TOWN OF WILLISTON

TOWN-WIDE WATERSHED IMPROVEMENT PLAN - PHASE 2

ALLEN BROOK

MUDDY BROOK

SUCKER BROOK

WINOOSKI RIVER

FINAL REPORT

Stone Project ID 12-055

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1. INTRODUCTION

The Town of Williston is a vibrant community located in Chittenden County, Vermont. Since the construction of I-89 in the late 1960's, Williston has slowly transformed from a small village surrounded by working farms to a multi-faceted community with dynamic residential, commercial, and industrial activity as well as valuable open space, rural areas, and plentiful natural resources. The Town has taken a proactive approach to community planning that includes both utilization and protection of land and water resources. As noted in the 2011 Town Plan, "the town has a strong history of using the planning process to moderate the impacts of population growth and land use change on the environment, public facilities and services, and the character of the community."

As development has increased within the Town of Williston, so has the complexity of managing the Town's water resources. The Town of Williston faces a range of regulatory and non-regulatory issues related to surface water protection and stormwater management. Two of the Town's major streams, Allen Brook and Muddy Brook, are considered impaired by contaminants primarily from storm runoff (see sidebar). Lake Champlain, which is the ultimate receiving water for streams and rivers leaving the Town, is also considered to be impaired. Areas of Williston are experiencing increased stormwater runoff volumes as a result of development; localized stream channel and land erosion concerns are problematic in their own right, but also contribute phosphorus to Lake Champlain.

Impaired Waters

Allen Brook
Pollutants of Concern: *E. Coli*
Stormwater Volume

Muddy Brook
Pollutants of Concern: Toxics
Nutrients
Temperature

Lake Champlain
Pollutants of Concern: Mercury & PCBs (in fish tissue)
Phosphorus

Stormwater runoff is commonly transported through Municipal Separate Storm Sewer Systems (MS4s), from which it is often discharged untreated into local receiving waters. The most effective strategy for reducing pollutant loads in stormwater is to prevent harmful pollutants from being washed or dumped into the storm sewer system in the first place. MS4 permit holders, including the Town of Williston, must develop and implement a stormwater management program. Vermont issued a revised MS4 in late 2012 which, in addition to the stormwater management program, requires the development and implementation of flow restoration plans (FRP) for streams designated as being impaired by stormwater runoff, including Allen Brook in Williston. These "big-picture" issues, along with an assortment of localized stormwater problems, ranging from the flooding that occurred in the spring of 2011 to on-going erosion along several town roads, together represent a need for significant investment in stormwater management by the Town.

This Town-wide Watershed Improvement Plan was developed to provide a strategic approach that allows the Town to meet stormwater regulatory requirements while also addressing other pressing water resource concerns throughout the Town in an efficient and targeted manner.

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, stormwater management, and surface water (i.e. stream and lakes) are interrelated, and the management practices chosen all influence water quality and stream health.

Watersheds are interconnected networks of streams and watercourses in which a change at any location can carry throughout the system. Many factors influence exactly how stormwater runoff from a particular site will affect the other parts of the watershed, but this impact 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, and 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).

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.

Watershed management practices have direct impacts on water quality in local creeks and streams (e.g., Allen Brook, Muddy Brook), as well as downstream waterbodies (e.g., Winooski River, 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. In Chittenden County, 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 Plan

The Town of Williston has three over-arching goals with regard to its surface water resources:

- Restoring the health of Allen Brook and Muddy Brook, to the point where these waters can be removed from the state's 303(d) list of impaired waters;
- Preventing the addition of other local streams to the list of impaired waters; and
- Promoting healthy populations of fish and other aquatic organisms in all of the Town's waters (Town of Williston, 2010, Chapter 29).

Although there are numerous stressors in any watershed – ranging from bacterial contamination to the presence of toxics to excess nutrients – the focus of this Town-Wide Watershed Improvement Plan is identifying locations adversely impacted by stormwater runoff. This plan focuses specifically on identifying places where

there is active, on-going erosion, often caused by excess stormwater flows, and developing appropriate priorities and recommendations for addressing these concerns.

While the town will continue to explore and implement a variety of approaches to achieve all of the goals described above, such as improving development standards and addressing MS4 permit requirements, the town will use this plan to identify stormwater treatment practices and retrofits that, if implemented, will reduce sediment loads delivered to Williston's streams and result in improved stream quality.

1.3. Project Overview

In order to achieve the most effective and efficient solutions, issues related to land use, surface water quality, and stormwater management should not be viewed independently. Rather, localized stormwater problems need to be examined in a regional context to determine their relative contribution to the overall condition of the watershed. This Town-Wide Watershed Improvement Plan is responsive to the existing characteristics of the watershed, connecting land use, stormwater management, floodplain management, river corridor management, and public infrastructure needs to more effectively address all of the issues which contribute to water quality. This will enable the Town to more efficiently plan for and implement watershed management activities.

The overall objective of this project and resulting report is to provide the Town of Williston with a strategic approach for meeting stormwater regulatory requirements while addressing pressing water resource concerns in an efficient and targeted manner. Specific project goals include:

- Incorporating information from existing plans and datasets to create a single, town-specific resource to guide future stormwater management activities;
- Providing a means for comparing information about different watersheds and the anticipated benefits of individual stormwater improvements projects, both within a particular watershed and across watersheds;
- Developing recommendations to address stormwater problems, including:
    - A prioritized list of problem areas that can assist stakeholders in directing resources to high priority projects; and
    - A list of potential revisions to town regulations or ordinances needed to encourage location-specific management activities.
- Presenting conceptual solutions for stormwater management measures to address high priority problem areas, specifically reviewing the following attributes of each site:
    - Contributing drainage area, to compare the space available with the size of the practice that would be required to address the issue;
    - Water table elevation and soil conditions, to identify areas where the soils appear suitable for infiltration-based practices; and,
    - Existing infrastructure, along with traffic and pedestrian flow, to flag potential conflicts that might arise with the installation of new stormwater management measures.

2. GENERAL DESCRIPTION OF THE STUDY AREAS

The Town of Williston, located in Chittenden County, had a population of 8,698 at the 2010 Census, an increase of over 1,000 people since the 2000 census (U.S. Census Bureau, 2011). The Town covers a total area of more than 30 square miles, although most of the residential and commercial development is concentrated along Vermont Routes 2 and 2A. Since this document is focused on water resource concerns, watersheds, rather than political boundaries or transportation corridors, are the basic unit of analysis for planning. The Town of Williston lies wholly within the Lake Champlain basin. Runoff from the town eventually finds its way to the lake by one of several paths, most notably the Winooski River, which are shown on Map 1 in Appendix A. Each of the Town's watersheds is described in more detail below.

2.1. Allen Brook

Allen Brook originates above Mud Pond and flows northwest to join Muddy Brook just before that stream's confluence with the Winooski River. The Allen Brook watershed is Williston's largest, encompassing roughly 10.8 square miles (6,900 acres), or about one-third of the town (Town of Williston, 2011). The main stem of Allen Brook is approximately 11 miles long from its headwaters in the Sunset Hill area of Williston to its confluence with Muddy Brook along River Cove Rd.

Allen Brook is designated as a Class B waterway by the State of Vermont, meaning that the brook is suitable for "aquatic habitat, boating, swimming and public water supply with filtration and disinfection." Since 1992, the section of the Allen Brook upstream of Industrial Avenue has been included on the *Vermont 303(d) List of Waters* as impaired for *E. coli* and stormwater (Vermont DEC, 2012); the impaired reaches are highlighted on Map 8 in Appendix A.

The bacteria impairment has been identified in a 4.6-mile segment of Allen Brook from River Cove Road upstream to Route 2. As part of a Statewide Bacteria Total Maximum Daily Load (TMDL), Vermont DEC identified the following as potential sources of bacterial contamination in Allen Brook: illicit sewer connections; sewer line leaks; septic systems; urban stormwater runoff; and animal waste including wildlife, agriculture, and pets (Vermont DEC, 2011a). The TMDL also provides a broad framework for addressing bacterial pollution in the streams and rivers of Vermont, predicated mainly on improved stormwater management.

A hydrologically-based TMDL was developed in 2008 to address the impacts of the stormwater runoff in Allen Brook, with a particular focus on biological impairments in the stream (Vermont DEC, 2008). Although the major goal of the TMDL is to address stormwater runoff, the report describes how mitigation of this runoff will help reduce the impacts of other pollutants of concern in the watershed, including sediments, nutrients, heavy metals, and fecal bacteria.

In response to the TMDL, and as required by the Town's MS4 permit, the Town has drafted a Flow Restoration Plan (FRP) for Allen Brook. The purpose of a FRP is to identify stormwater treatment practices (including retrofits to existing practices) that will be recommended for implementation in an effort to achieve established TMDL flow targets, and eventually to allow the impacted stream to be removed from the state's list of impaired waters. Because the "pollutant of concern" in waters designated as stormwater-impaired is stormwater runoff volume, the practices identified in the FRP are specifically targeted towards reducing the large volumes of runoff that enter a stream during rainfall events.

2.2. Muddy Brook

Muddy Brook runs along Williston's western border, forming the town's boundary with South Burlington. Approximately 9.8 square miles (6,300 acres) of this 20.8-square mile watershed is in Williston. The headwaters of Muddy Brook are found upslope of Shelburne Pond in the towns of Shelburne and South Burlington. Shelburne Pond is the dominant surface water feature in the upper watershed. It has an area of 452 acres and is fed by the mainstem of Muddy Brook, as well as other smaller tributaries. The Muddy Brook watershed also includes the Sucker Brook watershed (Section 2.3). In addition, the watershed includes the commercial and retail development in Taft Corners and Maple Tree Place. Muddy Brook is listed on the *Vermont 303(d) List of Waters* as impaired for toxins, nutrients, and temperature; the impaired reaches are highlighted on Map 8 in Appendix A.

2.3. Sucker Brook

Sucker Brook is the major tributary to Muddy Brook and spans portions of the towns of Williston and St. George. The brook drains an area of approximately 7.4 square miles, 3 square miles (1,920 acres) of which is in Williston. Land cover in the watershed is predominantly second-growth forest and agriculture with some areas of low density residential development.

In the 1980s, a severe rainstorm forced a tributary of the Sucker Brook to change its course, abandoning a 30-foot waterfall and flowing instead into a nearby gravel pit located on town land just off Route 2A. Over time, the gravel pit eroded, forming a large unstable canyon and sending substantial volumes of sediment downstream. From 2003-2007, the Town conducted a multi-phase stream stabilization and restoration project along the eroded canyon to successfully address the erosion.

In 2011, elevated levels of lead were measured in the headwaters of Sucker Brook and were determined to have been caused by shooting practices at the North Country Sportsman's Club, which has been in operation since 1962 on a parcel located off Old Creamery Road. The Club has since developed and implemented an Environmental Stewardship Plan for management of lead shot that relocated parts of the shooting range and increased maintenance activities to remove shot fall in order to minimize the impacts of the shooting range on Sucker Brook.

Periodic monitoring by the State of Vermont has found that the water quality in along the mainstem of Sucker Brook meets standards and is able to fully support aquatic life.

2.4. Winooski River

The Winooski River has its source in the northeast corner of Washington County in the town of Cabot, then courses northwesterly for approximately 90 miles before flowing into Lake Champlain just north of Burlington. Its drainage area of about 1,080 square miles covers 11.9 percent of Vermont. The basin occupies all of Washington County, a little less than half of Chittenden County and small parts of Lamoille and Orange Counties (Vermont ANR, 2012). In Williston, several small tributaries flow directly into the Winooski River. Cumulatively, the watersheds of these streams cover about 8.4 square miles (5,400 acres) of the town (Town of Williston, 2011). Although upstream segments of the Winooski River, near Montpelier, are listed as on the *Vermont 303(d) List of Waters* as impaired for *E. coli*, assessments by the State of Vermont have found that water quality in the river as it passes through Williston meets standards (Vermont DEC, 2012).

2.5. Lake Iroquois

Lake Iroquois is a 229-acre reservoir in the southeast corner of Williston. Approximately half the lake is located within the town boundaries; the Lake Iroquois watershed also includes parts of the towns of St. George, Richmond, and Hinesburg. A dam built on the outlet at the south end of the lake was used historically to control the water supply to mills downstream in Hinesburg. During the 1960s the dam was intentionally cemented in its top position, keeping the pond at an artificially high level throughout the year.

The Vermont Agency of Natural Resources has classified Lake Iroquois as eutrophic, and the elevated nutrient levels in the Lake have contributed to the spread of the invasive aquatic plant Eurasian Watermilfoil (Myriophyllum spicatum) (Town of Williston, 2011).

2.6. Other Watersheds in Williston

Watersheds that are located partially within the Town of Williston, but which were not within the scope or focus of this project, include Patrick Brook and Johnnie Brook. Each of these watersheds is described briefly below.

2.6.1. Patrick Brook

Lake Iroquois and the surrounding lands are part of the LaPlatte River watershed. The lake drains into Patrick Brook, which joins the LaPlatte River in Hinesburg. The river then flows into Shelburne Bay. This watershed includes about 1.7 square miles (1,100 acres) in Williston (Town of Williston, 2011).

2.6.2. Johnnie Brook

The Town of Williston also includes less than one hundred acres of the Johnnie Brook watershed (Town of Williston, 2011). The portion of the Johnnie Brook watershed in Williston, along the town's eastern border south of I-89, is mostly wooded with low-density residential development.

3. EXISTING PLANS AND DATA

Numerous and varied groups and individuals have invested considerable effort in evaluating different components of Williston'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 to date, with emphasis on work most relevant to the Town of Williston, and most relevant to future efforts to develop a list of strategic, prioritized projects that could be undertaken to improve water quality in and around Williston.

3.1. Allen Brook

A substantial number of assessments, including all four of the types of assessments described above, have been completed or are in progress for Allen Brook and its watershed. The work products resulting from these efforts are briefly summarized below from past to present.

3.1.1. Watershed Improvement Plan and Recommendations for a TMDL for Sediment (2003)

Prior to the development of the stormwater TMDL for Allen Brook, which was approved by EPA in 2008, VTDEC sponsored an effort to develop a watershed restoration plan for Allen Brook and to make recommendations for the development of a sediment-based TMDL (Barg et al., 2003). The objective of the plan was to develop an alternative approach to restore Allen Brook, and more generally determine a cost-effective means of restoring waters impaired by non-point sources.

The authors of the plan collected substantial scientific data and completed a variety of assessments on the Allen Brook watershed. These datasets included fluvial geomorphology characteristics, stream biology indicators, and water quality parameters. The team also performed watershed analyses including calculations of watershed impervious coverage and modeling of sediment loads in the watershed.

The information collected and compiled for this report was analyzed and used to provide specific recommendations for management activities that should be implemented to address existing impairments and prevent future degradation of the watershed. The report provides recommendations on areas that may be addressed through the development of ordinances and incentives to prevent further degradation of Allen Brook. Groups of recommendations in the report include:

- Stormwater Management and Retrofit Opportunities
- Prediction of stream adjustment based on land use
- Adopting Management and Maintenance Suggestions
- Changes to local ordinances
- Pollution prevention
- Developing a stormwater utility
- Best Management Practices During Construction
- Better Site Design
- Road Management
- Best Management Practices (BMPs)
- Prevention (via application of non-structural stormwater credits for new projects)

Detailed recommendations for retrofit opportunities are included with priority rankings for over 100 stormwater management systems in the watershed. At the time this report was finalized, the highest-priority retrofit opportunities included the following areas and issues, which are quoted directly from the report:

1. Meadow Ridge subdivision. Uncontrolled runoff from the subdivision overtops South Road and has washed manure from the Siple farm manure pit into Allen Brook. This has contributed to high nutrient loading to Allen Brook that is evident by the presence of long strands of attached filamentous algae in Reach 9. A stormwater detention pond was never built as required by the VTDEC Stormwater Discharge Permit. Swales were not dimensioned as shown in the permit and are conveyance ditches instead that are a source of sediment. **Elements of this need are also documented Problem Area Data Sheets AB-50 and AB-52, presented in Appendix C.1.**
2. South Ridge subdivision. The stream inventory of Allen Brook showed it to be in poor condition immediately downstream of this subdivision. While there are two other subdivisions in the general area, South Ridge is the largest, closest to the brook, and contains the most impervious area. Existing stormwater ponds need maintenance and retrofitting. **Elements of this need are also documented Problem Area Data Sheet AB-48, presented in Appendix C.1.**
3. Taft's Farm subdivision. This subdivision straddles Allen Brook with very little buffer left along the stream corridor. Significant erosion from some storm drain outfalls exists, treatment at certain discharge points to Allen Brook is insufficient or nonexistent, and basins are in need of maintenance and retrofitting. **Various elements of this need are also documented Problem Area Data Sheets AB-16, AB-17, AB-18, AB-19, AB-20 and AB-21, presented in Appendix C.1.**
4. Williston Hills subdivision. There was extensive gully erosion below the culvert outfall for the storm drain collection system serving this area.
    - In 2006, the Winooski Natural Resources Conservation District began efforts to stabilize the gullies. Construction for Gullies A and B occurred in the fall of 2007. Construction for the largest of the three gullies, Gully C, was completed in the fall of 2008. In November 2008, the site was re-vegetated with 185 trees and more than 400 shrubs from local nurseries.
5. Avenue D (Whitcomb Industrial Park). Most lots were not required to have a stormwater discharge permit since provisions to infiltrate stormwater on-site were included in construction plans. Many of the proposed infiltration STPs were never built or are not functioning as intended. There is gully erosion from both permitted and non-permitted discharge points. Groundwater impacts are a concern since this site was once a sand pit and has soils with high infiltration rates. **This need is also documented Problem Area Data Sheets AB-26 and AB-29, presented in Appendix C.1.**

3.1.2. Stream Geomorphic Assessment (2005)

Stream geomorphic assessment data specific to Allen Brook was collected in 2005. This work confirmed the significance of in-stream sediment generation, as opposed to production zone sediment inputs, and its resultant negative impact on aquatic biota and habitat (Fitzgerald, 2005). Results from the geomorphic assessment indicate that the stream channel is highly unstable and that the potential for more degradation is high. Of 15 reaches assessed in the Allen Brook watershed, one was rated as being in "poor" geomorphic condition, 11 were rated as being in "fair" condition and 3 were rated as "good". In the same 15 reaches, sensitivity to

further channel instability was rated as "very high" in 11 reaches, "high" in three reaches and "moderate" in the remaining reach. These conditions reflect a generally degraded aquatic habitat, where 10 reaches were rated as having "fair" habitat conditions with the remaining five were rated as "good".

Building on this work, since 2001 the Town has collected cross-section data and conducted pebble counts at 13 sites in the Allen Brook watershed. The locations of completed transects are shown in Map 9 in Appendix A.

3.1.3. USGS Stream Gage (2007-present)

Since October 2007, the U.S. Geologic Survey (USGS) has operated a flow monitoring station in cooperation with the Vermont Agency of Transportation and the Town of Williston on Allen Brook where it passes under Route 2A. The data are available on-line at: http://waterdata.usgs.gov/vt/nwis/uv?04290335.

3.1.4. Water Quality Monitoring (2007-present)

The Williston Conservation Commission (WCC) has collected water quality samples along the Allen Brook since 2007 (no samples were taken in 2009 and not all parameters were sampled every year). The parameters sampled include Total Nitrogen (TN), Total Phosphorus (TP), E. coli, Chloride (Cl), Turbidity (NTU), and temperature. Key findings from the sampling effort include:

- TN and TP concentrations were greatest in the upstream reach of the Allen Brook and lowest in the downstream reach. These results were somewhat expected because agricultural land is concentrated in the upstream reach.
  - TP levels ranged from 0.021 to 0.157 mg/L
  - TN levels ranged from 0.31 to 1.05 mg/L
- Concentrations of *E. coli* were highly variable over the sampling period. There appeared to be no strong correlation between *E. coli* spikes and rain events.
- Turbidity levels were generally greater downstream than upstream, though no trends or explanations were apparent.
  - Turbidity levels ranged from 0.79 to 17.20 NTU
- Chloride concentrations generally increased as samples were taken further downstream.
  - Chloride levels ranged from 20.5 to 150.4 mg/L
- Allen Brook exceeded the water quality standards for *E. coli* and turbidity in the majority of samples collected; Allen Brook did not exceed the federal standards for Cl. Numerical standards do not yet exist for TN and TP levels in streams and rivers, but TP concentrations observed are generally above the in-lake standard (0.010 mg/L) established for phosphorus in segment of Lake Champlain to which Allen Brook ultimately discharges.

The locations where samples are collected are shown on Map 11 in Appendix A; tabular summaries of water quality data trends are also included in Appendix A (Tables A.1 through A.5).

3.1.5. Chloride Assessment of Select Urban Streams in Chittenden County (2007)

Chloride concentrations were measured in six locations in the greater Burlington area, including two locations in Williston – one on Allen Brook and a second on a tributary to Muddy Brook. The data were used to evaluate the extent to which chloride levels in the streams could be contributing to observed impacts to aquatic life

(Vermont DEC, 2007). During the study period, Allen Brook never exceeded the EPA's chronic criterion for chloride. The study concluded that it is unlikely chloride is significantly contributing to the biological impacts observed in Allen Brook. Results for the Muddy Brook are provided in Section 3.2.1.

3.1.6. Allen Brook Stream Bank Restoration Project (2008 - Present)

Stream geomorphic studies of Allen Brook (see Section 3.1.2, above, and 3.1.8, below) found that a number of reaches of Allen Brook lack forested riparian buffers. Inadequate buffers have led to stream bank failure and incision, which in turn has caused devastating habitat loss for fish and aquatic insects. The Town is committed to acquiring conservation easements and reforesting riparian buffer corridors along impaired portions of the Allen Brook and its tributaries, but needed a systematic approach for prioritizing the planning, design, coordination, and implementation of permanently conserved vegetated riparian buffer areas along segments of the Allen Brook and its tributaries.

The *Allen Brook Restoration Project* (KAS, 2011) identified 158 parcels that contain property within a 150' buffer corridor along the impaired portion of the Allen Brook and its tributaries. Each parcel was ranked based on suitability, need, and feasibility for restoration within the 2011 calendar year; a "short list" of 30 parcels was identified and cross-checked against the list of project sites contained within the Allen Brook Watershed Departure Analysis and Project Identification Summary (see section 3.1.8, below). In general, parcels on the short list tended to have larger riparian buffer areas (over an acre), incised stream banks, poor riparian buffer quality, and erodible soils. The Town has used the short list of parcels from this report to guide its conservation efforts in the Allen Brook watershed.

To date, the Town has permanently conserved approximately 25 acres of stream buffer (ranging in width from 50 to 150 feet) and re-vegetated 18 acres along the banks of the Allen Brook (Town of Williston, 2011).

3.1.7. TMDL to Address Biological Impairment (2008)

Allen Brook is listed as impaired because of diminished biological integrity due to "excessive stormwater flows." A TMDL for excess stormwater in Allen Brook has been developed by VT DEC and subsequently approved by EPA Region 1 (Vermont DEC, 2008). Because the "pollutant of concern" is stormwater runoff volume, the loading capacity is the greatest volume of stormwater runoff Allen Brook can receive without violating the stream's aquatic life criteria. Background and reasoning behind the impaired designation is discussed as well as TMDL development.

3.1.8. Watershed Departure Analysis and Project Identification Summary (2008)

The watershed departure analysis presents the findings of a study of the sediment source and transport characteristics in Allen Brook (Fitzgerald, 2008). Results indicated that impervious cover, man-made drainage infrastructure, and loss of wetlands have impacted the geomorphology of the Allen Brook, leading to increased erosion rates and sediment transport capacity. A prioritized list of 21 watershed improvement projects was provided as part of the report, with 12 restoration projects identified as high or medium priority. These projects were further characterized as "passive" (generally conservation based and do not require further study to pursue implementation) or "active" (projects which will require further study prior to implementation).

A stream reach map for Allen Brook is included as Map 3 in Appendix A. Projects ready to pursue implementation (passive restoration), by stream reach and project number, included:

6. M01-1: Develop conservation easements for parcels on lower and middle reach. Ideally completed in conjunction with buffer planting project described in project M01-2 (high priority).
7. M02-1: Develop conservation easements for parcels on lower section of reach where lower sloped land adjacent stream channel could face development pressure in future (medium priority).
8. M03-A-1: Develop conservation easements for parcels on west bank parcels in middle and upper segment where adjacent land could face development pressure in future (medium priority).
9. M03-C-1: Develop conservation easements for parcels on lower and middle segment, on the left bank. Ideally completed in conjunction with buffer planting project described in project M03-C-2 (high priority).
10. M05-B-1: In areas where corridor is not developed, pursue conservation easements for parcels in upper reach in between Route 2 and I-89 (high priority).

Projects requiring further study (active restoration), by stream reach and project number, included:

1. M01-2: Plant buffer with native woody vegetation in the middle and lower reach (high priority).
2. M01-3: Replace bridges with appropriately sized structures. Follow new River Management Program guidelines to accommodate 100% of equilibrium channel width (medium priority). **Additional information is provided on Problem Area Data Sheet AB-03, presented in Appendix C.1.**
3. M03-C-2: Plant buffers in middle-lower segment where no woody vegetation exists on either side, and in upper segment on left bank where there is limited woody vegetation. Other active restoration approaches for this segment, such as restoration of channel geometry, are discouraged in the short term due to the current state of channel adjustment (high incision; stage II CEM; medium priority).
4. M04-A-1: Plant stream buffer in areas above Old Stage Rd where bank vegetation is lacking (medium priority). **Additional information on this need is provided on Problem Area Data Sheet AB-46, presented in Appendix C.1.**
5. M04-A-2: Investigate feasibility of active channel restoration of bedforms and floodplain features in upper segment (medium priority). **Additional information is provided on Problem Area Data Sheet AB-47, presented in Appendix C.1.**
6. M05-B-2: Plant stream buffers in vicinity of Route 2 crossing. Stream boundaries lack native woody vegetation above and below crossing for ~300’ on both sides (medium priority).
7. M07-1: Plant stream buffer, and install fencing to exclude grazing animals from stream channel in lower reach (high priority). **Additional information is provided on Problem Area Data Sheet AB-50, presented in Appendix C.1.**

3.1.9. Biological and Aquatic Life Use Attainment Assessment of Allen Brook (2011)

Vermont DEC uses standard protocols for periodically assessing the biological condition of stream sites across Vermont, including segments of Allen Brook, Muddy Brook, and Sucker Brook. An in-depth evaluation of the biological data was completed for Allen Brook following the 2010 monitoring season (Vermont DEC 2011). In addition to observations related to the biological condition of Allen Brook, the report summarizes habitat

observations and water quality measures collected simultaneously with the biomonitoring data, including canopy cover, silt rating, pH, and nutrient and chloride concentrations.

The report includes a number of interesting findings, such as:

- Macroinvertebrate assessments in Allen Brook are higher (more favorable) than for the fish communities. In fact, the macroinvertebrate community has consistently met water quality standards for aquatic life use support at all locations on Allen Brook since 2005.
- Habitat observations show a slight trend in decreased canopy cover, moving from upstream to downstream;
- A number of freshwater mussel species, including two uncommon species, are present in Allen Brook;
- It is likely, given the level of activity in the watershed, as well as the complexity and diversity of the landscape in the Allen Brook watershed, that factors other than "sediment" (e.g., nutrients and hydrology) contribute to the impacts observed within the biological community.

3.1.10. Winooski River Basin Water Quality Management Plan (2012)

The Vermont ANR published the water quality management plan for the Winooski River basin in 2012. This report provides an overview of the Winooski River Basin's surface waters, including Allen Brook, and a description of ongoing and future steps to restore and protect those waters. The plan presents the recommendations of local watershed residents, stakeholders with varying interests, Vermont ANR, and professionals from other State and federal agencies that will guide efforts to improve both water quality and aquatic habitat, in the basin over the next five years. It includes several statements specific to Allen Brook, including:

- Identifying the implementation of efforts to address the Bacteria TMDL for Allen Brook is one of the top ten priority strategies in the management plan. Specific measures that are likely to be incorporated in Vermont ANR's implementation plan to meet the Bacteria TMDL include:
  - Identifying agricultural operations in the watershed and working with agricultural resource staff to identify and address pathogen sources;
  - Identifying and implementing stormwater management opportunities that reduce bacterial loads to receiving streams; and
  - Developing and implementing a pet waste management plan with the Town and other landowners.
- Increasing the establishment and enhancement of woody riparian corridors on stable reaches of Allen Brook as a priority strategy for enhancing stream stability; and
- Supporting the implementation of this Town-Wide Watershed Improvement Plan, once complete.

3.1.11. Flow Restoration Plan (2012)

A draft flow restoration plan (FRP) was recently completed as part of an effort to implement the stormwater TMDL for Allen Brook (DuBois and King, 2012). The goal of the FRP was to identify best management practices (BMPs) that will achieve flow targets set forth in the 2008 TMDL. The plan identifies expired

stormwater discharge permits and opportunities for implementation of BMPs within town boundaries. The two specific opportunities for BMP implementation on town-owned land that were identified in the FRP are:

- A parcel south of and behind the Town offices located off of U.S. Route 2. A majority of the parcel is wetland and the uplands are occupied by 25 pole mounted solar trackers, which were installed in 2013. The BMP could be installed near the south side of the parcel where it abuts I-89, and thus capture drainage from the wooded areas to the south of the highway.
- A parcel between U.S Route 2 and Interstate I-89. This parcel is currently undeveloped; portions are utilized as farmland. The BMP could be installed near the south side of the parcel where it abuts I-89, and thus capture drainage from Hurricane Lane and the wooded areas to the south of the interstate.

The FRP also identified three opportunities within VTrans right-of-way for additional stormwater management. In addition to identifying these opportunities, a construction schedule is generally discussed, and construction cost estimates are provided for individual BMP projects. The municipal separate storm sewer system (MS4 permit), issued on December 5, 2012, requires the development and implementation of a FRP for each of Vermont's stormwater impaired watersheds (Vermont DEC, 2012a).

3.2. Muddy Brook

Geomorphic assessments and water quality monitoring efforts have been completed or are underway in the Muddy Brook watershed. The work products resulting from these efforts are briefly summarized below from past to present.

3.2.1. Chloride Assessment of Select Urban Streams in Chittenden County (2007)

Chloride concentrations were measured in six locations in the greater Burlington area, including two locations in Williston – one on Allen Brook (see Section 3.1.5, above) and a second on a tributary to Muddy Brook. The data were used to evaluate the extent to which chloride levels in the streams could be contributing to observed impacts to aquatic life (Vermont DEC, 2007). During the study period, chloride concentrations at the study site in Muddy Brook exceeded the criterion 66% of the time. The study concluded that chloride is likely contributing to stormwater-driven impacts in the tributary to Muddy Brook. Results for Allen Brook are provided in Section 3.1.5.

3.2.2. Phase 1 and 2 Stream Geomorphic Assessment Summary (2009)

This report provides the results from Phase 1 and 2 stream geomorphic assessments of Muddy Brook (Fitzgerald and Parker, 2009). The two goals of the report are:

- Assessing the current geomorphic stability and habitat conditions in the watershed to compliment Vermont DEC biological sampling data, and
- Establishing baseline data for long-term monitoring purposes.

The nature of the watershed was characterized. The extent of departure from reference conditions was reported, along with suspected causative factors; 16 bridges and culverts were specifically assessed for their impact on channel equilibrium conditions. A stream reach map for Muddy Brook is provided as Map 4 in Appendix A. Reach-specific recommendations for restoration activities from this work are presented below without modification:

- Arrest Headcuts: The two headcuts noted on Tributary 3 are causing the export of large amounts of sediment to the downstream reaches. The headcut located downstream of Harvest Lane on T3.01-E has the potential to impact the road crossing in the near future (5-10 years), and will need to be addressed with an active channel management approach.
- Continuous monitoring of both headcut sites is recommended to determine the rates of migration and the immediacy of restoration needs.
- Corridor Protection: Protecting the stream corridor through conservation easements is recommended along reaches of the lower and middle watershed that are susceptible to future development. This approach is especially important in reaches or segments that are in vertical adjustment: M02, M10, T3.01-E.
- Undersized Stream Crossings: Severely undersized culverts are causing channel adjustments in the following reaches: M02, M08, M13, T2.01-A, T3.02-A. As noted in the structures summary, these structures should be considered high priority for replacement by town and state agencies.
- Derelict Stream Crossing: There is an inactive stream crossing in Reach M09. The abutments act as a channel constriction and are causing erosion and bifurcation of the channel. Given that the stream crossing is no longer in use, removal of the abutments is recommended.

The Problem Area Data Sheets for Muddy Brook, presented in Appendix C.2, indicate which problem areas were initially identified by reviewing the Phase 1 and 2 SGAs. **In total, nine of the 19 stormwater problem areas documented in the Muddy Brook watershed were drawn from the SGAs; these are: MB-02, MB-06, MB-07, MB-08, MB-09, MB-11, MB-14, MB-15, and MB-25.**

3.2.3. Water Quality Monitoring (2012-present)

The Chittenden County Stream Team (CCST) initiated a volunteer-led water quality monitoring effort in six Chittenden County streams in the summer of 2012, including Muddy Brook. Samples were collected twice monthly at three sites along Muddy Brook (one in Williston and two in South Burlington), and analyzed for phosphorus, nitrogen, turbidity and chloride levels. This data is being made available on-line on the Stream Team website (CCST, 2013), and shows:

- Total phosphorus levels ranging from 0.043 to 0.266 mg/L
- Total nitrogen levels ranging from 0.70 to 2.75 mg/L
- Turbidity levels ranging from 4.81 to 53.7 NTU
- Chloride levels ranging from 21.3 to 143 mg/L

Although it is impossible to make direct comparisons between sediment and nutrient loads in Allen and Muddy Brooks based on this data, the data do suggest that nutrient concentrations and turbidity levels are generally higher in Muddy Brook than in Allen Brook (see Section 3.1.1.4); chloride levels are comparable in both brooks.

3.3. Sucker Brook

Only Phase 1 and 2 Stream Geomorphic Assessments have been completed for Sucker Brook.

3.3.1. Phase 1 and 2 Stream Geomorphic Assessment Summary (2007)

This report provides the results from Phase 1 and 2 stream geomorphic assessments of Sucker Brook (Fitzgerald, 2007). The intent of the document is to:

- Concisely summarize Sucker Brook watershed zones and geomorphic processes; and
- Highlight important or extraordinary information for those using the data.

The nature of each section of the watershed is characterized and each reach described. The report concluded that the Sucker Brook watershed supports many sections in good to reference conditions – especially in steeper terrain. The lower reaches are more impacted due to a lack of riparian buffers and channel straightening associated with agricultural use. Stream reach maps for Sucker Brook are presented in Maps 5-7 in Appendix A. Potential restoration projects identified during this work are listed and briefly described below by stream reach:

- Route 2A Valley (M04 to M07; T1.01):
  - Protection of the corridor from future encroachment
  - Replacement or retrofit of several undersized culverts to accommodate the large volume of sediment working its way through the reach, and the resulting vertical (aggradation followed by incision) and lateral (planform change) adjustments that will continue to occur over the next 10 to 20 years. The severe aggradation of coarse material in reach T1.01 has been problematic for the Town of Williston and the landowners whose driveways and roads cross the channel. **This need is also documented Problem Area Data Sheet SB-01, presented in Appendix C.3.**
- North Branch Middle Zone (T1.02 to T1.04-A):
  - An incised tributary entering from the north was noted in Segment T1.04-A. This tributary enters the north branch channel west of Lyman Road and originates from an area of recent residential development on the north side of Old Creamery Road. Recently built housing on Highlands Drive and Overlake View, and an increase in upslope impervious cover, may be resulting in excess hydraulic loading and channel incision. **This need is also documented Problem Area Data Sheet SB-09, presented in Appendix C.3.**
- Old Creamery Road Zone (T1.04-B to T1.05-C)
  - In-stream structures (e.g., weirs) in reaches T1.04-B and T1.05-A are permanent enough to remain in place during moderate flow events (below bankfull) when fine sediment is being transported through the channel. This is resulting in aggradation upstream of the structures that is degrading the habitat. It is recommended that these structures be removed to reduce further habitat impacts.
  - Additional projects in this densely residential zone would include the re-vegetation of the buffers with native woody vegetation.
  - Future efforts to identify specific projects in this watershed zone would involve extensive public outreach, given the large number of residential properties found along the channel, especially in segment T1.05-A.

3.4. Winooski River

A substantial number of assessments have been completed for the Winooski River watershed. The work products resulting from these efforts are briefly summarized below from past to present.

3.4.1. Fluvial Geomorphology Assessment of the Lower Winooski River, Vermont (2006)

This report provides a geomorphological assessment of six identified reaches of the lower 21.7 miles of the Winooski River—from the confluence of Alder Brook to Lake Champlain (Field Geology Services, 2006). The report cites the natural constrictive effect of the Winooski Gorge, reduced sediment loads (due to dams and 20th century reforestation of the watershed), and minor channel straightening as being the primary factors inhibiting sediment-transport equilibrium. Recommendations for restoring channel stability and aquatic habitat are provided, though all of the substantial project identification in this report is for the reaches of the Winooski River downstream of Winooski Falls, well outside of the Town of Williston.

3.4.2. Mid-Winooski Watershed Phase I Stream Geomorphic Assessment (2007)

This report provides a broad assessment of geomorphic conditions in the Winooski River from Montpelier downstream to Alder Brook (Bear Creek Environmental, 2007). The goal of the report is to provide a stream-impact ranking to each reach to help direct the focus of more detailed Phase 2 Geomorphic Assessments. Significant channel alterations and development within the watershed are cited as the major influences on the geomorphic conditions of this stretch of the Winooski River. Specific reaches of the Winooski and major tributaries are identified in fair to poor condition and are recommended for more detailed, Phase 2 Assessments. Due to high levels of observed impact and reach condition, all of the main stem reaches are recommended for a Phase 2 assessment, including Reach R07 on the Winooski River, located on Williston's northern border between Alder Brook and the I-89 and Route 2 bridges in Richmond.

3.4.3. Winooski River Basin Water Quality Management Plan (2012)

As discussed in Section 3.1.1.1, this report gives an overview of the waters of Winooski River watershed, and describes present and future measures for restoration and protection of these water resources (Vermont ANR, 2012). The ten highest-priority strategies for improvement initiatives are presented and discussed. High-priority strategies that are generally relevant to the Town of Williston include:

- Identify culvert replacement projects in the basin that will improve geomorphic stability of the stream as well as improve fish passage.
- Promote agricultural programs in targeted areas that incentivize fencing, buffers, grassed waterways, barnyard treatments, conservation tillage practices, and cover cropping.
- Work with towns to protect river corridors and promote flood resiliency by establishing Fluvial Erosion Hazard zones and buffer zones in local zoning.
- Identify wetlands on agricultural lands for phosphorus retention, and in the river corridor for sediment attenuation, prioritize and conserve and/or restore.
- Hold an annual Vermont Invasive Patrollers (VIP) training to support the establishment of VIP programs for lakes and ponds in the basin.
- Encourage use of rivers and lakes in the basin to increase people's appreciation.

3.5. Lake Iroquois

The Town's 2011 Comprehensive Plan, Chapter 11.4, contains two key goals and actions concerning Lake Iroquois:

- Support the efforts of the Lake Iroquois Association, through direct funding and in-kind contributions, to help them achieve their mission to restore the lake.
- Develop a Lake Iroquois District Overlay to protect water quality, particularly with regard to the potential conversion of seasonal camps to year-round use where the existing camps do not conform to Williston's current watershed protection buffer regulations.

Several studies have been completed on Lake Iroquois since the summer of 2007 when the Lake Iroquois Association was formed. Of particular interest:

- In 2010, volunteers for the Lake Iroquois Association, with assistance from Vermont DEC, completed a three-phase survey (in-lake, shoreland, and watershed) to identify and prioritize required actions that make the biggest impact on improving the lake, though this plan has not yet been published (Lake Iroquois Association, 2012). This survey resulted in the identification of several stormwater mitigation projects.
- In 2010, the organization received a Better Backroads grant from Vermont ANR to study an ongoing storm runoff issue at Pine Shore Drive in Hinesburg and design solutions to mitigate flow of storm water into the lake, resulting in the construction of improvements in the summer of 2012 (Handler, 2012).
- In 2011, LIA received a Vermont ANR Ecosystem Restoration Grant to develop a stormwater runoff mitigation solution for the area of Shadow Lane, also in Hinesburg (Lake Iroquois Association, 2012). A similar Ecosystem Restoration grant that will enable the Lake Iroquois Association (LIA) and the Lake Iroquois Recreation District (LIRD) to stop gullying on the Lake Iroquois public beach and the resulting erosion of sediments into the lake was awarded in the 2012 funding cycle, with completion of a final design expected in the late summer of 2013.
- LIA participates actively in both the Lay Monitoring and Vermont Invasive Patroller (VIP) programs, both of which are implemented state-wide by the Vermont DEC. Volunteers measure water clarity and nutrient levels, and regularly traverse the lake looking for new invasive aquatic plants and animals. This effort is supported by a grant to cover the cost of chemical analysis at the state's LaRosa Lab.

Recent work by volunteers of the Lake Iroquois Association and staff of Vermont DEC identified areas along the lakeshore as potential input points for nutrients and stormwater. In 2012, LIA volunteers collected water samples at ten sites in the watershed, as shown on Map 10 in Appendix A. The following observations were made following the testing:

- Significant spikes are observed in phosphorus levels resulting from heavy precipitation.
- Much of the water entering the lake exceeds 15 ug P/L in phosphorus and thus contributes to the eutrophication of the lake.
- Chloride levels are notably higher along the west side of the lake.

- Instances of relatively low turbidity but high phosphorus levels may indicate sources other than erosion as a source for phosphorus pollution.

A graphical summary of the monitoring results is also included in Appendix A (Figures A.1 through A.4).

3.6. Other Watershed Assessments

An evaluation of potential stormwater problem areas in the Patrick Brook and Johnnie Brook watersheds was not undertaken as part of this project. The geomorphic assessments of Patrick Brook that have been completed are described below, as is the on-going effort by EPA to revise the Lake Champlain Phosphorus TMDL.

3.6.1. Patrick Brook

Phase 1 and 2 geomorphic assessments have been completed for the LaPlatte River and its major tributaries including Patrick Brook (LaPlatte Watershed Partnership, 2006). Each of three main reaches in Williston was characterized as follows:

- Habitat and geomorphic conditions were assessed;
- Channel alterations, obstructions, and constructions were noted;
- Extraneous influences were documented; and
- Channel evolution stage was documented.

Channel alteration and channel constrictions were found to be major factors affecting the geomorphology of the reaches studied. Reaches that were altered are expected to be the most sensitive to future development. Guidance for future work is provided, though no potential restoration projects were identified in the Patrick Brook watershed up-stream of Lake Iroquois.

3.6.2. Lake Champlain

In early 2011, EPA withdrew their 2002 approval of the Vermont portion of the Lake Champlain TMDL for phosphorus. In reversing their decision, EPA noted that two elements of the TMDL did not comply with EPA regulations and guidance. Specifically, EPA found that the TMDL did not provide an adequate “margin of safety” to account for uncertainty in the true capacity of the lake to accommodate phosphorus pollution, and did not offer “reasonable assurances” that the called-for reductions in non-point source pollution would actually be achieved.

EPA has specifically noted that the 2002 TMDL allowed most of Vermont’s wastewater treatment facilities to have effluent phosphorus concentrations “well above levels that would otherwise be required in the absence of nonpoint source load reductions”. This statement suggests that additional phosphorus removal requirements for wastewater treatment facilities are likely under consideration. In addition, EPA has indicated their intention to treat MS4s as “point sources” in the revised TMDL. Other changes that EPA may be contemplating are less clear, but could involve:

- Requiring more communities to obtain MS4 (municipal separate storm sewer system) permit coverage. Currently, MS4 designations are confined to the more densely populated areas of Chittenden County, with Rutland City and Town and St. Albans City and Town being added with the new MS4 permit signed in December 2012.
- Expanding the use of “residual designation authority” to require larger developed tracts to install stormwater management systems and obtain permit coverage.

- Requiring agricultural operations to obtain additional permit coverage beyond the medium-farm or large-farm operation (MFO or LFO) permits currently issued by the Agency of Agriculture.

3.7. Town-Wide Assessments and Programs

The Town of Williston's existing plans, resources, and data related to this Watershed Improvement Plan include policy documents, municipal ordinances, implementation documents related to the Town's MS4 permit, and a detailed Stormwater Management Practices Study. Each of these resources is described in more detail below.

3.7.1. Municipal Ordinances and Regulations

Chapter 11 of the Williston Town Plan provides a policy basis for the Town's efforts to maintain and restore the health of its watersheds. It specifically highlights the following objectives related to this Watershed Improvement Plan:

- Improving stormwater management;
- Expanding stream restoration efforts;
- Monitoring in-stream water quality;
- Identifying and alleviating problem areas affecting Lake Iroquois; and
- Promoting land stewardship opportunities.

Chapter 29 of the Williston Unified Development Bylaw is dedicated to the protection of water quality and watershed health. Chapter 29 regulates construction site erosion and stormwater management in new developments and on redevelopment sites. This chapter also establishes standards for riparian buffers along streams and around wetlands and lakes.

Town regulations require runoff and erosion control plans for development in which the cumulative land disturbance is greater than two acres, and for projects greater than ¼ acre that will disturb land within watershed protection buffers or on slopes greater than eight percent (Town of Williston 2010, Chapter 29, Sections 29.2-29.4). Projects that disturb more than ¼-acre but less than two acres are required to follow the *Low Risk Site Handbook for Erosion Prevention and Sediment Control*, published by Vermont DEC. In addition, Section 29.5.7 requires that runoff be retained on-site to be "infiltrated and/or released at a rate not exceeding the pre-development rate of release".

Town regulations also include "watershed protection buffers" for all streams, ponds, lakes and for certain wetlands. These are:

- A buffer of at least 150 feet above the ordinary high water mark of all ponds or lakes that have more than a half-acre of water surface and along Allen Brook, Muddy Brook, Sucker Brook and the Winooski River; and,
- A buffer of at least 50 feet above the ordinary high water mark of all unnamed streams – perennial or intermittent – identified on the 7.5' U.S. Geological Survey quadrangle maps covering the town, as well as above the delineated boundary of any Class II wetland or Class III wetland upon the recommendation of the Conservation Commission.

Although Chapter 29 explicitly ensures that erosion prevention measures are used during construction in projects that disturb more than ¼-acre and that riparian areas and wetland buffers are protected, the bylaws are

less explicit in prescribing strategies to help limit the impacts of post-construction stormwater runoff associated with development. Chapter 29 states only in general terms that runoff needs to be retained on-site and infiltrated and/or released at a rate not exceeding the pre-development rate of release, thoughtful site planning to minimize impervious surfaces is encouraged, and porous pavements should be employed where site conditions permit. Recommendations for additional stormwater management measures that could be incorporated into the Town's Unified Development Bylaw and/or the *Town of Williston Public Works Standards* are presented in Section 5.

3.7.2. NPDES MS4 Program and Minimum Control Measures

Williston is designated as an MS4 under the National Pollutant Discharge Elimination System (NPDES) Phase II stormwater requirements of the Clean Water Act (Vermont DEC, 2012a). This MS4 designation requires Williston to file a five year Stormwater Management Program (SWMP) which responds to six "Minimum Control Measures" (or "MCM"):

- Public Education and Outreach on Stormwater Impacts (MCM 1)
- Public Involvement/Participation (MCM 2)
- Illicit Discharge Detection & Elimination (MCM 3)
- Construction Site Stormwater Runoff Control (MCM 4)
- Post-Construction Stormwater Management for New Development and Redevelopment (MCM 5)
- Pollution Prevention/Good Housekeeping for Municipal Operations (MCM 6)

In addition, the Town is obligated to file an annual report describing stormwater management activities completed during the preceding planning year.

