STORMWATER MANAGEMENT PLAN FOR HIGHGATE

FINAL REPORT

Stone Project ID 112475-W

March 1, 2013

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ACKNOWLEDGEMENTS

This project was performed by Stone Environmental, Inc. for the Friends of Northern Lake Champlain, the Town of Highgate with funding provided by Vermont Department of Environmental Conservation - Ecosystem Restoration Program.

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1. INTRODUCTION

Water knows no political boundaries. As such, evaluations of water quality tend to be undertaken along watershed boundaries and involve land areas in multiple towns. From a strict water quality perspective, it would be ideal to manage water resources along watershed lines—but the reality is that many decisions, particularly those about land use, are made at the site or local levels.

A Stormwater Management Plan ensures that issues related to land use, surface water quality, and stormwater management are not viewed independently. Rather, localized stormwater problems are examined at a larger scale (e.g., town-wide) to determine their relative contribution. A Town-wide Stormwater Management Plan is responsive to existing landscape characteristics, connecting land use, stormwater management, floodplain management, river management, and public infrastructure needs to more effectively address all of the issues which contribute to water quality impairment or improvement. Furthermore, as adjoining towns also take increasingly comprehensive views of stormwater management issues and planning, these plans are one-stop resources that can improve coordination and increase opportunities for collaboration in meeting watershed-related needs across political boundaries.

1.1. Project Background

As precipitation falls on an undisturbed, natural landscape and moves through the hydrologic cycle, it flows through a complex system of vegetation, soil, groundwater, and surface waters. Natural events have shaped these components over time to create a system that can efficiently handle stormwater through evaporation, transpiration, infiltration, and runoff. Alterations to the landscape change the way it responds to precipitation events. Management of land use, rainfall, storm runoff, and surface water (streams and lakes) are interrelated, and the management practices chosen all influence water quality and stream health.

What is a watershed?

A **watershed** is any area of land in which all water runoff from its surface flows to the same drainage point. Watersheds are sometimes referred to as drainage areas.

Watersheds are important because they are the basic unit of analysis for all surface water management. They come in all shapes and sizes, and are defined based on the intended study area.

Watersheds are interconnected networks in which a change at any location can carry throughout the system. There are many factors that influence exactly how stormwater runoff from a particular site will affect other areas of the watershed. The degree and type of impact varies from location to location, but it can be significant relative to other sources of pollution. Stormwater runoff affects water quality, water quantity, habitat and biological resources, public health, and the aesthetic appearance of the receiving water. Stormwater controls, in contrast, are typically conceived and implemented on a project-by-project basis. These projects are analyzed for their individual stormwater impacts, not in the context of their impact on an interconnected hydrologic and hydraulic system. It is well documented, however, that the cumulative effects of individual land surface changes dramatically influence flooding conditions and contribute to degradation of water quality (NRC 2009).

Watershed management practices have direct impacts on water quality in local creeks and streams (e.g., Hungerford Brook, Missisquoi River), as well as downstream waterbodies (e.g., Lake Champlain). Any decisions that affect land use have stormwater management ramifications and, in turn, impact all downstream water resources. The findings of one recent study (Troy et al. 2007) suggest that “land-use changes in the

Basin have increased phosphorus levels in Lake Champlain, especially conversion of agricultural areas and forests to developed uses."

Vermont's streams, rivers, and Lake Champlain are vital economic resources. As such, the quality of local receiving waters affects both economic interests and quality of life in the surrounding areas. Throughout the Champlain Valley, the local economy depends, in part, on the revenue gained from outdoor activities enjoyed in and on the water. Protecting the quality of surface waters is one of the most important commitments communities can make to protect the economic interests of residents.

Taken together, these elements emphasize the need for a holistic planning effort that considers the interconnected nature of land use, stormwater management, and river management in order to achieve overall watershed goals.

1.2. Goals of this Project

The Highgate Town Plan states: *Highgate's topography is defined by two watersheds; the Rock River Watershed and the Missisquoi Watershed. [Both] drain into Missisquoi Bay, a valuable recreational and water resource for the Town and the region. While the Bay provide opportunities for swimming, boating, and fishing, problems of pollution continue. High phosphorus levels promote the growth of algae and aquatic plants, and reduce the health, aesthetic and recreational values of the Bay* (Town of Highgate 2010).

The ultimate goal of this project is to provide the Town of Highgate with a list of high priority water resource concerns, including conceptual solutions, which will support the development and implementation of restoration projects in an efficient and targeted manner. The Stormwater Management Plan first, however, incorporates information from existing plans and datasets to create a single, town-specific resource to guide future stormwater management activities. This Stormwater Management Planning Library, included as Appendix B, is a valuable resource for the future regarding any water quality-related work in Highgate.

This Stormwater Management Plan also:

- Identifies stormwater-related areas of active erosion or other sources of sediment that are being delivered directly to water bodies in the Town of Highgate;
- Develops recommendations to address stormwater problems, including:
    - A list of problem areas that can assist stakeholders in directing resources to high priority projects; and
    - Conceptual solutions for high-priority problem areas (Section 4.3 and Appendix E), and
    - Potential revisions to town ordinances needed to encourage location-specific management activities.

2. GENERAL DESCRIPTION OF THE STUDY AREAS

The Town of Highgate is located in Franklin County, in the northwestern corner of Vermont. It is bordered by three towns (Franklin, Sheldon, and Swanton), Lake Champlain, and the Province of Quebec. The Town covers approximately 52.8 square miles and has four distinct village centers: Highgate Center, Highgate Falls, Highgate Springs, and East Highgate. The total population of the Town was 3,535 as of the 2010 census (U.S. Census Bureau 2011).

The Town of Highgate lies wholly within the Lake Champlain basin, and has a number of surface water features within its boundaries. The Town includes portions of the Missisquoi River (and its tributary Hungerford Brook) and the Rock River (and major tributaries Saxe and Steele Brooks). In addition, a number of smaller streams and brooks—such as Carman Brook and Youngman Brook—drain directly to Lake Champlain. Each of the watersheds is described below, and watershed boundaries are shown on Map 1 in Appendix A.

2.1. Lake Champlain Direct Drainage

Much of the Highgate Springs area drains directly to Lake Champlain. There are also two smaller brooks, Youngman Brook and Carman Brook, which drain small sections of west-central Highgate, where a number of lake-accessible vacation homes and the Tyler Place resort are located. The town maintains a boat launch on Lake Champlain off the northern end of Shipyard Road. The Missisquoi National Wildlife Refuge is located nearby at the mouth of the Missisquoi River. The previously approved Lake Champlain phosphorus TMDL is currently under review by EPA Region 1.

2.2. Missisquoi River

The Missisquoi River is the largest tributary to Lake Champlain's Missisquoi Bay. From its headwaters in Lowell, Vermont, the Missisquoi River flows north into Quebec where the Missisquoi Nord joins the main stem at Highwater, QC. The river then returns to Vermont at East Richford and flows south into Berkshire and ultimately west, through the southern and western portions of Highgate, to Missisquoi Bay—for a total length of approximately 88 miles. There are five major subwatersheds that drain into the Missisquoi River: Hungerford Brook, Black Creek, Tyler Branch, Trout River, and Mud Creek. A small portion of the Hungerford Brook watershed falls within Highgate's boundaries. The whole length of the Missisquoi River is considered by the State of Vermont to be stressed from high sediment loads, turbidity, nutrient enrichment, and increased water temperature, likely from agricultural land uses, loss of riparian vegetation, and streambank erosion. However, no specific impairment cause or remedial action has yet been identified by the state.

2.3. Rock River

The Rock River, and its major Saxe Brook and Steele Brook tributaries, drains the northern half of the town before crossing the Franklin/Highgate town line and traveling north into Phillipsburg, Quebec. The river then travels south into Highgate and flows into Rock River Bay, and ultimately into Missisquoi Bay. Both the Rock River and its tributary Saxe Brook are considered to be "impaired" waterbodies, meaning they do not currently meet water quality standards. The state has identified the pollutants of concern as nutrients in both waterbodies, and also identified sediment as a concern in the main stem of the Rock River. The pollutants are attributed primarily to agricultural runoff. Within one to three years (roughly 2014-2016), the State of Vermont will develop TMDLs for both the Rock River and Saxe Brook (VTDEC 2012).

2.4. Other Watersheds in Highgate

Watersheds that are located partially within Highgate but which were not the focus of this project include Hungerford Brook and McGowan Brook. Both of these watersheds are described briefly below.

2.4.1. Hungerford Brook

Hungerford Brook flows northward from St Albans Town into Swanton before entering Highgate, where it ultimately empties into the Missisquoi River. Watershed impacts such as direct cattle access to the stream, close cropping with small or absent buffers, channel alteration, and direct inputs of stormwater runoff have been repeatedly observed during numerous studies of the brook.

2.4.2. McGowan Brook

McGowan Brook flows south through the heavily wooded, southeastern corner of town on its way to the Missisquoi River. Only about 2,500 feet of the brook's 6.4 mile long main channel is located within the Town of Highgate.

3. EXISTING PLANS AND DATA

Numerous and varied groups and individuals have invested considerable effort in evaluating different components of Highgate's water resources, and the important interface between water resources and local land use decisions. Some evaluations have followed watershed boundaries, while others have followed political boundaries. The following sections identify evaluations completed over the past ten years, with emphasis on work most relevant to the Town of Highgate and to future efforts to develop a list of strategic, prioritized projects that could be undertaken to improve water quality in and around Highgate. A detailed review of each assessment is included as Appendix B of this report.

3.1. Watershed-Based Assessments

The assessments described below are generally led by the Agency of Natural Resources. These include:

- Basin planning, completed primarily to guide VTANR in its own work and in collaborative projects with the public, municipalities, and other State and federal agencies. The basin plans have a five-year scope. The draft *Missisquoi River Basin Water Quality Management Plan* (VTANR 2013) includes the Rock River watershed and therefore covers the entire Town of Highgate. In addition, in 2008, USDA's Natural Resource Conservation Service (NRCS) completed the *Missisquoi Areawide Plan*, a watershed-based plan specifically structured to inform and help guide the conservation efforts of partner agencies and cooperating farmers.
- Critical source area (CSA) evaluation, to identify areas of the landscape that, absent proper management, are likely to produce disproportionate amount of phosphorus loading to adjacent waterways. In 2011, detailed data about the distribution of potential CSAs of phosphorus pollution in the Missisquoi River watershed were developed using a Soil and Water Assessment (SWAT) model.
- Stream geomorphic assessments (SGA), undertaken to understand the natural tendencies of a particular reach of stream or river, its current condition, and what changes may be anticipated in the future. Stream geomorphic assessments have been completed for the Rock River and its major tributaries within Highgate.

- Water quality monitoring, including biological assessments. Assessment data has been collected along the mainstem of the Rock River, as well as in the Saxe and Steele Brooks in Highgate. A USGS gaging station is being operated on the Rock River in Highgate as part of the Lake Champlain Long-Term Water Quality Monitoring Program.
- TMDL development, to establish the maximum amount of a pollutant (e.g., bacteria, nutrients, excess stormwater flows) that a waterbody can assimilate and still meet state-established water quality standards. TMDLs are based on the relationship between pollution sources and in-stream water quality conditions, and a TMDL addresses a single pollutant or stressor for each waterbody.

3.2. Town-Wide Assessments and Programs

In addition to the watershed-based assessments, a number of pieces of data are developed on a municipality-by-municipality basis that are important to any effort to develop a list of strategic, prioritized projects that could be undertaken to improve local water quality. These include direct feedback from the Town, work by the Vermont Agency of Transportation (VTrans), and past and current planning initiatives, specifically:

- During meetings with the former Town Administrator and his replacement, a list of potential problem areas was identified. These include both areas with current concerns, such as localized flooding or erosion, and areas of future concerns, focusing on areas where new development may be concentrated. The identified areas were investigated and documented, as appropriate, in Appendix B.
- VTrans-sponsored programs, including routine inspections of bridges and culverts, have identified a number of potential projects to protect existing infrastructure whose implementation would also improve stormwater management.
- Highgate's Town Plan recognizes both the important recreational opportunities that the Town's surface water resources provide, and that problems of pollution continue.
- Highgate's zoning regulations include stormwater management standards for development on "sensitive resource lands" (slopes in excess of 20%), but the standards do not apply to development on less sensitive parcels. The regulations do not include specific support for low impact development (LID) stormwater management strategies.

4. STORMWATER PROBLEM AREAS

One of the goals of this Plan is to "develop a comprehensive list of stormwater problems". To achieve this goal, a thorough effort was made to identify existing problem areas, and then to evaluate existing conditions and potential solutions.

4.1. Identification of Problem Areas

The first task was to identify the location and nature of existing drainage problems, and where appropriate, to gather field data for further analysis. The approach to identifying potential problem areas included the following elements:

- Reviewing existing plans and data, as described in Section 3 above, and noting the location of any concerns related to stormwater
- Engagement with local officials, including:
  - March 29th, kick-off meeting with then-Town Administrator, David Jescavage
  - September 27th, follow-up meeting with new Town Administrator, Heidi Valenta
- Targeted site visits to verify problems areas (July-September 2012)
- Documentation (with photos) of existing problem areas

A “problem area data sheet” was developed and used as a guide to ensure consistent information was collected as site visits were completed. More than 30 potential problem areas were identified and geo-located. The data sheets for all of the problem areas identified in the Town of Highgate are provided in Appendix C of this report.

4.2. Evaluation of Problem Areas

Working from the list of potential problem areas, the Consultant Team visited each potential problem area to directly observe the site. Where an unresolved problem was found, photos were taken of any areas of active erosion, as well as observations about the source or cause.

Each problem area was given a score, with the intent of generally assessing the severity of existing problems, removing low priority problem areas from the dataset, and providing general guidance on the relative order in which the problems should be addressed when considered town-wide (Appendix C). Scores were assigned as follows:

Level	Classification
1	Outside of project scope.
2a	Stable, no urgency.
2b	Stable, but problem could escalate with future change in surrounding land use.
3	Small to moderate erosion and/or drainage problems are present; issues could be readily addressed.
4	Significant erosion and/or drainage problems are present; issues may be readily addressed.

4.3. Conceptual Solutions to High Priority Problem Areas

The 15 problem areas that were assigned a Level 3 or 4 classification were subject to more detailed investigation. The first phase of the detailed investigation involved desktop analysis to determine:

- Drainage area contributing to the known problem,
- Underlying soils, with particular attention to the presence of highly erodible soils (e.g., $k > 0.17$),
- Location of any existing stormwater infrastructure,
- Proximity to the nearest surface water feature,

- Whether the Town identified the area for planned future growth, and
- Potential location or locations most suitable for stormwater treatment practices, taking into account topography and existing development (if any).

A map of each high-priority problem area including all of these features was prepared (Appendix D). These sites were revisited to further investigate treatment potential and gather information for conceptual solutions, including more detailed information on the contributing drainage area, soil conditions, and traffic and pedestrian flow. These data were collected in order to better evaluate anticipated water quality benefits and constructability. In some locations, several areas were grouped together because of the inter-related nature of the stormwater management needs. In other locations, conceptual solutions were not developed for one of the following reasons:

- The stormwater concerns involve issues where it would be not be appropriate for the Town to assume a leadership role (e.g., private property);
- The stormwater concern did not rise to the level of demanding immediate action.

In total, seven conceptual solutions were developed. Each of the conceptual solutions is described in the report sections that follow, and the complete analyses are presented in Appendix E.

4.3.1. Durkee Road, Highgate Center

Recent roadway improvement work along Durkee Road in Highgate Center has resulted in over-steepened banks, causing erosion of sections of the ditch backslopes along both sides of the road. The section of road affected is fairly steep, and is located only about a third of a mile from the Missisquoi River. Approximately 300 feet of road side ditch is affected, with the backslope reaching a maximum approximate height of 10 feet. Appropriate grading of ditch side slopes and re-seeding to establish a stable channel are recommended practices. If a stable grade cannot be achieved, armoring the ditches would also help to stop the erosion.

Figure 1. An area of eroding slopes along Durkee Road is highlighted in yellow.

4.3.2. Highgate Elementary School

The Highgate Elementary School campus includes 2.3 acres of impervious roof top and asphalt parking area, the runoff from much of which was identified as potentially treatable. Figure 2 shows treatable impervious area (blue outline) and potential stormwater treatment practice (STP) locations (yellow outline). Roof runoff could be captured and treated in bioretention areas, and rain gardens could be installed both below the drip-edge around the perimeter of the building and in the two center courtyards.

The soils at the school campus, from the west edge of the building to the east edge of the parking lot, appear to be well-drained Windsor loamy fine sands (Hydrologic Soil Group A) with no seasonal high water table limitations identified within the first five feet below ground surface. Infiltration practices are expected to be very effective in these conditions.

There is no closed drainage storm sewer infrastructure on or near the property, and little change in grade to accommodate underdrain outlets to the ground surface. Thus, any STPs constructed at this site would rely on the natural capacity of the underlying soils to infiltrate stormwater. Careful analysis of infiltration rates at proposed STP locations would be essential to insure the development of a properly functioning design.

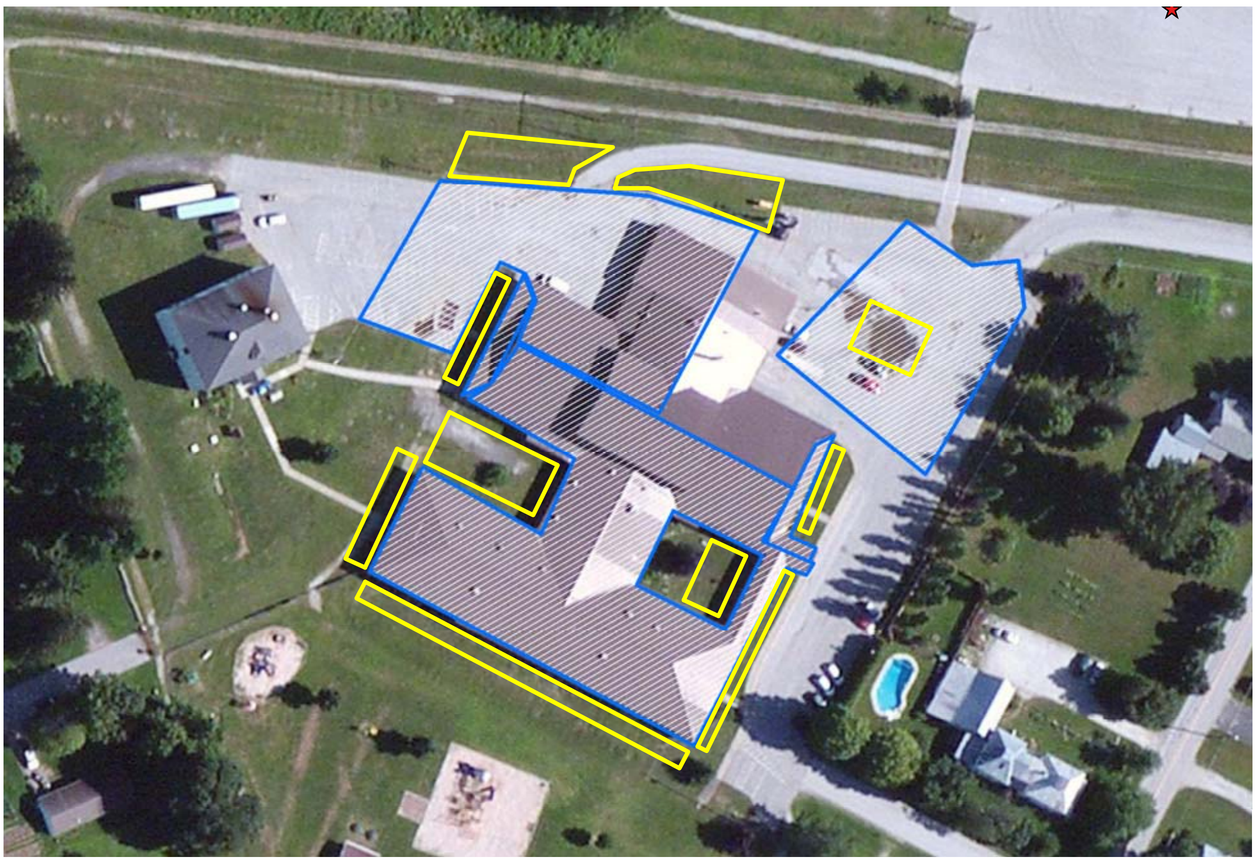

Figure 2. Highgate Elementary School. Treatable impervious surface is highlighted in blue, and potential treatment practice locations are shown in yellow.

4.3.3. Mill Hill Road Storm Sewer Outfall

Nearly all of the village area of Highgate, a 32 acre catchment, drains south to a swale located along Mill Hill Road. A closed drainage system that collects stormwater along a section Vermont Route 78 discharges directly to this swale (Figure 3). Direct drainage from the street surfaces and this storm sewer are causing localized erosion at the outfall. Armoring this outfall with riprap is recommended—and to achieve more substantial improvements, source control is recommended to reduce the volume of runoff reaching the outfall. A "green street" approach could be employed, to turn out stormwater runoff from the road (particularly along St. Armand Road) into a series of small soak-away areas. Another treatment practice option could include a more centralized STP in the triangle median at the intersection of St. Armand Road, Vermont Routes 207 and 78, and Mill Hill Road. Much of this catchment area is underlain by well-drained Windsor loamy fine sand (HSG A), meaning the soils have a high infiltrative capacity and few seasonal high groundwater or shallow bedrock limitations.

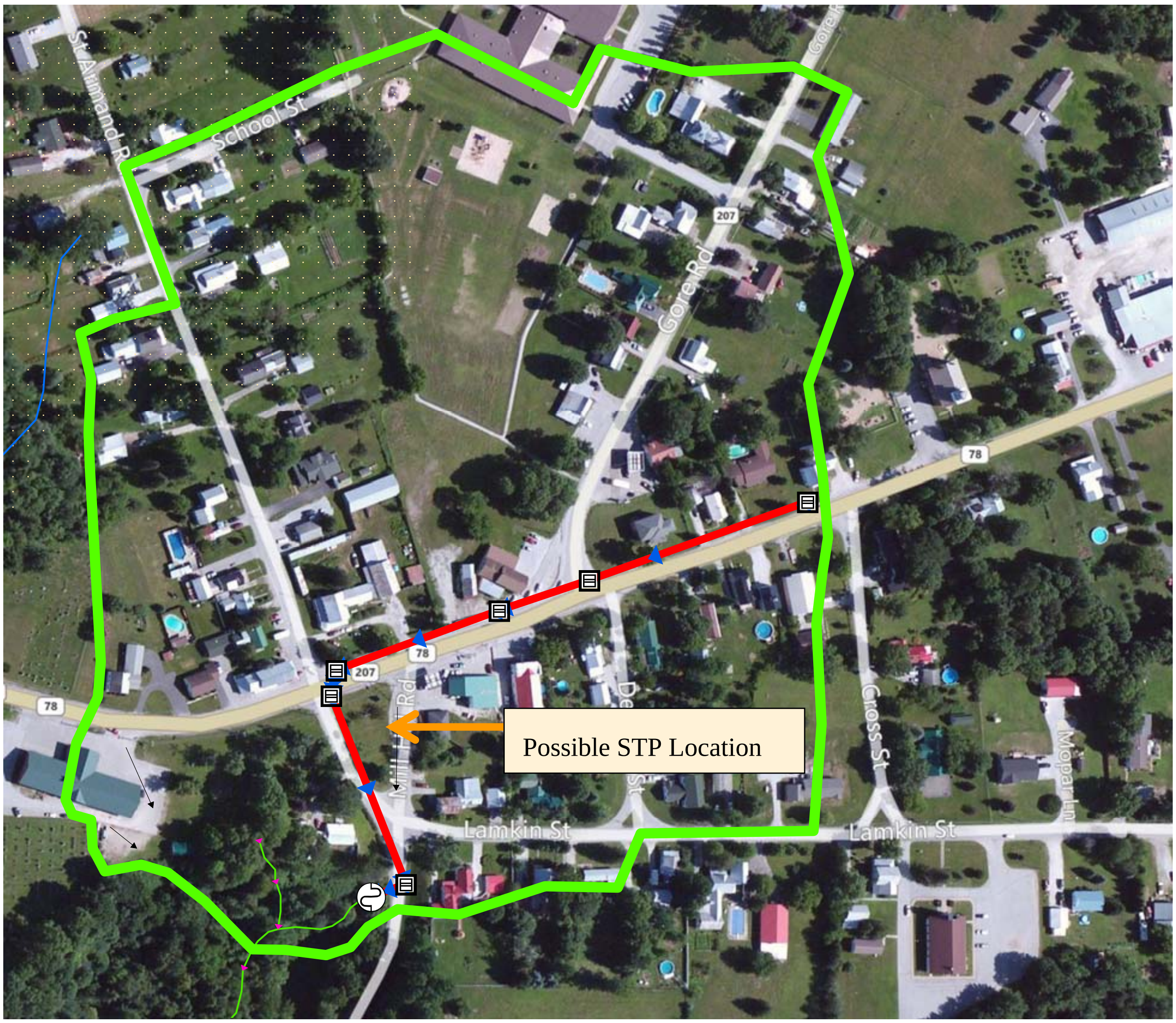

Figure 2. The downtown area of Highgate is shown in this figure. Storm sewer is shown flowing from east to west, then to an outfall south of town on Mill Hill Rd. The contributing watershed is shown in green.

4.3.4. Transfer Station

The Town of Highgate's sand shed property (Figure 4), located on Transfer Station Road, is a potential source of sediment to an unnamed tributary of the Missisquoi River. This property was the site of a slope failure that occurred in the spring of 2011; the orthophoto below shows the slope failure clearly. The failed slope was repaired and stabilized, but stormwater is concentrating and leaving the site west of the repaired slope, and a gully is evident at this location (outlined in red). Stabilization measures should be considered to prevent propagation of the gully. In addition, during a December 2012 inspection, a catch basin (located near the western edge of the proposed STP, outlined in yellow) was found to be filled with sediment to the point where it did not function. It was not clear whether this catch basin drained to a dry well or to a conventional outlet.

Soils at the site appear to be well-drained Windsor loamy fine sand (HSG A), with a seasonal water table more than five feet below ground surface. Infiltration-based STPs will be effective if the native soils have not been overly compacted by grading or heavy equipment movement over the site. An infiltration-based STP could be constructed that used the existing catch basin as a high-flow outlet. The STP would keep sediment on-site, reduce impacts to water quality, and reduce the need to frequently clean out the catch basin.

