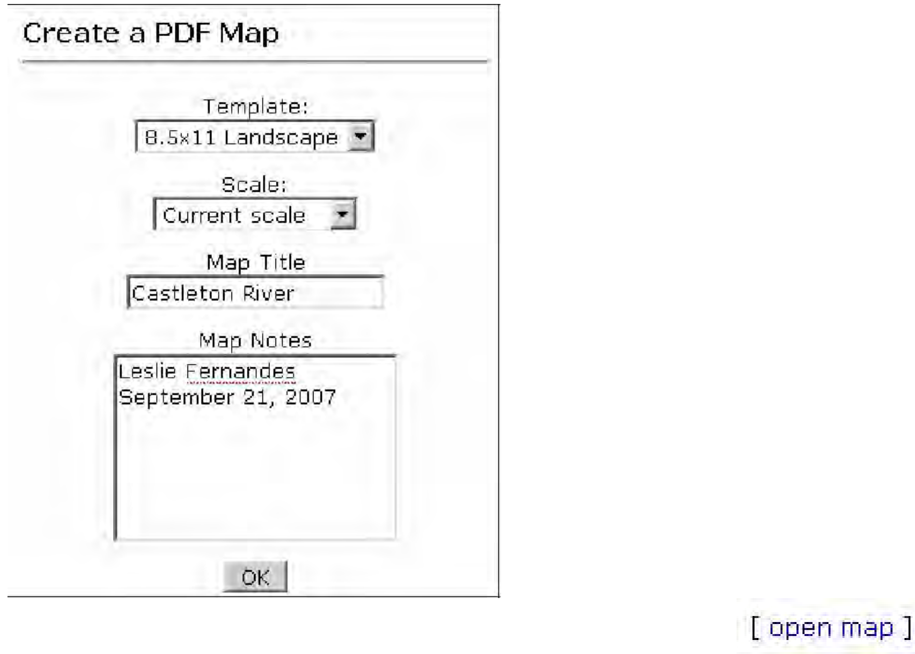
-Now click on the grayed out label  to turn the labels back on.

Creating a PDF 

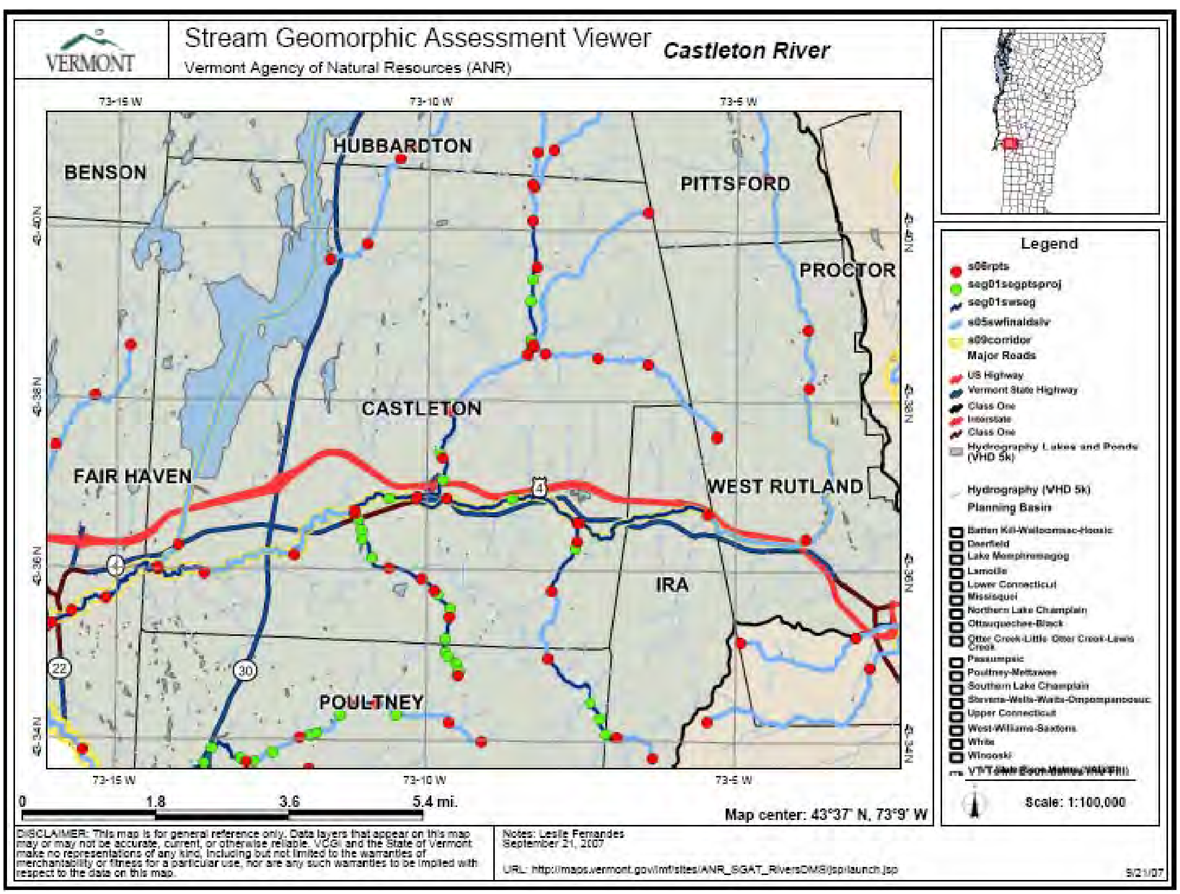
-Click on the button in the menu bar. This will bring up the "Create a PDF Map" view in the active menu window. Here you will have to choose:

A template A scale A title Some notes

Let's choose the template of 8.5x11 Landscape, the current scale, the title "Castleton River" and the Maps notes of the person who created the map and the date. -Click the "OK" button After a few seconds the map will be generated. To view the map click on the hyperlink.



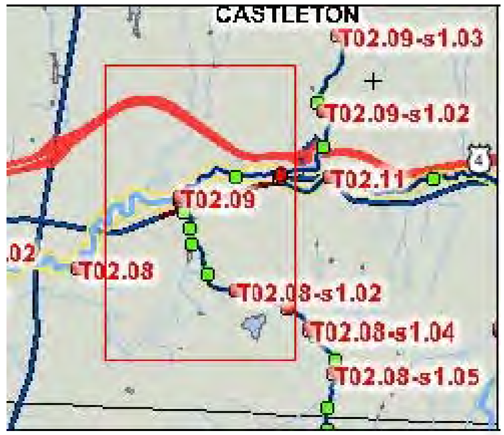
Here you see a pretty nice looking PDF of the Map with your title, scale, and notes. This opens in Adobe Acrobat, where you have the option of saving, printing, or viewing the product.

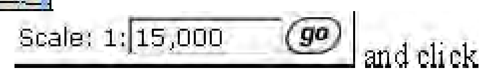


.Part 2.

Now we want to gather info on the reaches T02.08, T02.08-s1.01, and T02.09.  - Choose the zoom in tool

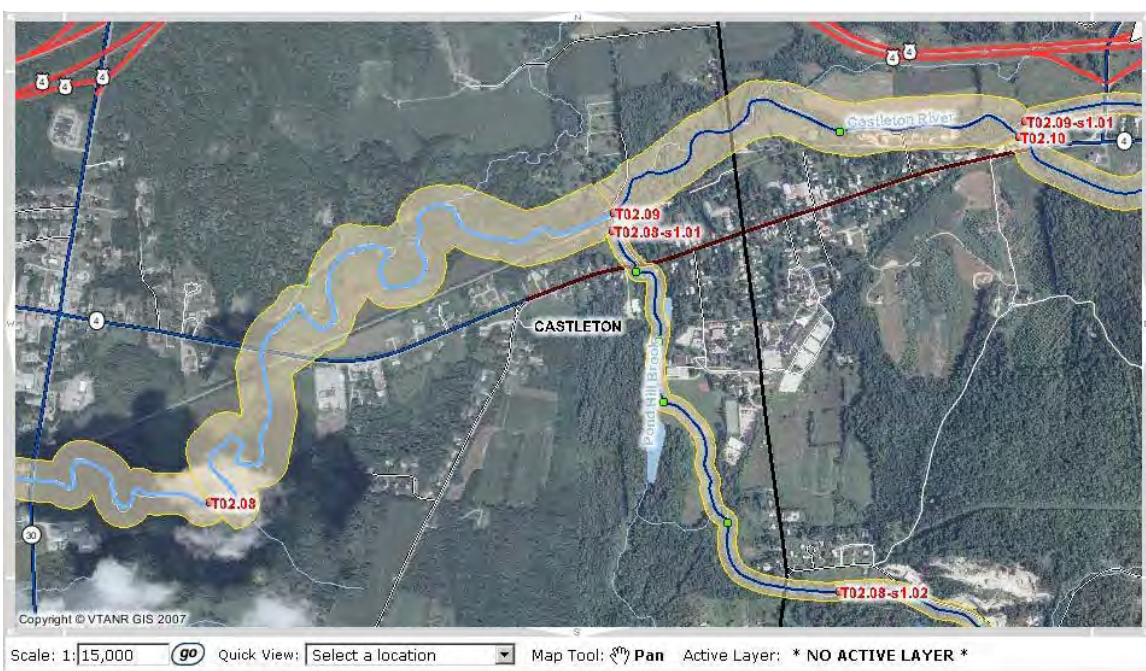
from the tool bar. Click and drag a box around the reaches of interest.





To keep things standard, change your scale to 1:15,000
“go”.

Now we have reached the viewable extent of the NAIP photos. We also see the phase 1 assessed reaches in light blue and the Phase 2 assessed reaches in green blue.



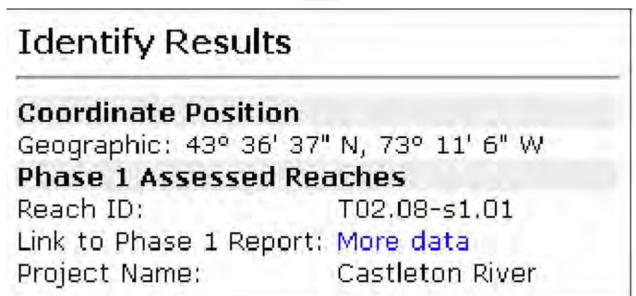
Acquiring attribute data

Ok, so we want to get some attribute and report data for these sections of river. There are a few ways we can go about acquiring this info.

