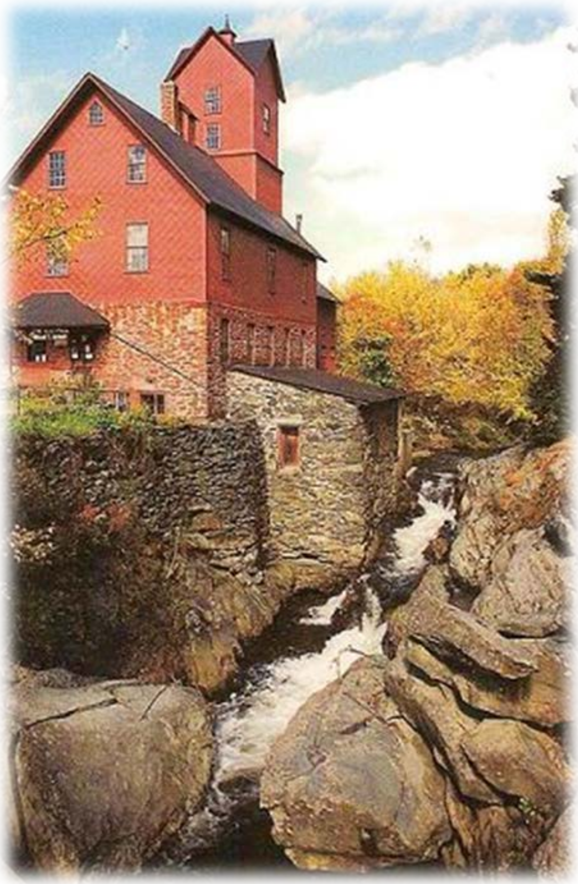

JERICHO, VT – STORMWATER MASTER PLAN

JERICHO, VERMONT

FINAL REPORT
April 19, 2017

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TABLE OF CONTENTS

List of Tables:

List of Appendices:

I. Disclaimer

The intent of this report is to present the data collected, evaluations, analyses, designs, and cost estimates for subwatersheds in Jericho under a contract between the Chittenden County Regional Planning Commission and Watershed Consulting Associates, LLC. Funding for the project was provided by the Vermont Department of Environmental Conservation's Ecosystem Restoration Program. The plan presented is intended to provide the watershed's stakeholders a means by which to identify and prioritize future stormwater management efforts. This planning study presents a recommended collection of Best Management Practices (BMPs) that would address specific concerns that have been raised for these areas. In particular, there is great need to reduce stormwater impacts including phosphorus and sediment from stormwater runoff to receiving waters within the Town and the greater Lake Champlain Basin in light of future regulation under the Lake Champlain Total Maximum Daily Load. Although there are other BMP strategies that could be implemented in the watershed, these are the sites and practices that project stakeholders believe will have the greatest impact and probability of implementation. **These practices do not represent a regulatory obligation of any type, nor is any property owner within the watershed obligated to implement them.**

1 Project Overview

In May 2013, the State of Vermont Department of Environmental Conservation (VT DEC) issued a document titled *Vermont Stormwater Master Planning Guidelines*. Designed to provide VT communities with a standardized guideline and series of templates, the document assists communities in planning for future stormwater management practices and programs. Our Plan is a combination of Templates 2A: Hybrid site & community retrofit approach with green stormwater infrastructure (GSI) stormwater management, and 3A: Large watershed or regional approach with planned build out analysis and traditional (end of pipe or centralized) stormwater management.

Vermont has had stormwater regulations in place since 1978, with updates concerning unified sizing criteria made in 2002. Currently, the State is re-writing the stormwater manual to reflect new priorities. Recognizing that stormwater management can be a costly endeavor, the guidelines are written to help identify the appropriate practices for each watershed, community, and site, in order to maximize the use of funds.

The guidelines encourage each stormwater master plan (SWMP) to follow the same procedures, and include:

- Problem Definition
- Collection of Existing Data
- Development of New Data
- Existing and Proposed Program, Procedure, or Practice Evaluation
- Summary and Recommendations

Additionally, pre-existing data was used to further inform the development of this Plan. See Appendix A for reference documents. These include:

- *2012 Stormwater Mapping Project,*
- *2015 Better (Back) Roads Gravel Road Inventory/Report,*
- *August 2016 Road Erosion Inventory Assessment,*
- and data from the *Lamoille River Tactical Basin Plan.*

In keeping with these guidelines, we have prepared the following report.

2 Background

2.1 Problem Definition

The Town of Jericho is located within the Winooski and Lamoille River Watersheds of the Lake Champlain Basin. Focus areas for this study drain to the Browns River which flows through Jericho Corners, and include the village centers of Jericho Center and Jericho Corners, as well as the Town's educational institutions. The village centers have been substantially developed with mixed land uses along high-traffic roads (VT Route 15 and Browns Trace Road).