3.7.3. Stormwater Management Practices Study

In 2004, Hoyle, Tanner & Associates (HTA) completed a study intended to assist the Town of Williston in identifying appropriate stormwater treatments practices that could be used within the planned densely developed "downtown" area that are consistent with current State stormwater treatment requirements (HTA 2004). The report includes an extensive literature review and a detailed discussion of nine specific stormwater treatment technologies. The technologies are: infiltration trenches and basins; porous pavement; open channel systems; underground and perimeter sand filter systems; manufactured underground filtering systems; detention ponds; underground storage systems; chambered separation treatment practices; and, swirl concentration treatment practices.

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 the 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. A variety of strategies were employed to identify potential problem areas, including:

- Holding a public meeting to describe the project and solicit suggestions of potential problem areas;
- Distributing a "Citizen Questionnaire" via the Town's website to gather additional public input on problem areas (see Appendix C);
- Performing windshield surveys of strategic areas throughout Town during, or immediately following, rain events;
- Meeting with representatives from the Lake Iroquois Association to gather input on problem areas within the lake's watershed; and,
- Meeting with Town staff to review the draft list of stormwater problem areas and solicit input.

In total, 76 problem areas were identified and geo-located. The geographical location data were used to plot all of the problem areas on a single map (see Appendix A, Map 2). Mapping problem area locations in this manner allows the viewer to identify isolated problems, and make a visual assessment of which problems may be part of a larger systemic issue. Systemic problems may warrant consideration of additional stormwater management regulations, in addition to efforts to correct the existing problems.

4.2. Evaluation of Problem Areas

Working from the list of potential problem areas, the Consultant Team visited each potential problem area location to directly observe the site. When no stormwater problems were evident and/or it was obvious that a solution had been implemented, the site was not evaluated further. Where an unresolved problem was found, photos were taken of any areas of active erosion, and observations about the source or cause were documented. Each problem area was also evaluated with respect to:

- Relative environmental impact on receiving water (e.g., proximity, location, amount of sediment being mobilized), with 1 being least impact and 3 being greatest impact;
- Frequency of occurrence, with 1 = rarely/extreme rain events, 2 = occasional/moderate rain events, and 3 = frequent/ nearly every rain event;
- Current condition of existing facilities and related infrastructure, with 1 = good to excellent; 2 = fair to good; 3 = poor;
- Urgency of the need to fix the problem, with 1 = problem is unlikely to get worse if left untreated; 2 = problem may get worse, but immediate action not necessary; 3 = problem is getting worse, immediate action is necessary.
- Whether the problem is impacting public infrastructure
- How realistic it is to fix the problem
- Whether there were impacts beyond water quality (e.g., aquatic organism passage inhibited)
- Whether the problem was part of a larger or more systemic problem

Each problem area was then given a score, with the intent of generally assessing the severity of existing problems, and providing general guidance on the relative order in which the problems should be addressed when considered town-wide. Scores were assigned as follows:

The complete set of problem area data sheets developed as part of this project are provided as Appendix C of this report, and summaries of evaluation results are presented in Tables 1-4 below. Only sites that scored priority 5 or above were listed in the tables, and the sites are listed in order of priority.

All problem areas that received an evaluation score of 8 or higher – generally indicative of an on-going or significant erosion and/or drainage problem – were advanced to Phase 2 of the *Williston Town-Wide Watershed Improvement Plan* project where a preliminary engineering analysis was conducted. As part of this analysis, a site-specific feasibility assessment was completed that defined contributing drainage area, water table elevation, soil conditions, existing infrastructure, and traffic and pedestrian flow in order to more fully evaluate anticipated water quality benefits and constructability at each priority problem area.

Table 1: Allen Brook Watershed Problem Area Evaluation

	Site ID	Relative Impact	Frequency	Current Conditions	Urgency	Priority[1]
High Priority	AB-53	3	3	3	3	12
	AB-19	3	2	3	2	10
	AB-09	2	2	3	2	9
	AB-11	3	2	2	2	9
	AB-13	2	3	2	2	9
	AB-18	2	2	3	2	9
	AB-20	2	2	3	2	9
	AB-43	2	2	3	2	9
	AB-44	2	2	3	2	9
	AB-45	3	2	2	2	9
	AB-01	3	2	1	2	8
	AB-05	1	3	2	2	8
	AB-07	2	2	2	2	8
	AB-17	2	2	2	2	8
	AB-24	2	2	2	2	8
	AB-26	1	2	3	2	8
	AB-29	2	2	2	2	8
	AB-30	2	2	3	1	8
	AB-32	1	3	2	2	8
	AB-34	3	1	2	2	8
	AB-39	2	2	2	2	8
	AB-46	2	2	2	2	8
	AB-49	2	2	2	2	8
	AB-50	2	3	2	1	10

	Site ID	Relative Impact	Frequency	Current Conditions	Urgency	Priority[1]
	AB-02	2	1	2	2	7
	AB-14	2	2	2	1	7
	AB-16	2	1	2	2	7
	AB-35	1	2	2	2	7
	AB-36	2	1	2	2	7
	AB-40	2	2	1	2	7
	AB-41	1	2	2	2	7
	AB-47	2	1	2	2	7
	AB-48	2	2	2	1	7
Lower Priority	AB-04	2	1	2	1	6
	AB-21	1	2	2	1	6
	AB-38	1	2	2	1	6
	AB-42	1	2	1	2	6
	AB-52	2	1	2	1	6
	AB-03	1	1	2	1	5
	AB-10	1	2	1	1	5
	AB-33	1	1	2	1	5

1 Only sites that scored priority 5 or above are listed. Sites are listed in order of priority, with the highest priority first.

Table 2: Muddy Brook Watershed Problem Area Evaluation

	Site ID	Relative Impact	Frequency	Current Conditions	Urgency	Priority[1]
High Priority	MB-14	3	2	3	3	11
	MB-28	3	2	3	2	10
	MB-11	3	2	2	2	9
	MB-18	2	2	2	3	9
	MB-26	2	2	2	3	9
	MB-02	2	2	2	2	8
	MB-08	2	2	2	2	8
	MB-20	2	2	2	2	8
	MB-23	2	2	2	2	8
Lower Priority	MB-10	2	2	1	2	7
	MB-12	1	2	2	2	7
	MB-13	2	2	1	2	7
	MB-15	2	2	2	1	7
	MB-19	1	2	2	2	7
	MB-27	2	1	2	2	7
	MB-07	1	1	2	2	6
	MB-09	1	1	2	2	7
	MB-03	2	1	1	1	5
	MB-25	1	1	2	1	5

1 Only sites that scored priority 5 or above are listed. Sites are listed in order of priority, with the highest priority first.

Table 3: Sucker Brook Watershed Problem Area Evaluation

		Relative Impact	Frequency	Current Conditions	Urgency	Priority
High Priority	SB-01	3	2	2	1	8
	SB-09	2	2	2	2	8
	SB-12	2	2	2	2	8
	SB-13	1	2	3	1	7

Table 4: Winooski Direct Drainage Problem Area Evaluation

		Relative Impact	Frequency	Current Conditions	Urgency	Priority[1]
High Priority	WR-01	3	3	3	3	12
	WR-04	3	3	3	2	11
	WR-10	2	3	2	3	11
	WR-03	3	2	2	2	9
	WR-05	2	2	2	2	8
	WR-06	2	2	2	1	7
	WR-08	1	2	2	2	7
	WR-02	1	2	1	1	5

1 Only sites that scored priority 5 or above are listed. Sites are listed in order of priority, with the highest priority first.

Table 5: Lake Iroquois Watershed Problem Area Evaluation

		Relative Impact	Frequency	Current Conditions	Urgency	Priority
High Priority	LI-04	3	3	3	3	12
	LI-01	3	2	3	3	11
	LI-03	3	3	3	2	11
	LI-02	3	2	1	1	7

5. EVALUATING POSSIBLE FUTURE CONDITIONS

The data collection and field observation approach described above is well-suited for identifying existing stormwater problem areas, but is not designed to anticipate impacts from future projected land uses within the Town. The ability to proactively identify areas of the landscape that may be particularly susceptible to changes in hydrology resulting from land use changes will enable the Town to develop strategies to avoid such impacts as opposed to being relegated to remediating problems only after they occur.

This sort of "future condition" analysis was completed for Allen Brook as part of the process used to develop the stormwater TMDL and draft Flow Restoration Plan (see Sections 3.1.7 and 3.1.11). Prior to this report, however, a similar evaluation had not been made in other watersheds of Williston. Given development patterns in Williston and the lower sensitivity of larger rivers (such as the Winooski River) to modest increases in stormwater flows, effort future conditions analysis was focused on the Muddy Brook/Sucker Brook watershed. As a part of this effort, GIS-based approach was employed to estimate how stormwater flows may increase as a result of projected future land use and build-out changes within the watershed.

Before considering a build-out scenario, it is important to understand baseline environmental and development conditions and how those conditions relate to the mapped or total impervious area (TIA) and effective impervious area (EIA), in order to predict changes in stormwater runoff in the target watersheds. The distinction between TIA and EIA is that EIA recognizes that some impervious areas are completely surrounded by pervious areas and therefore have less of an impact on aquatic ecosystems. EIA is the impervious cover that provides stormwater flows fairly directly and quickly to streams.

As part of the current condition GIS-based design flow analysis, sub-watersheds were classified based on the type and amount of stormwater management infrastructure to estimate EIA. The Consultant Team combined parcel-specific information – linking spatial GIS datasets such as parcel boundaries, land cover, and soil properties with database information such as property use – with the estimated EIA to predict current flows.

The Consultant Team then incorporated results from the current condition analysis and the build-out analysis previously completed by the Chittenden County Regional Planning Commission (CCRPC) to determine areas of current and future development and the underlying soil, slope, and land cover conditions. This analysis was further modified based on the number of new buildings from the build-out analysis, and associated assumptions regarding residential building footprint size, land cover, and impervious surface. Estimated stormwater runoff volumes were determined based on the soil properties of the parcel, and the amount of impervious surface and land cover as a result of current and future development. The results were then used to rank estimated increases in stormwater flows at build-out in different subwatersheds within the Muddy Brook/Sucker Brook watershed (see Appendix D, Figure 1). The approach is further detailed in Appendix D.

Currently, Chapter 29 of Williston's *Unified Development Bylaw* requires that developments that are not exempted (projects < ¼ acre) or defined as 'low risk' (more than ¼ acre but less than 2 acres of disturbance and located outside watershed protection buffers) be accompanied by a runoff and erosion control plan, with runoff retained on-site to be "infiltrated and/or released at a rate not exceeding the pre-development rate of release" (Section 29.5.7).

More could be done to explicitly incentivize or require developers to employ low impact design (LID) approaches and other green stormwater infrastructure (GSI) practices to further manage stormwater runoff – particularly on parcels that do not trigger state-led regulatory oversight (projects > 1 acre). Additional incentives and/or requirements for LID and GSI could be implemented in a targeted manner, using an overlay district, in areas of town expected to see the most growth as new, sub-jurisdictional development. The build-

out analysis suggests that in the Muddy Brook watershed this will be the area north of I-89. Options for expanding stormwater management could include:

- Completing an in-depth evaluation of current parking requirements contained in Chapter 14 against regional "smart growth" guidelines and/or modifying parking requirements to be consistent with suggested parking maximums and minimums from the state of Massachusetts' Smart Growth / Smart Energy Toolkit (http://www.mass.gov/envir/smart_growth_toolkit/bylaws/SP-Bylaw.pdf) or other regional guidance for low-impact development specifically related to parking requirements. Requirements for off-street parking and loading spaces could be stated as a maximum only; currently both minimum and maximum requirements are provided.
- Revising Chapter 25 of the bylaws, which currently states "wherever feasible, parking lot landscaping should be designed to function as part of the stormwater management system…", to explicitly require parking lots be graded to drain to "landscaped islands" or to the medians that are already required to occupy a minimum of 5% of the parking area.
- Reworking Chapter 29 to create incentives to disconnect impervious surfaces from drainage systems, and/or to use landscaping practices and soil amendments to capture stormwater runoff. Potential changes could include articulating a clear preference for practices that seek to infiltrate, as opposed to detain, stormwater runoff, and explicitly requiring a certain amount of rainfall be managed on-site (e.g., the first inch of precipitation);
- Increasing the tree planting strip minimum width to 10 feet, or even 15 feet from the 8-foot minimum width currently proscribed in Chapter 26, and adding a requirement to protect planting strips from compaction during construction. These measures would improve the long-term health of street trees, and increase the runoff-reduction-related benefits the trees could provide over time. In cases where a wider planting strip cannot be accommodated, options such as structural soils or engineered support cells (such as the Silva Cell system recently applied on Cherry Street in Burlington) could be utilized to supply the needed uncompacted soil volume while also supporting streets, sidewalks, and traffic.
- Establishing a maximum front yard setback distance, especially in the Agricultural/Rural Residential Zoning District (Chapter 31), to avoid the construction of excessively long driveways. Currently, the maximum permissible driveway length is established at 1,320 feet in Chapter 13. A variance could be offered at the discretion of the DRB, but establishing maximum as well as minimum setback distances would give the Town an opportunity to request adequate stormwater management measures if an applicant wishes to set a structure an exceptional distance from the nearest public ROW.

6. DEVELOPMENT OF CONCEPTUAL SOLUTIONS

As was described in Section 4 of this report, the first phase of this work identified and geo-located 76 stormwater problem areas, 45 of which were identified as high priority. The Consultant Team revisited each of the high priority problem areas in order to consider each with respect to:

- ***Constructability*** –including whether the recommended practice(s) could be constructed on town-owned land, existing access to the site, and the amount of engineering design work that would be required to move the project to implementation. The maximum score a site could receive is 6 points, indicating a project that should move quickly and easily to implementation.
- ***Ease of operation*** – including the extent of maintenance likely to be required and whether it will be straightforward to complete. The maximum score a site could receive is 2 points, indicating a project with lesser maintenance needs.
- ***Anticipated pollutant abatement*** – including the ability of the recommended practice to reduce flow and/or address sediment and nutrient pollution. The maximum score a site could receive is 3 points, meaning the project both controls flow and should provide a significant reduction in the amount of sediment being delivered to a receiving water.

The scores for each of these criteria were combined with the "Environmental Priority" for each site tabulated in Section 4, which took into account relative environmental impact the site was having on the nearest receiving water, the frequency of events that would make the problem worse, the current condition of any attendant existing facilities or related infrastructure, and the stability of the site. The combined score establishes an Implementation Rank for each site.

The 30 sites with the highest Implementation Rank scores are shown in Table 6, a decision matrix that facilitates reviewing and comparing the conceptual solutions. The decision matrix identifies one or more solutions that could be implemented to address each of the high priority problem areas and allows for weighing the cost of constructing and operating each project against its anticipated water quality benefits and the role the Town may be able to fill in project implementation.

These same 30 sites were also advanced forward to the development of conceptual solutions. The conceptual solutions highlight areas that appear to be available and suitable for potential project implementation. Conceptual solutions for each of the 30 sites are included as Appendix E of this report.

In developing the conceptual solutions, the Consultant Team identified potential locations for stormwater management measures and specifically reviewed the following attributes for each site:

- Contributing drainage area, to compare the space available with the size of the practice that would be required to address the issue;
- Water table elevation and soil conditions, to identify areas where the soils appear suitable for infiltration-based practices; and,
- Existing infrastructure, along with traffic and pedestrian flow, to flag potential conflicts that might arise with the installation of new stormwater management measures.

Table 6: Decision Matrix for Reviewing Conceptual Solutions

Site ID	Site Name	Recommended Practice(s)	*Environmental Priority (scale 1-12)*	*Constructability (scale 1-6)*	*Ease of Operation (scale 1-2)*	*Anticipated Pollutant Abatement (scale 1-3)*	Implementation Rank	Cost	Ability to Phase Implementation?
LI-04	Martel Ln	bioswale w/ check dams	12	4	1	2	19	M	Y
MB-11 MB-14	Harvest Ln	bank stabilization culvert replacement	11	4	2	2	19	H	Y
WR-01	Shirley Circle	bioswale bioretention	12	3	1	2	18	M	Y
LI-03	Beebe Ln	culvert replacement	11	3	2	2	18	H	N
AB-50	South Rd	reinforced animal trail	10	4	2	2	18	L	N
WR-10	Route 2A (near Essex town line)	flow redirection (to existing swale)	10	4	2	2	18	L	N
WR-04	Chapman Ln	road grading/crowing bioswale	10	5	1	2	18	M	Y
AB-11	Pamela Ct	bioretention headcut stabilization	9	5	1	3	18	M	Y
LI-01	Oak Hill Rd	culvert replacement stone lining ditch	11	2	2	2	17	H	Y
MB-28	Williston Rd (near Miller Ln)	bioretention headcut stabilization	10	3	1	3	17	H	Y
AB-09	Horseshoe Dr	bioretention	9	4	1	3	17	M	Y
MB-08	South Brownell Rd	bank stabilization (tree planting)	8	6	2	1	17	L	Y
AB-43	Central School Dr	culvert replacement stone lining ditch	8	5	1	3	17	M	Y
AB-19 AB-20	Talcott Rd	bank stabilization culvert replacement	9	3	2	2	16	H	N
AB-44	Old Stage Rd	culvert replacement	9	3	2	1	15	H	N
SB-12	Lincoln Rd	bioswale w/ check dams	8	4	1	2	15	M	Y
WR-05	Fontaine Ln	bioswale w/ and w/out check dams	8	4	1	2	15	M	Y
MB-06	Marshall Ave (at Shunpike Rd)	culvert replacement headcut stabilization	8	3	2	2	15	H	Y
AB-05	Palmer Ct	bioretention	8	5	1	1	15	M	N
MB-20	Kirby Ln	improved conveyance	8	4	2	1	15	M	N
MB-23	Lamplite Ln	bioretention	8	5	1	1	15	H	Y
MB-26	Walker Hill Rd	headcut stabilization	9	3	1	1	14	M	N
SB-01	Route 2A (at Ridge Rd)	culvert reset/replace bank stabilization	8	2	2	2	14	H	Y
MB-02	SD Ireland haul road	culvert replacement	8	2	2	2	14	M	N
AB-14	O'Brien Ct	bioretention	7	4	1	2	14	M	Y
WR-06	Gov Chittenden Rd	road grading/crowning bioswale	7	4	1	2	14	M	Y
AB-40	Route 2 (Armory)	bioretention	7	4	1	2	14	M	Y
WR-08	Sunrise Circle	bioretention	7	5	1	1	14	M	Y
AB-52	East Hill Rd	stormwater system stone lining ditch	6	5	2	1	14	M	Y
MB-09	Route 116	bridge replacement	7	2	2	1	12	H	N

7. NEXT STEPS

This Plan represents an extensive effort to identify and evaluate potential stormwater problem areas throughout the Town of Williston, and has resulted in the identification of 30 potential stormwater improvement projects that the Town could pursue (see Table 6, above). This section describes the recommended approach for supporting the implementation of high priority stormwater improvement projects, while also taking steps to guard against potential future impacts.

7.1. Project Implementation

7.1.1. FY13 Ecosystem Restoration Program Grant

Since 2008, Vermont DEC has made available competitive grant funding thru its Ecosystem Restoration Program (ERP). The Town of Williston has applied for and received grants from Vermont DEC to implement measures to address two of the high priority problem areas from the list presented in Table 6. At the writing of this report, the Town is in the process of selecting the two problem areas for design and implementation of a solution. Vermont DEC has also indicated that it plans to make additional funding available in early 2014. The ERP grant application indicates that a prioritized plan, such as the Town-Wide Watershed Implementation Plan, is a prerequisite for projects to be eligible for implementation funding. Thus, the Town should be well-positioned with regard to obtaining additional ERP funding to support implementation. That said, discharges that are or could be regulated as point source discharges (e.g., projects within areas of Town considered "stormwater impaired" and that could be required as part of a Flow Restoration Plan) are not eligible for ERP funding.

7.1.2. LCBP Grants

Since 1992, the Lake Champlain Basin Program has awarded nearly $3.6 million in local grants. While the Basin Program offers a number of different local grant programs in most years, the two that are most pertinent to the implementation of this plan are:

- Pollution Prevention – to support technical projects which address LCBP's pollution prevention priorities, including urban stormwater management; and,
- Education & Outreach – for projects that increase awareness, knowledge, skills, and commitments to Lake Champlain issues.

Information on current grant opportunities available through the Basin Program is available at http://www.lcbp.org/about-us/grants-rfps/available-grants/.

7.1.3. Town Capital Funds

For several years, the Town of Williston has included line items within its Capital & Equipment Projects Budget related to water quality improvements. Included in the FY2014 budget is $6,000 in town funds for continued restoration work along Allen Brook (see Section 7.1.4 for more information). In addition, the six-year capital budget and program for the period 2014-2019 includes more than $3 million in capital project needs for stormwater management and water quality improvements (Town of Williston, 2012a). The budget indicates that the Town anticipates addressing the majority of the funding need via bonding and grants.

7.1.4. Stream Bank Restoration and Conservation Easements

The Allen Brook Restoration Project is an ongoing effort that began in 2007 and culminated in 2011, as described in Section 3.1.6, with the release of the *Allen Brook Restoration Project* report (KAS, 2011). To date, the Town has permanently conserved approximately 25 acres of stream buffer (ranging in width from 50 to 150 feet) and re-vegetated 18 acres along the banks of the Allen Brook (Town of Williston, 2011). As noted in Section 7.1.3, the Town continues to make a modest annual allocation to support conservation efforts in the Allen Brook watershed.

7.2. Town Bylaw Revisions

As was discussed in Section 5, above, the Town's Unified Development Bylaw could more explicitly incentivize or require developers to employ low-impact design measures. This report offers several broad recommendations for areas where stormwater BMPs could be incorporated into the bylaws. The next step in this effort will be to undertake a comprehensive review of the bylaws that looks not only for places where stormwater management requirements could be made more explicit, but also places where the bylaws may, often unintentionally, present barriers or disincentives to the implementation of low-impact development strategies and infiltration-based stormwater management practices. This analysis would make suggestions for improvements or modifications to the bylaws, and include an analysis of the impact that changes will have on development and development patterns, incorporating the results of the future condition analysis described in Section 5. In addition, an evaluation could be completed to understand whether it would be most appropriate and practical to target changes to the bylaws to specific areas of town, or to apply them town-wide.

7.3. Continued Monitoring and Assessment

As described in Section 4, there are a significant number of monitoring efforts, both completed and ongoing, to assess the quality of surface waters within the Town of Williston. These efforts employ a range of different techniques designed to assess the physical, chemical, and biological health of the surface waters. Monitoring is important not only for identifying problems, but also for tracking change and progress over time in order to make informed decisions about which approaches yield the most significant water quality benefits, and where resources might be effectively invested to yield desired results.

For example, biological assessment data for Allen Brook shows that the macroinvertebrate community has consistently met water quality standards for aquatic life use support at all locations on Allen Brook since 2005, and the fish community has shown some improvement in recent surveys. When Allen Brook is able to support both macroinvertebrate and fish communities, it will be removed from the State's list of impaired waters. It is important for the Town and the State to continue to track progress toward meeting this important goal.

7.4. MS4 Permit Requirements

Vermont's latest MS4 Permit was issued on December 5, 2012. This is the second MS4 General Permit issued by the State of Vermont. The first MS4 permit was issued in 2003 and amended in 2004. The most significant change in the 2012 MS4 permit is the requirement for municipalities to develop FRPs to implement TMDLs developed for stormwater-impaired watersheds. The FRPs must be developed for each impaired watershed within three years, and must include the following elements:

- Identification of the required controls,
- Design and construction schedule,

- A financial plan,
- A regulatory analysis,
- Identification of regulatory assistance, and
- Identification of any third party implementation.

The schedule needs to provide for implementation of the required BMPs as soon as possible, but within 20 years of the effective date of the permit.

The issuance of the MS4 permit has direct implications for stormwater management in Williston, in particular with regard to the implementation of the Allen Brook FRP. As was noted in Section 3.1.11 above, a draft FRP has been prepared that addresses the elements identified here. The narrative for the Town's 2014 capital budget anticipates that nearly $600,000 will be required to implement the two stormwater management practices on Town-owned land identified in the FRP between 2014 and 2019 (Town of Williston, 2012a).

In June 2013, the Town delivered its updated Stormwater Management Program (Town of Williston, 2013) to VT DEC. The SWMP specifically addresses how the Town has responded to each of the six minimum measures required by the MS4 permit. The SWMP makes specific reference to this watershed improvement plan as a tool for helping address the nutrient and temperature impairments in Muddy Brook, for which there currently are no TMDLs.

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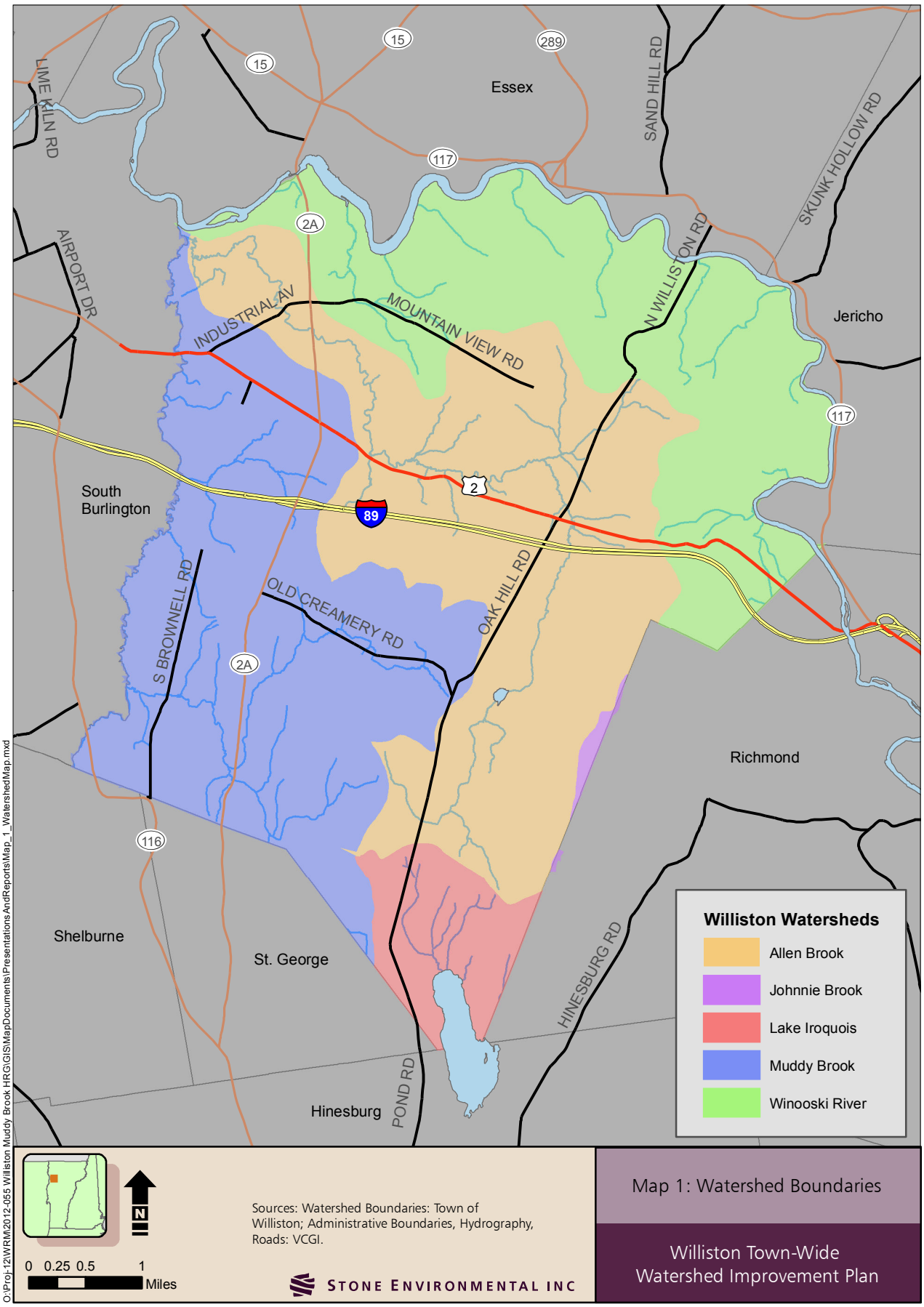
APPENDICES

APPENDIX A: MAPS & FIGURES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South Burlington
Shelburne
St. George
Hinesburg
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AIRPORT DR
INDUSTRIAL AV
MOUNTAIN VIEW RD
SAND HILL RD
SKUNK HOLLOW RD
N WILLISTON RD
S BROWNELL RD
OLD CREAMERY RD
OAK HILL RD
HINESBURG RD
POND RD
15
289
117
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2
89
116
Williston Watersheds
Allen Brook
Johnnie Brook
Lake Iroquois
Muddy Brook
Winooski River
N
0 0.25 0.5 1
Miles
Sources: Watershed Boundaries: Town of Williston; Administrative Boundaries, Hydrography, Roads: VCGI.
STONE ENVIRONMENTAL INC
Map 1: Watershed Boundaries
Williston Town-Wide Watershed Improvement Plan
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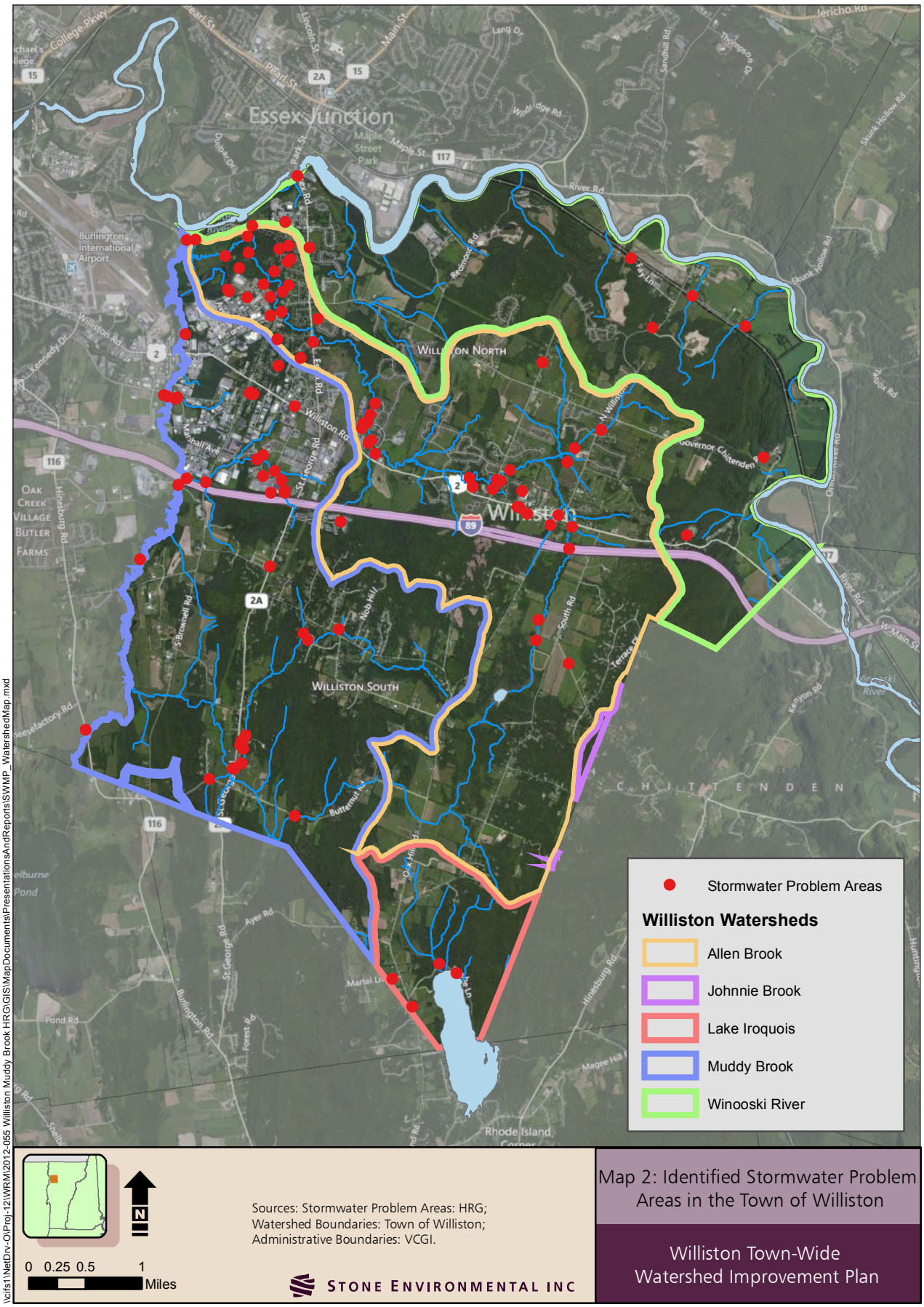
Stormwater Problem Areas
Williston Watersheds
Allen Brook
Johnnie Brook
Lake Iroquois
Muddy Brook
Winooski River
Essex Junction
Williston North
Williston South
Burlington International Airport
Oak Creek Village
Butler Farms
Rhode Island
N
0 0.25 0.5 1
Miles
Sources: Stormwater Problem Areas: HRG;
Watershed Boundaries: Town of Williston;
Administrative Boundaries: VCGI.
Stone Environmental Inc
Map 2: Identified Stormwater Problem Areas in the Town of Williston
Williston Town-Wide Watershed Improvement Plan
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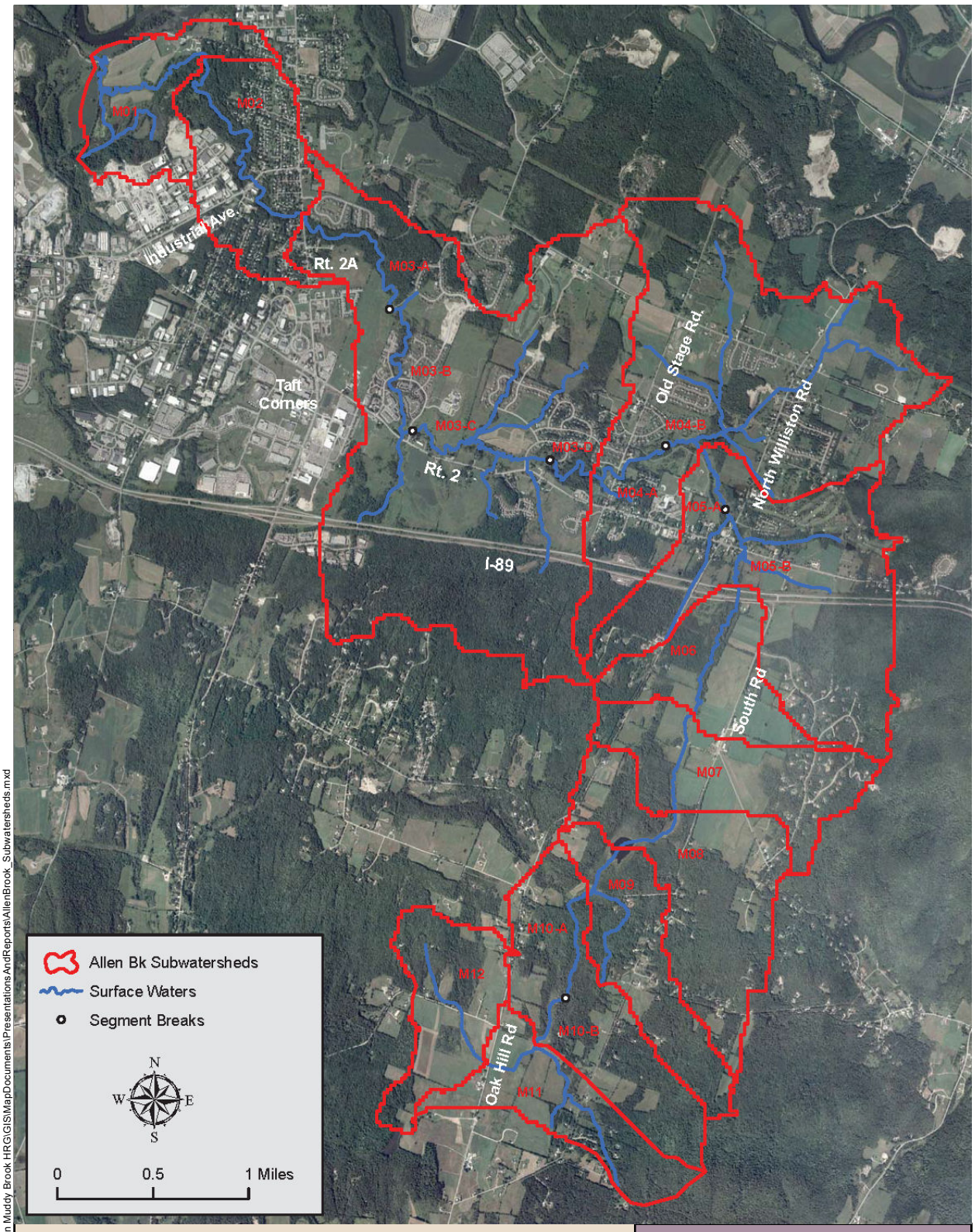

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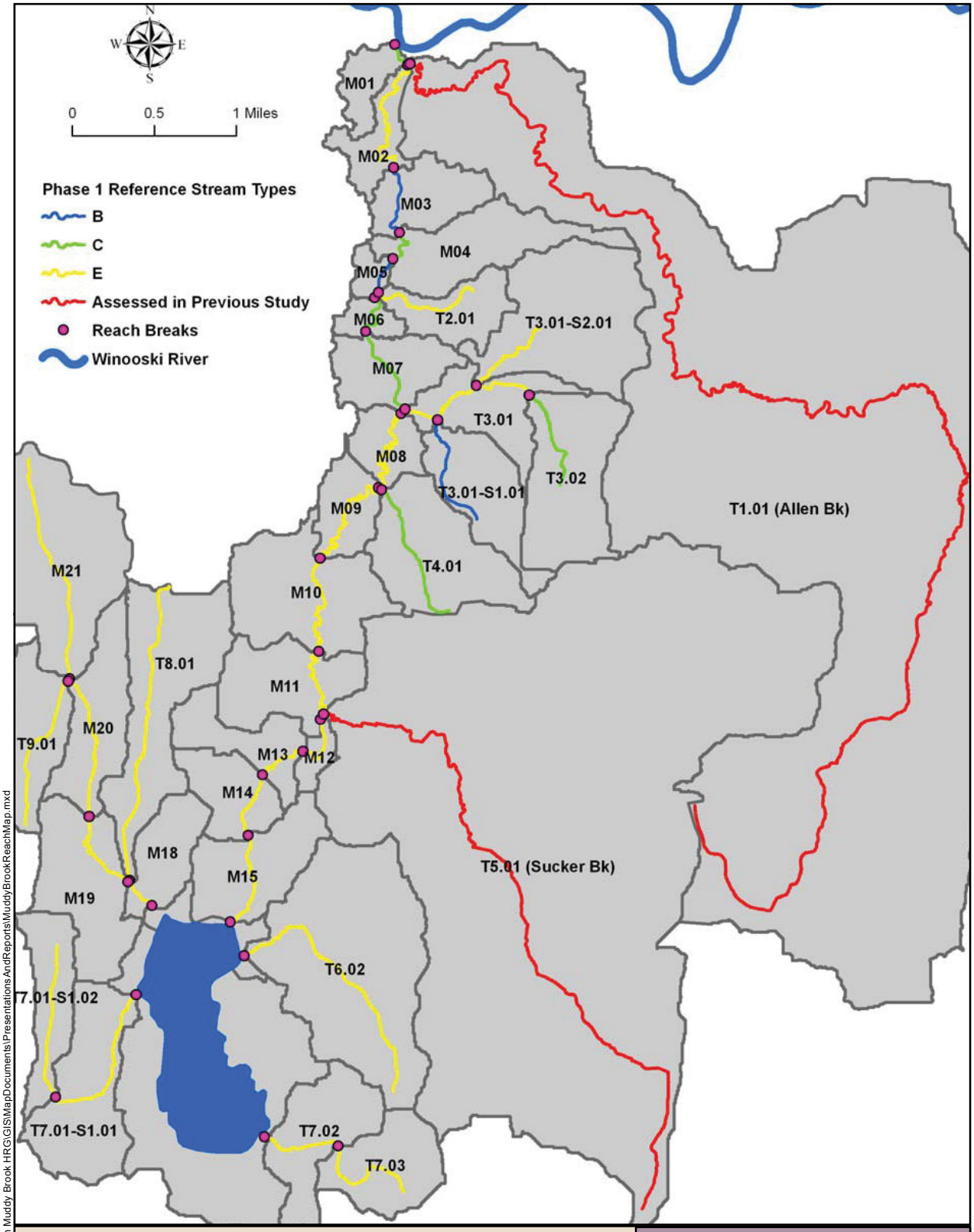
Sources: Watershed Boundaries: Fitzgerald Environmental Associates.

