Stormwater Master Plan
Town of Sandgate, Vermont

December 29, 2017

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1.0 Introduction

The Town of Sandgate is situated within the steep mountains of the Taconic Range. The mountains, especially in the eastern and northern portions of the Town are densely forested with very limited roadways and development. The Town of Sandgate is entirely drained by Batten Kill tributaries, including the Green River and its tributaries, Chunks Brook, Sandgate Brook, and Terry Brook. These streams mainly begin to the east and north of the village and find their way into idyllic, wide valleys where the land has been in agricultural use for over two centuries. The Town of Sandgate is predominantly forested with areas of low density residential and agricultural land use. As with most mountain-valley villages of rural Vermont, stormwater concerns are typically related to road washouts and localized erosional areas. Since 1996, the Town of Sandgate has experienced eight moderate floods and one extreme flood, some of which have caused severe damage to private and public land and infrastructure from fluvial erosion and stormwater runoff. The most recent event, Tropical Storm Irene in August 2011, caused widespread damage in southern Vermont, including the Town of Sandgate.

In summer 2016, the Bennington County Regional Commission (BCRC) received a grant from the Vermont Agency of Natural Resources (Ecosystem Restoration Program) to develop a Stormwater Master Plan (SWMP) for the Town of Sandgate. Fitzgerald Environmental Associates, LLC (FEA) was hired by BCRC in the fall of 2016 to develop the plan. The Sandgate 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 Sandgate to prioritize projects, and follow-up analysis and design work.

1.1 Project Background

Stormwater runoff is generated any time rain or melting snow runs off the land; stormwater runoff typically increases when the land use has been altered from its natural state. Typically, hardened surfaces such as rooftops and roads are the primary sources of stormwater runoff, however in a rural setting it is important to consider hayfields, pasture, and other developed or agricultural areas that may increase and concentrate runoff. Increased runoff from these areas can exceed the capacity of natural hydrologic systems leading to erosion, flooding, and degradation of downstream receiving water bodies. The network of roads, ditches, and culverts that are found in steep rural settings are important for conveying stormwater and protecting infrastructure. However, these systems concentrate runoff, reduce infiltration, and may lead to areas of erosion and sediment generation.

Stormwater planning efforts in rural areas are most successful when carried out within a context of overarching watershed and stream corridor concerns including transportation infrastructure and maintenance, agricultural land uses, and areas of problematic stream channel erosion. The Batten Kill Corridor Plan (FGS, 2007), the White Creek and Mill Brook Corridor Plan (FEA, 2013), and Batten Kill, Walloomsac and Hoosic Tactical Basin Plan (VTANR, 2016) summarized stream corridor conflicts and watershed scale stressors and prioritized areas where specific projects and management strategies could reduce erosion conflicts and improve the ecological health of the watersheds. Additional information from high-resolution Light Detection and Ranging (LiDAR) elevation data, a detailed culvert assessment completed by the Bennington County Regional Commission (BCRC), meetings with stakeholders in Sandgate, and field visits to the Town were incorporated into this planning effort to build on past work and identify problem areas associated with stormwater in Sandgate. Best

Management Practices (BMPs) are suggested to mitigate stormwater problem areas contributing to infrastructure vulnerability and degradation of water quality in the watershed.

1.2 Project Goals

The goal of this project was to evaluate developed lands and road corridors in the Town to identify sources of increased stormwater runoff and associated sediments and nutrients discharging to the Batten Kill or its tributaries. The SWMP for Sandgate follows template 3b of the Vermont Stormwater Master Planning Guidelines with a focus on rural roads (VTDEC, 2013). The project tasks were to identify stormwater problem areas throughout the Town, develop one-page summary sheets for approximately 30 projects, complete detailed subwatershed mapping as needed for problem sites, and develop conceptual designs for five (5) high-priority projects.

The Sandgate Town Plan includes stormwater runoff and flood vulnerability as primary concerns for protecting water quality and infrastructure. It lists low impact development incorporating green stormwater infrastructure, stream crossing upgrades, and gravel road maintenance as specific opportunities to reduce water quality impacts and improve infrastructure resiliency (Town of Sandgate, 2015). The Town Highway Department has taken a number of steps to address stormwater runoff and water quality concerns by stabilizing ditches and culvert headers throughout the road network.

