Nitrogen Source Identification Report

Per Requirements of the 2017 New Hampshire Small MS4 General Permit, Appendix H

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1 Introduction

The 2017 New Hampshire Small MS4 General Permit (MS4 Permit) requires regulated communities to develop a Nutrient Source Identification Report (NSIR) that identifies additional measures that can be used to address nutrient impaired water bodies as identified on the state's 303(d) list. This report was developed for the City of Portsmouth to address the additional requirements of Appendix H of the 2017 MS4 Permit.

1.1 Regulatory Context

As required by the federal Clean Water Act, the New Hampshire Department of Environmental Services (NHDES) produces a biennial report that identifies water bodies that are threatened or impaired by a pollutant and exceed water quality standards. Surface waters that are identified as not meeting state water quality criteria are included on the list of impaired water bodies known as the 303(d) List.

The recently approved 2020/22 state 303(d) list (March 14, 2022)[1] has identified the Upper Sagamore Creek (AUID: NHEST600031001-03) and the Lower Sagamore Creek (NHEST600031001-04) as the only nitrogen impaired water bodies in Portsmouth. The previous 2018 303(d) list had identified the Back Channel (NHEST600031001-05) as being nitrogen impaired and it is now listed as impaired under Estuarine Bioassessments. Since this impairment is typically related to symptoms of eutrophication and Sagamore Creek is essentially a tributary to the Back Channel, this water body was included in this NSIR.

This NSIR includes the following Items as outlined by the Appendix H of the 2017 MS4 Permit that are required to be completed by June 2022 or the end of Permit Year 4.

This NSIR includes the following five (5) required NSIR elements as listed in Part I.b.i of Appendix H:

1. An estimate of the total MS4 area draining to the water quality limited water segment(s) or their tributaries and a map of the MS4 area and catchment delineations.
2. A summary of all screening and monitoring results associated with the receiving water segment(s)
3. An estimate of the impervious area and DCIA for the target catchment
4. Identification, delineation, and prioritization of potential catchments with high nitrogen loading
5. Identified potential structural BMP retrofit locations for future redevelopment projects.

This NSIR also includes the following Part I.1.c.i. elements of Appendix H, which are to be completed by the end of 5-years of the effective permit date or by June 2023:

[1] NHDES 2022/22 303(d) List https://www.des.nh.gov/water/rivers-and-lakes/water-quality-assessment/swqa-publications#faq38801

Within five years of the permit effective date, the City shall evaluate all City-owned properties identified in the Nitrogen Source Identification Report as potential retrofit opportunities or as new redevelopment projects arise within the drainage area of the impaired water or its tributaries. The evaluation shall include:

1. The timing of the next planned infrastructure, resurfacing or redevelopment activity planned for the property (if applicable) or planned retrofit date;
2. The estimated cost of redevelopment or retrofit BMPs; and
3. The engineering and regulatory feasibility of redevelopment or retrofit BMPs.

1.2 Regulated Area

The City of Portsmouth, New Hampshire encompasses a total of 15.7 square miles and as of 2020 has an estimated population of 21,956.[2] The entire City area is included in the 2017 MS4 Permit regulated area. This report focuses on the areas that the Upper and Lower Sagamore Creek and their tributaries. The Upper and Lower Sagamore Creeks were added as nitrogen impaired to the recently approved 2020/22 303d list, which include estuarine and freshwater portions and several smaller tributary streams that drain from the City MS4 area. These water bodies are also drain into the Back Channel, which was previously listed as nitrogen impaired, but now listed as impaired based on poor conditions identified under Estuarine Bioassessments.

The Back Channel (AU ID# NHEST600031001-05) is a tidal backwater channel situated between the City of Portsmouth and the Town of New Castle to the east. The northerly boundary limits consist of the Newcastle Ave / Route 1B causeway and the southerly limit consists of the Route 1A-Sagamore Bridge. The Back Channel exchanges tidal flow from the Lower Piscataqua River (NHEST600031001-02-02) to the north and the Little Harbor (NHEST600031002-02) to the south and an adjacent separate water assessment unit referred to as the Wentworth-by-the-Sea (NHEST600031001-08).

Table 1 lists nine (9) unique NHDES Assessment Units or tributaries in the overall Sagamore Creek / Back Channel watershed. The total MS4 land area that drains to the Back Channel is estimated to be approximately 2,310 acres or about 25% of the total City land area (*meets Element 1 of the NSIR requirements above*).

Table 1. Water Body Assessment Units in the Upper Sagamore Creek/ Back Channel Watershed

Assessment Unit	Assessment Unit ID
Upper Sagamore Creek	NHEST600031001-03
Lower Sagamore Creek	NHEST600031001-04
Back Channel	NHEST600031001-05
Freshwater Assessment Units	
Sagamore Creek (freshwater portion)	NHRIV600031001-03
Unnamed Brook – Sagamore Creek Dam	NHIMP600031001-01
Elwyn Brook	NHRIV600031001-12
Unnamed Brook	NHRIV600031001-24
Unnamed Brook	NHRIV600031001-11
Unnamed Brook	NHRIV600031001-21

Source: NHDES 2020/22 Surface Water Quality Assessment Viewer. https://www.arcgis.com/apps/webappviewer/index.html?id=aa5a11f8b8c341058fc031701a2fb3c9

Figure 1 depicts the direct drainage area to the Back Channel, which consists primarily of residential areas along South Street and Marcy Street (Route 1B) to the north, and by Sagamore Ave (Route 1A) to the west.

2 U.S. Census Bureau. "Portsmouth city, New Hampshire." Accessed January 31, 2022. https://data.census.gov/cedsci/all?q=Portsmouth%20city,%20New%20Hampshire

The Little Harbour Elementary School represents one of the few City-owned parcels in the direct watershed area. Several large less or undeveloped parcels include the South Street cemetery (approx. 35 acres) and a large conservation land parcel, and the state-owned historic site (the Wentworth Coolidge Historic Site).

The Sagamore Creek watershed area includes a mix of residential and commercial land uses. The Creek is bisected into Upper and Lower Assessment Units by Sagamore Ave (Route 1A). In the vicinity of Route 1A in this area is a mix of single and multi-family residential and commercial properties, as well as a marina. Upper Sagamore Creek is bisected by Route 1 (Lafayette Road) and in this area the Creek is adjacent to many large commercial properties, including shopping plazas, car dealerships, restaurants, a water park, and the Department of Public Works facility. To the north of the Creek is also the Portsmouth High School that is on a 55-acre property which includes school buildings, parking areas, athletic fields, and small forest.

Figures 1 and 2 below illustrate 26 separate smaller catchment areas that drain to the Back Channel and Sagamore Creek watershed areas. These catchment areas were delineated based on 2-foot contour elevations., the City's mapped storm drain infrastructure and best professional judgement to identify areas with a common drainage outfall location or a group of outfalls in close proximity.