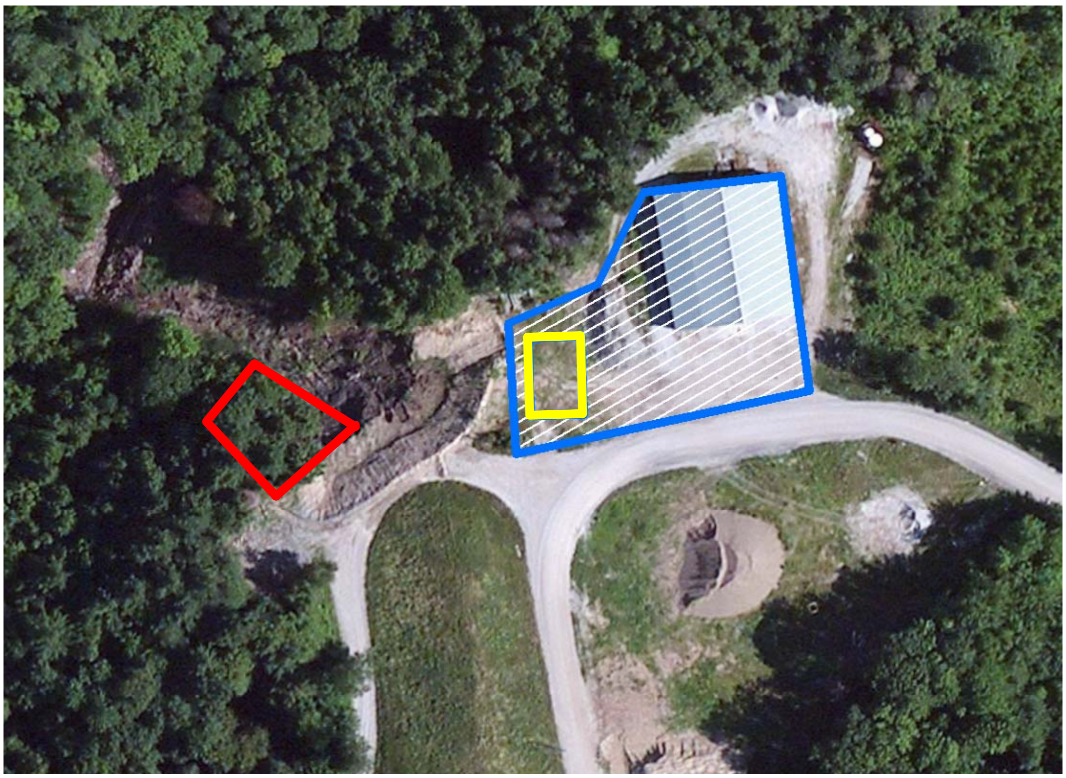

Figure 4. Highgate town sand shed property. 0.65 acres of treatable impervious area is shown in blue, proposed STP location in yellow, and erosion gully shown in red. Note: slope damage shown in photo has been repaired.

4.3.5. Proposed Park-and-Ride Facility

The Town of Highgate Municipal Plan (2010) reports an on-going initiative to locate a Park-and-Ride facility at the corner of Vermont Routes 207 and 78 in the village of Highgate. This area is part of the catchment draining to the stormwater outfall described in Section 4.3.3 above. A significant portion of the area is currently paved, due to the reconfiguration of this intersection several years ago.

Soils in at this location appear to be well-drained Windsor loamy fine sands, with a seasonal high water table more than five feet below ground surface. These soil conditions, coupled with the site's flat topography, make infiltration-based practices an effective STP option. As plans develop, low-impact design practices such as porous pavement and infiltration features should be strongly promoted. Alternatively, if plans for a Park-and-Ride facility at this location have been abandoned, the existing impervious pavement could be removed and natural site hydrology restored.

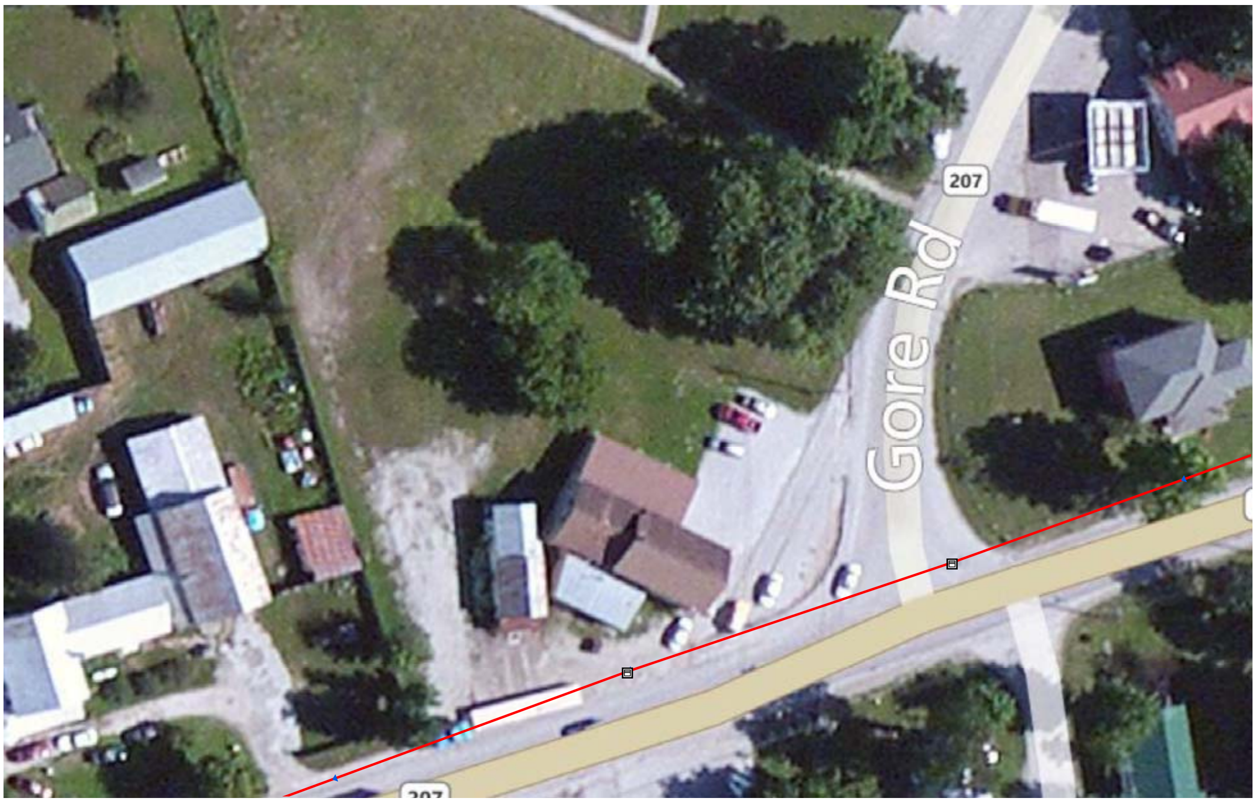

Figure 5. The Highgate Municipal Town Plan proposes the construction of a Park-and-Ride facility at the corner of Vermont Routes 207 and 78. Soil conditions favor infiltration-based practices, such as porous pavement, at this site.

4.3.6. Pine Plains Rd.

Pine Plains Road was found to be in poorly maintained condition (Figure 6). Only a short section of the road is maintained by the Town of Highgate, with the steepest sections maintained by private interests. Roadside ditches are in need of maintenance or do not exist. The lack of maintenance of the private section of the road is impacting the town-operated section. Poor ditch condition, coupled with poor grading, has resulted in substantial erosion of the road surface, which is turned out into the adjacent woodland and eventually deposited in a small tributary stream just upstream of its confluence with the Missisquoi River (Figure 6).

The problems associated with Pine Plains Road could be remedied by excavating roadside ditches and properly grading the road. In steeper sections, road grade dips may be required to direct water off of the road surface. Roadside ditches in steeply sloping locations may need to be rock-lined. Ultimately, however, it is unclear what authority the Town has to require correction of drainage issues located on the privately-maintained section of Pine Plains Road.

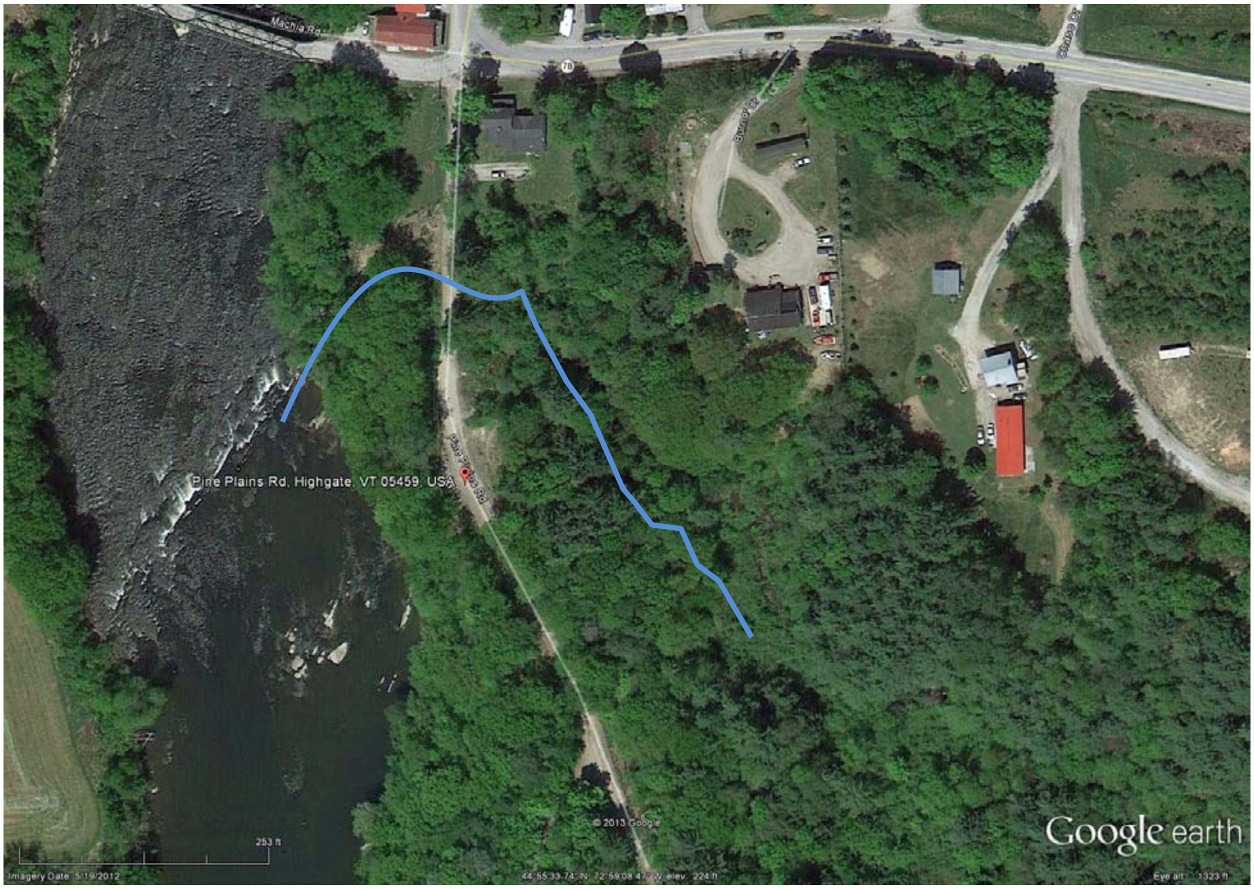

Figure 6. Pine Plains Rd. (south of Vermont Route 78) is poorly maintained. Eroding sediment from the road is impacting an unnamed stream near its confluence with the Missisquoi River.

4.3.7. Farm Road Crossings

Unimproved or poorly constructed farm road stream crossings are a significant source of sediment to the Rock River and its tributaries in the Town of Highgate. During this project, landowners granted access to and provided Project Team staff the opportunity to observe four specific crossings; an example of the conditions observed is provided in Figure 7 below. While these crossings are on private land and thus are not directly within the purview of the Town, they have a significant and on-going impact on stream water quality. Implementation of best management practices for agricultural road crossings will also improve property owners' ability to access their land. State and federal programs may be available to aid with implementing these improvements.

Figure 7. Unimproved farm road crossing, shown during high flow conditions. Significant ruts suggest the landowner is often challenged to ford the river.

5. NEXT STEPS

This document represents an extensive effort to identify and evaluate potential stormwater problem areas throughout the Town of Highgate. Several high priority potential stormwater improvement projects were identified that the Town could either pursue directly, or could work with local landowners to address. Detailed information about these high priority projects can be found in Appendix E.

In addition to exploring opportunities to address current stormwater management needs, the Town of Highgate can take steps to prevent future stormwater problems by expanding how stormwater management is addressed in zoning regulations. Specifically, the Town could consider incorporating one or more of the following elements into the zoning regulations:

- Require a certain amount of stormwater runoff be treated, as part of all development and redevelopment projects; and.
- Articulate a clear preference for low impact development practices that seek to infiltrate and soak away, as opposed to store and release, stormwater runoff into the land use and development

regulations. Substantial areas of Town are underlain by soils that are highly suitable for infiltration, and the Town should take advantage of this beneficial characteristic. However, caution should be exercised if runoff is directed over steep slopes, as these sandy soils are also highly erodible.

Some specific examples of how this might be accomplished include:

- Modifying access requirements to minimize impervious surfaces. Thoughtful siting and design of streets helps achieve stormwater control "at the source," which means less runoff requiring management and less impact on downstream waterbodies. Further, reducing paving lowers development and maintenance costs.
    - Highgate's current subdivision regulations (Town of Highgate 2008) and road acceptance policy require a right-of-way that serves as "access to property for the purposes of development of not more than two lots" be at least 20 feet wide, that a right-of-way serving more than two lots be a minimum of 50 feet wide, and that the "minimum traveled way width of road shall be 22 feet, not including the shoulders."
        - Consider reducing the minimum travel width for a private right-of-way serving up to four houses to 9 feet.
- Revising parking standards to encourage minimal use of impervious surface. For example:
    - Changing the definition of a "parking space" to no longer require a minimum of 200 square feet of space; 9' by 18' parking spaces are more typical.
    - Recommend or require smaller stalls for compact cars, up to 30% of the total number of parking spaces.
    - Re-evaluate specified parking minimums to prevent the creation of surplus parking. This could involve establishing maximum parking requirements that closely mirror or are slightly less than current minimum parking requirements, and providing a maximum parking requirement that is 20-80% of the maximum, depending on the associated property use. Using a minimum and a maximum effectively creates a range of acceptable parking requirements, providing the development community a chance to be more flexible and efficient in site design.

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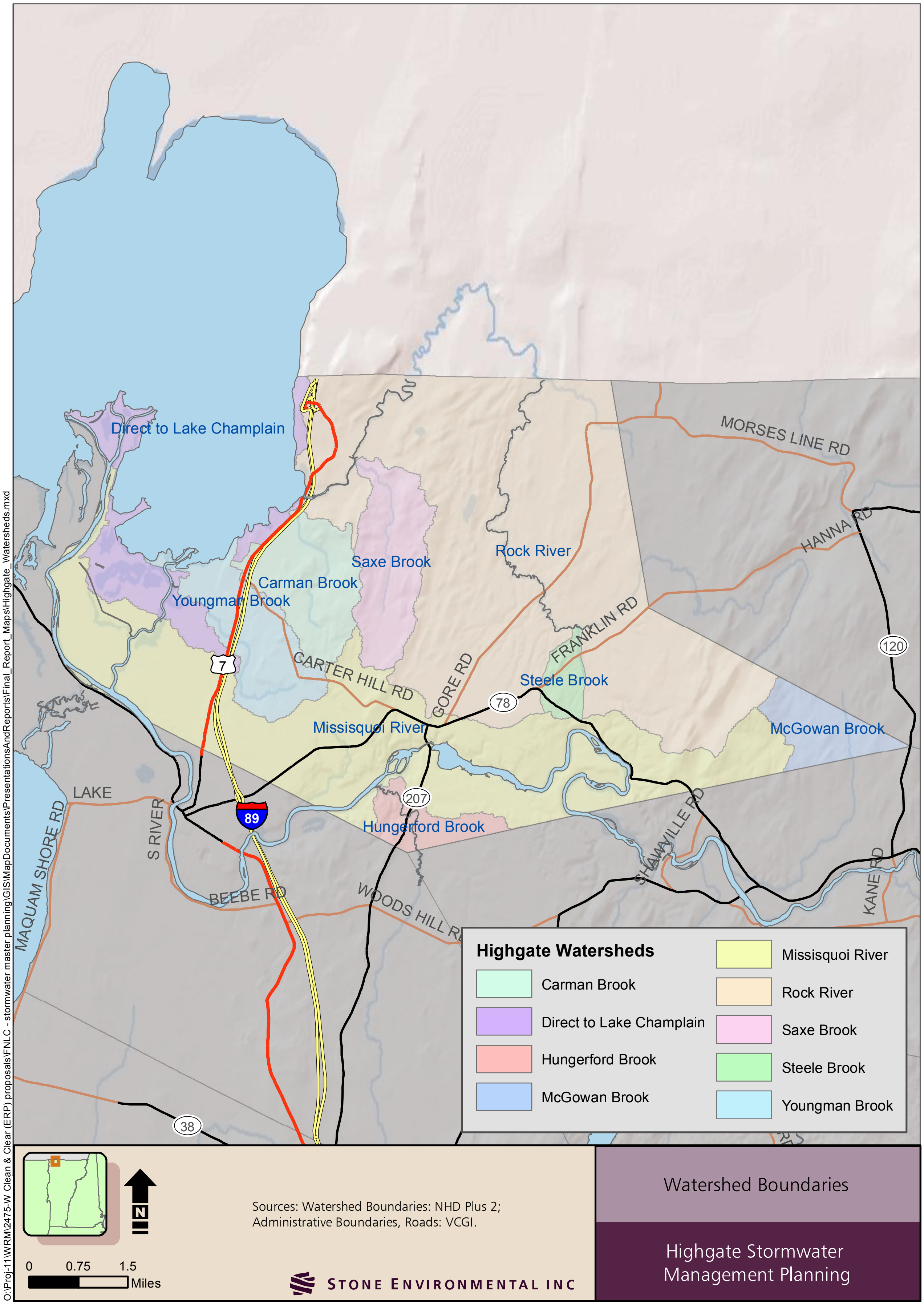
APPENDICES

APPENDIX A: WATERSHED MAPS



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APPENDIX B: STORMWATER MANAGEMENT PLANNING LIBRARY

STORMWATER MANAGEMENT PLANNING LIBRARY

TOWN OF HIGHGATE

July 13, 2012

Revised February 15, 2013

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1. BACKGROUND

Water knows no political boundaries. As such, evaluations of water quality tend to be undertaken along watershed boundaries and involve land areas in multiple municipalities, counties, and, in the case of the Missisquoi River, countries. For example, the Missisquoi River watershed area includes part or all of twenty northern Vermont communities in three counties. Although from a strict water quality perspective it would be ideal to manage our water resources along watershed lines, the reality is that many decisions, in particular decisions about land use, are made at the local level. This report is designed to summarize the information currently available from the suite of reports that speak to water quality in the various rivers, lakes, and streams that pass through or are located wholly within the Town of Highgate, Vermont. Although water quality assessment data dating back to the early 1970s is available for the Missisquoi River watershed, this summary focuses on assessments and reports that have been prepared in the past twenty years.

A 2007 basin-wide study of the sources of pollution in Lake Champlain found that stormwater runoff from developed areas and agricultural runoff are the primary sources of Lake Champlain pollution. This report will serve as the basis for developing Highgate-specific list of strategic, prioritized projects that could be undertaken to improve water quality.

2. INTRODUCTION

The Town of Highgate is located in Franklin County in northwest Vermont, and has a total area of 59.9 square miles, including more than 10 miles of Lake Champlain shoreline on Missisquoi Bay. In recent years, Missisquoi Bay has shown profound effects of on-going sediment and nutrient pollution including recurrent algae blooms and nuisance plant growth.

Highgate is home to over 3,700 people and more than 30 large dairy farms[1]. The town's northern border follows the Canadian border in Philipsburg, Quebec[2]. The Rock River and Missisquoi River are the major surface water features in the town; Highgate also includes a portion of the Missisquoi River delta which includes the Missisquoi National Wildlife Refuge. Other significant features in town are the Franklin County Airport, the Highgate Falls Hydroelectric Dam, the Missisquoi Valley Union High School, the Highgate Elementary School, the Highgate Town Library, and the Highgate Sports Center. The Northern Forest Canoe Trail on the Missisquoi River and the Lamoille Valley Rail Trail pass through town.

The Rock River drains the northern half of the town crossing the Franklin/Highgate town line and traveling north into Phillipsburg, Quebec. It then travels back down into Highgate and flows out into the Rock River Bay, an inlet from Missisquoi Bay. The Missisquoi River drains the southern half of the town. It travels from the Sheldon/Highgate town line, through Highgate Center, and across the Swanton/Highgate town line. The Highgate Falls are located near Highgate Center. The falls were altered by the construction of the hydroelectric dam in 1804 or 1805[3].

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[1] http://highgate.weebly.com/

[2] en.wikipedia.org/wiki/Highgate,_Vermont

[3] www.northeastwaterfalls.com/waterfall.php?num=167&p=0

Numerous and varied groups and individuals have invested considerable effort in evaluating different components of Highgate's water resources, and the important interface between water resources and local land use decisions. At times these evaluations have followed watershed boundaries and other times they have followed political boundaries. The following sections identify evaluations that have been done to date and pull out the pieces 1) most relevant to the Town of Highgate and 2) most relevant to future efforts to develop a list of strategic, prioritized projects that could be undertaken to improve water quality in and around Highgate.

3. WATERSHED-BASED ASSESSMENTS

The ongoing assessments described below are generally led by the State of Vermont's Agency of Natural Resources (ANR). These include:

- Basin planning efforts, whose main purpose is to guide ANR in its own work and in collaborative projects with the public, municipalities, and other state and federal agencies. The basin plans have a five-year scope. The town of Highgate is addressed within the Missisquoi Basin, last updated in 2004.[4]
- Stream geomorphic assessment work, undertaken to understand the natural tendencies of a particular reach of stream or river, its current condition, and what changes may be anticipated in the future. Within Highgate, stream geomorphic assessments have been completed for the Rock River.
- In-stream water quality assessment work, including the watershed load monitoring program and biological assessments.

3.1. Vermont 303(d) List of Waters[5]

This document provides a list of impaired watersheds that are not meeting water quality standards as a result of one of more sources of pollution, and as such are scheduled for total maximum daily load (TMDL) development. The Department of Environmental Conservation updates the list every-other year; the list was last updated in 2012. Three watersheds on this list are within Highgate town boundaries.

Impaired Watersheds:

Rock River – Mouth to VT/QUE Border (3.6 miles)

- Pollutants: Undefined
- Use impaired: Aesthetics
- Surface Water Quality Problems: Algal Growth, Agricultural Runoff, Fish Kill
- TMDL Priority: Medium, assessment should be completed within 4-8 years

[4] http://www.vtwaterquality.org/mapp/docs/mp_basin6assessmntrpt.pdf

[5] http://www.vtwaterquality.org/mapp/docs/mp_303d_final_approved_2010.pdf

Rock River – Upstream from VT/QUE Border (~13 miles)

- Pollutants: Undefined
- Use impaired: Aquatic Life Support
- Surface Water Quality Problems: Agricultural Runoff, Nutrient Enrichment
- TMDL Priority: Medium, assessment should be completed within 4-8 years

Saxe Brook (Tributary to Rock River) – From Mouth Upstream 1 Mile

- Pollutants: Undefined
- Use impaired: Aquatic Life Support
- Surface Water Quality Problems: Agricultural Runoff
- TMDL Priority: Medium, assessment should be completed within 4-8 years

3.2. Missisquoi Bay Watershed Phosphorous Load Monitoring Program[6] (Missisquoi Bay Phosphorous Reduction Task Force, 2005)

This document locates river flow gages and phosphorus sampling areas on the Missisquoi River. While there are no sampling stations in Highgate, the document also includes information for sampling and river flow gage locations along the Rock River in Canada. While these stations may not be in the town of Highgate, their information is useful considering the majority of water passing the sampling point has flowed through Highgate.

The Rock River has a flow gauge in Saint Armand. Daily mean flow for the past week is available on-line; follow the link below to view Quebec flow gauge data, choose station De La Roche for the Rock River. Requests for historical average daily flow may also be sent via the web page below.

http://www.cehq.gouv.qc.ca/suivihydro/ListeStation.asp?regionhydro=03&Tri=Non

The phosphorus concentration sampling stations are also located north of the border on the Rock River. The map on the above website shows the sampling locations. The data for these two sampling locations is maintained by the DSEE, Quebec's State of the Environment Monitoring Directorate. This data is not available from the web but requests for phosphorous and historical flow gauge data can be sent to: mario.berube@mddep.gouv.qc.ca

3.3. Missisquoi River Watershed Water Quality and Aquatic Habitat Assessment Report[7] (ANR/DEC/WQD, 2004)

The Missisquoi River Basin Water Quality Management Plan identifies water resource concerns within the more than 619 square miles of Vermont that drain to the Missisquoi River, and identifies opportunities for

[6] http://www.lcbp.org/PDFs/MissisquoiPLoadMonitoringPlan.pdf

[7] http://www.vtwaterquality.org/mapp/docs/mp_basin6assessmntrpt.pdf

sustaining and improving water quality and aquatic habitat. In addition to the plan, ANR has published a draft set of preliminary strategies to address water quality and aquatic habitat concerns in the Missisquoi River Basin. The primary focus of the strategies is addressing nonpoint source pollution threats to surface waters, wetlands, lakes and ponds, and streams throughout the Missisquoi watershed. The section of interest for Highgate is the Lower Missisquoi River, from the mouth up to the confluence of the Tyler Branch.

In 2010, ANR's Watershed Management Division began revising basin plans to include more tactical strategies[8], meaning that plans will be updated to included objectives, prioritized strategies, benchmarks, and tasks in order to facilitate their implementation. Priority will be given to sub-basins for direct remediation actions where there are severe water quality problems, or to areas of excellent condition that require increased protection. Additional tactical strategies are likely to be incorporated into the Missisquoi Basin Plan as it moves forward. The Northwest Regional Planning Commission recently completed a series of edits to the draft plan. See below for info pertaining to Highgate:

Stressed Miles:

- Missisquoi River: whole length - aquatic biota/habitat and aesthetics stressed from high sediment loads, turbidity, nutrient enrichment, likely temperature from agricultural land uses, loss of riparian vegetation and streambank erosion. Also (subset of above) aesthetics stressed below Highgate Falls Hydro facility due to 35 cfs minimum flow (1/10 of 7Q10) and habitat, aesthetics stressed for 3 miles upstream of the facility due to impoundment.

