Advanced Illicit Discharge Investigations in the Lamoille River, Otter Creek, and Poultney River Basins: Final Report

PROJECT NO.

15-090

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Cover photo: Smoke testing of a stormdrain in Proctor revealed a sanitary wastewater connection from this house (note smoking sewer vent)

Contents

Table of Figures

Table of Tables

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 or 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 stormdrains from directly connected municipal sewers or building sewer pipe connections can result in significant nutrient and microbial pollution. Sanitary wastewater can also enter stormdrains 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 stormdrain 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 the 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 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. This project involved follow-up investigative work in 14 municipalities of illicit discharges suspected in 38 stormwater drainage systems in the Otter Creek, Poultney River, and Lamoille River Basins. These stormwater drainage systems were flagged for follow-up investigation in IDDE studies performed between 2011 and 2013. There were three general categories of follow-up investigative work required: reassessment, post-correction sampling, and additional advanced investigation.

The objectives of this project were to:

- Conclusively establish the presence (or absence) of a suspected illicit discharge where previous results were inconclusive (systems in the reassessment category);
- Demonstrate whether recent corrective actions in fact eliminated previously identified illicit discharges (systems in the post-correction sampling category); and
- Locate the source of the illicit discharge and provide sufficient information for the owner of the discharge to take corrective actions (systems in the advanced investigation category).

1.1. Previous IDDE Studies in the Participating Municipalities

In the 2011–2014 timeframe, Stone Environmental performed IDDE studies in the Otter Creek, Poultney River, and Lamoille River Basins. Assessment data and investigation findings for stormwater drainage systems in these basins were presented in three final reports prepared by Stone:

Detecting and Eliminating Illicit Discharges in Rutland County to Improve Water Quality, March 31, 2014.
Otter Creek Basin Illicit Discharge Detection and Elimination Project, May 31, 2014.
Detecting and Eliminating Illicit Discharges to Improve Water Quality in the Lamoille River Basin, July 11, 2014.

Significant illicit discharges were identified and eliminated during these studies. However, in certain systems discharge assessment results were inconclusive or suspected illicit discharges could not be eliminated within the timeframes of the projects. In reviewing the data and findings, Stone and DEC flagged a total of 38 stormwater drainage systems in 14 municipalities requiring further work.

1.2. Scope of Present Study

The scope of the present study entailed reassessment or further investigation of 38 stormwater drainage systems located in 14 municipalities in the Lamoille, Otter Creek, and Poultney River Basins. Table 1 presents the list of systems requiring reassessment, resampling, or advanced investigation. Stormwater systems were classified according to the type of follow-up work considered necessary at the time of DEC's Request for Proposals.

Table 1. Systems requiring reassessment, post-correction sampling, or advanced investigation

Original IDDE Project	Municipality	Investigation Category: Reassessment	Post-correction Sampling	Additional Advanced Investigation
Otter Creek Basin				
	Brandon	BN340		BN250 BN260
	Middlebury	MB2100		MB170-#1 MB230 MB330 MB350 MB1220-#1 MB1220-#2
	Rutland City	RU130[1]	RU980 RU1650	
	Rutland Town		RT730 RT1210 RT1250	RT270
	Vergennes			VG450 VG470 VG570 VG640 VG670
Rutland County				
	Fair Haven		FH280 FH350	
	Poultney		PY140	
	Proctor		PR390 CB-K, pipe A	PR240 PR390 CB-N, pipe C PR-West St.[1]
	Wallingford		WA090	
Lamoille River Basin				
	Fairfax	FX070[1]		
	Hardwick		HA070	
	Hyde Park	HP170	HP090	HP160[1]
	Morrisville			MO150 MO300
	Wolcott		WO050	
Total systems		5	13	20

1. In consultation with the DEC project administrator, systems PR-West St. and HP160 were moved from reassessment to advanced investigation and systems RU130 and FX070 were moved from advanced investigation to reassessment

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 earlier IDDE projects, kickoff meetings with the participating municipalities were not needed.

2.2. Reassessments

The goal of the reassessments was to establish conclusively whether an illicit discharge of wastewater or industrial process water was present in these systems. 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 (OB). 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 6.38.1 (Appendix B). To test for OB, 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 OB. 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 OB 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 monitoring pad under fluorescent (left) and UV (right) lamps

Table 2, 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 2. 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. Post-correction Sampling

Certain stormwater drainage systems were designated for resampling—identified in Table 1—where previously identified illicit discharges were expected to have been corrected. The objectives of resampling were to confirm elimination of the identified illicit discharge and to determine whether any additional discharges were present in the drainage system. Stormwater outfalls were resampled during dry weather to minimize dilution by stormwater. Dry weather will be defined as negligible rainfall (less than 0.1 inches) since approximately 12:00 p.m. on the previous day. In larger stormwater collection systems where the effects of dilution must be considered, selected catchbasins and junction manholes will also be assessed. Stormwater structures will be accessed along the public right-of-way or from the receiving waterbody, as appropriate.

2.4. Advanced Investigations

Stormwater drainage systems suspected of passing illicit discharges—identified in Table 1—were investigated further, employing bracket sampling procedures, camera inspection, dye testing, and/or smoke testing. The goal of the additional advanced investigations was to provide the town and DEC with accurate information regarding the source of the contamination to enable correction by the Town and/or property owners within the Town. DEC's stormwater infrastructure mapping was used to guide this effort.

The most reliable method to bracket sources of wastewater contamination is usually OB monitoring throughout the drainage system. In several instances, we used OB 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 Brandon, Hyde Park, Middlebury, Morrisville, Proctor, and Vergennes to identify specific improper connections.

2.4.1. *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 3.

Table 3. 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. Reassessment Results

Reassessments of the systems identified in Table 1 were performed over the course of two field seasons, 2015-2016. Five separate stormwater drainage systems required reassessment due to inconclusive or insufficiently complete results obtained in the assessments performed for the original studies. To our knowledge no corrections have been made in these systems. Reassessment data for these systems are included in Appendix C, Table 1. Our findings relative to each of these systems are presented below and are summarized in Table 4.

Table 4. Summary of status of reassessed systems

System	Municipality	Status	Comment
BN340	Brandon	No chronic illicit discharge	No OB or other contaminants were detected, July 21, 2016.
MB2100	Middlebury	No chronic illicit discharge	No OB or other contaminants were detected, August 16 and 26, 2016.
RU130	Rutland City	A minor wastewater leak is suspected in this system	Further investigation was determined not to be a priority.
FX070	Fairfax	No chronic illicit discharge	No OB or other contaminants were detected, October 23, 2015.
HP170	Hyde Park	No chronic illicit discharge	No OB or other contaminants were detected, October 21, 2015.

3.1. BN340 (Brandon)

Outfall BN340 is a 12-inch diameter corrugated metal pipe located on Union Street below Barlow Avenue, just upstream of the wastewater treatment plant. Monitoring pads deployed on June 12, 2012 indicated OB at the outfall and in the first upstream structure, MH-A, but not at the next upstream structure, CB-A. Zero *E. coli* and a low total phosphorus concentration (15.2 μg/L) were measured at the outfall on August 22, 2013. No OB was detected in MH-A when the system was retested on November 6, 2013. Our conclusion following the original study was that the OB detected in 2012 may have resulted from the river surcharging the outfall and MH-A. The elevations of the outfall and the MH-A invert are close to the low river stage.

The outfall was retested on July 21, 2016. No contaminants were measured above levels of concern and OB was not detected (Appendix C, Table 1). The *E. coli* level in a sample collected on July 28, 2016 was low (185 MPN/100 mL) (Table 7). There is only one house that could conceivably have a connection to this system, 48 Union Street. On July 21, 2016, a plumbing inspection was performed at 48 Union Street, which revealed that the washing machine is connected to a separate sewer pipe exiting the basement. However, both a toilet and the washing machine were dye tested and no dye was observed at the outfall. Based on the test results and observations in this system, we conclude there is no illicit discharge present.

3.2. MB2100 (Middlebury)

Culvert MB2100 crosses the train tracks west of the Agri-Mark facility on Industrial Avenue. A system of swales on the Agri-Mark property drains to this culvert. A sample collected at the culvert on December 15, 2011 had a moderately high ammonia concentration of 3.0 mg/L. The chlorine and MBAS detergent concentrations were below the limit of detection. Zero ammonia was detected in follow-up sampling on May 27, 2014.

This system was retested on August 26, 2016. No contaminants were detected above levels of concern Appendix C, Table 1). Therefore, based on the weight of evidence, we conclude there is no illicit discharge present in this system.

3.3. RU130 (Rutland City)

Outfall RU130 is an 18-inch diameter metal pipe located north of Killington Avenue, west of Ronaldo Court (Appendix D, Map 1). OB was detected at the outfall on June 20, 2012. Pads were deployed throughout the system on July 19, 2012 and OB was detected at the outfall and in the manhole at the intersection of East Washington Street and Lafayette Street (MH-C). Catchbasins in this system are off-line, complicating bracket sampling.

Elevated *E. coli* (350 MPN/100 mL) and low total phosphorus (30.3 μg/L) concentrations were measured at the outfall on August 28, 2013. Dye testing of homes on East Washington Street was performed on November 20, 2013. Only one house was successfully dye tested, 61 East Washington Street. Testing was generally inconclusive because most residents were not at home, traffic was a problem, and dye took over 30 minutes to pass from 61 East Washington Street to the sanitary manhole at the intersection of Lafayette and East Washington Streets. No dye was observed in stormwater manhole MH-C. The Rutland City Public Works Department provided camera footage of the East Washington Street sewer line. This footage was reviewed for any obvious leaks or inappropriate connections and none were seen.

On September 28, 2016 the outfall was resampled. A low concentration of ammonia (0.3 mg/L) was measured and OB was detected (Appendix C, Table 1). An *E. coli* sample collected on October 12, 2016 was slightly elevated, 364 MPN/100 mL (Table 7). While these data suggest an indirect wastewater connection somewhere in the drainage system, we concluded that the likelihood of finding its source was low, based on unsuccessful efforts in 2012-2013, and that it poses little risk to water quality. Therefore, with the VTDEC project administrator's concurrence, an alternate system (PR-West-St.) with a suspected direct connection was substituted for RU130 on the advanced investigations list.

3.4. FX070 (Fairfax)

This system drains a portion of Route 104/Main Street and discharges on the west side of Route 104 downhill from the Fairfax Commons development (Appendix D, Map 2). The outfall was retested on October 22, 2015 and no indications of contamination were present (Appendix C, Table 1). An OB pad set in the first catchbasin (CB-A) upstream of the outfall was negative. *E. coli* (60 MPN/100 mL) and total phosphorus concentrations (126 μg/L) were low in a sample collected at the outfall on October 23, 2015 (Table 7). Therefore, we do not believe there is an illicit discharge in this location.

3.5. HP170 (Hyde Park)

System HP170 is mapped as a former sanitary sewer repurposed as a stormdrain (Appendix D, Map 3). It was not assessed during the original Lamoille Basin IDDE study because it is now a small stream flowing in an open channel. Only remnants of the earlier sewer exist. On three occasions (October 23, October 27, and December 8, 2015), the stream channel in this location was walked from the culvert by the rail trail up to the top of the channel. There are sections of vitrified clay pipe lying within and next to the stream channel that are clearly remnants of the former sewer system. We found no intact pipes discharging to the stream channel. OB pads were set in the stream in two places: at the top of the channel near the groundwater seep and at the entrance to the culvert under the rail trail. No OB was detected on these pads (Appendix C, Table 1). Therefore, we do not believe there is an illicit discharge in this location.

4. Post-Correction Sampling Results

Thirteen (13) separate stormwater drainage systems were designated for post-correction sampling. In each case, a correction to eliminate a wastewater or process water discharge was made or was planned by the end of the summer of 2014. Several corrections took much longer to complete. In one case, FH280 in Fair Haven, a correction was not confirmed until December 31, 2018.

Water quality data for these systems are included in Appendix C, Table 2. Our findings relative to each of these systems are presented below and are summarized in Table 5.

Table 5. Summary of status of resampled systems

Original IDDE Project	System	Municipality	Status	Comment
Otter Creek	RU980	Rutland City	Confirmed elimination of illicit discharge	Use of floor drains in the former Rutland Plywood facility has been discontinued.
	RU1650	Rutland City	Improved HVAC cleaning practices implemented	Improved HVAC cleaning practices were reportedly implemented, which should reduce discharge of cleaning products.
	RT730	Rutland Town	Confirmed elimination of illicit discharge	The owner of 586 Gleason Road removed a washing machine that was discharging to this drainage system.
	RT1210	Rutland Town	No ongoing illicit discharge present	Rutland Town Department of Public Works personnel confirmed no sanitary or washwater discharge is occurring from 167 Annette Terrace.
	RT1250	Rutland Town	Confirmed elimination of illicit discharge	A washwater discharge to this drainage system from 26 Easy Street appears to have been eliminated.
Rutland County	FH280	Fair Haven	Confirmed elimination of illicit discharge	The sewer lateral serving 12 Prospect Street was replaced per approved plans in 2018.
	FH350	Fair Haven	The discharge was apparently resolved in 2016; however, we are concerned it could reoccur.	The septic tank serving 70 South Main Street was reportedly pumped out in 2016. VTDEC enforcement division found no evidence of a failed or failing septic system in 2016. We recommend this site be revisited in 2019 to confirm that the failure Stone observed in 2013 has not reoccurred.
	PY140	Poultney	Confirmed elimination of illicit discharge	A replacement septic system was constructed at 358 York Street Extension in 2016 and the pipe conveying wastewater to the stormdrain was eliminated. No OB was detected in subsequent sampling.
	PR390 CB-K, pipe A	Proctor	Confirmed elimination of illicit discharge	OB monitoring confirmed that the sanitary wastewater discharge previously entering catchbasin CB-M on the lawn of the OMYA Geology building had been eliminated. Positive OB results consistently found in the Portico drain appear to result from residual petroleum contamination related to a historic release.
	WA090	Wallingford	Confirmed elimination of illicit discharge	No OB or other contaminants detected in sampling following abandonment of failed septic system at 56

Original IDDE Project	System	Municipality	Status	Comment
				Church Street and connection to municipal sanitary sewer.
Lamoille River	HA070	Hardwick	Confirmed elimination of illicit discharge	No dry weather flow observed in this system following connection of the Hardwick Elementary School wing to the municipal sanitary sewer.
	HP090	Hyde Park	Confirmed elimination of illicit discharges	No OB was detected in this system following elimination of three illicit discharges: one sanitary connection, one washwater connection, and one floor drain discharge.
	WO050	Wolcott	No ongoing illicit discharge present	It is unclear whether the leaking pump chamber in the former Buck's Furniture building is still in place. The building is vacant.

4.1. RU980 (Rutland City)

Outfall RU980 is an 18-inch diameter corrugated black plastic pipe located on the north side of the Rutland Plywood facility off Park Street (Appendix D, Map 4). The flow appeared milky in color on July 05, 2012. A low level of chlorine (0.05 mg/L) and exceedingly high specific conductance (53,500 μs/cm) were measured at the outfall. On a subsequent visit in 2013, a blackish colored discharge was observed (Figure 2). The source of the flow and contamination was determined to be two floor drains within the facility. A building tenant had been rinsing equipment into these drains, thinking they were connected to the sanitary sewer. This practice has been permanently halted, so the drains will no longer be a source of discharges.

On September 28, 2016 there was no flow observed at the outfall. An OB pad placed at the outfall was negative (Appendix C, Table 2). We conclude that this illicit discharge has been eliminated.

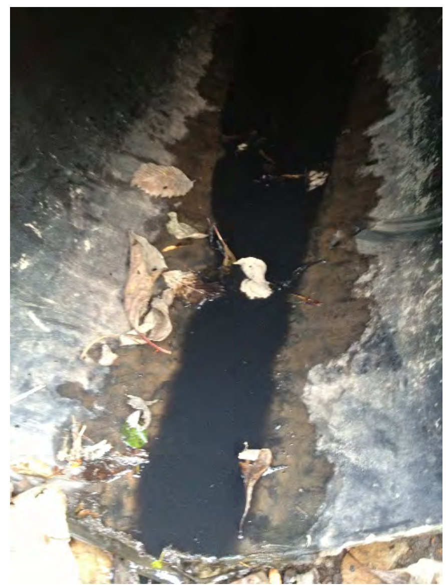


Figure 2. Discolored discharge from RU980 outfall

4.2. RU1650 (Rutland City)

Outfall RU1650 is an 18-inch diameter corrugated black plastic pipe located west of the office building at 271 North Main Street (Appendix D, Map 5). It was dripping when assessed on July 11, 2012. The concentration of ammonia (1.0 mg/L) was moderate and concentrations of chlorine (0.08 mg/L) and MBAS detergent (0.5 mg/L) were low. No OB was detected. On October 30, 2013 low concentrations of ammonia (0.5 mg/L) and MBAS detergents (0.75 mg/L) were measured at the outfall. Moderate ammonia (1.0 mg/L) and low MBAS detergent (0.5 mg/L) concentrations were also measured in the sump of catchbasin CB-C. The only flow entering catchbasin CB-C was from a plastic pipe aligned with the corner of the office building.

