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# LAKE MEMPHREMAGOG BASIN ADDITIONAL ADVANCED INVESTIGATIONS

## FINAL REPORT

FEBRUARY 21, 2016



*Stormwater manhole at the Newport Elementary School with visible wastewater solids, June 16, 2015*

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# 1. INTRODUCTION

The final report *Detecting and Eliminating Illicit Discharges to Improve Water Quality in the Lake Memphremagog Basin* was completed by Stone Environmental (Stone) in August 2015. The report may be accessed at: <http://www.dec.vermont.gov/watershed/cwi/manage/idde>. The present report serves as an addendum to the original final report. This report summarizes further investigation of eight stormwater drainage systems in Newport City where advanced investigation could not be completed under the original contract, plus continued assessment of system OR220 in Orleans and systems BA300 and BA310 in Barton.

The goal of the Lake Memphremagog Basin Illicit Discharge Detection and Elimination (IDDE) Project was to improve water quality by identifying and eliminating contaminated, non-stormwater discharges entering stormwater drainage systems and discharging to Lake Memphremagog and its tributaries. The original project was administered by the Memphremagog Watershed Association (MWA) under a grant from the Vermont Department of Environmental Conservation (DEC). Stone received a direct contract from DEC for continued investigation of the Newport City systems, working in cooperation with the Newport City Public Works Department.

Seven municipalities participated in the Memphremagog Basin IDDE project: the Town of Barton, the Village of Orleans in Barton, the Town of Brighton, Newport City, and the Town of Derby and its villages of Derby Line and Derby Village. The geographic scope of the project included the entire extents of the municipal closed drainage systems. Prior to the IDDE assessment, DEC prepared stormwater infrastructure mapping for all of these municipalities. This infrastructure mapping was used to plan the assessment in each municipality and to guide further investigations in systems with suspected illicit discharges.

Between June and December, 2014, Stone assessed stormwater outfalls and certain manholes and catchbasins in each participating municipality for the presence of illicit discharges. A total of 375 stormwater drainage systems were assessed. Of the total, 320 systems were assessed at the outfall. 55 systems were assessed in structures up-pipe from the mapped outfall location because the outfall could not be located, was inaccessible, or was inundated by the receiving waterbody. Field tests were performed for ammonia, free chlorine, common anionic detergents [using the methylene blue active substances (MBAS) method], and optical brighteners. Optical brighteners are fluorescent whitening dyes contained in most laundry detergents. Specific conductance was also measured. Of the 375 systems assessed, 90 were flowing or dripping when inspected.

Among the 375 stormwater drainage systems assessed, contaminants indicating a possible illicit discharge were detected in 69 systems. However, there were two suspected illicit discharges in system NC350 in Newport and three in system BA270 in Barton, for a total of 73 suspected illicit discharges: 17 in Barton, 10 in Derby (Town, Village, and Line), 11 in Orleans, and 35 in Newport City.

In the fall of 2014 and spring of 2015, Stone completed investigation of systems with suspected illicit discharges to confirm the presence of illicit discharges and to attempt to determine their sources. Investigations were categorized as either “simple” or “complex” according to the types of contaminants detected and the time expended on the investigation. At the outset of the investigation phase, it was clear that the number of simple and complex investigations that needed to be performed exceeded the maximum numbers specified in MWA’s contract with Stone. Stone was able to complete simple investigations at all systems with suspected illicit discharges, as well as more complex investigations where needed in Barton and Derby. Eight complex investigations could not be completed in Newport City within the scope and budget of the original contract. These eight systems are the subject of this report.

## 2. METHODS

The methods used to assess stormwater systems for presence of illicit discharges were detailed in the Memphremagog Basin IDDE final report, available at:

<http://www.dec.vermont.gov/watershed/cwi/manage/idde>.

In June 2015, Stone began investigating the eight Newport City systems to confirm the presence of illicit discharges and to attempt to determine their sources. Additional sampling was performed where necessary to locate or bracket the origin of the contaminated flow, if present. Stone worked with the Newport City Public Works Department to investigate the Newport systems, performing dye testing and camera inspection as warranted. The City recently purchased a push camera, which was instrumental in the investigations.

### 2.1. *E. coli* and phosphorus

In the eight stormwater drainage systems investigated under this contract, water samples were collected for total phosphorus and *E. coli* analyses at outfalls where wastewater contamination was suspected (because of a positive optical brightener test, elevated ammonia, and/or wastewater odor). The State of Vermont Agriculture and Environmental Laboratory performed both analyses. Total phosphorus was analyzed because of its impact on the ecology and use of Lake Memphremagog. *E. coli* bacteria levels provide an indication of fecal contamination; based on 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 for both sample parameters are given in Table 1.

**Table 1. 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
<i>E. coli</i>	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 either by timing the filling of a container of known volume or using the float method.

## 3. RESULTS

Illicit discharge detection in Newport City was performed during the summer and fall of 2014. Of the 180 systems assessed, 37 were either flowing or dripping during dry weather. Thirty-five systems were designated for further investigation due to the detection of one or more contaminants. Stone was able to complete simple investigations at all systems; however, more complex levels of investigation warranted for eight systems could not be completed within the scope and budget of the original contract. Map 1 in Appendix A illustrates the locations of these eight systems. This report describes completion of the investigations of these eight systems.

The status of the additional Newport City illicit discharge investigations is summarized in Table 2 and the systems are described in detail below.

**Table 2. Status of investigations in Newport City**

Structure ID	Status
NC120	No chronic illicit discharge.
NC230	No chronic illicit discharge.
NC350 MH1 Pipe A	No chronic illicit discharge.
NC350 MH1 Pipe B	No chronic illicit discharge.
NC360 CB1	An improperly sealed sewer overflow pipe was identified. This was corrected in February, 2016.
NC640	Infrastructure mapping in error. No chronic illicit discharge.
NC680	Sanitary wastewater connection at the apartment building at 20 Fern Street eliminated.
NC880 CB1	No chronic illicit discharge.
NC1050	Sanitary wastewater connection identified in the Newport City Elementary School. The connection was eliminated during the summer of 2015.

### 3.1. NC120

The NC120 outfall discharges to the NC110 system within the pipe section immediately above the sediment trap. There are no known surface inlets to this system. The NC120 outfall pipe is oriented toward a commercial building at 84 Farrant Street (Map 2).

**Table 3. Water analysis data for outfall NC120**

Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
6/16/14	Flowing	0.00	0.02	0.60	449	Negative	Clear, no odor
10/13/14	Dripping	0.75	0.00	0.00	600	--	Clear, sewage odor
11/25/14	Flowing	0.00	0.02	0.10	338	--	Clear, iron odor

#### Findings:

- On June 16, 2014, a moderate MBAS concentration (0.60 mg/L) was measured at the outfall.
- On October 13, 2014, a moderate concentration of ammonia (0.75 mg/L) was detected.
- No contaminants were detected on November 25, 2014.
- On June 16, 2015 dye was flushed in a utility sink in the commercial building at 84 Farrant Street. No dye was observed at the outfall. The building appears to be on a poured slab foundation. No floor drains were observed.
- On December 11, 2015, the Newport City Public Works Department inspected the pipe in question using a push camera. No improper connections were observed. The first 20-30 feet of pipe was solid. The pipe was perforated from this point in to the limit of inspection at 120 feet (the camera stopped at 120 ft.). Flow was only observed within the first ~20 feet of pipe.

**Conclusion:** This pipe appears to be a perimeter drain of some type. It is perforated and no inlets to it were identified. Flow was only present in the first ~20 feet of pipe, which indicates that groundwater was the source

of flow on the inspection date. Considering these factors and the intermittent detection of ammonia and MBAS, we must conclude that no chronic illicit discharge is present in this system.

**Resolution:** NA

### 3.2. NC230

The NC230 system drains portions of Main Street, Governor Drive, Third Street, Summer Street, and Pleasant Street. It discharges directly to Lake Memphremagog across from 477 Main Street (Map 3).

**Table 4. Water analysis data for outfall NC230**

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC230	6/16/14	Trickling	0.25	0.11	0.50	397	Negative	Clear, no odor
	10/13/14	Dripping	0.25	0.82	--	320	--	Cloudy, no odor
	11/25/14	Trickling	0.00	0.09	0.20	1075	--	Clear, no odor
	11/25/14	Trickling	--	0.04	--	--	--	--
	12/16/15	Dry	--	--	--	--	--	No odor
CBA, CBB, CBC	11/25/14	Wet, no flow	--	--	--	--	--	--
CBF	6/16/14	Trickling	--	0.02	0.10	--	--	--
	10/13/14	Dripping	0.10	0.06	0.10	106	--	Clear, no odor
CBG Pipe A	11/25/14	Dripping	0.00	0.02	--	--	--	--
CBG Pipe B	11/25/14	Trickling	0.00	0.09	--	--	--	--
	11/25/14	Trickling	0.00	0.00	--	--	--	--
CBH	11/25/14	Wet, no flow	--	0.00	--	--	--	--
CBI	6/16/14	Trickling	--	0.06	0.10	--	--	--

#### Findings:

- On June 16, 2014, low concentrations of ammonia (0.25 mg/L), MBAS (0.50 mg/L), and chlorine (0.11 mg/L) were measured at the outfall.
- On October 13, 2014, a low concentration of ammonia (0.25 mg/L) and high concentration of chlorine (0.82 mg/L) were measured at the outfall. It is possible this was related to a house being washed between catchbasin CBF and the outfall, although there was no apparent runoff to nearby storm drainage structures.
- On November 25, 2014, low chlorine (0.09 mg/L) and MBAS (0.20 mg/L) concentrations were measured at the outfall. The source of chlorine appeared to be from CBG Pipe B (0.09 mg/L). However, we were unable to isolate a source of contamination on this line above CBG, and when CBG Pipe B was resampled an hour later no chlorine was detected.