This SWMP provides Town officials and stakeholders with a list of high priority stormwater problem areas and conceptual solutions, which will support the development and implementation of future mitigation and restoration projects to improve water quality and reduce stormwater runoff impacts in Sandgate.

2.0 Study Area Description

Sandgate is a 42.3 square mile town located in Bennington County in the southwestern corner of Vermont (Fig. 1). Sandgate is bordered by 5 towns in Vermont (Rupert, Dorset, Manchester, Sunderland, and Arlington) and 1 in New York (Salem). The Town is entirely drained by Batten Kill tributaries, with the 30.4 square mile Green River watershed draining approximately half of Sandgate. The Town has a total population of 405 as of the 2010 Census (U.S. Census Bureau, 2011). Land cover data based on imagery from 2011 National Land Cover Dataset (Homer et al., 2015) are summarized in Table 1. The Green River and the Town of Sandgate as a whole are drained by a rural watershed, with forests representing the dominant land cover type. Agricultural lands, primarily as pasture land and hay fields, cover 3.2% of the Town, with a majority

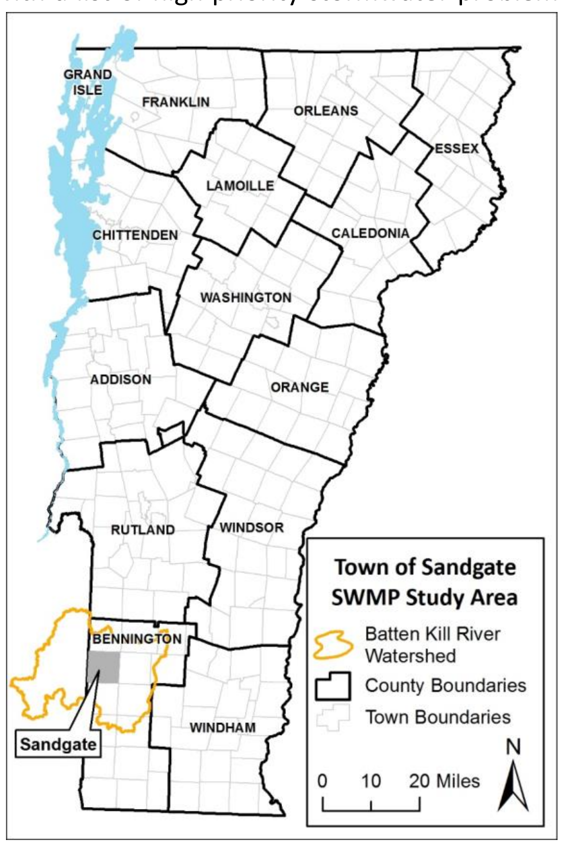


Figure 1: Town of Sandgate and Batten Kill watershed location map.

Table 1: Land cover in Sandgate.

Land Cover/Land Use Type	% of Town
Agriculture	3.2
Developed	1.6
Forest	93.9
Open Water	0.1
Shrub/Scrub	0.6
Grassland/Herbaceous	0.1
Wetland	0.5

of the farmlands found along the Sandgate and West Road corridors. Development is low throughout the study area (1.6%). There are 46.9 miles of roads in Sandgate (Table 2), made up of town highways (71.6%) and private roads (28.4%).

Table 2: Road length by AOT class in Sandgate.

AOT Class	Description	Length (miles)	% of Town Road Length
2	Class 2 Town Highway	7.5	16.0
3	Class 3 Town Highway	22.3	47.5
4	Class 4 Town Highway	3.8	8.1
8 & 9	Private Road	13.3	28.4

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 Sandgate. This section summarizes available documentation and other potential sources of information we explored. Much of this information is from previously completed studies in Sandgate or its associated watersheds, but also includes data sources discussed during a SWMP steering committee meeting on October 3rd, 2016. Other potential sources of data and data gaps are also addressed.

Basin Plan

The Tactical Basin Plan for the Batten Kill, Walloomsac and Hoosic Rivers was prepared by the Vermont Agency of Natural Resources in 2015 (VTANR, 2016). The basin plan catalogs current surface water quality conditions, stressors, and recommended actions for water quality restoration. Sandgate surface waters include the Batten Kill tributaries Green River and Chunks Brook and the White Creek tributary Sandgate Brook. Overall the water quality of the streams in Sandgate is good to excellent based on data collected by VTDEC over the last 10 years.