3.4. Missisquoi Areawide Plan[9] (Natural Resources Conservation Service)

In 2008, the NRCS completed the Missisquoi Areawide Plan, a watershed-based plan designed to reduce the phosphorus load delivered to Missisquoi Bay. The document was structured to inform and help partner agencies and cooperating farmers. The Areawide Plan consists of a series of water quality improvement strategies that target efforts to specific priority areas. The strategies were developed in consultation with local stakeholders and representatives of various state and federal agencies. The Areawide Plan was designed to help move conservation implementation actions away from a "first come, first served basis" in order to target financial and technical resources to the areas of the watershed with the greatest conservation need. The plan includes a considerable amount of geospatial data, including information on farmstead location, annual crop and hay lands, and the adjacency of cropland to areas with steep slopes.

3.5. Identification of Critical Source Areas of Phosphorus in the Vermont Sector of the Missisquoi Bay Basin[10] (Lake Champlain Basin Program, 2011)

Critical Source Areas are areas of the landscape that, absent proper management, are likely to produce disproportionate amount of phosphorus loading to adjacent waterways. Detailed data about the distribution of potential Critical Source Areas (CSAs) of phosphorus to Missisquoi Bay were developed using a Soil and Water Assessment (SWAT) model. The areas identified using this modeling approach were selected primarily

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[8] http://www.vtwaterquality.org/wqd_mgtplan/swms_planningprocessintro.htm

[9] http://www.lcbp.org/PDFs/IJC_MBBP/Missisquoi_Areawide_plan.pdf

[10] http://www.lcbp.org/PDFs/IJC_MBBP/LCBP_CSA_Modeling_Report_EN.pdf

by their soils, landscape features, proximity and connectivity to streams, and the land use or farm crop practices that are in place or are likely to be in place. To view this data in an interactive map, visit lcbp.stone-env.com.

From a stormwater management standpoint, phosphorous critical source areas are areas of development (including roads) with a high potential for stormwater runoff. In general, roads with steep grades are particularly vulnerable to runoff and likely to be identified as CSAs. In Highgate, almost all town roads had phosphorous values of 0.75 – 1.25 lb/ac-yr, which is high for developed land. In particular, Rollo Rd. had P values greater than 1.25 lb/ac-yr, likely due to its grade and proximity to the Rock River.

3.6. Stream Geomorphic Assessment Final Reports[11]

Phase 1 and Phase 2 stream geomorphic assessments have been completed for the Rock River. Assessment results are designed to direct future stream corridor restoration and protection measures. Figure 1 reports the results of these assessments by reach. This data is then summarized to determine the sensitivity of each segment based on the relative magnitude of these channel adjustment processes, together with the topographic, geologic, and vegetative settings. Figure 2 shows the results of this sensitivity analysis by reach, Figure 3 displays the locations of culverts and bridges along the Rock River.

3.7. Stream Geomorphic "Tactical" Assessments Phase 1 and 2

A stream geomorphic assessment has been completed for the Rock River. The assessment results are designed to direct future stream corridor restoration and protection measures. The nature of each section of the watershed is characterized and each reach described. Potential restoration projects identified during this work with ties to stormwater management and/or high flows are listed and briefly described below by stream and stream reach; the reach map is included in Appendix A. A stream geomorphic assessment has also been completed for the Lower Missisquoi River between Black Creek and Hungerford Brook; unfortunately the report is not currently available through DEC's website; the reach map is included in Appendix A nonetheless.

3.7.1. Rock River SGA Phase 2[12]

- M06 (Franklin/Highgate town line to Cassidy Road crossing): This section of the Rock River Several tile drains and ditches were observed leading from adjacent hay and corn fields to join the main channel and its tributaries. Two of these channels had developed into small gullies with active head-cutting. The observed practices of tilling/cropping on moderate slopes and cropping directly through surface swales are contributing to the mobilization of fine sediments and nutrients.
- M05 (Cassidy Road crossing to Gore Road crossing, near Rollo Road): Several tributaries draining residential and agricultural sub-watersheds join the Rock River within this reach. Small deltas of fine sand were observed at four of these tributary confluences, and fine sediments were accumulating in these tributaries upstream of the confluence. In addition, scour holes were observed at several tile outlets in this reach and its tributaries.

[11] https://anrnode.anr.state.vt.us/SGA/finalReports.aspx

[12] https://anrnode.anr.state.vt.us/SGA/finalReports.aspx

- M04 (Gore Road crossing, near Rollo Road, to the Canadian border: Areas of active erosion in this segment are associated with close pasturing and localized absence of tree buffers. Sediment loading from pasture areas and equipment fords are also contributing to turbidity in the reach and likely nutrient impacts.
- M1S1 (Saxe Brook): Residential lands surrounding the upstream end of the segment have been recently cleared of shrubs and small trees. There are several sections of the brook where direct access by livestock is also contributing to nutrient and fine sediment loading.

3.8. Ambient Biomonitoring Data[13] (VT DEC, 1985 – present)

The biomonitoring program evaluates the abundance and composition of the stream insect (macroinvertebrate) community to assess the overall environmental condition of wadable streams and rivers. Assessed streams are given a qualitative ranking, ranging from Poor to Excellent. Data on fish communities is often collected at the same time, although it was not included in any assessment in Highgate. ANR is able to use this data to assess impacts of wastewater treatment plants, acid rain, agricultural practices, and the removal of streamside vegetation. In Highgate, biomonitoring data has been collected for the Saxe and Steele Brooks, both tributaries of the Rock River.

Location	River Mile	Date	Assessment
Saxe Brook	0.4	10/14/2009	Good/Fair
Saxe Brook	0.4	10/5/2004	Fair
Saxe Brook	0.4	10/21/1999	Fair

3.9. Biological Use Support Attainment of the Rock River[14] (VT DEC, 2009)

In addition to collecting ambient biomonitoring data in Highgate, VT DEC conducted a ten year study of fish, macroinvertebrates, habitat and water quality along the Rock River. Three sampling points were in Highgate: river mile 5.9 (along the western-most part of Rollo Rd), river mile 7.9 (Tarte Rd, south of its intersection with Boucher Rd), and river mile 9.4 (Gore Rd, south of its intersection with Cassidy Rd). See below for the summary prepared by the DEC, source data may be found in the associated report.

> "Biological data from the Rock River indicate that the lower reaches - downstream from river mile 14.9 - are failing to meet Class B WQS. The fish and macroinvertebrate assemblages failed to meet Class B criteria for ALS at site 7.9 for all six assessments from 1999 to 2008. The Fish assessment at RM 5.9, and the macroinvertebrate assessments at RM 9.4 also failed. At site 14.8 and 14.9 the early assessments in 1999 and 2000 also failed to meet Class B WQS for aquatic life use. The last three macroinvertebrate assessments from 2004 to 2008, and fish assessment in 2007 show this reach is supporting Class B WQS for aquatic life use. The upper most reach 19.0 has consistently met Class B aquatic life use for all three

[13] Courtesy of Rich Langdon, VT DEC (Rich.Langdon@state.vt.us)

[14] http://www.vtwaterquality.org/bass/docs/bs_Rock_River_Biological_Assessment.pdf

macroinvertebrate assessments 1999 to 2008. The fish community assessments at this upper site are inconclusive.

The taxonomic and functional structure of both fish and macroinvertebrates indicated excessive nutrient enrichment. Temperature stress was evident for the macroinvertebrate community at the impaired lower reaches sites 5.9 to 9.4. At site 14.8 and 14.9 these same stressors were evident in the community structure and function through the year 2000. The latter assessments from 2004-2008 show a lessening of nutrient enrichment stress, while a moderate temperature stress is still indicated at this mid stream sites."

3.10. Rock River Targeted BMP Implementation Project[15] (VT DEC, 2010 – present)

The Rock River Watershed Targeted Best Management Practice (BMP) Implementation Project is an attempt to quantify the effect of agricultural BMPs on water quality. The project began in 2010, with NRCS and the UVM Extension Service providing assessments and technical assistance to approximately 16 farms within the study area. Vermont DEC constructed water quality monitoring stations within the Rock River watershed both upstream and downstream of the treatment area. FNLC trained volunteers to take water samples, which are submitted to the DEC laboratory for analysis.

Sampling points are in Highgate (Station #14, Cassidy Rd at Bouchard Rd) and Franklin (Station #20, Barnum Rd, North of Brown's Corner Rd). Farms that drain to the downstream station were recruited to add BMPs to their land, providing a comparison to the un-treated area above the upstream station.

Given that the BMPs are still being implemented, current project data have not been analyzed for changes in water quality. Pre-BMP data does show that concentrations of total phosphorous, dissolved phosphorous and total suspended solids are all significantly greater at the downstream sample location.

3.11. LaRosa Volunteer Data[16] (2005 – 2007)

Members of the Missisquoi River Basin Association collected water samples from the Missisquoi (Highgate Falls, 2005 – 2007) and the Hungerford Brook (at Rt. 207, 2006 – 2007). Data was also collected by the Friends of the Missisquoi Bay at the Rock River (at Tarte Rd, 2007) and the Saxe Brook (at Ballard Rd, 2007). Samples were analyzed by the VT DEC's LaRosa laboratory for total nitrogen, total phosphorous, total suspended solids (TSS), and turbidity.

Data analysis revealed periods of high pollutant load, particularly in the smaller rivers. The Saxe Brook, a tributary to the Rock and the smallest stream in this assessment, recorded a peak phosphorous load of 1500 ug/L. This is approximately 15 times higher than its yearly average, and is comparable to the Rock's highest value, 1050 ug/L of P over the same period. Other samples yielded fairly consistent phosphorous values by stream, with means of 166 ug/L for the Saxe, 192 ug/L for the Rock, 101 ug/L for the Hungerford, and 32 ug/L for the Missisquoi River. Vermont does not currently have a statewide in-stream water quality standard for P,

[15] Eric Smeltzer (Vermont Dept. of Environmental Conservation), personal communication

[16] http://www.vtwaterquality.org/cfm/larosavm/mp_larosavolmon.cfm

but the in-lake standard established for Missisquoi Bay is 25 ug/L, which is below the mean reported for the Missisquoi River.

Nitrogen and turbidity values were only recorded for the Missisquoi and Hungerford Brook samples. Nitrogen concentrations ranged from 0.29 – 1.07 mg/L for the Missisquoi and 0.79 – 3.61 mg/L for the Hungerford. Samples tested for turbidity (measured in nephelometric turbidity units or NTU) ranged from 1.02 – 27.6 NTU in the Missisquoi, and 1.78 – 107 in the Hungerford. Total suspended solids were measured in 2005 in the Missisquoi, these values ranged between 1.26 and 17.5. Vermont Water Quality Standards[17] require that nitrogen not exceed 5.0 mg/L (as NO_3-N) for Class B waters such as the Hungerford and Missisquoi, and that turbidity not exceed 10 NTU.

3.12. Lake Champlain Long Term Tributary Monitoring[18]

The Lake Champlain Long-Term Water Quality and Biological Monitoring Program has conducted sampling in the lake and its tributaries since 1990. In 2007 a station on the Rock River was added to the project. Results from this sampling are available online, with samples processed for total phosphorous, dissolved phosphorous, alkalinity, pH, chloride, conductivity, temperature, total nitrogen, calcium, iron, magnesium, potassium, sodium, and total suspended solids. Funding is provided by the Vermont DEC, New York DEC, and the Lake Champlain Basin program.

3.13. Flow Gauge Data (USGS)

The U.S. Geological Survey maintains discharge gauging stations across the country. Over the past twenty years there have been two such stations operated in Highgate. One station (now closed) was monitoring the Hungerford Brook, located on Route 207 south of the intersection of Cook Rd. This station operated from September 2009 through October 2011.[19] The other station in Highgate began collecting data in November 2010 and remains in operation. As described in Section 3.10, this station measures flow in the Rock River near the intersection of Cassidy Rd and Buchanan Rd.[20]

4. MUNICIPALITY-SPECIFIC ASSESSMENTS

In addition to the watershed-based assessments, a number of pieces of data are developed on a municipality-by-municipality basis. These are important to fold in to any effort to develop a list of strategic, prioritized projects that could be undertaken to improve water quality in and around Highgate. These include direct feedback from the Town, work by the Vermont Agency of Transportation, as well as past and current planning initiatives.

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[17] http://www.nrb.state.vt.us/wrp/publications/wqs.pdf

[18] http://www.vtwaterquality.org/cfm/champlain/lp_longterm-tribs.cfm

[19] http://waterdata.usgs.gov/nwis/uv/?site_no=04293900&agency_cd=USGS

[20] http://waterdata.usgs.gov/vt/nwis/uv/?site_no=04294140&agency_cd=USGS

4.1. Town Feedback

In addition to the watershed-based assessments, a number of pieces of data are developed on a municipality-by-municipality basis. These are important to fold in to any effort to develop a list of strategic, prioritized projects that could be undertaken to improve water quality in and around Highgate. These include direct feedback from the Town, work by the Vermont Agency of Transportation, as well as past and current planning initiatives. See below for a list of priority projects identified by Town officials in meetings with Stone Environmental.

- Town officials identified a number of developed areas that could potentially benefit from stormwater management. These include the ice arena, the park and ride at Joey's Junction, and the downtown area north of Franklin St and bounded by St. Armand Rd and Gore Rd. The Town indicated a preference for projects that could be built on land already owned by the Town.
- Ditch erosion along roads and trails. Mill Hill Rd and Machia Rd have cracked pavement and ditch erosion, likely indicating a stormwater issue. Town personnel have also observed erosion on the rail trail, west of the VELCO station.
- Landslides. Three major landslides occurred in Highgate in spring 2011—at the Town sand shed, on the VELCO power line, and on Whitetail Drive at Brosseau Rd. These areas should be priorities for stormwater investigation.
- Areas of spring flooding. In addition to flooding along Lake Champlain, the Rock River often overflows at St. Armand Rd and along Route 7. A manure pit on Hanna Rd at Route 78 floods annually, often draining to the property of a downhill neighbor.
- Future water and sewer studies. Town personnel anticipate the need for a water and sewer system evaluation, likely focused on Highgate Center. Continued development and low septic system capacity around Highgate Springs and Country Club Rd may also require feasibility studies.

4.1.1. Vermont Online Bridge and Culvert Inventory Data[21]

Vermont has 2,699 long structures (bridges and culverts) greater than 20 feet on interstate, state, and town routes and another 1,276 short structures between 6 and 20 feet on the state system that the state Agency of Transportation (VTrans) inspects. Inspections are conducted every 24 months on long structures and every 60 months on short structures unless conditions warrant more frequent inspections. Data collected as part of these inspections can help identify not only bridges and culverts with structural deficiencies but also structures that may be adversely impacting water quality. The system contains a more detailed accounting of five bridges and 275 culverts in Highgate.

4.1.2. Stream Geomorphic Assessment, Failure Modes Data[22]

Failure Modes- Problems and Causes

[21] http://apps.vtrans.vermont.gov/BridgeAndCulvert/Login.aspx?ReturnUrl=%2fBridgeAndCulvert%2fDefault.aspx

[22] https://anrnode.anr.state.vt.us/SGA/datasets/selectReport.aspx?sortType=Town&bid=06&bnm=Missisquoi

This document records the failure modes of bridges and culverts in Highgate. Typical problems with structures are scouring of the bank, other erosion issues, and poor structure placement. In Highgate, three bridges and 68 culverts are listed in the failure modes database.

Structure Failure Modes

This document is similar to the Failure Modes Problems and Causes, but includes issues such as sediment deposits, obstructed structures, floodplain problems, and beaver dams.

4.2. Vermont DEC Stormwater Permitting Program

4.2.1. State Stormwater Permits

Currently, Vermont DEC requires that a stormwater permit be obtained when any construction, new development, or redevelopment, results in impervious or disturbed area equal to or greater than one acre, with stricter requirements in watersheds that are classified as stormwater impaired. The State has developed a suite of technical standards for stormwater-related mitigation that are outlined in the Vermont Storm Water Management Manual, Volumes I and II. For example, the goal of a stormwater management program during construction is to mitigate sediment loss during storm events—while during and after construction, the objective is to maintain as much of the pre-developed hydrology as possible.

4.2.2. Environmental Research Tool[23]

ANR's Environmental Research Tool allows the user to look up the location of stormwater permits that have been issued by ANR, as well as hazardous waste sites, brownfields, and spills. There are approximately 91 documented stormwater permits that have been issued to sites in Highgate. Depending on the age, style, size, and upkeep of an existing facility, these may be excellent candidates for improvement to enhance stormwater management capabilities.

4.3. Missisquoi River Basin Urban Areas Stormwater Mapping Project[24]

In 2009, Vermont DEC developed up-to-date municipal drainage maps for six communities in the Missisquoi River Basin. The drainage maps show stormwater infrastructure, including features like pipes, manholes, catch-basins, and swales within a municipality. Data sources include data collected from field work, available state permit plans, record drawings, town plans, existing GIS data from contractors, and the input and guidance of knowledgeable members of the municipalities. As part of the project, Vermont DEC also identified potential locations for Best Management Practice (BMP) stormwater retrofit sites. Eight high-priority sites were identified in Highgate. These are sites where stormwater treatment structures could be cost-effectively added or improved. See Table 1 for a list of these prioritized areas.

[23] http://www.anr.state.vt.us/WMID/StormWater.aspx

[24] http://www.vtwaterquality.org/erp/news/Missisquoi_FINAL_Report.pdf

4.4. Illicit Discharge Detection and Elimination (IDDE) in Six Missisquoi River Basin Communities[25]

An assessment of the Highgate Center stormwater system for illicit discharges was conducted between July and September 2009. An illicit discharge is defined as any discharge to the municipal separate storm sewer system that is not composed entirely of storm water. These non-stormwater discharges occur due to illegal connections to the storm drain system. Illicit connections may be intentional or unknown to the property owner. As a result of an illicit connection, contaminated wastewater enters into storm drains or directly into local waterways without receiving treatment from a wastewater treatment plant.

From the report:

> *There are two closed drainage systems in Highgate Center, each consisting of several catch basins discharging to an outfall that was inaccessible or that could not be located . . . No ammonia, detergents, or optical brighteners were detected in any of the catch basins tested with the exception of a low concentration of detergents at catch basin HC-020. We suspect the apparent detergents detection at HC-020 resulted from interference by high turbidity (colloidal clays) rather than presence of synthetic detergent. Because the detergents test result was low and likely not valid and there were no other indications of contamination at this catch basin, no further investigation was considered necessary. We concluded that no contaminated dry-weather flows were detected in stormwater structures in Highgate Center.*

4.5. Highgate Town Plan[26] (2010)

Three chapters of the Highgate town plan relate directly to stormwater management: Natural Resources (Chapter 4), Transportation (Chapter 6), and Land Use (Chapter 8). The natural resources section addresses phosphorous loading in the Missisquoi Bay, and includes language from ANR's revised Total Maximum Daily Load plan (2010):

> *Recommended actions identified in the plan included best management practices on farms to reduce nutrient runoff, stabilization of stream banks and stream channels, and better storm water management and erosion control on developable land and roadways.*

This section also details Critical Areas in Highgate, mapping wetlands, flood zones, and endangered species, see Figure 6 for a map of Critical Areas.

Transportation focuses on town roads, and also provides an inventory of the town's highways. Included in this inventory is a sufficiency rating divided into four categories: bad (0 – 40), poor (40 – 60) fair (60 – 80), and good (80 – 100). Sufficiency ratings measure various conditions such as structural condition, safety, and service. Additional information provided by VTrans states that 1.05 miles of Highgate State Highways were classified as bad, 1.88 miles were classified as poor, 12.62 miles were classified as fair, and 0.40 miles were classified as good.

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[25] http://www.vtwaterquality.org/erp/news/Missisquoi-IDDE-Report_Final-no-appendices.pdf

[26] http://highgate.weebly.com/town-plan-2010.html

Potential development areas should be the focus when determining future stormwater impact and the possible projects associated with it. The Downtown Growth Center Development section (in Chapter 8) outlines most of the areas set aside for development of residences, commercial, and industry, all of which would benefit from stormwater planning. See Figure 7 for a map of the proposed Downtown development.

5. OTHER RELATED INFORMATION

There are a significant number of farm operations in the Town of Highgate. Farmsteads (barn areas) often contain a large amount of impervious surface and may be an important source of stormwater pollution.

5.1. NRCS Conservation Practice #558—Roof Runoff Structure[27]

NRCS Standard #558 addresses the management of stormwater from farm structures; specifically, where roof runoff from precipitation needs to be:

- diverted away from structures or contaminated areas;
- collected, controlled, and transported to a stable outlet; or
- collected and used for other purposes such as irrigation or animal watering facility.

The total barn roof area on a farm can be substantial, often in excess of one acre (the threshold for state stormwater regulation in the developed landscape) and therefore roof runoff from farm barns can be an important source of unmanaged stormwater.

6. CONCLUSIONS

This report is being developed as part of a larger project, funded by Vermont DEC, which will ultimately lead to a set of community-specific, prioritized projects to address stormwater runoff. Rather than an entirely new effort to identify stormwater management needs, the project (and this report) is drawing from the extensive library of water quality assessments and information that already exists, and augmenting with interviews with local officials.

As this report demonstrates, there are numerous agencies and entities whose activities touch on various aspects of water quality in the Missisquoi watershed in general, and Highgate more specifically. This work is dynamic and ongoing, and so, while this summary is believed to be comprehensive, it will be important to periodically review and update the content to ensure the most current information can be incorporated. A comprehensive inventory of existing water quality assessments serves as a basis for connecting land use, stormwater management, floodplain management, river management activities; and public infrastructure needs to more effectively address all of the issues which contribute to degradation of a watershed.

[27] http://efotg.sc.egov.usda.gov//references/public/VT/VT558-0311.pdf

APPENDICES

APPENDIX A: FIGURES

Figure 1. Stressors by Reach/Segments, Rock River SGA Report

Reach / Segments	Deforestation in 1800s	Road Networks (1700s, 1800s)	Flood events	Channelization / Straightening	Dredging	Berming	Bank Armoring	Floodplain Encroachment	Loss of Forested Buffers	Impoundment (dam)	Gravel extraction	Undersized Bridge / Culvert	Constricting Old Abutments	Direct Pasturing by Livestock	Ford
	Watershed			Channel - Reach Scale							Channel - Site Scale				
Main Stem															
M04-B								√	√				√		√
M05							√	√	√			√			√
M06							√	√	√			√		√	√
M07-A				√				√	√			√			
M07-B						√	√	√	√					√	√
M09-C															√
M09-D				√	√		√		√			√			
M09-F				√			√	√	√			√			
M10				√	√	√		√	√			√		√	√
Tributaries															
M1S1.01-A				√			√	√	√			√		√	√
M1S1.01-B															
M1S1.02-A															
M1S1.02-B							√	√	√			√			
M1S1.03-A				√	√	√	√		√			√			
M1S1.03-B												√			
M5S2.01-A															
M5S2.01-B				√	√	√	√		√			√		√	
M5S3.01-A										√ (US)					
M5S3.01-C				√	√				√	√ (DS)					
M5S4.01-A															
M5S4.01-B															
M5S4.01-C				√					√					√	√
M5S4.01-D				√	√				√			√		√	
M5S4.01-E				√	√	√			√			√			
M5S5.01-A															
M6S1.01-A				√				√	√			√		√	√
M6S1.01-B				√	√	√		√	√			√			√
M6S1.1S1.01-A	▼	▼	▼	√	√			√	√			√		√	√

Figure 2. Reaches by Sensitivity, Rock River SGA Report. Saxe Brook seen in inset