STONE ENVIRONMENTAL INC

Map 3: Allen Brook Subwatersheds and Stream Reaches

Williston Town-Wide Watershed Improvement Plan



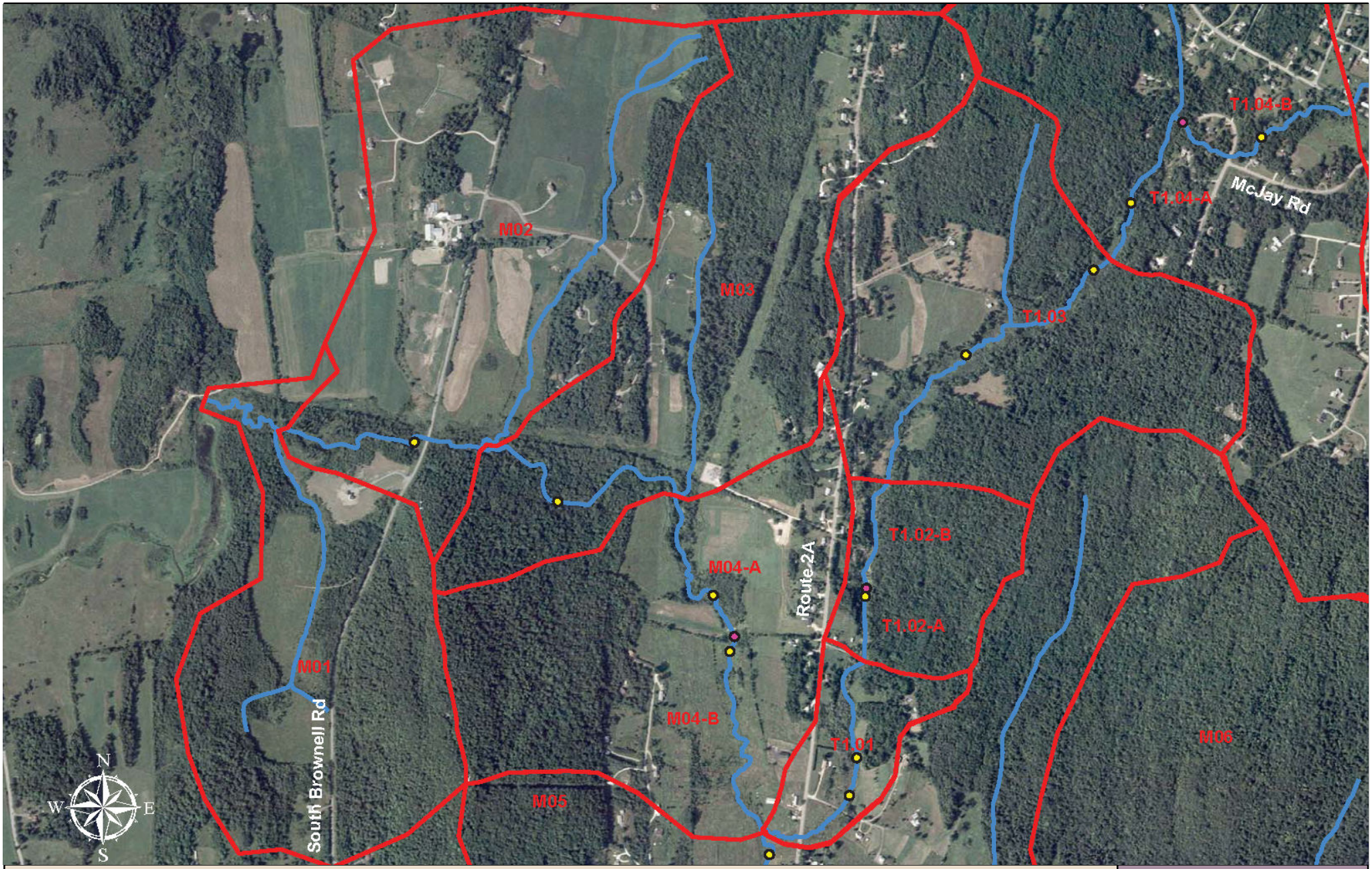
Sources: Watershed Boundaries:
Fitzgerald Environmental Associates

STONE ENVIRONMENTAL INC

Map 4: Muddy Brook
Subwatersheds and Stream Reaches

Williston Town-Wide
Watershed Improvement Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\MuddyBrookReachMap.mxd



Sucker Brook Cross Sections

Sucker Brook Segment Breaks

Sucker Brook Surface Waters

Sucker Brook Subwatershed Boundaries

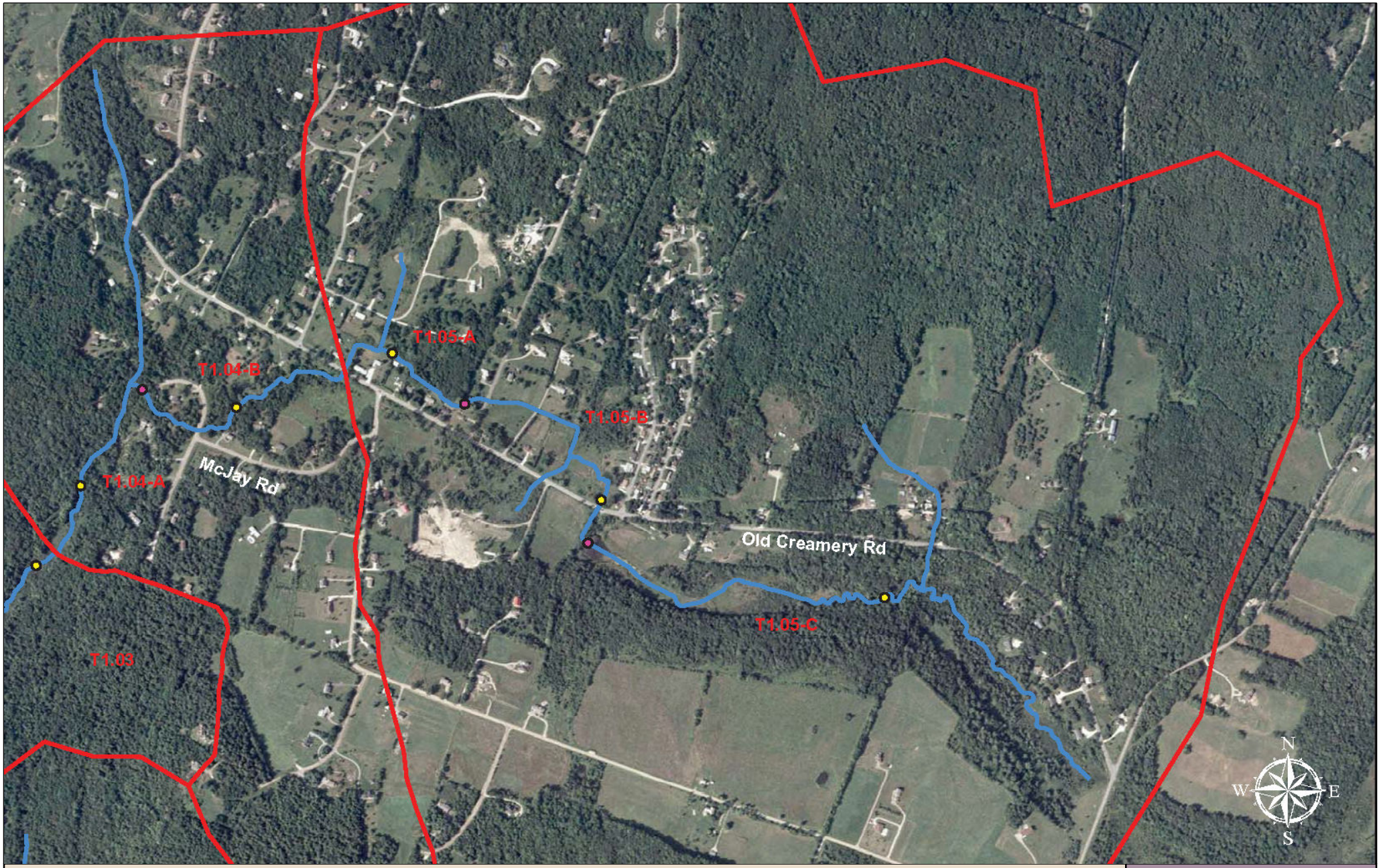
STONE ENVIRONMENTAL INC

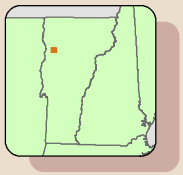
Sources: Sucker Brook Subwatershed data: Fitzgerald Environmental Associates

0 375 750 1,500 Feet

Map 5: Sucker Brook Subwatersheds and Stream Reaches

Williston Town-Wide Watershed Improvement Plan





Sucker Brook Cross Sections

Sucker Brook Segment Breaks

Sucker Brook Surface Waters

Sucker Brook Subwatershed Boundaries

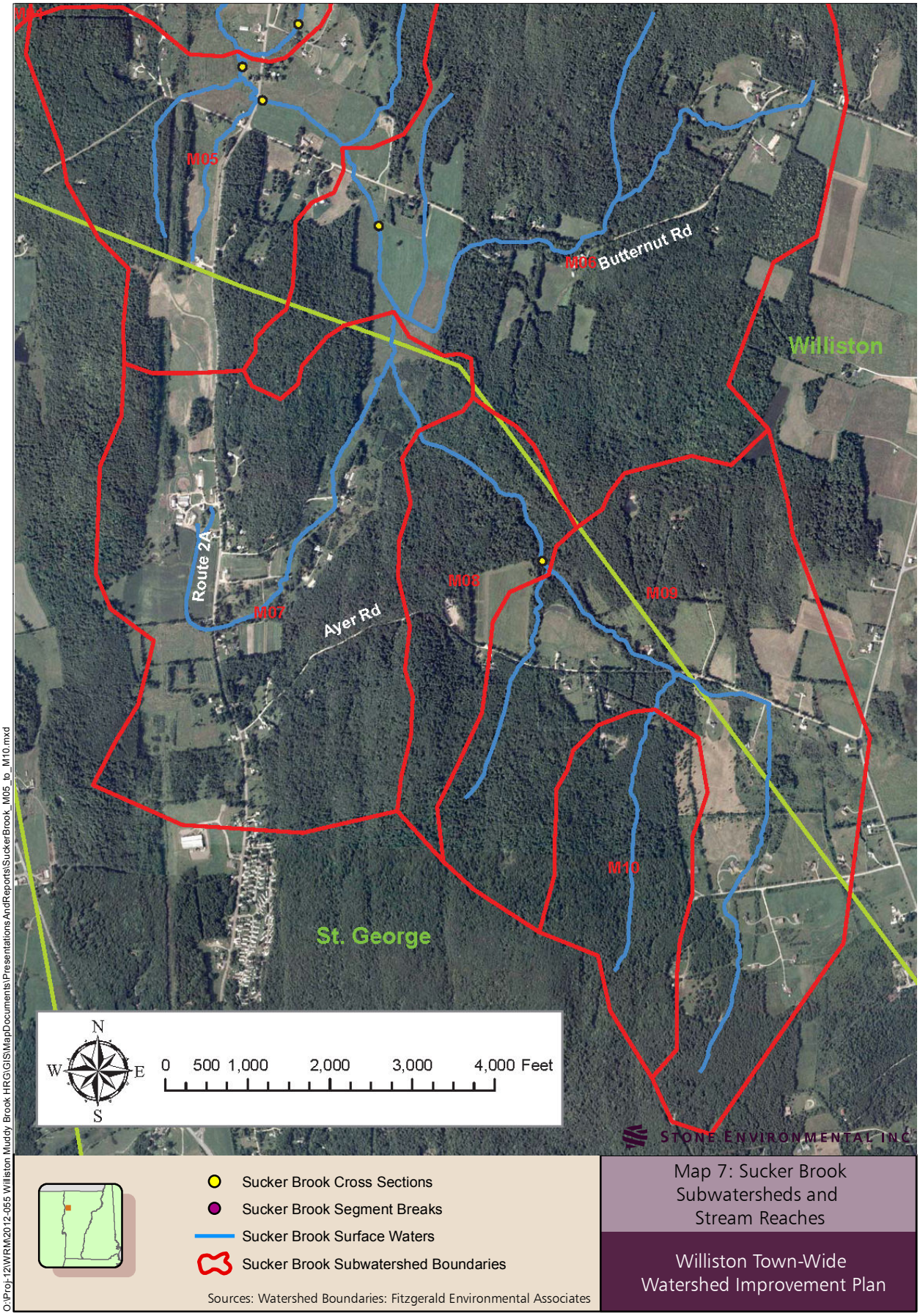
STONE ENVIRONMENTAL INC

Sources: Watershed Boundaries:
Fitzgerald Environmental Associates

0 250 500 1,000
Feet

Map 6: Sucker Brook Subwatersheds and Stream Reaches

Williston Town-Wide Watershed Improvement Plan


M05
M06
Butternut Rd
Williston
Route 2A
M07
Ayer Rd
M08
M09
M10
St. George
N
W
E
S
0 500 1,000 2,000 3,000 4,000 Feet
STONE ENVIRONMENTAL INC
Sucker Brook Cross Sections
Sucker Brook Segment Breaks
Sucker Brook Surface Waters
Sucker Brook Subwatershed Boundaries
Sources: Watershed Boundaries: Fitzgerald Environmental Associates
Map 7: Sucker Brook Subwatersheds and Stream Reaches
Williston Town-Wide Watershed Improvement Plan
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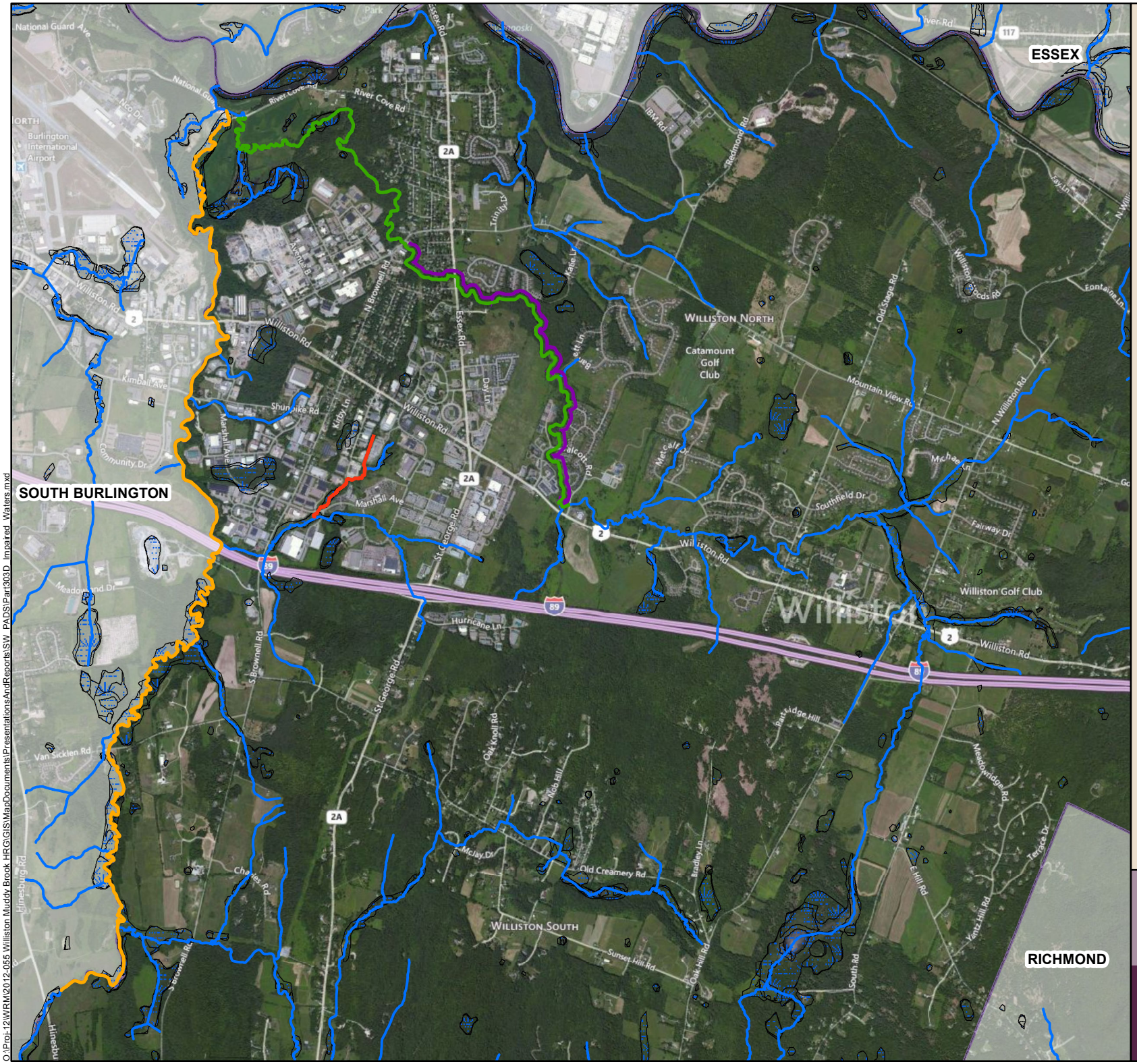

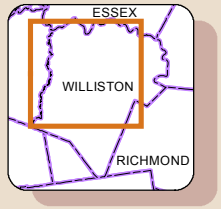

N

0 1,000 2,000 4,000
Feet

Pollutant

- E. coli
- Stormwater
- Nutrients, Temperature
- Toxics
- River or Stream
- Wetlands

Sources:Hydrography, Wetlands, Impaired Waters: VCGI; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Map 8: 303D Impaired Waters

Williston Town-Wide Stormwater Master Plan

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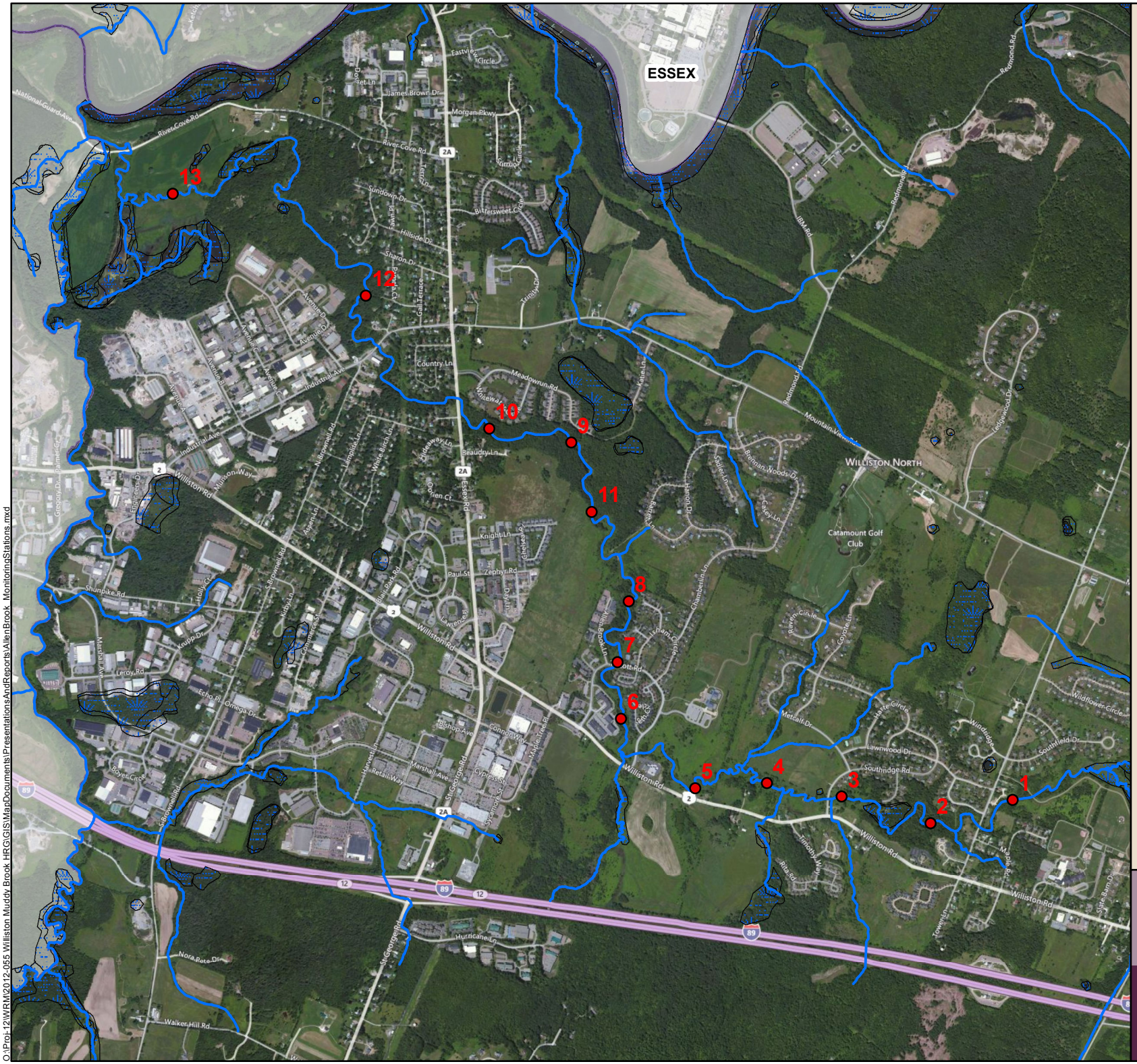
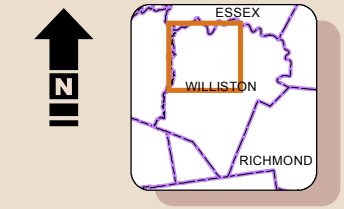




0 5001,000 2,000
Feet

- Monitoring Stations
- River or Stream
- Wetlands

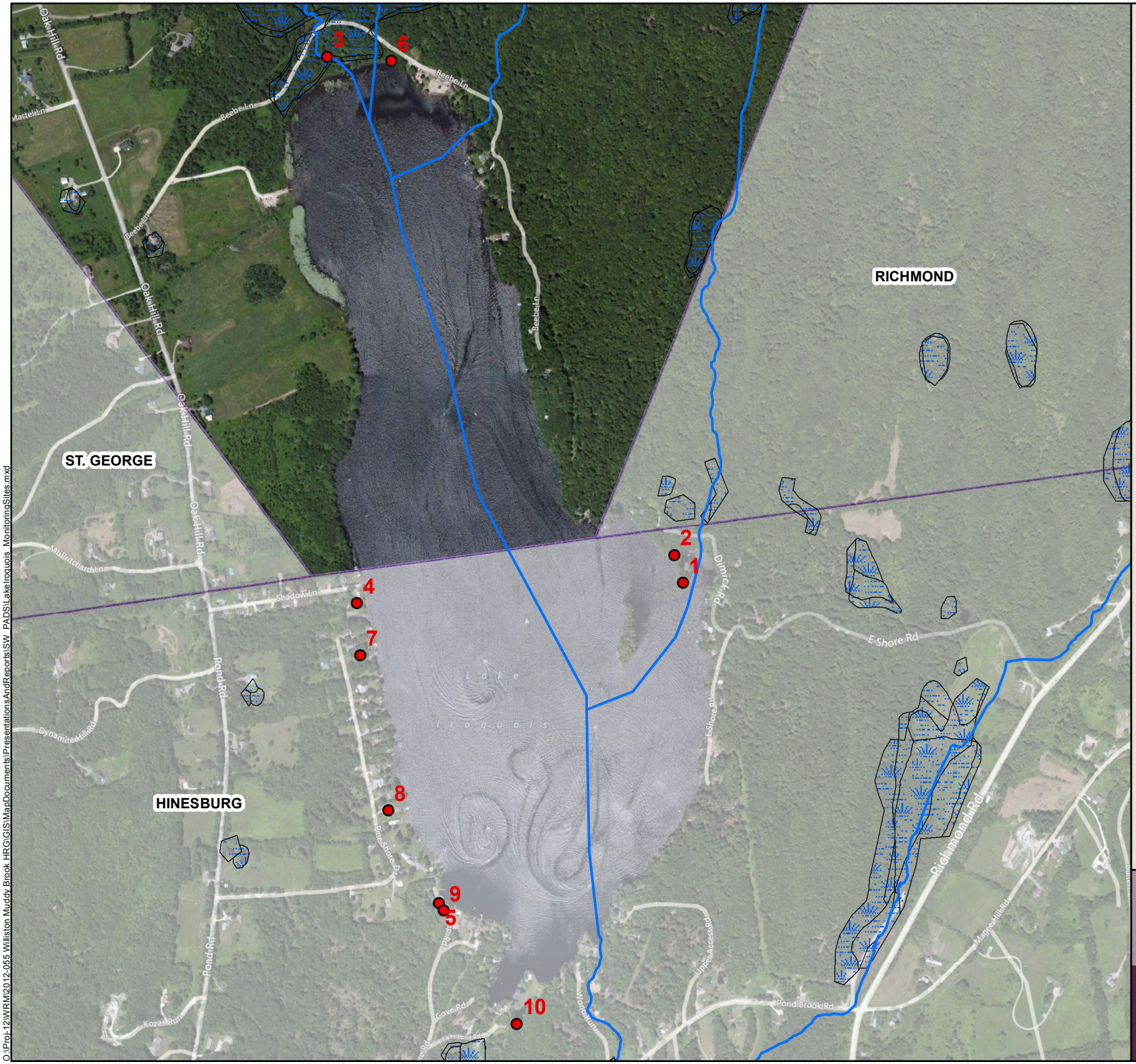
Sources: Hydrography, Wetlands: VCGI; Monitoring Sites: VT ANR; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Map 9: Town of Williston Allen Brook Stream Cross-Section Monitoring Stations

Williston Town-Wide Stormwater Master Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\AllenBrook_MonitoringStations.mxd



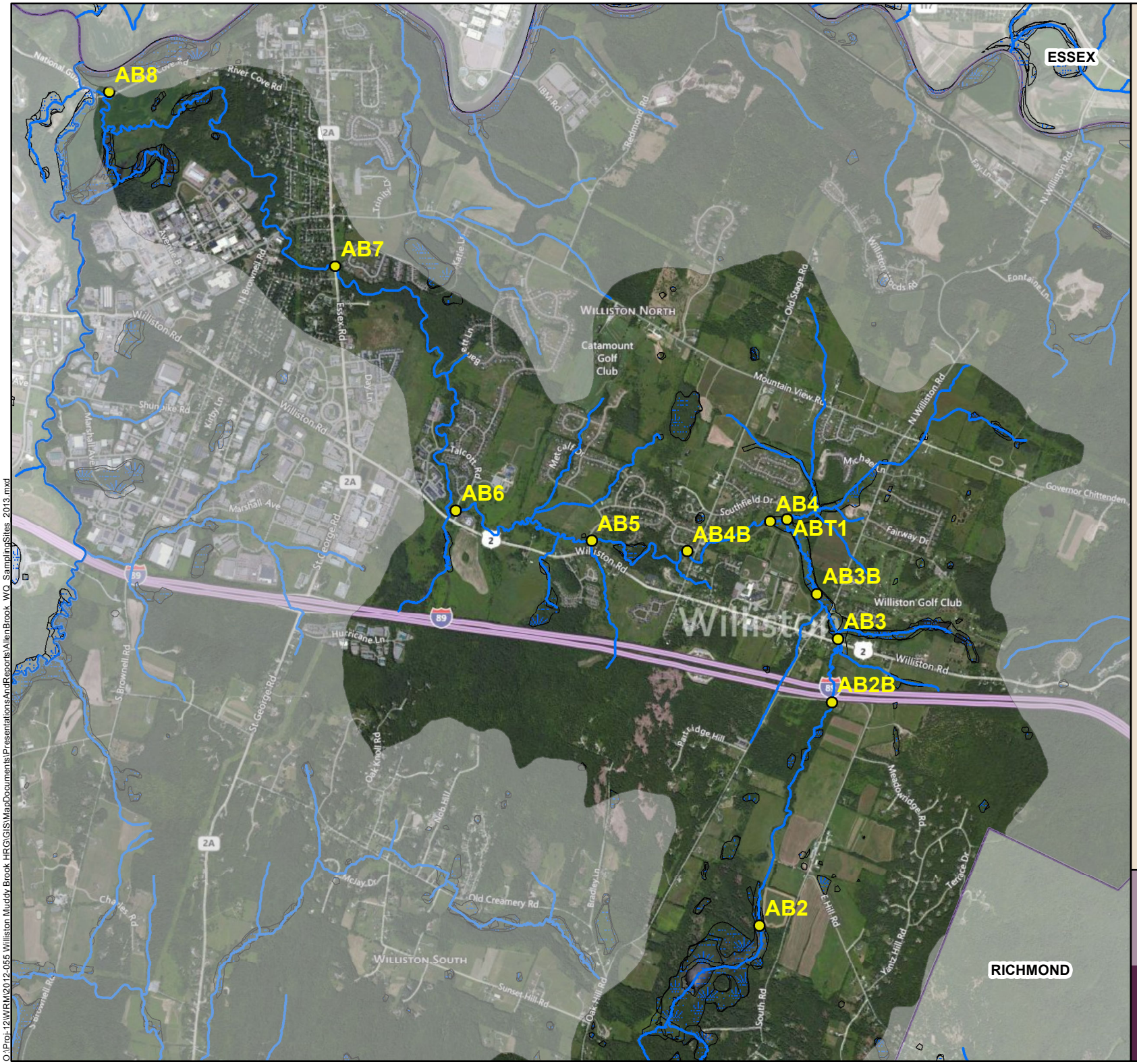
Sources: Hydrography, Wetlands: VCGI; Monitoring Sites: VT ANR; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Map 10: Lake Iroquois Monitoring Sites

Williston Town-Wide Stormwater Master Plan

O:\Proj-12WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\SW_PADS\LakeIroquois_MonitoringSites.mxd



Sources: Hydrography, Wetlands: VCGI; Monitoring Sites: VT ANR; Imagery: Bing Maps.

Stone Environmental Inc

Map 11: Allen Brook Water Quality Sampling Sites 2013

Williston Town-Wide Stormwater Master Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\AllenBrook_WQ_SamplingSites_2013.mxd

Tables A.1 through A.5. Allen Brook Water Quality Monitoring Trends, 2007 - 2012.

Table A.1. Total Nitrogen (mg/L)

Site ID	2007	2008	2010	2012
AB2	0.62	0.54	1.05	0.54
AB2B		0.51	0.62	
AB3	0.37	0.49	0.44	
AB3B		0.48	0.55	
ABT1		0.57	0.5	
AB4	0.6	0.49	0.53	
AB4B		0.47	0.52	
AB5	0.43	0.47	0.40	
AB6	0.46	0.44	0.45	0.44
AB7	0.41	0.45	0.46	
AB8	0.34	0.41	0.31	0.34

Table A.2. Total Phosphorus (mg/L)

Site ID	2007	2008	2010	2011	2012
AB2	60.8	30.4	139.0	70.0	47.0
AB2B		46.3	58.9		51.9
AB3	33.4	43.0	44.9	67.6	45.0
AB3B		39.1	38.8		48.7
ABT1		40.2	53.5		41.9
AB4	74.3	39.3	54.9	67.6	44.7
AB4B		37.1	46.7	68.2	37.4
AB5	21	32.8	36.4	91.9	27.6
AB6	32	34.7	42.5	80.8	42.5
AB7	28.5	30.7	40.5	110.5	40.9
AB8	21.5	25.2	26.7	156.5	27.6

Table A.3. *E. Coli* (MPN/100 mL)

Site ID	2007	2008	2010	2011	2012
AB2	29	48	42	48	156
AB2B		145			
AB3	119	138	286.5	144	231
AB3B		144			
ABT1		148			
AB4	162	249	176.5	378	204
AB4B		152			
AB5	201	152			
AB6	303.5	236	106	239	78
AB7	39	172			
AB8	139	137	133		

Table A.4. Chloride (mg/L)

Site ID	2010	2012
AB2		20.5
AB2B		
AB3		
AB3B		
ABT1		
AB4	67.6	
AB4B	68.2	
AB5	91.9	
AB6	76.75	63.7
AB7	110.5	
AB8	150.4	130

Table A.5. Turbidity (NTU)

Site ID	2010	2011	2012
AB2	3.56	1.24	1.75
AB2B	0.79	1.85	1.84
AB3	2.25	2.22	2.14
AB3B	3.17	3.20	4.26
ABT1	5.55	8.37	6.64
AB4	6.76	5.14	3.95
AB4B	3.89	3.62	2.55
AB5	1.90	1.84	1.37
AB6	3.45	4.54	4.91
AB7	2.86	3.33	4.64
AB8	17.2	5.88	10.7

Notes: Sampling of each parameter did not occur at every site each year. No data were collected in 2009.

Color Key for Median Concentration at each Sampling Site:

Red = High Concentration (top 33% of the median)

White = Moderate Concentration (middle 33% of the median)

Green = Low Concentration (lowest 33% of the median)

Figure A.1: Mean Chloride

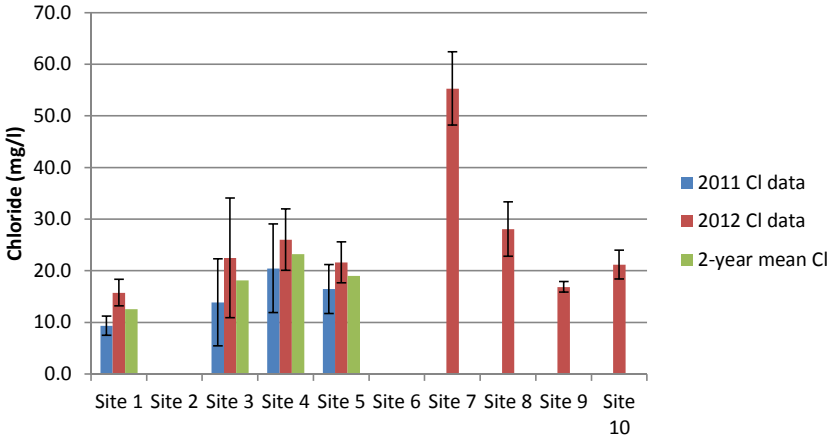


Figure A.2: Mean Total Nitrogen

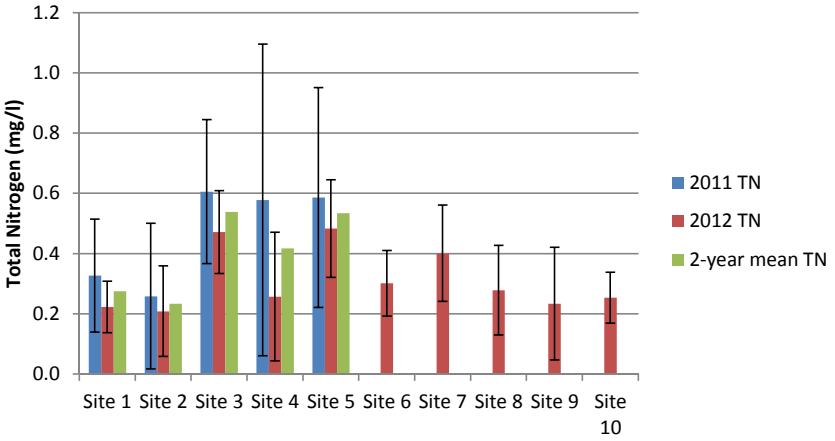


Figure A.3: Mean Total Phosphorus

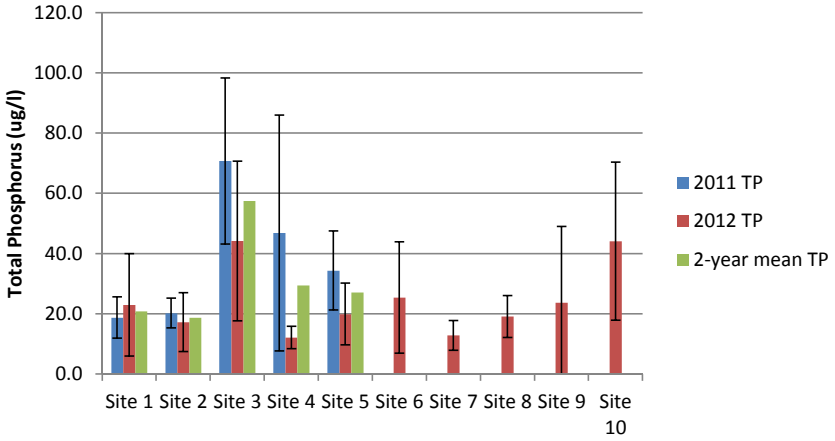
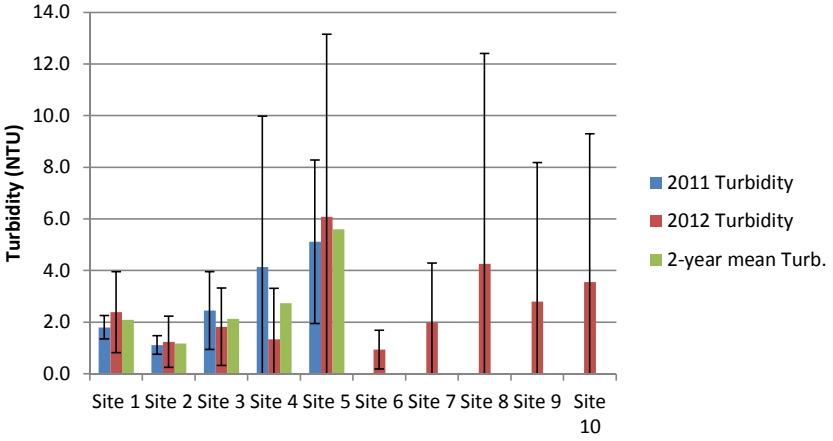


Figure A.4: Mean Turbidity



Figures A.1 through A.4. Mean concentrations of chloride, total nitrogen, total phosphorus, and turbidity at the ten tributary monitoring sites for the 2011-2012 Lake Iroquois Tributary Monitoring Program. Error bars are 1 SD.

APPENDIX B: SWMP CITIZEN QUESTIONNAIRE

Citizen Questionnaire

Town of Williston Town-Wide Stormwater Master Plan

The Town is seeking information from residents about stormwater problems on your property and other locations throughout town. This information will be used to develop a stormwater study that is currently being completed to help shape the Town's strategy for how stormwater can be managed more effectively throughout Williston. Please take a few minutes to check the appropriate answer and write comments where needed.

Thank you in advance for your input.

PLEASE COMPLETE THE FOLLOWING QUESTIONNAIRE AND RETURN BY OCTOBER 31, 2011 TO:	
Adam R. Zahniser, PE Herbert, Rowland & Grubic, Inc. 3755 East State Street Hermitage, PA 16148	Or, send by email to: azahniser@hrg-inc.com

PERSON COMPLETING QUESTIONNAIRE (OPTIONAL; May be used if needed to contact you for additional information)	
Name:	
Owner Address:	
Property Address: (If different from above)	
Phone:	
e-mail:	
How long have you owned or lived at this location?	☐ Less than 1 year ☐ 1 - 5 years ☐ 5 - 15 years ☐ More than 15 years

Local Drainage Problems			
1. Have you experienced flooding or other drainage problems caused by stormwater?	☐ Yes	☐ No	
1.1. If yes, describe the location:			
1.2. If yes, how frequently does the stormwater problem occur at this location?	☐ Less than once per year ☐ Once per year ☐ More than once per year		
1.3. If yes, does it:			
1.3.1. Flood yards or other open space with little or no damage?	☐ Yes	☐ No	☐ N/A
1.3.2. Damage public infrastructure such as roads or utility lines?	☐ Yes	☐ No	☐ N/A
1.3.3. Damage the basement of your primary structure?	☐ Yes	☐ No	☐ N/A
1.3.4. Damage other private property such as landscaping, or accessory structures?	☐ Yes	☐ No	☐ N/A
1.4. If water enters your home (primary structure) does it enter through the (please check all that apply): ☐ Floor ☐ Walls ☐ Drains ☐ Bathtub ☐ Toilet ☐ Windows ☐ Window-Wells ☐ N/A			
2. Where does the excess stormwater that causes this problem come from?			
Street or Road (name)			
Creek or Stream (name)			
Adjacent Property (describe)			
Other Sources (list)			
3. Are you aware of any other problems with the storm drainage system (i.e., ditches, pipes, drains, or streams)?	☐ Yes	☐ No	
3.1 If yes, check all situations that apply. ☐ Corroded pipes ☐ Pipe blockage ☐ Drains in need of repair ☐ Stream or ditch blockage ☐ Other _____			

Stream Flooding Problems

4. Do you know of flooding that occurs as a result of streams / rivers overflowing their banks?	☐ Yes ☐ No
4.1. If yes, describe the location:	
4.2. If yes, how frequently does flooding occur at this location?	☐ Less than once per year ☐ Once per year ☐ More than once per year
4.3. If yes, does it:	
4.3.1. Flood yards or other open space with little or no damage?	☐ Yes ☐ No ☐ N/A
4.3.2. Damage private property such as landscaping, accessory structures, or homes?	☐ Yes ☐ No ☐ N/A
4.3.3. Damage public infrastructure such as roads or utility lines?	☐ Yes ☐ No ☐ N/A

Erosion Problems

5. Do you know of any soil erosion problems from a storm drainage system (i.e. ditches, pipes, drains, or streams)?	☐ Yes ☐ No
5.1. If yes, please indicate the location and severity of the problem(s):	
Location:	☐ Minor ☐ Moderate ☐ Severe
Location:	☐ Minor ☐ Moderate ☐ Severe
Location:	☐ Minor ☐ Moderate ☐ Severe

Water Quality Problems

6. Are you aware any sources of pollution such as trash, sediment, fertilizer, or other chemicals entering a storm drainage system (i.e. ditches, pipes, drains, or streams)?	☐ Yes ☐ No
6.1. If yes, please indicate the location and describe the nature of problem(s):	
Location:	Description:
Location:	Description:
Location:	Description:

Please describe in detail any flood-related or stormwater-related problems that have not already been described above:

Do you have any photographs, videotape, or other records of flooding problems that occurred on your property or in your neighborhood? If so, please send to the address listed above on this questionnaire. Any documentation or media that you provide will be used to help complete this study.

☐ No	☐ Video
☐ Written	☐ Other _____
☐ Photos	

APPENDIX C: PROBLEM AREA DATA SHEETS

C.1. Allen Brook

Problem Area Data Sheet

Problem Area ID:	**AB-01**	Latitude: 44.472829 ° N	Longitude: 73.133329 ° W
Watershed:	Allen Brook		
Location	River Cove Rd, 1 mi. west of Route 2A		
Problem Type:	Local Drainage		
Identification Source:	Allen Brook SGA		
Ownership:	Public (Town)		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Bridge appears to be in good condition. During flood stages bridge width may be an issue. Bridge is 73% of bankfull channel width. Significant sedimentation has "smothered" rock substrate in channel; source of sediment was not immediately apparent.

SWMP Field Assessment Photos

Photo 1. Evidence of significant sedimentation

Photo 2. Downstream view of River Cove Road bridge during flood stage (4/28/2012)

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	2	1	2	Yes	No	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-02**	Latitude: 44.470772 ° N	Longitude: 73.127990 ° W
Watershed:	Allen Brook		
Location:	Griswold Property b/w Industrial Park- Ave C and River Cove Rd		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Historical straightening of Allen Brook channel as part of the adjacent agricultural operation led to channel incision and increased bed and bank erosion that continues today. Numerous instances of eroding channels banks and tall adjacent terraces that are actively eroding into the channel. Several corrective measures have been implemented, but more work remains to be done.

Field Photos

Photo 1.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	1	2	2	No	No	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	AB-03	Latitude: 44.473282 ° N	Longitude: 73.124069 ° W
Watershed:	Allen Brook		
Location:	River Cove Rd, 0.5 mi. west of Route 2A		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Concrete support blocks on North side of bridge have failed and collapsed into brook. Bridge does not appear to be causing a mid-channel deposition in brook as was noted in the SGA.

Field Photos

Photo 1. Support blocks in stream channel

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	1	2	1	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-04**	Latitude: 44.471239 ° N	Longitude: 73.123822 ° W
Watershed:	Allen Brook		
Location:	North of industrial complex, at the west of the end of Sundown Dr.		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Aggradation has caused new (braided) channel to form; visible erosion on outer bank. Large riparian buffer zone, including some woody vegetation, present.

Field Photos

Photo 1. Visible erosion/undercutting of bank

Photo 2. Evidence of aggradation

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	1	2	1	No	No	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	AB-05	Latitude: 44.472150 ° N	Longitude: 73.116677 ° W
Watershed:	Allen Brook		
Location:	Palmer Court		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (Town)/Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Lawns on east-side of circle all slope towards road, and water reaching the road has no place to drain to. No catch basins or other stormwater collection devices (such as rain gardens) in area. Catch basins in road seem to have house drains flowing into them. Lawns drain to cul-de-sac with no stormwater facilities to collect runoff.

Update 6/18/2013: Opportunity on cul-de-sac for rain garden. CB on west side of street, directly in front of #49 Palmer Ct. emitting sewage smell. Sediment is being deposited along curb line on either side of street.

SWMP Field Assessment Photos

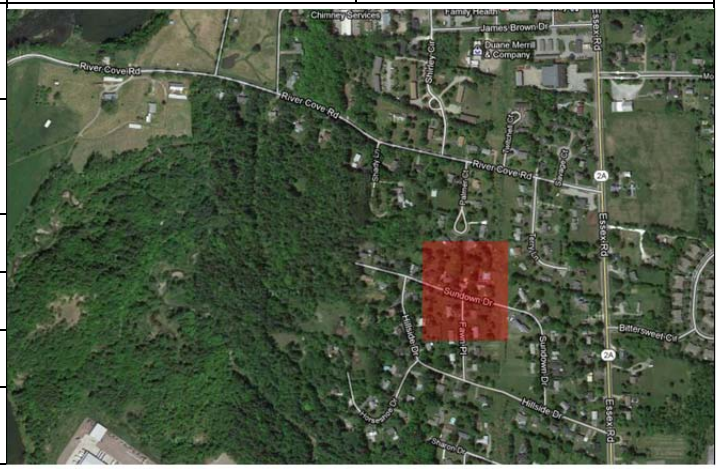
Photo 1. Stormwater runoff flowing into the cul-de-sac from surrounding residential properties.

Photo 2. Runoff ponding in the cul-de-sac and overflowing to the north along Palmer Court.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	3	2	2	Yes	Yes	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-07**	Latitude: 44.470441 ° N	Longitude: 73.116337 ° W
Watershed:	Allen Brook		
Location:	Fawn Place and Sundown Dr.		
Problem Type:	Local Drainage		
Identification Source:	Public Works Department		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012, 8/9/2012

Description of Observed Conditions:

Water is apparently coming from Sundown Dr; there are no catch basins or other drainage infrastructure on Fawn Pl. A curb cut was poorly repaired leading to water running on road to jump curb and flow through the lawns on Fawn Pl, into driveways and then being homes on Fawn Place. Residents indicated runoff eventually reaches the backyard to house on 264 Hillside Dr. Owners have installed a French drain to protect house and foundation from flooding. Owner at 55 Fawn Place is very concerned about flooding and damage to driveway.

Field Photos

Photo 1. Looking south along Fawn Place

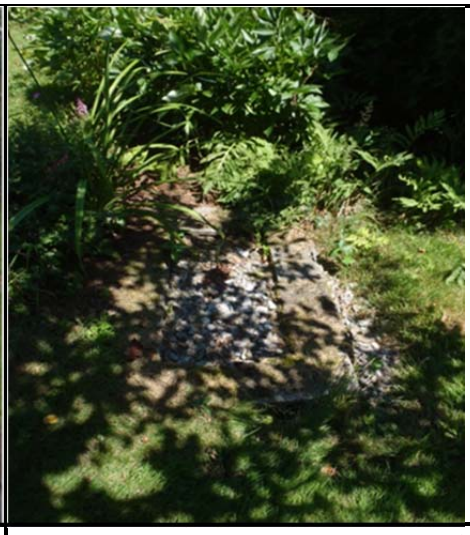


Photo 2. Owner installed catch basin/leach field at 264 Hillside

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	2	Yes	Yes	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-09**	Latitude: 44.468854 ° N	Longitude: 73.119234 ° W
Watershed:	Allen Brook		
Location:	Horseshoe Drive		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (Town)/Private		

Date of Field Data Collection: 04/28/2011

Description of Observed Conditions:

Catch basins at end of pavement are clogged with sediment, causing localized flooding. Catch basin on top of hill (in lawn) appears to be about 80% full of debris. French drain between houses on curve appears to be in good working order, channeling water from Sharon Dr. neighborhood. Discharges to an incline in woods that leads to Allen Brook, showing signs of gullying.

Updated 6/18/2013: Catch basins at bottom of hill remain full. CBs uphill are clear. Gully erosion continues in wooded area. May be another community outreach opportunity for curb cuts with rain gardens on residential properties.

SWMP Field Assessment Photos

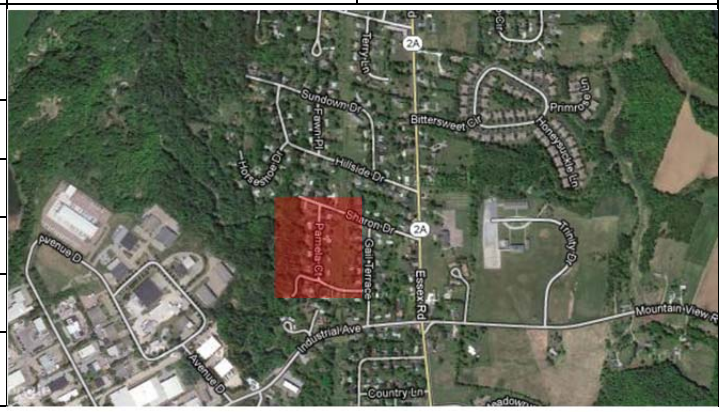
Photo 1. Catch basin clogged with sediment.

Photo 2. Erosion of the gravel cul-de-sac.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	3	2	Yes	Yes	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	AB-10	Latitude: 44.467116 ° N	Longitude: 73.116643 ° W
Watershed:	Allen Brook		
Location:	Gail Terrace		
Problem Type:	Local Drainage		
Identification Source:	Resident report		
Ownership:	Public (Town)/Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Stormwater from Pamela Ct, Lea Dr, and N. Gail Terr all flows to culvert at intersection of Pamela and Lea (photo 1). Culvert is 18" corrugated metal pipe. At outfall, some sediment is building up; may contribute to localized road flooding reported by residents. Gail Terr catch basins are clear or debris. At 92 Gail, basin in yard is full of debris. No catch basins present on Pamela Ct, ditch drainage through culverts under driveways - most are 12" pipes.

Field Photos

Photo 1. Culvert at intersection of Gail/Pamela

Photo 2. Culvert outfall

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	2	1	1	Yes	Yes	Yes	No

Problem Area Data Sheet

Problem Area ID:	**AB-11**	Latitude: 44.466269 ° N	Longitude: 73.117744 ° W
Watershed:	Allen Brook		
Location:	Forested area between Pamela Ct & Horseshoe Dr		
Problem Type:	Channel Erosion		
Identification Source:	SWMP Questionnaire		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Channel is main run-off path for nearby neighborhood. Where the unnamed tributary enters the woods, severe erosion and overgrowth around channel is present. Incline in woods is steep and mass failures have occurred all the way to Allen Brook.

Field Photos

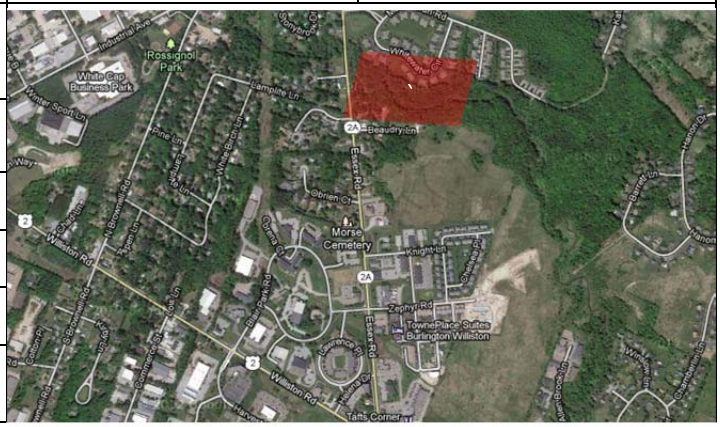
Photo 3. Overgrowth and undercutting

Photo 4. Mass failure on approach to Allen Brook

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	2	2	2	No	Yes	No	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-13**	Latitude: 44.459864 ° N	Longitude: 73.112169 ° W
Watershed:	Allen Brook		
Location:	Route 2A and Hideaway Ln		
Problem Type:	Overland Erosion		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (VTrans)		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Rip rap has been placed in the ditch/gully alongside road. Small headcut (<1') and channeling in lower half of rip rap. Some sediment deposition, presumably carried from road is present, where the rip rap ends (Photo 1).

Field Photos

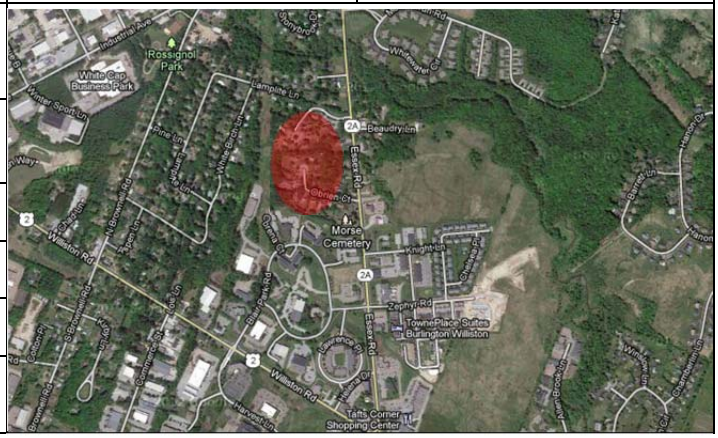
Photo 1. Looking down riprap

Photo 2. Looking up riprap, channeling

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	3	2	2	Yes	Yes	Yes	No

Problem Area Data Sheet

Problem Area ID:	**AB-14**	Latitude: 44.457800 ° N	Longitude: 73.114360 ° W
Watershed:	Allen Brook		
Location:	O'Brien Court		
Problem Type:	Local Drainage		
Identification Source:	Public Works Department		
Ownership:	Public (Town)/Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Catch basins at curve in road appear to have high water flow and sediment deposits during rain events. Signs of sediment and water flow down street towards the two catch basins. Catch basin grate is partially obstructed by accumulated sediment and debris.

Update 6/25/2013: CBs in neighborhood all had sediment accumulation. Water volume does not appear to be an issue. Few gutters in the area drain to driveways/road. Area lawns are very sandy (thin with grass). Lawn elevations are all above the curb and are source of sediment on roads.