**Figure 1. Sanitary manhole showing dye from service station pit drain**

- On December 16, 2015, camera inspection was attempted of the stormline on Third Street between catchbasin CB-G and CB-H. From CB-G, only 10-20 feet of the storm line were inspected before the camera was stopped. Progress was better from the other direction, yet the critical section south of CB-G where we speculated a connection from the service station on the corner could exist could not be reached. However, no protruding pipe penetration was seen when siting down the pipe towards the suspected connection.
- On December 16, 2015, Newport City Public Works staff dye tested the drain line leading from the service bay pits to determine if this drain was connected to the storm or the sanitary sewer. Dye showed in the sanitary sewer (Figure 1) and not in the storm sewer.
- There was no flow in the system on December 16, 2015.

**Conclusion:** Given the types of contaminants detected and the intermittent pattern in their concentrations, we suspected a washwater contribution to this system in the vicinity of catchbasin CBG. However, no interior drains were found connected to the storm sewer. Therefore, we now believe that the contaminants detected intermittently in this system are the result of runoff from outdoor washing and other activities.

**Resolution:** NA

### 3.3. NC350

The NC350 system consists of two main branches. Branch A drains a portion of the Lake Memphremagog waterfront north of 100 Main Street. Branch B drains the 70 and 100 Main Street properties and portions of Main Street and Second Street (Map 4). Branches A and B converge in the first manhole (MH1) above the outfall. MH1 was assessed because the outfall is partially submerged.

**Table 5. Water analysis data for outfall NC350**

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC350 MH1 Pipe A	6/17/14	Trickling	0.40	0.21	0.40	209	--	Clear, no odor
	10/13/14	Dripping	0.10	0.07	0.10	76	--	Clear, no odor
	11/25/14	Trickling	0.00	0.01	0.20	--	--	--
	5/7/15	Wet, no flow	--	--	--	--	--	--
	12/16/15	Surcharged	--	--	--	--	--	Surcharged by lake water
NC350 CB-1A	6/17/14	Trickling	--	--	--	--	Negative	--
	5/7/15	Wet, no flow	--	--	--	--	--	No odor

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC350 CB-2A	6/17/14	Wet, no flow	--	--	--	--	--	--
NC350 MH1 Pipe B	6/17/14	Trickling	0.25	0.11	Invalid	5110	--	Clear, no odor
	10/13/14	Dry	--	--	--	--	--	--
	11/25/14	Wet, no flow	--	--	--	--	--	--
	5/7/15	Lake waves	--	--	--	--	--	--
	12/16/15	Surcharged	--	--	--	--	--	Surcharged by lake water
NC350 CB-1	6/17/14	Trickling	--	--	--	--	Positive	--
	10/3/14	Dry	--	--	--	--	Negative	--
	10/13/14	Wet, no flow	--	--	--	--	--	No odor
	5/7/15	Wet, no flow	--	--	--	--	--	--
	12/16/15		--	--	--	--	--	--
NC350 CB-2B	10/3/14	Dry	--	--	--	--	Negative	--
	5/7/15	Wet, no flow	--	--	--	--	--	--
NC350 CB-3B	10/3/14	Dry	--	--	--	--	Negative	--
NC350 MH6	5/7/15	Wet, no flow	--	--	--	--	--	No odor

#### Findings:

- On June 17, 2014, low concentrations of ammonia (0.40 mg/L) and MBAS (0.40 mg/L) and a moderate concentration of chlorine (0.21 mg/L) were measured from Pipe A in manhole MH1. Low ammonia (0.25 mg/L) and moderate chlorine (0.11 mg/L) concentrations and exceedingly high specific conductivity (5,110 µs/cm) were measured from Pipe B in manhole MH1. Optical brightener was detected in CB1.
- On October 13, 2014, a low concentration of chlorine (0.07 mg/L) was measured at MH1 Pipe A.
- On May 7, 2015, manhole MH1 was surcharged by Lake Memphremagog. There was no flow from Branch A to manhole MH1, at catchbasin CB1, or in the manhole MH6, which is located on Main Street up-pipe from catchbasin CB5. Most mapped stormwater structures in the 100 Main Street lot were either covered over and inaccessible, or were beneath parked cars.
- Both pipes A and B in manhole MH1 were surcharged by Lake Memphremagog when inspected on December 16, 2015, precluding sampling. Camera inspection of inflowing pipes (pipes A and pipe B) was not successful because both pipes were surcharged for approximately 80 feet (the camera was underwater).

**Conclusion:** Optical brightener and significant chlorine concentrations were detected in June 2014, but there was very little dry weather flow in Branch A and none in Branch B in follow up sampling in the fall of 2014. On both sampling dates in 2015, MH1 pipes A and B were either surcharged or not flowing. The fact that this system has been observed repeatedly at multiple structures and the only contaminants detected were on one date when there was construction occurring around the pipe B branch of the system suggests that there are not chronic illicit discharges in this system. We speculate that construction activities in the area may have contributed to the contaminants detected on the June 17, 2014 assessment date.

**Resolution:** NA

### 3.4. NC360

The NC360 system drains a portion of Main Street before discharging to Lake Memphremagog northeast of 70 Main Street (Map 4). The first structure up-pipe from the outfall (catchbasin CB1) was assessed because the outfall extends into the lake.

**Table 6. Water analysis data for outfall NC360**

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC360 CB1	6/17/14	Trickling	0.10	0.13	1.0	9,500	Negative	Strong sewer odor
	10/13/14	Dry	--	--	--	--	--	No sewer odor
	11/25/14	Trickling	--	0.01	0.30	2,180	--	No odor
	5/7/15	Stagnant pool	0.5	0.10	0.30	340	--	No odor
	12/16/15	Wet, no flow	--	--	--	--	--	--
NC360 MH1 Pipe A	6/17/14	Flowing	--	--	--	--	--	--
	11/25/14	Dry	--	--	--	--	--	--
	5/7/15	Wet, no flow	--	--	--	--	--	Wastewater odor
	6/16/15	Trickling	0.25	--	--	--	--	Wastewater odor
	12/16/15	Wet, no flow	--	--	--	--	--	--
NC360 MH1 Pipe B	6/17/14	Flowing	--	--	--	--	--	--
	11/25/14	Wet, no flow	--	--	--	--	--	--
	5/7/15	Wet, no flow	--	--	--	--	--	Wastewater odor
	6/16/15	Trickling	0.25	--	--	--	--	Wastewater odor
	12/16/15	Wet, no flow	--	--	--	--	--	--
NC360 MH1 Pipe C	6/17/14	Dry	--	--	--	--	--	--
	11/25/14	Wet, no flow	--	--	--	--	--	--
	5/7/15	Wet, no flow	--	--	--	--	--	Wastewater odor
	6/16/15	Trickling	0.25	--	--	--	--	Wastewater odor
	12/16/15	Wet, no flow	--	--	--	--	--	--

#### Findings:

- On June 17, 2014, moderate concentrations of chlorine (0.13 mg/L) and MBAS (1.0 mg/L) and exceedingly high specific conductivity (9,500 µg/L) were measured in catchbasin CB1. A strong wastewater odor was emanating from CB1. There was no wastewater odor in the next up-pipe structure, MH1.
- No flow or wastewater odor was observed in CB1 on October 13, 2014.
- On November 25, 2014, CB1 was trickling and no flow was observed in manhole MH1. Specific conductance was dramatically lower though still elevated.
- On May 7, 2015, none of the three pipes entering manhole MH1 were flowing, but a slight wastewater odor was observed. Although catchbasin CB1 was not flowing, samples were collected from the sump for *E. coli* and total phosphorus analysis (Table 14). The *E. coli* concentration was elevated (540 MPN/100 mL) and the total phosphorus concentration was moderate (97 µg/L).
- A definite wastewater odor was observed in manhole MH1 on June 16, 2015. The flow was insufficient to collect any samples except ammonia, the concentration of which was low in all three pipes.