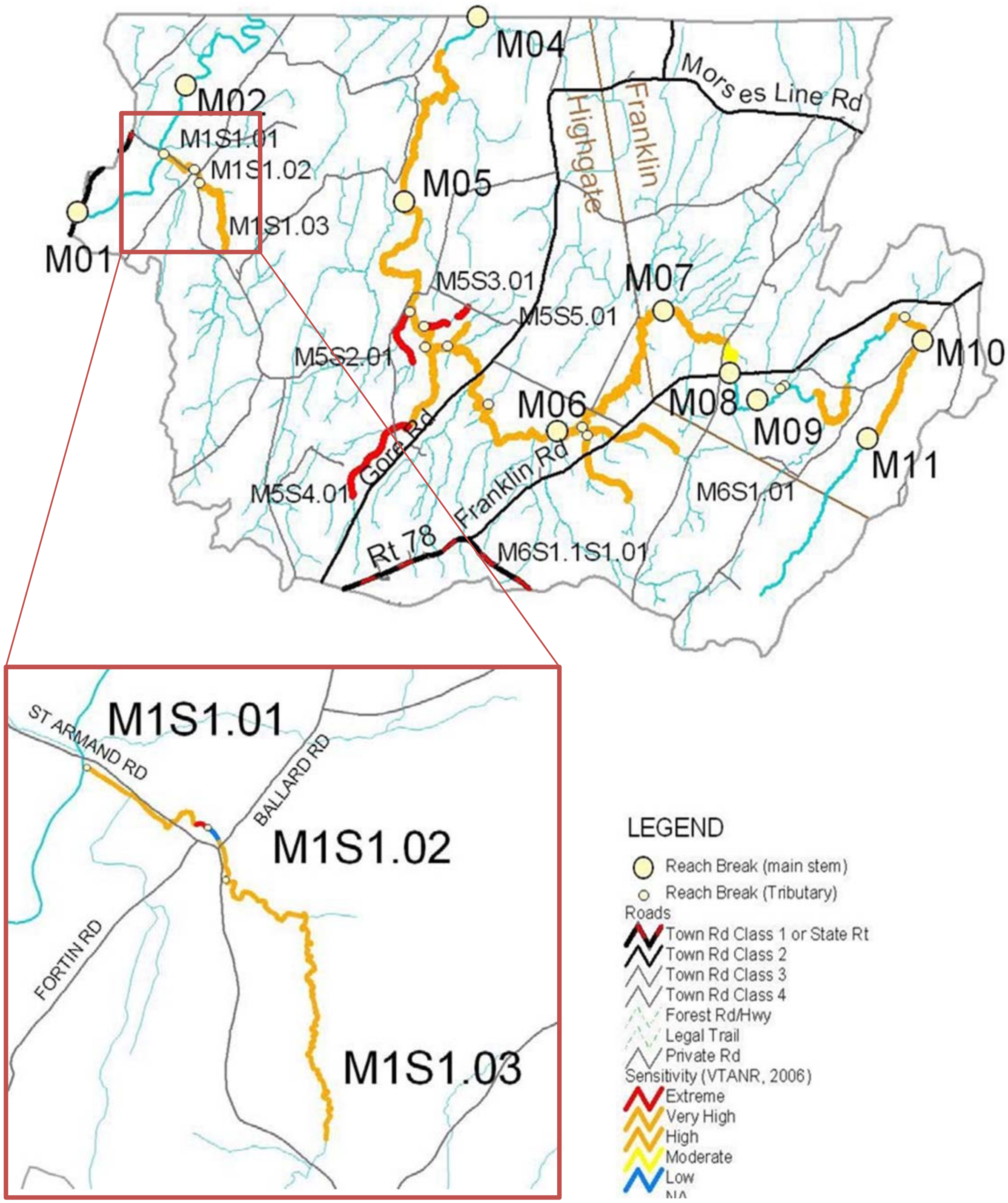


Figure 3. Bridges and Culverts in Rock River watershed, including Highgate

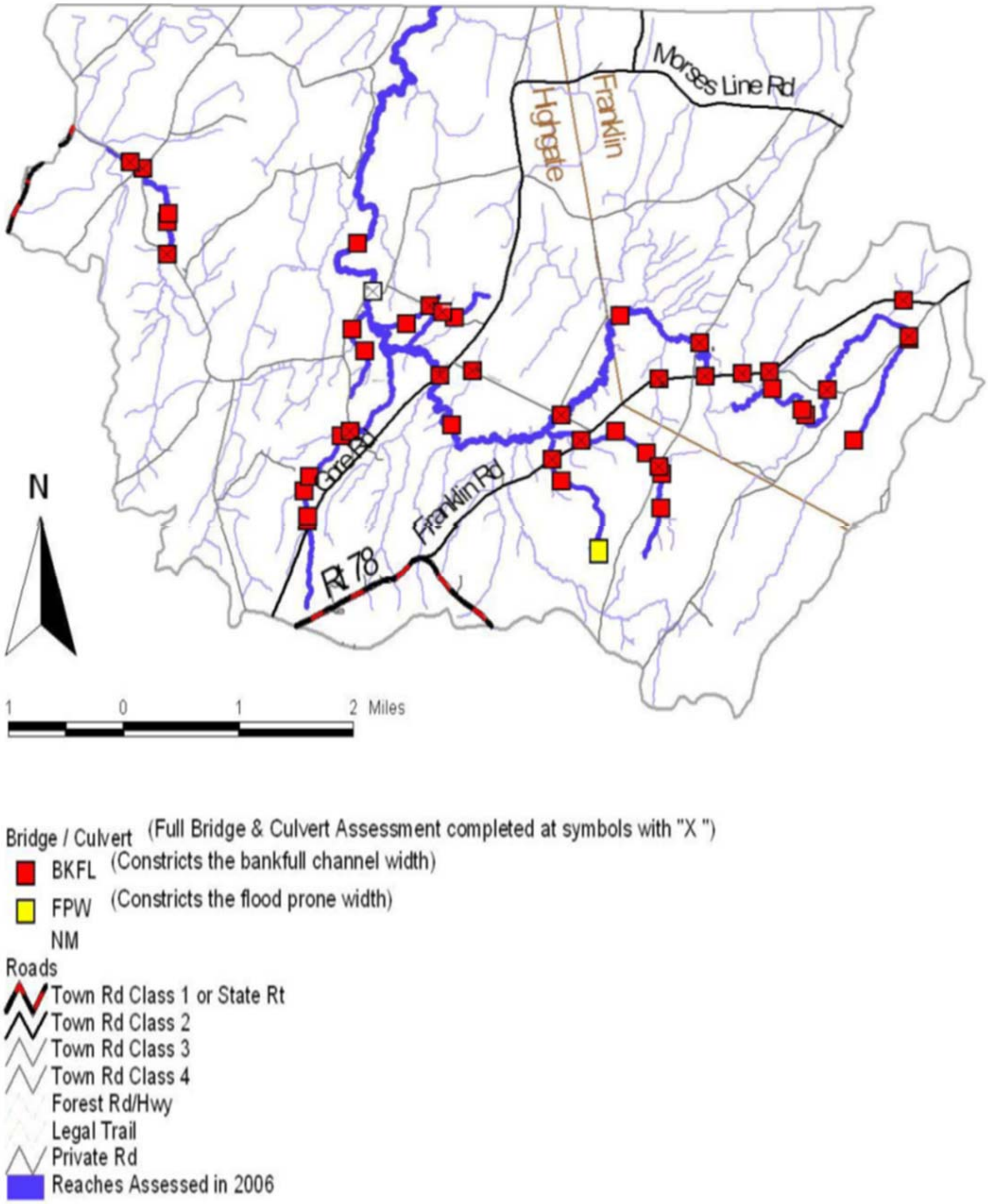


Figure 4. Missisquoi River Black Creek to Hungerford Brook

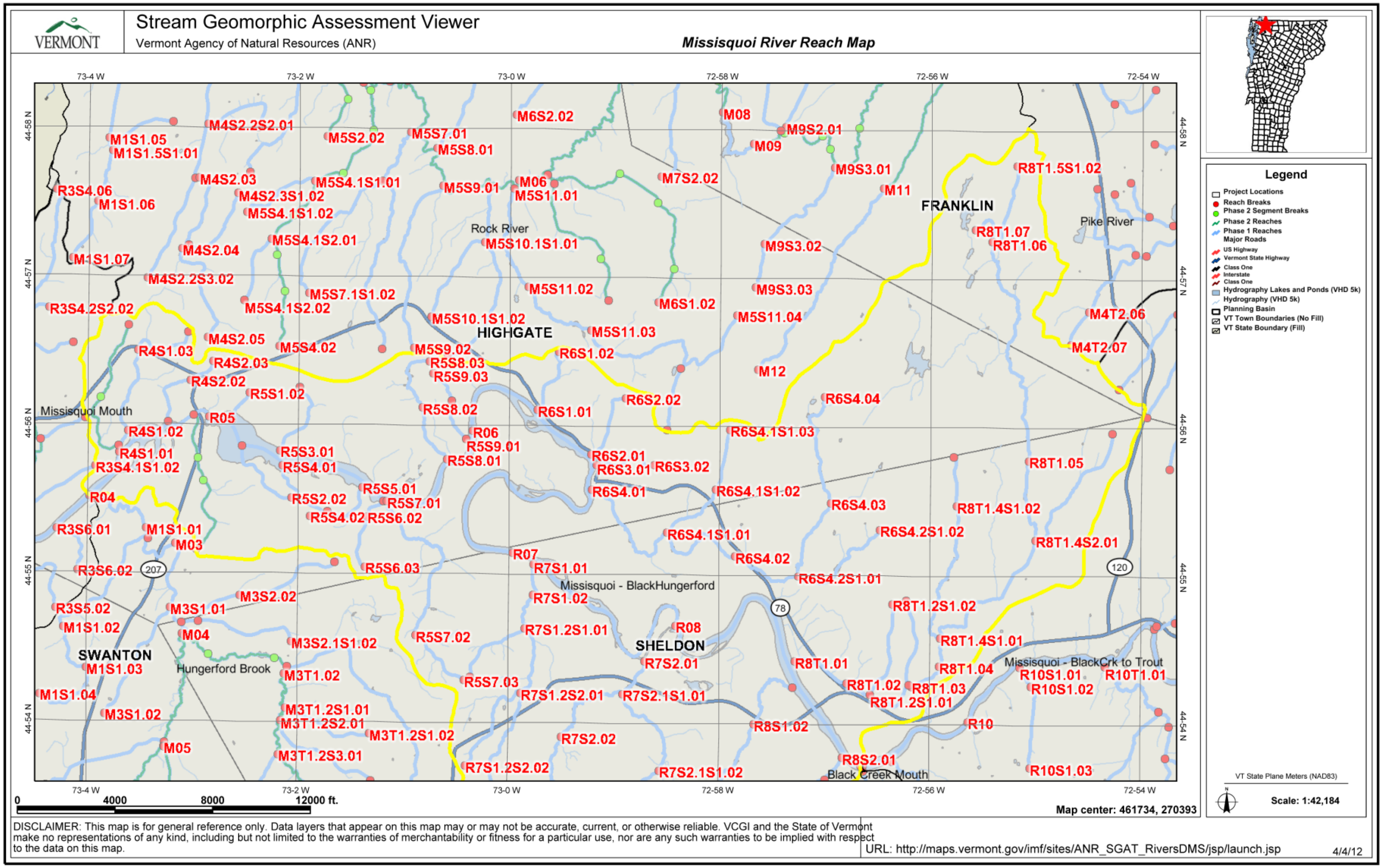


Figure 5. Rock River Reach Map

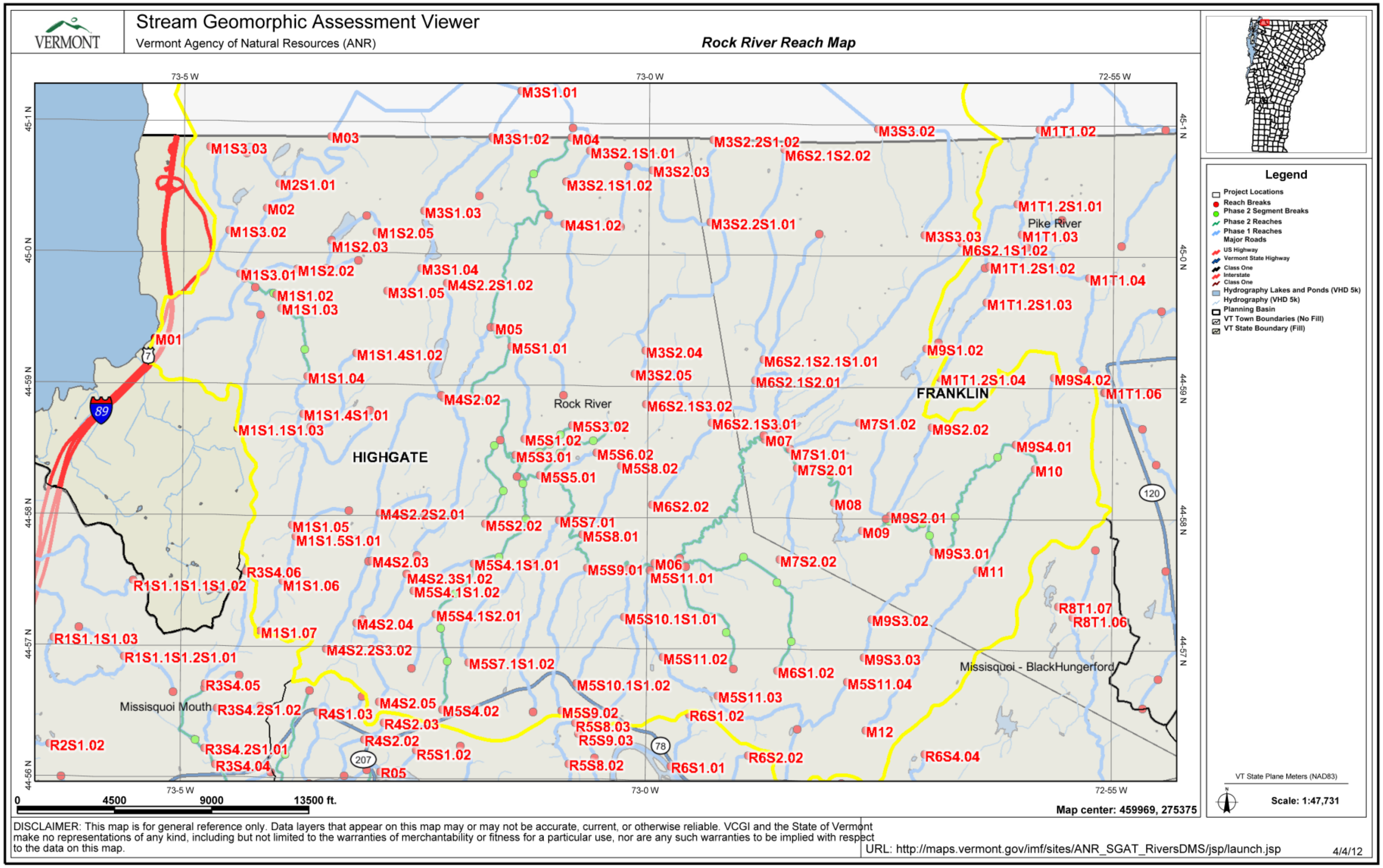


Table 1. Highgate Stormwater Prioritization Table

Highgate - Subwatershed Prioritization and Recommendations													
Watershed Number	**Action List**	**Proposed or Existing Stormwater Treatment Practice**	**Permit Number**	**Watershed Area (Acres)**	**Mapped Impervious Area (MIA)**	**EIA Equation (RANK)**	**Percent Effective Impervious Area**	**Water Quality Volume (Acre-Feet)**	**Channel Protection (Acre-Feet)**	**Estimated Basin Construction Cost**	**Estimated Other BMP Construction Cost**	**Assistance Program**
2	**1**	Investigate Ravine for Erosion/Stabilize		32.33	34.9	1	21	0.57	1.19		UNK	Better Backroads/VYCC
5	**1**	Investigate Ravine for Erosion/Stabilize		26.16	28.0	1	15	0.36	0.77		UNK	Better Backroads/VYCC
4	**2**	Ext Det. Micro Pool		18.62	30.3	1	17	0.28	0.59			
1		Existing Wet Pond		2.81	26.7	1	14	0.04	0.08			
8		Existing Wet Pond		3.28	18.7	1	8	0.03	0.06			
3		NA		9.89	20.9	1	10	0.10	0.22			
6		NA		9.60	19.0	1	8	0.09	0.19			
7		NA		6.61	28.6	1	15	0.09	NA - Receiving Water Missisquoi			
TOTALS				**109.30**				**1.56**	**3.10**			

Figure 6. Highgate Critical Areas

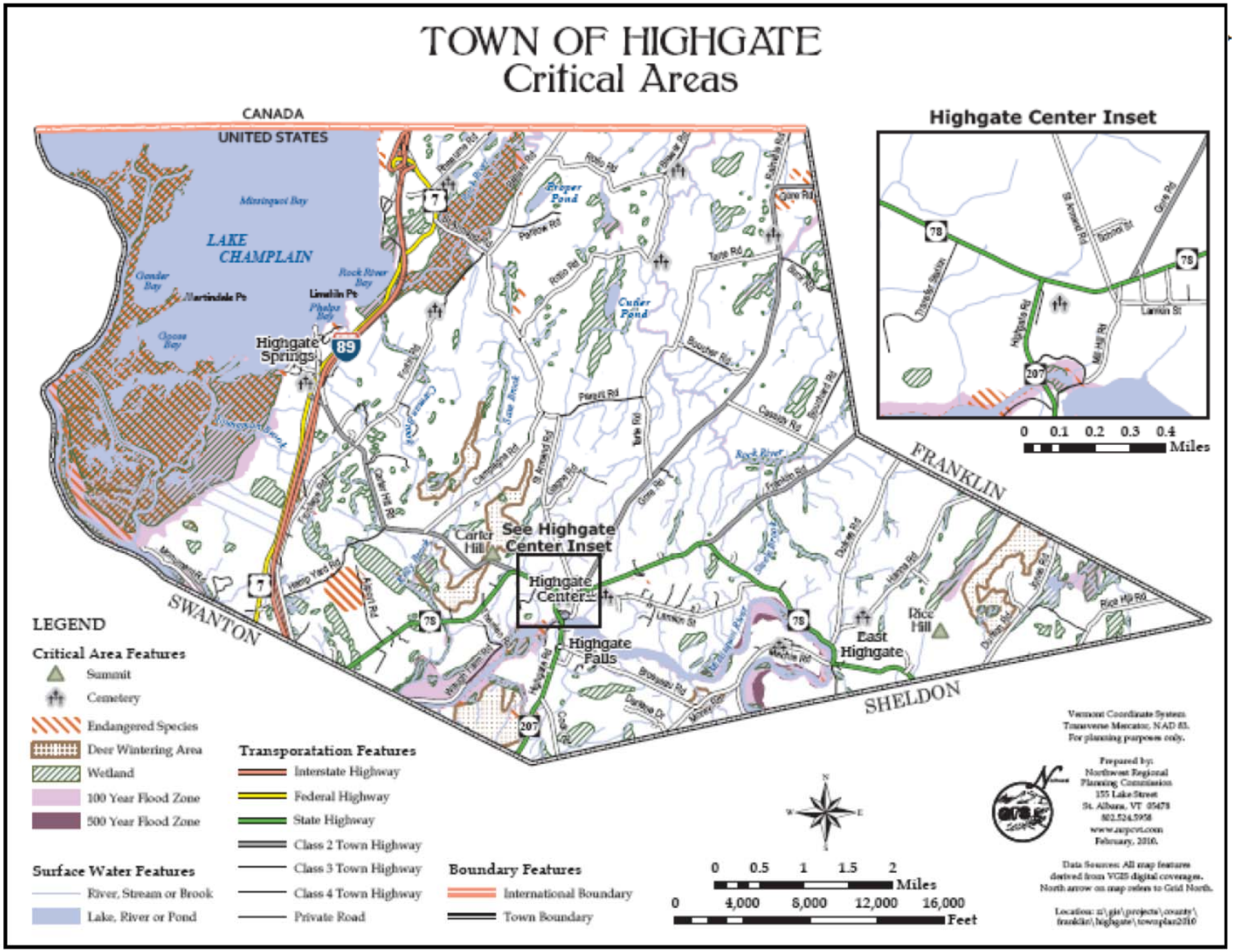
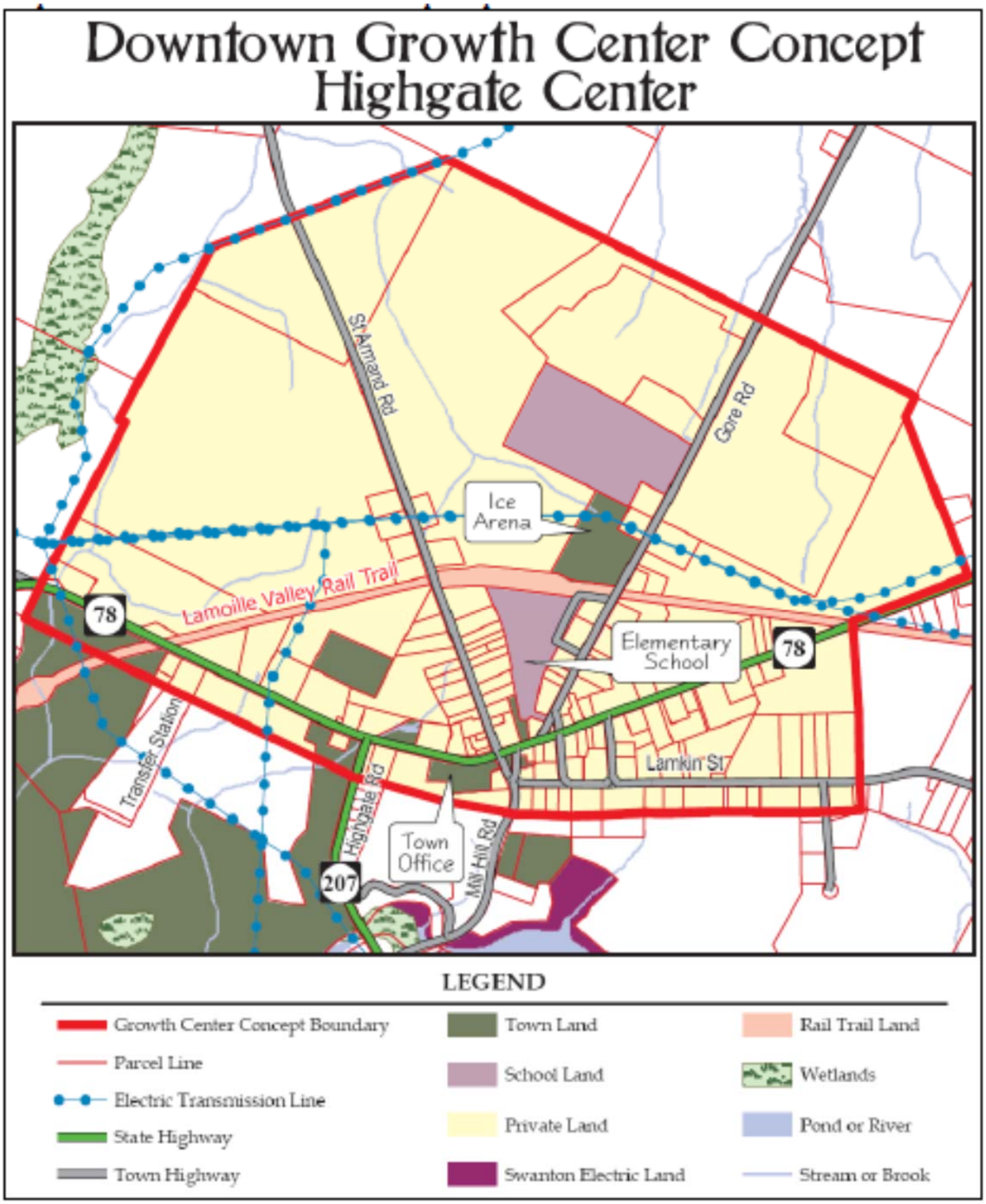


Figure 7. Highgate Downtown Growth Center Development



APPENDIX C: PROBLEM AREA DATA SHEETS

MEMO

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To: Paul Madden
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From: Julie Moore
Direct Phone: 802-229-1881
E-Mail: jmoore@stone-env.com

SEI No. 112475-W, task 2
Re: Stormwater Problem Areas in the Town of Highgate

Stone Environmental has reviewed existing reports and also worked directly with the Town to identify current problem areas (e.g., actively eroding sites, roadway flooding and/or water ponding areas, culverts or other structures with insufficient hydraulic capacity) that are a direct, or indirect, result of stormwater runoff.

The approach to identifying problem areas included the following elements:

- Engagement with local officials, including:
  - March 29th, kick-off meeting with then-Town Administrator, David Jescavage
  - September 27th, follow-up meeting with new Town Administrator Heidi Valenta
- Targeted site visits to verify problems areas (July - September 2012)
- Documentation (with photos) of existing problem areas

A "problem area data sheet" was developed and used as a guide to ensure consistent information was collected as site visits were completed. The data sheets for all of the problem areas identified in Swanton are attached to this memo. Each problem area was given a preliminary classification according to the following system:

Level	Classification
1	Outside of project scope.
2a	Stable, no urgency.
2b	Stable, but problem could escalate with future change in surrounding land use.
3	Small to moderate erosion and/or drainage problems are present; issues could be readily addressed.
4	Significant erosion and/or drainage problems are present; issues may be readily addressed.

Going forward, we will work with the Friends of Northern Lake Champlain to combine the information collected during this phase into a scoring matrix that considers both the municipality's priorities and anticipated water quality benefits of addressing each problem area to develop a short of 6-10 high priority projects for implementation.

Problem Area Data Sheet

Problem Area ID:	**RR-1**	Latitude: 44.999875 N	Longitude: 73.026413 W

Watershed:	Rock River
Location:	Rollo Rd.
Problem Type:	Local Drainage
Identification Source:	LCBP CSA Model
Ownership:	Local
Classification Level:	3

Problem Description:

LCBP's Missisquoi Bay Basin Critical Source Area model indicated that Rollo Road may be a significant source of phosphorous and sediment pollution due to its steep grade and proximity to the Rock River.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Pasture on Rollo Rd. sloping to Rock River

Photo 2. Erosion on Rollo Rd

Description of Observed Conditions:

There is a very steep embankment below Rollo Rd that leads down to the Rock River. Some localized erosion is evident along road shoulder (Photo 2). Resident on SE corner of road (NE of Cutler Pond) mentioned speeding eighteen wheel trucks—suggesting there may be additional reasons for some road surface erosion.

Problem Area Data Sheet

Problem Area ID:	**RR-3**	Latitude: 44.988905 N	Longitude: 73.088372 W

Watershed:	Rock River
Location:	Route 7, as it crosses over the mouth of the Rock River
Problem Type:	Flooding
Identification Source:	Town Feedback
Ownership:	State
Classification Level:	1

Problem Description:

River often overflows its banks along Rt. 7, flooding the road.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Route 7 bridge over the Rock River

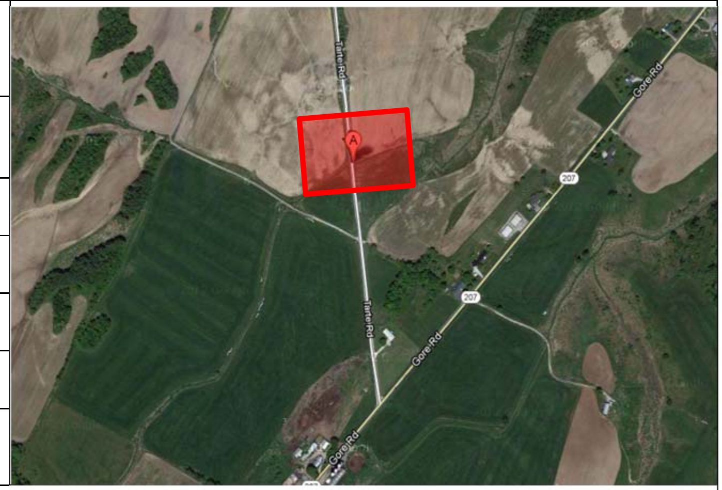
Photo 2. Evidence of flooding upstream of bridge

Description of Observed Conditions:

Bridge constricts the floodplain near mouth at Missisquoi Bay. Rock River is channelized by bridges over both Route 7 and Interstate 89. This structure was identified during the Phase 2 Stream Geomorphic Assessment as "constricting the bankfull channel width".

Problem Area Data Sheet

Problem Area ID:	**RR-4**	Latitude: 44.961307 N	Longitude: 73.029138 W



Watershed:	Rock River
Location:	Tarte Rd, just north of the intersection with Gore Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Local
Classification Level:	2a

Problem Description:

Culvert is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1.

Photo 2.

Description of Observed Conditions:

Upstream entrance of culvert is undamaged; downstream end is covered by vegetation. Center of culvert squashed by road weight. Some scouring evident at both ends of the culvert. One foot of flow after heavy rain event in previous 24 hours; during low flow conditions may not reach culvert. Corn and hay fields upstream.

Problem Area Data Sheet

Problem Area ID:	**RR-5**	Latitude: 44.968423 N	Longitude: 73.013391 W

Watershed:	Rock River
Location:	Gore Rd, southeast of intersection with Cassidy Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Local
Classification Level:	1

Problem Description:

Bridge is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Upstream of bridge

Photo 2. Downstream of bridge

Description of Observed Conditions:

Large concrete structure, square opening with wingwalls. Heavy flow from recent storm event, scour/pooling upstream, some pooling downstream. No damage to bridge, 1-2 foot drop on downstream side. Animal trail (cow path) within fifty feet of stream on downstream side; farmer says that none of his cows have access to stream.

Problem Area Data Sheet

Problem Area ID:	**RR-6**	Latitude: 44.96357 N	Longitude: 72.991937 W

Watershed:	Rock River
Location:	Cassidy Rd, just east of intersection with Bouchard Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Private
Classification Level:	1

Problem Description:

Bridge is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Downstream of bridge

Photo 2. Upstream of bridge

Description of Observed Conditions:

USGS gauge station present at river crossing, stream level is 1.1 ft. Water is silty and brown, likely due to recent storm event. No roadside or bank erosion visible; no damage to bridge. Scour pool has formed at the downstream end of the crossing. Agricultural land immediately upstream is currently in hay.

