# Upper Winooski River Basin Illicit Discharge Detection and Elimination Project: Final Report

STONE
ENVIRONMENTAL

PROJECT NO.
**15-090**

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*Cover photo: wastewater from a broken sewer lateral leaking through the walls of a catchbasin in Barre*

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# 1. Introduction

Illicit discharges contribute to the degradation of local receiving waters and can pose a public health risk. Illicit Discharge Detection and Elimination (IDDE) studies are performed to identify contaminated discharges, locate the sources of contaminants, and plan infrastructure repairs of other corrective actions. Without special study many illicit discharges can go undetected for years, even decades.

Among the many types of illicit discharges that have been identified in Vermont, sanitary wastewater is generally considered as having the greatest impact. Wastewater flowing to storm drains from directly connected municipal sewers or building sewer pipe connections can result in significant nutrient and microbial pollution. Sanitary wastewater can also enter storm drains through indirect connections, leaking from sanitary sewers, sewer service laterals, and malfunctioning septic systems into stormwater pipes and structures. Other types of illicit discharges encountered in previous studies include graywater connections (washwater from laundry machines, sinks, dishwashers, etc.), mop water and oil dumping via floor drains and catchbasins, pet waste and trash dumping, vehicle washing runoff, and (infrequently) industrial discharges. Municipal water leaks are also discovered in IDDE studies.

Diluted wastewater flows may appear clean and may travel a circuitous path to reach the storm drain outfall. Other discharges, such as illegal dumping to catchbasins, are intermittent; hence difficult to catch. Without exception, our experience has been that municipalities and private owners on whose properties we have discovered an illicit discharge were previously unaware the discharge was occurring. Through the sustained efforts of Vermont Department of Environmental Conservation (DEC), municipalities, organizations, and private contractors the prevalence of illicit discharges in Vermont has been declining over the last decade. However; it must also be recognized that new illicit discharges arise every year as aging infrastructure fails, and plumbing mistakes are inevitably made.

The goal of this Upper Winooski River Basin IDDE project was to improve water quality by identifying and eliminating contaminated, non-stormwater discharges (illicit discharges) entering stormwater drainage systems and discharging to surface waters in the participating municipalities. Five municipalities participated in this project: Barre City, Barre Town, Berlin, Plainfield, and Stowe. IDDE studies had previously been conducted by FWR and/or Stone in all five municipalities. The largest of these studies, the Stevens Branch plus Stowe IDDE project, was conducted by Stone and FWR in 2014-2015 and involved assessment of 595 stormwater drainage systems. The present study was recommended in the 2014-2015 Stevens Branch plus Stowe study final report. The scope and findings of all the previous studies in these municipalities are summarized in the following section.

## 1.1. Previous IDDE studies in the participating municipalities

Five previous IDDE studies involving the participating municipalities were conducted by FWR and/or Stone, as follows:

1. 2003 Barre City project by FWR, funded by a Section 319 Water Quality Grant administered by DEC: Primarily a visual survey of the major outfalls to the Stevens Branch, conducted by volunteers. This study was completed without the benefit of DEC's stormwater infrastructure mapping.

2. 2006 Barre City project by FWR and Stone, funded by Barre City as a Supplemental Environmental Project (in lieu of a state fine for an ammonia release to the Stevens Branch): An assessment of 78 outfalls to the Stevens Branch and its major tributaries with advanced investigations (primarily camera inspection) of approximately 12 stormwater drainage systems with suspected illicit discharges. Among other outcomes, a significant repair was made to the municipal sewer on River Street, eliminating a wastewater discharge to system BC1120. This study was completed without the benefit of DEC's stormwater infrastructure mapping

3. 2009 Mid-Winooski project by FWR and Stone, funded by a DEC Clean and Clear water quality grant: Outfalls were assessed in Berlin, Montpelier, and Northfield. In Berlin, 60 outfalls to the Stevens Branch were assessed. As a result of this study, four significant wastewater cross-connections were eliminated in Montpelier. This study was completed without the benefit of DEC's stormwater infrastructure mapping.

4. 2013 Headwaters IDDE project by FWR and Stone, funded by a DEC Clean and Clear water quality grant: Systems were assessed in Cabot, Marshfield, and Plainfield. Among other outcomes, this study resulted in identification of wastewater contamination in catchbasin P-CB-100 in Plainfield, although the source was not identified.

5. 2014–2015 Stevens Branch plus Stowe project by FWR and Stone, funded by a DEC Ecosystem Restoration grant: The geographic scope of the project included the entire extents of the municipal closed drainage systems in Barre City, Barre Town, Berlin, Stowe, and Williamstown. Prior to this assessment, DEC prepared stormwater infrastructure maps for each municipality. This infrastructure mapping was used to plan the assessment and to guide further investigations in certain systems with suspected illicit discharges.

   In Barre City and Berlin, the results of studies #2 and #3 were reviewed to select stormwater drainage systems to assess or reassess. The locations of the outfalls assessed in studies #2 and #3 were compared with DEC's infrastructure mapping to identify which outfalls in Barre City and Berlin had been previously assessed. The 2003 study was not considered in this comparison because, while it provided some relevant information, it was not sufficiently rigorous for these purposes. This comparison was made in GIS using the proximity of the assessed outfalls to outfalls mapped in DEC's infrastructure geodatabase. All systems that were not previously assessed at the outfall were designated for assessment in this project apart from highway drainage systems along Route 62, which were considered to have minimal potential for illicit discharges. Previously assessed systems were then grouped in the following categories:

   I. Small and medium sized systems where contaminants had not been detected at the outfall.

   II. Large systems with no indication of contamination, but for which outfall assessment alone may not have been sufficient.

   III. Systems where contaminants had been detected and further investigation did not reveal a specific pollutant source.

IV. Systems in which contaminants had been detected, a specific pollutant source was identified, and a correction was either implemented or planned.

Together with the unassessed systems, the previously assessed systems in Barre City and Berlin in categories II, III, and IV above were reassessed. In total, FWR and Stone assessed 595 stormwater drainage systems. The distribution of the assessed systems by municipality and the time periods in which the assessments were completed are provided in Table 1.

*Table 1. Systems assessed and period of assessment in each municipality*

| Municipality | Total Number | Organization | Timeframe |
|---|---|---|---|
| Barre City | 227 | Stone/FWR | July–October, 2014 |
| Barre Town | 193 | Stone/FWR | June–July, 2014 |
| Berlin | 73 | FWR | July–September, 2015 |
| Stowe | 72 | Stone | July–September, 2015 |
| Williamstown | 30 | Stone | October–November, 2015 |

Among the 595 systems assessed, contaminants and/or observations indicating a possible illicit discharge were detected in 93 systems. In September 2015, Stone began investigating certain priority systems to confirm the presence of illicit discharges and attempt to determine their sources. The project contract allowed for advanced investigation of a maximum of 14 systems. Systems were prioritized for investigation based on their potential water quality impact as well as operational considerations. In cooperation with the municipalities, five systems were investigated in Barre City, five in Barre Town, and four in Williamstown. These investigations resulted in completion of repairs to municipal sewers to eliminate wastewater discharges to systems BC1630 (two repairs) and BC240.

Further assessment or advanced investigation of the 79 remaining systems in which contaminants were detected was outside the scope of the 2014-2015 project. We recommended further assessment and investigation in a follow-on study and separated the 79 systems into two categories—reassessment or advanced investigation—based on the level of effort we assumed would be required to address them. All systems in which optical brightener had been detected were placed in the advanced investigation category, because a chronic illicit discharge necessitating considerable investigation is more likely in these systems than in systems without optical brightener. Two additional systems, BE100 and ST370, were added to the advanced investigation category because the evidence strongly indicated presence of an illicit discharge.

## 1.2. Scope of Present Study

The scope of the present study was based on the recommendations for follow-on work contained in the Stevens Branch plus Stowe IDDE study, with minor adjustments by DEC, including the addition of system P-CB-100 in Plainfield. Table 2 presents the list of systems requiring reassessment or advanced investigation.

*Table 2. Systems designated for reassessment ("RE") or advanced investigation ("AI")*

| Barre City | | Barre Town | | Berlin | | Stowe | | Plainfield | |
|---|---|---|---|---|---|---|---|---|---|
| RE | AI | RE | AI | RE | AI | RE | AI | RE | AI |
| BC020 | BC130 | BT100 | BT2640 | BE080 | BE100 | ST010 | ST170 | | P-CB-100 |
| BC110 | BC140 | BT390 | | BE160 | | ST030 | ST250 | | |
| BC120 | BC290 | BT550 | | BE210 | | ST040 | ST350 | | |
| BC180 | BC410 | BT570 | | BE500 | | ST420 | ST370 | | |
| BC560 | BC450 | BT660 | | | | | ST700 | | |
| BC790 | BC520 | BT670 | | | | | | | |
| BC1100 | BC550 | BT680 | | | | | | | |
| BC1310 | BC570 | BT690 | | | | | | | |
| BC1320 | BC800 | BT950 | | | | | | | |
| BC1420 | BC830 | BT1010 | | | | | | | |
| BC1490 | BC990 | BT1050 | | | | | | | |
| BC1510 | BC1120 | BT1090 | | | | | | | |
| BC1630 | BC1290 | BT2000 | | | | | | | |
| BC1710 | BC1300 | BT2050 | | | | | | | |
| BCF020 | BC1620 | BT2120 | | | | | | | |
| BCF040 | BCF170 | BT2260 | | | | | | | |
| BCF050 | BCF470 | BT2370 | | | | | | | |
| BCF070 | | BT2420 | | | | | | | |
| BCF140 | | BT2440 | | | | | | | |
| BCF180 | | BT2470 | | | | | | | |
| | | BT2480 | | | | | | | |
| | | BT2510 | | | | | | | |
| | | BT2590 | | | | | | | |
| | | BT2650 | | | | | | | |
| | | BT2670 | | | | | | | |
| | | BT2740 | | | | | | | |
| | | BT2820 | | | | | | | |
| 20 | 17 | 27 | 1 | 4 | 1 | 4 | 5 | 0 | 1 |

# 2. Methods

## 2.1. Preparation for the Assessment

Preparation for this project involved updating field maps and assembling necessary equipment and supplies. Since the project was a continuation of the 2014-2015 Stevens Branch plus Stowe effort, kickoff meetings with the participating municipalities were not needed.

## 2.2. Reassessments

Stormwater drainage systems designated for reassessment were observed and tested during dry weather to minimize dilution by stormwater runoff. Dry weather was defined as negligible rainfall (less than 0.1 inches), beginning at approximately 12:00 p.m. the previous day. Stormwater drainage systems with ten or fewer inlets were typically assessed only at the outfall. Within larger stormwater drainage systems, catchbasins and junction manholes were also assessed to account for any effects of dilution. Stormwater structures were accessed along the public right-of-way or from the receiving waterbody, as appropriate. Where access permission was obtained, stormwater structures located on private property were also assessed, particularly if these structures were connected to a municipal drainage system.

At every outfall or other stormwater structure assessed, a visual inspection was made of the condition of each discharge point and the area immediately below each discharge point. If present, dry-weather flows were observed for color, odor, turbidity, and floatable matter. Obvious deficiencies in the structure, such as severe corrosion, were noted. Dry weather flows were sampled by hand or using a telescoping pole. At catchbasins and manholes located at junctions in the storm sewer, samples were collected independently from each in-flowing pipe, when possible. Field data were entered on printed assessment forms (**Appendix A**).

In order to identify potential illicit discharges from laundry facilities, leaking sanitary sewers, and cross-connections, each dry weather discharge was tested for ammonia, methylene blue active substances (common detergents), and the presence of optical brighteners. Specific conductance was measured as an indication of the dissolved solids content. To detect treated municipal water leakage, samples were also analyzed for free chlorine concentration.

With few exceptions, structures that were not flowing at the time of the initial inspection were assumed not to have illicit connections and no further assessment of these structures was performed. Our general procedure is to provide additional assessment of non-flowing structures only if there is evidence of contamination, such as suds, odors, or certain deposits.

### 2.2.1. Water Analysis Methods

The ammonia concentration was tested using Aquacheck ammonia test strips. Samples were tested for methylene blue active substances using CHEMetrics test kit K-9400, a method consistent with American Public Health Association Standard Methods, 21st ed., Method 5540 C (2005). Free chlorine analysis was conducted with powdered DPD reagent (Hach Method 8167, equivalent to USEPA method 330.5) and a portable Hach DR/900 colorimeter. Specific conductance was measured using an Oakton model conductivity meter, according to Stone Environmental Standard Operating Procedure (SOP) 5.23.3 (**Appendix B**).

Optical brightener monitoring was performed at outfalls and selected catchbasins and manholes that were flowing at the time of inspection, in accordance with Stone Environmental SOP 6.38.0 (**Appendix B**). To test for optical brightener, a cotton pad was placed in the flow stream for a period of 5–10 days, after which the pad was rinsed, dried, and viewed under a long-wave ultraviolet light ("black light"). Florescence of the pad (seen on the pad in Figure 1) indicates the presence of optical brightener. Pads were held in a sleeve of vinyl window screen, clipped to the rim of the outfall pipe or secured with fishing line to a rock or other anchor. At catchbasins and manholes located at junctions in the storm sewer, pads were deployed in incoming pipes if possible, but were often hung from the catchbasin grate or manhole rung into the sump. An advantage of optical brightener monitoring is that some intermittent or dilute wastewater discharges can be detected due to the multiple-day exposure of the pad, whereas the contaminant may not be detected in tests performed on grab samples.

*Figure 1. Positive optical brightener pad under fluorescent (left) and UV (right) lamps.*

Table 3, below, lists the water quality tests that Stone performed at all discharge points and selected catchbasins and manholes that were flowing at the time of inspection.

*Table 3. Water quality tests performed at flowing structures*

| Parameter | Sample Container | Analytical Method |
|---|---|---|
| Ammonia | Plastic vial | Aquacheck ammonia test strips |
| MBAS detergents (anionic surfactants) | Plastic vial | APHA Standard Methods, 21st ed., Method 5540 C (2005) |
| Free chlorine | Glass jar | By DPD, Hach Method 8167 (EPA 330.5) |
| Specific conductance | Glass jar | Stone SOP 5.23.3 |
| Optical brightener | Cotton test pads | Stone SOP 6.38.1 |

## 2.3. Advanced Investigations

Stormwater drainage systems suspected of passing illicit discharges—as identified in Table 2—were investigated further, employing bracket sampling procedures, camera inspection, dye testing, and/or smoke testing. The goal of bracket sampling is to isolate the contaminant source between adjacent structures, such as a catchbasin and a down-pipe manhole. DEC's stormwater infrastructure mapping was used to guide this effort.

The most reliable method to bracket sources of wastewater contamination is usually optical brightener monitoring throughout the drainage system. In several instances, we used optical brightener results to narrow the search area for illicit discharges to a specific structure or to the pipe between two structures. The presence and appearance of dry-weather flows were also useful in isolating sources of contamination within storm sewer segments.

After bracketing the discharge source as closely as possible using the water quality test methods, Stone worked with the participating municipalities to find specific improper connections, leaks, and other problems contributing to the contaminated flows observed in the stormwater drainage systems. Engineering plans were reviewed to identify possible cross-connections between sanitary sewers and stormwater drainage systems, particularly locations where leakage from a sanitary line could be intercepted by the stormwater system. Dye testing, camera inspections, and smoke testing were performed in Barre City, Plainfield, and Stowe to identify specific improper connections.

### 2.3.1. *E. coli* and Phosphorus

In the stormwater drainage systems investigated under this contract, water samples were collected for total phosphorus and *E. coli* analyses at outfalls, unless the outfall was dry or prior testing demonstrated negligible concentrations of these constituents. The State of Vermont Agriculture and Environmental Laboratory (VAEL) performed both analyses. Phosphorus was analyzed because of its impact on the ecology and use of Lake Champlain. *E. coli* bacteria levels provide an indication of fecal contamination; due to human health concerns, *E. coli* enumeration is recommended for all fresh waters used for contact recreation or for water supply.

Samples for *E. coli* analysis were collected in sterile, plastic 100-mL bottles and analyzed using Quanti-tray. Total phosphorus was analyzed by DEC's Standard Operating Procedure (SOP) for Determination of Phosphorus by Flow Injection, Revision 6. The preservation and holding time requirements are given in Table 4.

*Table 4. Laboratory sample analyses*

| Parameter | Sample Container | Analytical Method | Sample Preservation | Holding Time |
|---|---|---|---|---|
| Total P | Glass vial (50 mL) | DEC SOP, Revision 6 | Cool (4°C) | 28 days |
| *E. coli* | Plastic (100 mL) | SM 9223B (Colilert Quanti-Tray) | Cool (4°C), sodium thiosulfate | 6 hours |

At the same time that water samples were collected for *E. coli* and total phosphorus analyses, flow measurements were made to enable calculation of total phosphorus mass loading. Flow was measured by timing the filling of a container of known volume or using the float method.

# 3. Barre City Results

On January 19, 2016, a meeting was held with the City of Barre to discuss the findings of the Stevens Branch plus Stowe IDDE study in Barre City (Stone Environmental, Inc., 2016, dec.vermont.gov/sites/dec/files/wsm/erp/docs/IDDE/Stevens%20%2B%20Stowe%20IDDE%20Final%20Report.pdf ). The attendees were Steve Micheli (Superintendent of Water and Wastewater), Everett Hoyt (Barre Public Works), Jim Pease (DEC), Dave Braun (Stone), Ann Smith (FWR), and Shawn White (FWR). Mr. Micheli was provided with a set of maps of outfall locations where contaminants were detected. Information gathered during this meeting regarding completed or planned infrastructure improvements is discussed in the following sections, where applicable.

Reassessments of the systems identified in Table 2 were performed in the summer and fall of 2016. Advanced investigations were performed in the fall of 2016 and 2017. After bracketing the discharge sources as closely as possible, Stone communicated results to Mr. Hoyt and Mr. Micheli. Mr. Hoyt led the majority of the dye testing and camera inspections, in regular consultation with Dave Braun.

## 3.1. Reassessments

Reassessments were performed on 20 stormwater drainage systems in Barre City that had been assessed in the Stevens Branch plus Stowe IDDE project (Table 2). In addition to testing for ammonia, MBAS, free chlorine, conductivity, and optical brightener, samples were collected for *E. coli* and total phosphorus analysis where possible. In most cases, repeated sampling demonstrated that no chronic illicit discharge was present. Reassessment data for the 20 Barre City systems are included in **54,** Table 1. Our findings relative to each of these systems are presented in Table 5.

*Table 5. Summary of status of reassessed systems in Barre City*

| System | Status | Comment |
|---|---|---|
| BC020 | No chronic illicit discharge | The outfall was dry when visited, July 13, 2016. |
| BC110 | No chronic illicit discharge | No OB or other contaminants were detected, July 6 and 13, 2016. |
| BC120 | No chronic illicit discharge | The outfall was dry when visited, July 6, 2016. |
| BC180 | No chronic illicit discharge | The outfall was dry when visited on July 6, 2016. No foul odor was present. |
| BC560 (Maple Ave.) | Illicit discharge confirmed. A.I. included in separate DEC contract #33432. | OB was detected at outfall. A sample collected at the outfall on July 21, 2016 contained 710 MPN/100 mL *E. coli*. Samples collected at the outfall on July 29, 2016 contained 0.71 mg/L of MBAS and 0.11 mg/L of chlorine. |
| BC790 (Blackwell St.) | Illicit discharge suspected. A.I. included in separate DEC contract #33432. | Optical brightener was detected at the outfall on two occasions in 2016. The ammonia concentration at the outfall was slightly elevated on July 13, 2016. |
| BC1100 (Hersey Ave.) | Illicit discharge strongly suspected. A.I. included in separate DEC contract #33432. | The *E. coli* concentration on July 21, 2016 was high, 4,350 MPN/100 mL, and an elevated ammonia concentration (0.75 mg/L) was measured at the outfall. OB was detected in CB6 (junction CB), but not in CB8 or CB7 |

| System | Status | Comment |
|---|---|---|
| | | On July 5, 2016, Mr. Hoyt flushed dye at 10 Hersey Drive and did not observe dye in the stormdrain. He previously tested 17 Hersey Drive and did not observe dye in the stormdrain.<br>Mr. Hoyt plans to inspect the line up and down pipe of CB6 with a CCTV camera. |
| BC1310 | No chronic illicit discharge | The outfall and system were dry when visited on July 6, 2016. |
| BC1320 | No chronic illicit discharge | While the specific conductance was quite high (5.05 mS/cm), no optical brightener was detected and concentrations of ammonia, chlorine, MBAS, *E. coli*, and TP were negligible or below detection. |
| BC1420 | No chronic illicit discharge | The outfall was dry when visited on July 6, 2016. |
| BC1490 | No chronic illicit discharge | No optical brightener or other contaminants were detected. Concentrations of *E. coli* and TP were negligible. |
| BC1510 | An illicit industrial discharge is suspected. A.I. included in separate DEC contract #33432. | On July 21, 2016 a low concentration of free chlorine was measured (0.14 mg/L) and gray stone dust was observed at the outfall. An elevated TP concentration of 530 µg/L was measured at the outfall on July 2, 2016. No optical brightener was detected. |
| BC1630 (Hill St.) | A broken sewer lateral serving 204 Hill St. was replaced in September 2016. This is the third repair in BC1630. However, based on sampling conducted after the repair an additional illicit discharge is suspected. Further A.I. is included in separate DEC contract #33432. | Despite two previous repairs in BC1630, samples collected on July 21, 2016 had elevated *E. coli* (1,080 MPN/100 mL) and TP concentrations (357 µg/L). Optical brightener, ammonia, and a wastewater odor were also present. The sewer service for 204 Hill Street was determined to be broken and discharging to the stormdrain. Dye flushed at 204 Hill Street on August 4, 2016 showed immediately in the stormdrain. This problem was repaired in September 2016.<br>The system was reassessed on November 17, 2016. A wastewater odor was not observed; however, optical brightener was detected up the main stormline to MH11 at the intersection of Hill Street and Nelson Street (Map BC-14). |
| BC1710 | No chronic illicit discharge | The outfall was dry when visited on July 21, 2016. |
| BCF020 | No chronic illicit discharge | The outfall was dry when visited on July 13, 2016. |
| BCF040 | No chronic illicit discharge | The outfall was dry when visited on July 13, 2016. |
| BCF050 | No chronic illicit discharge | A very low ammonia concentration (0.25 mg/L) was measured, but optical brightener was not detected, and the concentrations of all other constituents were negligible. |
| BCF070 | No chronic illicit discharge | OB was not detected at the outfall and the concentrations of the other contaminants were below detection, confirming there is no chronic illicit discharge in this system. |
| BCF140 | No chronic illicit discharge | OB was not detected at the outfall and the concentrations of ammonia, chlorine, and MBAS were below detection. |
| BCF180 | No chronic illicit discharge | The outfall was dry when visited on July 21, 2016. |

The intent of the reassessment task was to establish with greater certainty whether an illicit discharge was present. Because the project scope of work did not include advanced investigation of these systems, it was expected that any follow-on investigations necessary to find and eliminate a discharge would occur under a separate contract. Subsequently, based on these data Watershed Consulting Associates (WCA) was awarded a contract (#33432) for advanced investigation of systems BC560 (Maple Ave.), BC790 (Blackwell St.), BC1100 (Hersey Ave.), BC1510, and BC1630 (Hill St.). Despite the limited scope of the reassessment task, the City of Barre Department of Public Works put considerable effort into evaluating systems BC1100 and BC1630. In the case of BC1100, the City has not been successful in determining the source of the wastewater contribution to this system. In system BC1630, the City found and compelled replacement of a bad sewer service lateral (204 Hill St.) in 2016, the third illicit discharge eliminated in this system; however, testing in November 2016 indicated there is still a wastewater component in the outflow.