Following the initial study, VTDEC worked with the building owner and determined that the source of the ammonia and MBAS in the system is the HVAC units located on the flat roof. Products used to clean the units are conveyed by the HVAC condensation drain pipes. VTDEC has worked with the building owner to minimize the discharge of these cleaning products. Pans are reportedly placed under the HVAC units to collect the wash water when the units are serviced. However, complete elimination does not appear feasible. This property is covered under SW permit 3401-9015, and managing the HVAC cleaning will be a condition going forward.

This system was resampled on August 3, 2016 and a low MBAS concentration (0.4 mg/L) was measured (Appendix C, Table 2). Zero ammonia was detected. We conclude that proper HVAC cleaning practices will need to be continually maintained to minimize contaminant discharge into this stormdrain.

4.3. RT730 (Rutland Town)

Outfall RT730 is a 6-inch diameter corrugated plastic pipe located at the end of East Mountain View Drive (Appendix D, Map 6). A 4-inch diameter pipe discharging to CB-D from the house at 586 Gleason Road was determined to be the source of OB in this system. This finding was referred to the Town Administrator, Joe Zingale, to follow up with the property owner. On September 26, 2016 Byron Hathaway of the Rutland Town Highway Department confirmed that the owner of 586 Gleason Road had removed a washing machine causing the discharge. On September 28, 2016 OB pads placed at the outfall and CB-D were both negative (Appendix C, Table 2). Therefore, we conclude that this illicit discharge has been eliminated.

4.4. RT1210 (Rutland Town)

Outfall RT1210 is a 15-inch diameter corrugated plastic pipe located opposite 167 Annette Terrace. OB was detected in this system on two sampling dates in August 2012. There is only one catchbasin draining to the outfall and all dry weather flow entering this catchbasin was from an underdrain. The underdrain was therefore assumed to be the source of the OB. On October 22, 2013, no optical brightener was detected on a pad placed in this pipe. Although optical brightener was not detected in monitoring in 2013, the two positive detections in 2012 suggested there was some type of laundry connection to the underdrain.

The Rutland Town Administrator, Joe Zingale, visited of 167 Annette Terrace in November 2016 to evaluate this matter. Apparently, Mr. Zingale determined that there was no active washwater connection to catchbasin near 167 Annette Terrace.

4.5. RT1250 (Rutland Town)

Outfall RT1250 is an 18-inch diameter corrugated plastic pipe located on Post Road, immediately west of the Easy Street intersection (Appendix D, Map 7). OB was detected at the outfall on August 16, 2012. Low concentrations of ammonia (0.25 mg/L) and MBAS detergents (0.5 mg/L) were also measured. The outfall was dry on a subsequent visit. On October 15, 2013, a laundry odor was detected in catchbasin CB-C, located in the yard of 26 Easy Street. When the owner of this home offered to run a load of laundry, the flow to CB-C from a small diameter pipe aligned with the house increased abruptly, confirming a washwater connection. On October 22, 2013, OB was detected in CB-C. The Town Administrator, Joe Zingale, agreed to work with the homeowner to resolve the problem.

On December 1, 2016, Rutland Town staff dye tested the washing machine at 26 Easy Street and observed no dye entering the stormdrain. Based on our earlier observations of a clear connection, we believe the owner of 26 Easy Street eliminated the washwater discharge to the stormdrain.

4.6. FH280 (Fair Haven)

The FH280 outfall is a 15-in. diameter corrugated steel pipe. This system drains a stream that originates east of South Main Street and enters the FH280 system west of Lee Avenue (Appendix D, Map 8). OB was detected at the outfall on May 8, 2013. On a subsequent visit in June 2013, optical brightener was detected at the outfall, but not at the stream inlet. Elevated *E. coli* (600 MPN/100 mL) and low total phosphorus (51.9 μg/L) concentrations were measured at the outfall on August 6, 2013.

Investigation of the FH280 system was challenging because there is no access to the system between the stream inlet and the outfall and neither the inlet nor the outfall end of the stormline is accessible for camera inspection due to drops and corrugations. On January 21, 2014, Stone dye tested houses on Prospect Street. 12 Prospect Street was found to have an illicit connection to system FH280. Dye added to the toilet appeared in the sanitary sewer, as expected, but was also seen at the outfall. This result suggested a badly leaking house sewer lateral. Two houses further up Prospect Street (18 and 22) were also tested and no dye was observed at the outfall.

After repeated attempts by the Town of Fair Haven to work with the owner of 12 Prospect Street to replace the leaking sewer lateral, the matter was turned over to the VTDEC enforcement division. After considerable delay, the homeowner ultimately rerouted and replaced the broken lateral in 2018, per approved plans (WW-1-2977). Replacement of this lateral was certified by Mark Courcelle of Courcelle Surveying Co. in a letter to VTDEC Regional Engineer, David Swift, on December 31, 2018.

4.7. FH350 (Fair Haven)

The FH350 outfall is an 18-in. diameter corrugated steel pipe. This system drains a series of catchbasins along South Main Street and a stream originating east of South Main Street, which enters the FH350 system by the M&B Snack Bar building (Appendix D, Map 9). A low concentration of ammonia (0.3 mg/L) was measured at the outfall during the initial visit on May 8, 2013. OB was detected on the pad set in the outfall during the same visit. On August 6, 2013, we collected a sample at the outfall and detected an exceedingly high *E. coli* concentration (> 24,200 MPN/100 mL). The total phosphorus concentration was also elevated, 725 μg/L. A second sample, collected on August 22, 2013 in the small stream where it flows over the embankment, also had an exceedingly high *E. coli* concentration (>24,190 MPN/100 mL). A wastewater odor was also detected at the culvert inlet during inspection on August 20, 2013. Based on our inspection of aerial imagery, there was only one residence upstream, 70 South Main Street. The Town of Fair Haven agreed to take the lead in working with the property owner at 70 South Main Street to inspect the septic system on the property.

The Town of Fair Haven reported that the owner of 70 South Main Street pumped out his septic tank in 2016. The VTDEC enforcement division made several site visits in 2016; we assume these visits occurred after the septic tank was pumped. At no point during these visits did enforcement staff observe any evidence of a failed or failing system and the case was closed. Because pumping out the septic tank is unlikely to be a permanent solution, we recommend VTDEC enforcement revisit the site in 2019, checking specifically the base of the embankment below 70 South Main Street.

4.8. PY140 (Poultney)

The PY140 outfall is an 18-in. diameter corrugated steel pipe. This system drains a series of catchbasins on Wilson Avenue, York Street, and College Street North (Appendix D, Map 10). Monitoring pads set throughout the system on July 25, 2013 indicated presence of optical brightener at the outfall. A major effort was made in 2013 to bracket the source of contamination within the system and to dye test houses located on York Street Extension.

On May 20, 2014, a pipeline camera was used to inspect the stormdrain between the outfall and the previously inaccessible structure labelled Structure C. An unmapped connection, which was flowing, was observed opposite 358 York Street Extension. A subsequent dye test by the Town of Poultney confirmed that 358 York Street Extension had a direct sanitary wastewater connection to the PY140 stormdrain.

The Town of Poultney worked with the homeowner to replace the septic system and eliminate the connection to the stormdrain. A new septic system was constructed in August 2016. When the outfall was revisited on September 28, 2016, no flow and no OB were detected (Appendix C, Table 2). Therefore, we conclude that the sanitary wastewater discharge has been eliminated.

4.9. PR390 CB-K (Proctor)

The PR390 outfall is a large concrete tunnel. The system drains the southern (Branch 1) and western (Branch 2) portions of Main Street and extends south of Main Street to include Church Street (Appendix D, Map 28). A large pond west of the village contributes substantial dry weather flow to Branch 2. In 2013, optical brightener was detected in catchbasins CB-L and CB-M on the second lateral off Branch 2 (Appendix D, Map 11). The fluorescence was strong. These structures are located in the driveway (CB-L) and yard (CB-M) of the former OMYA Geology building. Note that the CB-M connection is not properly mapped. CB-M is not connected to the Portico drain line. Rather it is directly connected to CB-L. Therefore, two sources of OB were present in this system.

Elevated total phosphorus (402.5 μg/L) and very high *E. coli* (15,531 MPN/100 mL) concentrations were measured at the outlet of this lateral, Pipe A in CB-K. In addition to CB-M and CB-L, strong fluorescence was also observed on pads placed in an inlet (the "portico" drain) on the west side of the OMYA building. No OB was detected in the next structure upstream from the portico, on the south side of the OMYA building, and this structure was not flowing.

A sanitary sewer line running beneath the OMYA building was assumed to be the source of optical brightener entering CB-M. In response to our findings, the Superintendent of the Proctor Water and Sewer Department, Todd Blow, reported that the sanitary sewer beneath the building was sliplined and the sewer manholes were sealed with shotcrete in December 2013. OB testing in November 2017 confirmed that no OB was present in catchbasin CB-M, which confirmed elimination of this discharge.

Lavatories in the vacant OMYA building were dye tested in 2017 and no dye was observed in the Portico drain. On October 3, 2018, the stormdrain on the west side of the building was inspected with a camera, from the catchbasin on the back side of the OMYA building to a point beyond the Portico drain. Two inlets were observed. The first inlet appeared to drain the area around the large HVAC system and the second appeared to be from a roof leader. No sanitary wastewater connections were observed. The flow appeared to increase in the vicinity of the HVAC system and the interior of the pipe became discolored (yellow staining). We conclude that groundwater with residual petroleum contamination from a historic release enters the Portico drain line in the vicinity of the HVAC system and that residual petroleum is the cause of fluorescence on the OB pads. Therefore, no significant illicit discharge occurs in this location.

4.10. WA090 (Wallingford)

The WA090 system drains a series of catchbasins along South Main Street (Appendix D, Map 12). All dry weather flow to the eastern branch of this system is from a spring-fed stream originating north of Church Street. The stream flows through a culvert under Church Street, flows a short distance into another culvert that crosses behind two houses, daylights in an ornamental pool behind the Stone Shop, flows over a weir into a box culvert beneath the Stone Shop, daylights in the front yard of the Stone Shop, and flows in an open channel a short distance to an inlet under South Main Street.

Optical brightener was detected at catchbasin CB-A on May 22, 2013. On August 6, 2013, total phosphorus and *E. coli* samples were collected from the box culvert outlet. Low total phosphorus (19.2 μg/L) and elevated *E. coli* (350 MPN/100 mL) concentrations were found.

After significant delays (related to the homeowner's difficulty finding a plumber willing to perform the work, given the condition of the house foundation), a new sewer line was constructed from 56 Church Street to the municipal sewer. Completion of this project was confirmed by Maureen Duchesne of Wallingford Fire District #1 on September 16, 2016. No OB or other contaminants were detected in follow-up sampling on September 28, 2016 (Appendix C, Table 2). Therefore, we conclude that the illicit sanitary wastewater discharge was eliminated.

4.11. HA070 (Hardwick)

The HA070 outfall is an 8-in. diameter smooth plastic pipe. This system drains a portion of Holton Hill Road and discharges on the northwest side of Route 15 (Appendix D, Map 13). The outfall pipe is located in the wall below the northwest corner of the triangular parking area at the intersection of South Main Street and Route 15. Exceedingly high ammonia concentrations (≥6 mg/L) were measured at the outfall on three sampling dates in 2012. A very high total phosphorus concentration (9,650 μg/L) was measured in a sample collected on December 4, 2012 and the *E. coli* concentration exceeded the analytical range.

Through dye testing and camera inspection, Stone and the Town of Hardwick confirmed that the sanitary sewer from one wing of the Hardwick Elementary School building was plumbed to a roof downspout leading to the stormdrain. A major repair was made over the summer of 2014, eliminating a significant contribution of untreated wastewater to the Lamoille River

On October 20, 2015 when HA070 was revisited, there was no flow at the outfall. Since school was in session, the fact that the outfall was not flowing at this time confirmed the disconnection of the Hardwick Elementary School bathrooms from this system.

4.12. HP090 (Hyde Park)

The HP090 outfall is a 15-in. diameter corrugated metal pipe. This system drains Church Street and the portion of Main Street between Church Street and Johnson Street Extension, although few inlets exist (Appendix D, Map 14). The pipeline was formerly the combined sewer. West of Johnson Street Extension the line runs through a wooded ravine. In 2012, OB was detected at the outfall and at a "sink hole" and *E. coli* exceeded the analytical range. Dye testing was performed in 2013 to check connections from residences located on Main Street and Church Street. With one exception, all the houses plus the post office and Village garage were tested. All the tested buildings had a plumbing connection to the sanitary sewer except 230 Church Street, which has two apartments. A dye test confirmed that there was a sanitary wastewater connection from 230 Church Street. In 2014, the Town Administrator, Ron Rodjenski, confirmed that the sanitary connection from 230 Church Street had been eliminated by the Village Public Works crew.

When this system was resampled on October 20, 2015, OB was found at the outfall, the "sink hole", and manhole MH-I (Appendix C, Table 2). The *E. coli* concentration was elevated, 504 MPN/100 mL. Through investigations led by Jim Pease (Stone was not contracted to perform advanced investigation of HP090), two additional sources of contamination were ultimately identified in system HP090: a direct washwater connection from 193 Church Street and a connected floor drain in the Village garage on Church Street. We believe 193 Church Street is the same property where we were refused access when dye testing in 2013. In the Village garage, washwater from vehicle washing was regularly discharged to the floor drain. The detergent used, "Wash N' Shine", was considered a possible source of optical brighteners.

In May 2017, the Village of Hyde Park agreed to abstain from washing any detergents or other wastes into the garage floor drain and to provide a secondary containment area for any hazardous wastes in the garage. The laundry connection at 193 Church Street was discovered through dye testing in July 2017 and eliminated later in the year by the owner by connecting to the new service and abandoning and capping the old service. Following elimination of the connection at 193 Church Street, no OB was detected on a pad deployed in manhole MH-E in June 2018, confirming elimination of illicit discharges to this system.

4.13. WO050 (Wolcott)

This drain discharges on the south side of the road between the Wolcott Town Hall and the post office (Appendix D, Map 15). Low concentrations of ammonia (0.25-0.5 mg/L) were measured on three sampling dates in 2012 and the *E. coli* concentration exceeded the analytical range.

The septic system serving the Town Hall building was determined to be malfunctioning and was therefore considered a likely source of *E. coli* at the outfall. The Town constructed a new leach field and installed a pump vault to route septic tank effluent to the new leach field. The PVC pipe discharging at WO050 was routed around the septic system and the outfall was extended to the top of the bank.

A leak was discovered in the wastewater pump chamber at Buck's Furniture, causing wastewater to flow into the perimeter ditch, which is connected to the WO050 drain. The owner indicated he would replace the leaking pump chamber expeditiously. However, due to delays, VTDEC began pursuing its options to resolve the problem. Buck's Furniture since went out of business.

There was no indication of contamination in this system on October 20, 2015 (Appendix C, Table 2). The former Bucks Furniture buildings appeared unoccupied and at least two buildings had been demolished. Should a new business move in to the former Buck's furniture building across Route 15 from the Wolcott Town Hall, the faulty wastewater pump chamber will need to be replaced (assuming it still exists).

5. Advanced Investigations

Twenty (20) stormwater drainage systems were designated for additional advanced investigations. In each of these systems, an ongoing illicit discharge was suspected, based on the results of the original studies. In the majority of these systems, Stone had already performed water quality testing throughout the drainage network.

Advanced investigation techniques involved additional bracket sampling of stormwater infrastructure, review of engineering plans, remote television scoping of storm lines, smoke testing, and/or dye testing. In certain cases (e.g., RT270, HP160) Stone's primary function was to support DEC's ongoing efforts to resolve the illicit discharge identified. This role involved consultation, review of engineering plans, and assistance with dye testing. In other cases (e.g., BN250, PR390 CB-N, and MO300), additional investigations were required at the outset in order to provide the municipality with actionable information.

Our findings relative to each of these systems are summarized in Table 6 below and are presented in the following sections.

