



PENNICHUCK WATER WORKS BOIRE FIELD BROOK SUBWATERSHED EVALUATION 2019



Prepared for:



PENNICHUCK

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Table of Contents

Section	Page No.
Table of Contents	i
Executive Summary	ii
1.0 Introduction.....	1
1.1 Project Background.....	1
1.2 Project Goal.....	1
2.0 Existing Conditions	1
2.1 Subwatershed Characteristics	1
2.2 Historical Water Quality Data	2
2.3 Previous Studies	3
2.4 Field Investigations.....	5
2.4.1 High Load Areas	5
2.4.2 Subwatershed Assessment	5
2.4.3 Corridor Walk and Drone Survey	6
3.0 Proposed Conditions.....	6
3.1 BMP Retrofit/Implementation Recommendations	6
3.1.1 BMP Retrofit/Implementation Recommendations Rationale	6
3.1.2 BMP Maintenance and Inspection Recommendations	7
3.2 Existing and Proposed Conditions Pollutant Loading/Removal	9
4.0 Follow-Up Actions	9

List of Appendices

Appendix A – Watershed Map
Appendix B – StreamStats Report
Appendix C – Historic Water Quality Data
Appendix D – 2000 Boire Field Brook Subwatershed Report
Appendix E – High Load Areas Map
Appendix F – BFB Subwatershed Assessment Summary Matrix and Photographs
Appendix G – BFB Corridor Walk Summary Matrix and Photographs
Appendix H – Boire Field Brook Drone Imagery
Appendix I – BMP Retrofits / Implementations Recommendations Summary Matrix
Appendix J – Conceptual Plans
Appendix K – Existing and Proposed Pollutant Loading / Removal Calculations

Executive Summary

The Boire Field Brook (BFB) subwatershed is one of ten subwatersheds within the Pennichuck Brook watershed and a direct tributary to Harris Pond. The BFB subwatershed is the smallest, but most heavily developed within the Pennichuck Brook watershed, consisting of an approximate 480-acre catchment area that flows directly into Harris Pond. Due to its highly developed land use and close proximity to the heavily commercialized areas of NH Route 101A, Nashua Municipal Airport, and the Everett Turnpike, Boire Field Brook may be receiving excess uncontrolled sediment and nutrient loading due to stormwater runoff from impervious areas, which can lead to compromised water quality within the water supply ponds.

As part of an ongoing tributary monitoring program conducted by Comprehensive Environmental Inc. (CEI) since 2007 throughout the Pennichuck Brook watershed, Boire Field Brook has been consistently identified as having degraded water quality. Tributary samples taken from the 01-BFB site consistently show the highest levels of conductivity as compared to the other tributary sampling locations. Total phosphorus levels recorded at the 01-BFB tributary are also, on average, higher than most of the other sampling locations which potentially indicates high sediment and nutrient loading into the tributary. Bacteria levels in tributary waters is also a concern with a high stormwater runoff influence, and the 01-BFB tributary consistently has the highest bacteria levels as compared with the other tributary sampling locations.

The project goal is to update a previous Study of Urban Non-Point Source Pollution report completed in 2000 that in part identified existing stormwater BMPs within the BFB subwatershed, made recommendations for BMP maintenance or improvements, and implemented conceptual practices and BMPs to reduce pollutant impacts to Boire Field Brook due to stormwater runoff. Additionally, the project identifies and recommends new opportunities for BMP construction, along with providing conceptual-level designs for these stormwater-pollution abatement opportunities and updates. Finally, this project addressed the stream corridor itself to identify additional opportunities for water quality improvement.

CEI conducted a subwatershed assessment and evaluation of existing stormwater BMPs discussed in the 2000 study which included a visual inspection of each existing BMP in order to assess the condition, identify a need for retrofit, and identify opportunities for implementing new BMPs. Results of the subwatershed assessment are summarized in the attached **Table 1 (expanded matrix is included in Appendix F)**. CEI also identified 16 areas within the Boire Field Brook stream corridor with potential sources of pollution, such as bank erosion, roadway crossings, or other deposits indicative of adverse water quality impacts as shown in the attached **Table 2 (expanded matrix is included in Appendix G)**. To address these impacts, CEI identified 13 potential BMP retrofit and/or new BMP opportunities, and 9 stream corridor improvements throughout the BFB subwatershed. A conceptual stormwater improvement design has been prepared for each location. Finally, approximate design, permitting, and construction costs and priority rankings based on potential pollutant removal capabilities have been determined for each location as shown in the attached **Table 3 (expanded matrix is included in Appendix I)**.

Most BMPs are located on privately owned property by landowners other than PWW. As PWW does not own most of the subject parcels or have regulatory authority to implement these improvements on privately owned property, CEI recommends that private property owners work with PWW and/or NHDES when undergoing redevelopment to review the feasibility of incorporating design elements contained within this report into revised site conditions. It is also recommended that the results of this study be provided to the Nashua Planning Board so these BMPs may be addressed in any permit applications for future development. There are no recommendations for altered or additional tributary or groundwater sampling and analyses at this time. The sampling program is revised continuously to add or remove sampling parameters and locations, most recently at the end of 2017. Based on the annual results, sampling and analyses protocols may be modified in the future if needed.

Table 1: Boire Field Brook Subwatershed Assessment Condensed Summary

<u>BMP Site</u>		<u>Location Description</u>	<u>Subcatchment</u>	<u>BMP Type & Condition</u>
1	Building 19 Pond	Located south of Route 101A; northwest of Birch Pond.	Based on topography, this subcatchment is 9.5 acres.	Wet Basin - The pond was in fair condition at the time of the inspection; there were no signs of algal blooms, excessive aquatic plants, odors, or discoloration. The pond banks were eroded in some areas, particularly along the guardrail, and there was fallen woody vegetation along the northwest side of the pond.
2	Birch Pond	Located south of Route 101A; southeast of the Building 19 Pond.	Based on topography, this subcatchment is 19.0 acres.	Wet Basin - The pond was in good condition at the time of the inspection; there were no signs of algal blooms, excessive aquatic plants, odors, or discoloration. Some bank undercutting and erosion was observed in some areas of the main body of the pond. The discharge channel was heavily littered with trash and debris. The pond also encounters large populations of waterfowl. Signs have been installed to discourage the public from feeding the wildlife in an attempt to deter the growth of the waterfowl population.
3	Cotton Road Pond	Located south of Cotton Road and Route 101A; southeast of Birch Pond.	Based on topography, this subcatchment is 19.1 acres.	Wet Basin - The pond was in good condition at the time of the inspection; there were no signs of algal blooms, excessive aquatic plants, odors, or discoloration. Some bank undercutting and erosion was observed in some areas of the pond, particularly near the two southeast outfalls.
4	Somerset Parkway Swales	Located along the westbound side of Route 101A and eastbound side of Somerset Parkway.	Based on topography, this subcatchment is 56.4 acres.	Water Quality Swale (Wet) - At the time of inspection the swales were in good condition. Erosion and debris/sediment buildup was observed in the first segment downstream of the Birch Pond discharge swale outfall. There was also an odor in this area. Overall, side slopes were mowed and well maintained, the swales were well established with vegetation, and some slopes have been stabilized with riprap.
5	DoubleTree Hotel Ponds	Located west and northwest of the existing DoubleTree Hotel building.	Based on topography, this subcatchment is 17.1 acres.	Wet Basin - The ponds were in good condition at the time of the inspection; there were no signs of algal blooms, excessive aquatic plants, odors, or discoloration. There was minor bank erosion in some areas of the northwestern DoubleTree Hotel Pond, along the side of Somerset Parkway. Additionally, some slope erosion was observed at the drainage swale that discharges to the western DoubleTree Hotel Pond. The pond also encounters large populations of waterfowl.
6	Somerset Plaza Perimeter Swale	Located along the northern edge of the Somerset Plaza parcel and the southern edge of Trafalgar Square area.	Based on topography, this subcatchment is 25.2 acres.	Biofilter Swale - At the time of inspection the swale was in fair condition. There were many signs of bank erosion throughout the swale, but particularly at the beginning of the swale at the outfall. Some curb breaks had riprap spillways that were maintained, while others were not. Debris and trash buildup was observed throughout the swale. Orange/rust-colored water was pooling around the outfall at the center of the swale.
7	Sullivan Tire Vegetated Area	Located at the north side of the Sullivan Tire parking lot.	Based on topography, this subcatchment is 2.2 acres.	Vegetated Filter Strip - At the time of inspection the vegetated area was in poor condition. The area was filled with dead vegetation, grass clippings, debris, and trash. There was no noticeable depression where stormwater would typically collect for infiltration or conveyance. Additionally, at the time of the inspection, stormwater was observed to be collecting at the back of the lot and not fully draining to the drainage area. In the 2000 Study, it was noted that an oily sheen was observed in the puddled area.
8	Park & Ride Lot Detention Basin	Located adjacent to the Park & Ride parking lot to the south.	Based on topography, this subcatchment is 3.6 acres.	Extended Dry Detention Basin - At the time of inspection the detention basin was in good condition, there were only minor signs of erosion around the riprap of the emergency spillway. Vegetation within the basin was well established and maintained.
9	Postal Service Vegetated Areas	Located along North Southwood Drive and west of the Postal Service Building.	Based on topography, this subcatchment is 7.9 acres.	Vegetated Filter Strip - At the time of inspection the vegetated areas were in fair condition. The first vegetated area was overgrown with vegetation near one of the outfalls and there was minor signs of erosion near the outfalls to the second and third vegetated areas.
10	Cornerstone Drive Swale	Located north of the Postal Service at the end of North Southwood Drive, off of Cornerstone Drive.	Based on topography, this subcatchment is 12.2 acres.	Biofilter Swale - At the time of inspection the swale was in fair condition, there were no signs of sediment buildup. However, the outfall area appeared to be slightly eroded from stormwater flow from the flared end and the slope/bank stabilization fabric of the swale has not been fully stabilized with vegetation.
11	Boire Field Brook Outlet to Harris Pond	Located east of Everett Turnpike and in between two BMPs constructed for Harris Pond.	BFB subwatershed is 496.3 acres, the immediate subcatchment of this outlet is approximately 9.4 acres.	Wet Basin - The area was in good condition at the time of the inspection; some aquatic vegetation build-up was observed near the Boire Field Brook outlet. The two BMPs on either side of the the outfall to Harris Pond consisted of a sediment forbay with outlet control structures (OCSs), a turbidity curtain, and a riprap overflow spillway. These BMPs trap any pollutants, sediment, or debris that runs off from Everett Turnpike before water discharging into Harris Pond; the BMP south of the Boire Field Brook outlet contained stagnant water with an oil sheen.
12	Somerset Parkway Detention Basin	Located along the westbound lane of Somerset Parkway to the east of the North Southwood Drive/Southwood Drive intersection.	Based on topography, this subcatchment is 7.0 acres.	Extended Dry Detention Basin - At the time of inspection the detention basin was in good condition, there was no sediment buildup. Minor erosion and trash was observed at some of the outfalls. Vegetation was well established and maintained.
13	Somerset Parkway / Southwood Drive Swales	Located along the either side of the Southwood Drive intersection on the eastbound side of Somerset Parkway.	Based on topography, this subcatchment is 26.2 acres.	Biofilter Swale - At the time of inspection the swales were in good condition, there were no signs of sediment buildup. Minor erosion and trash was observed at the end of the first segment of the swales.

Table 2: Boire Field Brook Corridor Walk Condensed Summary	
Corridor Site	
Somerset Parkway Swale	
1	Somerset Parkway culvert inlet from Somerset Parkway Swales (south side of crossing)
2	Somerset Parkway culvert outlet (north side of crossing)
3	North Southwood Drive culvert inlet (west side of crossing)
4	North Southwood Drive culvert outlet (east side of crossing)
5	North Southwood Drive On-Ramp culvert outlet from Somerset Parkway Detention Basin (north side of crossing)
6	Sediment deposit/debris build-up within the stream. Possible beaver activity.
7	Sediment deposit/debris build-up within the stream. Possible beaver activity.
8	Tinker Road culvert inlet (south side of crossing)
9	Tinker Road culvert outlet (north side of crossing)
10	Bank erosion and undercutting due to larger flows
11	Sediment deposit within the stream
12	Bank erosion and undercutting due to larger flows
13	Trash/debris build-up within the stream. Possible beaver activity.
14	Discolored water/oily sheen; likely from stormwater runoff from major roadways, including Everett Turnpike
15	Everett Turnpike culvert inlet (west side of crossing)
16	Everett Turnpike culvert outlet (east side of crossing)
Boire Field Brook Outlet to Harris Pond	

Table 3: Boire Field Brook BMP Retrofits/Implementations Recommendations Condensed Summary					
Priority	Site		Proposed BMP Type(s)	Retrofit Recommendations	Total Costs
1	BMP 4	Somerset Parkway Swales	Water Quality Swale (Wet); Sediment Forebay; Inlet Gabion	1. Vegetated Bank Stabilization 2. Vegetated Riprap Bank Stabilization 3. Riprap/Granite Sediment Forebays 4. Crushed Stone Gabion	Permitting: \$10,500 Design: \$21,000 Construction: \$34,000 Total: \$65,500
2	BMP 6	Somerset Plaza Perimeter Swale	Biofilter Swale; Sediment Forebay; Bioretention Area	1. Vegetated Riprap Bank Stabilization 2. Revegetate Swale 3. Stormwater Inlet Stabilization 4. Curb Installation and Riprap Spillway 5. Vegetated Bioretention Area 6. Riprap Sediment Forebay	Permitting: --- Design: \$21,000 Construction: \$97,000 Total: \$118,000
3	BMP 3	Cotton Road Pond	Wet Basin; Infiltration Trench	1. Buffer Zone Plantings 2. Vegetated Bank Stabilization 3. Crushed Stone Infiltration Trench	Permitting: \$10,500 Design: \$10,500 Construction: \$30,000 Total: \$51,000
4	BMP 2	Birch Pond	Wet Basin; Infiltration Trench; Bioretention Area; Inlet Gabion	1. Buffer Zone Plantings 2. Vegetated Bank Stabilization 3. Crushed Stone Infiltration Trench 4. Curb Installation and Riprap Spillways 5. Vegetated Bioretention Area 6. Crushed Stone Gabion	Permitting: \$10,500 Design: \$23,500 Construction: \$124,000 Total: \$158,000
5	BMP 5	DoubleTree Hotel Ponds	Wet Basin; Bioretention Area	1. Vegetated Riprap Bank Stabilization 2. Vegetated Bioretention Area	Permitting: \$10,500 Design: \$10,500 Construction: \$17,000 Total: \$38,000
6	BMP 1	Building 19 Pond	Wet Basin; Infiltration Trench	1. Buffer Zone Plantings 2. Vegetated Bank Stabilization 3. Crushed Stone Infiltration Trench 4. Pavement Improvements and Curb Installation	Permitting: \$10,500 Design: \$10,500 Construction: \$18,500 Total: \$39,500
7	BMP 13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale; Check Dams	1. Riprap Check Dams	Permitting: --- Design: \$4,000 Construction: \$5,000 Total: \$9,000
8	BMP 9	Postal Service Vegetated Areas	Bioretention Area	1. Stormwater Outlet Stabilization 2. Vegetated Bioretention Areas	Permitting: --- Design: \$13,000 Construction: \$91,000 Total: \$104,000
9	Corridor 2	Somerset Parkway culvert outlet (north side of crossing)	Infiltration Trench; Sediment Forebay	1. Crushed Stone Infiltration Trench 2. Riprap/Granite Sediment Forebay	Permitting: \$10,500 Design: \$10,500 Construction: \$47,000 Total: \$68,000
10	Corridor 15	Everett Turnpike culvert inlet (west side of crossing)	Infiltration Trench	1. Crushed Stone Infiltration Trench	Permitting: \$6,500 Design: \$5,500 Construction: \$15,000 Total: \$27,000
11	BMP 8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin; Sediment Forebay	1. Revegetate Swale 2. Riprap Sediment Forebay	Permitting: --- Design: \$5,500 Construction: \$6,500 Total: \$12,000
12	Corridor 4	North Southwood Drive culvert outlet (east side of crossing)	Infiltration Trench; Sediment Forebay	1. Crushed Stone Infiltration Trench 2. Riprap/Granite Sediment Forebay	Permitting: \$10,500 Design: \$10,500 Construction: \$47,000 Total: \$68,000
13	BMP 7	Sullivan Tire Vegetated Area	Bioretention Area	1. Vegetated Bioretention Area 2. Curb Installation and Riprap Spillways	Permitting: --- Design: \$10,500 Construction: \$78,000 Total: \$88,500
14	BMP 11	Boire Field Brook Outlet to Harris Pond	Wet Basin; Sediment Forebay	1. Riprap/Granite Sediment Forebay	Permitting: \$10,500 Design: \$12,000 Construction: \$18,000 Total: \$40,500
15	BMP 12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	1. Stormwater Outlet Stabilization	Permitting: --- Design: \$4,000 Construction: \$5,000 Total: \$9,000

Table 3: Boire Field Brook BMP Retrofits/Implementations Recommendations Condensed Summary					
Priority	Site		Proposed BMP Type(s)	Retrofit Recommendations	Total Costs
16	BMP 10	Cornerstone Drive Swale	Biofilter Swale	1. Vegetated Bank Stabilization 2. Stormwater Outlet Stabilization	Permitting: --- Design: \$5,500 Construction: \$6,500 Total: \$12,000
17	Corridor 5	North Southwood Drive On-Ramp culvert outlet from Somerset Parkway Detention Basin (north side of crossing)	Infiltration Trench; Sediment Forebay	1. Crushed Stone Infiltration Trench 2. Riprap/Granite Sediment Forebay	Permitting: \$10,500 Design: \$10,500 Construction: \$61,000 Total: \$82,000
18	Corridor 3	North Southwood Drive culvert inlet (west side of crossing)	Infiltration Trench; Bioretention Area	1. Crushed Stone Infiltration Trench 2. Vegetated Bioretention Area	Permitting: \$6,500 Design: \$13,000 Construction: \$110,000 Total: \$129,500
19	Corridor 9	Tinker Road culvert outlet (north side of crossing)	Infiltration Trench	1. Crushed Stone Infiltration Trench	Permitting: \$6,500 Design: \$5,500 Construction: \$10,500 Total: \$22,500
20	Corridor 8	Tinker Road culvert inlet (south side of crossing)	Infiltration Trench	1. Crushed Stone Infiltration Trench	Permitting: \$6,500 Design: \$5,500 Construction: \$10,500 Total: \$22,500
N/A	Corridor 10	Bank erosion and undercutting due to larger flows	Bank Stabilization	1. Vegetated Bank Stabilization	Permitting: \$10,500 Design: \$4,000 Construction: \$5,000 Total: \$19,500
N/A	Corridor 12	Bank erosion and undercutting due to larger flows	Bank Stabilization	1. Vegetated Bank Stabilization	Permitting: \$10,500 Design: \$4,000 Construction: \$5,000 Total: \$19,500

1.0 Introduction

1.1 Project Background

Pennichuck Water Works (PWW), established in 1852, is the largest subsidiary of the Pennichuck Corporation engaged in the collection, storage, treatment, distribution, and sale of potable water. PWW, located in the Town of Merrimack, supplies water to the City of Nashua and 10 surrounding municipalities, serving a population of approximately 110,000 people. PWW collects its water from the Pennichuck Brook watershed, which includes five Southern New Hampshire towns (Nashua, Merrimack, Amherst, Milford, and Hollis) and has an overall area of 17,300 acres. The water supply consists approximately 195 acres of water in a series of riverine chain ponds that includes Harris Pond, Bowers Pond, Holts Pond, and various smaller upstream ponds, as well as a backup supply from the Merrimack River.

The Boire Field Brook (BFB) subwatershed is one of ten subwatersheds within the Pennichuck Brook watershed and a direct tributary to Harris Pond. Due to its highly developed land use and close proximity to the heavily commercialized areas of NH Route 101A, Nashua Municipal Airport, and the Everett Turnpike, Boire Field Brook may be receiving excess uncontrolled sediment and nutrient loading due to stormwater runoff from impervious areas, which can lead to compromised water quality within the water supply ponds. Historic and future changes in land use, daily urban traffic, and commercial/industrial development also represent potential land-based sources of sediment and nutrient influx to the tributary.

As part of an ongoing tributary monitoring program conducted by Comprehensive Environmental Inc. (CEI) since 2007 throughout the Pennichuck Brook watershed, Boire Field Brook has been consistently identified as having degraded water quality. Additionally, field investigations conducted as part of the recent reservoir tributary sediment accumulation monitoring project identified a large sediment deposit within Boire Brook Field, immediately upstream of the Tinker Road culvert, further indicating that there are significant impacts to this tributary due to stormwater runoff.

1.2 Project Goal

The project goal is to update a previous Study of Urban Non-Point Source Pollution report completed in 2000 that in part identified existing stormwater BMPs within the BFB subwatershed, made recommendations for BMP maintenance or improvements, and implemented conceptual practices and BMPs to reduce pollutant impacts to Boire Field Brook due to stormwater runoff. As part of the update, this project revisited the BMP locations previously identified in the 2000 report and recommends updates or retrofits to the BMPs to reflect current conditions and maximize pollutant removal efficiency. Additionally, the project identifies and recommends new opportunities for BMP construction, along with providing conceptual-level designs for these stormwater-pollution abatement opportunities and updates. Pollutants of concern addressed under this project include total suspended solids (TSS), total phosphorus (TP), and bacteria (fecal coliform and/or E.coli), and other indicators typically associated with stormwater runoff.

2.0 Existing Conditions

2.1 Subwatershed Characteristics

The BFB subwatershed is the smallest, but most heavily developed within the Pennichuck Brook watershed, consisting of an approximate 480-acre catchment area that flows directly into Harris Pond. The BFB

subwatershed is shown on the Pennichuck Brook watershed map provided in **Appendix A**. According to the United States Geological Survey (USGS) StreamStats (**Appendix B**), approximately 89% of the BFB subwatershed consists of developed urban land ranging from open space development (NLCD 2011 Class 21) to high intensity development (NLCD 2011 Class 24). Open space (for example, large-lot single-family housing units, parks, or vegetation planted in developed areas), consists of impervious surfaces that account for approximately 20% of the total cover. High intensity development (for example, apartment complexes, row houses, or commercial/industrial areas) consists of impervious surfaces that account for approximately 80% to 100% of total cover. More developed areas are typically associated with higher pollutant and sediment loading potential.

2.2 Historical Water Quality Data

PWW has been monitoring tributaries and groundwater in the Pennichuck Brook watershed since 1991, and has used a standardized method and fixed sampling locations since 2007. Tributary and groundwater samples are tested for several water quality indicators approximately seven times per year. A complete list of parameters analyzed in the field and lab are summarized in **Table 2-1** below.

Table 2-1. Tributary and Groundwater Water Quality Sampling Parameters

Field Analysis (Tributaries & Groundwater)	Laboratory Analysis (Tributaries)	Laboratory Analysis (Groundwater)
• Conductivity • Dissolved Oxygen • pH • Temperature • Groundwater Level / Staff Gauge Reading	• Ammonia-Nitrogen • Chloride • E. Coli • Fecal Coliform • Nitrate-Nitrogen • Nitrite-Nitrogen • Total Kjeldahl Nitrogen • Total Nitrogen • Total Phosphorus • Total Suspended Solids	• Ammonia-Nitrogen • Chloride • Nitrate-Nitrogen • Nitrite-Nitrogen • Total Alkalinity • Total Dissolved Solids • Total Kjeldahl Nitrogen • Total Nitrogen • Total Phosphorus

The sampling location for Boire Field Brook (01-BFB) is located just east of Tinker Road and is shown on the watershed map provided in **Appendix A**. Tributary samples taken from the 01-BFB site consistently show the highest levels of conductivity as compared to the other tributary sampling locations. Conductivity levels can be indicative of a tributary's proximity to heavily salted major roads, highways, and municipal airport during the winter months. There is no criteria threshold for conductivity; however, the average conductivity reading at the 01-BFB tributary in the past eleven years (2007-2018) and past year (2018) was 690.5 $\mu\text{S}/\text{cm}$ and 851.9 $\mu\text{S}/\text{cm}$, respectively. For comparison, the average conductivity reading across all other tributary sampling locations, not including 01-BFB, in the last 11 years (2007-2018) and past year (2018) was only 159.4 $\mu\text{S}/\text{cm}$ and 169.7 $\mu\text{S}/\text{cm}$, respectively. Tributary pH levels have been consistently higher than the other sampling locations, further indicating potential influence from road salt carried by stormwater. Additionally, low groundwater levels are also observed at the 01-BFB groundwater location; this may be caused by insufficient stormwater infiltration due to the extensive impervious areas within and surrounding the BFB subwatershed.

The TP levels recorded at the 01-BFB tributary are also, on average, higher than most of the other sampling locations which potentially indicates high sediment and nutrient loading into the tributary. High TP also indicates potential contributions from fertilizer runoff from the heavily commercialized sites in the area. The most recent national guidance on nutrient standards for streams is provided by the USEPA in Quality

Criteria for Water (1986). According to this guidance, TP should not exceed 0.05 mg/L in any stream at the point where it enters any lake or reservoir, and natural background conditions are much lower still. The New Hampshire Department of Environmental Services (NHDES) also provides guidance that categorizes freshwater TP levels as shown in **Table 2-2**.

Table 2-2. NHDES Total Phosphorus in Freshwater Categories

TP (mg/L)	Category
< 0.010	Ideal
0.011- 0.025	Average
0.026 - 0.049	More than desirable
≥ 0.050	Potential nuisance concentration

The average TP concentration at the 01-BFB tributary in the past eleven years (2007-2018) and past year (2018) was 0.031 mg/L and 0.032 mg/L, respectively. These concentrations are in the “more than desirable” category, according to the NHDES guidelines, which could be intensified if stormwater runoff from highly developed and impervious areas continues to enter the tributary untreated and uncontrolled. For comparison, the average TP concentration across all other tributary sampling locations, not including 01-BFB, in the last 11 years (2007-2018) and past year (2018) was only 0.026 mg/L and 0.023 mg/L, respectively, or approximately 25% lower. These concentrations are closer to the “average” category, according to NHDES guidelines.

Bacteria levels in tributary waters is also a concern with a high stormwater runoff influence, and the 01-BFB tributary consistently has the highest bacteria levels as compared with the other tributary sampling locations. In the last 6 years (2013-2018) and last year (2018), the average fecal coliform concentration at the 01-BFB tributary was 140.8 counts/100mL and 155.3 counts/100mL, respectively. For comparison, the average fecal coliform concentrations across all other tributary sampling locations, not including 01-BFB, in the last 6 years (2013-2018) and last year (2018) was only 56.8 counts/100mL and 50.6 counts/100mL, respectively, or approximately 1/3 of BFB results.

In the last 11 years (2007-2018) and last year (2018), the average *E. coli* concentration was 125.9 counts/100mL and 98.1 counts/100mL, respectively. Contrarily, the average *E. coli* concentrations across all other tributary sampling locations, not including 01-BFB, in the last 11 years (2007-2018) and last year (2018) was only 60.7 counts/100mL and 55.2 counts/100mL, respectively, or approximately half of BFB results. *E. coli* bacteria concentrations over 150 counts/100mL are exceeding, according to NH Class A Water Quality Standards (RSA 485-A:8). Although on average, the *E. coli* concentrations at 01-BFB are less than 150 counts/100mL, concentrations spike well above the *E. coli* criteria at least once or twice during the summer months. Additionally, bacteria concentrations at the 01-BFB tributary sampling locations remain significantly higher than all the other tributary sampling locations. A summary of average pollutant concentrations discussed above for the 01-BFB tributary and all other tributary locations is provided in **Appendix C**.

2.3 Previous Studies

A Study of Urban Non-Point Source Pollution was completed in 2000 by PWW and CEI. Based on the Watershed Management Plan, BFB subwatershed was chosen at the time for an extensive field review to identify potential contaminant sources. As part of the field review, existing BMP sites within BFB subwatershed were identified and inspected. The following BMPs were identified during this field review and discussed in the 2000 report:

1. Kessler Farm Swales
2. Building 19 Pond
3. Birch Pond
4. Cotton Road Pond (formerly “Compaq Detention Pond”)
5. Somerset Parkway Swales
6. DoubleTree Hotel Ponds (formerly “Crown Plaza Detention Ponds”)
7. Somerset Plaza Perimeter Swale (formerly “Northern Perimeter Swale”)
8. Sullivan Tire Vegetated Area (formerly “Sullivan Tire Runoff”)
9. Park & Ride Lot Detention Basin (formerly “On-Site Detention at Park & Ride”)
10. Postal Service Vegetated Areas (formerly “Postal Service Detention”)
11. Cornerstone Drive Swale (“formerly Stormwater Collection Junction for Cornerstone Site”)
12. Boire Field Brook Outlet to Harris Pond (“formerly Controlled Outlet to Harris Pond”)

Water quality threats from these sites were evaluated and conceptual stormwater BMPs were recommended to reduce potential impacts. BMP site prioritization was based on the proximity of the site to its eventual discharge into Harris Pond. Based on recommendations made in the 2000 study, several structural and behavioral BMPs were implemented to address water quality issues.

Three BMPs were conceptually designed and implemented, as part of the 2000 study, to eliminate transport of sediment and nutrients at the Cornerstone Drive Swale site. The stormwater at this site was receiving some treatment from an existing grass and riprap swale, but the swale had collected sediment deposits due to the stormwater runoff from impervious areas and slope erosion. In order to eliminate erosion, the swale was re-graded to be shallower and the slopes were stabilized with a turf reinforcement. Pretreatment was implemented using a sediment forebay and baffle structure. Additionally, the existing grass and riprap swale was reconditioned through minor grading, re-vegetation, bank stabilization, and the addition of two check dams.

At the time of the 2000 study, large populations of waterfowl were observed in the detention ponds south of Somerset Parkway and adjacent to the DoubleTree Hotel (formerly Crowne Plaza). Therefore, several educational BMPs were implemented at this site, including leaflets in the lobby of the hotel, to dissuade the public from feeding the waterfowl. Structural deterrents and feeding deterrents were also recommended at the time of the 2000 study.

Other recommendations made as part of the 2000 study included the following:

- Monitoring and removal of sediment, trash, debris in all detention ponds, since a lack of maintenance may affect the treatment efficiencies and general aesthetics of the ponds;
- Sweeping parking lots and streets to prevent excess sedimentation in downstream BMPs and catch basins;
- Modify Sullivan Tire parking lot area in order to eliminate stormwater ponding and direct flow into the designated swale; and
- Effectively educate the general public to avoid dumping wastes into catch basins, and on the connection between the drainage system and the water supply.

The Study of Urban Non-Point Source Pollution, completed in 2000, is included in **Appendix D** of this report.

2.4 Field Investigations and Survey Results

All fieldwork was completed in accordance to the schedule, survey methodology, quality control protocols, and data evaluation approach described in the Watershed Survey Site Specific Project Plan (SSPP) approved on September 28, 2018, and developed through discussions with NHDES and EPA.

2.4.1 High Load Areas

Based on the New Hampshire Department of Environmental Services (NHDES) definition of a high load area (Env-Wq 1502.30), potential high load areas within the subwatershed have been identified as the Nashua Airport, gas stations, car maintenance facilities, and major roads or highways, including Everett Turnpike and Route 101A. These high load areas are areas of particular concern since their associated land use activities are such that regulated pollutants may be exposed to precipitation or mix with stormwater runoff. Many of these high load areas may be required to develop a Source Control Plan, in accordance to Alteration of Terrain (AoT) regulations (Env-Wq 1504.07) to minimize the volume of stormwater coming in contact with regulated substances. Regulated pollutants that may be potentially coming in contact with stormwater could travel to the BFB tributary and be the cause of or a contributing factor to the pollutants of concern in the BFB tributary, including Total Phosphorus (TP) and Total Nitrogen (TN). A figure showing the locations of these high load areas within BFB subwatershed is provided in **Appendix E**.

2.4.2 Subwatershed Assessment

CEI conducted a subwatershed assessment and evaluation of existing stormwater BMPs discussed in the 2000 study on April 12, 2019. The assessment included a visual inspection of each existing BMP in order to assess the condition, identify a need for retrofit, and identify opportunities for implementing new BMPs. A subwatershed assessment summary matrix of all identified BMPs within the BFB subwatershed, including BMP type, coordinates, observations, condition, and photographs taken at the time of the subwatershed assessment are provided in **Appendix F**.

In addition to the BMPs identified in the 2000 Study, the Somerset Parkway Detention Basin (BMP Site 12) and Somerset Parkway/Southwood Drive Swales (BMP Site 13) were identified during the subwatershed assessment and added to the list of existing BMPs within BFB subwatershed. Though Kessler Farm Swales were also identified in the 2000 Study, as dry water quality swales located throughout the Kessler Farm housing development, they could not be located at the time of inspection and have not been included. The following is an updated list of existing BMPs identified during the subwatershed assessment.

- BMP Site 1 - Building 19 Pond
- BMP Site 2 - Birch Pond
- BMP Site 3 - Cotton Road Pond
- BMP Site 4 - Somerset Parkway Swales
- BMP Site 5 - DoubleTree Hotel Ponds
- BMP Site 6 - Somerset Plaza Perimeter Swale
- BMP Site 7 - Sullivan Tire Vegetated Area
- BMP Site 8 - Park & Ride Lot Detention Basin
- BMP Site 9 - Postal Service Vegetated Areas
- BMP Site 10 - Cornerstone Drive Swale
- BMP Site 11 - Boire Field Brook Outlet to Harris Pond
- BMP Site 12 - Somerset Parkway Detention Basin
- BMP Site 13 - Somerset Parkway/Southwood Drive Swales

2.4.3 Corridor Walk and Drone Survey

In addition to an assessment of BFB subwatershed, a corridor walk of BFB itself was conducted by CEI on November 14, 2018. The purpose of the corridor walk was to identify any sources of contamination, stormwater discharges (pipes, culverts, etc.), sedimentation build-up, and areas of erosion or destabilization along the BFB stream corridor. Any problematic areas were noted and a photograph was taken to document it. Typical features encountered during the corridor walk included: stream bank erosion and undercutting, sediment deposits along the stream bank, trash and debris build-up, and stormwater discharges/structures. A corridor walk summary matrix of observed problem areas, including outfalls, along the BFB corridor, coordinates, and photographs taken at the time of the corridor walk is provided in **Appendix G**.

Drone imagery was also captured for the majority of the BFB corridor to identify any obvious inflow areas, sediment build-up, and erosion. The location of each observation summarized in the corridor walk matrix has been also marked on the drone images, which is provided in **Appendix H**. Due to the vicinity of BFB to the Nashua Airport and associated airspace restrictions, drone imagery could not be obtained south of Somerset Parkway.

3.0 Proposed Conditions

3.1 BMP Retrofit/Implementation Recommendations

A summary matrix of recommendations for existing BMP retrofits and proposed BMP implementation, including anticipated permitting requirements and conceptual-level permitting, design, and construction costs, is provided in **Appendix I**. The recommendations are prioritized based on the pollutant removal potential of each proposed altered site. These recommendations have also been incorporated into conceptual-level designs that consider target pollutants, site conditions, and estimated runoff volumes. Conceptual plans include cross sections and a site layout for each altered site, and also incorporate aerial imagery, GIS (parcel and building) data, and LIDAR (1-foot contour) data. BMP subcatchment areas were delineated using the available topography (LIDAR) and field observations; drainage infrastructure mapping was not completed as part of this project. An overview map identifying each site with proposed conditions and the conceptual plan sheets are included in **Appendix J**.

3.1.1 BMP Retrofit/Implementation Recommendations Rationale

The rationale behind these recommendations, and how they will improve Boire Field Brook and target pollutants of concern in the tributary, is summarized below.

- **Buffer Zone Plantings:** Install woody (tree/shrub) buffer zone plantings to improve pollutant attenuation along an existing BMP. This retrofit will slow down stormwater runoff, improve infiltration, and increase vegetative uptake of nutrients and other pollutants before they can enter the existing BMP. The buffer plantings can be designed to be an aesthetically pleasing landscaping amenity to the commercialized area, while still allowing views of the existing BMP and easy water access in specified areas. Design considerations include a preferred planting list, buffer width, BMP access for viewing, etc.
- **Vegetated/Riprap Stabilization:** Stabilize pond banks, stream banks, or swale side slopes with vegetation and/or riprap stone to reduce erosion and sedimentation downstream. This retrofit will slow down stormwater runoff from impervious areas before entering the existing BMP. The

vegetated/riprap stabilization can be designed to be an aesthetically pleasing landscaping feature. Design considerations include a preferred planting list, stone thickness, stone diameter, etc.

- **Spillway/Inlet/Outfall Stabilization:** Stabilize/install spillways, drainage inlet protection, and drainage outfall protection with crushed stone or riprap to reduce the erosive forces of stormwater runoff and discharges. This retrofit will also help reduce downstream sedimentation. Design considerations include apron/spillway size, stone thickness, stone diameter, etc.
- **Bioretention Areas/Raingardens:** Install a bioretention area/raingarden at an existing drainage outfall or drainage inlet. This BMP is used to collect and treat moderate amounts of stormwater discharge/runoff using conditioned planting soil/gravel beds, vegetation, and microbes within shallow depressions. The use of a variety of shrubs and perennials is key in the natural nutrient-uptake abilities of the bioretention area. This BMP is also efficient in reducing sediment, oil/grease, and trace metals. Bioretention areas may be designed for infiltration to recharge groundwater or with an underdrain system to discharge treated stormwater. Bioretention areas can also be an aesthetically pleasing landscaping feature and blend in seamlessly. Design considerations include preferred planting list (e.g. woody shrubs, perennial flowers), capacity (based on 1" water quality volume), other landscaping design features (e.g. mulch, stones, educational kiosk, etc.), and maintenance requirements.
- **Sediment Forebays:** Install a sediment forebay at a stormwater outfalls located within an existing BMP. This pretreatment BMP is an impoundment, basin, or other storage structure designed to dissipate the velocity of stormwater runoff/discharge and allow for initial settling of suspended solids. Other benefits include easier access for sediment removal, high longevity with proper maintenance, and a potentially long detention time. Design consideration include capacity (based on 0.1" water quality volume), forebay material (e.g. granite, vegetation, and riprap), spillway design, forebay depth, side slopes, and maintenance requirements.
- **Infiltration Trenches:** Install crushed stone infiltration trenches along the shoulder of a road or pavement. This BMP is used to temporarily store stormwater runoff and promote groundwater infiltration into the natural soils. Infiltration trenches also can reduce downstream flooding and protect stream/pond banks from erosive forces of stormwater runoff. Infiltration trenches are suitable where there is limited space (e.g. along a road/pavement), but effective in controlling stormwater runoff sediment and nutrient loading. Design considerations include infiltration media, stone diameter, setback requirements, trench width/depth, and maintenance requirements.
- **Check Dams:** Install check dams across a grassed/biofilter swale. This BMP retrofit is used to lower the velocity of stormwater flow, reduce erosion and gullyng of the swale, and trap sediment.
- **Gabions/Level Spreaders:** Install a crushed stone gabion/level spreader at an existing inlet/outlet. This BMP retrofit receives concentrated flows from channels/outlets and converts it to sheet flow, which slows down the velocity of stormwater flow, traps sediments, and reduces downstream sedimentation and erosion.

3.1.2 BMP Maintenance and Inspection Recommendations

General guidance for existing and proposed BMP maintenance and inspection frequencies are as follows:

- **Wet Basin:** Inspect wet basins annually. During annual inspections, make note of and address the following: clogging, overflow, sedimentation, or erosion at the inlet/outlet structure; subsidence,

erosion, cracking, or tree growth on the pond banks; condition of emergency spillways; and, emergence of invasive species or visible changes in water quality (algal blooms, discoloration, odor, etc.). Make necessary repairs immediately. Periodically mow the embankments/side slopes, remove woody vegetation from embankments/side slopes, and remove debris from inlet/outlet structures. Remove accumulated sediment in the wet basin as needed.

- **Water Quality Swale:** Inspect swales bi-annually. During bi-annual inspections, make note of and address the following: clogging, overflow, sedimentation, or erosion at the inlet/outlet structure; rills, gullyng, erosion, cracking, or tree growth on the swale banks; condition of culverts; and emergence of invasive species. Make necessary repairs immediately. Periodically mow the embankments/side slopes, remove woody vegetation from embankments/side slopes, and remove trash/debris from the swale and inlet/outlet structures. Reseed the swale with wetland seed mix as needed.
- **Biofilter Swale:** Inspect swales annually. During annual inspections, make note of and address the following: sedimentation or erosion at the inlet/outlet structure; rills, gullyng, erosion, cracking, or tree growth on the swale banks; and emergence of invasive species. Make necessary repairs immediately. Periodically mow the swale (do not mow shorter than water quality flow depth – maximum 4 inches), remove woody vegetation, and remove trash/debris from the swale and inlet/outlet structures. Reseed the swale with grass seed mix as needed.
- **Extended Dry Detention Basin:** Inspect basins annually. During annual inspections make note of and address the following: clogging, overflow, sedimentation, or erosion at the inlet/outlet structure; subsidence, erosion, cracking, or tree growth on the embankments or side slopes; condition of emergency spillways; and emergence of invasive species. Make necessary repairs immediately. Periodically mow the embankments/side slopes, remove woody vegetation from embankments/side slopes, and remove trash/debris from the basin and inlet/outlet structures. Remove accumulated sediment in the basin as needed. Reseed the basin with appropriate seed mix as needed.
- **Bioretention Areas/Raingardens:** Inspect bioretention areas bi-annually and following any rainfall event greater than 2.5 inches in a 24-hour period. During inspections make note of and address the following: condition of the vegetation; emergence of invasive species; sedimentation or accumulation of trash/debris; and clogging, overflow, erosion at the inlet/outlet structure. Periodically remove trash/debris/sediment from the bioretention area and inlet/outlet structures. Annually remove dead vegetation and prune vegetation in the bioretention area as needed. Replant the bioretention area with appropriate plant species annually, or as needed. If the bioretention area does not drain fully within 72 hours following a rain event, a qualified professional must assess the condition of the filter media and determine measures to rehabilitate the filtration/infiltration functions.
- **Sediment Forebays:** Inspect forebays annually. During annual inspections make note of and address the following: clogging, overflow, sedimentation, or erosion at the inlet/outlet structure; sediment/trash/debris accumulation within the forebay; and condition of spillways. Make necessary repairs immediately. Periodically mow the embankments (if applicable) and remove woody vegetation from embankments/side slopes. Annually remove sediment/trash/debris from the forebay and inlet/outlet structures. Additionally, a staff gage or other measuring device may be installed to monitor annual sediment accumulation.

- **Infiltration Trenches:** Inspect trenches bi-annually and following any rainfall event greater than 2.5 inches in a 24-hour period. During inspections make note of and address the following: sediment/trash/debris accumulation within the trenches. Make necessary repairs immediately. Periodically mow the embankments/vegetated filter strips adjacent to the trenches and remove woody vegetation from embankments/vegetated filter strips. Annually remove sediment/trash/debris from the trenches. If the trenches do not drain fully within 72 hours following a rain event, a qualified professional must assess the condition of the filter media and determine measures to rehabilitate the filtration/infiltration functions.
- **Check Dams:** Inspect check dams after every significant rainfall event. Repair any damage and remove sediment/trash/debris as needed.
- **Gabions/Level Spreaders:** Inspect gabions after every significant rainfall event. Repair any damage and remove sediment/trash/debris as needed.

3.2 Existing and Proposed Conditions Pollutant Loading/Removal

Aerial, GIS, and LIDAR data was also used to estimate the subcatchment area and characteristics for each BMP site, including land use and ownership. As stated above, BMP subcatchment areas were delineated using the available topography (LIDAR) and field observations. The subcatchment areas do not include any areas that may be collected and discharged to the BMP from the drainage system. Therefore, only the topographic subcatchment areas and land use information were used to estimate runoff volumes from impervious areas received by each BMP site. Pretreatment volume (0.1"/impervious acre) and treatment volume (1"/impervious acre) for each BMP site is summarized in **Appendix K**.

The pollutant reduction model used to estimate the pollutant loadings to the BFB tributary was the Simple Method Model spreadsheet according to a NHDES-approved QAPP. Annual pollutant loading estimates are based on impervious area, annual runoff, and pollutant concentrations based on land use for each BMP site's subcatchment. Pollutants that were analyzed included total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN), and fecal coliform (FC) bacteria. BMP pollutant removal efficiencies are based on the BMP type. The goal of these recommended BMP retrofits and implementations is to decrease these pollutant loadings to Boire Field Brook, which ultimately discharges to a PWW water supply pond. This model can be used to estimate current pollutant loading to existing and proposed devices and filter BMPs and/or retrofits, then determine the effectiveness of the existing and proposed BMPs and/or retrofits in removing pollutants. Changes in pollutant loading into the BFB tributary from existing and proposed conditions can then be determined. A summary of the existing and proposed conditions pollutant loading and reduction calculations is included in **Appendix K**.

As shown in the calculations, the pollutant removal capabilities of the scenario with retrofitted existing BMPs and implemented BMPs (proposed conditions) are higher. Cumulatively, if all recommended retrofits and BMPs are implemented, an additional 230,000 lbs of TSS, 50 lbs of TP, and 160 lbs of TN from Boire Field Brook subwatershed would be removed annually before loading to Boire Field Brook.

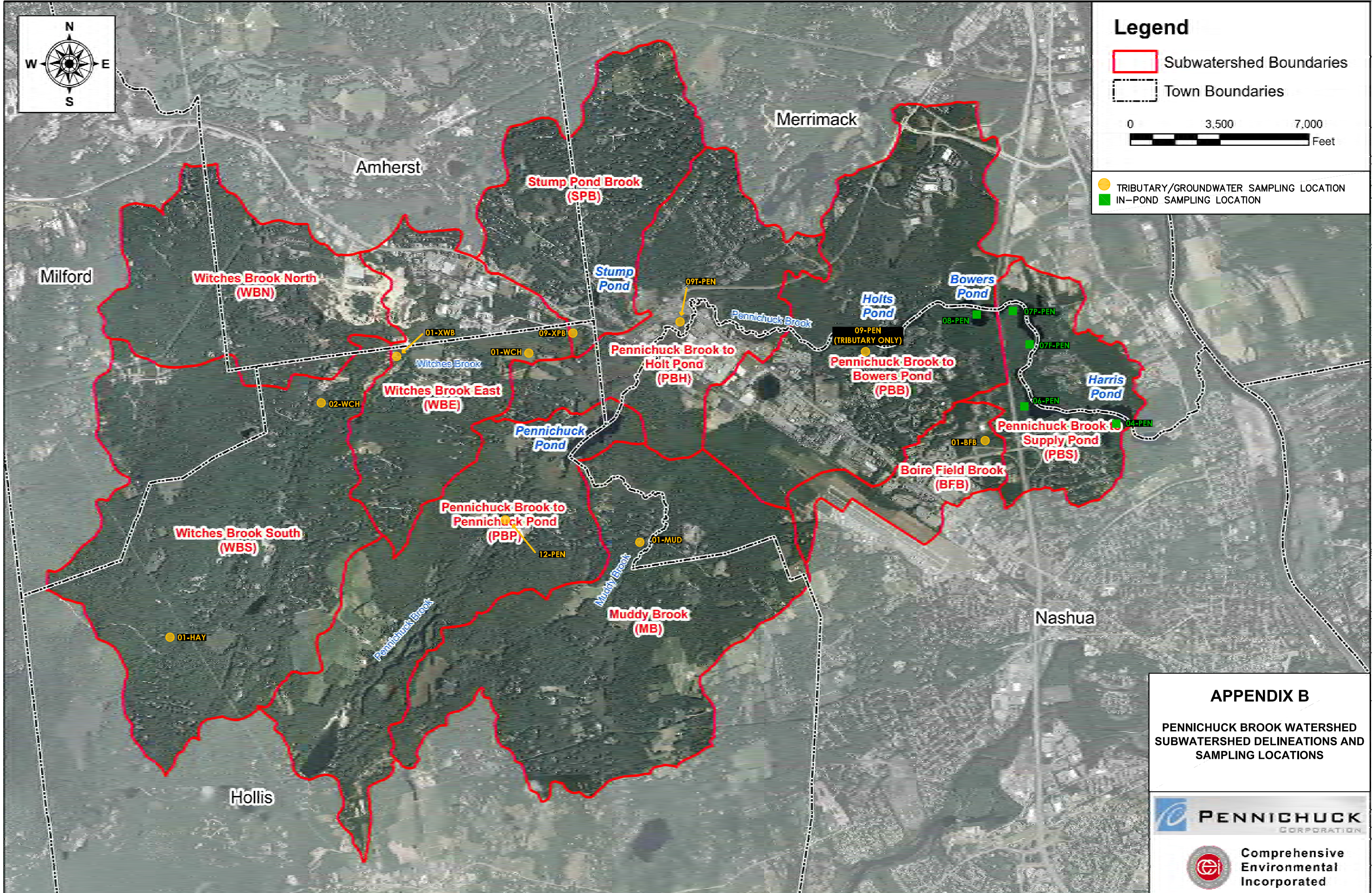
4.0 Follow-Up Actions

This report and associated attachments represent conceptual level designs for stormwater BMP improvements throughout the BFB watershed. Most BMPs are located on privately owned property by landowners other than PWW. As PWW does not own most of the subject parcels or have regulatory authority to implement these improvements on privately owned property, CEI recommends that private

property owners work with PWW and/or NHDES when undergoing redevelopment to review the feasibility of incorporating design elements contained within this report into revised site conditions. It is also recommended that the results of this study be provided to the Nashua Planning Board so these BMPs may be addressed in any permit applications for future development.