Problem Area Data Sheet

Problem Area ID:	RR-7	Latitude: 44.960288 N	Longitude: 72.988288 W

Watershed:	Rock River
Location:	Franklin Rd, southeast of the intersection with the Cassidy Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Local
Classification Level:	1

Problem Description:

Bridge is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Downstream of bridge

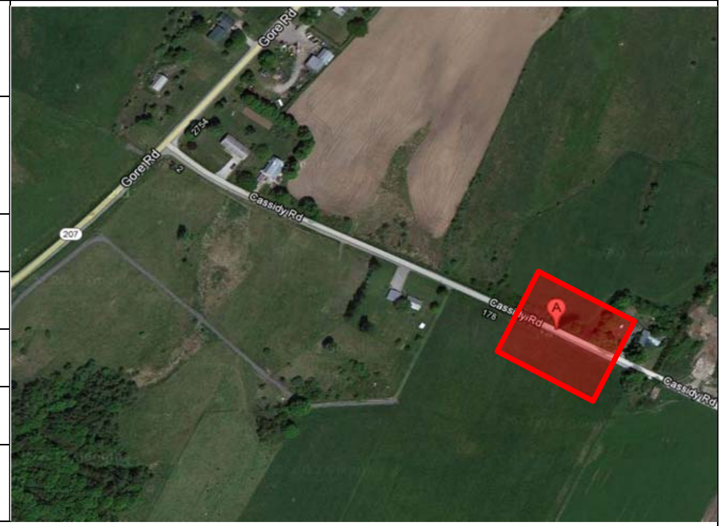
Photo 2. Upstream of bridge

Description of Observed Conditions:

Minor erosion at outlet, no sign of damage to upstream side. Label on bridge notes “Bridge number C17655, 6x6 “B” B-3, installed 9/13/05.”

Problem Area Data Sheet

Problem Area ID:	**RR-8**	Latitude: 44.968658 N	Longitude: 73.006697 W
Watershed:	Rock River		
Location:	Cassidy Rd, east of the intersection with the Gore Rd		
Problem Type:	Culvert/Bridge Issue		
Identification Source:	SGA, Rock River		
Ownership:	Local/Private		
Classification Level:	2a		



Problem Description:

Culvert is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Downstream culvert drains to pipe

Photo 2. Upstream culvert in dense veg. of road ditch

Description of Observed Conditions:

Culvert under Cassidy Rd drains agricultural ditches, 15”, wet no flow. Outflow of culvert drops into a vertical plastic pipe, we assume this pipe runs south through the pasture and to the stream. No significant erosion issues were noted. Both inlet and outlet surrounded by dense vegetation.

Problem Area Data Sheet

Problem Area ID: **RR-9**

Latitude: 44.976412 N

Longitude: 73.01337 W

Watershed:	Rock River
Location:	Boucher Rd, between Tarte Rd and Gore Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Local
Classification Level:	2a

Problem Description:

Culvert is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Upstream culvert

Photo 2. Downstream culvert

Description of Observed Conditions:

Culvert under Boucher Rd, 24-30", corrugated metal. Culvert ends show some damage. Water drains to culvert from a series of field and roadside ditches. Downstream is close to 8" deep. No presence of road erosion, but surface peastone looks fairly new—may indicate a recent repair or resurfacing.

Problem Area Data Sheet

Problem Area ID: **RR-10**

Latitude: 44.977222 N

Longitude: 73.015664 W

Watershed: Rock River

Location: Boucher Rd, between Tarte Rd and Gore Rd

Problem Type: Culvert/Bridge Issue

Identification Source: SGA, Rock River

Ownership: Local/Private

Classification Level: 2b

Problem Description:

Culvert is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Downstream culvert

Photo 2. Upstream culvert

Description of Observed Conditions:

Culvert under Boucher Rd, 15”, corrugated metal. Some pooling observed upstream—source of flow is from road and adjacent agricultural field drainage. Downstream end of culvert is perched (~1’ above channel), and erosion/scour at outfall and downstream is evident.

Problem Area Data Sheet

Problem Area ID: **RR-11**	Latitude: 44.978845 N	Longitude: 73.025319 W

Watershed:	Rock River
Location:	Tarte Rd, just south of the intersection with Boucher Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Local
Classification Level:	1

Problem Description:

Bridge is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Upstream of bridge

Photo 2. Downstream of bridge

Description of Observed Conditions:

No erosion present at bridge. Downstream bank shows bedrock, upstream densely vegetated. Bridge supports look strong, span looks old—cracking pavement and insufficient guardrails. Flow in the Rock River is brown and silty after previous day's rain event.

Problem Area Data Sheet

Problem Area ID:	**RR-12**	Latitude: 44.974189 N	Longitude: 73.029472 W

Watershed:	Rock River
Location:	Tarte Rd, approximately ¼ mile north of intersection with Parent Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Local/Private
Classification Level:	2b

Problem Description:

Culvert is undersized and unable to convey moderate or high flows.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Under-road culvert outfall

Photo 2. 4” white pipe downstream of culvert

Description of Observed Conditions:

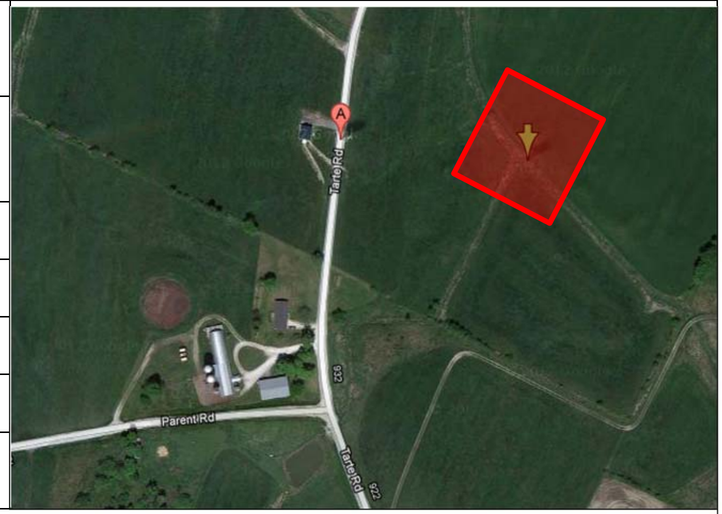
4” white pipe leads from farm to culvert under road to 15” corrugated metal culvert. Metal culvert then outlets to another 4” white pipe, which leads to cattails. 4” pipe does not appear to function in high flow situations. After cattails, runoff forms a stream and meets another Rock River tributary. Some evidence of erosion present

Problem Area Data Sheet

Problem Area ID: **RR-13**

Latitude: 44.972457 N

Longitude: 73.028284 W



Watershed:	Rock River
Location:	Tarte Rd, north of the intersection with Parent Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Private
Classification Level:	3

Problem Description:

Culvert is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Upstream of farm road bridge

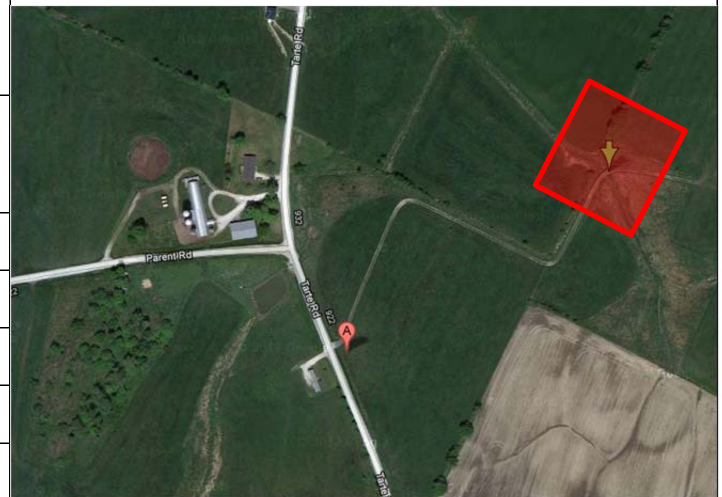
Photo 2. Downstream of farm road bridge

Description of Observed Conditions:

Culvert under farm road for tractor use. 24” pipe with scour/ponding at both ends—upstream culvert is submerged, downstream outlet is visible. Road is in fair condition. Some rip rap has been placed by the landowner to address localized erosion around the culvert.

Problem Area Data Sheet

Problem Area ID:	**RR-14**	Latitude: 44.971365 N	Longitude: 73.0266 W



Watershed:	Rock River
Location:	Tarte Rd, south of the intersection with Parent Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Private
Classification Level:	4

Problem Description:

Culvert is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Upstream of farm road bridge

Photo 2. Downstream of farm road bridge

Description of Observed Conditions:

Undersized culvert under farm road -- significant erosion visible. Culvert is fully submerged or possibly collapsed. No evidence of cow access to stream, as reported in the Rock River SGA.

Problem Area Data Sheet

Problem Area ID: **RR-15**	Latitude: 44.95707 N	Longitude: 72.974651 W

Watershed: Rock River

Location: Durkee Rd

Problem Type: Culvert/Bridge Issue

Identification Source: SGA, Rock River

Ownership: Local

Classification Level: 2b

Problem Description:

Culvert is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Upstream of culvert

Photo 2. Downstream of culvert

Description of Observed Conditions:

Partially submerged 24” corrugated metal culvert. Inlet is rip-rapped. Stream is less silty than others in the area, likely due to its path through the woods prior to going through the culvert. No damage to outlet, although some evidence of scour.

Problem Area Data Sheet

Problem Area ID:	**RR-16**	Latitude: 44.994111 N	Longitude: 73.066048 W

Watershed:	Rock River
Location:	St. Armand Rd, near intersection with Ballard Rd
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Local/Private
Classification Level:	1

Problem Description:

Bridge is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Upstream of bridge

Photo 2. Downstream of bridge

Description of Observed Conditions:

Stream crossing under Ballard Rd (bridge shown) and then flows under St. Armand Rd before meeting Rock River. Bridge appears to be in good condition. No fish passage, drop in excess of one foot at outlet. Area surrounding bridge shows exposed ledge. Cows may have access to stream below the bridge, along St. Armand Rd.

Problem Area Data Sheet

Problem Area ID:	**RR-17**	Latitude: 44.94982 N	Longitude: 73.036181 W

Watershed:	Rock River
Location:	Gore Rd, about 1 mile north of Highgate Center
Problem Type:	Culvert/Bridge Issue
Identification Source:	SGA, Rock River
Ownership:	Local/Private
Classification Level:	2a

Problem Description:

Culvert is constricting bankfull channel width.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Wetland upstream of culvert

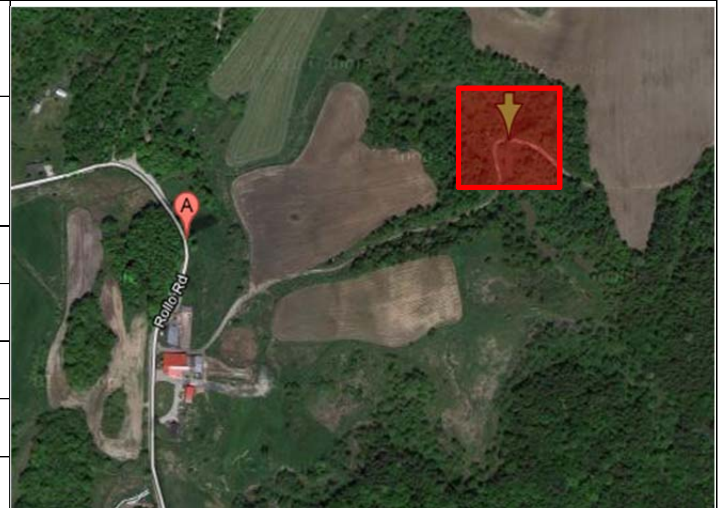
Photo 2. Downstream of culvert

Description of Observed Conditions:

24” corrugated metal culvert carries water draining from forest and wetland, through farm field, under Gore Road. Channel is somewhat incised, but appears stable.

Problem Area Data Sheet

Problem Area ID:	**RR-18**	Latitude: 45.007402 N	Longitude: 73.020006 W
Watershed:	Rock River		
Location:	Rollo Rd, about 1.5 miles east of the intersection with Ballard Rd		
Problem Type:	Stream Crossing		
Identification Source:	SGA, Rock River		
Ownership:	Private		
Classification Level:	3		



Problem Description:

Fords used as farm road crossing of Rock River; no bridges or culverts present.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Farm road ford across Rock River

Photo 2. River downstream of ford

Description of Observed Conditions:

Pooling upstream of ford, bank erosion on either side of crossing. Ford likely must be rebuilt after each flood event. Have contacted AAFM about resources that might be available to improve the crossing.

Problem Area Data Sheet

Problem Area ID:	RR-19	Latitude 45.002385 N	Longitude: 73.023749 W

Watershed: Rock River

Location: Rollo Rd, about 1.5 miles east of intersection with Ballard Rd

Problem Type: Stream Crossing

Identification Source: SGA, Rock River

Ownership: Private

Classification Level: 4

Problem Description:

Fords used as farm road crossing of Rock River; no bridges or culverts present.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Farm road ford across Rock River

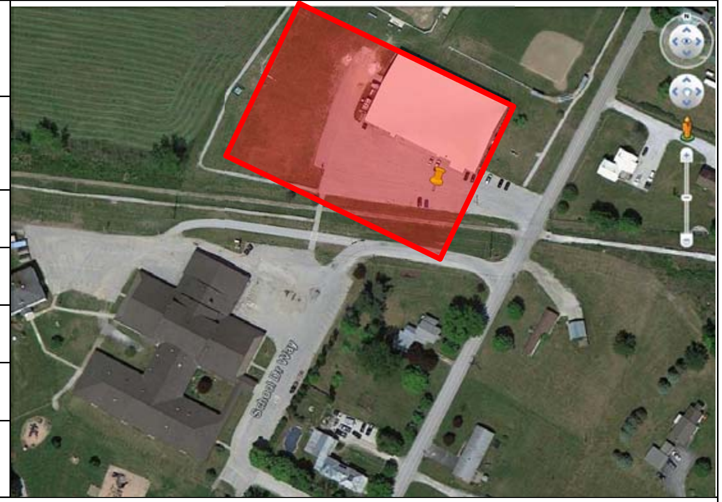
Photo 2. River downstream of ford

Description of Observed Conditions:

Major erosion along banks at farm crossing, and on unimproved access road down to the river. Obvious struggles to ford the Rock River evident. Entire farm area may be susceptible to erosion—steep banks, erosive soils. Have contacted AAFM about resources that might be available to improve the crossing.

Problem Area Data Sheet

Problem Area ID:	**MQ-1**	Latitude: 44.942248 N	Longitude: 73.042643 W



Watershed: Missisquoi River

Location: Gore Rd, just north of Highgate Center

Problem Type: Local Drainage

Identification Source: Town Feedback

Ownership: Public

Classification Level: 3

Problem Description:

Possible location for stormwater retrofit at Recreational Facility (ice arena).

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Ice Arena

Photo 2. Field west of Ice Arena

Description of Observed Conditions:

Significant amount of impervious area with unmanaged stormwater runoff; installing a treatment practice on the adjacent lawn is a potential solution. A planned expansion of the building, in addition to a doubling of parking area, will likely necessitate a stormwater permit. Potential improvements include tree-lined trenches in the parking lot, and a dry or wet pond for stormwater detention and treatment.

Problem Area Data Sheet

Problem Area ID: MQ-2

Latitude: 44.938733 N

Longitude: 73.048251 W

Watershed:	Missisquoi River
Location:	Intersection of Route 78 & Route 207
Problem Type:	Local Drainage
Identification Source:	Town Feedback
Ownership:	Local
Classification Level:	3

Problem Description:

Stormwater management at existing park and ride facility next to Joey's Junction.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Highgate Park and Ride

Photo 2. Wetland SW of junction of Routes 207 and 78

Description of Observed Conditions:

45' x 120' untreated gravel parking area. Parking lot drains to pond just north, ultimately outlets to wetland area on SW corner of Routes 207 and 78. Outfall into wetland is a 30" corrugated metal pipe, was trickling during the field investigation.

Problem Area Data Sheet

Problem Area ID:	MQ-3	Latitude: 44°56'24.71"N	Longitude: 73° 2'40.94"W

Watershed:	Missisquoi River
Location:	Franklin St, bounded by St. Armand and Gore Rds
Problem Type:	Local Drainage
Identification Source:	Town Feedback
Ownership:	Local/Private
Classification Level:	3

Problem Description:

Unmanaged stormwater runoff in village area north of Franklin St., bounded by St. Armand and Gore Rd, including Highgate Elementary School parcel.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Taken from west edge, looking south

Photo 2. Taken from west edge, looking north

Description of Observed Conditions:

Schoolyard includes large, flat green space. Area is slightly higher than the lawns to the west bordering St. Armand St. Many residences in the vicinity have reported high groundwater, leading to flooded basements in the spring. The old school building is surrounded by a French drain, but it appears to need to be re-trenched. A grassed swale could be constructed to treat the stormwater.

Problem Area Data Sheet

Problem Area ID: **MQ-4**

Latitude: 44°56'10.98"N

Longitude: 73° 2'43.72"W

Watershed:	Missisquoi River
Location:	Mill Hill Rd, between Lamkin St and Highgate Rd
Problem Type:	Local Drainage
Identification Source:	Town Feedback
Ownership:	Local
Classification Level:	3

Problem Description:

Some gully erosion near the bridge over an unnamed tributary to the Missisquoi River.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Erosion along roadside

Photo 2. Blowout at the end of guardrail

Description of Observed Conditions:

Erosion in ditches along road, and major blowout at the end of guardrail were observed. Additional turnouts or other measures could be used to help reduce the volume and velocity of stormwater flows along Mill Hill.

Problem Area Data Sheet

Problem Area ID: MQ-7	Latitude: 44.937381 N	Longitude: 73.058938 W

Watershed:	Missisquoi River
Location:	Transfer Station Rd
Problem Type:	Landslide
Identification Source:	Town Feedback
Ownership:	Local
Classification Level:	1 – geomorphology 3 – drainage from parking area

Problem Description:

Landslide and on-going erosion at the Town Sand Shed.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Looking down landslide from town shed

Photo 2. Debris obstructing waterflow at bottom

Description of Observed Conditions:

Flooding during Irene caused massive landslide; has been built back with stone and graded to approximately at 60 degree angle. Stream at bottom of hillside was plugged with sediment; the Town reports using an excavator to re-channelize the stream, but flow has been greatly restricted. Grass area near shed now has surface drain, flows down 18” corrugated plastic pipe to stream. Tile drain also installed—drains to 8” corrugated plastic pipe along bank. Water also flowing off parking area down SW bank, causing 8” gully erosion. (Additional photos included on the next page.)

Problem Area Data Sheet

Field Photos	
	
Photo 3. Channel dug by town to allow water flow	**Photo 4.** Standing water in the stream, upstream of debris jam

Field Photos	
	
Photo 5. Pipe that now drains parking lot area	**Photo 6.** Stormwater flow down hillside to west, with visible erosion

Problem Area Data Sheet

Problem Area ID: **MQ-8**

Latitude: 44.935463 N

Longitude: 73.050711 W

Watershed:	Missisquoi River
Location:	Route 207, about 1500' south of the junction with Route 78
Problem Type:	Landslide
Identification Source:	Town Feedback
Ownership:	Private
Classification Level:	1

Problem Description:

Landslide on the VELCO power line, north of Missisquoi, west of VT-207.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Landslide area from access road

Photo 2. Eroded bank

Description of Observed Conditions:

Massive landslide, caused by Irene, took down two utility poles. 25-50 feet of eroded banks above access road. Some evidence of dumping (e.g., tires and trash). No real source of flow upstream; some springs at toe of bank. Area north of landslide is the utility right-of-way (grass).

Problem Area Data Sheet

Problem Area ID: MQ-9	Latitude: 44.926865 N	Longitude: 73.038982 W

Watershed:	Missisquoi River
Location:	Whitetail Dr, near the intersection with Brosseau Rd
Problem Type:	Local Drainage
Identification Source:	Town Feedback
Ownership:	Private
Classification Level:	2b

Problem Description:

Erosion on Whitetail Dr. at Brosseau Rd.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Landslide area from Brosseau Rd

Photo 2. Outfall N or Brosseau Rd

Description of Observed Conditions:

Two separate farm ditches channel runoff to culvert upstream of road. Culvert is 18” corrugated metal, may be too small for heavy flows. Evidence of blowout east of culvert. Side of road rip-rapped and overgrown, some repairs may have been done already.

Problem Area Data Sheet

Problem Area ID:	**MQ-12**	Latitude: 45.000202 N	Longitude: 73.090162 W
Watershed:	Missisquoi River		
Location:	Country Club Rd, from Sunset Dr to Duck Pond Rd		
Problem Type:	Future Opportunities		
Identification Source:	Town Feedback		
Ownership:	Private		
Classification Level:	3		

Problem Description:

Continued development around Highgate Springs and Country Club Rd.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Potential culvert outfall area

Photo 2. Close-up of submerged outfall

Description of Observed Conditions:

Looks to be terminus of culverted ditches, potentially ending up in lake. Culvert seems to be submerged, and pipes leading to lake are buried in soil. Two bucket loads of earth removed on either side of road, piled on site. These piles also appear in the aerial photo, suggesting that this is not a temporary staging area.

Problem Area Data Sheet

Problem Area ID: **MQ-13**

Latitude: 44.937642 N

Longitude: 73.044989 W

Watershed:	Missisquoi River
Location:	Mill Hill Rd, at intersection with Lamkin St
Problem Type:	BMP Retrofits
Identification Source:	Missisquoi River Basin Urban Areas Stormwater Mapping Project
Ownership:	Private
Classification Level:	3

Problem Description:

Investigate ravine for areas of active erosion.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Outfall from under-road culvert

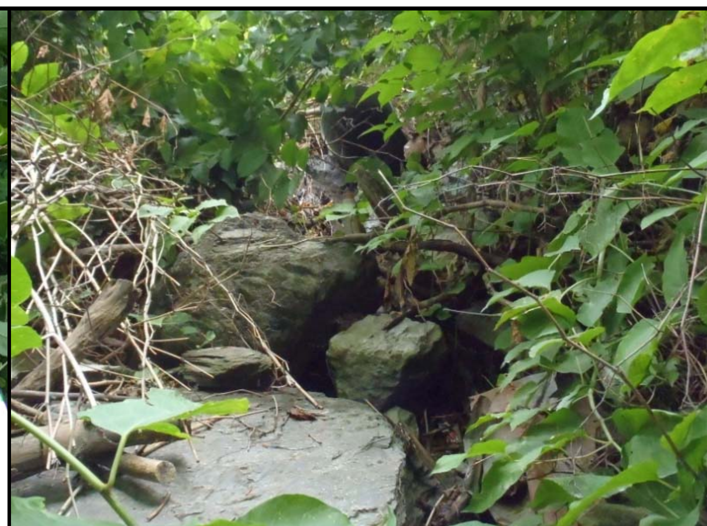


Photo 2. Looking back up at outfall

Description of Observed Conditions:

24” corrugated metal outfall at edge of the road; mapping suggests this pipe drains a significant portion of the village. Dripping flow. 18” abandoned pipe below. Rocks and trash also below outfall, down very steep bank. Evidence of erosion on embankment below outfall.

Problem Area Data Sheet

Problem Area ID: MQ-15	Latitude: 44.938998 N	Longitude: 73.044097 W

Watershed: Missisquoi River

Location: Gore Rd/VT-207

Problem Type: Future Opportunities

Identification Source: Town Plan

Ownership: Unknown

Classification Level: 3

Problem Description:

Unmanaged stormwater runoff from potential location of new park and ride at intersection of Routes 207 and 78.

Date of Field Data Collection: 7/16/12

Field Photos

Photo 1. Potential park and ride area

Photo 2. Intersection of Routes 207 and 78

Description of Observed Conditions:

Potential park and ride in town center, no stormwater infrastructure currently present. It is unclear whether the project would exceed an acre therefore trigger the need for a stormwater permit. Significant amount of "excess" pavement present from previous work to reconfigure intersection.

Problem Area Data Sheet

Problem Area ID:	MQ-16	Latitude: 44.933971 N	Longitude: 72.984957 W

Watershed:	Missisquoi River
Location:	Durkee Rd, north of the intersection with Hanna Rd
Problem Type:	Local Drainage
Identification Source:	Town Feedback
Ownership:	Unknown
Classification Level:	3

Problem Description:

Significant erosion in roadside ditches on Durkee Rd.

Date of Field Data Collection: 9/27/12

Field Photos

Photo 1. Ditching on East side of Durkee Rd

Photo 2. Erosion on West side of Durkee Rd

Description of Observed Conditions:

Construction/maintenance of roadside ditches has resulted in over-steepened banks along Durkee Rd. Vegetation has slumped off the banks in several spots (Photo 2), and erosion/scour is evident along both sides of the road.

Problem Area Data Sheet

Problem Area ID:	**MQ-17**	Latitude: 44.923322 N	Longitude: 72.985536 W

Watershed:	Missisquoi River
Location:	Pine Plains Rd, south of intersection with Route 78
Problem Type:	Local Drainage
Identification Source:	Town Feedback
Ownership:	Unknown
Classification Level:	4

Problem Description:

Significant erosion along Pine Plains Rd.