Table 6. Summary of status of advanced investigation

Original IDDE Project	System	Municipality	Status	Comment
Otter Creek	BN250	Brandon	Illicit discharge eliminated	A temporary plug was installed to prevent flow containing sanitary wastewater from entering catchbasin CB-D. A more permanent repair is planned for the spring of 2019.
	BN260	Brandon	Illicit discharge eliminated	The sanitary sewer main on this section of West Seminary Street was replaced in 2016. There has been no indication of wastewater contamination in this system since that time.
	MB170-#1	Middlebury	Confirmed elimination of illicit discharge	Construction of the new sanitary sewer on North Pleasant Street eliminated sanitary wastewater discharges to this system.
	MB230	Middlebury	No illicit discharge present	High specific conductance in this system (likely resulting from heavy deicing salt application) is believed to have interfered with ammonia and MBAS analyses in the original study.
	MB330	Middlebury	Illicit discharge not identified	The source of OB entering catchbasin MB330-E was not identified. Long-range transport of wastewater from a leaking gravity sewer main or lateral is the most likely explanation. Based on the additional testing we do not believe a significant water quality concern exists in this location.
	MB350	Middlebury	Illicit discharge not identified	The source of OB was not identified. We suspect a small amount of wastewater may leak from an overlying sanitary sewer pipe into this stormdrain under certain flow conditions. We do not believe a significant water quality concern exists in this location.
	MB1220	Middlebury	No illicit discharges identified	**Branch 1:** Despite dye testing and camera inspection, no illicit discharges were identified in

Original IDDE Project	System	Municipality	Status	Comment
				Branch 1 of system MB1220. However, OB results suggest a problem may remain. **Branch 2:** No OB was detected in this portion of system MB1220 in 2016; therefore, we do not believe an illicit discharge is present.
	RT270	Rutland Town	Confirmed elimination of illicit discharge	A direct sanitary wastewater connection was identified from a room in the Holiday Inn. Dye testing on July 12, 2018 confirmed that the problem has been corrected.
	VG450	Vergennes	No significant illicit discharge identified	The source of OB at the outfall may be either detergents used on the patio at 74 South Water Street or infiltration of contaminated groundwater due to long-range wastewater transport from leaking sanitary sewers. We do not believe a significant water quality concern exists in this location.
	VG470	Vergennes	No significant illicit discharge identified	No contaminants were detected, and no illicit connections or sewer leaks were identified. However, substantial foam was observed at the outfall in October 2018. We recommend the Town of Vergennes remain watchful for any direct dumping to catchbasins in this area.
	VG570	Vergennes	No significant illicit discharge identified	The source of OB in this system may be infiltration of contaminated groundwater due to long-range wastewater transport from leaking sanitary sewers. We do not believe a significant water quality concern exists in this location.
	VG640	Vergennes	No significant illicit discharge identified	The source of OB in this system may be infiltration of contaminated groundwater due to long-range wastewater transport from leaking sanitary sewers. We do not believe a significant water quality concern exists in this location.
	VG670	Vergennes	No significant illicit discharge identified	The source of OB in this system may be infiltration of contaminated groundwater due to long-range wastewater transport from leaking sanitary sewers. We do not believe a significant water quality concern exists in this location.
Rutland County	PR240	Proctor	A minor illicit discharge may be present. The Town plans to slipline the sanitary sewer on Holden Avenue.	OB is consistently detected in this system. The source of OB appears to be leaking joints in the sanitary sewer main on Holden Avenue. The Town of Proctor plans to reline this sewer main.
	PR390 CB-N, Pipe C	Proctor	Cross connection of the School Street sewer main was corrected. An additional illicit sewer connection was identified at 24 West St. Correction pending	A municipal sewer main on School Street serving the Proctor Gas offices, the Keyser facility, and a house at 40 School Street was found directly connected to this stormdrain. This illicit connection was corrected in 2016. Based on persistent OB, additional investigations in 2018 revealed a cross connection from 24 West Street. The Town of Proctor will eliminate this illicit connection in spring 2019.
	PR-West St.	Proctor	Illicit sewer connection identified	In October 2018, a house sewer lateral from 74 West Street was found connected to the stormdrain. The

Original IDDE Project	System	Municipality	Status	Comment
			at 74 West St. Correction pending	Town of Proctor will eliminate this illicit connection in spring 2019.
Lamoille River	HP160	Hyde Park	Two Illicit sewer lateral connections eliminated	Illicit sewer lateral connections from 13 Depot Street Extension and 264 Main Street were identified and eliminated. OB testing confirmed no further wastewater contamination.
	MO150	Morristown	No significant illicit discharge present	In further reviewing these data, we determined that no illicit discharge is occurring at the outfall.
	MO300	Morristown	Illicit discharge eliminated	A leaking sewer lateral from 406 Jersey Heights was intercepted and piped to a different sanitary manhole to eliminate wastewater leakage into this system.

5.1. BN250 (Brandon)

Outfall BN250 is a 15-inch diameter corrugated metal pipe. This system drains West Seminary Street (Appendix D, Map 16). OB was detected at the outfall in 2012. A high *E. coli* concentration (12,030 MPN/100 mL) measured at the outfall in August 2013 also suggested sanitary wastewater contamination.

OB was also present in CB-A through CB-D and in an unmapped pipe (Pipe A) entering CB-D. OB was not detected in catchbasins on North Seminary Street. Pipe A is the primary source of dry-weather flow in the system. This pipe extends a few feet north from CB-D and then transitions to an old stone box culvert that is partially filled with sediment. This box culvert is an abandoned section of the former combined sewer line.

There are four houses on West Seminary Street between the intersection of North Seminary Street and Case Street. Houses at 49 and 50 West Seminary Street were dye tested on November 20, 2013 and found to be connected to the sanitary sewer. 47 and 52 West Seminary could not be accessed.

Multiple attempts were made in 2016-2018 to identify the source of wastewater contamination in this system. All four houses (47, 49, 50, and 52) on West Seminary Street were dye tested on October 26, 2018; no dye was seen in CB-D. This result suggested that the source of wastewater contamination was not a house sewer lateral. Smoke testing in 2016 demonstrated a connection between the sanitary and storm sewer. Smoke blown into CB-D was observed in the sanitary manhole at the intersection of West Seminary and Case Street (after a ~10-minute delay). More definitive smoke testing was conducted on October 26, 2018. Smoke blown into the sanitary sewer emerged quickly at CB-D Pipe A. Smoke blown into catchbasin CB-D entered the sanitary sewer downstream of the furthest point reached with a sewer camera, approximately 20 feet downhill from the driveway at 47 West Seminary. In this position, the smoke travelled up the sanitary sewer toward the camera. Taken together, the dye testing, smoke testing, and pipeline inspection provided strong evidence that there is a crack or break in the sanitary sewer main quite close to catchbasin CB-D (within the 30-ft section that could not be inspected), allowing flow to enter the old stone box culvert and flow into catchbasin CB-D. The abandoned box culvert appears to run parallel and close to the sewer main in this location.

In December 2018, the Town of Brandon installed a plug in Pipe A to eliminate contaminated flow from the box culvert. The Town plans a more permanent repair in the spring of 2019. The Town is considering filling the box culvert and sliplining or replacing the leaking section of sanitary sewer main.

5.2. BN260 (Brandon)

Outfall BN260 is a 24-inch diameter corrugated metal pipe located on West Seminary Street, immediately south of outfall BN250 (Appendix D, Map 16). This system drains a swale on the east side of West Seminary Street and a single drop inlet (CB-A) in the roadway. OB was detected at the outfall and in CB-A in 2012. High *E. coli* (8,660 MPN/100 mL) was measured at the outfall on August 22, 2013.

On multiple visits between 2016-2017 the outfall was dry. OB pads placed at the outfall and in CB-A on June 14, 2017 were negative. We suspect that the occurrence of sanitary wastewater in this system was infrequent, possibly caused by leakage from the sewer main or wastewater flow over the roadway into CB-A or the swale during heavy rainstorms. We expect that the problem was resolved in 2016 when the Town of Brandon replaced the sanitary sewer main on West Seminary Street up to the intersection of North Street. There has been no indication of wastewater contamination in this system since the sewer main was replaced.

5.3. MB170-#1 (Middlebury)

Manhole MB170 is located on Lucius Shaw Lane at the former wastewater treatment plant (Appendix D, Map 17). This extensive drainage system discharges to Otter Creek at an outfall identified as Middlebury CSO #10. MB170 is the first structure upstream from the outfall, which is inaccessible.

OB was detected in every structure assessed from manhole MB170 up to manhole MB400, east of the old train station. A sample collected on December 1, 2011 from catchbasin MB380 had a high *E. coli* concentration (11,000 MPN/100 mL). This *E. coli* result, combined with the OB and ammonia detections, indicated that sanitary wastewater was entering the system east of manhole MB400. The stormline running between North Pleasant Street and manhole MB400 is an old combined sewer line that was believed to have been separated. Dye testing revealed multiple wastewater connections from houses on North Pleasant Street to this system. In 2015, the Town of Middlebury constructed a new sanitary sewer on North Pleasant Street to eliminate these illicit connections.

Manhole MB400 was retested on three dates in 2016 to confirm the elimination of sanitary wastewater flows (Appendix C, Table 3). On July 21, 2016, the OB result was indeterminant and no ammonia and negligible MBAS were measured. A sample collected from MB400 on July 28, 2017 had slightly elevated *E. coli*, 275 MPN/100 mL. On August 16 and September 28, 2016, OB was not detected at the outfall nor in several accessible stormwater structures on North Pleasant Street. Taken together, these results confirmed that construction of a new sanitary sewer on North Pleasant Street was successful in eliminating illicit discharges to this system.

5.4. MB230 (Middlebury)

Catchbasin MB230 is located on Buttolph Drive at the southeast corner of the Shaw's Supermarket parking lot, in front of the building (Appendix D, Map 18). Two stormlines discharge to this basin: Pipe A drains the Shaw's parking lot and an adjacent section of Washington Street and Pipe B drains a residential area on High Street, Washington Street, and Seminary Street. On November 1, 2011, a very high chlorine concentration (>1 mg/L) was measured in flow from Pipe A, in addition to a low concentration (0.4 mg/L) of MBAS detergents. No contaminants were detected in flow from Pipe B. When Pipe A was resampled on December 15, 2011, the MBAS concentration was higher, 0.9 mg/L, while the chlorine concentration was below the limit of detection. The next catchbasin up Pipe A also had a MBAS detergents concentration of 0.9 mg/L.

This system was reassessed on July 21, 2016. *E. coli* and total phosphorus concentrations were negligible in samples collected in manhole MB230 on July 28, 2016 (Table 7). High specific conductance was measured in manhole MB230 in flows from both Pipe A (4,460 μS/cm) and Pipe B (2,440 μS/cm) (Appendix C, Table 3). The specific conductance measured in the next catchbasin upstream of MB230 Pipe A was equally high (4,460 μS/cm). In our experience, specific conductance in this range often interferes with ammonia, chlorine, and especially MBAS analyses. When the original study was performed, we did not regularly test specific conductance nor understand how high dissolved solids content can affect other test results. Based on these more recent results, we conclude there is no illicit discharge present in this system. The high specific conductance measured in MB230 likely results from heavy application of deicing salt to the supermarket parking lot.

5.5. MB330 (Middlebury)

Outfall MB330 is a 15-inch diameter corrugated black plastic pipe that discharges south of Washington Street Extension (Appendix D, Map 19). The system drains residential areas on Colonial Drive and Washington Street. OB was detected at the outfall on November 1, 2011. No other contaminants were detected and negligible *E. coli* (20 MPN/100 mL) and total phosphorus (33.9 μg/L) concentrations were measured. On November 16, 2011, OB was detected at catchbasin MB330-E, while the result at outfall was indeterminate. OB was not detected in either pipe entering MB330-E. However, OB was detected in flow entering MB330-E beneath Pipe B.

This system was resampled on July 21, 2016. Concentrations of ammonia, free chlorine, and MBAS were at or below detection limits (Appendix C, Table 3). OB was not detected at the outfall or in Pipe A or Pipe B in catchbasin MB330-E, but OB was detected in the same flow entering MB330-E beneath Pipe B (although fluorescence was weak). *E. coli* and total phosphorus concentrations were negligible in samples collected at the outfall on July 28, 2016 (Table 7). No OB was detected in follow-up testing of the outfall and MB330-E in August 2016. Dye test were performed on August 16, 2016 at 281 Washington Street Extension and 12 Colonial Drive and dye was observed in the sanitary sewer and not in the stormdrain. The house at 294 Washington Street Extension was vacant.

One possible source of sanitary wastewater in the vicinity of catchbasin MB330-E is the sewer force main on Washington Street Extension. In communications with Bob Wells, Wastewater Superintendent, there was no practical way to test for a leak in this force main. The force main could not be inspected with the cameras to which we had access and the very large wet well at the wastewater pump station precludes dye testing.

Given the negligible concentrations of contaminants entering MB330-E, long-range transport of wastewater from a leaking gravity sewer main or lateral is perhaps at least as likely a source of OB than a leak in the force main. In any case, based on the additional testing we do not believe a significant water quality concern exists in this location.

5.6. MB350 (Middlebury)

Outfall MB350 is a 15-inch diameter corrugated black plastic pipe that discharges to a swale south of the "Five-Corner" intersection of Washington Street, Washington Street Extension, Seminary Street, Seminary Street Extension, and Springside Road (Appendix D, Map 20). The system drains a small area surrounding the Five Corner intersection. OB was detected at the outfall and in catchbasin MB350-A in November 2011. There were no other indications of contamination. The OB test in catchbasin MB350-B was indeterminate. Samples collected from the outfall had low concentrations of *E. coli* (110 MPN/100 mL) and total phosphorus (48.8 μg/L).

This system was resampled on July 21, 2016. Concentrations of ammonia, free chlorine, and MBAS were at or below detection limits (Appendix C, Table 3). There was no flow at the outfall during *E. coli* sample collection on July 28, 2016. OB was detected in MB350-A (CB1) on two dates in 2016, while the presence of OB at the outfall was weak or indeterminate; no OB was detected in MB350-B (CB2). Dye tests were performed on August 16, 2016 at 13, 53, and 68 Washington Street Extension and dye was observed in the sanitary sewer and not in the stormdrain. The house at 52 Seminary Street Extension had been dye tested previously.

The stormdrain between catchbasins CB1 and CB2 was partially inspected with a camera on October 19, 2016 and was found to be corroded and full of debris. It appears there is both a gravity sewer main and a force main on Seminary Street Extension that may pass over this stormdrain; unfortunately, these were inaccessible. We suspect a small amount of wastewater may leak from an overlying sanitary sewer pipe into this stormdrain under high flow conditions.

Given the negligible concentrations of contaminants and the usually dry condition of MB350, we do not believe a significant water quality concern exists in this location.

5.7. MB1220 (Middlebury)

Outfall MB1220 is a 30-inch diameter corrugated metal pipe discharging to a wetland area south of Monroe Street. The system drains the entire residential area to the south of Woodland Park including Meadow Way, Harrow Way, Swanage Court, and the east end of Monroe Street (Appendix D, Map 21). The stormwater pond located north of Woodland Park also discharges into this system. OB was detected in multiple structures in 2011, on two occasions. Further intensive OB monitoring appeared to narrow the sources to two locations:

Branch 1: Catchbasin MB1220-14 at the top of Swanage Court at the intersection with Woodland Park. OB was detected in MB1220-14 but not in any upstream catchbasins, including MB1220-15 and MB1220-16. 394 Woodland Park was considered the most likely source.

Branch 2: Catchbasin MB1220-45 at the intersection of Woodland Park and Heritage Circle. This catchbasin is the first structure downstream of the pond outlet structure. It was uncertain whether the source of the OB was the pond.

Samples collected at the outfall on July 28, 2016 had negligible concentrations of *E. coli* and total phosphorus (Table 7). Extensive optical brightener monitoring, dye testing, and camera inspection were performed in this system in 2016.

Branch 1: Optical brightener was detected in catchbasin CB13 and CB14 in July 2016. No OB was detected upstream of CB14. Houses at 399 and 429 Woodland Park were dye tested on August 16, 2016; entry was not permitted at 394 Woodland Park. On October 12, 2016, 394 Woodland Park was dye tested. In all cases, dye was observed in the sanitary sewer only. On October 12, 2016, the stormdrain on Woodland Park was inspected with a camera. No cracks or inappropriate connections were observed in the stormdrain. It is possible that the source of OB detected in CB14 is infiltration of contaminated groundwater from a leaking sewer line. A second possibility is direct dumping of washwater to CB14.

Branch 2: In contrast to the 2011 assessment, no OB was detected in the Heritage Circle neighborhood in 2016. OB was not detected on pads deployed in July 2016 in catchbasins CB31, CB33, CB42, CB43, or CB45. As OB was the only contaminant detected in Branch 1 in 2011, we concluded that no illicit discharge was present in this branch of the MB1220 system.

5.8. RT270 (Rutland Town)

Outfall RT270 is a 12-inch diameter corrugated metal pipe located behind the Holiday Inn on Route 7 (Appendix D, Map 22). An illicit discharge was suspected in this system when it was first inspected on August 8, 2012. White globs of fibrous material resembling toilet paper were noted below the outfall. OB was detected at the outfall, but not in CB-A. On August 22, 2013 high *E. coli* (3,250 MPN/100 mL) was measured at the outfall. On October 15, 2013 paper products and floss was observed at the outfall. The observations and *E. coli* data indicated a sanitary wastewater source.

In 2015, repeated attempts by the Town Administrator, Joe Zingale, to locate and address this problem with the Holiday Inn management were not successful and the problem was turned over to VTDEC enforcement staff to investigate. Surprisingly, VTDEC enforcement staff failed to find evidence of contamination and ultimately closed the case. Also, OB was not detected at the outfall or CB-D when the system was reassessed in September 2016.

Figure 3. Toilet paper at the RT730 outfall at the Holiday Inn

Repeated visits by Stone in 2016 and 2017 revealed ongoing sanitary wastewater contamination at the outfall, as illustrated in Figure 3, which was taken November 30, 2017. A time-lapse camera installed at the outfall also showed flows that did not coincide with rain events.