In addition to suburban growth, increasing development on rural roads has proved problematic for the Town of Jericho. With the occurrence of many small-scale subdivisions and the lack of stormwater management within these areas, there has been a substantial increase in both road and ditch erosion. This erosion is being further exacerbated by water ponding due to increased runoff from properties located outside of the road Right-of-Way (ROW). Ponding is especially prevalent along VT Route 15 shoulders (e.g. the junction of VT-15 and Browns Trace Road).

As impervious cover has increased within these areas, so has the volume of stormwater runoff. This is detrimental and has resulted in problems such as annual flooding, slope destabilization, and increased stormwater flow to surface waters within the Town. Springtime flooding has persisted most notably around South Main Street of Jericho Corners due to large neighborhood developments, steep upper-extent slopes, and frozen ground preventing infiltration. Stormwater runoff is prompting slope failure due to increased and concentrated stormwater flow within specific areas. Moreover, heavy rain events are resulting in excess stormwater flow, and therefore increased amounts of sediment and nutrients, such as nitrogen and phosphorus, from paved and gravel roads, and driveways and parking lots, to the Town's surface waters. These problems impact the health of local waterbodies, as well as the greater Lake Champlain Basin, and have persisted and are worsening in accordance with the Town centers' rapid development.

Although the Town has been making efforts to address drainage issues associated with increased numbers and usage of rural roads, additional support is required in those areas where estimated Total Phosphorus loads within a given catchment is high. As the majority of the study areas are considered to be suburban/developed, those areas where driveways and parking lots drain to road ditches, and where slope failure occurs due to concentrated stormwater flow, are important when considering potential GSI retrofit (low-impact development retrofits) opportunities, particularly older subdivisions off VT-15.

2.2 Existing Conditions

During this assessment, Jericho Corners and Jericho Center were identified as priority areas for the existing developed lands analysis. See Figure 1. The Jericho Corners focus area spans from the Underhill Town line in the east, and the Essex Town line in the west. This area is centered around VT-15. The Jericho Center study area is focused around Browns Trace Road and the area surrounding the Town green.

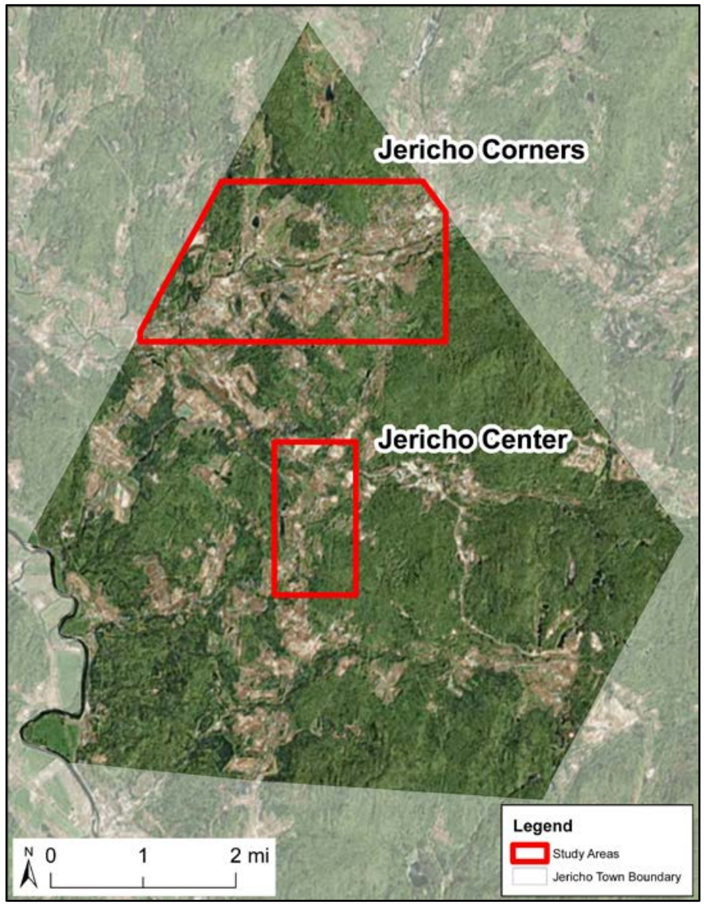

Figure 1. Overview map of the Town of Jericho and study areas Jericho Corners and Jericho Center

The majority of developments within these areas were constructed with minimal stormwater infrastructure and has resulted in poor stormwater management such as culverts draining large portions of developed lands and discharging directly to the Browns River. It has also provoked negative stormwater impacts such as flooding and erosion, particularly in Jericho Corners, due to flat slopes, inadequate drainage conveyance systems, and heavier soils in the upland extents of the watershed. Other areas where there are ≥3 acres of impervious cover in a parcel, such as school properties, are an issue given the large expanse of impervious surfaces on these sites, as well as upcoming regulatory requirements under Act 64.

