Stormwater Master Plan
Lyndon, Vermont

August 6, 2018


Fenton Chester Arena Parking Lot
Lyndon, VT

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1.0 Introduction

In 2016 the Caledonia County Natural Resources Conservation District (CCNRCD) received grant funding from the Vermont Agency of Natural Resources (VTANR) Ecosystem Restoration Program to develop a Stormwater Master Plan (SWMP) for the Town of Lyndon. The goal of the planning process is to build on past efforts by CCNRCD, VTANR, and the Town to understand flooding and erosion conflicts along the Passumpsic River, and water quality impacts from stormwater draining over 400 acres of impervious surfaces in the Town. The resulting SWMP will complement past river assessment and corridor planning efforts completed by CCNRCD, and will serve to introduce advanced and green stormwater infrastructure concepts in the Town.

CCNRCD hired Fitzgerald Environmental Associates (FEA) in September 2016 to assist with the development of the SWMP. The Lyndon SWMP follows the VTANR SWMP Guidelines and was developed over the course of 2016 and 2017 through extensive field survey work, interaction with multiple stakeholders in the Town of Lyndon and VTDEC to set priorities, and follow-up analysis and design work.

1.1 Project Background

The East and West Branch Passumpsic Rivers meet in Lyndon to form the Passumpsic River main stem, which meanders across wide floodplains through the Village of Lyndonville. Three other major tributaries have their confluence with the Passumpsic River in Lyndon. The interface of rivers and community has posed challenges for the Town, and Lyndon has had a long history of documented flooding problems, damages, and annual challenges with road closures due to high water (Lyndon Town Planning Commission 2014). The residential and commercial center of the Village of Lyndonville is situated around the river, with 427 acres of impervious surface in the Village of Lyndonville and Lyndon Center. Recently, the Town and Village updated their All Hazard Mitigation Plan (AHMP), which contained many action items to reduce risks and conflicts with rivers. The AHMP recommended the Town complete a SWMP and examine ways to utilize Green Stormwater Infrastructure (GSI) to help attenuate stormwater, reduce erosion and improve water quality (Town of Lyndon 2016b). With the unique challenges Lyndon has with river conflicts, the SWMP will provide a critical tool to introduce concepts of low impact development to the community, educate the community about the links between stormwater management and flooding, and strengthen partnerships with the Town and various stakeholders.

1.2 Project Goals

The goal of this project was to evaluate over 3,300 acres within mapped stormwater drainages in the Town to identify sources of increased stormwater runoff and associated sediments and nutrients discharging to the Passumpsic River. The work involved identifying sources of stormwater, prioritizing sources based on various environmental, economic, and social criteria, and designing projects to mitigate those sources. Stormwater mitigation projects are aimed at reducing or eliminating stormwater at the source through GSI approaches, retrofits of older and underperforming stormwater features, back road erosion projects, and improving floodplain access within the river corridor to increase sediment and nutrient attenuation. The initial project goals were to identify and evaluate at least 30 projects, develop site restoration plans (i.e., project concepts) for 12 sites, and develop conceptual designs (roughly 30% design) for at least four projects, including two design-build practices.

2.0 Study Area Description

Lyndon is a 39.7 square mile town located in Caledonia County in northeastern Vermont (Fig. 1). Lyndon is bordered by 6 towns in Vermont (Sutton, Burke, Kirby, St. Johnsbury, Danville, and Wheelock). The Town is drained by the Passumpsic River and its tributaries, including Miller's Run and Calendar Brook. The Town has a total population of 5,981 with 1,207 residing in Lyndonville Village as of the 2010 Census (U.S. Census Bureau, 2011). The Passumpsic River drains approximately 504 square miles of land area located in Caledonia, Essex, Orleans, and Washington Counties, Vermont (Fig. 1). The Passumpsic River joins the Connecticut River in Barnet, Vermont.

