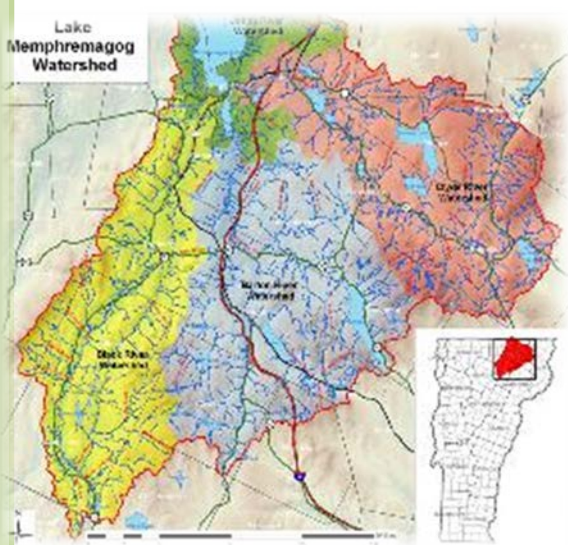

Memphremagog Watershed Association – Stormwater Master Plan

Derby, Vermont

FINAL REPORT
October 31, 2016

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1 Disclaimer

The intent of this report is to present the data collected, evaluations, analysis, designs, and cost estimates for the Stormwater Master Plan for the Memphremagog Watershed under a contract between the Memphremagog Watershed Association (MWA) and Watershed Consulting Associates, LLC (WCA). Funding for the project was provided from the Vermont Ecosystem Restoration Program (ERP), now Clean Water Initiative Program. The plan presented is intended to provide MWA's stakeholders a means by which to identify and prioritize future stormwater management efforts.

This planning study recommends Best Management Practices (BMPs) to address specific concerns that have been raised for this watershed, in particular the need to reduce phosphorus pollution from developed lands in light of the future Memphremagog Phosphorus Total Maximum Daily Load (TMDL). There are certainly other BMP strategies that could be implemented throughout the watershed, but these sites represent the locations and practices that project stakeholders felt would have the greatest impact and the greatest probability of implementation. **These practices do not represent a regulatory obligation of any type, nor are the concerned property owners obligated to implement them.**

2 Project Overview

In May 2013, the State of Vermont Department of Environmental Conservation (VT DEC) issued a document titled Vermont Stormwater Master Planning Guidelines. This document is designed to provide communities, watershed organizations, and individual sites in Vermont with a standardized guideline and series of templates to assist them in planning for future stormwater management practices and programs. Vermont has had stormwater regulations in place since 1978, with updates concerning unified sizing criteria in 2002. Currently, the State is re-writing the stormwater manual to reflect new priorities, particularly in light of the Lake Champlain and Lake Memphremagog TMDLs. The State recognizes that managing stormwater can be a costly endeavor. As such, 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. They are:

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

In keeping with these guidelines, we have prepared the following report which will detail the methods regarding the first four procedures as listed above as well as the final summary and recommendations for the stakeholders concerned.

3 Background

3.1 Problem Definition

The Tactical Basin Plan (TBP) for Basin 17 lists all the priority actions deemed necessary to re-establish healthy water quality in Lake Memphremagog. One of the stated goals is to reduce phosphorus loading in the basin to allow Lake Memphremagog to meet water quality standards, as well as to reduce and/or prevent increases in phosphorus levels in other nutrient sensitive lakes in the basin. Under this broader definition, an objective is listed to "reduce the impacts from stormwater runoff from developed lands." Under the aegis of this specific objective, the MWA undertook this Stormwater Master Plan.

Numerous studies within the Memphremagog Watershed have found that nutrient inputs to the Lake are higher than the Lake's capacity to absorb them, leading to its current designation as impaired. Stormwater runoff, while comprising a smaller fraction of total nutrient inputs than other sources in this largely rural watershed, still plays an important role in that equation. Identifying projects within the watershed that will more effectively treat stormwater runoff before conveying it to the Lake or any of its tributaries will only help to alleviate the Lake's issues with phosphorus pollution.

3.2 Memphremagog Watershed – Data Collection

In order to begin the master planning process, a variety of data was collected. This data included various studies pertinent to the Watershed, as well as GIS data necessary to conduct field visits to potential retrofit sites. Additionally, a review of all existing stormwater permits by town was conducted to provide MWA with a comprehensive list of all existing and pending stormwater permits. A summary of this process can be seen in Appendix A-1 – Data Library and Initial Retrofit Sites – All Materials (note that all referenced studies are provided in a separate folder as PDFs and the table of stormwater permits is provided as a searchable Excel spreadsheet).

Also, included in this Appendix are the initial field maps generated using GIS data. GIS data was drawn from a variety of public resources including the Vermont Agency of Natural Resources (VT ANR) Natural Resource Atlas, the Vermont Center for Geographic Information (VCGI), and the University of Vermont (UVM) Spatial Analysis Lab, as well the City of Newport. This data pertains primarily to soils, landuse (where available), topography, and infrastructure, particularly stormwater infrastructure. WCA performed select analyses on this data to focus efforts for the study. This data represents the best available data.

In addition to the aforementioned data, WCA also obtained stormwater subwatershed data from the VT DEC. Stormwater subwatersheds are delineations of drainage areas flowing to a single stormwater outfall pipe. In some cases, there are technically multiple outfalls within one larger subwatershed, yet they still flow to a single point. This subwatershed data was used to further focus the study in more discrete boundaries and greatly facilitated the field work component of the master planning process.

All these data were used to begin identifying sites for potential stormwater Best Management Practices (BMPs) to be included in the final Stormwater Master Plan.

4 Proposed Best Management Practices

4.1 Identification of Initial Concepts and Locations

Over the summer of 2015, WCA visited 43 sites in the towns of interest. Field work was guided by the GIS data (See Section 3.2) collected as an initial step in the master planning process.

Priority Scoring:

Sites were scored using the scoring matrix summarized in Table 1 below.

Table 1: Initial BMP Sites – Priority Scoring Matrix

State Priority (Y/N)	Drainage Area (H/M/L)	Soil Type (A/B/C/D)	CSO Mitigation (Y / N)	Ownership (Pub/Priv)
Y = 2	H = 3	A = 4	Y = 2	Public = 2
N = 1	M = 2	B = 3	N = 1	Private = 1
	L = 1	C = 2		
		D = 1		

Explanation of Criteria:

State Priority: The VT DEC had previously identified numerous locations during its mapping process that seemed suitable for BMP retrofits. These locations and watersheds were noted. If there was a potential BMP location, it was listed as a State priority.

Drainage Area: This refers to the relative size of each drainage area with H or High being the largest and L or Low being the smallest. These sizes are not representative of acreages, but rather just an initial attempt to rank drainage areas relative to each other.

Soil Type: These classifications refer to the NRCS mapped Soil Hydrologic Group (HSG) with A having the highest potential infiltration rate and D having the lowest (in relative terms). Some areas are mapped as a combination of two different soil groups – in those cases, the first HSG listed was used in this initial screening.

CSO Mitigation: Some areas, particularly in downtown Newport, are areas of combined sewer, where sanitary and storm sewers are commingled. In larger storms, it is possible that runoff will cause the sewer to overflow, resulting in untreated sewage overflows to the Lake. Potential BMPs in these areas ranked higher than BMPs outside of these areas as eliminating runoff that could cause sewer overflows has the potential to eliminate high pollutant loads.

Ownership: Typically, if land is publically owned, it may be easier to work with the municipal entity to establish a BMP on that land. With private ownership, more negotiation is typically necessary to make an agreement with the landowner work. Therefore, public ownership ranks higher as it is typically easier to take a project to implementation on public lands.

The results are shown in Table 2.

Table 2: Initial BMP Sites – Preliminary Ranking

Town	Site Code	State Priority (Y/N)	Drainage Area (H/M/L)	Soil Type (A/B/C/D)	CSO Mitigation (Y / N)	Ownership (Pub/Priv)	Score	Rank
Derby Town	DTB009	N	H	A	N	Public	11	H
Derby Town	DTB010	N	H	A	N	Public	11	H
Orleans	ORL006	N	H	B	N	Public	10	H
Newport City	NPC008	N	H	C	Y	Public	10	H
Barton	BRT004	N	H	C	N	Public	9	M
Barton	BRT010	N	H	C	N	Public	9	M
Orleans	ORL002	N	H	C	N	Public	9	M
Orleans	ORL005	N	H	C	N	Public	9	M
Derby Town	DTB001	N	H	B	N	Private	9	M
Derby Line	DLB001	Y	H	A	N	Private	9	M
Derby Line	DLB002	N	M	A	N	Private	9	M
Newport City	NPC010	N	M	A/C	Y	Public	9	M
Newport City	NPC011	N	M	A/C	Y	Public	9	M
Newport City	NPC012	N	M	A/C	Y	Public	9	M
Barton	BRT002	N	M	C	N	Public	8	M
Barton	BRT001	N	M	C	N	Public	8	M
Barton	BRT005	N	M	C	N	Public	8	M
Barton	BRT008	N	M	C	N	Public	8	M
Barton	BRT009	N	M	C	N	Public	8	M
Orleans	ORL003	N	M	C	N	Public	8	M
Orleans	ORL008	N	H	C	N	Private	8	M
Derby Town	DTB004	N	H	C	N	Private	8	M
Derby Town	DTB005	N	M	C	N	Public	8	M
Derby Town	DTB007	N	H	C	N	Private	8	M
Newport City	NPC001	N	M	A/C	N	Public	8	M
Newport City	NPC002	N	M	A/C	N	Public	8	M
Newport City	NPC003	N	H	A/C	N	Private	8	M
Newport City	NPC009	N	L	A/C	Y	Public	8	M
Newport City	NPC013	N	H	A/C	N	Private	8	M
Barton	BRT003	N	M	C	N	Private	7	L
Orleans	ORL007	N	L	C	N	Public	7	L
Derby Town	DTB002	N	M	C	N	Private	7	L
Derby Town	DTB006	N	M	C	N	Private	7	L
Derby Town	DTB008	N	M	C	N	Private	7	L
Newport City	NPC004	N	M	A/C	N	Private	7	L
Newport City	NPC007	N	L	A/C	N	Public	7	L
Barton	BRT006	N	L	C	N	Private	6	L
Barton	BRT007	N	L	C	N	Private	6	L
Orleans	ORL001	Y	M	C	N	Private	6	L
Orleans	ORL004	N	L	C	N	Private	6	L
Derby Town	DTB003	N	L	C	N	Private	6	L
Derby Town	DTB011	N	L	C	N	Private	6	L
Newport City	NPC005	N	L	A/C	N	Private	6	L
Newport City	NPC006	N	L	A/C	N	Private	6	L

Ranks were picked by adding all scored for each of the criteria. Any site of the 43 investigate scoring greater than 9 was assigned a rank of H or High, for high priority. Sites scoring 8 – 9 were assigned a score of M, or Medium priority. Anything below 8 was assigned a score of L, or Low priority.