1st

We can make an active layer.   Let's say we are interested in getting Phase 1 data. We will make the "Phase 1 Assessed Reaches" the Active layer, by clicking on the light blue circle with the "i" in it, next to the "Phase 1 Assessed Reaches" in the Map Layers Active menu window. This will make that blue "i" black.

-Now select the "Active layer info" button from the tool bar. With the "**Active layer info**" button selected click anywhere on the reach T02.08-s1.01. A few seconds later this info will appear in the Active menu window portion of your screen

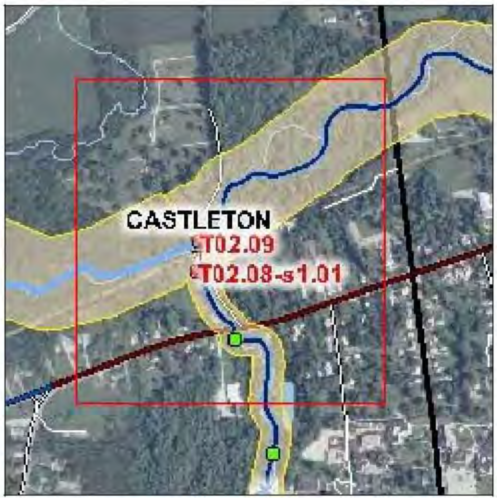


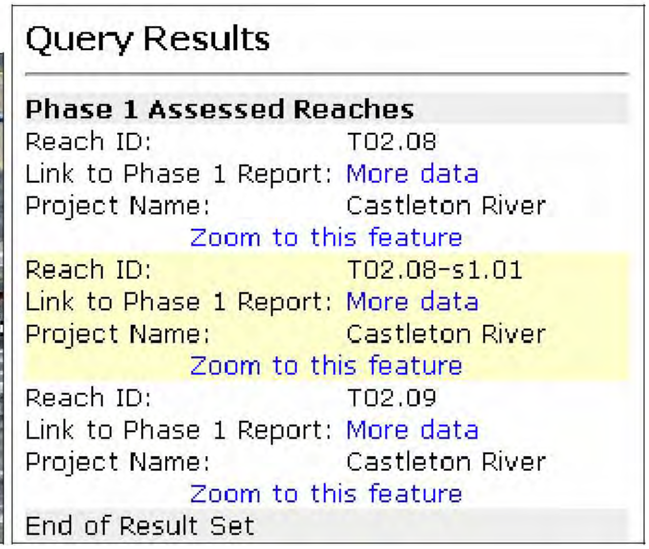
For the Phase 1 report, choose the "More data" hyperlink. And a pop-up window will open which contains a PDF phase 1 report from our online DMS (https://anrnode.anr.state.vt.us/ssl/sga/security/frmLogin.cfm).
-Repeat these steps with the "Phase 2 assessed reaches" as the active layer.

2nd

While the Phase 1 layer is active, open the blue tool box   and choose the "select by rectangle"

tool . -Make a box which includes all reaches of interest and with in a period of 3 seconds or so.. the phase 1 results will be generated. You have the option of zooming into the mapserve to see the location of each specific reach, or opening the Phase 1 report for each link.



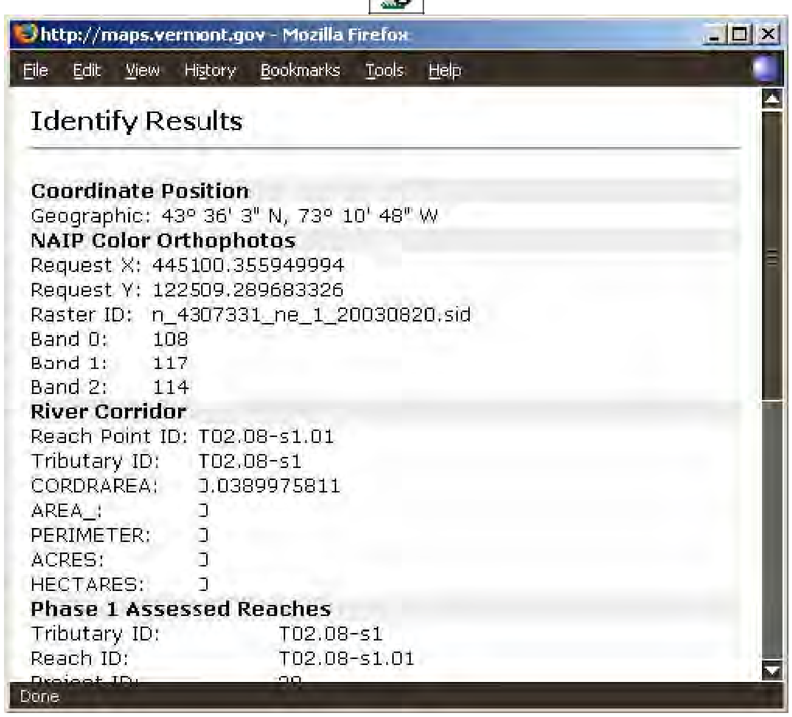


Repeat all these steps with the “Phase 2 Assessed Reaches” as your active layer.

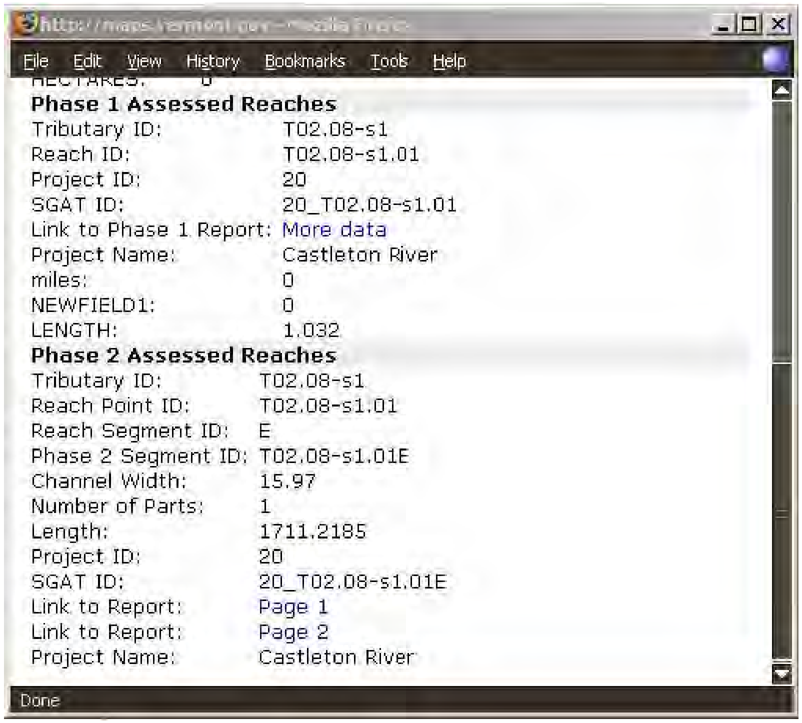
3rd

Choose the “Every layer info”

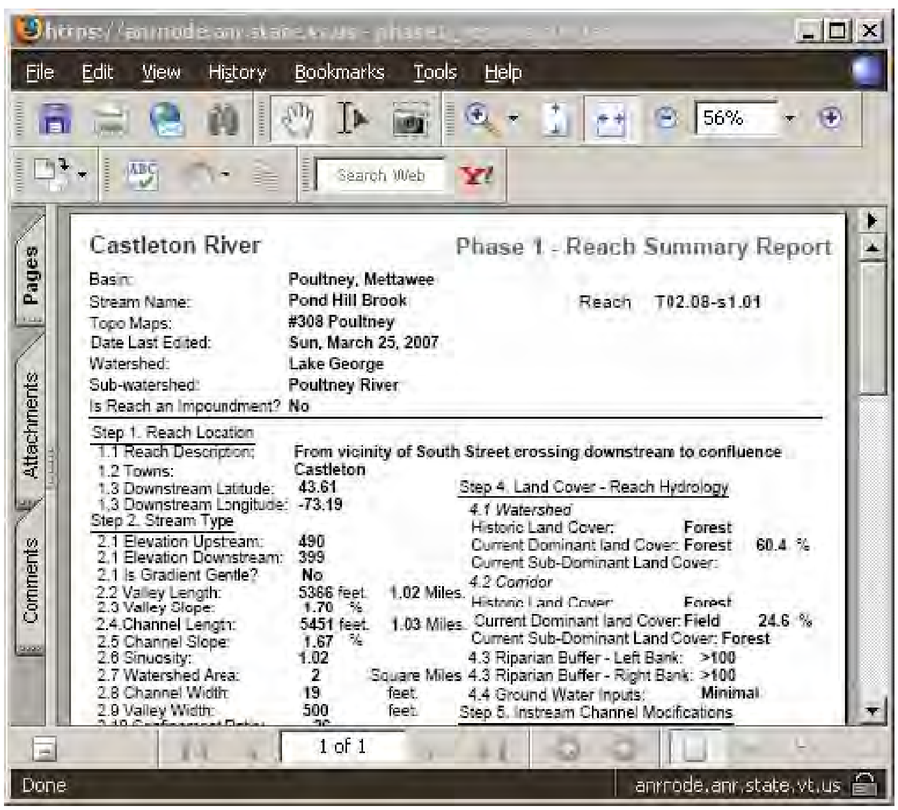
button and click on the T02.08-s1.01 reach. This process will take ~15-20 seconds and a pop-up window appear

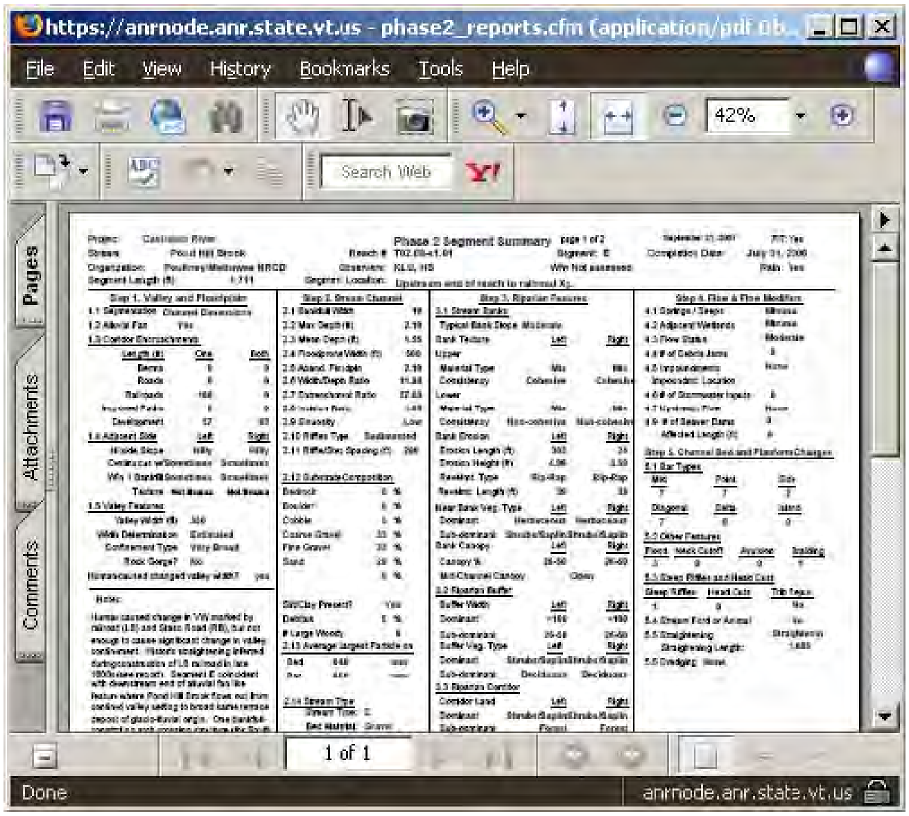


Scroll down. You will see that you have the option of selecting the hyper link for the phase 1 data or the phase 2 data reports.