Figure 1. Back Channel Catchments

Figure 2. Sagamore Creek Catchments

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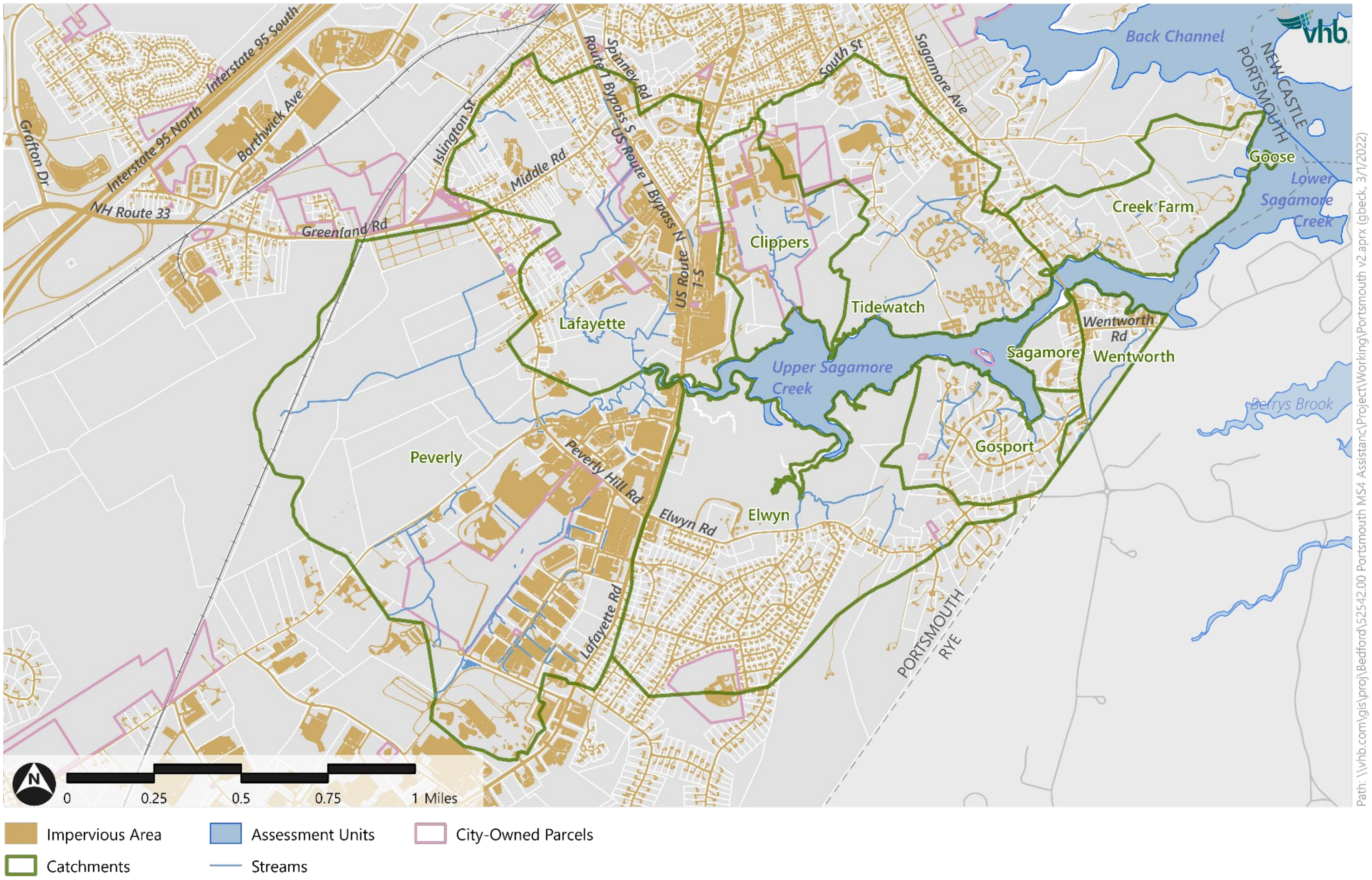


Source: City of Portsmouth, NHDES, NHGRANIT, VHB

2

Water Quality & Impervious Cover

This section addresses the NSIR Elements 2 and 3 required by Appendix H, including a summary of water quality monitoring results collected to date and an estimate of the impervious area and directly connected impervious area (DCIA) for each catchment area.

2.1 Outfall Screening

Table 2 below presents the results of samples collected during dry weather screening seven City storm drain outfalls that discharge to Upper Sagamore Creek and Back Channel. Two other outfalls had no flow present and therefore were not sampled. All outfalls included in Table 2 discharge to Upper Sagamore Creek.

Outfall	Temp (C)	Ammonia (mg/L)	Surfactants (mg/L)	Chloride (mg/L)	Conductivity (µs/cm)	Enterococcus (MPN)	TP (mg/L)	TN (mg/L)	pH
12738	20.8	0	0.20	--	1,377	9.7	--	1.2	7.43
1168	--	--	--	--	1,345	--	--	--	8.03
3027	19.8	0	0.18	250	969	38.0	0.02	1.3	--
1158	26.0	0.1	0.20	270	1,156	136.8	0.02	<1.0	7.75
3179	--	--	0.20	49	305	235.2	--	<1.0	--

Monitoring results from Outfalls 12738 and 3027, located in the Peverly Hill Road and Elywn Road catchment areas, respectively, revealed relatively higher TN concentrations that are several times greater than NHDES observed concentrations in the receiving waters provided in Table 3 below. Outfall 12738 drains much of the commercial impervious area along West Road to a low-lying area located behind the DEP facility. The City has since constructed two structural BMPs to treat the discharge from this outfall following the completion of this monitoring, These BMP were designed to provide enhanced nitrogen load reductions as discussed further in Section 3.3.

Outfall 3027 drains approximately 90 acres of densely developed residential areas in the Elwyn catchment area near the intersection of Elwyn Road and Harding Road and includes about half of the Dondero School property in the upper portion of the watershed. The outfall discharges to Upper Sagamore Creek. The elevated TN concentration observed is likely attributable to fertilizer use and high imperviousness of the dense residential properties on essentially ¼ acre lots.

Table 3. NHDES Water Quality Data Summary

Parameter (mg/L)	No. of Samples	Min.	Mean	Median	Max.	Date Range
Back Channel						
Nitrogen	10	0.161	0.292	0.282	0.556	2003 – 2010
Nitrogen, Nitrite (NO_2) + Nitrate (NO_3) as N	35	0.012	0.053	0.034	0.147	1999 – 2010
Upper Sagamore Creek						
Nitrogen, Dissolved	3	0.110	0.421	0.177	0.975	2004 – 2008
Nitrogen, Nitrite (NO_2) + Nitrate (NO_3) as N	11	0.003	0.166	0.170	0.426	2000 – 2017
Lower Sagamore Creek						
Nitrogen, Dissolved	1	0.140	0.140	0.140	0.140	2007 – 2007
Nitrogen, Nitrite (NO_2) + Nitrate (NO_3) as N	1	0.014	0.014	0.014	0.014	2007 – 2007

Source: NHDES 2018 Surface Water Quality Assessment Viewer.
https://www.arcgis.com/apps/webappviewer/index.html?id=aa5a11f8b8c341058fc031701a2fb3c9

2.2 Impervious Cover

The City maintains property parcel data as well as impervious cover data. Table 4 presents the estimated impervious cover (IC) area for each catchment and each of the major assessment units that are tributary to the Back Channel.

Table 4. Estimated Total Impervious Area by Catchment Area

Sub-watershed	Impervious Cover (Acres)
Back Channel	28
Lower Sagamore Creek	14
Upper Sagamore Creek	353
Total BC / Sag. Creek Watershed	**396**

Most of the IC area is in the Upper Sagamore Creek watershed and is associated with various commercial and institutional developed properties. Much of the developed area in the Upper Sagamore Creek is serviced by or drains to the City's stormwater drainage system, and thus, it seemed reasonable to assume that 100% of the 396 acres of IC area is directly connected to the MS4 system. Of the 2,310 acres that drain to the Back Channel / Sagamore Creek watersheds, approximately 613 acres or just over 26% of the watershed area consists as conservation land and other undeveloped land area that is not serviced by the City's MS4 system.