BMP practice summaries and locations by address can be found in Appendix A-1, Sub-Appendix A-5: Initial Retrofit Sites. Additional information for each of these sites, including a site photo for each potential retrofit site, can be found in Appendix A-1, Sub-Appendix A-6: Initial Retrofit Sites – Field Reports. Mapped locations for each of these sites can be seen in the map book under Appendix A-1, Sub-Appendix A-7: Initial Retrofit Sites Maps.

This initial list of 43 sites was presented to the Memphremagog Watershed Association and VT DEC staff for review. This list of sites was also vetted with each individual town (either public works directors, zoning staff, town managers, or sometimes all three) to gauge level of interest in each site, likely local buy-in, and potential feasibility with respect to other uses or management of each site. These meetings led to the selection and prioritization of 20 select priority sites for further investigation and modeling. These sites were selected from the initial 43 sites presented, but were not necessarily the top-ranked sites. Rather they were the sites that MWA and the VT DEC felt had the highest potential of getting implemented and with the highest impact. For the final deliverable, four of these sites will be chosen as 30% Concept Design sites.

These sites are presented in Table 3. Descriptions for each of these sites, along with the initially proposed BMP, can be seen in Section 4.2 below.

4.2 Top 20 Sites – Site and Practice Descriptions and Modeling and Prioritization

4.2.1 Site and Practice Descriptions

Table 3: Top 20 Sites Investigated with Retrofit Description (the practice initially conceptualized of for the site).

Site ID	BMP Type	Retrofit Description
CVY_001	Underground Chambers	10x26 MC-4500 Stormtech Chambers
DTB_009	Infiltration Trench	400'x15x3' deep infiltration trench
Numia	Underground Chambers	16x35 MC-4500 Stormtech Chambers
NPC_013	3x41 MC-4500 Stormtech Chambers	3x41 MC-4500 Stormtech Chambers located in City-owned pull-out area
ORL_006	Dry Basin and Infiltration Trench	66'x46'x4' deep dry basin with 3:1 sides outletting to a 400'x10'x3' deep infiltration trench with 2:1 sides
BRT_New_c	Underground Chambers	5x33 MC-4500 Stormtech Chambers
ORL_005	Infiltration Trench	175'x3'x3' deep infiltration trench with 2:1 sides
ORL_002	Underground Chambers	7x14 SC-740 Stormtech Chambers
DTB_007	Dry Basin	146'x70'x4' deep infiltration basin
NPC_School_a and NPC_School_b	Gravel Wetland	150'x10'x5' deep gravel wetland with 2:1 sides at outlet of larger stormwater system between two parcels
NPC_School_c	Underground Chambers	5x10 Stormtech MC-3500 Chambers
NPC_008	Gravel Wetland	220'x17'x2' deep narrow gravel wetland
Northpoint Auto	Underground Chambers	4x14 MC-4500 Stormtech Chambers
GLV_001	Bioretention - Swale	100'x5'x2' deep bioretention swale
NPC_009	Bioretention	60'x3'x2' deep bioretention with 3:1 sides in pedestrian area
DTB_Vtrans	Gravel Wetland	75'x20'x2' deep gravel wetland
Rte_5_Erosion_a	Pipe Storage	200' long 36" perforated pipe embedded underneath the road right of way with new catchbasin inlets installed to trap runoff
NPC_Main_School_Parking_Lot	Bioretention	50'x5'x2' deep with 3:1 sides bioretention
NPC_012	Bioretention	40'x6'x1' bioretention bump-in with 1:1 sides
BRT_New_a	Hydrodynamic Separator	10' HydroInternational Downstream Defender
NPC_010	Bioretention	20'x2'x2' with 3:1 sides bioretention in pedestrian path swale
Rte_5_Erosion_b	Bioretention	110'x3'x2' deep bioretention with 3:1 sides located on private property

4.2.1.1 *CVY_001 - Coventry Airport*

The potential retrofit site at the Coventry Airport was initially identified as an important site by Fritz Gerhardt, Conservation Scientist with Beck Pond, LLC, who sent an e-mail to the VT DEC (specifically, Ben Copans, Basin 17 Watershed Coordinator, and Staci Pomeroy, River Scientist). A large eroded channel is present below a culvert outfall that drains one of the airport's runways. Evidence suggests that this culvert outlet has been on the site since the airport was constructed sometime in the 1940s. As such, the channel is very large in its upper reaches (12' – 15' deep with an average width of 30' – 35'). From the steeper upper reach, it eventually flattens out and becomes less incised (4' – 6' deep) where it joins an intermittent stream (mapped by the VT DEC on the ANR Atlas). There is evidence in this stream channel of several mass failures along the banks. Between these mass failures and the sediment erosion below the outfall, it is clear there is sediment-bound P transported from this area to the Black River.

Figure 1: CVY_001 Drainage Area and Initial BMP Location.

Mapping reports provided by VTrans, along with onsite investigation conducted by WCA in the company of VTrans personnel, indicate that this culvert outfall is fed by a series of catch basins located in the grassy margins (formerly paved but since reduced after military operations ceased at the airport) of the runway.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
14.36	31.9	45%	$ 352,981.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
1,135,307	62429	74.00	58%

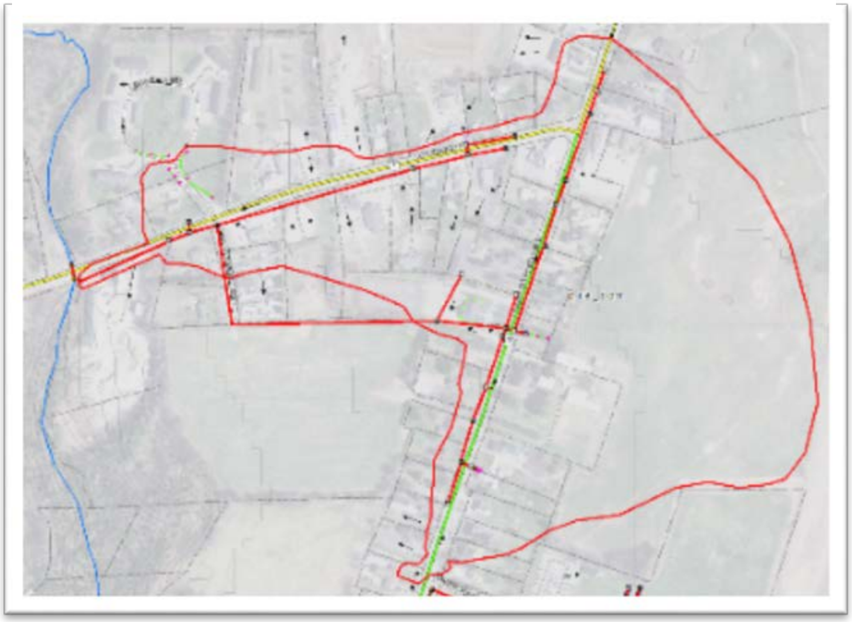
Table 4: Initial modeling results for CVY_001 (note: results have been updated and changed as part of the 30% Design process.

Initially a series of underground chambers were envisioned for this site as surface practices that would result in ponded water are not allowed at airports due to their attraction for wild fowl, which could endanger plane traffic. Soils testing for the newly installed wastewater treatment mound system did not indicate favorable conditions for such a practice, however. Seasonal high water table was indicated within 0.8' – 1.0' of the surface, precluding the use of chambers. In order to control erosion in the channel, a combination of stone armoring and vegetative revetment was chosen. This is one of the Top 4 30% Concept Design Sites. The armoring and revetment design is detailed in that section of the report.

4.2.1.2 *DTB_009 – Derby Town Garage*

The stormwater system outfall behind the Derby Town Garage is one of the largest in the Town with a contributing area of over 55 acres of mixed residential and commercial use. It was initially selected for this reason, as well as the fact that the outfall is on public land. The first design concept consisted of a long, narrow infiltration trench as soils reports indicated that the soils onsite were potentially suitable for an infiltration practice. However, usage and site topography prohibit the implementation of an infiltration trench where initially proposed.

Figure 2: DTB_009 Drainage area (outfall is off Route 5, adjacent to the Town Garage).



Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
15.20	55.71	27%	$ 57,016.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
1,682,000	75455	101.58	53%

Table 5: Preliminary modeling results for DTB_009 (infiltration trench practice).

Numerous meetings with the Town of Derby Zoning Administrator and Public Works director have indicated the Town's willingness to move forward with some sort of stormwater treatment feature on the site. After walking the site with public works staff, it was decided that an area of the parcel currently used for storage could be a good site to locate underground infiltration chambers. Though this would necessitate the installation of a lengthy pipe from the existing storm sewer to the new chambers, this practice was deemed the most feasible. This site has been chosen as one of the Top 4 30% Concept Design Sites and is detailed further in that section of the report.

4.2.1.3 *BRT_New_c – Barton Village public lot*

The Village of Barton owns a piece of property that has frontage along Church Street in the central section of the Village. While much of the property is in the River Corridor of the Barton River, a section of the property is located at a much higher elevation. Though no storm sewer outfall currently exists on the property, a stormwater trunkline runs along Church Street, and this line could be routed to the property.

Figure 3: Potential sub-surface chamber site in Barton Village.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
6.68	11.05	60%	$ 223,657.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
475,558	16100	15.80	74%

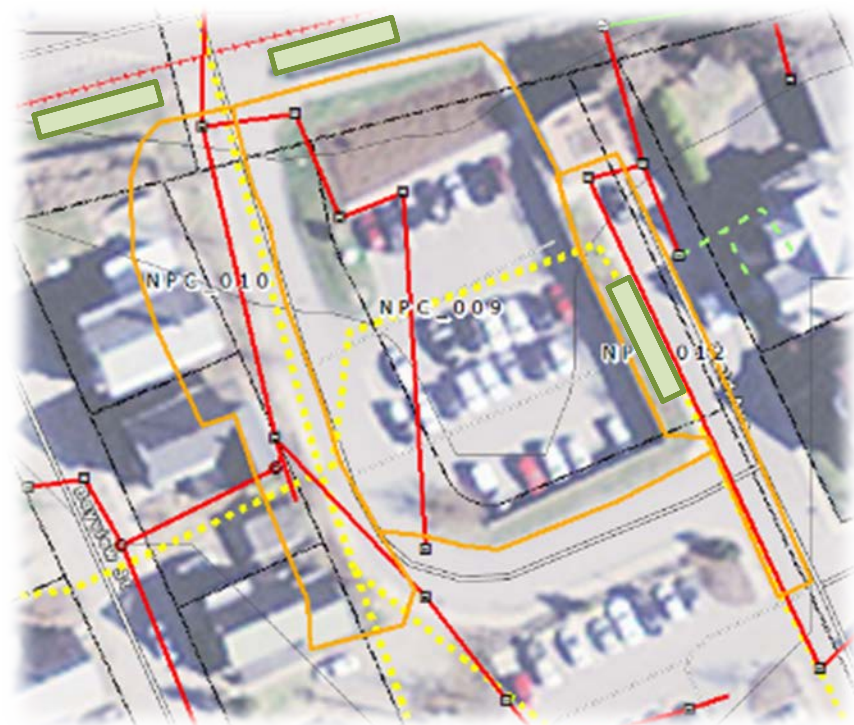
Table 6: Modeling results for BRT_New_c in the Village of Barton.