One such area is the Camp Ethan Allen Training Site located off Browns Trace Road by Mount Mansfield Union (MMU) High School. This facility is managed by the Vermont Army National Guard encompassing an area of approximately 5,074 acres, and has greater than 3 acres of impervious cover. The Lee River, tributary to the Browns River, flows directly through this site. Although the Camp is federally owned, they adhere to State stormwater permitting requirements and standards as well as to the U.S. Army Operational Range Assessment Program under the U.S. Department of Defense Sustainable Ranges Initiative. See Appendix A. From conversations with the Construction and Facilities Manager, all existing stormwater systems are permitted and inspected annually. Beyond efforts to control erosion and runoff, while containing and managing all stormwater from their installation, the Camp also reuses water collected in onsite stormwater ponds for fire prevention, dust control, and snow making. Flood mitigation has also been the focus of a number of recently implemented BMPs due to an increase in regional flooding events. Although the Camp was not included as a part of this study, a stand-alone master planning assessment could be completed for this property in future stormwater investigations.

Being the core of the developed lands in the Town, the aforementioned focus areas have a high density of impervious surface and managed pervious surfaces, along with channelized runoff paths. Surrounding the developed lands, rural roads are generally composed of gravel, with open roadside ditches, and cross culverts. Many of these roads have steep slopes, and traverse large watersheds. Furthermore, the rural roads access residential driveways which often convey drainage into, and through the Town road drainage system. This is a problem because runoff from private lands is negatively impacting the Town's overall drainage system. Note that after experiencing several large flooding events over the past several years, the Town is actively working to rebuild and replace infrastructure with increased resiliency to protect against future storm events.

Identified future growth locations include the riverside area by Dickensen Street on River Road, and North Main Street in Jericho Corners. A walkable, mixed-use, human-scaled community is envisioned for the riverside area, and an extension of North Main is being explored. See Appendix A for more information regarding these future growth areas. Planning for future developments such as these presents excellent opportunities for the integration of functional stormwater management systems focusing on decentralized GSI. Incorporating stormwater design into the development planning process also enables the protection of important resources such as favorable soils and stormwater collection points to be set aside for stormwater management purposes.

2.2.1 Major Watersheds:

The Town of Jericho spans an area of 22,725 acres and is located within the Lake Champlain Basin. Jericho is divided by two watersheds, one draining to the Winooski River, and the other to the Lamoille River. See Figure 2.

The Winooski River watershed drains the southern extent of the Town, covering approximately 11,277 acres, and includes the Snipe Island Brook sub-basin. Although the focus areas for this study are not located within the Winooski watershed, this is an important area as sections of the Winooski River are on the State's *2016*

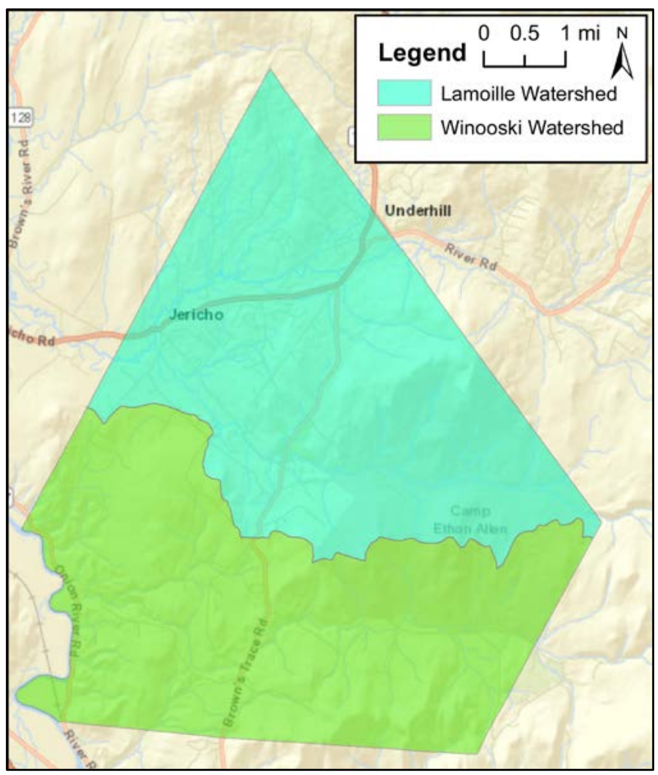

Figure 2. Winooski and Lamoille River watersheds in Jericho

Stressed Waters List. Other sections of the river are also classified as 'impaired' per the State's *303(d) List of Impaired Waters* (VT DEC, Watershed Management Division).

The Lamoille River watershed drains the northern extent of the Town, and covers approximately 11,448 acres. The focus areas for this study are included within the Lamoille watershed. This watershed is important as sections of the river are on the State's *2016 Stressed Waters List* as well as other sections being classified as 'impaired' per the State's *303(d) List of Impaired Waters.* Perennial streams flowing through the Lamoille watershed include the Lee River in the Jericho Center area, and The Creek, Abbey Brook, and the Browns River in the Jericho Corners area. This area is divided by two sub-basins, the Browns River and the Headwaters Browns River. See Figure 3.