## 3.2. Advanced Investigations

Advanced investigations were performed on 17 stormwater drainage systems in Barre City that had been assessed in the Stevens Branch plus Stowe IDDE project (Table 2). Our findings relative to each of these systems are presented below.

### 3.2.1. BC130

The BC130 system drains Daniel Drive and Country Way. It discharges via a 36-inch diameter corrugated metal culvert to an unnamed tributary of the Stevens Branch near the intersection of Daniel Drive and Westwood Parkway (Map BC-1). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- Optical brightener pads placed throughout the system on June 16, 2016 were all negative. The system was flowing clear and no odor, suds, or other indications of an illicit discharge were observed.

**Conclusion:** Based on the absence of optical brightener, we do not suspect a chronic illicit discharge in this system.

**Resolution:** NA

### 3.2.2. BC140

The BC140 system drains the northern end of Westwood Parkway and Palmisano Plaza, as well as Arioli Avenue. It discharges via a 24-inch diameter corrugated metal pipe to an unnamed tributary of the Stevens Branch at the intersection of Westwood Parkway and Prospect Street (Map BC-1). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

**<u>2014-2015 (prior study)</u>**

- Optical brightener was detected at the outfall on July 31, 2014. A foul order was observed in the receiving stream channel.
- On September 22, 2015, samples were collected at the outfall for *E. coli* and total phosphorus analysis. The phosphorus concentration was very low, 12 $\mu$g/L. The *E. coli* concentration (170 MPN/100 mL) was lower than expected given the presence of bags of dog waste in catchbasins in this system. The stream channel upstream and downstream of the outfall was also littered with bags of dog waste.
- On September 23, 2015, monitoring pads were set in all the flowing catchbasins throughout the system. Optical brightener was detected in all structures from the outfall up-pipe to catchbasin CB15 on Palmisano Plaza. Optical brightener was not detected in basins on Westwood Parkway above its intersection with Arioli Avenue.

- On September 23, 2015, a petroleum odor was observed in catchbasin CB12 and oily residue was observed in catchbasin CB13 on Palmisano Plaza. CB13 is located in front of #31 Palmisano Plaza. The catchbasin grate had an oily appearance, indicating waste oil had been recently dumped into the drain. A dumpster containing machine parts was located next to this catchbasin in front of #31 Palmisano Plaza.
- In mid-November, Mr. Hoyt TV'd the storm sewer from CB14 to CB15. There was clear flow the length of the pipe. There were pipe penetrations at 57 ft., 87 ft., and 160 ft. and clear flow from the pipes at 57 ft. and 160 ft.
- On November 24, 2015, Dave Braun and Mr. Hoyt inspected catchbasins on Palmisano Plaza. At #31 Palmisano Plaza, a material had been spread on the side path and around the dumpster to absorb spilled waste oil. Steve Micheli, Public Works Director, visited #31 Palmisano Plaza to advise the owners to dump no waste in the drain. Mr. Micheli also required them to move the dumpster away from catchbasin CB13.

**<u>2016-2017</u>**

- Monitoring pads were set throughout the system on June 16, 2016. All pads set on Palmisano Avenue were negative for OB. OB was detected at the outfall and in catchbasin CB1 only. Suds were observed at the outfall.
- In June 2016, Mr. Hoyt dye tested the sewer main on lower Westwood Avenue near CB5. No dye was observed crossing into the stormdrain.
- On September 28, 2016, samples collected at the outfall had very low total P (28.4 µg/L) and *E. coli* (11.5 MPN/100 mL) concentrations (54, Table 1).
- Pads deployed on September 27, 2016 indicated OB enters the stormdrain between CB2 and CB3. OB pads were positive in the outfall, CB1, and CB2. Pads were negative in CB3, CB4, and CB18.
- Mr. Hoyt dye tested the sanitary sewer on Daniel Drive and the house at #4 Westwood Parkway in October 2017. No dye appeared in the catchbasin CB2.
- Pads deployed on October 13, 2017 confirmed that OB enters the stormdrain between CB2 and CB3. OB pads were positive in CB1 and CB2, while the pad in CB3 was negative.
- On October 19, 2017, Mr. Hoyt dye tested the house at #8 Westwood Parkway. Dye was observed in CB2 and was not seen in CB3. This result suggested that the sewer lateral serving #8 Westwood Parkway is leaking into the stormdrain. The lateral appears to pass over the stormdrain.

**Conclusion:** Three apparently unrelated problems were identified in this system over several years. In 2016-2017, the source of optical brightener in the system was identified; a leaking residential sewer lateral at #8 Westwood Parkway.

**Resolution:**

- Disposal of dog waste in catchbasins on Westwood Parkway remains an ongoing concern.
- Disposal of waste oil in catchbasin CB13 by the homeowner at 31 Palmisano Plaza was resolved in 2016. There was no evidence of waste oil dumping in the system in 2017.

- An illicit sanitary wastewater discharge was identified at #8 Westwood Parkway. The sewer lateral serving this house is leaking into the underlying stormdrain. The City of Barre indicated that a repair is being planned with the homeowner for spring 2018.

### 3.2.3. BC290

The BC290 system drains a small portion of North Main St. (Route 302) near its intersection with Packard Street. It conveys a stream flowing to the Stevens Branch (Map BC-2). This system was included in the advanced investigation list due to detection of optical brightener in 2014.

**Findings:**

- Pads set throughout the system on June 3, 2016 were all negative for presence of optical brightener.
- Pads were set at the outfall and an adjacent outlet on June 14, 2016. Both pads were negative.

**Conclusion:** Based on the absence of optical brightener, we do not suspect a chronic illicit discharge in this system.

**Resolution:** NA

### 3.2.4. BC410

The BC410 system drains the property of the Barre City wastewater treatment facility. It flows to the Stevens Branch (Map BC-3). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- The system was dry when inspected on June 3, 2016.
- Monitoring pads were set throughout the system on June 3, 2016. Optical brightener was detected in the sump of catchbasin CB2 and within Pipe A discharging to CB2. No optical brightener was detected in CB4. The OB results at the outfall, CB1, and CB3 were indeterminate.
- Using a sewer camera, Mr. Hoyt inspected CB2 Pipe A in July or the first week of August 2016. Pipe A is aligned with the generator building. 28 feet into Pipe A from CB2, the pipe is sealed with bricks and mortar. Mr. Hoyt determined that there was no flow through the seal.

**Conclusion:** Steve Micheli of Barre City Public Works believes the optical brightener detected in this system is the inevitable consequence of activities at the wastewater treatment facility. He suspects the main source is residue on the tires of trucks used to transport pressing cake.

**Resolution:** NA

### 3.2.5. BC450

The BC450 system drains the lower portion of Beckley Hill Road. It discharges via a 14-inch diameter corrugated metal pipe to an unnamed stream which flows to the Stevens Branch (Map BC-4). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- The system was dry when visited on June 3, 2016. There were no indicators of a potential illicit discharge.
- Monitoring pads set throughout the system on June 3, 2016 indicated possible contamination in catchbasin CB4. OB was detected in CB4, although the fluorescence was weak. The OB results in CB3 and CB5 were indeterminate. No OB was detected at the outfall, CB1, CB2, or CB6.
- There are two apartment buildings on Bromur Street adjacent to catchbasins CB3 and CB4, both owned by Downstreet Housing and Community Development. Mr. Hoyt dye tested one apartment in each building on July 26, 2016. The dye did not cross over to the storm sewer.
- The system was dry when visited on September 28, 2017.
- A second set of monitoring pads was deployed on October 13, 2017 in CB3 and CB4. No OB was detected in either catchbasin.

**Conclusion:** Based on the weakness of the fluorescence observed on the original CB4 monitoring pad in 2016, the absence of OB in the October 2017 pads, and the results of the dye testing, we conclude there is no chronic illicit discharge in this system.

**Resolution:** The City of Barre plans to replace the stormwater drainage system on lower Beckley Hill Road. Replacement was initially scheduled for 2017; however, it was not completed and the current timeframe for this project is unknown. While we do not suspect a chronic illicit discharge in this system, replacement of the stormdrain should address any deficiency, should a problem exist that we have not identified.

### 3.2.6. BC520

The BC520 system drains a portion of Elmwood Avenue. It discharges via a 16-inch diameter vitrified clay pipe to Gunners Brook (Map BC-5). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- Monitoring pads were deployed throughout the system on July 29, 2016. No optical brightener was detected; however, the OB result was indeterminate at CB4 and CB7.
- The City of Barre replaced a buried sanitary manhole on Elmwood Avenue in August 2016 to alleviate clogging of the line.
- Shortly after the manhole was replaced, no optical brightener was detected at the outfall or in the four catchbasins tested (CB3, CB4, CB5, and CB7).
- A pad set at the outfall on September 27, 2016 was also negative.

**Conclusion:** We suspect a very slow sanitary wastewater leak was resolved when the City of Barre replaced a deteriorated sanitary manhole on Elmwood Avenue in August 2016. We do not believe there is an ongoing illicit discharge to this system.

**Resolution:** Repaired completed.

### 3.2.7. BC550

The BC550 system drains a portion of Newton Avenue, Pine St., Elmwood Ave., and Farwell St. It discharges via a 22-inch diameter corrugated metal pipe to Gunners Brook (Map BC-5). This system was designated for advanced investigation due to observation of a slight wastewater odor at the outfall and an indeterminate optical brightener result in the first catchbasin (CB1) up the line in 2014.

**Findings:**

- The City of Barre cleaned the stormline and inspected the main line with a CCTV in the spring of 2016.
- Monitoring pads were deployed throughout the system on June 3, 2016. Optical brightener was detected at the outfall, CB1, and CB4. The result at CB6 was indeterminate. These results suggested a wastewater contribution in the Newton Street branch.
- In August 2016, Mr. Hoyt dye tested the sanitary main and one or more houses on Newton Street between Beach St. and Elmwood Street. No dye appeared in the storm sewer, although he stated that he may not have used enough water for a definitive test.
- The *E. coli* concentration measured on September 28, 2016 was slightly elevated, 167 MPN/100 mL.
- On or about November 3, 2016, Mr. Hoyt dye tested the house at #1 Newton St. as well as Buzzi's garage (35 Farwell St.). No dye appeared in the stormwater system.
- In July 2017, a sewer lateral serving #15 Newton Street was replaced. The lateral was reportedly broken and clogged with roots. This lateral is believed to have crossed over the storm sewer and was likely leaking into the line.
- On October 18, 2017, Mr. Hoyt flushed dye at #28 Farwell St. No dye was observed in CB2; however, the 4-inch dimeter drain discharging to CB2 appeared to begin to drip after the dye was flushed.
- Monitoring pads deployed on November 1 and retrieved on November 7, 2017 indicated that optical brightener was present in CB1 and CB10. No OB was detected in the 4-inch diameter pipe discharging to CB2. The OB result at CB4 was indeterminate.
- On November 21, 2017 Dave Braun, Wayne Graham (VRWA), and Mr. Hoyt again inspected the main line with a CCTV and dye tested the Newton St. sewer main. We were unable to access #1 Newton Street. Dye did not cross over to the storm sewer and no obvious defects, contaminated flows, or wastewater solids were observed in the Newtown St. storm line.

**Conclusion:** We suspect wastewater was leaking from the sewer lateral at #15 Newton Ave. into the underlying storm drain. This problem was resolved when the lateral was replaced; however, optical brightener was detected in the same branch of the system four months afterward. At this time, we are unsure whether optical brightener is flushing out of the soil and stormline or whether a second wastewater discharge is present. If a second wastewater leak is present, we suspect a broken sewer lateral at either #1 Newton St. or #68 Elmwood Ave.

**Resolution:** We recommend further optical brightener testing of the Newton Street stormdrain in 2018 to establish whether there is an ongoing sanitary wastewater contribution. Residual OB from #15 Newton St. should have flushed out in the inventing months.

### 3.2.8. BC570

The BC570 system drains a portion of lower Farwell St. It discharges via a 12-inch diameter vitrified clay pipe to Gunners Brook (Map BC-6). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- Optical brightener was detected in CB1 on June 3, 2016.
- In June 2016, Mr. Hoyt dye tested the Farwell St. sewer main and#16 Farwell St. Dye flushed down the toilet at #16 Farwell St. seeped into the base of catchbasin CB1. The wall of catchbasin CB1 had a seepage line that was aligned with the sewer service for #16 Farwell St. Dye did not flow from the sewer main to the stormdrain.
- In September 2016, the owner of #16 Farwell St. replaced the sewer service from the house foundation to the sewer main.
- Samples collected at the outfall on September 28, 2016 had negligible *E. coli* and a moderate total P concentration (192 µg/L).
- An OB pad set at the outfall on September 27, 2016 was negative, confirming that the repair at #16 Farwell St. was successful and that no other illicit discharges are present in this system.

**Conclusion:** A broken sewer lateral serving #16 Farwell St. was replaced, which eliminated sanitary wastewater leakage to this system.

**Resolution:** Repaired completed and discharge eliminated.

### 3.2.9. BC800

The BC800 system drains portions of John St., Blackwell St., Thomas St., and Gallow Ave. It discharges via a 12-inch diameter plastic pipe to an unnamed tributary of the Stevens Branch. This system was designated for advanced investigation due to detection of optical brightener at manhole MH1 in 2014.

**Findings:**

- There was no flow in the system when it was visited on June 7, 2016. Monitoring pads were deployed throughout the system and no optical brightener was detected.

**Conclusion:** We do not suspect a chronic illicit discharge in this system.

**Resolution:** NA

### 3.2.10. BC830

The BC830 system drains a portion of Brown Avenue (Map BC-8). It consists of two catchbasins connected to a buried culvert, which conveys a stream beneath properties on Brown Ave. to a 38-inch diameter concrete outfall below Lawrence Ave. This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- On or about May 31, 2016, the sanitary manhole at the intersection of Brown Ave. and Harold St. was rebuilt. It had been caving in, causing the sewer to surcharge. The sewer lines were flushed after the repair.
- Monitoring pads were set throughout the system on June 7, 2016. No optical brightener was detected at either culvert inlet (Ci1 and Ci2) or either catchbasin (CB1 or CB2). The only location where optical brightener was detected was at the culvert outlet.
- Pads deployed in on July 29, 2016 revealed that optical brightener was still present at the outfall and was not present in CB1.
- Samples collected at the outfall on September 28, 2016 had low concentrations of *E. col*i (8.6 MPN/100 mL) and total P (125 μg/L).
- On several visits to the outfall between September and November 2017, the flow appeared clear and not malodorous. However, an OB pad deployed at the outfall on October 13, 2017 was positive. A second pad deployed on October 19, 2017 and retrieved on November 1, 2017 was strongly positive.
- On November 1, the sanitary manhole on Brown Avenue was inspected. Six 2-inch diameter PVC pipes discharge to the manhole. These are the outlets of sanitary force mains from houses on Lawrence Ave. The outlets of all six pipes appeared dry. To confirm that wastewater was discharging to the sanitary manhole (and not the inaccessible stream culvert), buckets were placed within the manhole to catch the effluent. This test confirmed the force mains discharge to the sanitary system.
- The house at #10 Lawrence Ave. reportedly has a septic system located in a yard either directly over or close to the stream culvert. The owner of this home refused to allow us to enter the house to perform a dye test.

**Conclusion:** We suspect the septic system at #10 Lawrence Ave. drains to the buried stream culvert. This is the only property located between CB1 and the outfall. The absence of odor and wastewater solids suggests an indirect sanitary wastewater connection. We suspect the stream culvert serves an underdrain for the leachfield on this property.

**Resolution:** Because there is no indication of surfacing wastewater at #10 Lawrence Ave., there does not appear to be a way to resolve the suspected, subsurface discharge of partially renovated wastewater from the leachfield at #10 Lawrence Ave. to the stream culvert.

### 3.2.11. BC990

The BC990 system drains a portion of Onward St. and Cassie St. It discharges via a 12-inch diameter plastic pipe to an unnamed stream draining to Potash Brook (Map BC-9). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- Monitoring pads were deployed throughout the system on June 7, 2016. Optical brightener was detected at the outfall. No optical brightener was detected in CB1 or in any upstream structures.
- The sanitary sewer was dye tested via a manhole at the intersection of Onward and Currier Street. No dye was observed at the outfall. This sanitary manhole is close to the stormdrain, but the sewer line is deeper than the stormdrain.
- The sanitary sewer on Currier Street is an old 6-inch diameter vitrified clay line. Mr. Hoyt inspected this line with a CCTV, noting cracks in the pipe but no major breaks. The sewer pipe is not a good candidate for slip lining due to its small diameter and depth (10-12 feet). The stormdrain between CB1 and the outfall is also in poor condition.
- Barre City plans to slip line the section of stormdrain between CB1 and the outfall in 2018, which should eliminate any infiltration of wastewater into the stormdrain.

**Conclusion:** We suspect there is a minor leak in the sanitary sewer near the intersection of Currier and Onward Streets and that the storm line between CB1 and the outfall is intercepting diluted wastewater.

**Resolution:** The City of Barre Department of Public Works plans to eliminate wastewater infiltration into the stormdrain by slip lining the storm sewer in 2018.

### 3.2.12. BC1120

The BC1120 system drains Center Street and its side streets, Oswald, Howard, and George Streets. It discharges to the Stevens Branch behind the Nativi Playground (Map BC-10). There has been a long history of problems in this system. A sanitary sewer pipe runs through a stormwater manhole MH1, making an unsupported bend within (Figure 2). This pipe has been broken and patched multiple times. In 2014 and 2015, optical brightener and a strong wastewater odor were detected in catchbasin CB1, which we attributed to the recurrent sewer line break. Optical brightener was also detected in manhole MH3, indicating a second wastewater discharge further up the system.

**Findings:**

**2014-2015 (prior study)**

- Optical brightener was detected at the outfall in a monitoring pad deployed on September 25, 2014. Optical brightener was also detected at catchbasin CB1 and manhole MH3. A strong wastewater odor was observed at CB1.
- An elevated *E. coli* concentration of 660 MPN/100 mL was measured at the outfall on September 22, 2015.
- On October 5, 2015, optical brightener monitoring pads were deployed in many locations in the drainage system. Optical brightener was detected at catchbasin CB1, manhole MH3, and catchbasin CB6 on Howard Street near its intersection with Center Street. The fluorescence of the pad was markedly greater at CB1 than at MH3 or CB6. Optical brightener was not detected at catchbasins CB5, CB7, or CB8.

- On October 13, 2015, additional monitoring pads were deployed at structures above CB6 on Howard Street (CB9, CB10, CB11, and CB12) to bracket the source of optical brightener entering this line. Optical brightener was detected at catchbasins CB6 and CB9 on Howard Street, but not in catchbasins CB10 or CB11 or in the stream inlet at the intersection of Pike and George Streets.

*Figure 2. Stormwater manhole MH1 with concrete sewer main running through it*

- The concrete sewer main flowing through stormwater manhole MH1 (Figure 2) has reportedly been repaired multiple times in the last decade. This pipe was found to be leaking badly when FWR and Stone performed the first Barre City IDDE project in 2006. According to the Department of Public Works, it was repaired in 2006 and again more recently. In a November 24, 2015 meeting, Everett Hoyt indicated he had recently inspected the pipe section and it was not leaking. Mr. Hoyt also explained that he had found and cleared a major obstruction in the sewer main in the sanitary manhole immediately below this section of pipe. The obstruction has caused wastewater to surcharge but not overflow the sanitary manhole.
- A monitoring pad placed in catchbasin CB1 on November 24, 2015 indicated presence of optical brightener (though fluorescence was weak). There was no odor or elevated temperature in this structure, in contrast to previous inspections.
- In November 2015, the Department of Public Works reportedly cleaned the storm line on Howard Street in preparation for inspecting it with a closed-circuit TV camera. A camera malfunction delayed the work. Oil stains were observed on the catchbasin CB9 grate.

**2016-2017**

- In June 2016, optical brightener was detected at the outfall, CB1, and CB9, which were the only structures tested.
- In August 2016, the stormline on Howard Street was cleaned of hard mineral deposits. The sewer main on Howard Street was dye tested near #12 or #14 Howard Street. Dye did not cross over to the stormdrain. The house at #12 Howard (closer to CB10) is under foreclosure.
- On September 13, 2017, suds were observed in CB11, which appeared to flow from an 8-inch diameter SDR35 pipe entering CB11 (Pipe A). Optical brightener was detected in this pipe and was not detected in the other two pipes discharging to CB11. This finding indicated a source of optical brightener above CB11.

- On September 13, 2017 and again on October 3, 2017, a strong wastewater odor was observed in catchbasin CB1. A pad placed in this catchbasin was strongly positive. This finding indicates that a significant sewer leak is present near this catchbasin.
- OB pads were placed in CB11 pipe A and CB12 on October 13, 2017 and retrieved on November 1, 2017. Both pads were negative. CB12 is offline and was dry, so a negative result was expected; however, the absence of OB in CB11 Pipe A was surprising given the detection and suds in September.
- Barre City plans to slip line the section of sewer main crossing through the stormdrain manhole MH1. The City requested price quotations to complete this work.
- On November 21, 2017, Dave Braun, Mr. Graham, and Mr. Hoyt smoke tested catchbasin CB11 on Howard Street. No smoke was observed venting from the sanitary sewer or houses on Pike Street. A dye test was performed at #44 Pike St. and no dye was observed in the stormdrain. We were unable to access #36 Pike St. We also attempted to inspect the 8-inch SDR pipe entering CB11 and hit an obstruction a short distance into the pipe.

**Conclusions:** We suspect there are two sources of optical brightener—and wastewater—entering this system. One source is in the area where the sanitary sewer crosses through storm manhole MH1. In 2014, water pressure in the sewer main resulting from an obstruction in the sanitary manhole likely caused wastewater and sewer odors to infiltrate the storm drain. Cleaning the sewer main appears to have reduced this problem temporarily; however, by the fall of 2017, significant wastewater leakage was occurring in this area.