The BMP concept for the site would be to use underground infiltration chambers to capture and infiltrate water on the site. In meetings with the Village of Barton, officials indicated that there are potential plans to put some sort of public park space on the site, though nothing formal has been done at this point. Utilizing chambers would preserve the site's ability to serve as a public park, while also treating runoff. Though this site was not chosen as one of the final 30% Design sites, it is strongly urged that this site be considered for future practice implementation as there is willingness on the part of the landowner and site conditions indicate that the project is feasible.

4.2.1.4 *NPC Small Sites – NPC_009, NPC_010, NPC_012 – Downtown Newport*

During initial field work in downtown Newport during the summer of 2015, numerous small sites were investigated that had potential to treat stormwater in smaller, dispersed practices. Three of these sites were located in proximity to one another and are presented here as a collective of practices that could be implemented as one project. Together these projects manage 0.5 acres of impervious surfaces, not an insignificant amount. Located on Newport City-owned R.O.W.s at the end of Field Avenue and off Fyfe Drive, these practices haven been reviewed for development by the City of Newport's Public Works Department. The locations and practice types were deemed suitable and feasible.

Figure 4: NPC Small Sites in downtown Newport is a collection of small GSI practices that could manage 0.5 impervious acres.



Impervious Acres Managed	Total Drainage Area (ac)	% Impervious	Project Cost
0.50	0.73	68%	$ 18,919.00

Volume Infiltrated Annually	Annual TSS Load Reduced	Annual P Load Reduced	Annual Fecal Coliforms Reduced (%)
33,802	732.42	1.22	74%

Table 7: NPC Small Sites – preliminary modeling results.

NPC_009: Located at the end of Fyfe Drive just prior to crossing the railroad tracks and adjacent to the paved walking path, this practice would consist of upgrading the existing grass swale by making it wider and deeper to accept more runoff. The existing catch basin could be retained as an overflow in larger storm events.

NPC_010: Located on the opposite side of Fyfe Drive from NPC_009, the concept for this retrofit is nearly identical to NPC_009.

NPC_012: Located at the end of Field Avenue, this practice is envisioned as bioretention 'bump-in' where runoff would be allowed to flow under the sidewalk via some type of conveyance (pipe/swale) and the existing green space could be re-graded to allow for runoff to pond and infiltrate into soil. This area is in the pubic R.O.W.

4.2.1.5 *Numia Medical – Newport City*

The Numia Medial facility is located along the shores of Lake Memphremagog in Newport City. According to infrastructure mapped by the VT DEC, there is a large storm sewer pipe carrying runoff that is routed between Numia's two buildings (connected by an elevated breezeway).

Figure 5: Numia Medical outfall – overall drainage area and approximate BMP location.

The initial concept for this practice was to intercept that pipe and route it to either a series of underground chambers, or, if groundwater proved to be too high on the site, a gravel wetland that would filter out pollutants from runoff. Initial modeling was conducted for chambers.

Outreach was conducted to Numia Medical's administrative staff with the assistance of the City of Newport's Public Works Department. The stormwater treatment practice concept was explained to them and WCA was told that they would consider it and reply. However, after the initial contact and response, no further response was offered by Numia, despite several follow-up e-mails and a phone call. It was concluded due to this lack of response that the site was not worth pursuing for further design given the lack of interest and/or willingness on the part of the landowner. There are, however, other opportunities upstream of this particular outfall identified by the VT DEC that may merit further exploration. It is recommended that these be considered in future studies.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
23.58	107.1	22%	$ 748,495.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
2,686,000	132220	133.40	53%

Table 8: Preliminary modeling results for Numia Medical.

4.2.1.6 *NPC_013 – Newport City R.O.W. Turnout*

A nearly 40-acre drainage area collecting a large portion of stormwater runoff from downtown Newport's commercial center, as well as a portion of its central residential area along Pleasant Avenue, drains to an outfall directly into Lake Memphremagog adjacent to the entry drive of the Newport Furniture Company.

Figure 6: NPC_013 – potential BMP location and drainage area in downtown Newport. Drainage area boundary in orange.

Preliminary investigation of this site revealed a sizable gravel turnout off Main Street that is wholly owned by the City of Newport. Though not suitable for a surface practice given its proximity to the road, it is potentially suitable for underground chambers to collect and infiltrate runoff. It is recognized that, for the volume of runoff this drainage area could generate, that this site is undersized to treat the full water quality volume (WQv). However, given the space available, preliminary modeling suggests treatment of 50% (or better) WQv treatment.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
20.42	39.39	52%	$ 167,052.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
743,000	40627	54.63	32%

Table 9: NPC_013 preliminary modeling results. Note that these results were updated during the 30% Design process.

The site was submitted to the City of Newport for consideration, along with the preliminary practice recommendation. The City's Department of Public Works was in favor of pursuing this practice, pending additional design.

This site was chosen by MWA and VT DEC as one of the Top 4 30% Design sites. Further information pertaining to site investigation and practice design is provided in that section of the report.

4.2.1.7 *ORL_006 – Orleans Park and Ride*

The drainage area for ORL_006 consists primarily of the on/off ramp interchange area for Orleans Village from Interstate 91, draining both high-use highway and highway ramp surfaces, as well as a portion of VT Route 5/58. With a 20-acre drainage area including over 4 acres of impervious surfaces, this drainage collects a substantial volume of runoff. The outfall is on VTrans-owned land. Though not directly connected to the Barton River, the outfall has created a channel over time which exhibits some erosion, though it is fairly stable and vegetated in most locations.

Figure 7: ORL_006 drainage area and infiltration basin site on VTrans-owned land in Orleans Village.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
4.03	20.06	20%	$ 349,958.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
744,791	37106	46.68	59%

Table 10: ORL_006 preliminary modeling results. Please note that these results were updated in the 30% Design process.

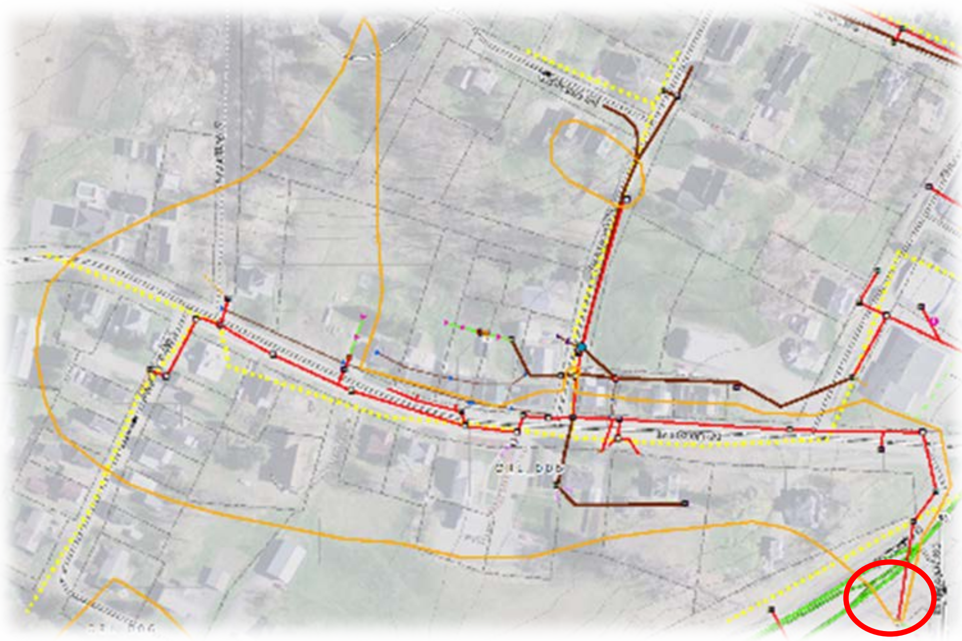
The proposed practice here would be an infiltration basin with an armored forebay to capture and infiltrate water to provide formal treatment for these impervious surfaces. This would also stop any further erosion in the channel that may occur over time, or with the addition of impervious cover through future development in the drainage area

Outreach to VTrans personnel, in particular Tyler Hansen and Jennifer Callahan with the VTrans stormwater division, indicated that VTrans would be interested in pursuing further design of this site. This site was subsequently chosen as one of the Top 4 30% Design sites. Additional information on this site will be presented in that part of the report.

4.2.1.8 *ORL_005 – Orleans VTrans R.O.W.*

Located in the same general area as ORL_006, ORL_005 is farther down VT Route 5/58 towards the Village of Orleans. The drainage area is a little over 9 acres, 3.3 of which is impervious. The landuse in the drainage area is a mixture of State highway and village residential. As the primary access to the Village, Route 5/58 is a high-traffic road with the potential generate high amounts of pollution.

Figure 8: ORL_005 retrofit site and drainage area located off VT Route 5/58 near the village of Orleans.



Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
3.33	9.15	36%	$ 14,199.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
200,508	8813	11.07	34%

Table 11: ORL_005 preliminary modeling results.

The outfall is located in a VTrans R.O.W. Below the outfall there is significant erosion directly to the Barton River. The potential proposed practice would be a long, narrow infiltration trench with 2:1 sides that would capture, spread, and infiltrate runoff from the outfall. Grading may be a significant challenge in this area, though it appears generally feasible. However, the area is mapped as a river corridor. This type of development, while beneficial for stormwater treatment, may not be in accordance with river corridor regulations. The site is out of the mapped floodway and floodplain.

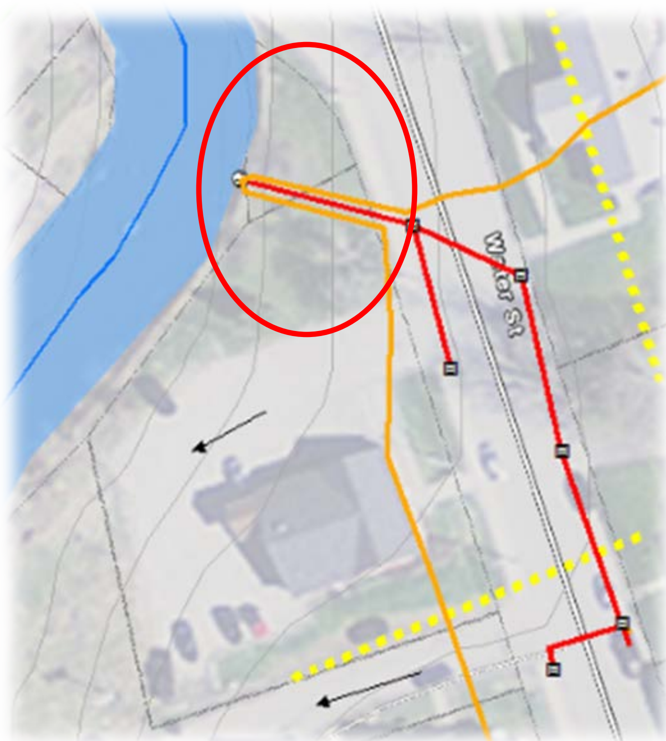
This site was not chosen for additional design, but may have potential as a retrofit for VTrans.

