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**FEASIBILITY ANALYSIS FOR EPA'S DRAFT GREAT BAY TOTAL  
NITROGEN GENERAL PERMIT IN DOVER, DURHAM, EPPING,  
EXETER, MILTON, NEWFIELDS, NEWINGTON, NEWMARKET,  
PORTSMOUTH, ROCHESTER, ROLLINSFORD, SOMERSWORTH NH  
AND BERWICK, KITTERY, NORTH BERWICK AND SOUTH BERWICK  
ME**

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**FEASIBILITY ANALYSIS  
FOR EPA'S DRAFT  
GREAT BAY TOTAL NITROGEN GENERAL PERMIT  
IN  
DOVER, DURHAM, EPPING, EXETER, MILTON, NEWFIELDS,  
NEWINGTON, NEWMARKET, PORTSMOUTH, ROCHESTER,  
ROLLINSFORD, SOMERSWORTH NH AND  
BERWICK, KITTERY, NORTH BERWICK  
AND SOUTH BERWICK ME**

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# ABBREVIATIONS

Acronym	Definition
BMP	STORMWATER BEST MANAGEMENT PRACTICE
CFR	CODE OF FEDERAL REGULATIONS
CLF	CONSERVATION LAW FOUNDATION
CN	CURVE NUMBER
CWA	CLEAN WATER ACT
EPA	ENVIRONMENTAL PROTECTION AGENCY
EMC	EVENT MEAN CONCENTRATION
GBE	GREAT BAY ESTUARY
GBNNPSS	GREAT BAY NITROGEN NON-POINT SOURCE STUDY
GIS	GEOGRAPHIC INFORMATION SYSTEMS
HRU	HYDROLOGIC RESPONSE UNIT
IC	IMPERVIOUS COVER
LA	LOAD ALLOCATION
LID	LOW IMPACT DEVELOPMENT
LIDAR	LIGHT DETECTION AND RANGING
LOA	LINEAR OPTIMIZATION ANALYSIS
LTCP	LONG TERM CONTROL PLAN
MEDEP	MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
NCDC	NATIONAL CLIMATE DATA CENTER
NCM	NITROGEN CONTROL MEASURE
NCP	NITROGEN CONTROL PLAN
NHDES	NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES
NOI	NOTICE OF INTENT
NPS	NON-POINT SOURCE
NRCC	NORTHEAST REGIONAL CLIMATE CENTER
NRCS	NATURAL RESOURCES CONSERVATION SERVICE
NPDES	NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM
PLA	POLLUTANT LOADING ANALYSES
PLER	POLLUTANT LOAD EXPORT RATES
PS	POINT SOURCE
RDA	RESIDUAL DESIGNATION AUTHORITY
SWM	STORMWATER MANAGEMENT
SWMM	STORMWATER MANAGEMENT MODEL
SWU	STORMWATER UTILITY
TMDL	TOTAL MAXIMUM DAILY LOAD
TN	TOTAL NITROGEN
TNGP	TOTAL NITROGEN GENERAL PERMIT
USGS	UNITED STATES GEOLOGICAL SURVEY
WLA	WASTE LOAD ALLOCATION
WQV	WATER QUALITY VOLUME
WWTF	WASTEWATER TREATMENT FACILITY

# 1. EXECUTIVE SUMMARY

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The purpose of this study is to determine the feasibility and cost for regulated communities in the Great Bay watershed to implement the optional non-point source and stormwater point source nitrogen reduction pathway (Appendix II) associated with EPA's draft Great Bay Total Nitrogen General Permit ((NPDES Permit No NHG58A000 published in Federal Register January 7, 2020). The Total Nitrogen General Permit (TNGP) covers nitrogen discharges from 12 New Hampshire communities in the Great Bay watershed that operate wastewater treatment facilities (WWTF) regulated under the Clean Water Act, including Dover, Durham, Epping, Exeter, Milton, Newfields, Newington, Newmarket, Portsmouth (Pease Tradeport and Peirce Island), Rochester, Rollinsford, Somersworth. There are four Maine communities within the watershed with wastewater treatment facilities that are *not* covered under this permit (Berwick, Kittery, North Berwick and South Berwick) because they are regulated separately by the Maine Department of Environmental Protection (MEDEP) however, as detailed in the TNGP factsheet, EPA expects the MEDEP to regulate nitrogen discharges from these facilities. The fact basis for the TNGP is based on the load reduction from all 16 regulated communities in the Great Bay Estuary (GBE), therefore this analysis looks at a potential scenario for all these communities to achieve required reductions outlined in the draft TNGP.

Feasibility was evaluated on the basis of a community's ability to reduce non-point source and stormwater-derived nitrogen by 45% over four 5-year permit periods as outlined in Appendix II of the draft TNGP. By looking at land use categories and modeled nitrogen loads in each category, this analysis demonstrates how to optimize nitrogen reductions through a variety of cost effective structural and non-structural approaches. Feasibility was based on both an assessment of methods to implement nitrogen controls and a corresponding cost analysis. This study demonstrates that a 45% reduction in non-point source (NPS) nitrogen loads is feasible and can be accomplished in the Great Bay Estuary over a 20-yr implementation period at costs well within national norms. If stormwater utilities were formed as a mechanism to fund a 20-year program, stormwater fees would vary amongst communities and range from \$26 - \$198, with an average annual cost of \$91 per year per household.

This feasibility analysis is based on nitrogen reductions achievable through a range of Best Management Practices (BMPs). The most cost-effective of such practices, if implemented widely, are non-structural BMPs such as catch basin cleaning, leaf litter collection, expanded vegetated buffers, and other green infrastructure. This analysis also modeled the use of low-cost structural BMPs with an emphasis on targeted, small-sized systems such as rain gardens, rooftop infiltration (e.g., dry wells), and gravel wetlands on commercial and industrial areas with the highest nutrient loads. Lastly, this analysis models the significant nitrogen reductions achievable with relatively low-cost retrofits of septic systems, one of the most significant BMPs identified in the optimization analysis.

Appendix B includes an example of a Nitrogen Control Plan for each regulated municipality. These plans are not a prescription for how to implement the optional pathway of the TNGP, rather they represents one scenario of many. Communities will need to determine which combination of management approaches is most suitable and achievable.

This study assumes that non-point source and stormwater management conducted to comply with this permit would be consistent with EPA's 2017 NH Small Municipal Separate Storm Sewer Discharge (MS4) permits (specifically Appendix H) requirements for communities discharging to nitrogen-impaired waters. All municipalities regulated under this draft TNGP communities are also MS4 communities or have an MS4 waiver (communities with waivers include Epping, Newfields, and Newington). Specific requirements common to both

the TNGP and MS4 programs that are included in this feasibility study are source identification reporting, stormwater best management practice (BMP) optimization for pollutant removal, retrofit inventory, priority ranking, cost assessment, and evaluation of stormwater program financing mechanisms.

The analytical methods used to determine pollutant loads and assess BMP performance are consistent with those published by EPA, USGS and others, and are generally accepted for water quality permitting purposes.

## 1.1. Background on Draft Great Bay Total Nitrogen General Permit for Wastewater Treatment Facilities In New Hampshire

On January 7, 2020, EPA filed notice in the Federal Register of the Draft Great Bay Total Nitrogen General Permit for Wastewater Treatment Facilities In New Hampshire NPDES General Permit: NHG58A000<sup>1</sup>. The General Permit would supersede the nitrogen requirements for individual NPDES permits for 13 wastewater treatment facilities (WWTF) in New Hampshire including Dover, Durham, Epping, Exeter, Milton, Newfields, Newington, Newmarket, Portsmouth (Pease Tradeport and Peirce Island), Rochester, Rollinsford and Somersworth. The four Maine communities with WWTFs located in the Great Bay Estuary (Berwick, Kittery, North Berwick, and South Berwick) would not be covered under this permit and are regulated separately by the Maine Department of Environmental Protection. As detailed in the TNGP factsheet, EPA expects the MEDEP to regulate nitrogen discharges from these facilities.

The draft TNGP details total loads as follows:

- From 2012-2016 the total nitrogen load to the Great Bay Estuary was 6,206 lbs/day, or 189.3 kg/ha/yr.
- Normalized to 1988-2017 rainfall, nitrogen load was 6,809 lbs/day or 207.7 kg/ha/yr.
- From 2012-2016, the WWTF loads were 2,717 lb/day (82.7 kg/ha/yr), and the non-point source and stormwater loads were 3,495 lbs/day (106.6 kg/ha/yr).
- Point source and non-point source loads normalized to 1988-2017 are 2,974 lbs/day (90.7 kg/ha/yr) and 3,836 lbs/day (117.0 kg/ha/yr), respectively.

The draft permit details three studies<sup>2,3,4</sup> as the scientific basis for establishing a 100 kg/ha/yr nitrogen loading threshold to protect water quality standards. These studies generally concur that at loading rates of 51-99 kg/ha/yr the “ability of eelgrass to thrive diminishes markedly” and that beyond 100 kg/ha/yr “eelgrass is essentially absent.” EPA has proposed a 100 kg/ha/yr loading threshold with subsequent WWTF discharge allocation limits totaling 35.4 kg/ha/yr, allowing for a remaining 64.6 kg/ha/yr for non-point source and stormwater point source loads. The current NPS load of 117.0 kg/ha/yr requires a reduction of approximately 45% to achieve the 100 kg/ha/yr threshold. EPA states that 100 kg/ha/yr is the least stringent threshold within the “critical range” needed as a reasonable next step in an adaptive management approach; EPA also recognizes that lower limits could be required, depending on ecosystem response.

Because some Great Bay communities have long expressed interest in having flexibility to determine where they can most cost-effectively reduce nitrogen discharges between improved wastewater and stormwater

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<sup>1</sup> EPA (2020). Draft Great Bay Total Nitrogen General Permit For Wastewater Treatment Facilities In New Hampshire. NPDES General Permit: NHG58A000. Boston, MA, Office of Ecosystem Protection, United States Environmental Protection Agency.

<sup>2</sup> Valiela, I. and M. L. Cole (2002). "Comparative evidence that salt marshes and mangroves may protect seagrass meadows from land-derived nitrogen loads." Ecosystems 5(1): 92-102.

<sup>3</sup> Hauxwell, J., J. Cebrián, et al. (2003). "Eelgrass *Zostera marina* loss in temperate estuaries: relationship to land-derived nitrogen loads and effect of light limitation imposed by algae." Marine Ecology Progress Series 247: 59-73.

<sup>4</sup> Latimer, J. S. and S. A. Rego (2010). "Empirical relationship between eelgrass extent and predicted watershed-derived nitrogen loading for shallow New England estuaries." Estuarine, Coastal and Shelf Science 90(4): 231-240.

management, EPA outlined an optional non-point source and stormwater point source nitrogen reduction approach contained in Appendix II of the permit, excerpted below:

*This permit sets forth an optional pathway to achieve such gross reductions at the scale needed to meet water quality standards and attain designated uses. To provide communities with guidance on the level of reductions needed, EPA and NHDES have identified a pathway to achieve this goal through a long-term, adaptive management approach. Communities who choose to adopt this optional approach would achieve the reductions through fulfillment of the following:*

1. *Upon the effective date of this permit, each Permittee may, at their election, coordinate with NHDES, other Great Bay communities and stakeholders to develop and utilize the Pollution Tracking and Accounting Program (PTAP) or its successor, a comprehensive subwatershed-based tracking/accounting system, for quantifying the nitrogen loading changes to the Great Bay estuary associated with activities within each municipality. These activities include, but are not limited to:*
  - a. *New/modified septic systems,*
  - b. *Decentralized wastewater treatment facilities,*
  - c. *Changes to the amount of effective impervious cover,*
  - d. *Changes to the amount of disconnected impervious cover,*
  - e. *Conversion of existing landscape to lawns/turf, and*
  - f. *Any new or modified structural or non-structural best management practices.*
2. *Within 12 months of the effective date of this permit, each Permittee may, at their election, develop, submit to NHDES (with a copy to EPA), and begin to implement a near-term nitrogen non-point source and stormwater point source control plan (“Short-Term Nitrogen Control Plan”), including:*
  - a. *A schedule of three years for implementing specific short-term (i.e., beginning within one year of submittal) control measures (e.g., fertilizer reduction) to address identified non-point source and stormwater point source nitrogen loadings in each municipality that contribute nitrogen to the Great Bay Estuary;*
  - b. *The identification of specific control measures and suitable locations within the great bay watershed for each of these control measures based on nitrogen reduction credits approved by PTAP or its successor at the time of plan submittal, cost, and site characteristics to achieve optimal reduction of nitrogen to the great bay estuary;*
  - c. *The estimated cost of each control measure identified in the schedule shall include a description of appropriate financing and regulatory mechanisms to implement the necessary reductions;*
  - d. *An operations and maintenance plan for control measures, as necessary; and*
  - e. *An explanation of any category of non-point source loadings that are not included in the plan.*
3. *Within 36 months of the effective date of this permit, each Permittee may, at their election, develop, submit to NHDES (with a copy to EPA), and begin to implement a five-year nitrogen non-point source and stormwater point source control plan (“Long-Term Nitrogen Control Plan – I”), for implementing specific long-term control measures to achieve a reduction of nitrogen delivered to the Great Bay estuary equivalent to 11% of the municipality-specific baseline to address identified non-point source and stormwater point source nitrogen. The plan may include:*
  - a. *A municipality-specific baseline of non-point source and stormwater point source nitrogen delivered to the Great Bay estuary using data directly from the 2014 Great Bay Non-Point Source Study1 (GBNPSS) or optionally providing a defensible update, normalized to average rainfall;*

- b. *The identification of specific control measures and suitable locations within the Great Bay watershed for each of these control measures based on nitrogen reduction credits approved by PTAP or its successor at the time of plan submittal, cost, and site characteristics to achieve optimal reduction of nitrogen to the Great Bay estuary;*
  - c. *The estimated cost of each control measure identified in the schedule shall include a description of appropriate financing and regulatory mechanisms to implement the necessary reductions;*
  - d. *An operations and maintenance plan for control measures, as necessary; and*
  - e. *An explanation of any category of non-point source loadings that are not included in the plan.*
  - f. *If the municipality's WWTF nitrogen loading is below the annual average allocation, the difference between actual annual average loading and the permitted annual average allocation can be applied toward the non-point source and stormwater point source loading reduction target.*
4. *Within 8 years of the effective date of this permit, each Permittee may, at their election, develop, submit to NHDES (with a copy to EPA), and begin to implement a long-term nitrogen non-point source and stormwater point source control plan ("Long-Term Nitrogen Control Plan – 2"), for implementing specific long-term control measures to address identified non-point source and stormwater point source nitrogen to achieve a cumulative reduction of nitrogen delivered to the Great Bay estuary equivalent to 22% of the original municipality-specific baseline. The plan may include items (b) through (f) listed in Part 3 above.*
  5. *Within 13 years of the effective date of this permit, each Permittee may, at their election, develop, submit to NHDES (with a copy to EPA), and begin to implement a long-term nitrogen non-point source and stormwater point source control plan ("Long-Term Nitrogen Control Plan – 3"), for implementing specific long-term control measures to address identified non-point source and stormwater point source nitrogen to achieve a cumulative reduction of nitrogen delivered to the Great Bay estuary equivalent to 33% of the original municipality-specific baseline. The plan may include items (b) through (f) listed in Part 3 above.*
  6. *Within 18 years of the effective date of this permit, each Permittee may, at their election, develop, submit to NHDES (with a copy to EPA), and begin to implement a long-term nitrogen non-point source and stormwater point source control plan ("Long-Term Nitrogen Control Plan – 4"), for implementing specific long-term control measures to address identified non-point source and stormwater point source nitrogen to achieve a cumulative reduction of nitrogen delivered to the Great Bay estuary equivalent to 45% of the original municipality-specific baseline. The plan may include items (b) through (f) listed in Part 3 above.*

*The optional cumulative reduction targets identified above may be adjusted to account for non-point source and stormwater point source changes that occur outside of the scope of the Permittees' efforts (e.g., changes in atmospheric deposition of nitrogen to the watershed).*

*In the event the activities described above are not carried out and water quality standards are not achieved, EPA may reopen the General Permit within the timeframe of the permit (5 years) or reissue the General Permit beyond the timeframe of the permit (5 years) and incorporate any more stringent nitrogen effluent limits for the WWTFs necessary to ensure compliance with water quality standards. Conversely, if water quality standards are achieved before the activities described above are fully carried out, further nitrogen reductions from non-point source and stormwater point sources or from more stringent nitrogen effluent limits for the WWTFs may not be necessary (assuming that nitrogen loads do not increase from that level because of significant changes in land use, weather, atmospheric deposition or other reasons that can affect water quality).*

*The Permittees shall all participate in the annual ambient monitoring program detailed below. Each Permittee shall be responsible for a percentage of the overall ambient monitoring cost equivalent to the percentage of the design flow of their WWTF(s) divided by the total design flow of all WWTFs covered by the permit.*

## **1.2. Summary Findings from Feasibility Analysis of Draft TNGP**

This study demonstrates that a 45% reduction in non-point source (NPS) loads in the Great Bay Estuary is feasible and can be accomplished over a 20-yr implementation period at costs well within national norms. By looking at land use categories and modeled nutrient loads in each category, this analysis demonstrates how to optimize nitrogen reductions to select a variety of cost effective structural and non-structural means. It is important to underscore that this feasibility study is not a prescription for how to implement the optional pathway of the TNGP - it represents one scenario of many possible pathways. Ultimately communities will need to assess what combination of nutrient-reduction approaches will be most suitable.

### Principle Findings:

- Costs of BMPs vary by community depending largely on density and development patterns, with an average unit cost of \$561 per pound of N and a range of \$429 - \$755 per pound N between communities. In comparison, nitrogen removal in wastewater commonly costs between \$300-\$1,500 per pound of nitrogen removed, depending on the WWTF limit.
- Total costs to implement the TNGP over 20 years range from a low of \$2.2 million for Newfields, \$3.1 for Rollinsford and \$5.2 for Somersworth, to a high of \$13.4 million for Berwick, \$17.5 for Dover, and \$22.3 for Rochester.
- If implemented widely, non-structural BMPs such as street sweeping, catch basin cleaning, and leaf litter collection, are the most cost-effective management approaches at an average unit cost of \$282/lb N/yr.
- Low-cost structural BMPs such as rain gardens, dry wells and gravel wetlands, with an average unit cost of \$557/ lb N/yr, can be small-sized and used widely and efficiently in areas with the highest nutrient loads.
- Septic system retrofits offer significant opportunities to reduce nitrogen loads at an average cost of \$630/lb N/yr, and could reduce nearly 40% of the entire NPS load.
- To meet the 45% target reductions, municipalities would need to implement structural BMPs to treat stormwater from 5, 10 and 20 acres per year in smaller municipalities like Newfields, Rollinsford and North Berwick respectively, while the cities of Rochester, Portsmouth and Dover would need to treat runoff from 67, 77, and 107 acres per year over 20 years.
- Local examples of BMP retrofits in 2019 had a unit cost of \$5,833 per treated acre when combined with roadway capital improvements.
- While four communities may struggle to achieve 45% reductions with above-average costs, other communities can go well beyond 45%, potentially achieving load reductions of 71% at \$561 per pound Nitrogen removed.
- The load reduction shortfall in certain communities could be addressed if the TNGP were to
  - 1) Allow inter-municipal trading;
  - 2) Keep the existing draft allocations and reevaluate over time through adaptive management;
  - 3) Establish a watershed-based load reduction of 45% but vary individual load reduction targets based on an equitable and equivalent unit cost of \$560/lb N, rather than a uniform 45% load reduction for each regulated community;
  - 4) Distribute load reduction requirements to watershed communities not regulated under this TNGP through other regulatory means such as Residual Designation.



- Using stormwater utilities as the mechanism to fund a 20-yr program, stormwater fees would average \$91 per year per residential household with a range of \$26 (Portsmouth) to \$198 (Milton). The majority of fees were between \$52 and \$135 per year, within the national range and consistent with a local study<sup>5</sup>. An alternative approach based on equivalent unit cost for each community would be \$88/yr. per residential household. It is important to note that stormwater utility program costs derived in this analysis are conservatively assumed to be borne entirely by the municipality. In fact, in many communities up to 50% of stormwater-related nitrogen reductions could occur through private sector redevelopment if low impact development (LID) stormwater regulations are in place, thus shifting a significant portion of the cost burden to private development.

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<sup>5</sup> AMEC (2011). Portsmouth, NH Stormwater Utility Feasibility Study - Final Report. Westford, MA, AMEC Earth & Environmental.



# 2. INTRODUCTION TO FEASIBILITY ANALYSIS

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## 2.1. Overview

The purpose of this study was to determine whether EPA’s draft permit to reduce nitrogen load in the Great Bay Estuary by 45% over 20 years is feasible - and at what cost – if the regulated municipalities choose the optional non-point source and stormwater point source nitrogen reduction pathway outlined in Appendix II of the TNGP. Feasibility studies were conducted for nitrogen control plan development for the Great Bay towns and surrounding areas. These include the New Hampshire towns of Dover, Durham, Epping, Exeter, Milton, Newfields, Newington, Newmarket, Portsmouth (Pease Tradeport and Peirce Island), Rochester, Rollinsford, Somersworth, as well as the Maine communities including Berwick, Kittery, North Berwick, and South Berwick.

This study provides information on the assessment methods, BMP implementation, and program costing to implement the TNGP for the 17 communities. It also examines the advantages of using green infrastructure as a critical tool for nitrogen control. This study assumes that all aspects of non-point source and stormwater management would be consistent with the 2017 NH Small MS4. Components of this study include source identification reporting, BMPs optimized for pollutant removal<sup>6</sup>, retrofit inventory, priority ranking, cost assessment, and an evaluation of stormwater program financing mechanisms.

The analytical methods used to determine the pollutant loads, waste load allocations, and to assess BMP performance are consistent with those published by EPA<sup>7</sup>, USGS<sup>8</sup> and others<sup>9</sup>, and are generally accepted for water quality permitting purposes.

This study includes the following information regarding the feasibility of the draft Total Nitrogen (TN) General Permit for stormwater and wastewater:

- A review of the requirements and fact basis for the Draft Total Nitrogen General Permit (TNGP)
- An overview of relevant regulatory issues
- A review of current nitrogen loading data for wastewater and non-point sources by individual community
- A discussion of nutrient control strategies as well as structural and non-structural BMPs, including examples and costing
- A review of methods used to conduct nitrogen control planning, including baseline source identification, BMP optimization, retrofit inventory and priority ranking
- A review of nutrient control optimization for structural and non-structural strategies
- A feasibility analysis of nitrogen control plan implementation based on a 20-yr program
- A study of stormwater program financing by stormwater utility to determine residential fees by community
- A review of guidance for developing implementation schedules
- A discussion about the possibility of credit trading within the TNGP
- A discussion about examples of septic system retrofit programs
- A review of residual designation authority.

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<sup>6</sup> Appendix H. Part I, 1.a Additional or Enhanced BMPs.i.2

<sup>7</sup> EPA (2010a)

<sup>8</sup> Zarriello, P. J. and L. K. Barlow (2002)

<sup>9</sup> Gamache, M., M. Heineman, et al. (2013)

## 2.2. Water Quality Overview in the Great Bay Estuary

The Great Bay Estuary (GBE) covers 21 square miles, 144 miles of shoreline, and includes input from eight rivers (Winnicut, Squamscott, Lamprey, Oyster, Bellamy, Cocheco, Salmon Falls, and the Great Works). Like many estuaries in the northeast, GBE is extremely vulnerable to non-point source (NPS) loadings with limited fringing wetlands to buffer impacts from developed areas (Bricker et al., 1999; Bricker et al., 2003).

Like many other coastal regions, the Great Bay watershed has experienced population growth and an associated increase in development, which has impacted the water quality and health of Great Bay. The estuary receives treated wastewater effluent from 17 wastewater treatment facilities -13 in New Hampshire and four in Maine. Increased municipal sewage, impervious cover, residential landscaping, and altered hydrology (including storm and sanitary sewer systems) have increased the amount of wastewater and stormwater runoff flowing into the Great Bay Estuary. In 2009, NHDES concluded that eleven sub-estuaries in the Great Bay Estuary failed to meet state water quality standards for their designated uses and were identified as “impaired” on the Clean Water Act (CWA) Sec. 303(d) list of impaired and threatened waters (NHDES, 2009).

Monitoring and research conducted by various university, local, state, and federal programs and projects have documented stresses in the Great Bay system. Prominent drivers of change include watershed modification and development, resulting in increased impervious cover; increased nutrient and pollutant loading from a rapidly growing coastal population; and ecosystem instability and loss of diversity caused by factors including, but not limited to: invasive species, habitat destruction, and disease. Each stress drives additional physical, chemical, and biological pressures on the Great Bay system, which affect the environmental, lifestyle, and economic benefits valued by local communities.