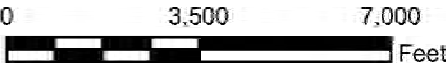
There are no recommendations for altered or additional tributary or groundwater sampling and analyses at this time. The sampling program is revised continuously to add or remove sampling parameters and locations, most recently at the end of 2017. Based on the annual results, sampling and analyses protocols may be modified in the future if needed.

APPENDIX A
Watershed Map



Legend

- Subwatershed Boundaries
- Town Boundaries



- TRIBUTARY/GROUNDWATER SAMPLING LOCATION
- IN-POND SAMPLING LOCATION

APPENDIX B

PENNICHUCK BROOK WATERSHED
SUBWATERSHED DELINEATIONS AND
SAMPLING LOCATIONS

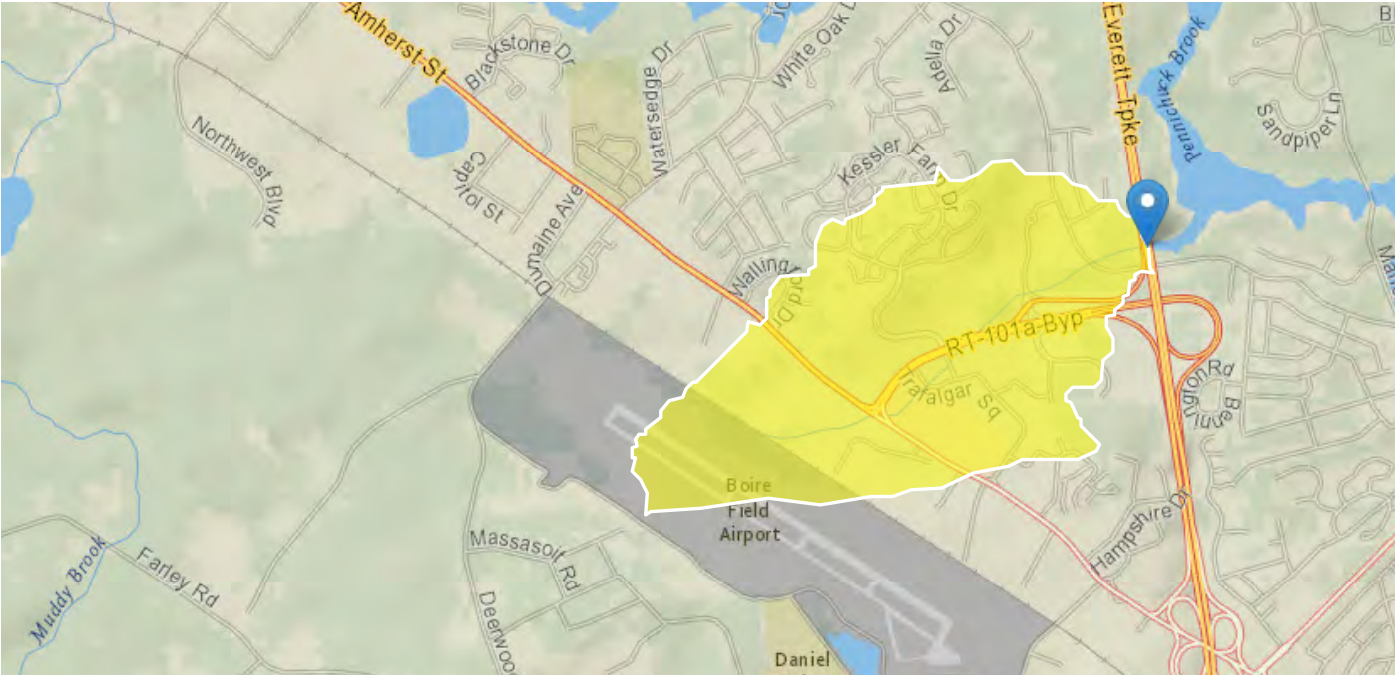


**Comprehensive
Environmental
Incorporated**

APPENDIX B
StreamStats Report

StreamStats Report

Region ID: NH
Workspace ID: NH20180713164442615000
Clicked Point (Latitude, Longitude): 42.79186, -71.49626
Time: 2018-07-13 12:44:58 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.77	square miles
CONIF	Percentage of land surface covered by coniferous forest	22.117	percent
PREBC0103	Mean annual precipitation of basin centroid for January 1 to March 15 winter period	8.39	inches
BSLDEM30M	Mean basin slope computed from 30 m DEM	4.707	percent
MIXFOR	Percentage of land area covered by mixed deciduous and coniferous forest	4.7877	percent
PREG_03_05	Mean precipitation at gaging station location for March 16 to May 31 spring period	8.9	inches
TEMP	Mean Annual Temperature	46.88	degrees F
TEMP_06_10	Basinwide average temperature for June to October summer period	62.935	degrees F
PREG_06_10	Mean precipitation at gaging station location for June to October summer period	17.3	inches

Parameter Code	Parameter Description	Value	Unit
ELEVMAX	Maximum basin elevation	350.001	feet
SNOFALL	Mean Annual Snowfall	63.518	inches
PREBC_1112	Mean annual precipitation of basin centroid for November 1 to December 31 period	8.31	inches
PRECIPCENT	Mean Annual Precip at Basin Centroid	43.1	inches
PRECIPOUT	Mean annual precip at the stream outlet (based on annual PRISM precip data in inches from 1971-2000)	43	inches
MINTEMP_W	Mean winter minimum air temperature over basin surface area	15.779	degrees F
APRAVPRE	Mean April Precipitation	3.878	inches
WETLAND	Percentage of Wetlands	0	percent
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	69	feet per mi
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	1026759.3	feet
CENTROIDY	Basin centroid vertical (y) location in state plane units	104995.1	feet
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	89.2	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	50.1	percent
OUTLETX	Basin outlet horizontal (x) location in state plane coordinates	1030005	feet
OUTLETY	Basin outlet vertical (y) location in state plane coordinates	106395	feet

Seasonal Flow Statistics Parameters [Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.77	square miles	3.26	689
CONIF	Percent Coniferous Forest	22.117	percent	3.07	56.2
PREBC0103	Jan to Mar Basin Centroid Precip	8.39	inches	5.79	15.1
BSLDEM30M	Mean Basin Slope from 30m DEM	4.707	percent	3.19	38.1
MIXFOR	Percent Mixed Forest	4.7877	percent	6.21	46.1
PREG_03_05	Mar to May Gage Precipitation	8.9	inches	6.83	11.5
TEMP	Mean Annual Temperature	46.88	degrees F	36	48.7
TEMP_06_10	Jun to Oct Mean Basinwide Temp	62.935	degrees F	52.9	64.4
PREG_06_10	Jun to Oct Gage Precipitation	17.3	inches	16.5	23.1
ELEVMAX	Maximum Basin Elevation	350.001	feet	260	6290

Seasonal Flow Statistics Disclaimers [Low Flow Statewide]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Seasonal Flow Statistics Flow Report [Low Flow Statewide]

Statistic	Value	Unit
Jan to Mar15 60 Percent Flow	0.481	ft ³ /s
Jan to Mar15 70 Percent Flow	0.401	ft ³ /s
Jan to Mar15 80 Percent Flow	0.349	ft ³ /s
Jan to Mar15 90 Percent Flow	0.258	ft ³ /s
Jan to Mar15 95 Percent Flow	0.204	ft ³ /s
Jan to Mar15 98 Percent Flow	0.169	ft ³ /s
Jan to Mar15 7 Day 2 Year Low Flow	0.345	ft ³ /s
Jan to Mar15 7 Day 10 Year Low Flow	0.183	ft ³ /s
Mar16 to May 60 Percent Flow	1.25	ft ³ /s
Mar16 to May 70 Percent Flow	1.01	ft ³ /s
Mar16 to May 80 Percent Flow	0.924	ft ³ /s
Mar16 to May 90 Percent Flow	0.742	ft ³ /s
Mar16 to May 95 Percent Flow	0.613	ft ³ /s
Mar16 to May 98 Percent Flow	0.498	ft ³ /s
Mar16 to May 7 Day 2 Year Low Flow	0.467	ft ³ /s
Mar16 to May 7 Day 10 Year Low Flow	0.247	ft ³ /s
Jun to Oct 60 Percent Flow	0.0512	ft ³ /s
Jun to Oct 70 Percent Flow	0.0343	ft ³ /s
Jun to Oct 80 Percent Flow	0.0255	ft ³ /s
Jun to Oct 90 Percent Flow	0.0139	ft ³ /s
Jun to Oct 95 Percent Flow	0.00837	ft ³ /s
Jun to Oct 98 Percent Flow	0.00677	ft ³ /s
Jun to Oct 7 Day 2 Year Low Flow	0.0173	ft ³ /s
Jun to Oct 7 Day 10 Year Low Flow	0.00408	ft ³ /s
Nov to Dec 60 Percent Flow	0.533	ft ³ /s
Nov to Dec 70 Percent Flow	0.358	ft ³ /s
Nov to Dec 80 Percent Flow	0.232	ft ³ /s
Nov to Dec 90 Percent Flow	0.126	ft ³ /s
Nov to Dec 95 Percent Flow	0.0684	ft ³ /s
Nov to Dec 98 Percent Flow	0.0339	ft ³ /s
Oct to Nov 7 Day 2 Year Low Flow	0.236	ft ³ /s
Oct to Nov 7 Day 10 Year Low Flow	0.0623	ft ³ /s

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (<http://pubs.water.usgs.gov/wrir02-4298>)

Flow-Duration Statistics Parameters [Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.77	square miles	3.26	689
PREG_06_10	Jun to Oct Gage Precipitation	17.3	inches	16.5	23.1
TEMP	Mean Annual Temperature	46.88	degrees F	36	48.7

Flow-Duration Statistics Disclaimers [Low Flow Statewide]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Flow-Duration Statistics Flow Report [Low Flow Statewide]

Statistic	Value	Unit
60 Percent Duration	0.316	ft^3/s
70 Percent Duration	0.189	ft^3/s
80 Percent Duration	0.0911	ft^3/s
90 Percent Duration	0.0366	ft^3/s
95 Percent Duration	0.0191	ft^3/s
98 Percent Duration	0.0101	ft^3/s

Flow-Duration Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (<http://pubs.water.usgs.gov/wrir02-4298>)

Low-Flow Statistics Parameters [Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.77	square miles	3.26	689
TEMP	Mean Annual Temperature	46.88	degrees F	36	48.7
PREG_06_10	Jun to Oct Gage Precipitation	17.3	inches	16.5	23.1

Low-Flow Statistics Disclaimers [Low Flow Statewide]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Low-Flow Statistics Flow Report [Low Flow Statewide]

Statistic	Value	Unit
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Statistic	Value	Unit
7 Day 2 Year Low Flow	0.0177	ft^3/s
7 Day 10 Year Low Flow	0.00417	ft^3/s

Low-Flow Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (<http://pubs.water.usgs.gov/wrir02-4298>)

Recharge Statistics Parameters [Groundwater Recharge Statewide 2004 5019]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
PREG_03_05	Mar to May Gage Precipitation	8.9	inches	6.83	11.54
CONIF	Percent Coniferous Forest	22.117	percent	3.07	56.18
SNOFALL	Mean Annual Snowfall	63.518	inches	54.46	219.07
PREG_06_10	Jun to Oct Gage Precipitation	17.3	inches	16.46	23.11
TEMP	Mean Annual Temperature	46.88	degrees F	36.05	48.69
MIXFOR	Percent Mixed Forest	4.7877	percent	6.21	46.13
PREBC_1112	Nov to Dec Basin Centroid Precip	8.31	inches	6.57	15.2
PRECIPCENT	Mean Annual Precip at Basin Centroid	43.1	inches	37.44	75.91
PRECIPOUT	Mean Annual Precip at Gage	43	inches	35.83	53.11
MINTEMP_W	Mean Winter Min Temperature	15.779	degrees F	0.8	19.88

Recharge Statistics Disclaimers [Groundwater Recharge Statewide 2004 5019]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Recharge Statistics Flow Report [Groundwater Recharge Statewide 2004 5019]

Statistic	Value	Unit
GW_Recharge_Jan_to_Mar15	5.14	in
GW_Recharge_Mar16_to_May	7.02	in
GW_Recharge_Jun_to_Oct	3	in
GW_Recharge_Nov_to_Dec	3.45	in
GW_Recharge_Ann	19.6	in

Recharge Statistics Citations

Flynn, R.H. and Tasker, G.D.,2004, Generalized Estimates from Streamflow Data of Annual and Seasonal Ground-Water-Recharge Rates for Drainage Basins in New Hampshire, U.S. Geological Survey Scientific Investigations Report 2004-5019, 67 p. (http://pubs.usgs.gov/sir/2004/5019/StreamStatsDB_2014-11-21 - Copy - Copy.mdb)

Peak-Flow Statistics Parameters [Peak Flow Statewide SIR2008 5206]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.77	square miles	0.7	1290
APRAVPRE	Mean April Precipitation	3.878	inches	2.79	6.23
WETLAND	Percent Wetlands	0	percent	0	21.8
CSL10_85	Stream Slope 10 and 85 Method	69	feet per mi	5.43	543

Peak-Flow Statistics Flow Report [Peak Flow Statewide SIR2008 5206]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp	Equiv. Yrs.
2 Year Peak Flood	36.8	ft ³ /s	22	61.6	30.1	3.2
5 Year Peak Flood	64.6	ft ³ /s	37.9	110	31.1	4.7
10 Year Peak Flood	89.2	ft ³ /s	51.2	155	32.3	6.2
25 Year Peak Flood	125	ft ³ /s	68.9	226	34.3	8
50 Year Peak Flood	155	ft ³ /s	82.9	290	36.4	9
100 Year Peak Flood	192	ft ³ /s	99	374	38.6	9.8
500 Year Peak Flood	289	ft ³ /s	136	615	44.1	11

Peak-Flow Statistics Citations

Olson, S.A.,2009, Estimation of flood discharges at selected recurrence intervals for streams in New Hampshire: U.S.Geological Survey Scientific Investigations Report 2008-5206, 57 p.
(<http://pubs.usgs.gov/sir/2008/5206/>)

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Application Version: 4.2.1

APPENDIX C
Historic Water Quality Data

Historic Tributary Data - Average Pollutant Concentrations

		Ammonia	Chloride	Conductivity	DO	E. coli	Fecal Coliform	Nitrate	Nitrite	Nitrate/Nitrite	pH	Temperature	TKN	Total Nitrogen	Total Phosphorus	TSS
All Data Average	01-BFB	0.20	201	690.5	8.18	125.9	140.8	0.29	0.20	0.30	7.60	15.4	0.589	0.768	0.031	5
	09-XPB	0.26	58	236.2	5.98	51.4	27.4	0.24	0.20	0.25	6.77	16.8	0.693	0.875	0.030	6
	09T-PEN	0.19	50	179.8	4.64	56.0	61.9	0.20	0.20	0.21	6.85	16.4	0.741	0.751	0.030	6
	09-PEN	0.20	66	230.6	6.42	32.0	46.8	0.20	0.20	0.21	7.19	17.3	0.571	0.578	0.025	5
	01-XWB	0.19	36	135.1	7.27	118.1	119.9	0.22	0.20	0.23	6.59	16.1	0.557	0.553	0.030	6
	01-WCH	4.79	55	182.9	5.74	90.9	65.4	0.20	0.20	0.21	6.56	16.1	0.525	0.491	0.027	5
	01-MUD	0.18	25	155.0	5.64	61.5	65.2	0.20	0.20	0.21	6.83	16.9	0.584	0.571	0.030	5
	01-HAY	0.21	8	48.4	8.77	44.1	47.9	0.20	0.20	0.20	6.70	15.1	0.780	0.798	0.017	5
	02-WCH	0.21	37	125.6	10.17	30.2	33.0	0.42	0.20	0.47	6.69	14.0	0.591	0.978	0.021	5
2018 Average	12-PEN	0.19	38	140.5	8.90	62.4	43.6	0.21	0.20	0.21	6.81	15.9	0.659	0.744	0.026	6
	All Other	0.71	41	159.4	7.06	60.7	56.8	0.23	0.20	0.24	6.78	16.1	0.633	0.704	0.026	5
	01-BFB	0.20	220	851.9	8.96	98.1	155.3	0.33	0.20	0.33	8.65	16.4	0.888	1.194	0.032	4
	09-XPB	0.22	62	255.5	6.87	21.4	21.2	0.22	0.20	0.22	7.49	18.3	0.982	1.099	0.020	4
	09T-PEN	0.20	44	191.0	5.44	51.1	38.7	0.20	0.20	0.20	7.88	18.1	1.547	1.547	0.032	5
	09-PEN	0.20	54	228.9	6.75	55.1	55.6	0.20	0.20	0.20	8.32	18.4	1.123	1.123	0.028	5
	01-XWB	0.21	36	149.5	7.76	85.8	56.4	0.21	0.22	0.23	6.86	17.9	0.912	1.069	0.029	5
	01-WCH	0.20	45	173.6	5.71	105.3	109.0	0.20	0.20	0.20	7.03	17.6	0.866	0.866	0.021	4
	01-MUD	0.20	24	166.3	6.39	63.9	59.7	0.20	0.20	0.20	6.94	18.6	0.924	0.925	0.017	4
	01-HAY	0.20	9	51.4	10.51	32.2	42.0	0.20	0.20	0.20	6.77	15.5	0.886	0.929	0.022	5
	02-WCH	0.30	36	128.7	11.42	29.7	24.3	0.41	0.23	0.46	6.67	15.8	1.032	1.570	0.028	6
	12-PEN	0.20	43	182.1	10.99	52.7	48.1	0.23	0.20	0.23	6.90	16.9	0.653	0.711	0.013	4
	All Other	0.22	39	169.7	7.98	55.2	50.6	0.23	0.21	0.24	7.21	17.4	0.992	1.093	0.023	5

APPENDIX D
2000 Boire Field Brook Subwatershed Report

Comprehensive Environmental Inc.

Study of Urban Non-Point Source Pollution Boire Field Brook Subwatershed



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Table of Contents

Section	Page Number
Summary of Project	
1.0 History of Project	1-1
2.0 Drainage Areas	
2.1 Site Selection Methodology	2-1
2.2 Drainage Area Descriptions	2-1
2.21 Western and Northwestern Drainage Area.....	2-2
2.22 Boire Airfield	2-2
2.23 Southeastern Drainage Area	2-2
2.24 Area of Focus	2-3
3.0 Sites Recommended For Improvement	
3.1 Cornerstone Site	3-1
3.1.1 Identification of Problem.....	3-1
3.1.2 Water Quality Threat.....	3-2
3.1.3 Method of Correction/Treatment.....	3-2
3.1.4 Estimated Cost to Construct	3-4
3.1.5 Annual Maintenance Requirements	3-4
3.1.6 Funding Sources.....	3-4
3.1.7 Ownership	3-5
3.1.8 Implementation Difficulty	3-5
3.2 Crowne Plaza	3-5
3.2.1 Identification of Problem	3-5
3.2.2 Water Quality Threat.....	3-6
3.2.3 Method of Correction/Treatment.....	3-6
3.2.4 Estimated Cost to Construct	3-7
3.2.5 Annual Maintenance Requirements	3-8
3.2.6 Funding Sources	3-8
3.2.7 Ownership	3-8
3.2.8 Implementation Difficulty	3-8
4.0 Other Recommendations	
4.1 Maintenance/Overuse of Detention Ponds.....	4-1
4.2 Aesthetics of Detention Ponds and Other Structures	4-1
4.3 Storage and Disposal of Street Sweepings.....	4-2
4.4 Sullivan Tire Runoff	4-2
4.5 Paint Disposal in Catchbasin	4-2
4.6 Scum Found on Stormwater Near Bank	4-3

Table of Contents

Figure Title

Section 2

- Figure 2-1. Drainage Schematic
- Figure 2-2. Kessler Farm Swale
- Figure 2-3. Building 19 Pond
- Figure 2-4. Birch Pond
- Figure 2-5. Stormwater Discharges to Crowne Plaza Detention Pond
- Figure 2-6. Compaq Detention Pond
- Figure 2-7. Somerset Plaza Wet Swale
- Figure 2-8. Sullivan Tire Runoff
- Figure 2-9. Northern Perimeter Swale
- Figure 2-10. Crowne Plaza Detention Ponds
- Figure 2-11. Area of Focus
- Figure 2-12. Onsite Detention at Park and Ride
- Figure 2-13. Postal Service Detention
- Figure 2-14. Controlled Outlet to Harris Pond
- Figure 2-15. Large Discharge From North Southwood Drive
- Figure 2-16. Cornerstone Discharge Blockage
- Figure 2-17. Existing Grass Swale
- Figure 2-18. Stormwater Collection Junction for the Cornerstone Site

Section 3

- Figure 3-1. Settling of Large Particles
- Figure 3-2-A Conceptual Slope Stabilization Plan
- Figure 3-2-B Sedimentation Forebay Detail
- Figure 3-3. Turf Reinforcement Material
- Figure 3-4. Original Swale Design
- Figure 3-5. Crowne Plaza Detention Ponds
- Figure 3-6. Crowne Plaza Waterfoul Concentrations
- Figure 3-7. Winter and Summer Preferred Habitat

Section 4

- Figure 4-1. Ponding Problem at Sullivan Tire
- Figure 4-2. Petroleum Sheen at Sullivan Tire
- Figure 4-3. Paint Thinner Being Dumped in Catchbasin
- Figure 4-4. Scum Found Near Bank Boston.

Summary of Project

This report contains information necessary to efficiently allocate resources for water supply protection. Based on a Watershed Management Plan, the Boire Field Brook subwatershed of the Pennichuck Water Works supply ponds was chosen for an intense field review to identify potential contaminant sources. Water quality threats from these sites were evaluated and Best Management Practices were proposed to minimize the threats.

This report and the results of the study have been structured to provide the reader with:

- A knowledge of the drainage patterns within the subwatershed studied.
- An understanding of the methodology used to identify water quality threats.
- A review of two sites in most need of water quality controls.
- Proposed conceptual Best Management Practices suitable for implementation at the identified sites.

Furthermore the prioritized nature of this study and its recommendations allows it to be useful to readers well after the proposed Best Management Practices have been implemented. Readers are referred to section 4 that contains short descriptions of other recommendations for this subwatershed.

Lastly, credit is to be given to the New Hampshire Department of Environmental Services and Pennichuck Water Works for their funding and interest in supporting this valuable study from which many New Hampshire citizens will benefit.



1.0 History of Project

From August to November 1999 Comprehensive Environmental Inc. (CEI) conducted a detailed review of an area of the Pennichuck watershed. This area is a 1000-acre subwatershed known as the Boire Field Brook (BFB) Subwatershed as identified in a 1998 *Watershed Management Report* (Comprehensive Environmental Inc., 1998)

Field information was gathered during the extremely dry conditions of late summer and also during a number of heavy rainstorms this fall. These unusual weather extremes provided a good range of conditions for observing the drainage of the BFB.

It appears that a significant amount of development has taken place since the original Watershed Management Plan was written only two years ago. New roads were built and now there are few vacant properties. Anytime there is demand to develop lands within a town, there is a unique opportunity for watershed managers to raise the bar for developers to minimize their impacts and eventual long term costs to society. Pennichuck's interest and technical assistance and the Nashua Conservation Commission's vigilance clearly have had an effect within the BFB subwatershed since many in-place BMPs were found during the study.



2.0 Drainage Areas

2.1 Site Selection Methodology

Because much of the development in this particular area has occurred recently, new techniques and performance standards for stormwater management can, and have, been required. During site walks many swales and detention ponds were observed. Much of the stormwater generated within this subwatershed must travel through these treatment structures. Because of the superior sediment trapping and water treatment that properly designed and operated detention ponds provide, an evaluation and prioritization of water quality threats must consider more than just impermeable areas, runoff volumes, and pollutant types and concentrations.

Because of the relatively good treatment that water from the BFB periphery receives, BMP site prioritization focused mainly on the areas closest to Pennichuck's water supply known as Harris Pond. While the distance that a contaminant must travel is often an important consideration in evaluating the threat from a source, in this subwatershed it became the overriding criteria in establishing the value of siting a BMP in one location as opposed to another. Therefore, while recommended locations of BMPs considered the interrelationships between many factors, site selection was ultimately based primarily on the proximity of the site to its eventual discharge into Harris Pond. A description of the drainage patterns within the BFB follows. The drainage schematic presented in Figure 2-1 (located at the end of Section 2) may be useful in visualizing these patterns.

2.2 Drainage Area Descriptions

In general much of the stormwater generated in the western and northwestern portion of this subwatershed flows through a series of detention ponds before it crosses under Somerset Parkway in the vicinity of the Exit 8 intersection. This stormwater is represented as a green arrow on Figure 2-1. Stormwater from the Boire Airfield appears to flow southward out of the BFB and is represented by a light blue arrow on Figure 2-1. Stormwater from the southeastern portion of the watershed is represented by an orange arrow on Figure 2-1. Stormwater generated in the northeastern corner of the watershed flows southerly and joins the other flows in Pennichuck Brook. It is shown as a red arrow on figure 2-1



2.2.1 Western and Northwestern Drainage Area (Green flow)

In the western edge of the BFB, runoff generated just east of Deerwood Drive flows through a combination of ditches to wetlands in the vicinity of the railroad tracks and behind the Building 19 property. The water in the wetlands flows to Birch Pond and eventually to the detention ponds that front on Somerset Parkway. A portion of stormwater from the large Kessler Farm development flows through a series of swales (Figure 2-2) and small detention devices before it crosses under Amherst Street to a detention pond (Figure 2-3) series in front of the Building 19 parcel. The Building 19 ponds act as a retention system that retains stormwater, except during large storm events when this and other adjacent parking lot drainage spills over a raised outlet to another pond known as Birch Pond (Figure 2-4). This water then flows to the series of detention ponds fronting on Amherst Street before heading northerly under Somerset Parkway.

Stormwater from the southern aspect of the Kessler Farm development and access drive does not benefit from as long a detention time as it short circuits the flow path seen in green on Figure 2-1 and instead discharges directly into the last detention pond (Figure 2-5) before crossing under Somerset Parkway.

2.2.2 Boire Airfield (Blue flow)

Drainage modifications appear to have altered natural drainage patterns on the airfield property with the result being that the majority of surface water generated on this site flows southeasterly toward the Nashua River. A grassed area east of the airstrip may have a subsurface influence (and likely surface influence during high groundwater and heavy rainstorms) toward the railroad bed in the vicinity of the Building 19. The extent of the influence is unclear due to the fact that a culvert under the rail grade appears to be collapsed and there was no evidence of recent surface water conveyance through the pipe. Groundwater elevation records were sought, but no representative records for the area of our concern were found.

2.2.3 Southeastern Drainage Area (Orange flow)

Stormwater from the southeastern portion of the BFB is shown in orange on figure 2-1. Most of the stormwater originates in and around Somerset Plaza and to a lesser extent from the Compaq Computer Area.

Most runoff generated south of Amherst Street in the vicinity of the Compaq computer facility flows to a detention pond (Figure 2-6.) and then northerly towards Somerset Plaza into the same swale (Figure 2-7)



and detention pond series previously mentioned on Somerset Parkway. Some of the runoff generated north of the Compaq facility does not have the advantage of treatment in the Compaq pond although all flows are picked up by the aforementioned swale and pond series.

Stormwater generated north of Amherst Street, and inclusive and west of Sullivan Tire (Figure 2-8) flow westerly in one of two swales that surround and pick up flows from Somerset Plaza.

A portion of Trafalgar Square Road and a portion of the parking lot drainage north of Pfieffer Vacuum flows to the swale on the northern perimeter of Somerset Plaza (Figure 2-9). The water in these perimeter swales flows to the detention ponds fronting on and eventually crossing underneath Somerset Parkway with discharge into Pennichuck Brook.

All of the stormwater from the above-mentioned areas is treated to some degree as it flows through various stormwater treatment structures. All stormwater must flow through at least one of the detention ponds located in front of Crowne Plaza hotel (Figure 2-10). Because of the excellent treatment that detention ponds provide, Pennichuck water supply is not as vulnerable to direct contamination from stormwater from these outlying drainage areas as it is from other areas within the watershed that are closer to Harris Pond that produce stormwater that does not flow through a detention pond.

Therefore the focus for finding high priority BMP sites shifted further down the watershed (note area of focus shown in Figure 2-11) to areas that generate runoff that does not have the benefit of flowing through multiple treatment structures.

2.2.4 Area of Focus (Red flow)

This area of focus is represented as a red arrow on Figure 2-1, but also includes flows generated in the eastern edge of those represented in orange on Figure 2-1.

As seen in Figure 2-1 the red arrow depicts stormwater generated in the Northeastern portion of the BFB that discharges into Pennichuck Brook. This area encompasses the remainder of the watershed and is typified by onsite treatment structures such as those located at the *Park and Ride* lot (Figure 2-12) and the Postal Service property (Figure 2-13).

Water from these and other adjacent areas discharges to Pennichuck Brook, which flows under Tinker Road, through a controlled outlet, under the Everett Turnpike to another controlled outlet (Figure 2-14) that discharges to Harris Pond.



Some of the stormwater in this area flows through grass treatment swales before it enters the main stem of the Pennichuck Brook. The discharge pipes in this area are quite large (Figure 2-15), presumably to handle the stormwater from development of the presently vacant lands. Although two of the grass swales appear to be intact and functioning properly, there was little evidence to suggest that either had experienced high flows.

Another treatment swale located downstream, however, showed signs of extreme sedimentation (Figure 2-16) to the point of almost complete blockage. This swale handles stormwater from the Cornerstone Computer site located on north Southwood Drive. Much of the beneficial vegetation in this grass treatment swale has been choked by sand. The remaining vegetation consisted of small woody plants typical of disturbed soils. These plants offer little treatment of stormwater beyond their minor energy dissipating qualities.

This discharge site (Figure 2-17) and an upstream collection junction (Figure 2-18) were picked for installation of BMPs and are described in greater detail in section 3.1.



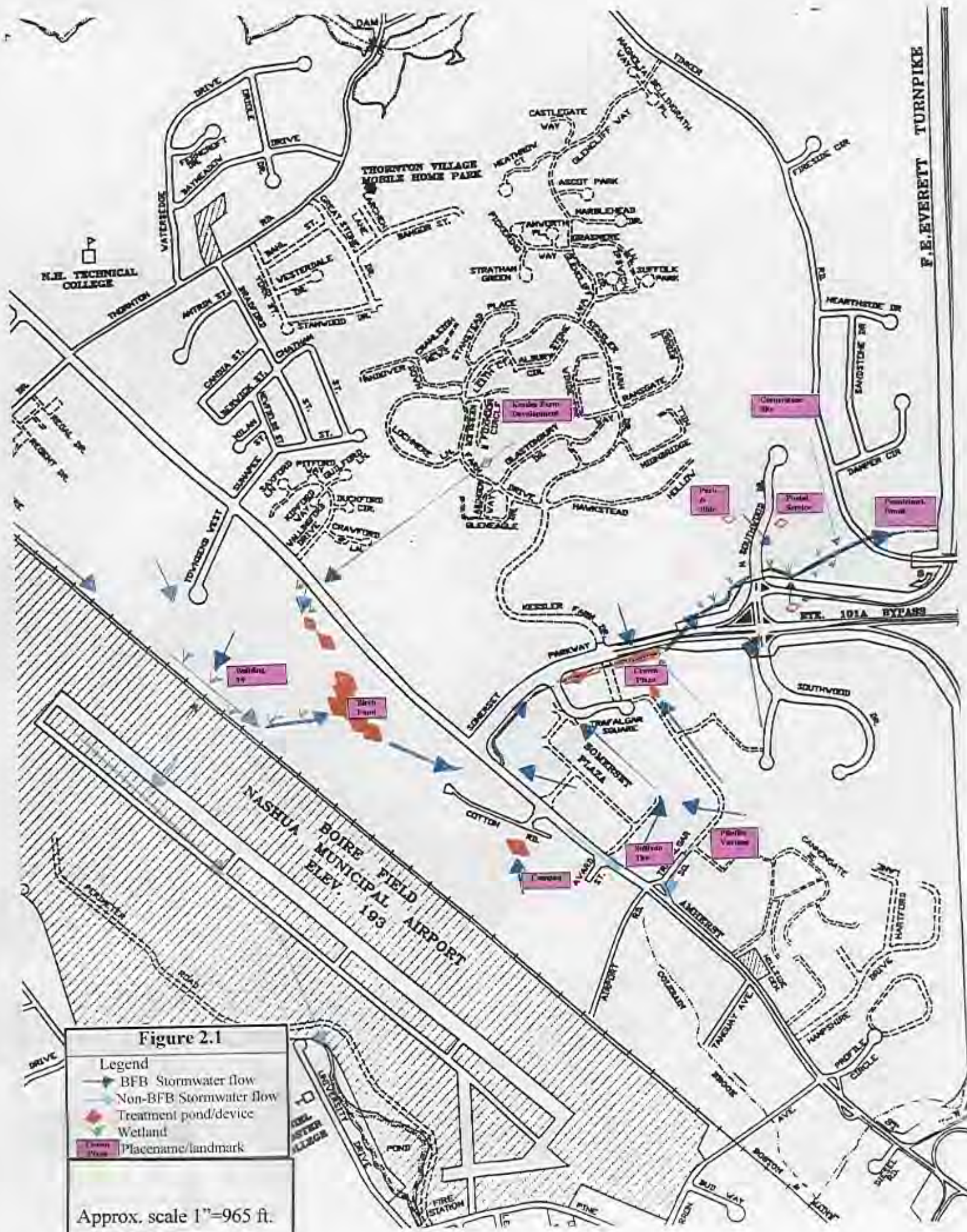




Figure 2-2. Kessler Farm Swale



Figure 2-3. Building 19 Detention Pond



Figure 2-4. Birch Pond



Figure 2-5. Stormwater Discharges to
Crowne Plaza Detention Pond



Figure 2-6. Compaq Detention Pond



Figure 2-7.
Somerset Plaza
Wet Swale



Figure 2-8. Sullivan Tire Runoff



Figure 2-9. Northern Perimeter Swale



Figure 2-10. Crowne Plaza Detention Ponds



Figure 2-11.
Area of Focus



Figure 2-12. Onsite Detention at Park and Ride Lot



Figure 2-13. Postal Service Detention



Figure 2-14. Controlled Outlet to Harris Pond



Figure 2-15. Large Discharge From North Southwood Drive



Figure 2-16. Cornerstone Discharge Blockage



Figure 2-17. Existing Grass Swale



Figure 2-18. Stormwater Collection Junction for the Cornerstone Site

3.0 Sites Recommended for Improvement

Within the BFB, there are two general observations that relate to water quality: sediment and associated phosphorus transport can be improved, and public education is needed to reduce bacteria and sediment inputs.

While the existing stormwater treatment structures will remove some of the sediments suspended in the stormwater flow, efforts to control the entrainment of these particles and thus phosphorus should be made. This will add both longevity and treatment effectiveness to the existing stormwater treatment structures. Sediment management is needed in the watershed to control sources such as erosion, and in some cases to remove sediment once suspended in storm flows. Reducing these loadings should lessen the need to clean out detention ponds and other stormwater treatment devices that currently appear to be overtaxed.

Bacteria of many forms are present in nature, and a large chain pond system such as Pennichuck's can be expected to have a certain amount of bacterial contributors even in its supply waters. However in the BFB subwatershed, unnaturally high concentrations of waterfowl produce large amounts of fecal matter containing fecal bacteria. Because this unnaturally large population of waterfowl relates to human feeding, public education that discourages feeding allows citizens to have direct control over the quality of the quality of source water.

A blend of structural and behavioral BMPs were selected to address the water quality problems at two sites.

3.1 Cornerstone Site.

The Cornerstone site can be seen as a landmark site in Figure 2-1. The three BMP components proposed for this site are described below in section 3.13.

3.1.1 Identification of Problem.

Stormwater generated on the impervious surfaces at the Cornerstone Computer Facility receives some treatment from an existing grass treatment swale before it enters Pennichuck Brook. However, the grass treatment swale has been choked with sand and sediments contained in the stormwater and possibly the side slopes of the swale itself. While some infiltration exists in the sandy soils that underlie the swale, it appears that high velocity stormwater flows down through the swale as noted by the settling (Figure 3-1 located at the end of this section) of large particles quite a distance from the pipe's discharge.



Because of the large volume of sand and sediment contained in the stormwater, the pipe's discharge has become clogged. The source of sand and sediment found in the existing grass swale was traced to a developed site that discharges rooftop and parking lot runoff onto a steep slope before entering the conveyance system. Stone has been placed on top of fabric on the receiving slope of this upstream site in an attempt to protect the slope from erosion (unfortunately the stone that has been used is relatively flat and does not have the many faceted, angular structure required to function as riprap). The stone has slid down the fabric and the unprotected lateral walls have slumped and eroded (as seen in Figure 2-19). Much of this eroded material has been carried through the storm pipe and discharged onto the existing grass swale.

3.1.2 Water Quality Threat.

The water quality threat from this site is from sediment and the associated phosphorus transport to Pennichuck Brook. Some of this phosphorus in its dissolved form may reach Harris Pond. Sediments that settle in the brook occupy the valuable space and thus volume that slows the rate of flow in the brook. A slower rate of flow allows the finer silts and sediments high in nutrients to settle out. The natural settling that occurs in the brook and the metered outlets are the last line of defense before stormwater enters Harris Pond.

3.1.3 Method of Correction/Treatment.

To eliminate sediment transport to the existing swale two measures should be taken; slope stabilization and sediment collection. Once the erosion and sediment transport problems have been dealt with at the upstream end of the conveyance system, the problems in the existing swale at the outlet should be lessened dramatically. However this existing grass treatment swale should be reconditioned and two checkdams should be added. These three BMP components: eliminating erosion, collecting sediments, and reconditioning the existing grass swale are described conceptually below in the three respective sub-sections sections.

Slope Stabilization

First, the slope receiving the runoff should be stabilized. The stone and fabric should be removed from the bank receiving the sites runoff. This area should be re-contoured in a shallow swale configuration so as to maximize the floor area of the swale (see Figure 3-2-A). The swale should be stabilized with a turf reinforcement material (see Figure 3-3), loamed and seeded with grass that will establish quickly. A flat longitudinal slope will allow a more shallow sheet flow to occur, thereby using the energy dissipating qualities of the grass to slow the velocity of water on the slope.



Sediment Collection

The second feature needed at this site is a sediment forebay (see Figure 3-2-B) to trap stormwater sediments. The forebay should be excavated upstream of the existing headwall and lined with the stone removed from the slope. A baffle structure (which could be in the form of flutes or a short gabion wall) placed within the perimeter of the forebay to intercept incoming water from the slope could be employed to enhance sediment-settling rates. Finally, a box outlet structure tied into the existing headwall made with gabions will force water upwards and/or through the pore space of the stone. This will have the effect of adding sediment storage space, lengthening the stormwater travel time and preventing short-circuiting the system.

Once the erosion and sediment transport problems have been addressed at the upstream end of the conveyance system, the sedimentation problems in the existing grass treatment swale at the outlet should be reduced dramatically. However the existing grass treatment swale is in need of some improvements to fully utilize its treatment abilities.

Reconditioning Existing Grass Swale

The third BMP component is the reconditioning of the existing grass swale so that it polishes stormwater from the above two components prior to its entrance to Pennichuck Brook. Reconditioning should consist of some minor regrading, re-vegetation and bank stabilization, and the addition of two check dams. These three efforts are described below.

The swale is in need of some minor regrading to re-establish its original design slope (See figure 3-4). Cleaning accumulated sediments from the pipes discharge (as shown in Figure 2-16) should be done at this time.

Although some woody vegetation is thriving in the disturbed soils of the swale, the bare stalks do little to break up the velocity of water. A coarse type of vegetation tolerant of sandy soils should be seeded on the floor of the swale to slow stormwater flow, and to help maintain the infiltration capacity of the swale's floor. Although the direct phosphorus removal by this vegetation is typically nominal unless intensely harvested, the physical characteristics of a healthy stand of dense vegetation are worth employing. This need not be done for the entire length of the swale floor as some of the vigorously growing established vegetation at the downstream end of this swale supports complementary treatment functions.

A grass, vetch or sedge known for its bank stabilization properties could be seeded on the sandy side slopes. This should be done on an as-needed basis either in areas where the bank has slumped or eroded.

Adding two check dams near the toe of the swale slope would encourage water to infiltrate into the sandy soils present on the site. Any stormwater



generated from low intensity storm events is probably infiltrating into the sandy soils of the swale without the aid of the check dams, but higher intensity events likely exceed the capacity of the natural soils to infiltrate the portion of runoff associated contaminant transport. Adding checkdams to the swale will allow this portion of water greater time to infiltrate. Enhanced groundwater recharge and storage also has the advantage of staggering the release of water from the watershed so that water is available to the supplier over a greater period of time.

3.1.4 Estimated Cost to Construct.

It is estimated that costs to install these BMPs would range from \$15,000 to \$20,000 depending on whether all of the options components mentioned above are implemented.

3.1.5 Annual Maintenance Requirements

Maintenance needed for these two BMPs to function properly should be generally confined to the upstream sediment removal BMP. However, periodic inspection of the reconditioned swale is suggested.

Once vegetation has been established on the slope it should be mowed cross slope with a conventional push or walk behind mower. Grass should not be mowed to less than two and one half inches. Clippings should be collected if they are likely to smother the grass, however fine clippings may be allowed to disperse evenly on the slope. Removal of thatch in spring or fall should only be done if there is evidence that excessive thatch is causing water to channelize on the slope. An alternative to conventional grass is to use a “no mow” mix (dwarf fescues) and clover to minimize maintenance. Mowing is needed only once per year, but fall cleanup of leaves is required.

Sediment that is collected in the forebay should be removed periodically. The rate of accumulation will depend on many factors from winter sanding applications that may vary depending on the severity of the winter, and how well the vegetation establishes on the eroded slope. As a post-construction follow-up the depth of sediment in the forebay should be checked with a measuring stick quarterly and after big storms. Knowing the rate of accumulation will help in predicting when the foerbay will become full and in identifying problems upstream. Sediments should be removed prior to using all of the storage capacity (freeboard) in the forebay.

3.1.6 Funding Sources.

This project is eligible for grant funding under the New Hampshire Department of Environmental Protection’s Drinking Water Protection Program:

- *Local Water Protection Grants* –typically due by November 15th.
- *Drinking Water Protection Projects*-typically due by November 15th.



Application for design and construction of this project has been submitted under the 1999/2000 New Hampshire Department of Environmental Services' *Non-Point Source Local Initiative Grant Program*. Partial grant funding was awarded for the construction of the aforementioned BMPs.

3.1.7 Ownership.

The city of Nashua tax maps indicate that M n'D Properties LLC. is the owner of the upstream property in need of erosion and sediment control. They are located at 15 N. Southwood Drive in Nashua. The land containing the grass treatment swale near Pennichuck Brook is owned by Pennichuck Water Works.

3.1.8 Implementation Difficulty.

It is anticipated that the physical limitations of both BMP sites will present only low to moderate construction difficulties.

Initial investigations of the soil characteristics at both proposed BMP locations indicate that it may be droughty and contain little organic matter. This will present challenges to quick establishment of thick grass cover. Adding loam should hasten turf growth during the vulnerable establishment period. Thoroughly watering the established grass will encourage deep root growth if the topsoil to just above the root depth is allowed to dry. Access for construction equipment to both locations should be good, although contractors should be aware of water, gas, and other underground utilities near both locations. As always, DIG SAFE should be notified.

Landowner concerns are expected to be minimal for two reasons. First, one of the locations is owned by Pennichuck Water Works. Second, the other location is unsightly with visible degradation of the existing stone and fabric system. The proposed use of grass in its place will blend with the surrounding landscape far better than even a properly operating riprap structure. The gabion outlet structure should not be very noticeable.

3.2 Crowne Plaza Waterfowl

A behavioral BMP and several physical deterrents are proposed at the site shown in Figure 3-5 just North of the Crowne Plaza Hotel.

3.2.1 Identification of Problem

Waterfowl are present throughout the BFB subwatershed frequenting the various detention structures and adjacent grounds. Limiting waterfowl throughout the watershed would be a highly impractical goal, but deterring waterfowl from this critical location near the water source is a realistic objective. The focus of these efforts should be in the detention ponds to the North of the Crowne Plaza Hotel between the hotel and Somerset Parkway. These two connected ponds attract an unnaturally



high concentration of waterfowl in ponds that are closest to the water supply.

There are a large number of waterfowl that frequent these ponds and it appears that the general public and guests of the hotel are feeding these ducks. The ducks should to be discouraged from these two ponds and their reliance upon public feeding must be stopped at this location due to the impact on water quality

3.2.2 Water Quality Threat

The abundance of waterfowl (see Figure 3-6) that defecate both in and along the banks of the Crowne Plaza detention ponds are a source for both bacteria and phosphorus. Currently, both bacteria and phosphorus pose the most significant threat to Pennichuck's water supply. The reasons for this are twofold.

First, water high in algal matter and bacteria place additional burdens (and therefore costs) on the treatment plants filtering and flocculation processes. Second, threats to Pennichuck's water supply relate to long-term reduction in storage capacity due to excess phosphorus inputs. Phosphorus-laden waters support enhanced flora and fauna production in the reservoirs. The yearly die off results in accumulation of biomatter within the reservoirs and the space that this biomatter occupies is not available for water storage. The likelihood of internal phosphorus cycling in the reservoirs from bottom sediments is also enhanced as a result of anoxic conditions that may form due to the increased decomposition of organic matter and associated oxygen demand.

3.2.3 Method of Correction

A multifaceted approach is necessary to control waterfowl. Public education in the form of signs around the pond and leaflets in the lobby of the hotel would be useful in explaining to guests the importance of not feeding ducks at this location. Articles in the paper and leaflets in the lobbies of the adjacent businesses will reach locals and employees who might otherwise spend a lunch hour feeding the ducks. If ineffective, an ordinance prohibiting the feeding activity may be needed. Three methods of deterrents and ordinance adoption are explained below.

Educational Outreach

Educational materials should not only stress the water quality issues involved, but should also mention the detrimental effects on the waterfowl themselves. Ducks that are fed bread can develop metabolic bone disease and other nutritional diseases. Additionally ducks that migrate need not be fed, but feeding ducks leads to human dependency and increases the likelihood of diseases spreading through the flock due to the limited gene pool. Moreover high concentrations of ducks in close proximity to humans also presents possible public health threats. Duck



feeding need not be the focus of all public education efforts; it could for example also occupy a portion of a leaflet or article on how the average citizen can make a difference in their community's water quality.

Structural Deterrents

Structural deterrents are numerous, but many are impractical for this compact urban setting. One method that has been used successfully once the human food source has been eliminated is to make a pond unattractive to ducks by suspending small diameter wire slightly above the water surface in a grid network. Purchase and installation of gridding can be expensive, but many variations of this deterrent idea are possible using cheaper materials or limiting its installation to only those areas preferred by ducks (see Figure 3-7). Grids for ducks should be five feet by five feet and heights may be from two inches to three feet off of the water.

Feeding Deterrents

An option to deter ducks from these two ponds is the use of a natural substance found in grape flavoring. Some trials have shown this product (sold under the trade name of Bird Shield) to be effective at deterring ducks when applied to grass or water. Some users feel that the product must be re-applied too frequently to be of value when compared to other deterrents. The product is food grade and would impart a grape flavor to the water if applied directly on the water and therefore is not recommended for direct application to drinking water sources. Applying the product to the root zone of the grass surrounding the ponds would deter the ducks from eating it. The manufacturer claims that if properly applied with a high pressure (50 psi) injection-type boom sprayer the substance with its coagulative properties tends to adhere to the roots and generally resists washoff. Again if this product is used it should be on a trial basis and only when human feeding of ducks has ceased and the ducks have taken to eating the grass surrounding the ponds.

Ordinance Adoption

The use of the aforementioned deterrents will tend to encourage waterfowl to move into areas where citizen feeding of waterfowl still takes place and the waterfowl are not disturbed. Because of this the City of Nashua should consider adopting an ordinance against feeding waterfowl in and around waterbodies that flow to Pennicuck's water supply. Cities in many other areas have adopted ordinances that prohibit the feeding of wildlife to reduce the health risks to humans.

3.2.4 Estimated Costs

- Public education need not be costly if press releases are used. Generating and submitting a series of press releases would cost approximately \$200 per release
- A rough estimate to produce and distribute three-fold brochure is \$5,000.