4.2.1.9 *ORL_002 – Orleans Village public lot*

The potential retrofit site for ORL_002 is a small parcel of public land located directly adjacent to the Barton River in downtown Orleans next to the Post Office. There is a significant drainage area (over 60 acres) with over 15 acres of impervious cover that drains to this one outfall. This is one of the largest drainage areas in Orleans.

Outreach conducted with the Village of Orleans Manager, John Morley, indicated that this was one of the only Village-owned parcels where a retrofit would potentially be feasible from a usage standpoint. For this reason, this site should be investigated further under the scope of an additional study. It was not chosen as a Top 4 30% Concept Design under the current scope of work as this site is within the Barton River corridor and, as such, may not be acceptable under river corridor regulations to promote development in this area.

Figure 9: ORL_002 potential BMP site. The small triangle to the north is the Village-owned parcel while the rest is owned by the Post Office landlord.



It may be feasible to treat the full WQv using a series of StormTech SC-740 underground storage chambers on this site, though a chamber layout of this size would potentially require using nearly the entirety of the Village-owned parcel as well as a portion of the adjacent Post Office's parking lot. Another potential option on this site is to implement a gravel wetland if site conditions don't prove to be suitable for a chamber system (infiltration rate too low, groundwater too high, etc.) or the adjacent landowner is not interested in participating in a larger chamber system. Though a gravel wetland would not necessarily be able to treat the same volume of runoff as that treated by the chamber system, it could still have an appreciable impact on runoff quality.

Additionally, given the size of the drainage area, further studies should be conducted to investigate distributed green infrastructure options in this particular drainage area.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
15.25	60.19	25%	$ 63,107.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
362,000	17230	17.70	11%

Table 12: Preliminary modeling results for ORL_002 (chamber system – modeling results for gravel wetland not given).

4.2.1.10 *DTB_007 – Derby Town Shaw's Shopping Center outfall*

The potential BMP is located on land owned by Shaw's Shopping Center in Derby. The total drainage area for the site is over 9 acres, with 7.3 acres made up of impervious surfaces (flat roofs, parking lot, and parking access roads). The parking area does have a series of catch basins that drain to an eroded swale behind the Shaw's building. Despite its impervious coverage, Shaw's does not have a stormwater permit as it was built before such regulations took effect. The proposed practice would be a 140'X70'X4' deep infiltration basin (or similar practice) designed to fully infiltrate the WQv and channel protection volume (CPv).

Figure 10: DTB_007 drainage area and approximate BMP location (Shaw's Shopping Center).

WCA conducted initial outreach to the Shaw's Shopping Center to gauge their potential level of interest in pursuing additional design on the site. While WCA was able to make contact with the store's manager, the manager did not indicate a willingness on the part of Shaw's ownership to pursue any additional design for the site.

It should be noted that this site does have a good deal of potential for implementation of a stormwater management practice in the form of a large infiltration basin. Soils on the site are good, with a reported infiltration rate of 5"/hour, and there is an abundance of open space that is currently unused. Integrating a practice would not be overly difficult. If future stormwater permit regulations under the Lake Memphremagog TMDL progress in a similar manner as they have in the Lake Champlain Basin under the TMDL there, this site may be subject to stormwater regulations. In the Lake Champlain TMDL, a new requirement was introduced stipulating that sites with existing impervious coverage of over 3 acres must obtain a stormwater permit. As such, it may or may not be prudent to pursue this site for inclusion in voluntary BMP implementation as it may be required under future rules.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
7.31	9.7	75%	$ 431,127.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
568,208	25596	35.85	94%

Table 13: Preliminary modeling results for DTB_007 (Shaw's Shopping Center).

4.2.1.11 *NPC_School_a & b*

The proposed practice for the drainage areas described by NPC_School_a and NPC_School_b would be a gravel wetland located on private property off Sias Avenue, near the Newport City Elementary School. The outfall collects drainage from nearly 20 acres, 8.4 of which is impervious cover from a mixture of uses including local roads, the School campus, and village residential uses.

The gravel wetland practice would be a 'best fit' practice sized for the available open space and designed to minimize visual impact on the neighboring properties. As such, it would only be able to manage approximately 50% of the WQv. Additional practices could be pursued within the drainage area for this outfall (for example at the Elementary School campus) that would reduce the pollutants that this practice would need to manage.

The owner of the land was contacted both by the City of Newport and WCA, and they indicated their willingness to move forward with further study. Unfortunately the outreach process took longer than anticipated and the decision had already been made to move forward with other sites for further study. However, this site has the potential to provide a good deal of stormwater treatment, and pursuing this project in the future is a highly recommended joint project between the City, VT DEC, and the private landowners.

Figure 11: Drainage area and approximate BMP location for NPC_School_a & b.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
8.44	29.59	29%	$ 152,424.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
N/A	42768	49.40	70%

Table 14: Preliminary modeling results for NPC_School_a & b.

4.2.1.12 *NPC_School_c*

This potential BMP is a series of underground chambers (50 StormTech MC-3500) located underneath the parking lot at the Newport City Elementary School. It would treat a 10.8 acre portion of the drainage described in NPC_School_a, nearly 3 acres of which is impervious. These impervious surfaces are a mix of residential and institutional surfaces.

As the chambers would be located underneath the School's parking lot, they would not interfere with the School's normal usage of the property. Overflow would bypass to the City's storm sewer.

MWA and WCA conducted preliminary outreach to School administrative staff. They indicated that they would be amenable to pursuing further design on the property, dependent on design concept and how it would affect the school. Because of this, this site should be pursued for future design work, whether for the chamber system described here or the School-site specific bioretention (described under the section for NPC_School_Main_Parking_Lot).

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
2.94	10.8	27%	$ 61,425.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
258,121	4300	13.90	39%

Table 15: Preliminary modeling results for NPC_School_c.

Figure 12: NPC_School_c drainage area and potential BMP site underneath the School's parking lot.

4.2.1.13 *NPC_008 – Newport City – Gardner Park*

The potential BMP is envisioned as a long, narrow (220'L X 17'W) gravel wetland constructed along the roadside edge of Gardner Park in Newport. The practice has the potential to treat an over 5 acre drainage area, nearly 4 of which is impervious coverage. Landuse within the drainage area is primarily busy road surfaces with some mixed commercial/residential usage. As this corridor is main thoroughfare between Newport and Interstate 91, it has the potential to generate high pollutant loads. A practice here could be very effective at removing a portion of that load.

Figure 13: NPC_008 proposed BMP location along the roadway margin in Gardner Park.

A long, narrow gravel wetland is one of the only stormwater BMPs that would work on this site, given the high groundwater likely present (Lake-level is only 2-4' below the site, depending on time of year). The park is also a much-used site making adding any infrastructure a difficult proposition. WCA met with the City of Newport to discuss this idea. Tom Bernier, City of Newport's Public Works Director, cited the Park as a difficult location from a management standpoint. With so many activities present, it tends be very busy. However a gravel wetland located so near to the road in an area that is likely lightly used potentially wouldn't have an undue impact on Park activity. For this reason, this is a BMP that should be pursued under future scopes of work. Though it would require a concerted effort as far as outreach and gathering of support, it has the potential to be an important part of Newport's, and the greater watershed's, management strategy for P pollution.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
3.77	5.14	73%	$ 86,255.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
N/A	14552	12.24	70%

Table 16: NPC_008 preliminary modeling results.

4.2.1.14 *Northpoint Auto – Derby Town auto dealership*

The Northpoint Auto site was brought into the study on the recommendation of Ben Copans (VT DEC) who had previously noticed a large area of erosion off the back edge of the Northpoint Auto parking lot. WCA investigated the site, and noted that the area of erosion is significant and potentially poses a risk both to the parking lot and a small road along the Clyde River below it.

Figure 14: Northpoint Auto drainage area and approximate BMP location.

Because the site is a high-use commercial auto dealership parking lot, there is very little open, available space to implement a treatment feature. For this reason underground storage chambers capable of infiltrating runoff were envisioned as the optimal solution for the site. A system of 64 StormTech MC-4500 chambers could fully infiltrate the WQv, CPv, and 10-year overbank flood protection (QP10) storm from the approximately 2.5 acres that make up the drainage area for the dealership. This would prevent further erosion along the bank. Soils in this area are suitable for infiltration, both as reported by NRCS soils information and as evidenced by the small infiltration basin located next to the auto dealership lot that is part of a stormwater permit that reportedly infiltrates up the 100-year storm (from a small drainage).

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
2.50	2.5	100%	$ 80,269.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
116,898	5045	2.41	96%

Table 17: Preliminary modeling results for the underground chamber system at Northpoint Auto.

WCA conducted initial outreach to the landowners, Ronnie Lyster and Abel Toll of the Autosaver Group. Both owners were somewhat supportive of pursuing a design solution to the issue but deferred to their lawyer, Edward Zuccaro. In conversations with Mr. Zuccaro, it was made clear that the Autosaver Group is potentially amenable to pursuing further design for the issue, dependent on solution type and location. Because this site is a demonstrated water pollution and safety issue, it is worth pursuing as a site for further design and potential implementation, especially given the potential willingness of the landowners to work with the State and MWA.

4.2.1.15 *GLV_001 – Glover Town Office lot*

Figure 15: GLV_001 drainage area and potential BMP location.

Though Glover does not have a large, developed area, it does have a few stormwater issues, one of which was highlighted by Jim Pease of the VT DEC. During large storm events, the intersection of Bean Hill Road and VT Route 16 will occasionally accumulate runoff, ponding up enough to cause nuisance flooding. A portion of this runoff comes for the adjacent school access road, fire station parking lot and rooftop, as well as the Town Office roof and parking lot. Though this drainage is relatively small at 0.87 acres, 0.54 of which is impervious, the landuse in the drainage is relatively high-use between traffic to the school and the Town Offices.

The potential BMP for this drainage is a long linear (100'L x 5'W X 2'H) swale bioretention around the perimeter of the Town Office parking lot that would capture runoff from this surface, as well as the uphill drainage areas. The BMP would be located entirely on Town-owned land. Mapping indicates that this area is within the river corridor for the Barton River. However as this area is currently maintained as mowed lawn and the BMP would not constitute a material change to that usage, it would likely be acceptable under the river corridor regulations.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
0.54	0.87	62%	$ 17,534.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
35,534	608	1.41	85%

Table 18: Preliminary modeling results for GLV_001.