Environmental indicators used by the Piscataqua Regions Estuaries Partnership to identify and track ecosystem health clearly demonstrate an ecosystem in trouble. In the most recent *State of Our Estuaries 2018* report (PREP, 2018), 14 of 24 indicators showed declining or cautionary trends within GBE. Impervious cover, an indicator of development, shows a long-term increasing trend with indicators including nutrient concentration, eelgrass, dissolved oxygen, and macroalgae showing either no improvement or continued decline. Eelgrass is a critical indicator as it provides water quality, habitat, and resilience benefits, and it is widely considered a cornerstone species for healthy estuaries. In recent decades, the GBE has lost over half of its eelgrass coverage due to development, declining water quality, and changing climate (Burdick et al 2019). Between 1996 and 2014, Great Bay lost 44% of its eelgrass acreage and 79% of eelgrass biomass (Short 2016). Eelgrass loss indicates both a diminishing resilience and reduced ability to recover from extreme storms.

Positive trends include nitrogen loading and WWTF upgrades. According to the PREP *State of Our Estuaries 2018* report:

*Total nitrogen loading from 2012 to 2016 was 903 tons per year, which is 26% percent lower than the 2009 to 2011 levels (1,224 tons per year). Low rainfall and corresponding streamflow during this period, as well as significant reductions in nitrogen loading at municipal wastewater treatment facilities, are the primary reasons for this decrease (PREP 2018).*

Important advances are being made with the 2017, 2019, and 2020 WWTF upgrades in Newmarket, Exeter, and Portsmouth, which will reduce nitrogen loads by 80%, 65%, and 73% respectively, assuming operation at 8 mg/L.

### 2.2.1. TNGP Permittees

The Total Nitrogen General Permit (TNGP) includes National Pollution Discharge Elimination System (NPDES) permits for 13 wastewater treatment facilities (WWTF) in New Hampshire, including Dover, Durham, Epping, Exeter, Milton, Newfields, Newington, Newmarket, Portsmouth (Pease Tradeport and Peirce Island), Rochester, Rollinsford, Somersworth. The four Maine communities with WWTFs located in the Great Feasibility Analysis for EPA’s Draft Great Bay Total Nitrogen General Permit  
May 2020

Bay Estuary (Kittery, Berwick, North Berwick and South Berwick) would not be covered under this permit and are regulated separately by the Maine Department of Environmental Protection. As detailed in the TNGP factsheet, EPA expects the MEDEP to regulate nitrogen discharges from these facilities. In this study, Pease ITP was not examined individually because the EPA and DES calculations in the Great Bay Nitrogen Non-Point Source Study do not examine an individual NPS load for Pease ITP and instead combine it with Newington and Portsmouth.



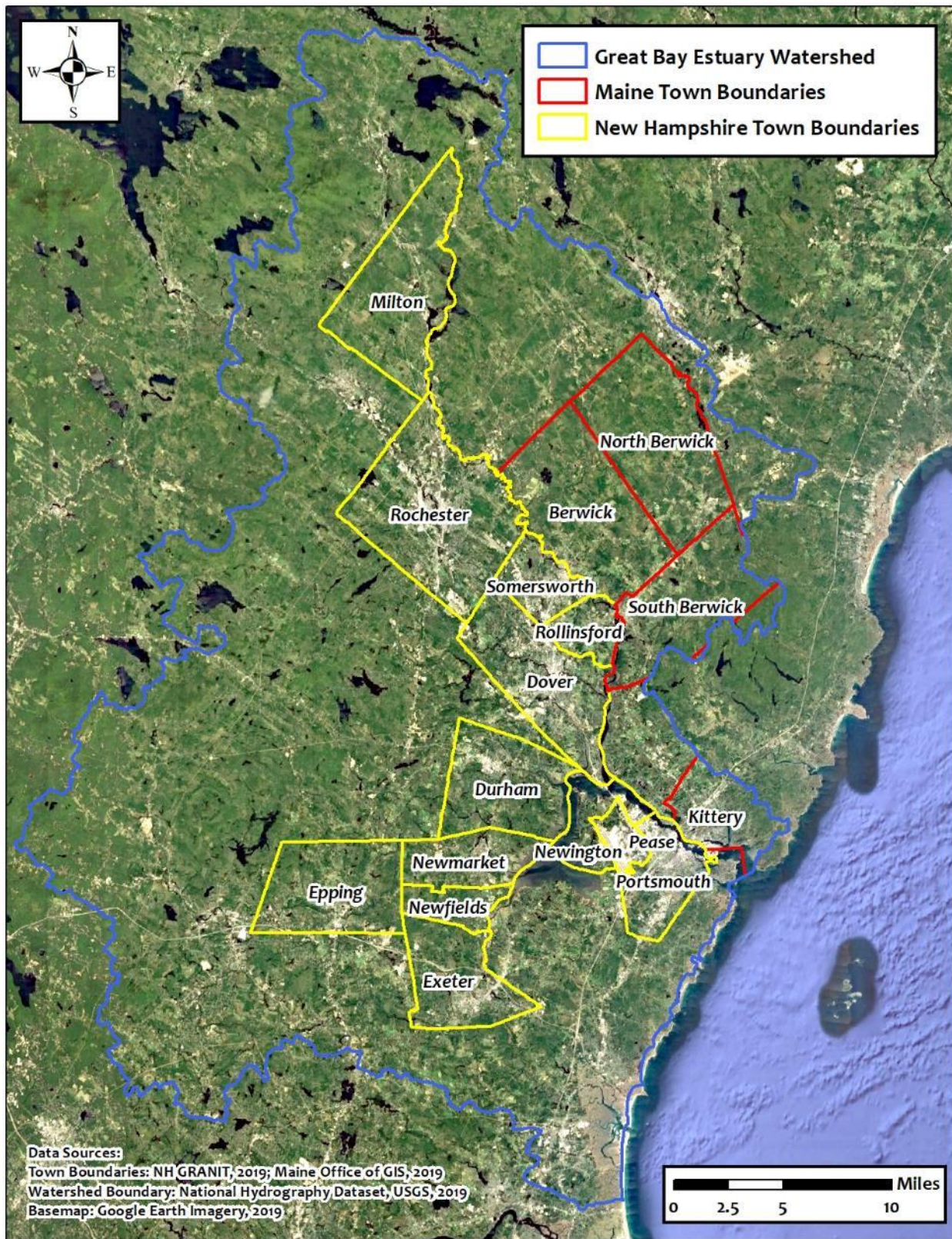


Figure 2.1 - Study Area



## 2.3. Great Bay Nitrogen Non-Point Source Study

The Great Bay Nitrogen Non-Point Source Study (GBNNPSS) was completed in June of 2014 by the New Hampshire Department of Environmental Services (NHDES) and was the basis for many of the EPA findings of fact for the TNGP. It also served as the data source for this feasibility study for atmospheric and septic system derived nitrogen loading. The model used by NHDES is the Nitrogen Loading Model (NLM), which was originally introduced in Valiela et al. (1997). The NLM, as customized for this study, tracks nitrogen inputs from atmospheric deposition, chemical fertilizers, human waste through septic systems, and animal wastes. These sources are then routed through surface waters, stormwater, and groundwater to the estuary as a delivered load of nitrogen. Local data were developed as inputs to the model. The model output was found to match field measurements of total non-point source (NPS) nitrogen loads from eight watersheds within the model uncertainty of +/-13%. For the watershed draining to the Great Bay Estuary, the model predicted an NPS nitrogen load of 800 tons per year (+/-100 tons/yr). This estimate corresponds well with field measurement of NPS, which were 835 tons/yr (PREP, 2013). The breakdown of nitrogen NPS from the model of delivered loads to the estuary is:

- Atmospheric Deposition: 42% (350 +/-50 tons/yr). Out-of-state sources account for 62% of this source.
- Human Waste: 29% (240 +/-30 tons/yr). This load is exclusively from septic systems because loads from wastewater treatment facilities, which accounted for 390 tons/yr (PREP, 2013), were not considered in this study.
- Chemical Fertilizer: 15% (130 +/-20 tons/yr). Lawns contributed 70% of this total; agricultural areas contributed 23%; and recreational fields were responsible for 8% of this load.
- Animal Waste: 14% (120 +/-20 tons/yr). Livestock accounted for 58% of this load, while pet waste accounted for the remaining 42%.

Nitrogen loads were modeled for individual subwatersheds and towns in the study area in order to identify “hot spots” of non-point source pollution. The model also concluded that 34% of the non-point source loads were delivered through stormwater. The model tracks stormwater from its point of origin as overland flow and applies attenuation factors to account for initial load versus delivered load to the GBE. The Great Bay Nitrogen Non-Point Source Study (GBNNPSS) does not differentiate between regulated and unregulated stormwater sources.

# 3. REGULATORY OVERVIEW

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There has been a complex series of regulatory decisions, federal permits, and legal challenges relating to wastewater and stormwater in the Great Bay watershed. In 2009 NHDES published an update of the 303(d) listing of impaired waters that included the Great Bay Estuary, based on nutrient impairments and eelgrass habitat loss<sup>10</sup>. In response to the 2009 nitrogen impairment listing, EPA began to issue new and revised discharge permits in the Great Bay watershed with nitrogen limits. The primary municipal permits are 1) National Pollutant Discharge Elimination System (NPDES) permits for wastewater treatment facilities and 2) and Municipal Separate Storm Sewer Discharge (MS4) permits for stormwater. On January 7, 2020, EPA filed notice in the Federal Register of the Draft Great Bay Total Nitrogen General Permit for Wastewater Treatment Facilities In New Hampshire NPDES General Permit: NHG58A000.

## 3.1. Great Bay Regulatory Status

The Clean Water Act directs EPA to develop criteria (numeric or narrative) based on a determination that there exists a “reasonable potential to cause or contribute to<sup>11</sup>” an impairment. This determination is based on ‘the best available science’ at the time, which acknowledges that although our understanding of an ecosystem is necessarily incomplete, further delay in corrective measures will clearly contribute to increasing degradation. Permits may be issued to comply with numeric criteria if they exist, or narrative criteria if they do not.

In 2009, NHDES developed draft numeric nutrient criteria for the protection of eelgrass and low dissolved oxygen conditions. In 2012, EPA issued final WWTF discharge permits in Newmarket and Exeter based on these total nitrogen (TN) numeric criteria and a reasonable potential analysis. A 2014 peer review<sup>12</sup> was critical of the draft numeric criteria. Consequently, the numeric criteria were dropped as part of a 2014 settlement agreement between NHDES and the Municipal Coalition<sup>13</sup>. The standard upon which the peer review was tasked to review the draft numeric criteria was in part “whether the available data support the conclusion that excess nitrogen was the primary factor that caused the decline of eelgrass populations”.<sup>14</sup> It should be noted that the authors’ emphasis on what they call “the primary factor” is a higher standard than the EPA standard of a “reasonable potential to cause or contribute”. In 2012, the Environmental Appeals Board upheld the EPA’s standard for determining effluent limitations; upon further appeal, this decision was also upheld in 2013 by the Supreme Court.<sup>15</sup>

In preparation for the 2018 *State of Our Estuaries* report, PREP reconvened the 2014 peer review panel engaged initially by the Municipal Coalition, in order to consider current conditions. The advisors developed a joint statement<sup>16</sup> regarding eelgrass stressors, which includes numerous findings and recommendations. These include the following including:

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<sup>10</sup> NHDES (2009). Amendment to the New Hampshire 2008 Section 303(d) List Related to Nitrogen and Eelgrass in the Great Bay Estuary. Concord, NH, NHDES.

<sup>11</sup> 40 CFR § 122.44

<sup>12</sup> Bierman, V. J., R. J. Diaz, et al. (2014). Joint Report of Peer Review Panel-Great Bay Estuary.

<sup>13</sup> April 2014, Settlement Agreement between the Great Bay Municipal Coalition (Portsmouth, Dover, Rochester, NH) and the State of New Hampshire.

<sup>14</sup> Pg 46, section b) from the “Joint Report of Peer Review Panel-Great Bay Estuary”, February 13, 2014 Victor J. Bierman, Robert J. Diaz, W. Judson Kenworthy, Kenneth H. Reckhow.

<sup>15</sup> (2012). "Upper Blackstone Water Pollution Dist. v. EPA." F. 3d, Court of Appeals, 1st Circuit, 9.

<sup>16</sup> Gobler, C., J. Kenworthy, et al. (2017). External Advisors to PREP Technical Advisory Committee Statement Regarding Eelgrass Stressors in the Great Bay Estuary. Durham, NH, Piscataqua Region Estuaries Partnership.

- Despite encouraging reductions in nitrogen from wastewater treatment plants, loading levels are still well above levels found to be related to environmental degradation and reduced estuarine ecosystem resiliency in many other systems (Latimer and Rego, 2010).
- The most recent physiological measurements of *Ulva* (a green seaweed) that is abundant in the estuary indicate complete nitrogen saturation (Nettleton et al., 2011).
- The Great Bay Estuary is extremely vulnerable to non-point source loadings given that only 2.6% of the estuarine watershed area contains wetlands, and thus experiences the lack of wetland mitigating effects, (Bricker et al., 1999; Bricker et al., 2003).
- Addressing these non-point source loads is a natural next source for managers to consider, especially as non-point source reduction can also mitigate other run-off related pollutants. These include toxic contaminants such as herbicides and petrochemicals, both of which have been linked to eelgrass stress.

In 2017, EPA issued the NH Small MS4 Permit, which replaced the expired 2003 permit and expanded the non-point source (NPS) management requirements, particularly for impaired waters. For communities with impaired waters there are additional requirements for source detection, stormwater best management practice (BMP) optimization, and the allowance to establish milestones extending over multiple permit cycles. Under the MS4 program, towns with urbanized areas as defined by the U.S. Census are required to obtain permit coverage for their stormwater discharges. The 2017 permit includes additional requirements for communities that discharge to impaired waters. The towns of Danville, Derry, Dover, Durham, Exeter, Greenland, Hampstead, Hampton, Kingston, Milton, New Castle, Newmarket, North Hampton, Portsmouth, Raymond, Rochester, Rollinsford, Rye, Sandown, Somersworth, Stratham are subject to MS4 Appendix H for nitrogen impaired waters. Appendix H defines an iterative approach addressing pollutant reductions to impaired waters including source identification reporting, BMPs to be optimized for pollutant removal<sup>17</sup>, retrofit inventory, and priority ranking, to name a few.

On January 1, 2019 Pease ITP agreed to apply for coverage of discharges subject to the NH Small MS4 Permit, either under the general permit or an individual permit.<sup>18</sup> The agreement details specific removal or treatment of impervious surfaces in addition to the standard MS4 requirements.

On December 27, 2019, EPA announced a draft settlement agreement regarding NH and MA Small MS4 Permits between EPA, the National Association of Homebuilders, the Home Builders and Remodelers Association of Massachusetts, Inc., the New Hampshire Home Builders Association, the Center for Regulatory Reasonableness, the Massachusetts Coalition for Water Resources Stewardship, the Town of Franklin, Massachusetts, the City of Lowell, Massachusetts, the Conservation Law Foundation, and the Charles River Watershed Association. The settlement agreement was executed on April 15, 2020 and on April 23, 2020 EPA published proposed modifications to the MS4 permit in the Federal Register (85 FR 22735) for a 45 day public comment period.

On January 7, 2020, EPA released the *Draft Great Bay Total Nitrogen General Permit for Wastewater Treatment Facilities In New Hampshire*, which covers Rochester, Portsmouth, Dover, Exeter, Durham, Somersworth, Pease ITP, Newmarket, Epping, Newington, Rollinsford, Newfields, and Milton. A non-point source (NPS) management “Optional Pathway”, included in Appendix II, reflects the desire of some communities to have a more flexible approach that integrates stormwater and wastewater. EPA’s position on integrated planning was detailed in a 2012 memo.<sup>19</sup> This June 2012 EPA memorandum, “Integrated Municipal

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<sup>17</sup> Appendix H. Part I, 1.a Additional or Enhanced BMPs.i.2

<sup>18</sup> Irwin, T. Z. Griefen, et al. (2019). Settlement Agreement between Conservation Law Foundation v. Pease Development Authority, US District Court for NH. Case No 1:16-cv-00493-SM.

<sup>19</sup> Stoner, N. and C. Gyles (2011). Achieving Water Quality Through Integrated Municipal Stormwater and Wastewater Plans, US EPA.

Stormwater and Wastewater Planning Approach Framework,” provides guidance for EPA, as well as state and local governments, to develop and implement effective integrated plans that satisfy the Clean Water Act (CWA). The framework included there outlines the overarching principles and essential elements of a successful integrated plan, which includes:

- Maintaining existing regulatory standards that protect public health and water quality.
- Allowing a municipality to balance CWA requirements in a manner that addresses the most pressing public health and environmental protection issues first.
- Ensuring that the responsibility to develop an integrated plan rests on the municipality that chooses to pursue the approach. To this end, EPA and/or the State will determine appropriate actions, which may include developing requirements and schedules in enforceable documents.
- Promoting innovative technologies, including green infrastructure, as important tools that can generate many benefits, and may be fundamental aspects of municipalities’ plans for integrated solutions.
- Using adaptive management to modify or change milestones and strategies throughout the permit cycle based on new and improving information from monitoring of ecosystem health to address concerns about uncertainty in the regulatory process and LTCP implementation.

### **3.2. Pollutant Tracking and Accounting Project (PTAP)**

Many communities in the Great Bay with National Pollution Discharge Elimination System (NPDES) permits either are currently required or will soon be required to document nitrogen load reductions to record progress towards achieving water quality goals. The Pollutant Tracking and Accounting Project (PTAP) is a regional collaboration between UNH Stormwater Center, NHDES, EPA, and watershed communities. Its purpose is to develop a uniform system for tracking progress for nutrient control strategies for point-source and non-point source parameters, and for calculating and crediting reductions associated with the various control strategies. The TNGP requires permittees to participate in and use PTAP or its successor, a comprehensive subwatershed-based tracking/accounting system, for quantifying the nitrogen loading changes.

The tracking tools and accounting metrics in PTAP provide communities with a consistent, watershed-wide method to account for both existing gray and green infrastructure and for new treatment infrastructure and land use changes. “Tracking” refers to compiling information about activities that may contribute to increases or decreases in pollutant loading. This includes items such as land use conversion, impervious cover, BMP retrofits, etc. Accounting refers to the process of measuring the changes in tracking elements (such as nutrient control measures, changes in impervious cover) on a routine basis to determine a net change in pollutant load. Both tracking and accounting relate to a permit requirement to assure interim progress milestones for nutrient control measures (e.g. the number of acres treated per year). Crediting refers to how much a particular tracking element is worth (e.g. pounds of nitrogen removed per BMP).

### **3.3. Adaptive Management**

The TNGP formalizes an adaptive management approach based on an ambient monitoring plan and ecosystem response at 5-year intervals when the permit would be reviewed. The ambient monitoring program is funded by permittees in an amount proportional to the volume of discharge from their WWFTs.

Long-term implementation schedules and adaptive management are one means for communities and regulators to minimize uncertainty in environmental management. A long-term schedule, combined with monitoring, supports an iterative process of management actions. This, in turn, reduces uncertainty over time; it also offers potential cost savings. Under a long-term approach, “when” or “if” management actions (such as the requirement to operate the wastewater facilities at 3 mg/l) will be informed by future information, with an



emphasis on designated uses of Primary Contact Recreation and Aquatic Life Use Support. The adaptive management process also provides a long-term strategy for addressing uncertainty in declining estuarine health, with commitments to monitoring that should expand confidence in both environmental conditions and management actions.

Ecosystem restoration is an inherently uncertain process: ecosystem health and the role of nutrients and other impacts from urbanization are complex, and the time needed for recovery may be decades or longer. Some aspects of ecosystem response, such as *chlorophyll-a* reduction may occur very rapidly, while others, including long-term recovery of eelgrass, have a much higher uncertainty. Permit requirements, on the other hand, require substantive assurance that goals will be met. EPA is required to issue permits that address a “reasonable potential to cause or contribute to impairments”, while communities and residents naturally want a high level of confidence in the outcome of substantial investments in wastewater and stormwater.

### 3.4. EPA’s Fact Basis for Proposed Great Bay Total Nitrogen General Permit

As the basis for the TNGP, EPA conducted a “reasonable potential analysis” in order to determine the cause or contribution of nitrogen to the degradation of water quality standards<sup>20</sup>. This analysis included a review of existing data that assessed nitrogen loads to the estuary.

Table 3.1 lists nitrogen loads from 2012-2016 for the 17 WWTFs. Table 3.2 lists nitrogen loads as reported by PREP (2018) and adapted by EPA for the period from 2012-2016 for both non-point sources and point sources. Table 3.3 lists the existing and proposed non-point source, WWTF, and total nitrogen loads.

The total nitrogen load to the Great Bay Estuary was 6,206 lbs/day, or 189.3 kg/ha/yr. , and normalized to long-term rainfall conditions 1988-2017 was 6,809 lbs/day or 207.7 kg/ha/yr. From 2012-2016, the WWTF loads were 2,717 lb/day (82.7 kg/ha/yr); non-point source and stormwater loads were 3,495 lbs/day (106.6 kg/ha/yr). Point source and non-point source loads normalized to 1988-2017 are 2,974 lbs/day (90.7 kg/ha/yr) and 3,836 lbs/day (117.0 kg/ha/yr), respectively.

The TNGP details three studies as the scientific basis for establishing a 100 kg/ha/yr nitrogen loading threshold to protect water quality standards. It notes that estuaries could be grouped into three loading categories: 1) < 50 kg/ha/yr; 2) 51-99 kg/ha/yr the “ability of eelgrass to thrive diminishes markedly”; and 3) >100 kg/ha/yr “eelgrass is essentially absent.” EPA has thus proposed a 100 kg/ha/yr loading threshold with subsequent WWTF discharge allocation limits totaling 35.4 kg/ha/yr, while also allowing for a remaining 64.6 kg/ha/yr for non-point source and stormwater point source loads. The current NPS load of 117.0 kg/ha/yr requires a reduction of approximately 45% to achieve the 100 kg/ha/yr threshold. EPA states that 100 kg/ha/yr is the least stringent threshold within the “critical range” as a reasonable next step in an adaptive management approach, recognizing that lower limits could be required, depending on ecosystem response.

Load allocations, or wastewater treatment facilities (WWTF) limits and NPS load reductions, were developed based on the loading threshold of 100 kg/ha-yr to the entire Great Bay Estuary (Table 3.4). EPA details the reasoning for the variations in effluent limitations based on the facility size. The 7 largest facilities are given annual total nitrogen (TN) load limits based on 2012-2016 average annual flow and an effluent TN concentration of 8 mg/L. These totals are considered the level of treatment achievable at most of the existing facilities without requiring major upgrades in the near future. A “hold the load” requirement for the 10 smallest

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<sup>20</sup> EPA (2020). Fact Sheet: Draft Great Bay Total Nitrogen General Permit For Wastewater Treatment Facilities In New Hampshire. [NPDES General Permit: NHG58A000](#). Boston, MA, Office of Ecosystem Protection, United States Environmental Protection Agency.

facilities will have annual TN load limits based on 2012-2016 average annual flows and average effluent TN concentrations.