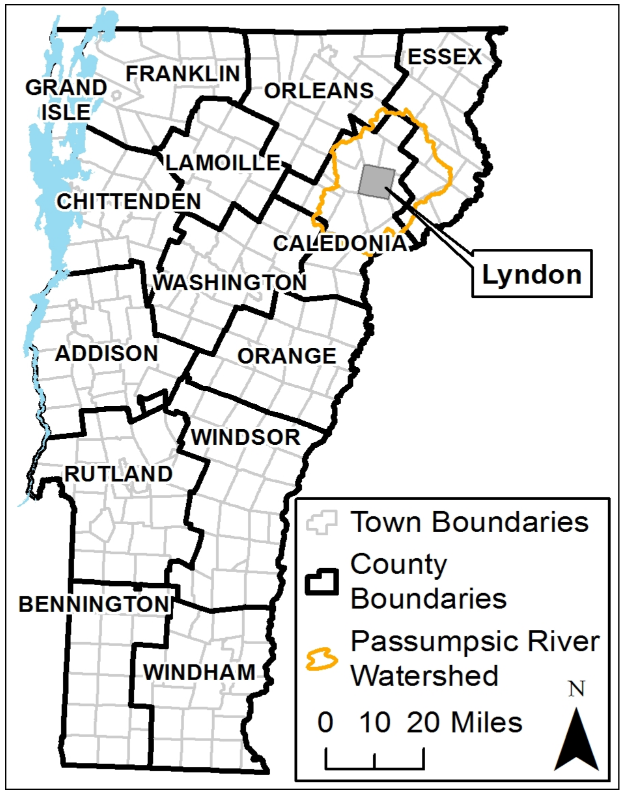

Figure 1: Town of Lyndon and Passumpsic River watershed location map.

Land cover data based on imagery from 2011 National Land Cover Dataset (Homer et al., 2015) are summarized in Table 1. Parts of the town of Lyndon are drained by a rural watershed, with forests representing the dominant land cover type. Agricultural lands, primarily as pasture land and hay fields, cover 21.3% of the Town, with a majority of the farmlands found on the outskirts of the Village of Lyndonville. Developed areas are a significant consideration for stormwater planning, making up 12.2% of the Town. Developed lands are concentrated in the Village of Lyndonville. There are 146.1 miles of roads in Lyndon (Table 2), made up mostly of town highways (64.5%) and private roads (13.6%), and interstate 91 (11.3%).

Table 1: Land cover in Lyndon, Vermont (Homer et al., 2015).

Land Cover/Land Use Type	% of Watershed
Agriculture	21.3
Barren	0.5
Development	12.2
Forest	58.7
Open Water	0.1
Scrub/Shrub	3.9
Grassland	0.7
Wetland	2.5

Table 2: Road length by AOT class in Lyndon.

AOT Class	Description	Length (miles)	% of Town Road Length
1	Class 1 Town Highway	2.0	1.4
2	Class 2 Town Highway	19.1	13.1
3	Class 3 Town Highway	64.2	44.0
4	Class 4 Town Highway	8.9	6.1
5	State Forest Road	0.7	0.5
7	Legal Trail	0.2	0.1
8 & 17	Other/Private Road	19.8	13.6
30, 35	State Highway	8.5	5.8
40	US Highway	6	4.1
51, 52, 55, 56, 57	Interstate	16.6	11.3

3.0 Stormwater Management Planning Library

We began our SWMP efforts by gathering and reviewing information and documentation related to stormwater runoff and watershed management in the Town of Lyndon as it pertains to the Lyndon SWMP. Below is a summary of available data, mapping, and documentation at the local, state, and federal level. Much of this information is from previously completed studies in Lyndon, but also includes sites discussed during a SWMP steering committee meeting on September 28th, 2016. Other potential sources of data and data gaps are also addressed. The planning library is included in Appendix A. Sources for this information include:

- **Local Data**
  - Ordinances for the Village of Lyndonville and Town of Lyndon - 2016
  - Lyndon Town Plan – 2014
  - Lyndon Hazard Mitigation Plan - 2016
  - VOBCIT Culvert Inventory - 2008
- **State and Federal Data and Plans**
  - Passumpsic River and Upper Connecticut River Tactical Basin Plan – 2014
  - VTDEC Stormwater Infrastructure Mapping – 2014
  - VTDEC Hydrologically Collected Road Segment Data
- **Corridor Plans and Stream Geomorphic Assessments**
  - East Branch Passumpsic River Corridor Plan - 2009
  - West Branch Passumpsic River & Calendar Brook Corridor Plan - 2010
  - Miller's Run River Corridor Plan - 2009
  - Lower Passumpsic River Tributaries River Corridor Plan - 2014

4.0 Stormwater Problem Areas

One of the primary objectives of the SWMP is to "develop a comprehensive list of stormwater problems" within the Town of Lyndon. FEA and CCNRCD conducted a total of six (6) field tours of the project area and had meetings with representatives from Lyndon State College, Lyndon Institute, Village of Lyndonville, and the Town of Lyndon to identify existing problem areas, evaluate and prioritize sites, and recommend potential solutions.

4.1 Identification of Problem Areas

The initial round of problem area identification began by identifying stormwater related projects using a desktop exercise scanning the watershed with aerial imagery, NRCS soils data, VTDEC stormwater infrastructure mapping, contour data, and road erosion risk in a GIS. Potential project areas were identified and mapped for review during site visits. A total of 72 stormwater problem areas were identified and assessed in the field (see map in Appendix B and table in Appendix C). We grouped the problem areas into four (4) project categories described below.

- **BMP Installation or Retrofit –** Many sites were identified where sediment and nutrient loads could be reduced through the implementation or retrofit of stormwater best management practices in areas of concentrated surface runoff or stormwater drainage infrastructure.
- **Road Erosion, Ditch Erosion & Improvement, Road Maintenance, Road/Parking Runoff –** Potential areas of sediment and nutrient loading from road and parking lot erosion were identified during field visits. Runoff and erosion projects were identified in many areas where runoff from steep roads (typically gravel) was causing increased sediment and nutrient loading due to ditch erosion.
- **Gully Prevention & Stabilization –** Locations of gullies and areas prone to gully erosion were identified remotely and during field visits. Actively eroding gullies are likely moderate to large sources of sediment and nutrient loads.
- **Other Erosion –** Potential sediment loading from other sources of erosion were identified during remotely and during field visits.

4.2 Evaluation and Prioritization of Problem Areas

The 72 projects described in Appendix C were prioritized based on the potential for each project to reduce nutrient and sediment inputs to surface waters, landowner support for the project, operation and maintenance requirements for the recommended project, cost and constructability of the project, and additional benefits associated with implementation of the project.

GIS-based Site Screening

Using the field data points collected with sub-meter GPS during our watershed tours, we evaluated key characteristics for each site indicating the potential for increased stormwater runoff and pollutant loading, among several other factors described below. These GIS-based observations, along with field-based observations of site characteristics, are summarized in Table 3 under the "Site Description" column and the final "Notes" column.

The following geospatial data were reviewed and evaluated as part of the GIS-based screening:

- **Aerial Photography** – We used the 0.5 m imagery collected for Northeastern Vermont in 2014 to review the site land cover characteristics (i.e., forest, grass, impervious) and measure the total impervious area in acres draining to the project area as identified in the field.
- **NRCS Soils** – We used the Caledonia County Soils data to evaluate the inherent runoff and erosion potential of native soil types (i.e., hydrologic soil group, erodible land class). For project sites with potential for green stormwater infrastructure (GSI), we assessed the general runoff characteristics of the drainage area based on hydrologic soil group (HSG).
- **Parcel Data** – We used the parcel data available through VCGI to scope the limits of potential projects based on approximate parcel boundaries and road right-of-way.
- **VTDEC Stormwater Infrastructure Mapping** – We used maps completed by VTDEC in 2014 to locate outfalls and other drainage features as well as determine drainage areas and flow paths of stormwater features.
- **VTDEC Hydrologically Collected Road Segment Data –** We used a statewide inventory of road erosion risk and hydrologic connectivity of road segments to prioritize areas of potential sediment loading to visit for field surveys.