Ecological Condition

The Basin Plan summarizes streams and waterbodies with notable in ecological significance in the watersheds. The Green River is designated as very high quality by the Vermont Department of Fish and Wildlife for trout population densities. The ecological integrity of two Sandgate streams, Chunks Brook and the Green River, was rated as exceptional based on macroinvertebrate surveys collected in 2007 (Green River), 2008 (Chunks Brook), and 2013 (Green River).

Water Quality Stressors

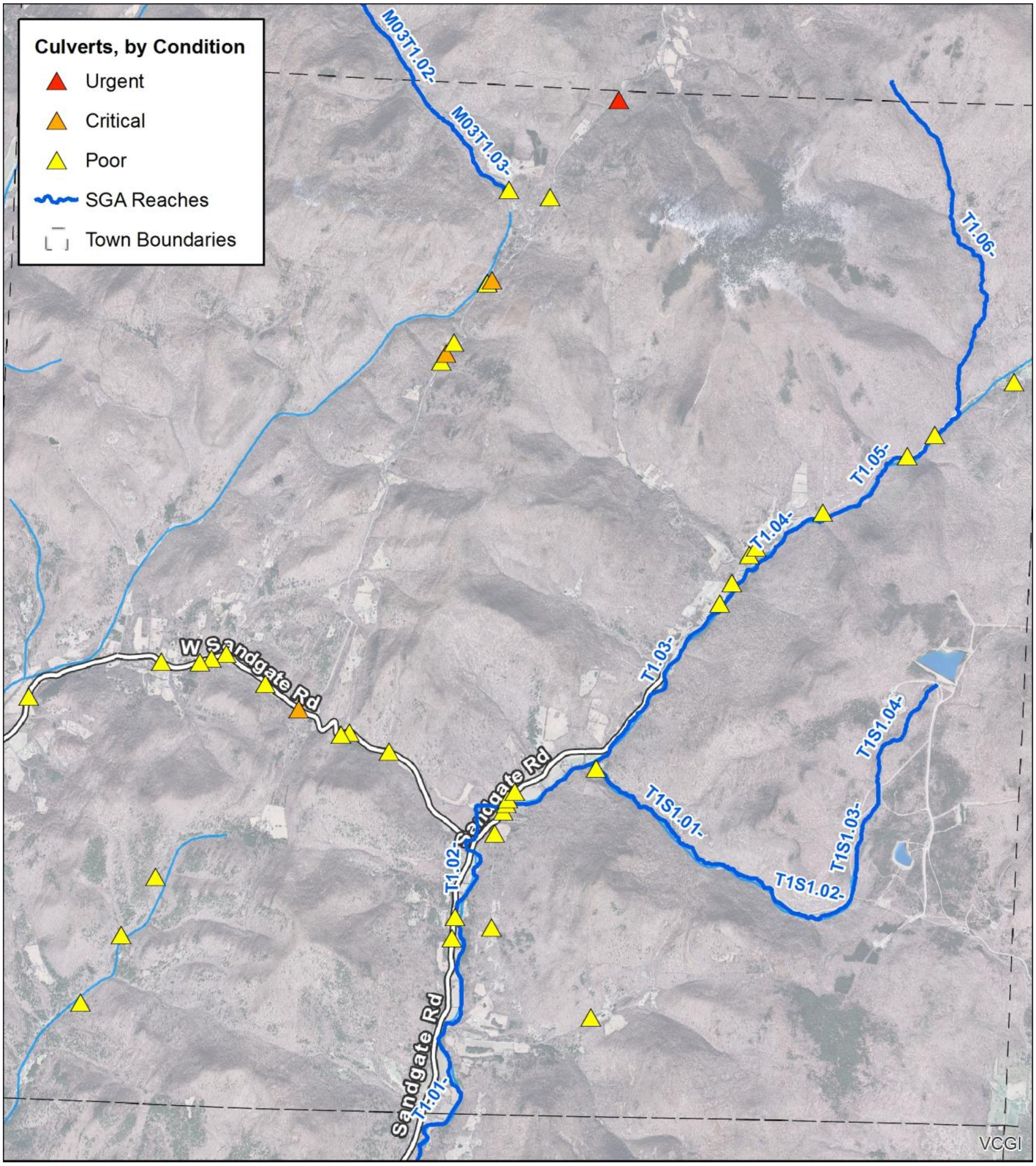
Potential water quality stressors specific to the Town of Sandgate include non-point source pollution from gravel roads and flow regulation from the hydroelectric operation at Lake Madeline in the headwaters of Hopper Brook (a tributary to Green River). Basin-wide restoration recommendations include riparian buffer plantings, agricultural BMP implementation in fields with high erosion risk, and identifying opportunities for dam removals and retrofits.