**Figure 2. Manhole MH1—a gap in the plug is visible in the pipe in the 11:00 position**

- On December 16, 2015, a push camera was used to view manhole MH1 and the pipes entering and exiting the structure. The nearby sanitary manhole was also inspected. The inspection revealed that a grout plug on a cross connection between the sanitary manhole and stormwater manhole MH1 was not properly sealing the pipe. A gap was visible at the top of the pipe opening (the grout apparently settled) (Figure 2). This gap in the plug was believed to be the source of the wastewater odor in MH1. Under surcharged conditions in the sanitary sewer, this gap would have allowed wastewater to flow into manhole MH1.

**Conclusion:** A direct connection between the sanitary sewer and stormwater manhole MH1 was identified. A faulty plug on a cross connecting line appears to have been responsible for wastewater odors in manhole MH1. When the sanitary sewer was surcharged this may have caused wastewater to enter MH1. Conversely, at high flows MH1 may have been a source of inflow to the sanitary sewer.

**Resolution:** The Newport City Public Works Department sealed the cross connection pipe in early February, 2016.

### 3.5. NC640

The NC640 system drains a portion of Herrick Street. This system is mapped as a sanitary sewer repurposed as a separated storm drain, which discharges offshore in Lake Memphremagog (Map 5). However, we were unable to locate any stormwater infrastructure on Herrick Street below catchbasin CB1. Manhole MH2 is mapped as being part of the NC640 system, but it is actually part of the sanitary sewer.

According to Tom Bernier, Director of Public Works, the sanitary sewer on Herrick Street is the original sewer system from which stormwater inputs were eliminated in a 1996 sewer separation project. A new stormline was run from the catchbasin (CB1) at the 90 degree bend in Herrick Street to convey stormwater from upper Herrick Street downhill to Limlaw Hill Road.

**Table 7. Water analysis data for outfall NC640**

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC640 CB1	6/23/14	Dripping	--	--	--	--	Negative	--

#### Findings:

- Catchbasin CB1 is the lowest catchbasin on Herrick Street. The inlet pipe to CB1 was dripping and no optical brightener was detected.

**Conclusion:** Stormwater and sanitary infrastructure mapping appears to be in error. There does not appear to be an old sanitary line repurposed for stormwater on lower Herrick Street. We do not believe there is an illicit discharge in this system at or above catchbasin CB1, the lowest catchbasin on Herrick Street.

**Resolution:** NA

### 3.6. NC680

The NC680 system drains portions of Glen Road, Weaver Street, and Fern Street before discharging to Lake Memphremagog across from 20 Fern Street (Map 6).

**Table 8. Water analysis data for outfall NC680**

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC680	6/23/14	Trickling	0.50	0.00	0.30	1890	Indeterminate	Orange, slight oil odor
	7/23/14	Trickling	--	--	--	--	Negative	--
	10/13/14	Trickling	0.75	0.01	0.10	1190	--	Cloudy, no odor
	11/25/14	Trickling	0.50	0.00	0.20	1300	Negative	Minor suds, no odor
NC680 CB2	10/13/14	Trickling	0.10	--	--	--	--	--
NC680 CB3	10/13/14	Trickling	1.0	--	--	--	--	--
NC680 CB5	10/13/14	Dry	--	--	--	--	--	--
NC680 CB4 Pipe A	10/13/14	Trickling	1.5	--	0.10	513	--	Cloudy, orange, strong odor
	11/25/14	Trickling	--	--	--	--	--	Iron staining, no odor
	5/7/15	Trickling	--	--	--	--	--	--
	6/16/15	--	1.5	--	--	--	--	--
NC680 CB4 Pipe B	10/13/14	Trickling	0.50	--	--	440	--	Clear, slight odor
	11/25/14	Trickling	--	--	--	--	--	Iron staining, no odor
	5/7/15	Trickling	--	--	--	--	--	--
	6/16/15	--	0.25	--	--	--	--	--
NC680 MH2	10/13/14	Dripping	0.10	--	--	--	--	Clear, no odor

#### Findings:

- On June 23, 2014, a moderate ammonia concentration (0.50 mg/L) and low MBAS concentration (0.30 mg/L) were both measured at the outfall. An indeterminate optical brightener result was recorded. Resampling for optical brightener on July 23, 2014 yielded a negative result.
- Bracket sampling for ammonia on October 13, 2014 isolated the ammonia source to catchbasin CB4. Two pipes enter this structure. A four inch diameter drain (“Pipe A”) enters from the main stormline (“Pipe B”) enters from south. The ammonia concentration in Pipe A was higher than in Pipe B (1.5 mg/L versus 0.75 mg/L).
- On November 25, 2014, a low concentration of ammonia (0.50 mg/L) was measured at the outfall. Some suds were observed.
- On May 7, 2015, concentrations of *E. coli* (<1 MPN/100 mL) and total phosphorus (42 µg/L) measured at the outfall were very low (Table 14).

- On June 16, 2015, the ammonia concentration at CB4 Pipe A was in the same moderately high range as on October 13, 2014.
- A dye test was performed on June 16, 2015 of the four unit apartment building at 20 Fern Street. The two apartments on the north side of the building were unoccupied at the time. Only the second floor apartment on the south side of the building could be tested. No dye was seen in catchbasin CB4 shortly after the test or several hours later when CB4 was rechecked.



**Figure 3. Pavement patch on Fern Street over apartment building's new sewer service connection**

- The Director of Public Works, Tom Bernier, visited the property in late summer 2015 and observed wastewater solids in catchbasin CB4. Apparently, an excavator working on the septic system tied the building sewer for the two apartments on the north side of the building into the perimeter drain which discharges to CB4. Mr. Bernier required the building owner to make a proper connection to the municipal sewer on Fern Street (Figure 3). This repair was made in the fall of 2015.

**Conclusion:** Although some of the details are unclear, it appears that Pipe A in catchbasin CB4 is a perimeter drain that conveyed partially renovated wastewater from a saturated septic system leachfield to CB4. Over the summer of 2015 a contractor tied a sewer line serving two units into this drain, resulting in discharge of raw wastewater to CB4.

**Resolution:** The Newport City Public Works Department required the owner of the apartment building at 20 Fern Street to connect the building to the municipal sewer on Fern Street.

### 3.7. NC880

The NC880 system drains portions of the property at 424 East Main Street, Western Avenue, East Main Street, and Autumn Street (Map 7). It discharges to a stream behind 120 Hill Street. It was assessed primarily at catchbasin CB1 next to the Subway parking lot.

**Table 9. Water analysis data for outfall NC880**

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC880 CB1 Upper basin	6/30/14	Trickling	--	--	--	--	Indeterminate	--
	7/23/14	Trickling	--	--	--	--	Positive	--
	10/9/14	Dry	--	--	--	--	Negative	--
NC880 CB1 Pipe B	5/7/15	Trickling	0.0	0.00	0.0	572	--	--

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC880 CB1 Lower basin	10/9/14	--	--	--	--	--	Negative	--
NC880 CB2	6/30/14 11/5/14	Trickling Trickling	0.10 0.35	0.05 0.04	0.50 0.20	1355 91	Negative --	Clear, no odor Tan, no odor
NC880 CB3 Pipe A	11/5/14	Trickling	0.40	--	0.20	--	--	Tan, no odor
NC880 CB5 Pipe B	11/5/14	Dripping	0.25	--	0.40	--	--	Particles, no odor
NC880 CB8 Pipe A	11/5/14	Dripping	0.25	0.20	--	--	--	Tan, no odor

### Findings:

- Catchbasin CB1 is an unusual structure, with an upper basin that drains through a grate in the floor to a lower basin that is difficult to access. There are four pipes entering the upper basin. There are no mapped inlets to pipes B and C. Pipe D connects CB1 to CB2 and up-pipe structures.
- On July 23, 2014, optical brightener was detected in the upper basin of catchbasin CB1.
- Low MBAS concentrations ranging from 0.20 mg/L to 0.50 mg/L were detected in CB2, CB3 Pipe A, and CB5 Pipe B. Low ammonia concentrations ranging from 0.25 mg/L to 0.40 mg/L were detected in CB2, CB3 Pipe A, and CB5 Pipe B.
- On May 7, 2014, there was a trickle of flow from Pipe B in CB1, while Pipes A, C, and D were dripping or dry. No *E. coli* were detected and total phosphorus concentrations were very low (42 µg/L) in the flow from Pipe B (Table 14).
- On December 16, 2016, Pipe B in CB1 was trickling and Pipe C was dripping. Pipe B was inspected with a push camera. No inappropriate connections were seen up to the point the camera was stopped. The pipe appeared to bend around the back of the Subway restaurant. Dye was added to a pipe cleanout on the back side of the Subway building, and it quickly showed at the Pipe B outlet to CB1. This test confirmed that Pipe B is a subsurface drain that likely also receives air conditioning condensate from Subway.
- In January, 2016 the Newport City Public Works Department inspected the interior of the Subway restaurant. No floor drains were observed on the first floor. In the basement, a perimeter drain flows to a sump pump. The sump pump discharges to the foundation drain and hence to catchbasin CB1. While this perimeter drain and pump connect the building's interior to the stormwater drainage system, there is reportedly no activity in the basement.