The stormwater problem areas identified during field tours of the study area were assigned several numerical scoring metrics that are weighted to assist in prioritizing each project based on water quality benefits, project feasibility, maintenance requirements, costs, and any additional benefits. The maximum possible score is 30 and the individual site scores ranged from 10 to 25 (Figure 2). Each category is described below and includes a description of the scoring for each criterion. Final evaluation criteria summarized in the table in Appendix C included the overall prioritization and the following components of the score:

- **Water Quality Benefits (15 points total)**
  - **Nutrient Reduction Effectiveness (4 points)** – Degree of nutrient removal potential with project implementation, this accounts for both the existing nutrient loads and the removal efficiency and capacity of the proposed treatment. Nutrient loading was quantified based on the watershed size, the land cover types, and percent impervious surfaces, and the effectiveness was based on the treatment efficacy of the potential mitigation options appropriate for the space and location of the treatment area.
    - 0 points – No nutrient source and/or no increased treatment
    - 1 point – Minor nutrient source and/or minor increase in treatment
    - 2 points – Moderate nutrient source with some increase in treatment
    - 3 points – Moderate nutrient source with significant increase in treatment
    - 4 points – Major nutrient source with significant increase in treatment
  - **Sediment Reduction Effectiveness (4 points)** – Degree of sediment removal potential with project implementation, this accounts for both the existing sediment loads and the removal efficiency and capacity of the proposed treatment. Sediment loading was quantified based on the watershed size, the land cover types, and percent impervious surfaces, and the effectiveness was based on the treatment efficacy of the potential mitigation options appropriate for the space and location of the treatment area.

        - 0 points – No sediment source and/or no increased treatment
        - 1 point – Minor sediment source and/or minor increase in treatment
        - 2 points – Moderate sediment source with some increase in treatment
        - 3 points – Moderate sediment source with significant increase in treatment
        - 4 points – Major sediment source with significant increase in treatment
    - **Drainage Area (1 point)** – Approximate drainage area to site is greater than 2 acres
    - **Impervious Drainage (3 points)**– Approximate area of impervious surfaces draining to the site.
        - 0 points – Area of impervious surfaces is less than 0.25 acres
        - 1 point – Area of impervious surfaces is 0.25-0.5 acres
        - 2 points – Area of impervious surfaces is 0.5-1.0 acres
        - 3 points – Area of impervious surfaces is >1.0 acres
    - **Connectivity to Surface Waters (3 points)**
        - 0 points – All stormwater infiltrates on site
        - 1 point – Stormwater receives some treatment before reaching receiving waters
        - 2 points – Stormwater drains into drainage infrastructure that directly outlets to receiving waters (assumes no erosion or additional pollutant loading to discharge point)
        - 3 points – Stormwater drains directly into receiving waters (typically stormwater draining directly into a large wetland is assigned 2 points)
- **Landowner Support (2 points)**
    - 0 points – Project is located on private property, no contact with landowner
    - 1 point – Project is on Town or State property with no contact
    - 2 points – Project has been discussed and is supported by landowner
- **Operation and Maintenance Requirements (2 points)**
    - 0 points – Project will require significant increased maintenance effort
    - 1 point – Project will require some increased maintenance effort
    - 2 points – Project will require no additional maintenance effort
- **Cost and Constructability (6 points) –** This score is based on the overall project cost (low score for high cost) and accounts for additional design, permitting requirements, and implementation considerations, such as site constraints and utilities, prior to project implementation.
- **Additional Benefits (5 points total) –** Description of other project benefits, total score is roughly a count of the number of additional benefits. Additional benefits considered in the prioritization are as follows:
    - **(1) Chronic Problem Area** – The site requires frequent maintenance and/or is an ongoing problem affecting water quality
    - **(2) Seasonal Flooding** – The site is affected by or contributes to seasonal flooding
    - **(3) Educational** – The site provides an opportunity to educate the public about stormwater treatment practices
    - **(4) High Visibility** – The site is highly visible and will benefit from aesthetically designed treatment practices