Stone worked with the VTDEC Project Administrator, Jim Pease, to review engineering plans for the Holiday Inn to identify locations of potential cross connections. Six rooms were identified abutting roof leaders. On January 12, 2018, Jim Pease dye tested these rooms and discovered one room (Room 266) with facilities directly connected to the stormdrain. Holiday Inn management corrected the cross connection by June 27, 2018. On July 12, 2018 Jim Pease dye tested Room 266 and confirmed that the problem had been eliminated.

5.9. VG450 (Vergennes)

Outfall VG450 is a 4-inch diameter smooth plastic pipe located in the backyard of 74 South Water Street. The pipe discharges directly to Otter Creek and is assumed to be a foundation drain. There are no municipal stormwater structures connected.

When assessed on November 28, 2011, the ammonia, chlorine, and MBAS detergent concentrations were below detection; however, OB was detected. A second pad deployed on December 14, 2011 was also positive for OB. There is a consistent trickle of dry weather at the outfall.

Strong OB fluorescence was observed again on a pad set in the outfall in September 2018. Dye tests were performed in October 2018 at 70 or 74 South Water Street and no dye was observed at the outfall. Jim Larrow, Public Works Supervisor, also inspected interior plumbing at 74 Water Street and found no problems. Finally, a camera was pushed from the outfall toward a patio drain in the backyard of 74 Water Street and no cross-connections or sources of inflow were observed. Mr. Larrow reported that the homeowner periodically washes down the patio with a detergent. The homeowner was asked not to wash his patio with detergent in the future.

The source of optical brightener at this outfall may be either detergents used on the patio at 74 South Water Street or infiltration of contaminated groundwater due to long-range wastewater transport from leaking sanitary sewers. Long-range transport of OB is suspected in several systems in Vergennes, possibly due to leaking sewer pipe joints in the heavy clay soils of the area. In any case, we do not believe a significant water quality concern exists in this location.

5.10. VG470 (Vergennes)

Outfall VG470 is a 24-inch corrugated metal pipe located north of the intersection of South Maple Street and Victory Street (Appendix D, Map 23). The system drains a segment of South Maple Street between School Street and Victory Street. The MBAS concentration was at the limit of detection and no ammonia or chlorine were detected at the outfall; however, OB was detected both at the outfall and at catchbasin VG480. On December 14, 2011, the source of OB was effectively narrowed to catchbasin VG470-6 at the intersection of South Maple Street and Roberts Street.

Extensive optical brightener monitoring, dye testing, smoke testing, and camera inspection were performed in this system in September and October 2018. Surprisingly, OB was not detected in pads deployed throughout the system. Smoke testing the sanitary sewer revealed several houses where the sewer vents did not emit smoke. Given their locations, the likely explanation for this is the presence of water traps on their sewer laterals. While smoke testing, the basement of 66 South Maple Street filled with smoke. A crack was found on the building sewer line inside the house. The homeowners have since repaired the sewer line and installed a proper sewer vent. Dye testing of several houses in the vicinity of catchbasin VG470-6 revealed no inappropriate connections.

Results of the advanced investigation of VG470 revealed no illicit connections or sewer leaks. However, on September 28, 2018, substantial foam was observed at the outfall and slight foam was observed in VG470-6. Given the absence of OB and the intermittent occurrence of this foam, we suspect the cause of the foam was washwater discharged to a catchbasin near the upper end of this system. We recommend the Town of Vergennes remain watchful for any direct dumping to catchbasins in this area.

5.11. VG570 (Vergennes)

Outfall VG570 is a 15-inch smooth plastic pipe located behind 12 Sunset Drive (Appendix D, Map 24). The system drains all of Sunset Drive and discharges to a rip-rapped gully leading to a swampy area. Dry weather flow sampled on November 28, 2011 had no detectable ammonia, chlorine, or MBAS detergent; however, OB was detected at the outfall. The tests were repeated on December 14, 2011 and OB was detected at the outfall and at the second catchbasin upstream from the outfall, CB3.

Extensive optical brightener monitoring, dye testing, smoke testing, and camera inspection were performed in this system in September and October 2018. OB was detected in manhole MH1, but not in upstream structures MH2 and CB7. All the houses adjacent to the stormdrains connecting MH2 to MH1 and CB7 to MH1 were dye tested and no dye was observed in MH1. Camera inspection revealed multiple drains outletting to these lines, including an odd small diameter pipe entering the drain between 7 and 5 Sunset Drive. However, based on the dye testing and smoke testing results we conclude there are no illicit connections to this stormdrain.

The source of optical brightener in this system is believed to be infiltration of contaminated groundwater due to long-range wastewater transport from leaking sanitary sewers. Long-range transport of OB is suspected in several systems in Vergennes, possibly due to leaking municipal sewer pipe joints in the heavy clay soils of the area. In any case, we do not believe a significant water quality concern exists in this location.

5.12. VG640 (Vergennes)

Outfall VG640 is a 24-inch corrugated metal pipe located at the eastern edge of Bowman Road (Appendix D, Map 25). It discharges to a stormwater pond. The system drains Bowman Road, Crosby Court, and Booska Court as well as an extensive system of swales. In 2011, OB was detected in Pipe A in catchbasin VG640-2; OB was not detected in Pipe B. OB was subsequently detected in upstream catchbasins VG640-2, VG640-3, VG640-6, and VG640-16.

Extensive optical brightener monitoring, dye testing, smoke testing, and camera inspection were performed in this system in September and October 2018. OB was again detected in VG640-6, but not in VG640-16. OB was also detected in Pipe A draining to VG640-6 from the direction of 2 Crosby Court. The houses adjacent VG640-6 (21 Bowman Road and 2 Crosby Court) were dye tested and no dye was observed in the stormdrain. When smoke testing the sanitary sewer, no smoke was seen from vents at 2 and 4 Crosby Court. Camera inspection of VG640-6 Pipe A revealed no inappropriate connection, as far as could be inspected.

The source of optical brightener in this system is believed to be infiltration of contaminated groundwater into VG640-6 Pipe A due to long-range wastewater transport from leaking sanitary sewers. Long-range transport of OB is suspected in several systems in Vergennes, possibly due to leaking municipal sewer pipe joints in the heavy clay soils of the area. In any case, we do not believe a significant water quality concern exists in this location.

5.13. VG670 (Vergennes)

Outfall VG670 is a 24-inch corrugated black plastic pipe that discharges directly to Otter Creek at the southeast corner of the Main Street bridge (Appendix D, Map 26). The system drains West Main Street from the bridge up to Elm Street. On November 29, 2011, ammonia, chlorine, and MBAS detergents were below the detection limit in dry weather flow; however, OB was detected.

Pads were deployed throughout the system on December 14, 2011 to bracket the source of OB. OB was again detected at the outfall, the only positive result in this system. An indeterminate result was obtained in the first upstream catchbasin (labeled VG670-3) along the eastern stormline.

Extensive optical brightener monitoring, smoke testing, dye testing, and camera inspection were performed in this system in September and October 2018. As in 2011, the only positive OB result was at the outfall. Smoke testing and dye testing revealed no inappropriate connections. Camera inspection of the stormline between the outfall and the first upstream manhole appeared to show a flow of clear water entering at a pipe joint. We assume this was groundwater.

The source of optical brightener in this system is believed to be infiltration of contaminated groundwater into the section of the stormdrain immediately above the outfall due to long-range wastewater transport from leaking sanitary sewers. Long-range transport of OB is suspected in several systems in Vergennes, possibly due to leaking municipal sewer pipe joints in the heavy clay soils of the area. In any case, we do not believe a significant water quality concern exists in this location.

5.14. PR240 (Proctor)

This system drains portions of South Street, Holden Avenue, and Park Street via a stone box culvert running west from Holden Avenue beneath South Street and the La Fond's Auto building. The PR240 system was incorrectly mapped as discharging southwest of Grove Street and South Street, directly to the Otter Creek. In fact, the outfall is located behind La Fond's Auto on the west side of South Street (Appendix D, Map 27). The outfall could not be located during the initial assessment, on April 26, 2013, because it is buried in rubble; therefore, the first upstream catchbasin (CB-J) was assessed. Pipes B and C in catchbasin CB-J were flowing, while pipe A (the main line draining Holden Avenue) and pipe D (from CB-I) were not flowing. Pipes B and C were tested for optical brightener, which was detected at pipe B only (Figure 4).

Figure 4. Catchbasin CB-J. The green pipe in the 10:00 position is Pipe B

In 2013, moderate concentrations of MBAS detergent (1.0 mg/L) and total chlorine (0.11 mg/L) were measured and optical brightener was detected at the outfall.

Due to positive optical brightener results at the outfall and in pipe B in catchbasin CB-J, samples were collected on August 15, 2013 for total phosphorus and *E. coli* analysis. Total phosphorus concentrations were very low at CB-J pipe B (21.1 μg/L) and pipe C (7.62 μg/L) and at the outfall (16.6 μg/L). *E. coli* concentrations were low at both pipe B (51.6 MPN/100 mL) and pipe C (108.9 MPN/100 mL). However, the *E. coli* concentration measured at the outfall was high (1,249.8 MPN/100 mL).

Optical brightener was again detected in CB-J pipe B on September 5, 2013. Upstream from CB-J, CB-K pipe A also tested positive for optical brightener. We concluded that optical brightener detected at CB-K pipe A resulted from a leak in the sanitary sewer main on Holden Avenue. The stormline parallels the Holden Avenue sanitary sewer line and the sanitary sewer invert along Holden Avenue is relatively shallow (3-4 feet below grade), which suggests that wastewater leaking from the sanitary sewer line could migrate to the stormline between MH-Q and CB-K.

To investigate whether a house sewer lateral was responsible, dye tests and plumbing inspections were performed on January 21, 2014 at each of the three houses on the south side of Holden Avenue (1, 3, and 11

Holden Avenue). All three houses had a single sewer pipe at the foundation penetration. No dye was observed at CB-K, CB-J, or the outfall following the dye tests. Dye was quickly observed in a sanitary manhole on Holden Avenue (Figure 5) after tests at 3 and 11 Holden Avenue, while no downstream sanitary manhole could be accessed for the test at 1 Holden Avenue. These results indicated that the house sewer laterals are not the source of optical brightener.

In the sanitary manhole on Holden Avenue, dye was observed within the open PVC channel spanning the structure and also on the floor of the manhole (Figure 5). The dye appeared to flow onto the floor of the manhole from beneath the incoming PVC pipe (on left in Figure 5). It also appears that wastewater pools on the floor of the structure. This wastewater may be migrating from the manhole (and possibly other points along the vitrified clay line) to the stormline between MH-Q to CB-K. Given the substantial increase in flow along the stormdrain from MH-Q to CB-K, the shallow depth of the pipe, and the wastewater leak into the manhole beneath the PVC pipe, we suspected that wastewater is migrating from the sewer line to the stormline on Holden Avenue.

Optical brightener monitoring of system PR240 in July 2017 yielded results identical to our 2013 findings. OB was detected in CB-J Pipe B and was not detected in CB-J Pipe C or MH-Q. Additional dye testing, smoke testing, and camera inspection were performed in 2018. No dye was observed in the stormdrain when the Holden Ave. sanitary sewer, 10 Holden Ave., and LaFond's Autos were dye tested. Smoke testing revealed no connection between the sanitary sewer and the stormdrain, in either direction. Given the OB results and the absence of a cross-connection, we reaffirm our earlier conclusion that the most likely source of wastewater contamination in PR240 is migration of wastewater from the sewer main on Holden Avenue into the stormdrain between structures MH-Q and CB-K. The Town of Proctor indicated that the Holden Avenue sanitary sewer will be sliplined when possible.

Figure 5. Sanitary manhole on Holden Avenue

5.15. PR390 CB-N, Pipe C (Proctor)

The PR390 outfall is a large concrete tunnel. The system drains the southern (Branch 1) and western (Branch 2) portions of Main Street and extends south of Main Street to include Church Street (Appendix D, Map 28). A large pond west of the village contributes substantial dry weather flow to Branch 2. In September 2013, optical brightener was detected in catchbasin CB-N on the main line upstream from catchbasin CB-K. In CB-N, we observed a slight wastewater odor and a suspicious pipe discharging to the basin. The pipe invert had a grayish film, presumably due to bacterial or fungal growth fed by sanitary wastewater. Optical brightener was detected in this pipe and the *E. coli* level was high (1,250 MPN/100 mL).

On August 3, 2016 Stone dye tested several houses on West Street Extension, Beaver Pond Road, and School Street. All the houses tested on West Street Extension and Beaver Pond Road appeared properly connected to the sanitary sewer. However, a sanitary manhole on the lawn of the Proctor Gas office at the intersection of Market Street and School Street was determined to be connected to the PR390 system upstream of CB-N. After a delay of about an hour, we observed dye in the stormdrain, not in the sanitary sewer. We then tested 40 School Street and determined that this house was connected to the sanitary manhole in the Proctor Gas office lawn (thus, it was also improperly connected to the stormdrain). Further dye testing by town representatives on August 26, 2016 demonstrated that both the Proctor Gas office building and the Keyser facility across School Street were connected to the same old sewer line to which 40 School Street was connected. The wastewater from all three properties flowed to the stormwater drainage system. The Town of Proctor reacted expeditiously to this finding by constructing a proper sanitary sewer connection and eliminating the stormdrain connection.

Instead of confirming absence of wastewater in this system, follow-up OB testing in 2017 demonstrated that an additional source of wastewater was present in this system upstream of the School Street intersection. Efforts by the Town of Proctor, VTDEC, and Stone to find this source were not successful until the stormdrain was smoke tested on October 3, 2018. Smoke testing revealed a direct sanitary wastewater connection from 24 West Street (Figure 6). It appears that the old lateral was never disconnected, and a new lateral never installed when the new sanitary sewer was installed. No other structures in this neighborhood vented smoke when the stormdrain was tested.

Figure 6. Smoke venting from sewer vent at 24 West Street

The Town of Proctor plan to eliminate this illicit connection in the spring of 2019.

5.16. PR-West St. (Proctor)

PR-West St. drains an old sewer line converted to a stormdrain on West Street (Appendix D, Map 29). There are few inlets to this system. Optical brightener monitoring in July 2016 confirmed presence of OB in the manhole near 91 West Street (Appendix C, Table 3). Testing in November 2018 also confirmed presence of OB at the manhole on Columbian Avenue (upstream from the outfall) and in a manhole on West Street at the intersection of Larry Lane. Further OB testing in May 2018 confirmed presence of OB in manholes near 3, 16, 74, and 91 West Street.

On October 3, 2018, smoke testing of the sanitary sewer revealed two houses without properly vented sewer connections, 74 and 38 West Street. No smoke was observed from any house when the stormdrain was smoke tested. Dye testing at 38 West Street demonstrated that this house has a sanitary sewer connection (although it may not be properly vented). Dye testing was not possible at 74 West Street because the house was vacant. However, a lateral from the stormwater manhole at 79 West Street was viewed with a camera. The lateral extends under West Street to 74 West Street. The lateral appears to be connected to the indoor plumbing of 74 West Street. Following this discovery, the Town of Proctor gained access to 74 West Street and confirmed that its sewer lateral is directly connected to the West Street stormdrain. The Town plans to eliminate the illicit connection and construct a proper sewer connection in spring 2019.

5.17. HP160 (Hyde Park)

The HP160 system drains a portion of the residential area south of Main Street (Appendix D, Map 30). The system discharges southeast of the town leach field, just above Centerfield Brook. On October 20, 2015, ammonia and OB were detected at the outfall (Appendix C, Table 3) and the *E. coli* and total phosphorus concentrations were slightly elevated (Table 7).

Figure 7. Sewer dye (and wastewater) flowing from the HP160 outfall

Smoke testing on December 8, 2015 revealed a sanitary wastewater connection to the stormdrain from 13 Depot Street Extension. This connection was confirmed with a dye test (Figure 7). The Town of Hyde Park worked with the property owner to eliminate this illicit connection in 2017. However, in June 2017 OB was again detected at the outfall and both the *E. coli* concentration (733 MPN/100 mL) and the total phosphorus concentration (428 μS/cm) indicated presence of sanitary wastewater (Table 7).

In September 2017 Jim Pease dye tested 264 Main Street, confirming a direct sanitary wastewater connection to the

stormdrain (Figure 8). The Town of Hyde Park worked with the property owner to eliminate this illicit connection in 2018.

In follow-up monitoring between October 28 – November 3, 2018, OB was not detected on a pad set at the Depot Street Extension crossing. This result confirmed elimination of illicit wastewater discharges to this system.

Figure 8. Sewer dye observed from a dye test at 264 Main Street

5.18. MO150 (Morrisville)

The MO150 outfall is a 15-in. diameter corrugated metal pipe. This system drains the northern and southern parking areas at Copley Hospital and discharges on the north side of Washington Highway between Mansfield Avenue and the entrance to Copley Hospital (Appendix D, Map 31). The outlet is located about 125 yards into the woods and is accessible via a cleared path. High specific conductance (1,836-1,920 μs/cm) and low concentrations of MBAS detergents (0.25-0.50 mg/L) were measured on three dates in 2012. Corrected for dissolved solids content, MBAS concentrations ranged from 0.12 to 0.37 mg/L. A very low total phosphorus concentration and no *E. coli* were measured in samples collected on December 4, 2012.