Date of Field Data Collection: 9/27/12

Field Photos

Photo 1. Overland flow near base of Pine Plains Rd

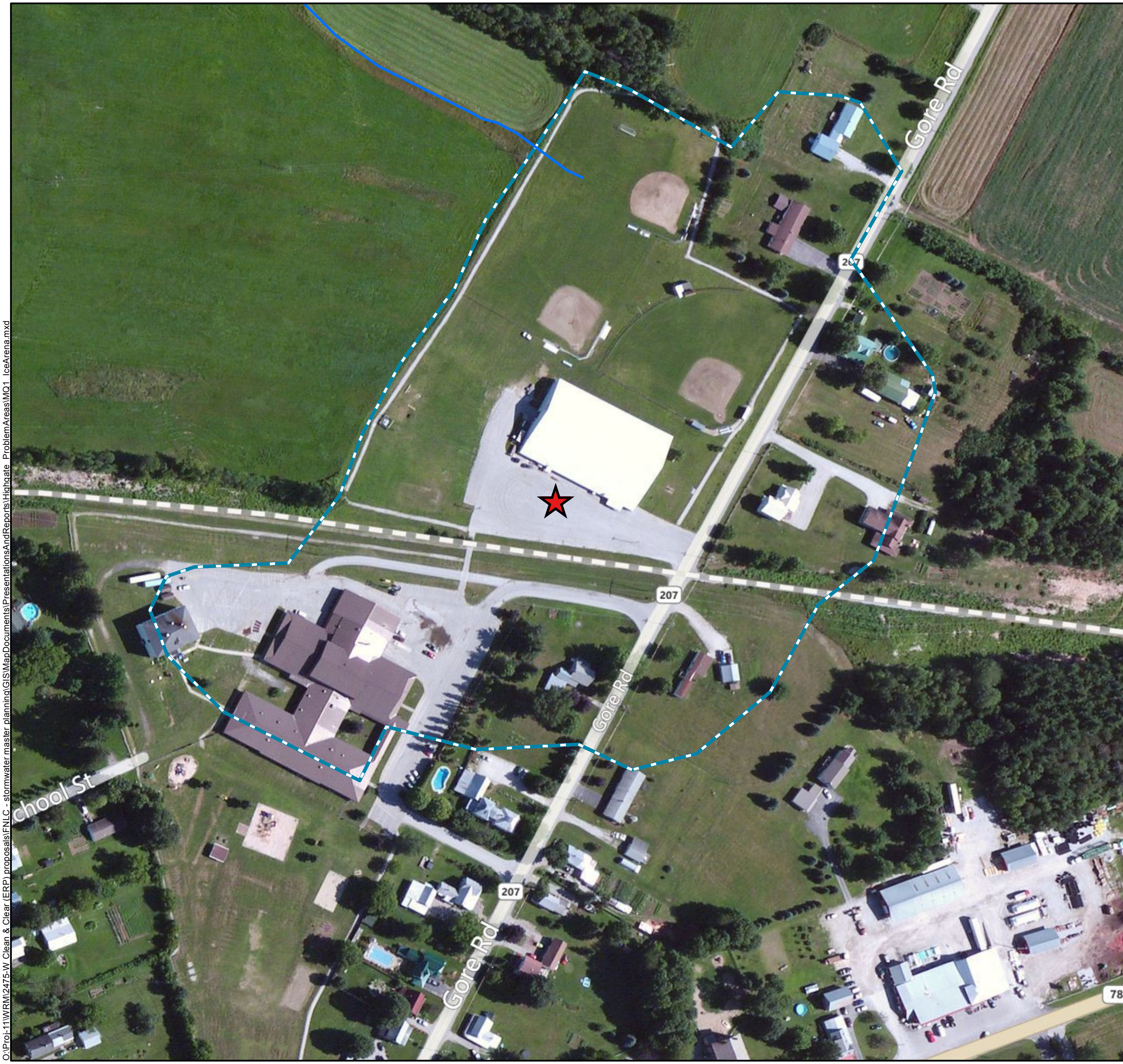
Photo 2. Separate instance of overland flow

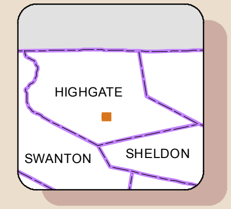
Description of Observed Conditions:

Pine Plains Rd is steep, as you move south along it from Highgate into Sheldon, with significant erosion in sections. Turnouts have been constructed leaving substantial sediment deposits in adjacent woodlands. In at least one instance the sediment "plume" extends to a small, unnamed tributary to the Missisquoi River. Road ownership is unclear and may complicate a complete solution:

- Lower portions of the road are owned/maintained by the Town of HIghgate;
- There is an open gate approximately 200 feet from the beginning of the road;
- Highgate/Sheldon town line is 0.2 mile from Pine Plains Rd/VT-78 intersection.

APPENDIX D: DRAINAGE AREA MAPS FOR PRIORITY STORMWATER PROBLEM AREAS





N

0 50 100 200 Feet

SW Treatment Opportunity

River or Stream

Drainage Area (19 Acres)

Erodible Soils (k > 0.17)

Treatment Opportunity:
Stormwater retrofits possible near Ice Arena.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Highgate Recreation Facility

MQ-1

Highgate Stormwater Management Planning

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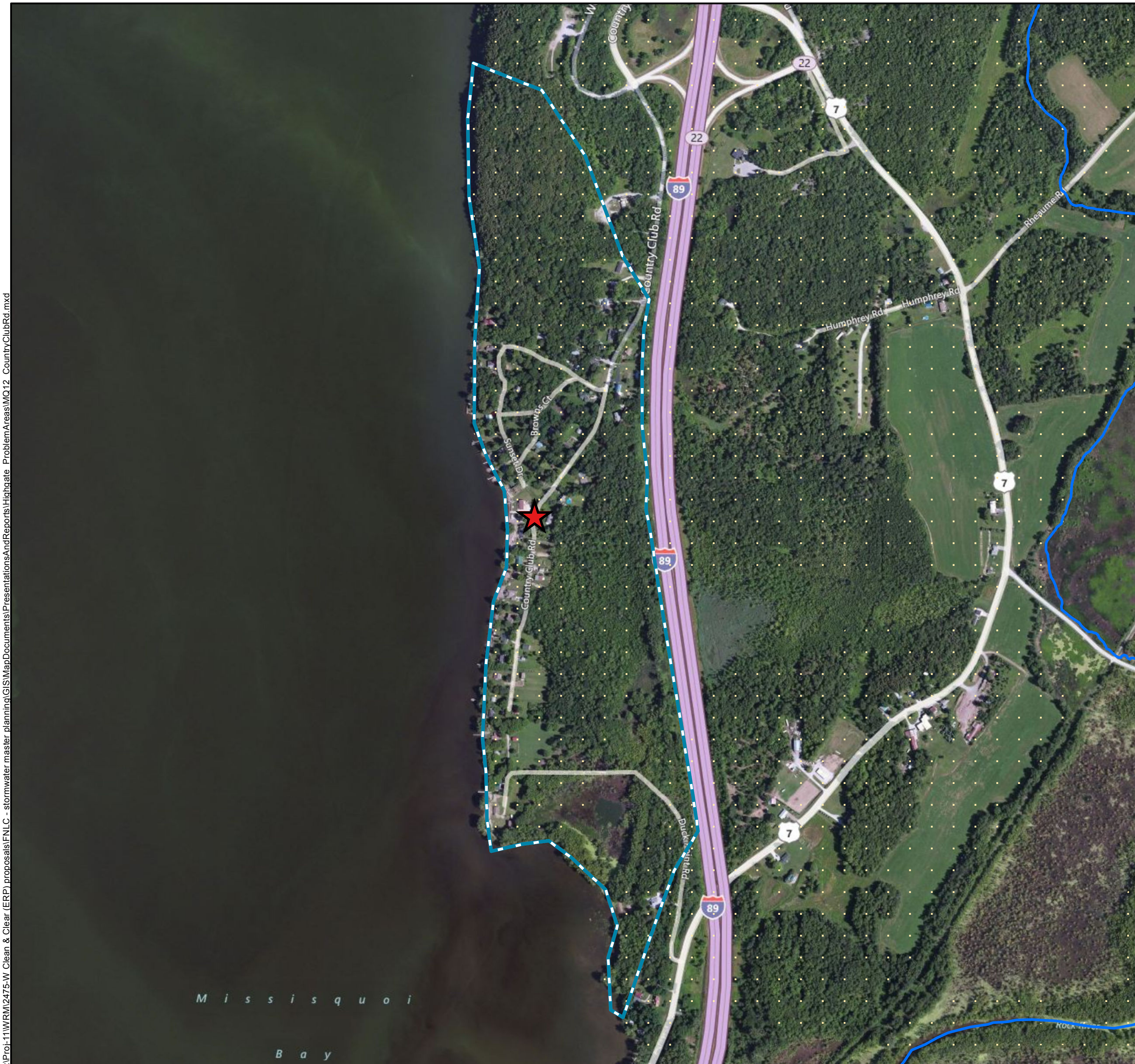

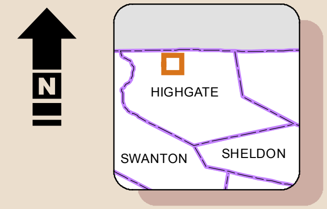

0 255 510 1,020
Feet

SW Treatment Opportunity

River or Stream

Drainage Area (122 Acres)

Erodible Soils (k > 0.17)

Treatment Opportunity:
Continued development around Country Club Rd.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Country Club Rd

MQ-12

Highgate Stormwater Management Planning

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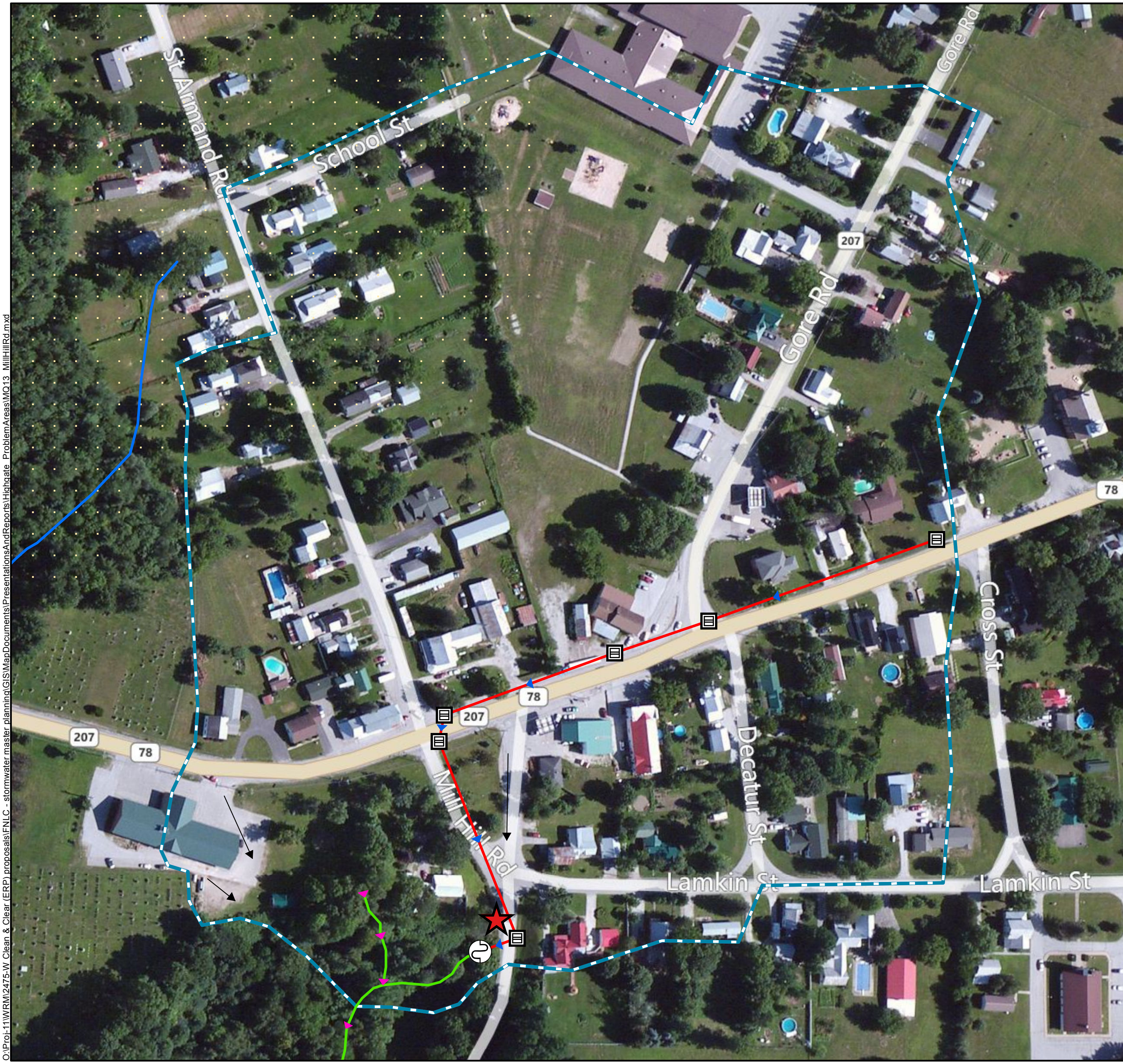

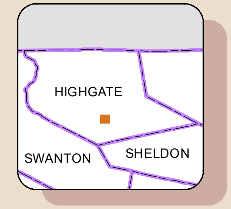

N

0 50 100 200
Feet

SW Treatment Opportunity
River or Stream
Drainage Area (33 Acres)
Erodible Soils (k > 0.17)
Catchbasin
Outfall
Storm line
Swale
Overland flow

Treatment Opportunity:
Ongoing erosion in ravine recieving storm flows from village area.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

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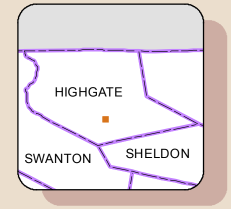
Mill Hill Rd Outfall

MQ-13

Highgate Stormwater Management Planning



N

0 30 60 Feet

SW Treatment Opportunity
River or Stream
Drainage Area (1 Acre)
Erodible Soils (k > 0.17)
Catchbasin
Outfall
Storm line
Swale
Overland flow

Treatment Opportunity:
Possible location of new Park and Ride at intersection of 207 and 78.

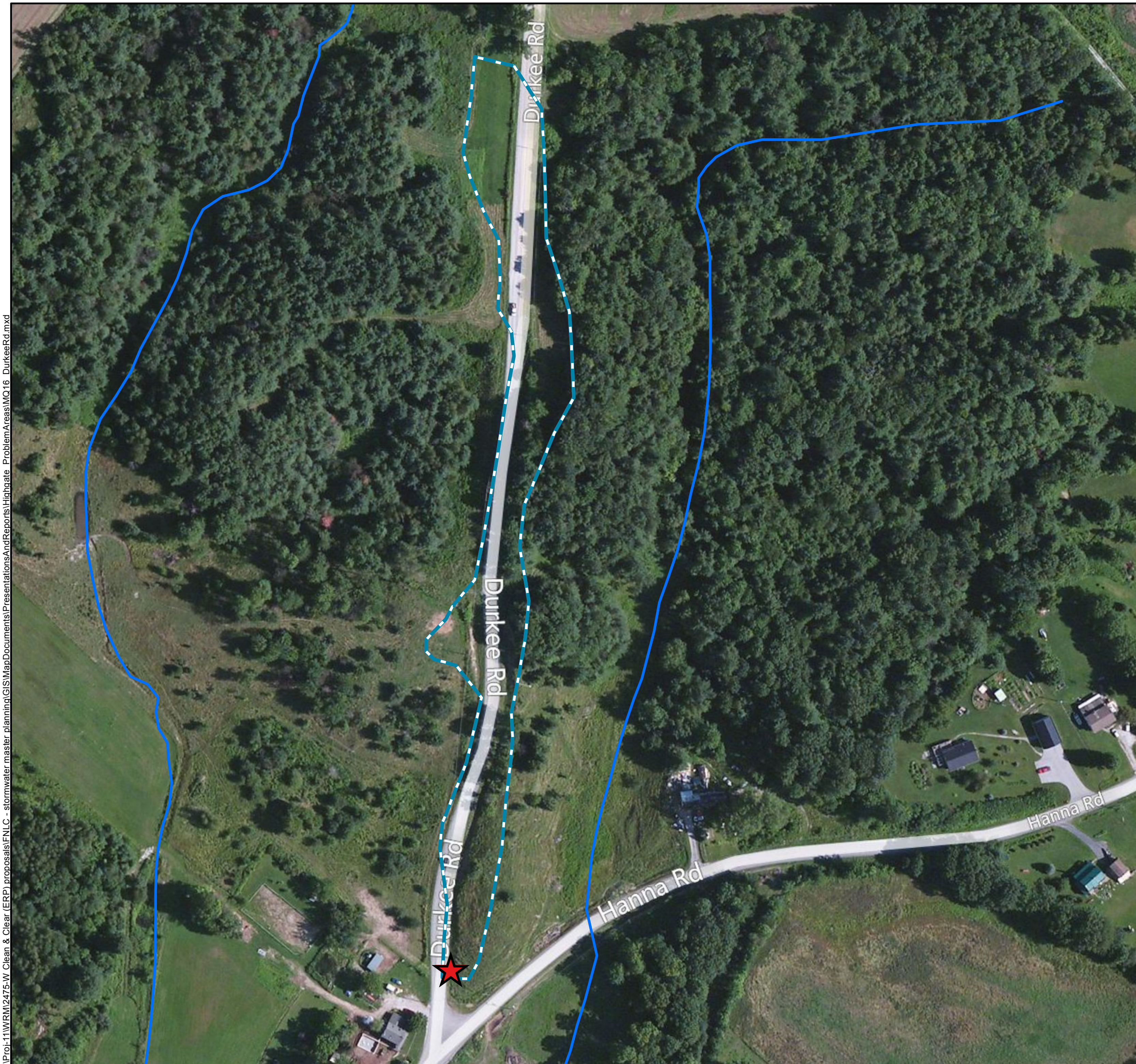
Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Gore Rd Potential Park and Ride Location

MQ-15

Highgate Stormwater Management Planning



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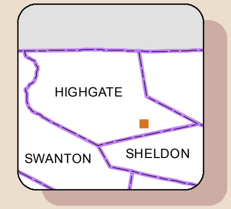

0 55 110 220 Feet

SW Treatment Opportunity

River or Stream

Drainage Area (2.3 Acres)

Erodible Soils (k > 0.17)

Treatment Opportunity:
Significant erosion in roadside ditches on Durkee Rd.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Durkee Rd

MQ-16

Highgate Stormwater Management Planning

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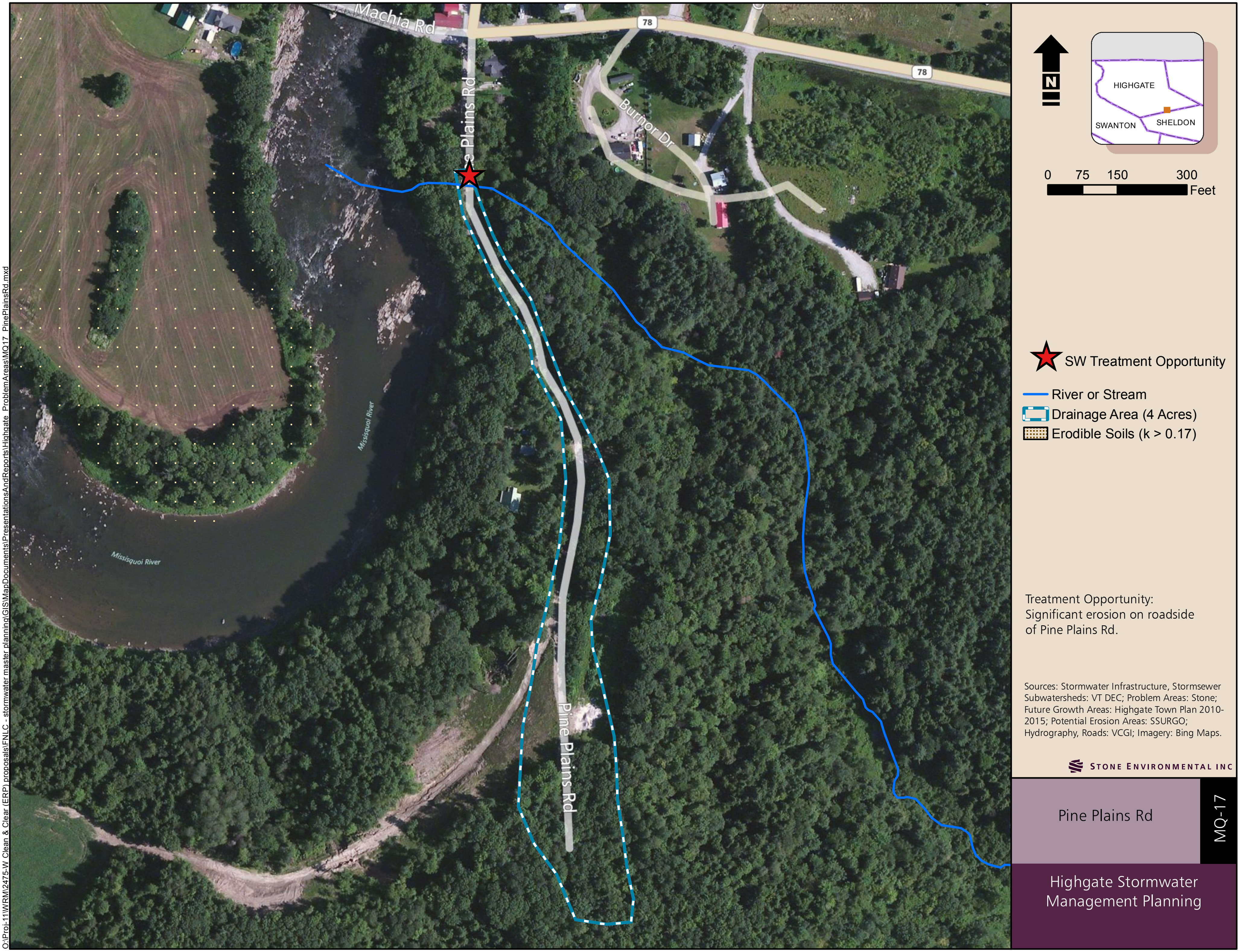

Machia Rd
78
78
Pine Plains Rd
Burnor Dr
Missisquoi River
Missisquoi River
Pine Plains Rd
N
HIGHGATE
SWANTON
SHELDON
0 75 150 300
Feet
SW Treatment Opportunity
River or Stream
Drainage Area (4 Acres)
Erodible Soils (k > 0.17)
Treatment Opportunity:
Significant erosion on roadside
of Pine Plains Rd.
Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.
STONE ENVIRONMENTAL INC
Pine Plains Rd
MQ-17
Highgate Stormwater
Management Planning
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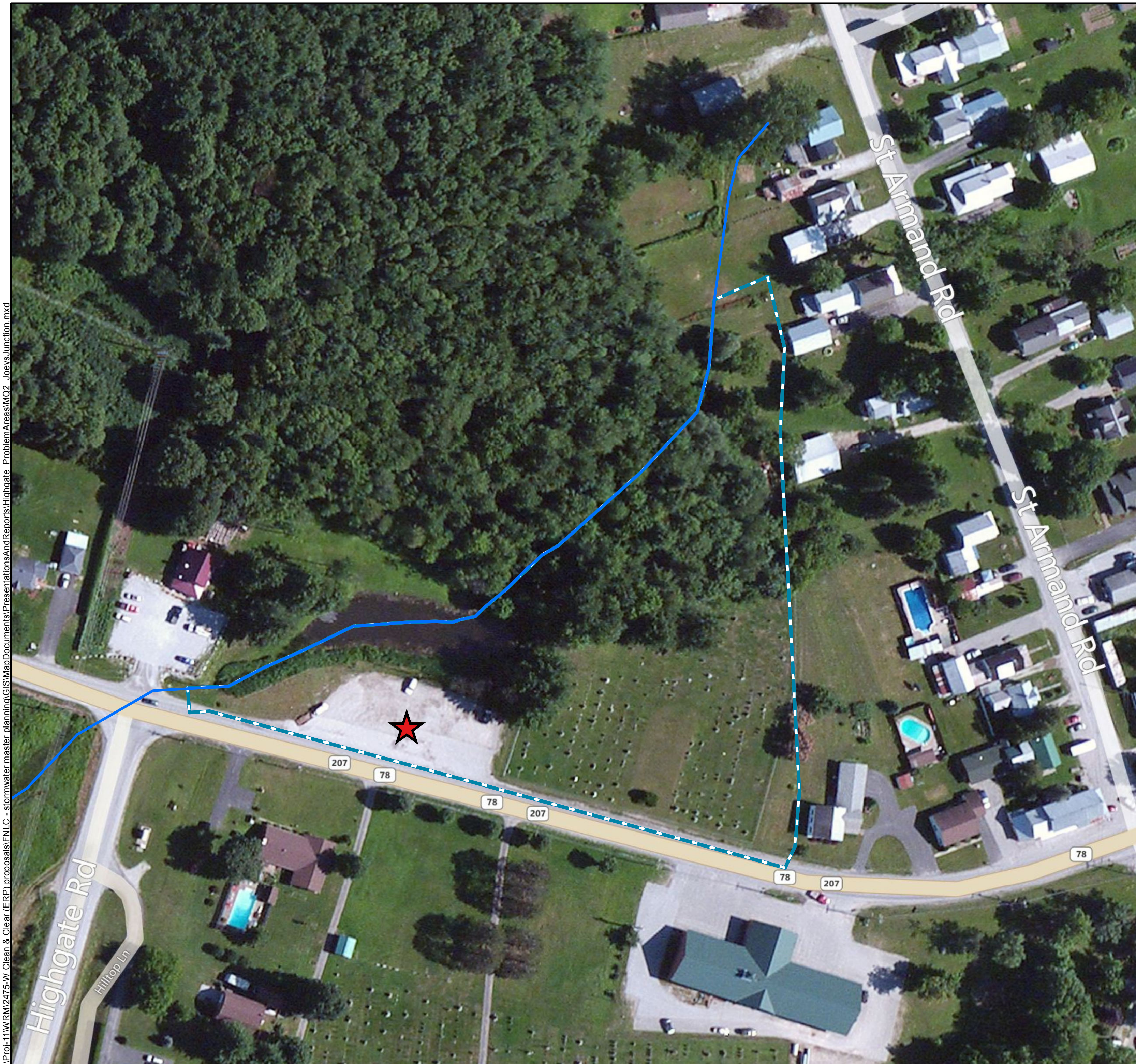

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N

HIGHGATE
SWANTON
SHELDON

0 25 50 100 Feet

SW Treatment Opportunity
River or Stream
Drainage Area (3 Acres)
Erodible Soils (k > 0.17)

Treatment Opportunity:
Stormwater retrofits possible at Park and Ride next to Joey's Junction.