Field Photos

Photo 1. Clogged catch basin

Photo 2. Debris accumulated at catch basin inlet

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	2	2	1	Yes	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-16**	Latitude: 44.445600 ° N	Longitude: 73.100988 ° W
Watershed:	Allen Brook		
Location:	East end of Talcott Rd, north of Route. 2		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Public		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Culvert is significantly less than bankfull width. Signs of channel scour just below culvert (Photo 2). Rock, sediment and debris are being deposited at outfall.

Field Photos

Photo 1. Debris deposits

Photo 2. Scour pool

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	1	2	2	No	No	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-17**	Latitude: 44.447016 ° N	Longitude: 73.102131 ° W
Watershed:	Allen Brook		
Location:	Between Tyler Way and Seth Circle		
Problem Type:	Overland Erosion		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Water from parking lot causing erosion; some localized erosion spots on hillside facing buildings (Photo 1). Work underway for drainage on edge of parking lot. Water marks are visible on edge of pavement and grass on approach to wet pond drainage area. Channeling is beginning to undermine rip rap leading to pond as well (Photo 2).

Field Photos

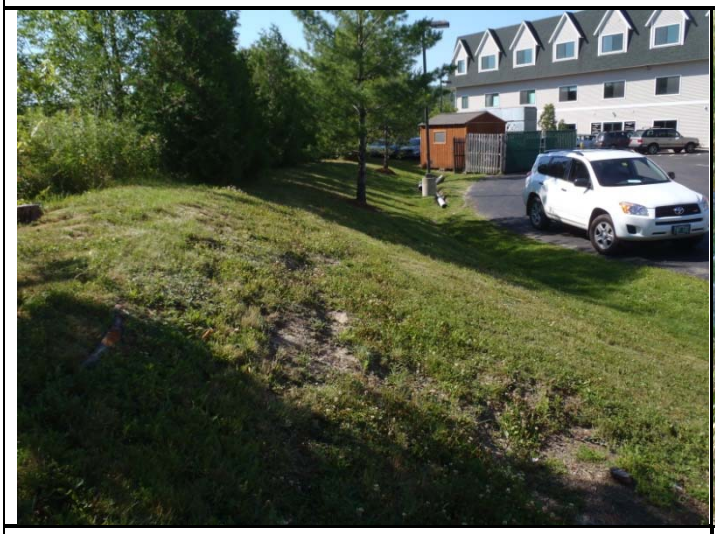


Photo 1. Water Damage

Photo 2. Channeling in rip rap

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	2	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	AB-18	Latitude: 44.447337 ° N	Longitude: 73.101646 ° W
Watershed:	Allen Brook		
Location:	Between Tyler Way and Seth Circle		
Problem Type:	Local Drainage		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

12" plastic pipe outfalls to two- 6" pipes that appear to help direct flow of water. Pipes appear to have been buried at one point, but erosion has caused them to be exposed. Scour pool and channelization has formed at outfall of two 6" pipes. Water leads to a wet bank buffer zone before flowing into Allen Brook.

Field Photos

Photo 1. "Intersection" of 12" and 6" pipes

Photo 2. Scour at outfall of 6" pipes

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	3	2	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-19**	Latitude: 44.448913 ° N	Longitude: 73.103306 ° W
Watershed:	Allen Brook		
Location:	Talcott Rd. South of Allen Brook Lane		
Problem Type:	Overland Erosion		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Note: Could be corrected through permit enforcement.

Description of Observed Conditions:

12" plastic outfall with broken end. Bank around outfall has failed and about 4' of pipe is exposed. Outfall drop is 4-5' to ground causing erosion issues. Major gully erosion present as water approaches Allen Brook. Sediment build up in Allen Brook, grass and weeds are growing on top of sediment causing a false bank to form in brook.

Field Photos

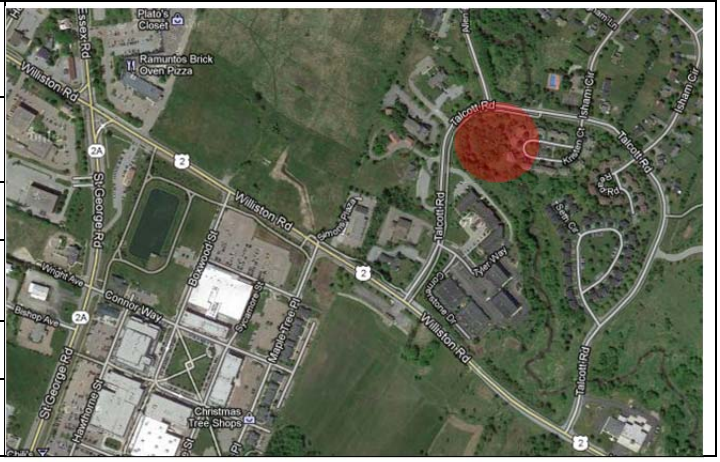
Photo 1. Failed bank and pipe outfall

Photo 2. Channel forming as water travels to Allen Brook

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	2	3	2	No	Yes	Yes	No

Problem Area Data Sheet

Problem Area ID:	**AB-20**	Latitude: 44.449467 ° N	Longitude: 73.103128 ° W
Watershed:	Allen Brook		
Location:	Talcott Rd. South of Allen Brook Lane		
Problem Type:	Overland Erosion		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012 Note: Could be corrected through permit enforcement.

Description of Observed Conditions:

12" plastic outfall; riprap has been placed below outfall - outfall drop is ~1'. Erosion is present in a few areas around riprap. Major sediment build up at intersection with Allen Brook. Large amounts of storm debris evident in brook.

Field Photos

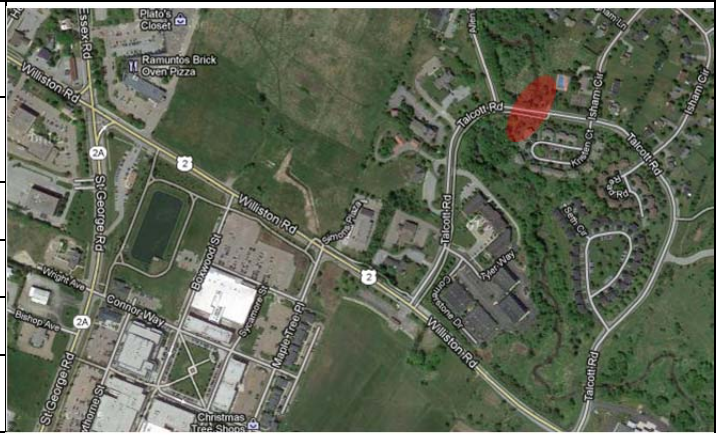
Photo 1. Erosion left of riprap

Photo 2. Sediment in Allen Brook

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	3	2	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-21**	Latitude: 44.449588 ° N	Longitude: 73.102386 ° W
Watershed:	Allen Brook		
Location:	Talcott Rd. east of Allen Brook Lane		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Public		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Sediment "delta" and scour pool forming at outfall of double-barrel culverts. Scour pool is developing at outfall. Culvert is less than bankfull width.

Field Photos

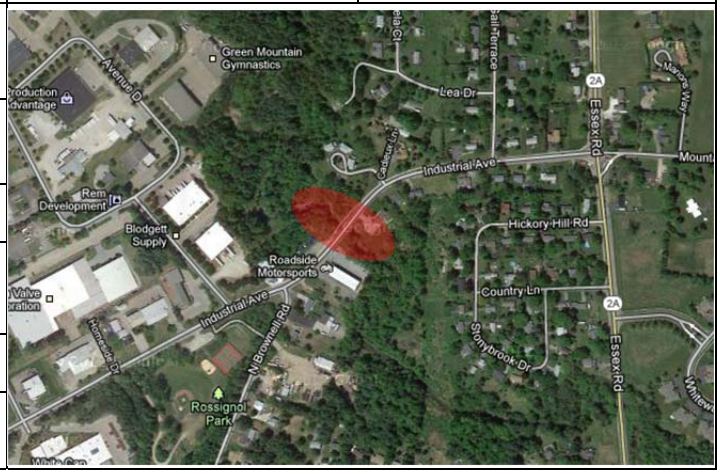
Photo 1. Looking downstream from culvert outfall

Photo 2. Culvert outfall

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	2	2	1	No	No	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-24**	Latitude: 44.463698 ° N	Longitude: 73.117848 ° W
Watershed:	Allen Brook		
Location:	Industrial Ave. and NE of N. Brownell Rd.		
Problem Type:	Local Drainage		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Erosion is present between entire length of parking lot and Industrial Ave. Minor pavement trenching is present. Significant sediment accumulation on bridge that spans Allen Brook near north end of parking lot.

Field Photos

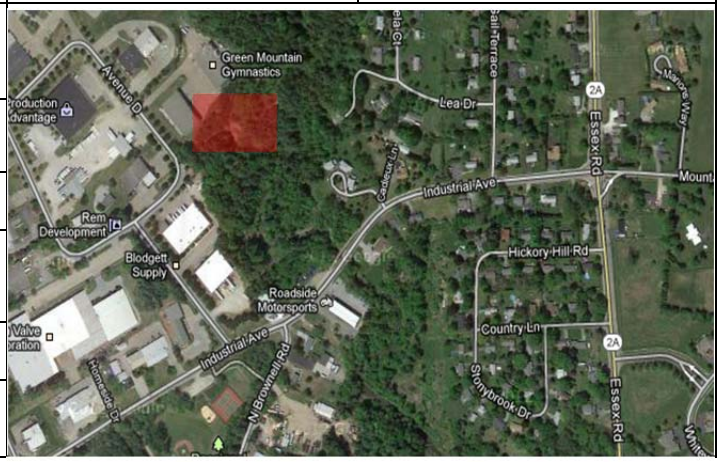
Photo 1. Erosion on Industrial Ave.

Photo 2. Sediment on bridge above Allen Brook

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	2	Yes	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-26**	Latitude: 44.465566 ° N	Longitude: 73.119906 ° W
Watershed:	Allen Brook		
Location:	East of Avenue D		
Problem Type:	Overland Erosion		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012 Note: Could be corrected through permit enforcement.

Description of Observed Conditions:

Minor gullying at outfall; iron staining visible. Culvert is ~75% clogged with debris. No catch basins in parking lot. Outfall may be roof drains, gullying in woods may indicate parking lot run-off to woods.

Field Photos

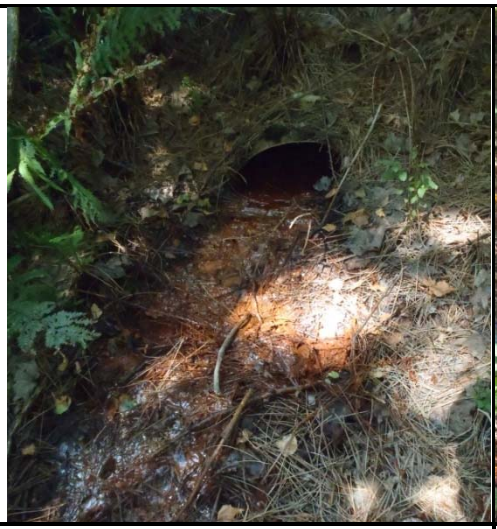


Photo 1. Blocked outfall, iron staining

Photo 2. Gully above outfall

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	2	3	2	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-29**	Latitude: 44.465507 ° N	Longitude: 73.124015 ° W
Watershed:	Allen Brook		
Location:	Avenue D		
Problem Type:	Overland Erosion		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012 Note: Could be corrected through permit enforcement.

Description of Observed Conditions:

Erosion in drainage ditches on west side of Avenue D; excess flows have begun to undermine. Check dams have been installed to slow water rate as it approaches culvert. Gullying present on the east side of road at bend in Avenue D. Some evidence of hillside cutting and erosion on bank from parking lot run-off at Production Advantage.

Field Photos

Photo 1. Culvert, beginning to be undermined

Photo 2. Curve side trenching

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	2	Yes	Yes	Yes	No

Problem Area Data Sheet

Problem Area ID:	**AB-30**	Latitude: 44.466510 ° N	Longitude: 73.127516 ° W
Watershed:	Allen Brook		
Location:	NW of end of Avenue C		
Problem Type:	Landslide		
Identification Source:	Public Works Department		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Note: Plans exist for resolution.

Description of Observed Conditions:

Major erosion and bank failure. Landslide extends several hundred feet down into old sand pit. Run-off from road could be contributing to erosion around outfall.

Field Photos

Photo 1. View from top of slide

Photo 2. Further down in slide

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	3	1	Yes	Yes	Yes	No

Problem Area Data Sheet

Problem Area ID:	**AB-32**	Latitude: 44.457444 ° N	Longitude: 73.071198 ° W
Watershed:	Allen Brook		
Location:	Old Stage Road south of Amber Ln		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Private		

Date of Field Data Collection: 6/24/11

Description of Observed Conditions:

Black 12” corrugated plastic culvert under Amber Ln. Sediment accumulating at outfall of culvert. Area is high point on Stage Rd where it appears that water may have no place to flow. Ditches are level, no gradient to them.

SWMP Field Assessment Photos

Photo 1. Water ponding along Old Stage Road at the intersection with Amber Lane

Photo 2. Water ponding along Amber Lane

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	3	2	2	Yes	Yes	Yes	No

Problem Area Data Sheet

Problem Area ID:	**AB-33**	Latitude: 44.448864 ° N	Longitude: 73.060633 ° W
Watershed:	Allen Brook		
Location:	North Williston Rd, north of Spruce Ln		
Problem Type:	Overland Erosion		
Identification Source:	SWMP Questionnaire		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Ponding of water before entering marsh area. Pond is 8' by 12' about 8" deep. Signs of small dam/blockage at one point with rebar in stream; obstruction has been breached.

Field Photos

Photo 1. Ponding of water

Photo 2. Remnants of blockage

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	1	2	1	No	No	Yes	No

Problem Area Data Sheet

Problem Area ID:	**AB-34**	Latitude: 44.446536 ° N	Longitude: 73.065333 ° W
Watershed:	Allen Brook		
Location:	Between Ian Pl and North Williston Rd		
Problem Type:	Channel Erosion		
Identification Source:	Planning Office		
Ownership:	Private		

Date of Field Data Collection: 11/11/2012

Description of Observed Conditions:

Incised banks are constantly failing. Conditions worsen as stream progresses down channel. Large amount of development in the watershed.

Field Photos

Photo 1. Stream in wetland area

Photo 2. Erosion of stream banks.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	1	2	2	No	Yes	No	Yes

Problem Area Data Sheet

Problem Area ID:	AB-35	Latitude: 44.444751 ° N	Longitude: 73.066618 ° W
Watershed:	Allen Brook		
Location:	North Williston Rd across from Golf Course Rd		
Problem Type:	Local Drainage		
Identification Source:	Planning Office		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Loose gravel around underground pipe is eroding. Pipe end is filling in with material and channelization occurring immediately after outfall. Pipe appears to drain field and house area upstream. Problem caused by piping and burying the natural drainage which conveys runoff form the golf course.

Field Photos

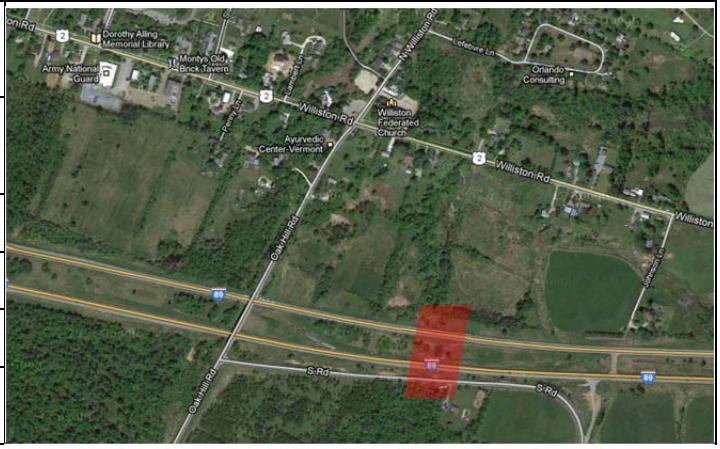
Photo 1.

Photo 2.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	2	2	2	No	Yes	No	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-36**	Latitude: 44.433674 ° N	Longitude: 73.066224 ° W
Watershed:	Allen Brook		
Location:	I-89, 0.25 mi. west of Oak Hill Rd		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Public (VTrans)		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Upstream, brook makes an "S" as it approaches culverts. Bank scouring at the entrance to culvert. Between N/S lanes of 89 small scour pool is present. Scour pool at North bound outfall with 6" headcut from concrete box culvert.

Field Photos

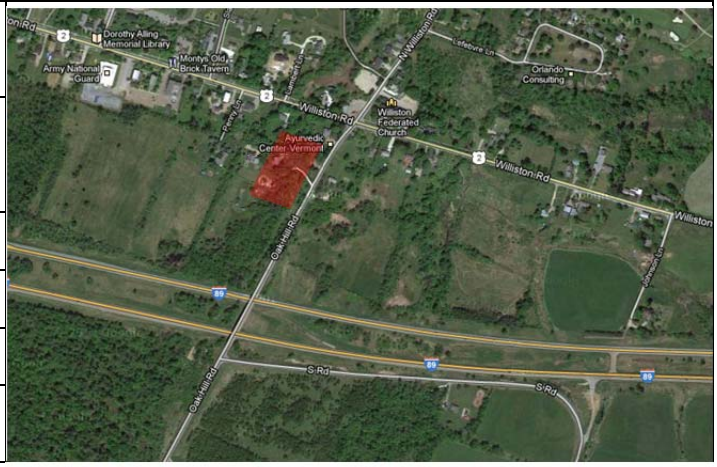
Photo 1.

Photo 2.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	1	2	2	Yes	No	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-38**	Latitude: 44.436697 ° N	Longitude: 73.069556 ° W
Watershed:	Allen Brook		
Location:	Private drive off of Oak Hill Rd, 0.35 mi. south of Rt. 2		
Problem Type:	Local Drainage		
Identification Source:	Planning Office		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Private drive washes into northeast side of stream. Road slopes towards the stream bringing road debris/gravel with it to stream. 3' corrugated culvert becoming overgrown with weeds; water flow is partially obstructed.

Field Photos

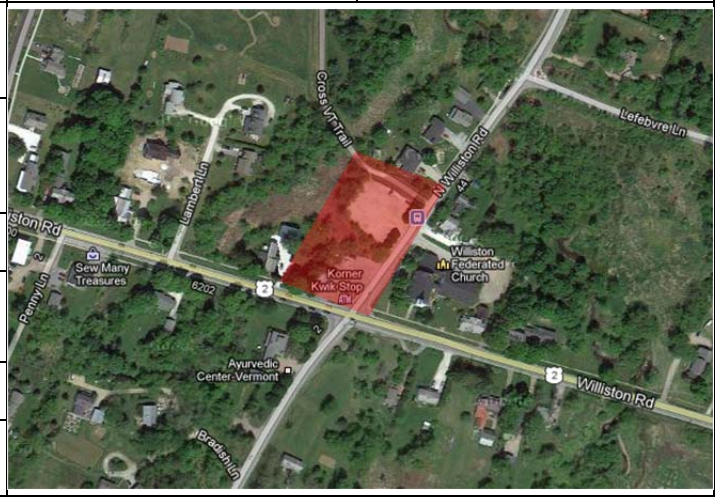
Photo 1. Overgrown culvert. Standing water

Photo 2. Overgrown weeds

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	2	2	1	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-39**	Latitude: 44.437938 ° N	Longitude: 73.068192 ° W
Watershed:	Allen Brook		
Location:	Northwest of the intersection of Route 2 and North Williston Rd		
Problem Type:	Local Drainage		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Run-off from gravel parking lot flows to natural area/wetland between gas station parking lot and bike path parking lot. Sediment has built up along north side of parking lot. No catch basins in area.

Field Photos

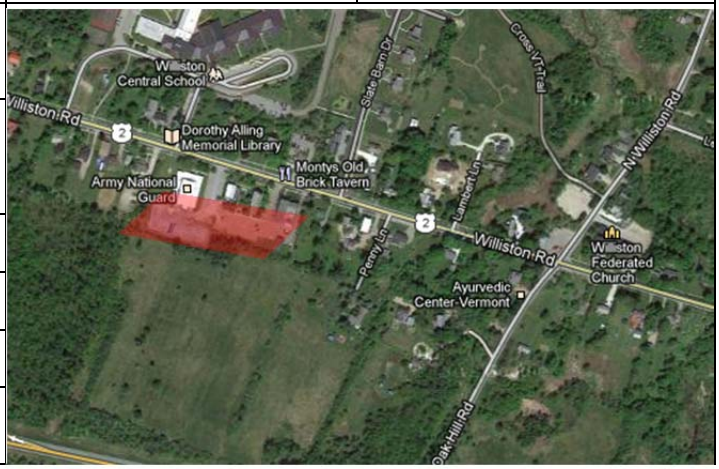
Photo 1. Edge of parking lot

Photo 2. Ponding in front of natural areas

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	2	No	Yes	Yes	No

Problem Area Data Sheet

Problem Area ID:	AB-40	Latitude: 44.438085 ° N	Longitude: 73.073711 ° W
Watershed:	Allen Brook		
Location:	Route 2, 0.25 mi west of intersection with North Williston Rd		
Problem Type:	Local Drainage		
Identification Source:	Planning Office		
Ownership:	Public (Federal, Town)		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

No catch basins/drainage ditch to provide water access to stormwater system. Signs of ponding and erosion on gravel drive and grass medians. Drainage ditch runs along south end of parking lot. Heavy truck and traffic use as town vehicles and National Guard use road.

Update 6/18/2013: Gravel parking lot appears to be slopping toward National Guard building. Swale surrounding property appears to be functioning properly. May be opportunity for addition swale or detention pond to redirect flow from northern, paved lot

Field Photos

Photo 1. Edge of gravel lot to paved lot

Photo 2. Runoff from gravel lot during rain event

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	1	2	Yes	Yes	Yes	No

Problem Area Data Sheet

Problem Area ID:	**AB-41**	Latitude: 44.438858 ° N	Longitude: 73.075100 ° W
Watershed:	Allen Brook	
Location:	Route 2, approximately 0.35 mi west of the intersection with North Williston Rd		
Problem Type:	Local Drainage		
Identification Source:	Planning Office		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012; 8/9/2012

Description of Observed Conditions:

There is a lawn swale that runs from under barn to edge of property and sidewalk. Some signs of standing water and localized erosion in private drive.

Field Photos

Photo 1.

Photo 2.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	2	2	2	Yes	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	AB-42	Latitude: 44.438945 ° N	Longitude: 73.075513 ° W
Watershed:	Allen Brook		
Location:	Route 2, approximately 0.35 mi west of the intersection with North Williston Rd		
Problem Type:	Local Drainage		
Identification Source:	Planning Office		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012; 8/3/2012

Description of Observed Conditions:

Stormwater pipe flows from French drain underground to catch basin. French drain is a 6" plastic pipe and stormwater pipe is 12". Signs of erosion and water bypass at French drain outlet causing water to flow into driveway and onto sidewalk and street.

Field Photos

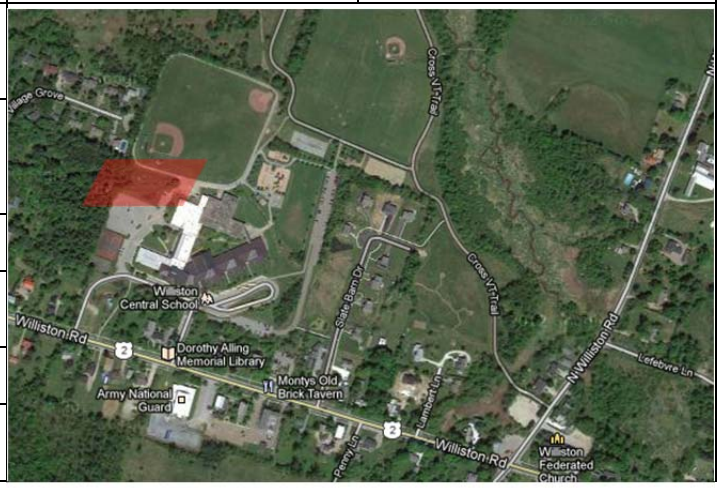
Photo 1.

Photo 2. Looking down to street

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
1	2	1	2	Yes	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-43**	Latitude: 44.441017 ° N	Longitude: 73.074658 ° W
Watershed:	Allen Brook		
Location:	Northeast corner of school complex on Central School Dr		
Problem Type:	Local Drainage		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Public		

Date of Field Data Collection: 7/11/2012 Note: Could be corrected through permit enforcement.

Description of Observed Conditions:

Swale is becoming incised about halfway through. Incision is approximately 1.5' deep. The 8" plastic pipe moving water from wet pond to swale is damaged and erosion is evident at outfall, as water drops 8" into swale.

Update 6/18/2013: Incision has reached clay layer. Lining the swale bottom with stone could prevent further erosion. Most of swale appears to be functioning properly.

Field Photos

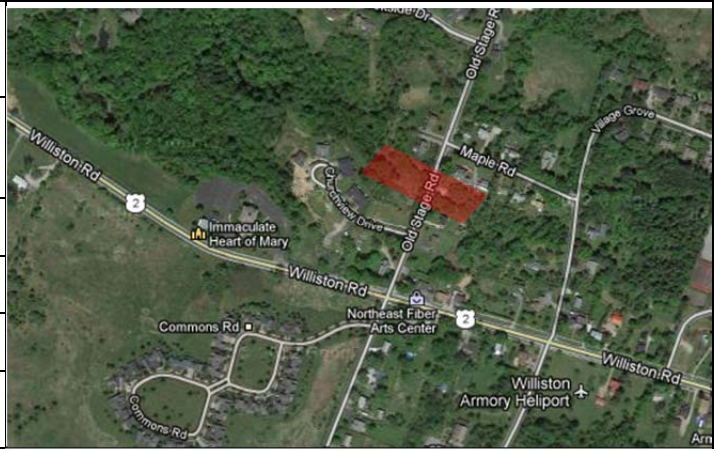
Photo 1. Erosion in swale

Photo 2. Damaged outfall pipe

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	2	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-44**	Latitude: 44.441194 ° N	Longitude: 73.079880 ° W
Watershed:	Allen Brook		
Location:	Old Stage Road just south of Maple Rd		
Problem Type:	Local Drainage		
Identification Source:	Public Works Department		
Ownership:	Public/Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

3' corrugated metal culvert; bottom has deteriorated. Culvert is ~50% of bank width; scour is evident at outfall and channel is incising.

Update 6/18/2013: Improvements could be made via permit enforcement for Churchview Estates (4462-9020, 4462-9020.1, 4462-INDS)

Field Photos

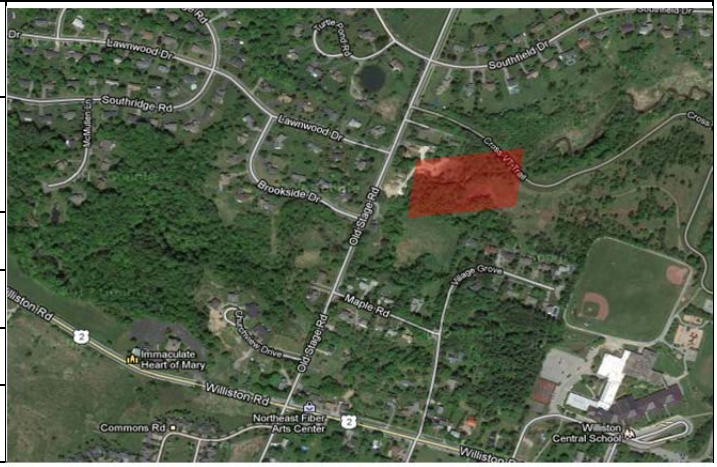
Photo 1. Inlet, grass on sides matted down

Photo 2. Deteriorated culvert

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	3	2	Yes	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-45**	Latitude: 44.443656 ° N	Longitude: 73.076827 ° W
Watershed:	Allen Brook		
Location:	Old Stage Rd, directly across from Lawnwood Dr		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Private		

Date of Field Data Collection: 8/3/2012

Description of Observed Conditions:

Mass wasting and erosion on outer bank of stream; streambanks are undercut. Local, sandy soils may be particularly sensitive to unraveling.

Field Photos

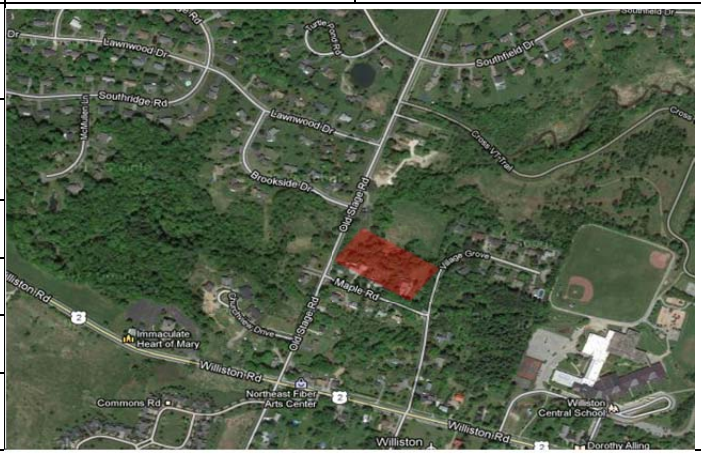
Photo 1.

Photo 2.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	2	2	2	No	No	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-46**	Latitude: 44.442238 ° N	Longitude: 73.078499 ° W
Watershed:	Allen Brook		
Location:	Old Stage Rd, just north of Maple Rd		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Bank erosion and undercutting. Old metal pipe of unknown discharging into brook; iron staining present.

Field Photos

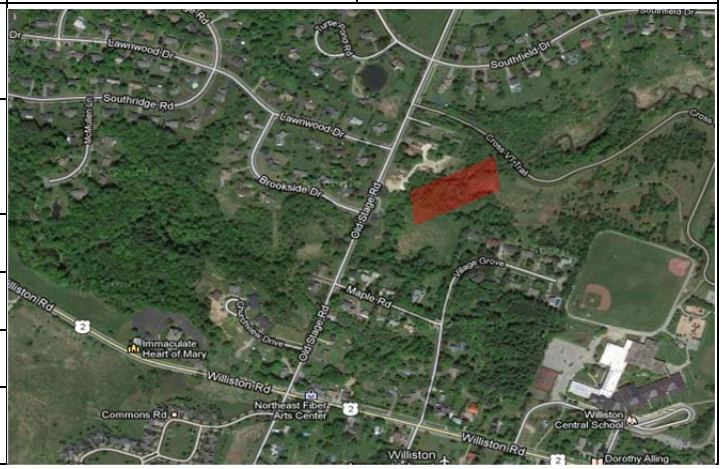
Photo 1. Bank cutting

Photo 2. Old metal pipe outlet

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	2	No	No	No	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-47**	Latitude: 44.442399 ° N	Longitude: 73.079245 ° W
Watershed:	Allen Brook		
Location:	Old Stage Rd, near Lawnwood Dr		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Public (Town)		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Large scour pool at outlet; standing water approximately 1.5’ deep in pool. New bank work and rip rap placed at outlet. Possible start of undermining on upstream inlet.

Field Photos

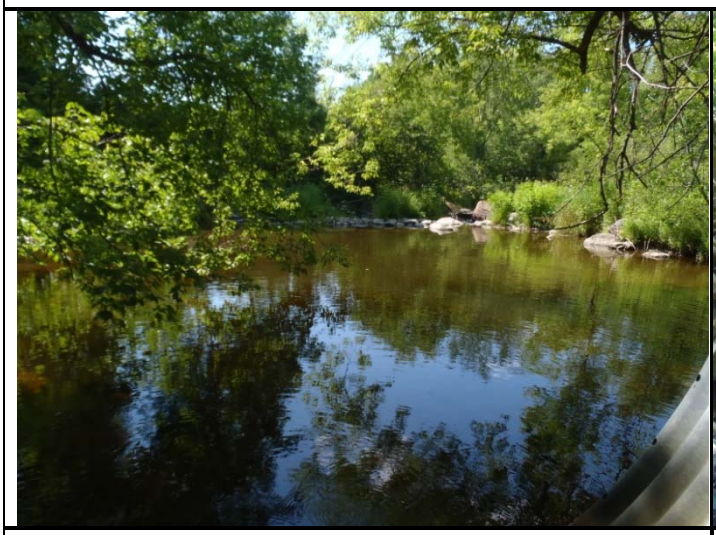


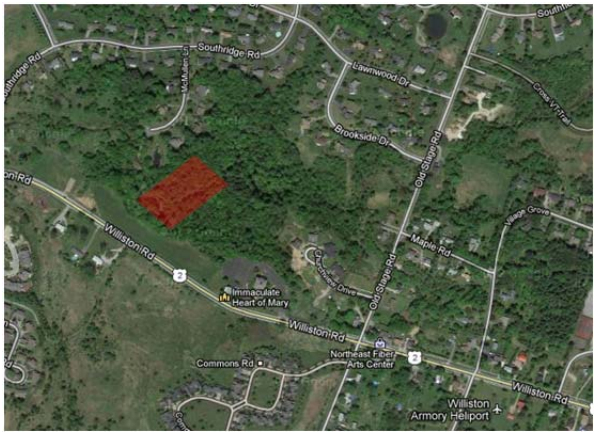
Photo 1. Large scour pool

Photo 2. Inlet, with possible undermining

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	1	2	2	Yes	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-48**	Latitude: 44.442636 ° N	Longitude: 73.084041 ° W
Watershed:	Allen Brook		
Location:	North of Route 2, near McMullen Ct		
Problem Type:	Channel Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Private		

Date of Field Data Collection: 8/3/2012

Description of Observed Conditions:

Areas of streambank erosion and small undercuts and bank collapses were observed. One area where water has jumped bank was also noted.

Field Photos

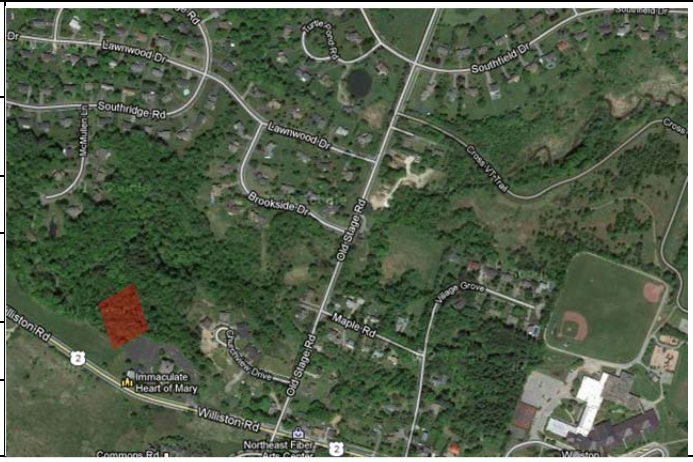
Photo 1. Streambank has been undermined

Photo 2. Localized bank collapses

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	1	No	No	No	Yes

Problem Area Data Sheet

Problem Area ID:	**AB-49**	Latitude: 44.441489 ° N	Longitude: 73.083500 ° W
Watershed:	Allen Brook		
Location:	Route 2, west of Old Stage Rd		
Problem Type:	Overland Erosion		
Identification Source:	Allen Brook Watershed Improvement Plan		
Ownership:	Private		

Date of Field Data Collection: 7/11/2012

Description of Observed Conditions:

Gully has formed in northwest corner of parking lot, where land slopes down to the woods line. Gully is not deep, but has potential to increase in size. Gully stops about 30 ft down into woods.

Field Photos

Photo 1. Looking up gully

Prioritization Ranking Factors							
Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	2	2	2	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-50**	Latitude: 44.424551 ° N	Longitude: 73.071560° W
Watershed:	Allen Brook		
Location:	West of the intersection of South Rd and E. Hill Rd		
Problem Type:	Overland Erosion		
Identification Source:	Allen Brook SGA		
Ownership:	Private		

Date of Field Data Collection: 8/10/2012

Description of Observed Conditions:
No buffer or fence between cattle grazing and stream. Evidence of direct animal access to the stream (Photo 2).

Field Photos

Photo 1.

Photo 2.

Prioritization Ranking Factors							
Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	3	2	2	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**AB-52**	Latitude: 44.418945 ° N	Longitude: 73.066184 ° W
Watershed:	Allen Brook		
Location:	East Hill Rd, 0.25 mi southeast of South Rd		
Problem Type:	Overland Erosion		
Identification Source:	Public Works Department		
Ownership:	Public		

Date of Field Data Collection: 8/10/2012

Description of Observed Conditions:

Roadside ditch is eroding/deepening over time; mostly stable now.

Update 6/25/2013: Ditch banks appear well vegetated and stable. Armoring the bottom with riprap may slow future erosion.

Field Photos

Photo 1. Ditch is mostly well-vegetated

Photo 2. Bank erosion/sloughing

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	1	2	1	Yes	Yes	Yes	No

C.2. Muddy Brook

Problem Area Data Sheet

Problem Area ID:	**MB-02**	Latitude: 44.441467° N	Longitude: 73.136081° W
Watershed:	Muddy Brook		
Location:	Private road off South Brownell Rd, leading to S.D. Ireland quarry		
Problem Type:	Channel Erosion		
Identification Source:	Muddy Brook SGA		
Ownership:	Private		
Classification Level:	1		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

Culvert carries Muddy Brook under haul road; haul road subject to heavy commercial truck traffic. As was noted in the SGA, this culvert is severely undersized (25% of bankfull channel width) and is causing severe scour and bank erosion downstream. Culvert bottom shows some signs of deterioration.

Field Photos

Photo 1. Scour pool at outfall

Photo 2. Bank scouring

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of a larger or systemic problem?
2	2	2	2	No	Yes	Yes	No

Relative Impact: Scour pool and bank erosion will continue to be exacerbated during rain events. Culvert is in fair to poor condition. Pro-active outreach to landowner could help ensure the replacement, when made, will be of sufficient capacity to alleviate scour and bank erosion concerns.

Problem Area Data Sheet

Problem Area ID:	**MB-03**	Latitude: 44.452948° N	Longitude: 73.138756° W
Watershed:	Muddy Brook		
Location:	Unnamed trib joins Muddy Brook just south of Kimball Ave, between Marshall Ave and Gregory Dr.		
Problem Type:	Channel Erosion		
Identification Source:	Town Planning Office		
Ownership:	Private		
Classification Level:	2		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

Steep banks line both side of the unnamed tributary to Muddy Brook; minor erosion along toe of bank evident throughout the area. One small headcut was found in the unnamed tributary.

Field Photos

Photo 1. Bank erosion in tributary

Photo 2. Steep bank leading into tributary

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of a larger or systemic problem?
2	1	1	1	No	No	No	Yes

Relative Impact: Minor, but on-going, erosion present at toe-of-slope.

Problem Area Data Sheet

Problem Area ID:	**MB-06**	Latitude: 44.452631° N	Longitude: 73.136370° W
Watershed:	Muddy Brook		
Location:	Unnamed trib to Muddy Brook passes under Marshall Ave near the intersection with Shunpike Rd		
Problem Type:	Channel Erosion		
Identification Source:	Muddy Brook SGA		
Ownership:	Public		
Classification Level:	2		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

36" black plastic corrugated culvert carries unnamed tributary under Marshall Ave. Culvert is undersized and is causing erosion upstream and downstream. A headcut has formed downstream of the Marshall Avenue crossing. The headcut does not appear to be migrating rapidly upslope, but increasing urbanization in the upslope watershed may make the stabilization of this feature a higher priority.

Field Photos

Photo 1. Existing 36" plastic culvert

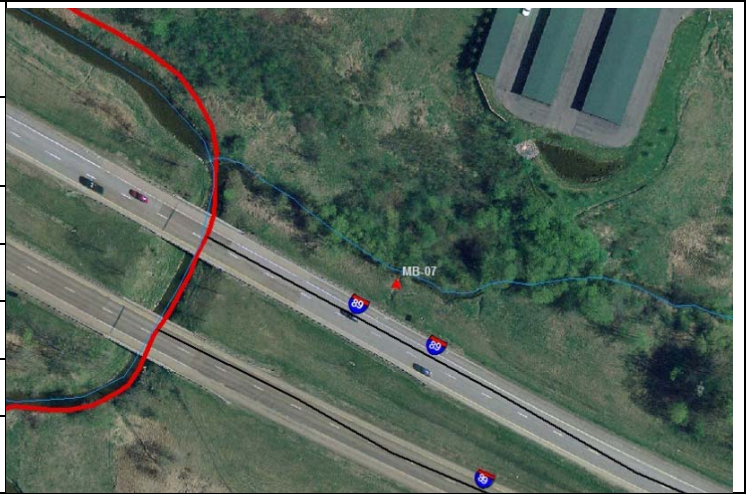
Photo 2. Incised channel

Prioritization Ranking Factors

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
2	2	2	2	Yes	No	No	Yes

Relative Impact: Undersized culvert and small headcut combine to increase sensitivity of this unnamed tributary to increased flows associated with development.

Problem Area Data Sheet

Problem Area ID:	**MB-07**	Latitude: 44.442306° N	Longitude: 73.134588° W
Watershed:	Muddy Brook		
Location:	I-89, just northwest of the So Brownell Rd crossing		
Problem Type:	Local Drainage		
Identification Source:	Muddy Brook SGA		
Ownership:	Public (VTrans)		
Classification Level:	1		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

Six drains from northbound lanes and three pipes from southbound lanes of I-89 discharge directly into Muddy Brook. Southbound drains causing erosion and trenching into Muddy Brook. New riprap was recently placed around culvert in question

Field Photos

Photo 1. Recent riprap around culvert

Photo 2. Highway drainage

Prioritization Ranking Factors

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
1	1	2	2	Yes	Yes	Yes	Yes

Relative Impact: Drainage pipes from I-89 discharge directly into Muddy Brook.

Problem Area Data Sheet

Problem Area ID:	MB-08	Latitude: 44.441830° N	Longitude: 73.131161° W
Watershed:	Muddy Brook		
Location:	South Brownell Road, just north of the I-89 crossing		
Problem Type:	Local Drainage		
Identification Source:	Muddy Brook SGA		
Ownership:	Public		
Classification Level:	3		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

Culvert under South Brownell Road appears undersized and causes sediment and debris deposition upstream of the structure.8-9' corrugated culvert with 4" of steady flow. Two small streams meet at mouth of culvert and take 90^0 turn into culvert. Pool has formed on upstream side of rock weir in stream. Wall appears to be man-made causing 18" deep pool of water with sediment build up.

Update 6/18/2013: Very step bank on east side of South Brownell road, above culvert. Elm trees (primary tree growth in area) appear to have been infected by Dutch Elm Disease. Once the trees are gone, the bank will be at greater risk of erosion. Pre-emptive tree planting may protect bank.

Field Photos

Photo 1. Downstream view towards culvert

Photo 2. Upstream rock weir causing pooling

Prioritization Ranking Factors

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
2	2	2	2	Yes	No	Yes	Yes

Relative Impact: Rock weir in stream causing sediment to build up. Culvert positioning not allowing for a fluid flow of either stream.

Problem Area Data Sheet

Problem Area ID:	**MB-09**	Latitude: 44.410058 ° N	Longitude: 73.152236 ° W
Watershed:	Muddy Brook		
Location:	Route 116/Hinesburg Rd, 0.25 mi south of Cheesefactory Rd.		
Problem Type:	Channel Erosion		
Identification Source:	Muddy Brook SGA		
Ownership:	Public (VTrans)		
Classification Level:	1		

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:

Stream originates in large pond/marsh area. Stream makes 90^0 turn before passing under bridge; minor scouring was observed at bend. Existing bridge is causing minor scour upstream of the structure. The existing bridge is 36% of bankfull channel width.

Field Photos

Photo 1. Upstream bank scouring

Photo 2. Entrance to bridge

Prioritization Ranking Factors

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
2	1	2	2	Yes	No	No	No

Relative Impact: Bridge alignment appear okay; possible bank armor needed to protect against erosion.

Problem Area Data Sheet

Problem Area ID:	MB-10	Latitude: 44.445367 ° N	Longitude: 73.120968 ° W
Watershed:	Muddy Brook		
Location:	Marshall Ave. just east of Harvest Ln.		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Private		
Classification Level:	1		

Date of Field Data Collection: 04/28/2011

Description of Observed Conditions:

Marshall Avenue and the adjacent sidewalk flood as the Muddy Brook floodplain overflows across private property. Town Public Works Department contacted the developer who cleaned the culvert; more observations are needed to ensure problem has been fully addressed.

Field Photos

Photo 1. Evidence of poor drainage

Photo 2.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
2	2	1	2	Yes	No	Yes	Yes

Relative Impact: Intersection and roads are in floodplain for the stream.

Problem Area Data Sheet

Problem Area ID:	**MB-11**	Latitude: 44.444799 ° N	Longitude: 73.122102 ° W
Watershed:	Muddy Brook		
Location:	Harvest Ln. south of Marshall Ave.		
Problem Type:	Channel Erosion		
Identification Source:	Muddy Brook SGA		
Ownership:	Unknown		
Classification Level:	3		

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:

Stream bed is eroding. Primary headcut measures 2.8’ feet with a steady 3” flow falling. The downstream erosion is about 15’ wide and extends into floodplain.

Field Photos

Photo 1. Bank erosion

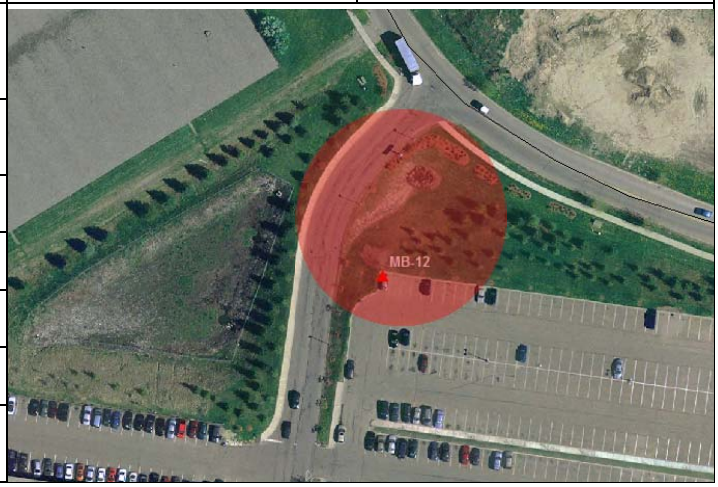
Photo 2. Head cut

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
3	2	2	2	No	No	No	Yes

Relative Impact: Small nick-point/headcut has resulted in significant localized erosion; left unchecked erosion likely to continue to migrate upstream.

Problem Area Data Sheet

Problem Area ID:	**MB-12**	Latitude: 44.442633 ° N	Longitude: 73.121009 ° W
Watershed:	Muddy Brook		
Location:	Wal-Mart parking lot		
Problem Type:	Local Drainage		
Identification Source:	Town Planning Office		
Ownership:	Private		
Classification Level:	2		

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:

Catch basin is slightly elevated or pavement/ground around the basin has settled and sunk in corner of parking lot. Water is flowing next to basin straight into the curb and then over and down the bank towards the Wal-Mart drive. Trenching is visible on west side of drive. Water is seeping from hillside between two basins, unsure of this source as it had been dry for a few days before observations.

Field Photos

Photo 1. Water seeping from ground

Photo 2. Bank damage

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
1	2	2	2	Yes	Yes	Yes	Yes

Relative Impact: Angle of parking lot and sediment build up would suggest high storm water run-off during rain events. This can be corrected by ANR permit enforcement.

Problem Area Data Sheet

Problem Area ID:	**MB-13**	Latitude: 44.440538 ° N	Longitude: 73.119519 ° W
Watershed:	Muddy Brook		
Location:	Near southwest corner of Home Depot building		
Problem Type:	Overland Erosion		
Identification Source:	SWMP Field Assessment		
Ownership:	Private		
Classification Level:	2		

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:

Gully erosion is occurring along the entire cut slope due, at least partially, to poor stabilization. Some are wet with minor water run-off. Rip-rap is in place on bank behind Wal-Mart with a couple trees lying on their sides. Unsure if the rip rap is from original construction or an attempt to abate on-going erosion.