On July 17, 2013 samples were collected from all catchbasins that could be accessed on the north and west sides of the hospital. Moderately high ammonia concentrations (1-2 mg/L) were detected in two catchbasins on the north side of the building. No ammonia was detected at the outfall. A small diameter pipe discharges to each catchbasin. The alignment of these pipes suggests they are connected to interior drains in the hospital. Given its constancy, clarity, and lack of odor, we assume the flow is air conditioner condensate, which is generally an allowable discharge. In further reviewing these data, we determined that no illicit discharge is occurring at the outfall.

5.19. MO300 (Morrisville)

The MO300 outfall is a 15-in. diameter concrete pipe. This system drains the portion of Route 100/Jersey Heights Road starting at its intersection with Best Street and discharges to the stream on the west side of A Street (Appendix D, Map 32). The outlet is located on the north side of Route 100. The pipe was dripping and the pool below had an oily sheen on October 16, 2012 when first inspected. OB was detected at the outfall and further OB testing indicated that a wastewater or washwater source entered this system between CB-B and CB-A. No ammonia or total chlorine were detected and low concentrations of *E. coli*, total phosphorus, and MBAS detergent were measured when the system was revisited on December 4, 2012.

On January 28, 2014, dye testing was performed at 406 Jersey Heights Road. The sewer lateral for this house passes under Jersey Heights Road and discharges to a sanitary manhole located more than 200 feet downhill. We observed dye discharging to this manhole via the sewer lateral and did not observe it at the MO300 outfall (although the outfall was frozen) or in the first catchbasin up the line (CB-A). The more interesting observation was a large flow discharging from this sewer lateral prior to the dye test, at a time when the homeowner said he was not running any water. This observation suggested substantial groundwater infiltration into the sewer lateral, and therefore a cracked or broken lateral.

On November 30, 2017 Wayne Graham of the Vermont Rural Water Association and Dave Braun of Stone Environmental smoke tested the sanitary sewer from a manhole on the property of 377 Jersey Heights. Smoke was observed through the sanitary system and from the vents at: 28 Best Street and 377, 453, 485, 511, and 426 Jersey Heights. No smoke was observed from 406 or 456 Jersey Heights. It is possible there are water traps on the sewer services from these old houses. Diffuse smoke was also observed from the catchbasin (CB-C) located next to the driveway of 406 Jersey Heights.

Diffuse smoke was observed issuing from the 6-inch diameter sewer connection serving 406 Jersey Hts. Substantial flow was also present considering that this line has only one connected house. We pushed the camera the maximum distance possible up the service line and restarted the smoke blower. Beyond (in front of) the camera, smoke filled the pipe. The position of the camera was determined to be under the road shoulder next to the driveway to 389 Jersey Heights.

Based on the movement of smoke from the sanitary sewer into the stormdrain and also movement of smoke from the stormdrain into the sanitary lateral serving 406 Jersey Heights, we concluded that the sanitary lateral serving 406 Jersey Heights was deficient (leaking) and needed to be repaired or replaced. The Morrisville Water and Light Department confirmed that Lamoille Construction intercepted the leaking sewer service line from 406 Jersey Heights and connected it to the sanitary manhole near the driveway to this residence on October 22, 2018.

6. 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 7). Note that sample collection was attempted at several other outfalls, but they were not flowing.

Table 7. 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)
BR340	7/28/2016	50 mL/4 s	0.8	185	10,500[A]	
FX070	10/23/2015			60	126	
HP090	10/20/2015	dripping		921	204	
HP090	6/28/2017	dripping		503.6	33.9	
HP160	10/20/2015	1 L/48 s	1.3	186	361	0.65
HP160	6/28/2017	1 L/48 s	1.3	732.8	428	0.77
MB1220	7/28/2016			41	58	
MB230	7/28/2016	100 mL/2.5 s	2.4	31	62	0.21
MB330	7/28/2016			10	32	
MB400	7/28/2016			275	650	
PR West St.	10/12/2016			<10	57	
RU130	10/12/2016	100 mL/1.75 s	3.4	364	100	0.49
WA090	10/12/2016			189	24	
WO050	10/20/2015	120 mL/52 s	0.14	<1	ns	

A. High TP concentration believed to result from flushing of sediment when flow was released from the obstructed outfall

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.

With the exception of the sample collected at the BR340 outfall as sediment flushed from the system following removal of an obstruction, total phosphorus concentrations were low to moderate (maximum of 730 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.

7. 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.

Appendix A. Assessment Data Form

IDDE Discharge Assessment Data Sheet

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 ______________ μS/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

System	Date	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Corrected MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
BN340	7/21/2016	Unknown	0.2	0.06	0.1	0.04	914	outfall: Neg.	Clear, no odor; released flow by clearing debris in pipe
FX070	10/22/2015	Flowing	0.1	0.01	0.25	0.16	1328	CB-A: Neg.	Clear, no odor
HP170	10/21/2015	Flowing	ns	ns	ns	ns	ns	culvert: Neg. top of channel: Neg.	Clear, no odor
MB2100	8/26/2016	Flowing (0.25")	0.2	0.05	0.2	0.18	366	outfall: Neg.	Clear, no odor
RU130	9/28/2016	Flowing (0.25")	0.3	0.06	0.3	0.21	1352	outfall: Pos.	Clear, no odor

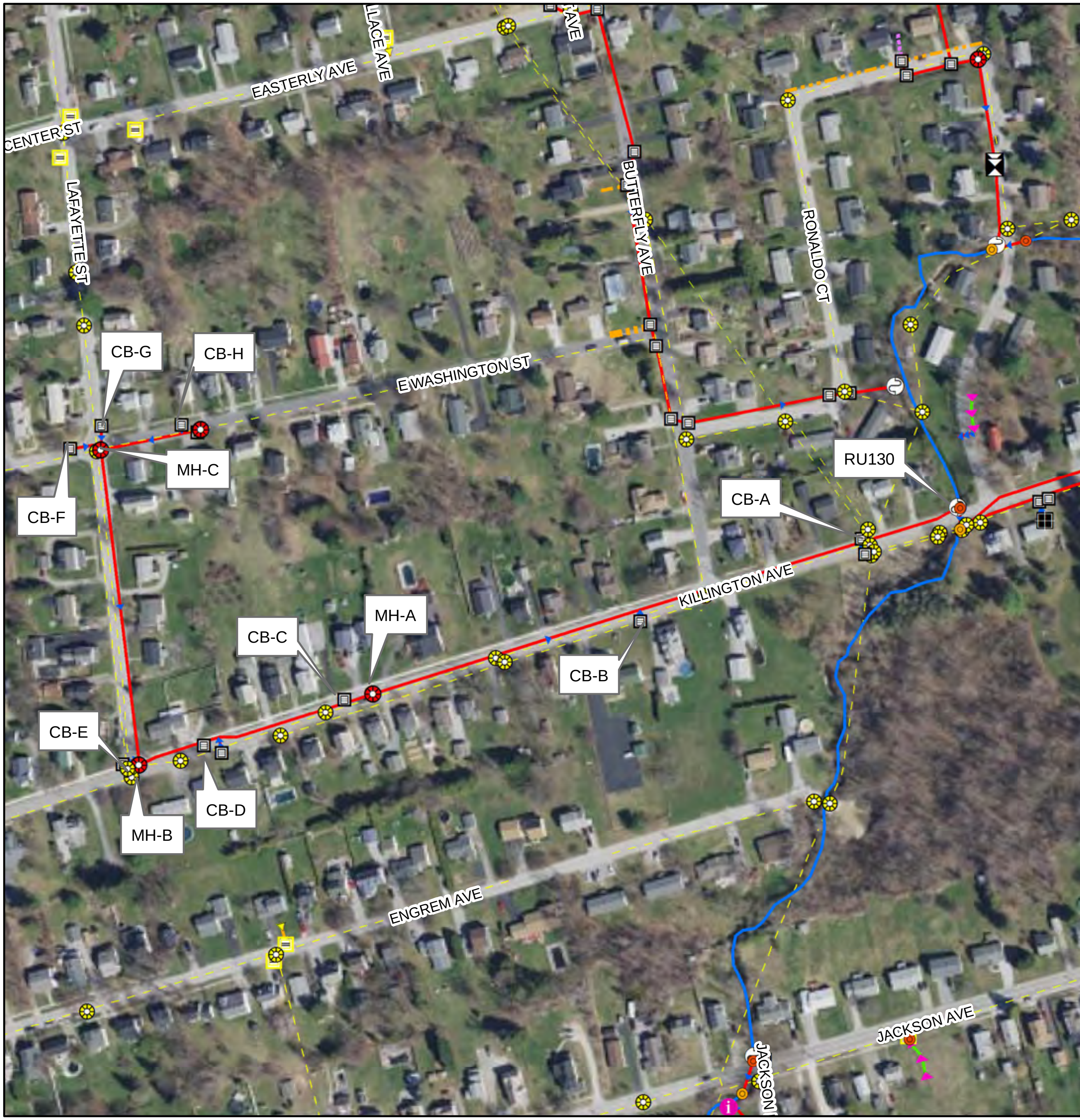
Appendix C, Table 2: Resampling Data

System	Date	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Corrected MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
RT730	9/28/2016	No flow	ns	ns	ns	ns	ns	outfall: Neg. CB-D: Neg.	
RU980	9/28/2016		ns	ns	ns	ns	ns	outfall: Neg	
RU1650	8/3/2016	Wet/no flow	0.0	0.00	0.4	0.40	58.2		Sampled CB-C sump, no incoming flow
PY140	9/28/2016	Dry	ns	ns	ns	ns	ns	outfall: Neg	
PR390 CB-K	7/14/2016		ns	ns	ns	ns	ns	CB-L: CB-M: portico: +	
PR390 CB-K	11/30/2017		ns	ns	ns	ns	ns	Portico: + CB-N: + (weak) Proctor Gas: Neg. CB-M: Neg. OMYA: Neg.	
WA090	9/28/2016	Flowing (1.5")	0.0	0.02	0.05	0.04	250	outfall: Neg	Clear, no odor
HA070	10/20/2015	Wet/no flow	ns	ns	ns	ns	ns	na	
HP090	10/20/2015	Dripping	0.1	0.03	0.1	0.04	962	outfall: + sinkhole: + MH-I:+ channel below sinkhole: + pipe on bank: Neg stream channel: Neg	Pipe rusted out. Sampled was yellow colored
HP090	6/14/2017	Dripping	0.0	0.02	0.0	0.00	111.9	outfall: + MH-E:+ upstream culvert: Neg	
HP090	6/18/2018		ns	ns	ns	ns	ns	MH-E: Neg	
WO050	10/20/2015	Trickling	0.1	0.00	0.1	0.05	822		Clear, no odor

Appendix C, Table 3: Advanced Investigations Data

System	Date	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Corrected MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
BN250	7/21/2016	Trickling	0.1	0.13	0.2	0.13	1120	outfall: + CB-D sump: Indeterminate CB-D pipe A: +	Slightly cloudy; trickle of flow from CB-D pipe A
BN250	7/28/2016	Dry	ns	ns	ns	ns	ns	na	
BN260	7/21/2016	Dry	ns	ns	ns	ns	ns	outfall: Neg. CB-A: Neg.	
BN260	7/28/2016	Dry	ns	ns	ns	ns	ns	na	
HP160	10/20/2015	Flowing	0.75	0.00	0.1	0.00	1612	outfall: + (strong) 7 upstream structures: Neg.	Musty odor. Particulates suspended in water.
HP160	6/14/2017	Dry	ns	ns	ns	ns	ns	outfall: + (strong)	
HP160	11/3/2018		ns	ns	ns	ns	ns	Depot St. : Neg.	
MB1220	7/21/2016	Flowing	0.2	0.03	0.2	0.11	1383	outfall: Neg. CB13: + CB14: + (strong) CB15: Neg. CB16: Neg. 4" bermico @377: Neg. CB42: Neg.	Clear, no odor
MB1220	8/16/2016		ns	ns	ns	ns	ns	CB-14: + CB-13: + MB1330: +	
MB170-#1	7/21/2016	Trickling	0.0	0.03	0.2	na	NS	MB400: Indeterminate	Clear, no odor; Pipe B dry
MB170-#1	8/16/2016		ns	ns	ns	ns	ns	MB400: Neg. MBNP1: Indeterminate MBNP3: Neg. MBNP4: Neg. MBST: Neg.	
MB170-#1	9/28/2016		ns	ns	ns	ns	ns	MB400: Neg. MBNP1: Neg.	
MB330	7/21/2016	Flowing (0.25")	0.2	0.06	0.05	0.00	729	outfall: Neg. CB1 pipe A: Neg. CB1 pipe B: Neg. leak below pipe B: + (weak) CB2 sump: Neg.	Clear, no odor, minor suds
MB330	8/16/2016		ns	ns	ns	ns	ns	outfall: Neg. CB1: Neg.	
MB350	7/21/2016	Wet/no flow	0.2	0.04	0.2	0.07	1879	outfall: Indeterminate CB1 sump:+ CB2 sump: Neg.	Clear, no odor
MB350	8/16/2016		ns	ns	ns	ns	ns	outfall: + (weak) CB1 sump: +	
MO300	10/20/2015	Flowing	ns	ns	ns	ns	ns	outfall: + (strong)	Clear, no odor
PR240	7/14/2016		ns	ns	ns	ns	ns	CB-J pipe B: + CB-J pipe C: Neg. CB-J sump: Neg. MH-Q: Neg.	
PR390 CB-N	7/14/2016		ns	ns	ns	ns	ns	CB-N: + storm MH inside gate: + culvert inlet west of Proctor gas: Neg. footbridge: Neg.	
PR-West St.	7/14/2016	Flowing (0.25")	0.2	0.05	0.2	0.07	1920	outfall: Neg. MH @91 West St.: +	Clear, slight WW odor
PR-West St.	8/3/2016	Flowing (1")	0.0	0.20	0.1	0.04	978		Clear, no odor
PR-West St.	9/28/2016	Flowing (1")	0.05	0.02	0.1	0.06	623	Outfall: Pos.	Clear, no odor
PR-West St.	11/30/2017		ns	ns	ns	ns	ns	MH near Larry Ln.: + MH near pump station: + (strong) Ditch outfall: Neg.	
PR-West St.	7/1/2018		ns	ns	ns	ns	ns	61 Main yard drain: + #79 West: + storm MH in RR bed: + #79 West lateral to #72: Neg. MH52 West St.: Indeterminate	
PR-West St.	5/1/2018		ns	ns	ns	ns	ns	3 West St.: + 16 West St.: + 74 West St.: + 91 West St.: +	
RT270	9/28/2016		ns	ns	ns	ns	ns	outfall: Pos. (strong)	
MB230 pipe A	7/21/2016	Trickling	0.3	0.48	0.2	0.00	4460		Clear, no odor
MB230 pipe B	7/21/2016	Trickling	0.2	0.01	0.1	0.00	2440		Clear, no odor
MB230-Branch A, CB1	7/21/2016	Trickling	0.4	0.07	0.2	0.00	4460		Clear, no odor