- **(5) Infrastructure Conflicts** – The stormwater problem area is increasing erosion or inundation vulnerability of adjacent infrastructure (i.e. roads, buildings, etc.)
- **(6) Drains to Connected Stormwater Infrastructure** – The site drains into a larger stormwater conveyance system that is less likely to receive downstream treatment
- **(7) Reduces Thermal Pollution** – Project implementation will reduce the risk of thermal loading from runoff to receiving surface waters
- **(8) Improves BMP Performance** – Project implementation will improve the performance of existing stormwater treatment practices that receive runoff from the site
- **(9) Peak Flow Reduction** – Project implementation will significantly reduce stormwater peak flows leaving the site


Figure 2: A stormwater pipe carrying runoff from portions of Williams Street to a stable grassed swale infiltration area had the lowest score (Rt5-9). Severe road erosion and large volumes of sediment along Lily Pond Road (LY-8) had the highest problem area score.

Problem area summary sheets were developed for 30 of the high-priority project sites, and are provided in Appendix D. These sites were selected based on the prioritization categories shown in the Problem Area Table in Appendix C, and from input from project stakeholders during several meetings and field tours. Problem areas and prioritization strategies were discussed and refined with input from representatives of CCNRCD, VTANR, Lyndon Institute, Lyndon State College, the Village of Lyndonville, and the Town of Lyndon. The one-page summary sheets found in Appendix D include a site map and description, site photographs, and prioritization categories.