- Signage can be done for about \$100 per sign.
- Wire gridding to cover both detention ponds including installation would cost between \$7,000 and \$9,000.
- Bird Shield costs about \$70 gallon with one gallon covering approximately 21,000 square feet. Bird Shield should be applied every three weeks or after mowing. Assuming four to six applications, material costs would be roughly \$500. Application with a 50 psi boom sprayer is required.
- Adopting a town ordinance to restrict waterfowl feeding would not result in any out of pocket expenses, however enforcement of this ordinance would require up to one hour per day of a police officers time and it may be difficult to get the cooperation of the police considering the life and death nature of many of their other duties.

3.2.5 Annual Maintenance Requirements

Maintenance of the wire gridding would consist of periodically cleaning the wires of any unsightly debris that may have accumulated on them, and occasionally tightening any sagging wires. Specifying construction of the gridding with either stainless steel wiring or a UV stable product will limit the need for replacement to seven years to ten years.

3.2.6 Funding Sources

This project is eligible for grant funding under the New Hampshire Department of Environmental Services's Drinking Water Protection Program:

- *Local Water Protection Grants* – typically due by November 15th.
- *Drinking Water Protection Projects*-typically due by November 15th

3.2.7 Ownership

Crowne Plaza Site:
Sam Hospital Corp.
Continental Wingate
63 Kendrick Street
Needham, MA 02494

3.2.8 Implementation Difficulty

The major obstacle in implementing any of these deterrents is that feeding of the ducks must be stopped if any of the other strategies are going to be employed. Additionally, behavior modifications (for humans) represent not only the most important part in waterfowl deterrence, but will also require the most effort and persistence.



Signage around the detention ponds and literature in the form of leaflets should be implemented to help support and publicize efforts to reduce waterfowl concentrations. Later, a couple of articles in the local paper would help to reinforce the importance of this endeavor to those who ignore the postings and leaflets, and inform other citizens not exposed the direct efforts of postings and leaflets. Articles will in time create a social pressure where it is unacceptable to feed ducks. For some citizens, for example, this social pressure has worked well in preventing littering when signs warning of a \$250 fine have not. Lastly, a local ordinance should be adopted and enforced to restrict those individuals not deterred by the aforementioned approaches

If substantial reductions in waterfowl are not noted despite successful public cooperation, a structural method of deterrent should be used. Gridding or another low cost option that has the effect of inconveniencing the waterfowl should be the next step. Lastly, Bird Shield or a similar product might be tried on the grass to make the grass surrounding the pond unpalatable to the ducks. The marketers of Bird Shield confirmed that Bird Shield is food grade, however, other manufacturers should be contacted to assure their products are drinking water compatible when applied to grass.





Figure 3-1. Settling of Large Particles

NOTES:

1. Remove existing Rip Rap swale lining and reuse as sediment forebay liner.
2. Widen and flatten swale to forebay.
3. Excavate forebay and install gabion outlet structure.
4. Reline swale with turf reinforcing material and seed.

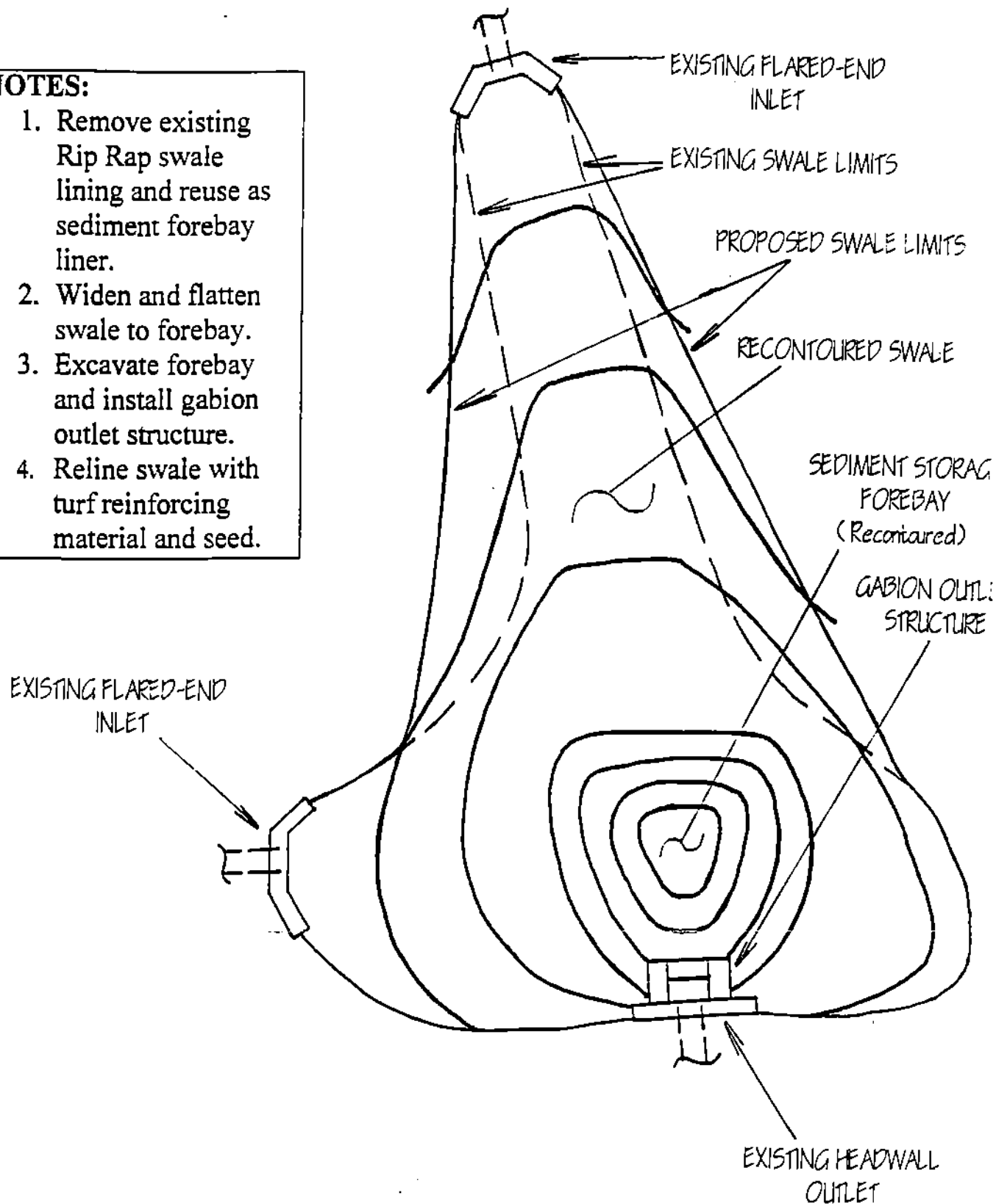


Figure 3-2-A
Conceptual Slope
Stabilization Plan

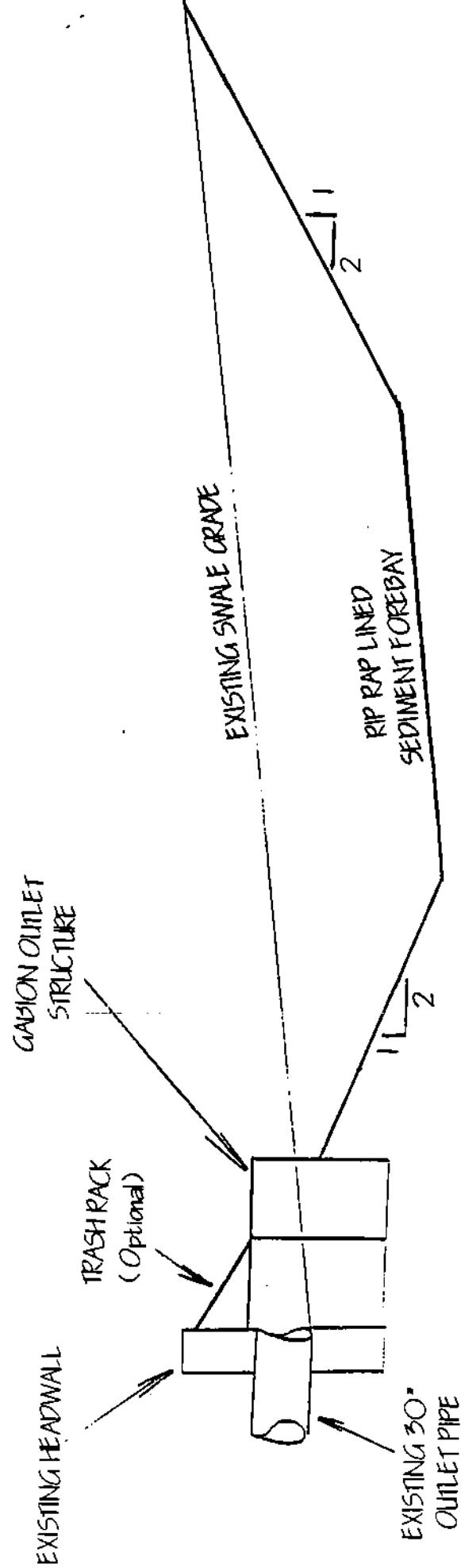


Figure 3-2-B
Sediment Forebay
Detail
Not to Scale



Figure 3-3. Turf Reinforcement Material

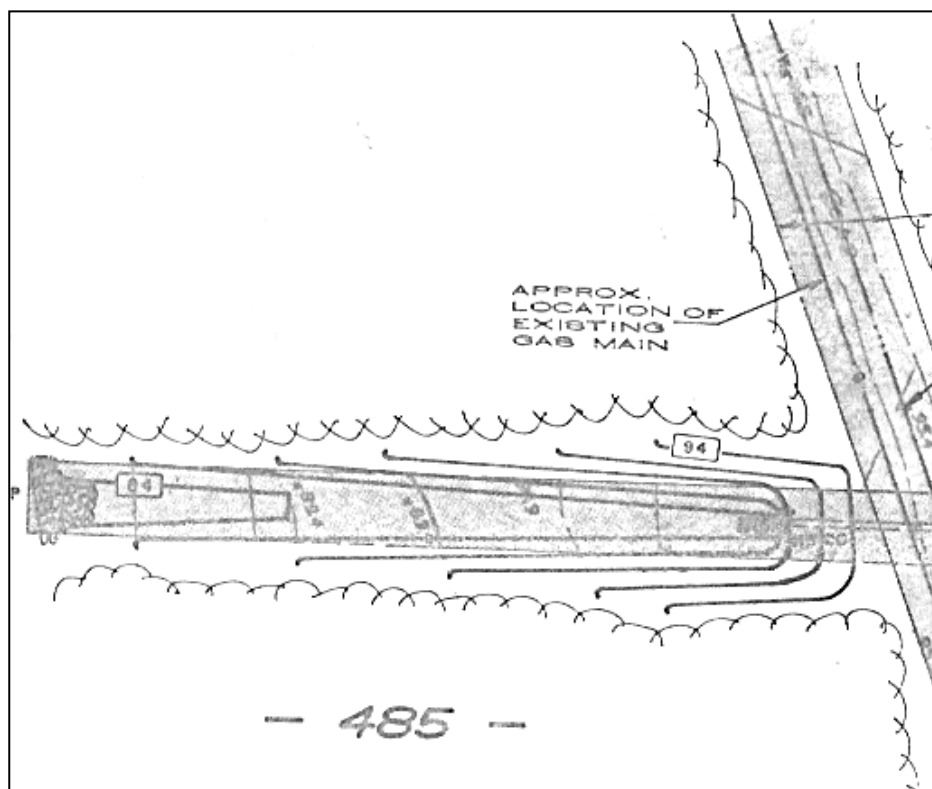


Figure 3-4. Original Swale Design



Figure 3-5. Crowne Plaza Detention Ponds



Figure 3-6. Typical Waterfowl Concentrations in Crowne Plaza Pond



Figure 3-7. In both winter and summer, ducks preferred this narrow pond. Installation of physical deterrents here are less costly.

4.0 Other recommendations

Based on days spent in the field (most of which were during rainstorms), a number of issues were noted. While alone, single acts or practices may not represent as significant or direct threat to water quality as those mentioned for BMP implementation, the consistency with which many of these issues were found deserves attention.

The following presents a short description of six of the most important issues and brief recommendations.

4.1 Maintenance/Overuse of Detention Ponds

Many detention ponds throughout the subwatershed appear to be working well. The accumulation of sediment within the ponds shows that they work. While a detailed review of design criteria for these ponds was not conducted, the accumulated volume of sediment may soon be affecting the treatment efficiencies due to significantly shortened detention times. Whether this accumulation is from lack of maintenance or other users tying into the pond is unclear.

It is recommended that developers proposing water quality structures in the future be required to submit and adhere to a thorough Operations and Maintenance Plan (O&M Plan). Provisions in the design and plan should allow the lay person (such as a Conservation Commission Member) to be able to check compliance with such a plan. For example placing a permanent measuring gauge or rod in the sedimentation pond that can be read from the shore would enable the owner or enforcing individual to easily recognize the need for maintenance or compliance with the O & M Plan. Provisions allowing either the Nashua Department of Public Works or Pennichuck Water Works to perform maintenance and back charge the landowner should also be included to address the issue should the owner refuse to perform required routine and special maintenance. Lastly, bylaws should empower an entity to fine for violations of the O & M Plan.

4.2 Aesthetics of Detention Ponds and Other Structures

The accumulation of trash and garbage in many of the water quality structures should be removed by the property owners. While this refuse may not be a direct threat to water quality, it gives the general public a bad impression about the effectiveness of stormwater treatment devices. In fact detention ponds and swales can blend in and even enhance the visual appearance and character of a development. Developers are far more likely to go beyond just the minimum requirements when designing



and constructing stormwater treatment devices if their clients view them as an asset to the appearance and landscaping design.

4.3 Storage and Disposal of Street Sweepings

Sweeping parking lot sediments saves catch basin cleaning costs and is beneficial to water quality. However a common practice in this watershed is to pile the sweepings uncovered near the corner of a parking lot or worse, in and on the slopes of drainage swales. Most owners and contractors may not be sweeping parking lots to prevent sediment entrainment in stormwater during rainstorms. Therefore contractors should be educated about proper storage and disposal of these sediments if their sweeping efforts are to have substantial water quality benefits. This should also be discussed by the Nashua Public Works Department.

4.4 Sullivan Tire Runoff

There is a significant ponding problem that occurs on the northeastern portion of the Sullivan Tire property (see Figure 4-1. at the end of this section). Currently runoff from the northeastern portion of the Sullivan Tire parking lot travels to the northern perimeter swale that flows around the Somerset Plaza. However sediment in the swale and curbing along the Sullivan lot prevent efficient drainage of the site. The resulting ponding that occurs both on the Sullivan parking lot and in a grassy area to the northeast can be six to eight inches deep.

Simply cleaning out the accumulated sediments would solve the ponding problem, however from a water quality standpoint, the frequent appearance of a petroleum sheen (Figure 4-2.) on the surface of the water indicates that the ponding “problem” may, in the short term, act to help treat the water. The ponding that occurs now detains the water and thus gives the floatable material a chance to degrade.

A long-term solution to eliminate the source of this petroleum should be sought. If the source is intermittent or diffused and inherent for this auto service facility, a floatables hood could be installed in the downstream catchbasin once the ponding problem on the grass has been eliminated.

4.5 Paint Disposal in Catchbasin

During field review of drainage, a painting contractor was spotted dumping paint or paint thinner into the storm drain (Figure 4-3.). Although this was an isolated instance, it highlights the need to effectively educate the general public of the connection between the drainage system and the water supply. Catchbasin templating programs might be helpful. Some towns enlist the efforts of The Boy Scouts or other volunteer groups to go out and paint a brief warning on the pavement surrounding a catch basin that the water entering the basin



drains to the river or reservoir. Annual repainting can become an educational project of great benefit.

4.6 Scum Found on Stormwater Near Bank

On one occasion a thick black floating scum (Figure 4-4.) was seen floating on the water at a stormwater discharge pipe near the Bank Boston drive thru. The scum looked similar to that found at wastewater discharges. A sewer manhole was quite close to this location however no surface evidence of linkage between the two was found. This area should be tested for bacteria under various weather conditions. This maybe able to be incorporated into Nashua's Phase II stormwater program.





Figure 4-1. Ponding Problem at Sullivan Tire



Figure 4-2. Petroleum Sheen at Sullivan Tire

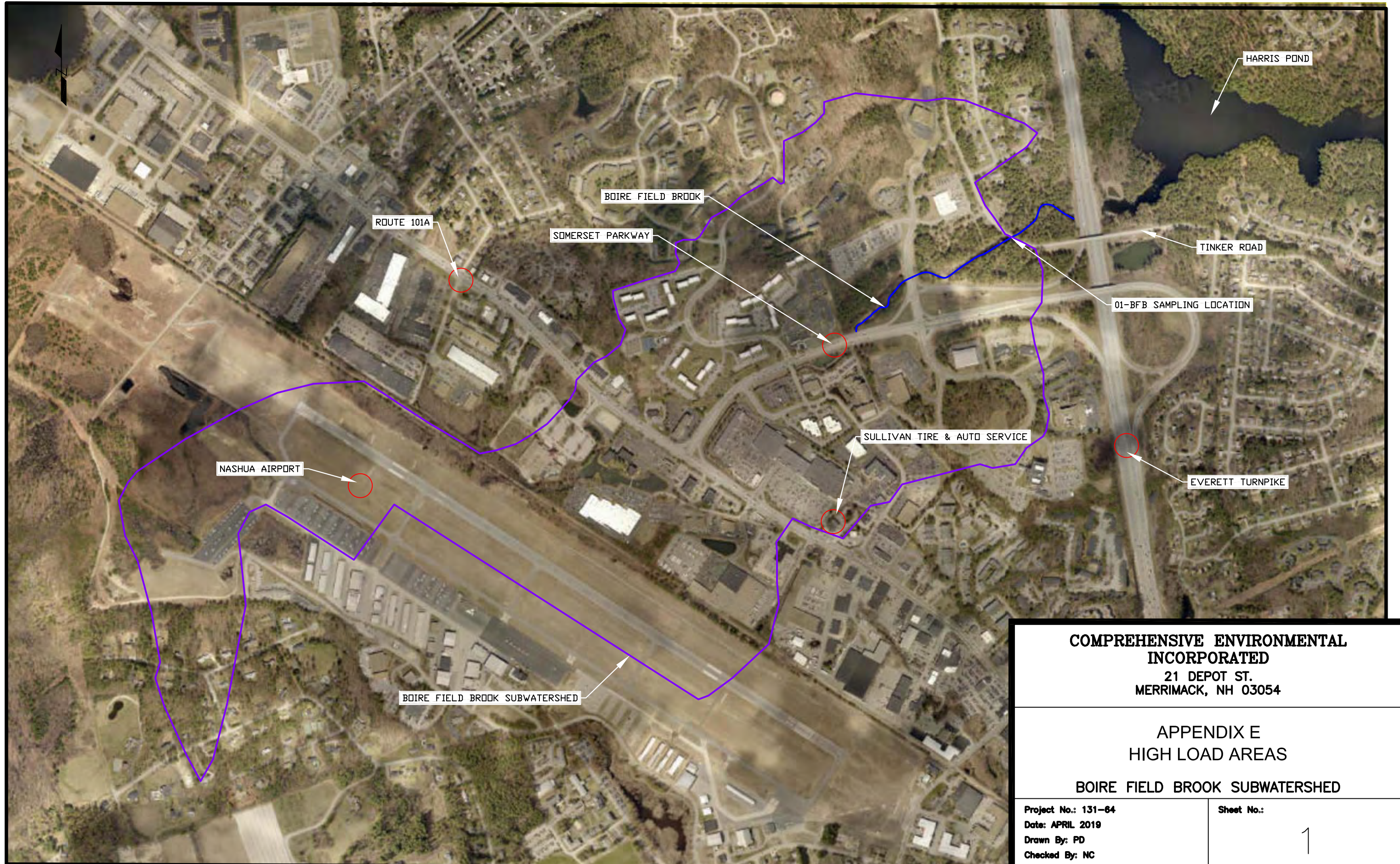


Figure 4-3. Paint Thinner Being Dumped in Catchbasin



Figure 4-4. Scum Found at Stormwater Discharge Near Bank Boston

APPENDIX E
High Load Areas Map



**COMPREHENSIVE ENVIRONMENTAL
INCORPORATED**
21 DEPOT ST.
MERRIMACK, NH 03054

**APPENDIX E
HIGH LOAD AREAS**

BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=800'

Sheet No.:

1

APPENDIX F

BFB Subwatershed Assessment Summary Matrix and Photographs

Boire Field Brook Subwatershed Assessment Summary							
BMP Site		Existing BMP Type(s)	Coordinates (lat/long)	Location Description	Subcatchment	Outfalls	Condition
1	Building 19 Pond	Wet Basin	42.786836, -71.514115	Located south of Route 101A; northwest of Birch Pond. The pond is in front of an abandoned building and parking lot.	Based on topography, this BMP collects stormwater runoff from the adjacent building, parking lot, driveways, and grassed areas, and a portion of Route 101A; this subcatchment is 9.5 acres.	One outfall to Building 19 Pond was observed in the left culvert headwall; the exact drainage area that is conveyed to the outfall, based on the drainage system, is not known. Ultimately, Building 19 Pond is culverted under the driveway to the northwest arm of Birch Pond.	The pond was in fair condition at the time of the inspection; there were no signs of algal blooms, excessive aquatic plants, odors, or discoloration. The pond banks were eroded in some areas, particularly along the guardrail, and there was fallen woody vegetation along the northwest side of the pond.
2	Birch Pond	Wet Basin	42.785097, -71.512749	Located south of Route 101A; southeast of the Building 19 Pond. The pond is behind the existing Internal Revenue Service and Bertucci's Italian Restaurant buildings and parking areas, and in front of the large Seaboard International Forest Products building and parking area.	Based on topography, this BMP collects stormwater runoff from the surrounding buildings, parking lots, driveways, and grassed areas, and a portion of Route 101A; this subcatchment is 19.0 acres.	Two outfalls to Birch Pond were observed at the northwest arm of the pond, originating from Building 19 Pond (culvert outfall) and a drainage swale (pipe) located just north. Three outfalls were observed within the main body of the pond; the exact drainage area that is conveyed to the outfalls, based on the drainage system, is not known. Ultimately, Birch Pond is culverted under a driveway to Cotton Road Pond and a discharge channel located east of the pond. The channel is culverted under Route 101A and discharges to the Somerset Parkway Swales.	The pond was in good condition at the time of the inspection; there were no signs of algal blooms, excessive aquatic plants, odors, or discoloration. Some bank undercutting and erosion was observed in some areas of the main body of the pond. The discharge channel was heavily littered with trash and debris. The pond also encounters large populations of waterfowl. Signs have been installed to discourage the public from feeding the wildlife in an attempt to deter the growth of the waterfowl population.
3	Cotton Road Pond	Wet Basin	42.783286, -71.508908	Located south of Cotton Road and Route 101A; southeast of Birch Pond. The pond is surrounded by several commercial/office buildings and their associated parking areas; surrounding buildings include Brayman Houle Keating, Freedom CAD Services, Inc., and Hudson RPM Distributors.	Based on topography, this BMP collects stormwater runoff from the surrounding buildings, parking lots, driveways, and grassed areas, and a portion of Route 101A; this subcatchment is 19.1 acres.	One culvert outfall to Cotton Road Pond was observed at the northwest corner of the pond, originating from Birch Pond. Two outfalls were observed on the southeast side of the pond; the exact drainage area that is conveyed to the outfalls, based on the drainage system, is not known. The ultimate destination of Cotton Road Pond is unknown; however, there was an existing culvert structure and building on the east side of the pond.	The pond was in good condition at the time of the inspection; there were no signs of algal blooms, excessive aquatic plants, odors, or discoloration. Some bank undercutting and erosion was observed in some areas of the pond, particularly near the two southeast outfalls.
4	Somerset Parkway Swales	Water Quality Swale (Wet)	(1) 42.785651, -71.509428 (2) 42.787515, -71.507155 (3) 42.787813, -71.505272	Consists of a series of three wet water quality swales located along the westbound side of Route 101A and eastbound side of Somerset Parkway. The series of swales starts south of Somerset Plaza along Route 101A and ends adjacent to the northwestern DoubleTree Hotel Pond.	Based on topography, these BMPs collect stormwater runoff from a large portion of Kessler Farm housing development, Route 101A, Somerset Parkway, and a portion of the Somerset Plaza and DoubleTree Hotel parking lots and driveways; this subcatchment is 56.4 acres.	(1) Two outfalls to the beginning of the first segment of Somerset Parkway Swales were observed; the exact drainage area that is conveyed to the outfalls, based on the drainage system, is not known. One outfall was observed near the intersection of Somerset Parkway and Route 101A, likely originating from the Birch Pond discharge swale. One outfall was observed at the end of the first segment, originating from the Somerset Plaza Perimeter Swale. The first segment of the swales is culverted under Trafalgar Square to the second segment. (2) The second segment of the swales is culverted under another driveway to the third segment and partially to the northwestern DoubleTree Hotel Pond. (3) Two outfalls to the third segment of the swales were observed, originating from both of the DoubleTree Hotel Ponds. Ultimately, the third segment of the Somerset Parkway Swales is culverted under Somerset Parkway to Boire Field Brook.	At the time of inspection the swales were in good condition. Erosion and debris/sediment buildup was observed in the first segment downstream of the Birch Pond discharge swale outfall. There was also an odor in this area. Overall, side slopes were mowed and well maintained, the swales were well established with vegetation, and some slopes have been stabilized with riprap.
5	DoubleTree Hotel Ponds	Wet Basin	(1) 42.788070, -71.505260 (2) 42.787200, -71.504863	Consists of two wet basins located west and northwest of the existing DoubleTree Hotel building.	Based on topography, these BMPs collect stormwater runoff from the DoubleTree Hotel parking lot and driveways, the building, parking area, and cul-de-sac behind the hotel, and a portion of Somerset Parkway and Trafalgar Square; this subcatchment is 17.1 acres.	(1) Two outfalls to the western DoubleTree Hotel Pond were observed on the south end and east side of the pond; the exact drainage area that is conveyed to the outfalls, based on the drainage system, is not known. One outfall was observed on the north side of the pond, adjacent to the culvert inlet and originating from a nearby drainage swale. (2) One outfall to the northwestern Double Tree Hotel Pond was observed at the west side, originating from the second segment of the Somerset Parkway Swales. One outfall was also observed at the north side of the pond; the exact drainage area that is conveyed to the outfall, based on the drainage system, is not known. Ultimately, both DoubleTree Hotel Ponds are culverted to the third segment of the Somerset Parkway Swales and then to Boire Field Brook.	The ponds were in good condition at the time of the inspection; there were no signs of algal blooms, excessive aquatic plants, odors, or discoloration. There was minor bank erosion in some areas of the northwestern DoubleTree Hotel Pond, along the side of Somerset Parkway. Additionally, some slope erosion was observed at the drainage swale that discharges to the western DoubleTree Hotel Pond. The pond also encounters large populations of waterfowl.
6	Somerset Plaza Perimeter Swale	Biofilter Swale	42.785816, -71.505659	Located along the northern edge of the Somerset Plaza parcel and the southern edge of Trafalgar Square area, or behind the large Somerset Plaza retail building.	Based on topography, this BMP collects stormwater runoff from a large portion of Trafalgar Square area and the northern part of Somerset Plaza, which includes buildings, parking areas, driveways, and grassed areas; this subcatchment is 25.2 acres.	One outfall to the Somerset Plaza Perimeter Swale was observed at the southeast end of the swale. Another outfall was observed near the center of the swale. The exact drainage area that is conveyed to the outfalls, based on the drainage system, is not known. Ultimately, the swale is piped and discharged to a drainage swale to the northwest, which leads to the culvert inlet of the first segment of the Somerset Parkway Swales.	At the time of inspection the swale was in fair condition. There were many signs of bank erosion throughout the swale, but particularly at the beginning of the swale at the outfall. Some curb breaks had riprap spillways that were maintained, while others were not. Debris and trash buildup was observed throughout the swale. Orange/rust-colored water was pooling around the outfall at the center of the swale.
7	Sullivan Tire Vegetated Area	Vegetated Filter Strip	42.784229, -71.504217	Located at the north side of the Sullivan Tire parking lot; the lot is located just east of the Somerset Plaza/Market Basket parking area and southeast of the Somerset Plaza Perimeter Swale.	Based on topography, this BMP collects stormwater runoff from the Sullivan Tire parking lot and immediate surroundings, including a small portion of the Somerset Plaza parking lot; this subcatchment is 2.2 acres.	No stormwater outfalls discharging to the Sullivan Tire Vegetated Area were observed.	At the time of inspection the vegetated area was in poor condition. The area was filled with dead vegetation, grass clippings, debris, and trash. There was no noticeable depression where stormwater would typically collect for infiltration or conveyance. Additionally, at the time of the inspection, stormwater was observed to be collecting at the back of the lot and not fully draining to the drainage area. In the 2000 Study, it was noted that an oily sheen was observed in the puddled area.
8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin	42.790685, -71.503412	Located adjacent to the parking lot to the south; the detention basin is directly north of BFB and west of North Southwood Drive.	Based on topography, this BMP collects stormwater runoff from the majority of the Park & Ride Lot; this subcatchment is 3.6 acres.	No stormwater outfalls discharging to the Park & Ride Lot Detention Basin were observed. The basin contains a structure; the purpose of this structure is unknown. An emergency spillway is located on the northeast end of the basin, and leads to an inlet; the destination of this inlet is unknown.	At the time of inspection the detention basin was in good condition, there were only minor signs of erosion around the riprap of the emergency spillway. Vegetation within the basin was well established and maintained.

Boire Field Brook Subwatershed Assessment Summary							
BMP Site		Existing BMP Type(s)	Coordinates (lat/long)	Location Description	Subcatchment	Outfalls	Condition
9	Postal Service Vegetated Areas	Vegetated Filter Strip	(1) 42.791386, -71.501648 (2) 42.791653, -71.501567 (3) 42.792408, -71.501715	Consists of three vegetated areas located along North Southwood Drive and west of the Postal Service Building.	Based on topography, these BMPs collect stormwater runoff from the whole Postal Service building and parking area, a portion of North Southwood Drive, a portion of Tinker Road, and adjacent grassed areas; this subcatchment is 7.9 acres.	(1) Three outfalls to the first Postal Service Vegetated Area were observed at the west side and center of the vegetated area. (2) One outfall to the second vegetated area was observed on the south side of the vegetated area. (3) Two outfalls to the third vegetated area were observed at the south side of the vegetated area. The exact drainage area that is conveyed to the outfalls, based on the drainage system, is not known.	At the time of inspection the vegetated areas were in fair condition. The first vegetated area was overgrown with vegetation near one of the outfalls and there was minor signs of erosion near the outfalls to the second and third vegetated areas.
10	Cornerstone Drive Swale	Biofilter Swale	42.793687, -71.501226	Located north of the Postal Service at the end of North Southwood Drive, off of Cornerstone Drive.	Based on topography, this BMP collects stormwater runoff from the majority of the Cornerstone building and parking area, a portion of North Southwood Drive, a portion of Tinker Road, and a large grassed or vegetated area; this subcatchment is 12.2 acres.	One outfall (flared end section) to the Cornerstone Drive Swale was observed at the top of a steep hill just northwest of the basin; the exact drainage area that is conveyed to the outfall, based on the drainage system, is not known. The outfall discharges to the vegetated and riprap swale to an inlet surrounded by a baffle structure for pretreatment; the destination of this inlet is unknown.	At the time of inspection the swale was in fair condition, there were no signs of sediment buildup. However, the outfall area appeared to be slightly eroded from stormwater flow from the flared end and the slope/bank stabilization fabric of the swale has not been fully stabilized with vegetation.
11	Boire Field Brook Outlet to Harris Pond	Wet Basin	42.791733, -71.495353	Located east of Everett Turnpike and in between two BMPs constructed for Harris Pond.	Ultimately, stormwater from the entire BFB subwatershed is discharged to this area, including stormwater from a large portion of Everett Turnpike. BFB subwatershed is 496.3 acres, the immediate subcatchment of this outlet is approximately 9.4 acres.	One outfall to Harris Pond was observed, originating from Boire Field Brook which is culverted under Everett Turnpike.	The area was in good condition at the time of the inspection; some aquatic vegetation build-up was observed near the Boire Field Brook outlet. The two BMPs on either side of the the outfall to Harris Pond consisted of a sediment forbay with outlet control structures (OCSs), a turbidity curtain, and a riprap overflow spillway. These BMPs trap any pollutants, sediment, or debris that runs off from Everett Turnpike before water discharging into Harris Pond; the BMP south of the Boire Field Brook outlet contained stagnant water with an oil sheen.
12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	42.789540, -71.500781	Located along the westbound lane of Somerset Parkway to the east of the North Southwood Drive/Southwood Drive intersection. The detention basin is directly south of BFB and east of North Southwood Drive.	Based on topography, this BMP collects stormwater runoff from the surrounding roads, including Somerset Parkway; this subcatchment is 7.0 acres.	Five outfalls to Somerset Parkway Detention Basin were observed. One of the outfalls, located on the south side, originates from the Somerset Parkway / Southwood Drive Swales. The the exact drainage area that is conveyed to the other four outfalls, based on the drainage system, is not known. Ultimately, Somerset Parkway Detention Basin is culverted under the southbound Everett Turnpike Exit 8 off ramp and discharged to Boire Field Brook.	At the time of inspection the detention basin was in good condition, there was no sediment buildup. Minor erosion and trash was observed at some of the outfalls. Vegetation was well established and maintained.
13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale	(1) 42.788471, -71.502197 (2) 42.788915, -71.500559	Consists of a series of two biofilter swales located along the either side of the Southwood Drive intersection on the eastbound side of Somerset Parkway. The series of swales starts adjacent to the northwest DoubleTree Hotel Ponds and ends opposite of the Somerset Parkway Detention Basin.	Based on topography, this BMP collects stormwater runoff from the surrounding parking areas, buildings, and roads, including Somerset Parkway and Southwood Drive; this subcatchment is 26.2 acres.	(1) One outfall to the end of the first segment of Somerset Parkway / Southwood Drive Swales was observed near the culvert inlet; the exact drainage area that is conveyed to the outfall, based on the drainage system is not known. The first segment is culverted under Southwood Drive to the second segment. (2) Ultimately, the second segment of the Somerset Parkway / Southwood Drive Swales is culverted under Somerset Parkway to the Somerset Parkway Detention Basin and then to Boire Field Brook.	At the time of inspection the swales were in good condition, there were no signs of sediment buildup. Minor erosion and trash was observed at the end of the first segment of the swales.

Appendix F – Subwatershed Assessment Photos



BMP SITE 1: Building 19 Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 1: Building 19 Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 1: Building 19 Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Birch Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Drainage Swale to Birch Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Birch Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Birch Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Birch Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Birch Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Birch Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Birch Pond/Birch Pond Discharge Channel

Appendix F – Subwatershed Assessment Photos



BMP SITE 2: Birch Pond Discharge Channel

Appendix F – Subwatershed Assessment Photos



BMP SITE 3: Cotton Road Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 3: Cotton Road Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 3: Cotton Road Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 3: Cotton Road Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 4: Somerset Parkway Swales

Appendix F – Subwatershed Assessment Photos



BMP SITE 4: Somerset Parkway Swales

Appendix F – Subwatershed Assessment Photos



BMP SITE 4: Somerset Parkway Swales

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BMP SITE 4: Somerset Parkway Swales

Appendix F – Subwatershed Assessment Photos



BMP SITE 5: DoubleTree Hotel Ponds

Appendix F – Subwatershed Assessment Photos



BMP SITE 5: DoubleTree Hotel Ponds

Appendix F – Subwatershed Assessment Photos



BMP SITE 5: DoubleTree Hotel Ponds

Appendix F – Subwatershed Assessment Photos



BMP SITE 5: Drainage Swale to DoubleTree Hotel Ponds

Appendix F – Subwatershed Assessment Photos



BMP SITE 6: Somerset Plaza Perimeter Swale

Appendix F – Subwatershed Assessment Photos



BMP SITE 6: Somerset Plaza Perimeter Swale

Appendix F – Subwatershed Assessment Photos



BMP SITE 6: Somerset Plaza Perimeter Swale

Appendix F – Subwatershed Assessment Photos



BMP SITE 6: Somerset Plaza Perimeter Swale

Appendix F – Subwatershed Assessment Photos



BMP SITE 6: Somerset Plaza Perimeter Swale

Appendix F – Subwatershed Assessment Photos



BMP SITE 6: Somerset Plaza Perimeter Swale

Appendix F – Subwatershed Assessment Photos



BMP SITE 7: Sullivan Tire Vegetated Area

Appendix F – Subwatershed Assessment Photos



BMP SITE 8: Park & Ride Lot Detention Basin

Appendix F – Subwatershed Assessment Photos



BMP SITE 8: Park & Ride Lot Detention Basin

Appendix F – Subwatershed Assessment Photos



BMP SITE 8: Park & Ride Lot Detention Basin

Appendix F – Subwatershed Assessment Photos



BMP SITE 9: Postal Service Vegetated Areas

Appendix F – Subwatershed Assessment Photos



BMP SITE 9: Postal Service Vegetated Areas

Appendix F – Subwatershed Assessment Photos



BMP SITE 9: Postal Service Vegetated Areas

Appendix F – Subwatershed Assessment Photos



BMP SITE 10: Cornerstone Drive Swale

Appendix F – Subwatershed Assessment Photos



BMP SITE 10: Cornerstone Drive Swale

Appendix F – Subwatershed Assessment Photos



BMP SITE 11: Boire Field Brook Outlet to Harris Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 11: Boire Field Brook Outlet to Harris Pond

Appendix F – Subwatershed Assessment Photos



BMP SITE 12: Somerset Parkway Detention Basin

Appendix F – Subwatershed Assessment Photos



BMP SITE 12: Somerset Parkway Detention Basin

Appendix F – Subwatershed Assessment Photos



BMP SITE 12: Somerset Parkway Detention Basin

Appendix F – Subwatershed Assessment Photos



BMP SITE 12: Somerset Parkway Detention Basin

Appendix F – Subwatershed Assessment Photos



BMP SITE 13: Somerset Parkway / Southwood Drive Swales

Appendix F – Subwatershed Assessment Photos



BMP SITE 13: Somerset Parkway / Southwood Drive Swales

Appendix F – Subwatershed Assessment Photos



BMP SITE 13: Somerset Parkway / Southwood Drive Swales

APPENDIX G
BFB Corridor Walk Summary Matrix and Photographs

Boire Field Brook Corridor Walk Summary				
Corridor Site		Coordinates (lat/long)	Northing (US Survey Feet)	Easting (US Survey Feet)
<i>Somerset Parkway Swale</i>				
1	Somerset Parkway culvert inlet from Somerset Parkway Swales (south side of crossing)	42.788343, -71.504566	105126.075	1027762.653
2	Somerset Parkway culvert outlet (north side of crossing)	42.788749, -71.504480	105274.086	1027785.454
3	North Southwood Drive culvert inlet (west side of crossing)	42.790062, -71.502550	105753.613	1028302.589
4	North Southwood Drive culvert outlet (east side of crossing)	42.790229, -71.502059	105814.733	1028434.265
5	North Southwood Drive On-Ramp culvert outlet from Somerset Parkway Detention Basin (north side of crossing)	42.789966, -71.501025	105719.426	1028712.002
6	Sediment deposit/debris build-up within the stream. Possible beaver activity.	42.790417, -71.500453	105884.132	1028865.128
7	Sediment deposit/debris build-up within the stream. Possible beaver activity.	42.790995, -71.499236	106095.353	1029191.379
8	Tinker Road culvert inlet (south side of crossing)	42.791144, -71.498985	106149.832	1029258.731
9	Tinker Road culvert outlet (north side of crossing)	42.791237, -71.498899	106183.772	1029281.747
10	Bank erosion and undercutting due to larger flows	42.791200, -71.498600	106170.446	1029362.031
11	Sediment deposit within the stream	42.791404, -71.498333	106244.771	1029433.636
12	Bank erosion and undercutting due to larger flows	42.791837, -71.497859	106402.998	1029560.349
13	Trash/debris build-up within the stream. Possible beaver activity.	42.791735, -71.497081	106366.157	1029769.262
14	Discolored water/oily sheen; likely from stormwater runoff from major roadways, including Everett Turnpike	42.791740, -71.496870	106367.991	1029826.126
15	Everett Turnpike culvert inlet (west side of crossing)	42.791625, -71.496664	106326.380	1029881.375
16	Everett Turnpike culvert outlet (east side of crossing)	42.791575, -71.495707	106308.676	1030138.286
<i>Boire Field Brook Outlet to Harris Pond</i>				

Appendix G – Corridor Walk Photos



**Corridor Site 1: Somerset Parkway culvert inlet from Somerset Parkway Swales
(south side of crossing)**

Appendix G – Corridor Walk Photos



Corridor Site 2: Somerset Parkway culvert outlet (north side of crossing)

Appendix G – Corridor Walk Photos



Corridor Site 3: North Southwood Drive culvert inlet (west side of crossing)

Appendix G – Corridor Walk Photos



Corridor Site 4: North Southwood Drive culvert outlet (east side of crossing)



Corridor Site 5: North Southwood Drive On-Ramp culvert outlet from Somerset Parkway Detention Basin (north side of crossing)

Appendix G – Corridor Walk Photos



Corridor Site 6: Sediment deposit/debris build-up within the stream; possible beaver activity

Appendix G – Corridor Walk Photos



Corridor Site 7: Sediment deposit/debris build-up within the stream; possible beaver activity

Appendix G – Corridor Walk Photos



Corridor Site 8: Tinker Road culvert inlet (south side of crossing)

Appendix G – Corridor Walk Photos



Corridor Site 9: Tinker Road culvert outlet (north side of crossing)

Appendix G – Corridor Walk Photos



Corridor Site 10: Bank erosion and undercutting due to larger flows



Corridor Site 11: Sediment deposit within the stream

Appendix G – Corridor Walk Photos



Corridor Site 12: Bank erosion and undercutting due to larger flows



Corridor Site 13: Trash/debris build-up within the stream; possible beaver activity



Corridor Site 14: Discolored water/oily sheen; likely from stormwater runoff from major roadways, including Everett Turnpike

Appendix G – Corridor Walk Photos



Corridor Site 16: Everett Turnpike culvert outlet (east side of crossing)

APPENDIX H

Boire Field Brook Drone Imagery

An aerial photograph showing a multi-lane highway running horizontally across the lower half of the frame. A white car is visible in the leftmost lane. To the right of the highway is a grassy area with patches of snow. A black arrow points from a text box to a small inlet in the grass. The background is a dense forest of evergreen trees.

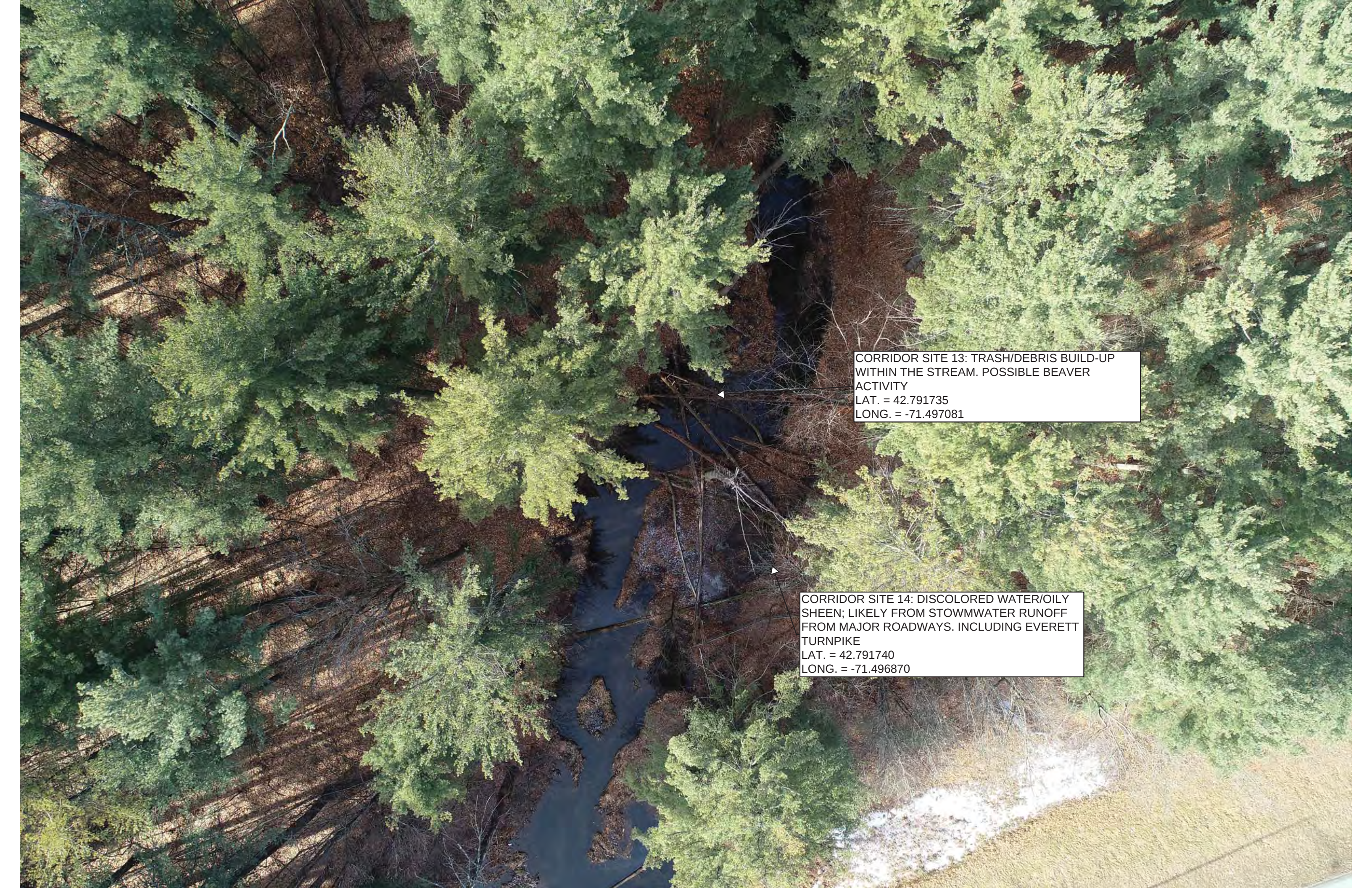
CORRIDOR SITE 15: EVERETT TURNPIKE
CULVERT INLET (WEST SIDE OF CROSSING)
LAT. = 42.791625
LONG. = -71.496664



CORRIDOR SITE 13: TRASH/DEBRIS BUILD-UP
WITHIN THE STREAM. POSSIBLE BEAVER
ACTIVITY
LAT. = 42.791735
LONG. = -71.497081

CORRIDOR SITE 14: DISCOLORED WATER/OILY
SHEEN; LIKELY FROM STOWMWATER RUNOFF
FROM MAJOR ROADWAYS. INCLUDING EVERETT
TURNPIKE
LAT. = 42.791740
LONG. = -71.496870

CORRIDOR SITE 15: EVERETT TURNPIKE
CULVERT INLET (WEST SIDE OF CROSSING)
LAT. = 42.791625
LONG. = -71.496664



CORRIDOR SITE 13: TRASH/DEBRIS BUILD-UP
WITHIN THE STREAM. POSSIBLE BEAVER
ACTIVITY
LAT. = 42.791735
LONG. = -71.497081

CORRIDOR SITE 14: DISCOLORED WATER/OILY
SHEEN; LIKELY FROM STORMWATER RUNOFF
FROM MAJOR ROADWAYS. INCLUDING EVERETT
TURNPIKE
LAT. = 42.791740
LONG. = -71.496870





An aerial photograph of a dense forest. A stream flows through the center of the image, surrounded by thick green foliage. A white callout box with a black border is positioned on the right side of the image. A thin black line extends from the box to a small white triangle on the stream. The text inside the box provides site information.

CORRIDOR SITE 12: BANK EROSION AND
UNDERCUTTING DUE TO LARGE FLOWS
LAT. = 42.791837
LONG. = -71.497859



An aerial photograph of a stream flowing through a dense forest. The stream is dark and narrow, winding through the center of the image. The surrounding forest is composed of tall, green trees with dense foliage. A white arrow points to a specific location on the stream, indicating a sediment deposit. A text box in the upper right corner provides the site name and coordinates.

CORRIDOR SITE 11: SEDIMENT
DEPOSIT WITHIN STREAM
LAT. = 42.791404
LONG. = -71.498333

An aerial photograph of a forest stream. The stream flows from the top center towards the bottom center. The banks are densely covered with green trees, likely spruce or fir. The water in the stream is dark and reflects the surrounding forest. A callout box with a black border and white background is positioned on the right side of the image. A black line extends from the box to a small white triangle on the left bank of the stream, indicating the location of Corridor Site 10. The text inside the box describes the site as an area of bank erosion and undercutting due to large flows, and provides its latitude and longitude coordinates.