3

Nitrogen Load Calculations

This section describes the methods, assumptions, and estimates of average annual nitrogen loads for the identified catchment areas to address Element 4 of the NSIR requirements.

3.1 Calculation Methods

VHB estimated average annual pollutant loads by parcel using the Pollutant Load Export Rates (PLERs) for nitrogen, phosphorus, TSS, and zinc as those included in Attachment 3 of Appendix F of the 2017 MS4 Permit. Since the PLERs vary based on land use, land cover (i.e., impervious vs. pervious) and hydrologic soil group (HSG) condition, we developed an ArcGIS model builder tool to assign appropriate PLERs for the various combinations of land use, soil type, and impervious cover conditions to develop average annual pollutant loads by land use type and property ownership. The GIS mapping data used in this analysis include the following:

- Land Use – New Hampshire's Statewide Geographic Information Systems Clearinghouse (GRANIT)
- Parcel Maps – City of Portsmouth
- City Boundary – VHB created from the parcel layer provided by the City of Portsmouth
- Hydrologic Soil Group (HSG) type – Natural Resources Conservation Service (NRCS)
- Impervious Surfaces – City of Portsmouth

The parcel layer data was modified in select areas to remove parcel overlaps, particularly with City-owned parcels, City-owned roads, state-owned roads parcels, and roads. In certain areas where the hydrologic soil group (HSG) mapping data was missing, we conservatively assumed that HSG C soils were present, which generate higher runoff volumes and pollutant loads.

The estimated pollutant loads by parcel and land use type were summed for each catchment area to obtain total TN load for each catchment area and then divided by the total area of the catchment to determine the total pollutant load per acre in each catchment.

3.2 Loading Results

Table 5 presents estimates of average annual Total Nitrogen (TN) loads (lbs./year) for the twenty-six individual catchment areas that drain to the Back Channel and Sagamore Creek. The catchment areas range in size from 0.8 to 702.2 acres. The total average annual TN load for the entire Sagamore Creek / Back Channel watershed is estimated to be 7,876.3 lbs./year, which translates to approximately 3.4 lbs. TN/ac/yr. The Upper Sagamore Creek watershed accounts for approximately 87% of the overall estimated TN load and three catchment areas in the Upper Sagamore Creek watershed, including those labeled as Peverly, Lafayette and Elwyn, account for approximately 67% or 2/3^{rds} of the estimated total load and approximately 61% (1,416 ac) of the total area.

The catchment areas were grouped by receiving water and sorted by the estimated average annual TN Load rate (lbs./ac./yr.), which range from 0.50 lbs./ac/yr. to 5.22 lbs./ac/yr. Catchment areas with loading rates greater than 4.0 lbs./ac/yr. were considered high priority for evaluating future BMP retrofit locations and between 3.0 and 4.0 lbs./ac/yr. as medium priority, and less than 3.0 lbs./ac/yr. as low priority.

Table 5. Nitrogen Loading Estimates by Receiving Water and Catchment Area

Receiving Water	Catchment ID	Area (Acres)	Total TN Load (lbs./year)	TN Load (lbs./ac./yr.)	Priority
BC	Boylan	4.9	25.7	5.22	H
BC	Haven	16.8	84.7	5.04	H
BC	Clough	9.5	45.0	4.74	H
BC	Robin	3.0	13.8	4.67	H
BC	Baycliff	8.0	34.7	4.35	H
BC	Curriers	21.8	94.3	4.33	H
BC	Shapleigh	7.7	32.3	4.19	H
BC	Frame Pt	2.6	10.1	3.91	M
BC	South	3.1	11.7	3.78	M
BC	Brackett	7.4	24.5	3.32	M
BC	Harmony Grove	30.5	76.0	2.49	L
BC	Belle Isle Road	57.9	140.8	2.43	L
BC	Lady Isle	12.5	24.7	1.97	L
BC	Coolidge	26.0	32.1	1.23	L
BC	Little Barbour	41.8	36.5	0.87	L
BC	Pest	13.3	6.6	0.50	L
LS	Wentworth	39.1	108.5	2.77	L
LS	Creek Farm	114.5	242.9	2.12	L
LS	Goose	0.8	1.3	1.64	L
US	Lafayette	342.0	1,539.5	4.50	H
US	Everly	702.2	2,675.4	3.81	M
US	Sagamore	22.6	77.2	3.41	M
US	Tidewatch	237.1	804.2	3.40	M
US	Clippers	116.8	372.3	3.19	M
US	Gosport	97.4	296.8	3.05	M
US	Elwyn	372.0	1,064.7	2.86	L
Summary totals					
Back Channel		266.6	693.5	2.6	
Lower Sagamore Creek		154.5	352.7	2.3	
Upper Sagamore Creek		1,890.1	6,830.1	3.6	
Overall Watershed Total		2,311.2.	7,876.3	3.4	

BC = Back Channel
LS = Lower Sagamore Creek
US = Upper Sagamore Creek

H = High Priority (>4.0 lbs./acre)
M = Medium Priority (>3.0 & <4.0 lbs./acre)
L = Low Priority (<3.0 lbs./acre)

Although the overall TN load to the Back Channel represents a relatively small portion (<10%) of the overall load, several catchment areas have relatively high estimated nitrogen loading rates including densely developed residential areas along Clough Drive, Haven Rd., Brackett Ln and Road, and the residential neighborhoods on Frame Point off of Newcastle Ave. and including Pleasant Point Dr. Baycliff Rd. Dr. Moebus Terrace, Robin Ln, and Ridge Court. These catchment areas may have higher loading rates due to the relatively high impervious area in these neighborhoods along the shores of Back Channel.

Other areas with relatively high nitrogen loading rates pertain to the commercially developed areas along the Route 1 Bypass / Lafayette Road in the Upper Sagamore Creek watershed. As Lafayette Road crosses the Upper Sagamore Creek channel, it splits the northern and southern catchment areas identified as Lafayette and Peverly, respectively. Due to both size and the density of commercial development, the Peverly Hill and Lafayette Road catchment areas have relatively higher total TN load estimates of 2,675 lbs./year and 1,540 lbs./year, respectively, or more than 50% of the total estimated TN load of 7,876.3 lbs./year for the entire Back Channel and Sagamore Creek watershed.

3.3 Existing Stormwater BMPs and Nitrogen Load Reductions

Table 6 presents the estimated treated areas and pollutant load reductions for various existing structural BMPs that the City have already installed at various locations. The larger structural BMPs include: 3 sand filters, 2 gravel wetlands, 1 biofiltration system, and 1 biofiltration system with an internal storage reservoir (ISR). Combined these BMPs are estimated to remove a total of approximately 850 lbs. of TN per year. Three of these BMPs are located within the Back Channel watershed, including the two recently installed BMPs at the DPW facility.

The City has also installed smaller Low Impact Development type BMPs consisting of tree filters and wells, underground hydrodynamic separators, and rain gardens. However, EPA has not developed pollutant removal efficiencies for these BMPs and, thus, load reduction estimates were not calculated for these BMPs.