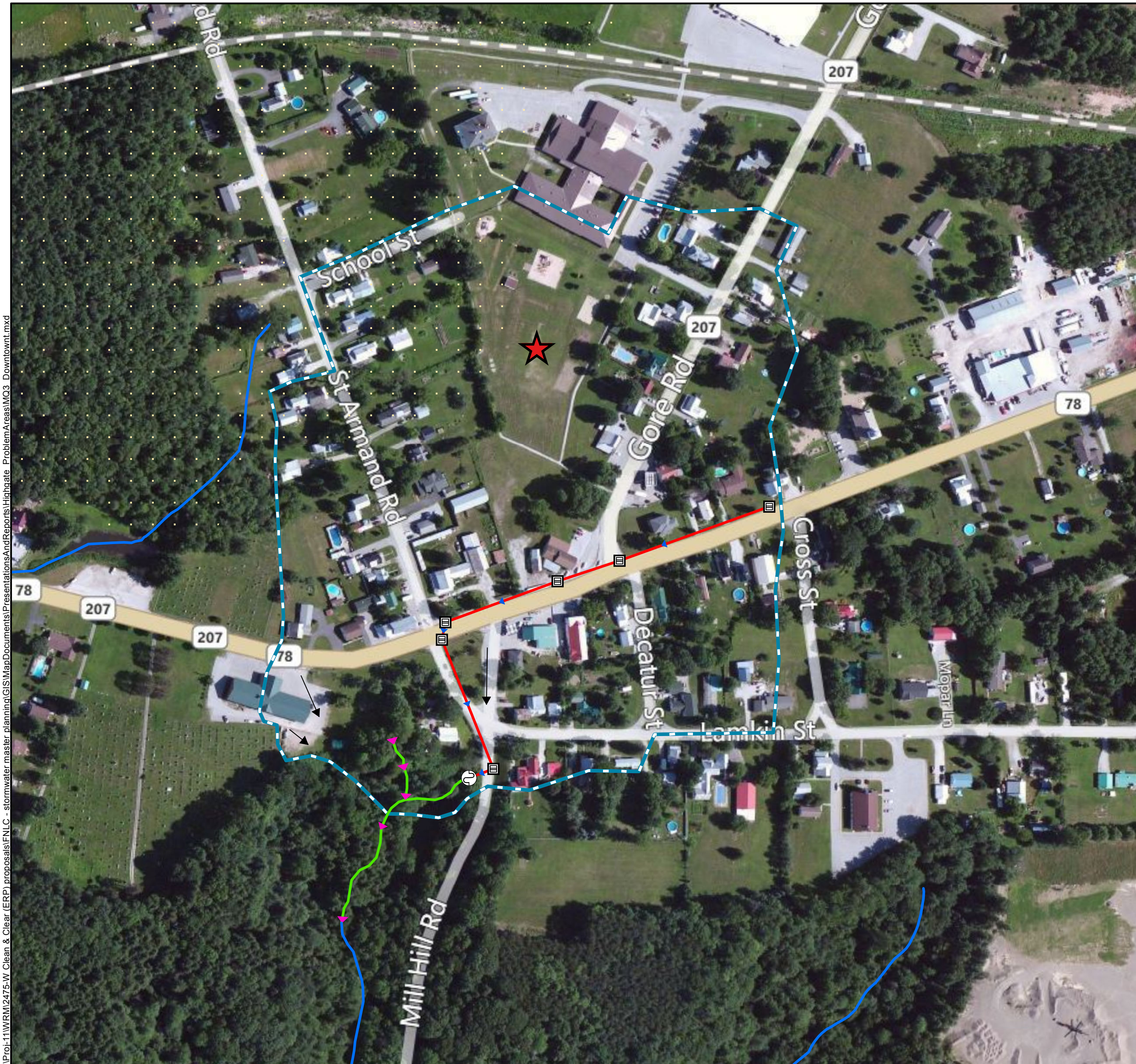
Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Joey's Junction
Park and Ride

MQ-2

Highgate Stormwater
Management Planning



Treatment Opportunity: Stormwater retrofits possible in village area; best opportunities are near school.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

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Downtown Highgate

MQ-3

Highgate Stormwater Management Planning

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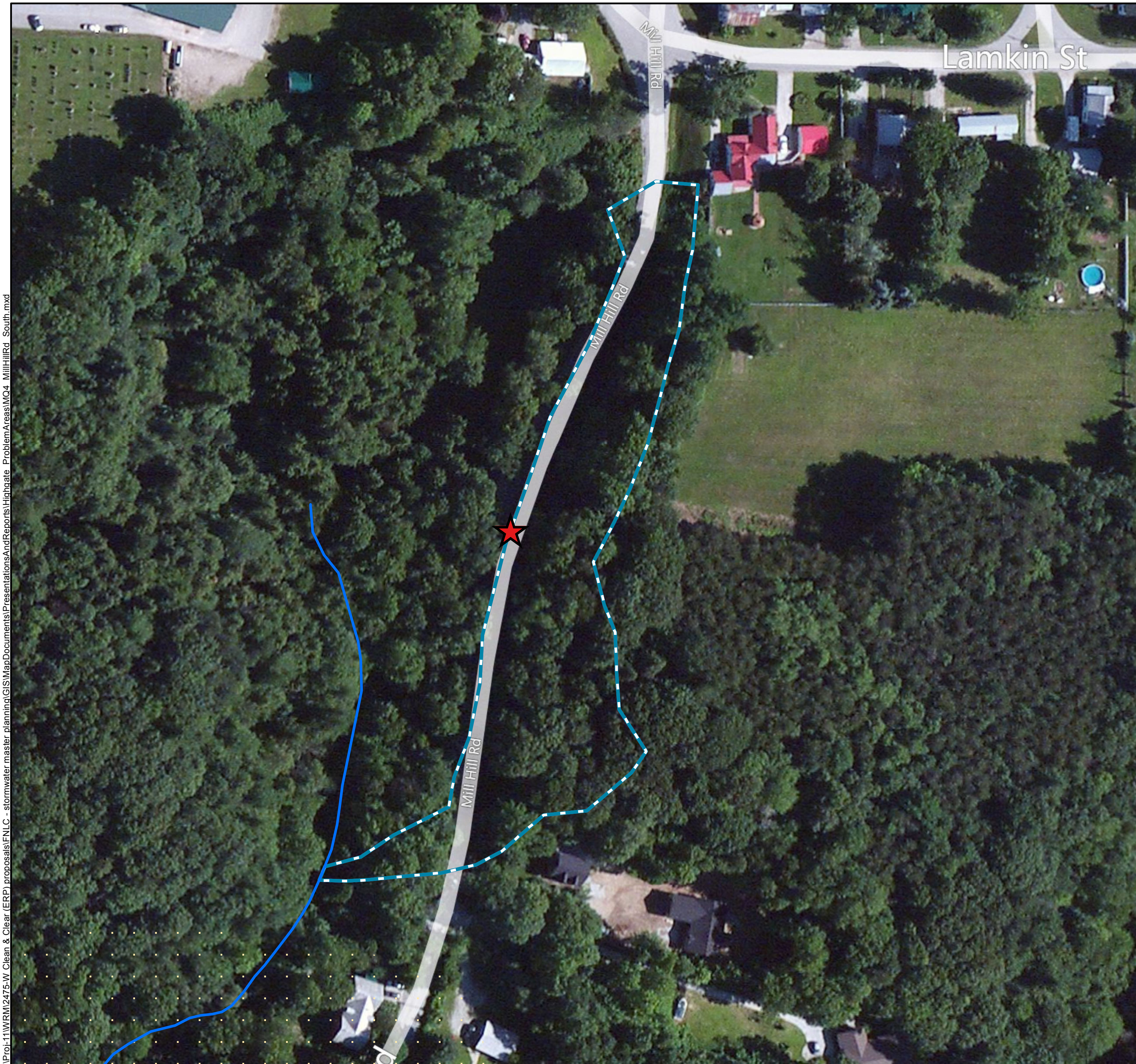

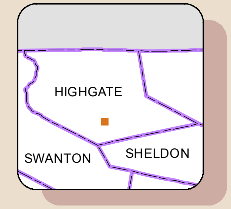

N

0 30 60 120 Feet

SW Treatment Opportunity

River or Stream

Drainage Area (1.6 Acres)

Erodible Soils (k > 0.17)

Treatment Opportunity:
Gully erosion present near the bridge over an unnamed tributary to the Missisquoi River.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Mill Hill Rd South

MQ-4

Highgate Stormwater Management Planning

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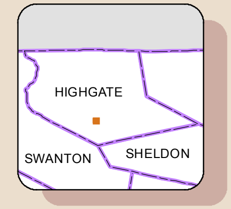

N

0 25 50 100 Feet

SW Treatment Opportunity
River or Stream
Drainage Area (2.8 Acres)
Erodible Soils (k > 0.17)

Treatment Opportunity:
Runoff from Town Garage continues to exacerbate landslide that occurred during May 2011 flooding.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Town Highway Garage

MQ-7

Highgate Stormwater Management Planning

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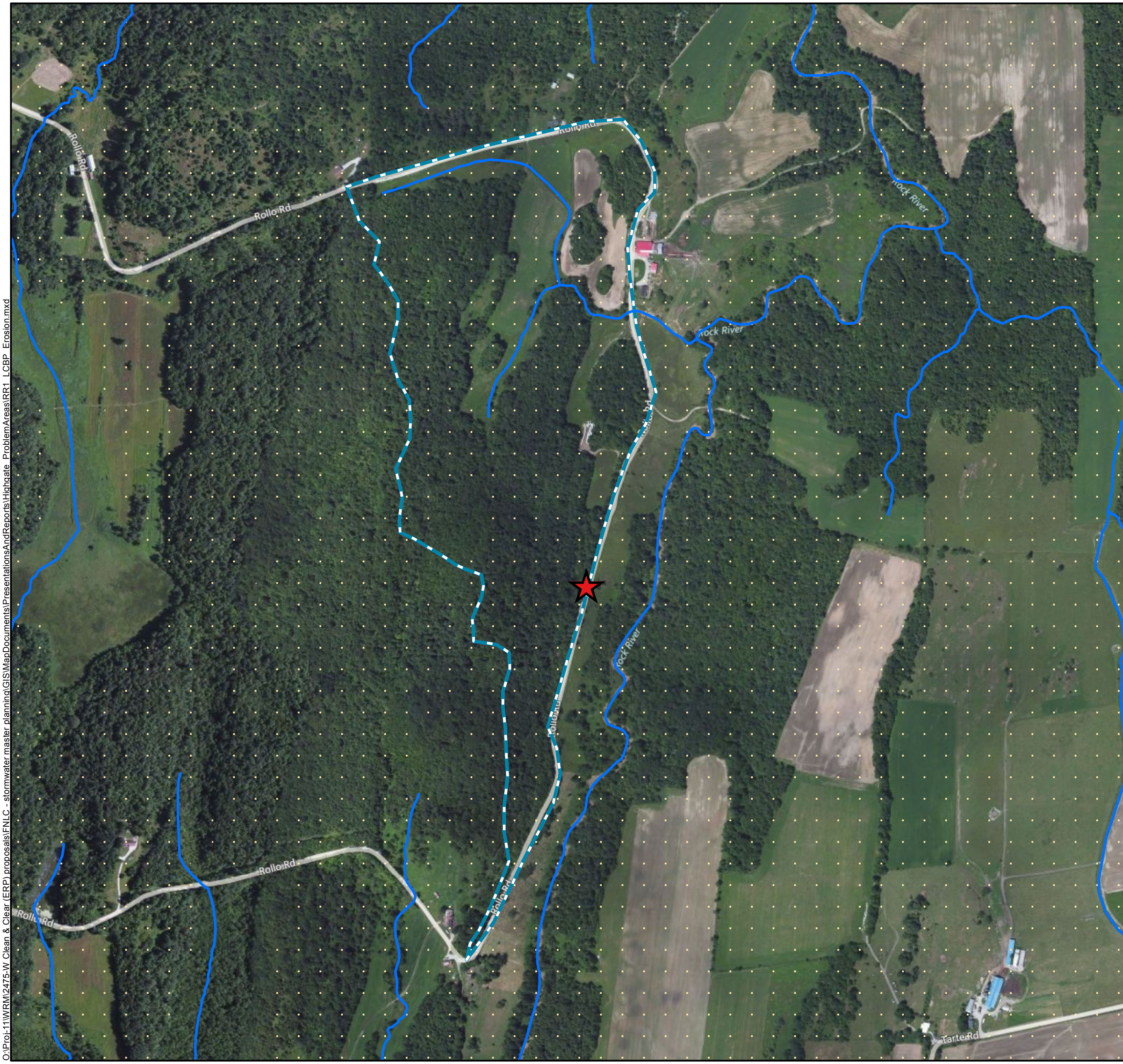
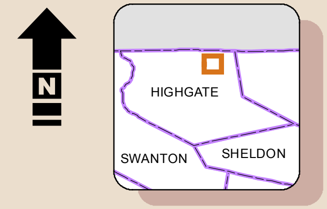




0 260 520 1,040 Feet

SW Treatment Opportunity
River or Stream
Drainage Area (103 Acres)
Erodible Soils (k > 0.17)

Treatment Opportunity:
Missisquoi Bay Basin CSA model indicates that Rollo Road may be a significant source of phosphorous and sediment pollution due to steep grade and proximity to Rock River.

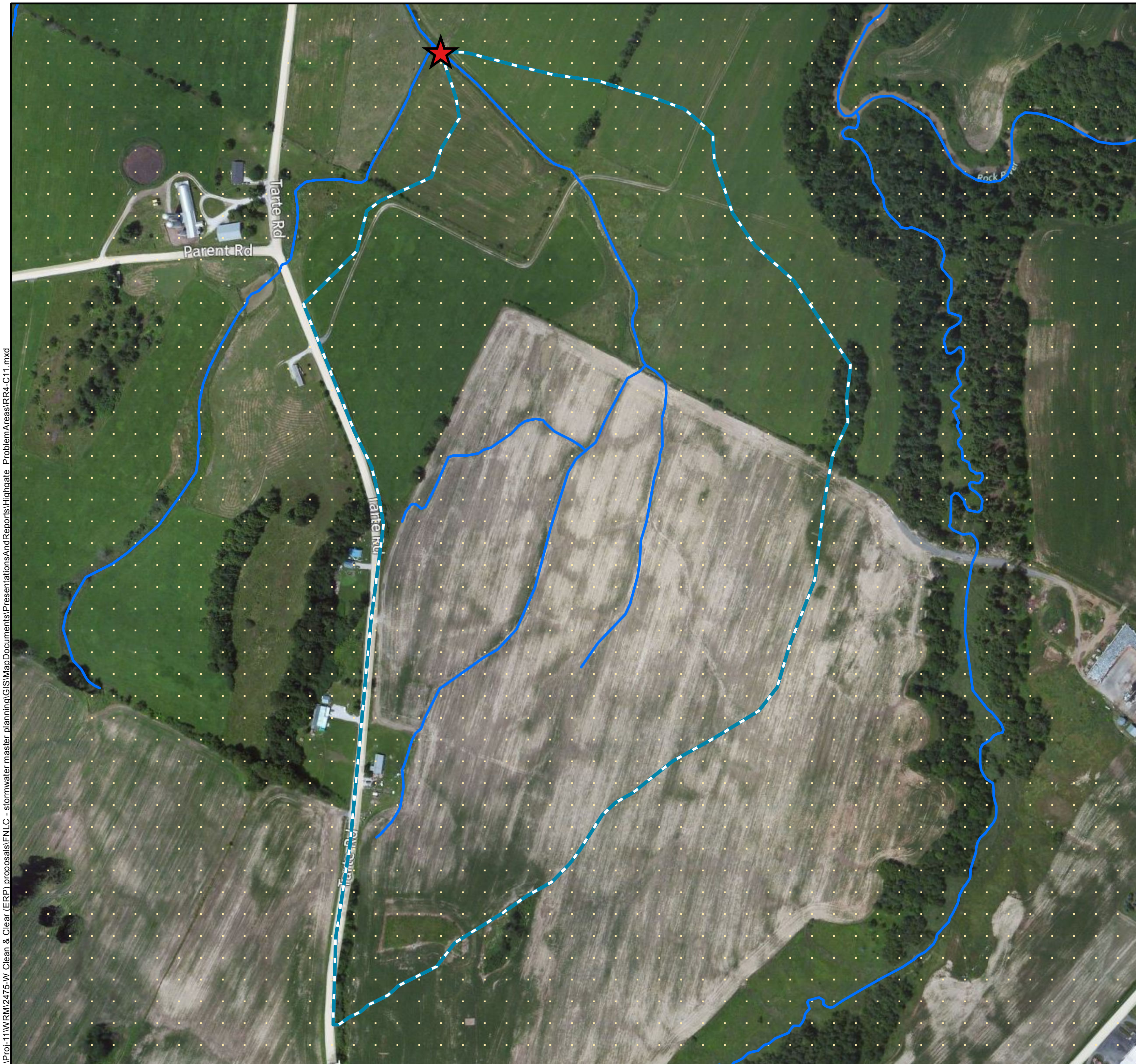
Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

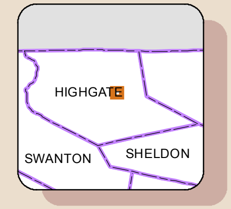
STONE ENVIRONMENTAL INC

Rollo Rd Drainage

RR-1

Highgate Stormwater Management Planning





N

0 130 260 520
Feet

SW Treatment Opportunity

River or Stream

Drainage Area (73 Acres)

Erodible Soils (k > 0.17)

Treatment Opportunity:
Ponding at both ends of culvert under farm road.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Tarte Road Farm Culvert

RR-4-C11

Highgate Stormwater Management Planning

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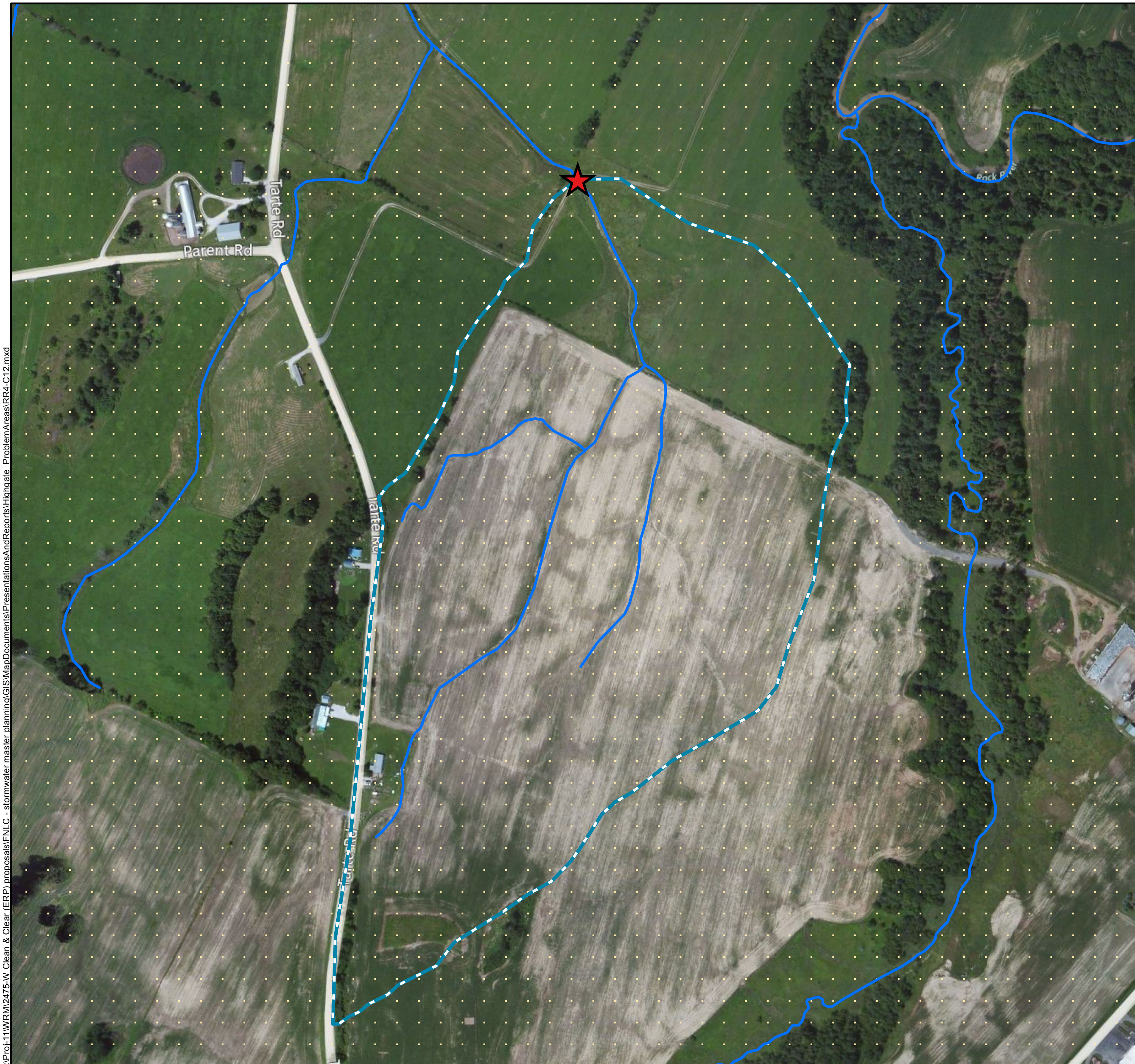

HIGHGATE
SWANTON
SHELDON

0 130 260 520
Feet

SW Treatment Opportunity
River or Stream
Drainage Area (58 Acres)
Erodible Soils (k > 0.17)

Treatment Opportunity:
Undersized culvert under farm road--significant erosion visible. Culvert is immediately upstream of RR-4-C11.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Tarte Road Farm Culvert

RR-4-C12

Highgate Stormwater Management Planning

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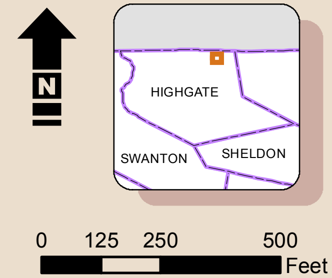

SW Treatment Opportunity

River or Stream

Drainage Area (29 Acres)

Erodible Soils (k > 0.17)

Treatment Opportunity:
Ford used to cross Rock River,
no bridges or culverts present.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Rollo Rd Ford

RR-8-1

Highgate Stormwater Management Planning

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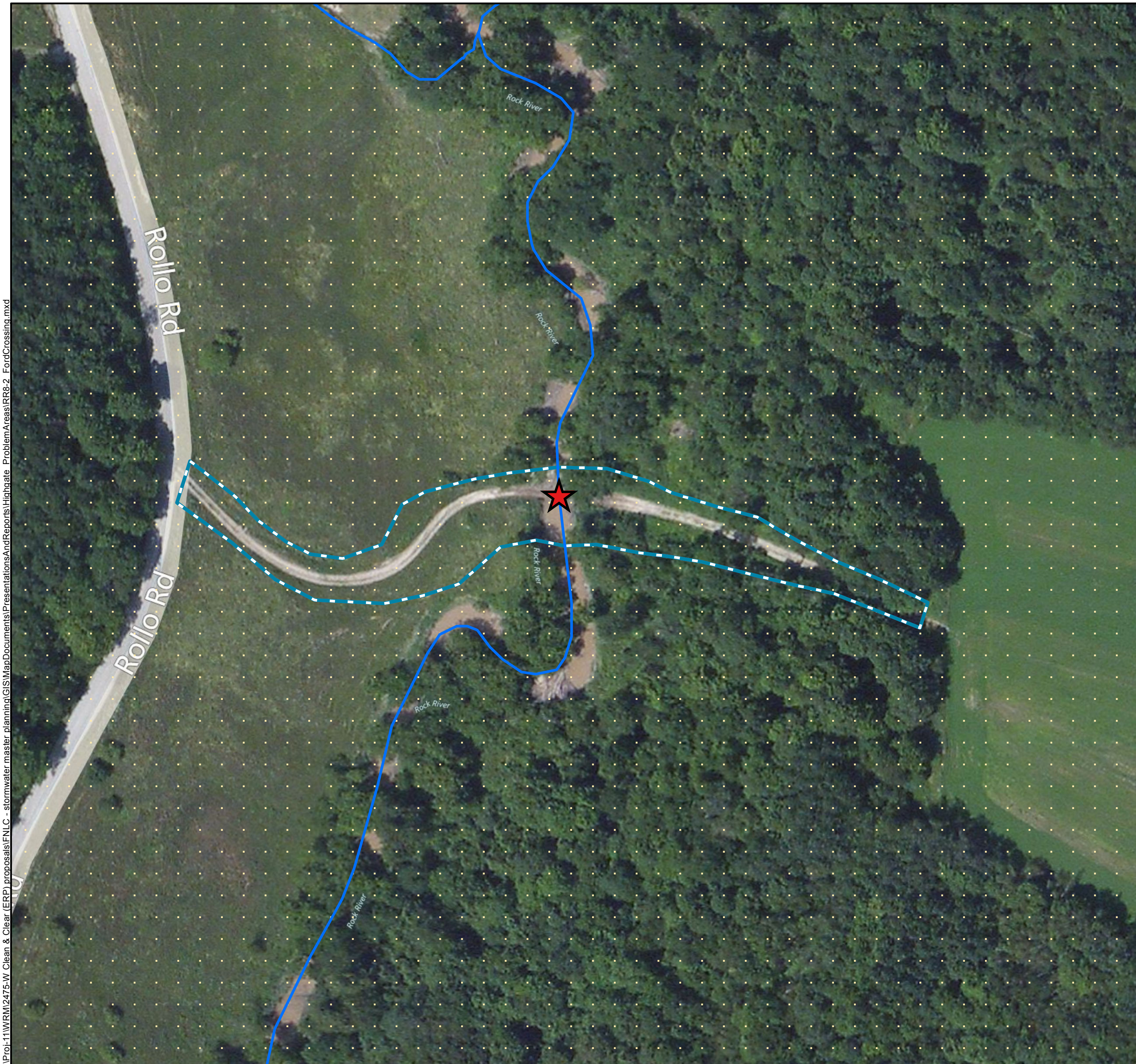

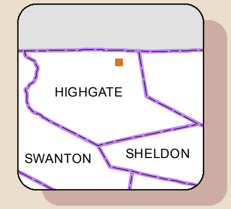

N

0 25 50 100
Feet

SW Treatment Opportunity
River or Stream
Drainage Area (1 Acre)
Erodible Soils (k > 0.17)

Treatment Opportunity:
Ford used to cross Rock River,
no bridges or culverts present.

Sources: Stormwater Infrastructure, Stormsewer Subwatersheds: VT DEC; Problem Areas: Stone; Future Growth Areas: Highgate Town Plan 2010-2015; Potential Erosion Areas: SSURGO; Hydrography, Roads: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Rollo Rd Ford

RR-8-2

Highgate Stormwater
Management Planning

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APPENDIX E: CONCEPTUAL SOLUTIONS FOR HIGHEST PRIORITY STORMWATER PROBLEM AREAS

MEMO

STONE ENVIRONMENTAL INC

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Montpelier, Vermont
05602 USA

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SEI No. 11-2475
Re: Highgate SWMP: Priority Projects

1.0 INTRODUCTION

During the spring and summer of 2012, Stone staff identified and evaluated problem areas in the Town of Highgate. The compiled list of problem areas gave priority to those with the most potential to improve water quality and/or where effective treatment was most feasible. Stone then revisited the highest priority sites to further investigate treatment potential and gather additional information needed to develop conceptual solutions.

The intent of this memo is to present a list of high priority stormwater improvement projects within the Town of Highgate. All references to soil types are based on reports produced by the USDA-NRCS Web Soil Survey[1]. Measurements, watershed delineations, and direction of flow as reported in this memo were based on GIS analysis or field investigation. While this information is sufficient to support the pre-engineering design concepts presented in this document, final design will require a more comprehensive and detailed survey of each site.