A second source of sanitary wastewater in this system was found entering CB11 on Howard Street via an 8-inch diameter SDR35 pipe. In 2014-2015, we suspected the problem on Howard Street was between CB9 and CB10; now we believe the source is upstream of CB11.

**Resolution:** The City of Barre's plan to slip line the sanitary main through storm MH1 should proceed as soon as possible. We recommend a thorough inspection of the sanitary sewer pipe and the sanitary manhole in this location in preparation for this work, in case there are multiple deficiencies that need to be remedied. Regarding the 8-inch diameter SDR pipe entering CB11 on Howard Street, we are certain there was a wastewater contribution in the line in September 2017. Although the problem apparently did not reoccur when we visited the site in October, we nevertheless recommend further investigation, starting with cleaning the line and inspecting it with a camera, as the City of Barre DPW had planned to do in the fall of 2017.

#### 3.2.13. BC1290

The BC1290 system drains a portion of Granite Street. It discharges via an 8-inch diameter corrugated metal pipe to the Stevens Branch (Map BC-11). This system was designated for advanced investigation due to detection of optical brightener and petroleum odor and sheen at the outfall in 2014.

**Findings:**

- On May 19, 2016, the sanitary sewer line was cleaned. A wastewater odor was observed in catchbasin CB2.

- The Granite Street sewer line was inspected with a CCTV on May 25, 2016. A misaligned pipe joint was found, which is believed to cause wastewater backups, resulting in wastewater infiltration into the stormdrain.
- Monitoring pads were deployed throughout the system on June 14, 2016. Optical brightener was not detected in the catchbasins tested, CB1, CB2, CB4, and CB5.
- A petroleum sheen and odor were repeatedly observed at the outfall. This finding will be referred to DEC for follow-up inspection, as it was in 2015.
- The Barre City Department of Public Works stated that they intended to replace both the sanitary sewer line and stormline on lower Granite Street in 2017. However, this work had not been performed through November 2017. Evidently it has been postponed until 2018.

**Conclusion:** We suspect there are occasional wastewater backups in this system, caused by a misaligned sanitary sewer pipe. The City of Barre intends to correct this problem by reconstructing the sewer main. With respect to the petroleum odor and sheen present at the outfall, we suspect contaminated groundwater from a historic hazardous materials release, possibly the Barre coal tar site, is migrating to the Stevens Branch in this location.

**Resolution:** Follow up with the City of Barre DPW is recommended to determine when the Granite Street sewer project will be completed.

### 3.2.14. BC1300

The BC1300 system drains portions of Granite St., Garfield Ave., Portland St., and Essex St. It discharges to the Stevens Branch via an 18-inch diameter corrugated plastic pipe immediately downstream of the Granite Street bridge (Map BC-12). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- In June 2016, optical brightener was detected in two swales (Swale 1 and Swale 2) draining to catchbasins on Granite Street, as well as in four catchbasins on Granite Street downstream of these swales. OB was also detected in CB8, which is on the main stormline above the points where the swales discharge to the stormdrain. The water was clear and was not malodorous.
- In July 2016, OB was detected in CB8, CB8.5, and CB9. OB was not detected in CB9 Pipe A or in CB13.
- On August 4, 2016, Mr. Hoyt dye tested the sewer main on Prospect Street and at the intersection of Garfield and Liberty Streets. In both tests, dye was observed in the sanitary sewer and did not cross over to the stormdrain.
- In September 2016, the house at 56 Bassett Street was dye tested. The sewer main on Bassett Street was also dye tested at multiple locations. No dye was observed in the stormdrain.
- Although neither swale was flowing on September 27, 2016, monitoring pads were deployed. No optical brightener was detected in either swale.

- Samples collected at the outfall on September 28, 2016 had no *E. coli* and an extremely low total P concentration.
- Optical brightener was detected on a pad collected at swale 2 on November 28, 2016, while a pad collected in swale 1 was negative.
- On September 13, 2017, gullies on the hillside between Granite, Bassett, and Prospect Streets were inspected. No possible sources of illicit discharges were found. There are two sources of flow to the swales, the BCF070 drainage system and groundwater seeps at the base of a steep riprapped slope. No optical brightener was detected on monitoring pads placed in the major gullies. A pad placed at the BCF070 outfall was also negative. However, a pad placed in CB8 at the intersection of Garfield and Lincoln Streets was positive. This indicates a contaminant source higher in the system.
- On October 13, 2017, OB pads were placed in multiple structures (CB8, CB8.5, CB9, CB14, and MH1) to attempt to bracket the OB observed at CB8. Pads were retrieved on October 26, 2017. The only structure in which OB was detected was CB8.5, and fluorescence was weak. There are no catchbasins on the main line upstream of CB8.5 that can be safely accessed.
- Mr. Hoyt plans to clean and inspect catchbasin CB8.5, which is a large, badly deteriorated structure. There is a 1-inch diameter steel pipe crossing through the basin that is unusual. There is the possibility that opening this structure will reveal an inappropriate connection.

**Conclusion:** A great deal of effort was expended attempting to identify a source of optical brightener in this system. Our OB results were inconsistent, which is unusual, and the system was also unusually difficult to assess due to the fact that the catchbasins above CB8.5 (intersection of Garfield Ave. and Lincoln Streets) are off-line and traffic conditions prevent assessment of manholes in the center of Portland Street.

Optical brightener is the only contaminant that has been detected in this system. Regarding intermittent detection of optical brightener in the swales, we suspect optical brightener is transported in groundwater from a wastewater leak, seeping into the swales at the base of the rip rapped slope. If this is the case, the source could be distant. Regardless of the actual source, we do not believe this problem warrants further investigation, given the water quality data collected at the outfall and the clarity of the water in the swales.

The source of the optical brightener detected at catchbasin CB8.5 is unknown, primarily because the upper portion of this system is unusually difficult to assess. All accessible structures upstream of CB8.5 are believed to be offline.

**Resolution:** NA

### 3.2.15. BC1620

The BC1620 system drains Camp Street, Delmont Ave., Clifton Street, and Tremont Street. It discharges via a 20-inch diameter concrete pipe to Potash Brook (Map BC-13). This system was designated for advanced investigation due to detection of optical brightener in catchbasin CB1 in 2014.

**Findings:**

- Pads deployed in this system on June 16, 2016 revealed OB contamination originating near the Clifton/Delmont intersection (CB31). A wastewater odor was observed at multiple catchbasins on the

Delmont Ave. branch of the system. On the Camp Street branch, the pad set in CB43 was negative and the pads in catchbasins CB15 and CB33 were lost.

- Optical brightener was detected on monitoring pads set in CB15 and CB33 on June 30, 2016, indicating an OB source on the Camp Street branch also.
- Mr. Hoyt dye tested houses on Delmont Ave. above Clifton Street and observed dye in the stormdrain. Excavation revealed a significant break in the 6-inch diameter VC sewer main on Delmont Avenue where it crosses over the VC stormline at the Delmont/Clifton intersection. Six houses are connected to the Delmont Ave. sanitary sewer main above the break in the pipe. The majority of the wastewater liquids appeared to leak from the sanitary sewer into the underlying stormdrain while the solids were retained in the pipe. On August 30, 2016 the 6-inch VC sanitary main was repaired using a section of PVC pipe. The underlying stormdrain was repaired by sealing a joint with QSR cement.
- Samples collected at the outfall on July 13, 2016 and September 28, 2016 had negligible *E. coli* and very low total P concentrations (41.9 µg/L).
- Monitoring pads were deployed throughout the system on September 27, 2016. Optical brightener was present on the CB31 and CB41 pads, and was absent in CB33, CB35, CB39, and CB49. Pads set in CB43, CB45, CB48, and CB51 all had indeterminate results.
- Pads deployed on November 17, 2016 still indicated a problem in both the Camp Street and Delmont Ave. lines. OB was detected in CB14, CB31, and CB15.
- OB pads were deployed in multiple structures on October 13, 2017. OB was detected in both the Delmont Ave. stormline (CB15) and the Camp St. stormline (CB14).
- OB pads were deployed in multiple structures on November 1 and retrieved on November 7, 2017. In contrast to the October 2017 results, OB was not detected in the Camp Street stormline at CB15 or CB41. However, OB was detected on the Delmont Ave. line at CB14 and CB31 (sump). CB31 is the catchbasin at the intersection of Delmont Ave. and Clifton St. Furthermore, a pad inserted in CB31 Pipe B was positive. There is significant dry weather flow in CB31 Pipe B, while Pipe A (the previously contaminated stormline) was dry. The catchbasin at the top of Delmont Ave. (CB55) was flowing, but optical brightener was not detected. There was a faint wastewater odor in CB31 that was also not present in CB55.
- On November 21, 2017, Dave Braun, Mr. Hoyt, and Mr. Graham performed smoke testing in combination with camera inspection of the Delmont Avenue sanitary and storm sewers. Smoke passed from the sanitary sewer into the storm sewer at pipe joints located approximately 20 and 23 feet above CB31. Smoke passed from the storm sewer into the sanitary sewer approximately 21 feet north of CB31. This testing confirmed a second defect in the Delmont Ave. sanitary sewer.
- In December 2017, the City of Barre excavated at the apparent sewer pipe break and a buried manhole was uncovered. The exact path of the smoke from the broken sewer pipe and manhole to the stormdrain is not entirely clear at this time. It is also not known whether the City intends to remove the manhole or repair it.

**Conclusion:** Optical brightener monitoring indicated three sanitary wastewater leaks to the BC1620 system, as follows:

1. On August 30, 2016, a repair was made in the Delmont Ave. sanitary sewer line near the intersection of Clifton St. A section of vitrified lay sewer pipe was replaced with PVC pipe and a joint in the underlying stormdrain was repaired by sealing with QSR cement.
2. A second problem was identified in Delmont Ave. sanitary sewer in the fall of 2017. Smoke passed from the storm sewer into the sanitary sewer, and vice-versa, approximately 21 feet north of CB31.
3. On the Camp Street branch of the system, optical brightener testing indicated an additional source of wastewater; however, bracketing this source was challenging due to inconsistent OB results. We suspect a sanitary wastewater contribution exists on Camp Street between CB33 and CB43, possibly from a broken sewer lateral crossing the stormdrain from a house on the east side of the street.

**Resolution:** The City of Barre repaired a significant break in the Delmont Avenue sanitary sewer in 2016. In 2017, a second problem was discovered on the same sewer line, about 20 feet north of the first problem. We believe the City will address this second problem in 2018. We recommend the City also dye test houses on Camp Street between CB33 and CB43 to identify any faulty laterals.

### 3.2.16. BCF170

The BCF170 system drains a portion of Stowe Street and Prospect Street. It discharges via a 36-inch diameter corrugated metal pipe to an unnamed tributary of the Stevens Branch (Map BC-15). This system was designated for advanced investigation due to detection of optical brightener, ammonia, and suds at the outfall in 2014.

**Findings:**

- The City of Barre DPW reportedly repaired a collapsed sewer main on Stowe Street in 2015, following the 2014 assessment and prior to the present study. Two houses on Stowe Street are reportedly connected to this sewer main.
- No optical brightener was detected on monitoring pads deployed throughout the system on June 14, 2016.

**Conclusion:** We suspect the collapsed sewer main on Stowe Street was discharging sanitary wastewater to the storm sewer when assessed in June 2014. The present study confirmed that the illicit discharge has been eliminated.

**Resolution:** NA

### 3.2.17. BCF470

The BCF470 system drains a portion of Washington Street. It discharges via an 18-inch diameter plastic pipe to the Jail Branch (Map BC-16). This system was designated for advanced investigation due to detection of optical brightener at the outfall in 2014.

**Findings:**

- Catchbasin CB4 is connected with an unmapped catchbasin on the opposite side of Washington Street. The mapped connection between CB4 and CB3 does not exist (Map BC-16).
- Optical brightener was detected at the outfall and CB4, but not in CB2 and CB3.
- Mr. Hoyt cleaned the stormdrain and dye tested the sewer main on Washington Street. No dye transfer to the stormdrain was observed. In September 2016, Mr. Hoyt dye tested the two houses in the vicinity (#336 and #342 Washington Street) as well as the bathroom in the garage immediately west on Washington Street. No dye was observed in the stormdrain.
- On September 13, 2017, monitoring pads were placed at the outfall and within a 4-inch diameter drain discharging to CB4. Optical brightener was detected at the outfall, but not in the 4-inch drain.
- A previously unidentified pipe was found in CB4 on October 19, 2017. This 12-inch diameter pipe appears to be an old sanitary sewer line. This pipe (Pipe A) was dripping when observed. OB pads were placed in Pipe A and Pipe B (the 4-inch diameter drain) on October 13, 2017 and retrieved on November 1, 2017. Optical brightener was detected in Pipe A but not in in Pipe B.

*Figure 3. Interior face of CB4 showing wastewater infiltration*

- On November 21, 2017, Dave Braun, Mr. Graham, and Mr. Hoyt inspected catchbasin CB4 Pipe A with a CCTV camera. While pipe A was wet at the outlet, the inside of the pipe was dry within three feet of the opening. The interior of the pipe was filled with dry debris, indicating the pipe flows rarely, if at all. However, water was seeping through the stone walls of the catchbasin and pooling at the base of the wall (Figure 3). A white film was observed on the walls and a foul odor and flies were present. The water seeping through the walls was also wetting the end of Pipe A, which explains the OB detection in Pipe A.

**Conclusion:** It is clear that sanitary wastewater is seeping into CB4 through its stone walls. The only possible source of this wastewater is the house at #336 Washington Street. We suspect the sanitary sewer lateral serving this house is broken and leaking wastewater into CB4.

**Resolution:** The City of Barre will require the owner of the house at #336 Washington Street to fix this problem.

# 4. Barre Town Results

Reassessments and advanced investigation of the Barre Town systems identified in Table 2 were performed in the summer and fall of 2016.

## 4.1. Reassessments

Reassessments were performed on 27 stormwater drainage systems in Barre Town that had been assessed in the Stevens Branch plus Stowe IDDE project (Table 2). In addition to testing for ammonia, MBAS, free chlorine, conductivity, and optical brightener, samples were collected for *E. coli* and total phosphorus analysis, where possible. In most cases, repeated sampling demonstrated that no chronic illicit discharge was present. Reassessment data for the 27 Barre Town systems are included in **Appendix C**, Table 2.

*Table 6. Summary of status of reassessed systems in Barre Town*

| System | Status | Comments |
|---|---|---|
| BT100 | No chronic illicit discharge | Concentrations of ammonia (0.4 mg/L) and MBAS (0.34 mg/L) were slightly elevated on May 27, 2016; however, OB was not detected, and concentration of *E. coli and* TP were below levels of concern. Ammonia and MBAS were below detection in a second set of samples, collected on July 28, 2016. |
| BT390 | No chronic illicit discharge | Not flowing on two visits, May 27, 2016 and June 20, 2016. |
| BT550 | No chronic illicit discharge | Ammonia (0.4 mg/L) and chlorine (0.48 mg/L) concentrations were both elevated in samples collected on May 27, 2016. However, the outfall was dry on June 20, 2016 and all contaminants were below detection on a third visit, on July 29, 2016. |
| BT570 | No chronic illicit discharge | Not flowing on two visits, May 27, 2016 and June 20, 2016. |
| BT660 | No chronic illicit discharge | The MBAS concentration (0.52 mg/L) was elevated on May 27, 2016; however, we suspect this result was due to interference by a high concentration of dissolved solids, as indicated by the specific conductivity measurement of 3,360 µS/cm. *E. coli* and TP levels were negligible and OB was not detected. |
| BT670 | No chronic illicit discharge | The MBAS concentration (0.43 mg/L) was elevated on May 27, 2016; however, we suspect this result was due to interference by a high concentration of dissolved solids, as indicated by the specific conductivity measurement of 4,340 µS/cm. *E. coli* and TP levels were negligible and OB was not detected. |
| BT680 | Illicit discharge suspected. A.I. included in separate DEC contract #33432. | A low concentration of ammonia (0.35 mg/L) and moderate concentration of free chlorine (0.82 mg/L) were measured at the outfall on May 27, 2016. A petroleum odor was also observed. No OB was detected. |
| BT690 | No chronic illicit discharge | Concentrations of ammonia (0.3 mg/L), free chlorine (0.18 mg/L), and MBAS (0.23 mg/L) were elevated on May 27, 2016; however, we suspect these results were due to interference by very high concentration of dissolved solids, as indicated by the specific conductivity measurement of 5,340 µS/cm. *E. coli* and TP levels were negligible and OB was not detected. |

| System | Status | Comments |
| --- | --- | --- |
| BT950 | No chronic illicit discharge | A moderate concentration of free chlorine (0.34 mg/L) was detected at the outfall on May 27, 2016. The system was not flowing when revisited on June 20, July 28, and July 29, 2016. |
| BT1010 | No chronic illicit discharge | Concentrations of ammonia and chlorine were below levels of concern on June 10, 2016. *E. coli* and TP levels were negligible, and OB was not detected. |
| BT1050 | No chronic illicit discharge | The concentrations of MBAS (0.26 mg/L) was slightly elevated on June 10, 2016; however, we suspect this result was due to interference by a high concentration of dissolved solids, as indicated by the specific conductivity measurement of 3,520 µS/cm. Concentrations of ammonia and chlorine were below levels of concern. *E. coli* and TP levels were low. |
| BT1090 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below levels of concern on June 10, 2016. *E. coli* and TP levels were negligible. |
| BT2000 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below levels of concern on June 10, 2016. *E. coli* and TP levels were negligible. |
| BT2050 | No chronic illicit discharge | The system was dry on two visits, June 10 and June 20, 2016. |
| BT2120 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below levels of concern on June 10, 2016. *E. coli* and TP levels were negligible. |
| BT2260 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below levels of concern on June 10, 2016. *E. coli* and TP levels were negligible. |
| BT2370 | No chronic illicit discharge | The system was dry on three visits, June 10, June 20, and June 30, 2016. OB was not detected at the outfall. |
| BT2420 | No chronic illicit discharge | The ammonia concentration (0.3 mg/L) was slightly elevated on June 10, 2016; however, concentrations of chlorine and MBAS were below levels of concern and *E. coli* and TP levels were negligible. |
| BT2440 | Illicit discharge suspected. A.I. included in separate DEC contract #33432. | The ammonia concentration was slightly elevated on June 10 and July 28, 2016. An elevated *E. coli* (987 MPN/100 mL) level was measured on June 20, 2016. OB was not detected. |
| BT2470 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below detection on June 20, 2016. The *E. coli* level was negligible; however, the TP concentration (802 µg/L) was elevated. On July 28, 2016, the chlorine concentration (0.32 mg/L) was elevated. Optical brightener was not detected at the outfall. |
| BT2480 | No chronic illicit discharge | The system was dry when assessed on June 20, 2016. |
| BT2510 | No chronic illicit discharge | The system was not flowing when assessed on June 20, 2016. |
| BT2590 | No chronic illicit discharge | The ammonia concentration (0.35 mg/L) was slightly elevated on July 6, 2016; however, concentrations of chlorine and MBAS were below detection and the *E. coli* level was negligible. |
| BT2650 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below levels of concern on July 6, 2016. The *E. coli* level was negligible. The system was dry on June 30, 2016. |
| BT2670 | Illicit discharge suspected. A.I. included in separate DEC contract #33432. | A low ammonia concentration (0.50 mg/L) was observed on July 6, 2017 and *E. coli* (160 MPN/100 mL) was slightly elevated. This system was dry on two subsequent visits, July 13 and July 28, 2016. |
| BT2740 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below detection on July 6, 2016. The *E. coli* level (170 MPN/100 mL) was slightly elevated. Optical brightener was not detected at the outfall. |
| BT2820 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below detection on July 6, 2016. The *E. coli* level was negligible. |

The intent of the reassessment task was to establish with greater certainty whether an illicit discharge was present. Because the project scope of work did not include advanced investigation of these systems, it was expected that any follow-on investigations necessary to find and eliminate a discharge would occur under a separate contract. Based on these data, systems BT680, BT2440, and BT2670 were designated for advanced investigation. Watershed Consulting Associates (WCA) was awarded a contract for this work. Three additional systems in East Barre—GV1, GV5, and GV6—were also included in WCA's advanced investigation scope. Although assessment of the East Barre systems was not included in Stone's scope of work, we have presented the assessment data for these systems in **Appendix C**, Table 2.

## 4.2. Advanced Investigations

One advanced investigation was performed in Barre Town. The source of the illicit discharge in system BT2640 was identified.

### 4.2.1. BT2640

The BT2640 system drains Beckley Hill Road from Lemay Drive down to Green Street, as well as Buena Vista Circle. The system discharges to a stream at the end of Green Street (Map BT-1).

During the Stevens Plus Stowe IDDE study, a great deal of effort was expended to isolate the source of optical brightener in this system to a drainage swale discharging to catchbasin BVCB1.

**Findings:**

- On May 17, 2016, monitoring pads were placed at multiple points along the drainage swale. Optical brightener was detected in a pad inserted in the end of a 4-inch diameter corrugated pipe discharging to the swale and in all pads downstream of this pipe. No optical brightener was detected upstream of this pipe.
- The pipe testing positive for optical brightener appeared to be a foundation drain for the house at #9 Buena Vista Circle.
- A site visit was made on (date missing) on Buena Vista Circle with the Town Engineer, Harry Hinrichson. The pipe in question was pointed out to Mr. Hinrichson. Mr. Hinrichson indicated that he would contact the property owner concerning identifying and correcting any interior source of the illicit discharge.

**Conclusion:** The source of optical brightener was determined to be an improperly connected mop sink and washing machine at #9 Buena Vista Circle.

**Resolution:** On or about May 18, 2017, the mop sink drain and washing machine were replumbed to discharge into the sanitary sewer, eliminating this illicit discharge of laundry washwater.

# 5. Berlin Results

Reassessments of the systems identified in Table 2 were performed in the summer and fall of 2016. Advanced investigations were performed in the fall of 2016.

## 5.1. Reassessments

Reassessments were performed on four stormwater drainage systems in Berlin that had been assessed in the Stevens Branch plus Stowe IDDE project (Table 2). Testing was performed for ammonia, MBAS, free chlorine, specific conductivity, and optical brightener. In all four systems, repeated sampling demonstrated that no chronic illicit discharge was present. Reassessment data for the four Berlin systems are included in **Appendix C**, Table 3.