Table 6. Estimated Pollutant Load Reductions for Existing BMPs

BMP ID	BMP Type	Catchment Impervious Area (ac)	N Load Reduction (lbs./year)	P Load Reduction (lbs./year)	TSS Load Reduction (lbs./year)	Zn Load Reduction (lbs./year)
26432*	Gravel wetland	40.3	523.0	46.0	16,642.0	45.0
26433*	Bioretention w/ISR	25.4	281.0	22.0	8,558.0	22.0
25480*	Sand filter	0.5	1.6	0.3	385.9	0.6
Total Upper Sagamore Creek		**66.2**	**805.6**	**68.3**	**25,585.9**	**67.6**
13423	Gravel wetland	2.1	26.3	2.5	1,777.3	2.5
13743	Bioretention	0.9	3.1	0.6	715.2	0.9
25627	Sand filter	0.3	2.4	0.4	361.0	0.4
12952	Sand filter	10.7	13.0	2.5	3,279.7	9.9
	Total All BMPs	**80.2**	**850.4**	**74.3**	**31,719.1**	**81.3**

Source: City of Portsmouth, VHB

Note: *Located within Back Channel watershed

The two BMPs recently constructed at the DPW facility, which include a subsurface gravel wetland (24632) and a bioretention area with an internal storage reservoir (26433) treat stormwater from approximately 146 acres that mostly consists of privately owned commercially developed land are in the Upper Sagamore Creek watershed. As mentioned previously, the subsurface gravel wetland also treats the Peverly Hill Road catchment area that includes the DPW facility and drains to Outfall 12738 which was identified as having a relatively high estimated TN load (see Table 2). The third BMP consists of a sand filter (25480) located near the Sagamore Avenue bridge.

Based on the pollutant load calculations, these three structural BMPs are estimated to reduce average annual loads of TN by 805.6 lbs./year, which accounts for most of the pollutant load reductions for the various existing structural BMPs. The two new BMPs behind the DPW drain to the Upper Sagamore Creek.

Figure 3. Back Channel Catchment Nitrogen Loading Estimates

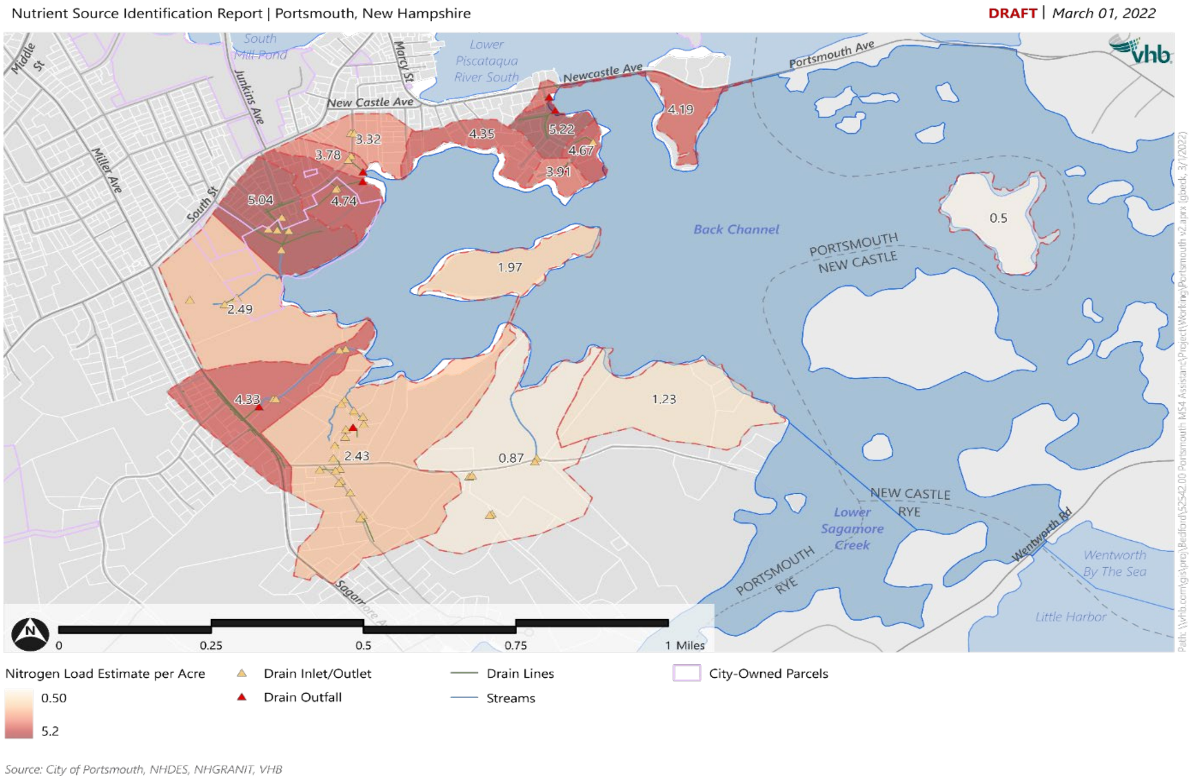
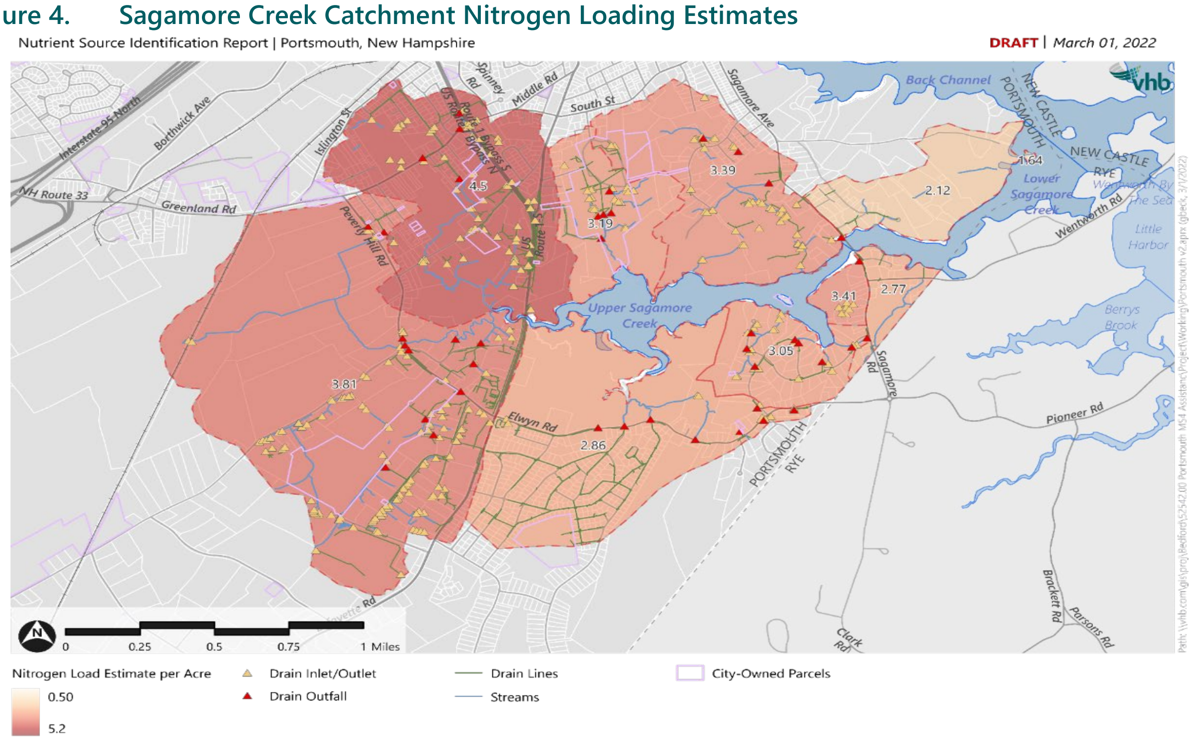


Figure 4. Sagamore Creek Catchment Nitrogen Loading Estimates



4

Nitrogen Reduction Opportunities

VHB evaluated City owned properties to identify several opportunities for structural and nonstructural BMPs to potentially achieve additional nitrogen load reductions within the Back Channel watershed. This Chapter addresses Element 5 of the NSIR requirements.