1 http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

1.1 Durkee Rd. Highgate Center

Figure 1. Area of eroding slopes highlighted in yellow.

Recent roadway improvement work along Durkee Road in Highgate Center has resulted in over-steepened banks causing erosion of sections of the ditch backslopes along both sides of the road. The section of road affected is fairly steep, and is located only about a third of a mile from the Missisquoi River. Approximately 300 feet of road side ditch is affected, with the backslope reaching a maximum approximate height of 10 ft (see Figure 2 and Figure 3).

Figure 2. Oversteepened and eroding ditch backslope on west side of Durkee Rd. in Highgate Center.

Figure 3. Eroding ditch backslope on the east side of Durkee Road in Highgate Center.

The simplest solution would be to re-grade the backslopes to a maximum 3:1 slope and establishing vegetation. A drawback to this solution is the encroachment on private land when the slopes are partially flattened. Alternatively the backslopes could be re-graded to a maximum 2:1 slope and erosion control matting or a riprap blanket (stone armoring) installed. A third and even more intensive solution would be to install structures such retain walls. This approach would require engineering design and heavy construction work, but would minimize encroachment on private property.

1.2 Highgate Elementary

The Highgate Elementary School campus includes a large amount of impervious surface; 2.3 acres of roof top and asphalt parking area have been identified as treatable impervious areas. Figure 4 shows treatable impervious area (blue outline) and potential stormwater treatment practice (STP) locations (yellow outline). Roof runoff could be captured and treated in bioretention areas and rain gardens installed around below the drip-edge around the perimeter of the building and in the two center courtyards (Figures 5-7).

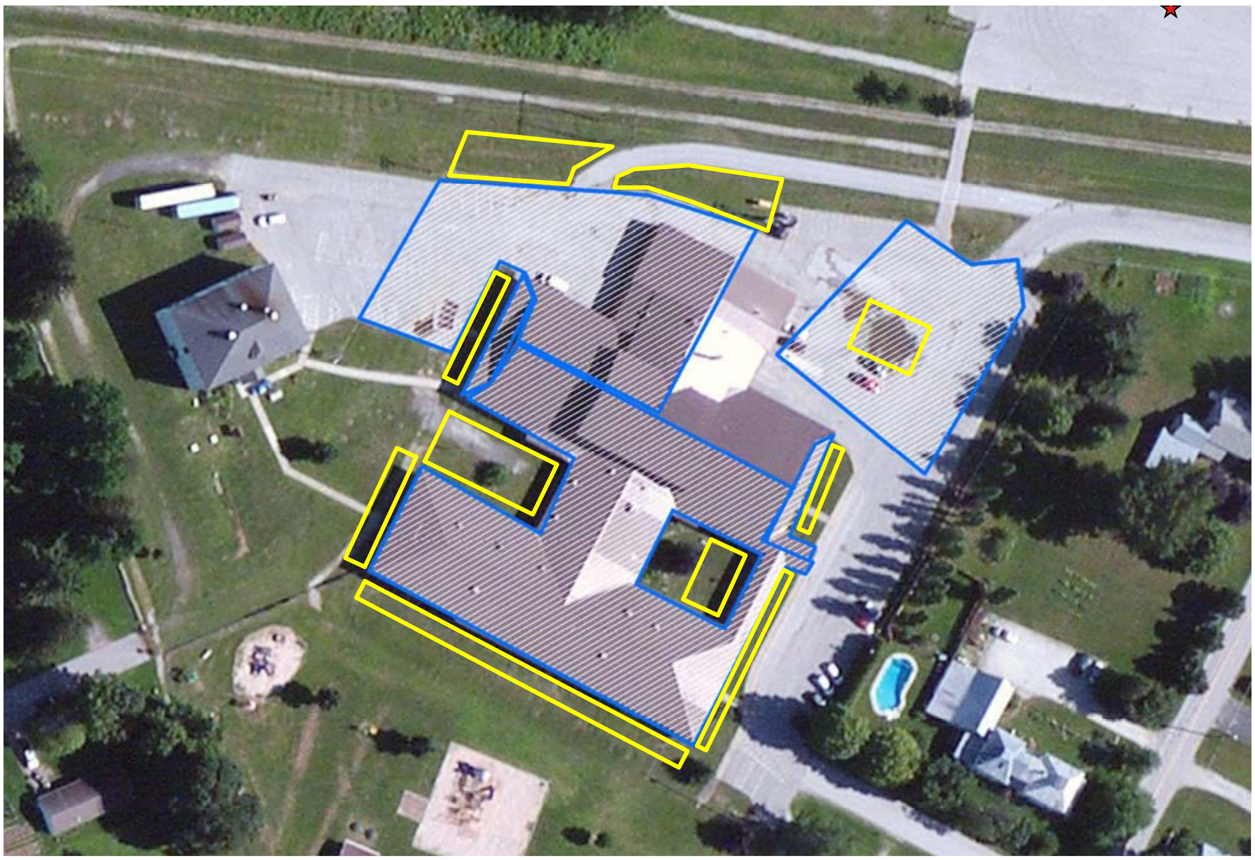

Figure 4. Highgate Elementary School. Treatable impervious surface is highlighted in blue and potential STP locations are shown in yellow.

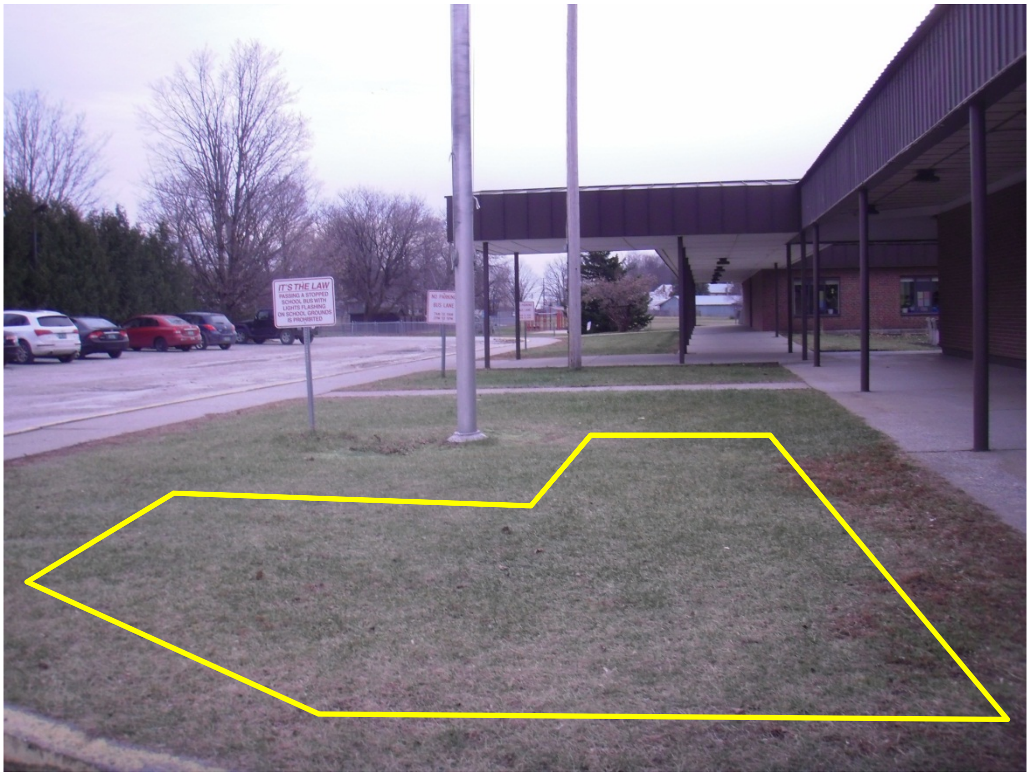

Figure 5. Bioretention areas located under the drip edge of the roof could collect and infiltrate runoff near the front entrance to the school.

Figure 6. Infiltration area opportunity in the back of the school.

Figure 7. A large rain garden or bioretention area could be installed in the rear courtyard of the school where green space is not currently utilized.

Parking lot runoff could be treated in STPs located around the perimeter as shown in Figure 4, or in the middle of the lot as shown in Figure 8. The area highlighted in yellow is a low point that currently collects a section of parking could be converted to act as an infiltration area—a parking island designed to collect and infiltrate stormwater. This STP would look similar to a typical parking lot island, only rather than being raised above the pavement, the island would sit slightly below the surrounding pavement. Stormwater would flow into the island where it would infiltrate. An example of this infiltration practice is shown in Figure 9.

Figure 8. Low area in parking lot (shown in yellow) could be converted to stormwater treatment practice.

Figure 9. Example of a parking island being used to treat stormwater (Photo source: Cougar Creek Streamkeepers, http://www.vcn.bc.ca/cougarcr/raingardensrichardson.html).

The NRCS reports soils at the school to the well-drained Windsor loamy fine sand, (Hydrologic Soil Group A) to extend from the west edge of the building to the east edge of the parking lot. The depth to water table is reported to be greater than 200 cm. Infiltration practices would be expected to be very effective in these soils.

All STPs at this site would have to rely on infiltration to discharge stormwater. There is no storm sewer infrastructure on the property to tie into and little change in grade to accommodate underdrain outlets to the ground surface. Thorough soil analysis and infiltration rate study would be essential to assure a properly functioning design.

The existing pavement is showing signs of wear. The soils under a large portion of the northern and eastern sections of parking lot are reported to be quite suitable for infiltration. When the pavement reaches the end of its service life and needs to be replaced a low-impact design concept should be considered. Porous asphalt or pavers would likely be effective in reducing stormwater given the well-drained soils underlying the parking lot.

1.3 Transfer Station

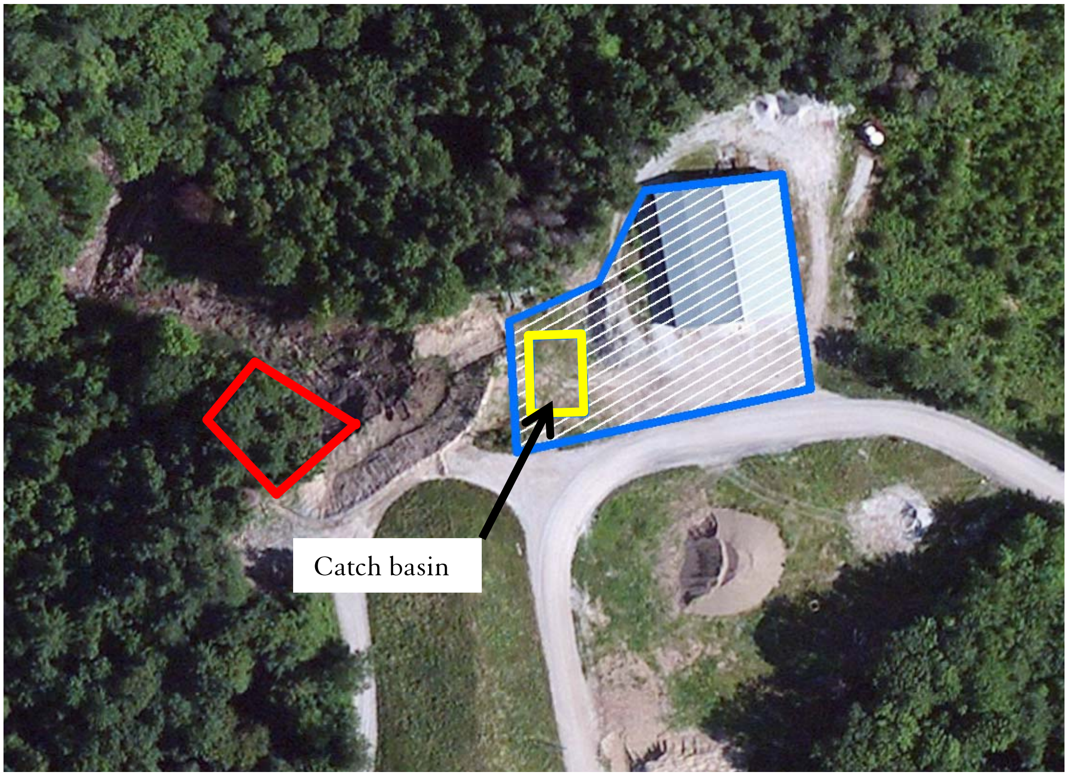

Figure 10. Highgate town sand shed property. 0.65 acres of treatable impervious area is shown in blue, proposed STP location in yellow, and erosion gully shown in red. Note: slope damage shown in photo has been repaired.

The Highgate town sand shed property (Figure 11), located on Transfer Station Road, is a potential source of sediment to a tributary of the Missisquoi River. This property was the site of a slope failure that occurred in spring of 2011 (visible in Figure 10). The failed slope has since be repaired and stabilized but some lingering issues remain. A catch basin was found to be completely filled with sediment during a December 2012 inspection (see Figure 12). It was not apparent whether this catch basin drained to a dry well or to a conventional outlet. Regardless, the catch basin is filled to a point where it does not function. Stormwater is also concentrating and leaving the site west of the repaired slope. A gully is evident at this location. Stabilization measures should be considered to prevent propagation of the gully.

Figure 11. Town sand shed and adjacent gravel lot includes more than 0.5 acres of potentially treatable impervious surface.

Figure 12. Sediment has completely filled catch basin at the Highgate town sand shed.

Figure 13. Erosion gully forming near repaired landslide at Highgate town sand shed.

The NRCS reports soils at the site to be well-drained Windsor loamy fine sand (HSG A) with a deep water table. Infiltration could be effective in an STP if the native soils are present as indicated.

An infiltration-based STP could be constructed using the existing catch basin as an outlet. The STP could help keep sediment on-site reduce impacts to water quality and reduce the need to clean out the catch basin as often.

1.4 Park and Ride

The Town of Highgate Municipal Plan reports an on-going initiative to locate a Park-and-Ride facility at the corner of VT-207 and VT-208 in downtown Highgate. A significant portion of the area is currently paved, the asphalt being a relic from when the intersection was reconfigured several years ago. This area currently drains to the stormwater outfall described in more detail in Section 1.5 of this memo.

Soils in at this location are reported by the NRCS as Windsor loamy, fine, sand with a deep water table (over 200 cm). These soil conditions and flat topography make infiltration practices an effective option. As plans develop, low-impact design practices such as porous pavement and infiltration features should be strongly promoted. Alternatively, if plans for the Park-and-Ride facility at this location are abandoned, the existing pavement could be removed and natural site hydrology restored.

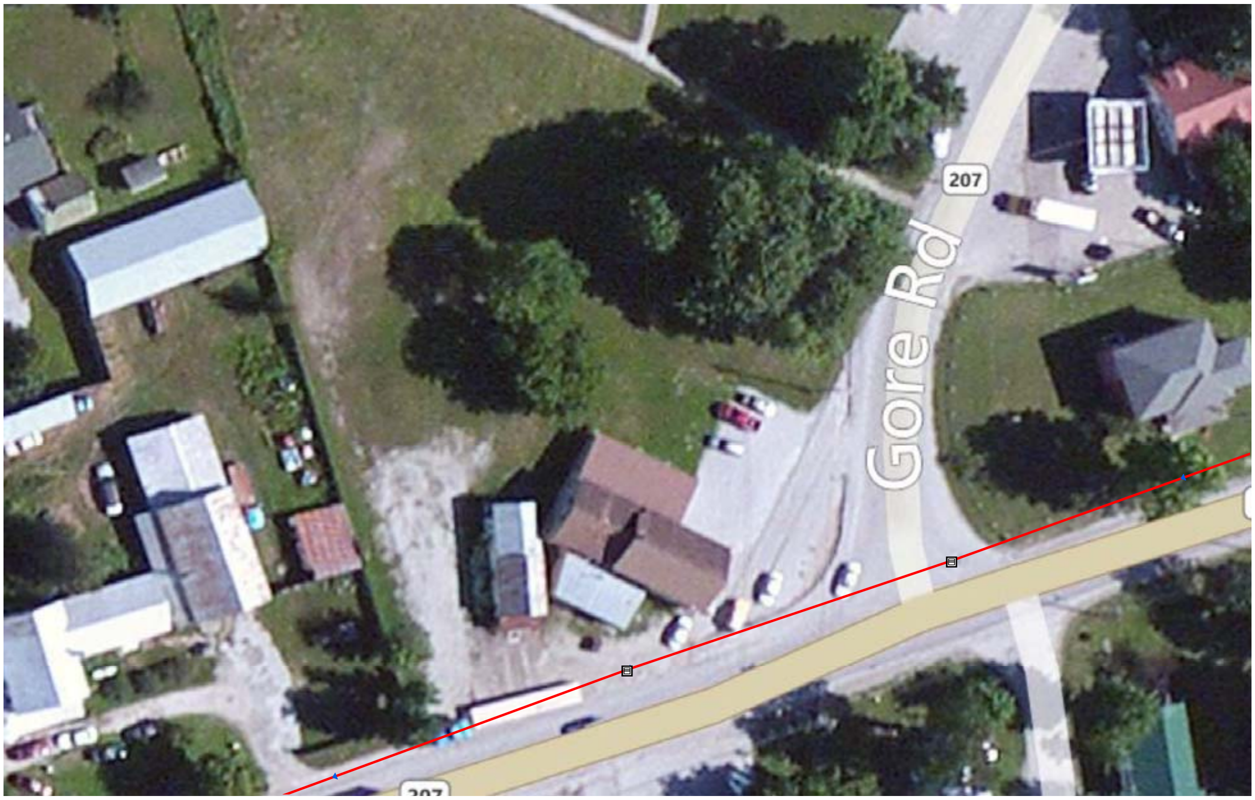

Figure 14. The Highgate Municipal Town Plan proposes the construction of a Park-and-Ride facility at the corner of VT-207 and VT-78. Soil conditions favor infiltration practices such as porous pavement at this site.

1.5 Mill Hill Road Storm Sewer Outfall

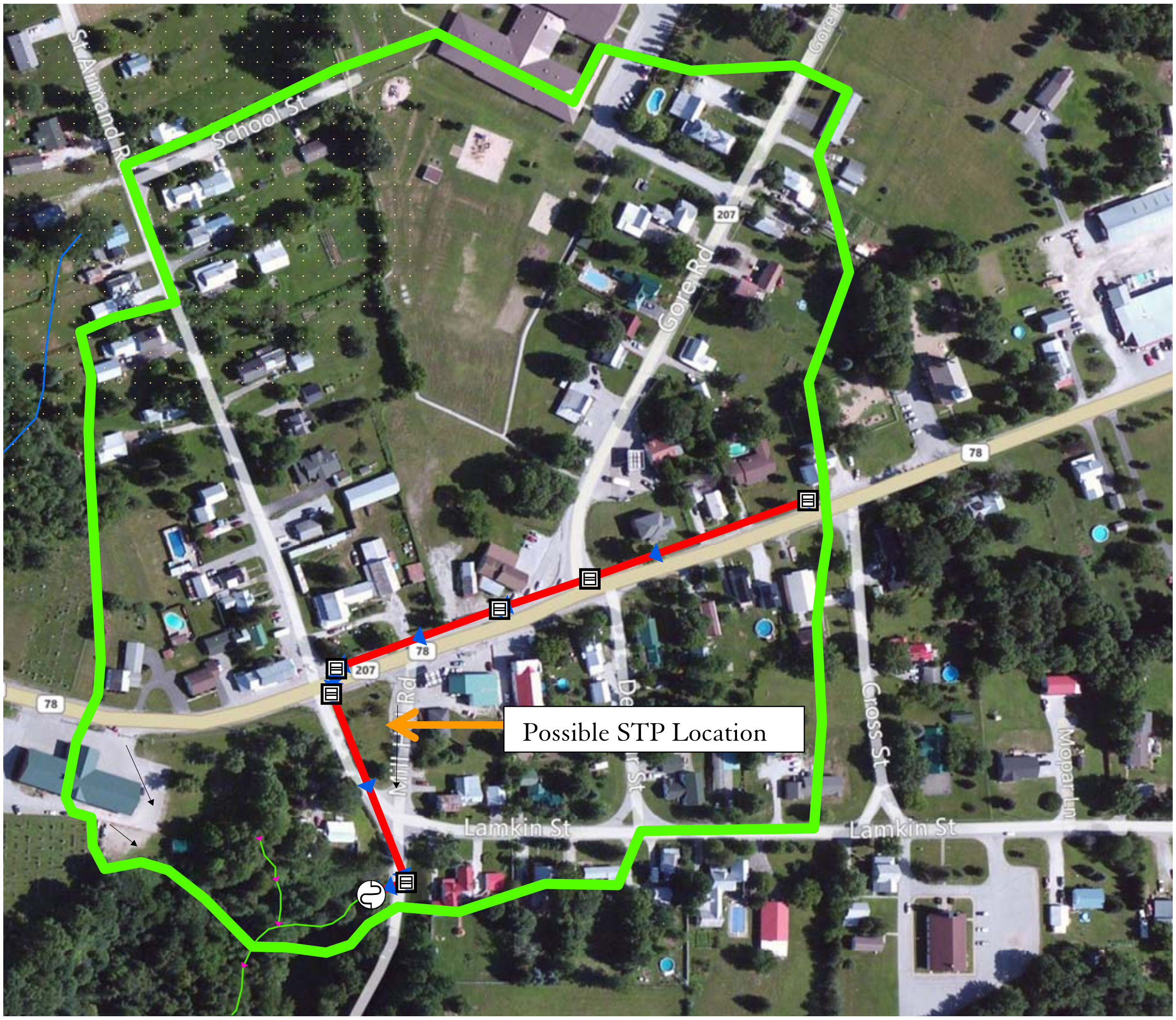

Figure 15. The downtown area of Highgate is shown in this figure. Storm sewer is shown flowing from east to west, then to an outfall south of town on Mill Hill Rd. The contributing watershed is shown in green.

Much of downtown Highgate, a 32 acre catchment, drains to a large swale along Mill Hill Rd. A storm sewer collects stormwater along a section VT-78 and discharges directly to this swale (see Figure 15). Direct drainage from the road and discharges from the storm sewer has created a localized erosion issue (see Figure 16). Armoring below this outfall with riprap is recommended, although this is obviously not a complete solution. To achieve more substantial improvements in stormwater conditions, source control is recommended. This would involve creating “upland” opportunities to capture and slow stormwater runoff, either within the road right-of-way or on adjacent private property. Another option to consider is the installation of a STP in the triangle median at the intersection of VT-207, VT-78, and Mill Hill Rd.

Soils in this area are generally reported by the NRCS as a loamy fine sand with a deep water table. These soil conditions and flat topography make infiltration practices an effective option.

Figure 16. Erosion at the Mill Hill Rd. storm sewer outfall.

1.6 Pine Plains Rd.

Figure 17. Pine Plains Rd. (south of VT-78) is poorly maintained. Eroding sediment from the road is impacting a tributary near the confluence with the Missisquoi River.

Pine Plains Road was found to be in poorly maintained condition. Only a shore section of the road is maintained by the Town of Highgate, with the steepest sections maintained by private interests. That said, the lack of maintenance of the private section of the road is impacting the town-operated section. Roadside ditches were in need of maintenance or altogether nonexistent. Ditch condition coupled with poor grading has resulted in a large amount of sediment being eroded from the road surface, turned out into the adjacent woodland and eventually carried and deposited in a small tributary just upstream of the Missisquoi River (see Figure 17 and Figure 18).

The problems associated with Pine Plains Road could be remedied by excavating roadside ditches and properly grading the road. In steeper sections road grade dips may be required to direct water off of the road surface. Sections of roadside ditch in steep locations may need to be rock-lined. It is unclear what authority the Town may have to require correction of the drainage issues on the privately-maintained section of Pine Plains Road.

Figure 18. Eroding sediment from the road entering tributary to Missisquoi River.

1.7 Farm Road Crossings

Poorly constructed and/or unimproved farm road crossings are a significant source of sediment to the Rock River and its tributaries in the Town of Highgate. While they are not issues directly within the purview of the Town, they do have a significant and on-going impact on water quality.

Implementation of best management practices for agricultural road crossings will improve also property owners' ability to access their land. State and federal programs may be available to aid in these improvements. As part of the field effort for this project, landowners granted access to and thus gave Stone staff the opportunity to observe four specific crossings. The following series of aerial photographs and fields images gives a sense of the need at the crossings.

1.7.1 ***Tarte Rd, Crossing #1***

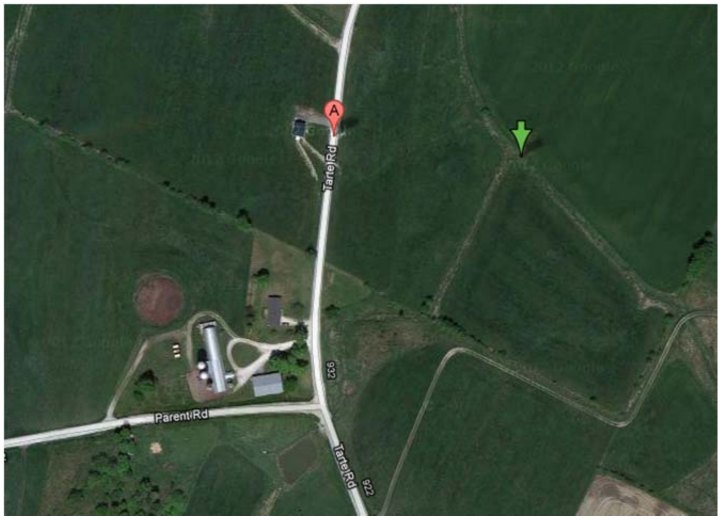

Figure 20. Farm road crossing #1.

Figure 21. Scour pool at outfall from undersized culvert that carries unnamed Rock River tributary under farm road. Some rip rap has been placed by the landowner to address localized erosion around the culvert.

1.7.2 ***Tarte Rd, Farm Road Crossing #2***

Figure 22. Farm road crossing #2.

Figure 23. Undersized culvert under farm road. Erosion occurring from road surface as well as in scour pools at the upstream (shown) and downstream ends of the culvert.

1.7.3 ***Rollo Rd, Farm Road Crossing #3***

Figure 24. Farm road crossing #4.

Figure 25. Unimproved farm road crossing, shown during high flow conditions. Bank erosion evident on both sides of the stream.

1.7.4 ***Rollo Rd, Farm Road Crossing #4***

Figure 26. Farm road crossing #4.

Figure 25. Unimproved farm road crossing, shown during high flow conditions. Significant ruts suggest landowner challenged to ford river during certain flow regimes.

1.7.5 *Improved Farm Road Crossing*

NRCS Conservation Practice 560 – Access Roads – addresses the construction and maintenance of access roads.[2] The practice standard includes recommendations for alignment, drainage including culvert spacing, and surfacing among others. The road shown in Figure 26, also on the Rock River, was constructed consistent with these standards and shows significantly fewer signs of wear.

[2] http://efotg.sc.egov.usda.gov/references/public/VT/VT560-0311.pdf