CORRIDOR SITE 10: BANK EROSION AND
UNDERCUTTING DUE TO LARGE FLOWS
LAT. = 42.791200
LONG. = -71.498600

CORRIDOR SITE 9: TINKER ROAD CULVERT
OUTLET (NORTH SIDE OF CROSSING)
LAT. = 42.791237
LONG. = -71.498899



An aerial photograph showing a two-lane road with double yellow lines crossing a stream. The stream flows from the top left towards the bottom right. On the left side of the road, there is a large, light-colored rock formation. On the right side, there are several bare trees and a small white car parked on a shoulder. Two white text boxes with black borders are overlaid on the image, each with a black arrow pointing to a specific location. The first box is at the top, pointing to the stream on the left side of the road. The second box is in the middle right, pointing to the stream on the right side of the road.

CORRIDOR SITE 8: TINKER ROAD CULVERT
INLET (SOUTH SIDE OF CROSSING)
LAT. = 42.791144
LONG. = -71.498985

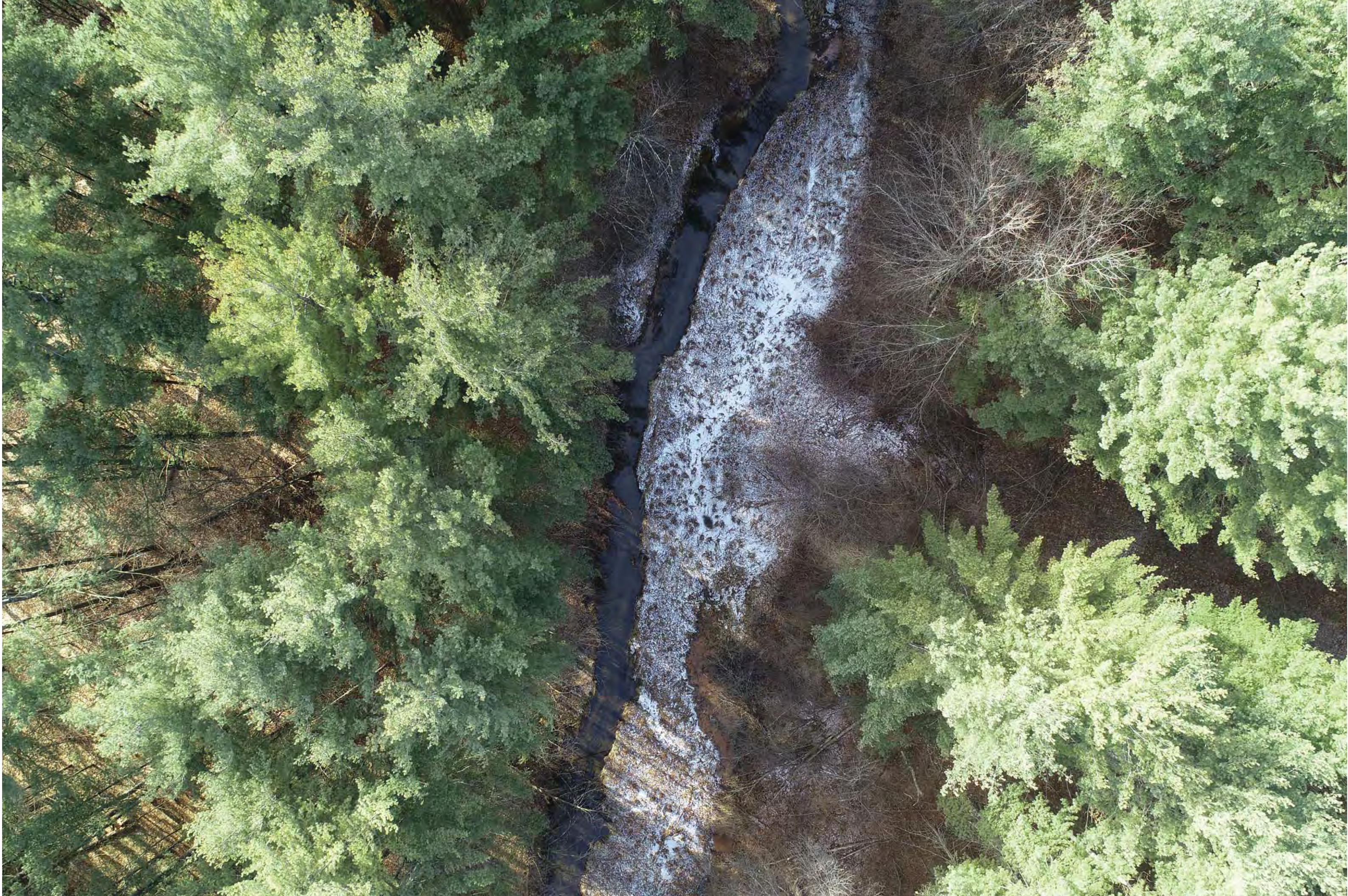
CORRIDOR SITE 9: TINKER ROAD CULVERT
OUTLET (NORTH SIDE OF CROSSING)
LAT. = 42.791237
LONG. = -71.498899



CORRIDOR SITE 7: SEDIMENT/DEBRIS BUILD-UP
WITHIN THE STREAM. POSSIBLE BEAVER
ACTIVITY
LAT. = 42.790995,
LONG. = -71.499236

CORRIDOR SITE 8: TINKER ROAD CULVERT
INLET (SOUTH SIDE OF CROSSING)
LAT. = 42.791144
LONG. = -71.498985









An aerial photograph of a stream flowing through a dense forest. The stream is surrounded by lush green trees, with some bare branches visible. A section of the stream shows a significant build-up of sediment and debris, creating a lighter-colored, textured area. A black arrow points from a text box to this area.

CORRIDOR SITE 6: SEDIMENT/DEBRIS BUILD-UP
WITHIN THE STREAM. POSSIBLE BEAVER ACTIVITY
LAT. = 42.790417
LONG. = -71.500453





CORRIDOR SITE 5: NORTH SOUTHWOOD DRIVE ON-
RAMP CULVERT OUTLET FROM SOMERSET PARKWAY
DETENTION BASIN (NORTH SIDE OF CROSSING)
LAT. = 42.789966
LONG. = -71.501025



An aerial photograph showing a multi-lane road with a white center line and yellow edge lines. A metal guardrail runs along the bottom edge of the road. Below the road is a large, rectangular detention basin filled with water. A small, dark, irregularly shaped area within the basin is pointed to by a white arrow. The surrounding landscape is a mix of dry, brown grass and green trees. A green highway sign is visible on the right side of the road.

CORRIDOR SITE 5: NORTH SOUTHWOOD DRIVE ON-
RAMP CULVERT OUTLET FROM SOMERSET PARKWAY
DETENTION BASIN (NORTH SIDE OF CROSSING)
LAT. = 42.789966
LONG. = -71.501025

BMP SITE 12: SOMERSET PARKWAY
DETENTION BASIN
LAT. = 42.789540
LONG. = -71.500781









CORRIDOR SITE 4: NORTH SOUTHWOOD DRIVE
CULVERT OUTLET (EAST SIDE OF CROSSING)
LAT. = 42.790229
LONG. = -71.502059

An aerial photograph showing a paved road with double yellow lines crossing a wooded area. The road curves from the top left towards the bottom left. The wooded area is filled with green evergreen trees and some bare deciduous trees. A small, dark, rectangular culvert outlet is visible in the wooded area, marked with a white arrow. A text box with a pointer line indicates the location of the culvert outlet.

CORRIDOR SITE 4: NORTH SOUTHWOOD DRIVE
CULVERT OUTLET (EAST SIDE OF CROSSING)
LAT. = 42.790229
LONG. = -71.502059

An aerial photograph showing a road crossing a wooded area. The road is at the bottom, with a concrete curb and a grassy shoulder. A line of trees separates the road from a larger wooded area. A small white arrow points to a dark spot in the trees, identified as a culvert inlet. The trees have autumn-colored leaves. A large, circular, rusted metal structure is visible in the upper right. A text box with location data is in the center.

CORRIDOR SITE 3: NORTH SOUTHWOOD DRIVE
CULVERT INLET (WEST SIDE OF CROSSING)
LAT. = 42.790062
LONG. = -71.502550



CORRIDOR SITE 3: NORTH SOUTHWOOD DRIVE
CULVERT INLET (WEST SIDE OF CROSSING)
LAT. = 42.790062
LONG. = -71.502550

This is an aerial photograph showing a landscape with a road on the left, a stream or culvert in the center, and a large circular structure on the right. The road is a two-lane asphalt road with a yellow center line. The stream is a narrow, dark waterway flowing through a wooded area. The circular structure is a large, light-colored, circular object, possibly a culvert inlet or a large pipe. The surrounding area is covered with trees and vegetation, with some areas showing bare ground or fallen leaves. The text overlay provides the site name, location, and coordinates.













An aerial photograph showing a multi-lane road on the left with several vehicles (a dark car, a black car, and a white truck) traveling away from the viewer. To the right of the road is a grassy area with some bare trees and a dense forest of evergreen trees. A small, dark, irregularly shaped area in the grassy field is pointed to by a line from a text box. This area appears to be a culvert outlet. The text box contains the following information:

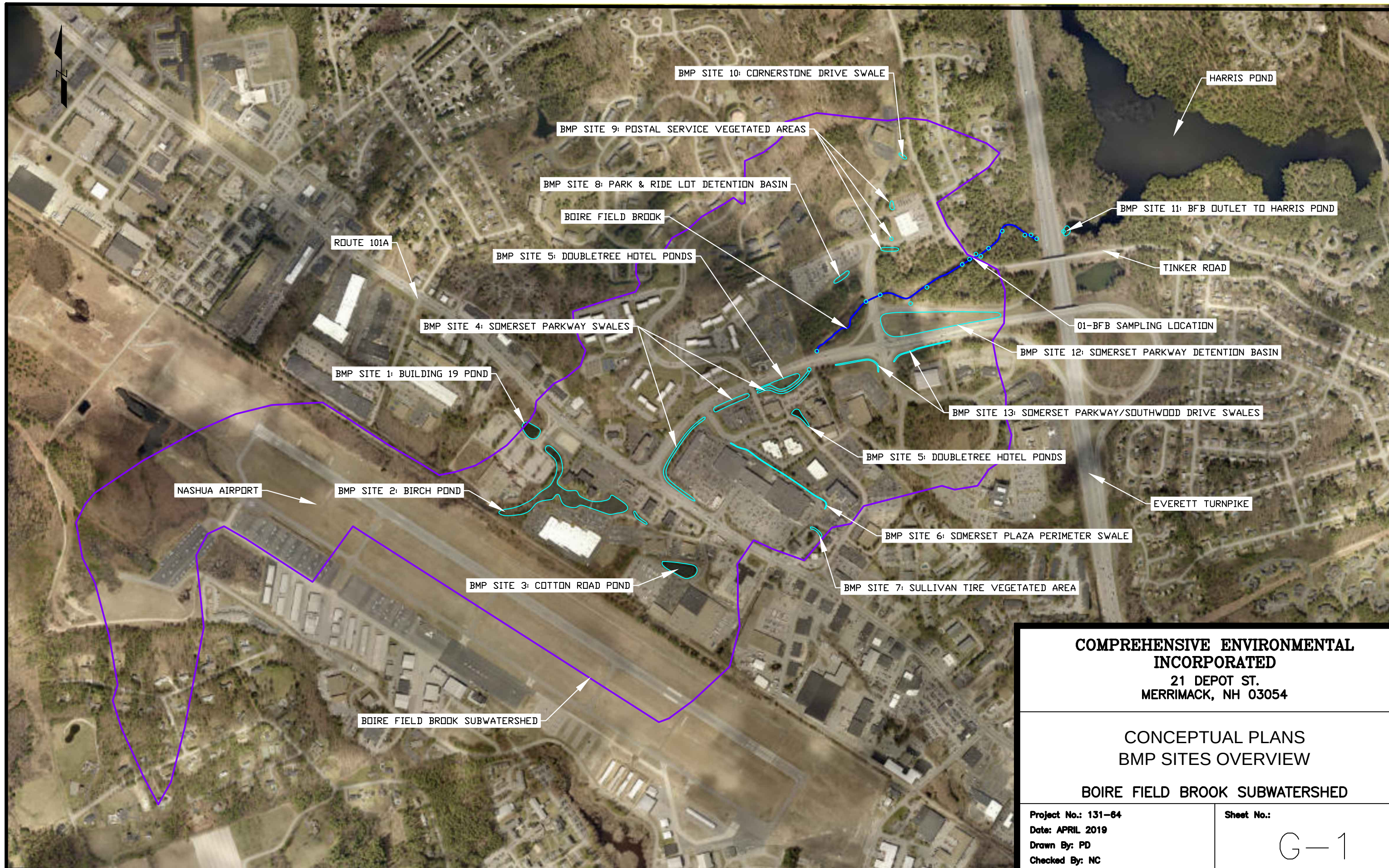
CORRIDOR SITE 2: SOMERSET PARKWAY
CULVERT OUTLET (NORTH SIDE OF CROSSING)
LAT. = 42.788749
LONG. = -71.504480

APPENDIX I
BMP Retrofits / Implementations
Recommendations Summary Matrix

Boire Field Brook BMP Retrofits/Implementations Recommendations Summary							
Priority	Site		Proposed BMP Type(s)	Coordinates (lat/long)	Retrofit Recommendations	Permitting Requirements	Total Costs
1	BMP 4	Somerset Parkway Swales	Water Quality Swale (Wet); Sediment Forebay; Inlet Gabion	(1) 42.785651, -71.509428 (2) 42.787515, -71.507155 (3) 42.787813, -71.505272	1. Vegetated Bank Stabilization: Stabilize eroded areas of the pond bank to decrease downstream sedimentation. 2. Vegetated Riprap Bank Stabilization: Reestablish existing existing vegetated riprap slopes to decrease downstream sedimentation from bank erosion, slow runoff velocities from Somerset Parkway, and promote infiltration. 3. Riprap/Granite Sediment Forebays: Install a riprap sediment forebay with granite lined bottom at the culvert outfalls from the Birch Pond discharge swale and the first segment of the Somerset Parkway Swales to settle out sediment and provide easier swale maintenance. 4. Crushed Stone Gabion: Install a crushed stone gabion in front of Somerset Parkway Swale culvert outlet to trap and filter out sediment, debris, trash, and other pollutants before entering the culvert.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$21,000 Construction: \$34,000 Total: \$65,500
2	BMP 6	Somerset Plaza Perimeter Swale	Biofilter Swale; Sediment Forebay; Bioretention Area	42.785816, -71.505659	1. Vegetated Riprap Bank Stabilization: Reestablish existing vegetated riprap slopes to decrease downstream sedimentation from bank erosion, slow runoff velocities from paved areas, and promote infiltration. 2. Revegetate Swale: Revegetate eroded areas of the swale channel to decrease downstream sedimentation. 3. Stormwater Inlet Stabilization: Install a riprap apron at the existing stormwater inlet to decrease downstream erosion. 4. Curb Installation and Riprap Spillways: Remove and replace granite curbing with breaks at existing riprap spillways; re-stabilize riprap spillways to promote designated stormwater entry points and decrease slope erosion. 5. Vegetated Bioretention Area: Install vegetated bioretention areas/raingardens at drainage outfalls from Somerset Plaza Perimeter Swale. Install native plant species that are resistant to wet and dry environments. 6. Riprap Sediment Forebay: Install a riprap sediment forebay with a vegetated bottom at the existing drainage outfall in the center of the swale to trap sediment and provide easier swale maintenance.	N/A	Permitting: --- Design: \$21,000 Construction: \$97,000 Total: \$118,000
3	BMP 3	Cotton Road Pond	Wet Basin; Infiltration Trench	42.783286, -71.508908	1. Buffer Zone Plantings: Install woody (tree/shrub) buffer zone plantings to improve pollutant attenuation along the south side of the pond. 2. Vegetated Bank Stabilization: Stabilize eroded areas of the pond bank to decrease downstream sedimentation. 3. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trenches on the south side of the pond to slow runoff velocity from the paved areas and promote infiltration.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$10,500 Construction: \$30,000 Total: \$51,000
4	BMP 2	Birch Pond	Wet Basin; Infiltration Trench; Bioretention Area; Inlet Gabion	42.785097, -71.512749	1. Buffer Zone Plantings: Install woody (tree/shrub) buffer zone plantings to improve pollutant attenuation along the south side of the pond. 2. Vegetated Bank Stabilization: Stabilize eroded areas of the pond bank to decrease downstream sedimentation. 3. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trenches on the east side of the pond to slow runoff velocity from the paved areas and promote infiltration. 4. Curb Installation and Riprap Spillways: Install low bit berm curbing with breaks at existing riprap spillways; re-stabilize riprap spillways to promote designated stormwater entry points and decrease bank erosion. 5. Vegetated Bioretention Area: Install a vegetated bioretention area/raingarden at the stormwater inlet located near the northern tip of the pond, and	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$23,500 Construction: \$124,000 Total: \$158,000
5	BMP 5	DoubleTree Hotel Ponds	Wet Basin; Bioretention Area	(1) 42.788070, -71.505260 (2) 42.787200, -71.504863	1. Vegetated Riprap Bank Stabilization: Reestablish existing vegetated riprap slopes to decrease downstream sedimentation from bank erosion, slow runoff velocities from Somerset Parkway, and promote infiltration. 2. Vegetated Bioretention Area: Install a vegetated bioretention area/raingarden at the existing stormwater inlet that discharges into the western DoubleTree Hotel Pond. Install native plant species that are resistant to wet and dry environments.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$10,500 Construction: \$17,000 Total: \$38,000
6	BMP 1	Building 19 Pond	Wet Basin; Infiltration Trench	42.786836, -71.514115	1. Buffer Zone Plantings: Install woody (tree/shrub) buffer zone plantings to improve pollutant attenuation along the south side of the pond. 2. Vegetated Bank Stabilization: Stabilize eroded areas of the pond bank to decrease downstream sedimentation. 3. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trenches on the east and south edges of the pond to slow runoff velocity from the paved areas and promote infiltration. 4. Pavement Improvements and Curb Installation: Repave damaged driveway and install low bit berm curbing with crushed stone trench backing; remove and replace existing guardrail.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$10,500 Construction: \$18,500 Total: \$39,500
7	BMP 13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale; Check Dams	(1) 42.788471, -71.502197 (2) 42.788915, -71.500559	1. Riprap Check Dams: Install riprap checkdams throughout the swales to slow down stormwater flow, promote infiltration, and minimze erosion within the swales.	N/A	Permitting: --- Design: \$4,000 Construction: \$5,000 Total: \$9,000
8	BMP 9	Postal Service Vegetated Areas	Bioretention Area	(1) 42.791386, -71.501648 (2) 42.791653, -71.501567 (3) 42.792408, -71.501715	1. Stormwater Outlet Stabilization: Install a riprap apron at the existing stormwater outfall to decrease downstream erosion. 2. Vegetated Bioretention Areas: Install vegetated bioretention areas/raingardens at drainage outfalls of the second and third vegetated areas. Install native plant species that are resistant to wet and dry environments.	N/A	Permitting: --- Design: \$13,000 Construction: \$91,000 Total: \$104,000
9	Corridor 2	Somerset Parkway culvert outlet (north side of crossing)	Infiltration Trench; Sediment Forebay	42.788749, -71.504480	1. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trench along the southeast side of Corridor Site 2 where the vegetated buffer is minimal in order to slow runoff velocity from the paved areas and promote infiltration before reaching the brook. 2. Riprap/Granite Sediment Forebay: Install a riprap sediment forebay with granite lined bottom at the Somerset Parkway culvert outfall to trap sediment and provide easier sedimentation maintenance.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$10,500 Construction: \$47,000 Total: \$68,000
10	Corridor 15	Everett Turnpike culvert inlet (west side of crossing)	Infiltration Trench	42.791625, -71.496664	1. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trench along the east side of Corridor Site 15 where the vegetated buffer is minimal in order to slow runoff velocity from the paved areas and promote infiltration before reaching the brook.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500)	Permitting: \$6,500 Design: \$5,500 Construction: \$15,000 Total: \$27,000

Boire Field Brook BMP Retrofits/Implementations Recommendations Summary							
Priority	Site		Proposed BMP Type(s)	Coordinates (lat/long)	Retrofit Recommendations	Permitting Requirements	Total Costs
11	BMP 8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin; Sediment Forebay	42.790685, -71.503412	1. Revegetate Swale: Revegetate eroded areas of the swale channel to decrease downstream sedimentation. 2. Riprap Sediment Forebay: Install a riprap sediment forebay with a vegetated bottom at the existing emergency spillway at the end of the detention basin to trap sediment and provide easier swale maintenance.	N/A	Permitting: --- Design: \$5,500 Construction: \$6,500 Total: \$12,000
12	Corridor 4	North Southwood Drive culvert outlet (east side of crossing)	Infiltration Trench; Sediment Forebay	42.790229, -71.502059	1. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trench along the west side of Corridor Site 4 where the vegetated buffer is minimal in order to slow runoff velocity from the paved areas and promote infiltration before reaching the brook. 2. Riprap/Granite Sediment Forebay: Install a riprap sediment forebay with granite lined bottom at the North Southwood Drive culvert outfall to trap sediment and provide easier sedimentation maintenance.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$10,500 Construction: \$47,000 Total: \$68,000
13	BMP 7	Sullivan Tire Vegetated Area	Bioretention Area	42.784229, -71.504217	1. Vegetated Bioretention Area: Regrade the existing vegetated area in order for stormwater to be able to accumulate and infiltrate. Install vegetated bioretention areas/raingarden with native plant species that are resistant to wet and dry environments. 2. Curb Installation and Riprap Spillways: Install granite curbing with breaks at proposed riprap spillways; install riprap spillways to promote designated stormwater entry points and decrease slope erosion.	N/A	Permitting: --- Design: \$10,500 Construction: \$78,000 Total: \$88,500
14	BMP 11	Boire Field Brook Outlet to Harris Pond	Wet Basin; Sediment Forebay	42.791733, -71.495353	1. Riprap/Granite Sediment Forebay: Install a riprap sediment forebay with granite lined bottom at the culvert outfall from Boire Field Brook to trap sediment and provide easier pond sedimentation maintenance.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$12,000 Construction: \$18,000 Total: \$40,500
15	BMP 12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	42.789540, -71.500781	1. Stormwater Outlet Stabilization: Install a riprap apron at the existing stormwater outfalls to decrease downstream erosion.	N/A	Permitting: --- Design: \$4,000 Construction: \$5,000 Total: \$9,000
16	BMP 10	Cornerstone Drive Swale	Biofilter Swale	42.793687, -71.501226	1. Vegetated Bank Stabilization: Stabilize the detention area banks and existing erosion control fabric with plantings and hydroseed to decrease downstream sedimentation. 2. Stormwater Outlet Stabilization: Install a riprap apron at the existing flared end section stormwater outfall to decrease downstream erosion.	N/A	Permitting: --- Design: \$5,500 Construction: \$6,500 Total: \$12,000
17	Corridor 5	North Southwood Drive On-Ramp culvert outlet from Somerset Parkway Detention Basin (north side of crossing)	Infiltration Trench; Sediment Forebay	42.789966, -71.501025	1. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trench along the south side of Corridor Site 5 where the vegetated buffer is minimal in order to slow runoff velocity from the paved areas and promote infiltration before reaching the brook. 2. Riprap/Granite Sediment Forebay: Install a riprap sediment forebay with granite lined bottom at the Somerset Parkway Detention Basin culvert outfall to trap sediment and provide easier sedimentation maintenance.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$10,500 Construction: \$61,000 Total: \$82,000
18	Corridor 3	North Southwood Drive culvert inlet (west side of crossing)	Infiltration Trench; Bioretention Area	42.790062, -71.502550	1. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trench along the southwest side of Corridor Site 3 where the vegetated buffer is minimal in order to slow runoff velocity from the paved areas and promote infiltration before reaching the brook. 2. Vegetated Bioretention Area: Install a vegetated bioretention area/raingarden northwest of Corridor Site 3 where there is sparse vegetated buffer. Install native plant species that are resistant to wet and dry environments.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500)	Permitting: \$6,500 Design: \$13,000 Construction: \$110,000 Total: \$129,500
19	Corridor 9	Tinker Road culvert outlet (north side of crossing)	Infiltration Trench	42.791237, -71.498899	1. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trench along the southwest side of Corridor Site 9 where the vegetated buffer is minimal in order to slow runoff velocity from the paved areas and promote infiltration before reaching the brook.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500)	Permitting: \$6,500 Design: \$5,500 Construction: \$10,500 Total: \$22,500
20	Corridor 8	Tinker Road culvert inlet (south side of crossing)	Infiltration Trench	42.791144, -71.498985	1. Crushed Stone Infiltration Trench: Install pavement-edge infiltration trench along the northeast side of Corridor Site 8 where the vegetated buffer is minimal in order to slow runoff velocity from the paved areas and promote infiltration before reaching the brook.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500)	Permitting: \$6,500 Design: \$5,500 Construction: \$10,500 Total: \$22,500
N/A	Corridor 10	Bank erosion and undercutting due to larger flows	Bank Stabilization	42.791200, -71.498600	1. Vegetated Bank Stabilization: Stabilize eroded areas of the stream bank to decrease downstream sedimentation.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$4,000 Construction: \$5,000 Total: \$19,500
N/A	Corridor 12	Bank erosion and undercutting due to larger flows	Bank Stabilization	42.791837, -71.497859	1. Vegetated Bank Stabilization: Stabilize eroded areas of the stream bank to decrease downstream sedimentation.	1. NHDES Shoreland Permit Application (RSA 485-A:17, Env-Wq 1500) 2. NHDES Wetland Permit Application (Minor) (RSA 482-A, Env-Wq 100-900) - NH Natural Heritage Bureau (NHB) Review - NH Division of Historical Resources (DHR) Review - NH Fish & Game Department (FGD) Review	Permitting: \$10,500 Design: \$4,000 Construction: \$5,000 Total: \$19,500

APPENDIX J
Conceptual Plans



**COMPREHENSIVE ENVIRONMENTAL
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21 DEPOT ST.
MERRIMACK, NH 03054

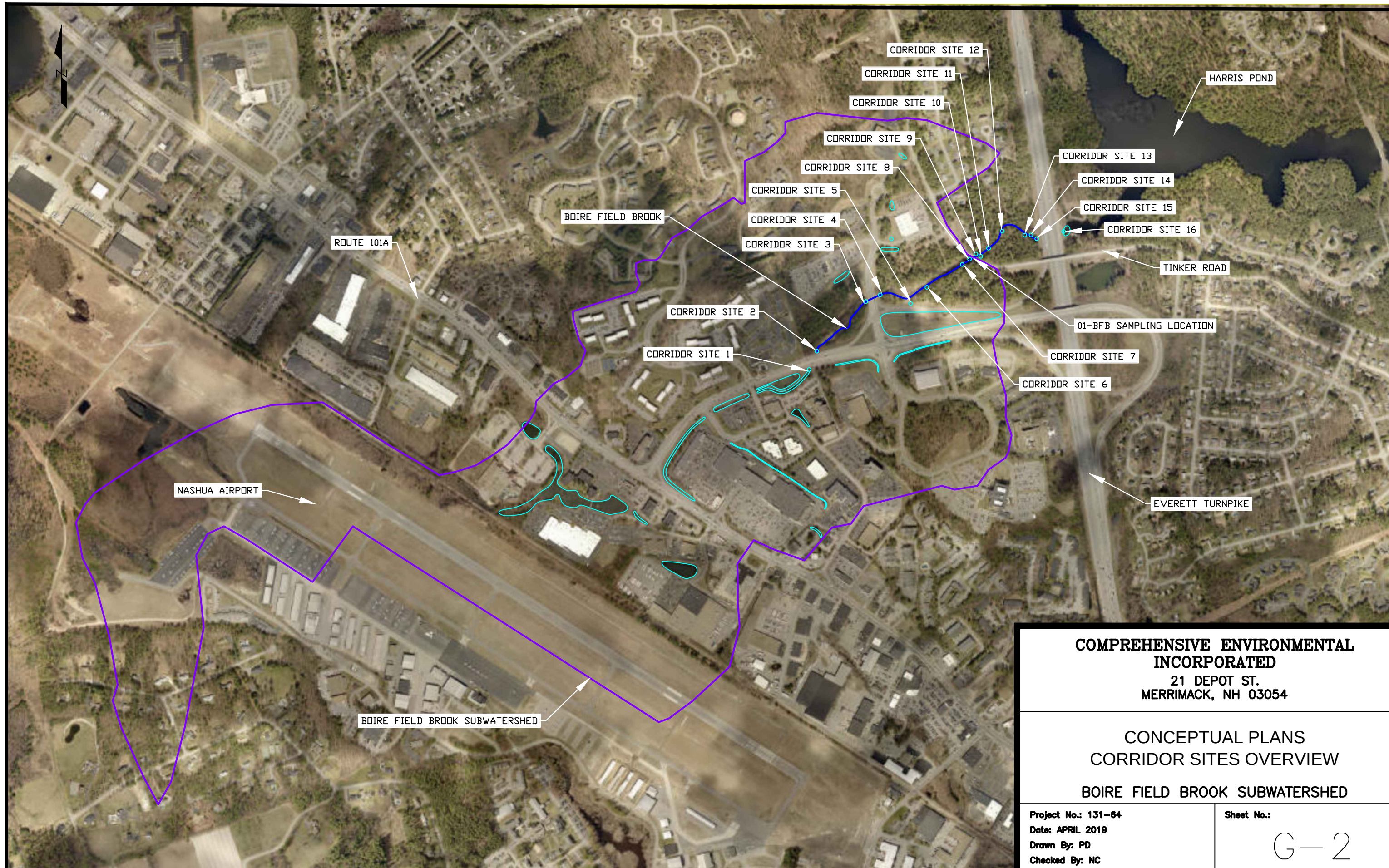
**CONCEPTUAL PLANS
BMP SITES OVERVIEW**

BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=800'

Sheet No.:

G-1



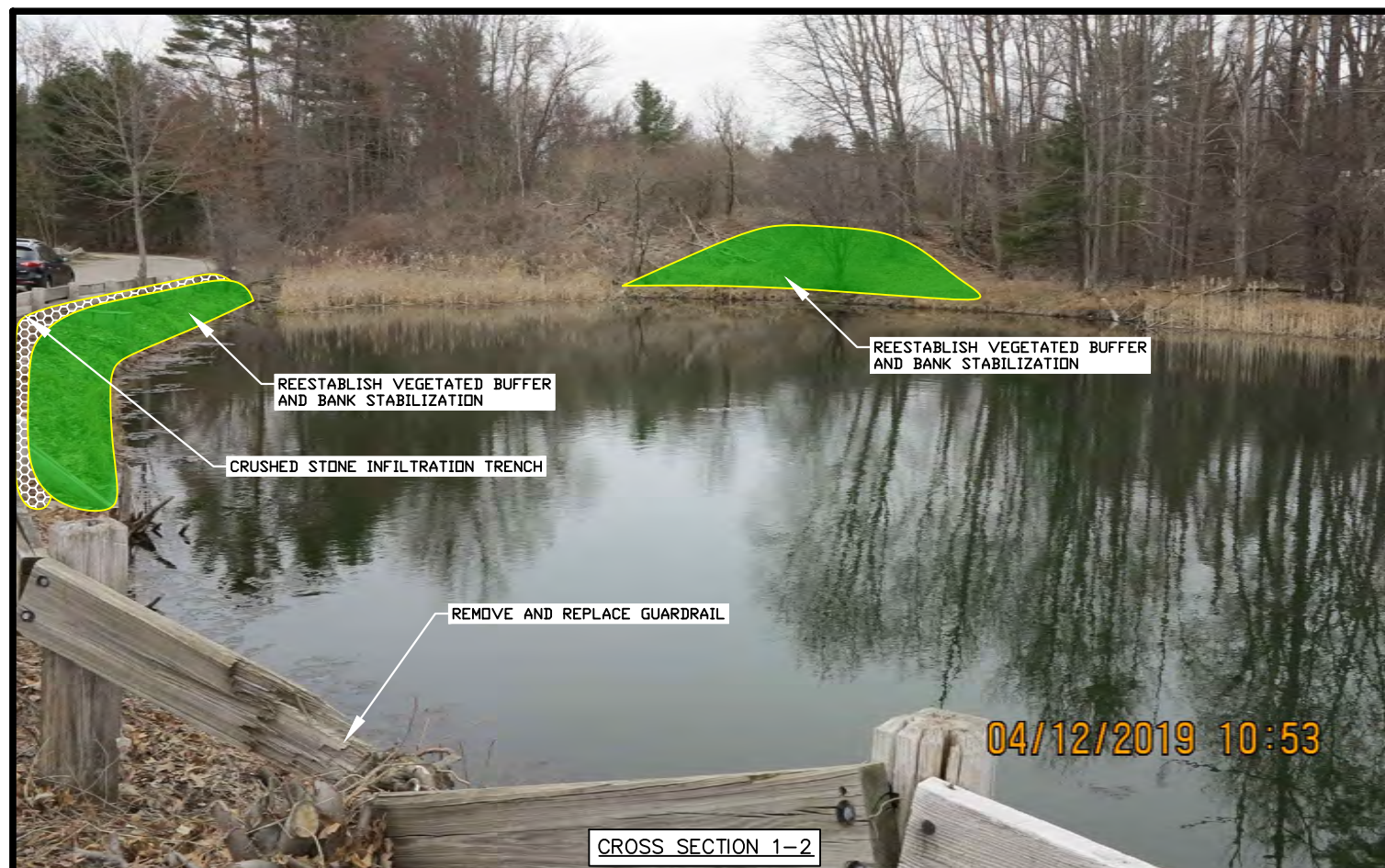
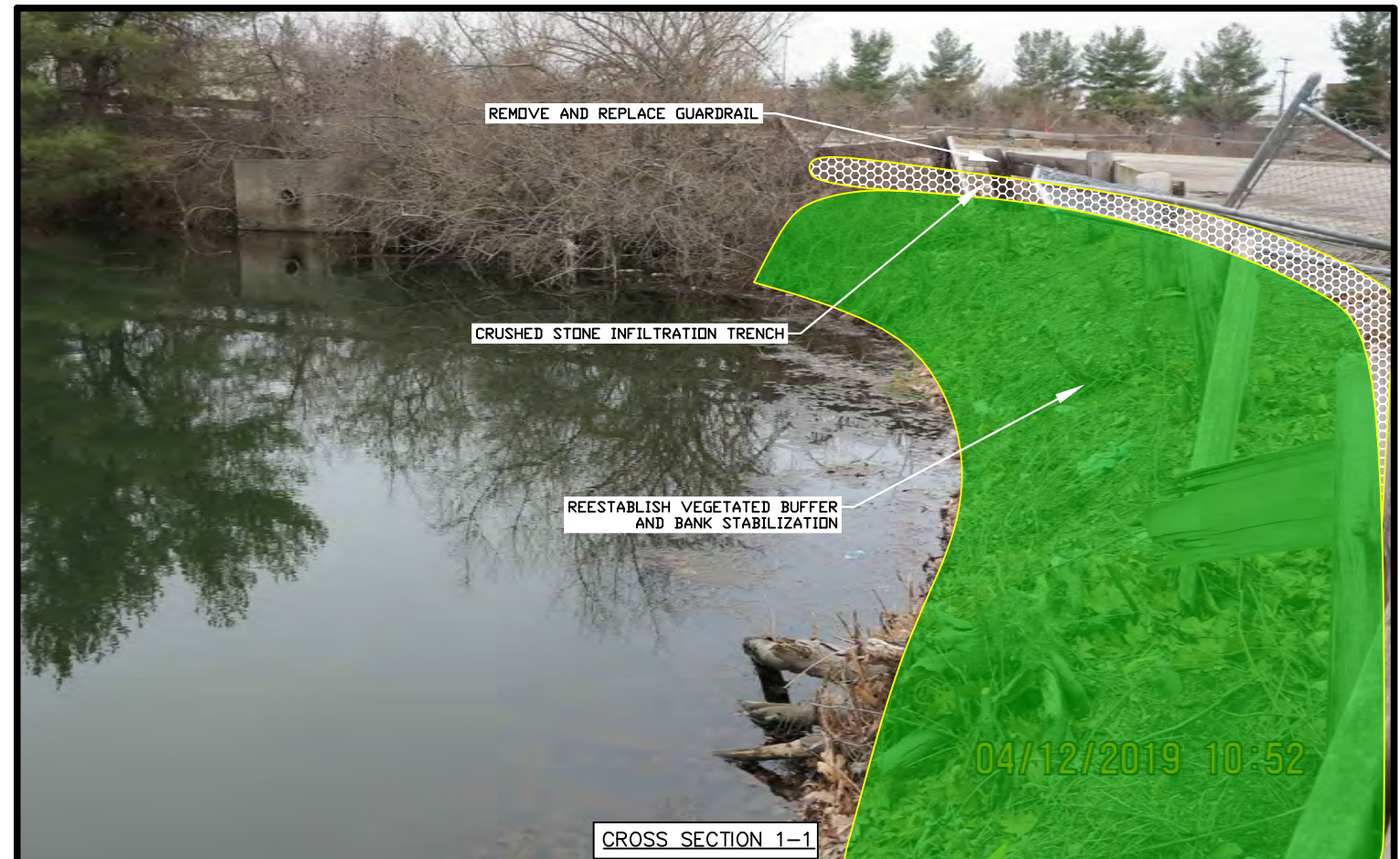
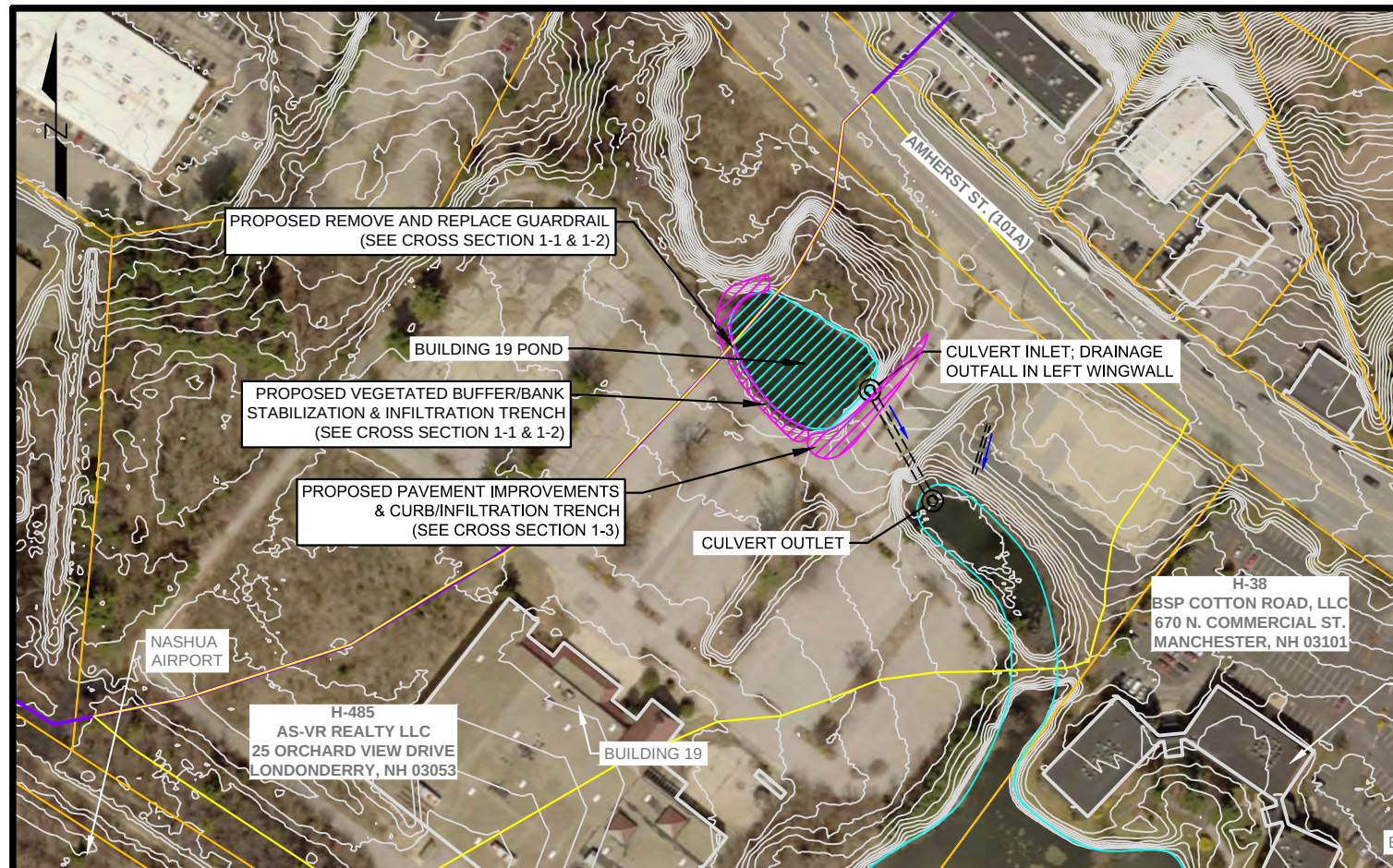
**COMPREHENSIVE ENVIRONMENTAL
INCORPORATED**
21 DEPOT ST.
MERRIMACK, NH 03054

**CONCEPTUAL PLANS
CORRIDOR SITES OVERVIEW
BOIRE FIELD BROOK SUBWATERSHED**

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=800'

Sheet No.:

G-2



LEGEND

- EXISTING 1FT CONTOURS
- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

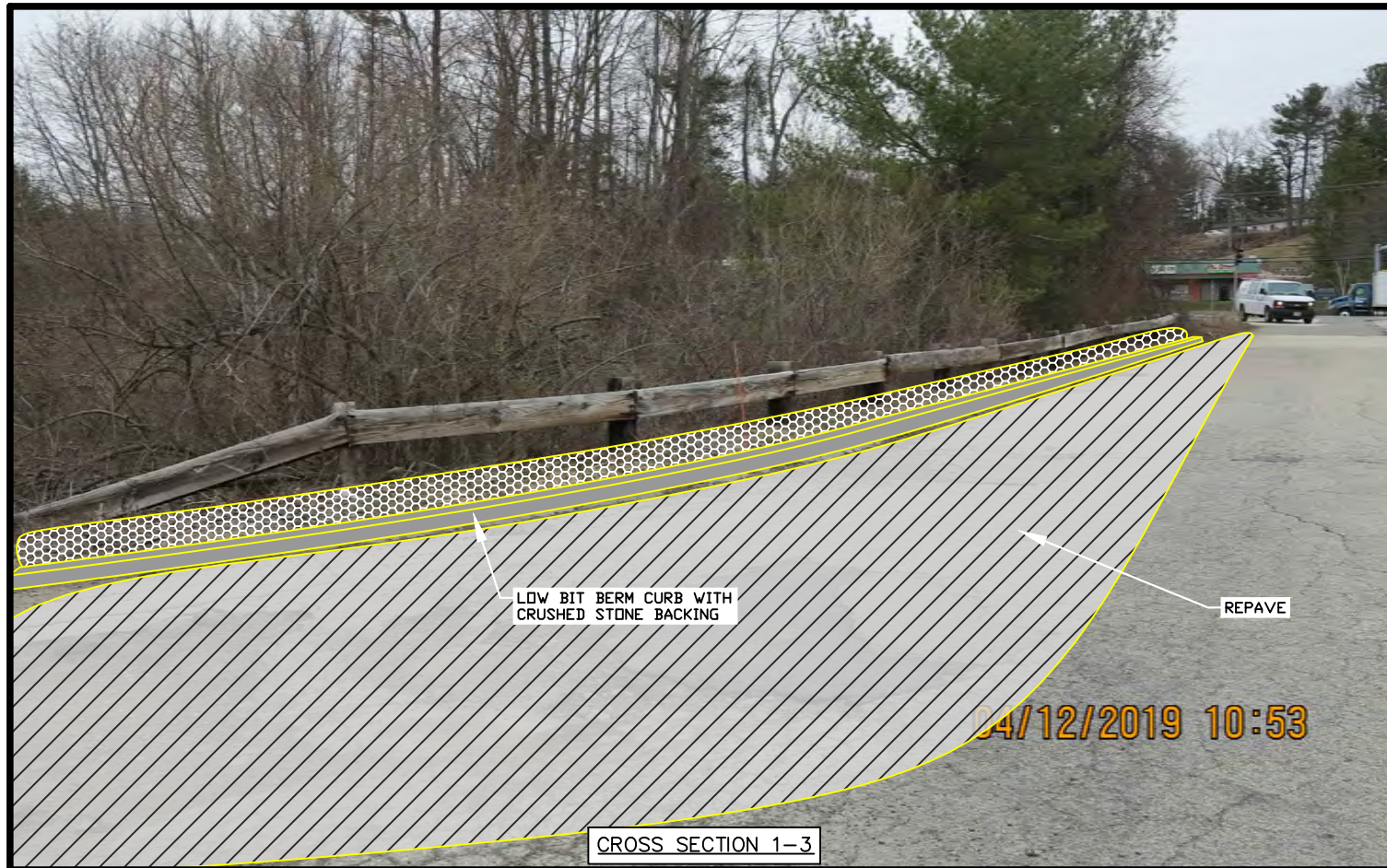
**COMPREHENSIVE ENVIRONMENTAL
INCORPORATED**
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MERRIMACK, NH 03054

CONCEPTUAL PLANS
BMP SITE 1 - BUILDING 19 POND
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:

C-1A



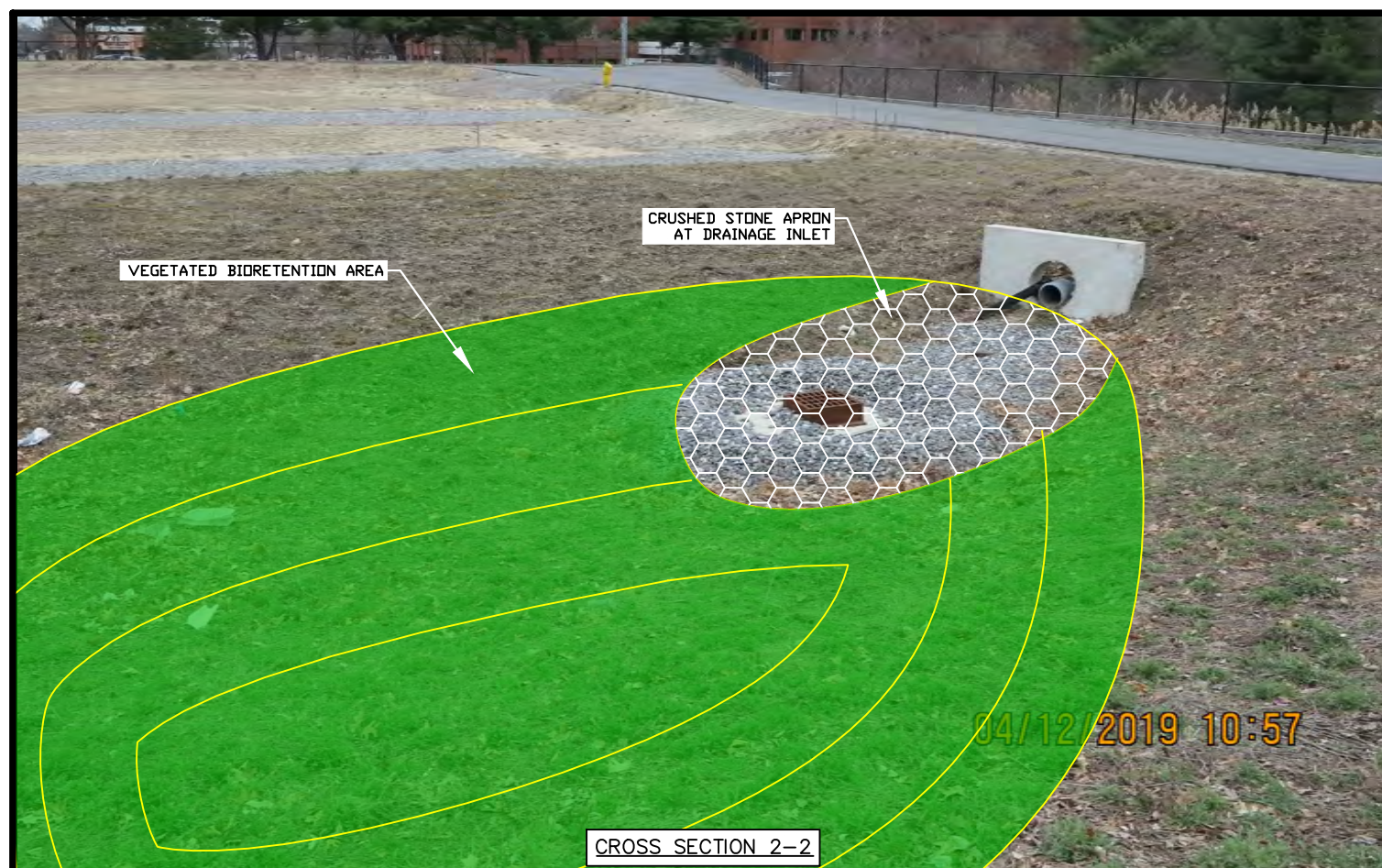
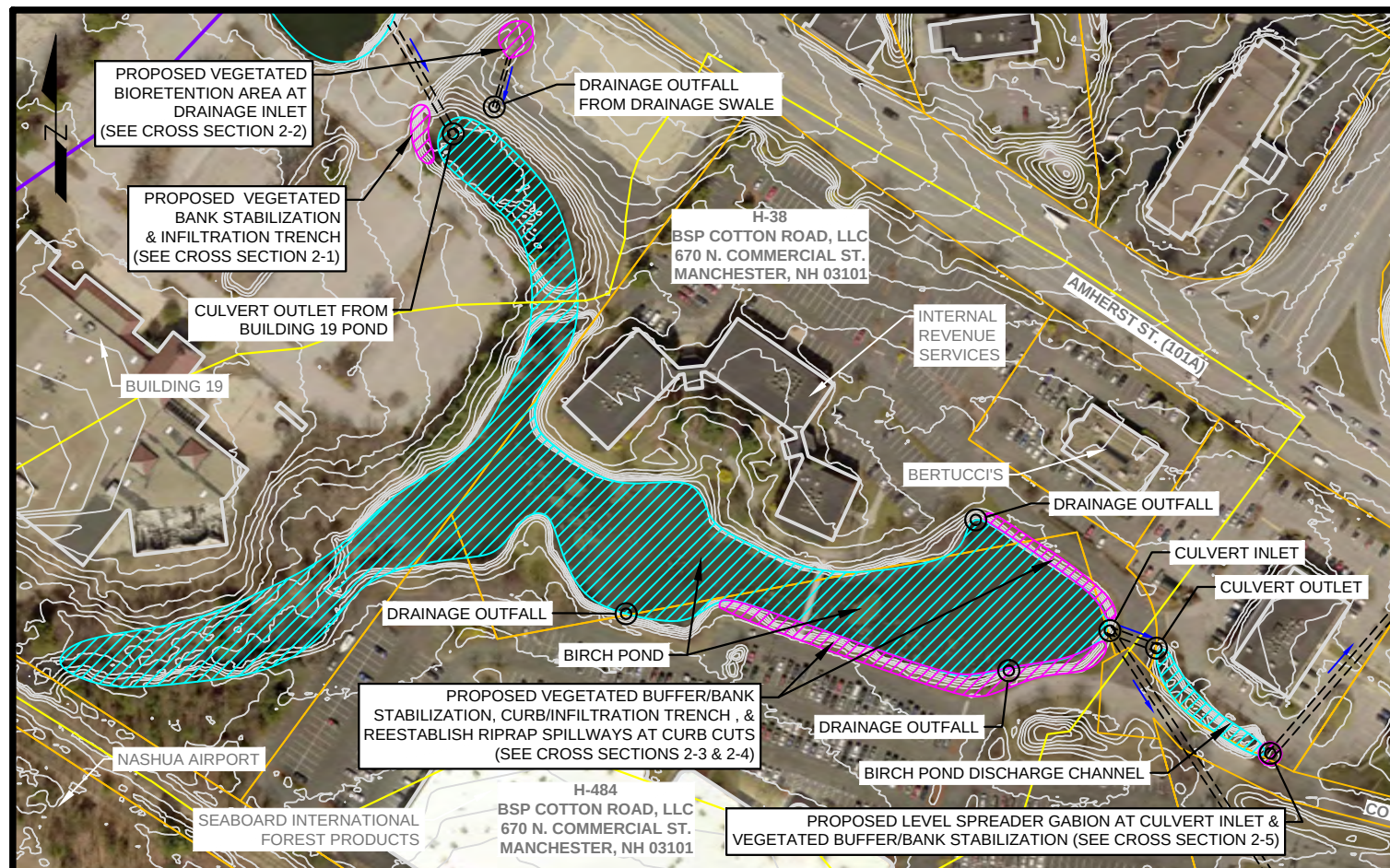
COMPREHENSIVE ENVIRONMENTAL
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MERRIMACK, NH 03054

CONCEPTUAL PLANS
BMP SITE 1 - BUILDING 19 POND
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: N.T.S.