4.1 Potential Structural BMP Locations

VHB conducted a desktop review of City-owned parcels using ArcGIS data and aerial photos to identify potential future BMP locations, focusing on impervious areas that drain to the existing storm drain system that outlet in upland, undeveloped green spaces with relatively few obvious physical constraints. VHB used City provided parcel and related ownership table to identify City-owned parcels. VHB primarily focused on developed City-owned parcels that have a relatively high percentage of impervious area as opposed to conservation parcels. City-owned roads were not specifically evaluated for BMP retrofit opportunities as this analysis focused primarily on City-owned parcels which generally have more space for a future BMP retrofit.

This initial screening identified nine locations on seven different City parcels that appear to have space and no obvious constraints for stormwater BMP implementation. Of these nine locations, four are located at either the Portsmouth High School or the Little Harbour Elementary School, and a fifth location along Lafayette Road where a City storm drain outfall collects and outlets stormwater from a privately owned commercial parcel that has a relatively high pollutant load reduction potential.

Table 7 presents estimated pollutant load contributions to five higher priority locations suggested for future structural BMP retrofit consideration (see Appendix A for Proposed BMP Locations).

Table 7. Estimated Existing Pollutant Loads to Priority BMP Locations Prior to Treatment

BMP ID	Location	N Load (lbs./year)	P Load (lbs./year)	TSS Load (lbs./year)	Zn Load (lbs./year)
26378	Portsmouth High School	36	4	1,379	3
26381	Portsmouth High School	6	1	161	1
26429	Little Harbour School	28	3	1,567	2
26434	Portsmouth High School	5	1	166	0.5
26435	Lafayette Road (not City-owned)	130	15	4,084	12
	Total	**205**	**24**	**7,357**	**16.5**

Note: Pollutant load estimates account for only the portion of the site area that drains to an existing storm drain outfall

Pollutant load reductions were calculated for each of the priority BMP locations based on an assumed BMP type, treated area water quality volume (WQV) treatment depth and associated removal efficiency using the BMP Performance Curves included in Attachment 3 of Appendix F of the 2017 NH MS4 Permit. The proposed BMPs were assumed to be either a gravel wetland or an enhanced biofiltration with internal storage reservoir as these BMPs are most appropriate for low-infiltrating soils.

Assuming a smaller water quality treatment depth of 0.5 inches, a proposed gravel wetland would have an estimated nitrogen removal efficiency of 52.5% and an enhanced biofiltration system with ISR would have an estimated TN removal efficiency of 62%. For purposes of this report, VHB used a combined average removal efficiency of 57% for both BMPs. Higher nitrogen removal efficiencies could be achieved if there is sufficient area and vertical depth to treat a larger WQV.

Table 8 provides estimates of potential pollutant load reductions for each of the five BMP retrofit locations identified in the Back Channel watershed. The total estimated nitrogen load reduction for all five potential BMPs is 116.7 lbs./year. When combined with the estimated 805.6 lbs./year of nitrogen removed by two BMPs recently completed at the DPW, the total estimated load reduction would be approximately 922.3 lbs./yr. of TN, which represents just under 12% of the total estimated TN load of 7,876.3 lbs./year for both the Back Channel and Sagamore Creek watersheds.

Table 8. Estimated Pollutant Load Reductions at the Five Priority BMP Locations

BMP ID	Location	N Load Reduction (lbs./year)	P Load Reduction (lbs./year)	TSS Load Reduction (lbs./year)	Zn Load Reduction (lbs./year)
26378	Portsmouth High School	20.7	2.4	786	1.8
26381	Portsmouth High School	3.5	0.4	92	0.3
26429	Little Harbour School	15.8	2.0	893	1.1
26434	Portsmouth High School	2.9	0.3	94	0.3
26435	Lafayette Road (not City-owned)	73.8	8.7	2,328	7.0
	Total	**116.7**	**13.8**	**4,193.5**	**10.4**

Source: VHB Draft Task 3 Results Memo dated Sept. 3, 2021.

Table 9 presents estimated planning level costs for each of the priority BMP locations for a gravel wetland and biofiltration with ISR. Relatively recent construction cost data is available for these BMP types, given the recently completed BMPs behind the DPW facility. However, these costs do not include initial design, site feasibility studies of permitting costs. Detailed site investigations will be needed to confirm the feasibility and any site constraints that may limit the potential BMP type, sizing, and constructability at each location, which may change any planning-level cost estimates provided.

Table 9. Priority BMP Planning Level Cost Estimates

BMP ID	Location	Area Treated (acres)	Estimated WQV (ft^3)	Gravel Wetland	Est, $$ per Pound N Removed	Biofiltration w/ ISR	Est. $$ per Pound N Removed
26378	Portsmouth High School	2.2	3,900	$78,000	$4,110	$138,000	$6,270
26381	Portsmouth High School	0.4	700	$14,000	$4,670	$25,000	$6,250
26429	Little Harbour School	1.7	3,100	$62,000	$4,130	$110,000	$6,470
26434	Portsmouth High School	0.3	600	$12,000	$4,000	$21,000	$7,000
26435	Lafayette Road (not City-owned)	8.7	15,800	$315,000*	$4,630	$560,000*	$7,000
	Total	**13.3**	**24,100**	**$481,000**	**Avg. $4,310**	**$854,000**	**Avg. $6,600**

Note: *Does not include land acquisition, engineering design and permitting costs

These planning level cost estimates indicate that the total cost to construct the four BMPs identified on the two school properties in the watershed could range from approximately $160,000 to $300,000 to reduce approximately 40 to 45 lbs./yr. of TN Load (Table 8). Alternatively, the planning level construction cost for a BMP to treat the privately owned commercial land along Lafayette Road, is estimated to be range from $315,000 to $560,000 and would potentially reduce approximately 70 to 75 lbs./yr. of TN Load to Sagamore Creek depending on BMP type and water quality volume sizing.

Table 10 identifies future planned CIP redevelopment projects currently included in the FY23 – FY28 Capital Improvement Plan where one or more of these BMP retrofits could be incorporated as the preliminary engineering phases of these CIP projects progress. The preliminary engineering should include a more detailed feasibility analysis to assess whether these locations are appropriate for BMP installation as part of planned facility or infrastructure upgrade. The first two projects listed are aimed at improving the High School facilities and athletic fields. The construction of BMPs as part of a facility upgrade or improvement may significantly reduce construction costs. The CIP project involving street paving and rehabilitation (#TSM-94-PW-71) may present opportunities for smaller structural BMPs in for roads in the Back Channel watershed such as tree filters, pervious pavements, or other small BMPs depending on which streets and sidewalks will be rehabilitated. Finally, the planned city-wide storm drainage improvement, may also provide opportunities to include structural BMPs as part of system capacity improvements, sewer separations, or as part of other infrastructure upgrades or replacements.