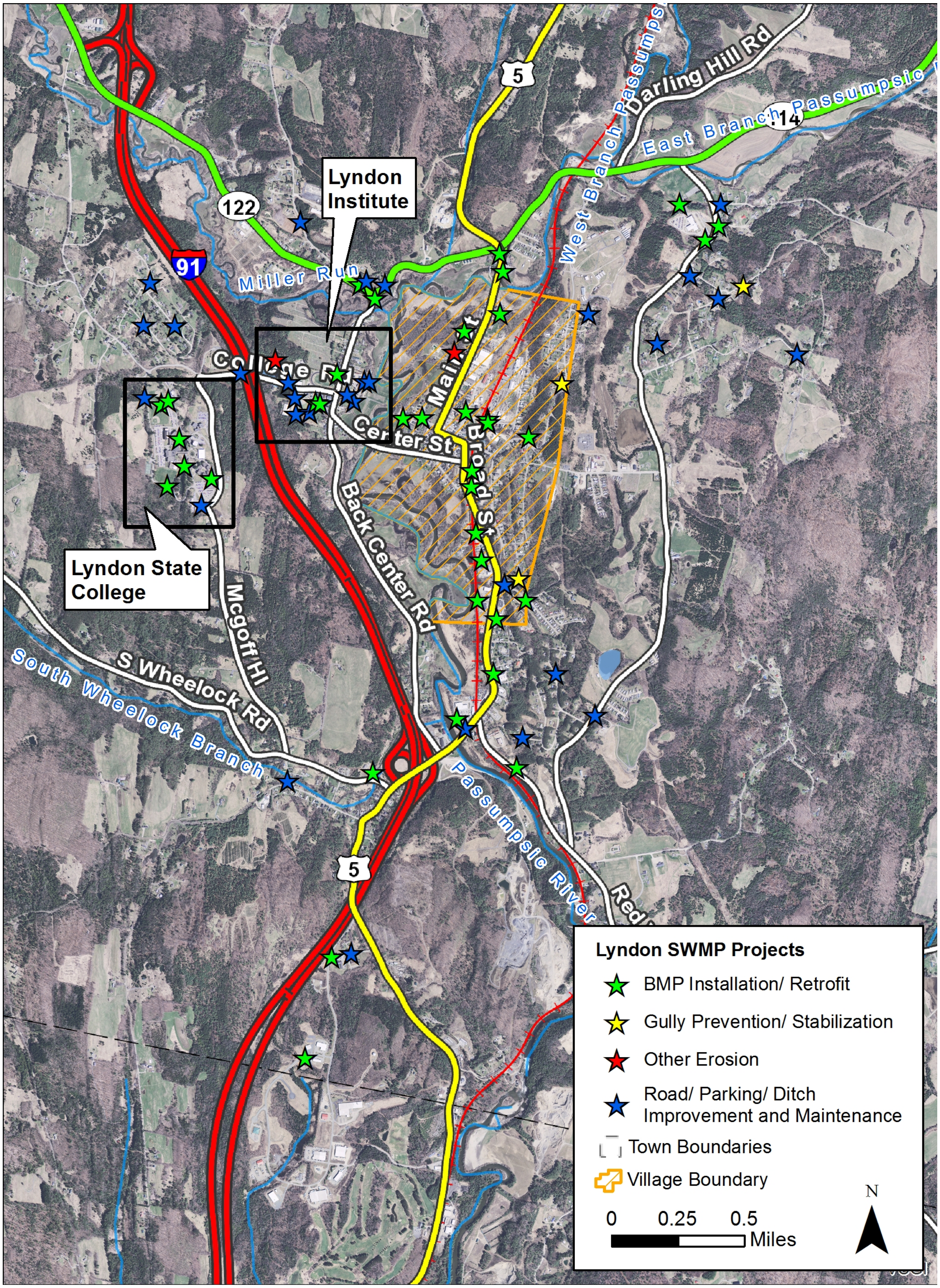

Figure 3: Stormwater Problem Area Overview Map. See large map in Appendix B for greater detail.

4.3 Project Prioritization and Conceptual Designs

The Lyndon SWMP partners reviewed and commented on the list of preliminary projects during various meetings and email correspondences. A total of 72 projects are described in the SWMP, and a subset of high-priority projects were discussed for further development. Based on stakeholder input twelve (12) projects from the list of high-priority sites were chosen for site restoration plan development, four (4) projects were chosen for design-build planning and implementation in the summer of 2017, and two (2) projects were chosen for 30 percent conceptual design development.

Site Restoration Plans

Twelve (12) projects from the list of high-priority sites were chosen for site restoration plan development. Project summaries are included in Appendix E. Each summary includes:

- A description of the site location and problems identified
- A summary of the recommended design and site plan
- Additional design and permitting requirements
- A list of the next steps towards project implementation
- A description of project benefits
- A preliminary cost opinion

The projects chosen for site restoration plan development were:

1. **Project LI-6 &LI-7: Lyndon Institute Fenton Chester Arena & Softball Fields Parking Area** – The 1.4-acre gravel parking lot drains south and is diverted into a water bar that empties into a narrow strip of vegetation along the top of the steep valley wall leading to the stream. Sediment is trapped in the vegetation; however, no additional treatment or slope stabilization measures are in place. A small but active gully was observed along the top of the steep slope. Erosion is also visible along the western edge of the parking lot and a large volume of sediment is delivered to a catch basin in front of the arena, which is piped directly to the stream (Figure 4).
2. **Project LSC-2: Lyndon State College Varsity Field –** A mowed grassed swale along the south edge of varsity field collects runoff from the field and portions of College Road. The swale drains in to a catch basin that empties directly in to Dragon Pond. Portions of the field along the swale are wet year-round and are considered a problem area. The underlying soils for the entire field are D-type and hydric. Fertilizer applications to the field likely result in excess nutrient delivery to the pond.
3. **Project LSC-4:** – Runoff from McGoff Hill is causing erosion along the road edges and flows directly in to Dragon Pond near the outlet.
4. **Project LY-4: –** Runoff from the intersection at the south end of the covered bridge is bypassing the storm drain and flowing down the embankment and through a steep yard, causing erosion of a large gully. Storm drain flows directly in to the river.