Sheet No.:

C-1B



LEGEND

- EXISTING 1FT CONTOURS
- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

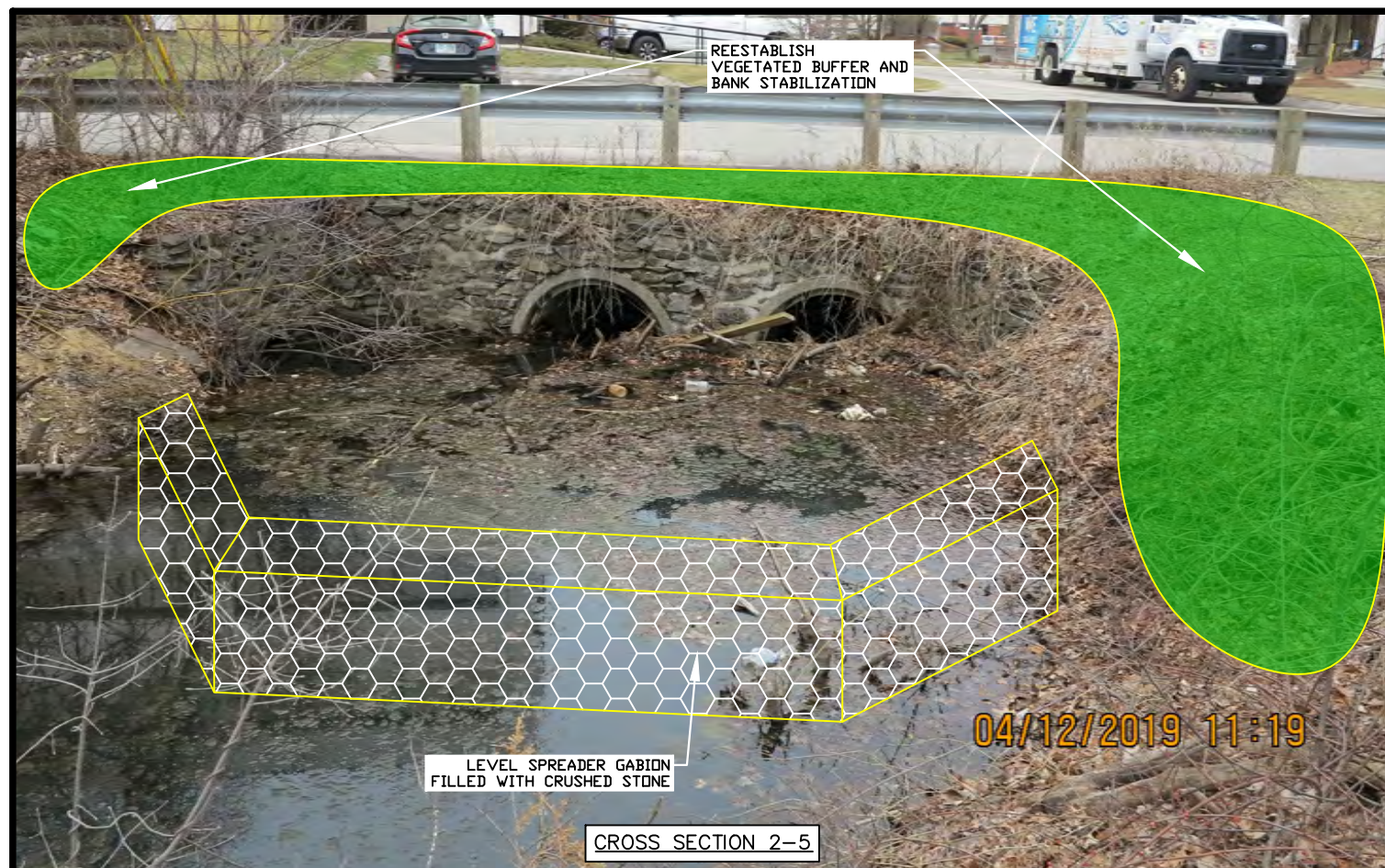
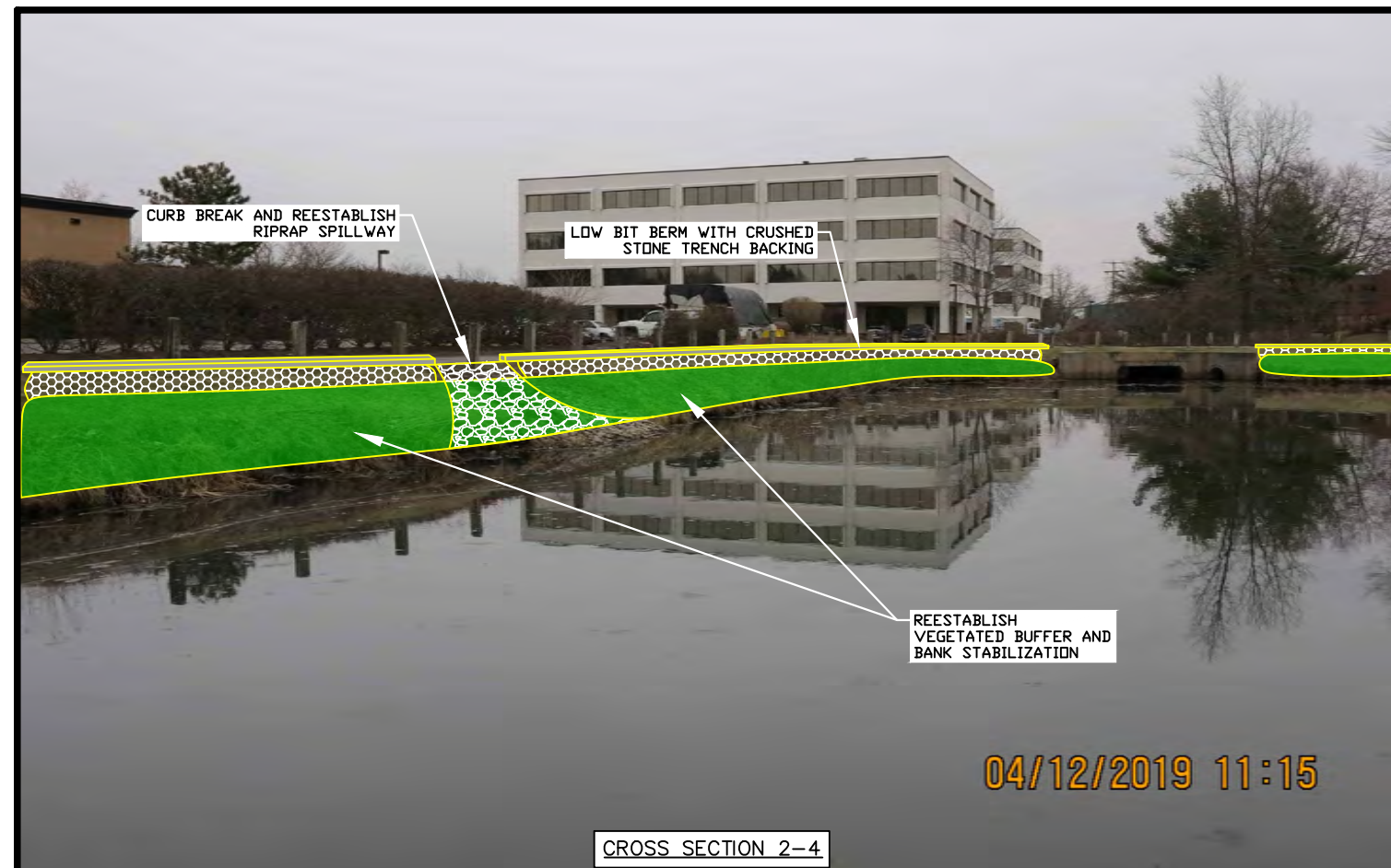
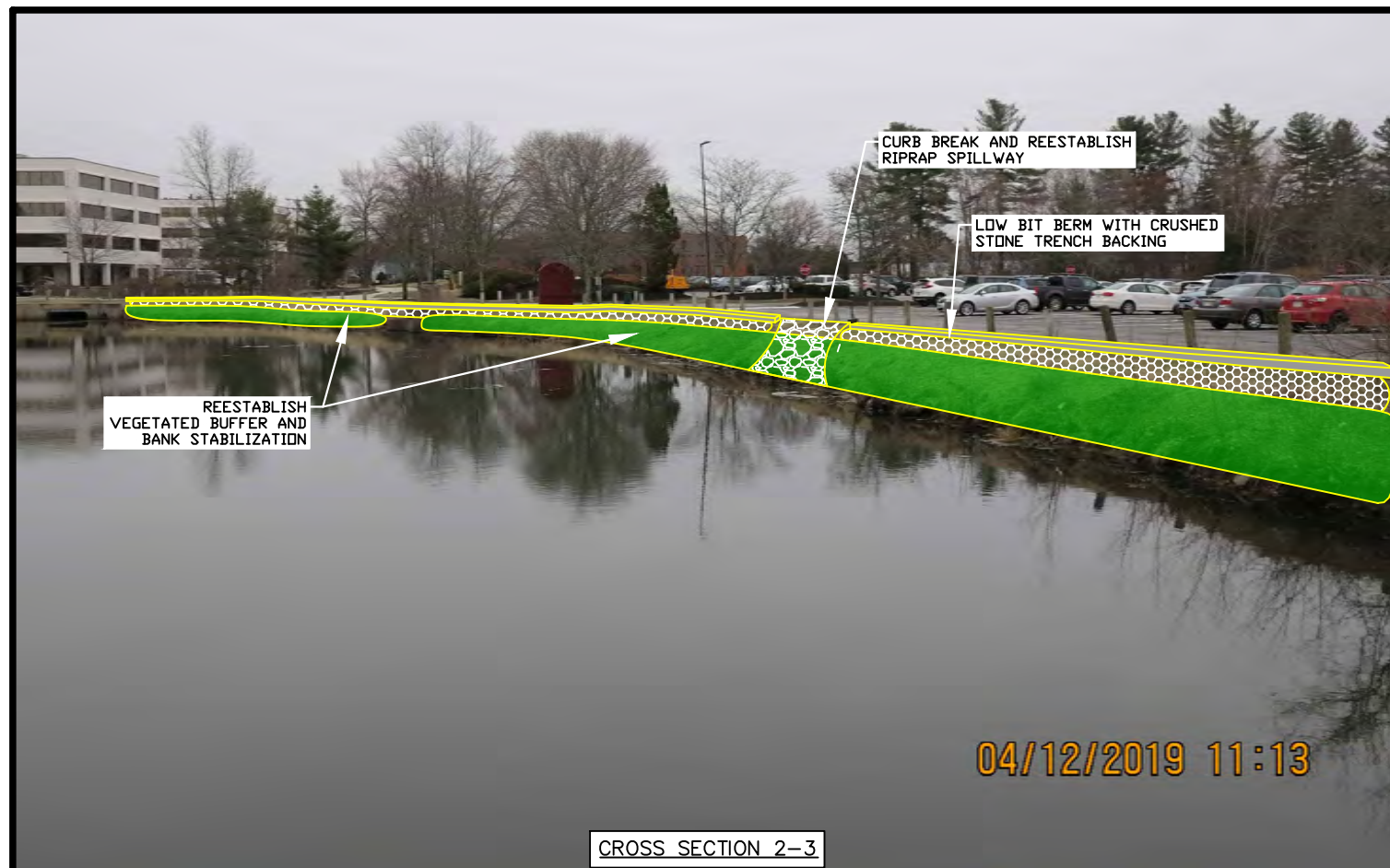
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21 DEPOT ST.
MERRIMACK, NH 03054

CONCEPTUAL PLANS
BMP SITE 2 - BIRCH POND

BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-2A



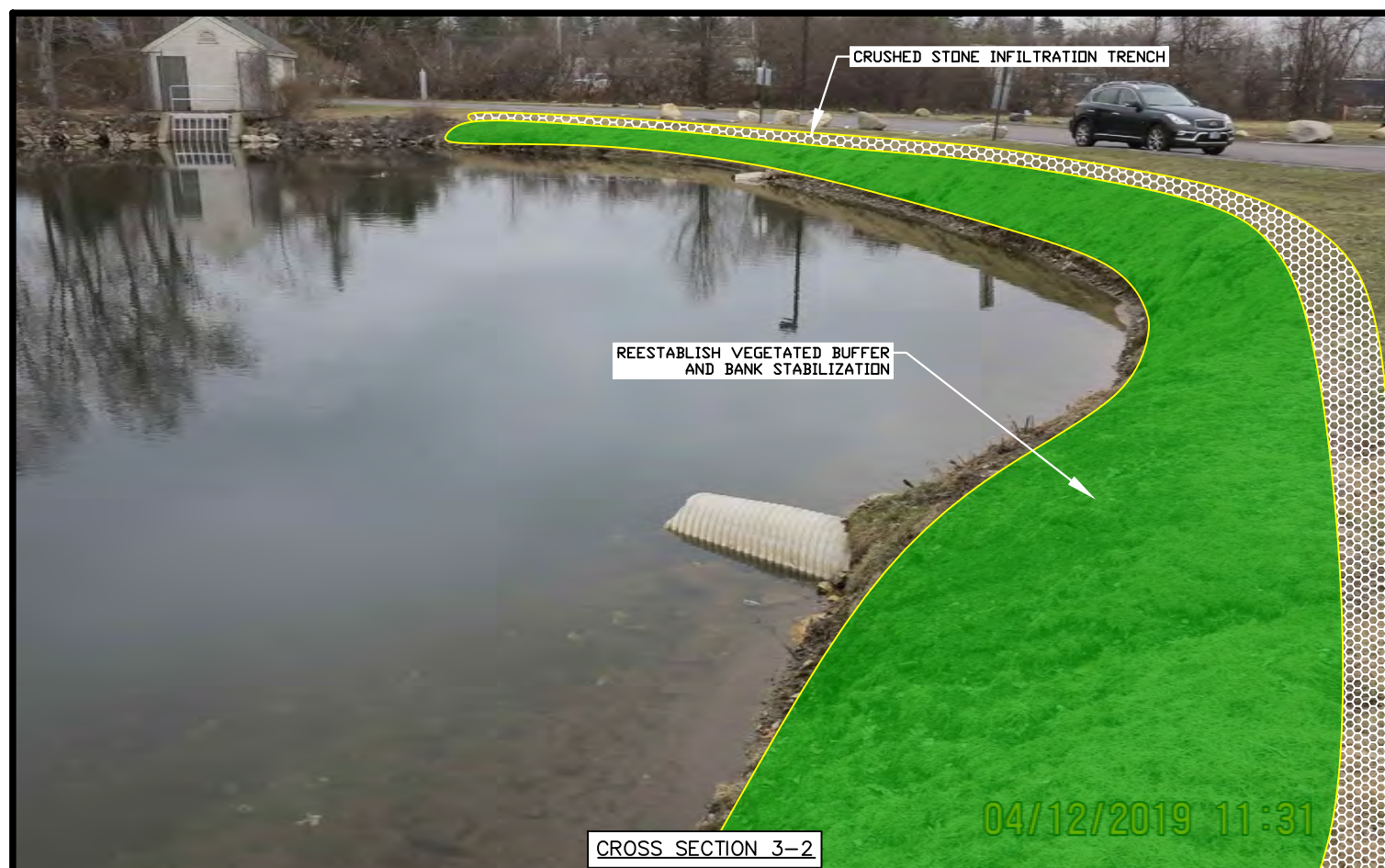
**COMPREHENSIVE ENVIRONMENTAL
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MERRIMACK, NH 03054

CONCEPTUAL PLANS
BMP SITE 2 - BIRCH POND

BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-2B



LEGEND

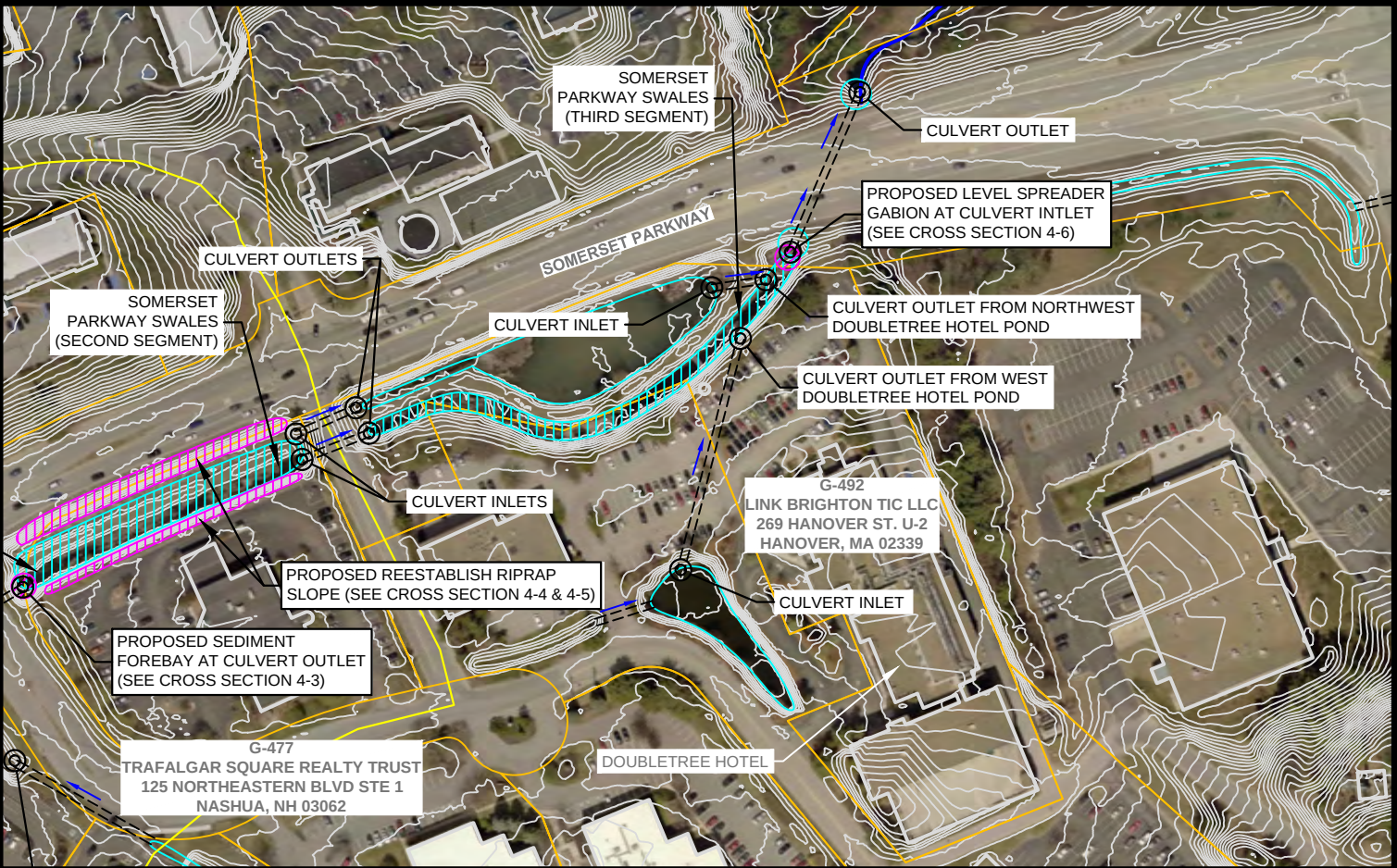
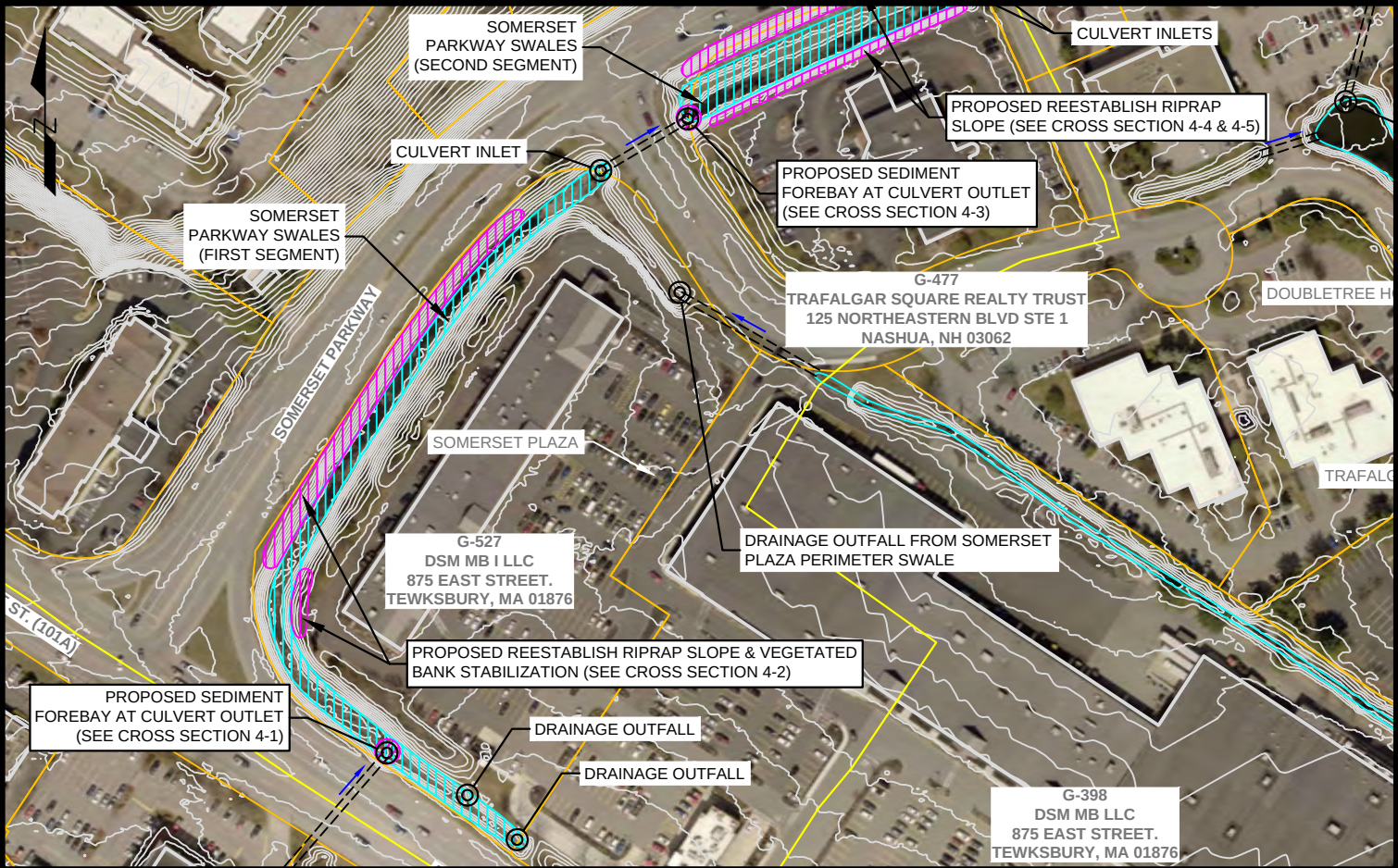
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- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

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CONCEPTUAL PLANS
BMP SITE 3 - COTTON ROAD POND
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-3A



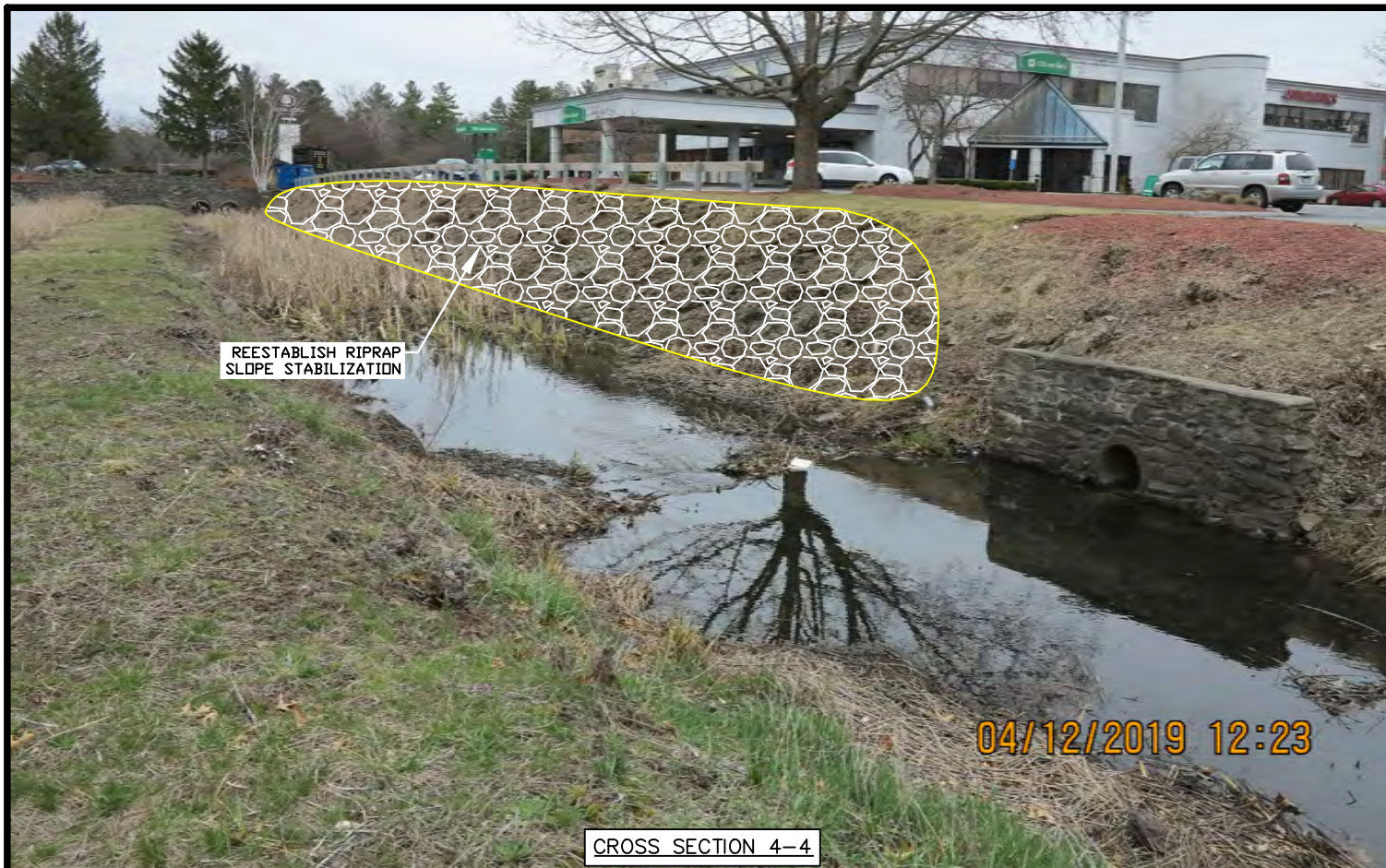
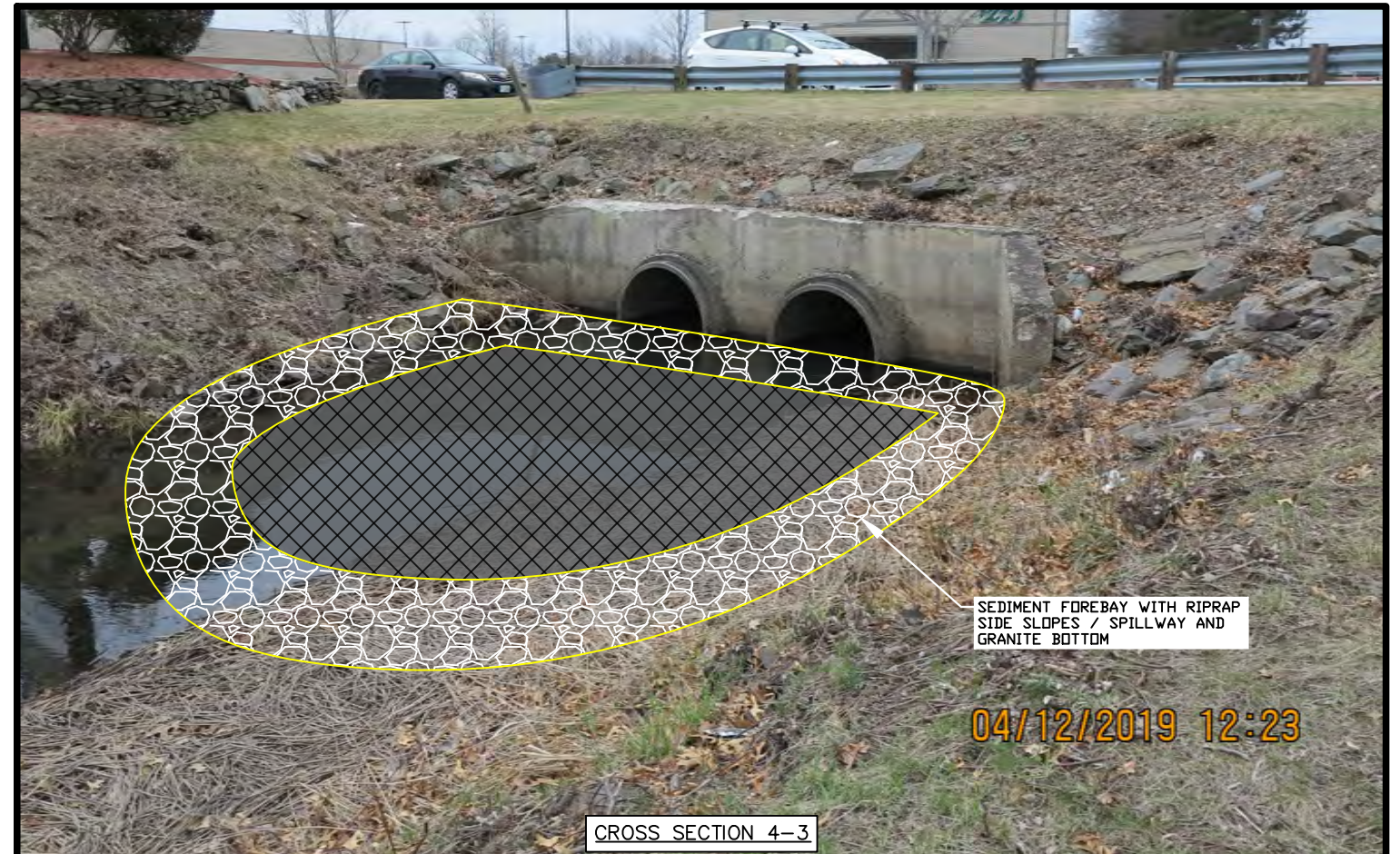
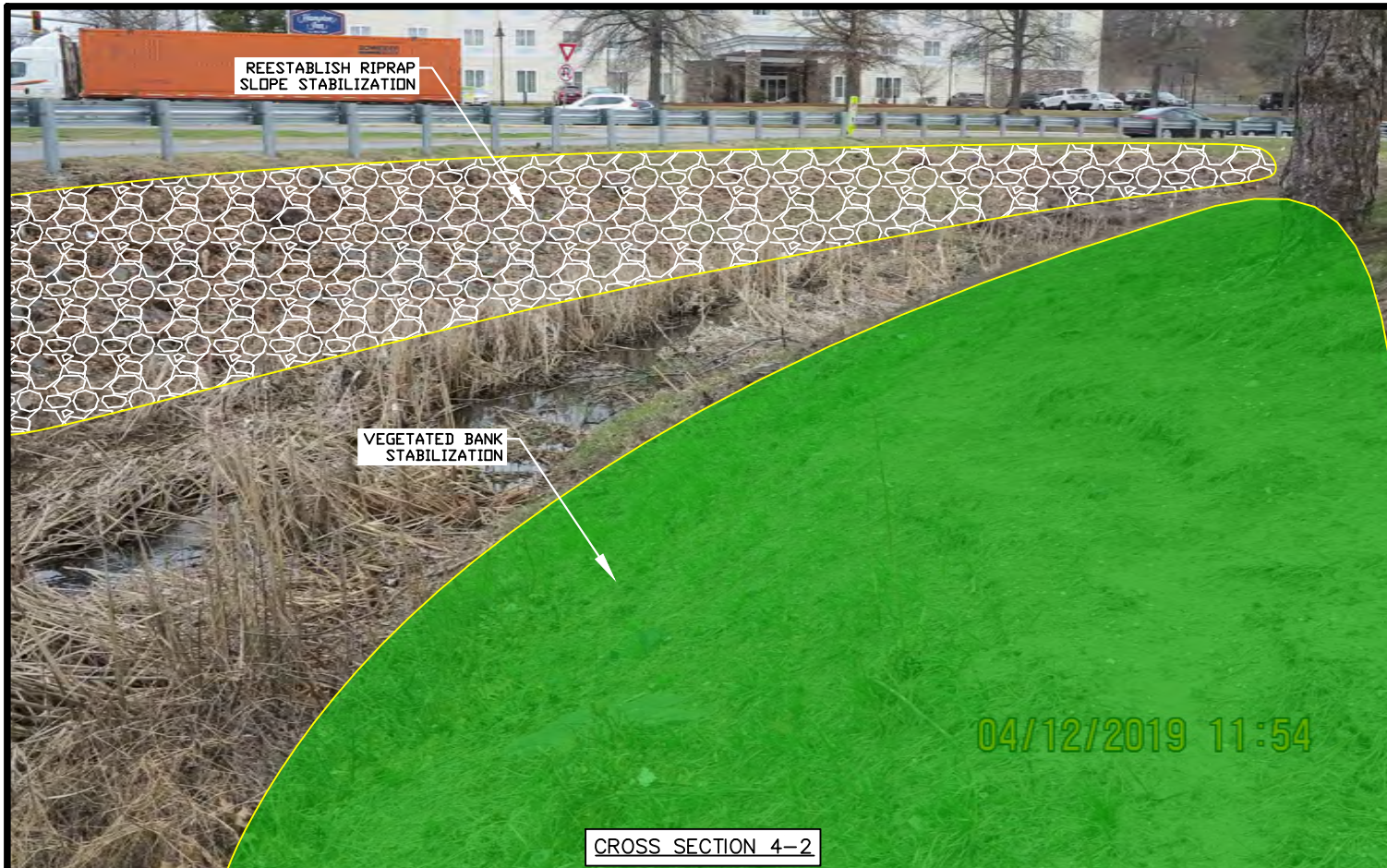
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 - PROPERTY LINE
 - BUILDING
 - BOIRE FIELD BROOK CORRIDOR
 - BFB SUBWATERSHED
 - BMP SUBCATCHMENT
 - EXISTING CULVERT
 - EXISTING BMP LIMITS
 - PROPOSED BMP LIMITS

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**CONCEPTUAL PLANS
BMP SITE 4 - SOMERSET PARKWAY SWALES
BOIRE FIELD BROOK SUBWATERSHED**

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-4A



COMPREHENSIVE ENVIRONMENTAL INCORPORATED 21 DEPOT ST. MERRIMACK, NH 03054	
CONCEPTUAL PLANS BMP SITE 4 - SOMERSET PARKWAY SWALES BOIRE FIELD BROOK SUBWATERSHED	
Project No.: 131-64 Date: APRIL 2019 Drawn By: PD Checked By: NC Scale: 1"=200'	Sheet No.: C-4B



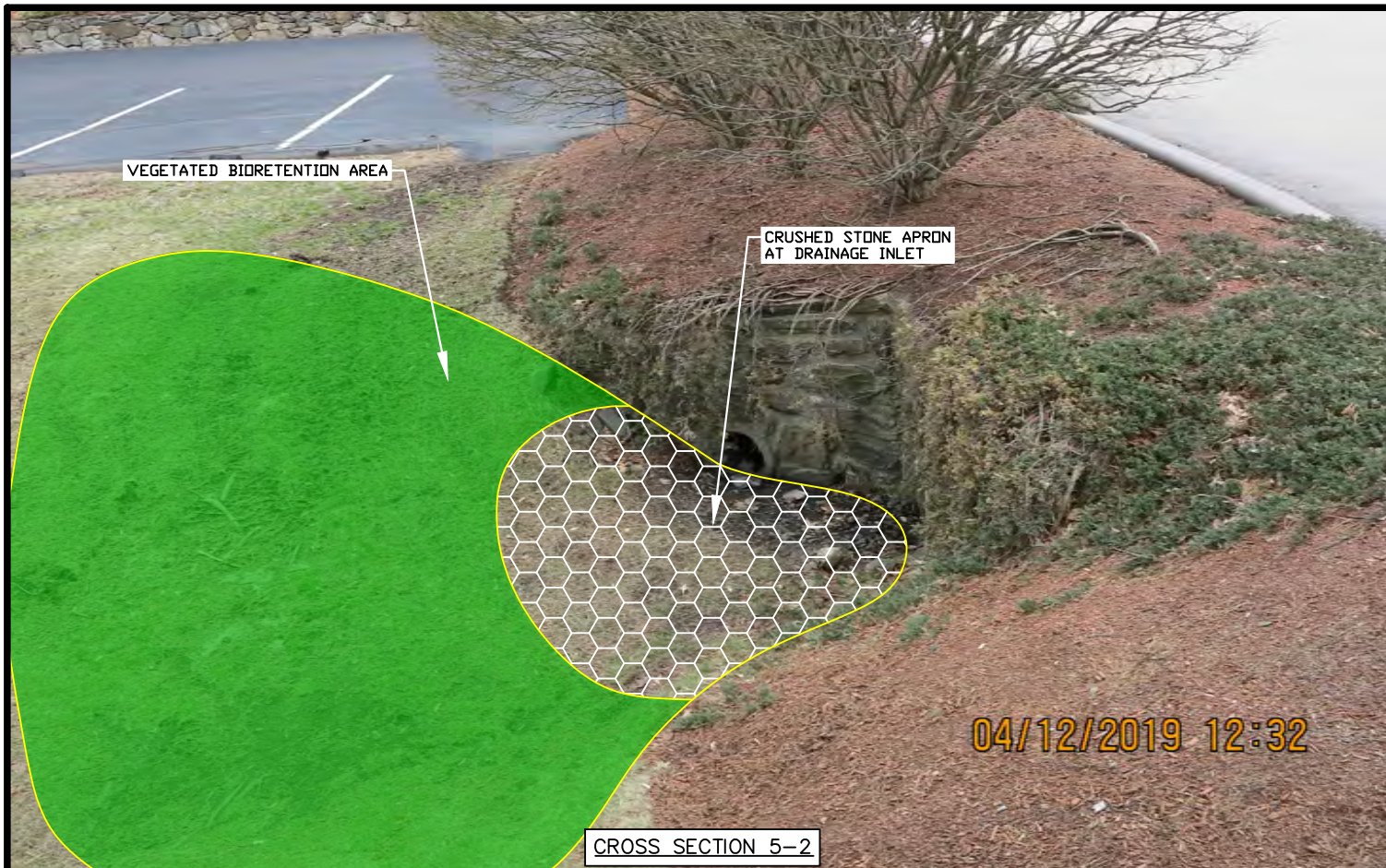
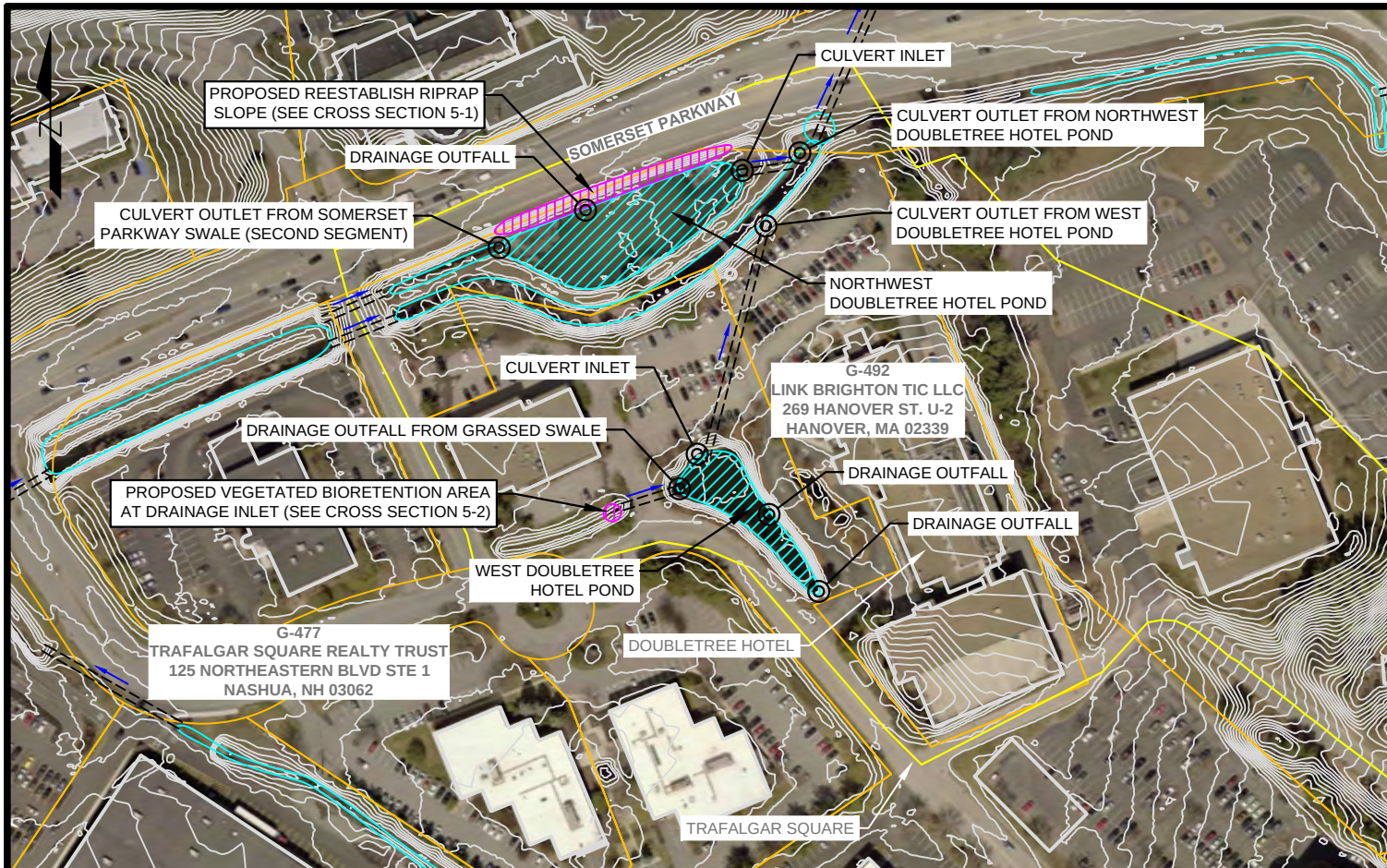
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CONCEPTUAL PLANS
BMP SITE 4 - SOMERSET PARKWAY SWALES
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:

C-4C



LEGEND

- EXISTING 1FT CONTOURS
- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

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MERRIMACK, NH 03054

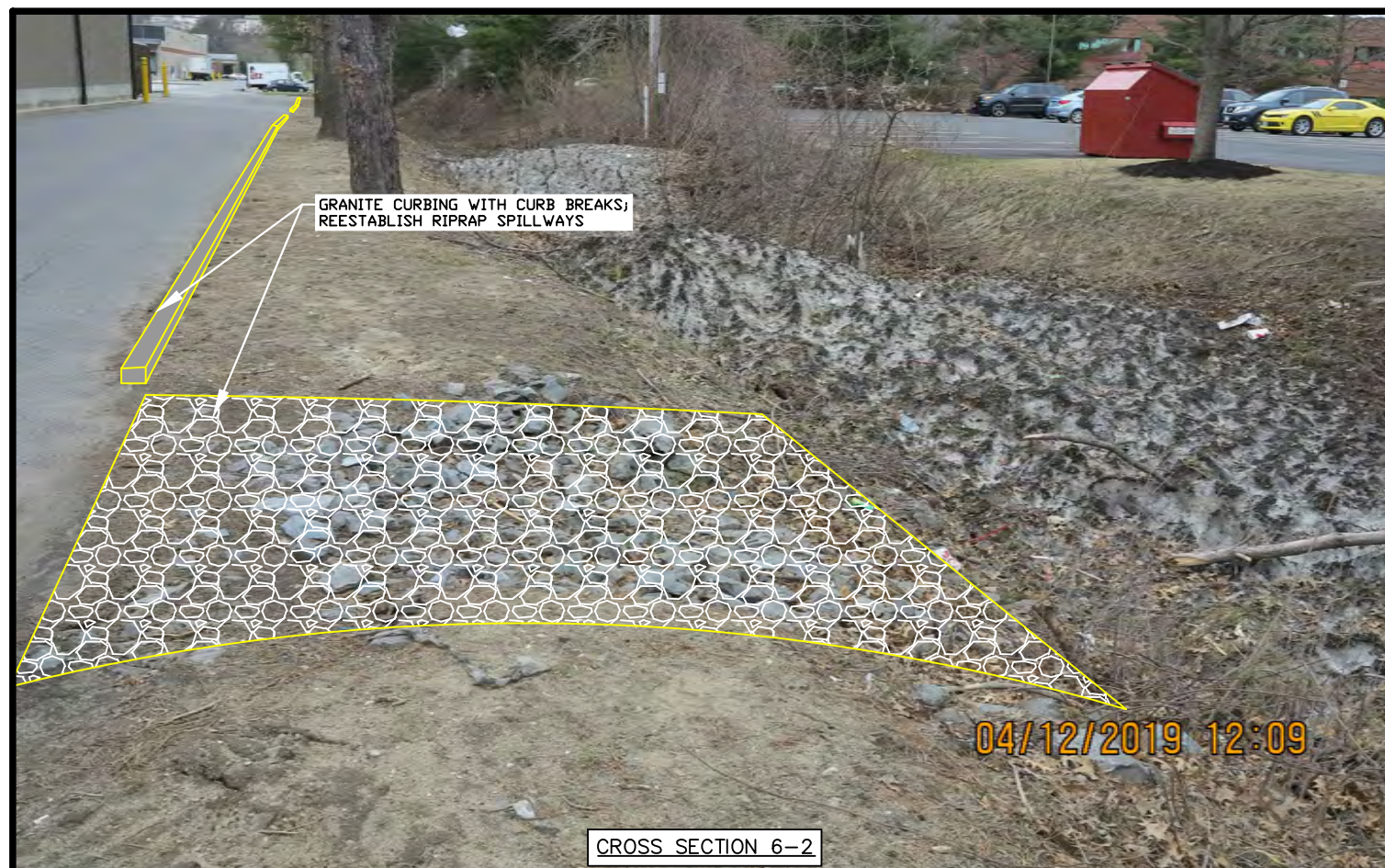
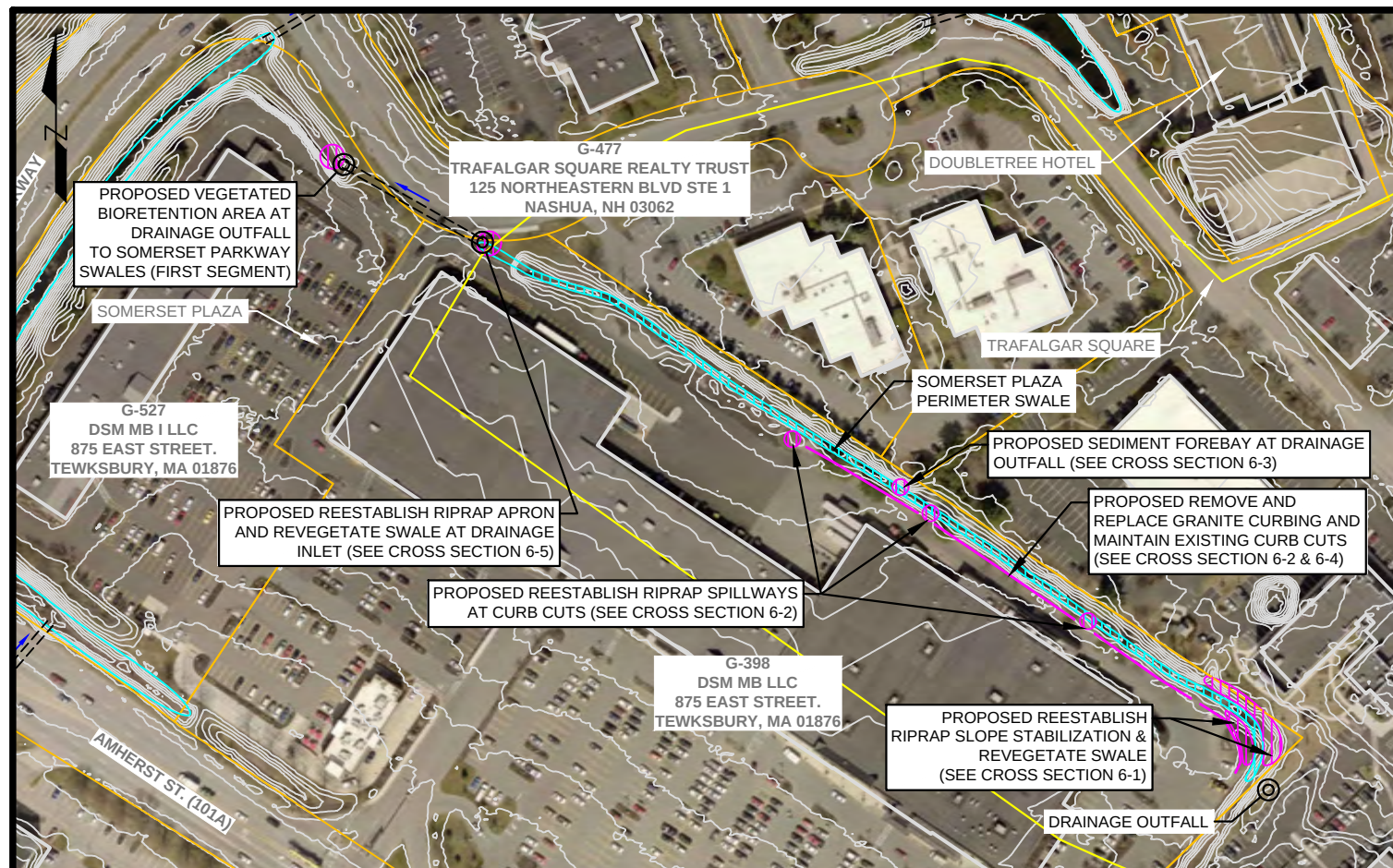
CONCEPTUAL PLANS BMP SITE 5 - DOUBLETREE HOTEL PONDS

BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:

C-5A



LEGEND

- EXISTING 1FT CONTOURS
- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
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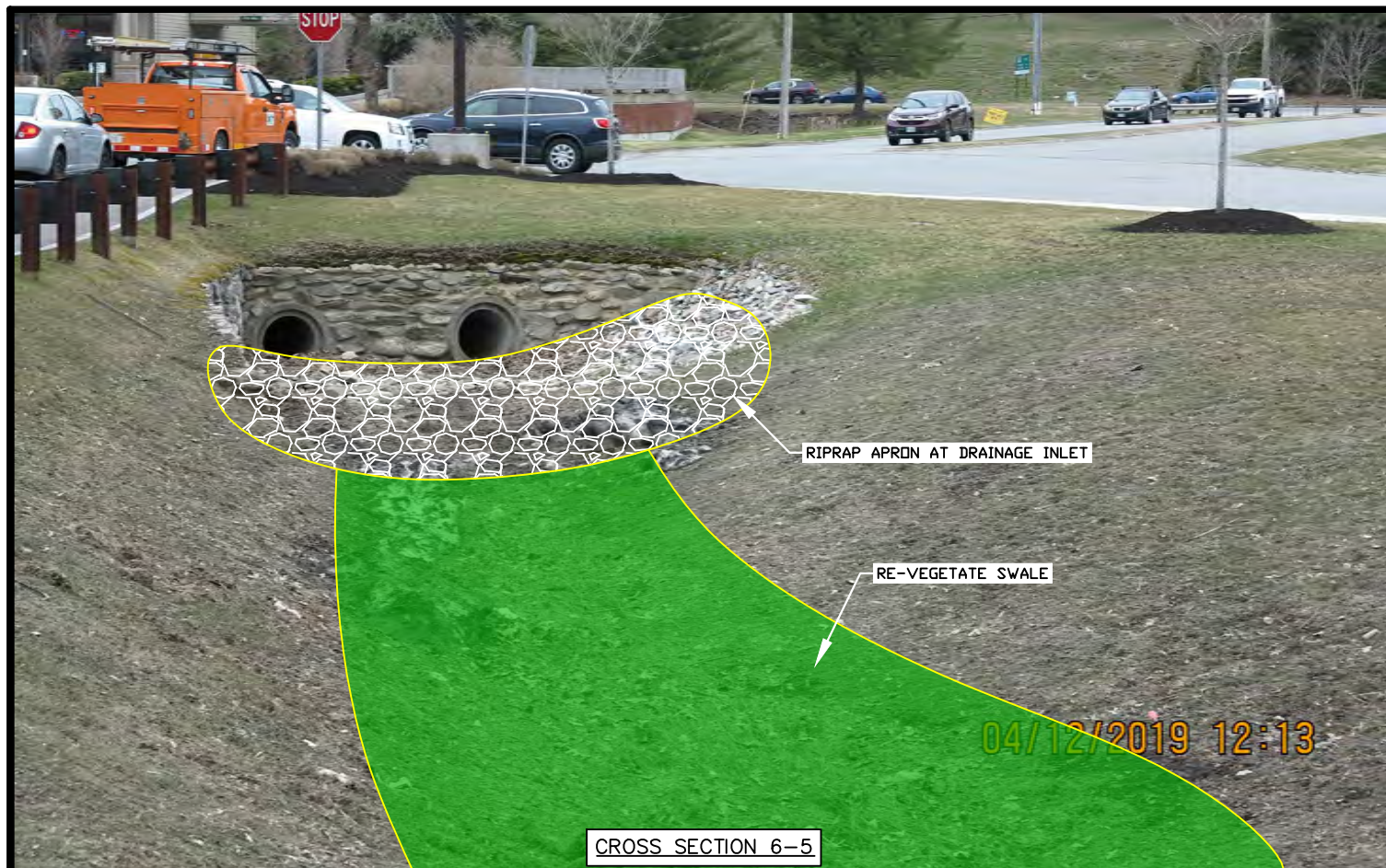
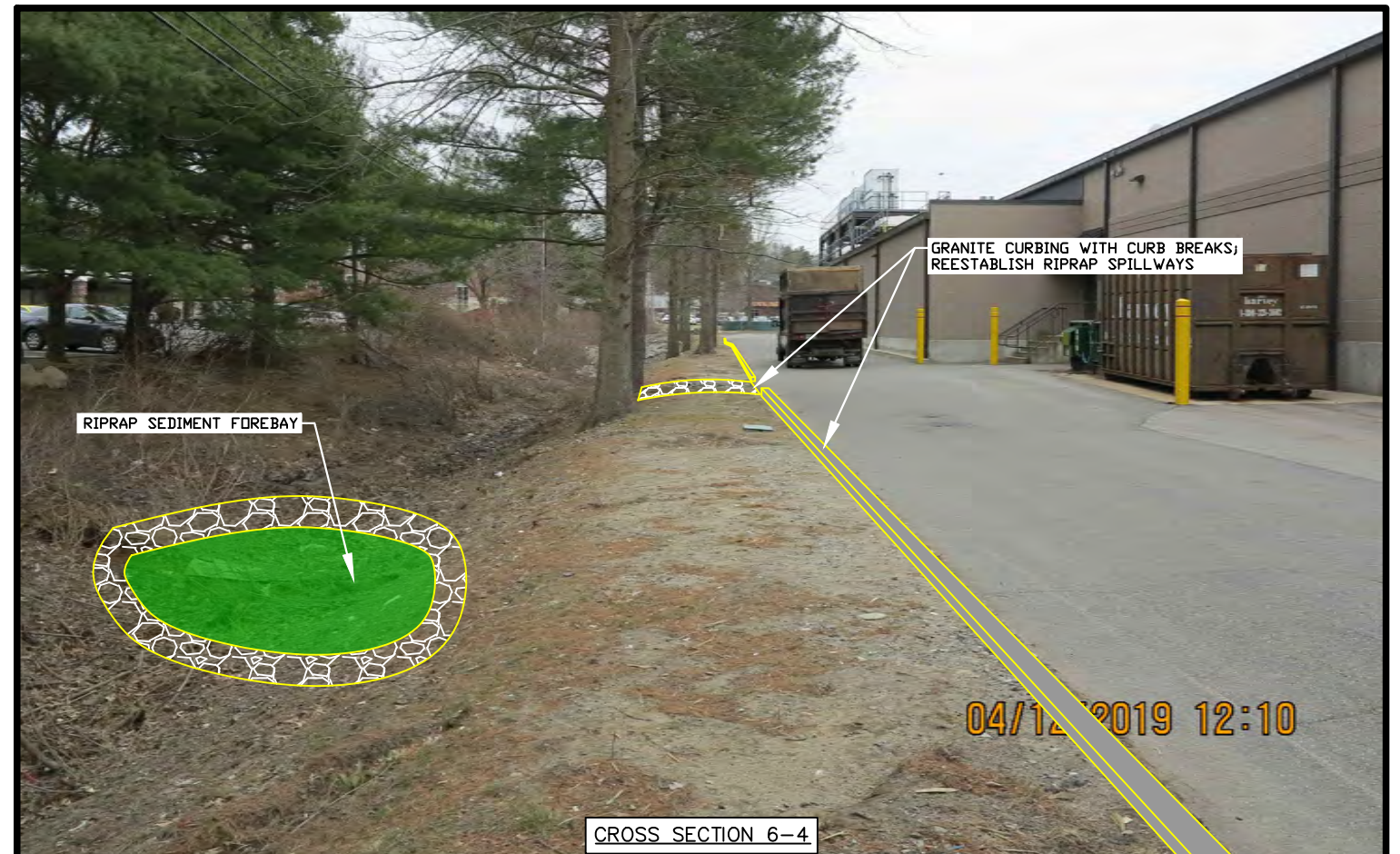
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CONCEPTUAL PLANS
**BMP SITE 6 - SOMERSET PLAZA PERIMETER
SWALE**
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
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Checked By: NC
Scale: 1"=200'

Sheet No.:

C-6A



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CONCEPTUAL PLANS
BMP SITE 6 - SOMERSET PLAZA PERIMETER
SWALE
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

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C-6B



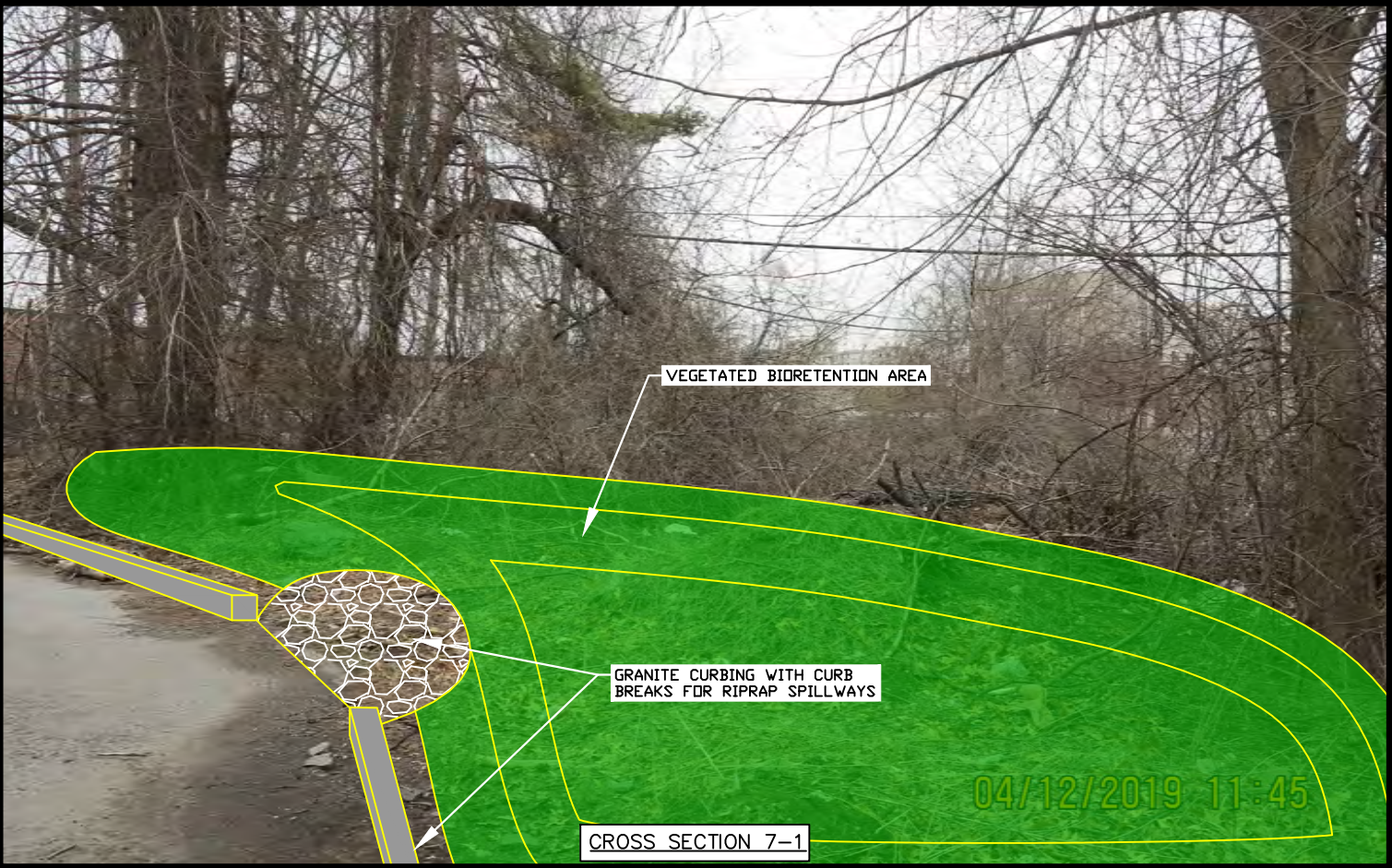
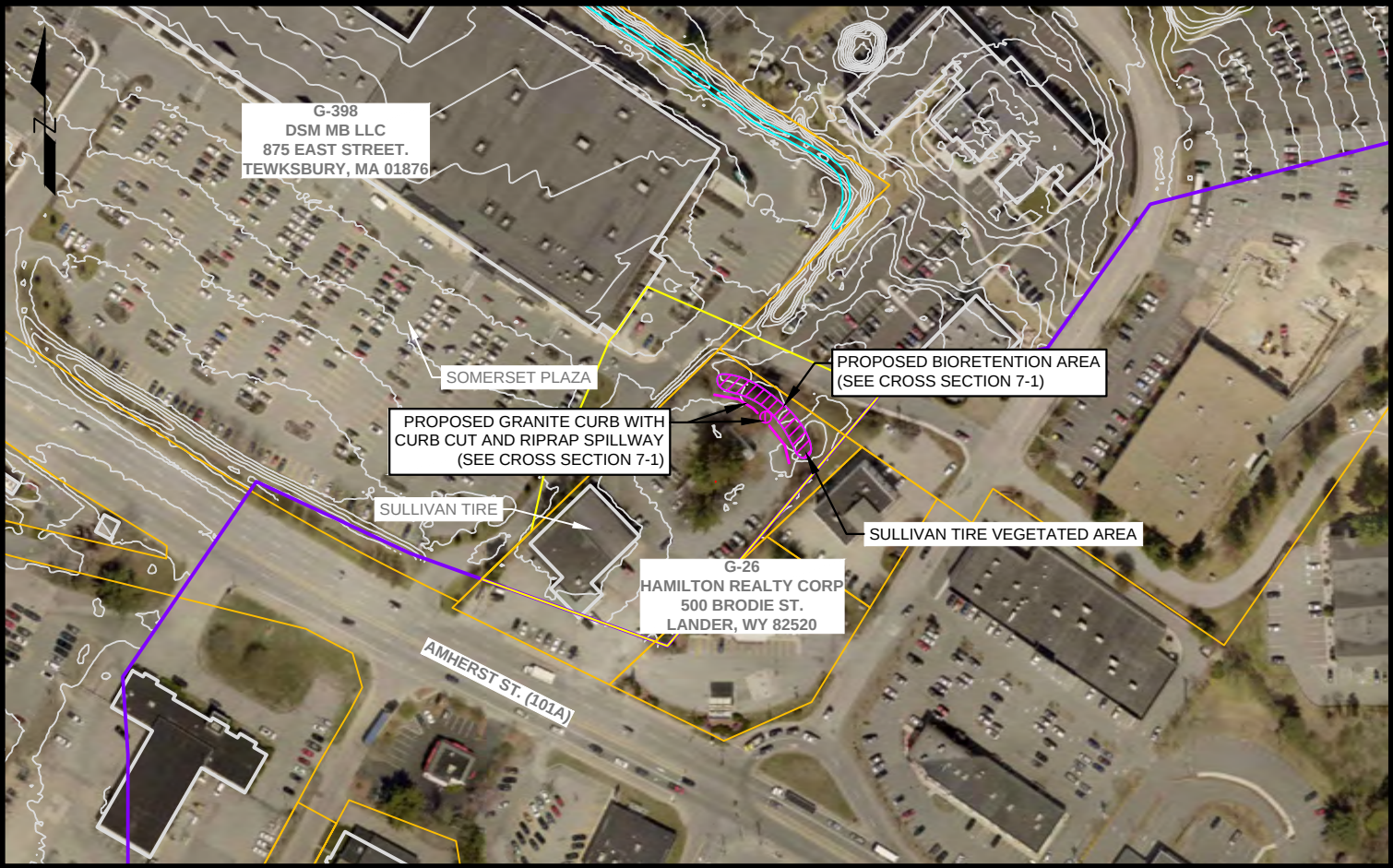
COMPREHENSIVE ENVIRONMENTAL
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CONCEPTUAL PLANS
BMP SITE 6 - SOMERSET PLAZA PERIMETER
SWALE
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
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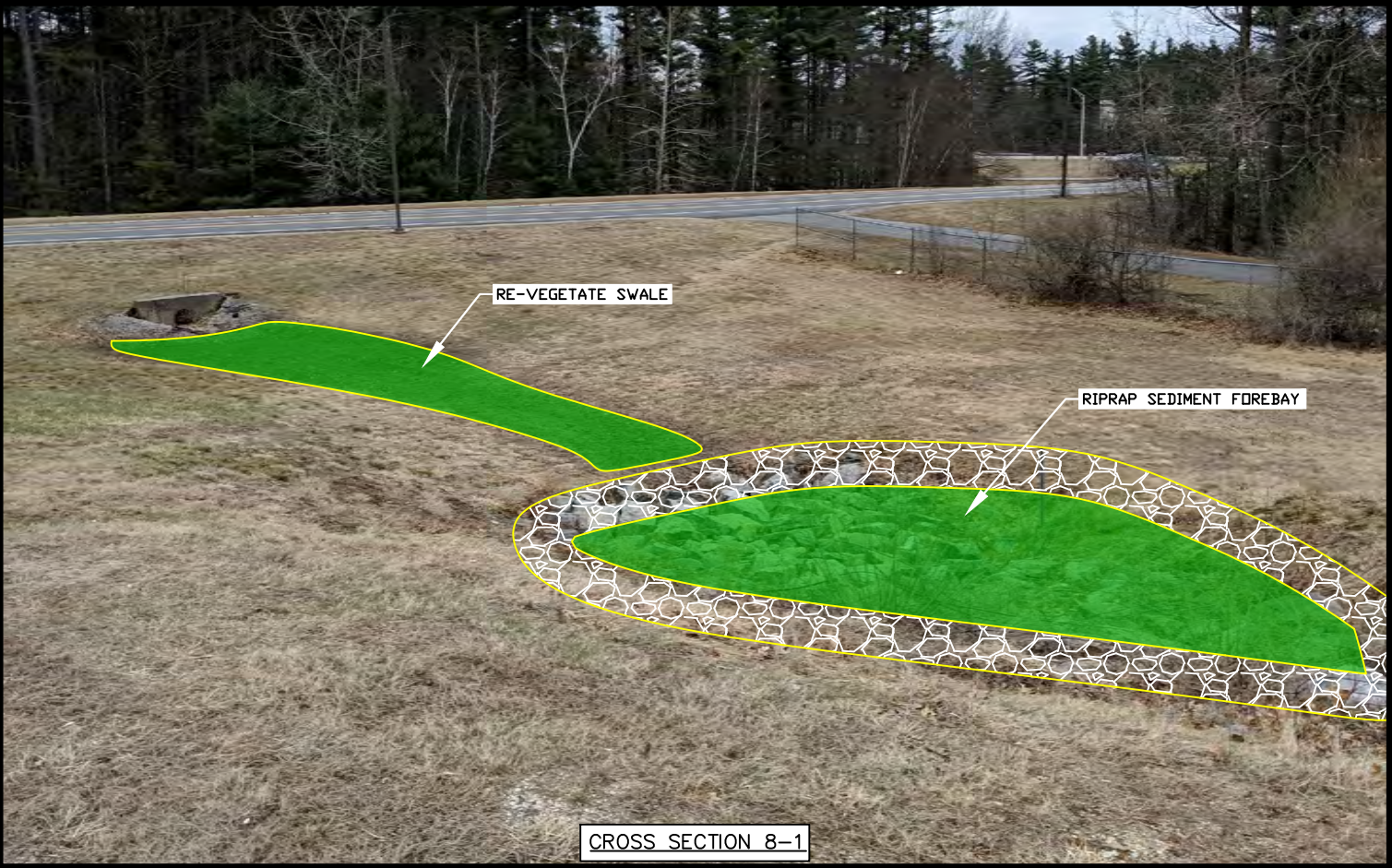
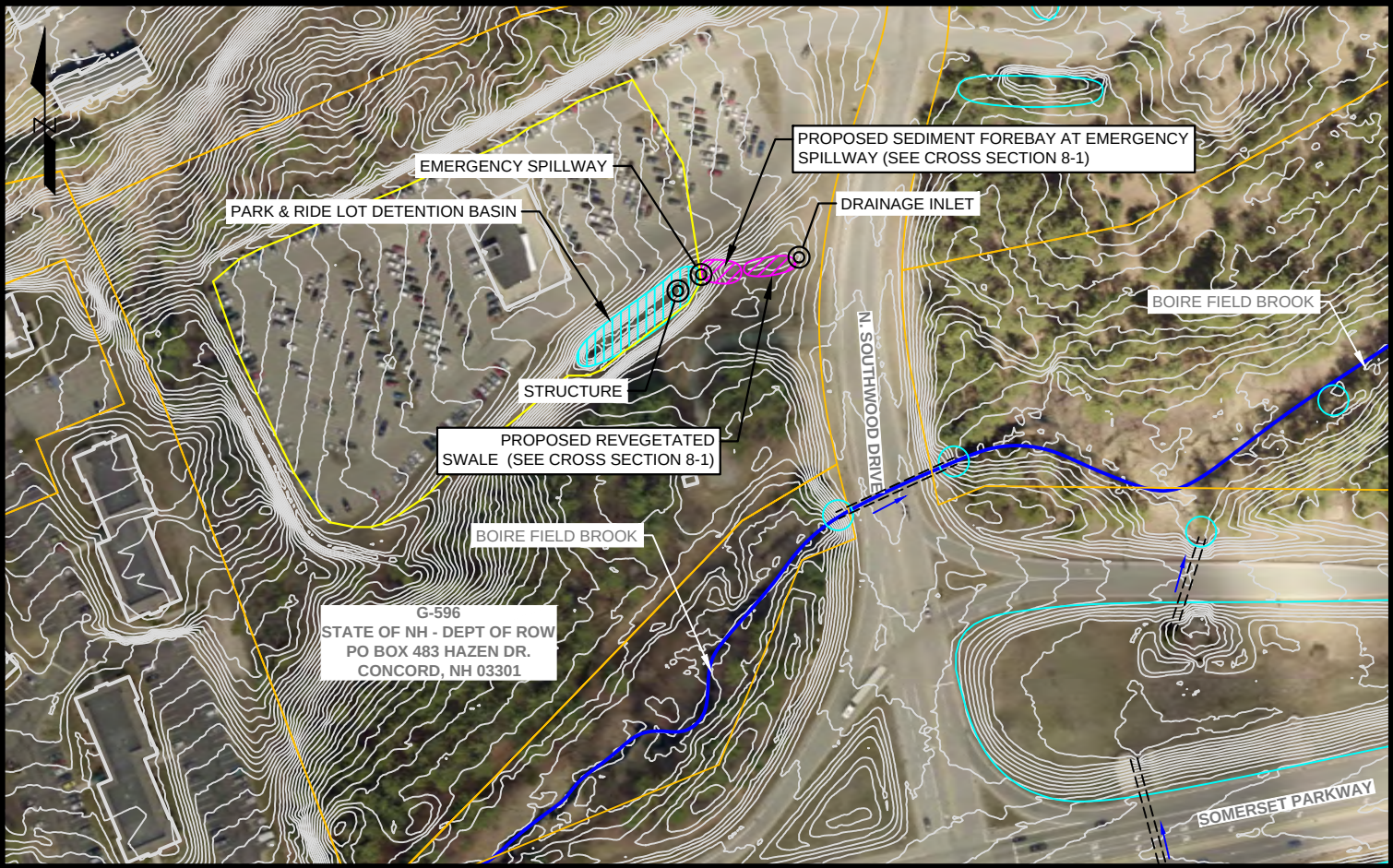
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- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

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MERRIMACK, NH 03054

**CONCEPTUAL PLANS
BMP SITE 7 - SULLIVAN TIRE
VEGETATED AREA
BOIRE FIELD BROOK SUBWATERSHED**

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-7A



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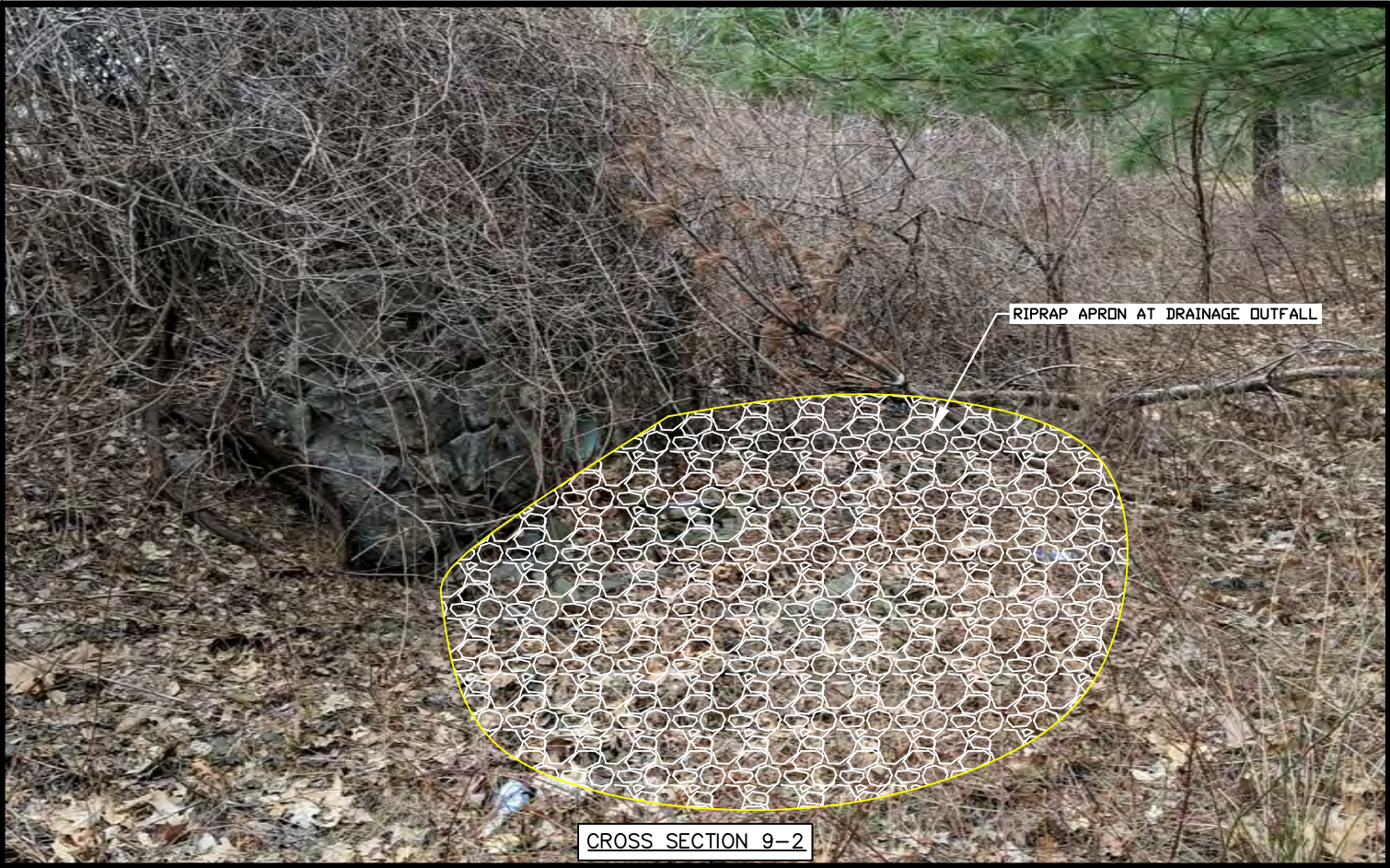
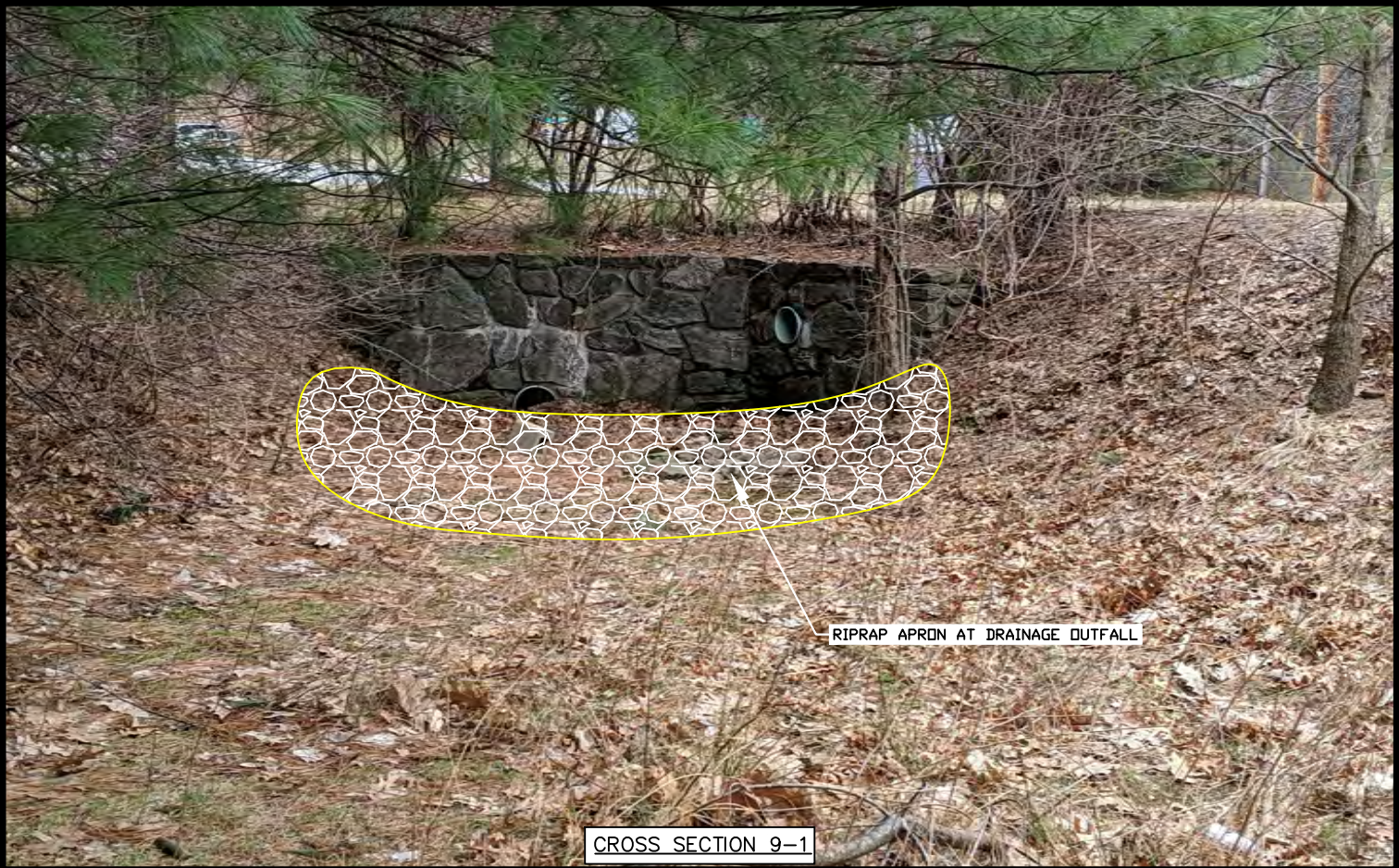
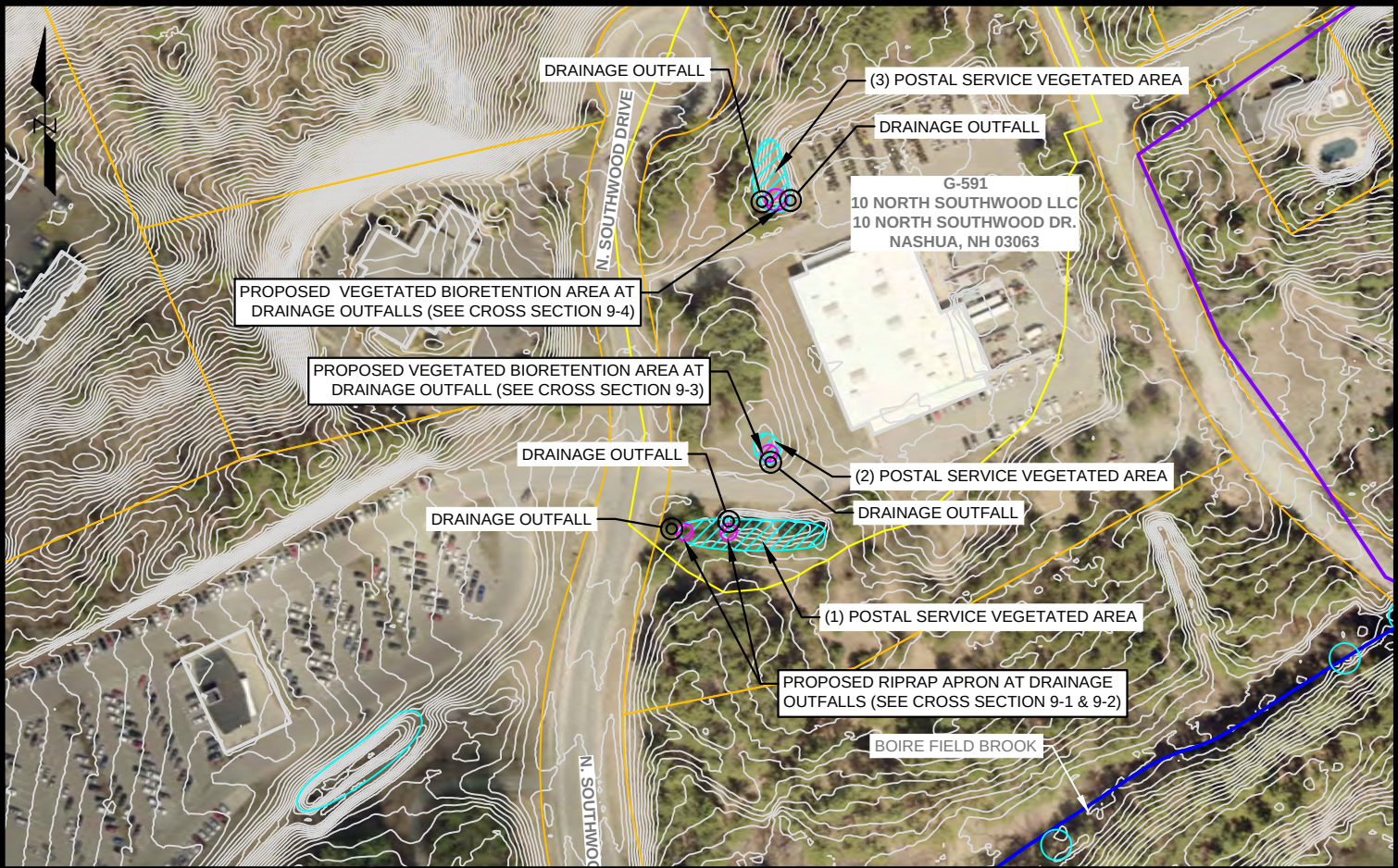
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- BFB SUBWATERSHED
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- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

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**CONCEPTUAL PLANS
BMP SITE 8 - PARK & RIDE LOT
DETENTION BASIN
BOIRE FIELD BROOK SUBWATERSHED**

**Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'**

Sheet No.:
C-8A



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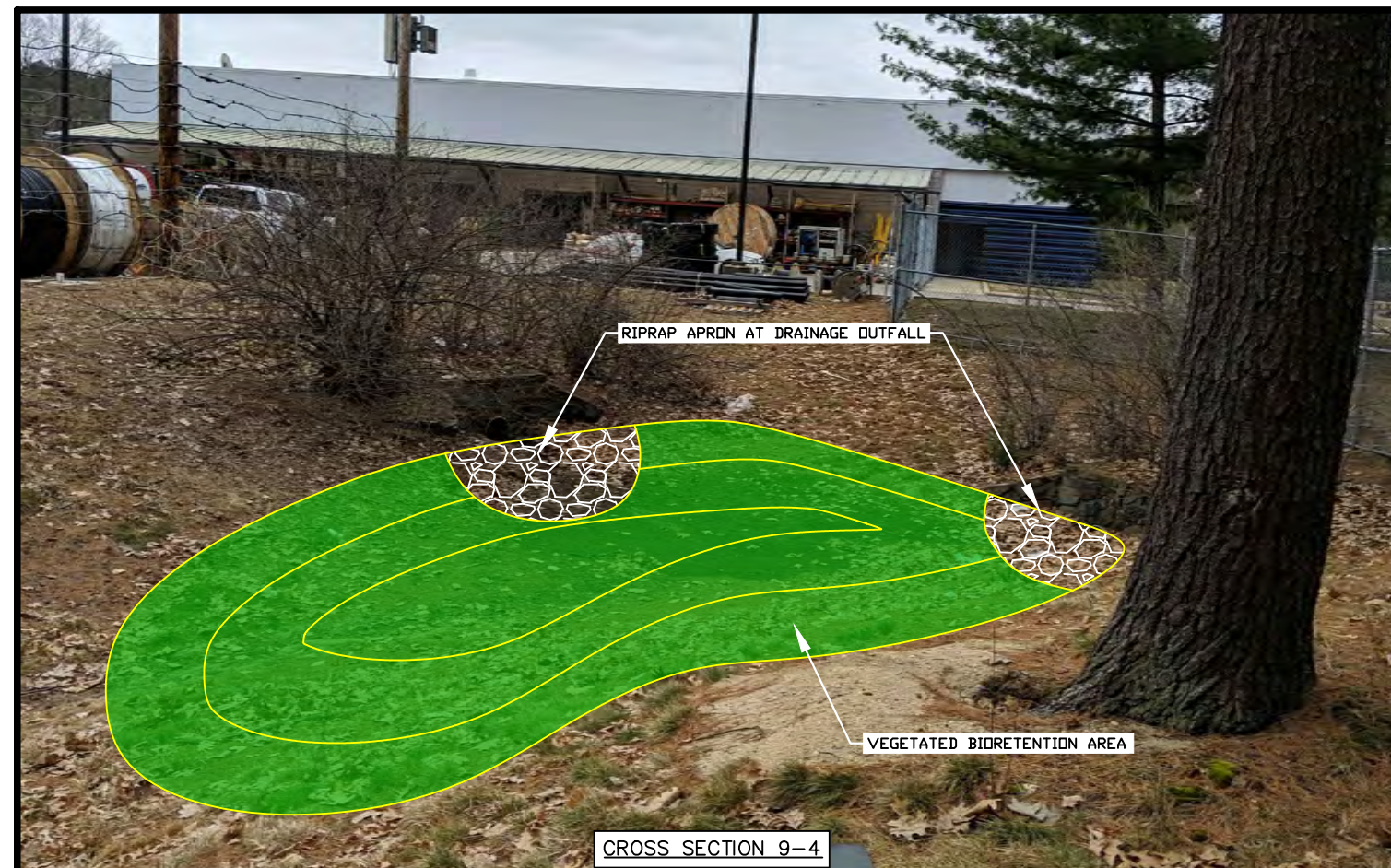
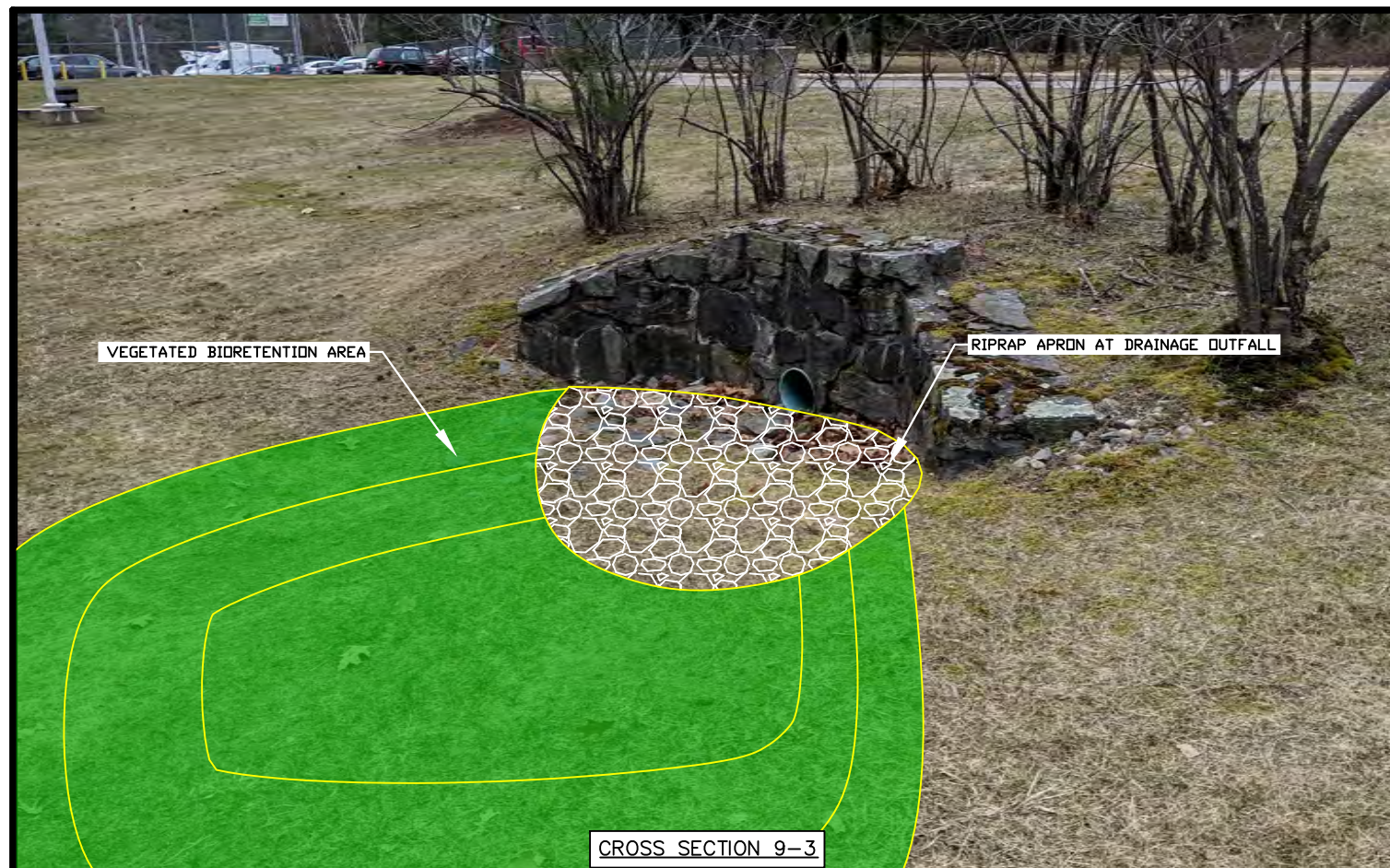
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- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