**Conclusion:** Low levels of ammonia and MBAS detergents and a single optical brightener detection in catchbasin CB1 were recorded in this system. A consistent pattern of detections failed to materialize. Based on pipe alignments, we believed the most likely source of these contaminants was washwater dumping to a floor drain in the Subway restaurant. However, no floor drains were seen within the restaurant and it appears the pipe aligned with the Subway building is a foundation drain. A basement perimeter drain is connected to this foundation drain, but there is apparently no activity within the restaurant's basement. Therefore, we conclude that the low levels of contaminants were from minor, transient sources.

**Resolution:** NA

### 3.8. NC1050

The NC1050 system is downstream of the NC1010 outfall and drains a portion of Sias Avenue and the Newport City Elementary School property (Map 8).

**Table 10. Water analysis data for outfall NC1050**

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
NC1050	6/30/14	Flowing	0.10	0.04	0.20	580	Negative	Clear, no odor
NC1050 CB1 Pipe A	6/30/14	Flowing	0.10	0.00	0.20	533	Positive	Clear, no odor
NC1050 CB2 Pipe A	5/7/15	Flowing	0.0	0.04	0.10	525	--	--
NC1050 CB2 Pipe B	5/7/15	Flowing	1.0	0.5	0.02	1232	--	Wastewater odor, toilet paper in sump.

#### Findings:

- On June 30, 2014, optical brightener was detected in Pipe A entering the first catchbasin above the NC1050 outfall (CB1). CB1 Pipe A drains the elementary school property, as well as an underdrain behind 110 Sias Avenue.
- On May 7, 2015, samples were collected from the two pipes entering the second catchbasin above the outfall (CB2). No *E. coli* or ammonia were detected in flow from Pipe A, which drains the north side of the school property, and the total phosphorus (23 µg/L), MBAS, and free chlorine concentrations were below levels of concern. However, flow from Pipe B, which drains the south side of the school, had elevated ammonia, MBAS, and total phosphorus (416 µg/L) concentrations, exceedingly high *E. coli* levels (17,320 MPN/100 mL), and a distinct wastewater odor.
- On June 16, 2015, the storm drainage system around the school was inspected and mapped connections were verified or corrected. Toilet paper and feces were observed in a manhole (labelled CB3 on Map 8) south of the school building (see cover photo). An unmapped vitrified clay pipe discharges to this manhole. From its appearance, location, and alignment, we suspected the vitrified clay pipe was the source of wastewater entering the system and that it originates in the old wing of the elementary school. Dye testing was therefore performed in every lavatory in the old wing of the school. The toilet in one classroom (Room 108) was found to be connected via a cross connection to a roof leader. Dye added to the toilet quickly appeared in the unmapped vitrified clay pipe discharging to the manhole. We do not believe there are any other connected toilets. The sink in the lavatory and a project sink in the classroom were presumed to be connected incorrectly also, as there appeared to be a single pipe connection to the roof leader.
- The Director of Public Works, Tom Bernier, revisited the site with a plumber the following day to develop a plan to correct the cross connection.

**Conclusion:** A direct connection was identified from a toilet and two sinks in a classroom in the Newport City Elementary School to the municipal storm drain.

**Resolution:** The school discontinued use of the bathroom until the inappropriate sewer connection was eliminated. Over the summer, the problem was corrected by cutting through the concrete floor and connecting the toilet and sinks into the building sanitary sewer. This classroom is used by 25 children per day during the



school year, and the problem had likely existed for many years. Therefore, correction of the cross connection resulted in a meaningful water quality improvement.

### 3.9. BA300

The BA300 outfall is in Barton. This outfall is a 4-in. diameter PVC pipe adjacent to the BA290 outfall. It discharges to a stream behind 153 Lincoln Avenue. The outfall was not mapped and there are no visible inlets (Map 9). The system appears to be a perimeter drain installed at the toe of the slope along the driveway serving the apartment at 153 Lincoln Avenue.

**Table 11. Water analysis data for outfall BA300**

Date Assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
7/30/14	Trickling	0.1	0.03	0.5	1004	Positive	Clear, no odor.
9/10/14	Trickling	0.1	0.09	0.2	710	Positive	Clear, no odor.
5/14/15	Dripping	--	--	--	--	--	--
6/18/15	Dripping	--	--	--	--	Negative	Clear, no odor.

#### Findings:

- On two visits, low MBAS concentrations (0.5 and 0.2 mg/L) were measured at the outfall.
- Optical brightener was detected at the outfall on two occasions in 2014.
- On November 12, 2014, dye testing was performed at 185 Lincoln Avenue and at the apartment at 153 Lincoln Avenue. Dye was not observed at outfalls BA300 or BA310. An inspection of the crawl space plumbing at 185 Lincoln Street did not suggest any cross connections. No one was home at the main residence at 153 Lincoln Avenue on five attempts between November, 2014 and May 2015.
- *E. coli* and total phosphorus concentrations were negligible in samples collected at the outfall on May 14, 2015 (Table 14).
- Arrangements were made to dye test 153 Lincoln Avenue on June 18, 2015. No connection between BA300 and interior drains was found. Dye flushed down the toilet was observed in a sanitary manhole and was not observed at the outfall. Neither sewer dye nor optical brightener was detected on a pad placed in the outfall on June 18 and retrieved on June 25, 2015.
- Recent (February 2016) map review and communications with DEC and the Village of Barton have revealed the possibility that the house at 185 Lincoln Avenue lacks a proper sewer connection. The house at 185 Lincoln Avenue is the only house on the block without a sewer connection clearly indicated on sanitary maps provided by DEC and the Village of Barton.

**Conclusion:** The source of intermittent optical brightener detected at this outfall is unknown. Based on the location of the outfall and the lack of direct connections, it appears unlikely that the source of the optical brightener detected in this drain is 153 Lincoln Avenue. An alternate explanation is that the drain intercepts contaminated groundwater from a sanitary wastewater discharge at 185 Lincoln Avenue, due to either a broken or an improperly connected sewer lateral.

**Resolution:** Considering the miniscule flows observed and absence of contaminants above levels of concern, we believe system BA300 is not a significant source of water pollution. However, recent map review has demonstrated that the existence of a proper sewer connection at 185 Lincoln Avenue must be confirmed.

### 3.10. BA310

The BA310 outfall is in Barton. This outfall was unmapped and appears to act primarily as a roof drain. It discharges directly behind 153 Lincoln Avenue (Map 9).

**Table 12. Water analysis data for outfall BA310**

Date Assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
7/30/14	Trickling	0.25	0.00	0.2	256	Positive	Clear, no odor.
9/10/14	Dry	--	--	--	--	Positive	Clear, no odor.
5/7/15	Flowing	--	--	--	--	--	--
6/18/15	Dripping	--	--	--	--	Positive	Clear, no odor.

#### Findings:

- On July 30, 2014, low ammonia (0.25 mg/L) and MBAS (0.2 mg/L) concentrations were measured at the outfall.
- Optical brightener was detected at the outfall all three times it was monitored.
- On November 12, 2014, dye testing was performed at 185 Lincoln Street and at the apartment at 153 Lincoln Street. Dye was not observed at outfalls BA300 or BA310. An inspection of the crawl space plumbing at 185 Lincoln Street did not suggest any cross connections. No one was home at the main residence at 153 Lincoln Avenue on five attempts between November, 2014 and May 2015.
- *E. coli* and total phosphorus concentrations were negligible in samples collected at the outfall on May 14, 2015 (see Table 14).
- Arrangements were made to dye test 153 Lincoln Avenue on June 18, 2015. Dye flushed down the toilet was observed in a sanitary manhole and was not observed at the outfall. Optical brightener was evident but no sewer dye was detected on a pad placed in the outfall on June 18 and retrieved on June 25, 2015.
- Inspection of plumbing at 153 Lincoln Avenue on June 18, 2015 did not reveal a definite source of contamination. No leaks were seen in the wastewater plumbing. Wastewater lines from the apartment are connected to those in the main house. The building sewer penetrates the foundation on the Lincoln Avenue side of the house (in the opposite direction from the stream). Outfall BA310 is connected to a roof leader and to a system of floor drains in the basement. One of these floor drains is located under a lawnmower. Another is next to an oil furnace. It is likely that water flows to these drains under high groundwater conditions, transporting small quantities of oil. However, the pipes leading from these floor drains and roof drain were dry on June 18 while the outfall was dripping. This indicates that groundwater is infiltrating into the line.
- Recent (February 2016) map review and communications with DEC and the Village of Barton have revealed the possibility that the house at 185 Lincoln Avenue lacks a proper sewer connection. The house at 185 Lincoln Avenue is the only house on the block without a sewer connection clearly indicated on sanitary maps provided by DEC and the Village of Barton.