2.2.2 Subwatersheds:

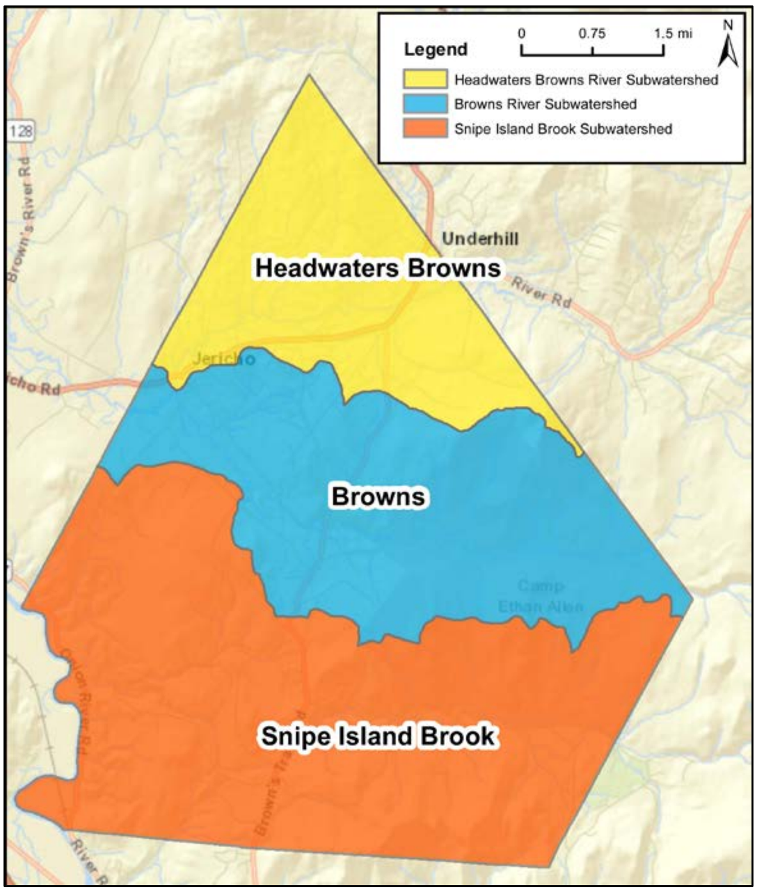

Figure 3. Sub-basins in Jericho

The Browns River subwatershed is approximately 6,933 acres and includes the focus area of Jericho Center and a portion of Jericho Corners. As identified in the *2016 Lamoille Tactical Basin Plan,* stressors to this subwatershed include encroachment, and channel and land erosion.

The Headwaters Browns River subwatershed is approximately 4,514 acres and includes the other portion of the Jericho Corners focus area. Stressors in this subwatershed include channel erosion and thermal stress.

Neither sub-basins are classified as 'impaired' per the State's *303(d) List of Impaired Waters*, but the Browns River is on the *2016 Stressed Waters List.* This 'stressed' categorization is attributed to former, large-scale gravel mining and streambank destabilization, with listed pollutants being sediments, physical alteration, and temperature. As noted by the VT DEC, these factors impede the water from attaining the highest water quality and contribute to the compounding pollution of Lake Champlain.

Increasing rural road developments and impervious surfaces in the Town centers is of further concern as the natural retention capacity of regional soils is already low. Between the Lamoille sub-basins, ≈36% of soils are classified by the Natural Resources Conservation Service as Hydrogroup Group D. D soils have the lowest infiltration rates and highest runoff potential of the soil groups (A-D). These soils can be found spread throughout the sub-basins, especially mixed with Hydrogroup C soils (≈24%) in the upper extent slopes. With this in mind, additional impervious surfaces will only stress the capacity to infiltrate runoff further.

Also of concern, is the prevalence of largely sub-jurisdictional development. Few developments, if any, are likely to be subject to new stormwater permitting requirements within the watershed, and fewer still are likely to be subject to any retroactive stormwater permitting requirements. Therefore, the opportunities for jurisdictional projects to curb pollution related to stormwater are limited. As the watershed directly impacts water quality in the Browns River and eventually Lake Champlain, curbing pollution, particularly phosphorus, is critical.

2.2.3 Divisions of Landuse and Impervious Surface Concentrations:

Land uses within the study areas include the village centers, schools, rural roads, residential areas, agricultural lands, undeveloped lands, and commercial areas. Although impervious surfaces are found throughout the focus areas, they are most concentrated around the main roads (Browns Trace and VT-15).

The Jericho Corners study area is approximately 3,176 acres, of which 645 acres can be classified as impervious (roofs, roads, and driveways). The Jericho Center study area is approximately 933 acres, of which 41 acres can be classified as impervious. This data is approximate and based off the impervious layer created by the Spatial Analysis Lab at the University of Vermont for the Lake Champlain Basin in 2011. National Agriculture Imagery Program, 1-meter spatial resolution imagery was used for the creation of this layer. Note that these numbers will have changed since 2011.