*Table 7. Summary of status of reassessed systems in Berlin*

| System | Status | Comments |
|---|---|---|
| BE080 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below detection on May 12, 2016 and OB was not detected. |
| BE160 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below detection on May 12, 2016 and OB was not detected. |
| BE210 | No chronic illicit discharge | The system was dry on May 12, 2016. |
| BE500 | No chronic illicit discharge | Concentrations of ammonia and chlorine were below detection on May 12, 2016 and OB was not detected. MBAS was not detected on May 17, 2016. |

## 5.2. Advanced Investigation

One advanced investigation was performed in Berlin, to attempt to identify the source of the illicit discharge in system BE100.

### 5.2.1. BE100

The BE100 system drains a portion of the Barre-Montpelier Road in Berlin. The system discharges to the Stevens Branch behind the Sunoco station (Map BE-1).

The BE100 system was assessed during the Stevens Branch Plus Stowe IDDE project. The system was designated for advanced investigation because on July 23, 2015 an MBAS concentration of 0.5 mg/L was measured at the outfall. Suds were observed at the outfall, although optical brightener was not detected at this time. Results from monitoring conducted in 2015 and 2016 are provided in Table 8, below.

*Table 8. Water quality results for system BE100*

| Structure ID | Date Assessed | Dry, Wet/no flow, Dripping, or Flowing? | Ammonia (mg/L) | Free Chlorine (mg/L) | MBAS (mg/L) | Specific Conductance (µs/cm) | OB Result | Observations |
|---|---|---|---|---|---|---|---|---|
| BE100 | 7/23/2015 | flowing | 0.0 | 0.03 | 0.50 | 134.8 | negative | clear, no odor |
| BE100 | 5/12/2016 | flowing | 0.2 | 0.03 | 0.00 | 690 | indeterminate | clear, no odor |
| BE100 | 5/26/2016 | trickling | 0.0 | 0.04 | 0.00 | 595 | NA | clear, no odor |
| BE100 | 9/30/2016 | flowing | 0.0 | 0.05 | 0.27 | 441 | positive | clear, no odor |

**Findings:**

- On September 30, 2016, monitoring pads were placed in the outfall, CB1, CB2, and CB3. Optical brightener was detected at the outfall, CB2, and CB3. Optical brightener was not detected at CB1.
- On September 30, 2016, the lateral pipes discharging to catchbasin CB2 were dry. Both pipes A and B in catchbasin CB3 were surcharged. Zero ammonia was detected in catchbasin CB3.
- Planned camera inspection with the Vermont Rural Water Association on November 30, 2017 was cancelled due to a scheduling conflict.

**Conclusion:** These results suggest a washwater contribution from the Twin City Motel.

**Resolution:** The exact source of the optical brightener detected in this system has yet to be identified. Camera inspection of Pipes A and B in catchbasin CB3 needs to be performed, likely in combination with dye testing.

# 6. Plainfield Results

No systems in Plainfield were designated for reassessment. One system, P-CB-100, was designated for advanced investigation.

## 6.1. Advanced Investigation

### 6.1.1. P-CB-100

Catchbasin P-CB-100 is located at the southeast corner of the intersection of Martin Meadow Road and Towne Avenue (Map PL-1). This is a deep structure immediately up the stormline from outfall P-O-090, which is difficult to access. Optical brightener was first detected in this system on August 23, 2013. Optical brightener has been detected consistently in the sump. On October 9 and 29, 2013 a laundry odor was observed. On October 9, 2013, optical brightener was detected in an unmapped pipe entering P-CB-100. It was not detected in the main stormline entering P-CB-100, from CB2.

**Findings:**

- In May 2016, monitoring pads were set in the P-CB-100 system. The pad set in CB1 was positive (strong) while the pad in the next catchbasin up the stormline, CB2, was negative.
- On October 19, 2016, Dave Braun, Wayne Graham (VRWA), and Greg Chamberlin (Chief Operator of the Plainfield wastewater treatment facility) smoke tested the sanitary sewer on Towne Avenue. Smoke was observed emanating from roof vents throughout the neighborhood with the exception of #237 and #223 High Street. A camera was inserted into the unmapped pipe entering P-CB-100. Within about 50 feet of the outlet, the camera hit an obstruction and was unable to continue.
- Mr. Chamberlin related that #237 and #223 High Street share a private sewer line that runs between the properties. According to Mr. Chamberlin, there have been problems with this line in past. It has needed repeated cleaning due to root penetration. The private sewer line is believed to discharge to the municipal sewer in the vicinity of the Towne Ave. and Martin Meadow Road intersection.

**Conclusion:** We suspect that the private sewer line shared by #237 and #223 High Street, or the connection of this line to the municipal sanitary sewer, is leaking wastewater that is intercepted by the deep, unmapped pipe entering P-CB-100. This conclusion is supported by the smoke testing results and the location and maintenance history of this sewer line.

**Resolution**: Mr. Chamberlin indicated he would request that the homeowners have their private sewer line inspected with a camera the next time it was cleaned, to ascertain the location of any break(s). We are unaware whether this has occurred. This system was designated for additional advanced investigation in a recently released contract through which this longstanding problem should finally be resolved.

# 7. Stowe Results

Reassessments of the systems identified in Table 2 were performed in the summer and fall of 2016. Advanced investigations were performed in the fall of 2016 and 2017.

## 7.1. Reassessments

Reassessments were performed on four stormwater drainage systems in Stowe that had been assessed in the Stevens Branch plus Stowe IDDE project (Table 2). Testing was performed for ammonia, MBAS, free chlorine, and specific conductivity. The earlier Stevens Branch Plus Stowe IDDE study demonstrated that optical brightener was not present in systems ST010, ST030, and ST040. In all four systems reassessed, repeated sampling demonstrated that no chronic illicit discharge was present. Reassessment data for the four Stowe systems are included in **Appendix C**, Table 4.

*Table 9. Summary of status of reassessed systems in Stowe*

| System | Status | Comment |
|---|---|---|
| ST010 | No chronic illicit discharge | The ammonia concentration (0.3 mg/L) was slightly elevated on May 10, 2016; however, concentrations of chlorine and MBAS were below detection. |
| ST030 | No chronic illicit discharge | The ammonia concentration (0.4 mg/L) was slightly elevated on May 10, 2016; however, concentrations of chlorine and MBAS were below detection. |
| ST040 | No chronic illicit discharge | Concentrations of ammonia, chlorine, and MBAS were below detection. |
| ST420 | No chronic illicit discharge | The ammonia concentration (0.4 mg/L) was slightly elevated on May 10, 2016, while concentrations of chlorine and MBAS were below detection. Concentrations of ammonia, chlorine, and MBAS were below detection on May 26, 2016 and OB was not detected. |

## 7.2. Advanced Investigations

Advanced investigations were performed on five stormwater drainage systems in Stowe that had been assessed in the Stevens Branch plus Stowe IDDE project (Table 2). Our findings relative to each of these systems are presented below.

### 7.2.1. ST170

The ST170 system drains a lane behind the Stowe town office on Main Street in Stowe. The system discharges over a rip-rapped bank beyond the cemetery (Map ST-1).

The ST170 system was assessed during the Stevens Branch Plus Stowe IDDE project. The system was designated for advanced investigation because of an optical brightener detection on August 6, 2015. No water sample was collected in 2015 or since because the system has not been observed flowing.

**Findings:**

- The system was observed on at least four occasions in 2016 and 2017 (May 10, 2016; May 26, 2016; June 9, 2016; and November 30, 2017). On no occasion was the outfall flowing sufficiently to collect a water sample.
- On May 10, 2016, monitoring pads were set in the outfall, catchbasin CB1 sump, CB1 Pipe A, and the CB2 sump. Optical brightener was detected only on the pad set at the outfall, and its fluorescence was weak.
- On May 26, 2016, monitoring pads were set in the outfall and catchbasin CB1 sump. In contrast to the pads set a couple weeks earlier, the pad in CB1 was positive. The pad at the outfall was also positive, though its fluorescence was weak.
- On November 30, 2017, Stone and Wayne Graham of the Vermont Rural Water Association performed camera inspection and smoke testing of the ST170 system. We smoke tested the stormdrain and observed no smoke in any sanitary structure or vent. We then smoke tested the sanitary sewer and observed no smoke in the storm drain. As expected, smoke was observed from the town office building vent and from vents on the three building to the east (#91, #109, and #137 Main Street). We also TV'd the sanitary sewer along the backside of the town offices. The pipe is SDR35 in good condition. No defects were observed. We attempted to TV the sanitary sewer from the same manhole, pushing in the downstream direction, but we were stopped almost immediately by sediment in the line.

**Conclusion:** The source of the optical brightener detected in this system was not conclusively identified; however, we demonstrated that the sanitary sewer is not cross connected or leaking to the stormdrain. It is possible that under high flow conditions, the sanitary sewer surcharges and effluent surfaces and enters catchbasin CB1. If true, this condition could be exacerbated by grease build up in the line when the grease trap at #91 has not been serviced routinely.

**Resolution:** In our view, we have adequately investigated ST170 and did not identify a significant wastewater contribution.

### 7.2.2. ST250

The ST250 system receives flow from ST240 and drains the base of the slope east of the Mountain Road and south of the transfer station. The system discharges to the West Branch Little River (Map ST-2).

The ST250 system was assessed during the Stevens Branch plus Stowe IDDE project. The system was designated for advanced investigation because on August 28, 2015 a very high ammonia concentration (3 mg/L) was measured and optical brightener was detected at the outfall. A manure odor and foam were also observed.

Table 10 presents water quality data collected for outfall ST250.

*Table 10. Water analysis data for outfall ST250*

| Structure ID | Date Assessed | Dry, Wet/no flow, Dripping, or Flowing? | Ammonia (mg/L) | Free Chlorine (mg/L) | MBAS (mg/L) | Specific Conductance (µs/cm) | OB Result | Observations |
|---|---|---|---|---|---|---|---|---|
| ST250 | 8/25/2015 | flowing | 3.0 | 0.03 | 0.20 | 1131 | negative | yellow foam, manure odor |
| ST250 | 5/10/2016 | flowing | 0.0 | 0.02 | 0.00 | 895 | negative | clear, no odor, suds |
| ST250 | 5/26/2016 | flowing | 0.0 | 0.01 | 0.00 | 985 | negative | foam |

**Findings:**

- Significant iron seeps drain into catchbasin CB1 from the base of the slope, through both pipes indicated in Map ST-2.
- Concentrations of ammonia, free chlorine, and MBAS were below detection on both sampling dates in May 2016. Optical brightener was not detected on either occasion, at the outfall or in CB1. The only indication of a potential problem on either date was foam at the outfall. The foam may have been produced by iron bacteria in the seeps.
- On November 30, 2017, Stone and Wayne Graham of VRWA smoke tested the sanitary sewer in the area of this drainage system. We did not observe smoke in the stormdrain. Smoke was observed from three of the four visible vents in the West Branch Apartments building (276 Mountain Road). The 4th may not have been connected. The smoke blower was set on the closet sanitary manhole to outfall ST250. This manhole is very deep and is in good repair. No scum line or other evidence of surcharging was present in the manhole.

**Conclusion:** On the date system ST250 was initially assessed (August 28, 2015), a definite discharge had recently occurred to this system. Construction activities were noted in the area in this timeframe. We suspect the high ammonia concentration and optical brightener resulted from a transient event, likely dumping of washwater to a catchbasin on the Mountain Road. We do not believe there is a chronic illicit discharge in this system.

**Resolution:** NA

### 7.2.3. ST350

The ST350 system was assessed during the Stevens Branch Plus Stowe IDDE project. The system was designated for advanced investigation because on August 28, 2015 moderately high ammonia (1.0 mg/L) and chlorine (0.23 mg/L) concentrations were measured at the outfall. The optical brightener result was indeterminate.

Table 11 presents water quality data collected for outfall ST350.

*Table 11. Water analysis data for outfall ST350*

| Structure ID | Date Assessed | Dry, Wet/no flow, Dripping, or Flowing? | Ammonia (mg/L) | Free Chlorine (mg/L) | MBAS (mg/L) | Specific Conductance (µs/cm) | OB Result | Observations |
|---|---|---|---|---|---|---|---|---|
| ST350 | 8/28/2015 | wet, no flow | 1.0 | 0.23 | 0.20 | 81 | indeterminate | clear, no odor |
| ST350 | 5/10/2016 | wet, no flow | | | | | negative | clear, no odor |
| ST350 | 5/17/2016 | wet, no flow | 0.1 | N.S. | 0.10 | 73 | NA | clear, no odor |
| ST350 | 5/26/2016 | wet, no flow | | | | | NA | clear, no odor |

**Findings:**

- On three dates in May 2016, no flow was observed at the outfall.
- Ammonia, free chlorine, and MBAS were below detection when stagnant water in the outfall pipe was sampled on May 17, 2016. Optical brightener was not detected.

**Conclusion:** We suspect the ammonia and chlorine present at this outfall on the initial assessment date resulted from a transient event, likely direct dumping of washwater to a catchbasin. We do not believe there is a chronic illicit discharge in this system.

**Resolution:** NA

### 7.2.4. ST370

The ST370 system drains a large area east of Main Street in the center of downtown Stowe. Wetland areas between School Street and Depot Street flow into this closed drainage system. ST370 discharges to a stream channel west of the Green Mountain Inn (Map ST-3).

The ST370 system was assessed during the Stevens Branch plus Stowe IDDE project. The system was designated for advanced investigation because on September 16, 2015 a very high ammonia concentration (4 mg/L) was measured in the Junction 1 drop inlet. A moderate MBAS concentration (0.7 mg/L) was also measured. Table 12 presents water quality data for system ST370.

*Table 12. Water analysis data for system ST370*

| Structure ID | Date | Dry, Wet/no flow, Dripping, or Flowing? | Ammonia (mg/L) | Free Chlorine (mg/L) | MBAS (mg/L) | Specific Conductance (µs/cm) | OB Result | Observations |
|---|---|---|---|---|---|---|---|---|
| ST370 | 9/16/15 | flowing | 0.75 | 0.14 | 0.0 | 520 | negative | cloudy, marshy odor, iron staining |
| ST370 JCT1 | 9/16/15 | dripping | 4.0 | 0.03 | 0.7 | 124 | negative | cloudy, slight odor |
| ST370 JCT2 | 9/16/15 | wet (no flow) | 0.0 | 0.06 | 0.0 | 1216 | negative | |
| ST370 JCT8 | 9/16/15 | wet (no flow) | na | na | na | na | negative | Iron staining |
| ST370 CB by Depot bldg.. | 9/16/15 | trickling | 0.1 | 0.09 | 0.0 | 1057 | na | |
| ST370 JCT1 | 5/10/2016 | flowing | 0.0 | 0.02 | 0.0 | 411 | NA | clear, no odor, iron staining |
| ST370 CB by Depot bldg. | 5/26/2016 | flowing | 0.4 | 0.03 | 1.0 | 216 | NA | clear, no odor, iron staining |

**Findings:**

- The JCT1 drop inlet was inspected on May 10, 2016. Pipe C is a very large diameter pipe conveying the stream through the eastern portion of the downtown area. There was no flow from pipes B and D. Pipe A, also dry, is a 15-inch diameter corrugated plastic pipe entering from the direction of the Depot building.
- On May 26, 2016, there was no flow in JCT1 Pipe A; however, stagnant water was sampled from the sump of the only catchbasin upstream. Moderate concentrations of MBAS (1.0 mg/L) and ammonia (0.4 mg/L) were detected in the sump. A SDR235 pipe discharges to this catchbasin from the direction of the Depot building.
- On May 26, 2016, dye testing was performed throughout the Depot building (bathroom sink on lower level and two kitchen sinks in the kitchen café on the second floor) in the company of the Inn's maintenance manager. No dye was observed in the stormdrain. The basement plumbing in the Depot building was inspected. A cast iron roof leader from the Depot building is connected to the SDR35 pipe entering the catchbasin. The only interior connections to this roof leader are from the sprinkler system and two HVAC units.
- The Inn's maintenance manager stated that he does not believe any staff dump washwater into the catchbasin in question but said he would speak with the maintenance staff about our findings.

**Conclusion:** We suspect that either transient dumping of washwater directly to the catchbasin in the Depot building parking lot or discharge from the HVAC units is the source of the ammonia and MBAS detected in this catchbasin. Unfortunately, we were not able to witness any discharge to this system. In any event, we do not believe this system warrants further investigation.

**Resolution:** NA

### 7.2.5. ST700

The ST700 system drains a portion of Sylvan Park Road and the area north of the Commodores Inn. ST700 discharges to the Little River west of Route 100.

The ST700 system was assessed during the Stevens Branch plus Stowe IDDE project. The system was designated for advanced investigation because on September 28, 2015 optical brightener was detected at the outfall, although the fluorescence was weak.

**Findings:**

- The ST700 system was dry when inspected on May 10, 2016.
- On May 10, 2016, pads were set throughout the system: at the outfall, CB1, DI sump, DI black pipe, DI culvert outlet, and houses #203, #53, #33 on Sylvan Park Road. Optical brightener was not detected anywhere in this system.

**Conclusion:** Given the weak fluorescence of the positive pad set in 2015 and the absence of optical brightener throughout the system in May 2016, we do not believe there is a chronic illicit discharge in this system.

**Resolution:** NA

# 8. Phosphorus and *E. coli* Concentrations

Samples were collected on June 20, July 6, July 13, July 21, and September 28, 2016 for *E. coli* and total phosphorus analysis. Where possible, flow was measured immediately following sampling. Daily total phosphorus loads were calculated from the concentration and discharge data. These data are presented below (Table 13). Note that sample collection was attempted at several other outfalls, but they were not flowing.

*Table 13. E. coli and total phosphorus data for selected drainage systems*

| System ID | Date sampled for *E. coli* & TP | Flow rate | Flow rate (L/min) | *E. coli* (MPN/100 mL) | TP (µg/L) | TP Load (g/day) |
|---|---|---|---|---|---|---|
| BC110 | 7/6/2015 | 500 mL/5 s | 6.0 | N.S. | <5 | <0.04 |
| BC110 | 7/13/2016 | 500 mL/5 s | 6.0 | 10 | N.S. | N.S. |
| BC140 | 9/28/2016 | 100 mL/20 s | 0.30 | 12 | 28.4 | 0.01 |
| BC550 | 9/28/2016 | | | 167 | 68.2 | |
| BC560 | 7/21/2016 | 100 mL/6 s | 1.0 | 710 | 82.6 | 0.1 |
| BC570 | 9/28/2016 | | | 2 | 192 | |
| BC790 | 7/6/2016 | 500 mL/136 s | 0.22 | N.S. | 15.2 | 0.005 |
| BC790 | 7/13/2016 | | | <10 | N.S. | N.S. |
| BC830 | 9/28/2016 | 100 mL/33 s | 0.18 | 9 | 125 | 0.03 |
| BC1100 | 7/21/2016 | | | 4350 | 218 | |
| BC1120 | 9/28/2016 | 1890 mL/50 s | 2.3 | 31 | 30.2 | 0.1 |
| BC1300 | 9/28/2016 | 946 mL/10 s | 5.7 | <1 | 9.34 | 0.08 |
| BC1320 | 7/6/2013 | 500 mL/56 s | 0.54 | N.S. | 7.78 | 0.006 |
| BC1320 | 7/13/2016 | | | <10 | N.S. | N.S. |
| BC1490 | 7/2/2016 | 3785 mL/6 s | 38 | <10 | 63.5 | 3 |
| BC1510 | 7/2/2016 | 3785 mL/30 s | 7.6 | 130 | 530 | 6 |
| BC1620 | 9/28/2016 | 2839 mL/100 s | 1.7 | 2 | 41.9 | 0.1 |
| BC1630 | 7/21/2016 | 3785 mL/15 s | 15 | 1080 | 357 | 8 |
| BCF050 | 7/13/2016 | 100 mL/46 s | 0.13 | 20 | 31.1 | 0.006 |
| BCF070 | 7/13/2016 | 500 mL/10 s | 3.0 | <10 | 13.1 | 0.06 |
| BCF140 | 7/6/2016 | 500 mL/47 s | 0.64 | N.S. | 9.24 | 0.01 |
| BCF140 | 7/13/2016 | | | 120 | N.S. | N.S. |
| BCF470 | 9/28/2016 | 3785 mL/60 s | 3.8 | 2 | 38.1 | 0.2 |
| BT100 | 6/20/2016 | 50 mL/9.5 s | 0.32 | <10 | 95.8 | 0.04 |
| BT660 | 6/20/2016 | 200 mL/9 s | 1.3 | 20 | 10.9 | 0.02 |
| BT670 | 6/20/2016 | 50 mL/3 s | 1.0 | <10 | 10.3 | 0.01 |
| BT690 | 6/20/2016 | | | <10 | 11.8 | |
| BT1010 | 6/20/2016 | 150 mL/18 s | 0.50 | <10 | 11.9 | 0.01 |
| BT1050 | 6/20/2016 | 500 mL/23 s | 1.3 | 41 | 142 | 0.3 |
| BT1090 | 6/20/2016 | 100 mL/13 s | 0.46 | <10 | 13.2 | 0.01 |
| BT2000 | 6/20/2016 | 10 mL/16 s | 0.04 | <10 | 13.8 | 0.001 |
| BT2120 | 6/20/2016 | 300 mL/7 s | 2.6 | <10 | 51.9 | 0.2 |
| BT2260 | 6/20/2016 | | | 10 | 28 | |
| BT2420 | 6/20/2016 | 300 mL/7 s | 2.6 | <10 | 8.03 | 0.03 |
| BT2440 | 6/20/2016 | 300 mL/13 s | 1.4 | 987 | 95 | 0.2 |

These data generally reinforce the interpretations made from earlier data and observations. Many of the systems investigated are quite extensive. The generally low *E. coli* levels measured, even in systems with confirmed wastewater contributions, may have been due to retention and die off within the storm lines.

Total phosphorus concentrations were low to moderate (maximum of 530 μg/L) at all sampling points. In certain systems, we would expect higher TP concentrations and loads during storm flows as accumulated wastewater solids are flushed from the storm lines.

# 9. References

American Public Health Association. Standard Methods for the Examination of Water and Wastewater, 21th edition, Washington D.C. 2005.

Hach Company. Hach Method #8167. Loveland, CO.

Stone Environmental, Inc. SEI SOP 5.23.3: Maintenance and Calibration of the pH/Con 10 Meter. February 24, 2003.

Stone Environmental, Inc. SEI SOP 6.38.0: Optical Brightener Testing, September 11, 2008.