Once you click on the reports, they will appear in their own PDF pop-up window. Here you have the option to save, view, print, or any options you would have with other PDFs.

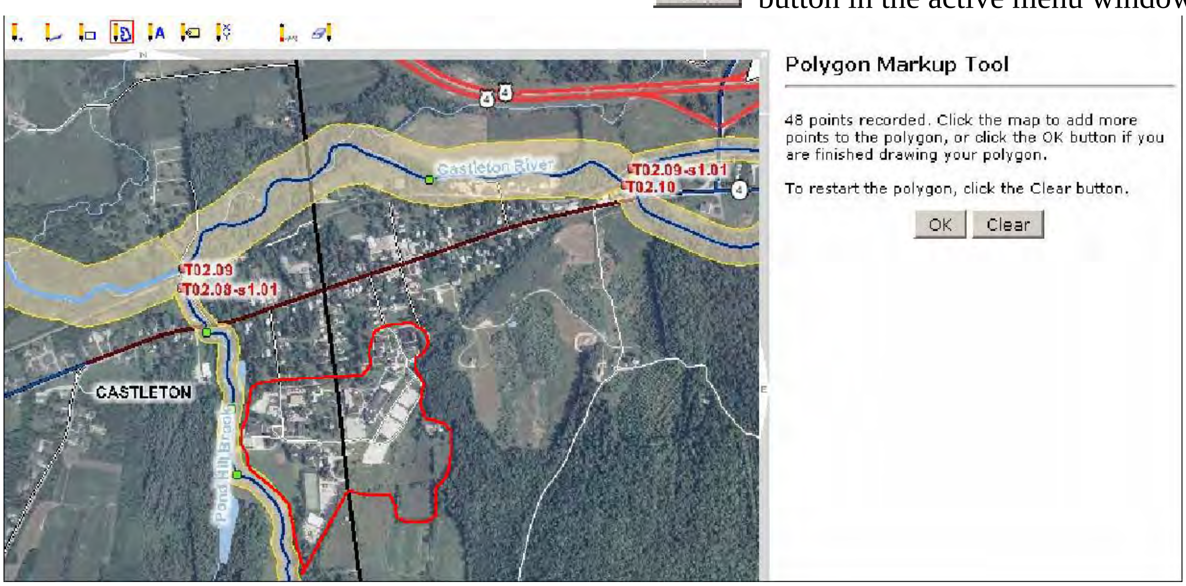




Mark-up the map
-Open the Green tool box.
-Choose the “add polygon to Map”

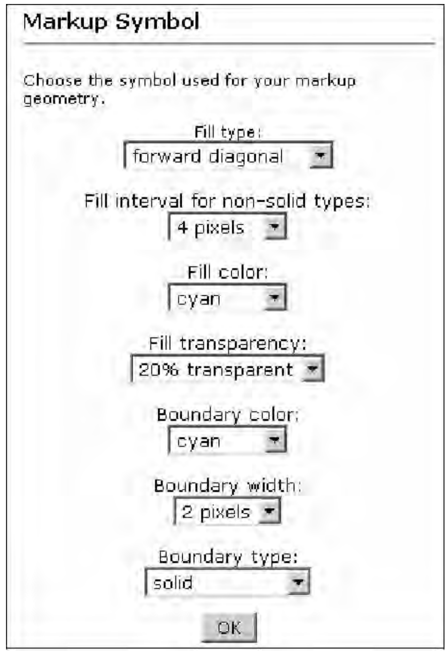
 tool and start clicking on the map making an outline of the Castleton State College campus. -When you have finished outlining the campus, click the

 button in the active menu window.

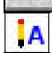


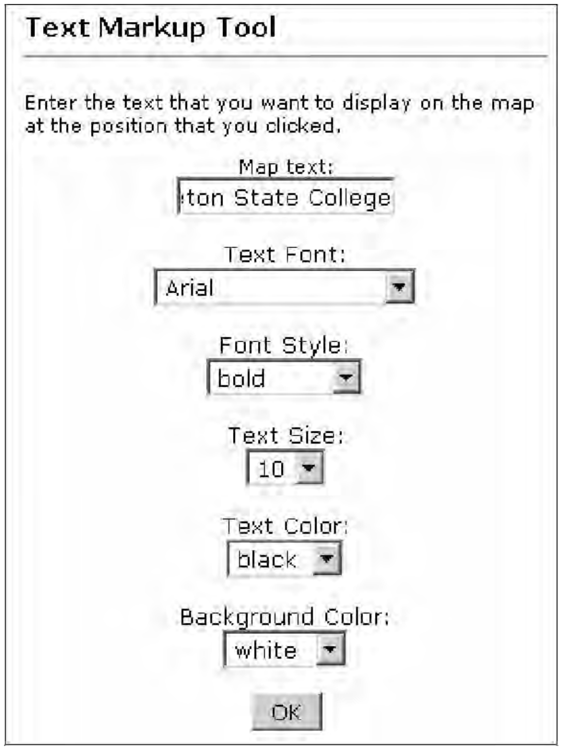
This will bring up the “Markup Symbol” screen in the active menu window.

-Select your options for: Fill type, Fill interval, Fill color, Fill transparency, Boundary color, Boundary width, and Boundary type



Then click -Now choose the "add text"

.

button. Click somewhere on the left side of campus (as text will start where you clicked and work its way right). This will bring up the "Text Markup Tool" screen in the active menu window. -Here you must choose you text (Castleton State College), your font (Arial), your font style (bold), you text size (10), your text color (black) and your background color (white).



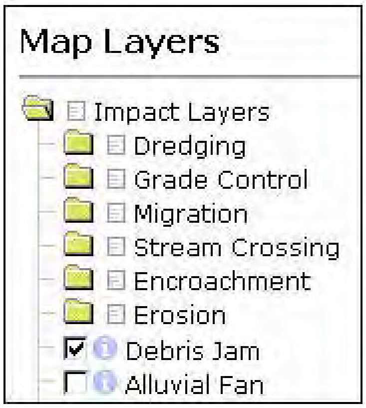
-Once all options have been selected click

Now we know where the campus is.

Adding Phase 2 Feature Data

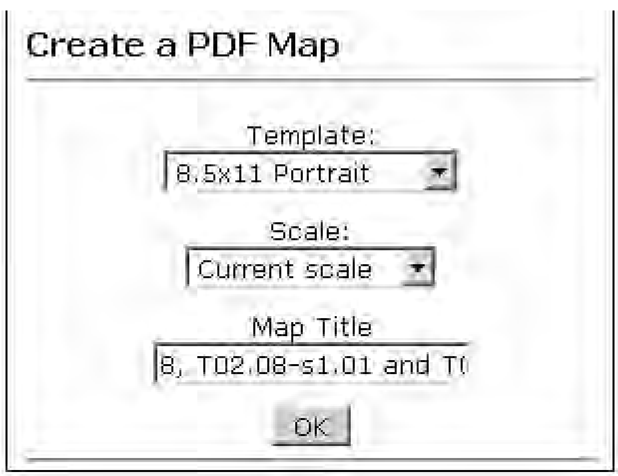
-Let’s add the location of debris jams.

-In the Map layers active menu window open the “Impact Layers” folder and check the box next to “Debris Jam”. If you are at a scale of 1:100,000 or closer you will be able to see the debris jam symbols.



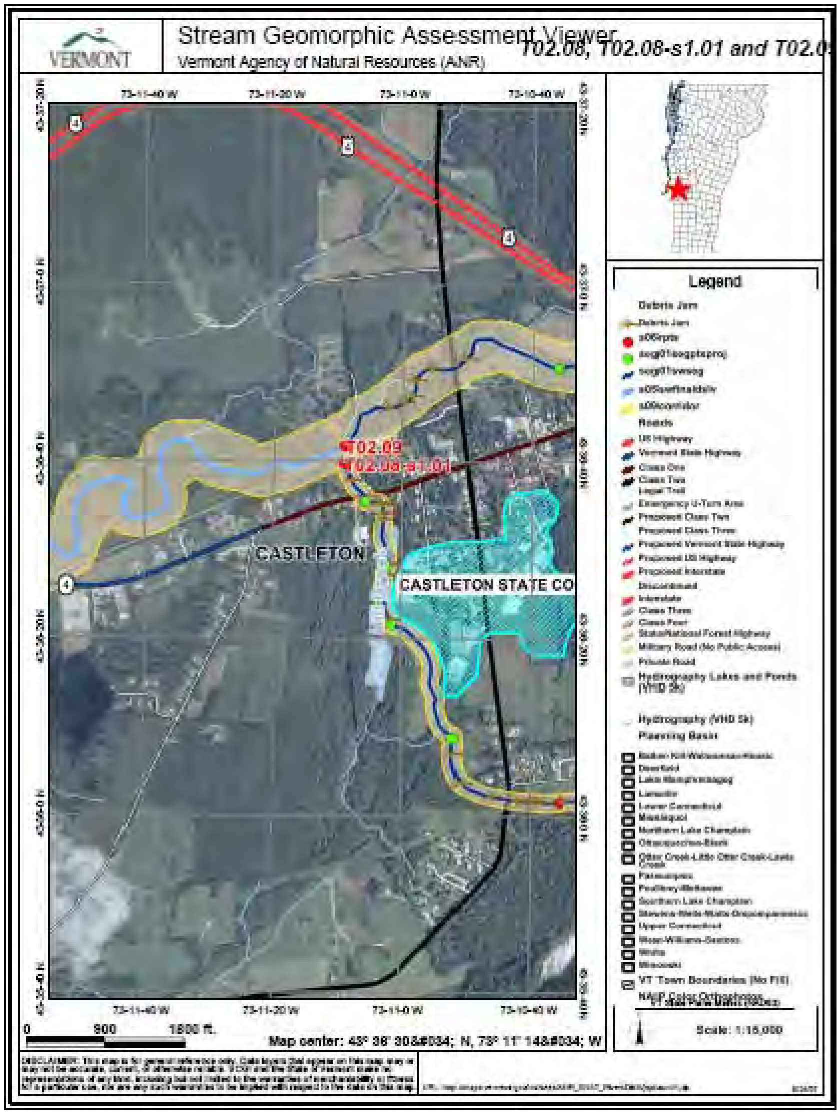
Creating a PDF (#2) 
-Click on the

button in the menu bar. -This time we will choose an 8.5x11 portrait template, the current scale, and a map title of "T02.08, T02.08-s1.01, & T02.09"



-Click the  button.