<u>Green River/Batten Kill and White Creek/Mill Brook Corridor Plans</u>

Field Geology Services prepared the Green River/Batten Kill Corridor Plan for the Vermont Department of Environmental Conservation in 2007 (FGS, 2007). Fitzgerald Environmental prepared the White Creek/Mill Brook Corridor Plan for the Bennington County Conservation District in 2013 (FEA, 2013). Several background themes relevant to stormwater master planning are touched on in the plans. Highlights from the Corridor Plans relevant to recent flooding and stormwater runoff in the watersheds are summarized below.

Overall Stream Stability and Habitat Conditions

A summary of the geomorphic and habitat conditions is provided below in Table 3, and a map of corresponding stream reaches is shown in Figure 2. Overall the stream conditions are fair to good for those river reaches assessed in more detail in the field. In the lower reaches of the Green River, the conditions are fair due to historic channel alterations resulting in reduced sinuosity, incision, and widening. In the upper reaches of Sandgate Brook where a steeper stream is found in a narrow valley, the conditions were assessed as good with limited impacts from road encroachment or adjacent development.



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Town of Sandgate Stormwater Master Plan

SGA and Culvert Inventory Data

Figure 2

Date: December 29, 2017
Drawn: EHB

Table 3. SGA reaches and selected attributes in Sandgate, VT

Stream	Reach	Reference Stream Type	Existing Stream Type	Confinement Type	Habitat Condition	Geomorphic Condition	Notes
Green River	T1.01	C	C	Very Broad	Fair	Fair	Departure to plane bed from riffle pool
	T1.02	C	C	Broad	Fair	Good	
	T1.03	B	B_c	Broad	Good	Good	
	T1.04*	B	-	Broad	-	-	
	T1.05*	B	-	Semi-confined	-	-	
	T1.06*	A	-	Semi-confined	-	-	
Hopper Brook	T1S1.01*	B	-	Narrow	-	-	
	T1S1.02*	B	-	Narrow	-	-	
	T1S1.03*	A	-	Narrow	-	-	
	T1S1.04*	C	-	Broad	-	-	
Sandgate Brook	M03T1.02	B_a	B	Narrow	Good	Good	
	M03T1.03*	A	-	Broad	-	-	

** Phase 1 assessment only*

Flood Damage

The Green River Phase 2 assessments were conducted prior to Tropical Storm Irene. However, berms constructed in response to flooding in 1973 and other historic floods were identified. These berms were generally found along the lower reaches of Batten Kill tributaries, such as the Green River in Sandgate.

Hydrologic and Sediment Regime Stressors

The Corridor Plans include maps of stressors on the hydrologic and sediment regimes of White Creek and the Green River based on data collected during the Phase 2 Stream Geomorphic Assessments in 2008 and from 2000-2005 respectively. These maps provide a means for linking the effects of increased stormwater runoff (i.e., gullying, severe channel sedimentation) to known stormwater problem areas in upslope watersheds. The hydrologic regime stressors identified in the Corridor Plans include areas of locally high road densities at the subwatershed level, wetland loss, and dam locations. The sediment regime stressors identified in the Corridor Plans include areas of higher densities of depositional and migration features in the channel such as bar features and flood chutes, identified at the reach-scale.

<ins>VTDEC Hydrologically Connected Road Segment Data</ins>

VTDEC created a statewide inventory of roads that are likely to be hydrologically connected to surface waters. The road network was split into 100m segments and then checked for proximity to surface waters and river corridors. Variables including road slope, adjacent hill slope, and soil erodibility were used to create a preliminary "road erosion risk rank". These ranking provide a good starting point for identifying areas of potential sediment generation from erosion of road surfaces and ditches. Road erosion risks are predicted to be low along the Green River valley bottom; moderate and high-risk segments become more prevalent along gravel roads in the steeper portions of the town.