Appendix D. Maps



N

0 130 260

Feet

Rutland

Rutland City

LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

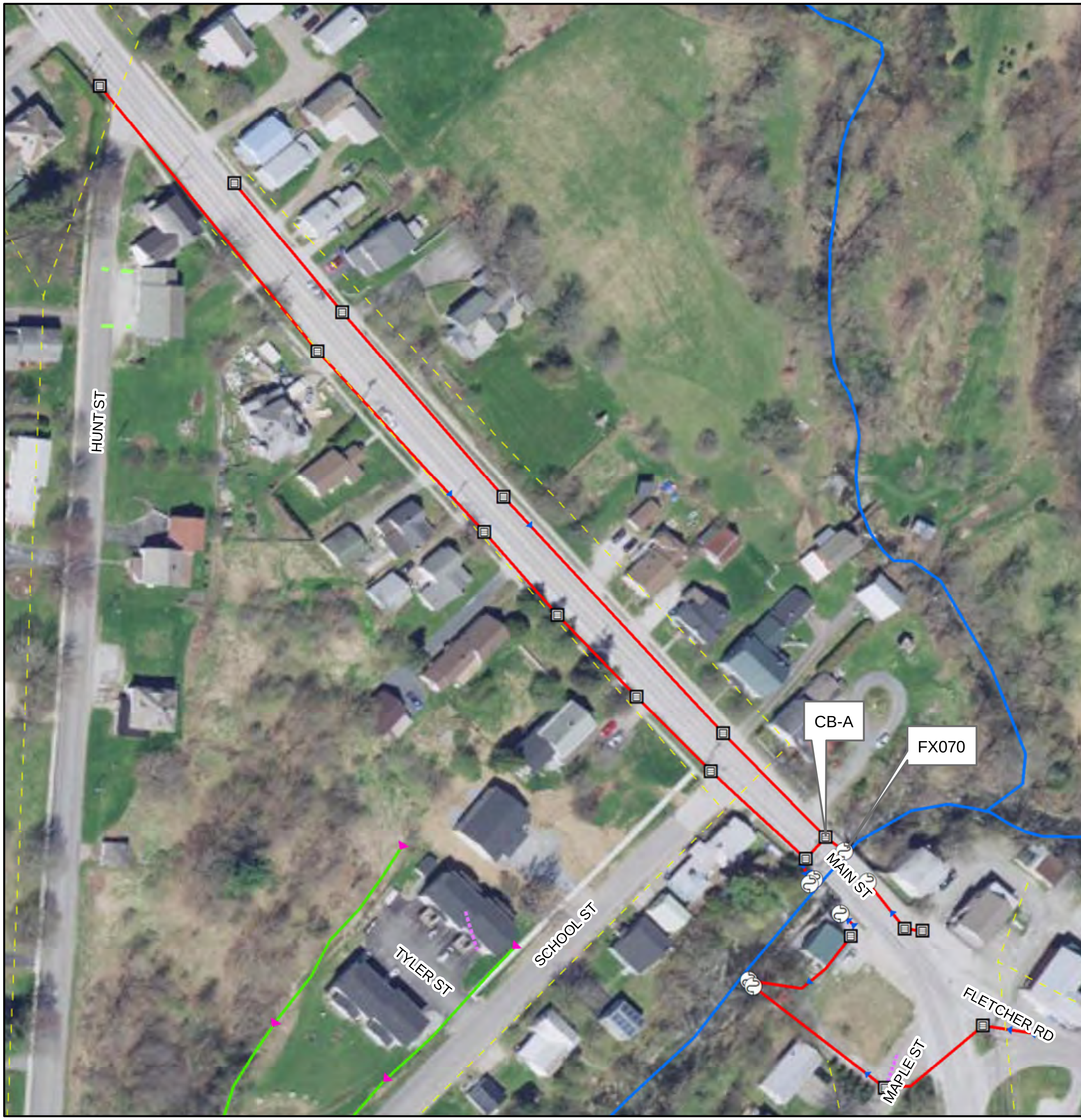
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

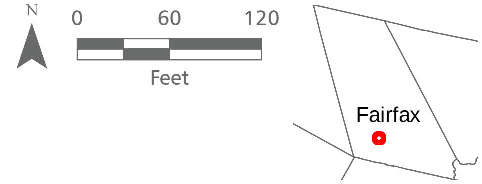
Map 01

Rutland City, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL





LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 02

Fairfax, Vermont

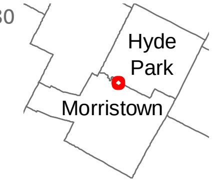
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 90 180

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 03

Hyde Park, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 60 120

Feet

Rutland

Rutland City

LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 04

Rutland City, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 40 80

Feet

LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 05

Rutland City, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 60 120

Feet

LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 06

Rutland Town, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N
0 25 50
Feet

LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

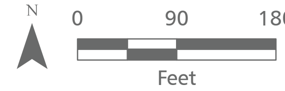
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

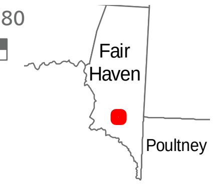
Map 07

Rutland Town, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL





LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
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- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

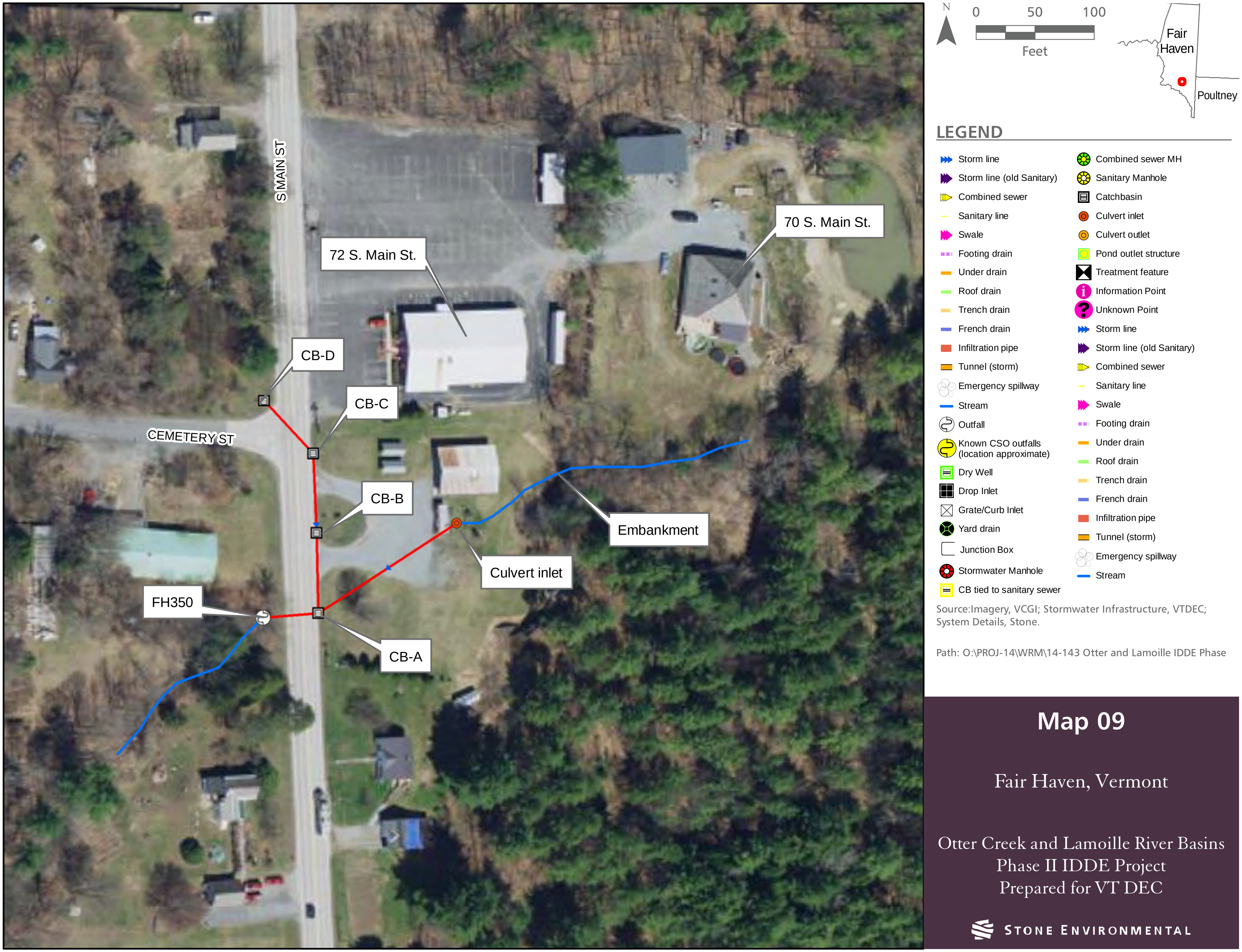
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 08

Fair Haven, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL



Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

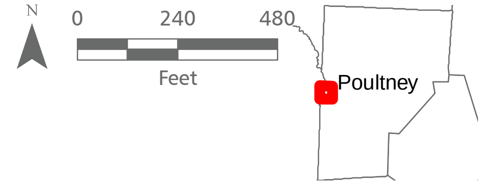
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 09

Fair Haven, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 10

Poultney, Vermont

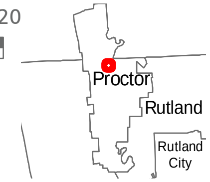
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 60 120

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

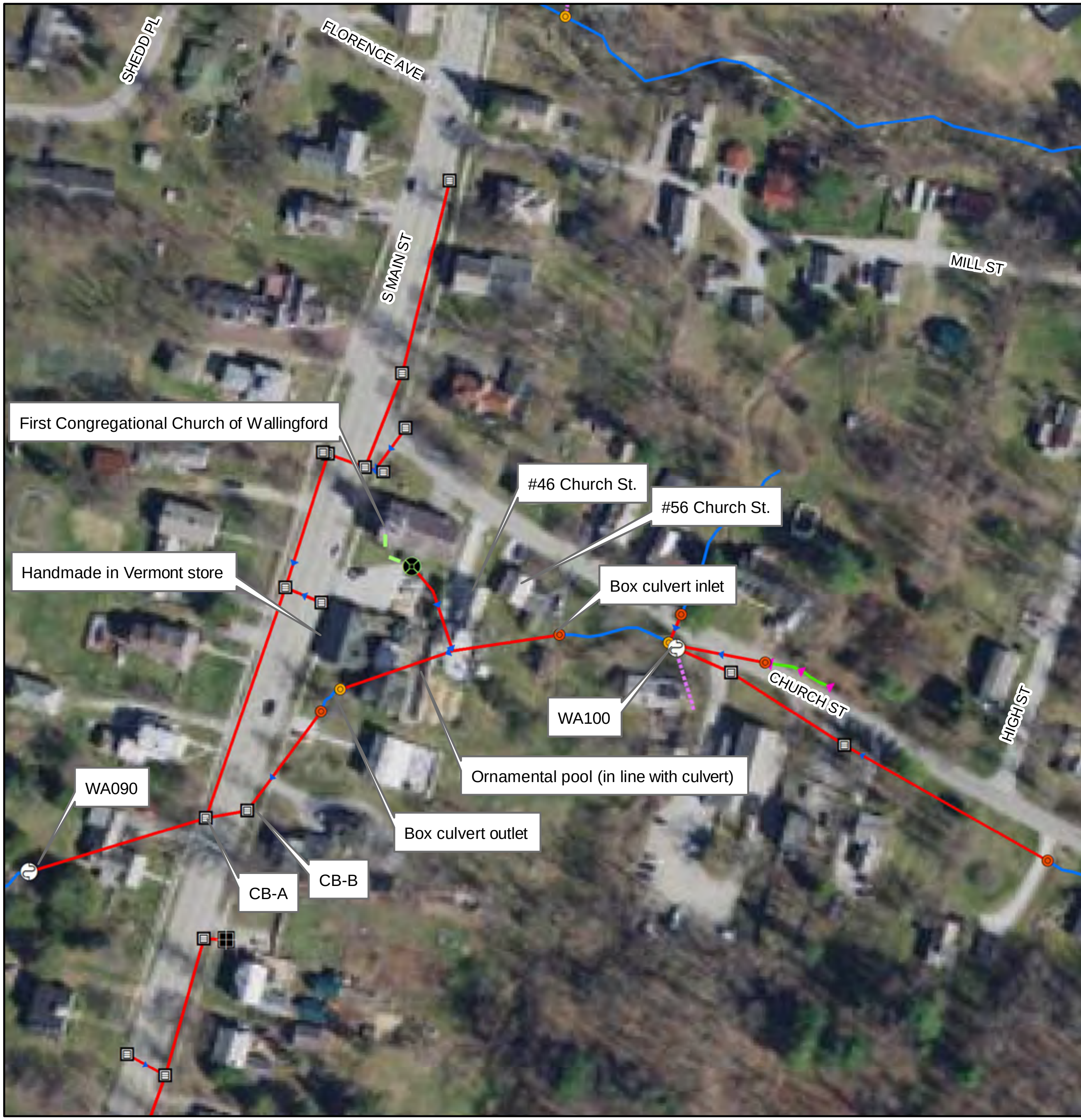
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 11

Proctor, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

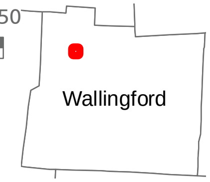
STONE ENVIRONMENTAL



N

0 75 150

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 12

Wallingford, Vermont

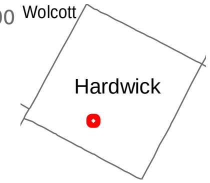
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 50 100

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 13

Hardwick, Vermont

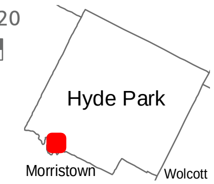
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 160 320

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 14

Hyde Park, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 50 100
Feet

Hyde Park
Wolcott
Hardwick

LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
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- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 15

Wolcott, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 50 100

Feet

LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

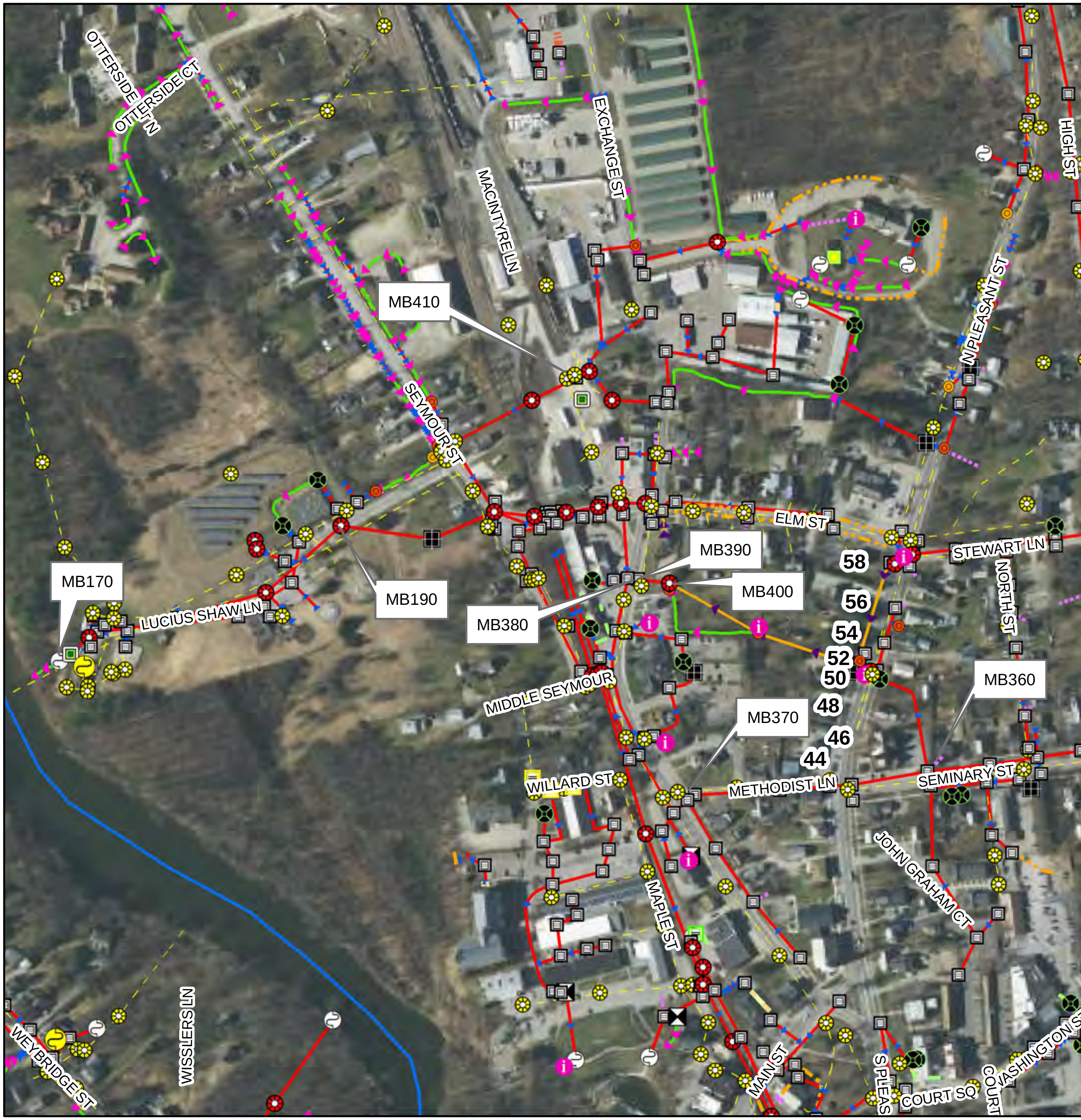
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 16