**Conclusion:** The source of intermittent optical brightener detected at this outfall is unknown. Based on the lack of a direct sanitary or graywater connection, it appears unlikely that the source of the optical brightener detected in this drain is 153 Lincoln Avenue. An alternate explanation is that the drain intercepts contaminated

groundwater from a sanitary wastewater discharge at 185 Lincoln Avenue, due to either a broken or an improperly connected sewer lateral.

**Resolution:** Considering the miniscule flows observed and absence of contaminants above levels of concern, we believe system BA310 is not a significant source of water pollution. However, recent map review has demonstrated that the existence of a proper sewer connection at 185 Lincoln Avenue must be confirmed.

### 3.11. OR220

The OR220 outfall is in Orleans. The OR220 system drains portions of South Street and a gravel road along the eastern perimeter of the Ethan Allen facility. The system discharges to the Barton River directly northwest of the sewer pump station behind 16 South Street (Map 10).

**Table 13. Water analysis data for outfall OR220**

Structure ID	Date assessed	Dry, Wet/no flow, Dripping, or Flowing?	Ammonia (mg/L)	Free Chlorine (mg/L)	MBAS (mg/L)	Specific Conductance (µs/cm)	OB Result	Observations
OR220	8/19/14	Trickling	0.10	0.02	0.2	932	Negative	Clear, no odor
	9/23/14	Trickling	0.10	0.03*	0.2	966	--	Cloudy, no odor
OR220 CB1 Pipe A	9/23/14	Trickling	0.10	0.03*	0.1	933	--	Clear, no odor
	6/18/15	Flowing	0.00	0.05	0.0	--	--	Clear, no odor
OR220 CB1 Pipe B	9/23/14	Dripping	0.10	0.33*	0.5	1087	--	Cloudy, no odor
	10/1/14	Dripping	0.40	0.13	0.5	1248	--	Cloudy, slight odor
	6/18/15	Trickling	0.00	0.13,0.03	0.2	---	--	Cloudy, no odor
OR220 CB2	10/1/14	Wet (no flow)	--	--	--	--	--	--

\*= Total chlorine

#### Findings:

- On August 19, 2014 and September 23, 2014, the same very low concentration of MBAS (0.20 mg/L) was measured at the outfall.
- On September 23 and October 1, 2014, a low concentration of MBAS (0.50 mg/L) was measured at CB1 Pipe B. Moderate concentrations of chlorine were measured on both dates (0.33 mg/L total chlorine on September 23 and 0.13 mg/L free chlorine on October 1). On October 1, a low ammonia concentration (0.40 mg/L) was also measured.
- On June 18, 2015, both pipes discharging to catchbasin CB1 were sampled. In Pipe B, chlorine was initially detected but was below detection in a second sample. Turbidity in the sample may have resulted in these inconsistent readings.
- On June 18, 2015, dye was added to a toilet in one of the South Street Apartments, located at the top of the bank above the storm drain. No dye was observed in the OR220 system or at any of the seeps at the toe of the slope.



**Figure 4. Deteriorated pipe penetrations in catchbasin CB1**

- Remnants of clay and steel pipes were found in three locations along the toe of the slope between CB1 and CB2. At these and other locations, water was seeping from the ground onto the gravel drive below.
- On December 16, 2015 catchbasin CB1 was inspected. Water was observed flowing from Pipe A into voids around the outside of the structure and emerging at the Pipe B penetration (Figure 4). A low ammonia concentration was measured in samples collected at both penetrations. Samples collected from the Pipe B penetration were turbid.

**Conclusion:** Based on repeated detection of chlorine and MBAS at CB1 Pipe B and the absence of flow at CB2, we initially suspected an illicit connection from the Ethan Allen manufacturing plant to the storm drain between CB2 and CB1. However, an Ethan Allen representative confirmed that there are no interior drains in the northern portion of the facility adjacent to the storm drain. A second explanation considered was that there was a cross connection from the sanitary sewer line to one of the mapped footing drains on the slope below the South Street Apartments. However, this explanation was not convincing because we could not find any intact drains on the slope, only pipe remnants, and the one apartment we visited appeared to be properly connected to the sanitary sewer. Another possibility is that the low concentrations of MBAS and chlorine in CB1 Pipe B simply result from measurement errors due to excessive turbidity in the samples. This explanation appears most likely. On December 16, 2015, we noted that water from the Pipe A line flows through voids around the outside of the basin, and enters at the base of the structure through the Pipe B penetration. Most of the dry weather flow at Pipe B appears to come from Pipe A. This observation supports the theory that poor sample quality is the problem and no chronic illicit discharge is present.

**Resolution:** NA

## 4. P LOADING AND E. COLI CONCENTRATIONS

Samples were collected on May 7 and 14, 2015 for *E. coli* and total phosphorus analysis by the Vermont DEC laboratory. If feasible, a discharge measurement was made immediately following sampling. Daily total phosphorus loads were calculated from the concentration and discharge data. These data are presented below (Table 14).

**Table 14. *E. coli* and total phosphorus data for selected drainage systems**

System	Date	<i>E. coli</i> (MPN/100 mL)	TP (µg/L)	Discharge (L/min)	TP loading (g/day)
BA300	5/14/15	40	30	Dripping	NA
BA310	5/14/15	<1	70	0.08	0.0
NC360 CB1	5/7/15	540	97	No flow	NA
NC680	5/7/15	<1	42	19.2	1.2
NC880 CB1-B	5/7/15	<1	68	Dripping	NA
NC1050 CB1-A	5/7/15	<1	23	3.7	0.1
NC1050 CB1-B	5/7/15	17,320	416	4.9	2.9

The *E. coli* data from the May 2015 sampling events generally reinforce the interpretations made from earlier data and observations. Sampling points with suspected sanitary wastewater connections (NC360 CB1 and NC1050 CB1 Pipe B) had elevated *E. coli* levels, and *E. coli* levels were low in the other systems.

Total phosphorus concentrations were low to moderate (<100 µg/L) at all sampling points except NC1050 CB1 Pipe B, where they were substantially higher

The opportunities for phosphorus reduction through elimination of these illicit discharges appear minor based on results of the May 7 and May 14 grab samples. In NC1050, the system with the highest daily loading, it is likely that substantially greater phosphorus loading occurred during heavy rains (which would have flushed wastes collected in the long horizontal pipe) than during dry weather, when the grab sample was collected. Similarly, if indeed wastewater flows to the NC360 system via manhole MH1 when the sanitary sewer is surcharged, P loading measured under these conditions would be substantially higher than indicated in Table 14.

## 5. REFERENCES

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

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

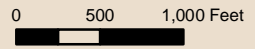
Stone Environmental, Inc. SEI SOP 5.23.3: Maintenance and Calibration of the pH/Con 10 Meter. February 24, 2003.