Field Photos

Photo 1. Gullying behind Home Depot

Photo 2. Bank armor behind Wal-Mart

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
2	2	1	2	No	No	No	Yes

Relative Impact: On-going erosion and mass failure attributable to previous construction activities. This may be addressed through ANR permit enforcement.

Problem Area Data Sheet

Problem Area ID:	MB-14	Latitude: 44.442133 ° N	Longitude: 73.117625 ° W
Watershed:	Muddy Brook		
Location:	East of the Home Depot parking lot		
Problem Type:	Erosion		
Identification Source:	Muddy Brook SGA		
Ownership:	Private		
Classification Level:	3		

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:

Severe bank erosion is present along most bends of reach. Major bank under cutting occurring, particularly along the bank that separates stream from Home Depot parking lot, only about 6' of bank left. Could be cause of sediment build up in MB 14, as it is just upstream of culvert.

Field Photos

Photo 1. Under cutting

Photo 2. Bank between Home Depot and Stream

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
3	2	3	3	No	Yes*	Yes	Yes

Relative Impact: Large amounts of erosion in stream causing downstream sediment build up and possible complete bank failure to Home Depot parking lot. Bank between stream and parking lot is severely eroded.

Problem Area Data Sheet

Problem Area ID:	MB-15	Latitude: 44.443329 ° N	Longitude: 73.118874 ° W
Watershed:	Muddy Brook		
Location:	Harvest Lane, near entrance to Home Depot		
Problem Type:	Erosion		
Identification Source:	Muddy Brook SGA		
Ownership:	Public (Town)		
Classification Level:	3		

Date of Field Data Collection: 6/12/2012

Description of Observed Conditions:

Sediment built up at outfall of culvert, which is causing pooling in the culvert and very slow moving water at outfall. Large amounts of sediment downstream of culvert altering flow of water. Town Public Works Department contacted the developer who cleaned the culvert; more observations are needed to ensure problem has been fully addressed.

Field Photos

Photo 1. Looking downstream

Photo 2. Looking upstream

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
2	2	2	1	Yes	Yes	Yes	Yes

Relative Impact: Upstream erosion from Home Depot site (see MB-15) causing sediment to build up near/in culvert.

Problem Area Data Sheet

Problem Area ID:	MB-18	Latitude: 44.431129 ° N	Longitude: 73.119568 ° W

Watershed:	Muddy Brook
Location:	VT 2A, northeast of Walker Hill Rd.
Problem Type:	Local Drainage
Identification Source:	Resident Questionnaire
Ownership:	Public (VTrans, Town)
Classification Level:	3

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:

Majority of the issues appear to be on the southeast side of 2A; road-side ditches are eroding road shoulders. Drainage ditch crosses 2A at #3283 with 24" plastic culvert. Culvert is ½ full of sediment and debris. Hydraulic capacity of culvert decreased from aggraded material.

Field Photos

Photo 1. Aggradation in culvert.

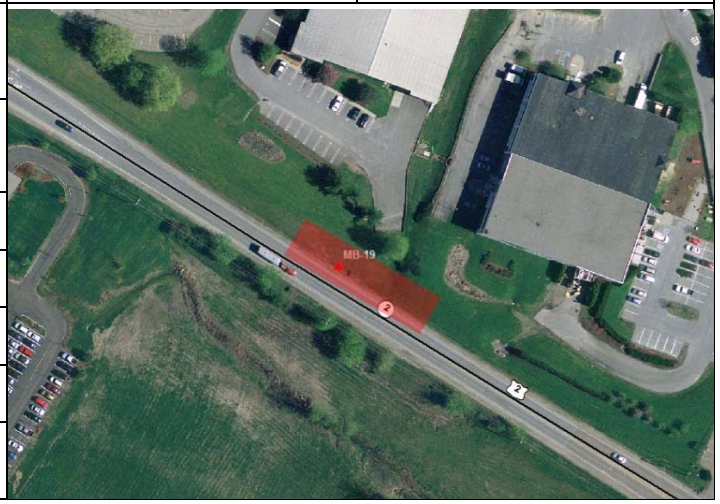
Photo 2. Road side erosion

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
2	2	2	3	Yes	Yes	Yes	Yes

Relative Impact: Drainage ditches along road needs repair; culvert needs to be cleaned out. Slope of culvert or source of backwater should be investigated to determine reason for aggradation.

Problem Area Data Sheet

Problem Area ID:	**MB-19**	Latitude: 44.451607 ° N	Longitude: 73.115406 ° W
Watershed:	Muddy Brook		
Location:	Rt. 2 (Williston Rd) 0.1 mi. southeast of Harvest Ln		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (VTrans, Town)		
Classification Level:	3		

Date of Field Data Collection: 06/15/2012

Description of Observed Conditions:
Evidence of road run-off is present on sidewalk. Trenching has formed between road and green belt.

SWMP Field Assessment Photos

Photo 1.

Photo 2.

Prioritization Ranking Factors							
Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
1	2	2	2	Yes	Yes	No	Yes
Relative Impact: Road run-off causing erosion between road and greenbelt leading to sediment build up in sidewalk. High visibility area that would benefit from improved stormwater management.							

Problem Area Data Sheet

Problem Area ID:	**MB-20**	Latitude: 44.453336 ° N	Longitude: 73.123286 ° W
Watershed:	Muddy Brook		
Location:	Kirby Lane		
Problem Type:	Local Drainage		
Identification Source:	SWMP Questionnaire		
Ownership:	Public (Town)		
Classification Level:	2		

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:

Catch basin / dry well does not drain and causes localized flooding.

Update 6/18/30: Problem persists. Water in front of residence may be, in part, a seep, flowing up through the lawn.

SWMP Field Assessment Photos

Photo 1. Evidence of overland flow and poor drainage

Photo 2. Standing water, as reported by local residents

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
2	2	2	2	No	Yes	Yes	Yes

Relative Impact: This is the area impacted by the Mitel toxic waste plume; it may be that the drains have intentionally not been maintained to prevent the spread of the subsurface contamination. Town Public Works Department indicates that fix will be part of planned brownfield remediation project.

Problem Area Data Sheet

Problem Area ID:	**MB-23**	Latitude: 44.456809 ° N	Longitude: 73.118364 ° W
Watershed:	Muddy Brook		
Location:	Lamplite Lane and White Birch Lane.		
Problem Type:	Local Drainage		
Identification Source:	Public Works Department		
Ownership:	Public (Town)		
Classification Level:	2		

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:
Catch basin appears to be clear of debris, difficult to determine exact cause of flooding.

Field Photos	
	
Photo 1. Limited storm sewer infrastructure in Lamplite Acres	**Photo 2.** Ponded water on roadways in Lamplite Acres following rainfall

Prioritization Ranking Factors							
Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
2	2	2	2	Yes	Yes	No	No
Relative Impact: Town Public Works Department indicates that a scoping study currently being developed and the Town has applied for EPA grant funding for design and construction.							

Problem Area Data Sheet

Problem Area ID:	**MB-25**	Latitude: 44.472759 ° N	Longitude: 73.134958° W
Watershed:	Muddy Brook		
Location:	River Cove Road, 1.2 mi., west of VT 2A		
Problem Type:	Erosion		
Identification Source:	Muddy Brook SGA		
Ownership:	Public (Town)		
Classification Level:	3		
Problem Description:			

Date of Field Data Collection: 6/15/2012

Description of Observed Conditions:

Sediment build up occurring downstream of bridge. Small, 1' head cut just upstream of bridge. Signs of bank erosion on both upstream and downstream edges, majority is on west side. Existing bridge is causing significant upstream and downstream erosion; existing bridge is 52% of bankfull width.

Field Photos

Photo 1. Looking downstream

Photo 2. Upstream

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
1	1	2	1	Yes	No	No	No

Relative Impact: On-going in channel erosion as brook continues to adjust to increased stormwater flows and constriction caused by undersized bridge.

Problem Area Data Sheet

Problem Area ID:	**MB-26**	Latitude: 44.472759 ° N	Longitude: 73.134958° W
Watershed:	Muddy Brook		
Location:	SW corner of Walker Hill Rd. and Blackberry Ridge.		
Problem Type:	Channel Erosion		
Identification Source:	VT DEC (Pease)		
Ownership:	Public/Private		
Classification Level:	3		
Problem Description:			

Date of Field Data Collection: 11/21/2012

Description of Observed Conditions:

4-5-foot headcut forming downstream from culvert under Blackberry Ridge; streambank is actively eroding.

Field Photos

Photo 1. Looking upstream

Photo 2. Downstream

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
2	2	2	3	No	Yes	No	Yes

Relative Impact: Headcut will eventually move up to culvert, endangering bank stability.

Problem Area Data Sheet

Problem Area ID:	MB-27	Latitude: 44.472759 ° N	Longitude: 73.134958° W

Watershed:	Muddy Brook
Location:	I-89 drainage, SW of Wal-Mart
Problem Type:	Channel Erosion
Identification Source:	VT DEC (Pease)
Ownership:	Public (VTrans)/Private
Classification Level:	2

Problem Description:

Date of Field Data Collection: 12/21/2012

Description of Observed Conditions:

Streambank erosion downstream of culvert. Access to floodplain ~100ft downstream.

Field Photos

Photo 1. Looking upstream at culvert under I-89 N.Bound

Photo 2. Looking downstream from culvert under I-89.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of larger systemic problem?
2	1	2	2	No	No	No	Yes

Relative Impact: Some stabilization measures have been implemented. Rip-rap has failed in places and bank erosion continues.

Problem Area Data Sheet

Problem Area ID:	**MB-28**	Latitude: 44°27'37.93"N	Longitude: 73° 8'4.70"W
Watershed:	Muddy Brook		
Location:	Williston Rd, behind VT Mattress Depot		
Problem Type:	Gully Erosion		
Identification Source:	SWMP Field Assessment		
Ownership:	Private		
Classification Level:	3		

Date of Field Data Collection: 6/25/2013

Description of Observed Conditions:

Large gully (40’ width, 30’ depth) at outfall from stormwater system at Extra Storage LLC (28 Adams Drive, stormwater discharge permit # 4148-9010.R). The bank around the outfall has been armored with stone. Repair of gully will be extremely costly and technically challenging. Stormwater should be addressed upstream.

SWMP Field Assessment Photos

Photo 1. Armored bank at outfall from Extra Storage LLC

Photo 2. Gully, 30 yards downstream from outfall. 20’ deep.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	2	3	2	No	No	Yes	Yes

C.3. Sucker Brook

Problem Area Data Sheet

Problem Area ID:	**SB-01**	Latitude: 44.405225° N	Longitude: 73.125938° W
Watershed:	Sucker Brook		
Location:	Where Sucker Brook crosses under Route 2A near Ridge Rd, north ~1500’		
Problem Type:	Channel Erosion		
Identification Source:	Sucker Brook SGA		
Ownership:	Public (VTrans, Town)/Private		
Classification Level:	3		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

A series of small headcuts (6-10” in height) and scour pools are visible in this section of Sucker Brook. As was noted in the 2007 SGA, and reconfirmed during this process, the culverts found in this reach are all undersized, especially the two which take the stream under Ridge Road (5.5’) and the driveway crossing at the reach break (4.5’). Channel width through this area ranges between 13 and 15 feet.

Update 6/18/2013: Culvert at northern private driveway is set with concrete barrier on either side, and is significantly undersized causing stream erosion on the downstream side. The stream appears to have shifted near the culvert at Ridge Rd. and has begun to erode an area that is not armored with riprap.

Field Photos

Photo 1. Culvert under Ridge Road

Photo 2. Culvert under private drive

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of a larger or systemic problem?
3	2	2	1	Yes	Yes	Yes	Yes

Relative Impact: The severe aggradation of coarse material in this stream reach has been problematic for the Town and the landowners whose driveways and roads cross the channel.

Problem Area Data Sheet

Problem Area ID:	**SB-09**	Latitude: 44.422601° N	Longitude: 73.113565° W
Watershed:	Sucker Brook		
Location:	Along Old Creamery Road, from Oak Knoll Road to Lyman Drive		
Problem Type:	Erosion		
Identification Source:	Sucker Brook SGA		
Ownership:	Private		
Classification Level:	3		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

In this area, Sucker Brook is being impacted by residential encroachment (and the attendant stormwater runoff) and unnatural structures placed in and across the channel. Specific observed problems include eroding streambanks and channel incision.

Field Photos

Photo 1. Bank erosion in channel

Photo 2. Foot bridge and "abutment"

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of a larger or systemic problem?
2	2	2	2	No	Yes	No	Yes

Relative Impact: Relatively new development upstream is likely to have increased hydraulic loading; promoting practices to keep stormwater on-site, limit channel encroachments and increase woody vegetation in the buffer may help reduce in-channel erosion.

Problem Area Data Sheet

Problem Area ID:	**SB-12**	Latitude: 44.403875° N	Longitude: 73.130124° W
Watershed:	Sucker Brook		
Location:	Near intersection of Chaloux Lane with Lincoln Road		
Problem Type:	Local Drainage		
Identification Source:	Public Works		
Ownership:	Public (Town)/Private		
Classification Level:	3		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

Culverts running under Chaloux Ln and private drive are significantly overgrown. Some sediment build up is present at outfalls. Northeast corner of intersection showing signs of erosion related to road run-off. Southern edge of Lincoln Road also showing signs of run-off and trenching.

Update 6/18/2013: Culverts and ditches are completely full of sediment. The erosion along the roadside persists. The stream was not observable due to poison ivy overgrowth.

Field Photos

Photo 1. Road erosion

Photo 2. Culvert under Chaloux Lane

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of a larger or systemic problem?
2	2	2	2	Yes	Yes	No	Yes

Relative Impact: Current drainage patterns lead to erosion during moderate and large runoff events.

Problem Area Data Sheet

Problem Area ID:	**SB-13**	Latitude: 44.399239° N	Longitude: 73.114895° W
Watershed:	Sucker Brook		
Location:	Butternut Road, approximately ½ mile east of intersection with Route 2A		
Problem Type:	Erosion		
Identification Source:	Public Works		
Ownership:	Public (Town)		
Classification Level:	1		

Date of Field Data Collection: 6/11/2012

Description of Observed Conditions:

Retaining wall is collapsing; guardrails are leaning as well. Wall is made of 2'x5' concrete blocks, stacked two high, running 17 columns long. Public Works is aware of the concern and has indicated plans to reinstall the retaining wall in 2013. Depending on where things stand in the design and funding of the fix, may have an opportunity to consider a less structural solution.

Update 6/18/2013: Public Works reports that Spring 2013 flooding exacerbated this condition; repair is underway.

Field Photos

Photo 1. Retaining wall (looking upstream)

Photo 2.

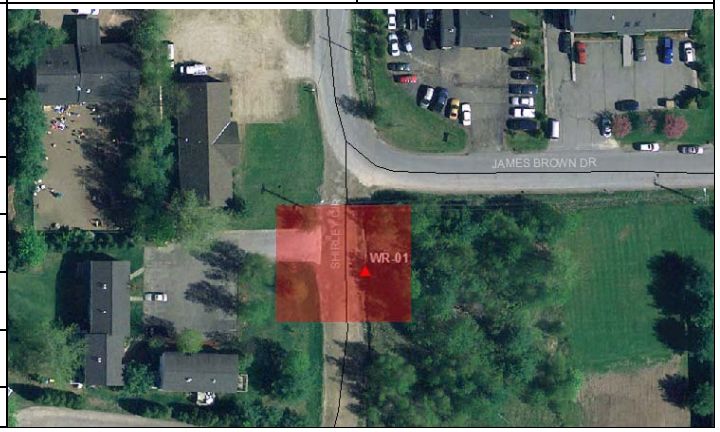
Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impacts beyond water resources?	Part of a larger or systemic problem?
1	2	3	1	Yes	Yes	Yes	No

Relative Impact: Failing retaining wall is impacting road surface and exacerbating erosion along road.

C.4. Winooski River

Problem Area Data Sheet

Problem Area ID:	**WR-01**	Latitude: 73.117346 N	Longitude: 44.475213 W
Watershed:	Winooski River		
Location:	Shirley Circle		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Private/Public (Town)		
Classification Level:	3		

Date of Field Data Collection: 05/14/2012

Description of Observed Conditions:

Heavy erosion, significant ruts and mud holes forming in road. Run off from neighboring lots on Shirley Circle and James Brown Dr exceeds the capacity of the ditch beside Shirley Circle and washes out the roadway. Private section of road that is over utilized by large vehicles from Town Garage located at end of public road.

Update 6/25/2013: Shirley Circle, south of the driveway leading to the western parking lot for the apartment building, appears to have recently lain stone and the adjacent ditch appeared to have recently been re-trenched. The section of Shirley Circle to the north of that driveway remains in poor condition, with large ruts and potholes and standing water from the previous day's storms. A large pile of gravel has been placed in the road to prevent through traffic.

Field Photos

Photo 1. Roadway washout.

Photo 2. Primary source of runoff.

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
3	3	3	3	No	Yes	No	Yes

Relative Impact: Heavy erosion in and along road; significant mud ruts and potholes abound. Evidence of sediment deposition in the area around the discharge pipe.

Problem Area Data Sheet

Problem Area ID:	**WR-02**	Latitude: 73.112286 N	Longitude: 44.471829 W
Watershed:	Winooski River		
Location:	Route 2A, just south of the intersection with River Cove Rd		
Problem Type:	Local Drainage		
Identification Source:	Reported by resident		
Ownership:	Private		
Classification Level:	1		

Date of Field Data Collection: 5/14/2012

Description of Observed Conditions:

New stone driveway in place. New 12" corrugated plastic culvert installed with ½" of flow moving from wetland adjacent to drive into what appears to be a 6" plastic pipe running underground into the woods. May be an issue if large amounts of water begin to flow through culvert. Second culvert is new 8" corrugated plastic helping to ease drainage. Some iron staining present. Disturbed areas have not been fully stabilized with seed and mulch.

Field Photos

Photo 1. New 12" culvert flowing into small 6" pipe

Photo 2. New culverts

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
1	2	1	1	No	No	No	No

Relative Impact: Localized erosion attributable to poor site stabilization; larger culvert likely to address original concern.

Problem Area Data Sheet

Problem Area ID:	**WR-03**	Latitude: 73.044511 N	Longitude: 44.466002 W
Watershed:	Winooski River		
Location:	Chapman Lane, about 400' east of North Williston Rd		
Problem Type:	Channel Erosion		
Identification Source:	SWMP Field Assessment		
Ownership:	Private (railroad)		
Classification Level:	1		

Date of Field Data Collection: 05/14/2012

Description of Observed Conditions:

Undercutting is occurring downstream of the box culvert under the railroad bed, including trees on NW side of bank. 1-2" of flow moving through with 6" drop at headcut.

Field Photos

Photo 1. Headcut at the outlet of box culvert under railroad bed.

Photo 2. South bank undercutting

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
3	2	2	2	No	Yes	Yes	No

Relative Impact: Bank erosion present, and will likely continue if left unchecked; culvert may be or become a barrier to aquatic organism passage if the headcut continues to deepen.

Problem Area Data Sheet

Problem Area ID:	**WR-04**	Latitude: 73.034995 N	Longitude: 44.462254 W
Watershed:	Winooski River		
Location:	Private drive off the end of Chapman Lane		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Private		
Classification Level:	3		

Date of Field Data Collection: 05/14/2012

Description of Observed Conditions:

Stream running parallel to farm road on south side. Road on both sides of existing culvert lower, causing drainage issue and ponding. Attempts made by landowner to channel water off of road do not seem to be working.

Field Photos

Photo 1. Straightened stream flowing to culvert

Photo 2. Erosion occurring at the discharge point.

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
3	2	3	2	No	Yes	No	Yes

Relative Impact: Water is channeling along road and ponding in middle of road at crossing; significant amount of sediment deposited along/ in stream.

Problem Area Data Sheet

Problem Area ID:	**WR-05**	Latitude: 73.051618 N	Longitude: 44.462005 W
Watershed:	Winooski River		
Road Name:	North Williston Rd, just east of Fontaine Ln		
Problem Type:	Overland Erosion		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (Town)/Private		
Classification Level:	3		

Date of Field Data Collection: 05/14/2012

Description of Observed Conditions:

Erosion occurring on both sides of No. Williston Road near intersection with Fontaine Lane, due in part to heavy weight vehicles turning in/out. Ditches are eroding across from drive for #1923/1925.

Update 6/18/2013: Ditch along eastern side of North Williston Rd appears to have been recently reshaped. It was difficult on this day to determine the impact of Fontaine Ln (private), just south of problem area, on the ditch. There is a large gravel pit at the top of Fontaine Ln, which appear to be the source of sediment deposits in the area.

Field Photos

Photo 1. Road decay along No. Williston Road

Photo 2. Shoulder erosion, sediment deposition in ditch

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
2	2	2	2	Yes	Yes	Yes	No

Relative Impact: Recent armoring is apparent in a few spots, including around the culvert; unlikely to be sufficient as long-term solution

Problem Area Data Sheet

Problem Area ID:	**WR-06**	Latitude: 73.031686 N	Longitude: 44.445523 W
Watershed:	Winooski River		
Road Name:	Gov Chittenden Rd, about 1.5 miles from the intersection with No. Williston Rd		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (Town)		
Classification Level:	3		

Date of Field Data Collection: 05/12/2012

Description of Observed Conditions:

Lack of roadside conveyance facilities and proper road crown/cross slope is causing runoff to erode the dirt/gravel roadway. Multiple in-road gullies beginning to form, as road is not crowned/sloped so as to reliably shed water. Undermining of tree and roots along north-side of road.

Field Photos

Photo 1. Erosion in the roadway.

Photo 2. Sediment discharge along road shoulder.

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
2	2	2	1	Yes	Yes	No	No
Relative Impact: Some sediment movement but Class 3 road is closed in winter (Nov 1-May1).							

Problem Area Data Sheet

Problem Area ID:	**WR-08**	Latitude: 73.045167 N	Longitude: 44.435489 W
Watershed:	Winooski River		
Road Name:	Sunrise Circle, about 500' north of Route 2		
Problem Type:	Local Drainage		
Identification Source:	Public Works		
Ownership:	Public (Town)		
Classification Level:	3		

Date of Field Data Collection: 5/14/2012

Description of Observed Conditions:

Catch basins positioned in lawns away from road. Storm water flows down edge of road causing gullying and road decay. Town remedy of cold patch working in areas it was installed but it appears that the material was not extended all of the way downhill. All storm water flows to catch basin at center of circle, causing some road damage. Water drains from the catch basin via an 8" corrugated metal pipe which discharges to a drainage ditch in the back of development.

Update 6/18/2013: Lots of loose gravel material observed along road, but little evidence of sand transport in around the cul-de-sac. Area has no topsoil layer. Grass on the slopes of cul-de-sac (the septic leach field for the subdivision) is sparse. No sediment observed in CBs. Another opportunity for community outreach with rain gardens.

Field Photos

Photo 1. End of town remedy, beginning of erosion

Photo 2. Soil/Rock depositing at "mid-circle" catch basin

Relative Impact	Frequency	Current Conditions	Urgency	Impact to Public Infrastructure	Realistic to Fix	Non-stormwater related	Larger/Systemic Problem
2	2	2	2	Yes	Yes	Yes	No

Relative Impact: High amounts of sediment moving downhill causing washouts; little evidence of sediment deposits at outfall pipe suggesting that much of the material may be settling out in yards.

Problem Area Data Sheet

Problem Area ID:	**WR-10**	Latitude: 44°25'59.02"N	Longitude: 73° 3'59.07"W
Watershed:	Winooski River		
Location:	Route 2A, just south of dam		
Problem Type:	Road Drainage		
Identification Source:	SWMP Assessment		
Ownership:	Public		
Classification Level:	3		

Date of Field Data Collection: 6/25/2013

Description of Observed Conditions:

Vegetated swale adjacent to south-bound Rt. 2A is mounded on the road-side, inhibiting water from entering. Runoff instead flows along the shoulder causing some erosion. Sediment from road and shoulder is depositing in the northern end of the Overlook Park lot, and also flowing down the recreation path leading directly to the Winooski River. Puddles near the river bank had sheen layer, indicating road/parking lot runoff.

SWMP Field Assessment Photos

Photo 1. Berm above swale does not allow water entry from road

Photo 2. Erosion at approach to catch basin near parking lot entrance

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
2	3	2	3	Yes	Yes	Yes	Yes

C.5. Lake Iroquois

Problem Area Data Sheet

Problem Area ID:	**LI-01**	Latitude: 44.374836°	Longitude: 73.116677 ° W
Watershed:	Lake Iroquois		
Location:	Oak Hill Rd., 500ft south of Beebe Ln.		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (Town)		
Classification	4		

Date of Field Data Collection: 08/01/13

Description of Observed Conditions:
Culvert appears to serve large drainage area and is undersized. The ditch along the Western side Oak Hill Rd. is incised. The bank above the culvert outfall (east side of Oak Hill Rd.) has degraded and the road edge is beginning to collapse. The bank has been armored with stone. Road barrels at the site indicate that the Town is aware of the problem.

SWMP Field Assessment Photos

Photo 1. Undersized culvert with riprap armored bank

Photo 2. Incised ditch along west side of Oak Hill Rd.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	3	3	3	Yes	Yes	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**LI-02**	Latitude: 44.379228°	Longitude: -73.085752°
Watershed:	Lake Iroquois		
Location:	Lake Iroquois public beach		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (Town)		
Classification	3		

Date of Field Data Collection: 08/01/13

Description of Observed Conditions:
Beach is at 25-35% grade. According to resident, new sand is brought in each spring to replace sand that has slumped into the lake. There are stormwater managements opportunities around the beach and parking lot. It may be necessary to reduce the elevation and install a retaining wall at of the back of the beach.

SWMP Field Assessment Photos

Photo 1. Back edge of beach

Photo 2. Area adjacent to parking lot for stormwater management opportunity.

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	2	1	1	No	Yes	No	No

Problem Area Data Sheet

Problem Area ID:	**LI-03**	Latitude: 44.380320°	Longitude: -73.089183°
Watershed:	Lake Iroquois		
Location:	Beebe Ln., 1000ft west of beach		
Problem Type:	Infrastructure		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (Town)/Private		
Classification	3		

Date of Field Data Collection: 08/01/13

Description of Observed Conditions:

Culvert under Beebe Ln is undersized. Upstream from culvert is marsh area with tributaries from several directions.

Daniel Sharpe of the Lake Iroquois Association monitors the mouth of the stream (*A) and has noted high turbidity. Marsh appears to be eroding and may be the source of sediment load.

SWMP Field Assessment Photos

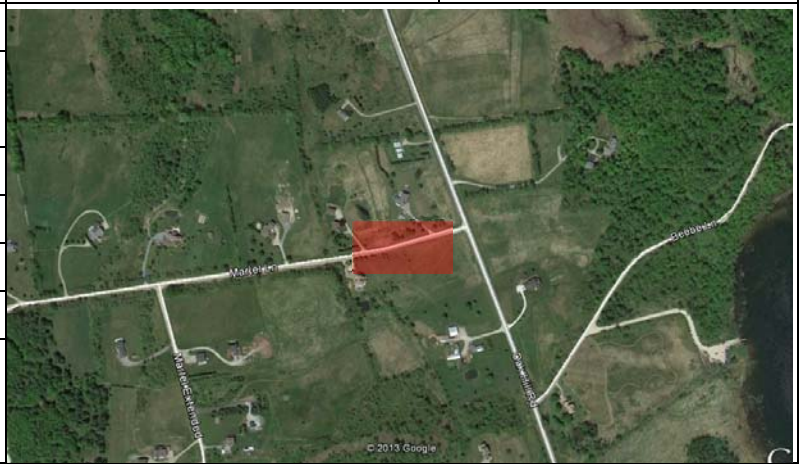
Photo 1. Tributaries to mash

Photo 2. Undersized culvert partially obstructed with debris

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	3	3	2	Yes	Yes	Yes	Yes

Problem Area Data Sheet

Problem Area ID:	**LI-04**	Latitude: 44.378467°	Longitude: -73.097289°
Watershed:	Lake Iroquois		
Location:	Martel Ln. Near Oak Hill Rd.		
Problem Type:	Local Drainage		
Identification Source:	SWMP Field Assessment		
Ownership:	Public (Town)/Private		
Classification	3		

Date of Field Data Collection: 08/01/13

Description of Observed Conditions:

Road surface condition is very poor. Ditch along southern edge of Martel Rd. is incised and actively degrading. There are large sediment deposits near the road, presumably from the road surface.

The eastern-most 300ft of Martel Rd. falls within the Town of Williston. The western portion of the road (uphill, and source of much of the sediment load) is the Town of St. George.

SWMP Field Assessment Photos

Photo 1. Incised ditch (facing west towards St. George)

Photo 2. Incised ditch and sediment deposit (facing east towards Oak Hill Rd.)

Prioritization Ranking Factors

Relative Impact	Frequency	Current Condition	Urgency	Impact to public infrastructure?	Realistic to fix?	Impact beyond water resources?	Part of larger or systemic problem?
3	3	3	3	Yes	Yes	Yes	Yes

APPENDIX D: ANALYSIS OF CURRENT AND BUILD-OUT STORMWATER DESIGN FLOW FOR MUDDY BROOK

November 14, 2012

MEMO

To: Jessica Andreoletti
Town of Williston
7900 Williston Road
Williston, VT 05495

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

STONE ENVIRONMENTAL INC

535 Stone Cutters Way
Montpelier, Vermont
05602 USA

Phone / 802.229.4541
Fax / 802.229.5417
Web Site / www.stone-env.com

SEI No. 12-055
Re: Current and Build-Out Stormwater Design Flow Analysis for Muddy Brook

1.1 Develop Analysis Unit Sub-Watersheds

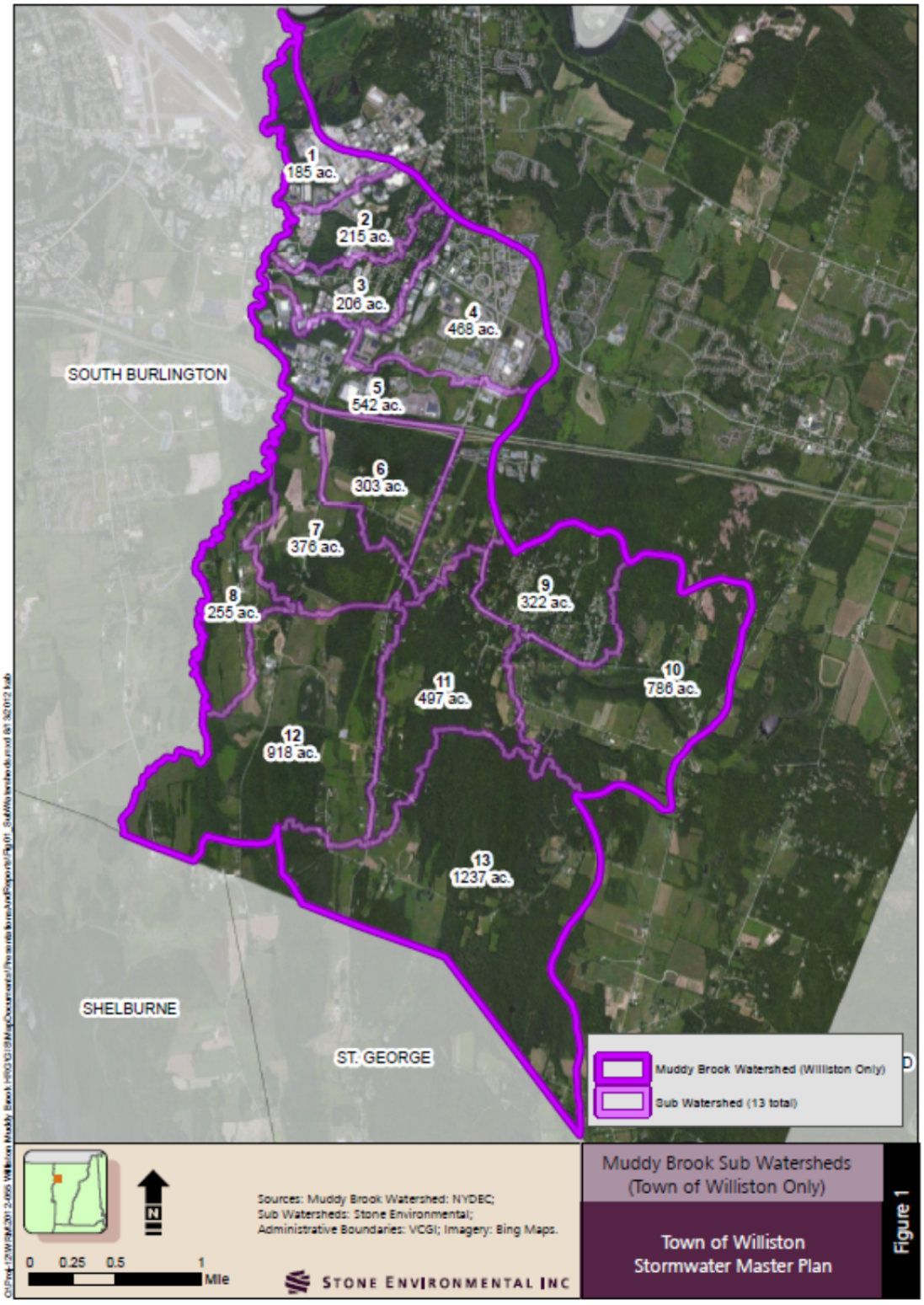
The current condition and build-out stormwater design flows were summarized at the sub-watershed level for the Muddy Brook watershed within the Town of Williston. Sub-watersheds were delineated using the 1.5 meter resolution 2004 LiDAR digital elevation model (DEM). Esri ArcGIS v.10 Hydro tools were used to delineate watersheds with at least 200 acres of flow. The resulting watersheds were then edited based on stormwater infrastructure and road features in ArcGIS. The final sub-watershed dataset includes 13 sub-watersheds within the Muddy Brook watershed in the Town of Williston. See Figure 1 for the sub-watersheds that are used for summarizing current condition and build-out condition stormwater design flows.

1.2 Evaluate Current Development and Stormwater Conditions

It is important to understand baseline environmental and development conditions and how those conditions relate to current land cover and effective impervious area in order to estimate stormwater runoff in the target subwatersheds, before assessing how stormwater flows may increase under future development patterns. Stone has completed a current condition stormwater peak flow analysis using the Rational Method.

1.2.1 Estimating Mapped Impervious Area at Current Condition

The first step in estimating stormwater runoff and design flow at the current condition was to estimate mapped impervious surface and effective impervious surface for sub-watersheds. Effective impervious area recognizes that some impervious areas are completely surrounded by pervious areas and therefore have less of an impact on aquatic ecosystems. “Effective impervious area” is basically the impervious cover that provides stormwater flows fairly directly and quickly to streams.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SHELBURNE
ST. GEORGE
Muddy Brook Watershed (Williston Only)
Sub Watershed (13 total)
N
0 0.25 0.5 1
Mile
Sources: Muddy Brook Watershed: NYDEC;
Sub Watersheds: Stone Environmental;
Administrative Boundaries: VCGI; Imagery: Bing Maps.
STONE ENVIRONMENTAL INC
Muddy Brook Sub Watersheds
(Town of Williston Only)
Town of Williston
Stormwater Master Plan
Figure 1

A statewide impervious surface dataset has just been completed by Vermont Department of Environmental Conservation (VTDEC), based on 2008 high resolution near infrared National Agriculture Imagery Program (NAIP) imagery. Stone reviewed the statewide dataset within the study area and made corrections based on various imagery sources, including Esri, Bing Maps, and Vermont Center for Geographic Information (VCGI). Examples of corrections included areas where there was a mis-classification or areas where development has occurred. since 2008. The finalized impervious surface layer served as the current condition mapped impervious area (MIA) data layer. The MIA was summarized by sub-watershed.

1.2.2 Estimating EIA at Current Condition

Effective impervious surface (EIA) area was calculated for each sub-watershed based on the methodology outlined by Sutherland (2005, http://pacificwr.com/Publications/Estimating_EIA.pdf). First, sub-watersheds were classified based on the type and amount of stormwater management infrastructure. There are five potential classes outlined by Sutherland including: 1) average basins, where the drainage is predominated by storm sewers, and curb and gutter, although rooftops are not connected to the storm sewer; 2) highly connected basins, where residential rooftops are connected to the storm sewer system; 3) totally connected basins, where 100% of the urbanized area within the basin is storm sewered and all impervious surfaces are directly connected; 4) somewhat disconnected basins, where at least 50% of the developed area are served by grassy swales or roadside ditches; and, 5) extremely disconnected basins, where runoff from a large portion (70%+) of the basin is not collected. See Figure 2 for the EIA classification by sub-watershed.

1.2.3 Estimating Stormwater Peak Flow at Current Condition

Hydrologic conditions were analyzed using the Rational Method (Equation 1). The Rational Method is the simplest technique used to calculate peak stormwater runoff flow rates. It is commonly used to design storm sewer systems for catchments up to 160 acres and to predict storm flows for watersheds up 20mi^2 (Gupta 2008, p.729). The Williston portion of the Muddy Brook watershed is approximately 9.8 mi^2, and we believe the resulting outputs from calculations are valid for watershed planning purposes. The calculated values should be used to compare relative flow and CxA product values as explained later. At this scale the Rational Method is not expected to provide design-level estimates for flow rates.

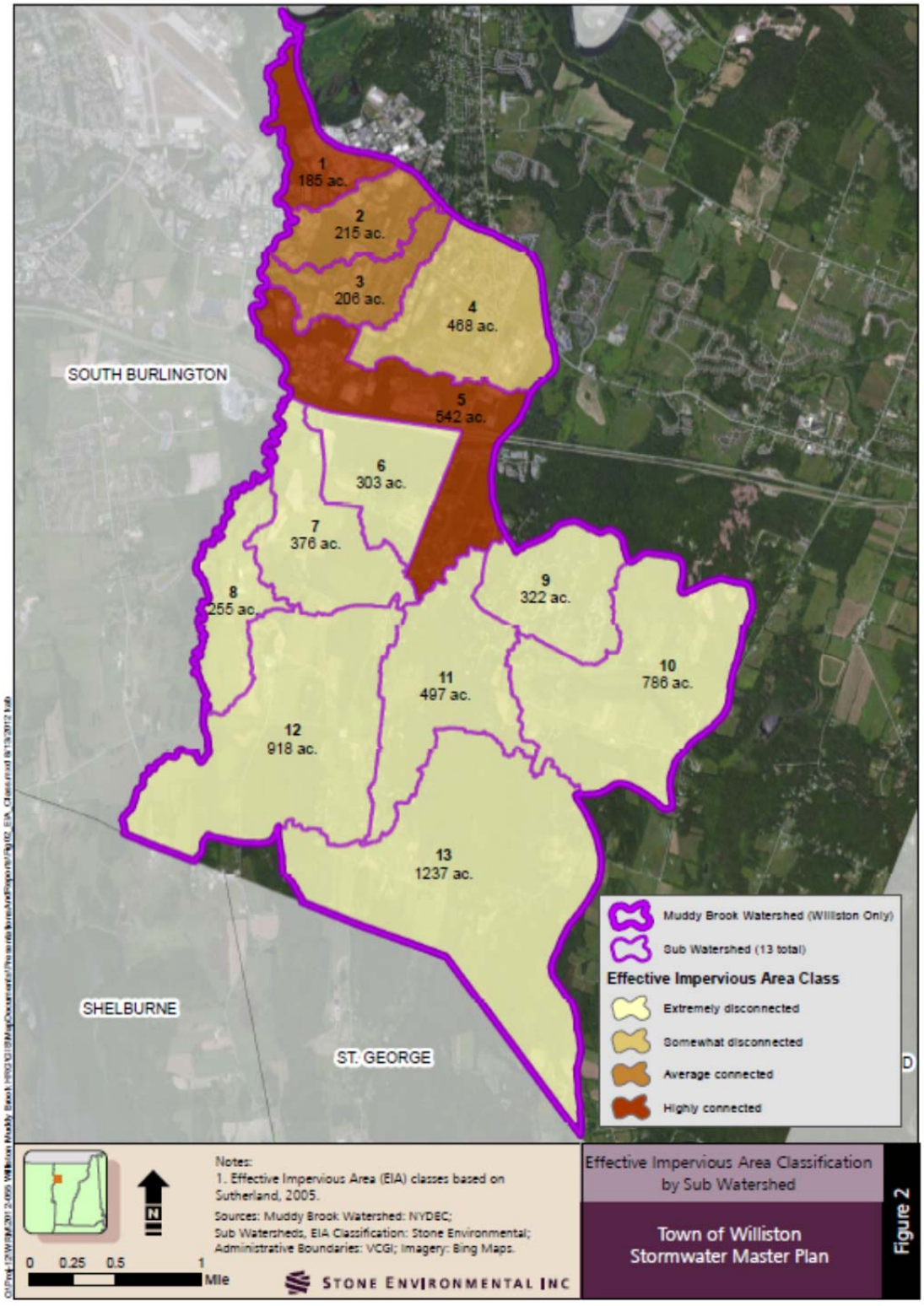
$$\boldsymbol{Q = CiA} \quad \text{(Equation 1)}$$

Where: C = Runoff Coefficient; i = intensity; A = Area

The unit-less runoff coefficient (C) was selected based on type of land cover. For example, assigning impervious areas a C-value of 0.9 and forested land a C-value of 0.18. For the Muddy Brook watershed, the EIA of each catchment was assigned a C-value of 0.9 for the EIA; a composite value was determined for the remaining land. This value is a weighted average based on the type of land cover and the respective amount of the catchment area in each classification using Equation 2.

$$C = \frac{\sum(C_i \times A_i)}{\sum A_i} \quad \text{(Equation 2)}$$

This composite C-value was then applied to the non-EIA portion of each sub-watershed catchment.



The rainfall intensity (i) is selected based on the time to concentration for the watershed. The time to concentration is the time it would take a water drop that falls on the most remote portion of a watershed to reach the mouth of the receiving stream. This value depends on the slope of the land, type of land cover, channel velocity, and other factors. These factors are all highly variable, so a precise value is not realistic; this is one on the reasons the Rational Method is not used for design in large catchment areas. In the Rational Method the time to concentration is assumed to equal the duration of the highest intensity storm-event for a watershed. For the Williston portion of the Muddy Brook watershed this was approximately 140 minutes. Estimated rainfall intensities for 2-yr, 10-yr, 25-yr, and 50-yr return rates were taken from the *Rainfall Frequency Atlas of the United States* for 120 and 180 minute intervals and interpolated at 140 minutes. (http://www.nws.noaa.gov/oh/hdsc/PF_documents/TechnicalPaper_No40.pdf).

The EIA, value as described in Section 1.2.2, was used for area (A) values to represent impervious land cover. The A-value for the remaining portion of the watershed was given by subtracting EIA from the total area for each sub-watershed catchment (Equation 3).

$$A = A_{total} - EIA \quad \text{(Equation 3)}$$

To compare current conditions to predicted build-out conditions, the respective current and build-out values for EIA were used for *Area* (A) in Equation 1.

1.3 Evaluate Design Flow for Build-Out

Stone used a residential zoning build-out analysis developed by the Town of Williston, a commercial zoning build-out analysis developed by Stone, and the current condition stormwater analysis results in conducting the build-out condition stormwater flow analysis. The analysis estimates stormwater runoff delivered to each receiving stream at the build-out condition based on current development, current zoning regulations, and projected growth under the 2-year, 10-year, 25-year, and 100-year design storm conditions. This evaluation and the predicted increases in stormwater runoff rates are a worst case scenario, in that it was assumed none of the new development that occurred would be subject to a state stormwater discharge permit. Although the majority of the developable parcels in Williston are larger than one-acre, it would be difficult to predict just how the development will unfold. As such, we decided to consider the worst case scenario where future development would occur absent stormwater controls.

1.3.1 Build-Out Analysis and Estimating MIA at Build-Out

The Town of Williston build-out analysis resulted in an estimate of additional build-out dwelling units per parcel for **residential** zoning classes. Stone conducted a separate build-out analysis for **commercial** and **industrial** zoning classes within the Muddy Brook watershed, based on guidance from the Town of Williston. The results of these analyses were used in estimating MIA at build-out.

1.3.1.1 Residential Zoning Classes

The Town of Williston build-out analysis resulted in an estimate of additional dwelling units at build-out (attribute 'pot_du') for parcels within the residential zoning classes. This estimated number of additional

dwelling units from the Town of Williston build-out analysis was used in estimating MIA for residential zoning class parcels. The residential zoning classes within the Muddy Brook watershed include the Agriculture/Rural Residential Zoning District (ARZD) and the Residential Zoning District (RZD). The build-out analysis took environmental and development setbacks into consideration to determine an appropriate number of additional dwelling units at build-out for these zoning classes.

To estimate the impervious surface for each additional dwelling unit, an average, per dwelling unit impervious area (acres) was calculated by zoning class, based on the current condition mapped impervious surface, within the Muddy Brook watershed. To calculate the average 'per dwelling unit' impervious surface acreage, the current condition mapped impervious surface layer (see Section 1.2.1 above) was intersected with parcels to determine the per parcel impervious surface area at current condition. The current number of dwelling units on each parcel was determined from the Town of Williston build-out analysis for parcels in residential zoning classes (attribute 'Num_Dwell'). The mapped impervious surface acreage at current condition was divided by the current number of dwelling units by parcel and averaged by zoning class. Table 1 gives the resulting average area of impervious surface per dwelling unit by zoning class.

Table 1. Average per dwelling unit impervious surface area at current condition by zoning class.

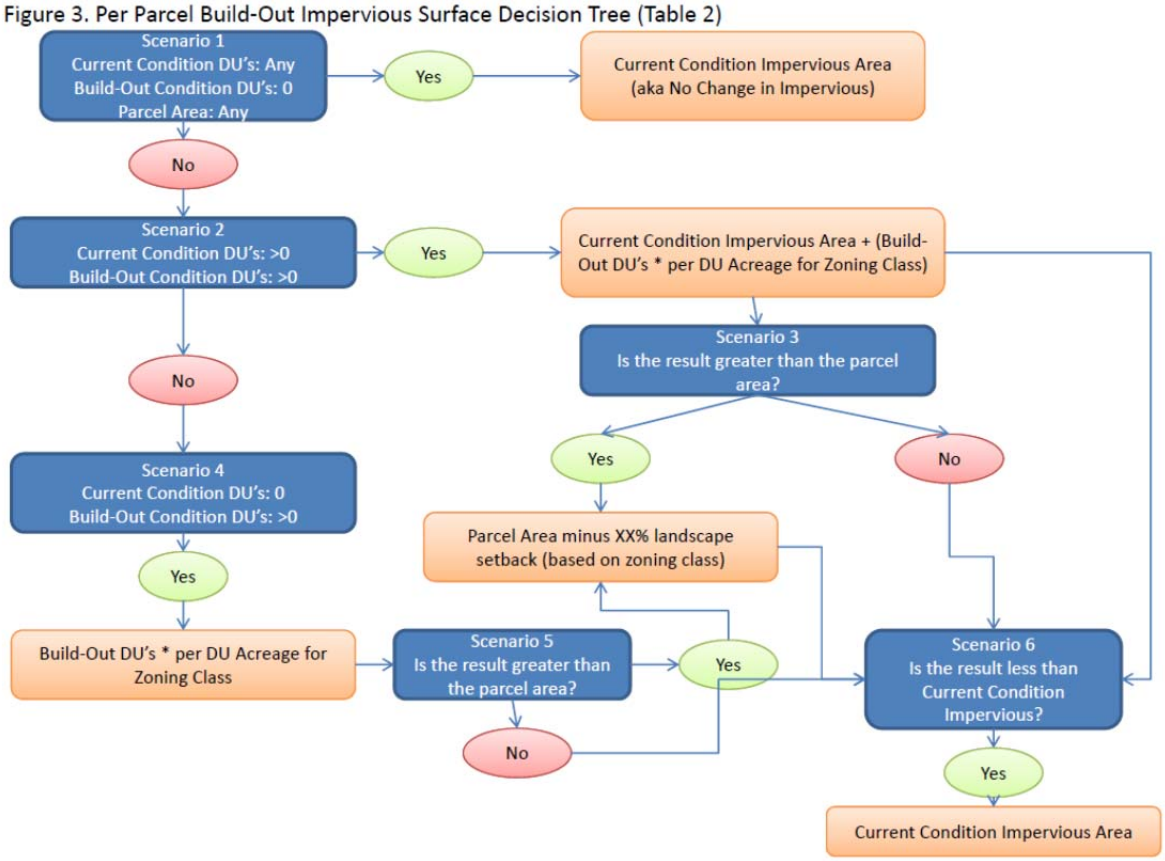
District	DistrictAb	Average Impervious Acreage Per Dwelling Unit at Current Condition	Number of Parcels (>0 DUs) at Current Condition
Agriculture/Rural Residential Zoning District	ARZD	0.242	451
Residential Zoning District	RZD	0.137	118

The estimated impervious surface area at build-out was calculated for each residential parcel. Table 2, below, provides the calculation based on the number of current condition dwelling units, the estimated build-out dwelling units, and parcel area as it relates to estimated build-out impervious surface. Also, see Figure 3 for a diagram of the scenario decision tree. The 'CC Dwelling Units' refers to the number of dwelling units at current condition, based on the 'Num_Dwell' attribute in the Town of Williston build-out analysis for parcels in residential zoning classes. The 'BO Dwelling Units' refers to the number of additional dwelling units at build-out, based on the 'pot_du' attribute in the Town of Williston build-out analysis for parcels in residential zoning classes.