2.3 Known Problem Areas

The Town's chronic problem areas were identified by the Project Team. See Figure 4. These are locations known to have issues such as erosion and flooding, and span between Jericho Corners and Jericho Center.

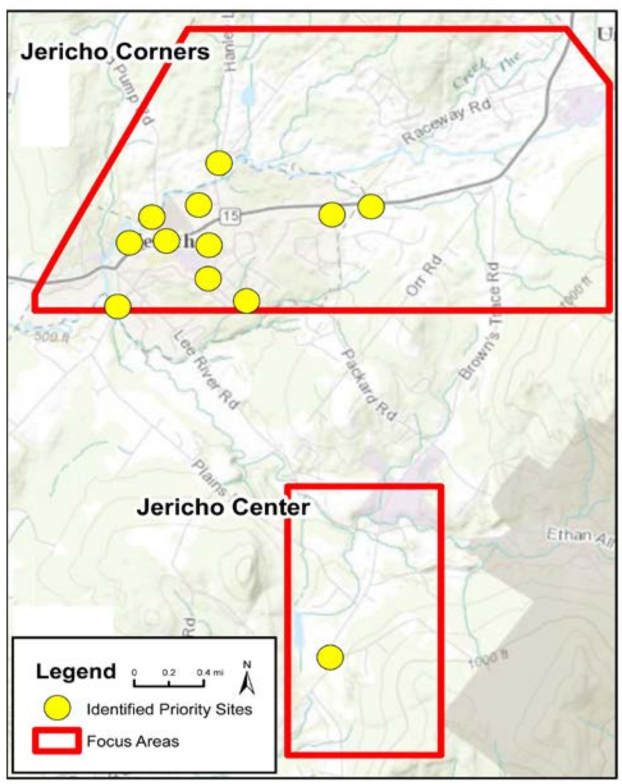

Figure 4. Identified problem locations

Problematic locations in Jericho Corners included:

- Plains Road
- Mill Street
- Old Pump Road
- Sunny View Drive
- Griswold Street
- Nathan Lane
- Cilley Hill Road
- Packard Road
- South Main Street
- Culvert outlet by North Main Street

The area of interest in Jericho Center was focused around Bolger Hill Road.

3 Methods

3.1 Identification of All Opportunities

3.1.1 Initial Data Collection and Review:

Initial data collection, data review, and field work for site identification was guided by a meeting with the Project Team, as well as reviews of the VT DEC's Stormwater Mapping project and 2015 Road and Culvert Inventory data. The focus areas were determined during this time. This was done as part of Task 1 – Kickoff Meeting. See Appendix B for Kick Off Meeting Minutes.

3.1.2 Desktop Assessment and Map Preparation:

A desktop assessment of the study areas was conducted involving a thorough review of existing GIS resources and associated attribute data. This included storm sewer infrastructure, subwatershed delineations, soils classifications, and impervious area landuse delineations (where applicable). The State's newly created Hydrologically Connected Road Erosion Segments layer was also reviewed and compared with the results of the 2015 Road and Culvert Inventory, as well as the information collected by the CCRPC during the summer of 2016.

A remote assessment of the streets in the Town was made to target field investigations over this large area to identify roads that had a high probability of being appropriate for GSI. This analysis was based on the methodology outlined in the *Promoting Green Streets* publication by the River Network and Hawkins Partners, Inc. (July 2016). See Appendix A. The methodology was modified to better fit specific conditions found in the Town. The analysis utilized two prerequisites and one secondary consideration.

Prerequisites:

1. Road Slope
    - 1-5% Slope = Ideal (Score: 2 points)
    - 5-7.5% Slope = Potential (Score: 1 point)
    - >7.5% Slope = Unsuitable (Score: 0 points; discarded from further analysis)

2. Road Right-of-Way Width
   - ≥ 50 ft = Ideal (Score: 2 points)
   - 46-50 ft = Potential (Score: 1 point)
   - < 46 ft = Unsuitable (Score: 0 points; discarded from further analysis)

Secondary Consideration:

1. Hydrologic Soil Group (indication of infiltration potential)
   - A/B (highest infiltration potential) = Ideal (Score: 2 points)
   - B/C (moderate infiltration potential) = Potential (Score: 1 point)
   - C/D (lowest infiltration potential) = Unsuitable (Score: 0 points; **not** discarded from further analysis)

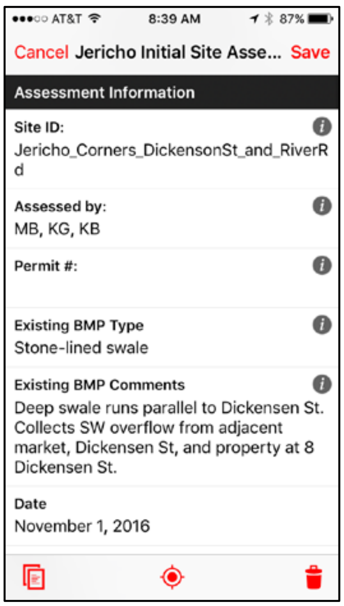

Figure 5. Example of Fulcrum App interface

The scores from each of the three criteria were added, and a score was assigned with higher scores indicating a greater potential for GSI suitability. Those sites with greater potential were assessed in the field as part of initial data collection efforts.