## APPENDIX A: SYSTEM MAPS


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**NEWPORT CITY**



**Legend**

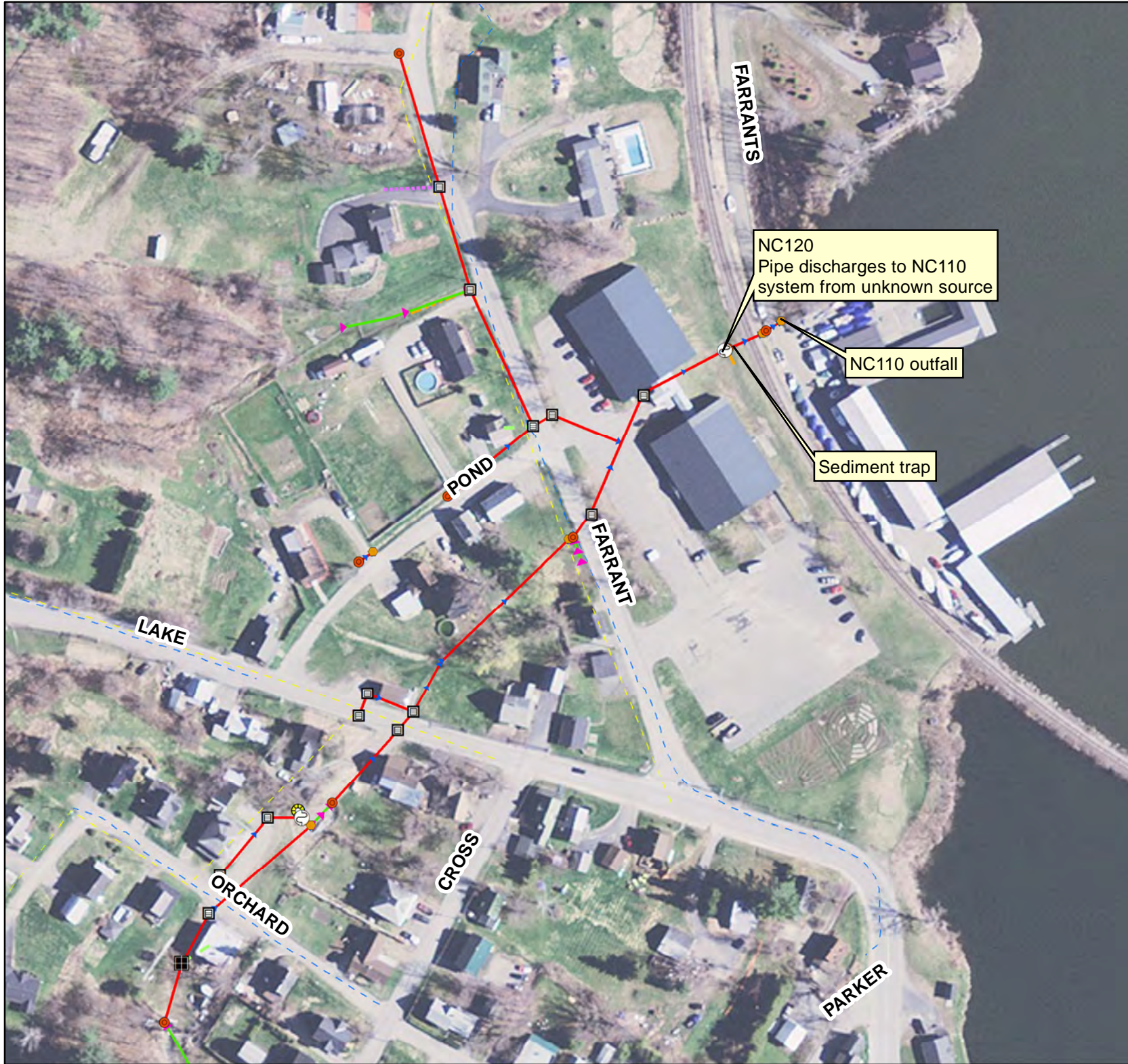
 Follow-up Locations



Sources: Follow-up Locations: Stone;  
Imagery: esri.

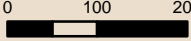
 **STONE ENVIRONMENTAL INC**

**Map 1:  
Investigation Locations  
Newport City, VT**














**Memphremagog Basin  
IDDE**





  
**NEWPORT CITY**

0      100      200 Feet
 

**Legend**

-  Existing, Catchbasin
-  Existing, Culvert inlet
-  Existing, Culvert outlet
-  Existing, Drop Inlet
-  Existing, Outfall
-  Existing, Sanitary Manhole
-  Newport City Water System
-  Existing, Footing drain
-  Existing, Roof drain
-  Existing, Sanitary line
-  Existing, Storm line
-  Existing, Swale
-  Existing, Under drain

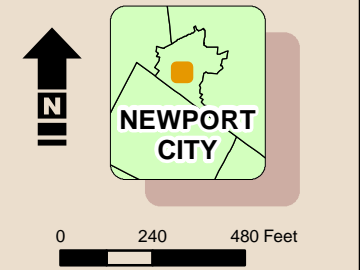
Sources: Stormwater infrastructure: VT ANR;  
Imagery: esri.



**Map 2: Systems NC110  
and NC120  
Newport City, VT**

**Memphremagog Basin  
IDDE**





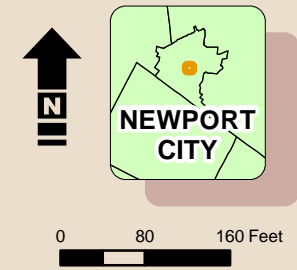
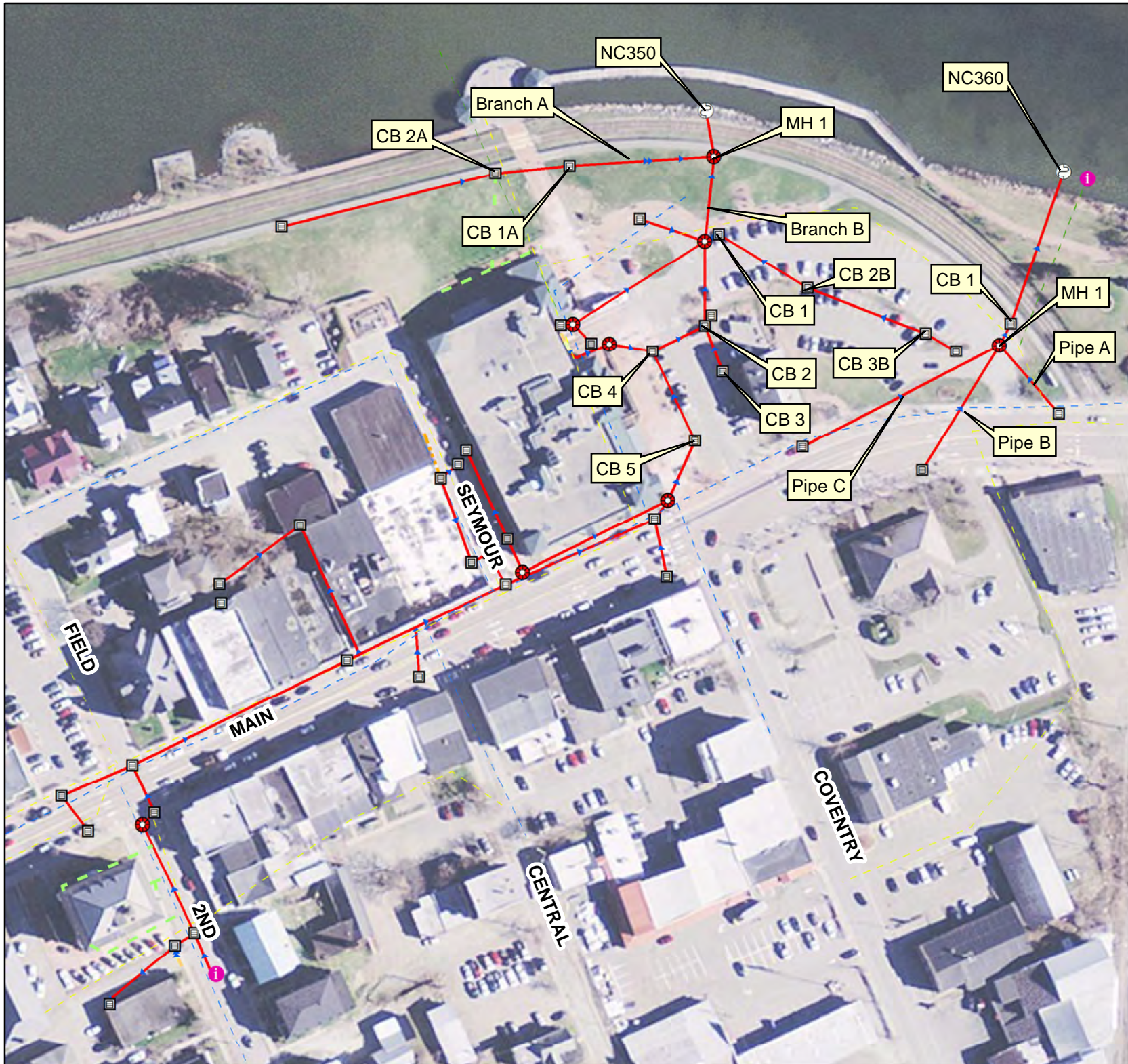
- ### Legend
- Existing, Catchbasin
  - Existing, Culvert inlet
  - Existing, Drop Inlet
  - Existing, Outfall
  - Existing, Stormwater Manhole
  - Newport City Water System
  - Abandoned, Storm line
  - Existing, Footing drain
  - Existing, Roof drain
  - Existing, Sanitary line
  - Existing, Storm line
  - Storm line (old Sanitary line)