-Wait a few seconds for the map to be generated and then click on the  hyperlink



If your title is over 29 characters long it will be a little messy (as seen above)

NEAT EXTRAS

EXTRACTING DATA

NEAT EXTRAS

Making a shape file from layers

This function is temporarily not available (check back later)

Making a KML file from layers

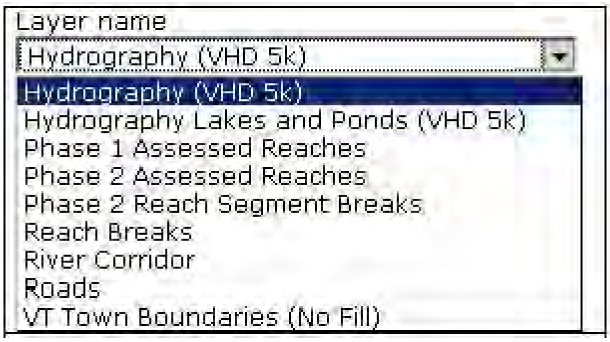
A KML file is the file type that Google Earth uses

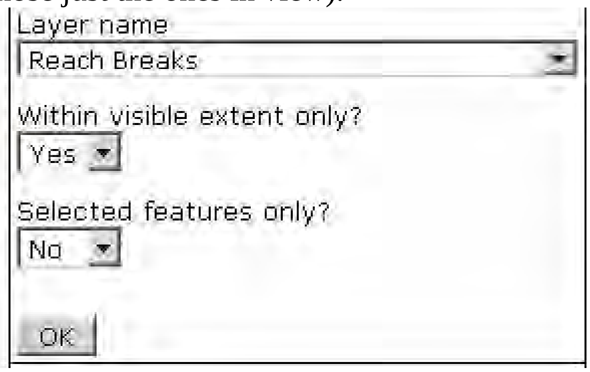
-Click on the extract data button

 then choose “KML” file

.

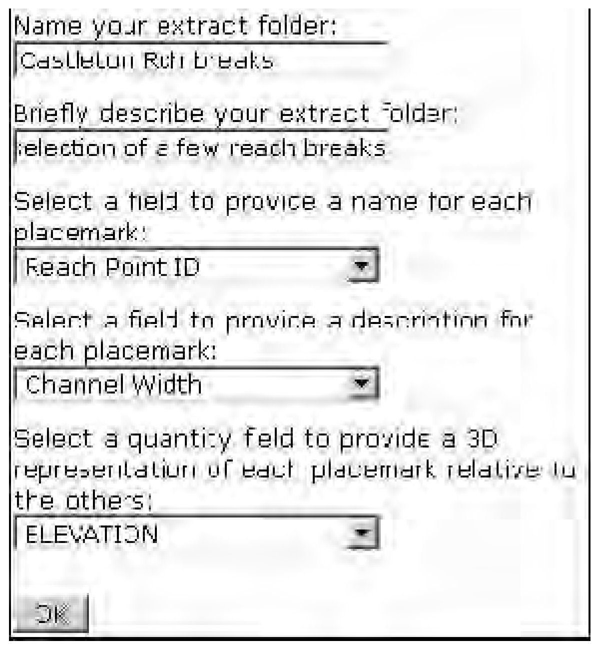
-You must choose the feature you would like to extract (in our case I have chose reach points) and you must choose the extent of extraction (i.e. would you like to export all the reach points for the entire state, or just the ones in your view right now (in our case I chose just the ones in view).





-Click the

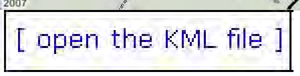
 button -You must also choose the attribute data that will be exported with this file



-Click the

 button

This will bring up the “Extract layer to KML” screen in the active menu window.

-Choose 

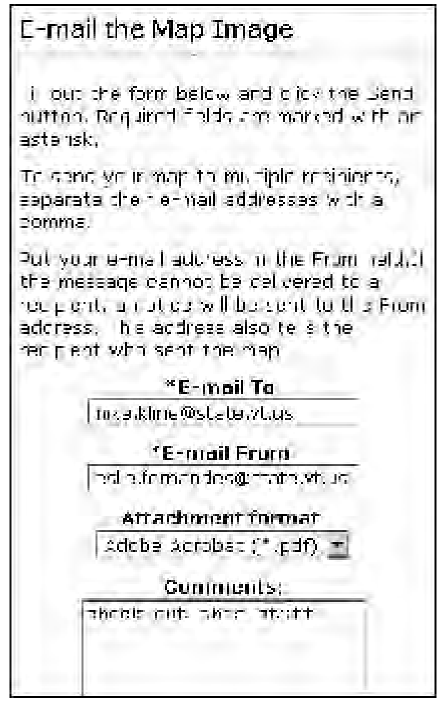
to view it in Google Earth.

Here you can see the yellow thumbtacks are the reach points in Castleton. You can even flip it into 3D mode

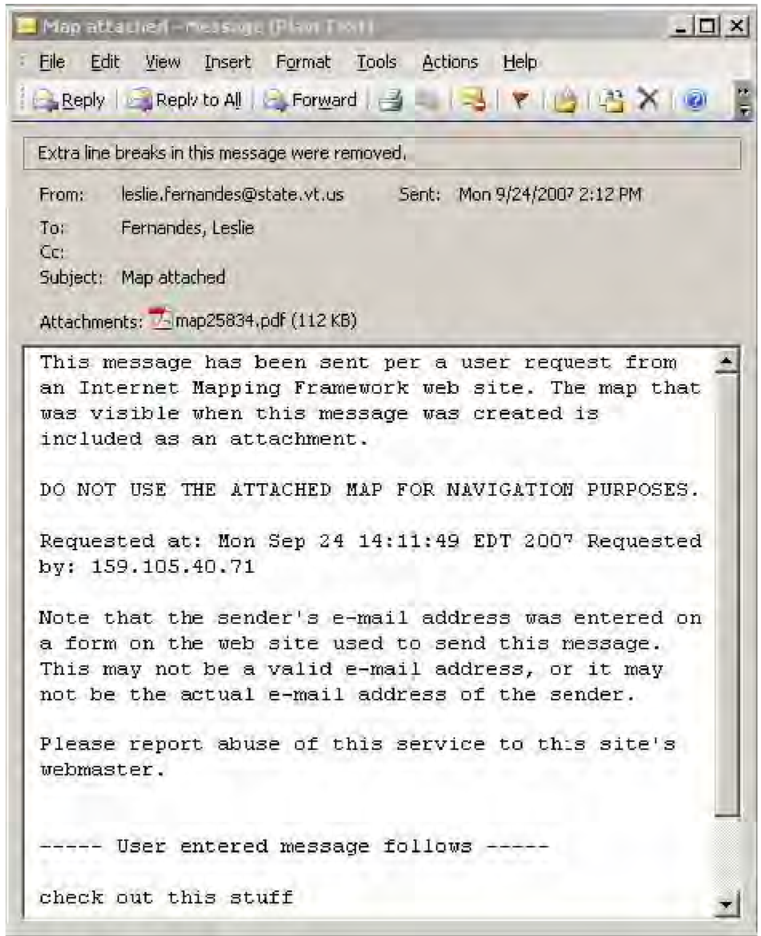
Emailing the data

- Email to a friend or colleague a jpeg or PDF of you Main Display Choose the email
- button from the top menu. This will bring up the “Email the Map Image” screen in the “active menu window” -Select:

-Who you want to email to -Who you are (your email) -If you want to save it as a PDF or a jpg -A short message



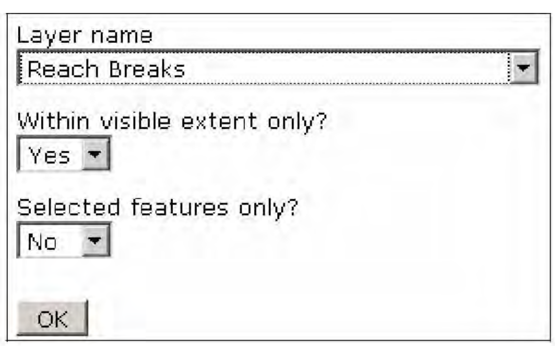
-Then click The image sent will be a screen shot of your Main display The email will look like the one seen below.



Making an Excel file

While currently our shape file creator is down, you will be able to turn all data into Excel

-click on the XLS (Excel) File option and this will bring up the “Extract Layer to Excel” Active menu window. -Here you must select the layer (from the drop down menu) that you want to extract and then choose your extent.



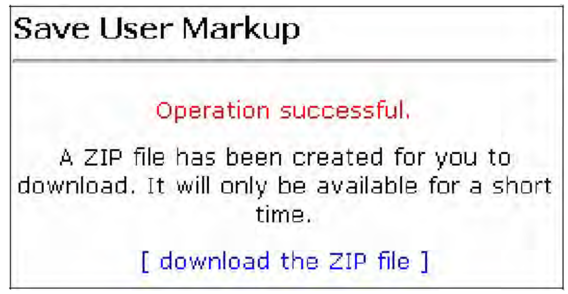
Now click 

If you export a point file (like “reach breaks”) the excel document will contain lat/long, which can be converted into a shapefile in ArcMap.