**Table 3.1: 2012-2016 WWTF Nitrogen Load to the Great Bay Estuary per Draft TNGP<sup>20</sup>**

Town	2012-2016 Ave Flow	2012-2016 Ave TN Conc	Actual Load in Effluent	Delivery Factor	Actual Load to GBE	% of Total Point Source Load
	(mgd)	(mg/l)	(lbs/day)	(%)	(lbs/day)	
Rochester	2.97	16.9	418.8	75.56	316.4	12%
Portsmouth	4.03	30	1009.4	100	1009.4	37%
Dover	2.46	18.2	372.9	100	372.9	14%
Exeter	1.61	22.6	304	100	304	11%
Durham	0.9	12.8	95.7	100	95.7	4%
Kittery	0.9	19.4	146.1	100	146.1	5%
Somersworth	1.44	6.8	81.6	94.94	77.5	3%
Pease ITP	0.64	16.4	87.4	100	87.4	3%
Berwick	0.21	16.7	28.9	94.55	27.3	1%
North Berwick	0.31	18.2	47.1	51.56	24.3	1%
Newmarket	0.52	8	170.2	100	170.2	6%
South Berwick	0.28	5.9	13.9	100	13.9	1%
Epping	0.25	18.2	37.4	58.2	21.8	1%
Newington	0.11	17.6	15.6	100	15.6	1%
Rollinsford	0.08	18.2	11.5	98.96	11.4	0%
Newfields	0.09	21.5	16	100	16	1%
Milton	0.07	18.2	10.8	65.7	7.1	0%
Total			2867.4		2717.1	100%
			87.3	kg/ha-yr	82.7	kg/ha-yr

**Table 3.2: Non-Point Source Nitrogen Loading and Load Summary for the Great Bay Estuary**

Year	2012-2016 NPS Load		1988-2017 NPS Load *
	tons/yr	kg/ha-yr	kg/ha-yr
2012	645.2	107.6	119.8
2013	642	107.1	110.1
2014	760.8	126.9	129.8
2015	498.5	83.1	99.4
2016	451.6	75.3	89.3
Average	599.62	100	109.7
LPR NPS Load **		6.6	7.3
Total NPS Load		106.6	117.0
Total Point Source Load		82.7	90.7
Total Nitrogen Load		189.3	207.7

\*2012-2016 rainfall (52.6 in/yr) normalized to 1988-2017 average rainfall in Durham, NH (45.2 in/yr), [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov) database

**Table 3.3: Existing and Proposed NPS, WWTF, and Total Nitrogen Loads**

Time	Total Load kg/ha-yr	WWTF Load kg/ha-yr	NPS Load Target kg/ha-yr	NPS % Reduction Required	
				Based on 2012-2016 data	Normalized to 1988-2017*
2012-2016	189.3	82.7	106.6		
Draft TNGP	100	35.3	64.7	39%	45%

\*\*LPR NPS Load taken from GBNNPSS Report because not accounted for in the SOOE NPS data

Abbreviations:

GBE = Great Bay Estuary

NPS =Non-Point Source

WWTF =Wastewater Treatment Facility

LPR = Lower Piscataqua River

GBNNPSS = Great Bay Nitrogen Non-Point Source Study (2014)

SOOE = State of Our Estuaries (2018 report)

**Table 3.4: Draft TNGP Annual WWTF Nitrogen Load Allocations**

Town	TN Load Allocation Permit Limit	Delivery Factor	Actual Load to GBE	% of Total Point Source Load
	(lbs/day)	(%)*	(lbs/day)	
Rochester	198	75.56	149.8	13%
Portsmouth	269	100	269.2	23%
Dover	164	100	163.9	14%
Exeter	108	100	107.6	9%
Durham	60	100	59.8	5%
Kittery	60	100	60.2	5%
Somersworth	96	94.94	91.1	8%
Pease ITP	87	100	87.4	8%
Berwick	29	94.55	27.3	2%
North Berwick	47	51.56	24.3	2%
Newmarket	35	100	34.8	3%
South Berwick	14	100	13.9	1%
Epping	37	58.2	21.8	2%
Newington	16	100	15.6	1%
Rollinsford	12	98.96	11.4	1%
Newfields	16	100	16	1%
Milton	11	65.7	7.1	1%
<b>Total</b>	<b>1259</b>		<b>1161.2</b>	<b>100%</b>
	<b>38.3</b>	<b>kg/ha-yr</b>	<b>35.3</b>	<b>kg/ha-yr</b>

# 4. NITROGEN CONTROL PLAN

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## 4.1. Land Use and Pollutant Load Analysis

For the purpose of this Feasibility Analysis, land use and land cover were evaluated for the 17 communities with wastewater treatment facilities (WWTF) in the Great Bay Estuary (GBE). This evaluation was followed by a pollutant load analysis (PLA) to quantify the significant sources of nitrogen to the GBE. The analysis included all major land uses and land cover, as well as atmospheric deposition and septic-derived groundwater loading. The analytical methods for the PLA are consistent with those published by EPA, USGS, and others; they are also generally accepted for water quality permitting purposes. Pease ITP was not examined individually because the EPA and DES calculations in GBNPSS do not examine an individual NPS load for Pease ITP.

***All Models Are Wrong  
Some Models Are Useful  
George Edward Pelham Box  
(1919 – 2013)***

Soils data<sup>21</sup> and impervious cover<sup>22</sup> data were processed to generate a land cover dataset for the entire Great Bay Estuary Watershed. In order to perform the pollutant load analysis, we employed detailed land use and land cover (LULC) data from the 2016 National Land Cover Dataset and the 2015 New Hampshire Land Use dataset. The LULC data was further organized to fit into categories for which pollutant load export rates (PLER) are available. A separate conversion was also performed to facilitate the linear optimization analysis (LOA), which relates specific nutrient control measures to specific land uses. Because New Hampshire and Maine use different LULC categorizations, Appendix A lists the detailed land uses and crosswalk categorization for land uses between the two states. Figures 2 and 3 show the land use, impervious cover, and soil type distribution for the communities of interest within the Great Bay Estuary Watershed. This analysis does not differentiate between connected and disconnected impervious cover (IC). A single generalized impervious cover PLER for each land use type was also used. Unique PLERs are used for each land use pervious cover (see Table 4.2).

Table 4.1 represents the major land use distributions amongst the 17 WWTF communities. Forest is the dominant land cover (64%) in the study area, followed by residential (13%) and nearly equal amounts of commercial industrial (5%), open land (5%), and agriculture (6%). Impervious cover within the GBE as a whole comprises 8%, although individual communities range from 3% in Milton and North Berwick to 29% at the Pease International Tradeport.

Figure 4.2 depicts land use by area and by nitrogen load for the study area. This figure demonstrates that the dominant use in the region is residential (28%), with commercial and industrial land uses comprising 24%. Highway and agriculture each account for 9%.

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<sup>21</sup> National Resources Conservation Service, Web Soil Survey, 2019

<sup>22</sup> Impervious Surfaces in the Coastal Watershed of NH and Maine, High Resolution – 2015, NH Granit

Table 4.3 illustrates the non-point source load for the study area, along with the 45% reduction target, and reduced annual load for the 17 entities. This includes load sources from runoff, atmospheric deposition to surface waters (lakes, rivers, estuaries), and septic system derived groundwater. Communities with the highest loads are Rochester (106,040 N lbs/yr), Dover (73,003 N lbs/yr), and Durham (47,967 N lbs/yr), while Newfields currently has the lowest load (10,750 N lbs/yr). Communities with the highest concentrated loading are Portsmouth (4.85 N lbs/ac/yr), Somersworth (4.41 N lbs/ac/yr), Newington (4.35 N lbs/ac/yr), in contrast with North Berwick, which has the lowest observed concentration (1.52 N lbs/ac/yr).

### **4.1.1. Nitrogen Source Identification**

Long-term control plan (LTCP) requirements mandate that a pollutant load analysis (PLA) be conducted to quantify the significant sources of nitrogen from the major land uses and land cover, atmospheric deposition, and septic-derived groundwater loading. For this study, data for the nitrogen loads from atmospheric deposition on surface waters (lakes, rivers, estuary) and septic derived groundwater were derived from the 2014 Great Bay nitrogen non-point source study (GBNNPSS).

This feasibility study also considers elements required in the new 2017 MS4 permit such as requirements to develop nitrogen source identification reports<sup>23</sup> for discharge to impaired water bodies. Source identification is used to assess all significant discharges to determine if said discharges could contribute to the waterbody impairment; It is also used to identify stormwater best management practices (BMPs) and a schedule for implementation to address the impairments. This study addresses required report elements 1, 3, 4, and 5 (partially), which include the following:

1. Calculation of total MS4 area draining to the water-quality-limited water segments or their tributaries. This calculation incorporates updated mapping of the MS4 and catchment delineations;
2. All screening and monitoring results targeting the receiving water segment(s);
3. Impervious area and disconnected impervious areas for the target catchment;
4. Identification, delineation, and prioritization of potential catchments with high nitrogen loading;
5. Identification of potential retrofit opportunities or opportunities for the installation of structural BMPs during redevelopment.

The TNGP assessment of nitrogen load includes the entire municipal nutrient load. For this study, pollutant load analysis was based on municipal boundaries and not limited to MS4 census designations. This was done for the following reasons:

- MS4 designations using census bureau delineations are imperfect because they are based on population density and often do not align with commercial and industrial land uses and actual hot spot assessments.
- Water quality impairments and pollutant loadings areas are based on contributing drainage areas and not limited to MS4 boundaries.
- Because MS4 requirements are based on nitrogen reductions for impaired waters, it would be less cost effective, might potentially target the wrong sources, and could conceivably make it

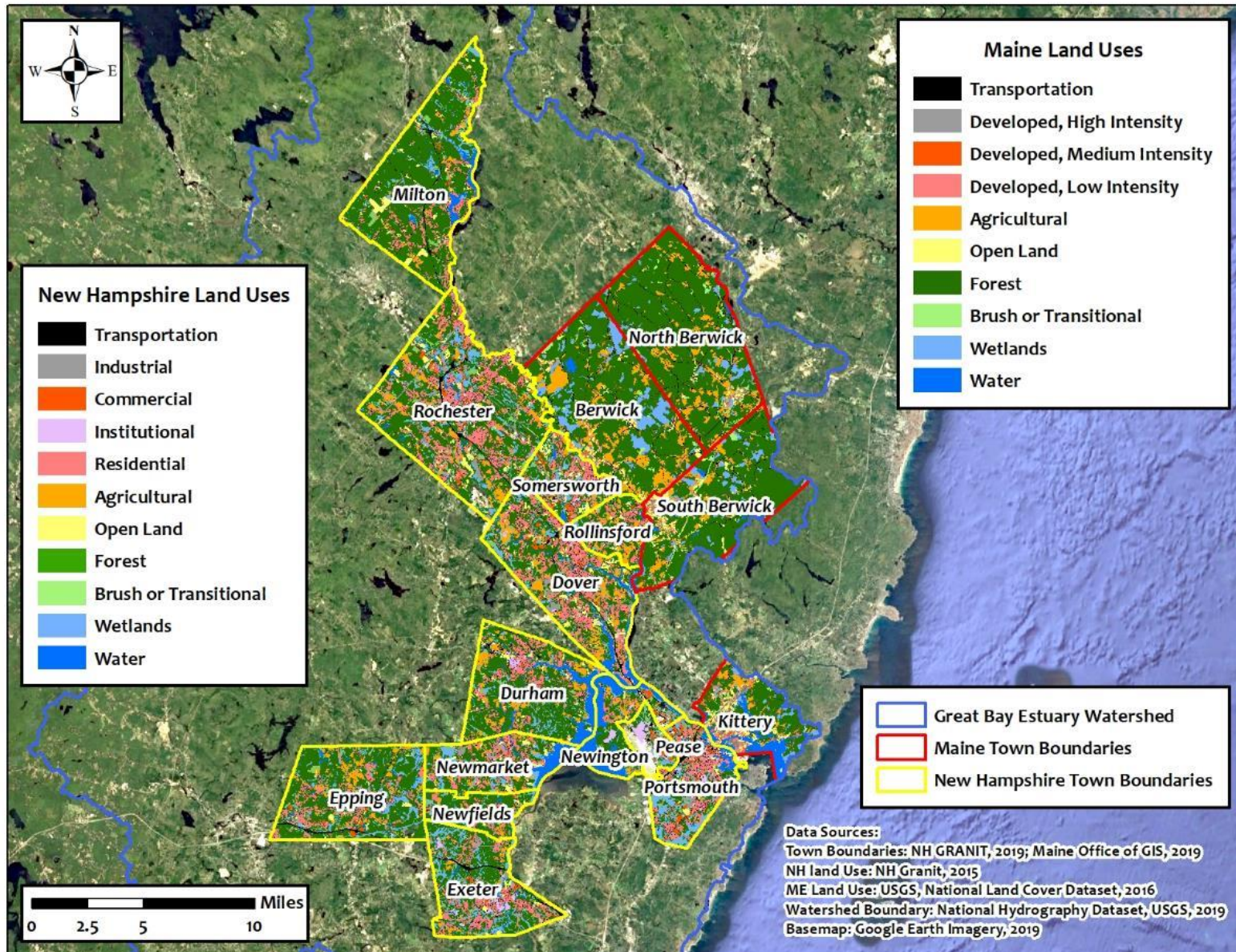
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<sup>23</sup> 2017 NH Small MS4 General Permit: Appendix H, Requirements Related to Discharges to Certain Water Quality Limited Waterbodies, I. Discharges to water quality limited waterbodies and their tributaries where nitrogen is the cause of the impairment, Part I, 1.b Nitrogen Source Identification Report

impossible to accomplish load reduction goals if implementation were limited strictly to the MS4 boundary.

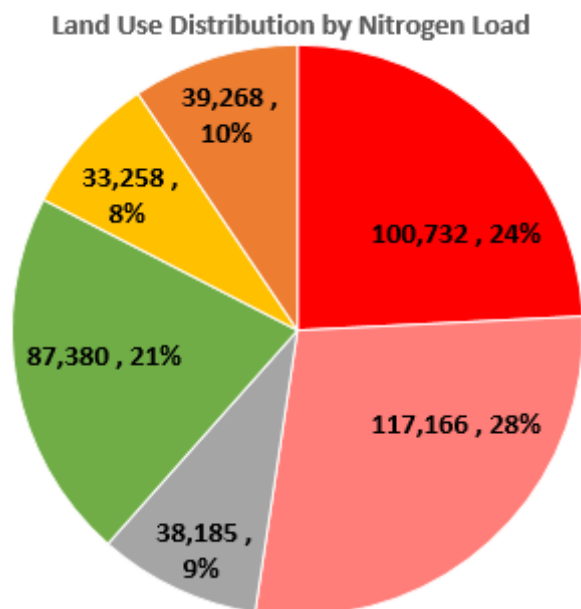
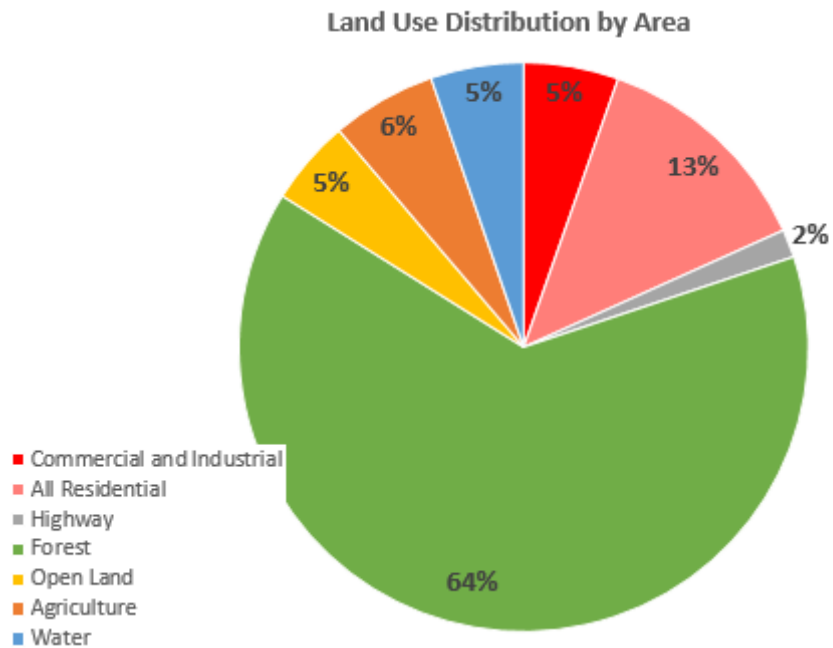
- In practice, municipal stormwater ordinances would be difficult to apply for areas in and out of the MS4 designation. More commonly, the stormwater ordinances are applied uniformly across a municipality and MS4 boundaries.





**Figure 4.1 - Land Use for 17 Communities with WWTF in the Great Bay Estuary Watershed**



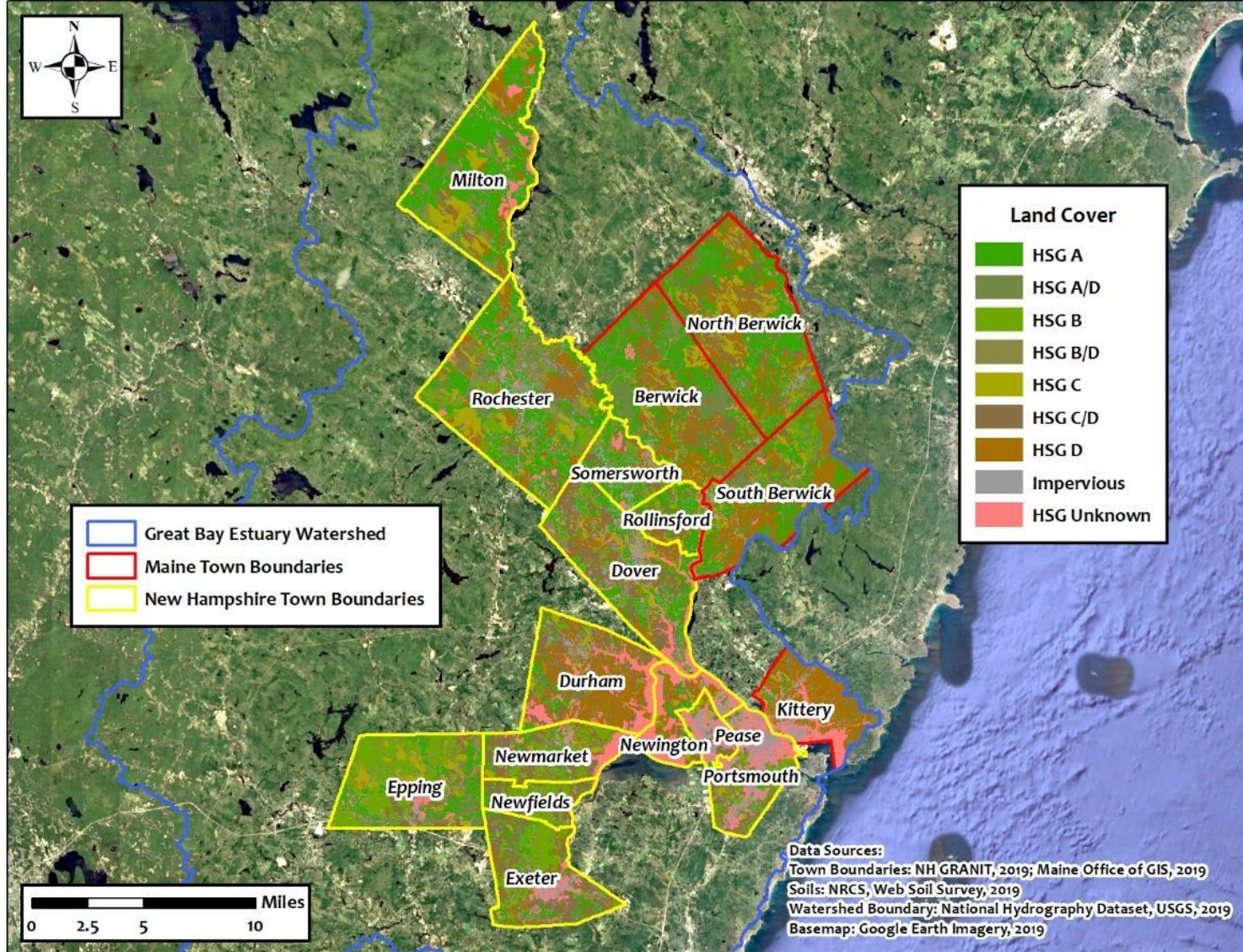


**Figure 4.2 - Land Use by Area (%) and Pollutant Load (N Lbs/Yr, %) of the 17 Communities**

**Table 4.1 –Land Cover Area (Acres) by Town for 17 Entities**

	Dover	Durham	Epping	Exeter	Milton	Newfields	Newington	Newmarket	Pease	Portsmouth	Rochester	Rollinsford	Somersworth	Berwick	Kittery	North Berwick	South Berwick
<b>Comm. and Indust.</b>	1,372	483	617	1,081	441	105	588	214	1,592	1,575	2,505	111	619	239	799	169	141
<b>All Resid.</b>	4,926	2,187	2,131	2,415	1,922	789	420	1,832	2	2,029	6,206	795	1,626	918	910	525	616
<b>Highway</b>	574	261	306	375	227	62	126	146	98	588	705	78	195	-	-	-	-
<b>Forest</b>	7,824	9,583	11,842	8,145	17,196	3,304	2,324	4,837	1,145	3,823	16,148	2,535	2,972	18,887	4,704	20,566	14,574
<b>Open Land</b>	993	462	443	199	817	53	77	377	188	239	1,371	147	619	1,730	928	1,438	1,327
<b>Agricult.</b>	1,439	1,332	1,100	355	349	241	426	648	7	79	1,637	1,021	181	2,211	338	1,587	1,037
<b>Water</b>	1,439	1,545	338	242	979	93	2,573	1,027	4	783	490	154	185	229	1,831	137	337
<b>Total</b>	18,567	15,852	16,776	12,813	21,931	4,647	6,534	9,080	3,036	9,116	29,062	4,841	6,397	24,214	9,510	24,423	18,032
<b>IC</b>	2,445	924	933	1,227	695	214	546	579	868	2,147	2,859	281	1,016	895	1,155	765	704
<b>%IC</b>	13%	6%	6%	10%	3%	5%	8%	6%	29%	24%	10%	6%	16%	4%	12%	3%	4%

IC= Impervious Cover



**Figure 4.3 - Land Cover (soils and impervious) in the Great Bay Estuary Watershed**

### 4.1.1.1. Modeling Stormwater Runoff and Nitrogen Load

A pollutant load analysis was conducted to determine the nitrogen load for each of the 16 communities. The volume and quality of stormwater runoff generated from each major land use within the study watershed was characterized by modeling hydrologic response units (HRUs). HRUs are idealized catchments, measuring one acre in size. They represent a land use cover, one of four hydrologic soil groups (HSG), and an imperviousness condition (either 100% impervious or 100% pervious). HRUs can be used as sub-elements to represent the various combinations of land use, land cover, imperviousness, and soil type within a watershed.

Each HRU was modeled in the EPA Stormwater Management Model (SWMM)<sup>24</sup> as a sub-catchment. Sub-catchments are defined as hydrologic units of land whose topography and drainage system elements direct surface runoff to a single discharge point. SWMM calculates estimated rates at which rainfall infiltrates the upper soil zone of a sub-catchment's pervious area.

Infiltration is estimated for each HRU using the curve number (CN) method. The CN Method is adopted from the Natural Resources Conservation Service (NRCS)<sup>(2001)</sup> and assumes that the total infiltration capacity of a soil can be found from the soil's tabulated CN. During a rain event, this capacity is depleted as a function of the cumulative rainfall and remaining capacity. The input parameters for this method are the CN and the time it takes a fully saturated soil to completely dry (used to compute the recovery of infiltration capacity during dry periods). Curve numbers were assigned to HRUs based on the soil type and impervious cover.

After the stormwater runoff volumes were determined by HRU analysis, we conducted a pollutant load analysis. This was accomplished using event mean concentrations (EMCs), or the flow weighted average concentration of a pollutant throughout a storm event. EMCs for nitrogen are available for a wide range of land uses. Pollutant load export rates (PLERs) are the mass of pollutant load that is expected to be produced by a specific land use and soil type combination for a given period of time. PLERs for nitrogen were developed in prior efforts and studies and published in the 2017 NH Small MS4 permit<sup>25</sup>, and are depicted in Table 4.2. A map of nitrogen load export rates (Figure 4.4) illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified. The urbanized areas can be observed to have the greatest nitrogen load and thus targeted for BMP retrofit.