Stone Environmental, Inc. Detecting and Eliminating Illicit Discharges in the Stevens Branch Watershed and Stowe. February 2016. (dec.vermont.gov/sites/dec/files/wsm/erp/docs/IDDE/Stevens%20%2B%20Stowe%20IDDE%20Final%20Report.pdf

# Appendix A. Assessment Data Form

## Upper Winooski River Basin plus Stowe IDDE Project

| | | | | | | |
|---|---|---|---|---|---|---|
| IDDE ID: ____________________ | | | | | | |
| Date: ____________ | Time: ____________ | Inspector: ____________________ | | | | |
| Structure type: ____________________ | | Inner diameter (outfall only): ____________ (in.) | | | | |
| | | | | | | |
| Material (outfall only): | corrugated metal | concrete | corrugated black plastic | smooth plastic | vitrified clay | other (describe): ________ |
| Flow depth (outfall only): | dry | wet (no flow) | dripping | trickling | Flowing Depth: ________ (in.) | |
| Outfall position: | free flow | partially submerged | submerged | If partially submerged, surcharged? YES NO | | |
| Erosion at outfall: | none | If present, describe: ____________________ | | | | |
| Discharge characteristics (observations on color, turbidity, and odor of flow): | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Floatables: | none | sheen | sewage | suds | other ____________ |
| Deposits or staining: | none | sediment | oily | iron staining | other____________ |
| Structural damage: | none | cracking, spalling | corrosion | crushed | other____________ |
| Obstructions: | none | partially obstructed | | fully obstructed | other____________ |

| | |
|---|---|
| Ammonia ________ mg/L | Date OB pad set: ____________ NA |
| Chlorine ________ mg/L Free or Total | Date OB pad retrieved: ____________ NA |
| MBAS ________ mg/L | |
| Specific conductance ________ $\mu$S/cm | |
| Sample collected for *E. coli* analysis: YES NO NA | Date: ________ Time: ________ |
| Sample collected for TP analysis: YES NO NA | Date: ________ Time: ________ |
| Flow measurement (if *E. coli* and/or nutrients sample collected): | |
| Comments: | |

# Appendix B. Stone Environmental SOPs

## STANDARD OPERATING PROCEDURE

## SEI-5.23.3

## MAINTENANCE AND CALIBRATION OF THE pH/CON 10 METER

SOP Number: SEI-5.23.3 Date Issued: 05/14/99
Revision Number: 3 Date of Revision: 02/24/03

### 1.0 OBJECTIVE

This standard operating procedure (SOP) explains the calibration and maintenance of the Oakton pH/Con 10 meter and the Cole-Parmer pH/Con 10 meter. The meters are identical except for the distributor's names. The meter is manufactured by Cole-Parmer and distributed by Cole-Parmer and Oakton. The operator's manual should be referred to for the applicable procedures described below. The pH/Con 10 meter is used for measuring the pH, conductivity, and temperature of water. The pH/conductivity meters generate and measure data, and thus must meet the requirements of 40 CFR part 160 subpart D.

### 2.0 POLICIES

1. According to 40 CFR Part 160, Subpart D, Section 160.61, Equipment used in the generation, measurement, or assessment of data and equipment used for facility environmental control shall be of appropriate design and adequate capacity to function according to the protocol and shall be suitable located for operation, inspection, cleaning, and maintenance.
2. Personnel will legibly record data and observations in the field to enable others to reconstruct project events and provide sufficient evidence of activities conducted.

### 3.0 SAFETY ISSUES

1. If necessary and appropriate, a site-specific health and safety plan shall be created for each study site. A template for creating a proper health and safety plan is provided on the SEI network.
2. If necessary and appropriate, all chemicals are required to be received with Material Safety Data Sheets (MSDS) or appropriate application label. These labels or MSDS shall be made available to all personnel involved in the sampling and testing.

### 4.0 PROCEDURES

#### 4.1 Equipment and Materials

1. The pH/Con 10 meter, pH/conductivity/ temperature probe. The probe cable has a notched 6-pin connector to attach to probe meter.

2. If necessary and appropriate, standard solutions (e.g., standard pH 4.0 and 7.0, conductivity standards)
3. Clean beakers or other appropriate containers
4. Log or other appropriate medium to record calibration.

### 4.2 Meter Set-up and Conditioning

1. The pH/Con 10 meter uses a combination pH/conductivity/temperature probe. The probe cable has a notched 6-pin connector to attach the probe meter. Keep connector dry and clean.
2. To connect the probe, line up the notches and 6-pins on the probe connector with the holes in the connector located on the top of the meter. Push down and the probe connector will lock into place.
3. To remove probe, slide up the metal sleeve on the probe connector. While holding onto metal sleeve, pull probe away from the meter. Do not pull on the probe cord or the probe wires might disconnect.
4. Be sure to decontaminate the probe prior to use. The probe shall be tripled rinsed with distilled or deionized water. Further decontamination and cleaning procedures may be called for in special situations or outlined in approved protocols or work plans. This will be documented in field notes or in an appropriate logbook.
5. Be sure to remove the protective rubber cap of the probe before conditioning, calibration, or measurement. If the probe is clean, free of corrosion, and the pH bulb has not become dehydrated, simply soak the probe in tap water for ten minutes before calibrating or taking readings to saturate the pH electrode surface to minimize drift. Wash the probe as necessary in a mild detergent solution. If corrosion appears on the steel pins in the conductivity cell, use a swab soaked in isopropyl alcohol to clean the pins. Do not wipe the probe; this causes a build-up of electrostatic charge on the glass surface. If the pH electrode has dehydrated, soak it for 30 minutes in a 2M-4M KCI boot solution prior to soaking in tap water.
6. Wash the probe in deionized water after use and store in pH 4.0 standard solution or an approved boot solution (per the manufacturer's instruction).

### 4.3 pH Calibration

1. The meter is capable of up to 3-point pH calibration to ensure accuracy across the entire pH range of the meter. At the beginning of each day of use, perform a 2 or 3-point calibration with standard pH buffers 4.00, 7.00, and 10.00. Calibration standards that bracket the expected sample range should be used. Never reuse buffer solutions; contaminants in the solution can affect the calibration.
2. Press the MODE key to select pH mode. The pH indicator appears in the upper right corner of the display.

3. Dip the probe into the calibration buffer. The end of the probe must be completely immersed into the buffer. Stir the probe gently to create a homogeneous buffer solution. Tap probe to remove any air bubbles.
4. Press CAL/MEAS to enter pH calibration mode. The primary display will show the measured reading while the smaller secondary display will indicate the pH standard buffer solution.
5. Press □ or □ keys to scroll up or down until the secondary display value is the same as the pH buffer value (pH 4.00, 7.00 or 10.00).
6. Wait for the measured pH value to stabilize. The READY indicator will display when the reading stabilizes. After the READY indicator turns on, press ENTER to confirm calibration. A confirming indicator (CON) flashes and disappears. The meter is now calibrated at the buffer indicated in the secondary display.
7. Repeat steps 3, 5, and 6 using a second or third pH standard
8. Press CAL/MEAS to return to pH measurement mode.

## 4.4 Conductivity Calibration

1. Select a conductivity standard with a value near the sample value expected. The meter should be calibrated by the user(s) at the beginning of each day of use.
2. Pour out two separate portions of your calibration standard and one of deionized water into separate clean containers.
3. Press MODE key to select Conductivity. The ΦS or mS indicator will appear on the right side of the display.
4. Rinse the probe with deionized water, and then rinse the probe in one of the portions of calibration standard Record the calibration standard on the per-use maintenance form or other appropriate medium.
5. Immerse the probe into the second portion of calibration standard. The meter's auto-ranging function selects the appropriate conductivity range (four ranges are possible). Be sure to tap the probe to remove air bubbles. Air bubbles will cause errors in calibration.
6. Wait for the reading to stabilize. The READY indicator lights when the reading is stable. Press the CAL/MEAS key. The CAL indicator appears above the primary display. The primary display shows the measured reading and the secondary display shows the temperature. Record the initial calibration standard on the per-use maintenance form or other appropriate medium.
7. Press the □ or □ keys to scroll to the value of your conductivity standard Press and hold the □ or □ keys to scroll faster. The meter automatically compensates for temperature differences using a factor of 2.00% per BC.

8. Press ENTER key to confirm calibration. Upon confirmation, the CON indicator appears briefly. The meter automatically switches back into Measurement mode. The display now shows the calibrated, temperature compensated conductivity value. However, if the calibration value input into the meter is different from the initial value displayed by more than 20%, the ERR annunciator appears in the lower left corner of the display

### 4.5 Temperature Calibration/Verification

1. The built-in temperature sensor is factory calibrated. Therefore, no additional calibration is necessary. However, the temperature may be verified against another working thermometer. However, if errors in temperature readings are suspected or if a replacement probe is used. Refer to the operating instructions if temperature calibration is necessary.

### 4.6 General and Annual Maintenance

Individual users are responsible for the calibration, cleaning, repair, and maintenance of the instrument.

Routine inspection and maintenance schedules vary from each piece of equipment. Typically, there are minor maintenance needs each piece of equipment will need to undergo prior to use in the field (such as cleaning or conditioning). Always consult the manufacturer=s instructions for general maintenance.

Specific per use maintenance needs for the pH /Con 10 meter include but are not limited to:

1. Inspect probe for physical damage and debris
2. Inspect meter for physical damage and debris
3. Clean probe w/ mild detergent
4. Rinse probe in distilled water
5. Clean conductivity pins with isopropyl alcohol (if necessary)
6. Condition probe
7. Calibrated to pH 7.0
8. Calibrated to pH 4.0
9. Calibrated to pH 10.0

The pH /con 10 meter shall be stored in a clean dry place, usually the padded box that it came in. Care should be given to keep the instrument from dust and contamination.

Wash the probe in distilled water after use, and store in pH 4 solution.

All maintenance, repairs, and calibrations are to be documented on an equipment maintenance log or other appropriate medium. Follow the checklist provided on the equipment maintenance log for regular use maintenance needs. Any maintenance must include documentation of whether the maintenance was routine and followed the SOP or not.

Equipment logs shall be brought to the field for documenting use and calibration. The logs will be returned to the office after each field use and filed in the equipment records filing cabinet.

In the event of failure due to breakage or loss of parts, an attempt will be made to repair or replace the necessary parts by the field personnel who discover the malfunction. All repairs will be documented in field notes and/or on a non-routine maintenance log. If the instrument is rendered "out of service" or "broken", it should be tagged as such. If further repair is necessary, return the instrument to the manufacturer following proper shipping procedures.

Non-routine repairs must include documentation of the nature of the defect, how and when the defect was discovered, and any remedial action taken in response to the defect.

## 5.0 RESPONSIBILITIES

1. All personnel will legibly record data and observations (including phone conversations) in accordance with this SOP to enable others to reconstruct project events and provide sufficient evidence of activities conducted.
2. Prior to use and after use, all equipment will be appropriately cleaned, decontaminated, calibrated (if necessary) and stored in accordance with the manufacturer's instructions and this SOP.

## 6.0 DEFINITIONS

1. *Decontamination* – Procedures followed to ensure cross contamination does not occur between sampling points or that potential contamination of equipment does not pose a hazard to sampling personnel.
2. *EPA* the U.S. Environmental Protection Agency.
3. *FIFRA* the Federal Insecticide, Fungicide, and Rodenticide Act as amended.
4. *Maintenance* – Actions performed on equipment to standardize and/or correct the accuracy and precision of a piece of equipment to ensure that the equipment is operating within the manufacturer's specifications and standard values.
5. *Study* means any experiment at one or more test sites, in which a test substance is studied in a test system under laboratory conditions or in the environment to determine or help predict its effects, metabolism, product performance (pesticide efficacy studies only as required by 40 CFR 158.640) environmental and chemical fate, persistence, or residue, or other characteristics in humans, other living organisms, or media. The term "study" does not include basic exploratory studies carried out to determine whether a test substance or a test method has any potential utility.

## 7.0 REFERENCES

40 CFR Part 160 Good Laboratory Practice Standards, August, 1989.

## 8.0 TABLES, DIAGRAMS, FLOWCHARTS, AND VALIDATION DATA

None

## 9.0 AUTHORIZATION

Revised by: ________________________________ Date: __________

Michael Nuss, Staff Scientist

Approved by: ________________________________ Date: __________

Christopher T. Stone, President

## 10.0 REVISION HISTORY

Revision number 1:

1. Changed title and references to Oakton in Sections 1.0 and 2.0 to enable this standard operating procedure to apply to both the Oakton pH/Con 10 meter and the Cole-Parmer pH/Con 10 meter, as these are identical meters.
2. Added instructions about cleaning and re-hydrating the probe to Section 3.1.
3. Added Section 9.0.
4. Reformatted.
5. Minor word editing.

Revision number 2:

1. Changed the title.
2. Removed sections 7.0 (Measurement) and 8.0 (Maintenance/Repairs).
3. Added section called (General and Annual Maintenance).
4. Minor editing.
5. Reformatted.

Revision number 3:

1. Minor wording edits in Section 1.0, Objective.
2. Updated style to match SEI Style Guide – font and text. Reformatted using MS Word
3. Added standardized section headers: 2.0 Policies, 3.0 Safety, 5.0 Responsibilities, 6.0 Definitions, 7.0 References, 8.0 Tables, Diagrams, Flowcharts and Validation data. Authorization moved to Section 9.0, andSection10.0 Revision History.
4. Deleted section on logs being given to the QAU.
5. Other minor wording edits.

## STANDARD OPERATING PROCEDURE

## SEI-6.38.1

## OPTICAL BRIGHTENER TESTING

SOP Number: SEI-6.38.1 Date Issued: 09/11/08

Revision Number: 1 Date of Revision: 03/18/13

### 1.0 OBJECTIVE

Optical brighteners are a class of fluorescent dyes used in almost all laundry detergents. Many paper products also contain optical brighteners. When optical brightener is applied to cotton fabrics, they will absorb ultraviolet (UV) rays in sunlight and release them as blue rays. These blue rays interact with the natural yellowish color of cottons to give the garment the appearance of being “whiter than white”. Optical brightener dyes are generally found in domestic wastewaters that have a laundry effluent component. Because optical brighteners absorb UV light and fluoresce in the blue region of the visible spectrum, they can be detected using a long wave UV light (a “black” light).

Optical brightener monitoring can be used to indicate the presence of wastewater in stormwater drainage systems, streams, and other water bodies. Since optical brighteners are removed by adsorption onto soil and organic materials as effluent passes through soil and aquifer media, optical brightener monitoring may also be used to identify incompletely renovated wastewater effluent in groundwater at wastewater dispersal sites.

To test for optical brightener, a cotton pad is placed in a flow stream for a period of 4-10 days, after which the pad is rinsed, air dried, and viewed under a long-range UV light. Florescence indicates the presence of optical brightener. Optical brighteners may be monitored in a wide range of structures and flow streams. For example, monitoring pads may be placed in stormwater outfall pipes, within catchbasins and manholes, or in any other man-made or natural water conveyance. Optical brightener pads may be placed in dry pipes or other dry structures to monitor possible intermittent flow streams. However, the more common application is to monitor discharge points that are flowing under dry weather conditions.

### 2.0 POLICIES

1. According to Stone’s Corporate Quality Management Plan, Stone shall have standard operating procedures in writing setting forth study methods that management is satisfied are adequate to ensure the quality and integrity of the data generated in the course of a study.
2. Personnel will legibly record data and observations in the field to enable others to reconstruct project events and provide sufficient evidence of activities conducted.

## 3.0 SAFETY ISSUES

1. If necessary and appropriate, a site-specific health and safety plan shall be created for each study site. A template for creating a proper health and safety plan is provided on the SEI network.
2. Care must always be taken when approaching a sampling location. Do not, under any circumstances, place yourself in danger to collect a sample.
3. If necessary and appropriate, all chemicals are required to be received with Material Safety Data Sheets (MSDS) or appropriate application labels. These labels or MSDS shall be made available to all personnel involved in the sampling and testing.

## 4.0 PROCEDURES

### 4.1 Equipment and Materials

1. Untreated cotton pad measuring approximately 10 cm by 10 cm (e.g., VWR cat no. 21902-985 or equivalent).
2. Fiberglass or nylon screen to enclose the cotton pad (sewn or stapled).
3. Monofilament fishing line (approximately 20 to 50 lb. test).
4. Binder clips of various sizes.
5. Field notebook, sample collection form, or other acceptable medium for recording field data.
6. Protective gloves if contamination is suspected in the water to be sampled, or if cold weather may be hazardous with wet hands.

### 4.2 Sampling Procedure and Sample Handling

#### *4.2.1 Optical Brightener Pad Assembly*

To assemble an optical brightener monitoring pad, place an untreated cotton pad measuring approximately 10 cm by 10 cm (e.g., VWR cat no. 21902-985) in an envelope made of a screen material. A light fiberglass screen is preferred. The pad may be folded in half to double its thickness. Sew, staple, or otherwise secure all open sides of the screen envelope to enclose the pad.

#### *4.2.2 Optical Brightener Pad Placement*

1. Secure the pad at the monitoring point using high test nylon fishing line (20 - 50 lb. test), a binder clip, or both. The pad may be attached to any convenient anchor, provided the pad is as well exposed to the flow stream as possible and the anchor point appears stable enough to resist the force of high flow events. When sampling culverts or stormwater outfall pipes, the pad may be clipped directly to the inner rim of the outfall. The pad should lie flat against the bottom surface of the pipe. The pad may also be hung from a catchbasin grate or manhole rung.

2. If a suitable anchor is not present, a heavy object may be placed in the flow stream or channel to anchor the pad. For example, a pad may be anchored in a stream by tying it to a concrete block.
3. Two or more optical brightener monitoring pads may be placed at monitoring points if appropriate. If more than a single pad is used, the pads should be anchored so that they do not become entangled.
4. Record the date each pad is deployed and any other relevant information in a field logbook or on a specified sample collection form.

#### *4.2.3 Optical Brightener Pad Retrieval and Handling*

1. After a 4-10 day period of exposure, optical brightener pads should be collected. The collection of each pad should be recorded in a field logbook or on a specified sample collection form.
2. Any object inserted in a pipe or other structure to anchor the pad should be removed.
3. Pads should be placed in individually labeled, re-sealable plastic bags. The sample label should indicate the monitoring point identification.
4. The pad should be removed from the screen envelope using scissors to cut open the envelope. The pad should be gently rinsed using cold tap water. Lightly squeeze out excess water with a clean hand. Do not wring out the pad. When processing the pads be aware that you may spread dye from one pad to another with your hands. Wear disposable gloves.
5. The pad should then be returned immediately to the labeled bag.
6. Pads should be air dried. The pad may be hung on a line to dry within the labeled bag. If a re-sealable plastic bag is used, cut the bottom corners of the bag to allow airflow to the pad.

### 4.3 Optical Brightener Analysis

1. When the pad is dry, expose the pad under a high quality long range UV light in a room that is completely dark. A non-exposed and an exposed pad are used as controls and compared to each test pad as it is exposed to the UV light.
2. There are three qualitative results: Positive, Negative, and Indeterminate. A pad will very definitely glow (fluoresce) if it is positive. If it is negative it will be noticeably drab and similar to the control pad. All other tests are indeterminate. Pads may be sorted into the basic categories: positive test, negative test, and indeterminate. Further, for positive tests, the pads may be sorted into categories by the relative strength of the fluorescence. A pad that is fluoresces brightly over most or all of its surface may be considered a strongly positive test, whereas a pad on which fluorescence appears patchy or faint may be considered a weakly positive test. Indeterminate results generally dictate that the test be repeated.
3. In some instances, only a portion of the pad or simply the outer edge will fluoresce after being exposed to optical brightener. This can be caused by many factors but is usually the result of an uneven exposure to the dye in the flow stream due to sedimentation or the way the pad was

positioned in the water. Regardless, as long as a portion of the pad fluoresces, it should be considered positive.

4. Since paper and cotton dust is so pervasive, it is common to see fluorescent fibers or specks on the test or control pads. These should be ignored and not used to indicate a positive result.
5. With the lights back on, record the identification number and the test result for each pad.
6. It is advisable to have a second reader perform the pad observations independently. The results are then compared. Any conflicting interpretations may be resolved though repeated observation of the pad in question, or a by a third observer.

## 5.0 RESPONSIBILITIES

1. All personnel will legibly record data and observations (including phone conversations) in accordance with this SOP to enable others to reconstruct project events and provide sufficient evidence of activities conducted.

## 6.0 DEFINITIONS

*1. Study* means any experiment at one or more test sites, in which a test substance is studied in a test system under laboratory conditions or in the environment to determine or help predict its effects, metabolism, product performance (pesticide efficacy studies only as required by 40 CFR 158.640) environmental and chemical fate, persistence, or residue, or other characteristics in humans, other living organisms, or media. The term “study” does not include basic exploratory studies carried out to determine whether a test substance or a test method has any potential utility.

## 7.0 REFERENCES

40 CFR Part 160 Good Laboratory Practice Standards, August, 1989.

MASS Bay Program. 1998. An Optical Brightener Handbook. http://www.thecompass.org/8TB/pages/SamplingContents.html

## 8.0 TABLES, DIAGRAMS, FLOWCHARTS, AND VALIDATION DATA

None

## 9.0 AUTHORIZATION

Revised by: ________________________________________ Date: _____________

Dave Braun, Project Scientist/Water Quality Specialist

Approved by: _______________________________________ Date: _____________

Christopher T. Stone, President

## 10.0 REVISION HISTORY

Revision number 1:

1. Minor clarifications and rewording throughout.
2. Changed 4-8 day pad exposure period to 4-10 day exposure period.
3. Changed description of indeterminate results.
4. Added use of binder clips to secure pads.
5. Updated procedure for processing exposed pads.