GDB_ANR_WEB.ANR_ADMIN.WATERHYDRO_SGAT_S06RPTS.LATITUDE	GDB_ANR_WEB.ANR_ADMIN.WATERHYDRO_SGAT_S06RPTS.LONGITUDE

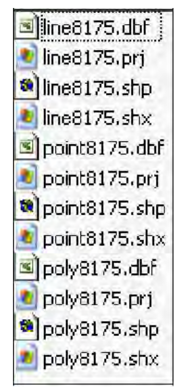
Making a shape file from markup

Click on the "Markup Shapefile" option and this will open the "Save User Markup" active menu window.



-Click on [download the ZIP file].

All points, lines, and polygons will be in the zipped folder

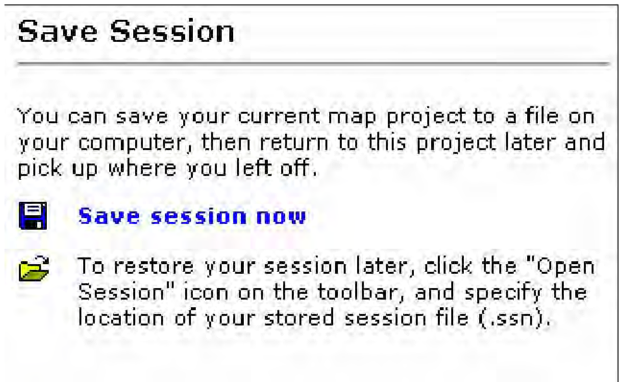


Saving your session

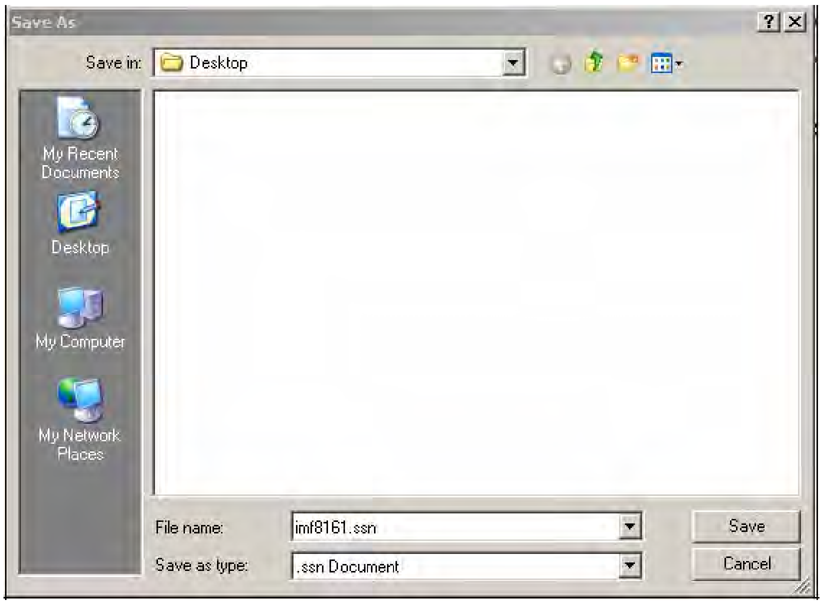
You may have invested a lot of time in the mapserve, marking the map with points, lines, polygons, X Y coordinates or text. You may also have made some bookmarks. The good news in that you have the ability to save your project on your own personal computer and the next time you are in the mapserve you can open your session.

-Click on the Save project button

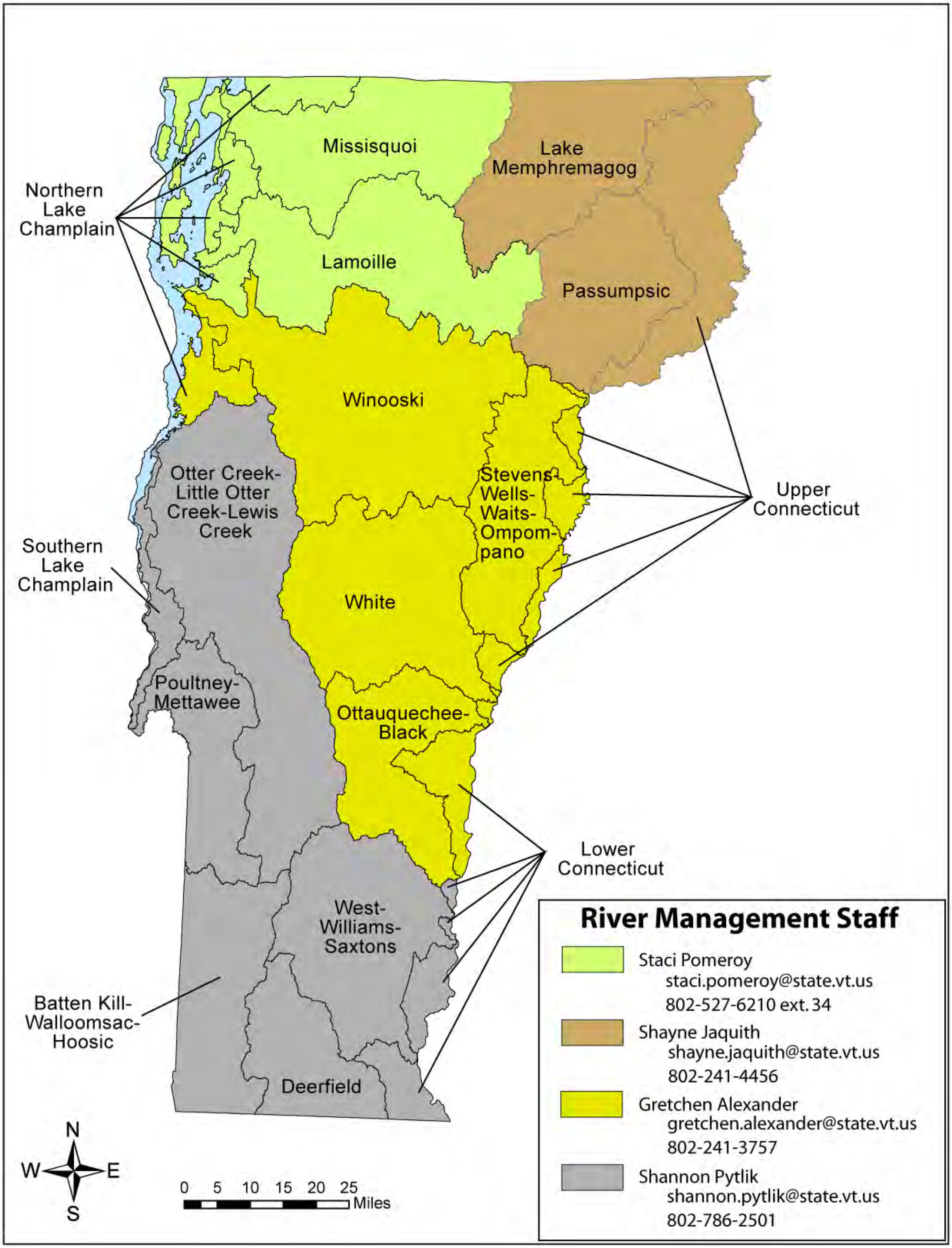
and this will bring up the "Save Session" Active layer window.



If running internet explorer, you will have the option to rename the file and choose where it is saved



If running mozilla fire fox the project will be automatically saved to your desktop with the default name. [The mapserve will choose a different name every time, so that you are not in threat of replacing the data]


Northern Lake Champlain
Missisquoi
Lake Memphremagog
Lamoille
Passumpsic
Winooski
Otter Creek-Little Otter Creek-Lewis Creek
Stevens-Wells-Waits-Ompom-pano
Upper Connecticut
Southern Lake Champlain
White
Poultney-Mettawee
Ottauquechee-Black
Lower Connecticut
West-Williams-Saxtons
Batten Kill-Walloomsac-Hoosic
Deerfield
N
W
E
S
0 5 10 15 20 25
Miles
River Management Staff
Staci Pomeroy
staci.pomeroy@state.vt.us
802-527-6210 ext. 34
Shayne Jaquith
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802-241-3757
Shannon Pytlik
shannon.pytlik@state.vt.us
802-786-2501

Appendix F - Procedure to Map Suitable Areas for No-Till Crop Management

Background
Detailed soils (SSURGO) data are stored in the NRCS National Soil Information System (NASIS). The criteria used to select Vermont soils map units that are good candidates for No-till are presented below. The soil map unit selection step was already performed by Vermont NRCS Soils Staff members.

Procedure
To apply the procedure for the Missisquoi Areawide Plan and come up with candidate crop fields:

1. Run the NASIS interpretation for no-till in Vermont. Our Soil Database Manager did this step and gave the team a table (Dbase IV .dbf file) which had map unit identifiers and interpretations for the two counties we needed data for.
2. Join the NASIS no-till interp table to the respective county soil data layers, using MUSYM as the key joining attribute.
3. Add a new attribute to the Crop&Hay_allMisq layer called NoTillGood, as a text attribute with 7 characters. This will be populated using selection techniques.
4. Select By Attributes the soil map units for which the attribute INTERPHRC is “Good” or “Excellent”. Do this for each county soils layer or combine the counties into a new soils layer that covers the whole area.
5. Select By Location the crop fields which intersect the selected soil map units (make sure the checkbox is checked to use only selected features).
6. Visually (there may be an automated way to do this) select from this set all the crop field polygons for which a Good or Excellent rating covers at least 50% of the field. As you check each field or groups of fields that qualify, assign a “y” to the NoTillGood attribute.
7. The Crop&Hay_allMisq feature class, in the Crop&Hay.mdb personal geodatabase now contains an attribute for selection or symbolizing purposes to indicate each field’s candidacy for the practice.

The following criteria are directly quoted from an internal Vermont NRCS document written by the State Soils Staff.

Criteria used to select soil map units
The interpretive rating is the least suited of the following soil features. Criteria are based on concepts expressed in NRCS Practice Standard, No Till/Strip Till, Code 329a, NRCS/NHCP, March 1999.

1. Cobble content: Excessive cobbles (rock fragments, 3 to 10 inches in size) in the surface layer interfere with the tillage, equipment operations, and plant growth. Soil feature considered is percent by weight coarse fragments 3 to 10 inches in size in the surface soil layer.