Brandon, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

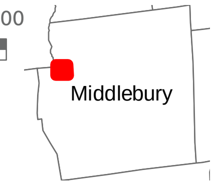
STONE ENVIRONMENTAL



N

0 200 400

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

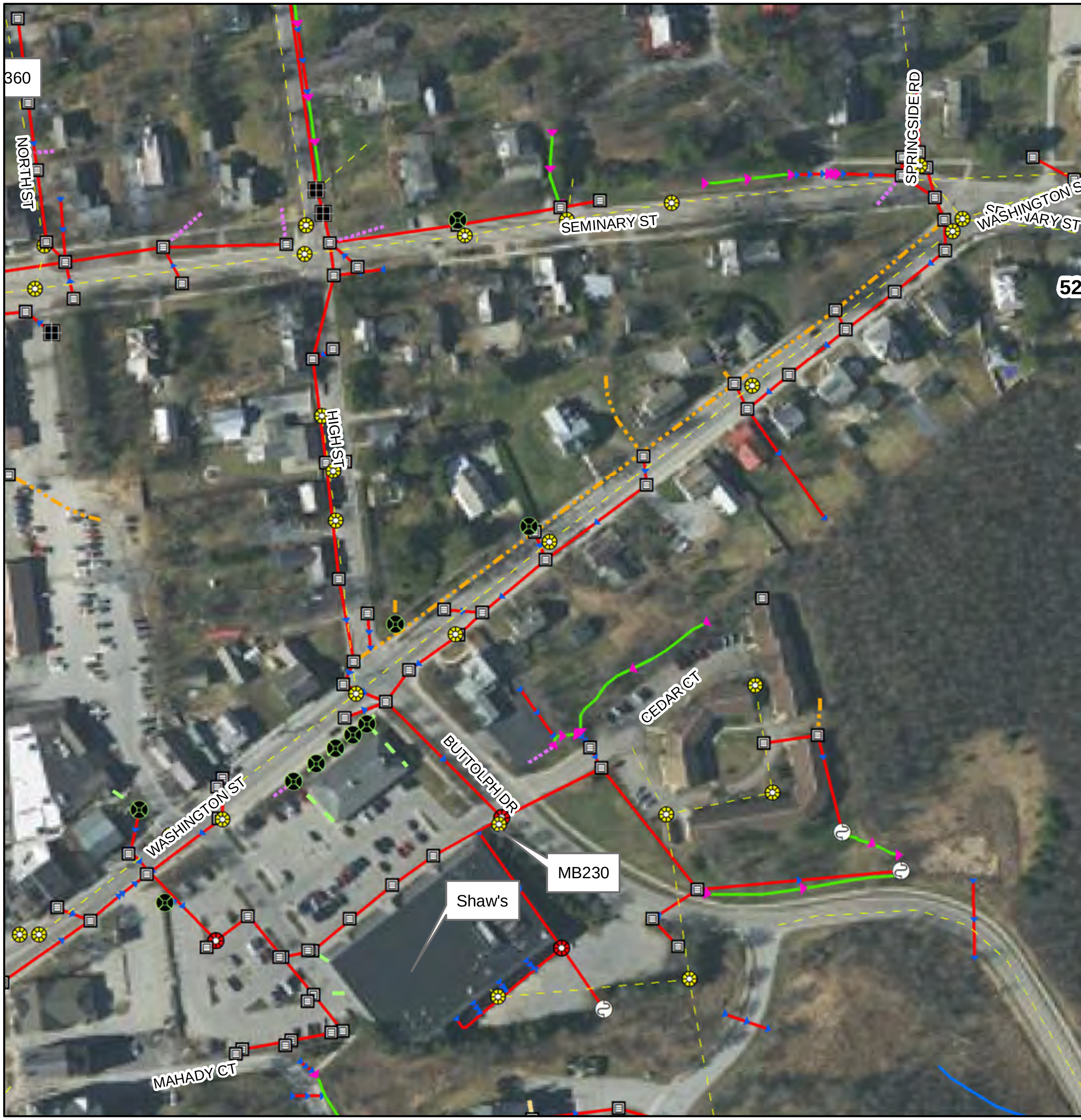
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 17

Middlebury, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

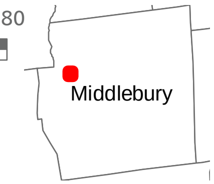
STONE ENVIRONMENTAL



N

0 90 180

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
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- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 18

Middlebury, Vermont

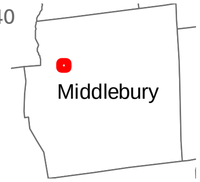
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 70 140

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

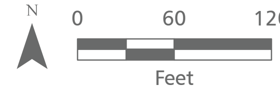
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

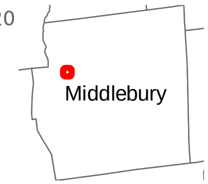
Map 19

Middlebury, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL





LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

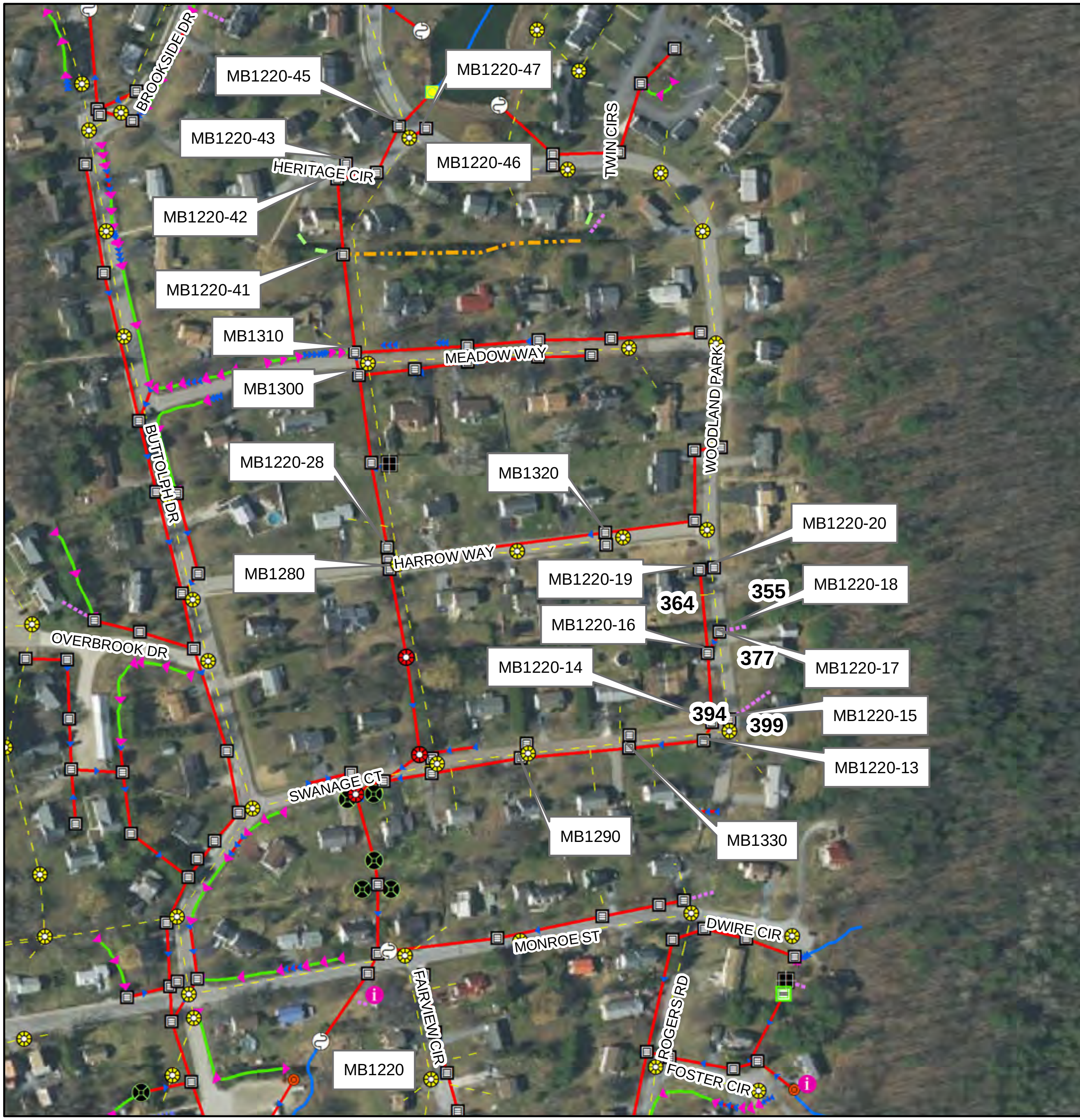
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

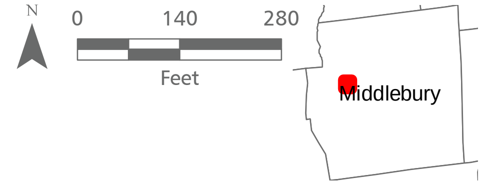
Map 20

Middlebury, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL





LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 21

Middlebury, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 40 80

Feet

LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
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- Junction Box
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- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 22

Rutland Town, Vermont

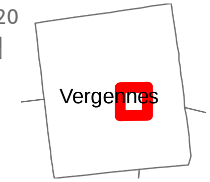
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 110 220

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
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- Junction Box
- Stormwater Manhole
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- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

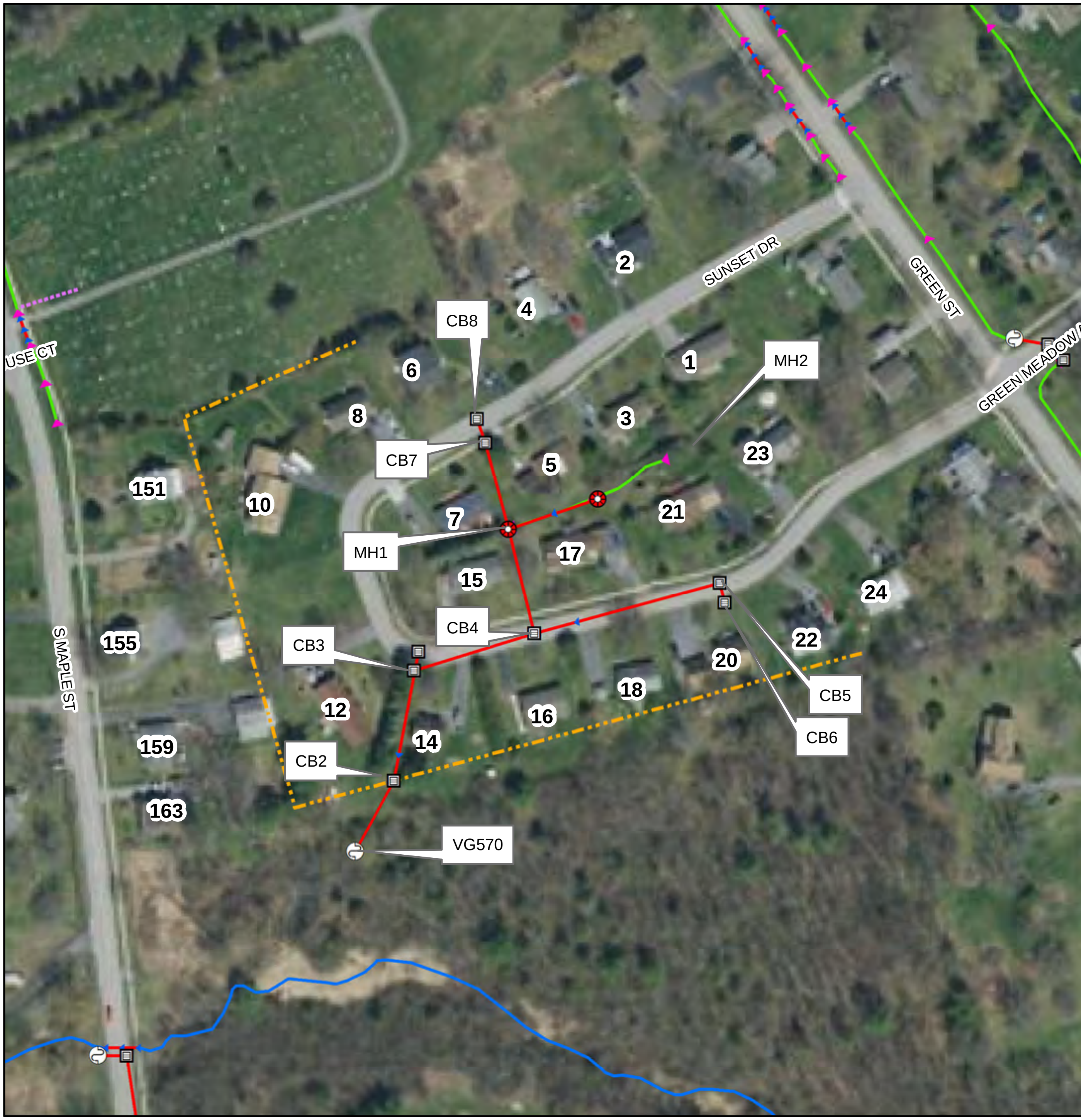
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

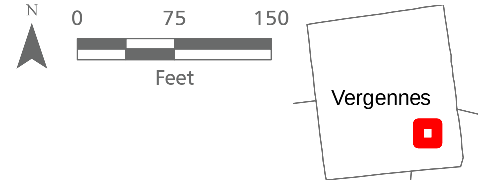
Map 23

Vergennes, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL





LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 24

Vergennes, Vermont

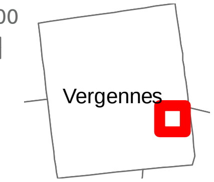
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 100 200

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
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- Sanitary Manhole
- Catchbasin
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- Culvert outlet
- Pond outlet structure
- Treatment feature
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- Unknown Point
- Storm line
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- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

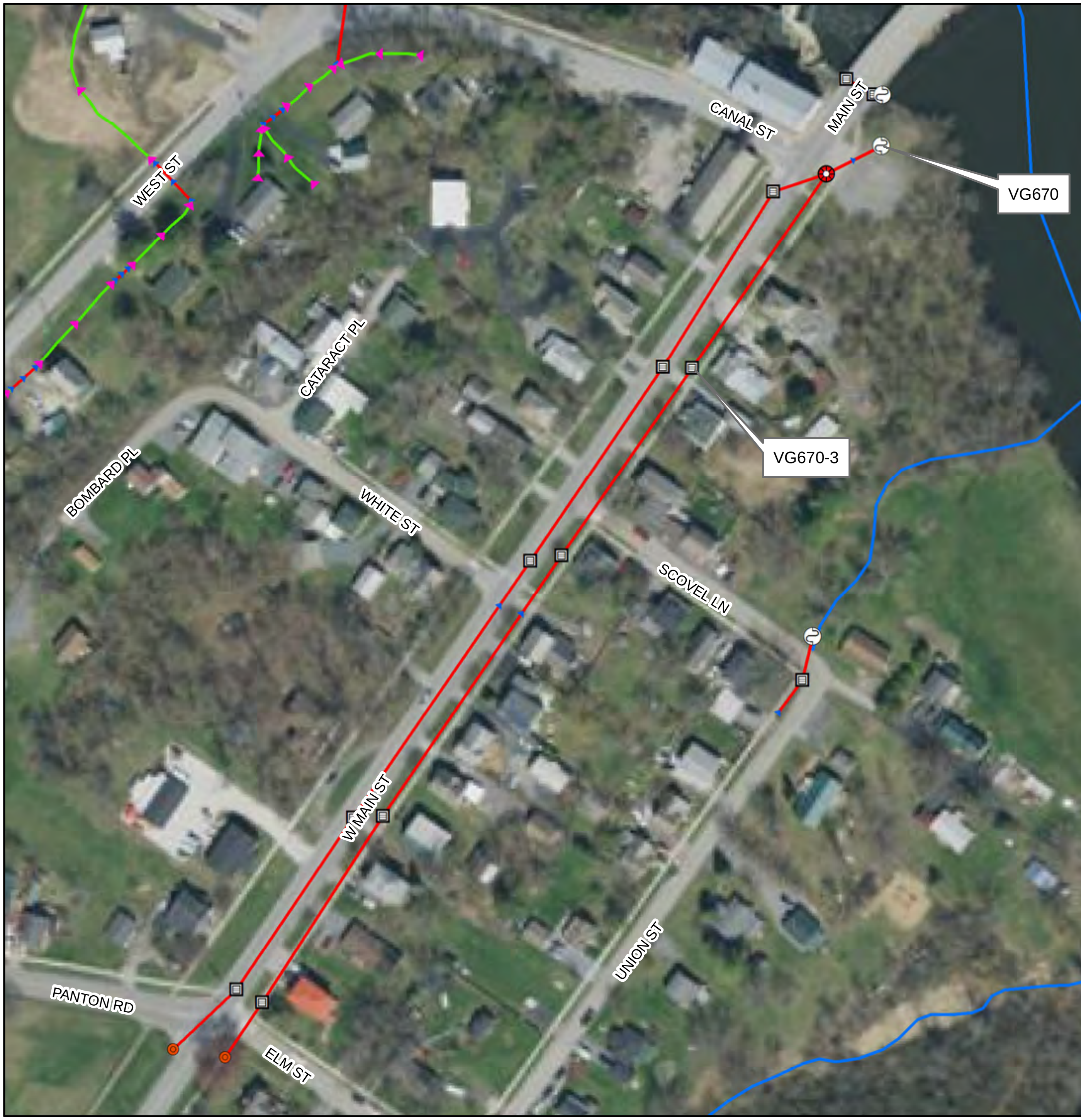
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 25

Vergennes, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

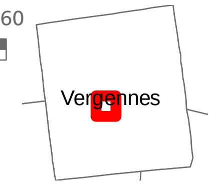
STONE ENVIRONMENTAL



N

0 80 160

Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
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- Culvert outlet
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- Treatment feature
- Information Point
- Unknown Point
- Storm line
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- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 26

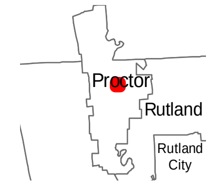
Vergennes, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N

0 50 100
Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
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- Stream
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- Drop Inlet
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- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