From this data review, field maps were prepared with layers including parcels, stormwater infrastructure, erosion-susceptible road segments, water bodies, river corridors, designated problem areas, and soil types. See Appendix C for field maps and the field plan memo. These were used to target field investigations of potential stormwater management sites. Additionally, an application for hand-held devices was created, using the third-party Fulcrum app, to assist with in-field data collection and facilitate mapping and photo-documentation of potential retrofit sites. See Figure 5. This was done as part of Task 2a – Desktop Data Collection and Review.

3.1.3 Field Data Collection:

Prior to conducting initial field visits, the Town's Public Works Department reviewed the list of problem areas documented by the Project Team, offering insight regarding the issues at each location. This meeting was followed by a field day assessing Jericho Center's Bolger Hill Road.

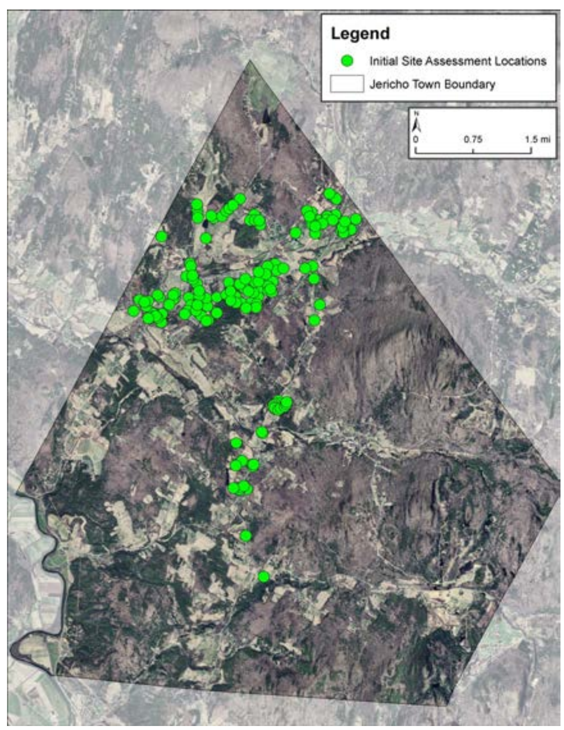

Figure 6. 165 sites visited during initial field assessment

Additional field days were conducted to assess other potential locations within Jericho Center, the designated problem areas in Jericho Corners, and areas with large amounts of impervious surfaces such as schools. A total of 165 locations were visited and assessed during this field collection process. See Figure 6. This involved field observations of actual drainage breaks, and verifying pipe connections, catch basin locations, culvert inlets/outlets, and swale/ditch direction and condition. Parcels of public property, public rights of way, and other pieces of property with potentially willing landowners where stormwater retrofits could be installed were also identified during this time. This was done as part of Task 2b – Initial Field Visits and Project Team Consultation. See Appendix D for the All Sites Spreadsheet.

3.2 Selection of 21 Potential BMPs

After the initial field visits were completed, a preliminary ranking system was devised which narrowed the list of possible projects from 165 to 21 locations. This was done by a basic assessment of project feasibility and associated benefits. A map was prepared showing the initial 21 retrofit sites, and individual maps were created for each site. Field data sheets were also created for each site including a site name, location, date and time assessed, Lat/Long, a photo and BMP information including BMP type, description, constraints, and any current site issues. See Appendix E.

Drainage areas were delineated for each potential project location and landuse land cover layers were digitized for modelling purposes. Using the Source Loading and Management Model (WinSLAMM) approximate pollutant load reductions for Total Suspended Solids and Total Phosphorus (TSS/TP) were derived from site-specific modeling and initial BMP scoping. In addition, HydroCAD was used to initially size BMPs and calculate the 1-year, 24-hour storm volume, known as the Channel Protection Volume (CPv). A preliminary construction cost projection was also prepared to normalize each project by cost per pound of pollutant removed. Hydraulic, hydrologic, and pollutant load modelling results were then added to the ranking matrix to continue the refinement of potential projects. This was done as part of Task 3a – Problem Area Assessment – Modeling/Ranking/Prioritization. See Appendix E for modelling results and the cost estimates spreadsheet.