Light Detection and Ranging (LiDAR)

LiDAR data for Bennington County were collected in a series of flights conducted in the spring of 2012 as part of the VT LiDAR Initiative. Derivations of LiDAR data, such as Digital Elevation Models (DEMs), terrain models, and contours are useful tools for stormwater feature identification and site design. The 2-meter DEM will assist in culvert watershed delineation and the design of stormwater management projects. Terrain models will assist in remote identification of erosion features, such as stormwater gullies.

Local Data

Sandgate Culvert Records

The Town of Sandgate completed bridge and culvert inventories in spring of 2013, and a follow-up inventory was conducted by Jim Henderson of Bennington County Regional Commission (BCRC) in the fall of 2016. A total of 379 culverts were included in the inventory. This assessment found 40 culverts that were rated as having an overall condition of poor, urgent, or critical (Figure 2). The assessments documented 18 culverts with a medium or high level of erosion. These culverts were further reviewed as part of our field surveys to determine whether upgrades or erosion control measures are warranted.

Town of Sandgate Hazard Mitigation Plan

The Town of Sandgate completed a Hazard Mitigation Plan in 2015. In support of flood and flash flood hazard analyses, the plan catalogues significant flood and rainfall events in Bennington County between 1996 and 2013. The plan includes a map of flood hazard areas and fluvial erosion hazard zones, as well as the locations of impoundments and beaver dams on Sandgate surface waters. Tropical Storm Irene landslide locations as well as road and culvert damages in Sandgate are mapped as well.

Tropical storm Irene (TSI) hit Vermont on August 28th, 2011 and dumped 3-5 inches of rain throughout the state with localized areas receiving totals from 7-11 inches. This rainfall coupled with high antecedent soil moisture conditions produced flooding that approached or exceeded the historic flood of 1927 in many large basins. In Sandgate, damage resulting from Tropical Storm Irene was significant, including road and culvert damages along Sandgate and Snow Roads.

Data Gaps

This watershed library describes the available documents, reports, and datasets that characterize stormwater and flooding concerns within the Town of Sandgate. The geomorphic field data available for the Green River and Hopper Brook through Sandgate were collected prior to Tropical Storm Irene. A full Phase 2 SGA may not be appropriate for these sections; however, additional data collection for stormwater concerns would be beneficial. Biomonitoring data is relatively sparse for the town, as most monitoring has occurred at downstream sites outside of Sandgate. Additional sampling effort in the Green River and smaller streams such as Chunks Brook would be helpful for tracking water quality within the Town.