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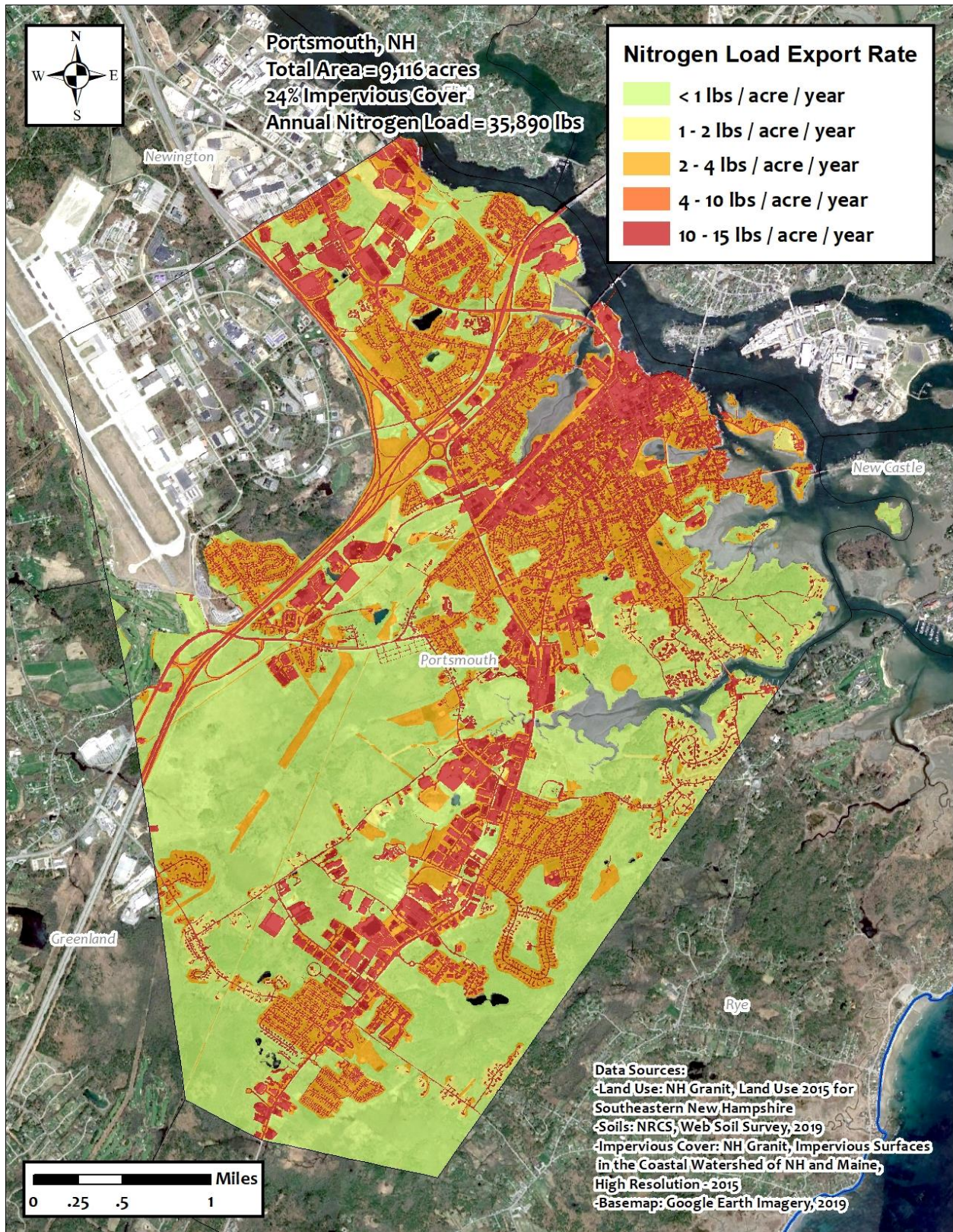
<sup>24</sup> EPA (2010b)

<sup>25</sup> EPA (2017). Appendix F: Requirements Of Approved Total Maximum Daily Loads, 2017 NH Small MS4. General Permits for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems. Boston, MA, Office of Ecosystem Protection, United States Environmental Protection Agency.

**Table 4.2 - Nitrogen Pollutant Load Export Rates from 2017 NH MS4 General Permit**

Land Use Category	Nitrogen Load Export Rate, lbs/acre/year
Commercial and Industrial (impervious)	15.0
All Residential (impervious)	14.1
Highway (impervious)	10.5
Forest (impervious)	11.3
Forest (pervious)	0.5
Open Land (impervious)	11.3
Agriculture (impervious)	11.3
Agriculture (pervious)	2.6
Developed-Pervious, HSG A	0.3
Developed-Pervious, HSG B	1.2
Developed-Pervious, HSG C	2.4
Developed-Pervious, HSG C/D	3.1
Developed-Pervious, HSG D	3.6





**Figure 4.4 – Example Map of Nitrogen Load Export Rates for Portsmouth**

**Table 4.3 –NPS Load by Town for 17 Entities**

	Dover	Durham	Epping	Exeter	Milton	Newfields	Newington	Newmarket	Portsmouth	Rochester	Rollinsford	Somersworth	Berwick	Kittery	North Berwick	South Berwick
Area (acres)	18,567	15,852	16,776	12,813	21,931	4,647	6,534	9,080	9,116	29,062	4,841	6,397	24,214	9,510	24,423	18,032
Impervious Area (acres)	2,445	924	933	1,227	695	214	546	579	2,147	2,859	281	1,016	895	1,155	765	704
% Impervious Cover	13%	6%	6%	10%	3%	5%	8%	6%	24%	10%	6%	16%	4%	12%	3%	4%
Surface Water Load (N lbs/year)	50,349	27,664	24,841	26,835	22,446	6,397	11,449	15,213	35,890	63,067	8,841	18,793	30,313	24,251	26,305	21,930
Atm. & SS Load (N lbs/year)	22,654	20,303	18,923	10,412	15,189	4,354	16,992	12,757	8,321	42,974	5,672	9,416	15,643	16,788	10,741	12,398
Total NPS Load (N lbs/year)	73,003	47,967	43,764	37,247	37,635	10,750	28,442	27,970	44,211	106,040	14,513	28,209	45,956	41,038	37,045	34,328
Per-Acre Load (N lbs/acre/year)	3.93	3.03	2.61	2.91	1.72	2.31	4.35	3.08	4.85	3.65	3.00	4.41	1.90	4.32	1.52	1.90
45% Reduction Target (N lbs/year)	32,603	23,553	17,024	14,909	13,307	3,970	12,346	11,000	21,616	42,151	7,142	10,721	23,502	16,361	15,512	16,237



### **4.1.1.2. Septic Systems**

For the purpose of this report, the amount of annual load derived from septic systems for each of the 17 communities was taken from the 2014 Great Bay nitrogen non-point source study (GBNNPSS). In this feasibility study, the nitrogen load from septic systems is factored as a component of the total nitrogen load budget. The process used to arrive at estimates of septic system loads is detailed in Appendix G of GBNNPSS. NHDES delineates regions that are serviced by municipal sewer systems based on direct information from regional municipalities and information in the USGS Water Demand Model for New Hampshire towns. The population outside these service areas, as determined by 2010 US Census block data, was assumed to use septic systems for waste disposal. The NHDES study used a per-capita excretion rate of 10.6 lb N per year was multiplied by the population using septic systems to calculate a nitrogen load to groundwater from said systems. Attenuation rates were then applied based on each septic system's location in relation to estuaries and large rivers (greater or less than 200-meters).

### **4.1.2. Agriculture and Its Role in Nitrogen Management**

Agriculture is not regulated under the national pollution discharge elimination permit (NPDES) program, which includes the MS4 and the draft TNGP. Agriculture presents a unique opportunity for collaboration at the watershed-scale. Implementation of agricultural stormwater best management could be done at a fraction of the cost of conventional stormwater management. Credit trading has great potential and has been discussed by resource managers for many years. Some of the greatest potential exists for the preservation of undeveloped areas and protection of riparian buffers to prevent future increases in nitrogen load.

Agriculture represents 6% of the land cover and 9.4% of the nitrogen load amongst the 16 communities in this study. Farmers and the agricultural community routinely employ agricultural best management practices to reduce nutrient loads. As population and corresponding development have increased in the region, the number of farms and the amount of actively farmed acres has decreased significantly. Data from the USDA census of agriculture indicate that the population of Rockingham County (which includes the communities of Portsmouth, Epping, Exeter, and Newmarket) increased 321% between 1954 and 2012. During that same time, the county witnessed a 75% reduction in farmland in Rockingham County (the southern portion of the watershed). Hay production decreased 77%; corn production decreased 70%; and orchards decreased 74%. The number of cattle and calves decreased 81%, and the number of chickens decreased by 99%. Over the same period, the number of horses in the region increased 285%, providing municipalities with an opportunity to engage horse owners and stable operators in a discussion about the need for proper manure management.

Hundreds of acres of land in the watershed are still actively farmed and support hay, grain, vegetable crops, and livestock. Keeping farms viable can prevent more sensitive land from being converted to development, which in turn places greater burdens on the GBE. Manure produced by livestock is generally spread on fields that are farmed for livestock feed. Farmers work to achieve a balance to match livestock feed demands with manure production and crop demand to minimize need for expensive chemical fertilizer. Communities in the Great Bay place a high



value on protecting the remaining farms, and residents see the agricultural character as part of the fabric of the community.

Prior studies<sup>39</sup> working in collaboration with local farmers and the Natural Resources Conservation Service (NRCS) documented best management practices applied to farmland, including the use of cover crops, vegetated and wooded buffers, slow release nitrogen on fields, the planting of alfalfa as a nitrogen fixer, and the development and implementation of Comprehensive Nutrient Management Plans (CNMP). Agricultural BMPs can generally be implemented at a fraction of the cost incurred by structural BMPs for nitrogen controls. The cost effectiveness of agricultural BMPs creates a unique opportunity for collaboration and credit trading.

Buffers are a well-known cost-effective way to protect water resources. The New Hampshire shoreland protection law and local zoning ordinances place strict requirements on what can be built (and how it will be built) in sensitive areas adjacent to wetlands and surface waters. In the instance of existing agricultural areas, this issue must be balanced with the pressure upon farms and the modest contribution of agriculture to the watershed nitrogen load. Some of the most productive farmland lies in valley bottoms closest to surface waters. Establishing and maintaining riparian or fenced buffers for grazing livestock is an important tool that will allow the continued farming of these productive areas while reducing water quality impacts. When developing new farmland, the protection of existing buffers from livestock should be one of the first nutrient management practices considered.

## **4.2. Nutrient Control Measures: Best Management Practices**

Best Management Practices (BMPs) are ways to reduce volume and improve quality of stormwater runoff from impervious surfaces (rooftops and parking lots), residential areas, commercial/industrial/institutional properties, roads, outdoor recreational spaces (e.g., parks), agricultural areas, and managed turf (e.g., golf courses, lawn). Structural BMPs are typically engineering-based systems constructed along with roadways and drainage networks, and include approaches such as bioretention, gravel wetlands, dry wells, and porous pavements. Non-structural BMPs, on the other hand, are typically planning- or maintenance-based strategies. While there are other types of Non-Structural Controls (NSCs), the methods considered in this study are street sweeping, leaf litter control, catch basin cleaning, septic system retrofits, and fertilizer reduction programs. These were chosen due to their inclusion in the 2017 MS4 or their successful usage elsewhere.

Common structural BMPs for nutrient controls include biofiltration (bioretention, raingardens, tree planters), gravel wetlands, infiltration practices (dry wells, and subsurface infiltration), and porous pavements. BMPs listed here for nutrient control will also be effective for removing sediment, mitigating flood risk, reducing runoff temperature and velocity for channel protection.

BMPs listed here represent one possible approach to nitrogen control planning in the regulated communities, but many other combinations may be possible and preferable. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

A wealth of technical information about BMPs exists in scientific literature and at the University of New Hampshire Stormwater Center (UNHSC). Semi-annual reports from the UNHSC provide

recent research updates on BMP research findings. The 2016 and 2020 reports provide information on BMP optimization for both filtration media and for system sizing. The use of anaerobic internal storage reservoirs (saturated sumps) within bioretention was shown to significantly improve the nitrogen removal (Roseen, 2013, Roseen and Stone, 2013). Details on specific BMPs can be found in the New Hampshire Stormwater Manual on the [NHDES website](#).

In this Feasibility Analysis, BMP optimization for nitrogen controls includes an evaluation of both structural and non-structural BMPs to determine which practices could be applied at the lowest unit cost. The BMPs considered in this analysis, along with their applicable land use types, are listed in Table 4.4, below. Not all BMPs are applied to each land use - for example, the non-structural BMP of leaf litter collection is limited to residential land uses because of the regulatory guidance from the 2017 MS4 and WDNR (2018). Individual BMPs are described in the following section.

### **4.2.1. Structural Best Management Practices**

There are a wide range of structural BMPs that can be used in municipal, commercial, industrial, and residential areas to manage runoff from rooftops, pavements, and other impervious and pervious surfaces. The present analysis used data for structural control BMP performance from the 2017 NH Small MS4 and the WISE project (Roseen et al 2015). BMP performance is typically a function of soil type and water quality volume (WQV) capture depth for each specific BMP. Common examples are dry wells, subsurface infiltration, gravel wetlands, porous pavements, tree planters, bioswales, bioretention, and raingardens. What follows is an account of possible structural BMPs that can be utilized in the Great Bay area:

Figure 4.5: residential rain garden used to manage both driveway and rooftop runoff. The driveway is sloped towards the rain garden and gutter downspouts are connected to a stone reservoir below.

Figure 4.6: tree planter installed as part of road reconstruction and sewer improvements. The tree planter combines a tree well and catchbasin with an engineered soil that provides a growing medium and water quality filter. The planter is designed to be low maintenance and suitable for winter operations. It can be cleared easily by snowplow, and sediment and debris can be cleaned by vactor truck. With the tree planter grate, the sidewalk area is usable for pedestrian travel. Tree planters, bioretention, and other forms of infiltration or biofiltration can be combined with streetscapes for added functionality.

Figure 4.7: grassed bioswale with pretreatment systems located in a commercial parking lot.

Figure 4.8: residential grassed bioswale with pretreatment located in the road right-of-way. These bioswale systems are designed to be low maintenance with pretreatment catchbasins for removal of trash and debris. They are grassed for simple mowing.

Figure 4.9: streetscape and tree planter that could easily be combined for stormwater management. The streetscape has a combination of pedestrian considerations, areas for local business to utilize sidewalks, and park benches, all of which could allow for use of some type of planter or infiltration below ground.

Figure 4.10: infiltration trench used for management of residential rooftop runoff. This low-cost approach is feasible for nearly all soil types: it can be sized up or down as needed with only a

modest cost impact (these infiltration trenches can generally be installed for less than \$2,000 per household).

Figure 4.11: large-scale commercial subsurface infiltration, combined with an isolator row for pretreatment. The isolator row is a wrapped chamber that prevents clogging of the stone bed. A subsurface infiltration system such as this, combined with a pretreatment design, could be used effectively for flood control and nutrient reduction.

**Table 4.4 –Structural and Non-Structural BMP by Land Use Types**

BMP Type	Residential	Commercial	Institutional	Road	Industrial	Outdoor	Agriculture
Rain Garden	x						
High Efficiency Bioretention	x	x	x		x	x	
Dry Well	x	x	x		x		
Permeable Pavement	x	x	x		x	x	
Bioretention		x	x	x	x	x	
Gravel Wetland		x	x	x	x	x	
Wet Pond		x	x	x	x		
Subsurface Infiltration		x	x		x	x	
Sand Filter		x	x		x	x	
Tree Box Filter		x	x			x	
Cover Crop							x
Slow Release Fertilizer							x
Septic Retrofit							
Street Sweeping	x	x	x	x	x		
Leaf Litter Removal	x						
Catch Basin Cleaning	x	x	x	x	x		
Urban Fertilizer Ban	x					x	



**Figure 4.5 – Residential Raingarden for Rooftop and Driveway Runoff**



**Figure 4.6 - Stormwater Tree Planter Combined with Catch Basin**





**Figure 4.7 – Commercial Parking Lot Bioretention with Pretreatment**



**Figure 4.8 – Residential Bioswale with Pretreatment**



**Figure 4.9: Streetscape with Street Trees Adaptable for Stormwater Management**

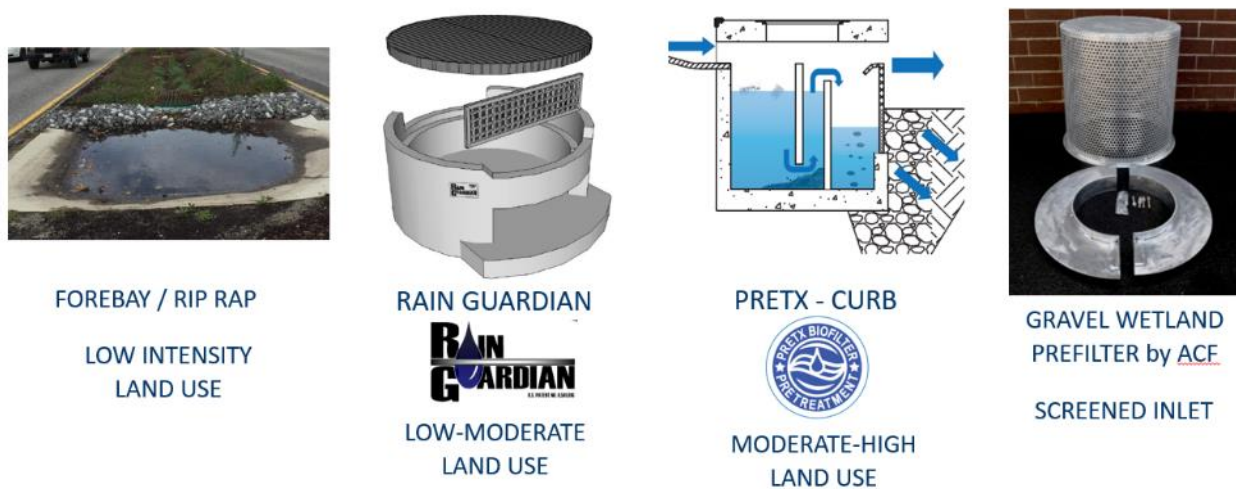


**Figure 4.10: Infiltration Trench for Residential Rooftop (left) and Downspout with Self-Cleaning Grate (right)**





**Figure 4.11: Subsurface Infiltration with Chambers and Pretreatment**



FOREBAY / RIP RAP  
LOW INTENSITY  
LAND USE

RAIN GUARDIAN  
**RAIN GUARDIAN**  
LOW-MODERATE  
LAND USE

PRETX - CURB  
**PRETX BIOFILTERS**  
PRETREATMENT  
MODERATE-HIGH  
LAND USE

GRAVEL WETLAND  
PREFILTER by ACF  
SCREENED INLET

**Figure 4.12: Biofilter Pretreatment Examples**

### 4.2.1.1. Low Maintenance Designs

Structural BMPs should be designed for low maintenance with an emphasis on pretreatment to reduce maintenance needs. The appropriate selection of pretreatment based on land use and anticipated trash and debris load can have a return on investment in 2 years. All medium and high intensity land uses (residential, commercial, and industrial) should include robust pretreatment to prevent more costly BMP maintenance. The maintenance goal should be to use existing staff and equipment for standard catch basin cleaning. A design focus on pretreatment should provide easy-to-maintain shallow sumps for collection of sediment and trash. Standard maintenance procedures using vector trucks require no specialty equipment or training. The absence of a pre-filter may allow trash and debris to prematurely clog the biofilter media or



infiltration bed. Trash and debris can require frequent maintenance for aesthetics in high loading land uses and reduce the infiltration rate of filtration media.

To ensure the effectiveness of BMPs, regular inspections and maintenance is necessary. Generally, inspection and maintenance falls into two categories: 1) expected routine maintenance and 2) non-routine (repair) maintenance. Routine maintenance is performed regularly to maintain both aesthetics and good working order. Routine inspection and maintenance help prevent potential nuisances (odors, mosquitoes, weeds, etc.), reduces the need for repair maintenance, and insures long-term performance.

Under MS4 rules, owners and operators are responsible for implementing BMP inspection and maintenance programs. Penalties are in place to deter infractions. The rules recommend that all stormwater BMPs should be inspected on a regular basis for continued effectiveness and structural integrity.

### 4.2.1.2. Example Costs of BMP Retrofits in the Great Bay Watershed

Cost estimates presented in this feasibility study are conservative. Tremendous cost reduction opportunities exist when BMP retrofits are phased with road and utility improvements, due to the shared costs of curbs, sidewalks, and paving.

Table 4.5 lists construction costs for two retrofit BMPs installed in 2019. These two systems were optimized for small storms and installed as part of a culvert replacement to provide treatment for about six acres of drainage area. These retrofits were relatively low cost, with an average cost of \$5,883 per acre treated. In comparison, a retrofit bioretention system designed to treat one acre of runoff might cost an estimated \$40,000. However, when paired with road improvements, the costs may be reduced to \$10,000, due to the shared costs of curbs, sidewalks, and roads. Of significant note, the unit cost for the bioswale (shown in Figure 4.13) was \$603 per pound of nitrogen. **In comparison, nitrogen removal in wastewater commonly costs between \$300-\$1,500 per pound of nitrogen removed, depending on the WWTF limit.**

**Table 4.5 –Example Costs of Bioswale and Tree Planter Retrofits for Nutrient Controls**

BMP Characteristics			BMP Performance		Cost		
BMP Type	Acres	System Size	TN Load Reduction (%)	TN Load Reduction (lbs)	Bid Cost (\$)	Unit Cost (\$/lb N)	Bid Cost per Acre of DA (\$)
Bioswale	4.53	0.25" WQV	76%	25.72	\$15,504	\$603	\$3,424
Tree Planter	1.68	0.75" WQV	95%	5.65	\$20,997	\$ 3,717	\$12,530
<b>Total</b>	<b>6.20</b>	-	<b>79%</b>	<b>31.37</b>	<b>\$36,501</b>	<b>\$ 1,164</b>	<b>\$5,883</b>



**Figure 4.13: Example Low-Cost Bioswale Retrofit Paired with Municipal Capital Improvement Project**

## **4.2.2. Non-Structural BMPs**

Non-structural controls (NSC) are institutional, educational, and other pollution-prevention practices designed to limit the amount of stormwater runoff or pollutants generated by a landscape. NSCs considered in this study are street sweeping, leaf litter control, catch basin cleaning, septic system retrofits, and fertilizer reduction programs. Other NSCs exist that could be similarly considered. Those included here were chosen due to their inclusion in the 2017 MS4 or their successful usage elsewhere.

NSC practices are often more economical than structural control measures, and they can also be implemented more rapidly. While structural control measures are an important component of any urban stormwater management plan, NSCs can greatly reduce the need for structural measures by decreasing the amount of runoff and nitrogen entering a stormwater system from source areas. NSCs, unlike some of the structural controls, typically include ongoing good-housekeeping programs such as street sweeping, catch basin cleaning, and leaf litter collection. Many of these efforts are already implemented to a lesser degree and would need to be expanded to meet EPA requirements as detailed in the MS4.

Programmatic considerations for non-structural control BMPs include resources for staffing, equipment, and verification needed to implement full scale programs as detailed below or in the 2017 MS4. The major non-structural controls are summarized below based on a review of significant programs in the Northeast. It is important to note that, in addition to providing nitrogen load reductions, many of the control measures discussed below also limit total runoff volume as well as phosphorus, total suspended solids (TSS), and bacteria.

### **4.2.2.1. Street Sweeping**

Nitrogen reduction performance associated with street sweeping varies depending upon whether a traditional mechanical broom sweeper is being deployed or communities employ a more advanced regenerative vacuum sweeper using water and suction along with sweeping. For this analysis, nitrogen reduction credit was based on the 2017 New Hampshire Small MS4 General Permit (Appendix F), which details expected reductions in nitrogen (up to 10%). A 2007 USGS study<sup>26</sup> evaluated the performance of three street-sweeper technologies (regenerative-air, vacuum-assisted, and mechanical-broom street sweepers) to help environmental managers meet the National Pollution Discharge Elimination System permit (NPDES) requirements. The authors found that the use of the regenerative-air and vacuum-assist sweepers resulted in the greatest total reductions in average basin street-dirt yield (the former resulted in a reduction of 76%; the latter, 63%). Use of the mechanical broom sweeper at high frequency resulted in an average reduction of 20%. However, in application, the regenerative-air, vacuum assist sweepers, and mechanical broom averaged removal efficiencies of 25 and 30, and 5 percent, respectively.

### **4.2.2.2. Leaf Litter Control**

Leaf litter control programs focus on removing leaves from urban areas before they enter the stormwater system. The 2017 New Hampshire Small MS4 General Permit (Appendix F) outlines a method for assigning nitrogen-removal credits for leaf litter control programs. Studies suggest that a significant amount of annual nitrogen loading from closed drainage systems comes from leaf litter during the fall season, and that leaf removal programs can reduce nitrogen concentrations in stormwater by up to 74%.<sup>27</sup> WDNR<sup>28</sup> guidance for municipalities describes timing and frequency for collection efforts occurring in fall.

### **4.2.2.3. Catch Basin Cleaning**

Expanding programs to clean debris and litter buildup in catch basins has been shown to be an effective means of reducing nitrogen in stormwater runoff. The 2017 New Hampshire Small MS4 General Permit (Appendix F) outlines a method for assigning nitrogen-removal credits for catch basin cleaning programs, with a 6% reduction in nitrogen loading for the contributing drainage area.

For this analysis, catchbasins were determined on a per town basis by a number of approaches. Specific considerations for each town are listed in Appendix A. Catch basin enumeration was

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<sup>26</sup> Selbig, W. R. and R. T. Bannerman (2007). Evaluation of street sweeping as a stormwater-quality-management tool in three residential basins in Madison, Wisconsin: Scientific Investigations Report, 2007–5156, U.S. Geological Survey: 103p.