Property used: "FRAGMENTS 75mm to 250mm SURFACE LAYER (TX)" (Modality - high, low, and representative value)

Restrictive limits:

- Poorly suited => 10%
- Suited> 2% to < 10%
- Well suited =< 2%
- Null 3 to 10 inch rock fragment data are assigned to the Not rated class.

2. Depth to bedrock: Shallow depth to bedrock restricts machine operations and crop rooting zone. Depth to restrictive feature must be synchronized with the depth to the restrictive feature horizon shown in the horizon table.

Property used: "DEPTH TO BEDROCK (VT)" (Modality - representative value)

Restrictive limits:
- Poorly suited =< 50cm
- Fairly well suited > 50 to < 100cm
- Well suited => 100cm
- Null depth is assigned to the Well suited class.

3. Depth to cemented pan: Shallow depth to cemented pan restricts machine operations. Depth to restrictive feature must be synchronized with the depth to the restrictive feature horizon shown in the horizon table.

Property used: "DEPTH TO FIRST RESTRICTIVE FEATURE (TX)" (Modality - representative value)

Restrictive limits:
- Poorly suited =< 25cm
- Fairly well suited > 25 to < 100cm
- Well suited => 100cm
- Null depth is assigned to the Well suited class.

AND Property used: "KIND OF FIRST RESTRICTION (TX)" (Modality - representative value)

Restrictive limits:
- Limiting = "fragipan" or "duripan" or "petrocalcic" or "ortstein" or "petrogypsic"
- Not limiting not = "fragipan" or "duripan" or "petrocalcic" or "ortstein" or "petrogypsic"
- Null restrictive feature kind is assigned to the Not limiting class.

AND Property used: "FIRST RESTRICTIVE FEATURE HARDNESS (TX)" (Modality - representative value)

Restrictive limits:
- Limiting not = "Noncemented"
- Not limiting = "Noncemented"
- Null hardness is assigned to the limiting class.

4. Slow percolation: Slow percolation restricts the internal drainage of the soil and can interfere with implementation and management of No Till practices and crop growth during wet periods. Soil feature considered is the depth to Ksat < 0.42.

Property used: ""DEPTH SOIL Ksat < 0.42 0 TO 100CM (TX)"" (Modality - high, low, and representative value) is:
- >= 60cm the soil Ksat is optimum and the degree of suitability is expressed as the number 1.0.
- 0 to 60cm the soil is less then optimum and the degree of suitability is expressed as a number between 0.0 and 1.0.

5. Depth to saturated zone: Soils with shallow depth to a water table maybe difficult to work and have a restricted rooting zone. These areas are slow to drain and can become waterlogged and boggy during periods of heavy precipitation. Soil feature considered is the top depth of the first layer where soil moisture layer status is wet or saturated during the growing season or the local soil phase is drained.

Property used: "DEPTH TO HIGH WATER TABLE, Growing Season (VT)" (Modality - high, low, representative value)

Restrictive limits:

- Poorly suited =< 36cm
- Fairly well suited > 36 to < 60cm
- Well suited => 60cm
- Null depth is assigned to the well suited class.

OR Property used: "LOCAL PHASE (TX)" (Modality - representative value)

- = "*drained*" -- Overrides the depth to water table rating and is Well suited.
- Not = "*drained*" -- uses the depth to water table rating.

6. Flooding: Flooding frequency during the growing season greater then rare restricts machine operations and crop growth. Soil feature considered is maximum flooding frequency classes during the months that comprise the growing season.

Property used: "FLOODING, Frequency in Growing Season (TX)" (Modality - representative value)

Restrictive limits:

- Poorly Suited = "very frequent" or "frequent"
- Fairly well suited = "occasional"
- Well suited = "very rare" or "rare"
- Null frequency is assigned to the well suited class.

7. Too Gravelly: Excessive gravel (rock fragments, 2mm to 3 inches in size) in the surface layer interferes with tillage, equipment operations, and plant growth. Soil feature considered is percent by weight coarse fragments 2nn to 75mm in size in the surface soil layer.

Property used: "COARSE FRAGMENTS 2 to 75MM IN SURFACE LAYER (TX)" (Modality - high, low, and representative value)

Restrictive limits:

- Poorly suited => 35%
- Suited> 15 to < 35%
- Well suited =< 15%
- Null passing #10 sieve is assigned to the Not rated class.

8. Content of large stones: Excessive stones (rock fragments, > 10 inch in diameter) on the soil surface impede tillage operations. Soil feature considered is percent rock fragments > 10 inches in size on the surface soil layer.

Property used: "FRAGMENTS >=250MM ON THE SURFACE (TX)" (Modality - high, low, and representative value)

Restrictive limits:

- Not Suited => 1%
- Somewhat Suited > 0 to < 1%
- Suited = 0%
- Null > 10 inch rock fragment data are assigned to the Not limiting class.

9. Ponding: Ponding during the growing season restricts or effects tillage, rooting depth, and plant growth. Soil feature considered is ponding duration.

Property used: "PONDING DURATION in Growing Season (TX)" (Modality - representative value)

Restrictive limits:

- Not suited = "very brief" or "brief" or "long" or "very long"
- Suited = "none"
- Null ponding duration is assigned to the Suited class.

10. Slope: Slopes between 3 to 15% are suited to no-till and mulch tillage practices. However, they maybe subject to soil erosion and could restricted machinery operations. The square root of the degree of suitability is applied as a modifier to reduce the effect slope has on No-Till practices and performance.

Property used: "SLOPE (TX)" (Modality - low, high, representative value)

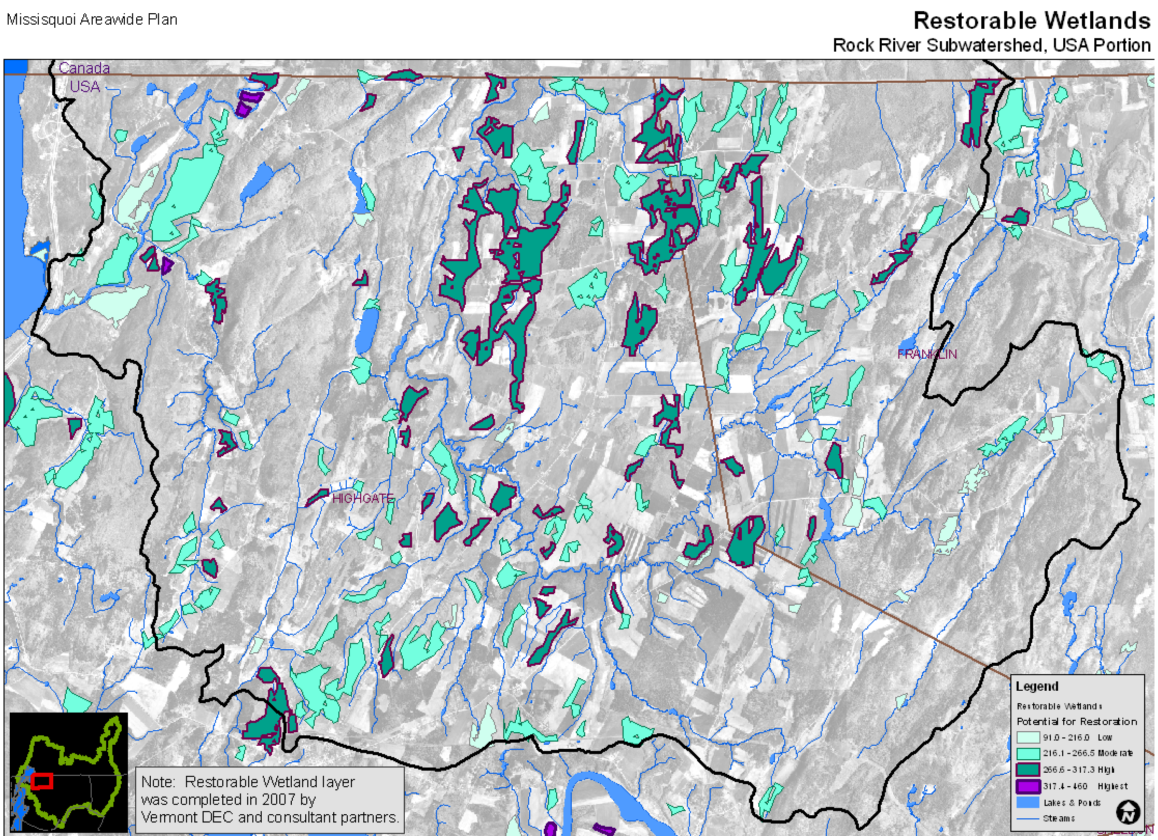
Restriction limits:

- Poorly suited => 15%
- Suited > 3 and < 15%
- Well suited =< 3%
- Null Slope is assigned Not rated."

Appendix G - Procedure to Prepare Maps of Higher Priority Restorable Wetlands

Background

Vermont ANR and their contractor, Pioneer Environmental Associates, LLC, used a GIS modeling approach to evaluate areas in the Lake Champlain Basin which have varying potential for restoration to wetland function. This procedure documents what was done to create maps of Missisquoi Areawide Plan sub-watersheds showing sites with high potential for restoration. An example map is shown below.