# Appendix C. Assessment Data Tables

Appendix C, Table 1: Reassessment data for Barre City stormwater drainage systems

| AI? | System ID | Date assessed | Inspector | Structure | Pipe diam. (in.) | Pipe material | Dry, wet (no flow), dripping, or flowing? | Flow depth (in.) | Pipe position | Erosion | Erosion description | Discharge characteristics | Floatables | Deposits/ Stains | Damage | Obstructions | OB pad set? | Date OB pad retrieved | OB Result | Ammonia (mg/L) | Chlorine (mg/L) | MBAS detergents-corrected (mg/L) | Sp. conductance (µs/cm) | Date sampled for EC & TP | Flow rate | Flow rate (L/min) | *E. coli* (MPN) | TP (µg/L) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BC020 | 7/13/2016 | DTC | outfall | 15 | smooth plastic | dry | NA | free flow | none | NA | dry | none | none | none | none | N | | NA | | | | | | | | | | |
| | BC110 | 7/6/2016 | DTC | outfall | 14 | smooth plastic | flowing | 0.25 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 7/13/2016 | negative | 0.0 | 0.00 | 0.00 | 1195 | 7/6/2015 | 500 mL/5 s | 6.0 | N.S. | <5 | |
| | BC110 | 7/13/2016 | DTC | outfall | 14 | smooth plastic | flowing | | free flow | none | NA | clear, no odor | none | none | none | none | N | | NA | | | | | 7/13/2016 | 500 mL/5 s | 6.0 | 10 | N.S. | |
| | BC120 | 7/6/2016 | DTC | outfall | 16 | concrete | dry | NA | partially submerged | none | NA | dry | none | sediment | none | partially obstructed | N | | NA | | | | | | | | | | |
| AI | BC130 | 6/16/2016 | DTC | outfall | 36 | corrugated metal | flowing | 0.5 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 6/21/2016 | negative | | | | | | | | | | Padded throughout system 6/16/16 (all negative). |
| AI | BC140 | 6/16/2016 | DTC | outfall | 24 | corrugated metal | flowing | 0.25 | free flow | none | NA | | suds | none | none | none | Y | 6/21/2016 | positive | | | | | 9/28/2016 | 100 mL/20 s | 0.30 | 11.53 | 28.4 | Padded system 6/16/16. Repadded several structures 9/27/16 and 10/13/17. |
| | BC180 | 7/6/2016 | DTC | outfall | 4 | smooth plastic | dry | NA | free flow | none | NA | dry, no foul odor | none | none | none | none | N | | NA | | | | | | | | | | No foul odor detected. |
| AI | BC290 | 6/2/2016 | DTC | culvert | | concrete/ corrugated bla | flowing | | free flow | none | NA | clear, no odor | none | none | none | none | Y | 6/7/2016 | negative | | | | | | | | | | Padded throughout system (all pads negative). Repadded outlets A and B on 6/14/16 (negative). |
| AI | BC410 | 6/3/2016 | DTC | outfall | 14 | steel | dry | NA | free flow | none | NA | dry | none | iron staining | none | none | Y | 6/14/2016 | positive | | | | | | | | | | Padded throughout system on 6/2/16. |
| AI | BC450 | 6/3/2016 | DTC | outfall | 14 | corrugated metal | dry | NA | free flow | none | NA | dry | none | none | none | partially obstructed | Y | 6/7/2016 | negative | | | | | | | | | | Padded system. Attempted EC & TP sampling on 9/28/16, but all dry. Padded system 10/13/17 & 11/1/17. |
| AI | BC520 | 7/29/2016 | DTC | outfall | 16 | vitrified clay | dry | NA | free flow | none | NA | dry | none | none | cracking | none | Y | 8/16/2016 | negative | | | | | | | | | | Padded system7/29/16. The OB=I at CB4 and CB7. Repadded in August 2016 and outfall 10/5/16. |
| AI | BC550 | 6/3/2016 | DTC | outfall | 22 | corrugated metal | flowing | 0.25 | partially submerged | none | NA | clear, no odor | none | none | none | none | Y | 6/7/2016 | positive | | | | | 9/28/2016 | | | 166.95 | 68.2 | Padded system 6/3/16, 10/13/16, and 11/1/17. EC & TP samples collected 9/28/16--could not measure Q |
| | BC560 | 7/21/2016 | DTC | outfall | 18 | vitrified clay | flowing | 0.13 | free flow | yes | bank erosion | clear, no odor | none | none | cracking | none | Y | 7/29/2016 | positive | 0.2 | 0.04 | 0.15 | 596 | 7/21/2016 | 100 mL/6 s | 1.0 | 710 | 82.6 | |
| | BC560 | 7/29/2016 | DTC | outfall | 18 | vitrified clay | trickling | NA | free flow | yes | bank erosion | clear, no odor | none | none | cracking | none | N | | NA | 0.0 | 0.11 | 0.71 | 596 | | | | | | |
| AI | BC570 | 6/3/2016 | DTC | outfall | 12 | vitrified clay | wet (no flow) | NA | free flow | none | NA | clear, no odor | none | none | cracking | partially obstructed | Y | 6/7/2016 | positive | | | | | 9/28/2016 | | | 2.02 | 192 | Padded system 6/3/16. Padded outfall 9/27/16. Padded CB1 and CB2 on 10/5/16. |
| | BC790 | 7/6/2016 | DTC | outfall | 4 | smooth plastic | trickling | NA | free flow | none | NA | clear, no odor | none | none | none | none | Y | 7/13/2016 | indeterminate | 0.25 | 0.03 | 0.05 | | 7/6/2016 | 500 mL/136 s | 0.22 | N.S. | 15.2 | Padded 7/6/16 (indeterminate), 7/29/16 (positive), and 9/27/16 (positive). |
| | BC790 | 7/13/2016 | DTC | outfall | 4 | smooth plastic | trickling | NA | free flow | none | NA | clear, no odor | none | none | none | none | N | | NA | | | | | 7/13/2016 | | | < 10 | N.S. | |
| AI | BC800 | 6/7/2016 | DTC | outfall | 12 | smooth plastic | dry | NA | free flow | none | NA | dry | none | none | none | none | Y | 6/21/2016 | negative | | | | | | | | | | Padded system 6/7/16 (all negative) |
| AI | BC830 | 6/7/2016 | DTC | outfall | 38 | concrete | flowing | 0.5 | free flow | none | NA | clear, no odor | none | none | cracking | none | Y | 6/21/2016 | positive | | | | | 9/28/2016 | 100 mL/33 s | 0.18 | 8.6 | 125 | Padded system 6/7/16, 9/13/17, and 10/13/17. DCB performed AI on 11/21/17. |
| AI | BC990 | 6/7/2016 | DTC | outfall | 12 | smooth plastic | trickling | NA | free flow | none | NA | clear, no odor | none | none | none | none | Y | 6/21/2016 | positive | | | | | | | | | | Padded system 6/7/16 (outfall positive). |
| | BC1100 | 7/21/2016 | DTC | outfall | 12 | smooth plastic | flowing | unknown | partially submerged/ | none | NA | clear, no odor | none | none | none | none | Y | 7/29/2016 | positive | 0.75 | 0.02 | 0.05 | 741 | 7/21/2016 | | | 4350 | 218 | Padded system 6/7/16, 6/21/16 (CB6 positive), and 7/29/16. |
| AI | BC1120 | 6/21/2016 | DTC | outfall | 12 | smooth plastic | flowing | 0.5 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 6/21/2016 | positive | | | | | 9/28/2016 | 1890 mL/50 s | 2.3 | 30.51 | 30.2 | Padded system 6/7/16 . Padded system 9/3/17. Padded system 9/13/17. |
| AI | BC1290 | 6/14/2016 | DTC | outfall | 8 | corrugated metal | wet, no flow | NA | partially submerged/ | none | NA | NAPL odor/ sheen | sheen | oil, iron staini | none | none | Y | 6/21/2016 | negative | | | | | | | | | | Padded system 6/14/16 (negative). NAPL sheen/ odor continually present. |
| AI | BC1300 | 6/14/2016 | DTC | outfall | 18 | corrugated black plastic | flowing | 0.25 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 6/21/2016 | positive | | | | | 9/28/2016 | 946 mL/10 s | 5.7 | < 1 | 9.34 | Padded system 6/14/16, 9/27/16, 11/17/16. Padded 9/13/17 and 10/13/17. |
| | BC1310 | 7/6/2016 | DTC | outfall | 9 | vitrified clay | dry | NA | free flow | none | NA | no odor | none | none | none | none | N | | NA | | | | | | | | | | No flow in system. |
| | BC1320 | 7/6/2016 | DTC | outfall | 15 | smooth plastic | flowing | 0.13 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 7/13/2016 | negative | 0.1 | 0.03 | 0.15 | 5050 | 7/6/2013 | 500 mL/56 s | 0.54 | N.S. | 7.78 | |
| | BC1320 | 7/13/2016 | DTC | outfall | 15 | smooth plastic | flowing | | free flow | none | NA | clear, no odor | none | none | none | none | N | | NA | | | | | 7/13/2016 | | | < 10 | N.S. | |
| | BC1420 | 7/6/2016 | DTC | outfall | 12 | smooth plastic | dry | NA | partially submerged | none | NA | no odor | none | sediment | none | partially obstructed | N | | NA | | | | | | | | | | Pipe is 50% buried in sediment. Next upline CB is dry. |
| | BC1490 | 7/21/2016 | DTC | outfall | 12 | smooth plastic | flowing | 0.5 | free flow | none | NA | clear, no odor | none | none | cracking | none | Y | 7/21/2016 | negative | 0.15 | 0.01 | 0.00 | 1032 | 7/2/2016 | 3785 mL/6 s | 38 | < 10 | 63.5 | No chemical odor observed on multiple visits. |
| | BC1510 | 7/21/2016 | DTC | outfall | 14 | corrugated metal | flowing | 0.5 | free flow | none | NA | cloudy, grey, sediment heavy | none | none | corrosion | none | Y | 7/21/2016 | negative | 0.1 | 0.14 | 0.00 | 424 | 7/2/2016 | 3785 mL/30 s | 7.6 | 130 | 530 | Discharge likely powdered stone residue. |
| | BC1510 | 7/29/2016 | DTC | outfall | 14 | corrugated metal | trickling | 0.5 | free flow | none | NA | cloudy, grey, sediment heavy | none | none | corrosion | none | N | | NA | 0.0 | 0.04 | 0.00 | 417 | | | | | | Not as much sediment as prior visit. |
| AI | BC1620 | 6/16/2016 | DTC | outfall | 20 | concrete | flowing | 0.25 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 6/21/2016 | positive | 0.0 | 0.02 | 0.19 | 916 | 9/28/2016 | 2839 mL/100 s | 1.7 | 2.02 | 41.9 | Padded system on 6/16/16, 9/27/16, 11/17/16, 10/13/17, and 11/1/17. |
| | BC1630 | 7/21/2016 | DTC | outfall | 20 | corrugated black plastic | flowing | 0.25 | free flow | none | NA | clear, slight WW odor | none | none | none | none | Y | 6/21/2016 | positive | 0.75 | 0.02 | 0.20 | 838 | 7/21/2016 | 3785 mL/15 s | 15 | 1080 | 357 | Padded system on 6/16/16. |
| | BC1630 | 9/27/2016 | DTC | outfall | 20 | corrugated black plastic | flowing | | free flow | none | NA | clear, laundry odor | suds | none | none | none | Y | 10/5/2016 | positive | 0.3 | 0.02 | 0.22 | 553 | | | | | | Padded system on 9/27/16. |
| | BC1630 | ####### | DTC | outfall | 20 | corrugated black plastic | flowing | | free flow | none | NA | clear, no odor | none | none | none | none | Y | 11/28/2016 | positive | 0.1 | 0.04 | 0.09 | 976 | | | | | | Padded system on 11/17/16. |
| | BC1710 | 7/21/2016 | DTC | outfall | | unknown | dry | NA | free flow | none | NA | dry | none | none | none | none | N | | NA | | | | | | | | | | CNL outfall, notes say buried in granite debris. No signs of flow in area, upline CBs are dry. |
| | BCF020 | 7/13/2016 | DTC | outfall | 15 | smooth plastic | dry | NA | free flow | none | NA | dry | none | none | none | none | N | | NA | | | | | | | | | | |
| | BCF040 | 7/13/2016 | DTC | outfall | 15 | corrugated black plastic | dry | NA | free flow | none | NA | dry | none | none | none | none | N | | NA | | | | | | | | | | |
| | BCF050 | 7/13/2016 | DTC | outfall | 12 | corrugated black plastic | dripping | NA | free flow | none | NA | clear, no odor | none | none | none | none | Y | 7/29/2016 | negative | 0.25 | 0.13 | 0.00 | 1707 | 7/13/2016 | 100 mL/46 s | 0.13 | 20 | 31.1 | |
| | BCF050 | 7/29/2016 | DTC | outfall | 12 | corrugated black plastic | dripping | NA | free flow | none | NA | clear, no odor | none | none | none | none | N | | NA | 0.2 | 0.06 | 0.14 | 1570 | | | | | | |
| | BCF070 | 7/13/2016 | DTC | outfall | 15 | corrugated metal | flowing | 0.5 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 7/29/2016 | negative | 0.0 | 0.02 | 0.00 | 551 | 7/13/2016 | 500 mL/10 s | 3.0 | < 10 | 13.1 | |
| | BCF070 | 9/27/2016 | DTC | outfall | 15 | corrugated metal | flowing | | free flow | none | NA | clear, no odor | none | none | none | none | Y | 10/5/2016 | negative | 0.0 | 0.00 | 0.00 | 373 | | | | | | Padded system 9/13/17. |
| | BCF140 | 7/6/2016 | DTC | outfall | 18 | corrugated metal | trickling | NA | free flow | none | NA | clear, no odor | none | none | none | none | Y | 7/13/2016 | negative | 0.1 | 0.00 | 0.01 | 1291 | 7/6/2016 | 500 mL/47 s | 0.64 | N.S. | 9.24 | |
| | BCF140 | 7/13/2016 | DTC | outfall | 18 | corrugated metal | trickling | NA | free flow | none | NA | clear, no odor | none | none | none | none | N | | NA | | | | | 7/13/2016 | | | 120 | N.S. | |
| AI | BCF170 | 6/14/2016 | DTC | outfall | 36 | corrugated metal | flowing | | free flow | none | NA | clear, no odor | none | none | none | none | Y | 6/21/2016 | negative | | | | | | | | | | |
| | BCF180 | 7/21/2016 | DTC | outfall | 18 | corrugated black plastic | dry | NA | free flow | yes | gulley | dry | none | none | none | none | N | | NA | | | | | | | | | | |
| AI | BCF470 | 6/16/2016 | DTC | outfall | 18 | smooth plastic | flowing | 0.25 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 6/21/2016 | positive | | | | | 9/28/2016 | 3785 mL/60 s | 3.8 | 2.02 | 38.1 | Padded 6/16/16. Padded system 9/13/17 and 10/13/17. DCB performed AI on 11/21/17. |

Appendix C, Table 2: Reassessment data for Barre Town stormwater drainage systems

| AI? | System ID | Date assessed | Inspector | Structure | Pipe diam. (in.) | Pipe material | Dry, wet (no flow), dripping, or flowing? | Flow depth (in.) | Pipe position | Erosion | Erosion description | Discharge characteristics | Floatables | Deposits/ Stains | Damage | Obstructions | OB pad set? | Date OB pad retrieved | OB Result | Ammonia (mg/L) | Chlorine (mg/L) | MBAS detergents-corrected (mg/L) | Sp. conductance (µs/cm) | Date sampled for EC & TP | Flow rate | Flow rate (L/min) | | *E. coli* (MPN) | TP (µg/L) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BT100 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | 0.35 | 0.07 | 0.34 | 265 | 6/20/2016 | 50 mL/9.5 s | 0.32 | < | 10 | 95.8 | |
| | BT100 | 7/28/2016 | DTC | outfall | 30 | corrugated metal | trickling | NA | free flow | none | NA | clear, no odor | none | none | none | none | N | | NA | 0.2 | 0.03 | 0.09 | 185 | | | | | | | |
| | BT390 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | | | | | | | | | NA | NA | Wet (no flow). Could not get a sample. No flow again on 6/20/16 |
| | BT550 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | 0.4 | 0.48 | 0.03 | 1421 | | | | | NA | NA | Considerable iron staining. No flow on 6/20/16: No *E. coli* sample collected. |
| | BT550 | 7/29/2016 | DTC | outfall | 4 | smooth plastic | trickling | NA | free flow | none | NA | clear, no odor | none | none | none | none | N | | NA | 0.0 | 0.02 | 0.00 | 392 | | | | | | | |
| | BT570 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | | | | | | | | | NA | NA | Wet (no flow). Could not get a sample. Dry again on 6/20/16 |
| | BT660 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | 0.3 | 0.02 | 0.52 | 3360 | 6/20/2016 | 200 mL/9 s | 1.3 | | 20.1 | 10.9 | Corrosion, rust, debris bits |
| | BT670 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | 0.3 | 0.03 | 0.43 | 4640 | 6/20/2016 | 50 mL/3 s | 1.0 | < | 10 | 10.3 | Musty odor |
| | BT680 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | 0.35 | 0.82 | 0.00 | 1879 | | | | | NA | NA | Petroleum odor still present, no flow on 6/20/16; no *E. coli* sample taken. |
| | BT690 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | 0.3 | 0.18 | 0.23 | 5340 | 6/20/2016 | | | < | 10 | 11.8 | Could not measure flow rate |
| | BT700 | 5/27/2016 | FWR | | | | | | | | | | | | | | | | | 0.0 | 0.00 | 0.05 | 725 | | | | | | | |
| | BT950 | 5/27/2016 | FWR | | | | | | | | | | | | | | Y | | negative | 0.2 | 0.34 | 0.05 | 725 | | | | | NA | NA | Half-filled with sediment; no flow on 6/20/16; no *E. coli* sample taken |
| | BT950 | 7/28/2016 | DTC | outfall | 12 | smooth plastic | dry | NA | free flow | none | NA | dry | none | sediment | none | partially obstructed | N | | NA | | | | | | | | | | | Strong WW odor in area, likely coming from MH in street. 7/29 dry after rain, WW odor persists. |
| | BT1010 | 6/10/2016 | FWR | | | | | | | | | | | | | | Y | | negative | 0.1 | 0.00 | 0.15 | 2190 | 6/20/2016 | 150 mL/18 s | 0.50 | < | 10 | 11.9 | Corrosion |
| | BT1050 | 6/10/2016 | FWR | | | | | | | | | | | | | | N | | NA | 0.1 | 0.00 | 0.26 | 3520 | 6/20/2016 | 500 mL/23 s | 1.3 | | 41.3 | 142 | |
| | BT1090 | 6/10/2016 | FWR | | | | | | | | | | | | | | N | | NA | 0.1 | 0.03 | 0.18 | 1797 | 6/20/2016 | 100 mL/13 s | 0.46 | < | 10 | 13.2 | |
| | BT2000 | 6/10/2016 | FWR | | | | | | | | | | | | | | N | | NA | 0.2 | 0.03 | 0.01 | 1283 | 6/20/2016 | 10 mL/16 s | 0.04 | < | 10 | 13.8 | Iron staining |
| | BT2050 | 6/10/2016 | FWR | | | | | | | | | | | | | | N | | NA | | | | | | | | | NA | NA | Dry; no samples taken; dry again on 6/20/16 |
| | BT2120 | 6/10/2016 | FWR | | | | | | | | | | | | | | N | | NA | 0.3 | 0.00 | 0.02 | 1156 | 6/20/2016 | 300 mL/7 s | 2.6 | < | 10 | 51.9 | Frog eggs inside of pipe |
| | BT2260 | 6/10/2016 | FWR | | | | | | | | | | | | | | N | | NA | 0.15 | 0.04 | 0.04 | 875 | 6/20/2016 | | | | 10 | 28 | Submerged and surcharged, heavy flow at CB1 and CB2 above. Totally submerged on 6/20/16. |
| | BT2370 | 6/10/2016 | FWR | outfall | | | | | | | | | | | | | Y | | negative | | | | | | | | | NA | NA | Dry; no samples taken. Dry again on 6/20/16, no *E. coli* sample taken. |
| | BT2370 | 6/30/2016 | DTC | | 12 | corrugated black plastic | dry | NA | free flow | none | NA | dry | none | none | none | none | Y | | negative | | | | | | | | | | | |
| | BT2420 | 6/10/2016 | FWR | | | | | | | | | | | | | | N | | NA | 0.3 | 0.00 | 0.00 | 248 | 6/20/2016 | 300 mL/7 s | 2.6 | < | 10 | 8.03 | Paint brush nearby. Considerable iron staining; pipe manipulated to divert water to pond |
| | BT2440 | 6/10/2016 | FWR | outfall | | | | | | | | | | | | | Y | | negative | 0.25 | 0.03 | 0.07 | 848 | 6/20/2016 | 300 mL/13 s | 1.4 | | 987 | 95 | |
| | BT2440 | 7/28/2016 | DTC | | 12 | corrugated black plastic | flowing | 0.06 | free flow | none | NA | clear, no odor | none | none | none | none | Y | | negative | 0.35 | 0.02 | 0.16 | 698 | | | | | | | |
| | BT2470 | 6/20/2016 | FWR | outfall | | | | | | | | | | | | | N | | NA | 0.0 | 0.00 | 0.13 | 402 | 6/20/2016 | 375 mL/5 s | 4.5 | < | 10 | 802 | DTC set OB pad |
| | BT2470 | 7/28/2016 | DTC | | 12 | smooth plastic | flowing | 0.13 | free flow | none | NA | clear, no odor | none | none | none | none | Y | | negative | 0.1 | 0.32 | 0.00 | 237 | | | | | | | Retested $Cl_2$=0.34 mg/L |
| | BT2480 | 6/20/2016 | FWR | | | | | | | | | | | | | | N | | NA | | | | | | | | | NA | NA | Dry, no sample taken. |
| | BT2510 | 6/20/2016 | FWR | | | | | | | | | | | | | | N | | NA | | | | | | | | | NA | NA | Wet, no flow; no samples taken |
| | BT2590 | 7/6/2016 | FWR | swale | | | | | | | | | | | | | | | | 0.35 | 0.00 | 0.00 | 867 | 7/6/2016 | | | | 60 | N.S. | Outfall covered in pile of debris. Flow is under debris. Sampled CB1, but could not measure flow. |
| AI | BT2640 | 5/17/2016 | DTC, DCB | outfall | | | wet, no flow | NA | NA | none | NA | clear, no odor | none | none | none | none | Y | | positive | | | | | | | | | | | Padded drainage swale. BVCB1, ditch 1 and ditch 2 were strongly positive, ditch 3-5 were negativ |
| | BT2650 | 6/30/2016 | DTC | | 16 | corrugated metal | dry | NA | free flow | none | NA | dry | none | none | none | none | N | | NA | | | | | | | | | | | |
| | BT2650 | 7/6/2016 | FWR | | | | | | | | | | | | | | N | | NA | 0.2 | 0.00 | 0.06 | 1002 | 7/6/2016 | 100 mL/1 s | 6.0 | < | 10 | N.S. | Crunchy" stalactite-like soil formation below outfall; no TP sample taken; some flow not measured |
| | BT2670 | 7/6/2016 | FWR | outfall | | | | | | | | | | | | | N | | NA | 0.5 | 0.00 | 0.00 | 647 | 7/6/2016 | 100 mL/3 s | 2.0 | | 160 | N.S. | No TP sample taken |
| | BT2670 | 7/13/2016 | DTC | | unknown | corrugated metal | dry | NA | free flow | none | NA | dry | none | sediment | none | fully obstructed | N | | NA | | | | | | | | | | | Outfall dry 7/13 and 7/28. No TP sample collected. |
| | BT2740 | 7/6/2016 | FWR | outfall | | | | | | | | | | | | | Y | | lost | 0.1 | 0.00 | 0.08 | 663 | 7/6/2016 | 105 mL/42 s | 0.15 | | 170 | N.S. | No TP sample taken |
| | BT2740 | 7/28/2016 | DTC | | 12 | smooth plastic | flowing | 0.25 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 8/16/2016 | negative | | | | | | | | | | | Repaded as original pad was prematurely thrown away. |
| | BT2820 | 7/6/2016 | FWR | | | | | | | | | | | | | | N | | NA | 0.2 | 0.00 | 0.04 | 1211 | 7/6/2016 | 100 mL/4 s | 1.5 | | 30 | N.S. | No TP sample taken |
| | East Barre | | | outfall | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | GV1 | 9/30/2016 | DTC | outfall | 18 | corrugated metal | trickling | NA | free flow | none | NA | clear, no odor | none | none | none | none | Y | 10/5/2016 | indeterminate | 0.0 | 0.16 | 0.22 | 453 | | | | | | | OB=I (spot) |
| | GV2 | 9/30/2016 | DTC | outfall | 24 | corrugated metal | dry | NA | free flow | none | NA | dry | none | yes | crushed | partially obstructed | N | | NA | | | | | | | | | | | |
| | GV3 | 9/30/2016 | DTC | outfall | 36 | corrugated black plastic | flowing | 0.25 | free flow | none | NA | clear, no odor | none | iron staining | none | none | Y | 10/5/2016 | negative | 0.0 | 0.02 | 0.62 | 3390 | | | | | | | Unclear mapping, see field sheet for details. |
| | GV4 | 9/30/2016 | DTC | outfall | 12 | corrugated black plastic | dry | NA | free flow | none | NA | clear, no odor | none | none | none | partially obstructed | N | | NA | | | | | | | | | | | |
| | GV5 | 9/30/2016 | DTC | outfall | 12 | corrugated black plastic | wet (no flow) | NA | partially submerged | none | NA | suds | none | none | none | partially obstructed | Y | 10/5/2016 | negative | 2.0 | 0.01 | 0.30 | 733 | | | | | | | |
| | GV6 | 9/30/2016 | DTC | outfall | 14 | corrugated black plastic | dripping | NA | free flow | none | NA | clear, no odor | none | none | none | none | Y | 10/5/2016 | negative | 0.0 | 0.01 | 0.30 | 1545 | | | | | | | |
| | GV7 | 9/30/2016 | DTC | outfall | 24 | corrugated black plastic | dry | NA | free flow | none | NA | clear, no odor | none | sediment | none | partially obstructed | N | | NA | | | | | | | | | | | |
| | GV8 | 9/30/2016 | DTC | | 18 | corrugated metal | dry | NA | free flow | none | NA | dry | none | none | none | none | N | | NA | | | | | | | | | | | |