For Scenario 1, if a parcel has no additional dwelling units at build-out, it is assumed that there is no change in impervious surface from current condition to build-out and the impervious surface acreage at build-out will be the same as the current condition.

For Scenario 2, for parcels that have greater than zero dwelling units at current condition and greater than zero additional dwelling units at build-out, the impervious surface acreage at current condition will be added to an estimated additional impervious surface acreage based on the number of additional dwelling units and the zoning-based impervious acreage per dwelling unit (see Table 1 above).

Figure 3. Per Parcel Build-Out Impervious Surface Decision Tree (Table 2)



There may be cases where the resulting impervious surface at build-out from Scenario 2 will result in an acreage that is greater than the parcel area. This may occur if the current condition impervious surface area is particularly high or if the per dwelling unit estimate of impervious surface from Table 1 is too high. An example of when this estimate may be too high is if the new development at build-out is assumed to be multi-story and the current condition development within the zoning class is in the form of traditional single family homes. If the resulting impervious surface area at build-out for Scenario 2 is greater than the parcel area, the total impervious surface area for that parcel will be scaled back to the Parcel Area minus an assumed, zoning-based, minimum landscaping setback. This is Scenario 3. Estimated impervious cover under build-out conditions for each zoning district is presented in Table 2 below.

Table 2. Estimated Impervious Cover, Under Build-Out Conditions.

	Impervious surface limited by density		Impervious surface limited by setbacks/landscape buffers	
Zoning District	**Max % imp**	**Density Description**	**Max % imp**	**Setback Description**
ARZD	13%	• Average density = 1DU/80,000 SF; 1DU/1.84 Acres • 25 ac = 1,088,975 SF • Allowable density = 1,088,975 SF / 80,000 SF = 13 DU *(round down)* • 13 DU x .242 imp/DU* = 3.146 imp • 3.146 imp of 25 ac = 13% imp and 87% green	N/A	Average Side/Rear = 15 ft Road Estimate = 37 ft 83% imp and 17% green
RZD	41%	• Average Density = 3DU/Acre; 1DU/.33 ac (14,520 SF) • 5 ac = 217,795 SF • 5 ac/.33 ac = 15 DU *(round down)* • 15 DU x .137 imp/DU = 2.055 imp • 2.055 imp of 5 ac = 41% imp and 59% green	N/A	Average Side/Rear = 12.5 ft Road Estimate = 37 ft 85% imp and 15% green
VZD	27%	• Average density = 2DU/ac; 1DU/.50 ac (21,779 SF) • 5 ac = 217,795 SF • 5 ac/.5 ac = 10 DU *(round down)* • 10 DU x .137 imp/DU = 1.37 imp • 1.37 imp of 5 ac = 27% imp and 73% green	N/A	Average Side/Rear = 15 ft Road Estimate = 37 ft 83% imp and 17% green
Mixed-Use/Commercial MURZD, MUCZD, TCZD, BPZD, GZDN, GZDS	N/A	While residential uses are allowed in the MURZD, MUCZD, and TCZD, impervious area should be calculated based on required landscaping and road setbacks. Dwellings will be situated in multi-family structures and above retail/commercial space.	85.5%	Average Side/Rear = 11 ft (13+9/2) Road Estimate = 37 ft ** 83% imp and 14.5% green
Industrial IZDE, IZDW	N/A	Residential not allowed.	83%	Average Side/Rear = 15 ft (23+13+9/3) Road Estimate = 37 ft 83% imp and 17% green

For Scenario 4, for parcels that have zero dwelling units at current condition and greater than zero additional dwelling units at build-out, an estimated impervious surface acreage based on the number of dwelling units at build-out and the zoning-based impervious acreage per dwelling unit (see Table 1 above) is used. The current condition impervious area will be ignored, because it is assumed that the parcels are either undeveloped at current condition, that there will be a change of use from commercial/industrial development to residential development, or that residential development will occur above commercial development.

Scenario 5 is similar to Scenario 3, where the impervious surface estimate at build-out will be scaled back to the Parcel Area minus an assumed, zoning-based landscaping setback, in cases where the results of Scenario 4 are greater than the parcel area. The maximum impervious cover for the ARZD class is 13% and the maximum impervious cover for the RZD class is 41%.

There may be cases where the estimated impervious surface area at build-out for a parcel is less than the current condition impervious surface area, for Scenarios 2 through 5. It is assumed that impervious surface will not decrease over time. For this reason, any parcel where the estimated impervious surface at build-out is less than the calculated impervious surface at current condition, the current condition impervious surface area will be used (Scenario 6). This approach, summarized in Table 3, can be used to calculate the BOI – which is the MIA at build-out for residential parcels.

Table 3. Impervious surface calculations based on the number of current condition dwelling units, estimated build-out dwelling units, and parcel area as it relates to estimated build-out impervious area.

Scenario	CC Dwelling Units	BO Dwelling Units	Parcel Area	BO Impervious Calculation (BOI)
1	Any	0	Any	CCI
2	>0	>0	> BOI	CCI + (BODU * BODU_Area)
3	>0	>0	< BOI	Parcel Area – Zoning-Based Landscaping Setback
4	0	>0	> BOI	BODU * BODU_Area
5	0	>0	< BOI	Parcel Area – Zoning-Based Landscaping Setback
6*	Any	>0	> BOI	CCI

** In cases where estimated BOI < CCI*

Where:
CCI = Current Condition Impervious Area in Acres
BOI = Total Build-Out Impervious Area in Acres
BODU = Build-Out Dwelling Units
BODU_Area = Assumed Per Dwelling Unit Impervious Area in Acres (by zoning class)

1.3.1.2 Commercial and Industrial Zoning Classes

Stone conducted a separate build-out analysis for **commercial** and **industrial** zoning classes within the Muddy Brook watershed, based on guidance from the Town of Williston. The commercial and industrial build-out analysis included parcels in the following zoning classes:

1. Business Park Zoning District (BPZD),
2. Gateway Zoning District North (GZDN), – NOT IN STUDY AREA, not included in analysis
3. Gateway South Zoning District (GZDS),
4. Mixed-Use Commercial Zoning District (MUCZD),

5. Mixed Use – Residential Zoning District (MURZD),
6. Industrial Zoning District East (IZDE),
7. Industrial Zoning District West (IZDW). – NOT IN STUDY AREA, not included in analysis
8. Taft Corners Downtown Zoning District (TCZD)

In the commercial and industrial zoning classes, a GIS analysis was used to remove land constraints (wetlands, floodplains, surface water, slope (>30%), road setbacks, conserved lands) from Williston parcels, in addition to a zoning specific landscaping setback. Sources for land constraint datasets are listed below.

1. Wetlands, floodplains, surface water, slope, state conserved lands: VCGI
2. Road setbacks (as described in Table 4, below), town conserved lands: Town of Williston

Table 4. Minimum Required Road Setbacks in Williston's Zoning Districts.

Zoning District	Setbacks from Streets and Roads			Side Yards	Rear Yards
	I-89	US 2 / VT 2A	Other Roads		
ARZD	150	50	50/25 (private)	15	15
RZD	150	50	50 (arterial)/25	10	15
VZD	150	50	25	15	15
MURZD	150	50	50 (arterial)	Chapter 23	Chapter 23
MUCZD	150	25	25	Chapter 23	Chapter 23
BPZD		50	50	Chapter 23	Chapter 23
TCZD	150	25	Build to	Chapter 23	Chapter 23
IZDW	150	35	35	Chapter 23	Chapter 23
IZDE			50	Chapter 23	Chapter 23
GZDS	150	75	50	Chapter 23	Chapter 23
GZDN		50	25	Chapter 23	Chapter 23

The remaining area was reduced by 17% for the IZDE zoning class and 14.5% for the other commercial zoning classes to account for additional yard and other landscaping setbacks. The resulting area equates to MIA at build-out for the commercial and industrial parcels.

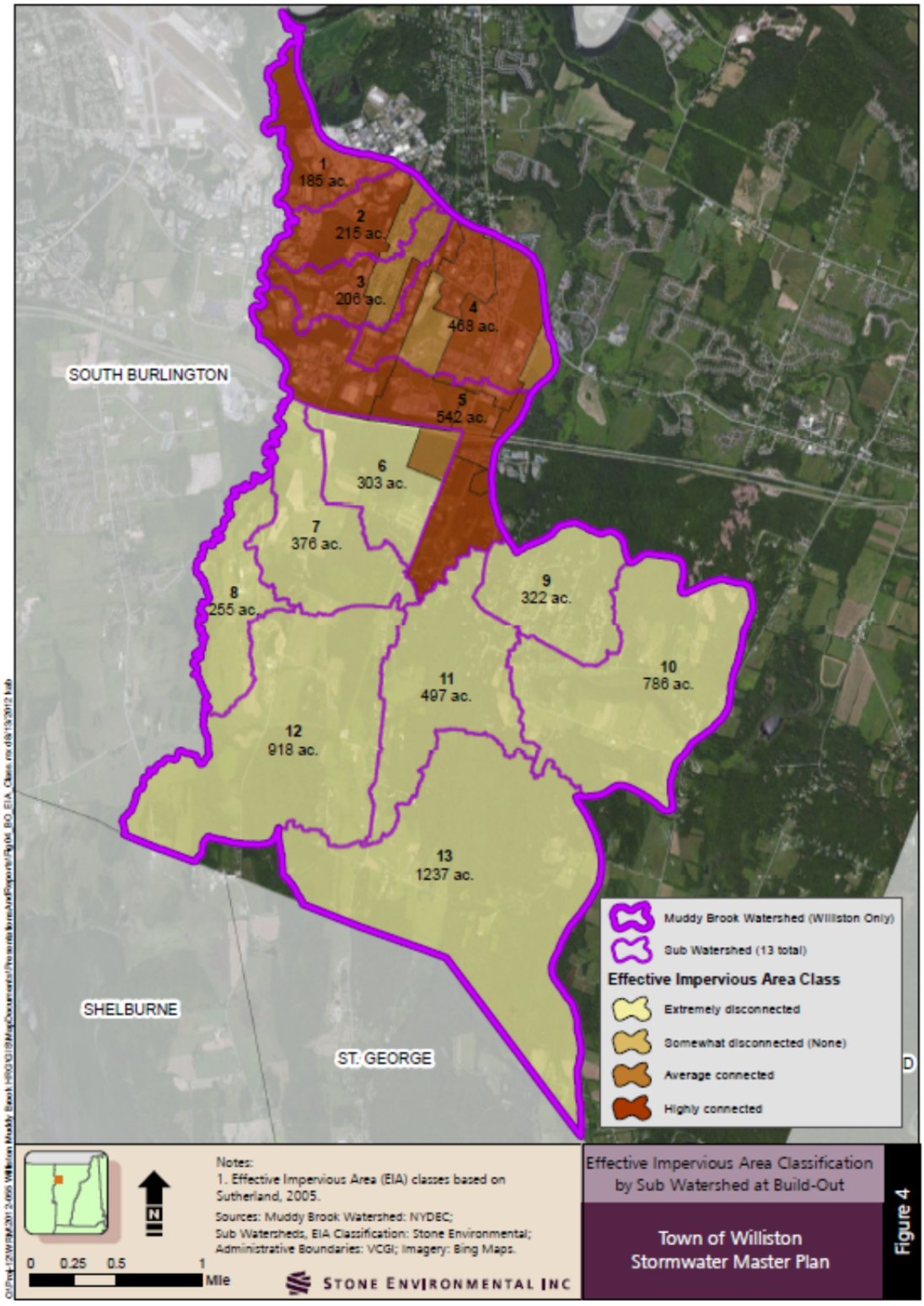
1.3.2 Estimating EIA at Build-Out

The residential MIA at build-out and commercial MIA at build-out were summarized by zoning class and sub-watershed. It was assumed that, at full build-out, sub-watersheds will have more stormwater infrastructure (e.g., storm sewers) than at the current condition in certain zoning classes. EIA classes were reassigned based on sub-watershed and zoning class district, for estimating EIA at build-out. See Table 5 for the Current Condition EIA Class and Build-Out EIA Class by sub-watershed and zoning class. Figure 4 illustrates the EIA classes by sub-watershed and zoning class.

Table 5. Effective impervious area (EIA) classes at current condition and build-out.

Watershed ID	District	DistrictAb	Current Condition EIA Class	Build-Out EIA Class
1	Industrial West Zoning District	IZDW	Highly connected	Highly connected
2	Industrial West Zoning District	IZDW	Average connected	Highly connected
2	Residential Zoning District	RZD	Average connected	Average connected
3	Industrial West Zoning District	IZDW	Average connected	Highly connected
3	Residential Zoning District	RZD	Average connected	Average connected
4	Business Park Zoning District	BPZD	Somewhat disconnected	Highly connected
4	Industrial West Zoning District	IZDW	Somewhat disconnected	Highly connected
4	Mixed Use - Commercial Zoning District	MUCZD	Somewhat disconnected	Average connected
4	Mixed Use - Residential Zoning District	MURZD	Somewhat disconnected	Average connected
4	Residential Zoning District	RZD	Somewhat disconnected	Average connected
4	Taft Corners Downtown Zoning District	TCZD	Somewhat disconnected	Highly connected
5	Agriculture/Rural Residential Zoning District	ARZD	Highly connected	Highly connected
5	Gateway South Zoning District	GZDS	Highly connected	Highly connected
5	Industrial West Zoning District	IZDW	Highly connected	Highly connected
5	Mixed Use - Commercial Zoning District	MUCZD	Highly connected	Highly connected
5	Mixed Use - Residential Zoning District	MURZD	Highly connected	Highly connected
5	Taft Corners Downtown Zoning District	TCZD	Highly connected	Highly connected
6	Agriculture/Rural Residential Zoning District	ARZD	Extremely disconnected	Extremely disconnected
6	Gateway South Zoning District	GZDS	Extremely disconnected	Average connected
6	Industrial West Zoning District	IZDW	Extremely disconnected	Highly connected
6	Mixed Use - Commercial Zoning District	MUCZD	Extremely disconnected	Average connected
7	Agriculture/Rural Residential Zoning District	ARZD	Extremely disconnected	Extremely disconnected
7	Industrial West Zoning District	IZDW	Extremely disconnected	Highly connected
8	Agriculture/Rural Residential Zoning District	ARZD	Extremely disconnected	Extremely disconnected
9	Agriculture/Rural Residential Zoning District	ARZD	Extremely disconnected	Extremely disconnected
10	Agriculture/Rural Residential Zoning District	ARZD	Extremely disconnected	Extremely disconnected
11	Agriculture/Rural Residential Zoning District	ARZD	Extremely disconnected	Extremely disconnected
12	Agriculture/Rural Residential Zoning District	ARZD	Extremely disconnected	Extremely disconnected
13	Agriculture/Rural Residential Zoning District	ARZD	Extremely disconnected	Extremely disconnected

Based on the EIA class and the estimated Residential and Commercial MIA at build-out, EIA at build-out was calculated and then summarized by sub-watershed. See Table 6 and Figure 5 for the change in EIA by sub-watershed.


1
185 ac.
2
215 ac.
3
206 ac.
4
468 ac.
5
542 ac.
6
303 ac.
7
376 ac.
8
255 ac.
9
322 ac.
10
786 ac.
11
497 ac.
12
918 ac.
13
1237 ac.
SOUTH BURLINGTON
SHELBURNE
ST. GEORGE
Muddy Brook Watershed (Williston Only)
Sub Watershed (13 total)
Effective Impervious Area Class
Extremely disconnected
Somewhat disconnected (None)
Average connected
Highly connected
Notes:
1. Effective Impervious Area (EIA) classes based on Sutherland, 2005.
Sources: Muddy Brook Watershed: NYDEC;
Sub Watersheds, EIA Classification: Stone Environmental;
Administrative Boundaries: VCGI; Imagery: Bing Maps.
0 0.25 0.5 1
Mile
STONE ENVIRONMENTAL INC
Effective Impervious Area Classification by Sub Watershed at Build-Out
Town of Williston
Stormwater Master Plan
Figure 4

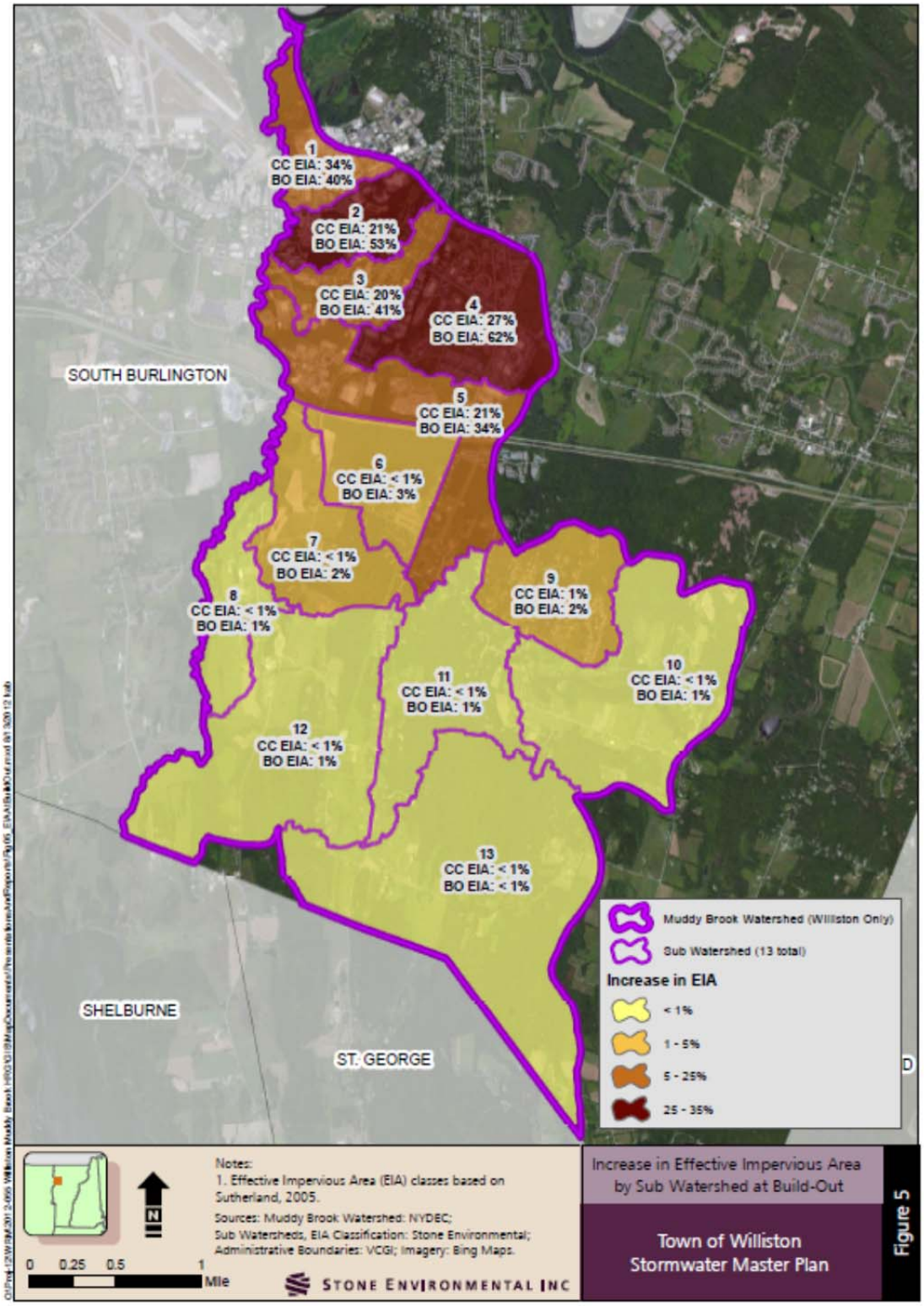

1
CC EIA: 34%
BO EIA: 40%
2
CC EIA: 21%
BO EIA: 53%
3
CC EIA: 20%
BO EIA: 41%
4
CC EIA: 27%
BO EIA: 62%
5
CC EIA: 21%
BO EIA: 34%
6
CC EIA: < 1%
BO EIA: 3%
7
CC EIA: < 1%
BO EIA: 2%
8
CC EIA: < 1%
BO EIA: 1%
9
CC EIA: 1%
BO EIA: 2%
10
CC EIA: < 1%
BO EIA: 1%
11
CC EIA: < 1%
BO EIA: 1%
12
CC EIA: < 1%
BO EIA: 1%
13
CC EIA: < 1%
BO EIA: < 1%
SOUTH BURLINGTON
SHELBURNE
ST. GEORGE
Muddy Brook Watershed (Williston Only)
Sub Watershed (13 total)
Increase in EIA
< 1%
1 - 5%
5 - 25%
25 - 35%
N
0 0.25 0.5 1
Mile
Notes:
1. Effective Impervious Area (EIA) classes based on Sutherland, 2005.
Sources: Muddy Brook Watershed: NYDEC;
Sub Watersheds, EIA Classification: Stone Environmental;
Administrative Boundaries: VCGI; Imagery: Bing Maps.
STONE ENVIRONMENTAL INC
Increase in Effective Impervious Area by Sub Watershed at Build-Out
Town of Williston
Stormwater Master Plan
Figure 5

Table 6. Estimated EIA at current condition and build-out by sub-watershed.

Watershed ID	Total Acres	Current Condition EIA (%)	Build-Out EIA (%)	Increase in EIA (%)
1	184.9	33.5	39.9	6.4
2	215.2	20.9	53.3	32.4
3	206.3	19.5	41.4	21.9
4	467.8	27.2	62.2	35.0
5	542	21.2	34.3	13.1
6	302.6	0.4	2.5	2.2
7	375.9	0.2	1.7	1.5
8	254.7	0.1	1.1	1.0
9	322.4	1	2.3	1.2
10	786.5	0.1	1.1	0.9
11	497.5	0.1	0.8	0.7
12	917.8	0.1	0.9	0.8
13	1236.6	0	0.7	0.7

1.3.3 Estimating Stormwater Design Flow at Build-out

The calculated peak flow rates under current and build-out conditions are presented in Table 7. These values provide "ballpark" numbers for flow rates in each catchment but are not easily used to compare each sub-watershed with the others.

Table 7. Estimated peak flow rates at current condition and build-out by sub-watershed for 2, 10, 25, and 100-yr storm-events.

Sub-Watershed Catchment	2-yr Storm		10-yr Storm		25-yr Storm		100-yr Storm	
	Current	Built-Out	Current	Built-Out	Current	Built-Out	Current	Built-Out
	acre-ft/hr		acre-ft/hr		acre-ft/hr		acre-ft/hr	
1	6.4	7.2	7.1	8.0	7.7	8.7	8.7	9.8
2	5.2	9.4	5.7	10.4	6.2	11.3	7.0	12.8
3	5.8	8.6	6.4	9.4	6.9	10.3	7.8	11.6
4	15.1	24.6	16.6	27.0	18.2	29.5	20.5	33.3
5	15.9	20.0	17.5	22.0	19.1	24.1	21.5	27.2
6	5.3	6.0	5.9	6.6	6.4	7.2	7.3	8.1
7	7.4	8.0	8.2	8.9	8.9	9.7	10.1	10.9
8	6.1	6.4	6.7	7.1	7.4	7.7	8.3	8.7
9	5.7	6.4	6.2	7.1	6.8	7.7	7.7	8.7
10	14.9	15.8	16.4	17.4	17.9	19.0	20.2	21.4
11	8.7	9.2	9.5	10.1	10.4	11.0	11.7	12.4
12	19.2	20.1	21.1	22.1	23.0	24.2	26.0	27.3
13	21.9	22.7	24.1	25.0	26.4	27.3	29.8	30.8

Since the same rainfall intensity is applied across each sub-watershed catchment, comparisons can be simplified by removing the i-value from the calculation. This leaves the runoff coefficient (C) and Area (A) product which can be more easily displayed and compared as shown. The root of the expected change in hydrologic conditions is a shift from pervious to more impervious land cover. Figure 6 provides a comparison of current and build-out condition EIA and total sub-watershed catchment areas. Also shown in the secondary axis is the percent change between current and build-out EIA. The blue columns show total

catchment area. Sub-watersheds 1 through 5 show a significant fraction of land as EIA with varying degrees of change (provided in on the secondary axis). Sub-watersheds 6 through 13 show a very small, nearly undetectable, fraction as EIA in both current and build-out conditions. It should be noted that the relative change for these EIA values were very large - large enough to distort the scale of the figure. The change in current to build-out EIA is for sub-watersheds 6 through 13, however, is expected to result in very little change in hydrologic conditions. For these reasons, the values for "relative change" were omitted for sub-watersheds 6-13.

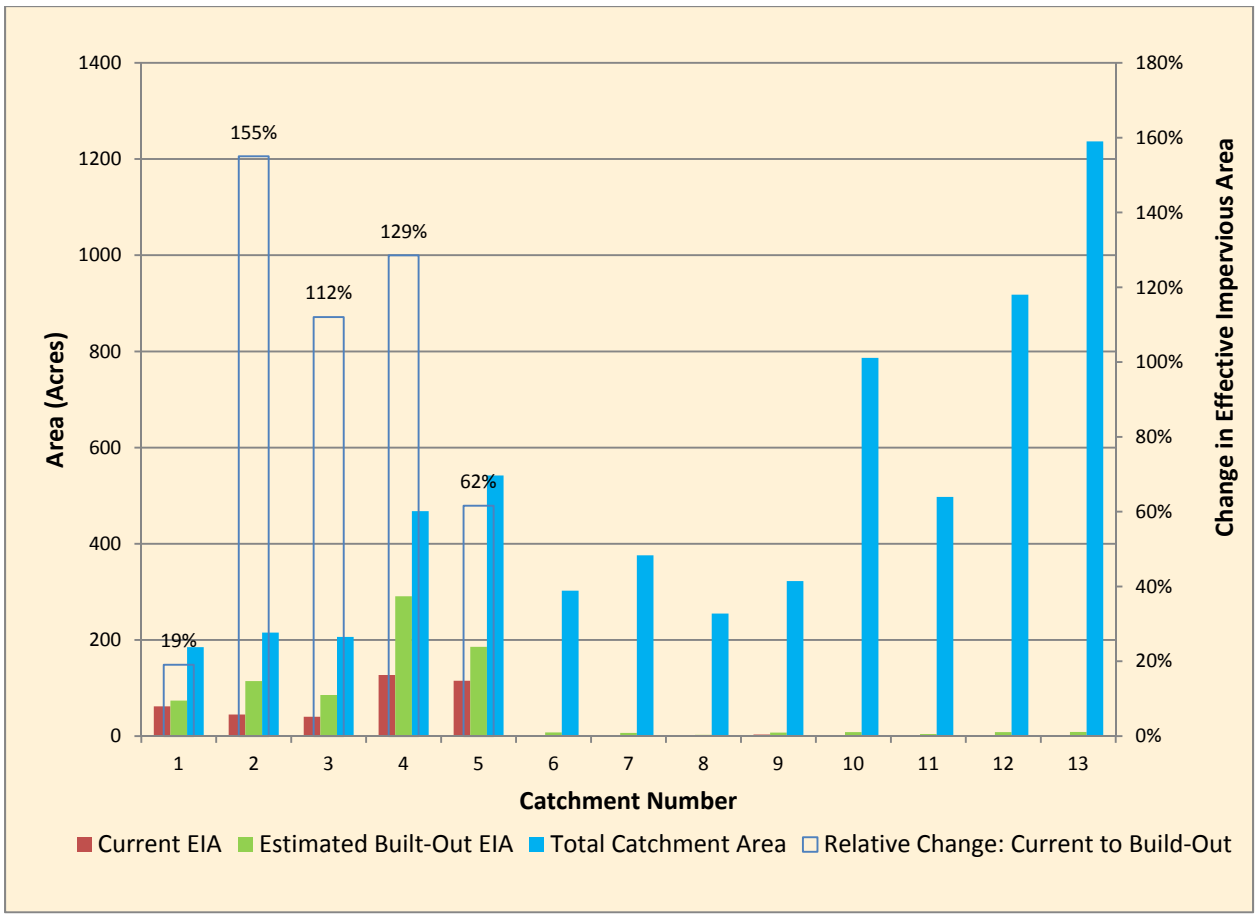


Figure 6. Comparison of current and build-out EIA, Total Catchment Area, and percent change.

The greatest potential for change can be expected in the sub-watershed catchments 2, 3, 4, and 5. This is the commercial district north of Interstate 89 (Tafts Corners). When compared to the catchments in the southern portion of the watershed, these areas are much smaller in area but are more highly-developed. Figure 7 factors in the land-use/land-cover type and assesses the associated runoff contributions by including the C-values for each sub-watershed catchment. Because the C-value relates the amount of runoff to the amount of precipitation received (i.e., it is a larger value for areas with low infiltration and high runoff such as pavement, and lower for permeable, well vegetated areas such as forests), the C x A product provides a way to compare the total relative runoff contributions from each sub-watershed. The figure shows contributions from current and build-out EIA and pervious areas.

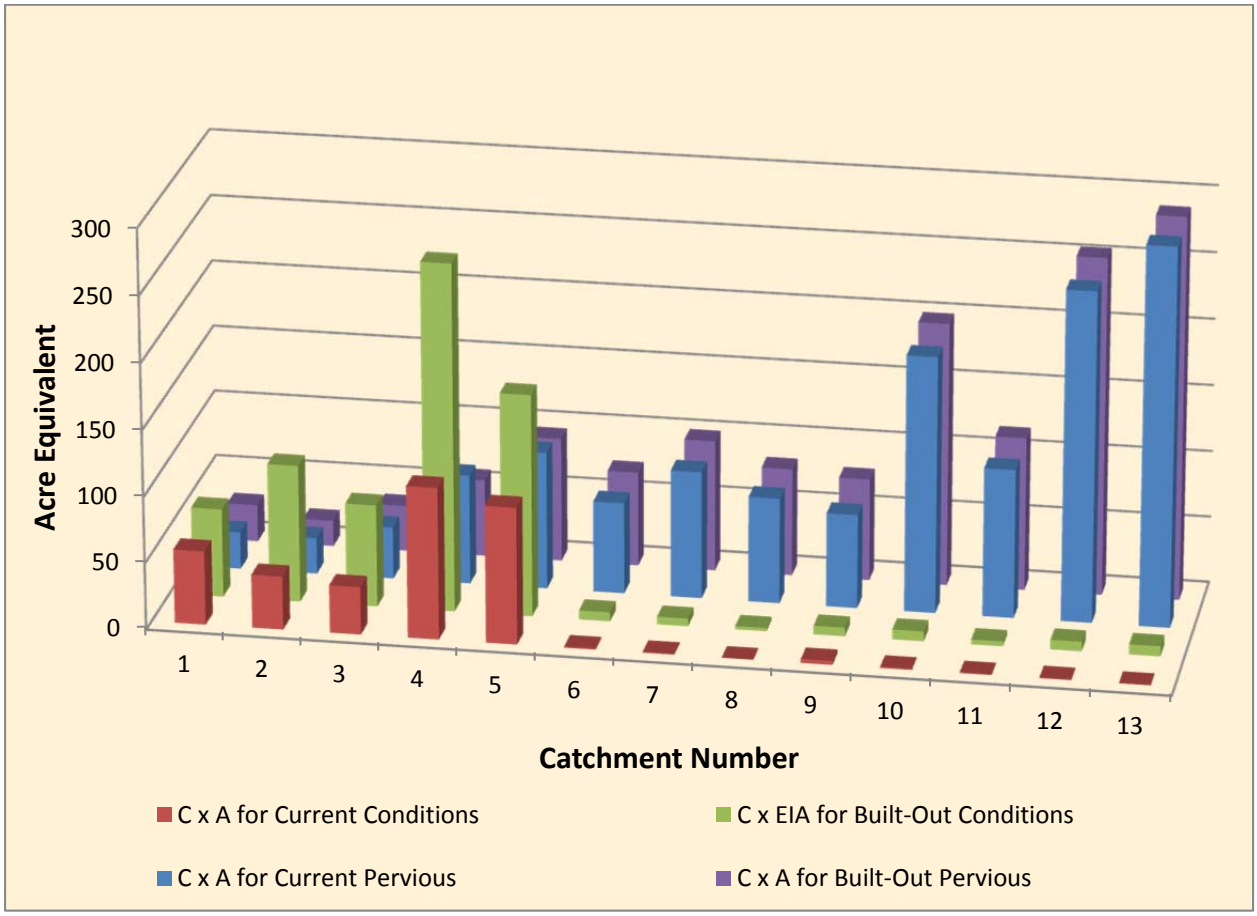


Figure 7. Comparison of Runoff Coefficient x Areas

Considering both Figure 6 and 7, one can see that while sub-watershed catchments 1 through 5 make up only a small part of the total watershed area, they contribute a disproportionately large amount of runoff under both current and build-out conditions. This is due to the large amount of impervious area associated with these highly-developed parts of Williston.

Another way to assess and compare hydrologic conditions across sub-watershed catchments and between current and build-out conditions is to look at runoff flow rates on a per-acre basis as show in Figure 8. A higher flow per acre value means flashier flows, which are more likely to lead to erosion in ditches, tributaries and mainstem streams.

Figure 8 shows higher intensity flow rates per acre of land for sub-watersheds 1 through 5. These are the most highly developed areas within the watershed, as well as where future development will be concentrated. This means that that the ditches and small streams in these areas are likely to already be significantly more stressed during a typical storm event by higher flows. Furthermore, when fully built out, flow rates per acre are expected to significantly increase.

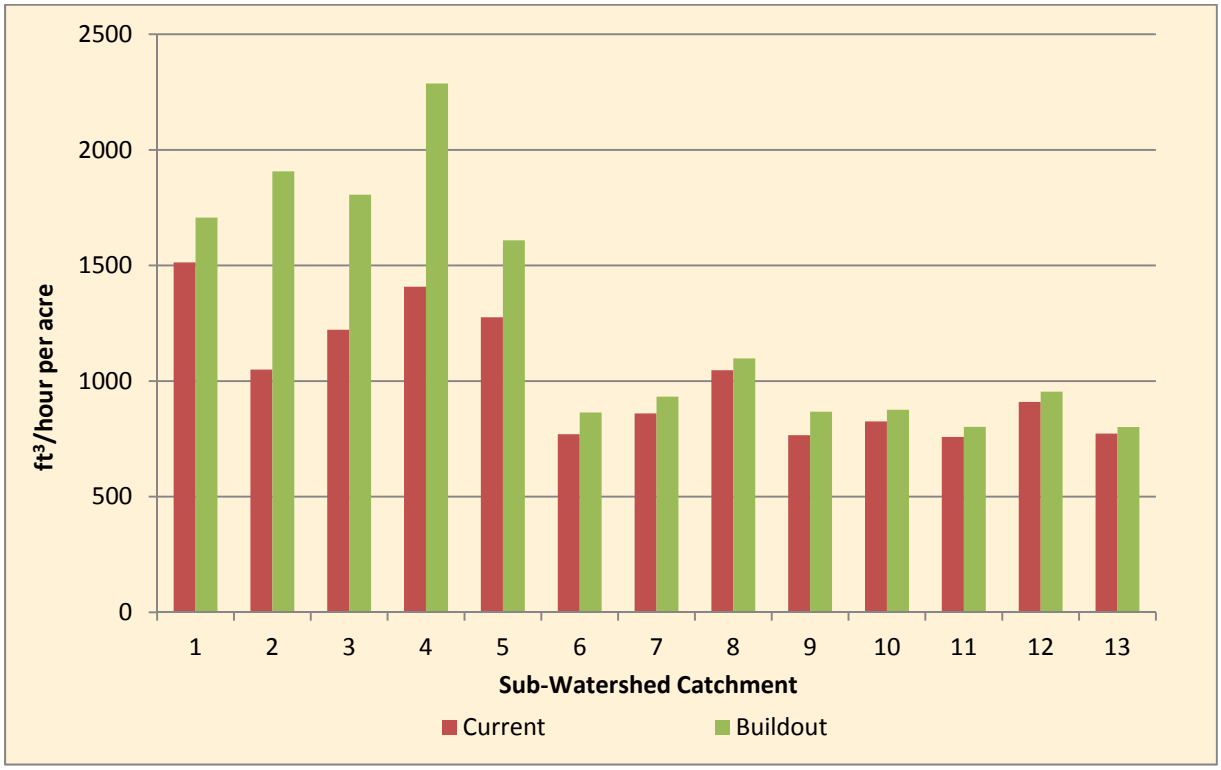


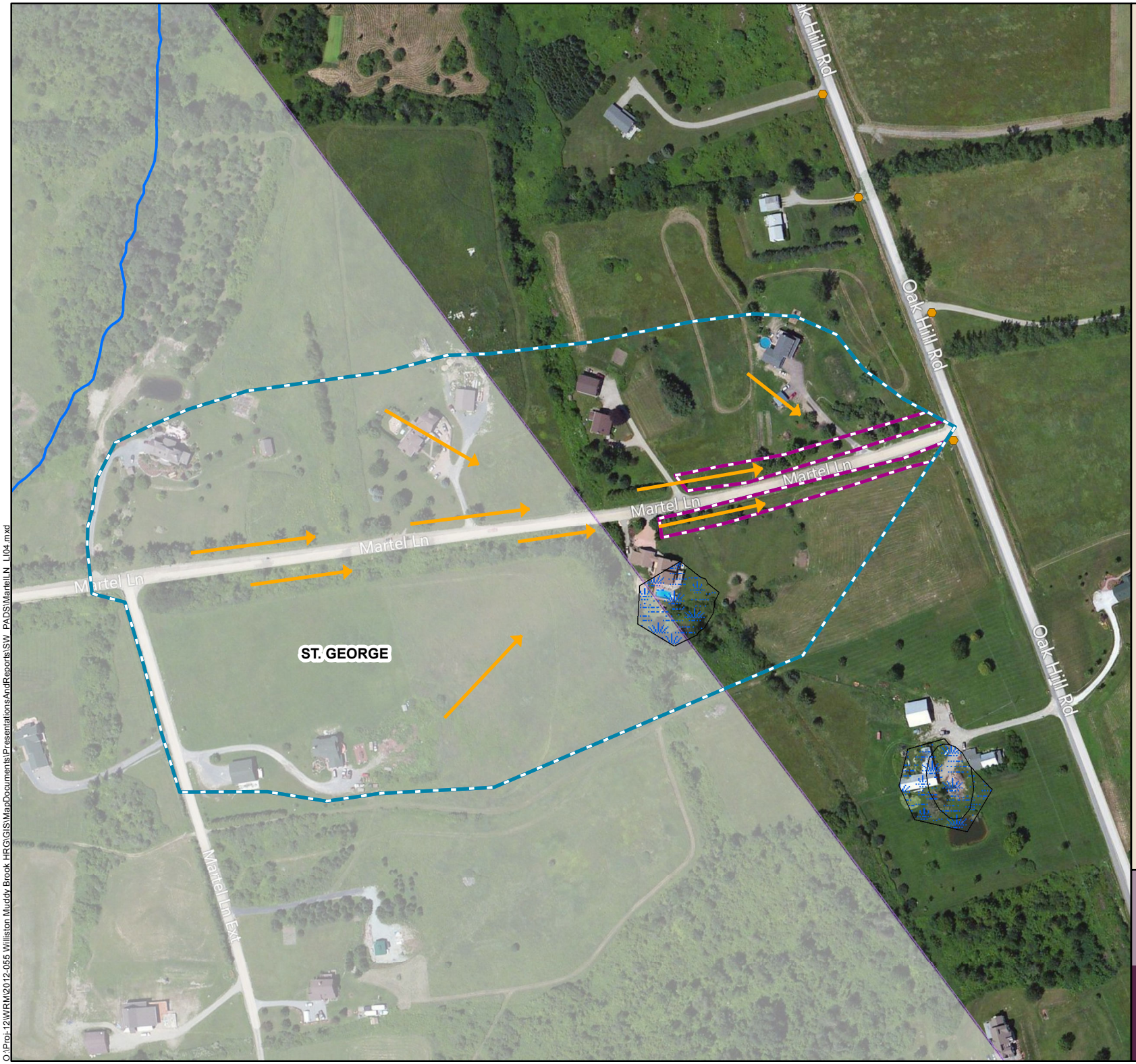
Figure 8. 2-yr/ 140 minute flow rates are shown as flow per acre for current and build-out conditions.

2.0 CONCLUSIONS

For future planning and stormwater management purposes the Town may wish to consider zoning conditions, low-impact design requirements, and other measures to help manage stormwater runoff – particularly from parcels that do not reach the regulatory threshold for state stormwater jurisdiction. Stormwater treatment retrofits could provide significant water quality benefits if implemented in sub-watershed 1 followed by 4, 5, 3 and 2 respectively. Low impact design could help to minimize stormwater impacts from new, sub-jurisdictional development in areas expecting to see the most growth. Based on our build-out analysis these are subwatersheds 2 and 4 followed by 3, 5, and 1 respectively.

The less developed sub-watersheds - 6 through 13 - should not be ignored, however. These sub-watersheds account for the majority of total area and in absolute terms contribute the greatest amount of runoff to Muddy Brook. A large portion of these areas are currently forested. From a water quality standpoint it is important to protect and sustain these valuable areas. Much of the remaining land is used for agriculture, mostly classified as hay fields and pasture-land, but also some annual row crops. In pasture areas efforts to exclude animals from streams and to create and maintain riparian buffers can significantly reduce erosion and nutrient runoff. Likewise conservative tillage practices can prevent erosion from annual cropland while helping to maintain soil quality.