5. **Project LY-6:** Two flow paths split the large gravel parking lot and rooftop drainage delivering sediment to grassed ditch that empties into a Passumpsic River side channel. Severe gullying is visible at the inlet and outlet of both driveway culverts.
6. **Project LY-8:** – The ditch along the east side of the road is badly eroded and is sending large volumes of sediment into the adjacent intermittent stream. The cross-culvert outlet is unstable and has a large gully along the road edge.
7. **Project LY-12 –** A very large and steep gully has formed along the steep valley wall. No obvious concentrated flow paths lead to the gully, a stormwater pipe outlet 4' from the top may be increasing erosion.
8. **Project LY-15 –** A large industrial complex with dirt parking areas partially drains to the southwest corner of the property near the train tracks. Runoff currently flows into a series of catch basins which appear non-functioning.
9. **Project LY-22 –** Huge volumes of sediment are deposited on the lawn adjacent to an intermittent stream channel. Sediment is coming from two different culvert outlets and from gully erosion along the road edge. Additional erosion was observed at the inlet and outlet of the stream culvert under Strawberry Hill Rd. Town has been dealing with erosion issues here for years.
10. **Projects LY-23 & LY24 –** An asphalt lined ditch carries runoff from a large portion of the Lyndon Town School property and portions of Lily Pond Road. The ditch spills down a steep bank into the stream with areas of moderate erosion and a small gully. Additionally, a ditch through the lawn area carries flow out of the wetland connecting to the roadside ditch. Portions of the roof and parking lots drain to the wetland.
11. **Project LY-34 & LY-35 –** A steep section of road is eroded with no ditches. The steep drop to cross-culvert inlet has gully erosion and a storm drain is directly connected to intermittent stream draining to wetland. Stormwater flows across road and empties in to wetland to the southwest. The Town appears to have made a temporary sediment trap in the wetland.
12. **Project RT5-2 –** Runoff from the parking lot drains to the west and into a poorly defined swale. Several low points collect water and discharge to the river. Soils along the edge of the pavement are extremely compacted.

Figure 4: Evan Fitzgerald (FEA) and Kerry O'Brien (CCNRCD) assessing catch basin retrofit options at the Fenton-Chester arena (Project LI-7).

Design-Build Plans

A partnership between CCNRCD and the NorthWoods Stewardship Center presented a unique opportunity to design and implement four (4) projects in the summer of 2017. These projects were selected based on implementation feasibility, land ownership, and overall project priority. Design-build plans were developed based on basic site survey and discussion with the property management staff for Lyndon Institute and Lyndon State College (see plans in Appendix F). Prior to the start of each project, Evan Fitzgerald and Joe Bartlett met with the NorthWoods crew leader and supervisor to review the design-build plans and goals for each project, and to assist with site layout (Figure 5).

Figure 5: NorthWoods crew beginning site work for the LSC-6 project.

The projects selected for design-build plans and for full project implementation in 2017 were:

1. **Project LI-1: Lyndon Institute Maintenance Building –** Runoff from a large rooftop area flows on to a high traffic gravel parking area before draining to a catch basin, significant rilling was observed along the flow path.
2. **Project LI-3a: Lyndon Institute Campbell House and Soccer Parking Area –** A stormwater pipe draining portions of Back Center Road and Matty House Circle outlets onto a dirt parking area causing severe rilling and erosion. The pipe is very steep and likely discharges large volumes of water directly onto the unpaved area. The catch basin along the circle receives sediment from the unpaved road shoulder that is used for parking and as a fire lane.
3. **Project LSC-3: Lyndon State College Stonehenge Complex Parking Lot –** A footpath across the swale leading to the dry detention basin is compacted and has bare soil with active erosion. Portions of the parking lot drain directly to this path and vegetation will be hard to establish due to foot traffic. Excess sediment from this site is likely reducing the effectiveness of the existing BMP.
4. **Project LSC-6: Lyndon State College Baseball Fields –** A mowed grassed swale between the two baseball fields collects runoff from a portion of the fields and adjacent grassed areas, draining to an existing low point at the top of the steep bank before spilling over into an armored swale down the steep bank. Nutrient loads from this drainage area likely very high.