**COMPREHENSIVE ENVIRONMENTAL
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MERRIMACK, NH 03054

**CONCEPTUAL PLANS
BMP SITE 9 - POSTAL SERVICE
VEGETATED AREAS
BOIRE FIELD BROOK SUBWATERSHED**

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-9A

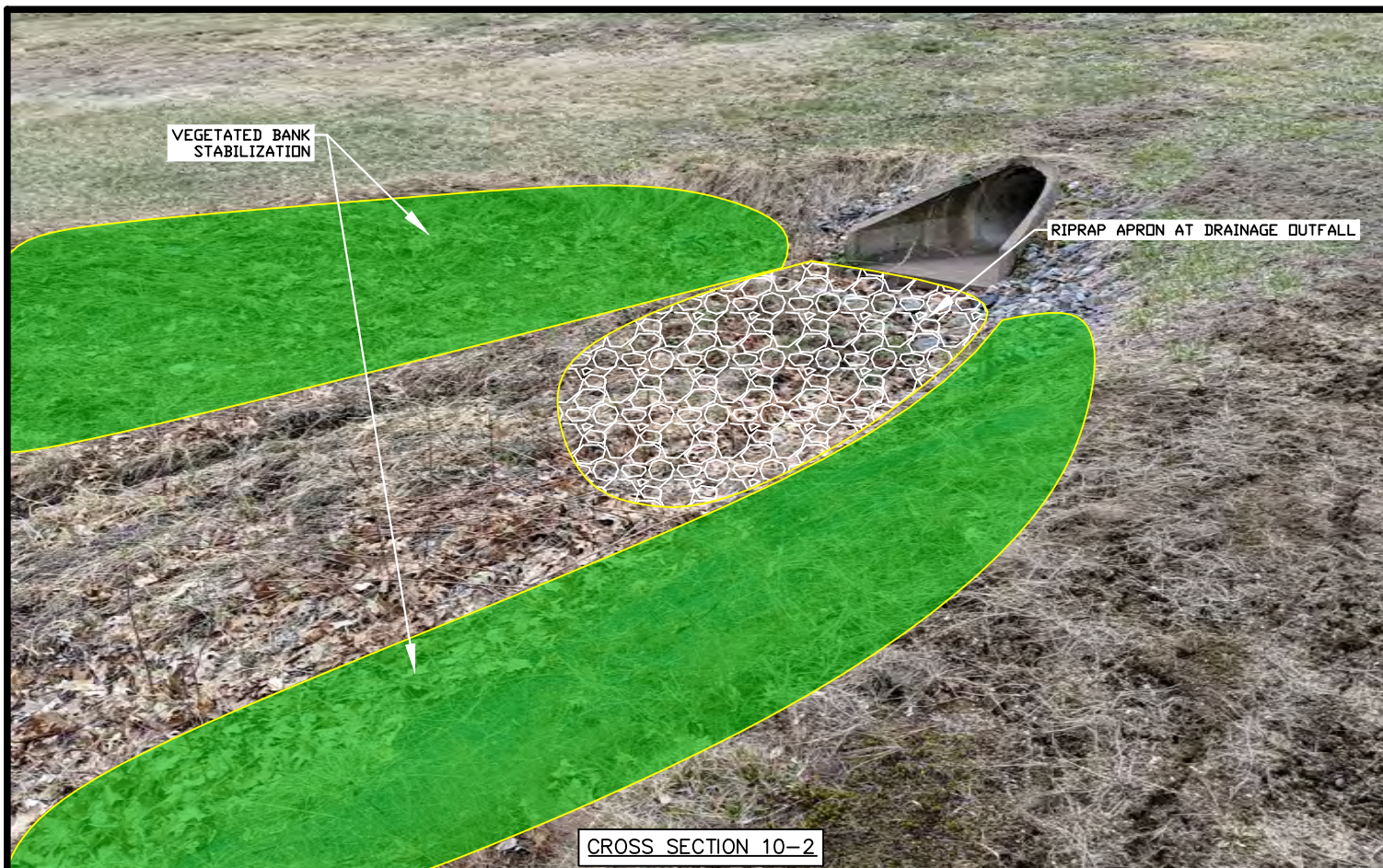
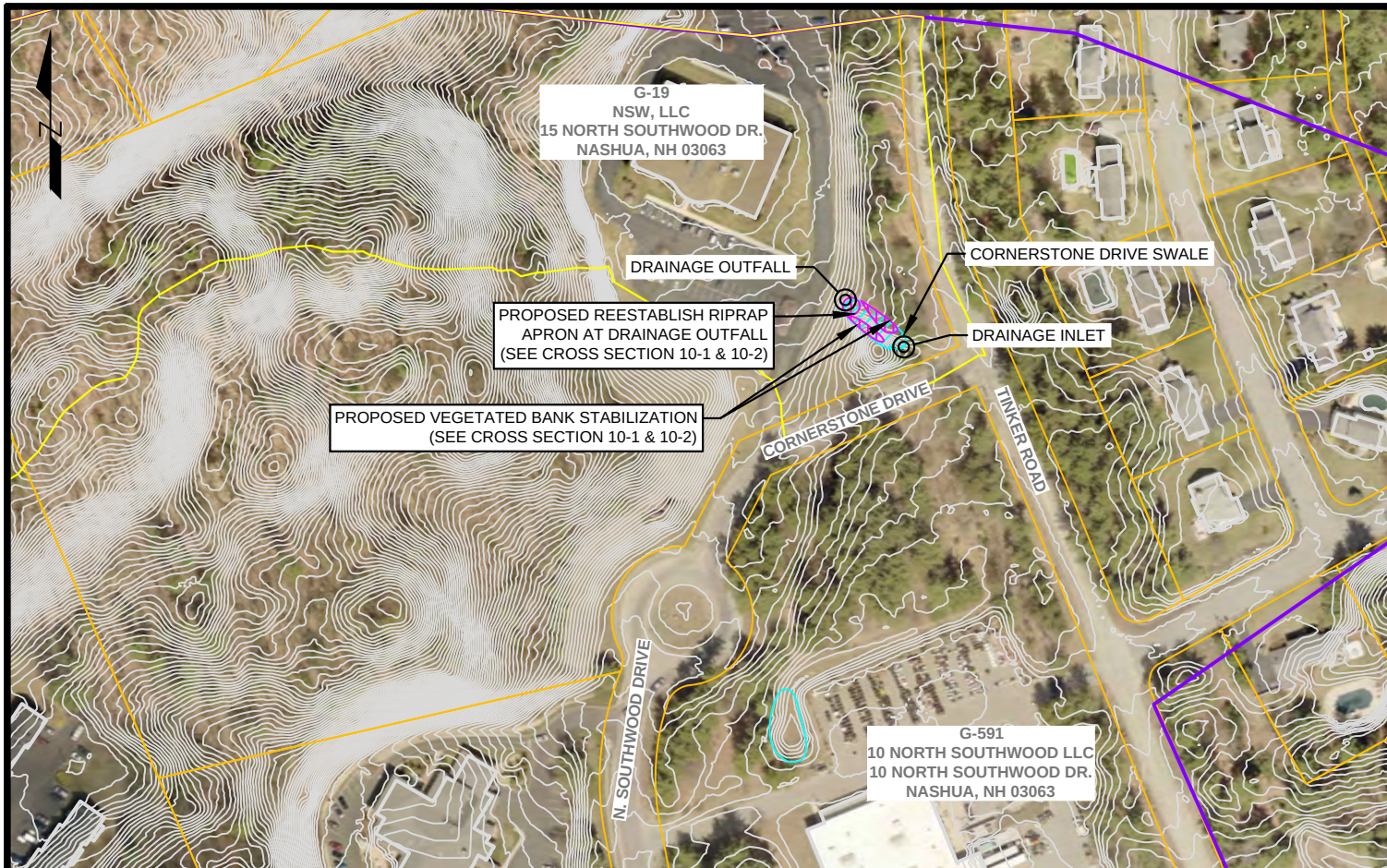


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21 DEPOT ST.
MERRIMACK, NH 03054

CONCEPTUAL PLANS
BMP SITE 9 - POSTAL SERVICE
VEGETATED AREAS
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-9B



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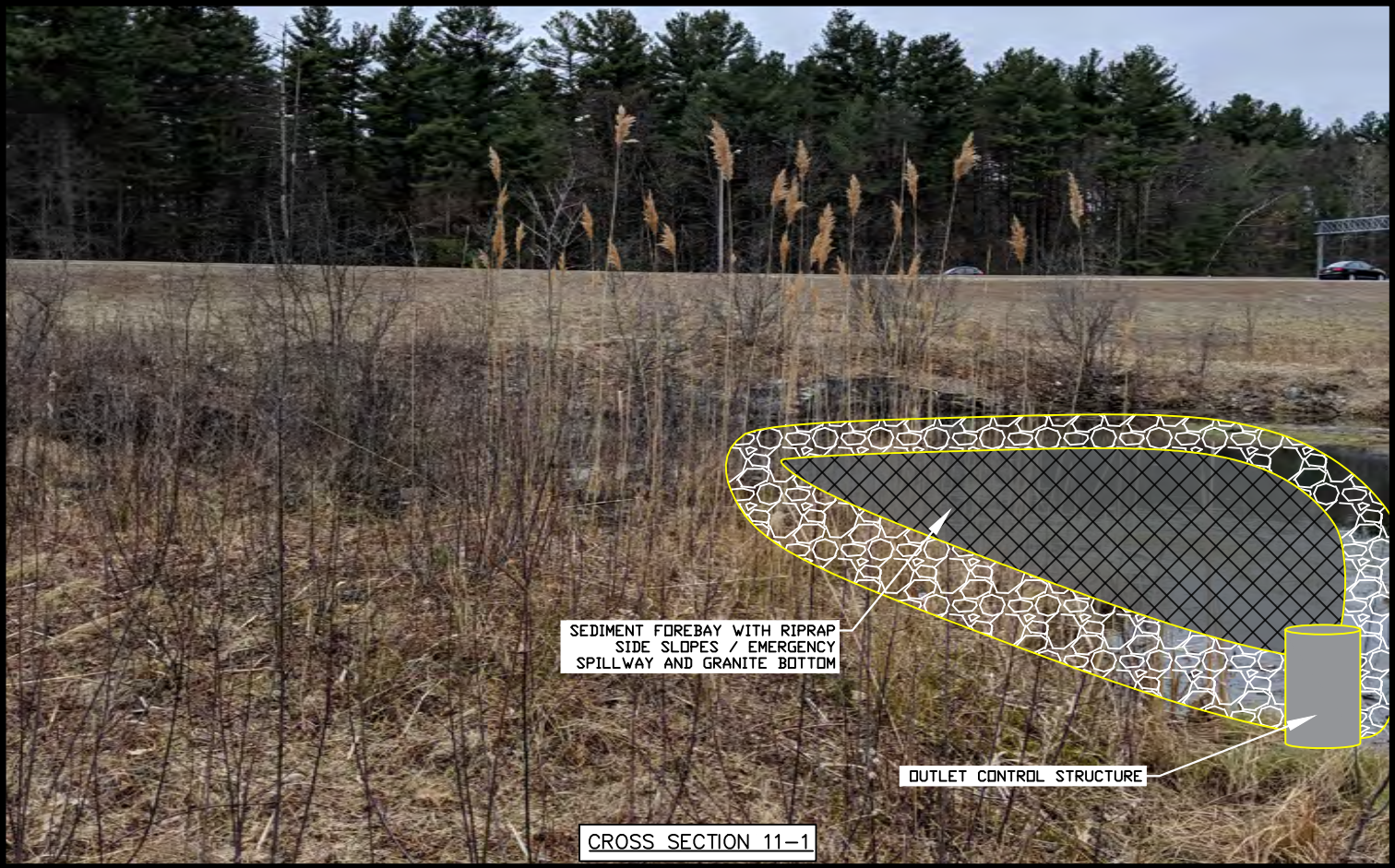
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- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- /// EXISTING BMP LIMITS
- /// PROPOSED BMP LIMITS

**COMPREHENSIVE ENVIRONMENTAL
INCORPORATED**
21 DEPOT ST.
MERRIMACK, NH 03054

**CONCEPTUAL PLANS
BMP SITE 10 - CORNERSTONE
DRIVE SWALE
BOIRE FIELD BROOK SUBWATERSHED**

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
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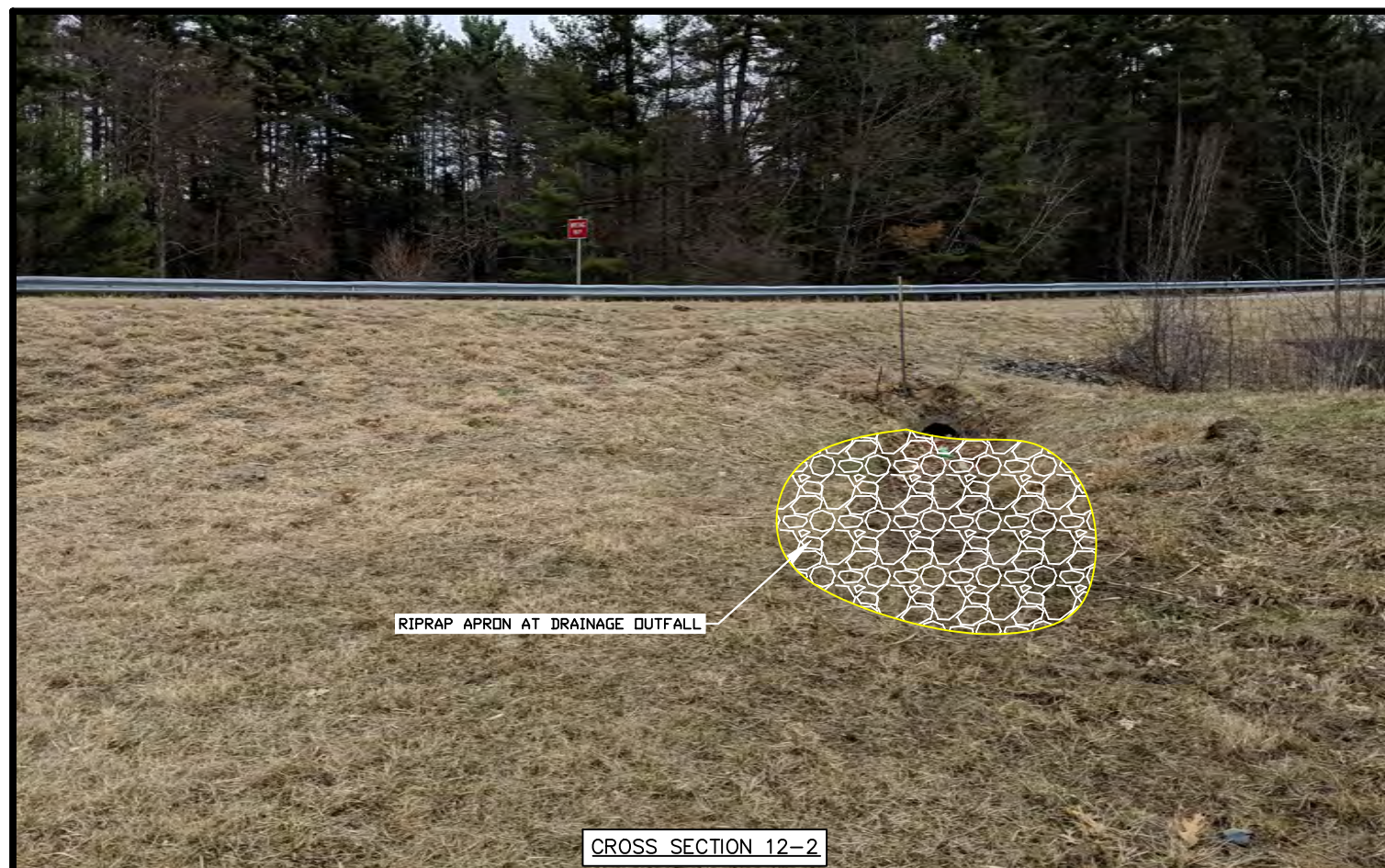
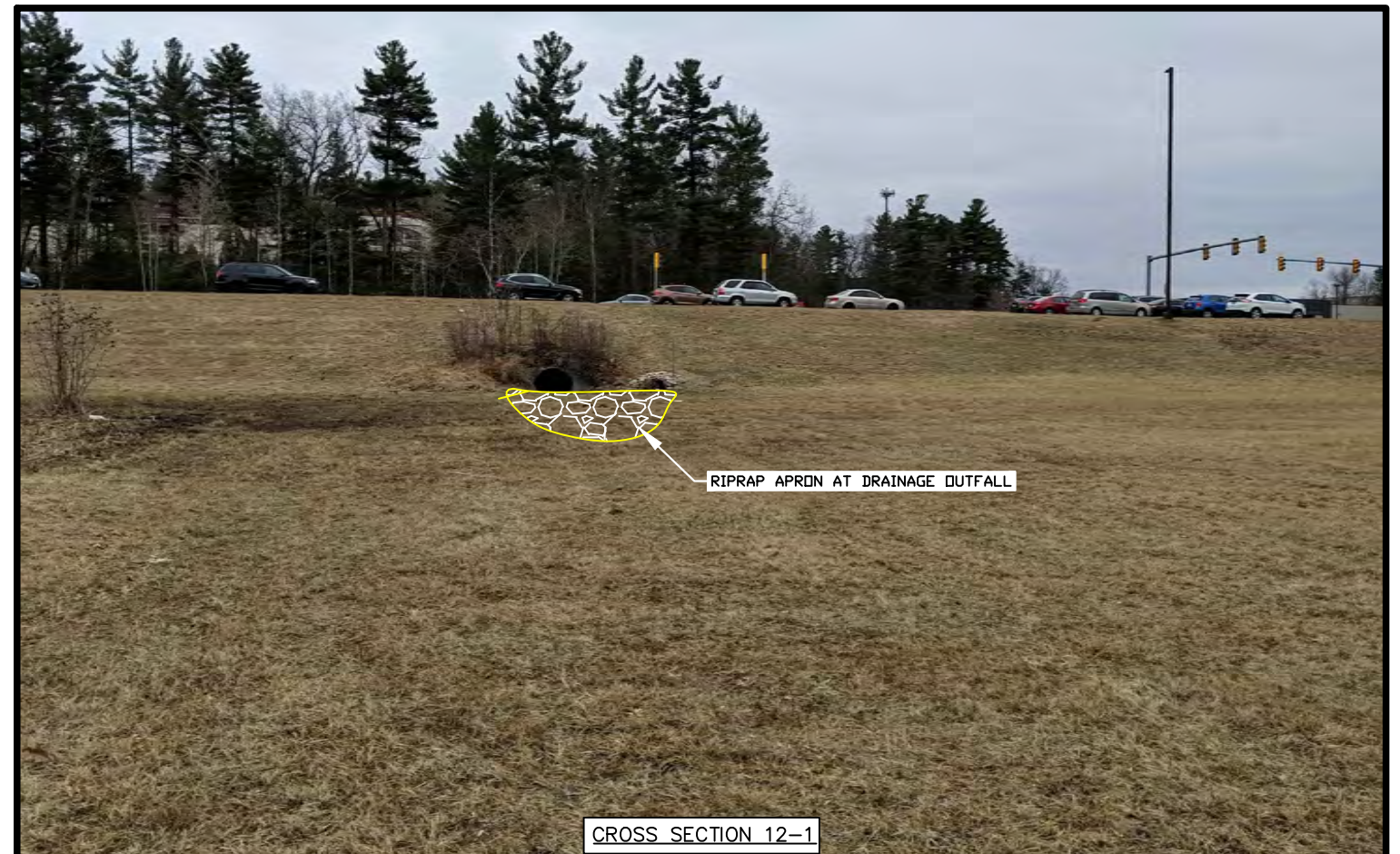
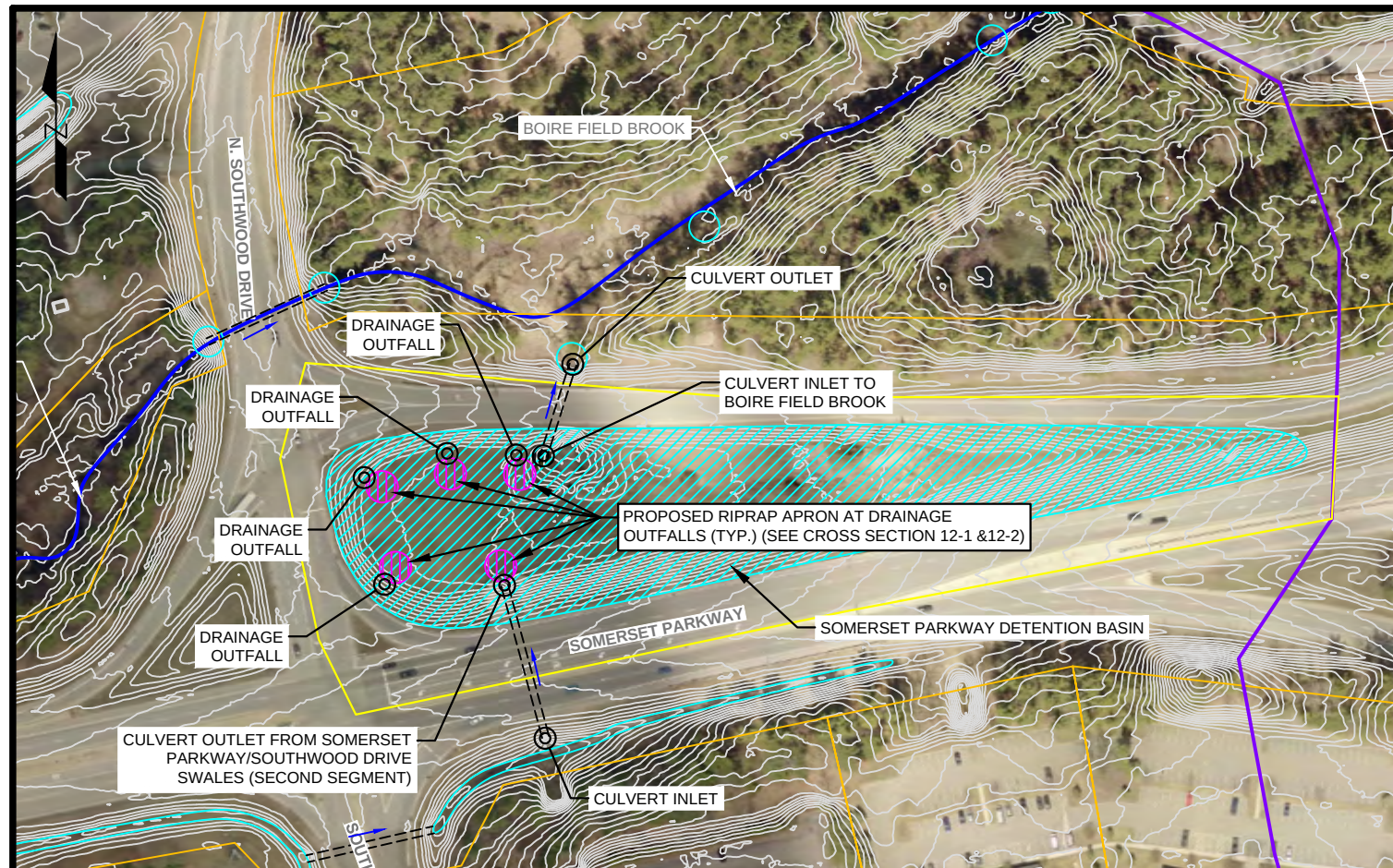
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- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

**COMPREHENSIVE ENVIRONMENTAL
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MERRIMACK, NH 03054

CONCEPTUAL PLANS
**BMP SITE 11 - BOIRE FIELD BROOK OUTLET
TO HARRIS POND**
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-11A



LEGEND

- EXISTING 1FT CONTOURS
- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
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- PROPOSED BMP LIMITS

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

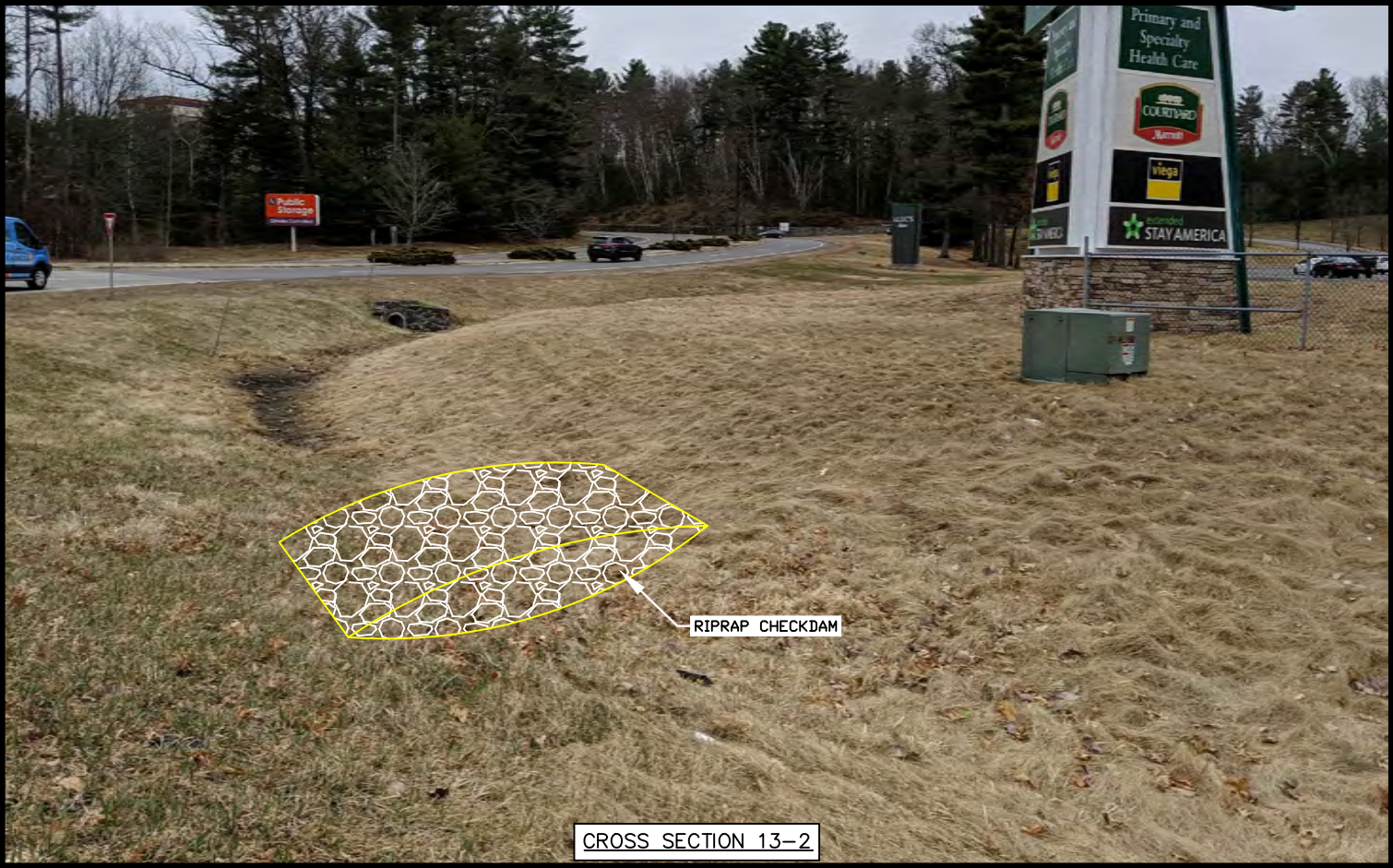
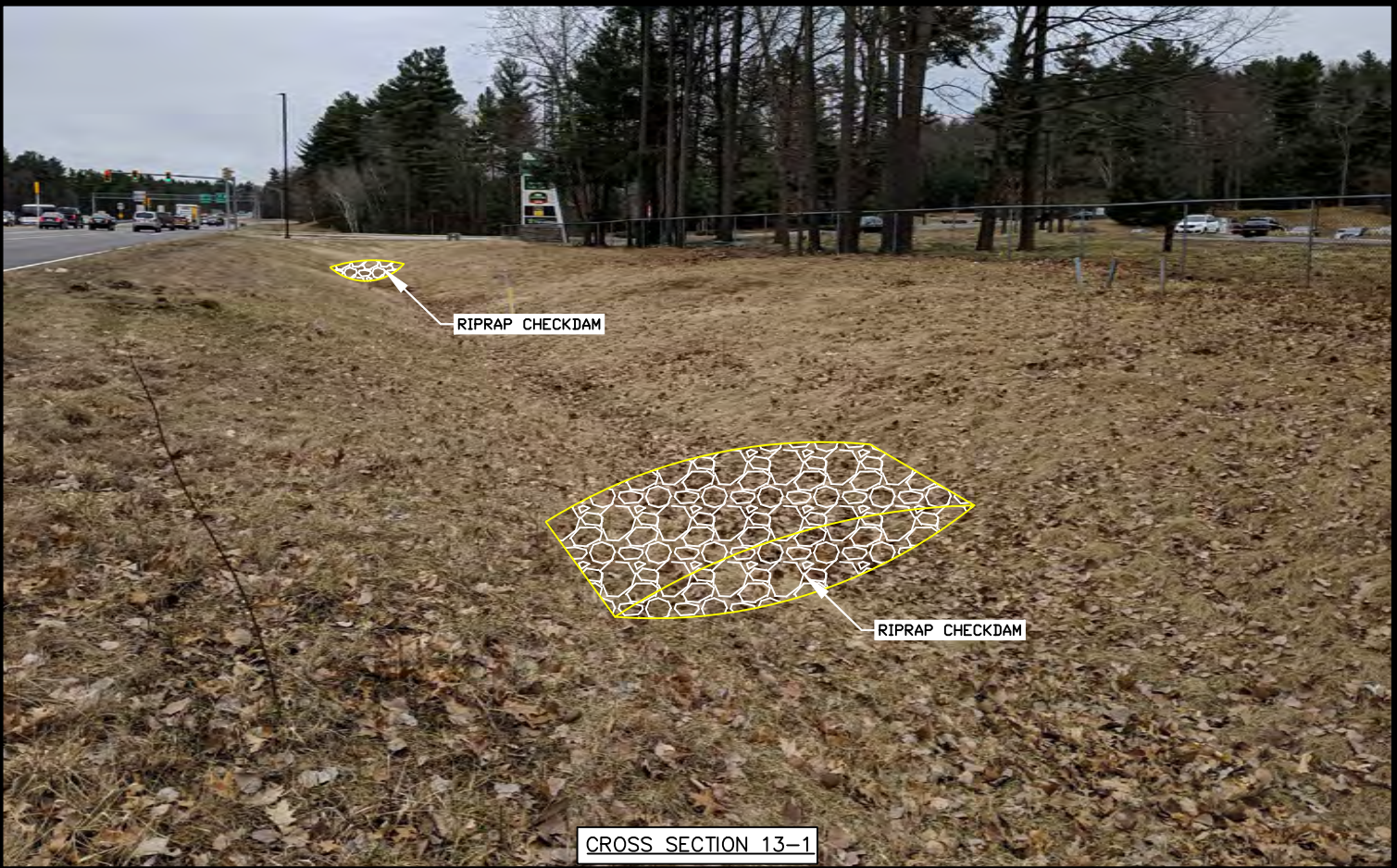
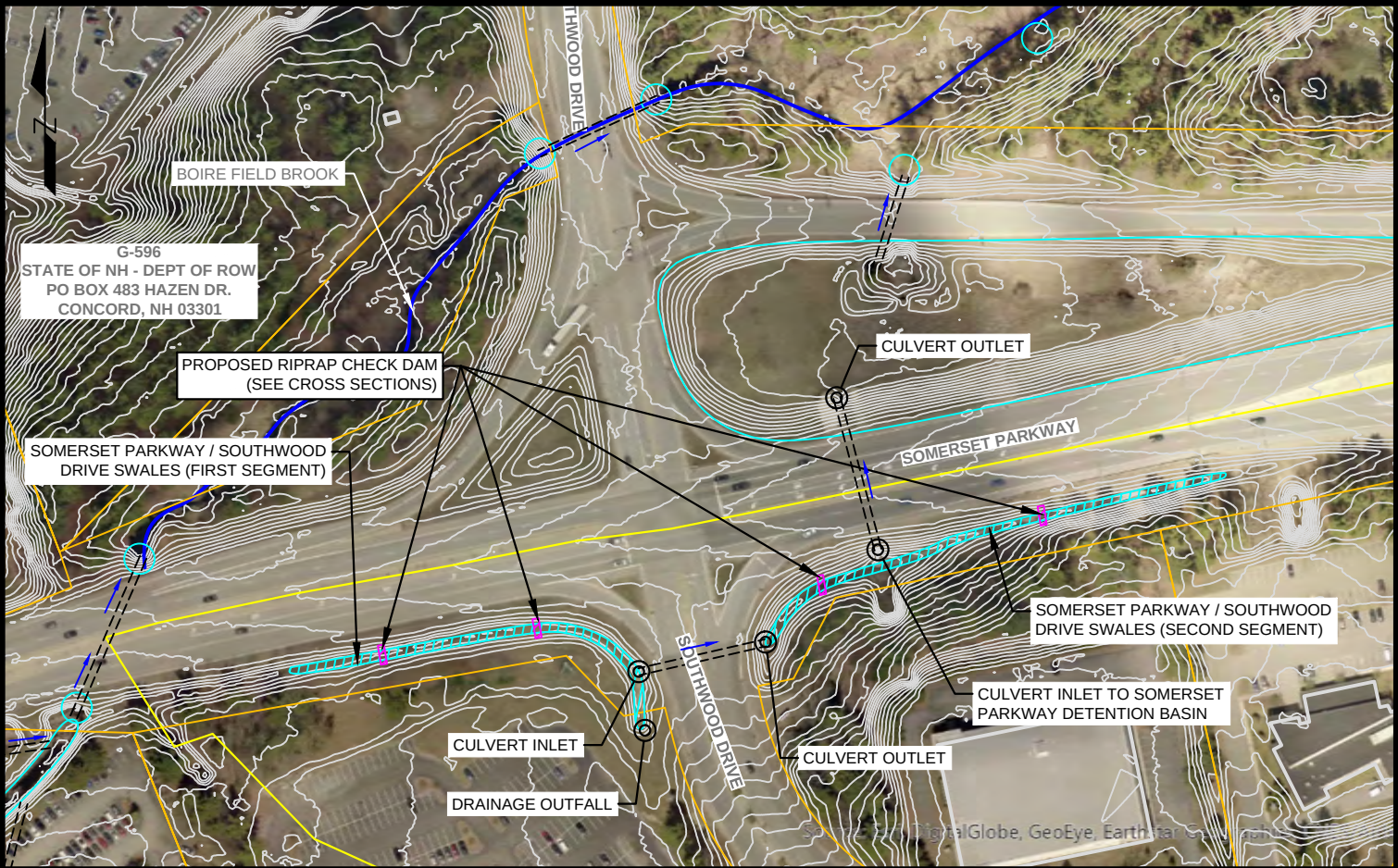
21 DEPOT ST.
MERRIMACK, NH 03054

CONCEPTUAL PLANS BMP SITE 12 - SOMERSET PARKWAY DETENTION BASIN BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:

C-12A



LEGEND

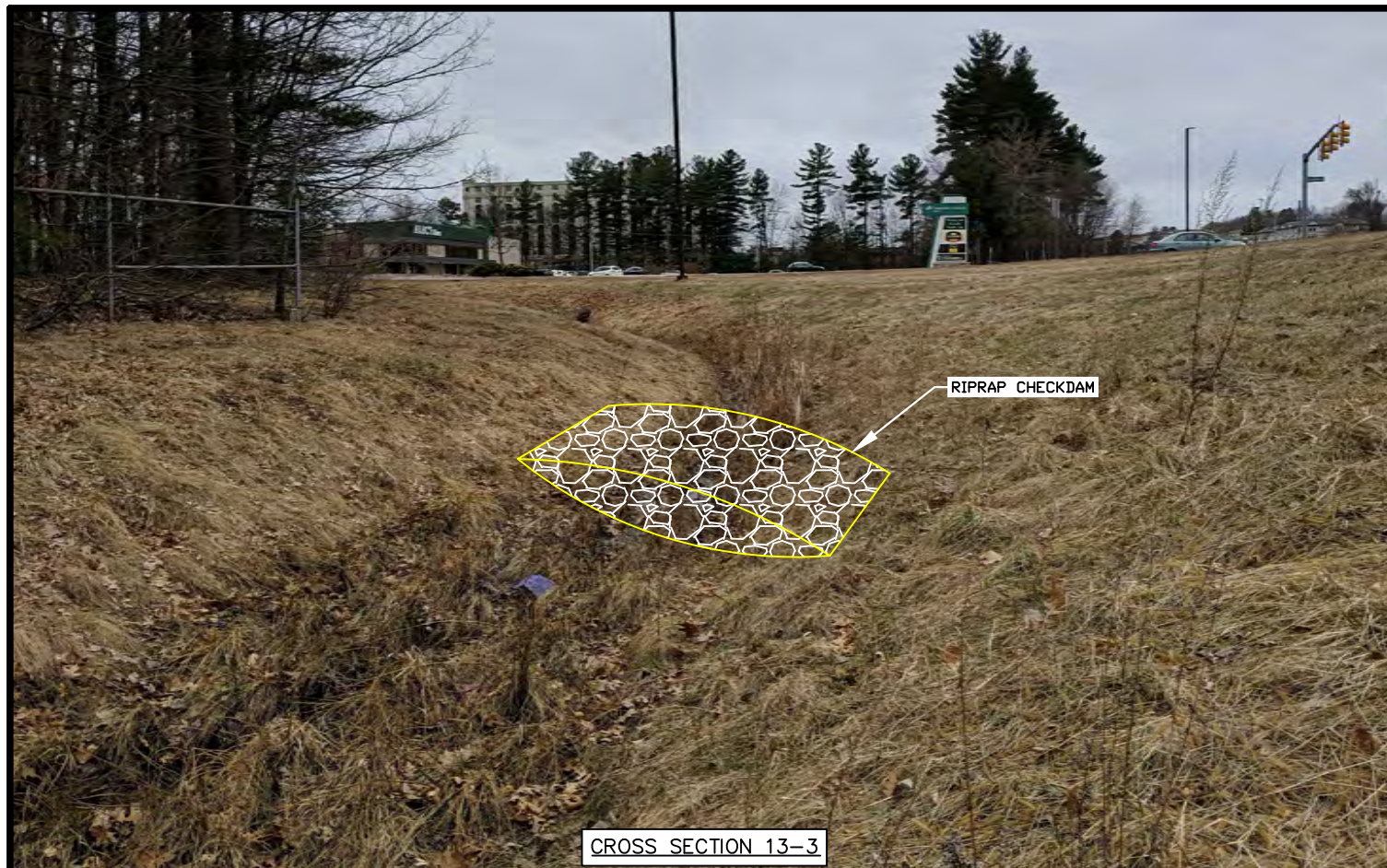
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- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

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CONCEPTUAL PLANS
BMP SITE 13 - SOMERSET PARKWAY /
SOUTHWOOD DRIVE SWALES
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-13A



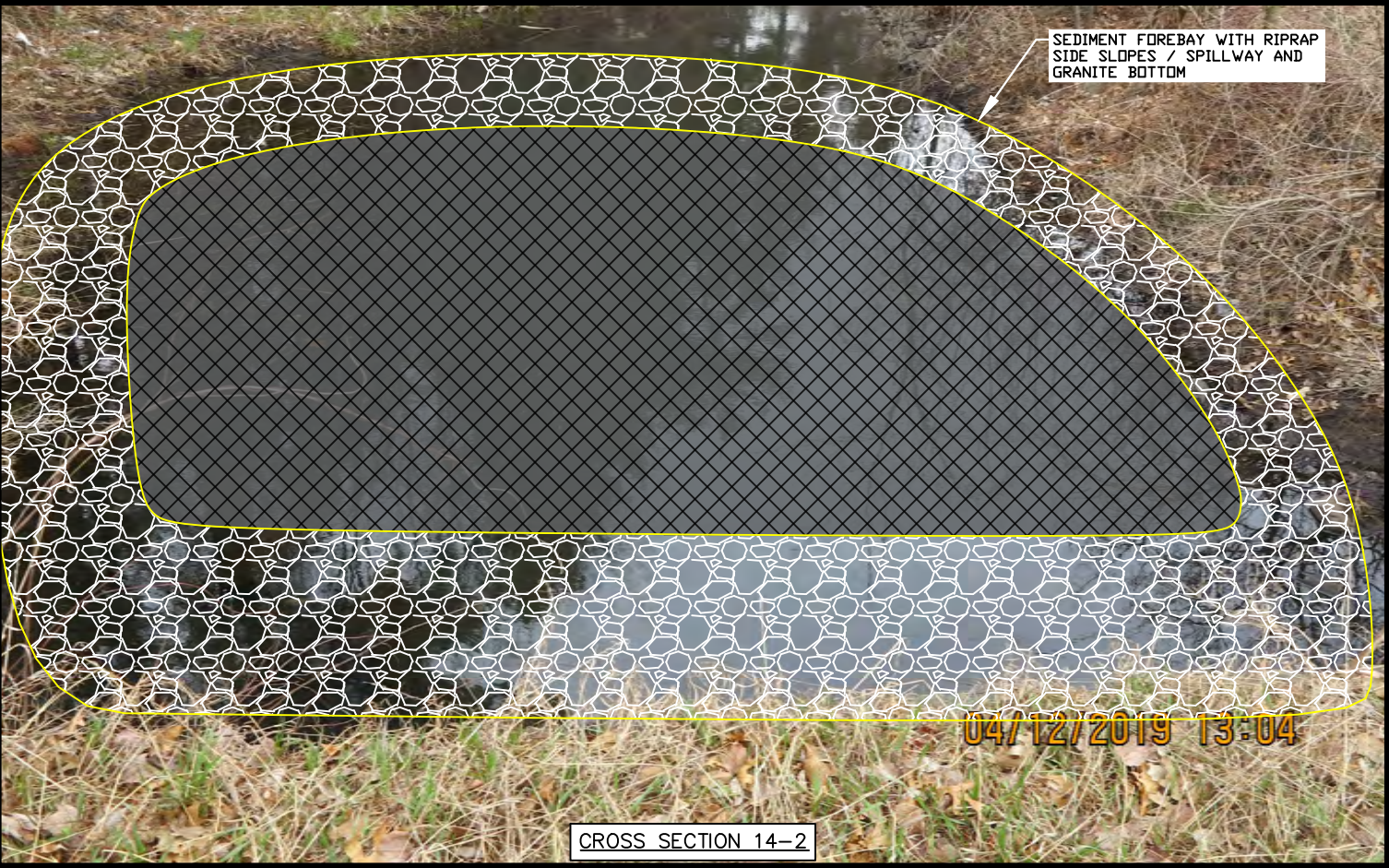
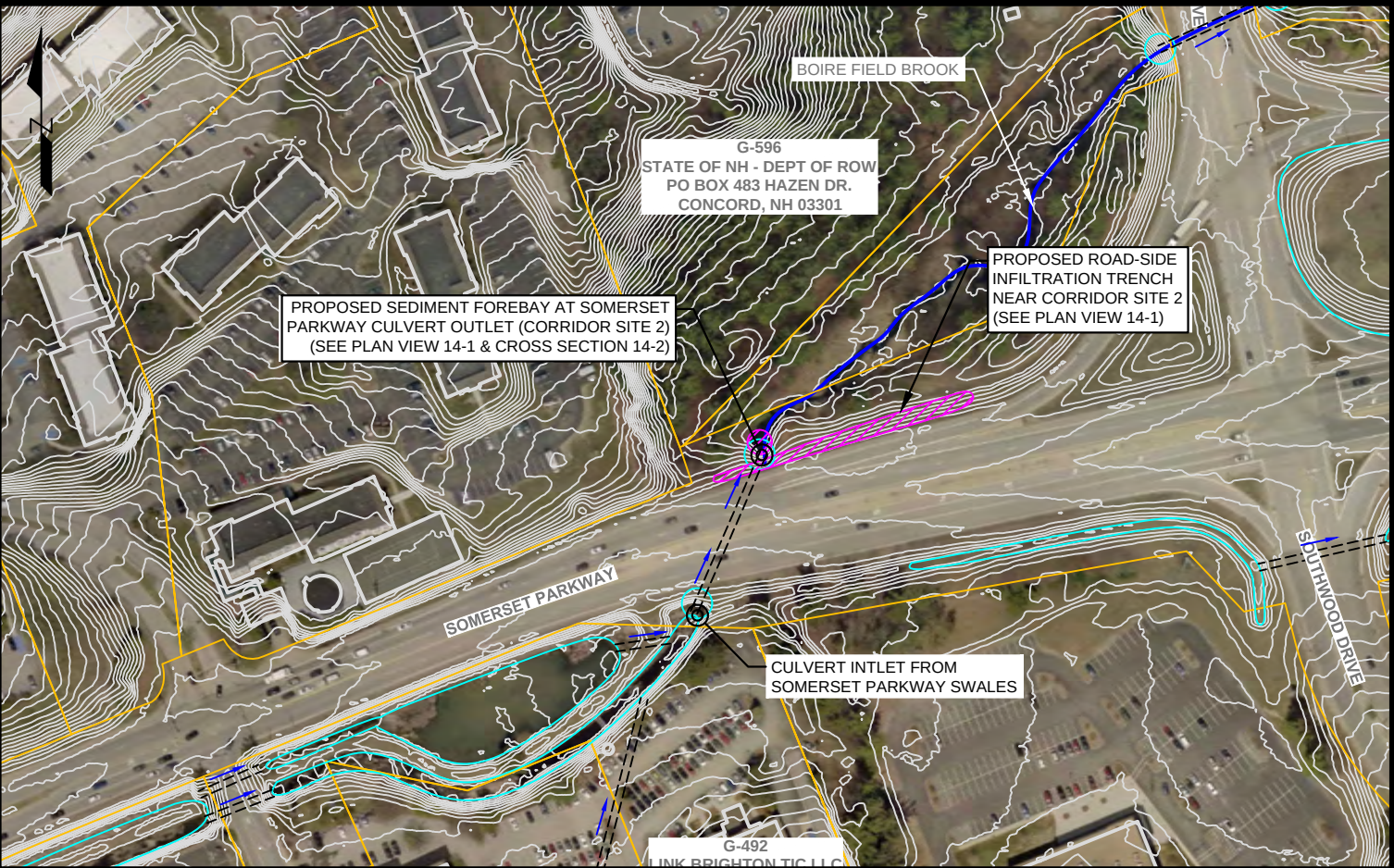
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CONCEPTUAL PLANS
BMP SITE 13 - SOMERSET PARKWAY /
SOUTHWOOD DRIVE SWALES
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:

C-13B



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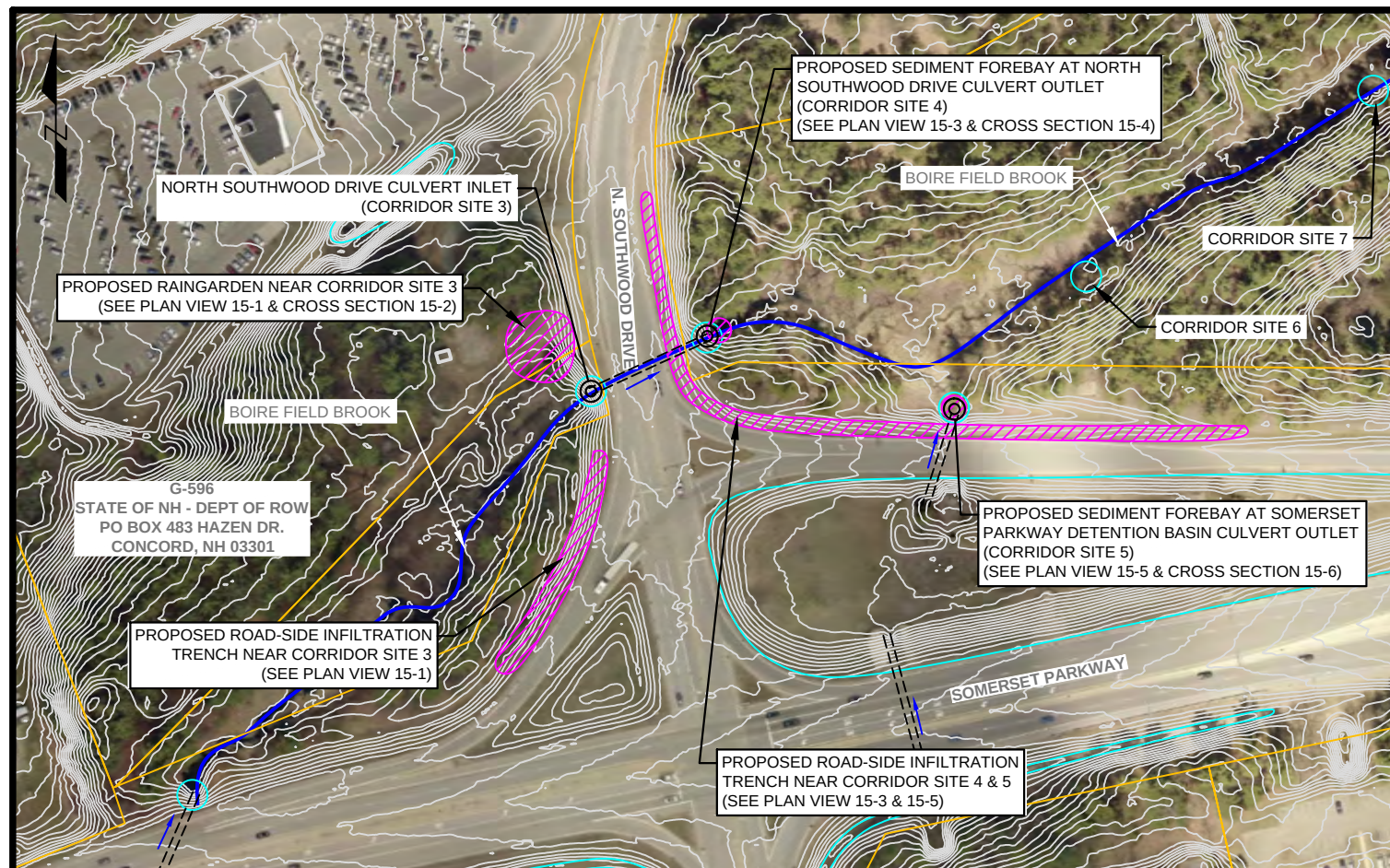
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- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