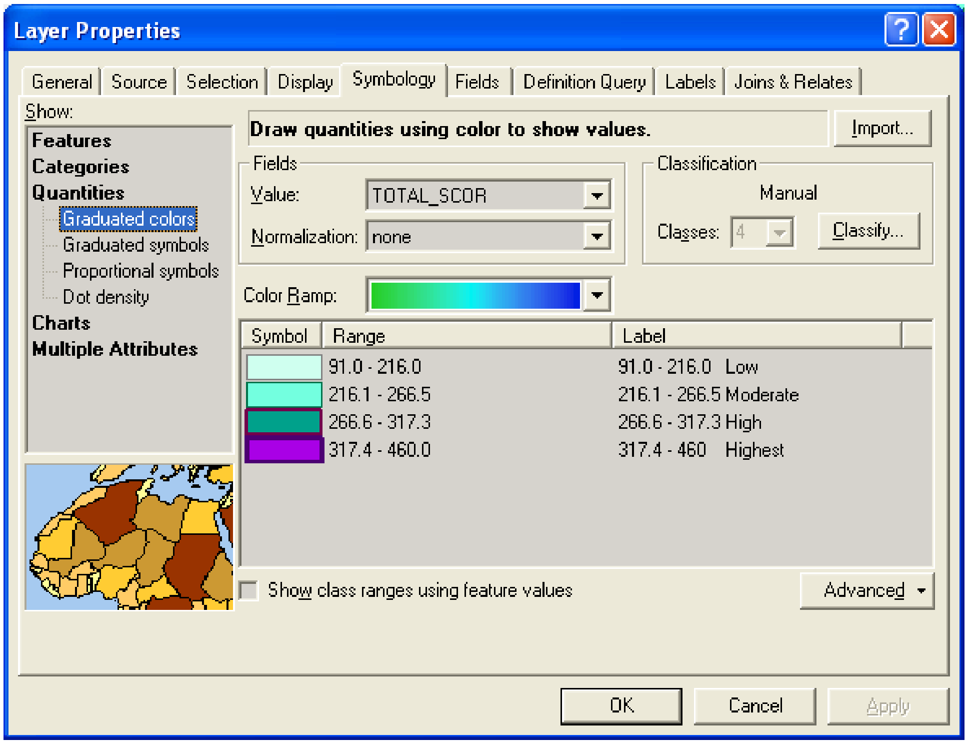
Procedure

To apply the procedure for the Missisquoi Areawide Plan and come up with candidate sites:

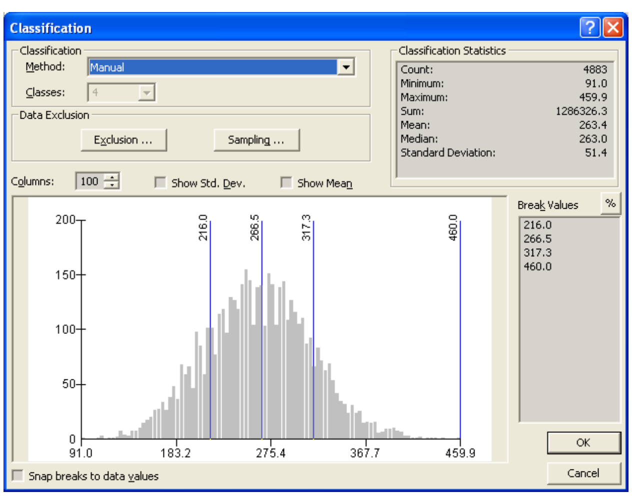
1. Set up an analysis Map Document in ArcGIS with the following layers:
   a. watershed boundaries
   b. siterank_final.shp (restorable wetland polygons)
   c. towns
   d. counties
   e. CREP projects
   f. vhd_l_vt011 (surface waters)
   g. lake champlain
   h. NAIP 2003 1-m orthophotography
   i. VT 1995 orthophotography
   j. vswi_vt011 (wetlands)
   k. the Crop&Hay file geodatabase (ArcGIS 9.2)

2. Import the data layer delivered by Vermont ANR called siterank_final.shp. This is a polygon layer that has all ranked sites for potential wetland restoration, Lake Champlain Basin-wide.

3. Symbolize the siterank_final shapefile as follows:



4. The breaks for each class were selected using the normal distribution of occurrence within the siterank layer. The are as shown below (this is accessible by clicking the “Classify…” button):



5. Save the symbolization as an ArcGIS Layer file (e.g. RestorableWetlands.lyr) so it will be easy to return to after other analyses.

6. The decision to highlight High and Highest sites is arbitrary. For purposes of the Missisquoi Areawide Plan and northern lake conservation prioritization, this narrowed the field of potential sites to the most important 62 sites – plenty of sites to choose from for the first year of conservation program targeting. These would need to be analyzed with other information such as riparian gap and stream encroachment locations to judge the likely success of restoration, and further narrow the field to the best possible sites.

Appendix H - Procedure for Setting Up 25 Foot Riparian Gap Buffers, Example for Rock River, VT

Background

To use existing VT-DEC Stream Geomorphic Assessment data to prepare buffers to assess for gaps in riparian vegetative cover along streams.

Methodology

Add 25 ft (7.62m) to calculated half-channel width, and create Left and Right buffer polygons using this width, which varies among reaches based on their contributing watershed areas.

Procedure

1. Pull up riparianMisq.mxd. Save this map document As riparianRock.mxd.

2. Add data:
   - H: \geodata\Missq_AreaPlan\SGA_data\Rock River\sgaRockR.shp
   - H: \geodata\Missq_AreaPlan\SGA_data\Rock River\Rock_PHASE1_2-6-07

3. Join SGA data with Phase 1 table using RCHPTID as linking attribute.

4. Export the joined layer to H:\geodata\Missq_AreaPlan\Riparian Gap Project\RiparianGapsMisq.mdb\SGAstarterdata data set.

5. Add this new sgaRockR personal geodatabase (from SGAstarterdata) feature class into riparianRock.mxd map document.

6. In the attribute table, add the field from which buffers will be constructed: Options—Add Field:
   - HalfWft_m8, double, precision15, scale1, alias 25ftbuffer
   - Do this to both layers if the sga data is split between headwaters and mouth sets.

7. If the sga data is split between headwaters and mouth, merge the 2 layers now and call the merged layer H:\geodata\Missq_AreaPlan\Riparian Gap Project\RiparianGapsMisq.mdb\SGAstarterdata\sgaRockR.

8. Calculate HalfWft_m8 to equal [CHL_WIDTH]/**6.56** + 7.62
   a. Explanation: since CHL_WIDTH is reported in feet, and the map units in the project are in meters, you have to divide by 2 to get Half-channelwidth, **then by 3.2808 to convert reported width to meters for buffering purposes,** since the buffer tool works in the riparianRock.mxd map document's map units. The 7.62m equals 25ft since this is to be a 25ft buffer.
   b. If there are records missing the CHL_WIDTH information, this can be calculated using sub-watershed sizes and the WTRSHD_SIZ attribute before calculating HalfWft_m8. The formula is

      13.1*([WTRSHD_SIZ]^.44)

   c. If there are records missing WTRSHD_SIZ information, ***this*** can be calculated by joining the sgaRockR data to the Rock River H:\geodata\Missq_AreaPlan\SGA_data\Rock River\subshed.shp layer (join them via the RCHPTID attribute). The SUBWSAREA attribute is the area in mi^2 of the immediate drainage around just the current reach, while WTRSHD_SIZ is the total for all subsheds that drains to the outlet of the current reach. In the attribute table of sgaRockR, drag the SUBWSAREA att over next to WTRSHD_SIZ. If WTRSHD_SIZ = 0, you must calculate it by adding up the SUBWSAREAs for all upstream reaches plus the current one. Choose these upstream subsheds spatially (visually), then show only selected polys. If the subshed directly above your null-value one has a value for WTRSHD_SIZ, then add that to the SUBWSAREA of the null-value one, and change <null> to this sum. *It can be done!* When all null WTRSHD_SIZ values have been populated, remove the sub shed join from sgaRockR. **If you had to do this step (8c), next go up to 8b, and then do 8a.**

9. After calculating HalfWft-m8, run buffer tool in ArcToolbox for Left side
    a. input sgaRockR
    b. output feature class H:\geodata\Missq_AreaPlan\Riparian Gap Project\RiparianGapsMisq.mdb\buffer25\Rock25Left
    c. distance – Field – HalfWft_m8
    d. LEFT side
    e. FLAT ends
    f. dissolve NONE
    g. OK

10. Add attributes to Rock25Left:
    a. side text, 4
    b. woody text, 5
    c. gap text, 5
    d. Acres double, precision 14, scale 1

11. Run buffer tool again for Right side
    a. input sgaRockR
    b. output feature class H:\geodata\Missq_AreaPlan\Riparian Gap Project\RiparianGapsMisq.mdb\buffer25\Rock25Right
    c. distance – Field – HalfWft_m8
    d. RIGHT side
    e. FLAT ends
    f. dissolve NONE
    g. OK

12. Add attributes to Rock25Right:
    a. side text, 4
    b. woody text, 5
    c. gap text, 5
    d. Acres double, precision 14, scale 1

13. In Properties..Symbology, import the layer file from \RiparianGapsProject\L&Rbufferconstr.lyr for both the Left and Right buffers

14. Go through and label the *side* attribute of each reach in Rock25Left. Many will be on the "wrong" side of stream – label all of these R for *side*, label all the left ones L for *side*.

15. To label the *side* attribute for Rock25Right:
    a. Select by Attributes all Rock25Left polygons where *side* = L

b. Select by Location all Rock25Right polygons that share a Line Segment with the selected polys of Rock25Left
c. Label these with *side* = R
d. Clear selected features
e. Select by atts all Rock25Right polys where *side* = R
f. switch selection
g. Label all the new selected polys in Rock25Right with *side* = L
h.

16. QA - Select by atts from each of these layer where "*side* =", look at possible unique values list and see if there are values other than R and L. Go visit any that do and re-attribute their *side* attribute.

17. QA – Recalculate acres for each of these layers. Do an acreage statistics on the attribute tables. See if the acreages are about equal. Should be.
18. Open attribute tables for both Rock25Left and Rock25Right. Click on Options—Turn All Fields On. The merge won't work unless all fields are on.

19. Combine (Merge) the two buffer layers into one:
a. using ArcToolbox Merge tool: input Rock25Right, Rock25Left
b. output feature class H:\geodata\Missq_AreaPlan\Riparian Gap Project\RiparianGapsMisq.mdb\buffer25\Rock25buffer
c. don't do any field mapping
d. Click OK

20. QA – Turn L & R sides different colors, and roam the layer looking for anyplace the buffers are 1) same color both sides of river, or 2) mislabeled (for the side they really are on).

21. Compact and Save the RiparianGapsMisq.mdb geodatabase. This will substantially reduce its file size.

Appendix I - Riparian Gap Mapping Conventions and Procedure, Example for Rock River, VT

Purpose
To map the presence of obvious gaps in riparian vegetative cover within a 25ft buffer of all DEC SGA Phase 1 assessed stream reaches, and to note whether mapped stretches of the buffer area contain 50%+ woody vegetative cover or not.

Methodology
Use ArcMap or ArcView polygon cut edit tool to divide the 25 foot buffer polygons into consistent stretches of gap and/or woody cover. For purposes of this project, the concept of a functioning riparian buffer is based primarily on its function as a sediment and nutrient trap, keeping these from entering streams adjacent to, or connected to, non-forested land uses.