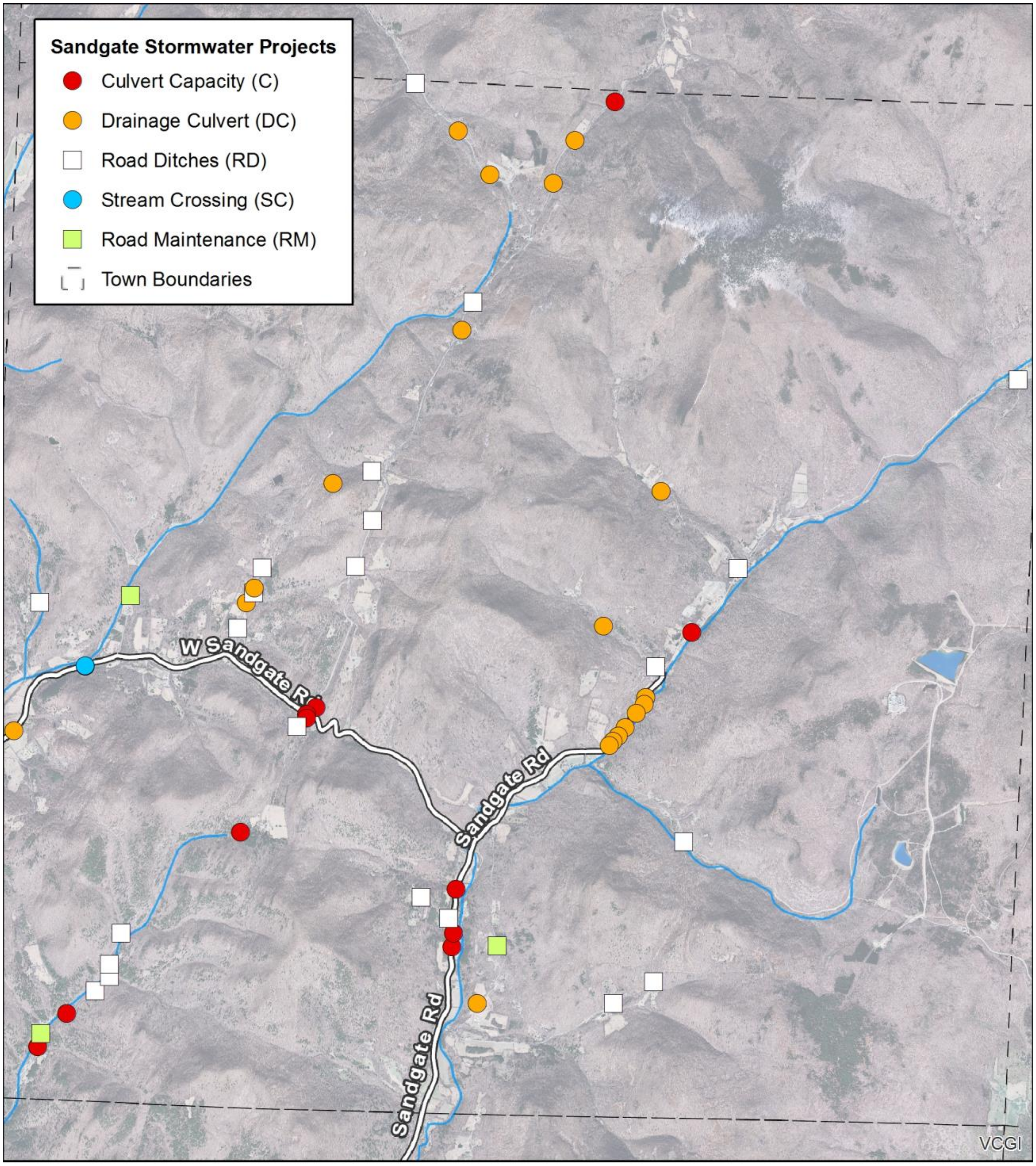
4.0 Stormwater Problem Areas

One of the primary goals of the stormwater master plan is to "develop a comprehensive list of stormwater problems" within the Town. FEA conducted several field tours of the project area and had meetings with the Sandgate Highway Department 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 with a desktop exercise scanning the watershed with imagery, NRCS soils data, Town of Sandgate culvert data, and high-resolution LiDAR contours and hillshade in a GIS. As part of this screening, FEA identified 12 culverts to visit mainly on first order and intermittent streams that were either in poor condition, had upstream or downstream bank erosion, or were suspected to be undersized. Meetings with Town officials including tours with the Town Road Foreman were conducted in the spring of 2017. A detailed watershed tour was conducted on two subsequent field visits by FEA staff to identify the remaining stormwater problem areas. A total of 51 stormwater problem areas were identified and assessed in the field (Figure 3, see detail map in Appendix A and table in Appendix B). We grouped the problem areas into five (5) categories described below.

- **C -** Eleven (11) culverts, mainly draining first order and intermittent streams, were analyzed for hydraulic capacity. Runoff volumes for different design storms (e.g., 2-year 24-hour rainfall) were modeled for each crossing using standard rainfall-runoff methods to recommend appropriate replacement culvert sizing.
- **DC** - Drainage culvert projects were identified in 14 locations where maintenance practices or stormwater runoff and associated sediment loads at cross-culverts located under Town maintained roads were deemed problematic.
- **RM** - Three (3) road maintenance projects were identified where longer stretches of road were deemed problematic and likely require work over a larger area than other projects in Sandgate.
- **RD** - Roadside ditch projects (22) were typically observed along steep sections of Town maintained gravel roads. Ditches may convey large volumes of sediment to receiving surface waters, especially if the ditch is eroding, or filling in causing water to run across the road surface.
- **SC** – One (1) stream crossing project was identified where a perennial stream crosses under a Town maintained road with an outlet drop that reduces Aquatic Organism Passage. Runoff volume and peak discharge for the contributing watershed was modeled to recommend appropriate replacement culvert size.