Before and after pictures for each design-build project are provided in Appendix F.

30% Concept Designs

Two (2) of the highest priority projects were selected for 30% concept designs (Appendix G). Additional survey data was collected at each site and hydrologic models were utilized to estimate runoff volumes and inform BMP design and sizing (Figure 5). Conceptual designs include:

- A description of the site location and problems identified
- Hydrologic and hydraulic modeling of the contributing drainage area, BMP, and existing/proposed outlet structures
- BMP sizing and design specifications
- Site plan figures and mapping
- A preliminary cost opinion
- A list of current and potential partners and funding
- A review of regulatory permitting requirements

The projects chosen for 30% conceptual design were:

1. **Project LY-13: High Street Extended Detention Basin** – Three catch basins draining steep sections of Chase Street, High Street, and Pinehurst Street drain to a settling pond. Significant erosion is visible along the flow path from the Pinehurst outfall. The pond outlet is too low and stone armor at the inlet is insufficient.
2. **Project LSC-7: Lyndon State College Faculty and Staff Parking Lot –** Runoff from the baseball fields through the swale described in LSC-6 and from a catch basin near the concession stand flow down an armored swale to a grassed swale along the southern end of the parking lot. Nutrient loads are very high from this drainage. The southern portion of the parking lot also drains to this area. The culvert under College Road is in poor condition.

Figure 6: Longitudinal survey collection through the existing sediment basin for Project LY-13.

5.0 Next Steps

This Stormwater Master Plan represents an extensive effort to identify, describe, and evaluate stormwater problem areas affecting Lyndon, Vermont. For each project recommendation, we provided a preliminary cost estimate and a site rating to aid the CCNRCD, the Town of Lyndon, the Village of Lyndonville, Lyndon Institute, and Lyndon State College in planning and prioritizing restoration efforts. Many of the problem area descriptions (e.g., roadside ditches) will aid the Town and Village Highway Departments in proactively stabilizing and maintaining these features to avoid future stormwater problems, and to come into compliance with the forthcoming VTANR Municipal Roads General Permit.

We recommend that CCNRCD works with VTDEC, the Town, Lyndon Institute, and Lyndon State College to secure funding for the high priority projects described in Appendices C, D, E, and G. Based on the level of scoping and design work already completed to date, overall project prioritization, and past stakeholder input, we recommend that the following projects are prioritized for further work in the near term.

- LY-13 (30% design already complete)
- LSC-7 (30% design already complete)
- LI-6 & LI-7 (site restoration plan completed)

- LSC-4 (site restoration plan completed)
- LY-4 (site restoration plan completed)
- LY-8 (site restoration plan completed)
- LY-12 (site restoration plan completed)
- LY-22 (site restoration plan completed)

In addition to addressing the problem areas identified in this document, the Village and Town can take steps to reduce future stormwater problems through planning and zoning regulations. The Lyndon Town Plan lists several important stormwater best management strategies that may be explored for future action (Town of Lyndon, 2016). These strategies and other planning and zoning regulations may be applied to existing and future growth to reduce the risk of stormwater runoff conflicts and nutrient and sediment loading to receiving waters.

Finally, though thirty projects were selected as high-priority based on selected criteria (Total score of 18 or higher), the other identified projects (and any additional new problem areas that develop over time) are also important and should be remediated as time and resources permit.

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