Appendix C, Table 3: Reassessment data for Berlin stormwater drainage systems

| AI? | System ID | Date assessed | Inspector | Structure | Pipe diam. (in.) | Pipe material | Dry, wet (no flow), dripping, or flowing? | Flow depth (in.) | Pipe position | Erosion | Erosion description | Discharge characteristics | Floatables | Deposits/ Stains | Damage | Obstructions | OB pad set? | Date OB pad retrieved | OB Result | Ammonia (mg/L) | Chlorine (mg/L) | MBAS detergents-corrected (mg/L) | Sp. conductance (µs/cm) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BE080 | 5/12/2016 | DTC,DCB | | | | | | | | | | | | | | Y | 5/17/2016 | negative | 0.0 | 0.04 | 0.00 | 814 | |
| AI | BE100 | 5/12/2016 | DTC,DCB | outfall | 14 | corrugated metal | flowing | | free flow | none | NA | clear, no odor | none | none | none | none | Y | 5/17/2016 | indeterminate | 0.2 | 0.03 | 0.00 | 690 | |
| AI | BE100 | 5/26/2016 | DTC,DCB | outfall | 14 | corrugated metal | trickling | | free flow | none | NA | clear, no odor | none | none | none | none | Y | lost | NA | 0.0 | 0.04 | 0.00 | 595 | |
| AI | BE100 | 9/30/2016 | DTC | outfall | 14 | corrugated metal | flowing | 0.13 | free flow | none | NA | clear, no odor | none | none | none | none | Y | 10/5/2016 | positive | 0.0 | 0.05 | 0.27 | 441 | Outfall (positive), CB1 (negative), CB2 (positive), CB3 (positive). |
| | BE160 | 5/12/2016 | DTC,DCB | | | | | | | | | | | | | | Y | 5/17/2016 | negative | 0.0 | 0.04 | 0.00 | 862 | |
| | BE210 | 5/12/2016 | DTC,DCB | | | | dry | | | | | dry | | | | | N | | NA | | | | | |
| | BE430 | 5/12/2016 | DTC,DCB | outfall | 12 | corrugated black plastic | trickling | NA | free flow | none | none | no odor or staining | none | none | none | none | N | | NA | 0.0 | 0.05 | 0.13 | 11060 | |
| | BE480 | 5/12/2016 | DTC,DCB | | | | flowing | | | | | | | | | | N | | NA | N.S. | N.S. | N.S. | 7060 | |
| | BE500 | 5/12/2016 | DTC,DCB | | 12 | corrugated black plastic | dripping | NA | free flow | none | NA | no odor or staining | none | none | none | none | Y | 5/17/2016 | negative | 0.1 | 0.00 | invalid | 0.11 | MBAS test invalid (green color developed) |
| | BE500 | 5/17/2016 | DTC | | 12 | corrugated black plastic | dripping | NA | free flow | none | NA | no odor or staining | none | none | none | none | N | | NA | 0.0 | N.S. | 0.00 | 35.3 | |

Appendix C, Table 4: Reassessment data for Stowe stormwater drainage systems

| AI? | System ID | Date assessed | Inspector | Structure | Pipe diam. (in.) | Pipe material | Dry, wet (no flow), dripping, or flowing? | Flow depth (in.) | Pipe position | Erosion | Erosion description | Discharge characteristics | Floatables | Deposits/ Stains | Damage | Obstructions | OB pad set? | Date OB pad retrieved | OB Result | Ammonia (mg/L) | Chlorine (mg/L) | MBAS detergents-corrected (mg/L) | Sp. conductance (µs/cm) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ST010 | 5/10/2016 | DTC, DCB | outfall | 28 | corrugated black plastic | flowing | 0.25 | free flow | none | NA | clear, no odor; iron staining and | none | iron staining | crushed | none | N | | NA | 0.3 | 0.02 | 0.06 | 647 | CBs behind condos all clear/no odor. No oil residue where previously observed. |
| | ST030 | 5/10/2016 | DTC, DCB | outfall | unknown | unknown | flowing | unknown | submerged | none | NA | no odor; iron staining and floc | sheen | iron staining | unknown | fully obstructed | N | | NA | 0.4 | 0.02 | 0.02 | 1235 | Found outfall buried in sediment, water welling up from outfall. |
| | ST040 | 5/10/2016 | DTC, DCB | catchbasin | Na | Na | wet, no flow | NA | Na | none | NA | no odor, no color | sheen | none | unknown | unknown | N | | NA | 0.1 | 0.03 | 0.07 | 518 | Outfall apparently buried in wetland sediment. Assessed first CB up line. |
| AI | ST170 | 5/10/2016 | DTC, DCB | outfall | | corrugated black plastic | dry | NA | free flow | none | NA | no odor | none | none | none | none | Y | 5/26/2017 | positive | N.S. | 0.03 | N.S. | N.S. | Padded system 5/10/16. |
| AI | ST250 | 5/10/2016 | DTC, DCB | outfall | 15 | corrugated black plastic | flowing | 0.25 | free flow | none | NA | clear, no odor | suds | none | none | none | Y | 5/17/2016 | negative | 0.0 | 0.02 | 0.00 | 895 | Padded system 5/10/16. |
| AI | ST250 | 5/26/2016 | DTC, DCB | outfall | 15 | corrugated black plastic | flowing | | free flow | none | NA | | suds | none | none | none | Y | 6/9/2016 | negative | 0.0 | 0.01 | 0.00 | 985 | CB1, CB1 pipe B negative. |
| AI | ST350 | 5/10/2016 | DTC, DCB | outfall | | corrugated metal | wet, no flow | | free flow | none | NA | clear, no odor | none | none | none | partially obstructed | Y | 5/17/2016 | negative | | | | | |
| AI | ST350 | 5/17/2016 | DTC, DCB | outfall | | corrugated metal | wet, no flow | | free flow | none | NA | clear, no odor | none | none | none | partially obstructed | N | | NA | 0.1 | N.S. | 0.10 | 73 | Sampled stagnant water in pipe |
| AI | ST350 | 5/26/2016 | DCB | outfall | | corrugated metal | wet, no flow | | free flow | none | NA | clear, no odor | none | none | none | none | N | | NA | | | | 411 | No sample collected. |
| AI | ST370 | 5/10/2016 | DTC, DCB | JCT1 DI | NA | corrugated metal | flowing | | free flow | none | NA | clear, no odor, iron staining | none | iron staining | corrosion | none | N | | NA | 0.0 | 0.02 | 0.00 | | Four pipes enter Junction 1, see field sheet for details |
| AI | ST370 | 5/26/2016 | DTC, DCB | CB by Depot b | NA | corrugated metal | flowing | | free flow | none | NA | clear, no odor, iron staining | none | iron staining | corrosion | none | N | | NA | 0.4 | 0.03 | 0.99 | 216 | No flow from CB next to Depot building or in SDR35 entering this CB. DCB met with manager. |
| | ST420 | 5/10/2016 | DTC, DCB | outfall | 24 | corrugated black plastic | flowing | 0.3 | free flow | none | NA | clear, no odor | none | iron staining | none | none | N | | NA | 0.25 | 0.01 | 0.00 | 810 | Map not accurate. See field sheet for DCB sketch. |
| | ST420 | 5/26/2017 | DTC | outfall | 24 | corrugated black plastic | flowing | | free flow | none | NA | clear, no odor | none | iron staining | none | none | Y | 5/26/2016 | negative | 0.1 | 0.01 | 0.00 | 875 | Set pad in MH "X" on 5/26/16, retrieved 6/19/16 |
| AI | ST700 | 5/10/2016 | DTC, DCB | outfall | 24 | corrugated metal | dry | | free flow | none | NA | dry | none | iron staining | corrosion | none | Y | 5/17/2016 | negative | | | | | Pads set at OF, CB1, DI sump, DI black pipe, DI culvert out, and #203, #53, #33 Sylvan Park. All neg |

# Appendix D. Maps

DAGMONT AV
DAGMONT AV
BERLIN
BAILEY
SKYLINE DR
HIGHGATE DR
PROSPECT
PROSPECT
PROSPECT
SKYLINE DR
COOLIDGE
JACQUES
ARIOLI AV
COUNTRY WY
DANIEL DR
PALMISANO PLZ
WESTWOOD PKWY
COUNTRY WY
COUNTRY WY
COUNTRY WY
CB1
BC140
BC130
CB2
#4
CB3
CB4
#8
CB5
CB6
CB17
CB16
CB18
CB15
CB7
CB14
CB8
CB9
CB13
CB12
31 Palmisano Plz
CB10
CB11
N
BARRE TOWN
0
250
500 Feet
Legend
Existing, Area drain
Existing, Catchbasin
Existing, Culvert inlet
Existing, Culvert outlet
Existing, Drop Inlet
Existing, Information Point
Existing, Outfall
Existing, Stormwater Manhole
Existing, Footing drain
Existing, Roof drain
Existing, Storm line
Existing, Stream
Existing, Swale
Sources: Stormwater infrastructure: VT ANR; Imagery: esri.
Map BC-1
Systems BC140 and BC130
Barre City, VT
Upper Winooski River Basin IDDE


0 50 100 Feet

Legend

- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Storm line
- Existing, Stream
- Existing, Tunnel (storm)

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

**Map BC-2**
**System BC290**
**Barre City, VT**

**Upper Winooski River Basin IDDE**

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps_IDDEComments\System Maps\Map BC-2 system BC290.mxd


**Map BC-3**
**System BC410**
**Barre City, VT**

**Upper Winooski River Basin IDDE**

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps_IDDEComments\System Maps\Map BC-3 system BC410.mxd


N

0 70 140 Feet

Legend

- Existing, Catchbasin
- Existing, Culvert outlet
- Existing, Outfall
- Existing, Storm line
- Existing, Swale

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

# Map BC-4
# System BC450
# Barre City, VT

## Upper Winooski River Basin IDDE

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps_IDDEComments\System Maps\Map BC-4 system BC450.mxd


N

0 100 200 Feet

Legend

- Existing, Catchbasin
- Existing, Information Point
- Existing, Outfall
- Existing, Stormwater Manhole
- Existing, Footing drain
- Existing, Storm line

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

# Map BC-5
# Systems BC520 & 550
# Barre City, VT

## Upper Winooski River Basin IDDE

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps\SystemMaps_IDDEComments\System Maps\Map BC-5 system BC520 & 550.mxd


Legend

- Abandoned, Outfall
- Existing, Catchbasin
- Existing, Outfall
- Existing, Stormwater Manhole
- Abandoned, Storm line
- Existing, Footing drain
- Existing, Storm line
- Existing, Stream
- Existing, Under drain

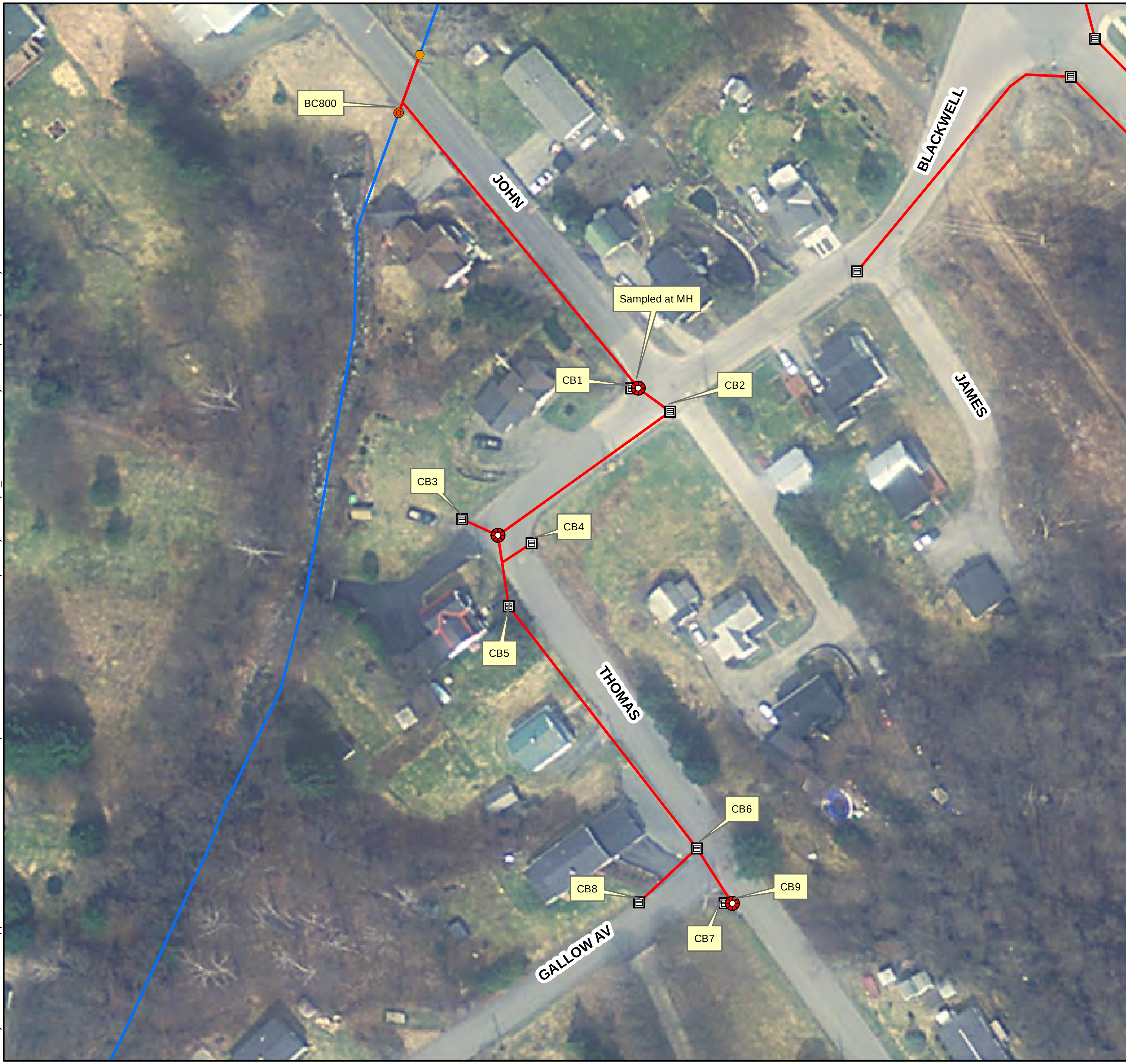
Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

**Map BC-6**
**Systems BC570**
**Barre City, VT**

**Upper Winooski River Basin IDDE**

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps\SystemMaps_IDDEComments\System Maps\Map BC-6 system BC570.mxd

# Map BC-7
# Systems BC800
# Barre City, VT




0 75 150 Feet

Legend

- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Stormwater Manhole
- Existing, Storm line
- Existing, Stream

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

**Upper Winooski River Basin IDDE**

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps_IDDEComments\System Maps\Map BC-7 system BC800.mxd




Legend

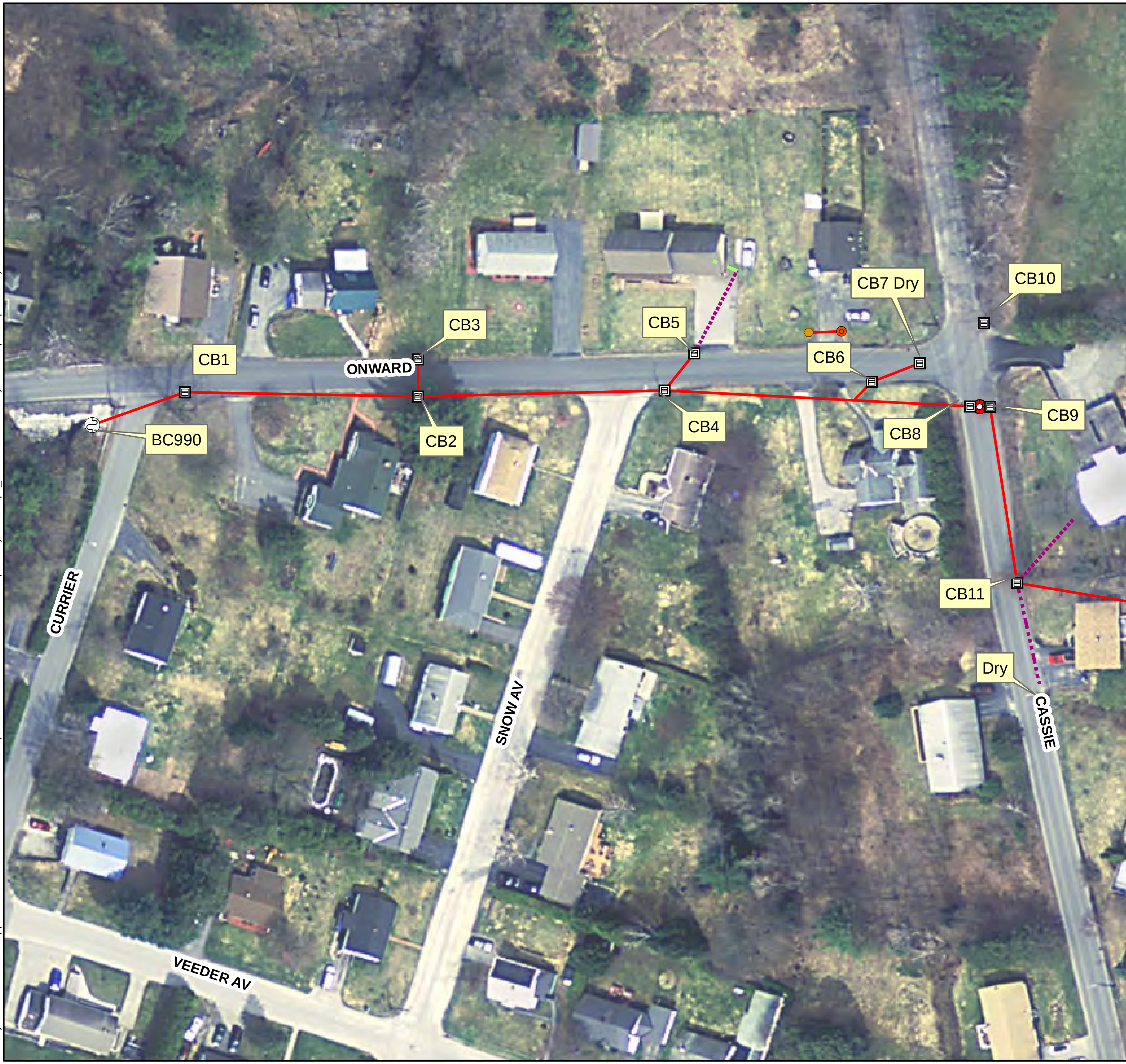
- E, 6
- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Outfall
- Existing, Stormwater Manhole
- Existing, Footing drain
- Existing, Storm line
- Existing, Swale
- Existing, Under drain

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

# Map BC-8 Systems BC830 Barre City, VT

## Upper Winooski River Basin IDDE

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps_IDDEComments\System Maps\Map BC-8 system BC830.mxd




N

0 80 160 Feet

Legend

- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Outfall
- Existing, Stormwater Manhole
- Existing, Footing drain
- Existing, Roof drain
- Existing, Storm line
- Existing, Under drain

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

# Map BC-9
# Systems BC990
# Barre City, VT

## Upper Winooski River Basin IDDE

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps_IDDEComments\System Maps\Map BC-9 system BC990.mxd


N

0 110 220 Feet

Legend

- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Drop Inlet
- Existing, Information Point
- Existing, Outfall
- Existing, Stormwater Manhole
- Existing, Treatment feature (see notes)
- Proposed, Culvert inlet
- Proposed, Culvert outlet
- Existing, Infiltration pipe
- Existing, Footing drain
- Existing, Roof drain
- Existing, Storm line
- Existing, Stream
- Existing, Swale
- Existing, Under drain
- Proposed, Storm line

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

**Map BC-10**
**Systems BC1120 & 1640**
**Barre City, VT**

**Upper Winooski River Basin IDDE**

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# Map BC-11
# Systems BC1290
# Barre City, VT