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Town of Sandgate Stormwater Master Plan

0 0.5 1 Miles
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Stormwater Problem Area Locator Map

Figure 3

Date: December 29, 2017
Drawn: EHB

4.2 Evaluation of Problem Areas

The 51 projects described in Appendix B 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, project cost and constructability, and additional benefits associated with project implementation.

GIS-based Site Screening

Using the field data points collected with a 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 Appendix B in the "problem area description" 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 Bennington and Windham counties in 2015 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 Bennington 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 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.

Prioritization Metrics

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, infrastructure resiliency, project feasibility, maintenance requirements, costs, and any additional benefits. The maximum possible score is 30 and the individual site scores ranged from 11 to 21 (Figure 4). Each category is described below and includes a description of the scoring for each criterion. Final evaluation criteria summarized in the table in Appendix B included the overall prioritization and the following components of the score:

- **Water Quality Benefits** (14 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 (2 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 acres
    - 2 points – Area of impervious surfaces is >0.5 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 receives minimal treatment before reaching receiving waters
    - 3 points – Stormwater drains directly into receiving waters (typically stormwater draining directly into a large wetland is assigned 2 points)
- **Infrastructure Resiliency/Flood Vulnerability (3 points)** – Reduction in flood vulnerability and/or improvement in infrastructure vulnerability associated with project implementation.
    - 0 points – No change in resiliency or vulnerability
    - 1 point – Some improvement in resiliency or reduced vulnerability, especially in smaller floods
    - 2 points – Project will increase resiliency and/or decrease vulnerability across a range of flood magnitudes
    - 3 points – Project will significantly increase resiliency and decrease vulnerability during large flood events

- **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 (3 points total)** – Description of other project benefits, total score is roughly a count of the number of additional benefits.
    - (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) High Visibility – The site is highly visible and will benefit from aesthetically designed treatment practices
    - (4) Improves BMP Performance – Project implementation will improve the performance of existing stormwater treatment practices that receive runoff from the site
    - (5) Improves Aquatic Organism Passage – Project implementation will improve fish passage through stream crossing structure

Figure 4: Ditch erosion at a culvert inlet along Woodcock Road (left) was one of the lowest scoring projects (DC-9). Large piles of loose sediment along Sandgate Road (right) following recent culvert and road work were the highest scoring project due partly to its proximity to the stream (DC-14).

Hydraulic Analysis

Hydrologic and hydraulic analyses were completed to determine predicted flow volumes and culvert capacity for selected culverts described in the C and SC projects. This process aids in prioritizing potential culvert replacement projects. The dimensions, inlet/outlet configuration, and slope for each culvert were determined in the field using laser surveying equipment. Culvert drainage areas were delineated using the USGS StreamStats software and contours generated from the LiDAR DEM. Field observations of ditch drainage areas were incorporated into the watershed delineations (drainage areas shown in Appendix A). Recurrence interval flow rates were estimated for each culvert using a TR-20 hydrologic model constructed with HydroCAD 10.0 software. The watershed was characterized by land cover, soils, and topography to estimate runoff volumes and peak flow rates. 24-hour rainfall depths for the recurrence interval storms were estimated using the Extreme Precipitation in New York and New England web tool created by the Northeast Regional Climate Center and the Natural Resources Conservation Service. Culvert capacity was calculated using the Federal Highway Administration HY-8 software. The software calculates headwater depth for each recurrence interval flow and estimates the culvert capacity before the road is overtopped (Table 4). We compared HydroCAD and HY-8 estimates of culvert capacity and, in all cases, the culvert capacity predicted by the HY-8 model was lower. The HY-8 modeling results are reported in Table 4.