<sup>27</sup> Selbig, W.R., 2016. Evaluation of leaf removal as a means to reduce nutrient concentrations and loads in urban stormwater. *Science of The Total Environment*, Volume 571, Pages 124-133, ISSN 0048-9697

<sup>28</sup> WDNR (2018). Interim Municipal Phosphorus Reduction Credit for Leaf Management Programs. Madison, WI, Bureau Of Watershed Management Program Guidance, Runoff Management Policy And Management Team, Storm Water Management Program, Wisconsin Department of Natural Resources.

based on reporting of actual numbers, or estimates based on population using the method employed by a 2017 EPA MS4 Costing Study.<sup>29</sup>

#### **4.2.2.4. Septic Systems Retrofits**

Advanced technologies for onsite wastewater treatment systems (OWTS) are an important strategy for nitrogen reduction. These systems typically include a septic tank with additional components that may disperse treated effluent to the soil and sometimes include with conventional soil absorption fields or alternative soil dispersal methods. Some systems promote water reuse, evaporation, or nutrient uptake by plants. Advanced OWTS have better performance than conventional technologies by using one or a combination of innovative designs, patented products, alternative materials, filtration processes, recirculation systems, pumps, or other electromechanical devices. The primary application for these technologies is at existing home sites on substandard lots with failing or otherwise inadequate OWTSs, and at other sensitive or difficult sites. EPA lists approved advanced systems by state<sup>30</sup>. Rhode Island has a robust program for review and approval of advanced OWTS<sup>31</sup>.

State sponsored septic system retrofit programs can be successfully implemented to offset homeowner costs in targeted areas, and are discussed in more detail in section 5.2 Septic System Retrofit Program.

For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation. It has been demonstrated to achieve 60% nitrogen load reduction from performance testing at the Massachusetts Septic System Test Center<sup>32</sup>. Cost to implement was based on sales figures from the vendor for a commercially available septic system retrofit for residential applications (see Appendix D for additional information). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems<sup>33</sup>.

#### **4.2.2.5. Urban Fertilizer Reduction**

A program for urban fertilizer reductions was evaluated as a means for nitrogen reduction. There are a number of methods for reducing runoff from urban fertilizer use, from state-level

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<sup>29</sup> EPA (2017). Stormwater Program Cost Evaluation for New Hampshire. Boston, MA, WaterVision, LLC.

<sup>30</sup> <https://www.epa.gov/septic/advanced-technology-onsite-treatment-wastewater-products-approved-state>

<sup>31</sup> Alternative or Experimental Onsite Wastewater Treatment System (OWTS) Technologies (2020). Rhode Island Department of Environmental Management.

<http://www.dem.ri.gov/programs/benviron/water/permits/isds/pdfs/ialist.pdf>

<sup>32</sup> MASSTC (2002). SludgeHammer Test Results. Buzzards Bay, MA, Massachusetts Advanced Septic System Test Center: 1.

<sup>33</sup> NHDES (2014). Appendix G: Methodology for Calculating the Number of People Using Onsite Septic Systems for Waste Disposal in the Piscataqua Region Watershed. Concord, NH, NH Department of Environmental Services.



legislation to local requirements for nutrient management planning. These programs have been shown to reduce pollutant loading from fertilized areas by up to 50%.<sup>34,35,36</sup>

In 2013, New Hampshire passed State Statute RSA: 431<sup>37</sup>, regulating the application and retail display of fertilizer intended for commercial and residential use. This act prohibits use of fertilizers with a total nitrogen content greater than 0.9lbs per 1,000 sq-ft, when applied according to the instructions on the label. Reducing urban fertilizer runoff can reduce stormwater nitrogen loads by up to 20% depending on the management actions taken, according to the Chesapeake Stormwater Network.<sup>36</sup>

This study determined that, rather than establishing different performance functions for fertilized areas of different soil types, a performance functions for C-type soils was assumed for all areas covered by this analysis. This was done because, in practice, there would be no feasible way to preferentially target specific soil types. Thus, a conservative generalized nitrogen loading rate for C-type soils was employed. Similarly, to determine the area of residential lawns, a generalized multiplier of 20% was used for residential areas, which represents the average ‘% lawn’ for medium density residential areas in the study area.

#### **4.2.2.6. Agriculture Strategies**

Agricultural BMPs are not included in the feasibility study because they are not regulated within the NPDES program. It is worth noting for informational purposes, however, that these BMPs present a unique opportunity for collaboration with farmers. Agricultural BMPs can be implemented at a fraction of the cost of structural controls for nitrogen control. As such, the market demand could exist for permittees to invest in agricultural BMPs for nutrient control. Nitrogen is one of the most important crop inputs; it is also one of the most complex. Two reasons for this are 1) because nitrogen is susceptible to environmental losses, and 2) its effectiveness is impacted by soil types and weather. Feasible and widely used agricultural BMPs identified by stakeholders include slow release fertilizer and the use of cover crops. Slow release fertilizer recommended by UNH Cooperative Extension contains at least 15% of the fertilizer to be of a reduced water solubility, which allows the gradual release and uptake of nitrogen and phosphorous. This, in turn, reduces excess nutrient washoff.  
([https://extension.unh.edu/resources/files/Resource000494\\_Rep516.pdf](https://extension.unh.edu/resources/files/Resource000494_Rep516.pdf))

Cover crops are one of the most valuable management practices available for protecting water quality, especially groundwater quality, from non-point sources of soluble nitrogen. Cover crops reduce soil erosion in several ways: they protect the soil surface from raindrop impact; increase water infiltration; trap and secure crop residues; improve soil aggregate stability; and provide a network of roots which protect soil from flowing water (USDA, 2013).

#### **4.2.2.7. Buffer Protection**

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<sup>34</sup>EPA, 2015. Appendix A, Lake Champlain BMP Scenario Tool, USEPA Region 1.

<sup>35</sup>EPA, 2016 Attachment 3 to MA Small MS4 Response to Comments.

<sup>36</sup> Chesapeake Stormwater Network, 2013. Urban Nutrient Management Expert Panel: Approved Final Report.

<sup>37</sup> <http://www.gencourt.state.nh.us/rsa/html/XL/431/431-mrg.htm>

Buffer protection was not included in this study because it is currently not credited within the National Pollution Discharge Elimination System (NPDES) or PTAP program. This is because it only represents a possibility of future development and nitrogen loading. Information is provided for this potential NSC strategy because buffers are well documented to provide important water quality protection and can be a low-cost approach that is worthy of consideration.

Buffers and riparian corridors are vegetated areas along a waterbody that serve to protect the waterbody from the effects of runoff by providing water quality filtering, bank stability, recharge, rate attenuation and volume reduction, and shading of the waterbody by vegetation (Audubon et.al, 1997). Riparian corridors also provide habitat and may include streambanks, wetlands, floodplains, and transitional areas. Riley et al (2015) examined the trends, science, and policy options of buffer management in the GBE, including maps towns in the watershed showing where buffers are likely to protect water quality, habitat, and flood storage. They recommend minimum buffer widths of 30 feet for temperature, 98 feet for water quality, 164 feet to reduce runoff volume and provide channel protection, and 330 feet for terrestrial habitat. Mayer et al (2007) did a meta-analysis of nutrient removal in riparian buffers and found that buffers of various vegetation types were equally effective at removing nitrogen. The authors also found that the wider the buffer, the greater the removal. They determined that the mean removal effectiveness associated with this technique was 68%, and the mean mass of nitrate removed per unit length was 0.394 mg/L per meter.

To minimize stormwater impacts, new and re-development projects should avoid affecting or encroaching upon areas with important natural stormwater functional values (floodplains, wetlands, riparian areas, drainage ways and buffers) and with stormwater impact sensitivities (steep slopes, adjoining properties, others) wherever practicable. Development should not occur in areas where sensitive resources exist so that their valuable natural functions are not lost and increasing stormwater impacts.



## 4.3. BMP Optimization for Nitrogen Removal

The 2017 NH Small MS4 Appendix H requirement for discharge to impaired waters details the requirement for BMP optimization<sup>38</sup>. *Part 2.3.6, Stormwater Management in New Development and Redevelopment*, requires BMPs be optimized for nitrogen removal; it also mandates a retrofit inventory and priority ranking to reduce nitrogen discharges. BMP optimization is the process of BMP selection and sizing based on lowest cost and highest performance (e.g., unit cost), which in turn is based on pollutant type, soils, land use, BMP performance and cost, and application constraints, such as the prohibition of certain BMPs for particular land uses. Optimization is especially valuable for retrofitting and redevelopment because optimized sizing of a BMP typically uses small sized BMPs that maximize available space. Optimization can occur at multiple scales. In its simplest sense, optimization is done at the BMP level by choosing the size of an individual system. At its most complex, it can be used at the watershed-scale to determine a menu of lowest-cost, highest-performance BMPs by type and size while factoring in multiple land uses, soils, performance, cost, and constraints.

For this study a BMP optimization analysis was performed using the results of the pollutant load and hydrologic considerations that are based on the municipal boundaries. This was done in order to assess the potential for mitigating nitrogen loading via structural and non-structural stormwater best management practices. The optimization analysis was conducted using a previously developed optimization model<sup>39</sup> developed in collaboration with and approved by EPA and NHDES. The model selects the most cost-effective management measures for a range of runoff reduction levels. Using a linear optimization analysis (LOA), the model runs repeatedly, changing the target volume reduction with each iteration. It evaluates the runoff control strategies based upon user defined constraints including available land for implementation, volume reduction capability based on capture depth of the BMP, and cost to implement the strategy. This model was applied at the municipal scale to identify the most cost-effective options for each particular land use. For this analysis, the optimization tool was focused on the study area described in previous sections for both the range of feasible runoff control measures and the range of land uses.

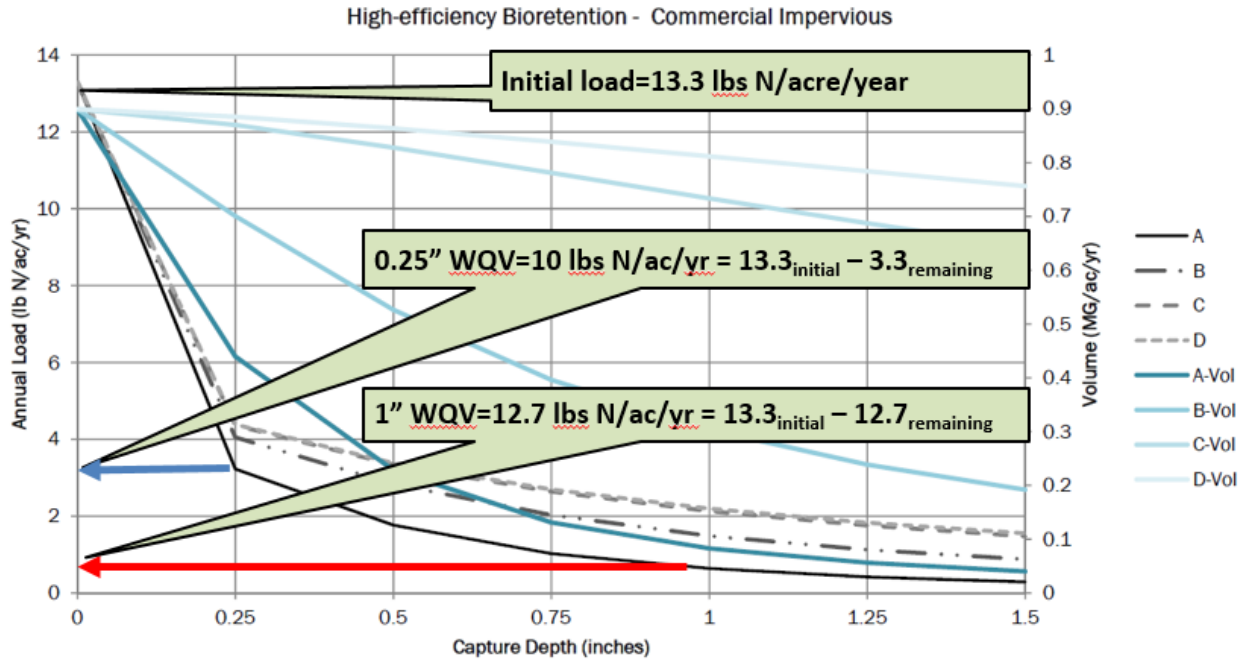
### 4.3.1. BMP-Scale Optimization

Example 1 and Figure 4.14, both included below, illustrate the process of BMP optimization by size by varying the capture depth of the water quality volume.

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<sup>38</sup> EPA (2017). Appendix H: Requirements Related to Discharges to Certain Water Quality Limited Waterbodies: Part I, 1.a Additional or Enhanced BMPs.i.2, Part 2.3.6, Stormwater Management in New Development and Redevelopment, 2017 NH Small MS4 General Permit. Boston, MA, Office of Ecosystem Protection, USEPA.

<sup>39</sup> Roseen, R., Watts, A., Bourdeau, R., Stacey, P., Sinnott, C., Walker, T., Thompson, D., Roberts, E., and Miller, S. (2015). Water Integration for Squamscott Exeter (WISE), Preliminary Integrated Plan, Final Technical Report. Portsmouth, NH, Geosyntec Consultants, University of New Hampshire, Rockingham Planning Commission, Great Bay National Estuarine Research Reserve, Consensus Building Institute.



**Figure 4.14 – BMP-Scale Optimization Example for Commercial Bioretention with Annual Exported Load and Volume based on Water Quality Volume (Aka Capture Depth)**

### Example 1: BMP Size Optimization for Bioretention at 0.25” and 1” Water Quality Volumes

From the BMP performance curve for a high-performance bioretention we can see that a single system treating a 1” water quality volume for one acre will remove approximately 12.7 lbs N/acre/year (=13.3 initial load – 0.6 remaining load). Four smaller systems across 4 acres designed to treat 0.25” water quality volume per acre will each remove 10 lbs N/acre/year (=13.3 initial load – 3.3 remaining load) for a total of 40 lbs N per year. For a type A soil, four systems designed to treat a 0.25” water quality volume in place of one system to treat a 1” water quality volume would remove an additional 27 lbs of Nitrogen per year at nearly equivalent costs, or approximately 315% greater optimization.

### 4.3.1. Land Use Scale Optimization

Example 2 and Figure 4.15 – Residential Land Use-Scale BMP Optimization Example illustrate how the optimization process occurs at a land-use scale.

#### Example 2: Land Use Scale BMP Optimization for a Range of Residential Nitrogen

Figure 4.15 – Residential Land Use-Scale BMP Optimization Example is an example of an optimization for a residential land use that shows the cost to achieve reduction in relation to the nitrogen management practices ordered in terms of cost efficiency. This process enables the identification of the point where cost effectiveness and pollutant reduction are at their greatest, and where the feasibility to implement cost effective and pollutant load reduction management practices begins to decline. In this example, 10,000

pounds of nitrogen can be reduced at a cost of about \$7 million dollars (\$700 per pound N reduced). In contrast, as cost efficiency begins to decline, removal of 12,500 pounds costs an estimated \$15 million dollars (\$1,200 per pound N reduced). When removal is increased to 15,000 pounds, the cost increases to nearly \$44 million (\$2,930 per pound N reduced). This process demonstrates the cost efficiency of low-cost rooftop infiltration and small BMPs sized to capture the first-flush for nitrogen, which results in the majority of pollutant mass being washed off from runoff in the beginning of a storm (0.25-0.5” WQV). Additional removal occurs at higher cost in more expensive systems.

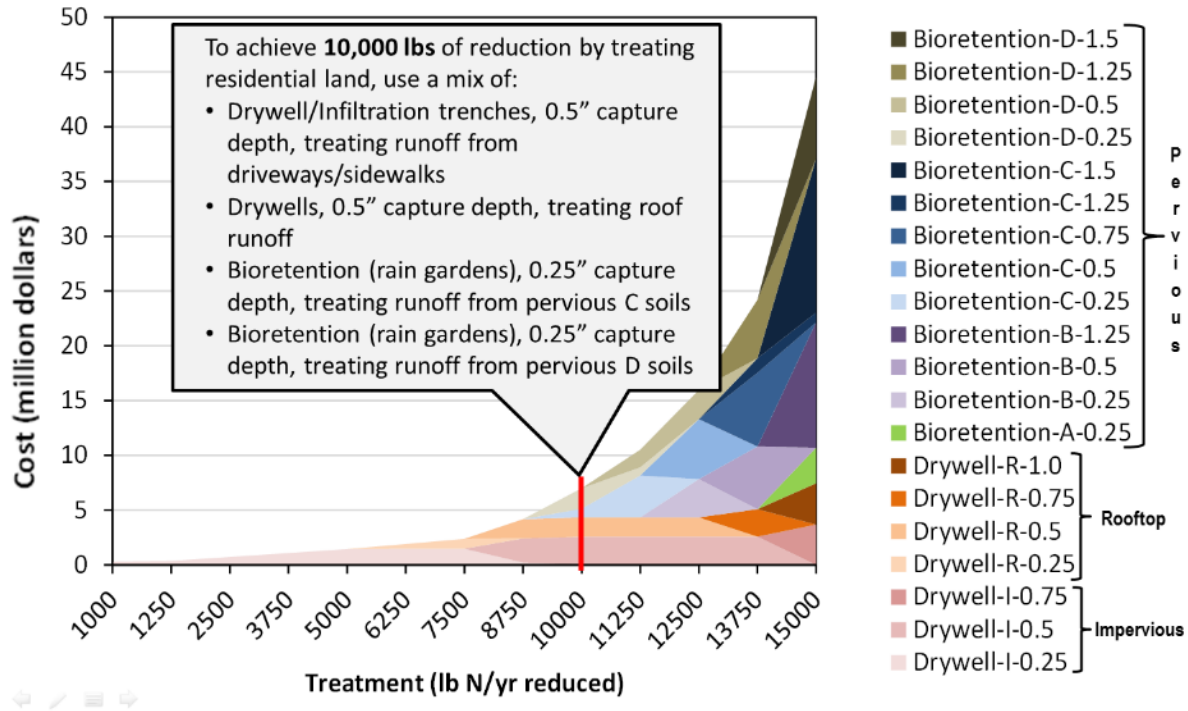


Figure 4.15 – Residential Land Use-Scale BMP Optimization Example

### 4.3.2. Optimization Model Setup

The Linear Optimization Analysis (LOA) model evaluates the runoff control strategies based upon user defined constraints, including available land for implementation, nitrogen load reduction capability based on capture depth of the BMP, and cost to implement the strategy. This section describes the model parameterization. The model examines water quality treatment of pollutants through settling, filtration, and biological activity, represented in the storage unit. Using a mathematical treatment expression that describes the changes in pollutant concentration at the storage unit, the treatment is modeled as a first-order decay process. This process estimates the concentration of pollutants removed by the BMP. Table 4.6 lists values and references for model inputs for each structural and non-structural control considered in this analysis. Where possible, information was drawn from analyses local to Great Bay. Structural control BMP

performance is from the 2017 NH Small MS4 and the WISE project (Roseen et al 2015). BMP performance is typically a function of soil type and capture depth for each specific BMP.

**Table 4.6 – BMP Model Parameterization**

BMP		Cost	Input Loads	BMP Performance and Output Loads	Groundwater Load	Max Land Use Areas
Structural Controls	Model Input	See Table 7	per-acre loads based on LULC as shown in Table 3	See BMP Performance Curves as a function of soil type and capture depth, % reductions applied to input loads; see Table 6	% of input load; see Table 6	Varies, see Table 4
	Source	WISE, 2015	2017 NH MS4 General Permit	2017 NH MS4, WISE, 2015	WISE, 2015	WISE, 2015
Septic	Model Input	\$4,000 per system	[10.6 lbs/person/yr] x [3 persons/system] = 31.8 lbs/system/year	60% reduction of input load	N/A	[population on septic] / 3
	Source	SludgeHammer Specs	GBNNPSS	SludgeHammer Specs	-	GNNPSS
Street Sweeping	Model Input	\$32 per acre	per-acre loads based on LULC as shown in Table 3	10% reduction of input load	N/A	impervious roadways
	Source	BIP, 2019	2017 NH MS4	BIP, 2019; 2017 NH MS4	-	BIP, 2019
Leaf Litter	Model Input	\$11 per acre	per-acre loads based on LULC as shown in Table 3	5% reduction	N/A	pervious Residential areas
	Source	BIP, 2019	2017 NH MS4	2017 NH MS4	-	WDNR, 2018 BIP, 2019
Catch Basin Cleaning	Model Input	\$320 per acre	per-acre loads based on LULC as shown in Table 3	6% reduction	N/A	Estimate varies by town; detailed in 'assumptions'
	Source	BIP, 2019	2017 NH MS4	BIP, 2019; 2017 NH MS4	-	BIP, 2019
Urban Fertilizer Control	Model Input	\$74 per acre	2.4 lbs-N/acre as per the 'Developed Pervious, HSG C' land use category shown in Table 3	9% reduction of input load	N/A	Residential lawns, golf courses, school fields, town rec. fields
	Source	BIP, 2019	2017 NH MS4	Chesapeake Stormwater Network, 2013	-	GBNNPSS

BMP performance data sources are detailed in Table 4.6. The summary range of BMP pollutant load reduction is shown in Table 4.7. This range varies as a function of BMP size and soil type and is detailed in the respective performance curves. ‘Output Load Range’ represents the percentage reduction of the influent nitrogen load for each BMP at discharge. Detailed load partitioning and BMP performance calculations are shown in Appendix A.

**Table 4.7 – Summary of BMP Nitrogen Load Reduction for Linear Optimization Analysis**

BMP	Removal Efficiency	Removal Efficiency	Output Load Range
	Low	High	
Bioretention	29%	91%	2-71%
Dry Well	72%	90%	0-20%
Gravel Wetland	75%	94%	6-25%
Bioretention-ISR	57%	95%	1-43%
Raingarden	42%	91%	2-58%
Permeable Pavement	87%	93%	1-4%
Sand Filter	19%	90%	4-81%
Subsurface Infiltration	13%	90%	0-87%
Tree Box Filter	21%	89%	5-79%
Wet Pond	32%	88%	12-68%

The cost to implement and maintain each structural control was characterized according to their estimated capital cost scaled to relative size by water quality volume. Sources for BMP capital costs information included local reports, compilations of studies from national literature, and professional judgement (EPA 1999; Narayanan, A. and R. Pitt, 2006; FB Environmental, 2009; Tetra Tech, 2009; UNHSC, 2012; Houle et al, 2013; CRWA, 2014; Geosyntec, 2014; and, Rosen, R. et al., 2015).

Capital cost data from these studies were normalized to represent the cost of treating the runoff from one acre of land (the standard size of an HRU) for a given capture depth (ranging from 0.25 – 1.5 inches). By normalizing the costs in this manner, the cost data was directly related to BMP performance as a function of capture depth.

Table 4.8 lists the range of per-acre capital costs for structural BMPs and non-structural BMPs that were used in this analysis.



**Table 4.8 - Modeled BMP Cost Parameters**

BMP	Size	Cost	Unit
Bioretention	0.25" – 1.5" WQV	\$11,400 - \$48,300	per acre
Raingarden	0.25" – 1.5" WQV	\$4,500 - \$18,000	per acre
Bioretention-ISR	0.25" – 1.5" WQV	\$12,255 - \$51,923	per acre
Tree Box Filter	0.25" – 1" WQV	\$11,800 - \$41,100	per acre
Dry Well	0.25" – 1.5" WQV	\$4,000 - \$20,000	per acre
Redev. Permeable Pavement	-	\$186,300	per acre
New Permeable Pavement	-	\$29,700	per acre
Gravel Wetland	0.25" – 1.5" WQV	\$5,900 - \$35,300	per acre
Wet Pond	0.25" – 1.5" WQV	\$5,500 - \$22,400	per acre
Infiltration Trench	0.25" – 1.5" WQV	\$4,000 - \$19,000	per acre
Subsurface Infiltration	0.25" – 1.5" WQV	\$18,500 - \$77,800	per acre
Sand Filter	0.25" – 1.5" WQV	\$30,000 - \$180,000	per acre
Septic SludgeHammer	-	\$4,000	per system
Street Sweeping	-	\$32	per acre
Leaf Litter Control	-	\$11	per acre
Catch Basin Cleaning	-	\$320	per acre
Urban Fertilizer Reduction	-	\$74	per acre

## 4.4. Nitrogen Control Planning

Nitrogen control planning was conducted for a target non-point source (NPS) load reduction of 45%, the reductions that will be required to meet the nitrogen load threshold in the TNGP. This was achieved through a process of stormwater best management practice (BMP) optimization at the community scale, based on the schedule listed in Table 4.9. Long-term control plans (LTCP) are required in 5-year intervals beginning in year 3. Plan elements are consistent with the MS4 and include:

- a. Nitrogen source identification and a baseline pollutant load analysis;
- b. BMP identification and optimization;
- c. Cost and financing mechanisms.

The analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). They are presented below. The analyses enable an assessment of cost effectiveness as a measure of unit cost (e.g. \$\$/lb of N removed). Optimization is especially valuable for retrofitting and redevelopment because optimized sizing of a BMP typically uses small BMPs that maximize available space. A scenario analysis examines two possible approaches to implement the TNGP.

Table 4.12 lists an example of BMPs optimized by cost for Dover. Appendix B provides detailed results for each of the 17 communities. A mix of structural and non-structural controls are used with an average unit cost of \$561/lb N. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands targeting about 7,500 acres. Non-structural controls are widely used targeting over 9,000 acres and are the most cost-effective management solution: they include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction at a unit cost of \$629/lb N.