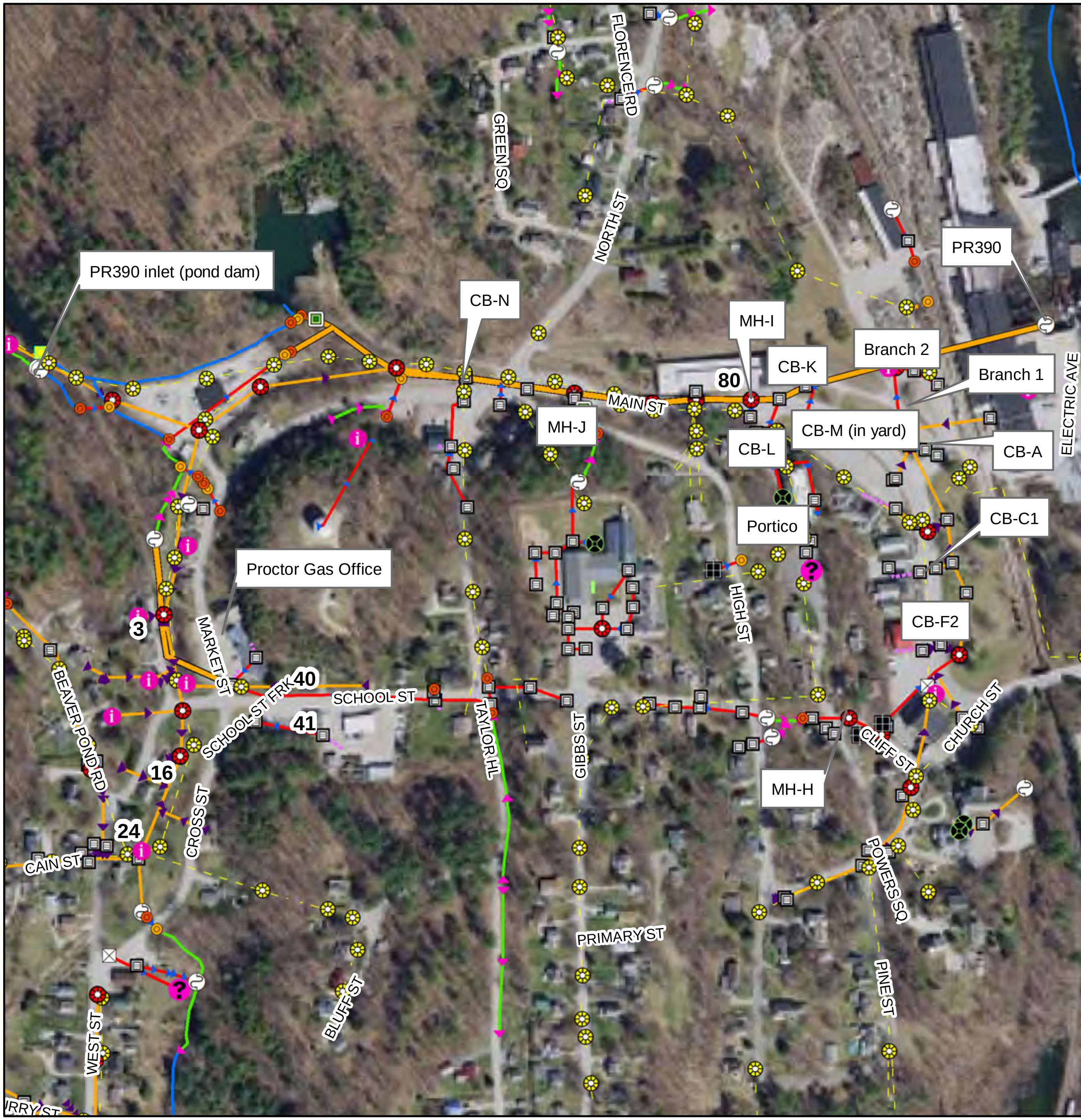
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 27

Proctor, Vermont

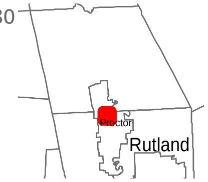
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL



N

0 190 380
Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
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- Combined sewer MH
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- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

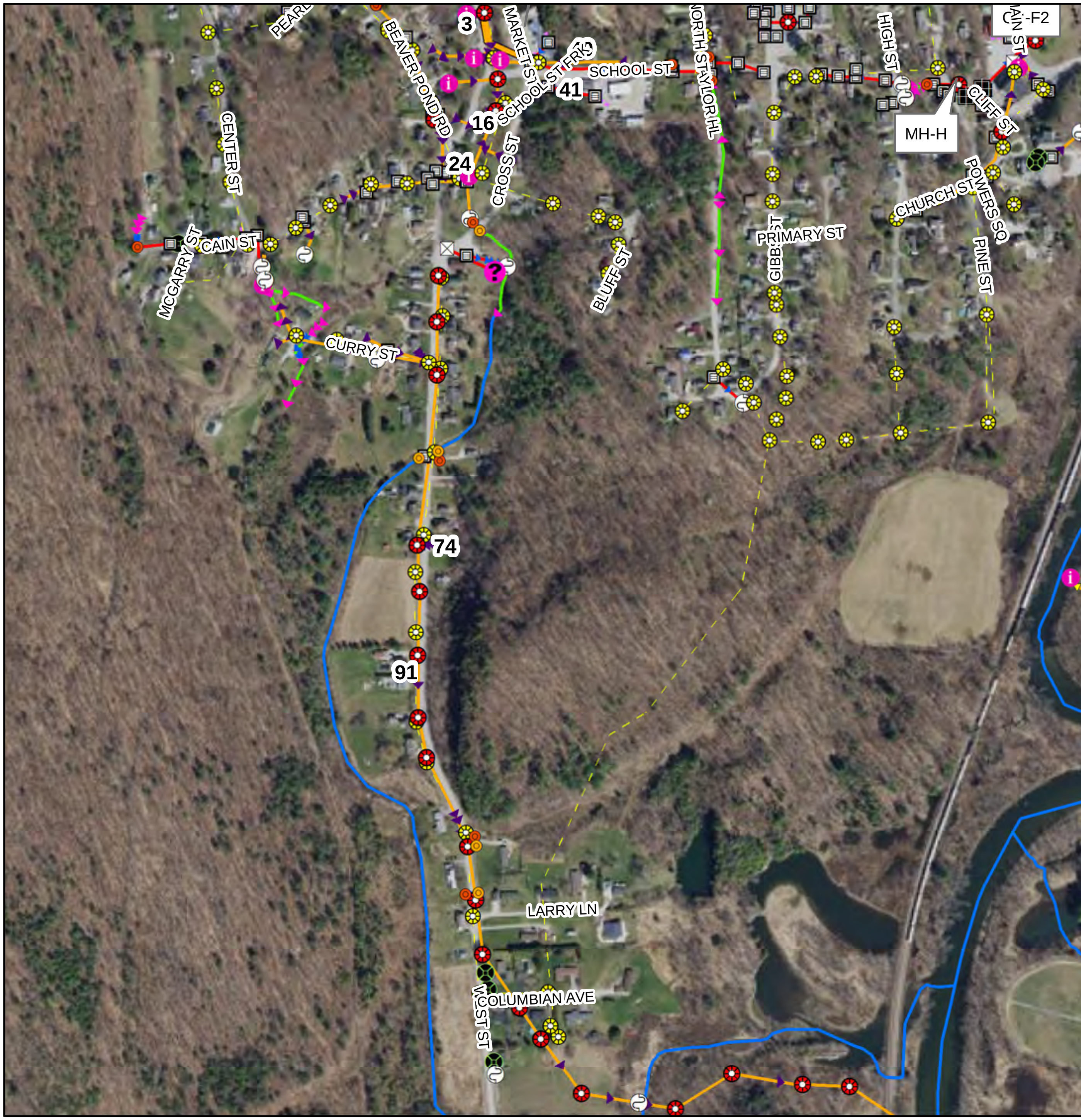
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

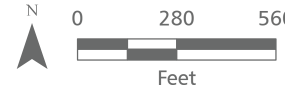
Map 28

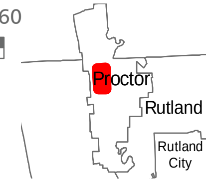
Proctor, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL







LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
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- Treatment feature
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- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

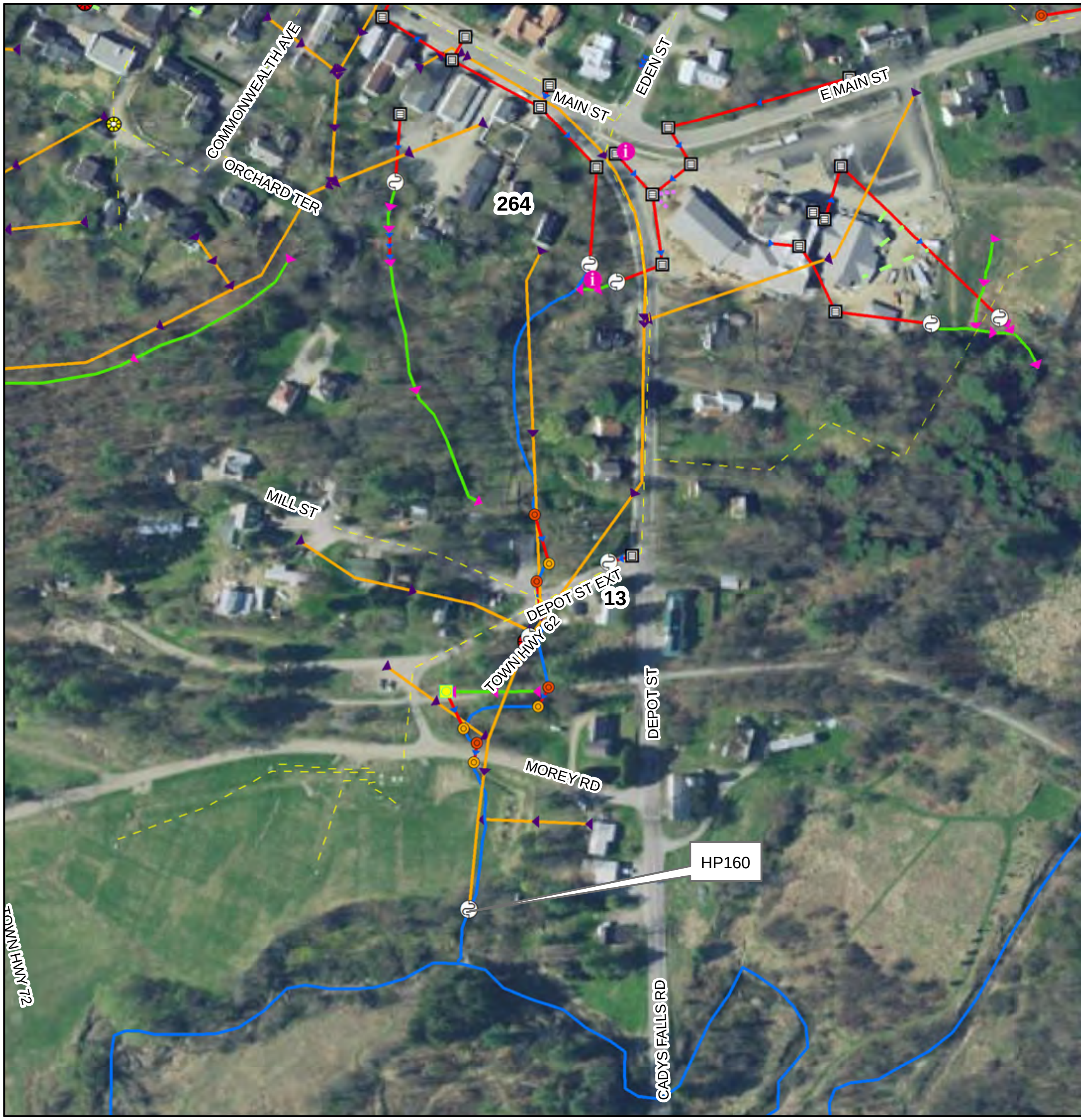
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 29

Procton, Vermont

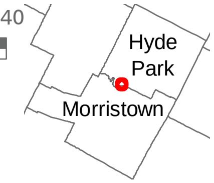
Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL



N

0 120 240
Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
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- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

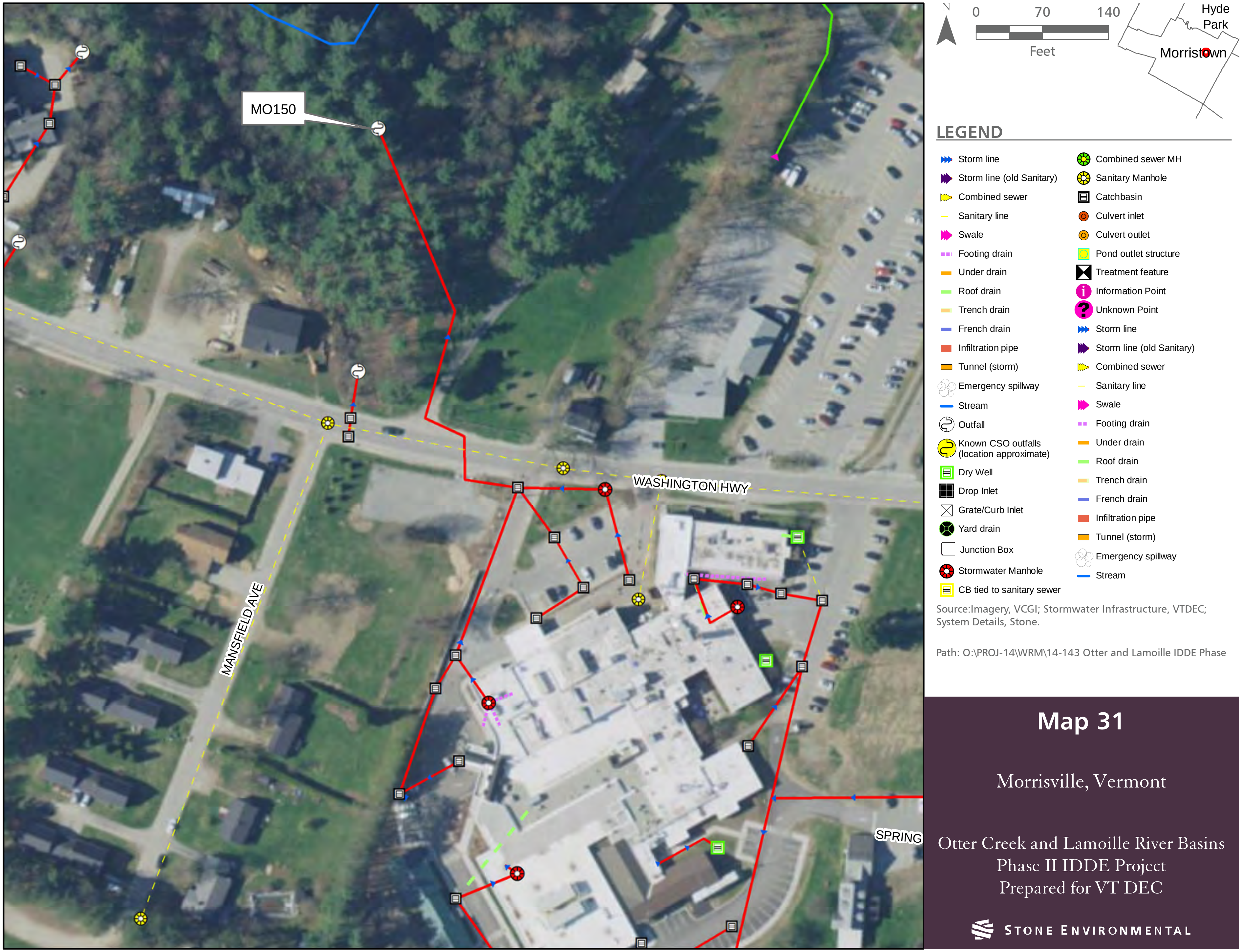
Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 30

Hyde Park, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
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- CB tied to sanitary sewer
- Combined sewer MH
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- Catchbasin
- Culvert inlet
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- Pond outlet structure
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- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

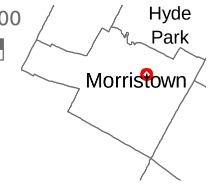
Map 31

Morrisville, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL

N
0 50 100
Feet



LEGEND

- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream
- Outfall
- Known CSO outfalls (location approximate)
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- Junction Box
- Stormwater Manhole
- CB tied to sanitary sewer
- Combined sewer MH
- Sanitary Manhole
- Catchbasin
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Information Point
- Unknown Point
- Storm line
- Storm line (old Sanitary)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Trench drain
- French drain
- Infiltration pipe
- Tunnel (storm)
- Emergency spillway
- Stream

Source:Imagery, VCGI; Stormwater Infrastructure, VTDEC; System Details, Stone.

Path: O:\PROJ-14\WRM\14-143 Otter and Lamoille IDDE Phase

Map 32

Morrisville, Vermont

Otter Creek and Lamoille River Basins
Phase II IDDE Project
Prepared for VT DEC

STONE ENVIRONMENTAL