APPENDIX E: CONCEPTUAL SOLUTIONS FOR HIGH PRIORITY STORMWATER PROBLEM AREAS



N

ESSEX
WILLISTON
RICHMOND

0 75 150 300
Feet

Drainage Area (28 Acres)
SW Treatment Opportunities
River or Stream
Culvert
Wetlands
Flow Direction

Recommended Practice:
Bioswale with check dams

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Martel Ln

LI-04

Williston Town-Wide Stormwater Master Plan

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N
ESSEX
WILLISTON
RICHMOND
0 250 500 1,000
Feet
Drainage Area (221 Acres)
SW Treatment Opportunities
River or Stream
Wetlands
Soil Condition Suitable for Infiltration
Water Line
Culvert
Wastewater Line
Electric Transmission Line
Vermont Gas Line
Recommended Practice:
Bank stabilization and culvert replacement
Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.
Stone Environmental Inc
Harvest Ln
(Near Marshall Ave)
MB-11
Williston Town-Wide
Stormwater Master Plan
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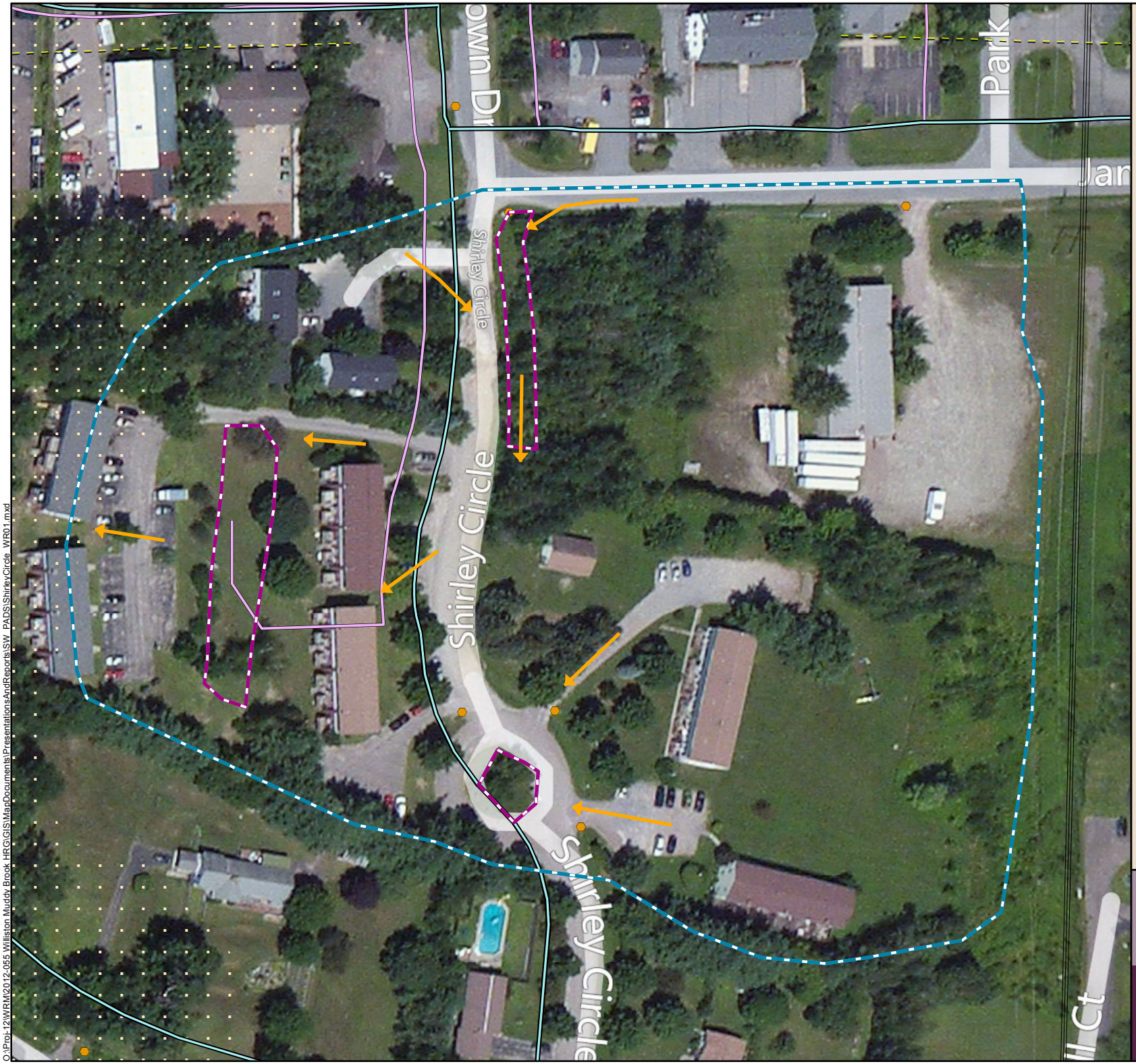

N

0 25 50 100
Feet

- Drainage Area (9.1 Acres)
- SW Treatment Opportunities
- River or Stream
- Culvert
- Wastewater Line
- Water Line
- Electric Transmission Line
- Vermont Gas Line
- Soil Condition Suitable for Infiltration
- Flow Direction

Recommended Practice:
Bioswale, bioretention

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Shirley Circle

WR-01

Williston Town-Wide Stormwater Master Plan

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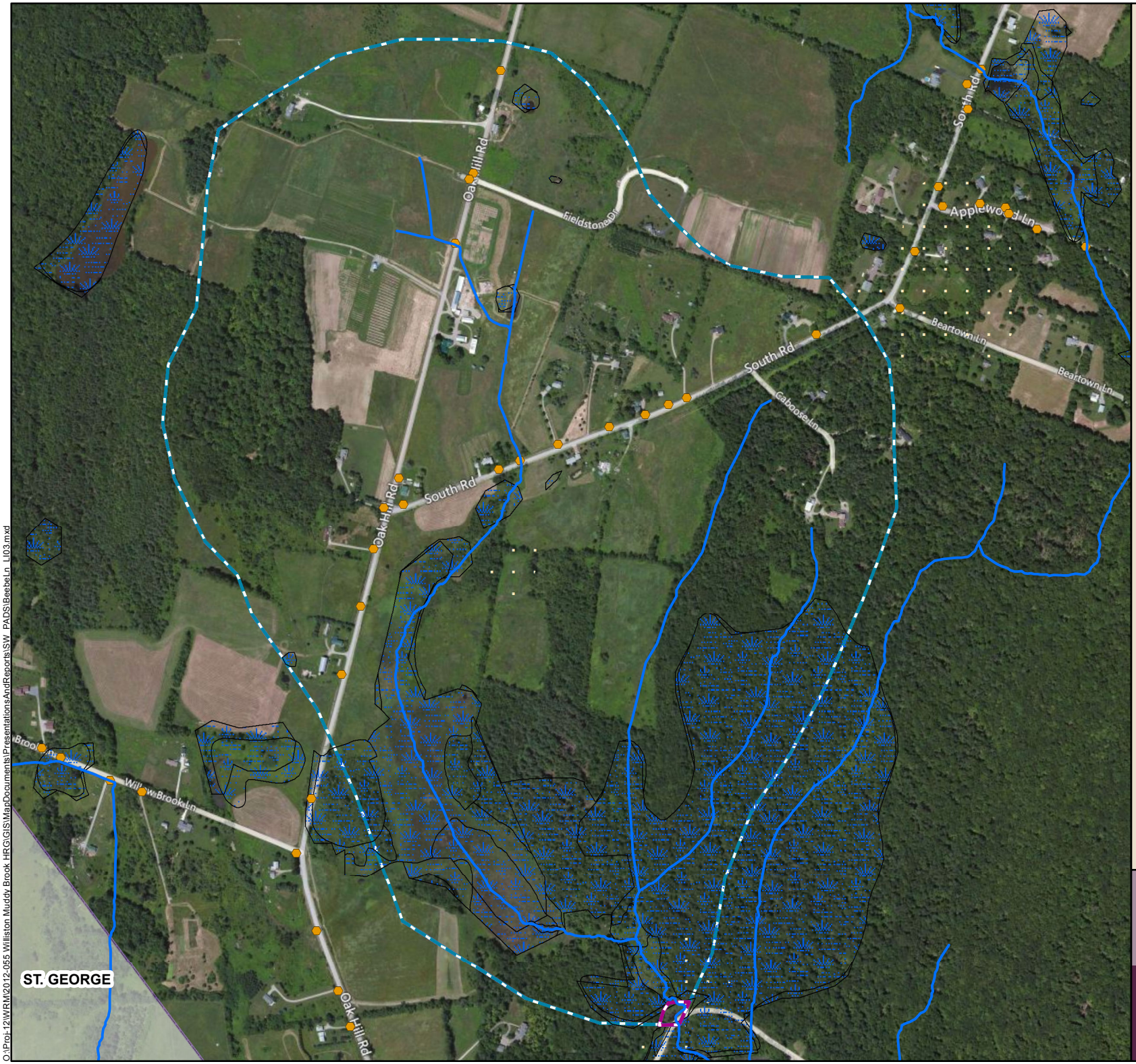

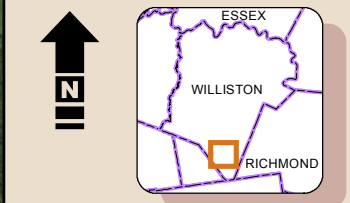

N

0 255 510 1,020 Feet

- Drainage Area (387 Acres)
- SW Treatment Opportunities
- River or Stream
- Wetlands
- Soil Condition Suitable for Infiltration
- Culvert

Recommended Practice:
Culvert replacement

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Beebe Ln

LI-03

Williston Town-Wide Stormwater Master Plan

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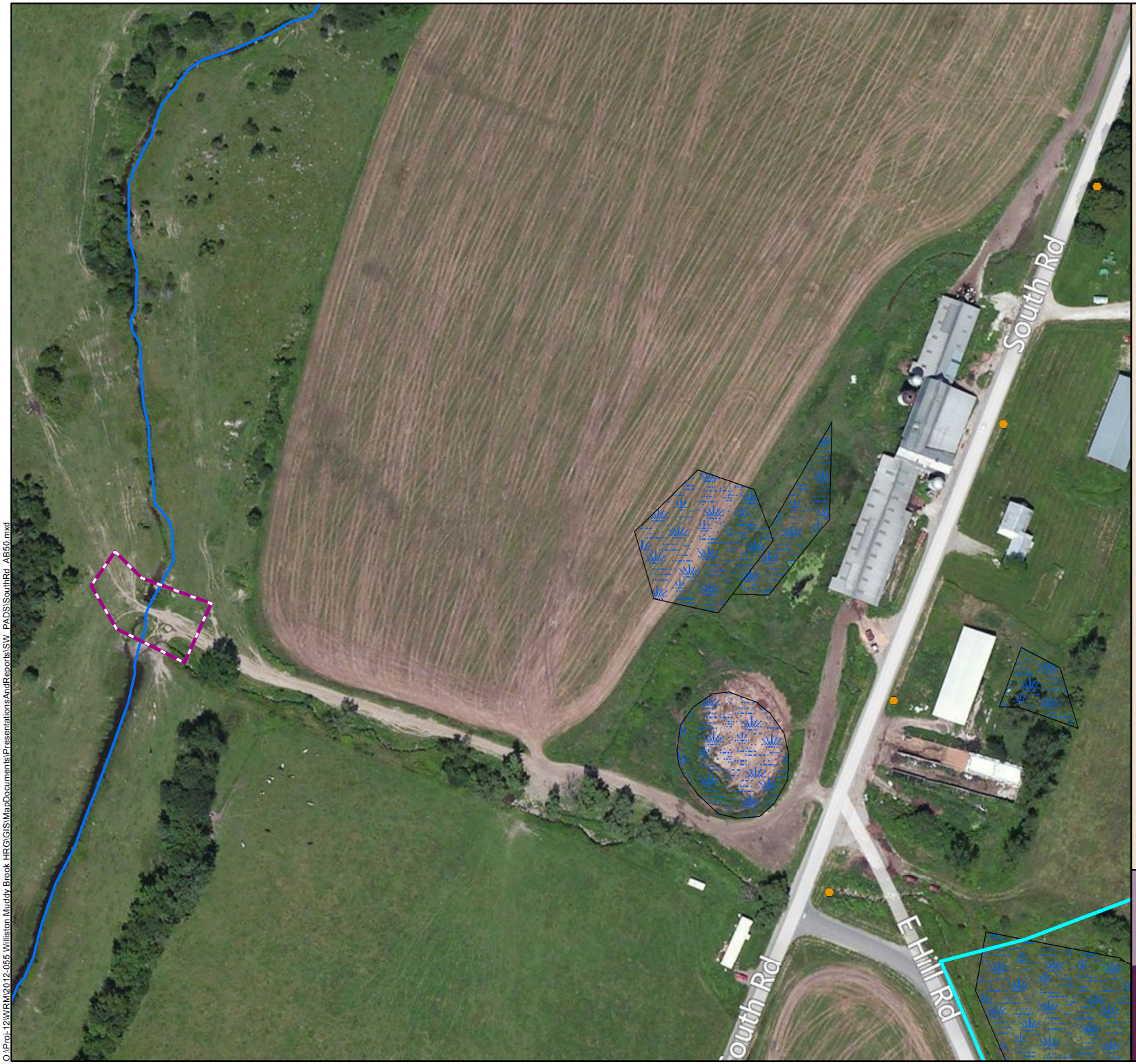

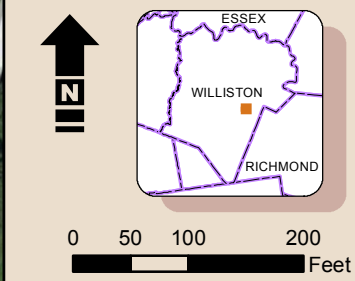

SW Treatment Opportunities
River or Stream
Wetlands
Culvert

Recommended Practice:
Reinforced animal trail

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

South Rd

AB-50

Williston Town-Wide Stormwater Master Plan

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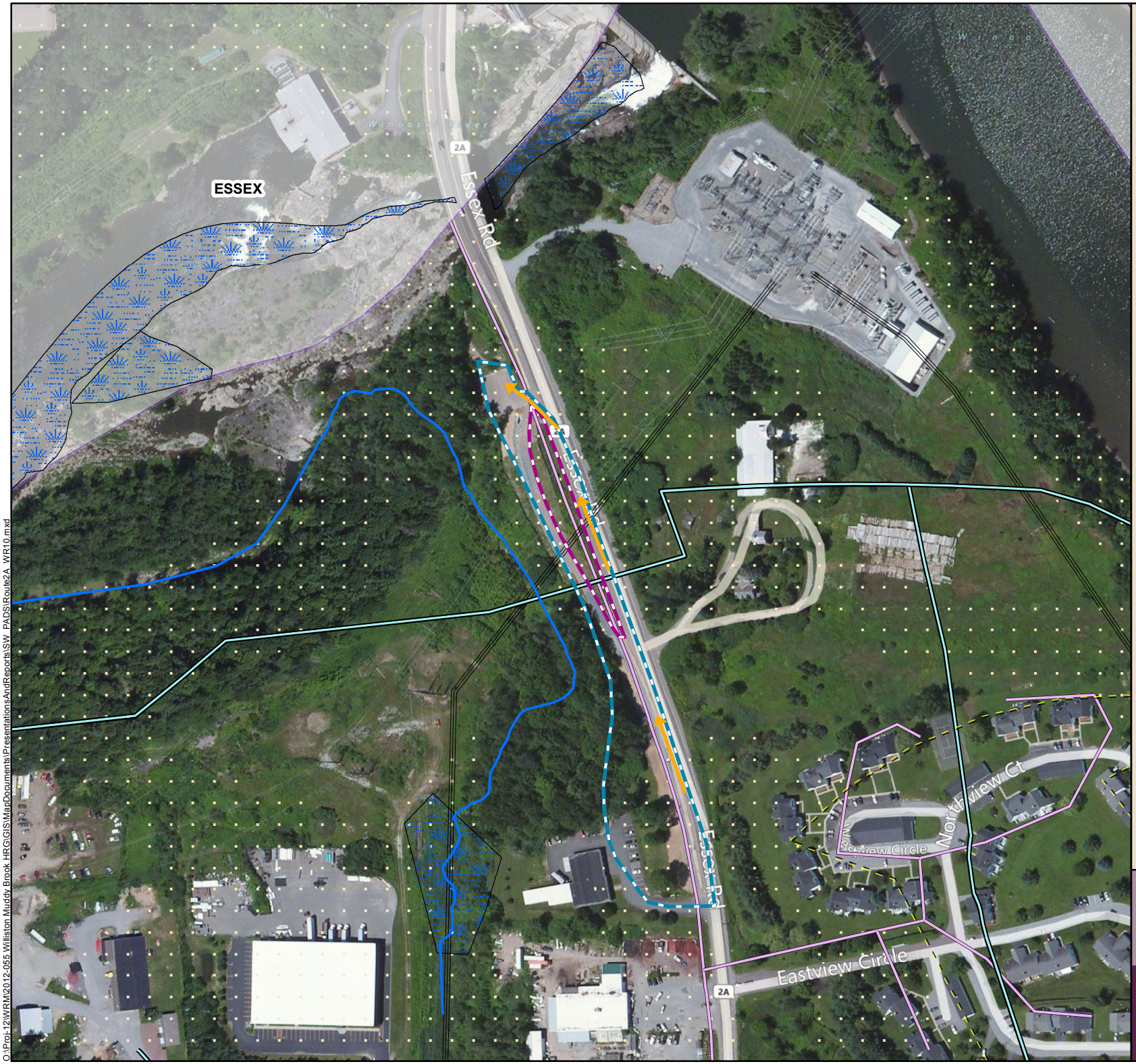

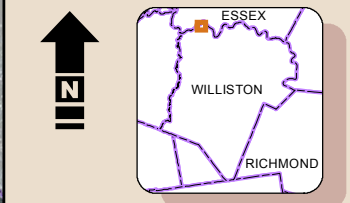

0 75 150 300 Feet

- Drainage Area (2.7 Acres)
- SW Treatment Opportunities
- River or Stream
- Wetlands
- Soil Condition Suitable for Infiltration
- Culvert
- Water Line
- Wastewater Line
- Electric Transmission Line
- Vermont Gas Line
- Flow Direction

Recommended Practice:
Flow redirection (to existing swale)

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Route 2A
(Near Essex Town Line)

WR-10

Williston Town-Wide
Stormwater Master Plan

O:\Proj-12\WRM\2012-055 Williston Muddy Brook HRG\GIS\MapDocuments\PresentationsAndReports\SW_PADS\Route2A_WR10.mxd

0 125 250 500
Feet

- Drainage Area (146 Acres)
- SW Treatment Opportunities
- River or Stream
- Culvert
- Wastewater Line
- Water Line
- Electric Transmission Line
- Vermont Gas Line
- Soil Condition Suitable for Infiltration

Recommended Practice:
Road crowning and grading, improved drainage

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Chapman Ln

WR-04

Williston Town-Wide Stormwater Master Plan

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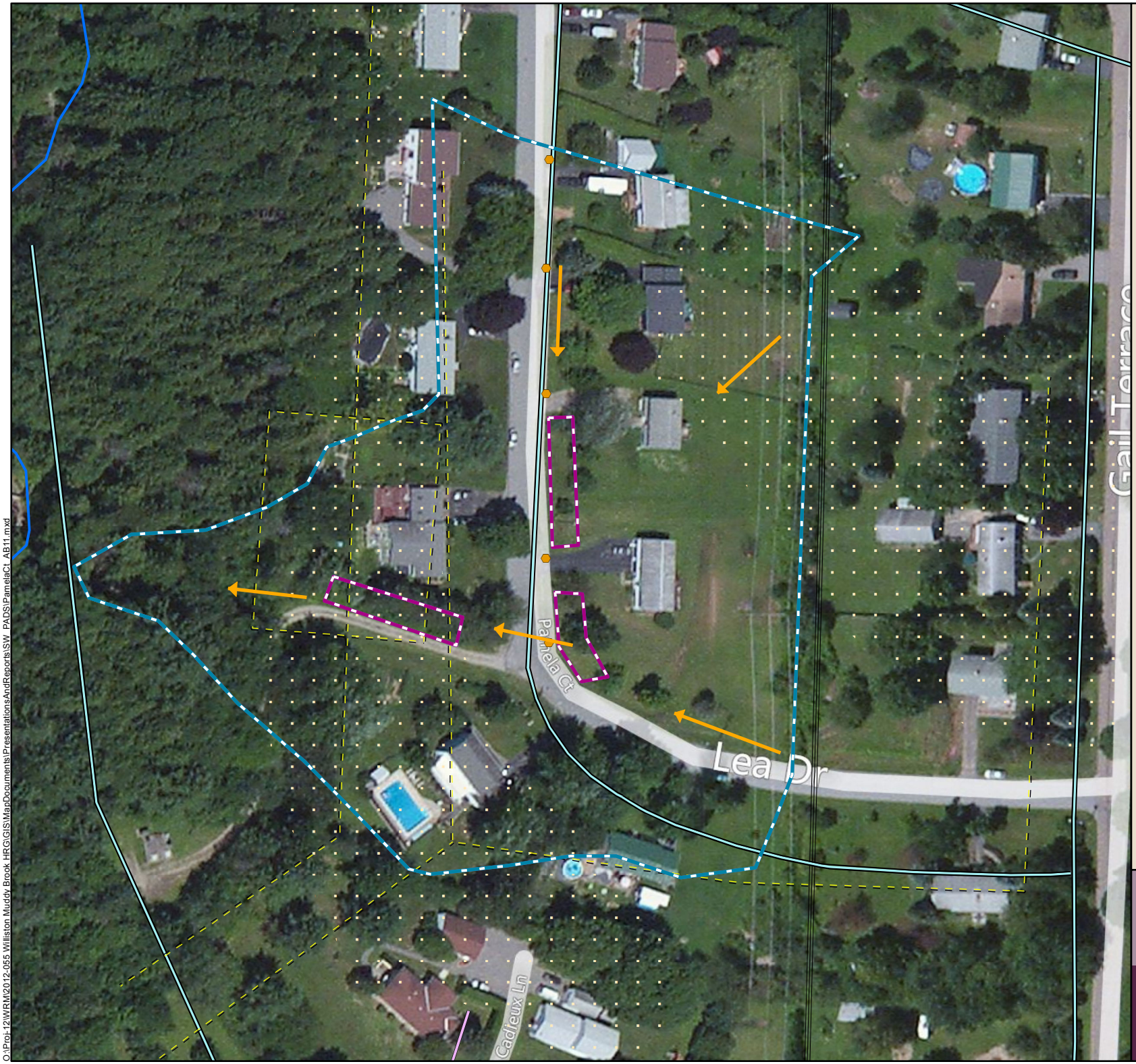

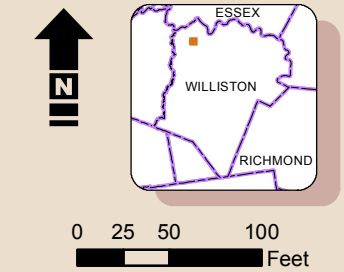

- Drainage Area (5.0 Acres)
- SW Treatment Opportunities
- River or Stream
- Wetlands
- Soil Condition Suitable for Infiltration
- Water Line
- Culvert
- Wastewater Line
- Electric Transmission Line
- Vermont Gas Line
- Flow Direction

Recommended Practice:
Bioretention, headcut stabilization

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Pamela Ct

AB-11

Williston Town-Wide Stormwater Master Plan

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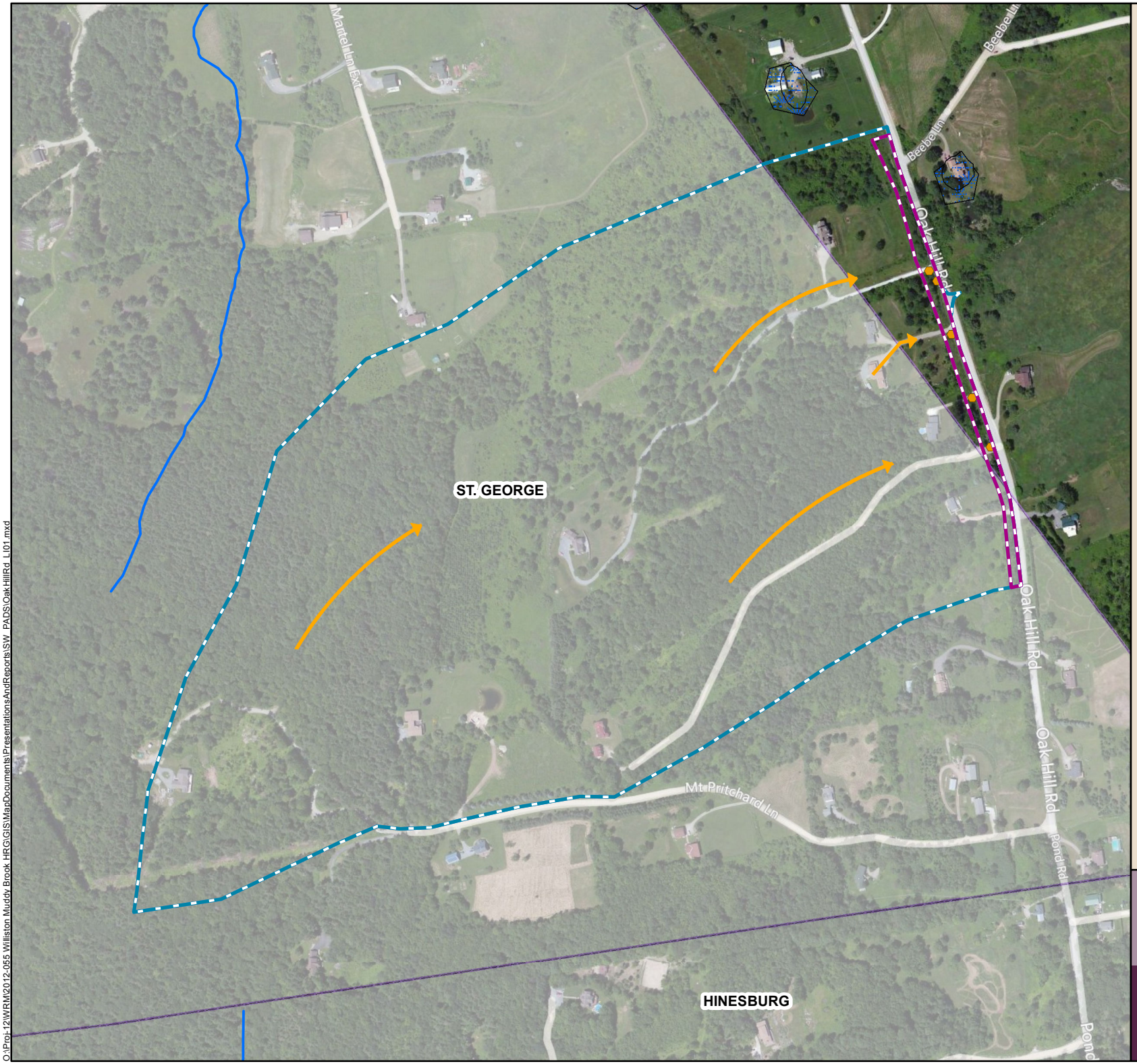

Recommended Practice:
Culvert replacement, stone lining ditch

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Oak Hill Rd

LI-01

Williston Town-Wide Stormwater Master Plan

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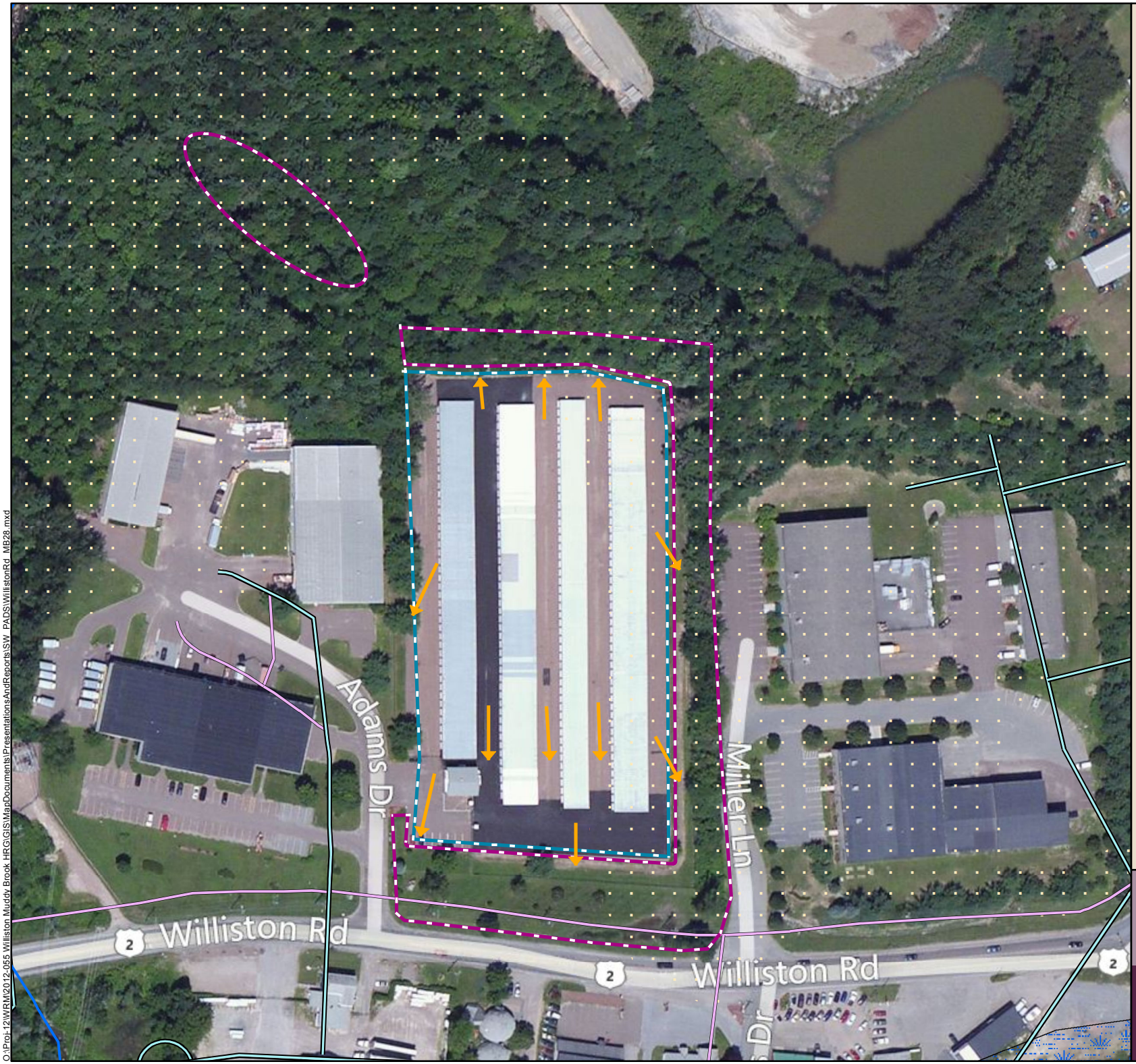

N

0 50 100 200
Feet

- Drainage Area (4.1 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Water Line
- Vermont Gas Line
- Wetlands
- Flow Direction

Recommended Practice:
Bioretention, bank stabilization

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Williston Rd
(Near Miller Ln)

MB-28

Williston Town-Wide
Stormwater Master Plan

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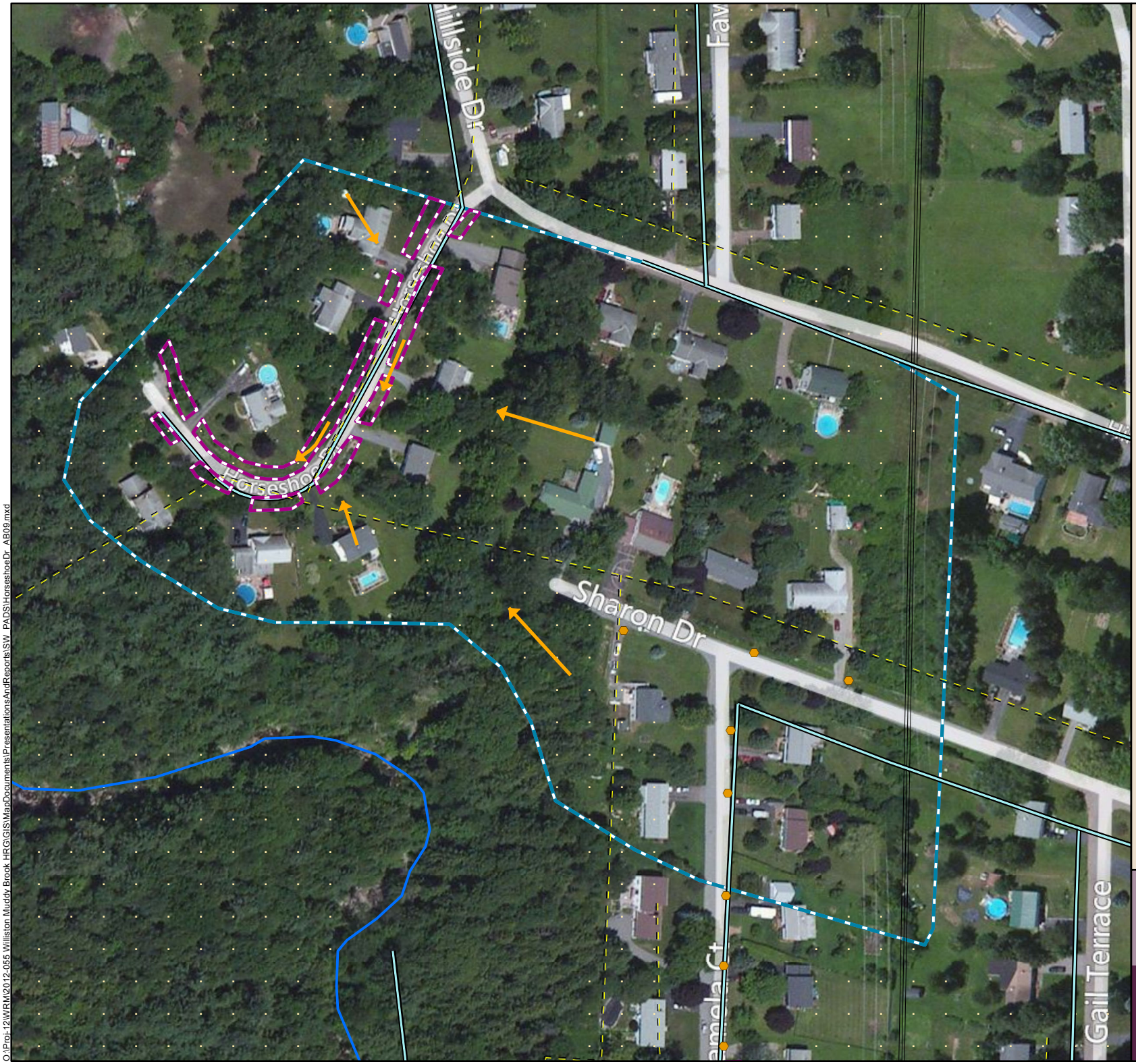

N

0 50 100 200
Feet

- Drainage Area (14.7 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Culvert
- Wastewater Line
- Water Line
- Electric Transmission Line
- Flow Direction

Recommended Practice:
Bioretention

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Horseshoe Dr

AB-09

Williston Town-Wide Stormwater Master Plan

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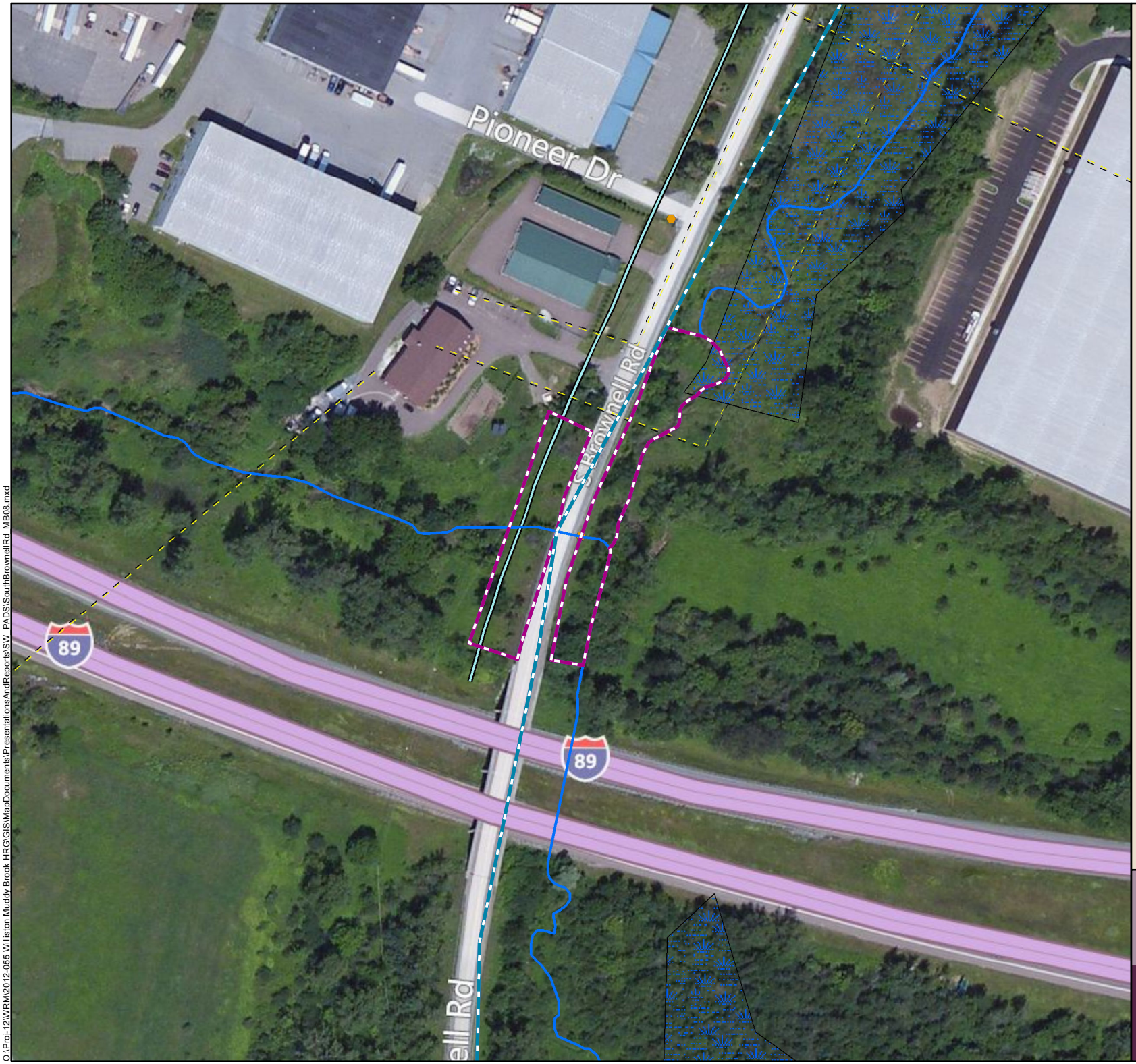

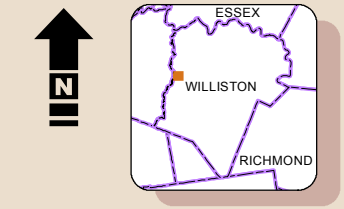

0 50 100 200
Feet

- Drainage Area (947 Acres)
- SW Treatment Opportunities
- River or Stream
- Wetlands
- Soil Condition Suitable for Infiltration
- Wastewater Line
- Water Line
- Culvert
- Vermont Gas Line

Recommended Practice:
Bank stabilization (tree planting)

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

South Brownell Rd

MB-08

Williston Town-Wide Stormwater Master Plan

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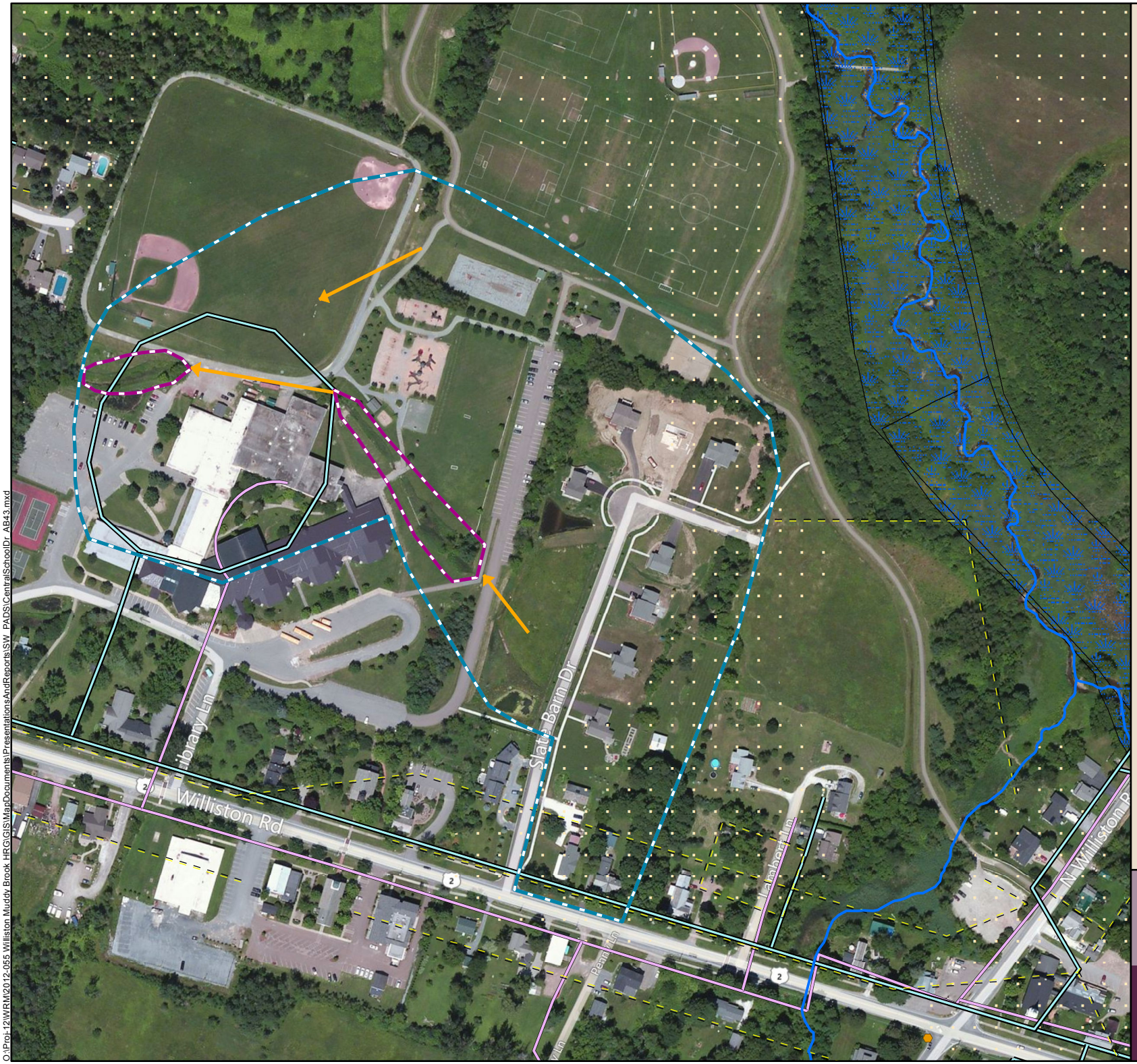

0 75 150 300 Feet

- Drainage Area (26 Acres)
- SW Treatment Opportunities
- River or Stream
- Culvert
- Wastewater Line
- Water Line
- Vermont Gas Line
- Wetlands
- Soil Condition Suitable for Infiltration
- Flow Direction

Recommended Practice:
Culvert replacement, stone lining ditch

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Central School Dr

AB-43

Williston Town-Wide Stormwater Master Plan

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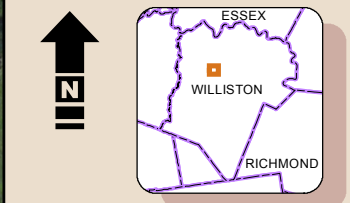

N

0 75 150 300
Feet

- Drainage Area (5,864 Acres)
- SW Treatment Opportunities
- River or Stream
- Culvert
- Wastewater Line
- Water Line
- Electric Transmission Line
- Vermont Gas Line
- Soil Condition Suitable for Infiltration

Recommended Practice:
Bank stabilization, culvert replacement

Notes:
Watershed extends South and East to Butternut Rd and Oak Hill Rd, and North to Governor Chittenden Rd and North Williston Rd.

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Talcott Rd

AB-21

Williston Town-Wide Stormwater Master Plan

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0 125 250 500 Feet

- Drainage Area (58 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Wastewater Line
- Water Line
- Culvert
- Vermont Gas Line
- Flow Direction

Recommended Practice:
Culvert replacement

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Old Stage Rd

AB-44

Williston Town-Wide Stormwater Master Plan

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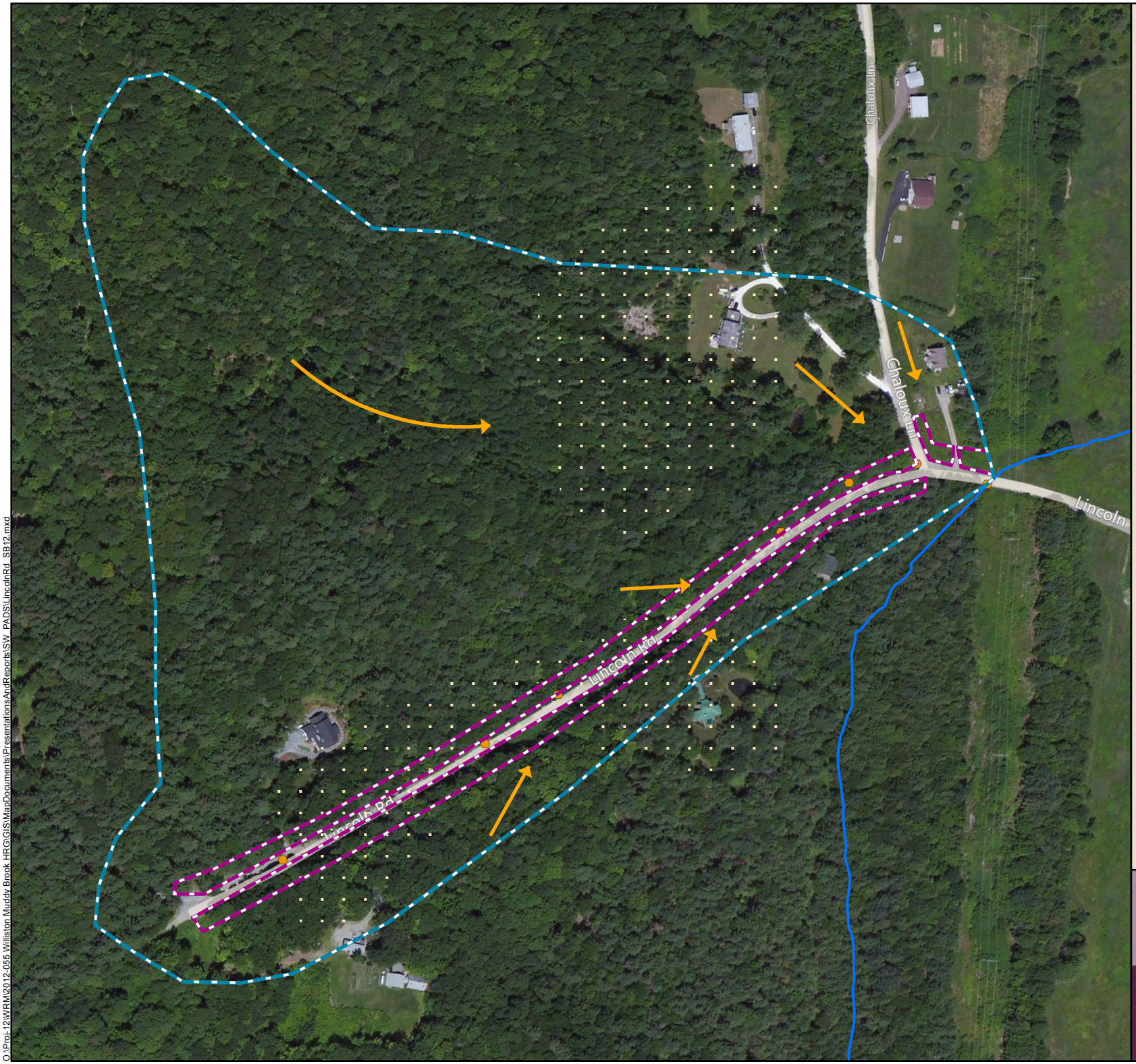

N

0 75 150 300
Feet

Drainage Area (42 Acres)
SW Treatment Opportunities
River or Stream
Soil Condition Suitable for Infiltration
Culvert
Flow Direction

Recommended Practice:
Bioswale with check dams

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Lincoln Rd

SB-12

Williston Town-Wide Stormwater Master Plan

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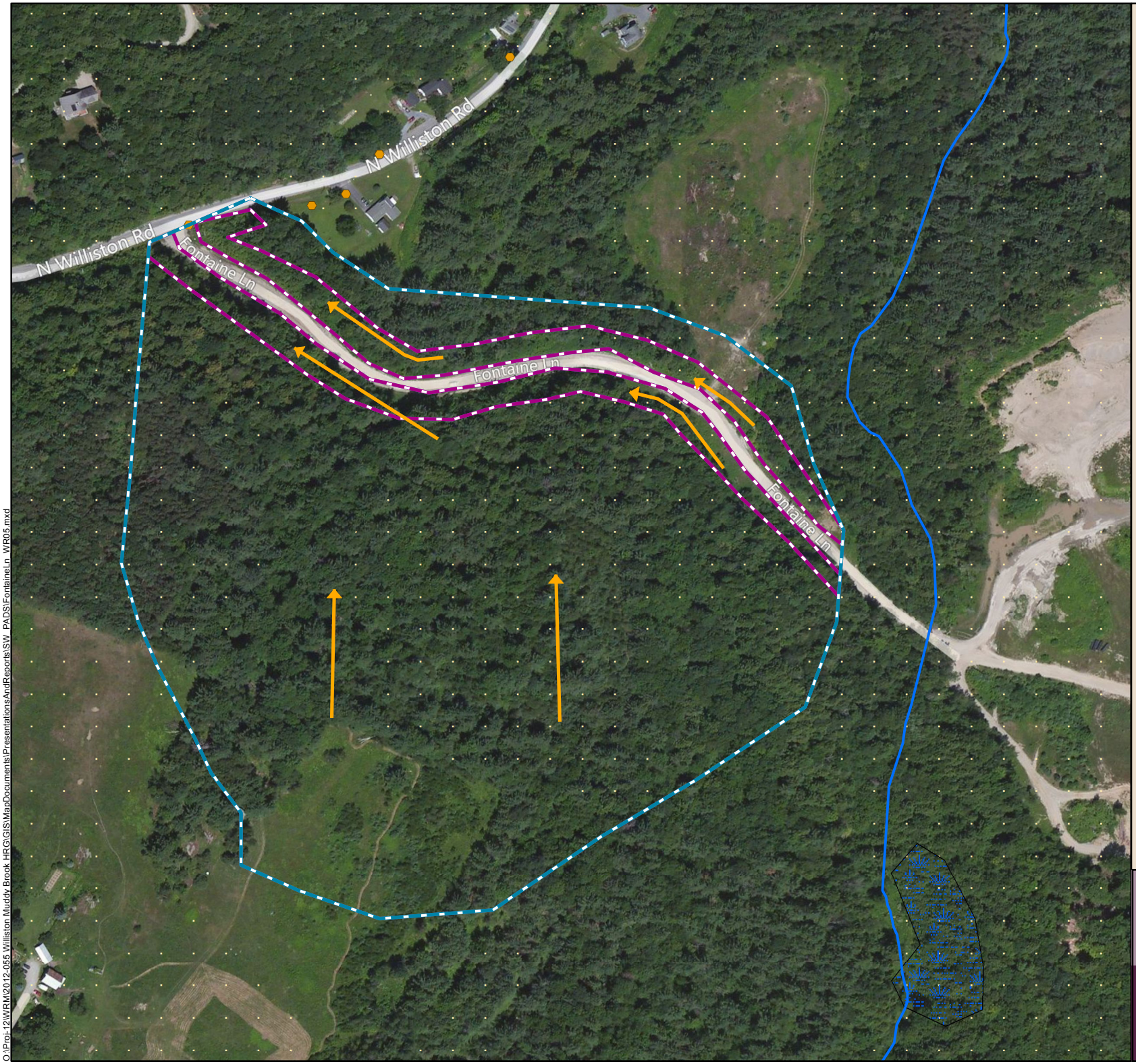

0 75 150 300
Feet

- Drainage Area (34 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Wetlands
- Culvert
- Flow Direction