Other BMP combinations are feasible and it may be that some communities will not want to consider certain BMPs due to concerns about program implementation, public acceptance, or otherwise. While most assumptions are that municipalities will cover all costs of permit compliance, much would be covered by the private sector by requiring improved stormwater management during new and re-development. The menu of BMPs shown in this analysis represent one low cost option of many.

Table 4.11 lists unit costs and total land use area possible within the 17 communities for structural and non-structural BMPs calculated as part of the optimization. These numbers would be expected to vary by land use and capture volume. Unit costs are a function of pollutant load export rates (PLER) and BMP capital cost. For example, leaf litter collection is more cost effective for areas with a Type D soil, simply because the cost to remove the leaves is the same; however, Type D soils export 3.6 lbs N/acre/year versus 0.3 for Type A soils.

Table 4.13 lists the nitrogen control plan summary by community including an account of total nitrogen reduction targets, load reduction (both in terms of percentage and total pounds), and cost. These figures are then further broken down to account for structural and non-structural BMPs. It's important to note that, in general, there can be some overlap between structural and non-structural BMPs. Appendix B includes complete details for each town of the optimization results by BMP type, land use, and capture depth. Results include the acreage treated and runoff volume managed for each BMP as well as a planning level cost analysis.

The analysis indicates that a target reduction of 45% and greater is attainable for the GBE as a whole, and feasible for 11 of the 13 NH communities. Durham and Rollinsford in NH, as well as Berwick, South Berwick, and North Berwick in Maine, can achieve 34% nitrogen reductions within optimized cost curves. Several communities can cost-effectively achieve greater than 45%, offsetting those that cannot (described in Section 4.4.1).

A feasibility target of \$1000/lb N/yr was chosen because it is less than a typical cost to remove nitrogen by wastewater treatment at 8 mg/L or below. At costs above \$1000/lb N/yr, it could be argued that treatment for nitrogen would be more economically achieved at the wastewater treatment facility. The total adjusted load reduction, including the lower total reduction of 34% in five communities, results in a 42% overall load reduction, or a 3% shortfall of 21,009 lbs N/yr. This could be addressed through a number of ways:

1. Keeping the existing draft load allocation (LA) and waste load allocation (WLA) and evaluating as part of the adaptive management process and ambient monitoring plan at 5-year LTCP reduction targets of 11%, 22%, 34% and 45%, respectively. The same rate of implementation could be held for all communities with the reassessment of total reduction needs at 34% for those 5 communities.
2. Increasing all reductions by an additional 8.6% of the target load for each community (rates of 48.6% and 36.7% respectively<sup>40</sup>) to achieve a total net reduction of 45% across the watershed (described in Section 4.4.1).
3. Establishing individual load reductions based on equivalent unit costs, rather than a uniform 45% load reduction (described in Section 4.4.1). This approach recognizes that in some instances greater load reduction can be accomplished at lower unit costs in areas with the highest pollutant loads. A unit cost of \$560/lb N for each community achieves a total net 45% load reduction with targets for individual communities ranging from 22-71% load reduction.
4. Adjusting reduction targets to account for changes in nitrogen sources beyond the permit scope. The draft TNGP has indicated that such an adjustment allows for continued declines in atmospheric deposition. A 24% decrease in atmospheric N was observed in the eastern US from 1990-2013 (Beachley et al, 2016).
5. Consideration of other nitrogen sources beyond the 17 communities and within the watershed. This option could include:
  - a. Likely new MS4 communities after the 2020 Census and existing MS4 communities with waivers not renewed.
  - b. The development of a credit-trading program to include nutrient control measures in unregulated communities (see Section 5.1).
  - c. Previously unregulated sources (new and existing) through residual designation authority (RDA) (see Section 5.2).

Table 4.10 lists the maximum achievable NPS load reduction by community.

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<sup>40</sup> Berwick would need to feasibly be 34% due to a maximum achievable reduction of 36%.

Table 4.13 illustrates ways in which costs for structural BMPs can be financially sustainable for communities, particularly where typical stormwater management is concerned. The chief reasons for the low cost structural BMPs are because of their limited use, the emphasis on small-sized systems (e.g., rain gardens), and the efficiency of rooftop infiltration (e.g., dry wells) and gravel wetlands on commercial and industrial areas with the highest nutrient loads. Perhaps not surprisingly, non-structural BMPs are the most cost-effective solution (they averaged \$282/lb N/yr.) Structural controls averaged \$557/ lb N/yr. The average unit cost of all BMPs was \$416/ lb N/yr. Septic system retrofits are one of the most significant BMPs identified in the optimization analysis at a cost of \$630/lb N/yr and have tremendous load reduction potential that account for nearly 40% of the entire NPS load reduction. The analysis suggests that new regulations to require advanced treatment on septic systems within certain setbacks, as well as a regional program to support septic system retrofits, could be very cost effective.

The five communities where it was either not possible or cost effective to achieve the 45% nitrogen reduction all are communities with significant rural areas. In the case of Durham and Rollinsford, it was technically possible to achieve 45% NPS load reduction, but not cost effective as measured by unit cost for structural BMPs (\$6,594 and \$2,693 lb N/yr respectively). At an implementation level of 34%, a total unit cost of \$701 and \$405 lb N/yr was possible. Three of the 4 communities in Maine (Berwick, South Berwick, and North Berwick) could not achieve 45% NPS reduction at any cost, however at 34% reduction, unit costs become feasible for Berwick (\$614), South Berwick (\$365), and North Berwick (\$322).

#### **4.4.1. Alternative Load Reduction Scenarios**

An analysis was conducted to assess the feasibility of alternative scenarios to achieve a total net reduction of 45% for the GBE. The analysis included the current TNGP proposed net total 45% load reduction and two additional scenarios to identify if some communities can feasibly achieve greater than 45%, offsetting those that cannot. Unit cost was examined as a measure of equivalent expense for each community.

**Scenario 1: 45% Load Reduction - TNGP.**

This scenario examined the currently proposed reduction of 45% for each community. The analysis shows an average unit costs of \$561/lb N and ranges from \$429-\$755/lb N. Because of the feasibility limitations for five communities only able to achieve 34% reduction, there is a net watershed reduction of 42%.

**Scenario 2: 45% Load Reduction – Marginal Increase.**

This scenario examined an increase of 8.6% for each community to achieve a net total 45% reduction, given the constraints in five communities. An equivalent amount of increased load reduction for each community resulted in the majority of communities with target reductions of 48.6%, and 36.9% for 4 of the 5, and 34% for a single. Scenario 2 has an average unit cost of \$606/lb N with a range of \$444-\$821/lb N.

**Scenario 3: 45% Load Reduction - Equivalent Unit Cost.**

This alternative examined a uniform unit cost for all communities to achieve 45% reduction. A unit cost of \$560/lb N for all communities resulted in a 45% reduction at the lowest average cost per household. Scenario 3 shows load reduction for individual communities ranging from 22-71% based on a unit cost of \$560/lb N for each community. Scenario 3 demonstrates that some communities can feasibly achieve greater than 45% and can sufficiently offset those that cannot to achieve an estuary-wide reduction of 45%.

Table 4.16 illustrates a comparison of the above three scenarios and shows the total cost, cost by community, and unit cost as an indication of feasibility. In general, high density communities can achieve reductions with greater cost-effectiveness simply because greater reductions can occur in areas with the highest pollutant load.

## 4.5. Cost and Financing Mechanisms

The TNGP schedule of four long-term control plans of five years each over a 20-year period was the basis for the cost analysis and financing mechanism. A range of implementation periods was examined to determine the yearly rate for treated acres and the estimated cost to implement. The cost in this instance is *total cost*: it does not differentiate between private and public sector, and it includes municipal costs. These figures are best considered conservative. With an extended implementation schedule, the four successive 5-yr LTCP periods would benefit from private sector redevelopment. It could be expected that, as redevelopment occurs, enhanced stormwater management will be required due to revised municipal stormwater regulations. The revised stormwater regulations require management of nitrogen for both new development and redevelopment, including municipal capital improvement projects that impact stormwater management. With this approach, the total cost of NPS management is covered by the land uses that generate stormwater runoff, which includes both the municipal and private sector. In many communities, up to 50% of the improvements could occur in the private sector. Municipally owned and managed areas with non-point source (NPS) contributions often include parks, schools, roads, municipal offices, police and fire, public works facilities, and impervious areas in the urban center. These NPS contributions are typically managed by the municipality.

Total costs are presented in Table 4.13 and range from a low of \$2.2 million for Newfields, \$3.1 for Rollinsford and \$5.2 for Somersworth, to a high of \$13.4 million for Berwick, \$17.5 for Dover, and \$22.3 for Rochester. It is important to note that the costs for Newington and Portsmouth include Pease International Tradeport, as per the Great Bay Nitrogen Non-Point Source Study (GBNPSS) PLA allocation. A total of 46% and 54% of Pease International Tradeport areas are allocated to Newington and Portsmouth respectively. Presumably those costs would be subtracted simply from Newington and Portsmouth based on the MS4 coverage boundaries.

Table 4.14 provides summary information by town for the amount of area to be treated by structural and non-structural BMPs (in acres) annually, and with implementation periods ranging from 15-25 years.

Table 4.15 presents the costs by town (in thousands of dollars per year) for the 15-25 years implementation periods. We determined that, for a 20-year implementation plan, structural BMP retrofits would be required to provide treatment ranging on the high end from total acreage of 67,



77, and 107 acres per year for Rochester, Portsmouth, and Dover to the low end range of five, 10, and 20 acres per year for Newfields, Rollinsford, and North Berwick. For context, consider the 2019 example cited in Section 4.2.1.2. This bioswale and tree filter, with a project cost of \$5,833 per acre for 6.2 acres of treatment, would satisfy the annual structural BMP requirements for Newfields at a cost of \$36,501. Alternatively, for Dover, approximately 17 equivalent installations would be required at an estimated cost of \$623,000.

### **4.5.1. Stormwater Utility Funding Analysis**

There are significant costs to design, build and maintain municipal stormwater management infrastructure, to prevent flooding and protect water quality. Stormwater utilities are a common mechanism used to generate a dedicated funding source to support a municipality's stormwater management program. The funding is provided via a stormwater user fee, which all developed properties within a municipality must pay. The program is analogous to drinking water or wastewater fee for service.

For this analysis, a stormwater utility (SWU) was examined as a financing mechanism to support a stormwater program over anticipated 15-25-year schedules. A stormwater management program is required under the 2017 NH Small MS4 permit; it typically includes personnel and services including stormwater system maintenance, capital improvement projects, permit compliance, erosion and sediment control, illicit discharge detection and elimination, engineering and design, stormwater system inventory and inspection, watershed assessments, and plan reviews. Many stormwater programs are funded by a stormwater utility. Typically, all developed properties are charged a fee proportional to the amount of runoff generated by the property, measured in terms of impervious cover, which is managed by the stormwater program. The stormwater utility revenue is dedicated solely to stormwater services. These funds can also be used to leverage state and federal grants available for stormwater projects.

As of 2012, approximately 1,500-2,000 U.S. communities were using stormwater utilities (Campbell 2012). Florida alone has 173 such utilities. Other states with a large number of SWU include Minnesota (129), Washington (110), and Wisconsin (103) (EPA 2013). As of 2012, ten such programs existed in New England. The average stormwater fee for a residential home was \$52 per year with a maximum of \$268 in Portland Oregon. (EPA 2013).

For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional. Table 4.17 presents the estimated annual fee for a stormwater utility as measured in ERUs. For a 20-year program, annual fees averaged \$91 with a high of \$198 (Milton) and a low of \$26 (Portsmouth). The majority of fees were between \$52 and \$135 per year, well within the national norm and consistent with a 2011 study for Portsmouth (AMEC 2011).

In contrast, Table 4.18, shows a comparison of the three scenarios discussed in section 4.4.1 and the basic elements of a stormwater utility: total cost to implement, yearly cost to implement, and annual residential stormwater fee (ERU). From this data, it can be seen that all three scenarios for stormwater programs range from \$145-\$168 million. Scenario 3, based on an equivalent unit cost, is the lowest average cost per household \$88/yr. Scenario 1 and 3 were \$91 and \$108 respectively. All three are well within the range of programs nationally.

As with calculations presented earlier in this assessment, these SWU costs are conservative, based on an assumption that they will be borne entirely by the municipality. However, in many communities, up to 50% of the improvements could occur in the private sector. The advantages of a 20-year program is that a community as a whole benefits from private sector redevelopment. Currently, many downtown areas are being redeveloped. Strong stormwater regulations required by the 2017 MS4 will ensure that the total cost of NPS management is covered by the land uses that generate stormwater runoff, both within the municipal and private sector. As a case in point, consider the town of Durham, which has mandated low impact development (LID) stormwater regulations consistent with the 2017 MS4 since 2010. As a result, this community has seen widespread usage of advanced stormwater management through private sector redevelopment in the downtown areas and in numerous significant developments in the outer watershed. These are costs that would otherwise have been incurred by the municipality or UNH. In contrast, Portsmouth has seen a tremendous amount of redevelopment and has arguably missed opportunities for private sector investment in green infrastructure for stormwater management, costs that will likely have to be borne by municipal budgets for retrofit programs.

#### **4.5.2. Guidance for Developing Implementation Schedules**

Implementation schedules are a requirement for the new MS4 and may be adjusted if a municipality can demonstrate an undue financial burden of the stormwater program. Typically, EPA provides guidance for development of implementation schedules as part of a financial capability analysis (FCA) (EPA 2014). An FCA is conducted to evaluate the impact on residential rate payers using indicators including household income, and existing rates and taxes. It also allows scheduling flexibility to accommodate the unique circumstances of a given community while advancing the goal of protecting clean water. EPA scheduling guidance is provided below for combined sewer long-term control plan development, Integrated Planning, and MS4 implementation:

- Wastewater and Long Term Control Plan (LTCP):FCA Analysis, “Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development” (FCA Guidance) (EPA 832-B-97-004).
- Integrated Planning -- FCA Framework 2014. Financial Capability Assessment Framework for Municipal Clean Water Act Requirements (EPA, 2014).
- MS4 implementation for New Hampshire currently does not indicate a specific implementation schedule. No minimum period for an implementation schedule for post construction stormwater management (Minimum Measure 5) is required. We have heard from EPA in the public forum that an extended period of time will be allowable.
- Similarly, EPA Headquarters, and Region 1 Leadership spoke at the September 2013 NACWA Integrated Planning Workshop in Portsmouth, NH. There, they indicated that extended implementation periods similar to CSO implementation are conceivable in the range of four or more permit cycle period.

## **4.6. BMP Identification, Retrofit Inventory, and Priority Ranking**

The TNGP and MS4 permits both require BMP identification as a component of an implementation plan following the source identification. BMP identification allows for the ranking and prioritizing of target areas to optimize implementation. For this study, BMP locations were identified by detailed hydrologic analysis of subwatershed and flow path delineation using high resolution topography from LiDAR data.

By overlaying sub-watersheds and flow paths with pollutant load export rates by land use, idealized locations were identified for BMP retrofits. Figure 4.16 is a sample subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. 22 possible BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. For example, catchment areas 18 and 19 would be ideal retrofit areas for prioritizing as they have both the greatest pollutant loads and the highest export rates. Sample analyses are provided in Appendix B for each community for BMP siting, ranking, and prioritizing.

**Table 4.9 – TNGP Nitrogen Control Plan Schedule and Reductions**

Plan	Due Date	Reduction Requirement	Start Year	End Year
Short-Term Control Plan	1 yr		1	3
Long-Term Control Plan-1	3 yrs	11%	3	8
Long-Term Control Plan-2	8 yrs	22%	8	13
Long-Term Control Plan-3	13 yrs	34%	13	18
Long-Term Control Plan-4	18 yrs	45%	18	23

**Table 4.10 - Maximum Achievable Nitrogen NPS Load Reduction for 17 Communities**

Town	Maximum Achievable Nitrogen Load Reduction
Berwick	36%
Dover	65%
Durham	45%
Epping	65%
Exeter	75%
Kittery	60%
Milton	60%
Newfields	70%
Newington	55%
Newmarket	65%
North Berwick	43%
Portsmouth	75%
Rochester	75%
Rollinsford	45%
Somersworth	75%
South Berwick	43%
Entire Area	65%

**Table 4.11 – Unit Costs from Optimization for Structural and Non-Structural BMPs**

Land Use, BMP Type, and Capture Depth	Potential Area (Acres)	Unit Cost (\$/lb N)
RESIDENTIAL IMPERVIOUS, RAINGARDEN, 0.25	3,635	\$633
RESIDENTIAL ROOF, DRY WELL, 0.25	2,526	\$396
COMMERCIAL IMPERVIOUS, GRAVEL WETLAND, 0.25	2,226	\$491
COMMERCIAL ROOF, DRY WELL, 0.25	556	\$337
INSTITUTIONAL I GRAVEL WETLAND, 0.25	838	\$498
INSTITUTIONAL ROOF, DRY WELL, 0.25	210	\$337
ROAD GRAVEL WETLAND, 0.25	3,613	\$746
INDUSTRIAL IMPERVIOUS, GRAVEL WETLAND, 0.25	1,305	\$491
INDUSTRIAL R DRY WELL, 0.25	702	\$337
OUTDOOR IMPERVIOUS, GRAVEL WETLAND, 0.25	978	\$693
SEPTIC RETROFIT*	19,385*	\$629
STREET_SWEEPING, RESIDENTIAL	536	\$23
STREET_SWEEPING, COMMERCIAL	396	\$21
STREET_SWEEPING, INDUSTRIAL	243	\$21
STREET_SWEEPING, HWY	3,613	\$30
LEAF LITTER, HSG-A	7,936	\$733
LEAF LITTER, HSG-B	3,920	\$183
LEAF LITTER, HSG-C	3,654	\$92
LEAF LITTER, HSG-D	8,580	\$61
CATCH_BASIN CLEANING RESIDENTIAL	11,699	\$378
URBAN_FERTILIZER_RESIDENTIAL	10,078	\$343
URBAN_FERTILIZER_GOLF	642	\$343
URBAN_FERTILIZER_SCHOOL	249	\$343
URBAN_FERTILIZER_PARK	122	\$343

\*Septic system retrofits are number of systems, not area treated



**Table 4.12 – Example BMP Optimization Menu for Dover to achieve 45% NPS Load Reduction**

	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		9,601.8	32,603.0	\$ 17,489,220	\$ 536
<b>Structural Controls</b>	<b>7,552.5</b>	2,136.6	20,126.1	\$ 10,579,206	\$ 496
<b>Non-Structural Controls</b>	<b>9,040.8</b>	9,040.8	12,476.9	\$ 6,910,014	\$ 316
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acres)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	627.91	627.9	4462.5	\$ 2,825,595	\$ 633
RESIDENTIAL R DRY WELLO.25	436.34	436.3	4402.9	\$ 1,745,360	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	270.43	270.4	3247.9	\$ 1,595,537	\$ 491
COMMERCIAL R DRY WELLO.25	67.61	67.6	803.3	\$ 270,440	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	105.63	105.6	1252.4	\$ 623,217	\$ 498
INSTITUTIONAL R DRY WELLO.25	26.41	26.4	313.8	\$ 105,640	\$ 337
ROAD I GRAVEL WETLAND0.25	567.35	346.9	2742.7	\$ 2,046,939	\$ 746
INDUSTRIAL I GRAVEL WETLAND0.25	136.92	136.9	1644.4	\$ 807,828	\$ 491
INDUSTRIAL R DRY WELLO.25	73.73	73.7	876.0	\$ 294,920	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	44.7	44.7	380.3	\$ 263,730	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	1,575.61	1575.6	10020.9	\$ 6,302,440	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	567.35	567.4	595.7	\$ 18,155	\$ 30
LEAF_LITTER_A LEAF_LITTER_A	1,543.08	1543.1	23.1	\$ 16,974	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	358.31	358.3	21.5	\$ 3,941	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	305.97	306.0	36.7	\$ 3,366	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	1654.26	1654.3	297.8	\$ 18,197	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	1310	1310.0	1108.3	\$ 419,200	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	1590.03	1590.0	343.4	\$ 117,662	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	86.84	86.8	18.8	\$ 6,426	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	31.4	31.4	6.8	\$ 2,324	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	17.96	18.0	3.9	\$ 1,329	\$ 343

**Table 4.13 – BMP Optimization Summary Results for Structural and Non-Structural Controls**

Town	Total Existing Load (lbs/yr)	TN Load Reduction Target (lbs/yr)	Total				Structural Controls				Non-Structural Controls				
			Treated Area (acres)	Load Reduction (%)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
Dover	72,451	32,603	9,602	45%	32,603	\$17,489,220	\$536	2,137	20,126	\$10,579,206	\$496	9,041	12,477	\$6,910,014	\$316
Durham	52,341	23,553	4,114	34%	17,796	\$11,932,150	\$670	1,133	9,298	\$7,006,407	\$978	4,170	8,498	\$4,925,743	\$313
Epping	37,831	17,024	2,894	45%	17,024	\$9,608,205	\$564	501	4,983	\$2,401,504	\$440	4,146	12,041	\$7,206,701	\$267
Exeter	33,130	14,909	6,047	45%	14,909	\$7,229,884	\$485	562	6,375	\$2,811,860	\$412	6,353	8,533	\$4,418,024	\$274
Milton	29,570	13,307	2,810	45%	13,307	\$7,654,894	\$575	459	4,195	\$2,174,328	\$496	3,695	9,111	\$5,480,565	\$310
Newfields	8,822	3,970	864	45%	3,970	\$2,237,924	\$564	105	1,074	\$488,678	\$440	1,192	2,896	\$1,749,246	\$257
Newington <sup>1</sup>	27,435	12,346	2,305	45%	12,346	\$6,476,901	\$525	960	10,239	\$5,392,634	\$887	1,572	2,107	\$1,084,267	\$313
Newmarket	24,445	11,000	3,287	45%	11,000	\$6,409,285	\$583	558	5,058	\$3,006,075	\$521	3,508	5,942	\$3,403,210	\$316
Pease	-	-													
Portsmouth <sup>1</sup>	48,035	21,616	7,262	45%	21,616	\$9,266,590	\$429	1,548	18,029	\$8,044,536	\$412	5,806	3,586	\$1,222,053	\$274
Rochester	93,668	42,151	8,946	45%	42,151	\$22,309,237	\$529	1,343	15,193	\$6,595,115	\$412	11,306	26,957	\$15,714,122	\$274
Rollinsford	15,871	7,142	1,271	34%	5,396	\$3,108,501	\$576	200	1,813	\$955,278	\$496	1,597	3,583	\$2,153,223	\$313
Somersworth	23,825	10,721	2,616	45%	10,721	\$5,252,508	\$490	538	6,137	\$2,698,084	\$412	2,658	4,585	\$2,554,424	\$274
Berwick	52,226	23,502	2,548	34%	17,757	\$13,412,688	\$755	1,090	7,319	\$7,136,596	\$995	3,010	10,437	\$6,276,092	\$264
Kittery	36,357	16,361	3,117	45%	16,361	\$8,374,193	\$512	968	10,248	\$5,215,570	\$518	2,888	6,113	\$3,158,623	\$257
North_Berwick	34,472	15,512	1,203	34%	11,720	\$6,820,648	\$582	395	3,746	\$2,026,556	\$483	1,986	7,975	\$4,794,092	\$209
South_Berwick	36,083	16,237	1,546	34%	12,268	\$7,276,758	\$593	453	4,229	\$2,443,448	\$518	2,288	8,039	\$4,833,310	\$270
<b>Total</b>	<b>626,562</b>	<b>281,953</b>	<b>60,430</b>	<b>42%</b>	<b>260,944</b>	<b>\$144,859,586</b>		<b>12,951</b>	<b>128,062</b>	<b>\$68,975,876</b>		<b>65,216</b>	<b>132,881</b>	<b>\$75,883,710</b>	

<sup>1</sup> Costs for Newington and Portsmouth include Pease as per GBNPSS allocation. 46% and 54% of Pease areas are allocated to Newington and Portsmouth respectively.