WCA conducted outreach to the Town of Glover. In a meeting with the Town Select Board member Jack Sumberg, it was indicated that the implementation of such a BMP would be acceptable and welcome by the Town. Though this project is not large in terms of its potential pollutant impact, it would be a valuable incubator project in a location where few, if any, projects like this currently exist. Given the ownership of the land and the willingness of the landowner to work with MWA on implementing a solution, it is recommended that this site be pursued for implementation.

4.2.1.16 *DTB_VTrans*

The proposed BMP site is located at the VTrans maintenance garage located in Derby Town. Though the site has a current, valid stormwater permit, there is an opportunity to upgrade that permit to treat runoff for P pollution to a greater degree. Most of the site's drainage collects in a low area via sheet flow, though there is a small closed system (two catch basins to a single pipe outfall), as well as a simple grass swale. A 75'L X 20'W gravel wetland could be constructed on the site that would treat the full WQv and CPv storm events. Gravel wetlands typically have excellent P removal capabilities. Implementing this practice on the site would be a meaningful management practice that would remove P runoff from this nearly 3.5 acre drainage area.

WCA did conduct outreach with VTrans staff. Tyler Hansen (VTrans stormwater) and Shane Morin (District 9 VTrans Manager) were both willing to look at the site for further design. Though, as the site has a current, valid permit, it was not seen as a priority. Nonetheless, it has potential to receive an upgrade for P removal.

Figure 16: DTB_VTrans drainage area and potential BMP site.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
2.87	3.45	83%	$ 79,986.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
N/A	10380	3.72	70%

Table 19: Preliminary modeling results for DTB_VTrans.

4.2.1.17 *Rte_5_Erosion_a*

There is an area of significant erosion located off Route 5 in Newport. The site is below the Mr. O's Sporting Goods store and was identified as a potential high-priority site for the project by Ben Copans (VT DEC). WCA performed preliminary investigation of the site and found an area of significant gully erosion directly below the road. The severity was such that it had the potential to threaten the road.

Figure 17: Drainage area for the Rte_5_Erosion_a gully. Gully location indicated in red below.

The first BMP envisioned by WCA for the purposes of this SWMP was a 200'L X 36" diameter perforated pipe installed under or near to the road R.O.W. that would be fed by a catch basin (to be installed as part of the project). This practice would have been able to collect and infiltrate up to the CPv storm event, both eliminating erosion at the current location and preventing the same problem from occurring farther down the road.

During the course of the project, the City of Newport installed simple wooden curbing (embedded 2"x6" wooden planks) to prevent runoff from continuously eroding the gully. Additionally, the City was able to use fill material (reinforced concrete scrap and gravel/stone fill) from the Wal-Mart construction site to fill in the gully and create a broad, flat platform adjacent to the road. This measure will certainly help protect the road from undermining from erosion. However, there is the possibility that runoff will run down the installed curbing, past the filled in area, and begin to create a similar problem farther down the road. It may be wise to continue to monitor this site to ensure that this does not happen, or to pursue a more permanent solution similar to the perforated pipe BMP proposed under the scope of this study.

Figure 18: Photo of the head of the gully (filled in and curbed).

4.2.1.18 *NPC_School_Main_Parking_Lot*

The envisioned BMP for this site came from the potential willingness of the School to work with the MWA's SWMP process. MWA chairperson Don Hendrich attended a Newport City Elementary School Board meeting and presented the stormwater master planning process to the Board. The Board indicated their willingness to see WCA investigate and potentially design stormwater BMPs on the school's property. As a result of that meeting, WCA began to investigate the potential for a small, school-specific BMP.

Figure 19: Potential location for the NPC_School_Main_Parking_Lot retrofit. The drainage area is approximately the parking area shown here.

The school's entrance has a small green open space. The parking lot is generally graded towards this open area. Though there are catch basins in the parking lot, capping one (or two) would result in a 0.72 acre drainage area (all of which is impervious). The open space has enough area to install a 50'L X 5'W X 2'H bioretention that could manage approximately 50% of the WQv from the drainage area.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
0.72	0.72	100%	$ 13,183.00

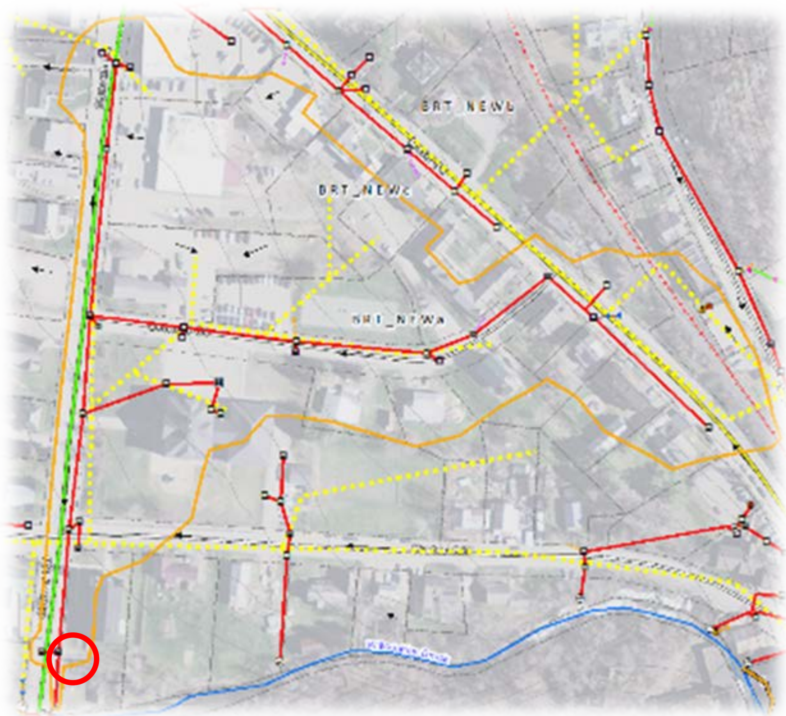
Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
28,125	355	0.56	63%

Table 20: Preliminary modeling for the bioretention at the Newport City Elementary School.

WCA conducted a preliminary impervious cover analysis for the school. Although it has a significant amount of impervious cover, the school won't likely be required to get a permit if a retroactive 3-acre threshold for stormwater permitting is applied. However, school campuses are typically good locations to implement BMPs. Because the school has already indicated a willingness to work with the SWMP process, and the site would require relatively little additional design for the practice to work, it could be an excellent opportunity to treat a small amount of impervious surface while promoting green infrastructure in the community in such a high-visibility location.

4.2.1.19 *BRT_New_a*

Figure 20: Drainage area and approximate BMP location for BRT_New_a



Many of the drainage areas in the Village of Barton are tightly confined by steep slopes and relatively confined open spaces at the outfalls. The drainage area for the BRT_New_a site has potential for some distributed green infrastructure practices within the drainage, but it is largely on private property. Few owners within the drainage were receptive to working with the SWMP process. However, the outfall for the drainage, which goes directly to a tributary of the Barton River, is both under the road R.O.W. and next to a small amount of open space. The possibility exists at this site to install a 10' hydrodynamic swirl separator. Such a practice could be installed under the road or next to it under the open space. In a meeting with the Village of Barton, Village officials indicated their willingness to maintain such a practice and indicated that the owner of the small area of open space, the Barton United Church, may be willing to work with them.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
6.30	10.06	63%	$ 45,000.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
N/A	14195	1.37	0%

Table 21: Preliminary modeling for the hydrodynamic swirl separator at the BRT_New_a outfall.

While a separator won't necessarily infiltrate runoff, or reduce peak discharge rates, it is space-efficient means by which some larger solids pollutants can be reduced from the drainage's runoff. Given the potential willingness of the Village to explore this solution, this may be a good practice to investigate further.

4.2.1.20 *Rte_5_Erosion_b*

The Rte_5_Erosion_b site is a continuation of the Rte_5_Erosion_a site. It is located downhill of the first site and captures an additional portion of drainage from Route 5, as well as some drainage from the newly-constructed North Country Federal Credit Union. Though the City of Newport has already curbed and filled in the erosion site described in the Rte_5_Erosion_a site, there is still the potential at that site to cause similar erosion to what was filled in. The Rte_5_Erosion_b BMP site has the potential to capture and treat at least a portion of both drainage areas' runoff. A 110'L X 3'W X 2'H bioretention could potentially prevent further erosion issues at both sites. However, the area where the BMP would be located is on private property and would require cooperation from the landowner. Neither WCA or MWA conducted outreach to that landowner during the SWMP process as the project was considered a lower priority in the larger scope of all other projects.

Figure 21: Drainage area and approximate BMP location for Rte_5_Erosion_b.

Impervious Acres Managed (ac)	Total Drainage Area (ac)	% Impervious	Project Cost
0.42	0.48	86%	$ 22,116.00

Volume Infiltrated Annually (cu. Ft.)	Annual TSS Load Reduced (lbs)	Annual P Load Reduced (lbs)	Annual Fecal Coliforms Reduced (%)
24,432	104	0.75	98%

Table 22: Preliminary modeling results for a bioretention practice at the North Country Federal Credit Union (Rte_5_Erosion_b).

Modeling and Prioritization

Under this phase of the project we contacted many of the land owners or controllers for the sites listed in our initial sites ranking matrix to gauge interest in participating in the stormwater master planning process. Where a willingness was found to participate in potentially scoping, designing, and implementing a stormwater management practice, we proceeded with additional investigation including follow-up field visits, drainage area delineation (if necessary), and hydrologic, hydraulic, and pollutant loading modeling. This work generated one-page summary reports for each potential BMP site showing drainage area, BMP location and type, hydrologic/hydraulic and pollutant loading data, preliminary cost projections, and relative rank based on each of these factors.

4.2.1.21 *Ranking Method:*

In order to give a relative cost/benefit to each site and practice, we conducted initial modeling to develop preliminary concept BMPs for each site. These BMPs are preliminary only and subject to revision but serve to provide an initial idea of both the potential benefit of a BMP as well as an estimated cost. We used quantitative criteria based on model output, as well as qualitative criteria based on professional judgment and past experience with certain types of BMPs, to assign scores and generate rankings.

Table 23: Ranking Criteria – Explanations for each category.