## Upper Winooski River Basin IDDE

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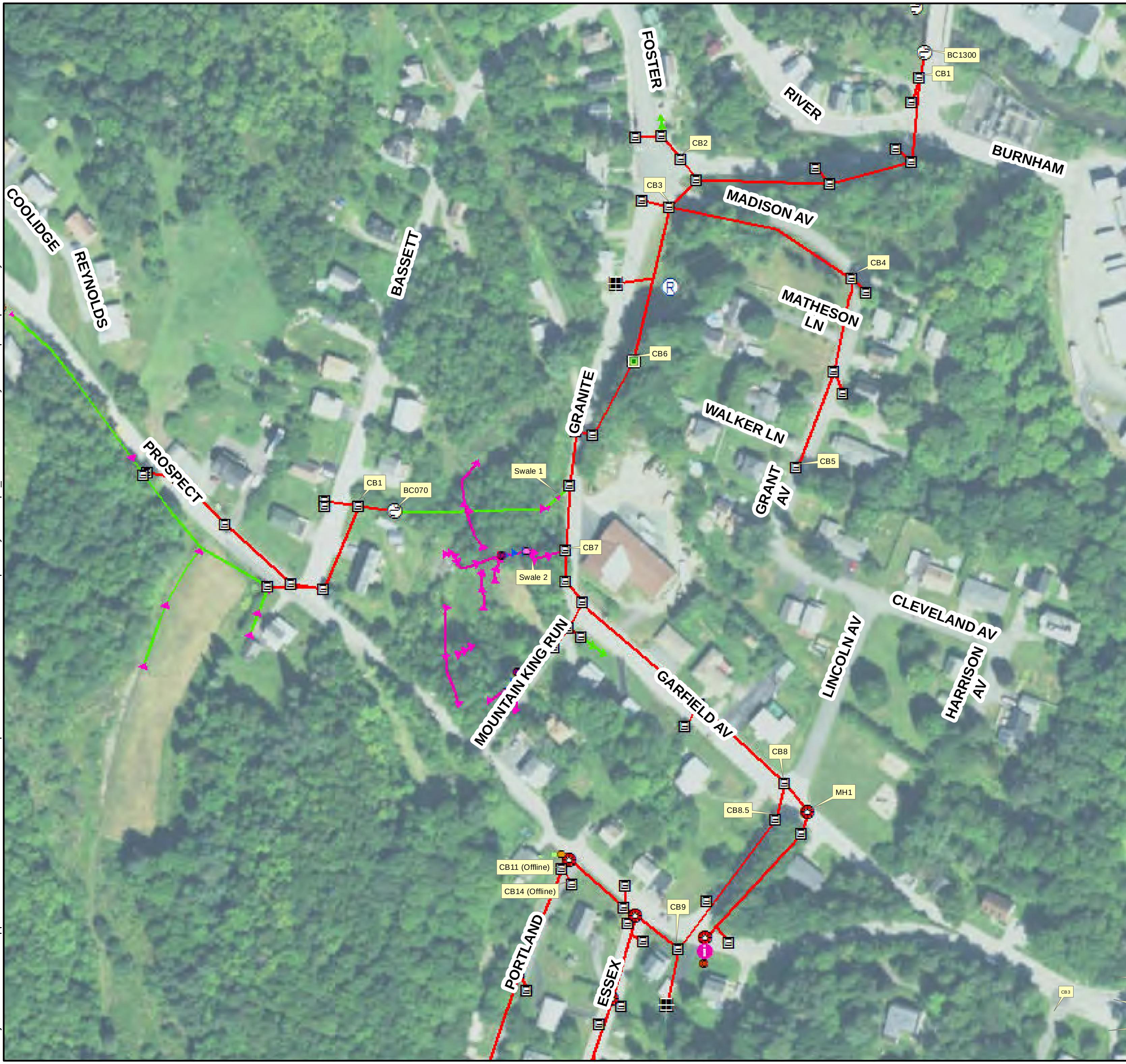


N

0 175 350 Feet

Legend

- E, 6
- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Drop Inlet
- Existing, Information Point
- Existing, Junction Box
- Existing, Outfall
- Existing, Stormwater Manhole
- Proposed, Culvert inlet
- Proposed, Culvert outlet
- Abandoned, Storm line
- Existing, Footing drain
- Existing, Roof drain
- Existing, Storm line
- Existing, Stream
- Existing, Swale
- Proposed, Storm line
- Proposed, Swale

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

# Map BC-12
# System BC1300
# Barre City, VT

## Upper Winooski River Basin IDDE

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps_IDDEComments\System Maps\Map BC-12 system BC1300.mxd


N

0 210 420 Feet

Legend

- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Junction Box
- Existing, Outfall
- Existing, Stormwater Manhole
- Existing, Storm line
- Existing, Stream
- Existing, Under drain

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

# Map BC-13 System BC1620 Barre City, VT

## Upper Winooski River Basin IDDE

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N

0 180 360 Feet

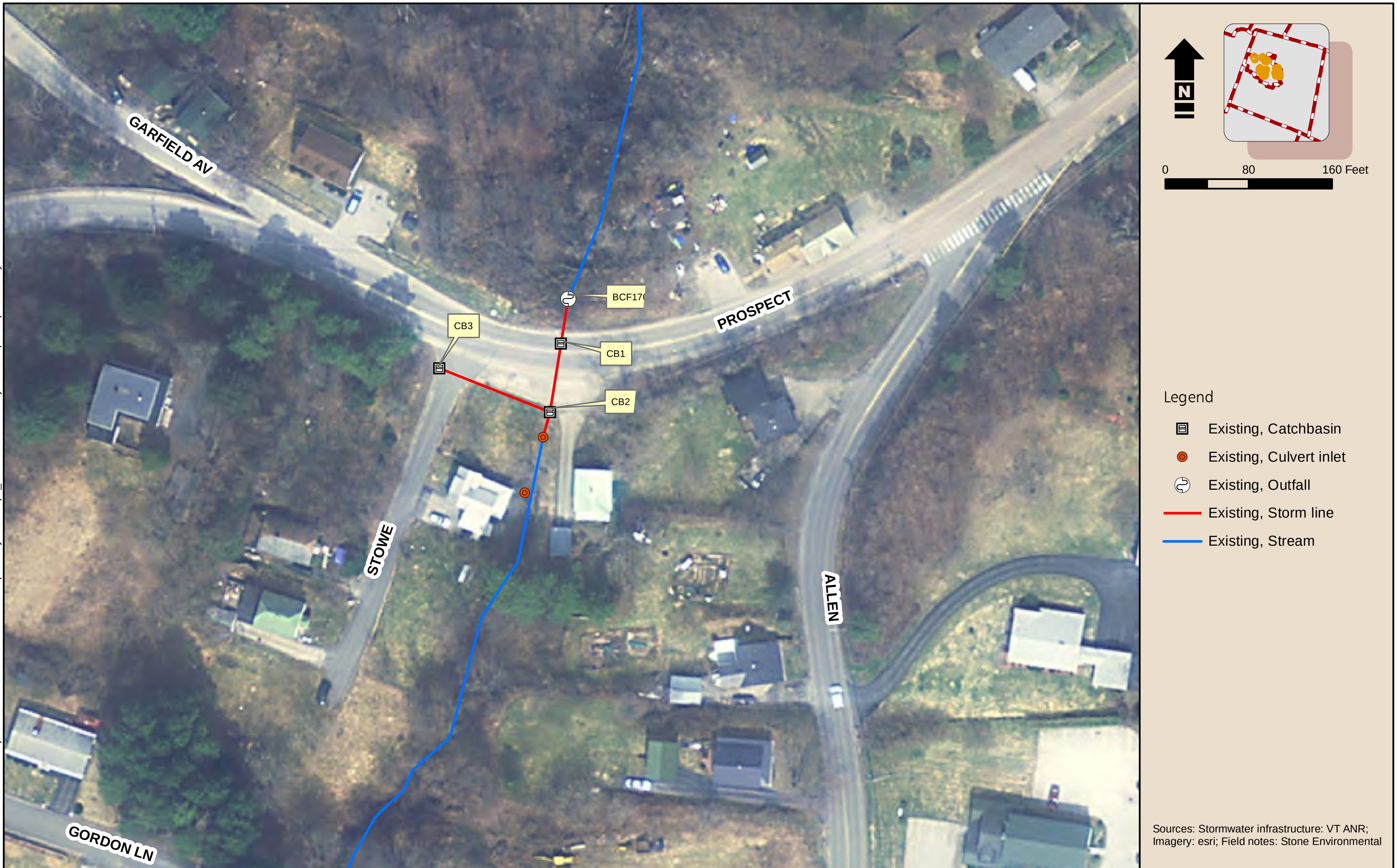
Legend

- E, 6
- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Junction Box
- Existing, Outfall
- Existing, Stormwater Manhole
- Existing, Storm line
- Existing, Stream
- Existing, Under drain

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

**Map BC-14**
**Systems BC1630**
**Barre City, VT**

**Upper Winooski River Basin IDDE**




# Map BC-15
# Systems BCF170
# Barre City, VT

## Upper Winooski River Basin IDDE

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Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

**Map BC-16**
**Systems BCF470**
**Barre City, VT**

**Upper Winooski River Basin IDDE**

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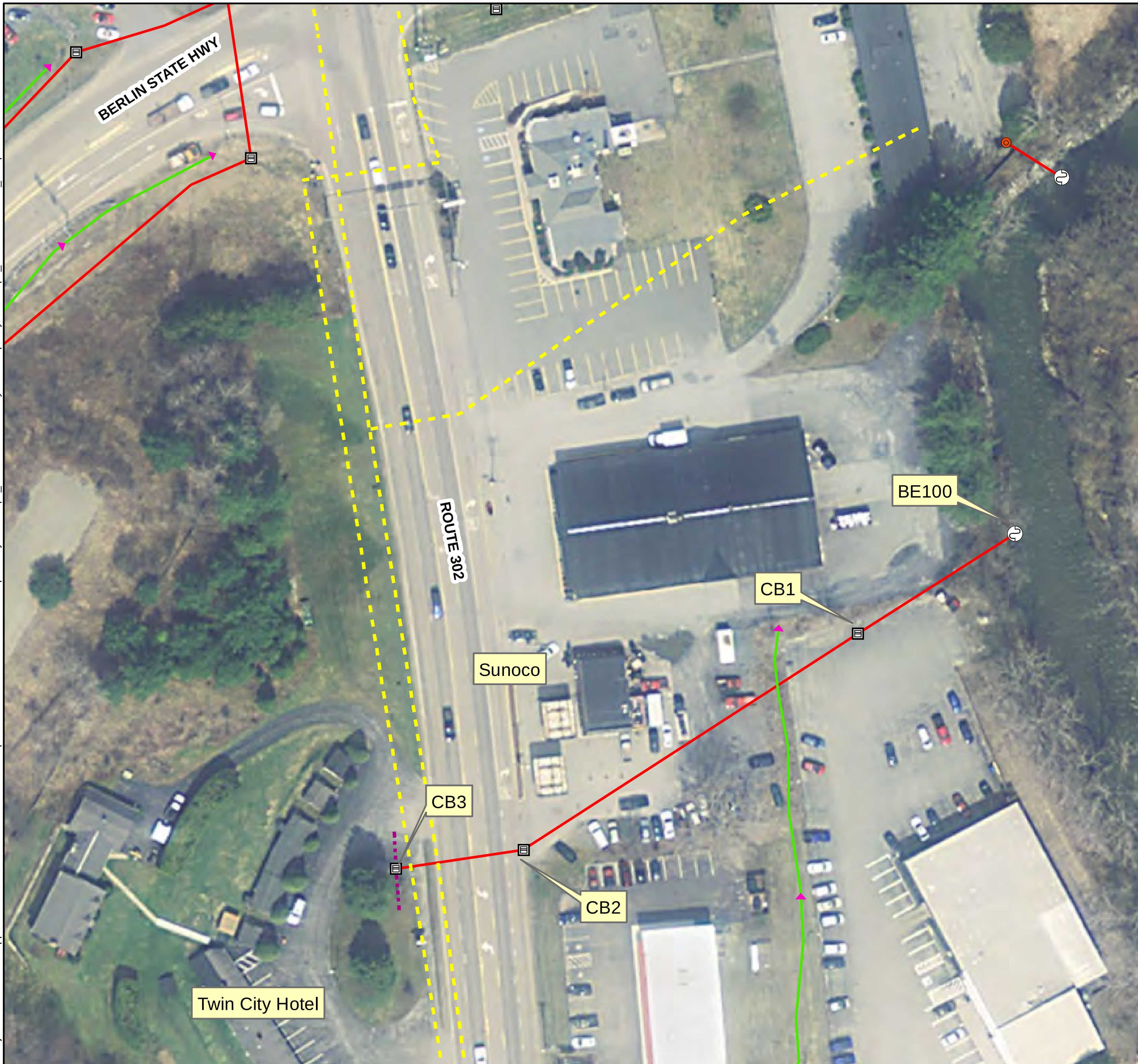


0 75 150 Feet

Legend

- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Outfall
- Existing, Overland flow
- Existing, Sanitary line
- Existing, Storm line
- Existing, Stream
- Existing, Swale
- Existing, Under drain

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

**Map BE-1**
**System BE100**
**Berlin, VT**

**Upper Winooski River Basin IDDE**

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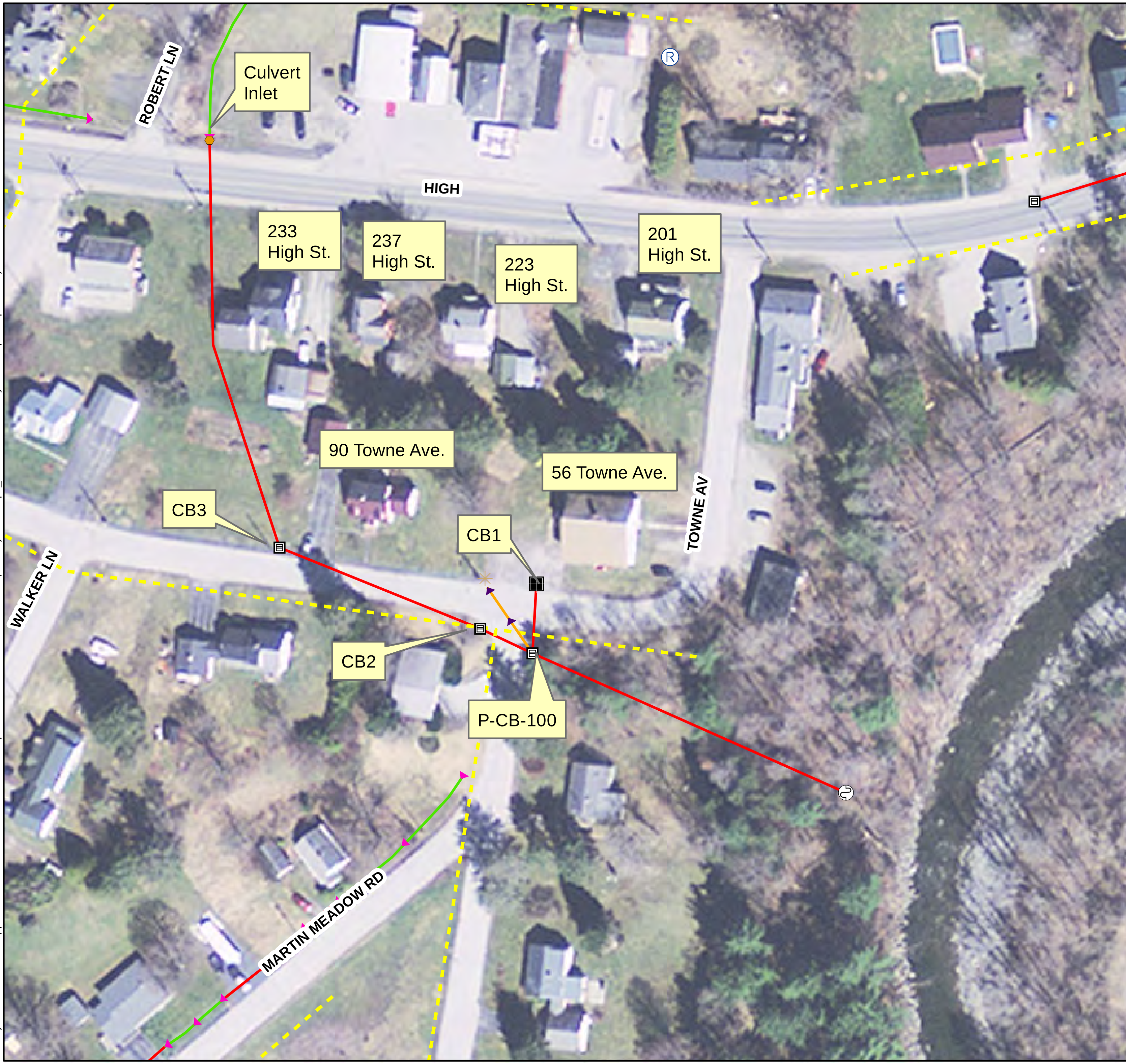
**Legend**

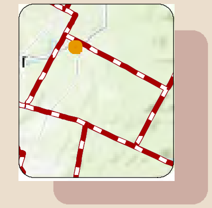
- Outfall
- Catchbasin
- Culvert inlet
- Culvert outlet
- Sanitary Manhole
- Footing drain
- Sanitary line
- Storm line
- Stream
- Swale
- Proposed, Storm line

Sources: Stormwater infrastructure: VT ANR; Imagery: esri.

**Map BT-1**
**System BT2640**
**Barre Town, VT**

**Upper Winooski IDDE**



N

0 60 120 Feet

Legend

- Existing, Unknown Point
- E, 6
- Existing, Catchbasin
- Existing, Culvert outlet
- Existing, Drop Inlet
- Existing, Outfall
- Existing, Sanitary line
- Existing, Storm line
- Existing, Storm line (old Sanitary line)
- Existing, Swale

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

# Map PL-1 System P-CB-100 Plainfield, VT

## Upper Winooski River Basin IDDE

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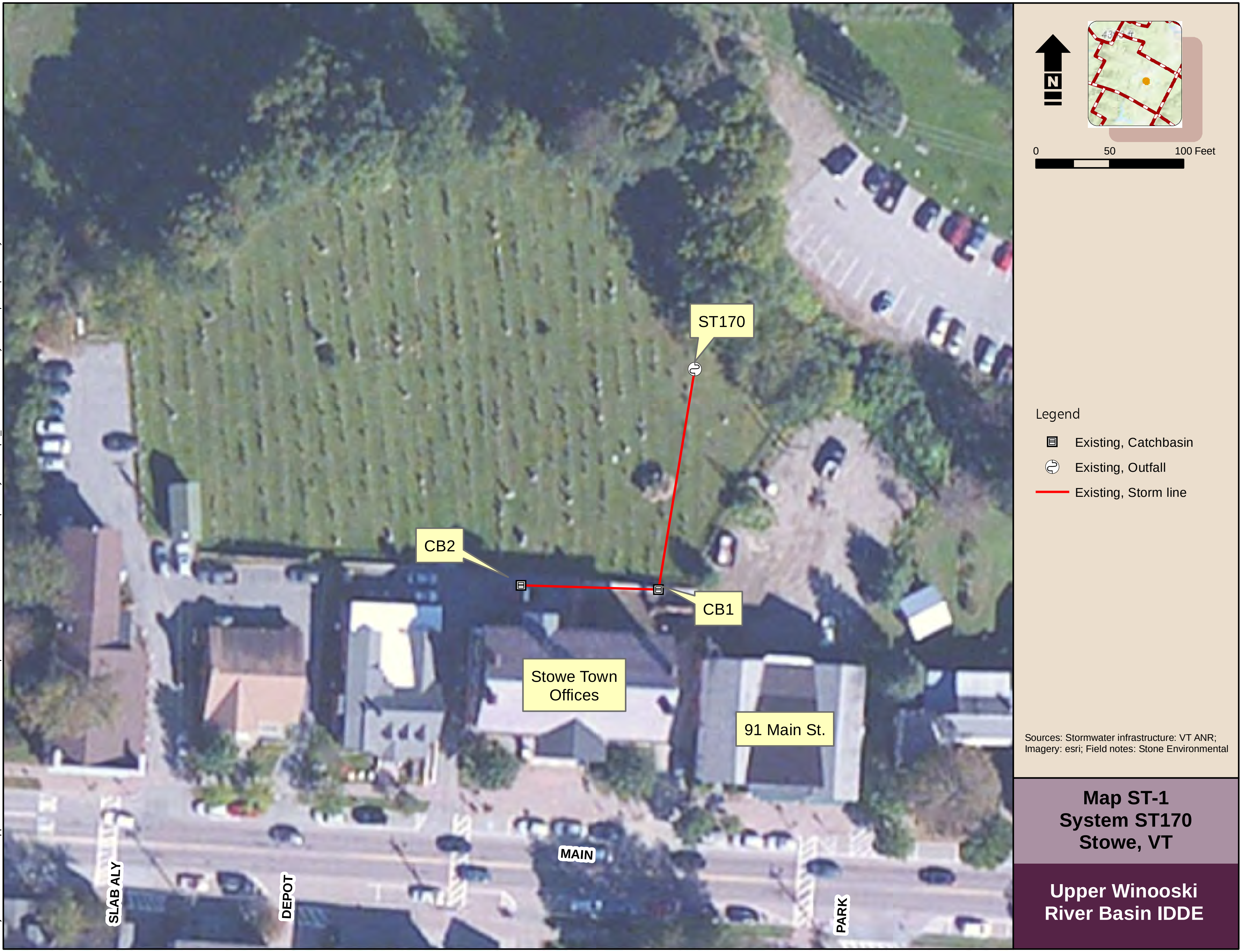


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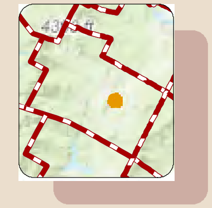

N

0 80 160 Feet

Legend

Potential, Retrofit
Existing, Catchbasin
Existing, Grate/Curb Inlet
Existing, Outfall
Existing, Stormwater Manhole
Existing, Footing drain
Existing, Roof drain
Existing, Storm line
Existing, Swale

Sources: Stormwater infrastructure: VT ANR;
Imagery: esri; Field notes: Stone Environmental

**Map ST-2**
**System ST250**
**Stowe, VT**

**Upper Winooski River Basin IDDE**

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0 60 120 Feet

Legend

- Existing, Catchbasin
- Existing, Outfall
- Existing, Stormwater Manhole
- Proposed, Catchbasin
- Existing, Overland flow
- Existing, Footing drain
- Existing, Storm line
- Existing, Under drain

Sources: Stormwater infrastructure: VT ANR; Imagery: esri; Field notes: Stone Environmental

# Map ST-3
# System ST370 (Detail)
# Stowe, VT

## Upper Winooski River Basin IDDE

O:\Proj-16\WRM\16-031 Upper Winooski River Basin IDDE\GIS\MapDocuments\PresentationsAndReports\SystemMaps\SystemMaps_IDDEComments\System Maps\Map ST-3 System ST370.mxd