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CONCEPTUAL PLANS
BOIRE FIELD BROOK CORRIDOR
SITE 2
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-14A



LEGEND

- EXISTING 1FT CONTOURS
- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- /// EXISTING BMP LIMITS
- /// PROPOSED BMP LIMITS

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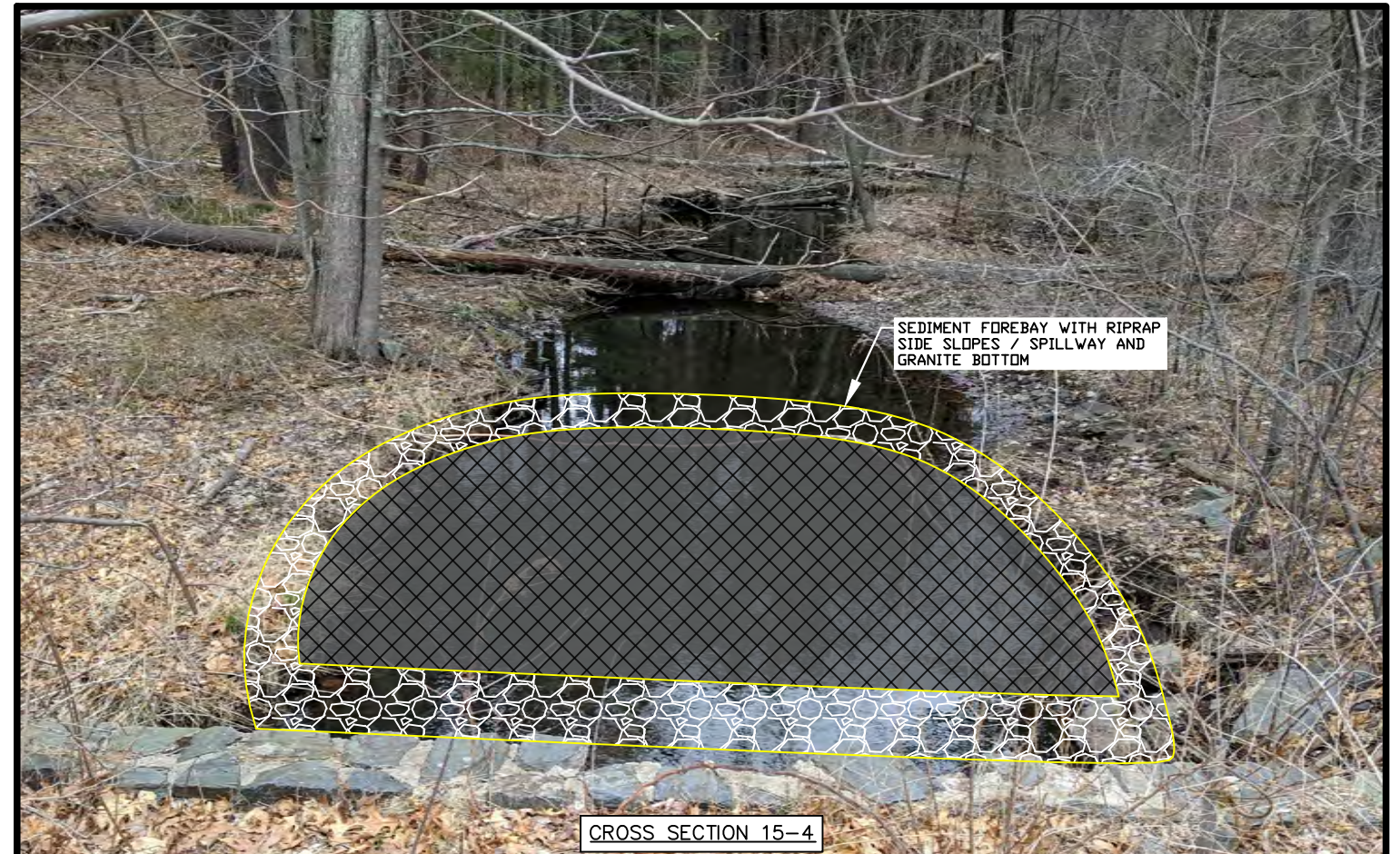
21 DEPOT ST.
MERRIMACK, NH 03054

CONCEPTUAL PLANS BOIRE FIELD BROOK CORRIDOR SITES 3, 4, & 5 BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:

C-15A



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CONCEPTUAL PLANS
BOIRE FIELD BROOK CORRIDOR
SITES 3, 4, & 5
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-15B

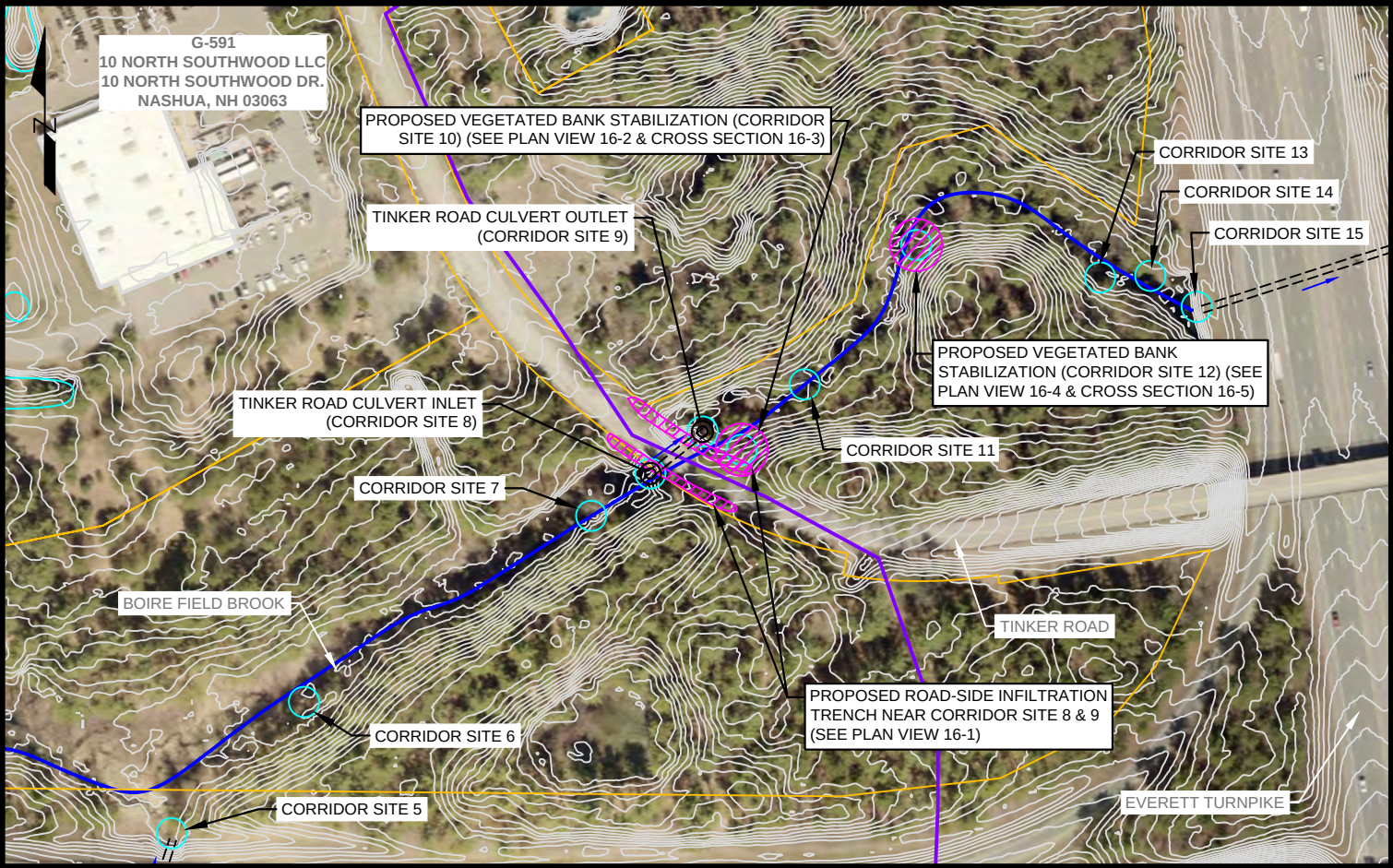


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CONCEPTUAL PLANS
BOIRE FIELD BROOK CORRIDOR
SITES 3, 4, & 5
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-15C



LEGEND

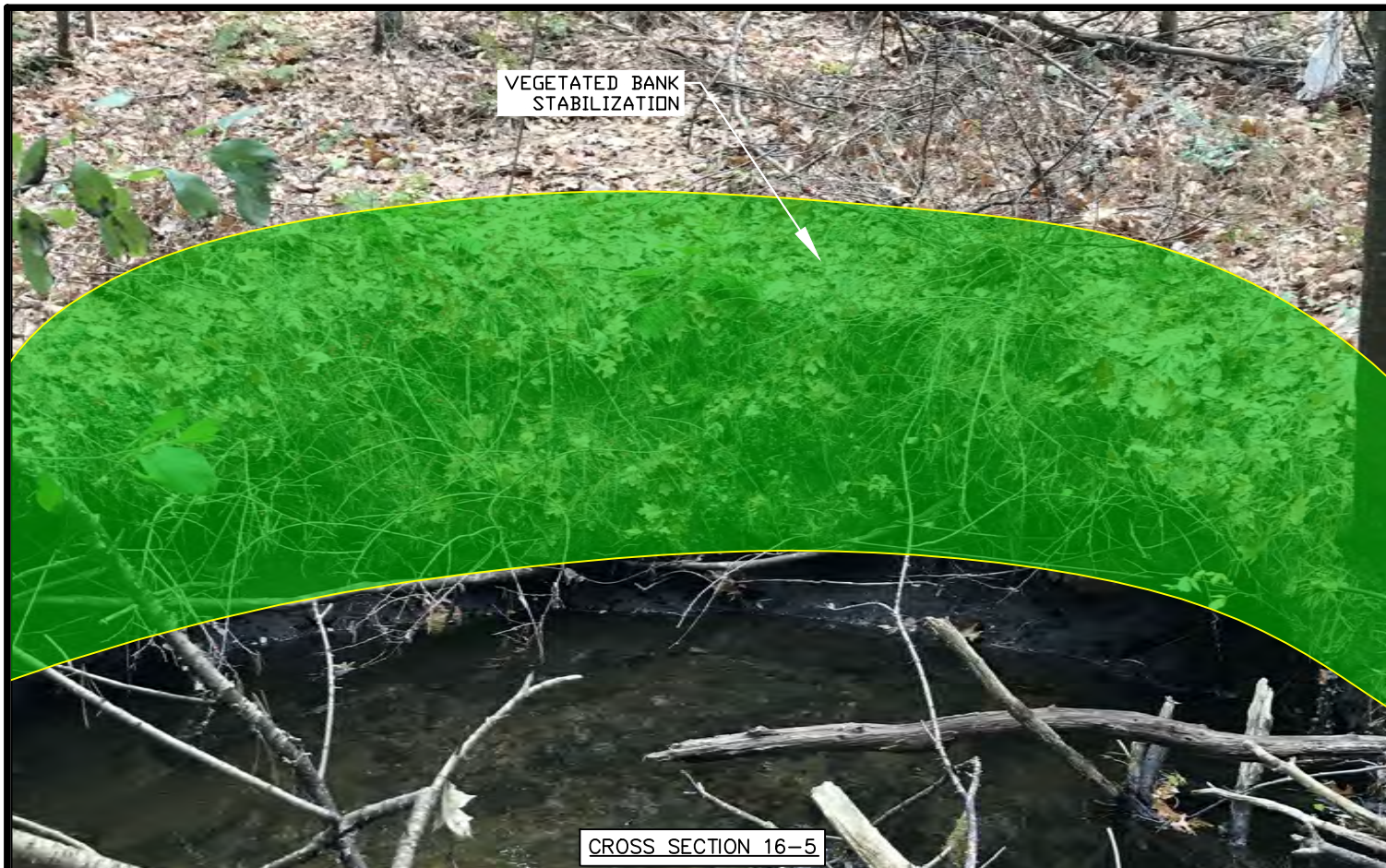
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- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

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CONCEPTUAL PLANS
BOIRE FIELD BROOK CORRIDOR
SITES 8, 9, 10, & 12
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:
C-16A



**COMPREHENSIVE ENVIRONMENTAL
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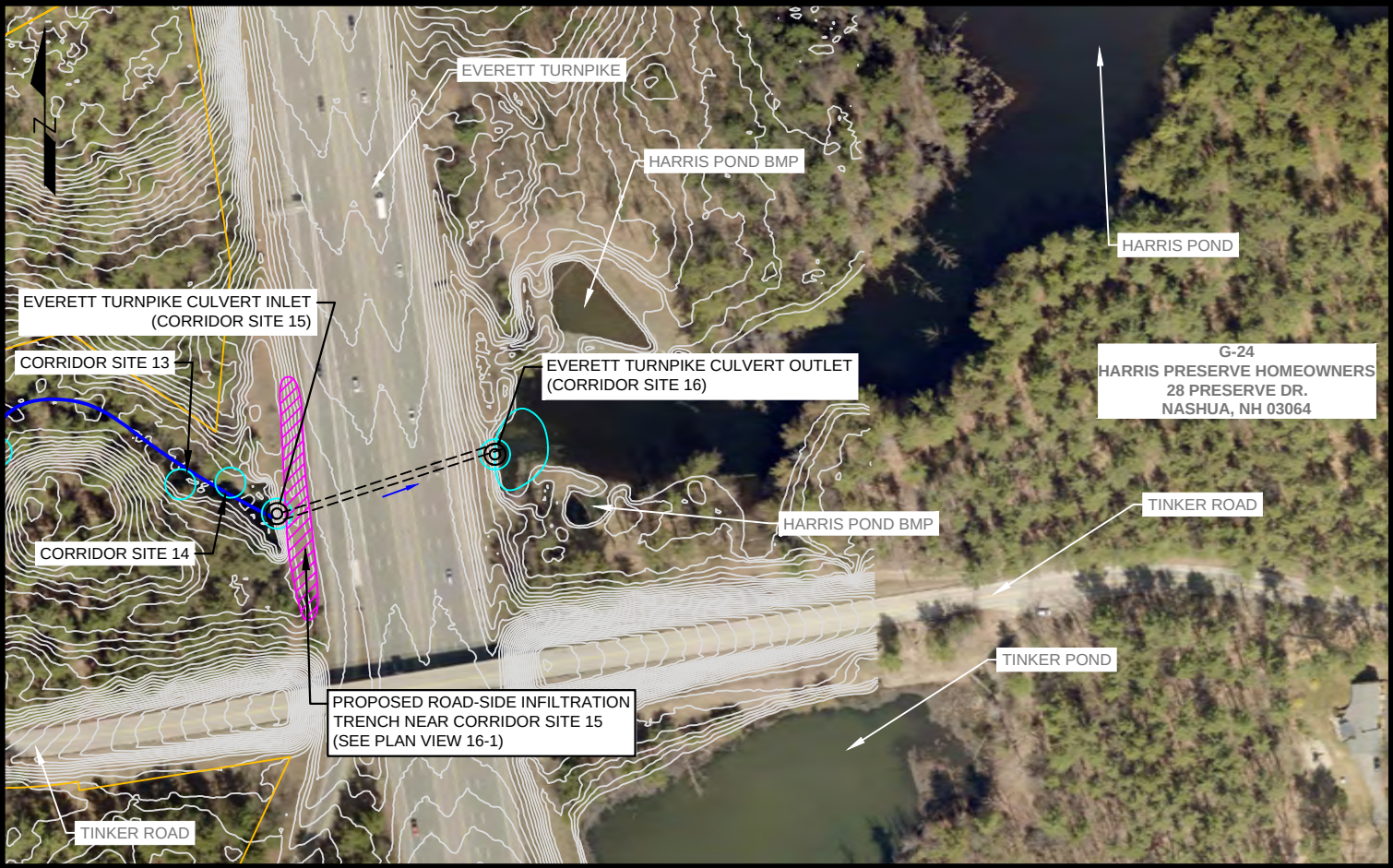
21 DEPOT ST.
MERRIMACK, NH 03054

CONCEPTUAL PLANS
BOIRE FIELD BROOK CORRIDOR
SITES 8, 9, 10, & 12
BOIRE FIELD BROOK SUBWATERSHED

Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'

Sheet No.:

C-16B



LEGEND

- EXISTING 1FT CONTOURS
- PROPERTY LINE
- BUILDING
- BOIRE FIELD BROOK CORRIDOR
- BFB SUBWATERSHED
- BMP SUBCATCHMENT
- EXISTING CULVERT
- EXISTING BMP LIMITS
- PROPOSED BMP LIMITS

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MERRIMACK, NH 03054

**CONCEPTUAL PLANS
BOIRE FIELD BROOK CORRIDOR
SITE 15
BOIRE FIELD BROOK SUBWATERSHED**

**Project No.: 131-64
Date: APRIL 2019
Drawn By: PD
Checked By: NC
Scale: 1"=200'**

Sheet No.:
C-17A

APPENDIX K

Existing and Proposed Conditions Pollutant Loading / Removal Calculations

Site		Existing BMP Type(s)	Boire Field Brook Existing BMP Pollutant Loading and Removal Summary											
			Total Subcatchment Area	Total Subcatchment Area	Commercial	Forested	Open Urban Land	Residential - High Density	Residential - Med Density	Residential - Low Density	Industrial	Roadway/ Parking Lot	Pasture	Total Area
			(SF)	(acres)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
BMP 1	Building 19 Pond	Wet Basin	414,069	9.5	25%	0%	10%	0%	0%	0%	0%	65%	0%	100%
BMP 2	Birch Pond	Wet Basin	826,177	19.0	20%	15%	25%	0%	0%	0%	0%	40%	0%	100%
BMP 3	Cotton Road Pond	Wet Basin	832,547	19.1	30%	0%	20%	0%	0%	0%	0%	50%	0%	100%
BMP 4	Somerset Parkway Swales	Water Quality Swale (Wet)	2,455,628	56.4	15%	0%	10%	0%	45%	0%	0%	30%	0%	100%
BMP 5	DoubleTree Hotel Ponds	Wet Basin	746,275	17.1	30%	10%	30%	0%	0%	0%	0%	30%	0%	100%
BMP 6	Somerset Plaza Perimeter Swale	Biofilter Swale	1,097,838	25.2	20%	0%	10%	0%	0%	0%	0%	70%	0%	100%
BMP 7	Sullivan Tire Vegetated Area	Vegetated Filter Strip	93,857	2.2	20%	10%	0%	0%	0%	0%	0%	70%	0%	100%
BMP 8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin	156,836	3.6	0%	0%	5%	0%	0%	0%	0%	95%	0%	100%
BMP 9	Postal Service Vegetated Areas	Vegetated Filter Strip	345,031	7.9	20%	20%	20%	0%	0%	0%	0%	40%	0%	100%
BMP 10	Cornerstone Drive Swale	Biofilter Swale	529,588	12.2	10%	50%	20%	0%	0%	0%	0%	20%	0%	100%
BMP 11	Boire Field Brook Outlet to Harris Pond	Wet Basin	409,796	9.4	0%	40%	25%	0%	0%	0%	0%	35%	0%	100%
BMP 12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	303,235	7.0	0%	0%	60%	0%	0%	0%	0%	40%	0%	100%
BMP 13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale	1,142,213	26.2	15%	35%	15%	0%	0%	0%	0%	35%	0%	100%
Boire Field Brook Subwatershed			21,620,473	496.3	20%	15%	15%	0%	20%	0%	0%	30%	0%	100%

Site		Existing BMP Type(s)	Boire Field Brook Existing BMP Pollutant Loading and Removal Summary															
			<u>Commercial</u>	<u>Forested</u>	<u>Open Urban Land</u>	<u>Residential - High Density</u>	<u>Residential - Med Density</u>	<u>Residential - Low Density</u>	<u>Industrial</u>	<u>Roadway/ Parking Lot</u>	<u>Pasture</u>	<u>Total Area</u>	<u>Impervious Area</u>	<u>Sanded Area</u>	<u>Pretreatment Volume (0.1"/Imp acre)</u>	<u>Treatment Volume (1"/Imp Acre)</u>	<u>Annual Runoff</u>	Annual Runoff
			(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(cf)	(cf)	(in)	(cf)
BMP 1	Building 19 Pond	Wet Basin	2.4	0.0	1.0	0.0	0.0	0.0	0.0	6.2	0.0	9.5	7.0	4.7	2,559	25,586	29	1,002,484
BMP 2	Birch Pond	Wet Basin	3.8	2.8	4.7	0.0	0.0	0.0	0.0	7.6	0.0	19.0	9.9	6.5	3,580	35,801	21	1,444,364
BMP 3	Cotton Road Pond	Wet Basin	5.7	0.0	3.8	0.0	0.0	0.0	0.0	9.6	0.0	19.1	12.9	8.5	4,669	46,692	27	1,842,416
BMP 4	Somerset Parkway Swales	Water Quality Swale (Wet)	8.5	0.0	5.6	0.0	25.4	0.0	0.0	16.9	0.0	56.4	23.8	15.7	8,625	86,254	17	3,558,343
BMP 5	DoubleTree Hotel Ponds	Wet Basin	5.1	1.7	5.1	0.0	0.0	0.0	0.0	5.1	0.0	17.1	9.0	6.0	3,277	32,774	21	1,320,543
BMP 6	Somerset Plaza Perimeter Swale	Biofilter Swale	5.0	0.0	2.5	0.0	0.0	0.0	0.0	17.6	0.0	25.2	18.6	12.3	6,761	67,609	29	2,649,591
BMP 7	Sullivan Tire Vegetated Area	Vegetated Filter Strip	0.4	0.2	0.0	0.0	0.0	0.0	0.0	1.5	0.0	2.2	1.6	1.0	575	5,749	29	225,380
BMP 8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin	0.0	0.0	0.2	0.0	0.0	0.0	0.0	3.4	0.0	3.6	2.8	1.8	999	9,992	30	390,666
BMP 9	Postal Service Vegetated Areas	Vegetated Filter Strip	1.6	1.6	1.6	0.0	0.0	0.0	0.0	3.2	0.0	7.9	4.1	2.7	1,489	14,894	21	601,104
BMP 10	Cornerstone Drive Swale	Biofilter Swale	1.2	6.1	2.4	0.0	0.0	0.0	0.0	2.4	0.0	12.2	3.5	2.3	1,271	12,710	13	552,652
BMP 11	Boire Field Brook Outlet to Harris Pond	Wet Basin	0.0	3.8	2.4	0.0	0.0	0.0	0.0	3.3	0.0	9.4	3.0	2.0	1,101	11,013	14	470,587
BMP 12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	0.0	0.0	4.2	0.0	0.0	0.0	0.0	2.8	0.0	7.0	2.6	1.7	945	9,451	16	395,653
BMP 13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale	3.9	9.2	3.9	0.0	0.0	0.0	0.0	9.2	0.0	26.2	11.5	7.6	4,174	41,738	18	1,714,112
Boire Field Brook Subwatershed			99.3	74.5	74.5	0.0	99.3	0.0	0.0	148.9	0.0	496.3	223.8	147.7	81,257	812,569	18	33,266,611

Site		Existing BMP Type(s)	Boire Field Brook Existing BMP Pollutant Loading and Removal Summary											
			Annual TSS Loading	Annual TP Loading	Annual TN Loading	Annual FC Loading	BMP Pollutant Removal Efficiencies				Annual TSS Removed	Annual TP Removed	Annual TN Removed	Annual FC Removed
			(lbs)	(lbs)	(lbs)	(bil.colonies)	TSS	TP	TN	Fecal Coliform	(lbs)	(lbs)	(lbs)	(bil.colonies)
BMP 1	Building 19 Pond	Wet Basin	29,879	28	114	650	75%	45%	25%	N/A	22,409	13	28	N/A
BMP 2	Birch Pond	Wet Basin	31,010	30	167	705	75%	45%	25%	N/A	23,257	13	42	N/A
BMP 3	Cotton Road Pond	Wet Basin	49,350	45	222	1,197	75%	45%	25%	N/A	37,012	20	56	N/A
BMP 4	Somerset Parkway Swales	Water Quality Swale (Wet)	68,230	90	450	4,422	70%	55%	50%	N/A	47,761	49	225	N/A
BMP 5	DoubleTree Hotel Ponds	Wet Basin	27,836	25	165	753	75%	45%	25%	N/A	20,877	11	41	N/A
BMP 6	Somerset Plaza Perimeter Swale	Biofilter Swale	79,564	76	288	1,609	45%	25%	20%	N/A	35,804	19	58	N/A
BMP 7	Sullivan Tire Vegetated Area	Vegetated Filter Strip	6,742	6	25	137	10%	0%	0%	N/A	674	0	0	N/A
BMP 8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin	12,627	13	34	181	50%	20%	35%	N/A	6,313	3	12	N/A
BMP 9	Postal Service Vegetated Areas	Vegetated Filter Strip	12,871	12	70	293	10%	0%	0%	N/A	1,287	0	0	N/A
BMP 10	Cornerstone Drive Swale	Biofilter Swale	7,255	8	62	158	45%	25%	20%	N/A	3,265	2	12	N/A
BMP 11	Boire Field Brook Outlet to Harris Pond	Wet Basin	7,100	8	48	105	75%	45%	25%	N/A	5,325	3	12	N/A
BMP 12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	6,705	7	40	97	50%	20%	35%	N/A	3,352	1	14	N/A
BMP 13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale	31,998	32	194	698	45%	25%	20%	N/A	14,399	8	39	N/A
Boire Field Brook Subwatershed			643,426	712	4,105	27,563					221,737	144	539	N/A
			Total Loading to Boire Field Brook Subwatershed								Total Removed by Existing BMPs			

Annual Rainfall	45	inches; user specified
P _j	0.9	%; default
Sanding Rate	70	lbs/acre; default
Sanding Applications	10	times/year; default

References:

Pitt, Robert. (2004, February 16). The National Stormwater Quality Database (NSQD, version 1.1). Retrieved July 22, 2005 from the World Wide Web: <http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm>
The New York Stormwater Management Design Manual Appendix A. Retrieved July 22, 2005 from the World Wide Web: <http://www.dec.state.ny.us/website/dow/toolbox/simple.pdf>
The Simple Method to Calculate Urban Stormwater Loads. Retrieved July 22, 2005 from the World Wide Web: <http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm>
*Table H-2 of the 2010 Rhode Island Storm Water Manual

Land use	TSS (mg/L)	TP (mg/L)	TN (mg/L)	Fecal Coliform (mg/L)	% Impervious
Commercial	77	0.33	2.97	4600	85
Forested	51	0.11	1.78	300	5
Open Urban Land	51	0.11	1.74	300	9
Residential - High Density	100	0.4	2.2	7000	40
Residential - Med Density	100	0.4	2.2	7000	10
Residential - Low Density	100	0.4	2.2	7000	30
Industrial	149	0.32	3.97	2400	75
Roadway/Parking Lot	172	0.55	1.4	1700	80
Pasture	145	0.37	5.98	300	5

Pollutant Loading Formulas (Simple Method Equations):

TSS, TP, TN

L = 0.226 * R * C * A

Where:

L = Annual Load (lbs)

R = Annual Runoff (inches)

C = Pollutant Concentration (mg/l)

A = Area (acres)

0.226 = Unit Conversion Factor

Fecal Coliform

L = .00103 * R * C * A

Where:

L = Annual Load (Billion Colonies)

R = Annual Runoff (inches)

C = Pollutant Concentration (#col/100mL)

A = Area (acres)

0.00103 = Unit Conversion Factor

Annual Rainfall

R = P * P_j * R_v

Where:

R = Annual Runoff (inches)

P = Annual Rainfall (inches)

P_j = % of rainfall events producing runoff

R_v = Runoff Coefficient = 0.05+0.9 * I_a

I_a = Impervious Fraction (%)

Notes:

- Sanding applications assume 66% (2/3) of the impervious area is sanded.
- Pollutant Concentrations (C) are derived from Volume 1 Appendix D of the New Hampshire Stormwater Manual (December 2008)

BMP Type	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Fecal Coliform Removal** (%)	Pretreatment / Treatment
Vegetated Filter Strip	10%	0%	0%	N/A	Pretreatment
Plunge Pool / Forebay	25%	0%	0%	N/A	Pretreatment
Grassed/Biofilter Swale	45%	25%	20%	N/A	Treatment
Extended Dry Detention Basin	50%	20%	35%	N/A	Treatment
Infiltration Trench	50%	55%	55%	N/A	Treatment
Water Quality Swale	70%	55%	50%	N/A	Treatment
Wet Pond	75%	45%	25%	N/A	Treatment
Bioretention/Raingarden	90%	60%	40%	N/A	Treatment

Site		Proposed BMP Type(s)	Boire Field Brook Existing and Proposed BMP Pollutant Loading and Removal Summary											
			Total Subcatchment Area	Total Subcatchment Area	Commercial	Forested	Open Urban Land	Residential - High Density	Residential - Med Density	Residential - Low Density	Industrial	Roadway/ Parking Lot	Pasture	Total Area
			(SF)	(acres)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
BMP 1	Building 19 Pond	Wet Basin; Infiltration Trench	414,069	9.5	25%	0%	10%	0%	0%	0%	0%	65%	0%	100%
BMP 2	Birch Pond	Wet Basin; Infiltration Trench; Bioretention Area; Inlet Gabion	826,177	19.0	20%	15%	25%	0%	0%	0%	0%	40%	0%	100%
BMP 3	Cotton Road Pond	Wet Basin; Infiltration Trench	832,547	19.1	30%	0%	20%	0%	0%	0%	0%	50%	0%	100%
BMP 4	Somerset Parkway Swales	Water Quality Swale (Wet); Sediment Forebay; Inlet Gabion	2,455,628	56.4	15%	0%	10%	0%	45%	0%	0%	30%	0%	100%
BMP 5	DoubleTree Hotel Ponds	Wet Basin; Bioretention Area	746,275	17.1	30%	10%	30%	0%	0%	0%	0%	30%	0%	100%
BMP 6	Somerset Plaza Perimeter Swale	Biofilter Swale; Sediment Forebay; Bioretention Area	1,097,838	25.2	20%	0%	10%	0%	0%	0%	0%	70%	0%	100%
BMP 7	Sullivan Tire Vegetated Area	Bioretention Area	93,857	2.2	20%	10%	0%	0%	0%	0%	0%	70%	0%	100%
BMP 8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin; Sediment Forebay	156,836	3.6	0%	0%	5%	0%	0%	0%	0%	95%	0%	100%
BMP 9	Postal Service Vegetated Areas	Bioretention Area	345,031	7.9	20%	20%	20%	0%	0%	0%	0%	40%	0%	100%
BMP 10	Cornerstone Drive Swale	Biofilter Swale	529,588	12.2	10%	50%	20%	0%	0%	0%	0%	20%	0%	100%
BMP 11	Boire Field Brook Outlet to Harris Pond	Wet Basin; Sediment Forebay	409,796	9.4	0%	40%	25%	0%	0%	0%	0%	35%	0%	100%
BMP 12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	303,235	7.0	0%	0%	60%	0%	0%	0%	0%	40%	0%	100%
BMP 13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale; Check Dams	1,142,213	26.2	15%	35%	15%	0%	0%	0%	0%	35%	0%	100%

Site		Proposed BMP Type(s)	Boire Field Brook Existing and Proposed BMP Pollutant Loading and Removal Summary															
			Commercial	Forested	Open Urban Land	Residential - High Density	Residential - Med Density	Residential - Low Density	Industrial	Roadway/ Parking Lot	Pasture	Total Area	Impervious Area	Sanded Area	Pretreatment Volume (0.1"/Imp acre)	Treatment Volume (1"/Imp Acre)	Annual Runoff	Annual Runoff
			(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(cf)	(cf)	(in)	(cf)
BMP 1	Building 19 Pond	Wet Basin; Infiltration Trench	2.4	0.0	1.0	0.0	0.0	0.0	0.0	6.2	0.0	9.5	7.0	4.7	2,559	25,586	29	1,002,484
BMP 2	Birch Pond	Wet Basin; Infiltration Trench; Bioretention Area; Inlet Gabion	3.8	2.8	4.7	0.0	0.0	0.0	0.0	7.6	0.0	19.0	9.9	6.5	3,580	35,801	21	1,444,364
BMP 3	Cotton Road Pond	Wet Basin; Infiltration Trench	5.7	0.0	3.8	0.0	0.0	0.0	0.0	9.6	0.0	19.1	12.9	8.5	4,669	46,692	27	1,842,416
BMP 4	Somerset Parkway Swales	Water Quality Swale (Wet); Sediment Forebay; Inlet Gabion	8.5	0.0	5.6	0.0	25.4	0.0	0.0	16.9	0.0	56.4	23.8	15.7	8,625	86,254	17	3,558,343
BMP 5	DoubleTree Hotel Ponds	Wet Basin; Bioretention Area	5.1	1.7	5.1	0.0	0.0	0.0	0.0	5.1	0.0	17.1	9.0	6.0	3,277	32,774	21	1,320,543
BMP 6	Somerset Plaza Perimeter Swale	Biofilter Swale; Sediment Forebay; Bioretention Area	5.0	0.0	2.5	0.0	0.0	0.0	0.0	17.6	0.0	25.2	18.6	12.3	6,761	67,609	29	2,649,591
BMP 7	Sullivan Tire Vegetated Area	Bioretention Area	0.4	0.2	0.0	0.0	0.0	0.0	0.0	1.5	0.0	2.2	1.6	1.0	575	5,749	29	225,380
BMP 8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin; Sediment Forebay	0.0	0.0	0.2	0.0	0.0	0.0	0.0	3.4	0.0	3.6	2.8	1.8	999	9,992	30	390,666
BMP 9	Postal Service Vegetated Areas	Bioretention Area	1.6	1.6	1.6	0.0	0.0	0.0	0.0	3.2	0.0	7.9	4.1	2.7	1,489	14,894	21	601,104
BMP 10	Cornerstone Drive Swale	Biofilter Swale	1.2	6.1	2.4	0.0	0.0	0.0	0.0	2.4	0.0	12.2	3.5	2.3	1,271	12,710	13	552,652
BMP 11	Boire Field Brook Outlet to Harris Pond	Wet Basin; Sediment Forebay	0.0	3.8	2.4	0.0	0.0	0.0	0.0	3.3	0.0	9.4	3.0	2.0	1,101	11,013	14	470,587
BMP 12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	0.0	0.0	4.2	0.0	0.0	0.0	0.0	2.8	0.0	7.0	2.6	1.7	945	9,451	16	395,653
BMP 13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale; Check Dams	3.9	9.2	3.9	0.0	0.0	0.0	0.0	9.2	0.0	26.2	11.5	7.6	4,174	41,738	18	1,714,112

Site		Proposed BMP Type(s)	Boire Field Brook Existing and Proposed BMP Pollutant Loading and Removal Summary											
			Annual TSS Loading	Annual TP Loading	Annual TN Loading	Annual FC Loading	BMP Pollutant Removal Efficiencies				Annual TSS Removed	Annual TP Removed	Annual TN Removed	Annual FC Removed
			(lbs)	(lbs)	(lbs)	(bil.colonies)	TSS	TP	TN	Fecal Coliform	(lbs)	(lbs)	(lbs)	(bil.colonies)
BMP 1	Building 19 Pond	Wet Basin; Infiltration Trench	29,879	28	114	650	80%	50%	30%	N/A	23,903	14	34	N/A
BMP 2	Birch Pond	Wet Basin; Infiltration Trench; Bioretention Area; Inlet Gabion	31,010	30	167	705	80%	50%	30%	N/A	24,808	15	50	N/A
BMP 3	Cotton Road Pond	Wet Basin; Infiltration Trench	49,350	45	222	1,197	80%	50%	30%	N/A	39,480	23	67	N/A
BMP 4	Somerset Parkway Swales	Water Quality Swale (Wet); Sediment Forebay; Inlet Gabion	68,230	90	450	4,422	75%	55%	50%	N/A	51,173	49	225	N/A
BMP 5	DoubleTree Hotel Ponds	Wet Basin; Bioretention Area	27,836	25	165	753	75%	45%	25%	N/A	20,877	11	41	N/A
BMP 6	Somerset Plaza Perimeter Swale	Biofilter Swale; Sediment Forebay; Bioretention Area	79,564	76	288	1,609	90%	60%	40%	N/A	71,607	46	115	N/A
BMP 7	Sullivan Tire Vegetated Area	Bioretention Area	6,742	6	25	137	90%	60%	40%	N/A	6,068	4	10	N/A
BMP 8	Park & Ride Lot Detention Basin	Extended Dry Detention Basin; Sediment Forebay	12,627	13	34	181	55%	20%	35%	N/A	6,945	3	12	N/A
BMP 9	Postal Service Vegetated Areas	Bioretention Area	12,871	12	70	293	90%	60%	40%	N/A	11,584	7	28	N/A
BMP 10	Cornerstone Drive Swale	Biofilter Swale	7,255	8	62	158	45%	25%	20%	N/A	3,265	2	12	N/A
BMP 11	Boire Field Brook Outlet to Harris Pond	Wet Basin; Sediment Forebay	7,100	8	48	105	80%	45%	25%	N/A	5,680	3	12	N/A
BMP 12	Somerset Parkway Detention Basin	Extended Dry Detention Basin	6,705	7	40	97	50%	20%	35%	N/A	3,352	1	14	N/A
BMP 13	Somerset Parkway / Southwood Drive Swales	Biofilter Swale; Check Dams	31,998	32	194	698	50%	25%	20%	N/A	15,999	8	39	N/A

Site		Proposed BMP Type(s)	Boire Field Brook Existing and Proposed BMP Pollutant Loading and Removal Summary											
			<u>Total Subcatchment Area</u>	<u>Total Subcatchment Area</u>	<u>Commercial</u>	<u>Forested</u>	<u>Open Urban Land</u>	<u>Residential - High Density</u>	<u>Residential - Med Density</u>	<u>Residential - Low Density</u>	<u>Industrial</u>	<u>Roadway/ Parking Lot</u>	<u>Pasture</u>	<u>Total Area</u>
			(SF)	(acres)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Corridor 2	Somerset Parkway culvert outlet (north side of crossing)	Sediment Forebay	5,539,987	127.2	23%	5%	15%	0%	6%	0%	0%	51%	0%	100%
Corridor 2	Somerset Parkway culvert outlet (north side of crossing)	Infiltration Trench	58,445	1.3	0%	5%	5%	0%	0%	0%	0%	90%	0%	100%
Corridor 3	North Southwood Drive culvert inlet (west side of crossing)	Infiltration Trench	39,998	0.9	0%	0%	5%	0%	0%	0%	0%	95%	0%	100%
Corridor 3	North Southwood Drive culvert inlet (west side of crossing)	Bioretention Area	34,566	0.8	0%	60%	5%	0%	0%	0%	0%	35%	0%	100%
Corridor 4	North Southwood Drive culvert outlet (east side of crossing)	Sediment Forebay	5,539,987	127.2	23%	5%	15%	0%	6%	0%	0%	51%	0%	100%
Corridor 4	North Southwood Drive culvert outlet (east side of crossing)	Infiltration Trench	34,359	0.8	0%	10%	10%	0%	0%	0%	0%	80%	0%	100%
Corridor 5	North Southwood Drive On-Ramp culvert outlet (north side of crossing)	Sediment Forebay	1,445,448	33.2	8%	18%	38%	0%	0%	0%	0%	38%	0%	100%
Corridor 5	North Southwood Drive On-Ramp culvert outlet (north side of crossing)	Infiltration Trench	34,359	0.8	0%	10%	10%	0%	0%	0%	0%	80%	0%	100%
Corridor 8	Tinker Road culvert inlet (south side of crossing)	Infiltration Trench	21,031	0.5	0%	75%	5%	0%	0%	0%	0%	20%	0%	100%
Corridor 9	Tinker Road culvert outlet (north side of crossing)	Infiltration Trench	27,497	0.6	0%	60%	5%	0%	0%	0%	0%	35%	0%	100%
Corridor 15	Everett Turnpike culvert inlet (west side of crossing)	Infiltration Trench	215,604	4.9	0%	20%	0%	0%	0%	0%	0%	80%	0%	100%
Boire Field Brook Subwatershed			21,620,473	496.3	20%	15%	15%	0%	20%	0%	0%	30%	0%	100%

Site		Proposed BMP Type(s)	Boire Field Brook Existing and Proposed BMP Pollutant Loading and Removal Summary															
			Commercial	Forested	Open Urban Land	Residential - High Density	Residential - Med Density	Residential - Low Density	Industrial	Roadway/ Parking Lot	Pasture	Total Area	Impervious Area	Sanded Area	Pretreatment Volume (0.1"/Imp acre)	Treatment Volume (1"/Imp Acre)	Annual Runoff	Annual Runoff
			(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(cf)	(cf)	(in)	(cf)
Corridor 2	Somerset Parkway culvert outlet (north side of crossing)	Sediment Forebay	29.1	6.4	19.1	0.0	8.1	0.0	0.0	64.5	0.0	127.2	79.2	52.3	28,746	287,456	25	11,412,647
Corridor 2	Somerset Parkway culvert outlet (north side of crossing)	Infiltration Trench	0.0	0.1	0.1	0.0	0.0	0.0	0.0	1.2	0.0	1.3	1.0	0.6	354	3,541	29	138,924
Corridor 3	North Southwood Drive culvert inlet (west side of crossing)	Infiltration Trench	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.9	0.7	0.5	255	2,548	30	99,632
Corridor 3	North Southwood Drive culvert inlet (west side of crossing)	Bioretention Area	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.8	0.2	0.2	91	906	13	38,854
Corridor 4	North Southwood Drive culvert outlet (east side of crossing)	Sediment Forebay	29.1	6.4	19.1	0.0	8.1	0.0	0.0	64.5	0.0	127.2	79.2	52.3	28,746	287,456	25	11,412,647
Corridor 4	North Southwood Drive culvert outlet (east side of crossing)	Infiltration Trench	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.6	0.0	0.8	0.5	0.3	187	1,873	26	74,053
Corridor 5	North Southwood Drive On-Ramp culvert outlet (north side of crossing)	Sediment Forebay	2.5	5.8	12.4	0.0	0.0	0.0	0.0	12.4	0.0	33.2	13.5	8.9	4,893	48,934	17	2,027,580
Corridor 5	North Southwood Drive On-Ramp culvert outlet (north side of crossing)	Infiltration Trench	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.6	0.0	0.8	0.5	0.3	187	1,873	26	74,053
Corridor 8	Tinker Road culvert inlet (south side of crossing)	Infiltration Trench	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.1	0.1	35	354	9	16,453
Corridor 9	Tinker Road culvert outlet (north side of crossing)	Infiltration Trench	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	0.2	0.1	72	721	13	30,908
Corridor 15	Everett Turnpike culvert inlet (west side of crossing)	Infiltration Trench	0.0	1.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	4.9	3.2	2.1	1,168	11,679	26	462,066
Boire Field Brook Subwatershed			99.3	74.5	74.5	0.0	99.3	0.0	0.0	148.9	0.0	496.3	223.8	147.7	81,257	812,569	18	33,266,611

Site		Proposed BMP Type(s)	Boire Field Brook Existing and Proposed BMP Pollutant Loading and Removal Summary											
			Annual TSS Loading	Annual TP Loading	Annual TN Loading	Annual FC Loading	BMP Pollutant Removal Efficiencies				Annual TSS Removed	Annual TP Removed	Annual TN Removed	Annual FC Removed
			(lbs)	(lbs)	(lbs)	(bil.colonies)	TSS	TP	TN	Fecal Coliform	(lbs)	(lbs)	(lbs)	(bil.colonies)
Corridor 2	Somerset Parkway culvert outlet (north side of crossing)	Sediment Forebay	290,683	286	1,336	7,847	25%	0%	0%	N/A	72,671	0	0	N/A
Corridor 2	Somerset Parkway culvert outlet (north side of crossing)	Infiltration Trench	4,288	4	12	61	50%	55%	55%	N/A	2,144	2	7	N/A
Corridor 3	North Southwood Drive culvert inlet (west side of crossing)	Infiltration Trench	3,220	3	9	46	50%	55%	55%	N/A	1,610	2	5	N/A
Corridor 3	North Southwood Drive culvert inlet (west side of crossing)	Bioretention Area	577	1	4	9	90%	60%	40%	N/A	520	0	2	N/A
Corridor 4	North Southwood Drive culvert outlet (east side of crossing)	Sediment Forebay	290,683	286	1,336	7,847	25%	0%	0%	N/A	72,671	0	0	N/A
Corridor 4	North Southwood Drive culvert outlet (east side of crossing)	Infiltration Trench	2,074	2	7	30	50%	55%	55%	N/A	1,037	1	4	N/A
Corridor 5	North Southwood Drive On-Ramp culvert outlet (north side of crossing)	Sediment Forebay	36,105	37	216	660	25%	0%	0%	N/A	9,026	0	0	N/A
Corridor 5	North Southwood Drive On-Ramp culvert outlet (north side of crossing)	Infiltration Trench	2,074	2	7	30	50%	55%	55%	N/A	1,037	1	4	N/A
Corridor 8	Tinker Road culvert inlet (south side of crossing)	Infiltration Trench	173	0	2	3	50%	55%	55%	N/A	86	0	1	N/A
Corridor 9	Tinker Road culvert outlet (north side of crossing)	Infiltration Trench	459	1	3	7	50%	55%	55%	N/A	230	0	2	N/A
Corridor 15	Everett Turnpike culvert inlet (west side of crossing)	Infiltration Trench	12,891	13	42	186	50%	55%	55%	N/A	6,445	7	23	N/A
Boire Field Brook Subwatershed			643,426	712	4,105	27,563					452,217	201	706	N/A
			Total Loading to Boire Field Brook Subwatershed								Total Removed by Existing and Proposed BMPs			

Annual Rainfall	45	inches; user specified
Pj	0.9	%; default
Sanding Rate	70	lbs/acre; default
Sanding Applications	10	times/year; default

References:

Pitt, Robert. (2004, February 16). The National Stormwater Quality Database (NSQD, version 1.1). Retrieved July 22, 2005 from the World Wide Web: <http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm>
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The Simple Method to Calculate Urban Stormwater Loads. Retrieved July 22, 2005 from the World Wide Web: <http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm>
*Table H-2 of the 2010 Rhode Island Storm Water Manual

Land use	TSS (mg/L)	TP (mg/L)	TN (mg/L)	Fecal Coliform (mg/L)	% Impervious
Commercial	77	0.33	2.97	4600	85
Forested	51	0.11	1.78	300	5
Open Urban Land	51	0.11	1.74	300	9
Residential - High Density	100	0.4	2.2	7000	40
Residential - Med Density	100	0.4	2.2	7000	10
Residential - Low Density	100	0.4	2.2	7000	30
Industrial	149	0.32	3.97	2400	75
Roadway/Parking Lot	172	0.55	1.4	1700	80
Pasture	145	0.37	5.98	300	5

Pollutant Loading Formulas (Simple Method Equations):

TSS, TP, TN

L = 0.226 * R * C * A

Where:

L = Annual Load (lbs)

R = Annual Runoff (inches)

C = Pollutant Concentration (mg/l)

A = Area (acres)

0.226 = Unit Conversion Factor

Fecal Coliform

L = .00103 * R * C * A

Where:

L = Annual Load (Billion Colonies)

R = Annual Runoff (inches)

C = Pollutant Concentration (#col/100mL)

A = Area (acres)

0.00103 = Unit Conversion Factor

Annual Rainfall

R = P * P_j * R_v

Where:

R = Annual Runoff (inches)

P = Annual Rainfall (inches)

P_j = % of rainfall events producing runoff

R_v = Runoff Coefficient = 0.05+0.9 * I_a

I_a = Impervious Fraction (%)

Notes:

- Sanding applications assume 66% (2/3) of the impervious area is sanded.
- Pollutant Concentrations (C) are derived from Volume 1 Appendix D of the New Hampshire Stormwater Manual (December 2008)

BMP Type	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Fecal Coliform Removal** (%)	Pretreatment / Treatment
Vegetated Filter Strip	10%	0%	0%	N/A	Pretreatment
Plunge Pool / Forebay	25%	0%	0%	N/A	Pretreatment
Grassed/Biofilter Swale	45%	25%	20%	N/A	Treatment
Extended Dry Detention Basin	50%	20%	35%	N/A	Treatment
Infiltration Trench	50%	55%	55%	N/A	Treatment
Water Quality Swale	70%	55%	50%	N/A	Treatment
Wet Pond	75%	45%	25%	N/A	Treatment
Bioretention/Raingarden	90%	60%	40%	N/A	Treatment