Criteria	Technical Description
Impervious Acres Managed (ac)	Natural groupings within the range of impervious managed for the proposed projects were identified. More impervious managed receives a higher score.
Relative Project Cost	The project costs were grouped into categories. Cost estimates were developed using an EPA estimate for GSI construction, with additional costs added for design and engineering, plantings, as well as adjustment for inflation. More expensive projects are ranked lower. These should be regarded as very 'rough' estimates.
Volume Treated (cu. Ft.)	Natural groupings within the range of volumes treated annually for the BMPs were identified to which relative points were assigned. The largest volume infiltrated or filtered was assigned the highest score. Volumes were calculated in WinSLAMM.
Annual Total Suspended Sediment (TSS) Mitigated (pounds)	Natural groupings within the range of TSS reductions were identified and points assigned to each grouping. TSS load reductions were modeled using WinSLAMM and based on land uses created using GIS and soils data derived the NRCS.
Annual Total Phosphorus (TP) Mitigated (pounds)	Natural groupings within the range of Phosphorous reductions were identified and points assigned to each grouping. Phosphorous load reductions were modeled using WinSLAMM and based on land uses created using GIS and soils data derived from the NRCS.
Annual Bacteria Mitigation (%)	Natural groupings within the range of bacteria reduction percentages were identified and points assigned to each grouping. Bacteria load reductions were modeled using WinSLAMM and based on land uses created using GIS and soils data derived from the NRCS.
Construction Constraints	Construction Constraints are divided into three basic categories: Minimal, Moderate, and Complex. These conditions are meant to reflect any potential issues facing possible construction such as utility conflicts, grading, site access, or space constraints.
Permitabilty	Permitabilty is simplified into three categories to reflect the common scenarios in permitting: minimal, moderate, or complex.. These are approximations of potential permitting issues to be faced.
Land Availability	Public land is preferred, followed by Private land with a participatory owner, Private land with unknown owner particpation, and Unknown.
Other Project Benefits	This criteria is to account for indirect project benefits like infrastructure improvements (e.g. aging culvert replacement, aesthetic improvements, or mitigation of nuisance flooding.
Ease of O/M	Some stormwater management practices are easier to operate and maintain than others. This category is separated in to three different categories of O/M requirements and ranked accordingly.

4.2.1.22 *Top 20 Sites – Primary Ranking Criteria:*

These criteria are based on desktop evaluation using GIS software for drainage area sizes, impervious acreage managed, as well as model outputs using HydroCAD (for hydrologic/hydraulic considerations and BMP sizing) and WinSLAMM (for pollutant load reduction benefits). Additionally, cost estimation was accomplished using either VTrans cost estimation tables for standard costs of activities (excavation, etc.) or materials (stone, soil, etc.) where most appropriate, or by using a cost estimate developed by the US EPA based on average cost of creating stormwater BMPs (adjusted for inflation and local conditions found over the course of previous projects in Vermont).

After all results were created, the range of values found within each category was evaluated and natural groupings were created based on the minimum, maximum, and mean/median values. Scores were assigned to each of these natural groupings based on their relative importance as shown in Table 23.

Table 24: Primary ranking criteria for the chosen Top 20 retrofit sites

Criteria	Quality	Score
Impervious Acres Managed (ac)	0-1.0	1
	1.0-3.0	2.5
	3.0-10.00	5
	>10.00	10
Relative Project Cost	$0 - $20K	10
	$20 - $65K	5
	$65K - $100K	2.5
	>$100K	1
Volume Treated (cu-ft)	0 - 10K	1
	10K - 100K	5
	100K - 750K	10
	>750K	15
	N/A	0
Annual TSS Load Mitigation (pounds)	0 - 1000	1
	1000 - 12,000	5
	12,000 - 30,000	10
	>30,000	15
Annual TP Load Mitigation (pounds)	0 - 1	1
	0-5	5
	5 - 20	10
	20 - 55	15
	>55	20
Annual Bacteria Reduction (%)	0 - 25%	1
	25% - 50%	2
	50% - 75%	3
	>75%	4

4.2.1.23 *Top 20 Sites - Secondary Ranking Criteria:*

Secondary criteria were not based on quantitative modeling results but rather on qualitative criteria that can have an impact on the project's success.

Table 25: Secondary ranking criteria for the chosen Top 20 retrofit sites

Criteria	Quality	Score
Construction Constraints	Minimal Issues/Concerns	4
	Moderate Issues/Concerns	1
	Complex issues	0
Permitting	Minimal Issues/Concerns	2
	Moderate Issues/Concerns	0
	Complex Issues	-2
Land Availability	Public	8
	Private - participatory owner	4
	Private - unknown participation status	1
	Unknown	0
Other Project Benefits	Infrastructure Improvement (e.g. Culvert Replacement)	1
	Downstream Discharge Rate Attenuation	1
	Neighborhood Aesthetic Improvement	1
	Water Re-use	1
	Natural Habitat Creation/Protection	1
	Traffic Calming / Pedestrian Benefits	1
	Outfall Erosion Control	1
Ease of O/M	Underground Storage/ Swirl Separator	0
	Bioretention/Rain Gardens/Tree Box Filters	1
	Ponds/Constructed Wetlands	2

4.2.1.24 *Top 20 Sites – Final Ranking Table*

Table 26: Top 20 Sites – Final Ranking Table with BMP Type and Retrofit Description

Site ID	BMP Type	Retrofit Description	Total Score	Rank
CVY_001	Underground Chambers	10x26 MC-4500 Stormtech Chambers	80	1
DTB_009	Infiltration Trench	400'x15x3' deep infiltration trench	76	2
Numia	Underground Chambers	16x35 MC-4500 Stormtech Chambers	66	3
NPC_013	3x41 MC-4500 Stormtech Chambers	3x41 MC-4500 Stormtech Chambers located in City-owned pull-out area	63	4
ORL_006	Dry Basin and Infiltration Trench	66'x46'x4' deep dry basin with 3:1 sides outletting to a 400'x10'x3' deep infiltration trench with 2:1 sides	62	5
BRT_New_c	Underground Chambers	5x33 MC-4500 Stormtech Chambers	55	6
ORL_005	Infiltration Trench	175'x3'x3' deep infiltration trench with 2:1 sides	53	7
ORL_002	Underground Chambers	7x14 SC-740 Stormtech Chambers	52	8
DTB_007	Dry Basin	146'x70'x4' deep infiltration basin	49	9
NPC_School_a and NPC_School_b	Gravel Wetland	150'x10'x5' deep gravel wetland with 2:1 sides at outlet of larger stormwater system between two parcels	39	10
NPC_School_c	Underground Chambers	5x10 Stormtech MC-3500 Chambers	39	10
NPC_008	Gravel Wetland	220'x17'x2' deep narrow gravel wetland	36.5	11
Northpoint Auto	Underground Chambers	4x14 MC-4500 Stormtech Chambers	36	12
GLV_001	Bioretention - Swale	100'x5'x2' deep bioretention swale	35	13
NPC_009	Bioretention	60'x3'x2' deep bioretention with 3:1 sides in pedestrian area	35	13
DTB_Vtrans	Gravel Wetland	75'x20'x2' deep gravel wetland	34	14
Rte_5_Erosion_a	Pipe Storage	200' long 36" perforated pipe embedded underneath the road right of way with new catchbasin inlets installed to trap runoff	33.5	15
NPC_Main_School_Parking_Lot	Bioretention	50'x5'x2' deep with 3:1 sides bioretention	32	16
NPC_012	Bioretention	40'x6'x1' bioretention bump-in with 1:1 sides	32	16
BRT_New_a	Hydrodynamic Separator	10' HydroInternational Downstream Defender	31	17
NPC_010	Bioretention	20'x2'x2' with 3:1 sides bioretention in pedestrian path swale	31	17
Rte_5_Erosion_b	Bioretention	110'x3'x2' deep bioretention with 3:1 sides located on private property	23.5	18

This table and the previously mentioned one-page summary documents were presented to the MWA and VT DEC staff at a meeting held on 5-25-2016. For a complete list of materials presented at that meeting, including the one-page summary reports and the ranking table inputs for each site, see Appendix A-2 – Top 20 Sites Selection and Report, Sub-Appendix 1: BMP Ranked List and Scoring Matrix and Sub-Appendix 2: Top 20 Sites Field Reports and Rankings. This Appendix also includes large-scale (2'X3') maps for each town showing the drainage areas associated with each BMP site as well as approximate BMP location (see Sub-Appendix 3: Drainage Area Display Maps by Town).

Please note – there are 22 sites listed here, not 20. This is because the NPC Small Sites (NPC_009, NPC_010, and NPC_012) were combined into one site. We chose to present them separately within this table to show how they ranked individually. Note also that ranking numbers only extend to 18 – this is because of tie scores.

4.2.2 *Top 4 30% Design Sites*

4.2.2.1 *Selection Process – Top 4 30% Design Sites:*

WCA made an initial recommendation for the final Top 4 30% Design sites of

- CVY_001 (Coventry Airport)
- DTB_009 (Derby Town Recycling Center)
- BRT_New_c (Barton Village Land)

- NPC Small Sites (Newport City near Fyfe Drive, consisting of sites NPC_009, NPC_010, and NPC_012)

At the conclusion of meeting with MWA and VT DEC, it was decided that though these initial recommendations had been made, there was additional analysis and reflection needed on the part of MWA and VT DEC staff based on the materials presented.

Subsequent to that meeting, a digital poll was sent around to determine the final Top 4 30% Design sites, with two alternates (in case any of the Top 4 sites owners did not want to proceed any further in the stormwater master planning process).

The sites chosen were:

- CVY_001 (Coventry Airport)
- DTB_009 (Derby Town Garage)
- NPC_School_a and NPC_School_b (outfall off Sias Ave near the Newport City Middle School)
- NPC_013 (Newport City road ROW)

The two back-up sites were:

- ORL_006 (Orleans 'unofficial' park and ride outfall)
- ORL_002 (Orleans village-owned land near the Post Office)

After selecting these sites, additional outreach to each landowner was conducted to gauge willingness to proceed with 30% Design with the understanding that said design level represents no obligation on the part of the landowner to accept or implement the solution without further review or input.

- CVY-001 – is administered by VTrans. VTrans was willing to proceed and permission was obtained to conduct additional design for the site.
- DTB_009 - is owned by the Town of Derby. With some revision to the initial BMP siting, the Town was willing to proceed with design.
- NPC_School_a and NPC_School_b – the outfall is actually on private land. The City of Newport, via Tom Bernier (Director of Public Works) conducted outreach to each of the private landowners on WCA's behalf. The landowner that owns the property where the pipe outlet daylights was amenable to proceeding with 30% Design. However, the outreach process took considerably longer than initially anticipated and the decision had already been made by the WCA team to proceed with other sites. However, it should be noted that this site is potentially viable for investigation and design under a follow-up scope of work.
- NPC_013 – the land is a City-owned gravel turnout. The City of Newport was willing to proceed with additional design.
- ORL_006 – VTrans owns and controls this site. It is currently operating as an 'unofficial' park and ride with open space beyond the limits of the parking area. VTrans was willing to pursue additional design.
- ORL_002 – this was the last of the selected six sites and the Village of Orleans was not contacted regarding this site as four suitable and preferred sites were already found. However, there is a small amount of publicly-owned land at this site and it could prove suitable for a retrofit in the future.

The final Top 4 30% Design Sites are:

- CVY_001

- DTB_009
- ORL_006
- NPC_013

4.2.2.2 *Top 4 30% Design Sites – Modeling and Design*

All final 30% Concept Design plans and details can be seen in Appendix A-9 – 30% Concept Designs. Note: these plans are all meant to be printed at 24"X36".