**Table 4.14 – Structural and Non-Structural BMPs Treated Areas (Acres/ Yr) for N-Load Reduction Targets for 15-25 Year Implementation Periods**

	Dover	Durham	Epping	Exeter	Milton	Newfields	Newing <sup>1</sup>	Newmark.	Portsmo. <sup>1</sup>	Rochester	Rollinsfo.	Somerswor.	Berwick	Kittery	North Berwick	South Berwick	
Cost in \$ Millions	\$17.49	\$11.93	\$9.61	\$7.23	\$7.65	\$2.24	\$6.48	\$6.41	\$9.27	\$22.31	\$8.39	\$5.25	\$13.41	\$8.37	\$6.82	\$7.28	
Percent Reduction	45%	34%	45%	45%	45%	45%	45%	45%	45%	45%	34%	45%	34%	45%	34%	34%	
Load Reduction Target (Lbs TN/Yr)	32,603	17,796	17,024	14,909	13,307	3,970	12,346	11,000	21,616	42,151	5,396	10,721	17,757	16,361	11,720	12,268	
Treated Area (Acres)	9,602	4,114	2,894	6,047	2,810	864	2,305	3,287	7,262	8,946	1,271	2,616	2,548	3,117	1,203	1,546	
<b>Structural BMPs - Yearly Rate of Area Treated (Acres/ Yr)</b>																	
Implementation Period (yrs)	15	142.4	75.5	33.4	37.4	30.6	7.0	64.0	37.2	103.2	89.5	13.3	35.9	72.7	64.5	26.3	30.2
	16	133.5	70.8	31.3	35.1	28.7	6.6	60.0	34.9	96.8	83.9	12.5	33.6	68.1	60.5	24.7	28.3
	17	125.7	66.6	29.5	33.0	27.0	6.2	56.5	32.8	91.1	79.0	11.8	31.7	64.1	56.9	23.2	26.7
	18	118.7	62.9	27.8	31.2	25.5	5.8	53.4	31.0	86.0	74.6	11.1	29.9	60.6	53.8	22.0	25.2
	19	112.5	59.6	26.4	29.6	24.2	5.5	50.6	29.4	81.5	70.7	10.5	28.3	57.4	50.9	20.8	23.9
	20	106.8	56.7	25.0	28.1	23.0	5.2	48.0	27.9	77.4	67.2	10.0	26.9	54.5	48.4	19.8	22.7
	21	101.7	54.0	23.9	26.7	21.9	5.0	45.7	26.6	73.7	64.0	9.5	25.6	51.9	46.1	18.8	21.6
	22	97.1	51.5	22.8	25.5	20.9	4.8	43.7	25.4	70.4	61.1	9.1	24.5	49.6	44.0	18.0	20.6
	23	92.9	49.3	21.8	24.4	20.0	4.6	41.8	24.3	67.3	58.4	8.7	23.4	47.4	42.1	17.2	19.7
	24	89.0	47.2	20.9	23.4	19.1	4.4	40.0	23.3	64.5	56.0	8.3	22.4	45.4	40.3	16.5	18.9
25	85.5	45.3	20.0	22.5	18.4	4.2	38.4	22.3	61.9	53.7	8.0	21.5	43.6	38.7	15.8	18.1	
<b>Non Structural BMPs - Yearly Rate of Area Treated (Acres/ Yr)</b>																	
Implementation Period (yrs)	15	602.7	278.0	276.4	423.5	246.4	79.5	104.8	233.9	387.1	753.8	106.5	177.2	200.6	192.5	132.4	152.5
	16	565.1	260.6	259.2	397.0	231.0	74.5	98.2	219.3	362.9	706.7	99.8	166.1	188.1	180.5	124.1	143.0
	17	531.8	245.3	243.9	373.7	217.4	70.1	92.5	206.4	341.5	665.1	93.9	156.4	177.0	169.9	116.8	134.6
	18	502.3	231.7	230.4	352.9	205.3	66.2	87.3	194.9	322.6	628.1	88.7	147.7	167.2	160.4	110.4	127.1
	19	475.8	219.5	218.2	334.4	194.5	62.7	82.7	184.6	305.6	595.1	84.1	139.9	158.4	152.0	104.5	120.4
	20	452.0	208.5	207.3	317.6	184.8	59.6	78.6	175.4	290.3	565.3	79.8	132.9	150.5	144.4	99.3	114.4
	21	430.5	198.6	197.4	302.5	176.0	56.8	74.9	167.1	276.5	538.4	76.0	126.6	143.3	137.5	94.6	108.9
	22	410.9	189.5	188.5	288.8	168.0	54.2	71.5	159.5	263.9	513.9	72.6	120.8	136.8	131.3	90.3	104.0
	23	393.1	181.3	180.3	276.2	160.7	51.8	68.3	152.5	252.4	491.6	69.4	115.6	130.8	125.5	86.4	99.5
	24	376.7	173.7	172.8	264.7	154.0	49.7	65.5	146.2	241.9	471.1	66.5	110.8	125.4	120.3	82.8	95.3
25	361.6	166.8	165.9	254.1	147.8	47.7	62.9	140.3	232.2	452.3	63.9	106.3	120.4	115.5	79.5	91.5	

<sup>1</sup> Costs for Newington and Portsmouth include Pease as per GBNPSS allocation. 46% and 54% of Pease areas are allocated to Newington and Portsmouth respectively

**Table 4.15 – Yearly Cost in \$1k to Implement N-Load Reduction Targets for 15-25 Year Implementation Periods**

	Dover	Durham	Epping	Exeter	Milton	Newfields	Newing.	Newmark.	Portsmo.	Rochester	Rollinsfo.	Somerswor.	Berwick	Kittery	North Berwick	South Berwick	
Cost in \$ Millions	\$17.49	\$11.93	\$9.61	\$7.23	\$7.65	\$2.24	\$6.48	\$6.41	\$9.27	\$22.31	\$8.39	\$5.25	\$13.41	\$8.37	\$6.82	\$7.28	
Percent Reduction	45%	34%	45%	45%	45%	45%	45%	45%	45%	45%	34%	45%	34%	45%	34%	34%	
Load Reduction Target (Lbs TN/Yr)	32,603	17,796	17,024	14,909	13,307	3,970	12,346	11,000	21,616	42,151	5,396	10,721	17,757	16,361	11,720	12,268	
Treated Area (Acres)	9,602	4,114	2,894	6,047	2,810	864	2,305	3,287	7,262	8,946	1,271	2,616	2,548	3,117	1,203	1,546	
	Yearly Cost in \$Thousands																
Implementation Period (yrs)	15	\$1,166	\$795	\$641	\$482	\$510	\$149	\$432	\$427	\$618	\$1,487	\$207	\$350	\$894	\$558	\$455	\$485
	16	\$1,093	\$746	\$601	\$452	\$478	\$140	\$405	\$401	\$579	\$1,394	\$194	\$328	\$838	\$523	\$426	\$455
	17	\$1,029	\$702	\$565	\$425	\$450	\$132	\$381	\$377	\$545	\$1,312	\$183	\$309	\$789	\$493	\$401	\$428
	18	\$972	\$663	\$534	\$402	\$425	\$124	\$360	\$356	\$515	\$1,239	\$173	\$292	\$745	\$465	\$379	\$404
	19	\$920	\$628	\$506	\$381	\$403	\$118	\$341	\$337	\$488	\$1,174	\$164	\$276	\$706	\$441	\$359	\$383
	20	\$874	\$597	\$480	\$361	\$383	\$112	\$324	\$320	\$463	\$1,115	\$155	\$263	\$671	\$419	\$341	\$364
	21	\$833	\$568	\$458	\$344	\$365	\$107	\$308	\$305	\$441	\$1,062	\$148	\$250	\$639	\$399	\$325	\$347
	22	\$795	\$542	\$437	\$329	\$348	\$102	\$294	\$291	\$421	\$1,014	\$141	\$239	\$610	\$381	\$310	\$331
	23	\$760	\$519	\$418	\$314	\$333	\$97	\$282	\$279	\$403	\$970	\$135	\$228	\$583	\$364	\$297	\$316
	24	\$729	\$497	\$400	\$301	\$319	\$93	\$270	\$267	\$386	\$930	\$130	\$219	\$559	\$349	\$284	\$303
25	\$700	\$477	\$384	\$289	\$306	\$90	\$259	\$256	\$371	\$892	\$124	\$210	\$537	\$335	\$273	\$291	

**Table 4.16 – Comparison of Program Costs and Performance for Three Scenarios: 1) 45% Load Reduction – TNGP, 2) 45% Load Reduction – Marginal Increase, 3) 45% Load Reduction - Equivalent Unit Cost**

Town	Total Existing Load (lbs/yr)	TN Load Reduction Target (lbs/yr)	@45% <sup>1</sup> Target				@48.9% <sup>2</sup> Target				@560 \$/lb			
			Load Reduction (%)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)	Load Reduction (%) <sup>3</sup>	Load Reduction (lbs) <sup>5</sup>	Cost (\$) <sup>6</sup>	Unit Cost (\$/lb) <sup>7</sup>	Load Reduction (%) <sup>2</sup>	Load Reduction (lbs) <sup>4</sup>	Cost (\$) <sup>5</sup>	Unit Cost (\$/lb) <sup>6</sup>
Dover	72,451	32,603	45%	32,603	\$17,489,220	\$ 536	48.9%	35,420	\$20,474,432	\$ 577	47%	34,261	\$19,246,532	\$ 560
Durham	52,341	23,553	34%	17,796	\$11,932,150	\$ 670	36.9%	19,333	\$15,957,965	\$ 821	29%	15,286	\$ 8,575,589	\$ 560
Epping	37,831	17,024	45%	17,024	\$ 9,608,205	\$ 564	48.9%	18,495	\$10,676,154	\$ 577	44%	16,555	\$ 9,268,046	\$ 560
Exeter	33,130	14,909	45%	14,909	\$ 7,229,884	\$ 485	48.9%	16,196	\$ 8,041,173	\$ 496	65%	21,509	\$12,050,360	\$ 560
Milton	29,570	13,307	45%	13,307	\$ 7,654,894	\$ 575	48.9%	14,456	\$ 8,571,048	\$ 593	38%	11,109	\$ 6,219,264	\$ 560
Newfields	8,822	3,970	45%	3,970	\$ 2,237,924	\$ 564	48.9%	4,313	\$ 2,470,832	\$ 573	44%	3,842	\$ 2,151,330	\$ 560
Newington	27,435	12,346	45%	12,346	\$ 6,476,901	\$ 525	48.9%	13,412	\$ 9,509,634	\$ 705	46%	12,557	\$ 7,078,455	\$ 560
Newmarket	24,445	11,000	45%	11,000	\$ 6,409,285	\$ 583	48.9%	11,951	\$ 8,310,388	\$ 693	43%	10,414	\$ 5,833,428	\$ 560
Portsmouth	48,035	21,616	45%	21,616	\$ 9,266,590	\$ 429	48.9%	23,483	\$10,441,079	\$ 444	70%	33,618	\$18,838,370	\$ 560
Rochester	93,668	42,151	45%	42,151	\$22,309,237	\$ 529	48.9%	45,792	\$24,601,514	\$ 537	59%	54,914	\$30,788,395	\$ 560
Rollinsford	15,871	7,142	34%	5,396	\$ 3,108,501	\$ 576	36.9%	5,862	\$ 3,587,102	\$ 610	29%	4,554	\$ 2,549,995	\$ 560
Somersworth	23,825	10,721	45%	10,721	\$ 5,252,508	\$ 490	48.9%	11,647	\$ 5,835,046	\$ 501	71%	16,854	\$ 9,454,515	\$ 560
Berwick	52,226	23,502	34%	17,757	\$13,412,688	\$ 755	34.0%	17,757	\$10,368,525	\$ 593	22%	11,693	\$ 6,554,236	\$ 560
Kittery	36,357	16,361	45%	16,361	\$ 8,374,193	\$ 512	48.9%	17,774	\$11,188,002	\$ 627	47%	16,957	\$ 9,561,928	\$ 560
North Berwick	34,472	15,512	34%	11,720	\$ 6,820,648	\$ 582	36.9%	12,733	\$ 8,150,083	\$ 637	26%	9,128	\$ 5,119,626	\$ 560
South Berwick	36,083	16,237	34%	12,268	\$ 7,276,758	\$ 593	36.9%	13,328	\$ 9,469,779	\$ 707	24%	8,700	\$ 4,870,975	\$ 560
<b>Total</b>	<b>626,562</b>	<b>281,953</b>	<b>42%</b>	<b>260,944</b>	<b>\$144,859,586</b>		<b>#REF!</b>	<b>281,953</b>	<b>\$167,652,756</b>		<b>45%</b>	<b>281,953</b>	<b>\$158,161,043</b>	
<b>Average</b>	<b>36,857</b>	<b>16,585</b>	<b>42%</b>	<b>16,309</b>	<b>\$ 9,053,724</b>	<b>\$ 561</b>	<b>45.0%</b>	<b>17,622</b>	<b>\$10,478,297</b>	<b>\$ 606</b>	<b>44%</b>	<b>17,622</b>	<b>\$ 9,885,065</b>	<b>\$ 560</b>
<b>Minimum</b>	<b>-</b>	<b>-</b>	<b>34%</b>	<b>3,970</b>	<b>\$ 2,237,924</b>	<b>\$ 429</b>	<b>34.0%</b>	<b>4,313</b>	<b>\$ 2,470,832</b>	<b>\$ 444</b>	<b>22%</b>	<b>3,842</b>	<b>\$ 2,151,330</b>	<b>\$ 560</b>
<b>Maximum</b>	<b>93,668</b>	<b>42,151</b>	<b>45%</b>	<b>42,151</b>	<b>\$22,309,237</b>	<b>\$ 755</b>	<b>48.9%</b>	<b>45,792</b>	<b>\$24,601,514</b>	<b>\$ 821</b>	<b>71%</b>	<b>54,914</b>	<b>\$30,788,395</b>	<b>\$ 560</b>

<sup>1</sup>45% Target is for 12 of 17 WWTFs, 5 at 34% totaling 42% load reduction; <sup>2</sup> 48.9% is a target increase to achieve 45% reduction overall



**Table 4.17 – Stormwater Utility Funding Annual Fee - Equivalent Residential Unit (ERU) \$\$/Yr at N-Load Reduction for 15-25 Year Implementation Periods**

	Dover	Durham	Epping	Exeter	Milton	Newfields	Newing. <sup>1</sup>	Newmark.	Portsmo. <sup>1</sup>	Rochester	Rollinsfo.	Somerswor.	Berwick	Kittery	North Berwick	South Berwick	
Total Cost in \$ Millions	\$17.49	\$11.93	\$9.61	\$7.23	\$7.65	\$2.24	\$6.48	\$6.41	\$9.27	\$22.31	\$8.39	\$5.25	\$13.41	\$8.37	\$6.82	\$7.28	
	Annual Fee - Equivalent Residential Unit (ERU) \$\$/Yr																
Implementation Period (yrs)	15	\$70	\$108	\$180	\$54	\$265	\$181	\$254	\$119	\$35	\$85	\$186	\$45	\$132	\$70	\$96	\$71
	16	\$65	\$101	\$169	\$50	\$249	\$170	\$238	\$111	\$33	\$80	\$174	\$42	\$124	\$65	\$90	\$66
	17	\$62	\$95	\$159	\$47	\$234	\$160	\$224	\$105	\$31	\$75	\$164	\$40	\$117	\$62	\$85	\$62
	18	\$58	\$90	\$150	\$45	\$221	\$151	\$212	\$99	\$29	\$71	\$155	\$38	\$110	\$58	\$80	\$59
	19	\$55	\$85	\$142	\$42	\$209	\$143	\$201	\$94	\$28	\$67	\$146	\$36	\$104	\$55	\$76	\$56
	20	\$52	\$81	\$135	\$40	\$199	\$136	\$191	\$89	\$26	\$64	\$139	\$34	\$99	\$52	\$72	\$53
	21	\$50	\$77	\$128	\$38	\$189	\$130	\$182	\$85	\$25	\$61	\$133	\$32	\$94	\$50	\$68	\$50
	22	\$48	\$74	\$123	\$37	\$181	\$124	\$173	\$81	\$24	\$58	\$126	\$31	\$90	\$48	\$65	\$48
	23	\$45	\$70	\$117	\$35	\$173	\$118	\$166	\$77	\$23	\$56	\$121	\$30	\$86	\$46	\$62	\$46
	24	\$44	\$67	\$112	\$34	\$166	\$113	\$159	\$74	\$22	\$53	\$116	\$28	\$83	\$44	\$60	\$44
25	\$42	\$65	\$108	\$32	\$159	\$109	\$153	\$71	\$21	\$51	\$111	\$27	\$79	\$42	\$57	\$42	
Est. # of Households	10,466	4,879	2,137	4,769	1,533	573	263	3,024	7,265	10,266	842	3,922	2,415	3,241	1,525	2,488	
% IC Residential	63%	66%	60%	53%	80%	70%	15%	84%	41%	59%	75%	51%	36%	41%	32%	36%	
%IC Comm/Ind/Inst	37%	34%	40%	47%	20%	30%	85%	16%	59%	41%	25%	49%	64%	59%	68%	64%	

<sup>1</sup> Costs for Newington and Portsmouth include Pease as per GBNPSS allocation. 46% and 54% of Pease areas are allocated to Newington and Portsmouth respectively

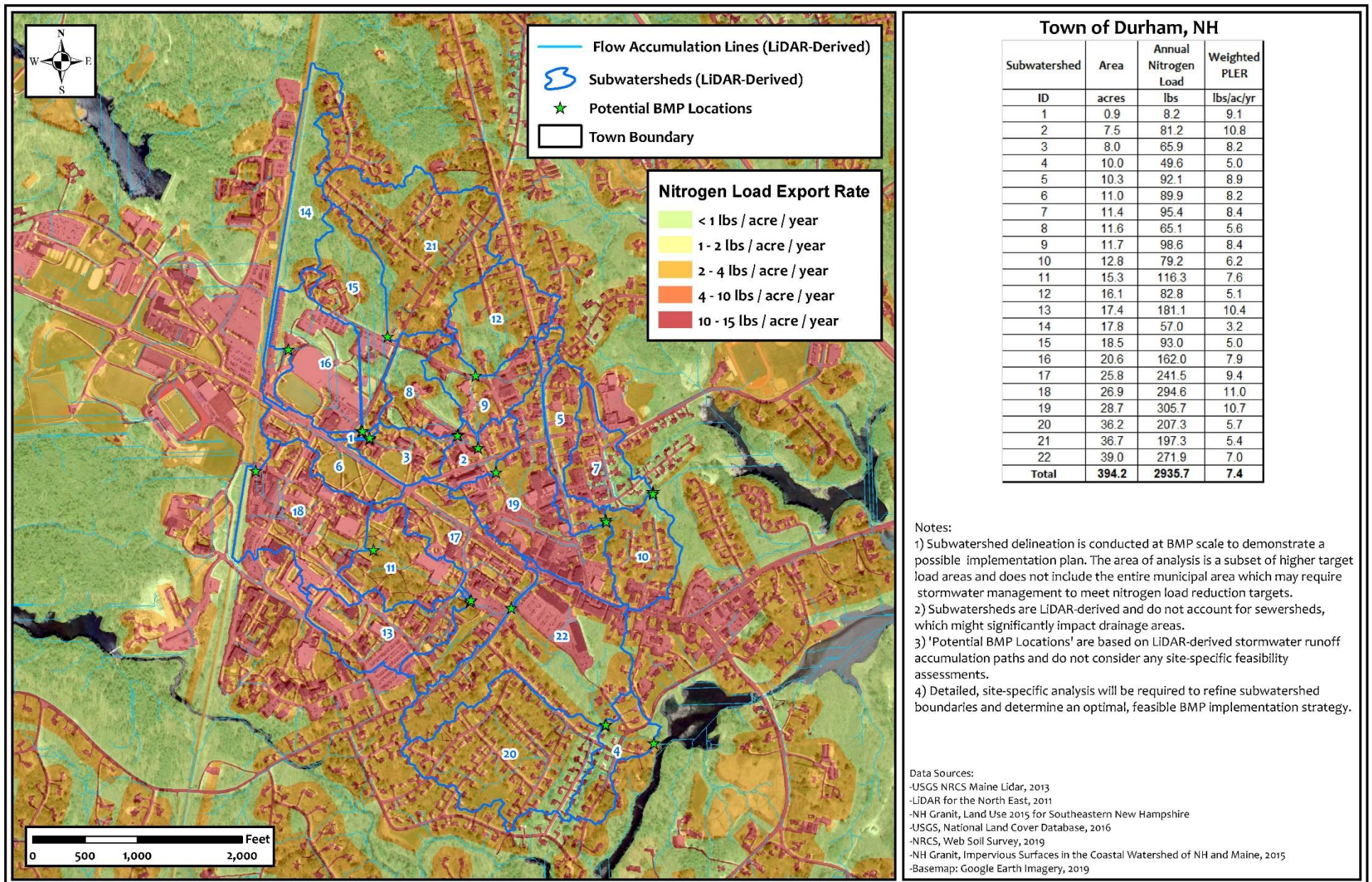
**Table 4.18 – Comparison of Stormwater Utility Program for Three Scenarios: 1) 45% Load Reduction – TNGP, 2) 45% Load Reduction – Marginal Increase, 3) 45% Load Reduction - Equivalent Unit Cost**

	Scenario	Dover	Durham	Epping	Exeter	Milton	Newfields	Newington <sup>1</sup>	Newmkt	Portsmouth <sup>1</sup>	Rochester	Rollinsford	Somerswth	Berwick	Kittery	North Berwick	South Berwick
Cost to Implement (\$ Millions)	45%	\$17.49	\$11.93	\$9.61	\$7.23	\$7.65	\$2.24	\$6.48	\$6.41	\$9.27	\$22.31	\$3.11	\$5.25	\$13.41	\$8.37	\$6.82	\$7.28
	48.6%	\$20.47	\$15.96	\$10.68	\$8.04	\$8.57	\$2.47	\$9.51	\$8.31	\$10.44	\$24.60	\$3.59	\$5.84	\$10.37	\$11.19	\$8.15	\$9.47
	\$560/lb N	\$19.25	\$8.58	\$9.27	\$12.05	\$6.22	\$2.15	\$7.08	\$5.83	\$18.84	\$30.79	\$2.55	\$9.45	\$6.55	\$9.56	\$5.12	\$4.87
Treated Area (Acres)	45%	9,602	4,114	2,894	6,047	2,810	864	2,305	3,287	7,262	8,946	1,271	2,616	2,548	3,117	1,203	1,546
	48.6%	9,773	4,755	3,479	6,088	2,941	966	2,774	3,452	7,262	9,013	1,329	2,616	1,411	3,523	1,562	1,839
	\$560/lb N	9,703	3,685	2,707	7,037	1,597	825	2,398	3,247	8,460	11,794	666	3,748	1,387	3,288	1,002	1,089
Yearly Cost to Implement (\$\$ Thousand)	45%	\$874.46	\$596.61	\$480.41	\$361.49	\$382.74	\$111.90	\$323.85	\$320.46	\$463.33	\$1,115.46	\$155.43	\$262.63	\$670.63	\$418.71	\$341.03	\$363.84
	48.6%	\$1,023.72	\$797.90	\$533.81	\$402.06	\$428.55	\$123.54	\$475.48	\$415.52	\$522.05	\$1,230.08	\$179.36	\$291.75	\$518.43	\$559.40	\$407.50	\$473.49
	\$560/lb N	\$962.33	\$428.78	\$463.40	\$602.52	\$310.96	\$107.57	\$353.92	\$291.67	\$941.92	\$1,539.42	\$127.50	\$472.73	\$327.71	\$478.10	\$255.98	\$243.55
SWU Annual Fee	45%	\$52	\$81	\$135	\$40	\$199	\$136	\$191	\$89	\$26	\$64	\$139	\$34	\$99	\$52	\$72	\$53
	48.6%	\$61	\$108	\$150	\$45	\$223	\$150	\$280	\$115	\$30	\$70	\$161	\$38	\$77	\$70	\$86	\$69
	\$560/lb N	\$58	\$58	\$130	\$67	\$162	\$131	\$208	\$81	\$54	\$88	\$114	\$61	\$48	\$60	\$54	\$35

<sup>1</sup> Costs for Newington and Portsmouth include Pease as per GBNPSS allocation. 46% and 54% of Pease areas are allocated to Newington and Portsmouth respectively

**Table 4.19 – Summary Comparison of Stormwater Utility Program for Three Scenarios**

	Scenario	Total	Min	25pct	Average	75pct	Max
Cost to Implement	45%	\$144,859,586	\$2,237,924	\$6,459,997	\$9,053,724	\$10,189,191	\$22,309,237
	48.6%	\$167,652,756	\$2,470,832	\$8,122,855	\$10,478,297	\$10,804,116	\$24,601,514
	\$560/lb N	\$158,161,043	\$2,151,330	\$5,654,977	\$9,885,065	\$10,184,036	\$30,788,395
Yearly Cost to Implement	45%		\$111,896	\$323,000	\$452,686	\$509,460	\$1,115,462
	48.6%		\$123,542	\$406,143	\$523,915	\$540,206	\$1,230,076
	\$560/lb N		\$107,566	\$282,749	\$494,253	\$509,202	\$1,539,420
SWU Annual Fee	45%		\$26	\$52	\$91	\$135	\$199
	48.6%		\$30	\$67	\$108	\$150	\$280
	\$560/lb N		\$35	\$57	\$88	\$118	\$208



**Figure 4.16: Sample Subwatershed Delineation and Potential BMP Siting Scheme**



## 5. FUTURE CONSIDERATIONS

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### 5.1. Credit Trading

Nitrogen credit trading<sup>39,41</sup> has great potential, and has been discussed by resource managers for many years. A market demand for trading could be developed as part of the total nitrogen general permit (TNGP) covering the entire Great Bay watershed. Upper watershed communities, often unregulated, have tremendous potential for the lowest-cost nutrient controls, such as agricultural BMPs and buffer protection. Likewise, the lower watershed communities (including the 12 in the TNGP) have a need for nutrient reduction. To this end, other successful watershed scale programs offer useful models for development. The 12 communities within the TNGP represent 35% of the land area within the Great Bay watershed. They offer many opportunities for nitrogen reduction outside of the existing NPDES program. Permittees could invest in agricultural BMPs, buffer protection, or other nutrient control activities elsewhere in the watershed at a fraction of the cost and potentially to greater effect. Some of the greatest potential for improvement exists for the preservation of undeveloped areas and protection of riparian buffers, which will prevent future nitrogen load increases in unregulated communities. Similarly, trading with farmers for the implementation of agricultural BMPs could be done at a fraction of the cost of conventional stormwater management.