Table 4: Basin runoff and culvert capacity from HY-8 modeling

							Discharge (cfs)					
Site ID	**Road**	**Drainage Area (ac)**	**Culvert Type**	**Slope (ft/ft)**	**Dimensions (ft)**	**Manning's Roughness**	**Q10**	**Q25 (design)**	**Q100 (extreme)**	**Culvert Capacity[1]**	**Q10 Free-board (ft)**	**Q25 Free-board (ft)**
C-1	Chunks Brook Road	112.9	Pipe Arch	0.04	2.2' x 3.5'	0.025	57.5	92.0	169.3	40.2	-0.25	-0.5
C-2	Tate Hill Road	56.4	CPP	0.11	2' Diameter	0.024	26.0	40.9	74.1	18.4	-0.19	-0.4
C-3	Tate Hill Road	73.7	CMP	0.02	2' Diameter	0.024	60.7	95.5	172.4	27.3	-0.30	-0.5
C-4	Tate Hill Road	134.3	Tank & CMP	0.05	3' Diameter	0.018	69.7	107.2	189.3	54.5	-0.19	-0.4
C-5	Sandgate Road	44.9	CPP	0.04	18" Diameter	0.024	10.3	19.2	41.3	14.5	2.25	-0.1
C-6	Sandgate Road	46.6	CMP	0.06	2' Dia. (0.7' sediment)	0.024/ 0.035	20.5	36.0	72.4	14.8	-0.12	-0.3
C-7	Sandgate Road	437.0	CMP	0.09	4' Diameter	0.024	153.0	257.8	499.6	115.7	-0.31	-0.8
C-8	Sandgate Road	103.4	CMP	0.01	1.5' Dia. (0.05' sediment)	0.024/ 0.035	19.8	38.0	84.1	10.1	-0.24	-0.5
C-9	Snow Road	108.6	Pipe Arch	0.08	2.5' x 3.5'	0.025	56.8	94.0	179.0	43.2	-0.48	-0.7
C-10	Rupert Road	53.2	CMP	0.02	2' Dia. (0.7' sediment)	0.024/ 0.035	34.2	53.8	97.5	16.3	-0.25	-0.4
SC-1	West Sandgate Road	1,715.4	Tank	0.02	5.3' Diameter	0.012	439.2	736.6	1,428.1	214.5	-0.53	-0.9
C-11	West Sandgate Road	56.5	CMP	0.04	2' Diameter	0.024	33.7	53.9	99.3	24.2	-0.26	-0.6

1 - Culvert capacity before road overtops using HY-8 model

4.3 Problem Area Summary Sheets

Problem area summary sheets were developed for 27 selected projects (Appendix C). The summary sheets include a site map, problem area description, site photographs, a summary of the prioritization categories, and ballpark cost estimates. These sheets were shared with BCRC and Town representatives.

4.4 Project Prioritization and Conceptual Designs

Evan Fitzgerald and Joe Bartlett met with Jim Henderson (BCRC) and Mike Hill (Sandgate) to review and prioritize the problem areas identified in this document. The following five (5) problem areas were selected for further investigation with conceptual designs provided in Appendix D.

- **RD-2:** Runoff from Rupert Road is exacerbating severe slope erosion along a very steep embankment to Terry Brook.
- **RD-8:** A long section of West Road lacks appropriate drainage increasing erosion and exacerbating poor road conditions during wet periods.
- **RD-14:** Concentrated runoff from the road surface is causing severe erosion at the outlet of a cross-culvert directly into a stream along lower Wilcox Hollow Road. The culvert outlet is also scoured.
- **RD-15:** Concentrated runoff from Wuerslin Road is causing erosion at the intersection with Sandgate Road.
- **RD-21:** Poor road drainage along Sandgate Road in "Beartown" is causing significant erosion along the road edges.

5.0 Next Steps

This Stormwater Master Plan represents an extensive effort to identify, describe, and evaluate stormwater problem areas throughout the Town of Sandgate. Many of the problem area descriptions (e.g., drainage culverts and roadside ditches) will aid the Town Highway Department in proactively sizing and constructing these features to avoid future stormwater problems. We provided a preliminary cost estimate and a site rating to aid the Town and other stakeholders in planning and prioritizing restoration efforts.

We recommend that the Town of Sandgate, BCRC and BCCD work together and with VTDEC and VTrans to secure funding for the highest priority projects listed above in Section 4.4 and described in detail in Appendix D. The remaining stormwater problem areas summarized in Section 4.3 and Appendices B and C could be prioritized based on their overall impact and programmed for funding in the future. In addition to addressing the problem areas identified in this document, the Town can take steps to reduce future stormwater problems through planning and zoning regulations as described in the Town Plan (Town of Sandgate, 2015). Many of the problem areas covered in this document are representative of typical issues encountered on gravel roads (i.e., stone lining ditches, culvert sizing, ditch maintenance) in steep watersheds. The recommended practices to address these issues should be applied to future projects to reduce the risk of stormwater runoff conflicts and sediment loading to receiving waters.

6.0 References

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