4.2.2.2.1 CVY_001 – Coventry Airport Swale

BMP Description and Configuration

The practice envisioned for CVY_001 is a combination of stone armoring, gabion baskets to provide easy-to-install check dams, and bioengineering along the swale side slopes (live-staking and straw wattles) to prevent the side slopes from continuing to erode.

Over the course of the past approximately 75 years since the airport runway was installed, a system of catch basins has conveyed water to a concrete pipe that outlets at the head of the swale. Over time, the swale has eroded significantly, as evidenced both by the dimensions of the gully itself at between 12' – 15' deep by 35' wide from top-of-bank to top-of-bank, and running over 250' long.

Originally the management practice envisioned for this site was either a surface feature that would infiltrate runoff or a system of underground chambers that would do the same. In conducting site visits with both VTrans and airport personnel, the possibility of managing runoff using a surface practice was ruled out. Such practices tend to attract wild fowl which can interfere with airplane operation. Airport management felt that it was better to avoid such issues.

Subsequently, underground chambers were explored as a potential option. Though most of the soils on the site are generally unsuitable for infiltration (Hydrological Soil Group (HSG) 'D,' there are pockets of HSG 'B' soils near the end of the runway where the swale is located. Initial concepts made use of the potential for these soils underneath the chambers. However, after conducting a site survey and reviewing plans for the wastewater system expansion currently being constructed, as well as soils investigation information generated for that project, it was concluded that a system of infiltration chambers would not be feasible on the site. According to wastewater system plans, there is the presence of seasonal high water table (SHWT) within 0.8' – 1.0' of the surface – see A-7 – Basis of Design for CVY_001. The presence of SHWT so near to the surface prompted the WW system designers to design two separate mound systems to work with this constraint. Unfortunately, a system of chambers would not be able to be installed in a similar configuration without also installing a pump system.

Using the chambers as a storage and detainment practice was also considered. Instead of infiltrating runoff, it would be detained and slowly bled off using a flow-control orifice. However, the concern for floatation of chambers due to SHWT made this option unattractive.

For these reasons, the armoring and bioengineering solution as designed to the 30% level was decided on as the most feasible option to reduce or eliminate runoff-causing erosion.

Pollutant Load Reductions

Using the EPA's Spreadsheet Tool for Estimating Pollutant Loads (STEPL) model, specifically the function related to gully erosion, an approximate annual erosion amount, expressed as total sediment eroded, was generated. Using the swale's dimensions (given above) and entering a time period of 75 years (1941 – 2016), along with the pipe outfall's specific drainage area (11.78 acres of impervious cover) and site-specific soil information, a total amount of 41 tons. The STEPL model estimates total P loading (as a percentage of the overall erosion amount) at 57 lbs.

Cost Projection

Based on VTrans's 5-year average costs for materials as placed and manufacturer's estimates for other costs, the cost projection for the sand infiltration terraces for erosion control at the Coventry Airport site is as follows:

Table 27: Cost projection for CVY_001 (Coventry Airport).

Project: CVY_001 - Coventry Airport Swale Stabilization					
Item Code	Description	Quantity	Units	Unit Price	Total
Swale Stabilization					
203.15	Common Excavation	250	CY	$ 8.98	$ 2,245.00
613.1	Stone Fill, Type 1	105	CY	$ 42.43	$ 4,455.15
203.35	Gravel Backfill for Slope Stabilization	335	CY	$ 13.83	$ 4,633.05
629.54	Crushed Stone Bedding	16.5	TON	$ 34.02	$ 561.33
N/A	Straw Wattles	700	LF	$ 1.75	$ 1,225.00
651.15	Seed	30	LBS	$ 8.32	$ 249.60
N/A	Plantings (plugs)	1000	EACH	$ 1.39	$ 1,390.00
653.2	Temporary Erosion Matting	1125	SY	$ 2.32	$ 2,610.00
TOTAL					$ 17,369.13

Cost per Pound P Removed

The projected cost per pound of phosphorus removed is approximately $304.

4.2.2.2.2 DTB_009 – Derby Town Garage

BMP Description and Configuration

A large stormwater outfall that drains much of the village of Derby outlets to a tributary of the Clyde River. This stormwater pipe passes near the Derby Town Garage site. Intercepting this pipe and employing a series of underground infiltration chambers on the site was chosen as the best possible management practice after several meetings with Derby staff and officials to discuss site usage and other potential management practices such as infiltration basins.

Installing a manhole structure at some point along the existing stormwater pipe will route stormwater to the chambers. Please note that there are multiple options for routing this pipe that will depend on the exact location and depth of the existing stormwater pipe. Routing from proposed structure 1A will work only if the invert of the existing pipe is 94’ or lower (relative datum). If the pipe invert is found to be higher than this, an outlet structure will have to be installed with the chambers to alleviate potential hydraulic pressure during larger storm events. If the pipe is found to be 94’ or lower, excess runoff can simple back up the diversion pipe and flood out the existing stormwater pipe to the outfall.

Installing a new diversion pipe at either structure 1B or 1C can also work, but there will be a question of existing utility infrastructure in those areas. Not enough is currently known about underground utilities and infrastructure (electric, water, sewer, leach field) to establish the exact routing of pipes from 1B and 1C. Additional plan review and survey will be necessary before installing those pipes, if those are the chosen options.

It is recommended that additional design proceed by determining the exact location and depth (to the greatest degree possible) of the existing stormwater pipe prior to proceeding with design. This may involve the use of exploratory digging, televising the storm line, and/or using pipe-locating services to make these determinations.

During soil profiling and infiltration testing, it was found that some of the soils underneath the proposed chamber site are composed of old fill material such as broken asphalt pavement, construction debris, and utility poles – see A-6 – Soils Reports for more information. Derby staff confirmed that this site was filled over time to provide a level surface on which to store materials and work. As an old dump site, as well as an old VTrans garage, there have been a variety of site uses that necessitate additional levels of soil screening prior to implementing this practice. Communication with Michael Nahmias of the DEC’s Waste Management Division indicate that no former Underground Storage Tanks (USTs) or other concerns are present directly beneath the proposed chamber site – see A-7 – Basis of Design for DTB_009. However, the site’s history indicates the need for additional screening. This screening should take the form of additional soil test pits throughout the proposed chamber footprint to obtain composite soil samples. Screening for hazardous compounds (PAHs, metals, etc.) should be also be completed.

For this site, the proposed plan calls for a 2’ layer of bedding sand beneath the chambers. This is to ensure that adequate treatment takes place for runoff before entering groundwater.

Pollutant Load Reductions

Pollutant load reductions as modeled by WinSLAMM indicate that a system of 8X36 StormTech MC-4500 chambers would reducing pollutants by the following amounts:

Total Suspended Solids:	89,780 lbs.
Total Phosphorus:	121 lbs.
Bacteria:	~64%

Note that the 30% Concept Design plan shows multiple chamber layout options for the site. This is to accommodate the possibility that Derby may want to move the chambers farther away from the garage pad to alleviate any possible conflicts. While we don’t anticipate it at this location, a reduced footprint is an option as well. Pollutant load reductions and costs would be subsequently reduced.

Cost Projection

Based on VTrans's 5-year average costs for materials as placed and manufacturer's estimates for chamber costs, the cost projection for the underground chamber system at the Derby Garage is as follows:

Table 28: Cost projection for DTB_009 (Derby Town Garage Chambers). Note that costs provided here are based on 8X36 chambers (largest system possible) using pipe routing from structure 1A.

Project: DTB_009 (Derby Town Garage Chambers)					
Item Code	Description	Quantity	Units	Unit Price	Total
Chamber Costs					
	StormTech MC-4500 Chamber Sections	288	EACH	$ 420.00	$ 120,960.00
	StormTech MC-4500 Chamber Sections	16	EACH	$ 550.00	$ 8,800.00
Piping Costs					
601.092	24" CPEP	500	LF	$ 54.09	$ 27,045.00
601.581	18" CPEP Elbow (sub. For 24" Elbow for estimating)	8	EACH	$ 200.00	$ 1,600.00
604.11	Concrete Manhole with Reinforced Cover	2	EACH	$ 3,090.00	$ 6,180.00
Materials and Excavation					
629.54	Crushed Stone Bedding	2230	TON	$ 34.02	$ 75,864.60
203.3	Earth Borrow	625	CY	$ 8.04	$ 5,025.00
649.31	Geotextile Under Stone Fill	1840	SY	$ 2.27	$ 4,176.80
203.15	Common Excavation	5000	CY	$ 8.98	$ 44,900.00
204.2	Trench Excavation of Earth	215	CY	$ 14.27	$ 3,068.05
301.26	Subbase of Crushed Gravel, Fine Graded	835	CY	$ 40.22	$ 33,583.70
613.1	Stone Fill, Type I	28	CY	$ 43.42	$ 1,215.76
TOTAL					$ 332,418.91

Cost per Pound P Removed

The projected cost per pound of phosphorus removed is approximately $2,750.

4.2.2.2.3 ORL_006 – Orleans Park and Ride

BMP Description and Configuration

The stormwater treatment feature at the Orleans Park and Ride is envisioned as a series of infiltration basins following the slope of the existing land surface. These basins will replace the existing swale. A flow-splitter will be installed to intercept the existing pipe outfall. The flow-splitter will pick up the existing 24" pipe (diameter is assumed as the pipe was not seen in the upstream catch basin due to sediment and water ponding in the sump nor was it seen at the outlet end as it was buried in soil and rip-rap). A smaller pipe (15") will be used to split off the water quality volume, while a 24" riser will be used to divert larger flows. This is primarily intended to prevent scouring of the forebay with high flow velocities.

The forebay will be armored using either Contech ArmorFlex or Watershed Geo's HydroTurf Z products. These products, while more expensive than using typical Type I stone rip-rap in the forebay to prevent forebay scouring and sediment settling, will facilitate annual maintenance and sediment removal by creating a durable smooth surface that can easily be scraped clean of sediment using an excavator bucket with a smooth bucket edge. If a vactor truck is used, these surfaces will provide a smoother, more resistant surface on which to create a vacuum and remove sediment.

The infiltration basins are designed to fully infiltrate the WQv and CPv, thereby protecting the Barton River from both pollutant loads as well as channel-changing flows. Infiltration rates were assessed in the field at 2"/hour – see Appendix A-6 – Soils Reports for more information.

Pollutant Load Reductions

Pollutant load reductions as modeled by WinSLAMM indicate that a system of infiltration basins with a forebay would reduce pollutants by the following amounts:

Total Suspended Solids:	14,387 lbs.
Total Phosphorus:	69 lbs.
Bacteria:	~88%

Cost Projection

Based on VTrans' 5-year average costs for materials as placed and manufacturer's estimates for Contech ArmorFlex or Watershed Geo's HydroTurf Z, the cost projection for the infiltration basins at the Orleans Park and Ride is as follows:

Table 29: Cost projection for the infiltration basin system for ORL_006 (Orleans Park and Ride).