Recommended Practice:
Bioswale with and without check dams

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Fontaine Ln

WR-05

Williston Town-Wide Stormwater Master Plan

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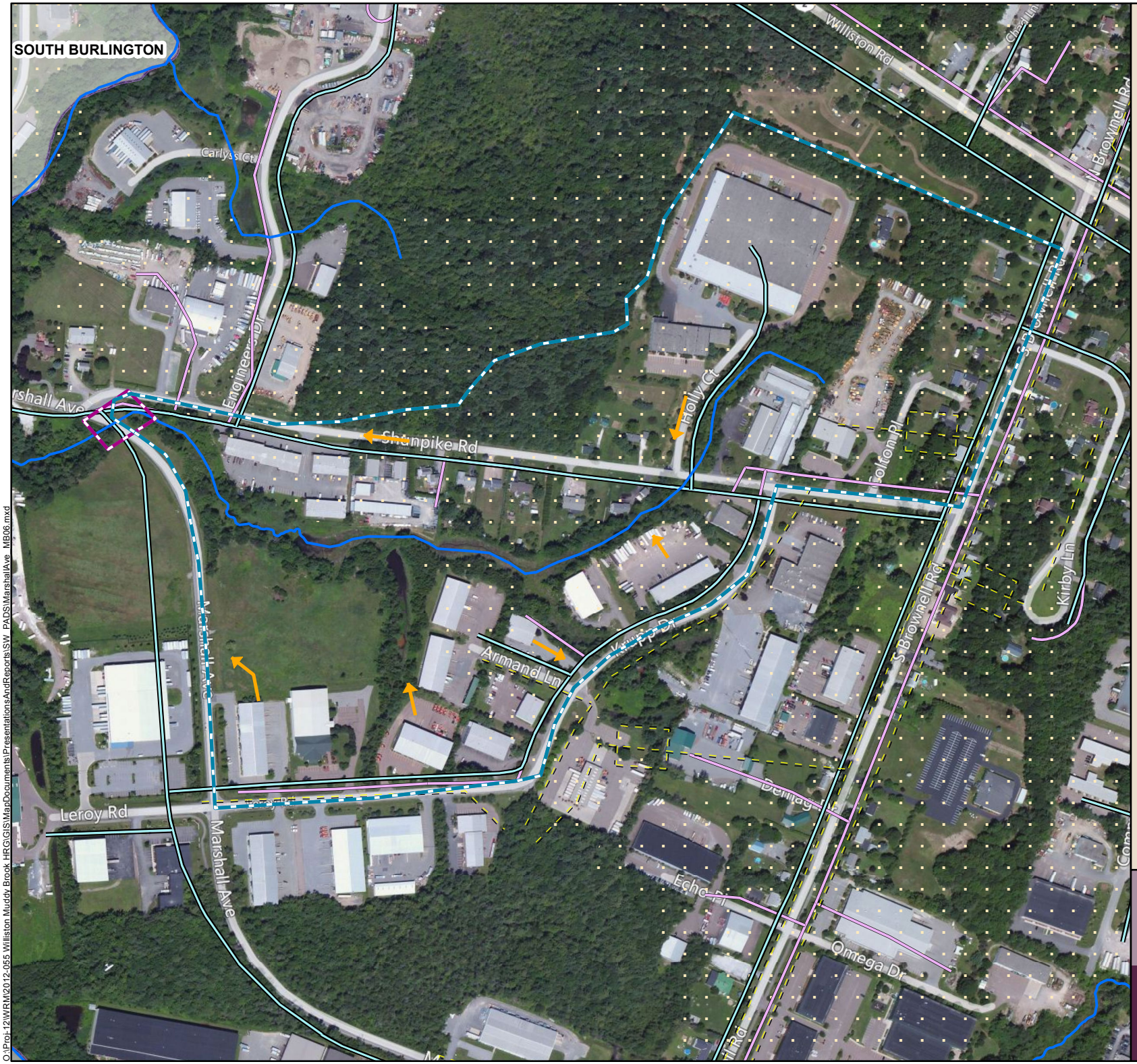

N

0 125 250 500 Feet

- Drainage Area (87 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Wastewater Line
- Water Line
- Culvert
- Vermont Gas Line
- Flow Direction

Recommended Practice:
Culvert replacement, headcut stabilization

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Marshall Ave
(at Shunpike Rd)

MB-06

Williston Town-Wide
Stormwater Master Plan

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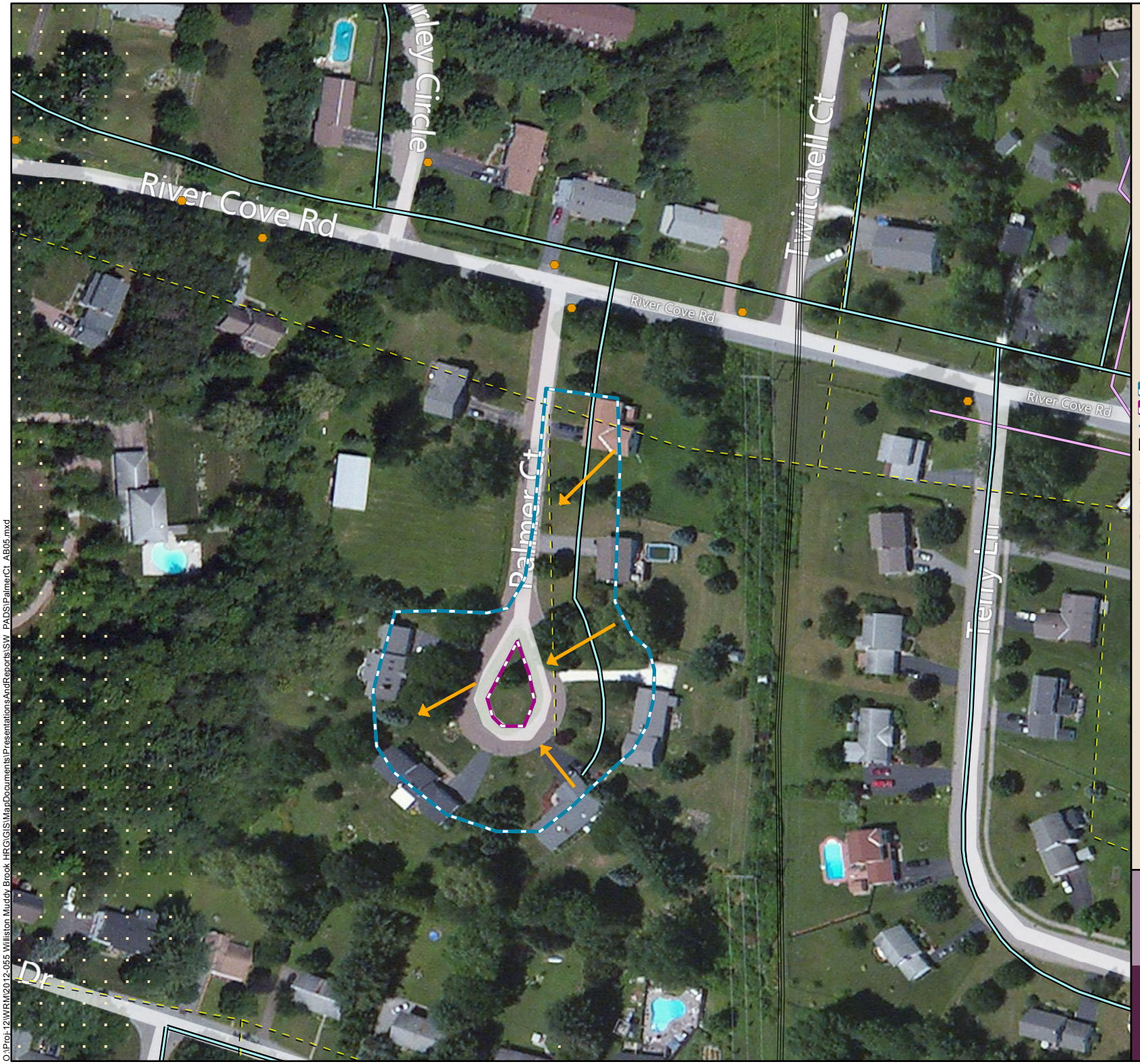

0 37.5 75 150 Feet

- Drainage Area (1.1 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Culvert
- Water Line
- Wastewater Line
- Electric Transmission Line
- Vermont Gas Line
- Flow Direction

Recommended Practice:
Bioretention

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Palmer Ct

AB-05

Williston Town-Wide Stormwater Master Plan

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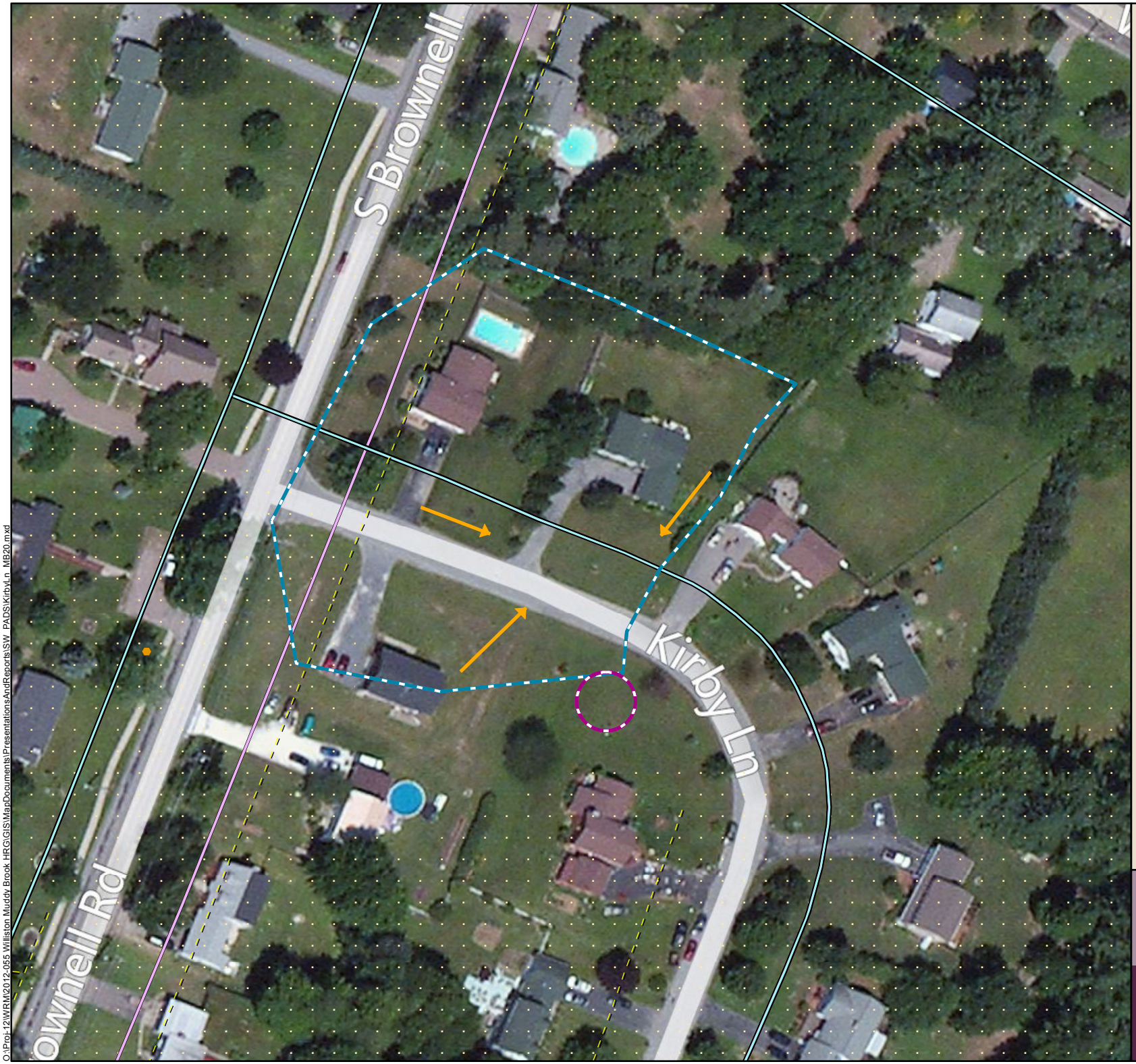

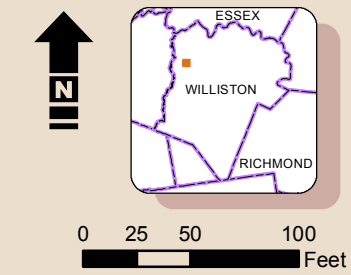

- SW Treatment Opportunities
- Drainage Area (3.5 Acres)
- River or Stream
- Culvert
- Wastewater Line
- Water Line
- Electric Transmission Line
- Vermont Gas Line
- Soil Condition Suitable for Infiltration
- Flow Direction

Recommended Practice:
Improved conveyance to detention storage

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Kirby Ln

MB-20

Williston Town-Wide Stormwater Master Plan

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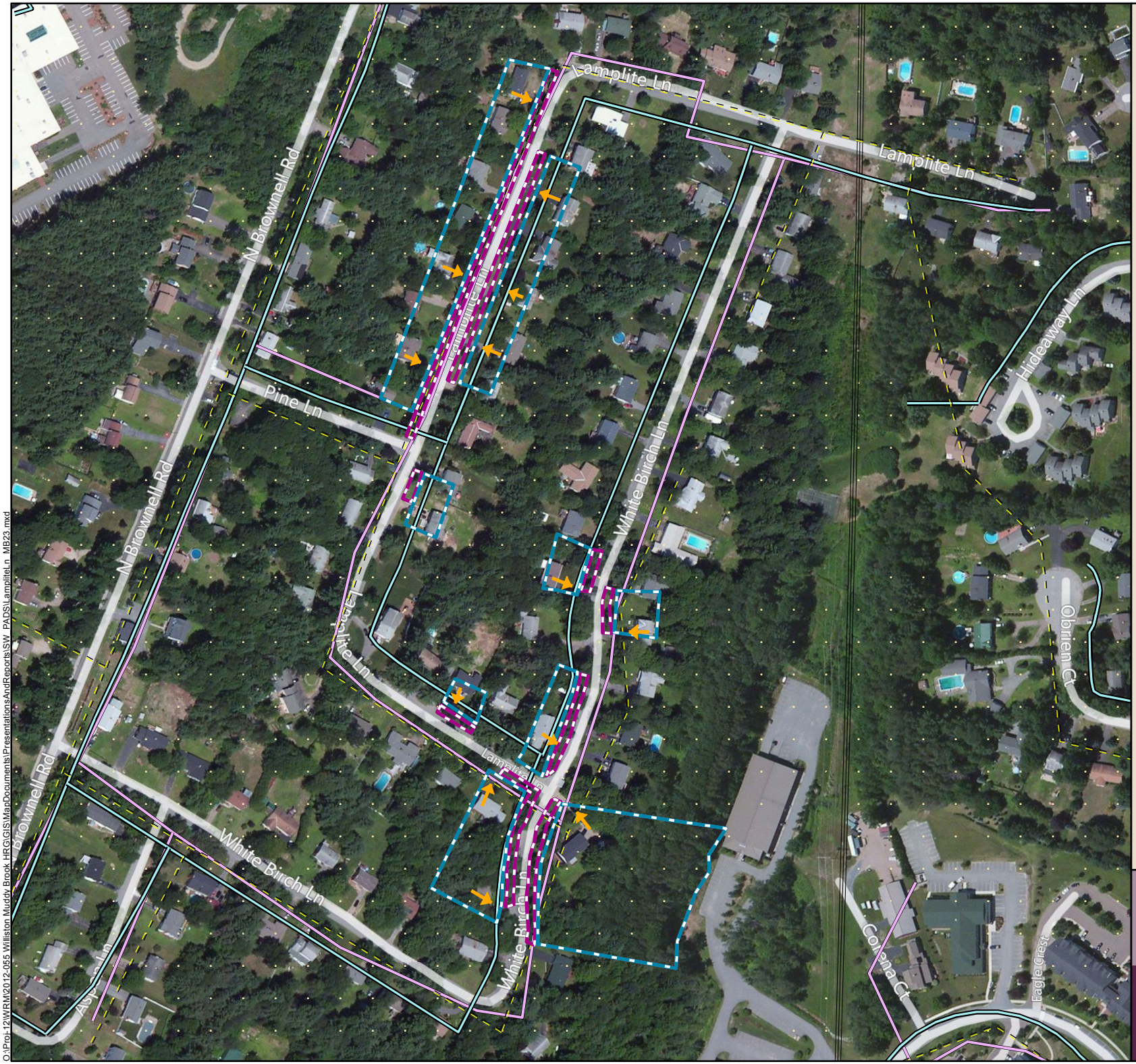

N

0 75 150 300
Feet

- Drainage Area (5.7 Acres)
- SW Treatment Opportunities
- River or Stream
- Wastewater Line
- Water Line
- Electric Transmission Line
- Vermont Gas Line
- Soil Condition Suitable for Infiltration
- Soil Condition Suitable for Infiltration
- Flow Direction

Recommended Practice:
Bioretention

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Lamplite Ln

MB-23

Williston Town-Wide Stormwater Master Plan

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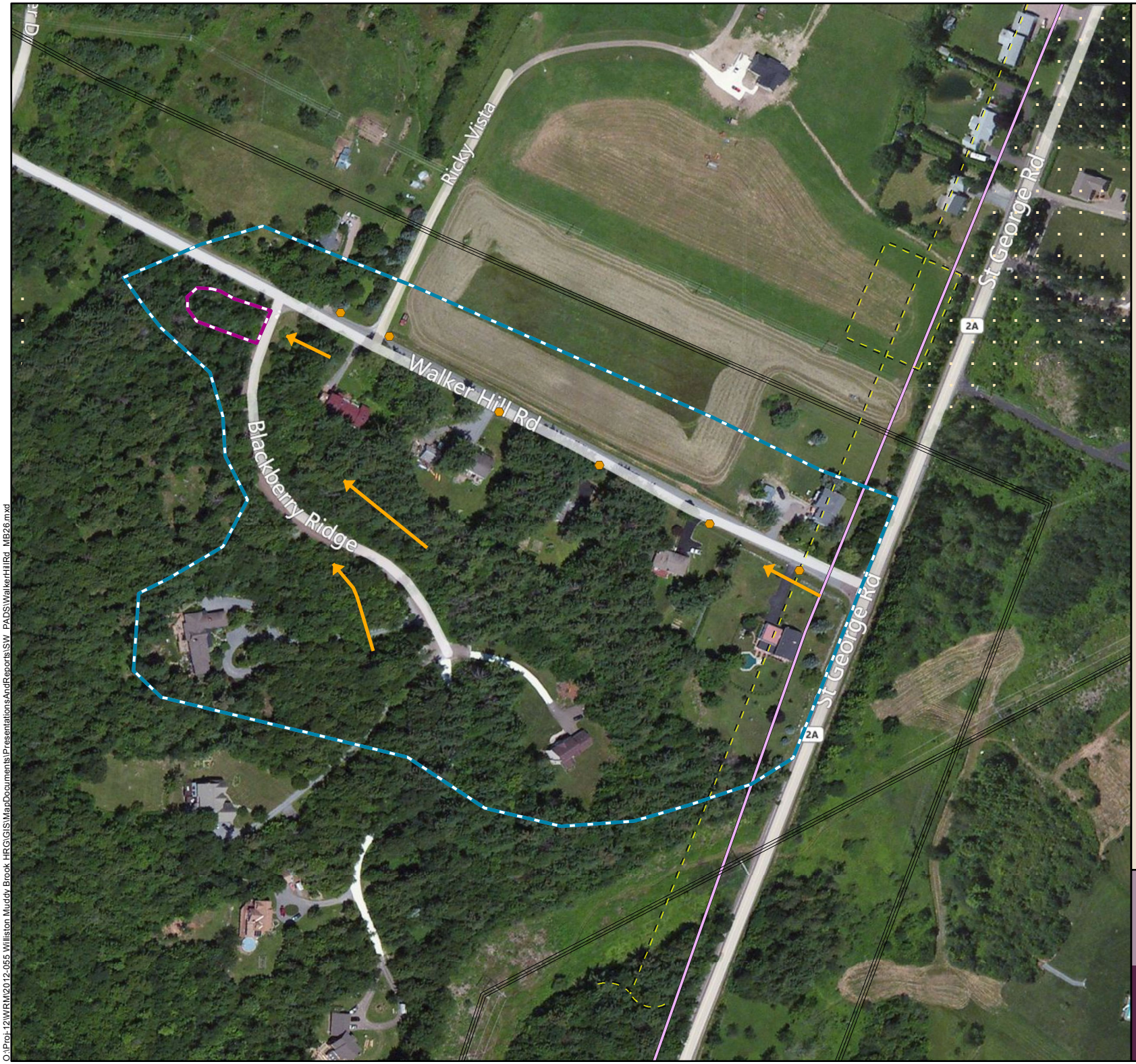

N

0 50 100 200
Feet

- Drainage Area (19 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Culvert
- Wastewater Line
- Electric Transmission Line
- Vermont Gas Line
- Flow Direction

Recommended Practice:
Headcut stabilization

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Walker Hill Rd

MB-26

Williston Town-Wide Stormwater Master Plan

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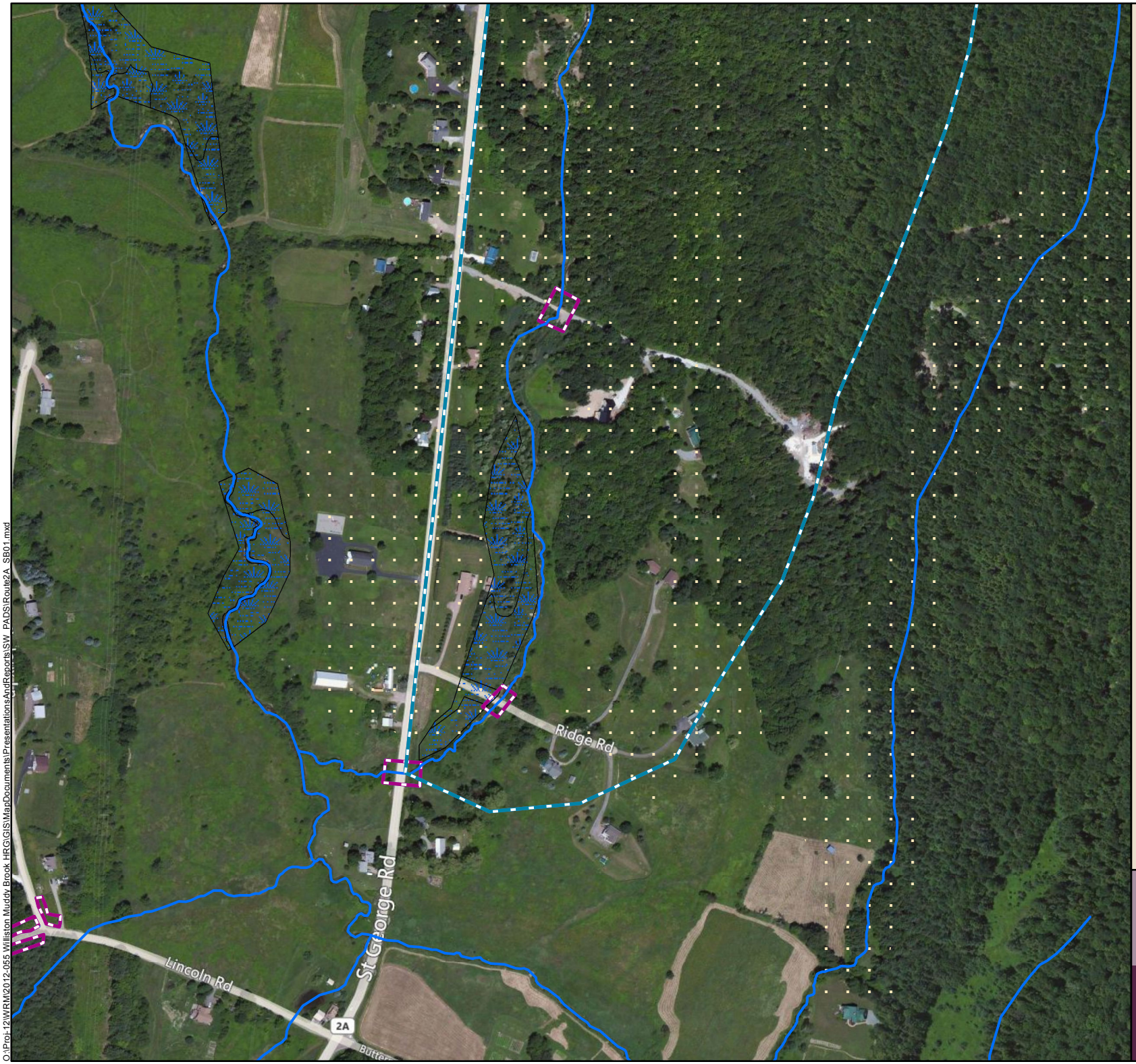

N

0 125 250 500
Feet

- Drainage Area (1,715 Acres)
- SW Treatment Opportunities
- River or Stream
- Wetlands
- Soil Condition Suitable for Infiltration
- Vermont Gas Line

Recommended Practice:
Culvert reset/replacement, bank stabilization

Note: Watershed extends North to include Sunset Hill Rd and Old Creamery Rd areas

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Route 2A
(at Ridge Rd)

SB-01

Williston Town-Wide
Stormwater Master Plan

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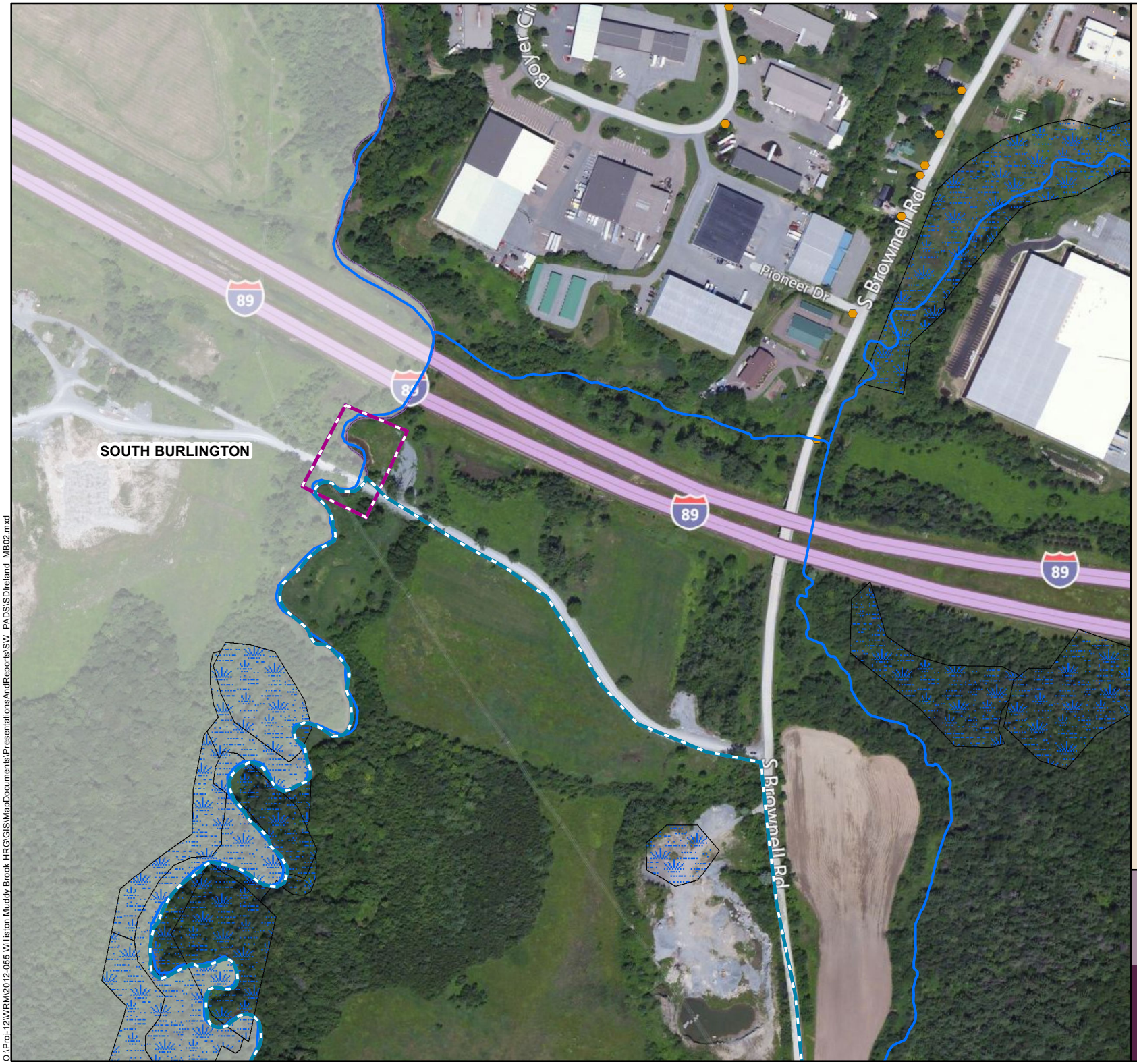

0 100 200 400 Feet

- Drainage Area (4,453 Acres)
- SW Treatment Opportunities
- River or Stream
- Wetlands
- Culvert

Recommended Practice:
Culvert replacement

Note:
Reported drainage area only includes area within Town of Williston

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

SD Ireland Haul Rd

MB-02

Williston Town-Wide Stormwater Master Plan

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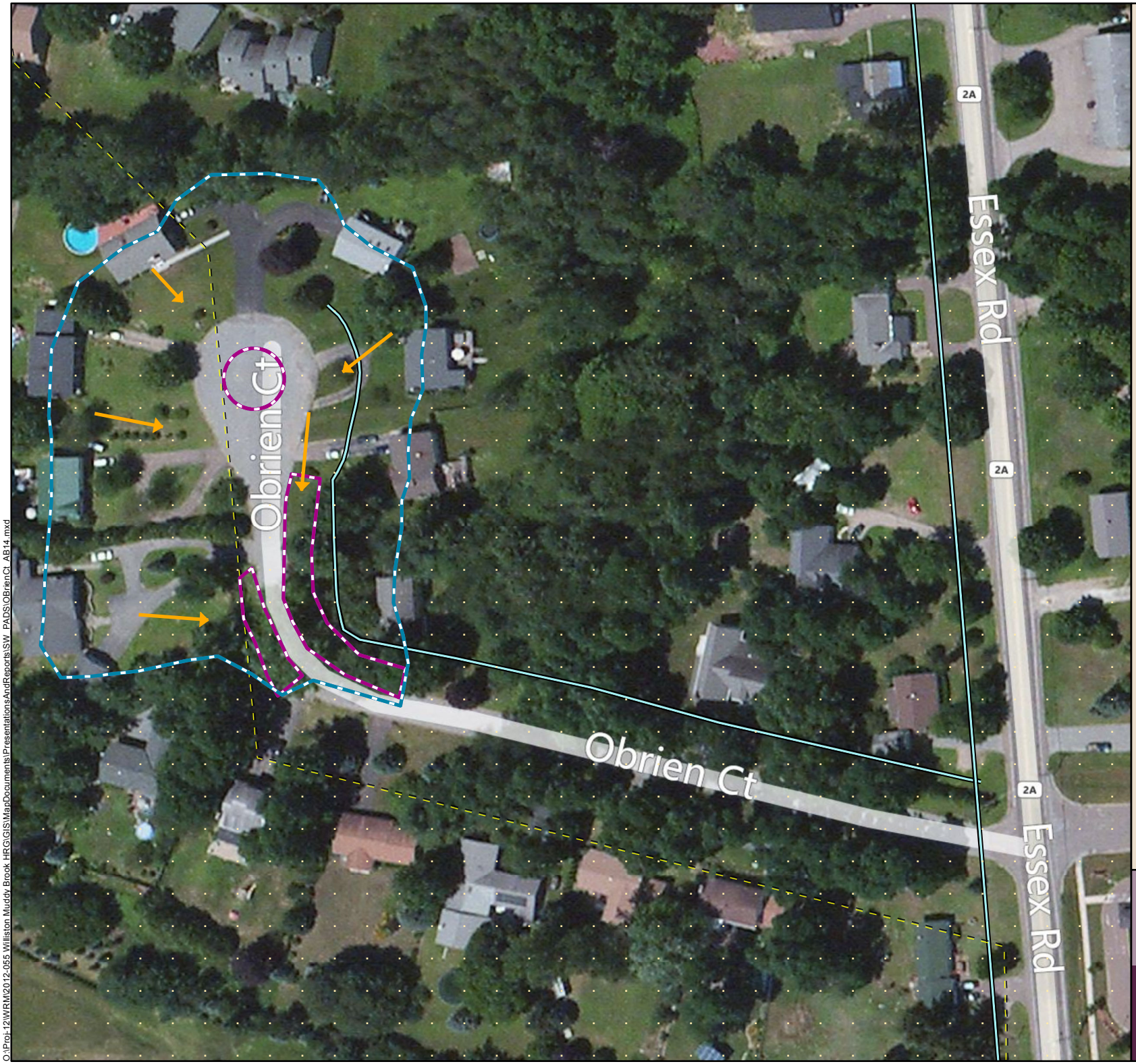

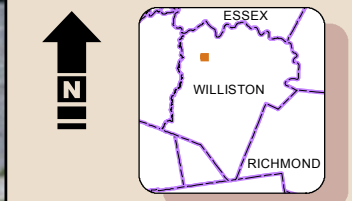

0 25 50 100 Feet

- Drainage Area (2.4 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Culvert
- Wastewater Line
- Water Line
- Flow Direction

Recommended Practice:
Bioretention

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

O'Brien Ct

AB-14

Williston Town-Wide Stormwater Master Plan

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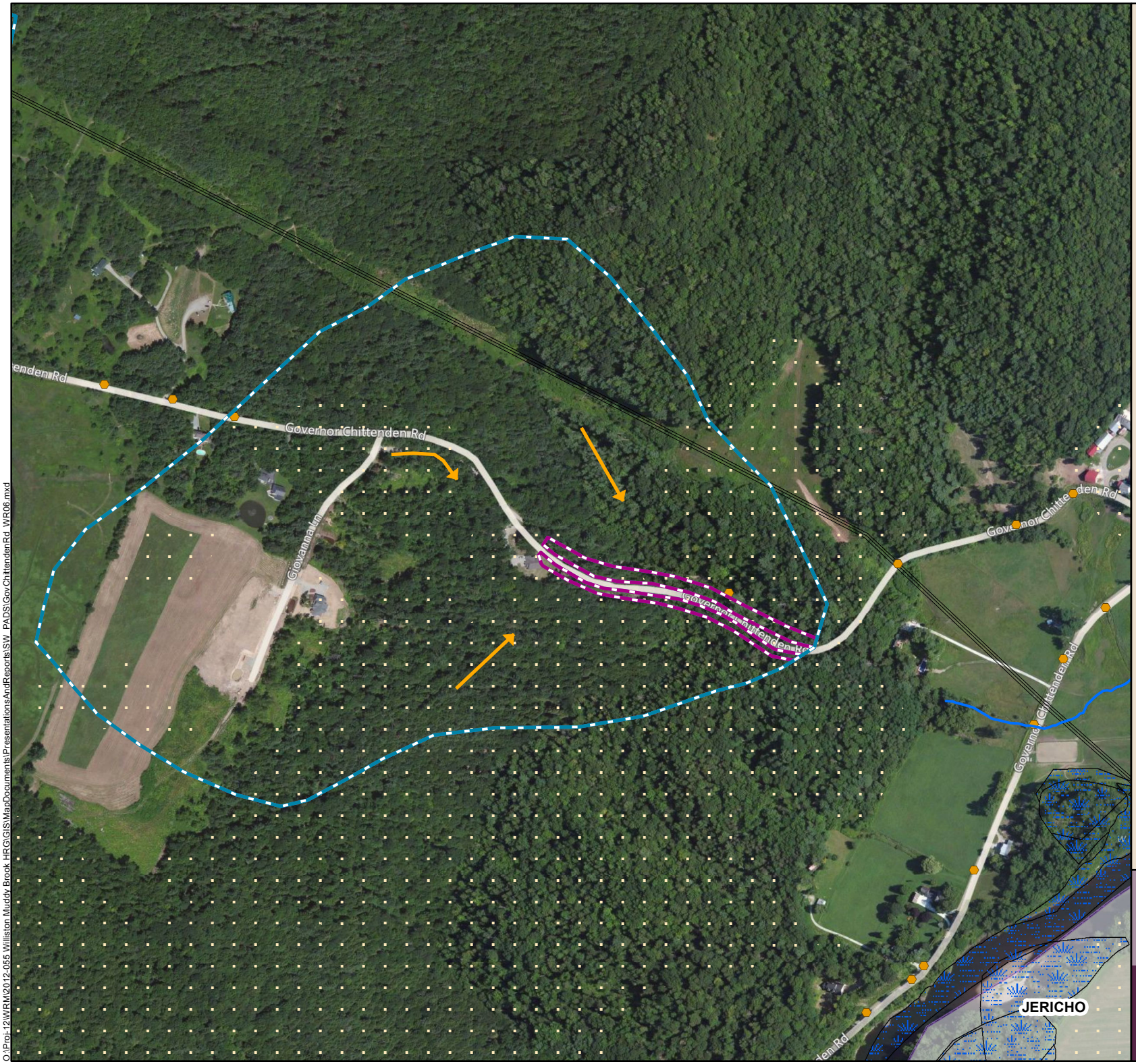

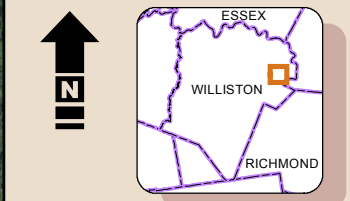

N

0 155 310 620
Feet

- Drainage Area (96 Acres)
- SW Treatment Opportunities
- River or Stream
- Wetlands
- Soil Condition Suitable for Infiltration
- Culvert
- Electric Transmission Line
- Flow Direction

Recommended Practice:
Road grading/crowning, bioswale

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Governor Chittenden Rd

WR-06

Williston Town-Wide Stormwater Master Plan

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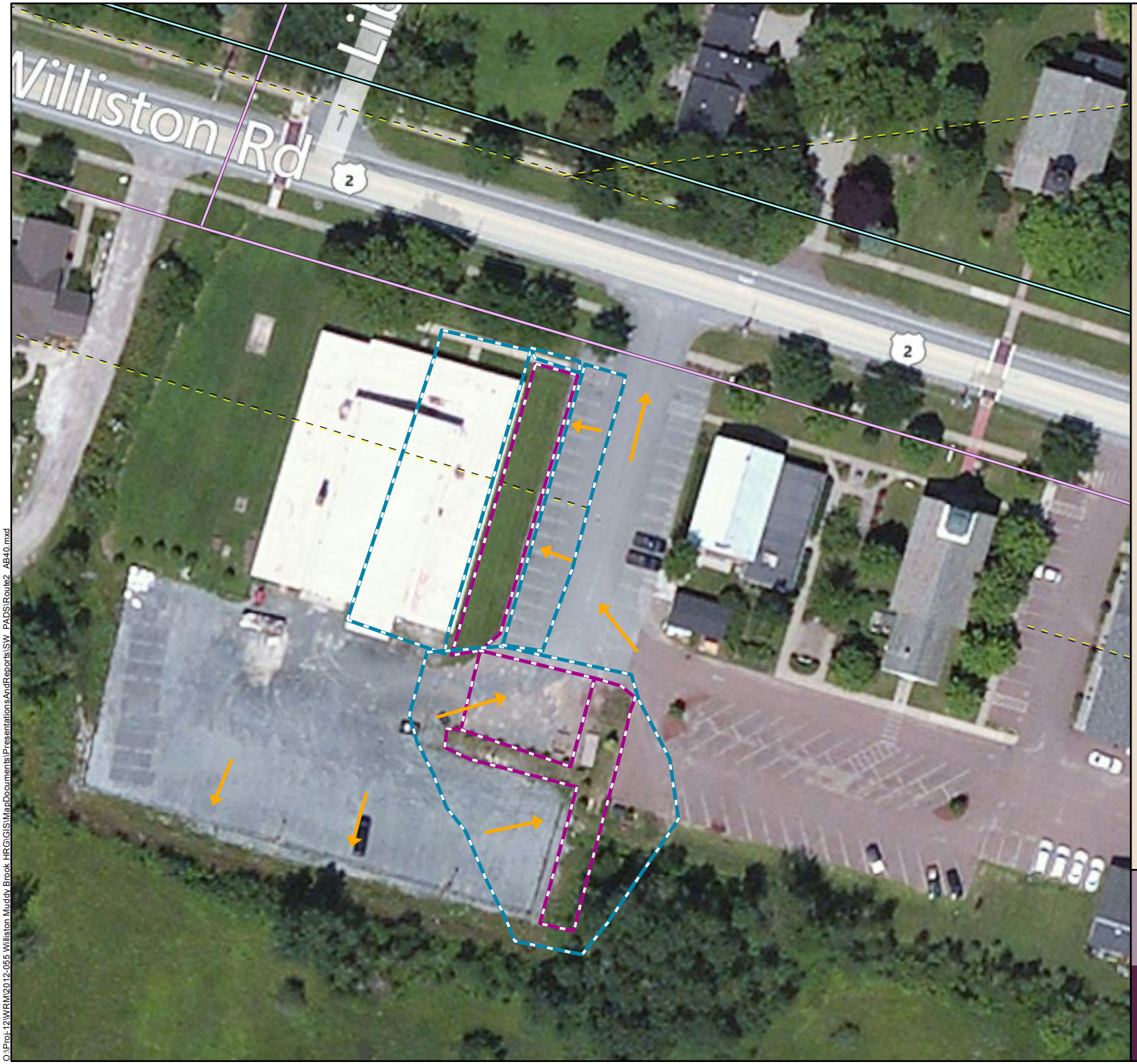

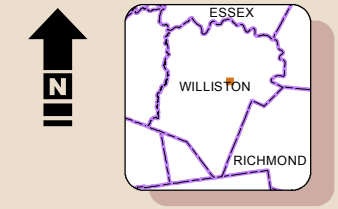

N

0 25 50 100 Feet

- Drainage Area (0.6 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Culvert
- Wastewater Line
- Water Line
- Vermont Gas Line
- Flow Direction

Recommended Practice:
Bioretention

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Route 2
(Armory)

AB-40

Williston Town-Wide
Stormwater Master Plan

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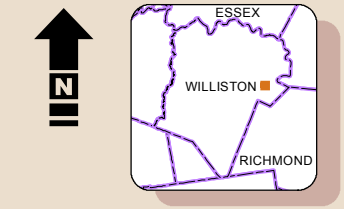

N

0 50 100 200 Feet

- Drainage Area (4.1 Acres)
- SW Treatment Opportunities
- River or Stream
- Soil Condition Suitable for Infiltration
- Culvert
- Water Line
- Flow Direction

Recommended Practice:
Bioretention

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Sunrise Circle

WR-08

Williston Town-Wide Stormwater Master Plan

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N

0 150 300 600
Feet

- Drainage Area (202 Acres)
- SW Treatment Opportunities
- River or Stream
- Wetlands
- Culvert
- Flow Direction

Recommended Practice:
Subdivision stormwater management system, stone lining ditch

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

East Hill Rd

AB-52

Williston Town-Wide Stormwater Master Plan

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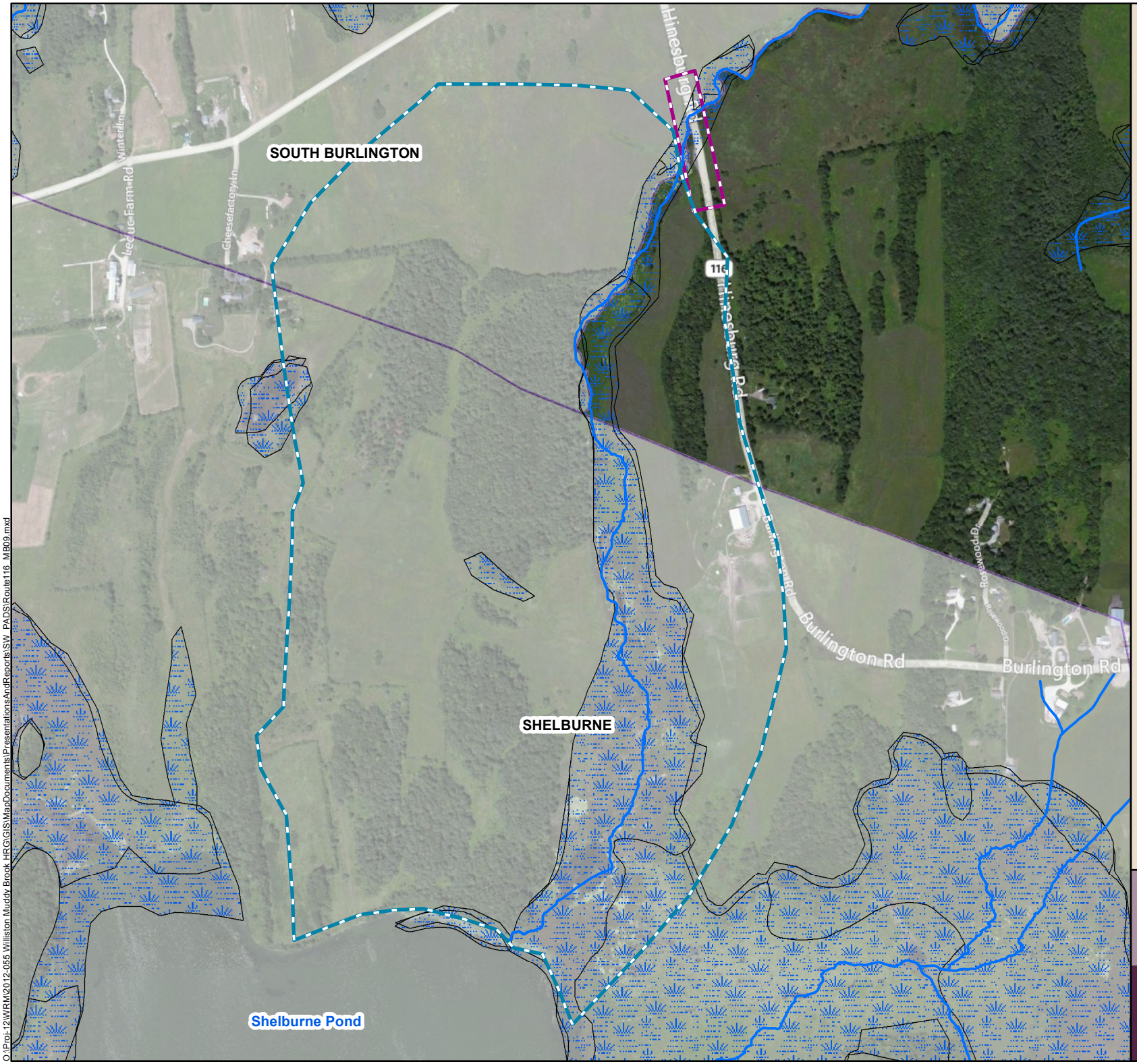

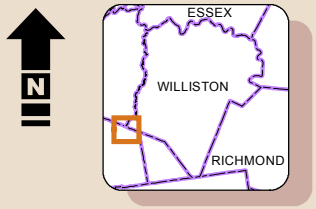

N

0 205 410 820
Feet

Drainage Area (284 Acres)
SW Treatment Opportunities
River or Stream
Wetlands

Recommended Practice:
Bridge replacement

Sources: Problem Areas: Stone, HRG; Hydrogroups: SSURGO; Hydrography, Wetlands: VCGI; Stormwater Infrastructure, Culverts, Utilities: Town of Williston; Imagery: Bing Maps.

STONE ENVIRONMENTAL INC

Route 116

MB-09

Williston Town-Wide Stormwater Master Plan

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