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

STONE ENVIRONMENTAL INC

**Map 3:**  
**System NC230**  
**Newport City, VT**

**Memphremagog Basin**  
**IDDE**



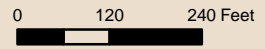
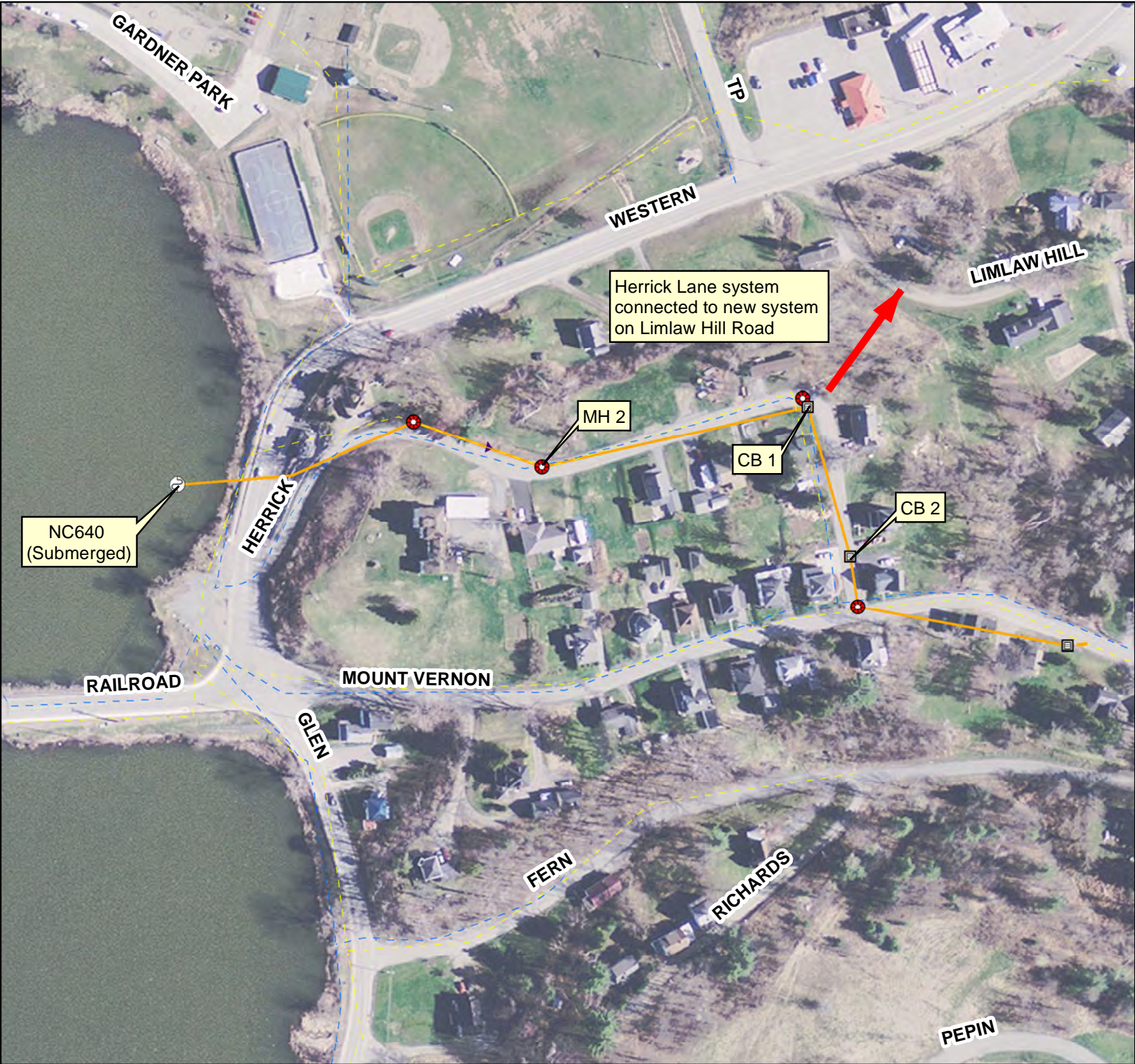
**Legend**

- Existing, Catchbasin
- Existing, Information Point
- Existing, Outfall
- Existing, Stormwater Manhole
- Newport City Water System
- Abandoned, Sanitary line
- Existing, Roof drain
- Existing, Sanitary line
- Existing, Storm line
- Existing, Trench drain
- Existing, Under drain








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



**Map 4: Systems  
NC350 and NC360  
Newport City, VT**



**Legend**

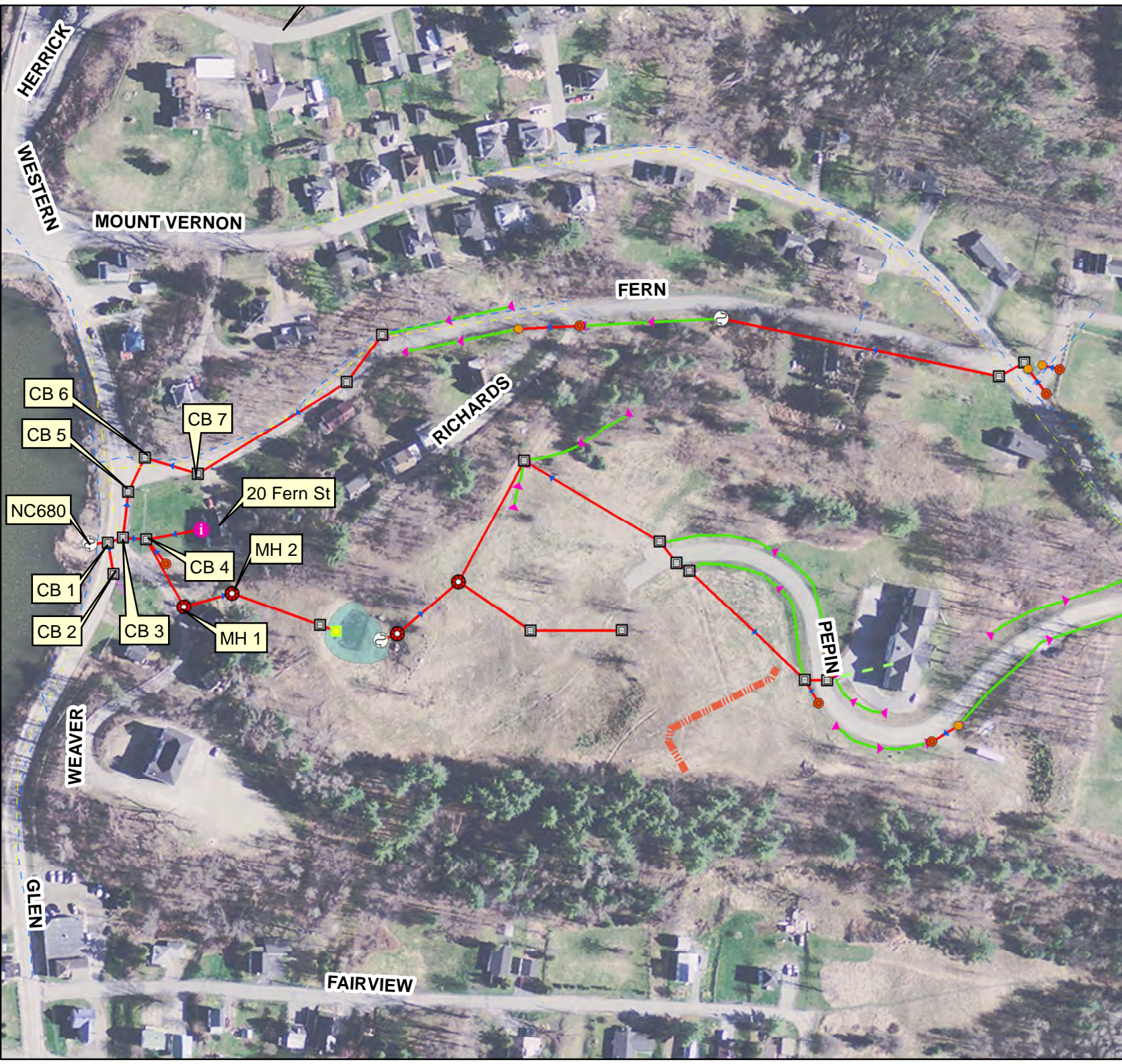
-  Existing, Catchbasin
-  Existing, Outfall
-  Existing, Stormwater Manhole
-  Newport City Water System
-  Existing, Sanitary line
-  Storm line (old Sanitary line)
-  Existing, Under drain



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











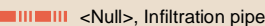




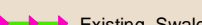
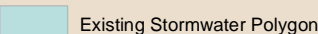
**Map 5:  
System NC640  
Newport City, VT**