Project: ORL_006 (Orleans Park and Ride Basin)					
Item Code	Description	Quantity	Units	Unit Price	Total
Materials and Excavation					
203.15	Common Excavation	1666	CY	$ 8.98	$ 14,960.68
649.31	Geotextile Under Stone Fill	250	SY	$ 2.27	$ 567.50
613.1	Stone Fill, Type I	105	CY	$ 42.43	$ 4,455.15
613.11	Stone Fill, Type II	45	CY	$ 37.26	$ 1,676.70
601.092	24" CPEP	120	LF	$ 54.09	$ 6,490.80
601.091	15" CPEP	65	LF	$ 31.07	$ 2,019.55
601.5814	18" CPEP Elbow (sub. For 15" CPEP elbow)	3	EACH	$ 200.00	$ 600.00
604.11	Concrete Manhole with Cast Iron Cover	1	EACH	$ 3,090.00	$ 3,090.00
N/A	ArmorFlex or HydroTurf Z	400	SF	$ 10.00	$ 4,000.00
651.15	Seed	25	LBS	$ 8.32	$ 208.00
631.35	Topsoil	130	CY	$ 29.20	$ 3,796.00
651.29	Straw Mulch	0.5	TON	$ 393.75	$ 196.88
TOTAL					$ 42,061.26

Cost per Pound P Removed

The projected cost per pound of phosphorus removed is approximately $609.

4.2.2.2.4 NPC_013 – Newport City Turnout

BMP Description and Configuration

Given the constrained site conditions at the Newport City turnout site, a system utilizing underground infiltration chambers was designed. This system makes the most of the site from a stormwater treatment perspective while maintaining its current use as the chambers are designed to be driven over. The size of the available land versus the size of the drainage is such that only approximately 75% of the WQv (0.75" rain per 24 hours) will be infiltrated – see Appendix A-6 for the full report.

A system of 115 StormTech MC-4500 chambers is proposed for this site. The system will intercept the existing stormwater outfall pipe with a flow splitter. A fabric-wrapped isolator row will take the first-flush of each storm to filter out the majority of solids. This row will have cleanouts to facilitate maintenance. Once the isolator row fills, the system will overflow into the other two rows of chambers, allowing water to infiltrate. Infiltration rates at this site were measured at 20"/hour due primarily to the sandy, gravelly nature of the soils. For this reason we propose a 2' deep layer of bedding sand to ensure that the infiltration rate is slowed to allow for adequate time of contact between soil media and runoff prior to infiltrated water reaching groundwater. This bedding sand layer will serve as part of the 3' of separation between the invert of the chambers and groundwater (groundwater elevation as shown on the 30% Concept Plans is theoretical and based on the surveyed elevation of Lake Memphremagog and an assumed slope of groundwater). The plan also proposed making use of a 6" perforated pipe underdrain beneath each row of chambers. This is designed to alleviate excessive groundwater mounding at the site. Given the steep slope of the embankment down to the Lake from the site, excessive groundwater mounding could lead to slumping and bank failure. Using an underdrain will prevent this as it will short-circuit mounding and outlet that water directly to the Lake. The water that is routed to the Lake will have passed through the sand layer, so treatment will have occurred.

Pollutant Load Reductions

Pollutant load reductions as modeled by WinSLAMM indicate that a system of underground chambers would reduce pollutants by the following amounts:

Total Suspended Solids:	96,404 lbs.
Total Phosphorus:	137 lbs.
Bacteria:	~92%

Cost Projection

Based on VTrans's 5-year average costs for materials as placed and manufacturer's estimates for StormTech MC-4500 chambers, the cost projection for the chamber system at the Newport City Turnout site is as follows:

Table 30: Cost projection for the infiltration chamber system at NPC_013 (Newport City Turnout site).

Project: NPC_013 (Newport City Turnout Chambers)					
Item Code	Description	Quantity	Units	Unit Price	Total
Chamber Costs					
	StormTech MC-4500 Chamber Sections	115	EACH	$ 420.00	$ 48,300.00
	StormTech MC-4500 Chamber Sections	6	EACH	$ 550.00	$ 3,300.00
Piping Costs					
601.0920	24" CPEP	100	LF	$ 54.09	$ 5,409.00
601.581	18" CPEP Elbow (sub. For 24" Elbow for estimating)	3	EACH	$ 200.00	$ 600.00
605.10	6" Underdrain Pipe	550	LF	$ 20.63	$ 11,346.50
604.11	Concrete Manhole with Reinforced Cover	2	EACH	$ 3,090.00	$ 6,180.00
Materials and Excavation					
629.54	Crushed Stone Bedding	945	TON	$ 34.02	$ 32,148.90
203.30	Earth Borrow	555	CY	$ 8.04	$ 4,462.20
649.31	Geotextile Under Stone Fill	1966	SY	$ 2.27	$ 4,462.82
203.15	Common Excavation	1666	CY	$ 8.98	$ 14,960.68
204.20	Trench Excavation of Earth	50	CY	$ 14.27	$ 713.50
301.26	Subbase of Crushed Gravel, Fine Graded	355	CY	$ 40.22	$ 14,278.10

TOTAL	$ 146,161.70

Cost per Pound P Removed

The projected cost per pound of phosphorus removed is approximately $1,065.

5 Future Recommendations:

This Stormwater Master Plan represents a first effort with respect to identifying and implementing stormwater management practices in the Memphremagog Watershed. We have created a table of potential next steps for each of the Top 20 selected sites listing possible future steps to take to implement these practices.

In addition to the recommendations made in the table, we also recommend several other general options to pursue.

1) Adopt the Vermont League of Cities and Towns (VLCT) Draft Stormwater Bylaws and use the VLCT-developed Green Stormwater Infrastructure (GSI) Sizing Tool to develop local stormwater regulations that will aid communities in the Lake Memphremagog Watershed in adopting stormwater practices that will go above and beyond State-required practices. Adopting these practices will help the Watershed achieve phosphorus reductions beyond what State-based measures will dictate. All of these materials are contained in A-8 – VLCT Stormwater (folder of documents).

2) For communities with developed stormwater and sewer networks, institute a recurring Illicit Discharge Detection and Elimination (IDDE) program. Currently in Vermont IDDE, which looks for non-stormwater discharges to stormwater sewers, is only required to be performed once by statute. However, in areas with older infrastructure or developments, there can be failed, failing, and unintentionally cross-connected sanitary sewer discharging to storm sewers. For this reason, IDDE should be conducted every five years to ensure that these issues, which can often be highly concentrated sources of pollutants, aren't continuously discharging to local water bodies.

Site	Practice	Next Steps	Timeline (approx.)	Comments
CVY_001	Bioengineered Armoring	Survey swale (leaf-off) for final design Complete armoring specifications from survey Obtain funding and implement	2017	Funding and implementation from VTrans is possible.
DTB_009	Underground Chambers	Conduct additional soils testing Determine final site suitability Finalize design with updated soil information Obtain funding and implement	2018	Primary concern is soil suitability - otherwise a good candidate for ERP funding.
ORL_006	Infiltration Basin	Finalize design Obtain funding and implement	2017	Funding and implementation from VTrans is possible.
NPC_013	Underground Chambers	Finalize design Obtain funding and implement	2018	Good candidate site for ERP funding.
NPC_School_a & b	Gravel Wetland	Formalize landowner permission Conduct site survey Finalize 30% Design	2018	Conducting outreach to landowners is most critical step.
		Determine final site suitability Finalize design Obtain funding and implement	2019	Good candidate site for ERP funding.
BRT_New_c	Underground Chambers	Formalize landowner permission Conduct site survey Finalize 30% Design	2018	Village is potentially willing - need to formalize commitment from them. Need to verify that soils are adequate for infiltration during 30% Design.
		Determine final site suitability Finalize design with updated soil information Obtain funding and implement	2020	Good candidate site for ERP funding.
NPC Small Sites	Bioretention / Grass Swales	Formalize landowner permission Conduct site survey Finalize 30% Design	2018	Need to definitively determine land ownership (proximity to railroad).
		Determine final site suitability Finalize design Obtain funding and implement	2019	Good candidate site for ERP funding.

Site	Practice	Next Steps	Timeline (approx.)	Comments
ORL_002	Gravel Wetland or Underground Chambers	Formalize landowner permission Conduct site survey Finalize 30% Design	2019	Need to formalize permission from Village of Orleans, conduct outreach to Post Office landowner, determine groundwater level, infiltration capacity of soils.
		Determine final site suitability Finalize design Obtain funding and implement	2021	This process is contingent on outreach and site suitability - one or the other could preclude this for this site.
Numia Medical	N/A	Do not recommend pursuing practice at Numia Medical site - potentially unwilling landowner. Consider doing additional study within drainage for other opportunities.	N/A	
ORL_005	Infiltration Trench (or other practice)	Establish site ownership definitively Conduct outreach to owner to establish willingness Establish feasibility with respect to river corridor 30 and 100% Design	2020	Ownership and willingness is the primary concern. River corridor concerns will need to be settled after the ownership outreach has been conducted.
DTB_007	Infiltration Basin	Recommend waiting for Memphremagog TMDL Rules to take effect - site may fall under new permit requirements	N/A	
NPC_School_c and NPC_School_Main_Parking_Lot	Various	Conduct outreach to school to formalize permission to conduct additional design	2016	This site is potentially an excellent 'stand-alone' project for ERP funding as the property is publicly owned and could (pending landowner willingness) be a good retrofit site.
NPC_008	Gravel Wetland	Conduct outreach to Newport City as well as various interest groups that operate in the park Establish willingness to move ahead with design	2016-2017	Outreach is most important component on this busy, constrained site.

Site	Practice	Next Steps	Timeline (approx.)	Comments
Northpoint Auto	Underground Chambers	Continue outreach to landowner	2016	Landowner is willing to work with State or other organization to move forward with a solution. Continuing outreach in the near term will further the process.
GLV_001	Bioretention	Work with Town of Glover to design and build bioretention	2017	Landowner is willing - design process will be relatively simple. Possible candidate for ERP funding, more likely a candidate for in-kind donation from Town for construction.
DTB_VTrans	Gravel Wetland	N/A	N/A	VTrans currently has a valid stormwater permit - they may choose to upgrade or alter under new Memphremagog TMDL rules.
Rte_5_Erosion_a	N/A	Monitor current fix for erosion below fill area	N/A	If current fix does not prevent erosion from occuring downhill, re-routing runoff may be best solution.
BRT_New_a	Hydrodynamic Separator	Work with Village of Barton to determine siting and feasibility Conduct outreach to neighboring landowner (if necessary) Conduct final design	2017-2018	If placing separator in road R.O.W., no extra outreach will be necessary. Project may be suitable for ERP funding (water quality benefit).
Rte_5_Erosion_b	Bioretention	Conduct outreach to North Country Federal Credit Union Conduct survey and design for 30% Design level	2018	Project is entirely contingent on landowner willingness.