Table 10. Related Capital Improvement Projects (CIP), FY23 – FY28 for Retrofit Opportunities

Reference	Name	Description	FY23 – FY28 Total Funding
BI-07-SC-11	School Facilities Capital Improvement	Includes funds for replacement of artificial turf and tennis court at Portsmouth HS	$3.6M
BI-12-RC-23	Existing Outdoor Recreation Field Improvements	Improve playability and drainage issues at existing athletic fields, at Portsmouth HS, Clough field and Lafayette ball field	$0.75M
BI-20-PW-22	Greenland Rd Practice Field	Include stormwater BMP for proposed parking area	$0.5M
TSM-94-PW-71	Street Paving, Management, & Rehabilitation	Paving & rehabilitation of streets throughout the City	$12M
TSM-20-PL-80	Coakley Borthwick Connector Road	Add stormwater BMP to improved road section along Hodgson Brook	$1.0M
COM-15-PW-95	Citywide Storm Drainage Improvements	Continual replacement of stormwater infrastructure city-wide	$1.5M

Source: City of Portsmouth, Draft Capital Improvement Plan FY23 – FY28. Accessed March 7, 2022. https://files.cityofportsmouth.com/files/planning/planportsmouth/cip/Capital_Improvements_Plan_FY2023_FY2028.pdf

4.2 Non-Structural BMPs

Table 10 lists various non-structural BMPs that the City has already implemented and the estimated potential nitrogen load reductions for each measure. These ongoing measures are estimated to reduce TN loading by approximately 1,135 pounds per year. The largest estimated load reduction is related to a change in fertilizer use on City properties and athletic fields. The City switched to using a compost tea produced from the composting of yard waste and grass clippings at the City's compost collection facility. The TN application rate using the compost tea is estimated to be approximately 0.70 lbs. per 1,000 square feet of area or approximately 30% less than the typical application rate of approximately 1 lb. per 1,000 sq, feet using conventional granular fertilizer. This change in application practices is estimated to result in a TN load reduction of approximately 570 lbs./year based on the amount of lawn area maintained by the City.

The City's leaf litter curbside collection program for residential properties is estimated to reduce TN loads by approximately 250 lbs./year based on EPA's nitrogen crediting information contained in Appendix F of the MS4 Permit. The City has also adopted new stormwater management regulations in January 2021 requiring enhance stormwater treatment for new or redevelopment projects which disturb more than 15,000 square feet of area. Redevelopment projects are required to treat 30% of the existing impervious area while new development will require treatment of 100% of the new impervious area. Assuming 45 acres of impervious area are redeveloped annually and approximately 15 acres of existing impervious area would be treated, this would lead to a load reduction of approximately 135 lbs./year. The City also conducts monthly street sweeping at least 8 months out of the year using an air regenerative vacuum sweeper and routinely cleans its catch basins on a rotating basis each year, which achieves close to the maximum allowable removal credit for street sweeping activity.

. Table 11. Existing Non-Structural BMPs & Annual Load Reduction

Measure	Project	Description	Estimated Load Reduction (lbs./TN/year)
Street Sweeping	Ongoing	City sweeps all streets monthly for 8 months/year, approx. 345 acres	70
Leaf Litter Management	Ongoing	City provides curbside leaf litter pickup for residential areas (~80% of City)	250
Catch Basin Cleaning	Ongoing	City cleans approx. 25% of total basins annually	80
Organic Fertilizer Program	Ongoing	City uses an organic liquid compost tea which reduces N application by ~30%	570
Impervious Disconnection	Recent IC Disconnection	City has installed at least 18 tree filters, 4 rain gardens, and converted select pavement to porous	30
Stormwater Regulations	New Regulations January 2021	City adopted new stormwater treatment requirements for new & redevelopment projects disturbing > 15,000 sq. ft.	135
		Estimated Annual N Load Reduction Total (lbs./year)	**1,135**

Source: City of Portsmouth, VHB

The 2014 NHDES Great Bay Nitrogen Nonpoint Source Study (GBNNPSS) estimated that fertilizer used on residential and commercial lawns may contribute approximately 16,000 lbs. TN load per year and is one of the largest nonpoint nitrogen sources in the City second to impervious areas. A fertilizer public education and outreach campaign for residents could be just as effective in reducing nitrogen loads as the proposed structural stormwater BMPs for much less cost. Such a campaign could focus on educating the public on the proper products, soil testing, application rates and frequency to reduce the number and amount of fertilizer application. The Chesapeake Bay program estimated that a well-structured education campaign could reduce annual TN Loads from fertilizer use by as much as 15%,[3] which would represent approximately 2,400 lbs. TN/yr. and is 20x greater than the estimated reduction associated with the proposed structural stormwater BMP retrofits discussed above. Measuring changes in fertilizer usage can be done via pre and post implementation homeowner surveys by a social science survey firm. The potential costs for such a program are estimated to be in the range of $150,000 to $200,000 and would involve both one-time, upfront costs for outside specialists and annual costs for ongoing messaging, surveying and coordination. Much depends on whether this effort could be done with cost-sharing with other regional partners.

[3] https://www.chesapeakebay.net/documents/Final_CBP_Approved_Expert_Panel_Report_on_Urban_Nutrient_Management--short.pdf

5

Conclusions & Recommendations

5.1 Conclusions

Within the City of Portsmouth's MS4 area, the Upper and Lower Sagamore Creek segments are the only water bodies listed as impaired for total nitrogen according to the approved 2020/22 303(d) list and subject to the 2017 MS4 Permit Appendix H. The Back Channel is also listed as impaired as not fully supporting aquatic life based on the results of Estuarine Bioassessments. Sagamore Creek also drains into the Back Channel and thus was included in this assessment for future potential stormwater BMP retrofits. However, the primary focus was to identify potential locations for future total nitrogen (TN) load reductions in the Sagamore Creek watershed, which includes eight smaller additional tributaries.

The three structural BMPs within the Sagamore Creek watershed that the City currently owns and maintains, two of which were constructed in 2021, are estimated to treat approximately 66 acres of impervious area and result an estimated nitrogen load reduction of 805.6 lbs./year. This is an initial significant reduction representing approximately 10% of the total estimated TN load of 7,876.3 lbs./yr. for the entire Sagamore Creek / Back Channel watershed.

The total estimated nitrogen load reduction for the five locations of potential future structural BMPs within the Sagamore Creek and Back Channel watersheds as approximately 116.7 lbs./year. The total costs for installing all five of these BMPs range from approximately $480,000 for gravel wetlands, and $854,000 for biofiltration with ISR, which results in an estimated capital cost range of approximately $4,100 to $7,300 per lb. of TN/year reduced.

Other non-structural BMPs that the City has implemented includes switching to an organic based source of fertilizer, street sweeping, catch basin cleaning and then annual yard waste/ leaf cleanup, which are estimated to result in annual nitrogen load reduction of approximately 1,135 lbs. TN/year, based on data provided in the City's Draft initial Element C Plan prepared for the Great Bay Total Nitrogen General Permit. However, this estimate includes areas beyond the Back Channel / Sagamore Creek watershed.

Future non-structural BMPs could include a combination of a public fertilizer education campaign and more frequent good housekeeping measures. Enhanced public education programs with assistance from social marketing and behavioral specialists could be quite cost-effective in reducing lawn fertilizer. As discussed herein, based on the total annual TN load of approximately 16,000 lbs./year estimated to be contributed from lawn fertilizer usage by the 2014 NHDES GPNNPS study, a potential 15% reduction in this TN load would represent approximately 2,400 lbs. TN/year and even a 5% reduction represents approximately 800 lbs.TN/year. Even a nominal 5% reduction and assuming an overall one-time cost of $200,000, world result in an estimated cost per lb. of TN reduced at $250, which is much lower than that expected for structural BMPs. The cost may be higher if ongoing annual education efforts were needed.