Table 1. Preliminary ranking criteria with scoring from 5-25

Criteria	Description	Score
Ancillary Benefits	Chronic Problem Area	20
	Seasonal Flooding	20
	Educational	10
	Reduce runoff from heavily used parking	10
	High Visibility	10
	Practice includes buffer to waterbodies	10
Drainage Area Size	L - Large	25
	M - Medium	10
	S - Small	5
Pollutant Load Reduction Potential	H - High	25
	M - Medium	10
	L - Low	5
Cost Projection	H - High (>$50K)	5
	M - Medium ($10-50K)	10
	L - Low (<$10K)	25
Additional Design Required	Min - Minimal	25
	Med - Medium	10
	Complex	5
Proximity to Water	L - Low	5
	L-M - Low to Medium	10
	M - Medium	15
	H - High	20
% Impervious in Drainage Area	L - Low (0-33%)	5
	Med - Medium (33-66%)	10
	High (66-100%)	25

3.3 Selection of Final 6 Potential BMPs

A follow-up meeting with the Project Team was held to obtain input on each site regarding feasibility and desire to see them implemented. A list of six sites was collaboratively chosen for additional retrofit design to the 30% level. See Appendix F. This was done as part of Task 3b – Priority Site Selection with Project Team.

3.4 Town Presentation and Community Input

On April 6th, 2017, WCA presented the master plan to the Jericho Town Select Board. The presentation consisted of an overview of the project funding, scope, methods, timeline, and deliverables. See Appendix F. The purpose of the presentation was to inform the Select Board of the project, and to highlight the six concept design projects that have been prepared. Concept designs can be utilized, along with the pollutant reduction values, to prepare future grant applications to fund final design and implementation.

Additionally, the presentation provided information to community members about the SWMP, along with the final recommendations. Suggestions were taken during this time. One such recommendation was made to evaluate an alternate location for the Jericho Center BMP on a parcel of land now owned by the Town (parcel ID BT356). Following the meeting, WCA reviewed the parcel in question and determined that a large wetland complex occupies much of the parcel. Due to permitting constraints citing a BMP at this location, it was concluded that this would not be feasible. For these reasons, this option was not evaluated further.

4 Proposed Priority BMPs

This plan includes a list of six, top-ranked potential BMP opportunities. See Table 2 for an overview of the ranking criteria. These opportunities are located on Town property, school property, and partially on private property. Descriptions of each site are provided below.

Site: 1
Project Name: Town Parcel Infiltration Basin
Description: Large infiltration basin in Town-owned parcel located on the corner of Packard Road and VT-15. The parcel consists of low-lying vegetation and is open and undeveloped. A large area drains to this location and contributes to annual, seasonal flooding. During times of high flow, stormwater is piped to the Browns River. The proposed feature would help to mitigate flooding and decrease stormwater flow to the river by detaining runoff and promoting infiltration.

Figure 7. Town Parcel

Site: 2
Project Name: South Main Street Underground Storage and Infiltration Chambers
Description: Underground chambers located in the Town's ROW along South Main Street, parallel to VT-15. Chambers would be implemented under the road surface and into the Town's ROW. This is a designated chronic problem area with annual, seasonal flooding. Neighborhood-wide flooding is prompted by poor soils in upper-extent slopes within the drainage area. Furthermore, there are many residential developments with large amounts of impervious surfaces and little existing stormwater infrastructure. The proposed feature would mitigate flooding by capturing and infiltrating a large volume of stormwater runoff from the drainage area.

Figure 8. South Main Street

Site: 3
Project Name: MMU Underground Storage and Infiltration Chambers
Description: Underground chambers at MMU located on Browns Trace Road. Chambers would be implemented beneath the school's lower parking lot, adjacent to a Lee River tributary. There is a large amount of impervious cover on this property, from which stormwater runoff is collected and piped to the stream. The proposed feature would improve water quality, decrease streambank erosion and the occurrence of poor pavement quality due to stormwater ponding, and capture and infiltrate runoff from the property.

Figure 9. MMU Parking Lot

Site: 4
Project Name: Jericho Center Circle Infiltration Basin
Description: Infiltration basin located in the island across from the Town green in Jericho Center. This is a designated problem area consisting of poorly drained soils and little existing stormwater infrastructure in the upper-extent slopes. Stormwater runoff is currently piped to the wetland at the end of Wilder Road. The proposed feature will accept and infiltrate drainage from Bolger Hill Road, the Town green, and Browns Trace Road.

Figure 10. Across from Jericho Center's Town green

Site: 5
Project Name: Jericho East Park Underground Storage and Infiltration Chambers
Description: Underground chambers located in the parcel on the corner of Kriste Lane and South Main Street. This is an undeveloped parcel of common land within the Jericho East Subdivision. Drainage from this area contributes to the flooding experienced along lower South Main Street. The proposed feature would accept and infiltrate drainage from upper-extents of the subdivision, and decrease stormwater flowing to South Main Street.


Figure 11. Park in Jericho East Subdivision

Site: 6
Project Name: Dickensen Street Gravel Wetland
Description: Gravel wetland located across from Dickensen Street, in front of the Browns River Middle School on River Road. This area drains commercial and residential land uses and includes the Town's Riverside future growth area. All stormwater is currently piped to a swale running directly to the Browns River.


Figure 12. Intersection of Dickensen Street and River Road

Substantial redevelopments are planned for this parcel, and there are limited possibilities to manage stormwater onsite. Managing this runoff could benefit the Town by providing an opportunity to collaborate with private developers to improve water quality and potentially meet permit requirements.