Procedure

1. In ArcMap, gather these data layers. In order to ensure you are working in VT State Plane NAD83 meters projection, bring in towns or counties first.
   - VT Counties and/or Towns layer
   - WBD or the individual watershed boundaries for watersheds you will be working with
   - SGA stream reaches datalayer, from which the buffers were created (obtained from Staci Pomeroy, DEC River Mgmt Team)
   - Valley walls polygon layer from SGA database (obtained from Staci Pomeroy, DEC River Mgmt Team)
   - 25 ft buffer template for the river (example: Rock25buffer)
   - NAIP 2003 images or county mosaic
   - VT Ortho ca. 1995 images or county mosaic
   - Vermont Hydrography Dataset (VHD) layer that covers this river system

2. Your first job in this procedure is to split polygons into areas that have a gap or no gap. Symbolize the 25 ft buffer layer using the *gap* attribute such that n (no gap) is a green outlined polygon, y (yes, there is a gap) is a red outlined poly, and ? (needs further discussion or site visit) is a yellow outlined poly. <all other values> (unlabeled polygons, Fig.1) should be some contrasting, easily recognized color so that you know where you have not worked.

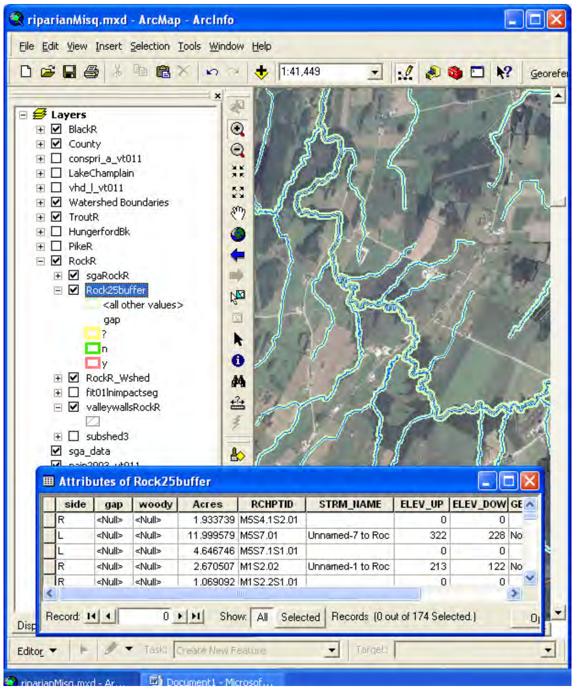


Fig. 1: screen capture of the riparian project in ArcMap 9.1. In this example, the attributes *gap* and *woody* are as yet unlabeled. Note symbology conventions for displaying the *gap* attribute while editing.

3. Zoom in to one end of a reach. There are two polygons flanking the sga stream reach. This layer has an attribute called *side*, which denotes which side of the stream this buffer is on, (always looking downstream).

4. There are many attributes associated with the Phase 1 stream geomorphic assessment, and retained in the Rock25buffer layer, which will be used later for analysis but are not useful for this procedure. It is recommended to go into the Properties..Fields tab for this layer and uncheck most of the attributes except for the ones showing in fig. 1. This will reduce the "noise" in the attribute table. Move the *side*, *gap*, *woody* and *Acres* columns to the left side of the table, where they will be easily accessible during editing.

5. Activate the Editor toolbar and start editing, using the directory you have the Rock25buffer file in as the workspace.

6. Select a polygon, right or left, doesn't matter. You will edit each buffer polygon separately so that the data layer will show which side of the stream a buffer gap is on. Zoom in so that you can see the photo, and determine whether there is a gap right on the end (see Figure 2).

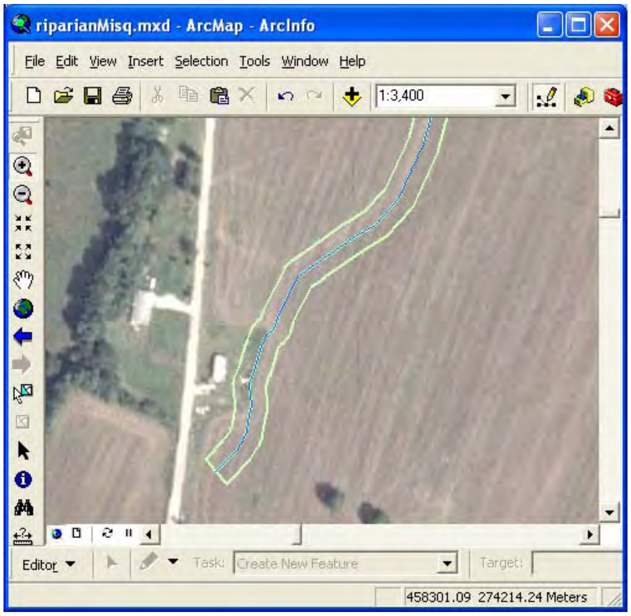


Fig. 2: zoomed in on the headwaters end of a stream. It is quite clear that here there is no buffer, so it constitutes a gap. To find the end of the gap area, you would pan up the stream until you finally arrive at an area of riparian buffer. It is possible that some entire buffer polygons will be considered “gap”. These would not be split, but simply labeled “y” for the *gap* attribute. In this example, both visible polys (R and L) would be labeled gap, although they may be split at different places further downstream.

7. When you have split out a polygon (a ‘segment’ of the buffer polygon) that is all “no gap” (n), next assess whether any of it is woody. If some is woody, but other areas are non-woody buffer areas, split the polygon between those such that individual buffer polygon contents are consistent, and label each “n” for *gap*, and label the woody polygon “y” for *woody*. Labeling a polygon as woody means it has more than 50% woody vegetative cover, and this cover does *not* constitute a single line of trees under which cows may roam and have access to the stream.

8. Wherever you see a stream crossing, that is considered a gap.

9. When you have a polygon that is “y” for *gap*, it is most likely “n” for *woody*, and you would label it as such. Some gap areas do have woody vegetation predominant, but under the trees, visible paths or marks show that human activity there is likely to defeat riparian functions. These are labeled “y” for *gap* and “y” for *woody.*

10. Repeat steps 6 – 8 for all polygons. When you label them as gaps or not-gaps, they will change color so you can see where you have not worked yet. SAVE OFTEN. ArcMap is imperfect and you can lose lots of time in a crash. It is recommended to also (not as often) save this layer in an archive directory you set up, saving as “Copy 1 of Rock25buffer”, “Copy 2 of R…”.

11. Where CREP shapefile data are available, overlay this with the buffer gap data and make sure CREP project areas are mapped “n” for *gap.* Some CREP areas will be woody; many others will not.

Mapping Conventions:

1. Where buffer crosses through water polygons, look 25ft beyond the lakeshore to assess for *gap* and *woody.*

2. Where there are very small areas (<0.5 acre) that may have trees within what is otherwise a gap polygon, these will not be cut out as separate non-gap polygons, but will be lumped in with the gap.

3. In areas of uncertainty, label the polygons with a "?" for *gap*, and these areas will be reviewed by all mappers as a group, and possibly noted for ground truth to resolve the uncertainty.

4. The mapping group decided to err on the side of calling a polygon a gap if we cannot make a site visit to ground truth it.

5. Where buffer extends beyond the "valley wall" (there is a valleywall SGA Shapefile for each assessed watershed), mentally add the overlap to the opposite side and assess for gaps on opposite side within the expanded area. This is because flood waters will spill into this extra area beyond the opposite buffer extent, being blocked on the one side by the valley wall elevation.

6. Where buffer extends beyond the valley wall on both sides, just assess the existing buffer polygon on both sides with no conceptual modification of the buffer boundary.

7. Where Agency of Ag CREP (Conservation Reserve Enhancement Program) polygons are available, use these data as background to determine that the coincident area is "n" for *gap*. Since our primary purpose for assessing gaps is water quality, not wildlife habitat functions, CREP areas which consist of grass filter strips will function well to improve water quality and should not be considered buffer gaps. They may function better for this purpose than woody riparian buffers.

<u>Data Limitations:</u>

1. For this project, we use only reach arcs that have been assessed with SGA Phase 1 methodology. While in many watersheds these constitute most of the waterways, some ditches, intermittent stream channels and small streams are missed. Without reach point IDs and other SGA data such as channel width, we felt that creating buffers for these extra waterways would not be helpful in bringing together the SGA and other Area-wide Plan databases, one of the primary purposes of the Plan.

2. Where there are hayfields or cornfields adjacent to the buffer area, and the buffer area has non-woody cover, it is a subjective judgment whether that buffer would provide water quality enhancement functions. Mappers look at CREP records (shapefiles provided by VT-AAFM), evidence of animal or machinery paths and crossings within the buffer area, and steepness of slope within the buffer area (if available) to determine whether the area constitutes a gap.

3. Aerial photography used for the gap mapping was flown in 2003 and earlier, so gaps in riparian buffer may have changed in the 4 years since. This methodology can be modified or used in the future to update buffer gap mapping to match more current photography. This mapping project requires image resolution of at least 1 meter, so 2006 NAIP photography (with 2m resolution) may not be useful for updates.

Appendix J - Procedure to Calculate Stream Length of Riparian Buffer and Gap Segments

Background

Riparian buffer projects are most often reported in terms of the length of stream along one bank that was treated. The riparian buffers were created separately along each bank of every stream that has had a Vermont DEC Phase 1 Stream Geomorphic Assessment. This procedure sets up the stream mile

Procedure

1. Make sure there is an accurate and updated Perimeter attribute in the buffer file. If it does not exist in the attribute table, ESRI has Help on that topic.

2. Also make sure there is an accurate HalfW8 attribute. It needs to be calculated as ([CHL_WIDTH] / 6.56) + 7.62.

3. Add a field to the buffer layer attribute table called StreamMiles, and make it Double.

4. Without any records selected, right click on the header of the StreamMiles att and choose Field Calculator from the menu.

5. Click Load… to fetch the stored calculation formula called StreamMilesFromPerimeter.cal (it should be (((Perimeter / 2) – HalfW8)/1600). Alternatively, just type in this formula and hit OK.

6. NOTE: If there is no Perimeter attribute with which to make this calculation, you will get an error message stating as much. If so, create a new attribute called Perimeter, and make it Double precision. To calculate values for each buffer/gap polygon, open the attribute table for the riparianMissisquoi file geodatabase feature class, click on the header of the Perimeter column, and choose "Calculate geometry…". In the dialog box that comes up, set Property to be Perimeter, set Coordinate System to use the coord. System of the data source (NAD 1983 StatePlane Vermont FIPS 4400), make units Meters, and click OK.

7. StreamMiles from step 5 is reported in **miles**. Most gaps will have a length less that 1.0, many less than 0.001.