**Memphremagog Basin  
IDDE**





  
**NEWPORT CITY**

0      150      300 Feet

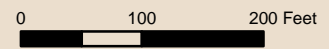
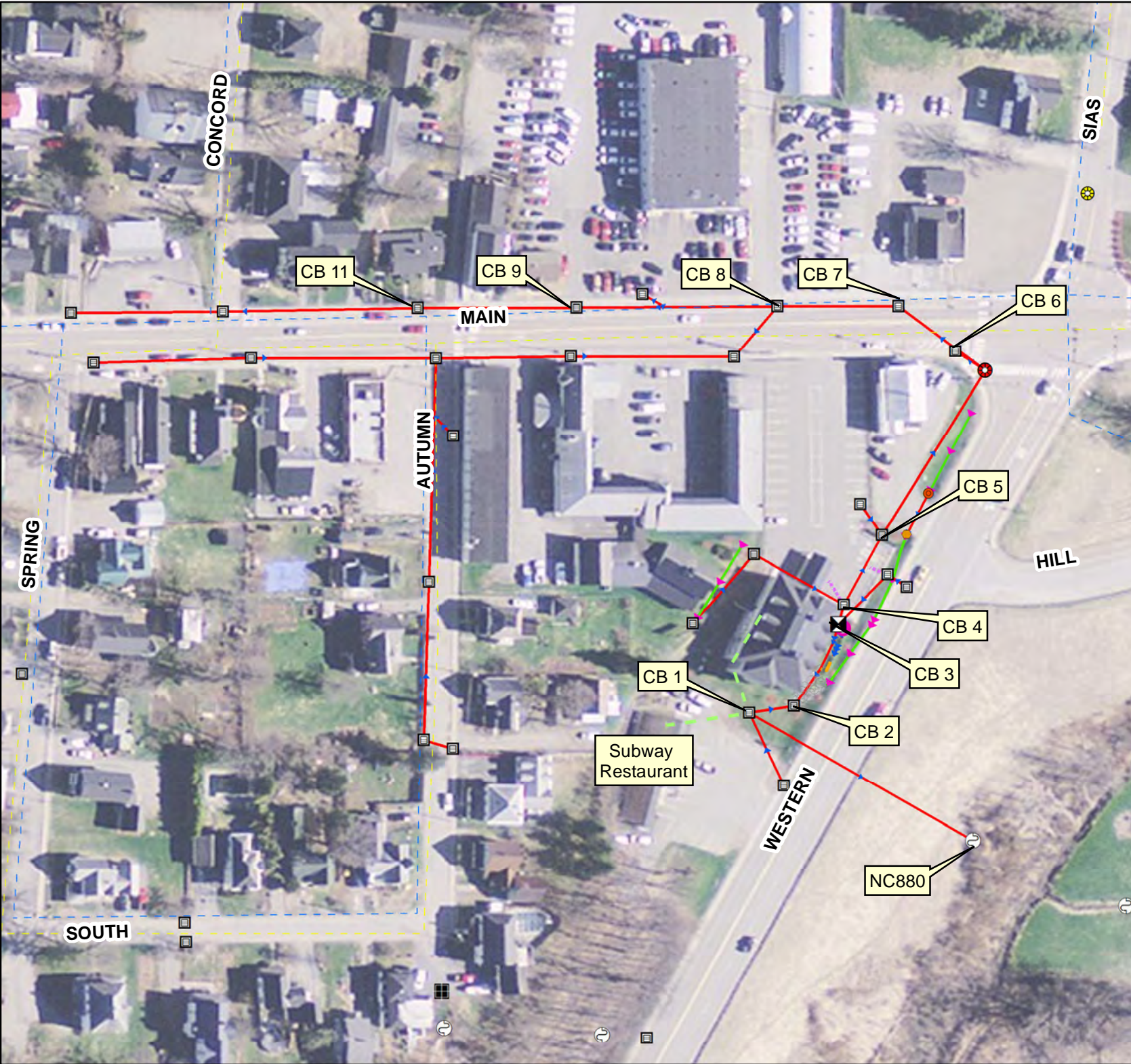
- Legend**
-  Existing, Catchbasin
  -  Existing, Culvert inlet
  -  Existing, Culvert outlet
  -  Existing, Information Point
  -  Existing, Outfall
  -  Existing, Pond outlet structure
  -  Existing, Stormwater Manhole
  -  Newport City Water System
  -  <Null>, Infiltration pipe
  -  Existing, Footing drain
  -  Existing, Roof drain
  -  Existing, Sanitary line
  -  Existing, Storm line
  -  Existing, Swale
  -  Existing Stormwater Polygon

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


















 STONE ENVIRONMENTAL INC

**Map 6:  
System NC680  
Newport City, VT**

**Memphremagog Basin  
IDDE**



**Legend**

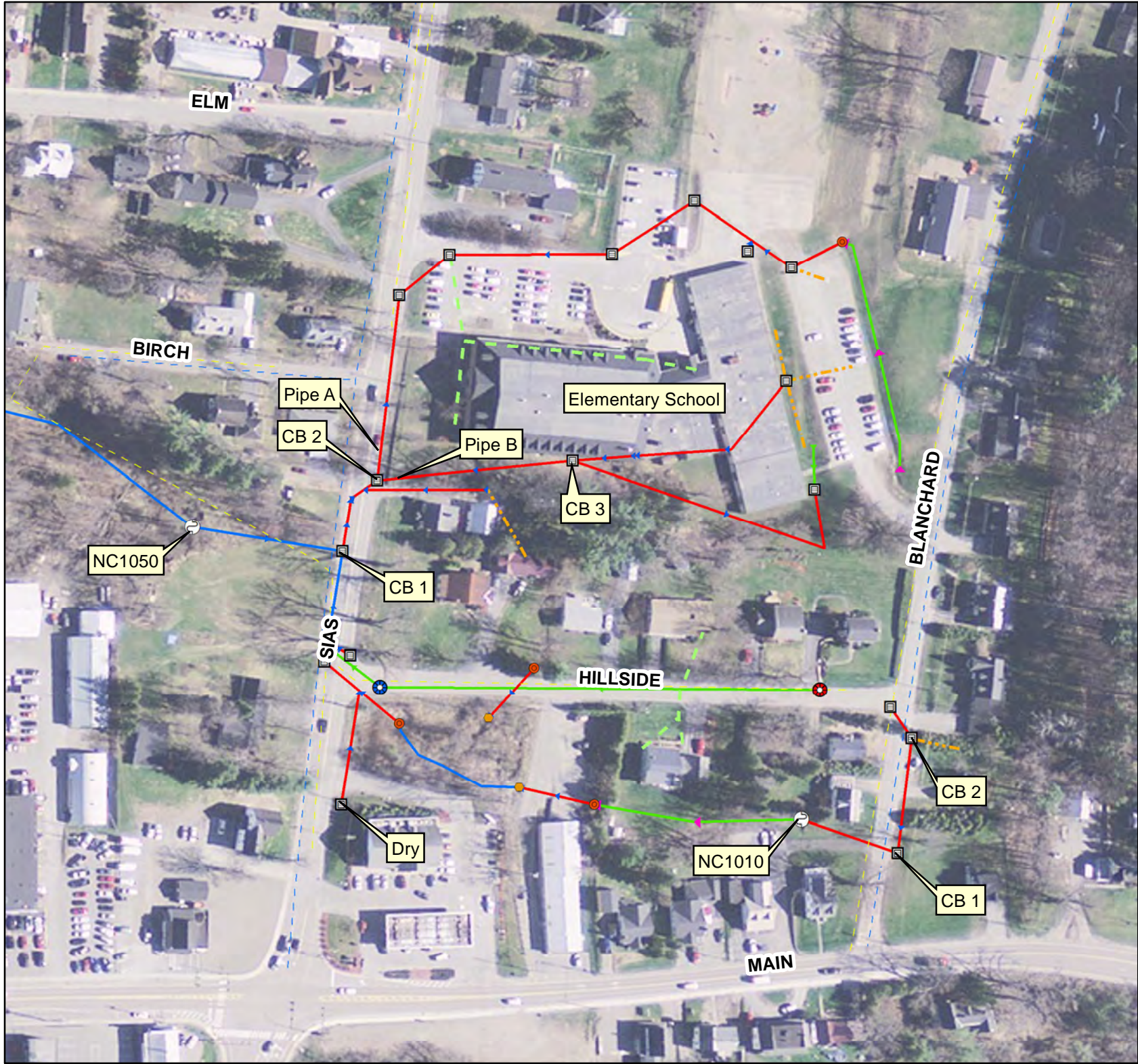
-  Existing, Stormwater Manhole
-  Existing, Catchbasin
-  Existing, Culvert inlet
-  Existing, Culvert outlet
-  Existing, Drop Inlet
-  Existing, Information Point
-  Existing, Outfall
-  Existing, Sanitary Manhole
-  Treatment feature (see notes)
-  Newport City Water System
-  Existing, Emergency spillway
-  Existing, Footing drain
-  Existing, Roof drain
-  Existing, Sanitary line
-  Existing, Storm line
-  Existing, Swale
-  Existing, Under drain

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

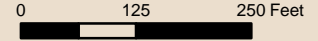
 STONE ENVIRONMENTAL INC

**Map 7:  
System NC880  
Newport City, VT**

**Memphremagog Basin  
IDDE**



**NEWPORT CITY**



**Legend**

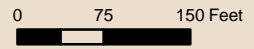
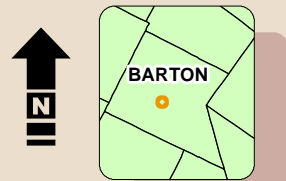
- Abandoned Manhole
- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Outfall
- Existing, Stormwater Manhole
- Newport City Water System
- Abandoned, Storm line
- Existing, Roof drain
- Existing, Sanitary line
- Existing, Storm line
- Existing, Stream
- Existing, Swale
- Existing, Under drain

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

STONE ENVIRONMENTAL INC

**Map 8:  
System NC1050  
Newport City, VT**

**Memphremagog Basin  
IDDE**



**Legend**

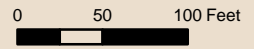
- Catchbasin
- Culvert inlet
- Culvert outlet
- Stormwater Manhole
- Outfall
- Storm line
- Sanitary line
- Swale
- Footing drain
- Under drain
- Stream







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



**Map 9: Systems**  
**BA290, BA300 and BA310**  
**Barton, VT**

**Memphremagog Basin**  
**IDDE**



-  Catchbasin
-  Outfall
-  Storm line
-  Sanitary line
-  Swale
-  Roof drain

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



**Map 10:  
System OR220  
Orleans, VT**

**Memphremagog Basin  
IDDE**