A spreadsheet-based method was used to develop planning level costs for all proposed BMPs. This methodology was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix A. Note that a variation of this method was used for this plan. This methodology provides consistent budgetary cost estimates.

Table 2. Pollutant Reduction, including other ranking criteria, for Proposed BMPs

Project Name	Ranking Criteria						Total Score
	Impervious Area Managed (ac)	Project Cost	Volume Managed (ac-ft)	Annual Reduction in TSS (lbs)	Annual Reduction in TP (lbs)	$/lb TP Removed	
Town Parcel Infiltration Basin	11.47	$42,734	2.06	102,478	147	$291	37
South Main Street Underground Storage and Infiltration Chambers	8.00	$226,403	1.53	74,099	108	$1,238	32
MMU Underground Storage and Infiltration Chambers	8.16	$226,403	1.21	5,384	9	$24,441	29
Jericho Center Circle Infiltration Basin	2.61	$48,158	0.64	22,956	33	$1,456	29
Jericho East Park Underground Storage and Infiltration Chambers	4.11	$223,622	1.25	59,868	87	$2,564	27
Dickenson Street Gravel Wetland	10.20	$477,865	0.91	33,930	103	$4,639	24

Estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. It is anticipated that there will be differences between project cost estimates presented in the plan, and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation and the application of a BMP estimating methodology previously developed by HW. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts due to actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the 1-year storm event for off-line, underground, or GSI-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a stream or storm drainage system. Control volumes for large, in-line infiltration or detention basins were based on the estimated runoff associated with the 100-year storm event, plus approximately 2 feet of freeboard volume. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the 1-year event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[1]. Underground detention

[1] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

chambers (UDC) and underground recharge chamber (URC) systems were typically designed using Stormtech SC-740™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table 3 below.

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

Permits and Engineering Costs: Used either 20% (for largest storage volume projects), and 35% for smaller or complex projects.

Table 3. Proposed BMP unit costs and adjustment factors

BMP	Base Cost ($/cu ft)
Detention Basin	$2
Infiltration Basin	$4
Underground Chamber (infiltration or detention)	$12
Bioretention/ Gravel Wetland	$10
Green Infrastructure/ Underground Chamber Combo	$22
Site Type	**Cost Multiplier**
Existing BMP retrofit	0.25
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Adjustment factor for large aboveground basin projects	0.5

*Excerpt from Horsley Witten Memorandum Dated January 9th, 2014 (Page 11)

Land Acquisition Costs *(Modified)*: A variation from the HW method was applied. Based on prior studies completed by WCA, the land acquisition cost was calculated as $120,000 per acre required for the BMP when located on private land. It should be noted that this value is based on a limited estimate and not necessarily an expected cost per acre.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual O&M was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving an outlet retrofit, such as a new outlet structure, were assigned a minimum cost of $25,000.

A summary of all project costs for the 21 top-ranked proposed BMPs are included in Appendix E.

5 Final Recommendations

5.1 Programmatic Recommendations:

- The practices proposed in this study all stand to have a substantial impact on abating water pollution and setting a precedent for integrating GSI in Jericho's landscape. It is our recommendation that the Town, in partnership with the Chittenden County Regional Planning Commission, Jericho Conservation Commission, and/or supporting nonprofit groups including the Friends of the Winooski River, move to implement these practices. As these practices are the result of a stormwater master planning effort under a VT DEC Clean Water Fund grant, they are well-suited as candidates for an implementation grant from this same source. We recommend the following steps in proceeding with this:

    - For priority projects already at the 30% concept level, consider grant request for final design and implementation.

    - Following implementation of the priority projects, submit grant funding request for higher scoring projects that may include both preliminary and final design.

- After reviewing existing land uses as described in the GSI analysis, many of the Town's roads were found to be excessively wide. Unnecessary road spans contribute to the large volume of impervious surface runoff produced throughout the Town. Much of this development predated the Town Land Use and Development Regulations (effective April 9th, 2015) which does provide substantial requirements for projects that create more than 0.5 acres of new imperious and major subdivisions requiring DRB approval. With the introduction of the new Vermont Stormwater Manual (2017), more innovative and GSI-focused practices will be introduced. The Town should consider revising technical standards to reference the new Manual. In addition, the Town may consider revising the threshold for applying stormwater standards below 0.5 acres to capture smaller incremental development projects.

5.2 Additional Recommendations:

- The Vermont Agency of Transportation (VTrans), as part of their Transportation Separate Storm Sewer System (TS4) General Permit, will be completing their own retrofit assessment of VTrans-owned impervious surfaces throughout the Town. Projects determined in this plan should be coordinated with the VTrans TS4 permitting efforts to allow for potential collaboration.

- An ongoing road erosion assessment is being completed by a Chittenden Regional Planning Commission contractor to develop a protocol for prioritizing road erosion issues across Chittenden County communities. Results of the assessment should be coordinated with this plan to determine any potential overlap in projects or opportunities, and for collaboration with landowners.