In addition, the City performs various good housekeeping measures including catch basin cleaning, street sweeping, and annual leaf litter collection and the current level of effort for these practices appear to be maximum extent for the available load reduction credits provided by the MS4 Permit. Expanding these good housekeeping practices would seem have marginal benefit on nitrogen load reductions.

5.2 Recommendations

Structural BMP Locations: Several planned Capital Improvement Projects provide opportunities to install one or more new structural BMPs to comply with the Year 6 or 2024 requirement. As identified earlier, these include the planned outdoor recreation/athletic field improvements projects at the Portsmouth High School, or the Little Harbour School and/or the new Greenland Road Practice field. Also, several major road improvement projects such as the proposed Borthwick-Coakley Connector Road, the Banfield Road Pedestrian Improvements and the Peverly Hill Road Project. At least one BMP should be installed by year 6 to comply the MS4 Permit requirement. The latter two BMP locations and the High School/ Little Harbour School account for some of the highest nitrogen load contribution areas in the Sagamore Creek / Back Channel watershed (See Appendix A for Map Figures showing BMP Locations). Other planned CIP projects may provide other opportunities for stormwater infrastructure upgrades and stormwater treatment.

Additionally, the City should explore opportunities to partner with commercial property owners and/or NHDOT to install one or more structural BMPs to treat impervious area associated with any redevelopment or upgrades along Lafayette Road. Residential and commercial partners may be essential given that there is a limited amount of City-owned property and can result in mutually beneficial outcomes of reducing the impact on adjacent water bodies.

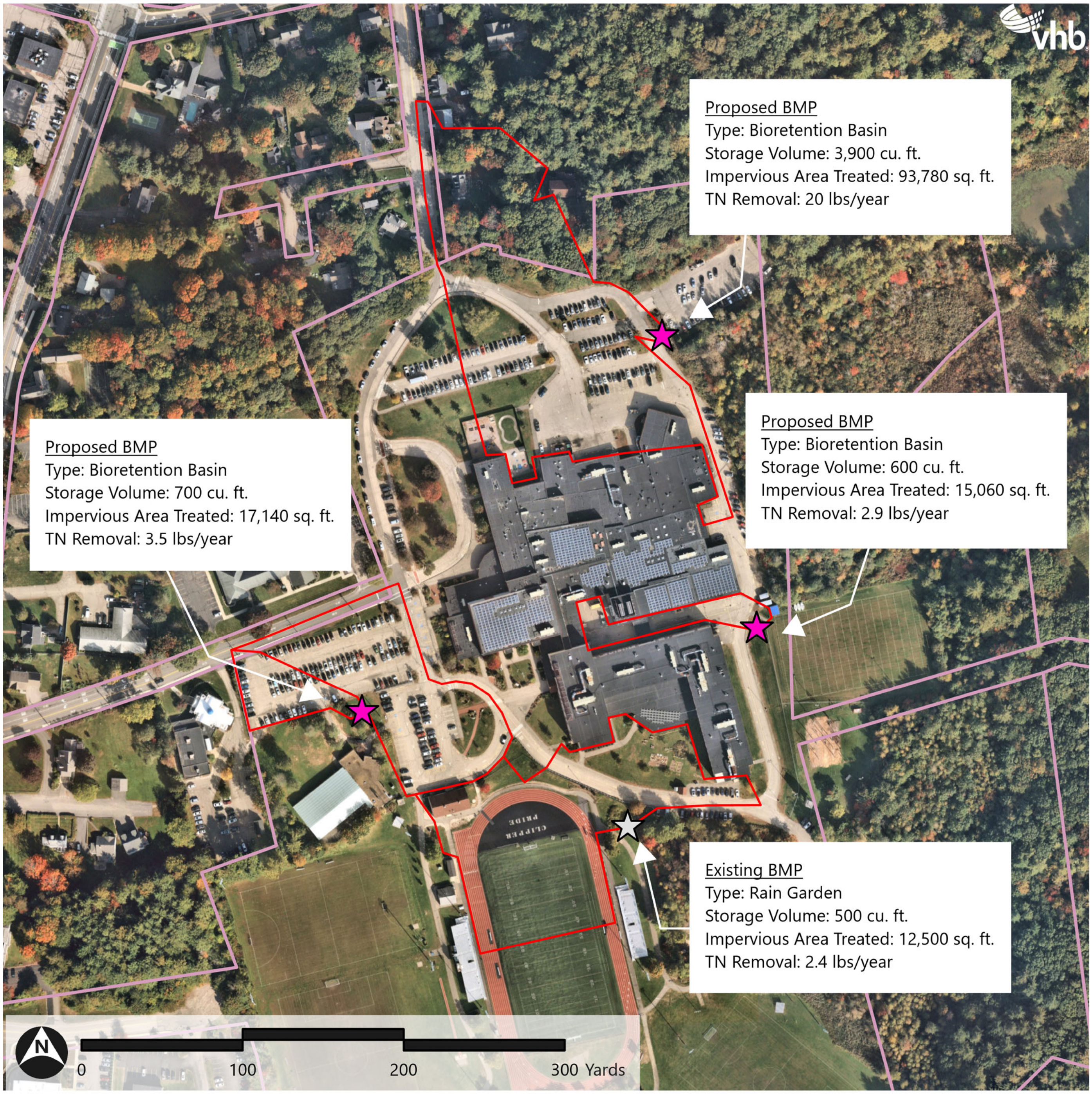
Lawn Fertilizers: The City should also explore the possibility of initiating a public fertilizer education campaign perhaps as a joint effort with other communities. Since RSA 431 precludes municipalities from banning the sale of fertilizers, the only effective alternative is to execute a public education and outreach effort (See Appendix B- DRAFT Summary Fact Sheet of Nitrogen Load from Lawn Fertilizers). This would require the assistance of social science and marketing professionals, where the campaign could focus on educating residents and commercial professionals on the proper type, rate, and frequency of lawn fertilizer applications to minimize runoff losses and maximize nutrient uptake by plants. A multi-faceted, media approach may be a good first step to stimulate public interest, but a more in-depth peer to peer, in person approach may be needed through workshops or other well placed outreach events to gain a broader audience and understanding of the issues. The measure of performance in detecting a change in homeowner behavior could be achieved through scientific-based or professionally executed survey of homeowners prior to and after the education program. Revisiting the current regulations to identify opportunities to increase restrictions on fertilizer use such as in wetland and shoreland buffer setbacks as outlined in the City’s Land Use and Zoning regulations may also be worthwhile but its effect may be difficult to enforce and measure.

Appendix A:

Map Figures of Potential Stormwater BMP Locations

Proposed BMP Locations

Portsmouth NSIR | Portsmouth High School



Path: \\vhb.com\gis\proj\Bedford\52542.00 Portsmouth MS4 Assistanc\Project\Working\Portsmouth v3.aprx (gbeck, 3/14/2022)

Legend

- BMP Catchments
- Existing BMP
- Proposed BMP
- City-Owned Parcels

Source: City of Portsmouth, NearMap, VHB

Proposed BMP Locations

Portsmouth NSIR | Lafayette Road

Legend

- BMP Catchments
- Proposed BMP
- Assessment Units
- City-Owned Parcels

Source: City of Portsmouth, NearMap, VHB

'roposed BMP Locations

ortsmouth NSIR | Little Harbour Elementary School

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egend

- BMP Catchments
- Proposed BMP
- Assessment Units
- City-Owned Parcels

ource: City of Portsmouth, NearMap, VHB

Appendix B:

DRAFT Lawn Fertilizer N Load Summary Sheet based on NHDES Great Bay Nonpoint Nitrogen Study

DRAFT Lawn Fertilizer Summary Sheet for Great Bay Communities

Estimated Lawn Area and Lawn Fertilizer Load

The Great Bay Nitrogen Non-Point Source Study (GBNNPSS) (NHDES, 2014) estimated that lawn fertilizer generates a total delivered nitrogen (N) load of approximately 182,000 lbs. N/yr. to the Great Bay Estuary from an estimated 19,080 acres of lawn area (NH only), which represents 2.7% of the total watershed area.

The lawn fertilizer N load associated with the 12 communities subject to the Great Bay Total Nitrogen General Permit (GBTN GP) was estimated to be approximately 89,272 lbs. N/yr. from an estimated 8,476 acres of lawn area (approximately 10.5 lbs. N/ac./yr). For comparison, the estimated N load from an estimated 10,481 acres of directly connected impervious area (DCIA) in the 12 communities was 70,032 lbs./yr. (includes atmosphere and pet waste) or roughly 6.7 lbs/ac/yr.

The lawn area was indirectly estimated using 2006 C-Cap land-use data and a limited analysis of 2010 high resolution, color aerial imagery to estimate average amount lawn (green) space per lot for various land uses.

GBNNPSS Loading Assumptions

The GBNNPSS used the following assumptions when estimating the total N load:

- Typical fertilizer application rate of 2.0 lbs N/1000 sf/yr (87.1 lbs N/ac/yr);
- Assumed 54% of the lawn area was treated resulting in an effective application rate of 1.08 lbs/1000 sf for all lawn area
- Partitioning Factors: 61% of the fertilizer infiltrates to groundwater; 39% travels in surface runoff
- Delivery factors: 15% of GW load and 87% of the Surface runoff delivered to Estuary

Lawn Fertilizer Crediting Approaches

Lawn fertilizer N load reductions can be achieved by:

- Reducing the amount of lawn area treated; or
- Reducing the application rate of fertilizer.

The following two approaches could be used to accomplish these reductions.

- **Regulatory Approach:** According to state statute RSA 431:4-d, municipalities are preempted or precluded from regulating the actual sale of fertilizers. An outright ban would have to be done by state legislature. The probability of a fertilizer ban being passed is highly uncertain especially for one region of the state and opposition from industry and others outside the watershed will likely be substantial. Even if a ban was successful, homeowners would still purchase fertilizer either online or from retailers outside the region or state. Communities can still restrict fertilizer use in environmentally sensitive areas such as shoreland buffers, although the consistency in imposing these restrictions across the communities will likely be highly variable. It would be difficult to measure the effect of a ban or even restrictions without a rigorous, local monitoring and enforcement program. Even using a random survey to measure changes in homeowner behavior would be challenging since most homeowners are not likely to admit to being noncompliant with a ban or restriction even if the survey is done anonymously.
- **Education Approach:** The Chesapeake Bay Program explored, via an expert panel process, N load crediting for lawn fertilizer through an Urban Nitrogen Management (UNM) Education Program. The results, although variable and not firmly defined, suggested potential reduction credits between 5% and 17% could be achieved depending on the number of elements and verification steps in the program. https://www.chesapeakebay.net/documents/Final_CBP_Approved_Expert_Panel_Report_on_Urban_Nutrient_Management--short.pdf

Suggested Key Elements of an Effective UNM Education Program

- Homeowner Surveys: Baseline and Post-Education
- Series of Focus Groups/Workshops
- Traditional and Social Media Messaging on Proper Fertilizer Techniques
- Promoting/ Incentivize Soil Testing
- Possible "GreenLawn" Certification Training for Professional Fertilizer Appliers

The basic premise was that the more education elements included in the Program, the higher the potential credit. A Program with only 1 or 2 of these elements may warrant only a 5% reduction credit whereas if all or most of the elements were included, then a 15% or 17% reduction credit could be assumed. Ultimately, the reduction credit could be confirmed through an observed difference in homeowner behavior using baseline and post-education survey. For example, if a baseline survey indicates that 50% of the homeowners fertilize their lawns today and a post-education survey finds that only 40% of homeowners treat their lawns this could be used to represent a 20% reduction in fertilizer use.

In developing the 2014 Oyster River Integrated Watershed Mgt Plan, the UNH Survey Center conducted a phone survey of 470 Durham residents and found that 43% of the residents applied fertilizer to their lawn at least once per year. This was lower than the 54% assumed in GBNNPSS and even after adjusting the effective rate to 0.9 lbs./1000 sf for the estimated 540 acres total lawn area in Durham, the total fertilizer nitrogen load was estimated to be 6,000 lbs. N/yr (3 tons/yr.). This represented 23% of the total Town NPS Load of 26,480 lbs N/yr.

The ORWM Plan proposed a multi-faceted Education Program including hiring a Social Marketing Specialist to conduct focus groups, develop public education materials and media messages and training for UNH and DPW staff. In this case, a 15% reduction credit was proposed at an estimated cost of $150,000, which would have represented a potential load reduction of a 1,000 lbs. N/yr. The percent reduction or credit would need to be verified and adjusted, if necessary, based on the results of a post-education survey.

It would seem reasonable to assume that an initial 5% load reduction credit could be used for the first 3 years of the permit recognizing that it will take time to fully implement a structured Education Program and for the education benefits to take effect. The Education Program scope elements and potential costs would need to be determined. The measure of performance and ultimate credit could be determined based on the number or percentage of homeowners who report to have changed their amount and frequency of applications as a result of the education program based on a scientifically based homeowner survey completed prior to and after the education program. Preliminarily, if we assume a general cost range of $200,000 or $300,000 to implement a fertilizer education program for the first 2 to 3-years, this will translate into a per unit cost $50 to $70 per lb. N reduced for an overall potential load reduction of 4,464 lbs. N/yr. based on a 5% credit for 12 communities, assuming there is support and participation by all 12 communities.

The potential N load reductions could be higher if the Education Program was expanded to other communities in the watershed, where reduction could be as high as approximately 9,000 lbs. N/yr if a 5% credit was applied to all communities in the watershed. Arguably, even if the other communities and residents were not directly involved the benefits of the Education Program would likely spread through the watershed given the general universal access to social media messaging.

Ultimately the fertilizer reduction credit would be based on the reported change in homeowner behavior as determined by baseline and post-education surveys and the effectiveness of the Program to affect change.

As communities develop their individual N Reduction Plans, this initial 5% credit could be applied to the lawn fertilizer load estimated for each community as provided by the GBNNPSS. Communities could also achieve additional reductions by reducing the number of acres of managed turf to naturally vegetated or mow only treatment or eliminating fertilizer use all together on municipal land.

Septic System Sidebar

An additional and even larger N source to be considered for education and non-structural measures relates to septic systems. As shown in the figure below, the estimated delivered load associated with septic systems is by far the largest source of N from the 12 communities. The estimated septic system N load varies more widely for the individual communities and depends on the percentage of population connected to the municipal sewer system. The systems that are considered to have the greatest impact based on the GBNNPS assumptions and results are those located within 200 meter of a major water body as these systems are considered to deliver higher N loads per system. Nine of the 12 communities are estimated to contribute 90% of the estimated N load from systems within 200 meters of a major water body or approximately 25,350 lbs. N/yr. Developing an education program to increase inspection and maintenance and to promote and/or fund retrofits for N removal technologies for these systems could result in meaningful load reductions.