In 2002, the Connecticut Department of Energy and Environmental Protection (DEEP) developed the successful Nitrogen Credit Exchange as one management strategy for the Long Island Sound Total Maximum Daily Load (TMDL). The innovative nitrogen-trading program includes 79 WWTF sewage treatment plants located throughout the state and by 2014 has reduced the WWTF load (the WLA) by nearly 65%.

Similarly, a watershed-based permit was successfully implemented in the Tualatin River Watershed in Oregon, where a single permit replaced numerous WWTF, industrial, and MS4 permits and included water quality credit trading. The permit enabled a focus on the most cost-effective management strategies in the watershed. Credit trading enabled planting of nearly ten miles of riparian buffers for shading at a fraction of the cost of conventional mechanical cooling, preventing 101 million kilocalories (Kcal) per day of thermal energy from impacting the Tualatin River. One of the primary benefits expressed by the permittees was the use of “sanitary user fees” outside the service areas to invest in more cost-effective natural solutions (stream plantings) without increasing fees (See Appendix C for credit trading fact sheet<sup>42</sup>).

For nitrogen trading to be effective (which is to say, for it to allow communities to meet permit requirements and broader water quality goals by drawing in unregulated sources), several

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<sup>41</sup> This section has been excerpted in part from prior reporting by the author and team as noted.

<sup>42</sup> EPA (2007). Watershed-Based Permitting Case Study: Tualatin River Watershed, Oregon, NPDES Program: 8.

guiding principles drawn from the EPA trading policy should be considered<sup>43</sup>. These principles stipulate that trading should:

1. Accomplish regulatory and environmental goals with optimum efficiency;
2. Be based on sound science;
3. Provide sufficient accountability for water quality improvements deliverables;
4. Refrain from producing localized water quality problems;
5. Remain consistent with the Clean Water Act regulatory framework.

The Water Environment Federation's *Advances in Water Quality Trading as a Flexible Compliance Tool* (Stacey, 2015) identified eight conditions essential for the successful point-to-point source trading program framework. Many of these conditions would exist as a result of the TNGP. They include the following:

1. All participating sources must contribute to a common water quality problem;
2. The pollutant reduction target (WLA) must be attainable;
3. Compelling member benefits from trading (especially economic benefits) must exist;
4. Pollution sources must be easily quantified and tracked;
5. Credit costs must be based on established and agreed upon protocols;
6. Credit costs among participating sources, which should be equalized by trading ratios if appropriate, must be diverse enough to create viable supply and demand conditions;
7. Overall implementation cost must be reduced;
8. Transaction, administrative, and operational costs (including monitoring and tracking) must be low, relative to credit prices.

## 5.2. Septic System Retrofit Program

The feasibility study identified septic system retrofits as a significant nitrogen reduction opportunity that could cost effectively reduce nearly 40% of the entire NPS load. For this to occur would likely require a state coordinated effort similar to other successful examples of septic system retrofit programs. The Florida Department of Environmental Protection operates an incentive program that offsets homeowner costs by providing up to \$10,000 after the installation of enhanced nitrogen-reducing features to existing septic systems located in targeted areas<sup>44</sup>. This is very similar to the retrofit scenario included in this feasibility study. New York offers a program to reimburse the property owner for up to 50% of the costs up to \$10,000<sup>45</sup>. For this

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<sup>43</sup> Willamette Partnership, The Freshwater Trust. 2014. Regional recommendations for the Pacific Northwest on water quality trading. USDA Conservation Innovation Grant Award to the Willamette Partnership, November 2012, for Multi-State Agency Guidance for Water Quality Trading: Joint Regional Water Quality Trading Agreement (69-3A75-12-255). Willamette Partnership, Portland, OR. 168 p.

<sup>44</sup> FLDEP (2020). Septic Upgrade Incentive Program, Florida Department of Environmental Protection. **2020**.

<sup>45</sup> EFC, N. (2020). Septic System Replacement Program, New York State Environmental Facilities Corporation. **2020**.



study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation. Appendix D includes a factsheet for the FLDEP program.

### 5.3. Residual Designation Authority

The Great Bay watershed as a whole has moderately low impervious cover and still retains tremendous potential for future growth and increasing nitrogen load in the upper watershed communities. Many of the coastal communities have experienced substantial growth during the past 50 years. Since 1960, some towns have experienced as much as 98% to 602% population growth and a 20-year increase of greater than 100% impervious cover. Many of these areas are outside of the MS4 program. The 12 communities within the draft TNGP represent 35% of the land area within the Great Bay watershed, with most areas outside of the existing NPDES program.

Under the Clean Water Act, “Residual Designation Authority” [found in § 402(p)(2)(E) of the Clean Water Act, and 40 C.F.R. § 122.26(a)(9)(i)(C) and (D)] EPA can require permits for new and existing stormwater discharges that either contribute to a water quality violation or are a significant contributor of pollutants to waters of the United States<sup>46</sup>. Residual Designation Authority (RDA) has been used to issue national pollution discharge (NPDES) permits to control unregulated discharges in addition to regulated discharges from wastewater treatment facilities and MS4 communities—to include requirements for pollutant reduction consistent with the wasteload allocations of a total maximum daily load (TMDL).

Total maximum daily loads typically set wasteload allocations (WLA), defined as the sum of the pollutant load discharged from all “discrete conveyances” contributing to the impairment (such as discharge pipes or ditches), and is regulated under a NPDES permit. Conversely, load allocation (LA), which is the sum of the remaining sources such as runoff, groundwater and atmospheric deposition that are more diffuse, is not subject to regulation under a NPDES permit. This division occasionally causes confusion, as certain classes of stormwater are regulated under the various stormwater permits (e.g., MS4, industrial stormwater, and construction stormwater) that were previously considered non-point sources. However, because the classes of stormwater come under a permit, they become part of the WLA. Nearly identical stormwater sources in non-MS4 areas are not regulated and remain in the LA and are not typically subject to an NPDES permit.

Since 2008, EPA Region 1 has exercised residual designation authority (RDA) in watersheds in Maine and Vermont where existing programs were not adequately addressing stormwater. In these instances, RDA was used to address sources of pollution not covered under existing NPDES programs such as communities outside of the MS4 jurisdiction, and large unregulated impervious areas such as malls and shopping centers.

Stormwater management programs are currently being implemented in impaired streams in South Burlington, Vermont, and in Long Creek, located near South Portland, Maine. These

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<sup>46</sup> EPA (2012). Fact Sheet For The General Permit For Designated Discharges In The Charles River Watershed In Milford, Bellingham And Franklin Massachusetts. [RD Fact Sheet](#), Office of Ecosystem Protection, U.S. Environmental Protection Agency, Region I, Boston, Massachusetts.

programs grew from residual designation determinations requiring stormwater controls on previously unregulated discharges. As such, they provide a third regional model for the designation and permitting of stormwater discharges to impaired waters, a significant environmental concern in New England. In these cases, the TMDLs address severe water quality impairments resulting from nutrients and bacteria in stormwater. At the time of the establishment of the TMDLs, NPDES stormwater permitting addressed only discharges from Municipal Separate Storm Sewer Systems (“MS4s”), limited industrial activity sectors, and construction activities disturbing one or more acres of land. In these cases, EPA has taken the position that the existing permitting regime is not sufficiently comprehensive to achieve the necessary cuts in WLAs; EPA has also indicated that new strategies are needed to implement the TMDL. Consequently in these instances, EPA has expanded the scope of its stormwater permitting program through the use of RDA by including large impervious areas, primarily in commercial and industrial use, to which are attributed significant pollutant loads.

EPA applies the designated discharge determination to cover discharges that flow directly into surface waters and their tributaries through MS4 systems or other private or public conveyance systems. Specifically, local, state and federal government properties that discharge wholly into an MS4 owned and operated by the government unit need not be included. Those discharges are already being addressed by the government unit under its MS4 permit. However, a nongovernment property that discharges into an MS4 system must be counted. In the instance of EPA’s proposed (but not implemented) draft RDA pilot in the Upper Charles River watershed, EPA defined “designated discharge” as those properties typically with a commercial land use designation with two or more acres of impervious surfaces located: (1) in the watershed; (2) in whole or in part in the municipalities; and (3) on a single lot or two or more contiguous lots.

## 6. CONCLUSION

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This feasibility study demonstrates that a 45% reduction in non-point source (NPS) loads in the Great Bay Estuary is feasible and can be accomplished over a 20-yr implementation period at costs well within national norms. Municipal funding with stormwater utilities could operate a 20-year program with fees ranging amongst communities from \$26 - \$198 per year per household, with an average annual cost of \$91. Smaller municipalities such as Newfields, Rollinsford and North Berwick would need to implement structural BMP retrofits to provide treatment of 5, 10 and 20 acres per year respectively, while larger municipalities such as Rochester, Portsmouth and Dover would need to retrofit treatment for 67, 77, and 107 acres per year over 20 years. If implemented widely, non-structural BMPs such as street sweeping, catch basin cleaning, and leaf litter collection, are the most cost-effective management approaches at an average unit cost of \$282/lb N/yr. Low-cost structural BMPs such as rain gardens, dry wells and gravel wetlands, with an average unit cost of \$557/ lb N/yr, can be small-sized and used widely and efficiently in areas with the highest nutrient loads. Septic system retrofits are a significant nitrogen reduction opportunity at an average cost of \$630/lb N/yr and could reduce nearly 40% of the entire NPS load. Some of the nitrogen control strategies identified in the study will need to be further developed to facilitate implementation such as state sponsored septic system retrofit programs, and municipal regulation of fertilizer use.

By looking at land use and modeled nutrient loads in each category, this analysis demonstrates how to optimize nitrogen reductions to select a variety of cost effective structural and non-structural means. It is important to underscore that this feasibility study is not a prescription for how to implement the optional pathway of the TNGP - it represents one scenario of many possible pathways. Ultimately communities will need to assess what combination of nutrient-reduction approaches will be most suitable and achievable.

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## **8. APPENDICES**

**Appendix A: Technical Methods Summary**

**Appendix B: BMP Siting, Ranking, and Prioritizing Results by Town**

**Appendix C: Credit Trading Fact Sheets**

**Appendix D: Septic System Retrofits**

# **APPENDIX A: MODELING METHODS SUMMARY**

**MODELING METHODS SUMMARY**

**FOR**

**FEASIBILITY ANALYSIS**

**FOR EPA'S DRAFT**

**GREAT BAY TOTAL NITROGEN GENERAL PERMIT**

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# 1. Methods

## 1.1. Land Use and Land Cover Assessment

Soils data<sup>1</sup> and impervious cover<sup>2</sup> data were overlaid to generate a land cover dataset for the entire Great Bay Estuary Watershed.

In order to perform the pollutant load analysis, detailed land use data from the 2016 National Land Cover Dataset and the 2015 New Hampshire Land Use dataset was generalized to fit into categories for which pollutant load export rates are available. A separate conversion was also performed to facilitate the linear optimization analysis which relates specific nutrient control measures to specific land uses. Table 1 and Table 2 list the detailed land uses and resultant categorization into more generalized land uses for Maine and New Hampshire. Figures 2 and 3 show the land use, impervious cover, and soil type distribution for the communities of interest within the Great Bay Estuary Watershed.

## 1.2. Connected Impervious Cover

This project does not differentiate between connected and disconnected impervious cover. That is a generalized PLER for a single

Detailed land use and land cover breakdowns by town are provided in the Appendix.

*Table 1 – Maine land use category generalization*

Land Use Category	Converted to...for PLA	Converted to...for LOA
Barren Land	Open Land	-
Cultivated Crops	Agriculture	Agriculture
Deciduous Forest	Forest	-
Developed, High Intensity	Commercial and Industrial	Commercial
Developed, Low Intensity	All Residential	Residential
Developed, Medium Intensity	Commercial and Industrial	Industrial
Developed, Open Space	Open Land	Outdoor
Emergent Herbaceous Wetlands	Forest	-
Evergreen Forest	Forest	-
Hay/Pasture	Agriculture	-
Herbaceous	Open Land	-
Mixed Forest	Forest	-
Open Water	Water	-
Shrub/Scrub	Forest	-
Woody Wetlands	Forest	-

<sup>1</sup> National Resources Conservation Service, Web Soil Survey, 2019

<sup>2</sup> Impervious Surfaces in the Coastal Watershed of NH and Maine, High Resolution – 2015, NH Granit

*Table 2 – New Hampshire land use category generalization*

<b>NH GRANIT Land Use Category</b>	<b>Converted to...for PLA</b>	<b>Converted to...for LOA</b>
Multi-family, medium to high rise	All Residential	Residential
Multi-family, low rise apartments	All Residential	Residential
Single family/duplex	All Residential	Residential
Mobile home parks	All Residential	Residential
Group and transient quarters	All Residential	Residential
Other residential	All Residential	Residential
Commercial retail	Commercial and Industrial	Commercial
Commercial wholesale	Commercial and Industrial	Commercial
Services	Commercial and Industrial	Commercial
Lodging	Commercial and Industrial	Commercial
Government	Commercial and Industrial	Institutional
Institutional	Commercial and Industrial	Institutional
Educational	Commercial and Industrial	Institutional
Indoor cultural/public assembly	Commercial and Industrial	Institutional
Other commercial, services, and institutional	Commercial and Industrial	Commercial
Industrial	Commercial and Industrial	Industrial
Mining	Commercial and Industrial	Industrial
Air transportation	Commercial and Industrial	Industrial
Rail transportation	Commercial and Industrial	Industrial
Water transportation	Commercial and Industrial	Industrial
Limited & controlled highway right-of-way	Highway	Road
Road right-of-way	Highway	Road
Park & ride lot	Commercial and Industrial	Commercial
Parking structure/lot	Commercial and Industrial	Commercial
Auxiliary transportation	Commercial and Industrial	Commercial
Other road transportation	Highway	Road
Communication	Commercial and Industrial	Industrial
Electric, gas and other utilities	Commercial and Industrial	Industrial
Water and wastewater utilities	Commercial and Industrial	Industrial
Solid waste utilities	Commercial and Industrial	Industrial
Other transportation, communications, and utilities	Commercial and Industrial	Industrial
Industrial park	Commercial and Industrial	Industrial
Office park	Commercial and Industrial	Commercial
Shopping mall	Commercial and Industrial	Commercial
Other industrial complexes	Commercial and Industrial	Industrial
Other commercial complexes	Commercial and Industrial	Commercial
Multiple stories, residential in upper stories only	Commercial and Industrial	Commercial
Other mixed uses	Commercial and Industrial	Commercial
Outdoor cultural	Open Land	Outdoor
Outdoor public assembly	Open Land	Outdoor
Outdoor recreation	Open Land	Outdoor
Cemeteries	Open Land	Outdoor
Maintained Open Areas	Open Land	Outdoor
Other outdoor and other urban or built-up land	Commercial and Industrial	Outdoor
Vacant Land	Open Land	-
Agricultural Land	Agriculture	Agriculture
Other Agricultural Land	Agriculture	Agriculture
Brush or Transitional Between Open and Forested	Forest	-
Forest Land	Forest	-
Water	Water	-
Wetlands	Forest	-
Beaches and River Banks	Open Land	-
Sandy Areas (non-beaches)	Open Land	-
Bare/Exposed Rock	Open Land	-
Strip Mine/Quarry or Gravel Pit	Commercial and Industrial	Industrial
Disturbed Land	Open Land	-
Other Barren Lands	Open Land	-



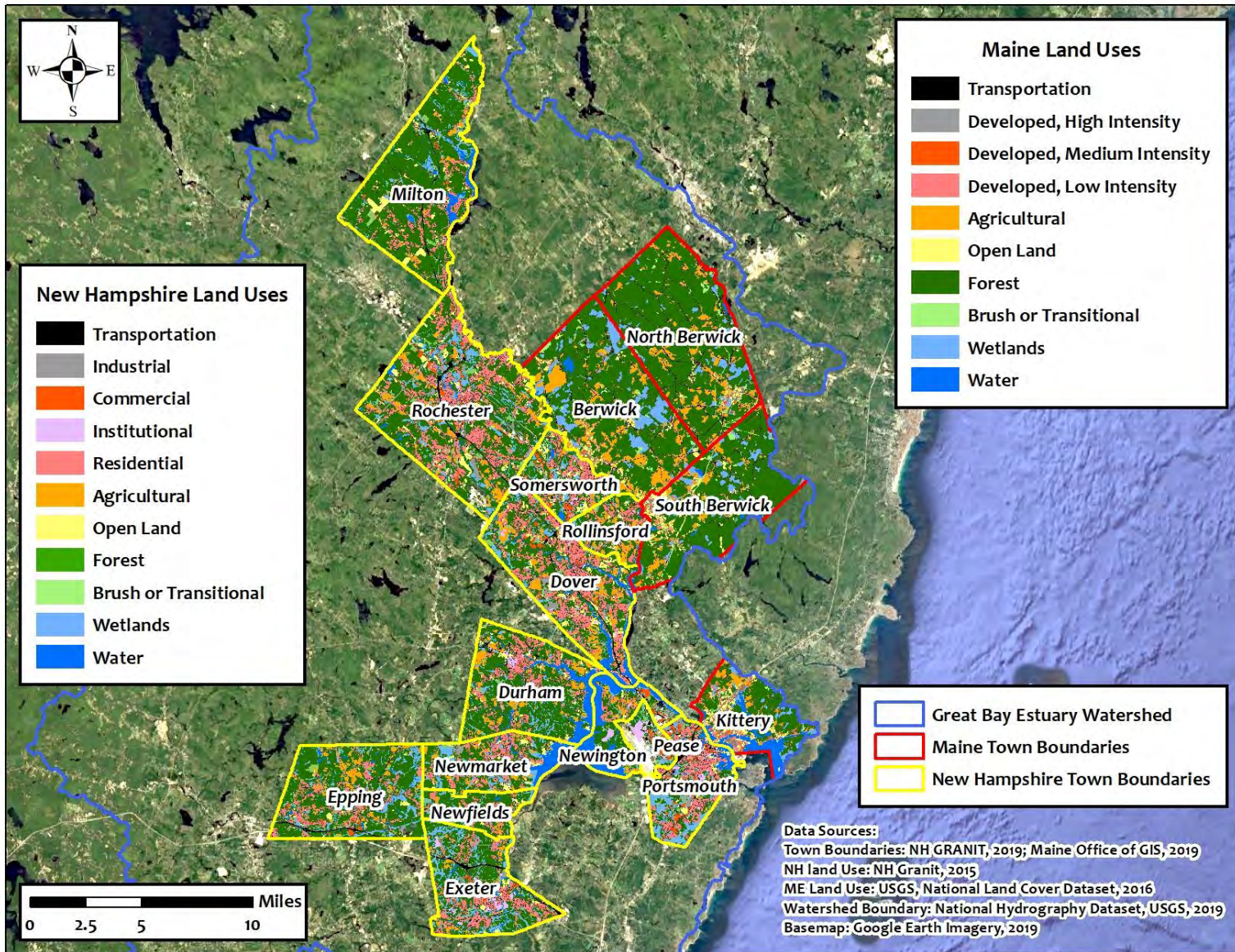


Figure 1 - Land Use in the Great Bay Estuary Watershed



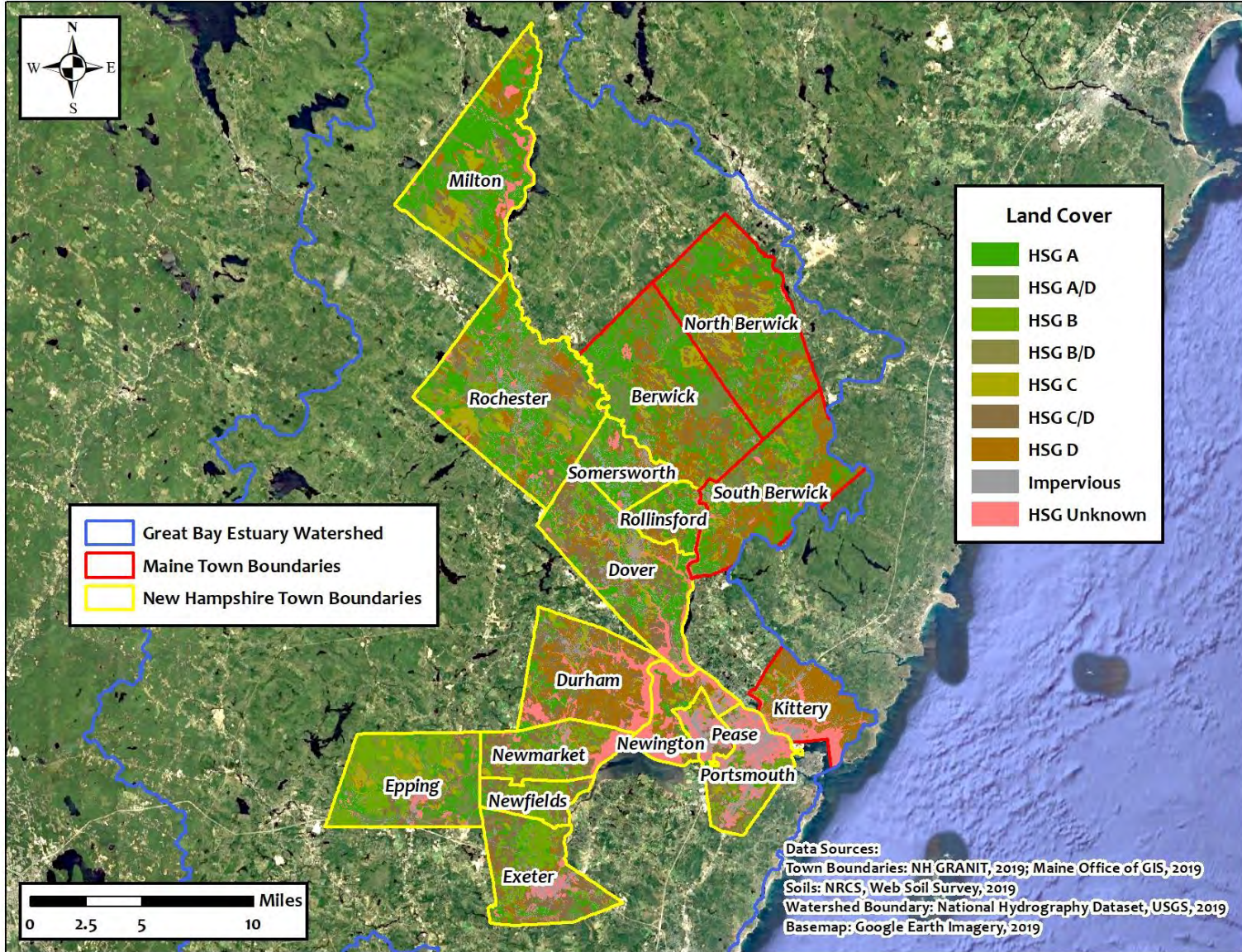


Figure 2 - Land Cover (soils and impervious) in the Great Bay Estuary Watershed

*Table 3 – Maine Land Use Details*

LU_Desc	Total Area (acres) - 2016 NLCD Dataset					Total
	Berwick	Kittery	North Berwick	South Berwick		
Total	24,214	9,510	24,423	18,032		76,179
Impervious	895	1,155	765	704		3,519
% Impervious	4%	12%	3%	4%		5%
Barren Land	Open Land	119	12	114	31	276.0
Cultivated Crops	Agriculture	51.6	15.6	10.3	55.1	132.6
Deciduous Forest	Forest	1,411.1	720.5	2,161.8	1,237.5	5,531.0
Developed, High Intensity	Commercial and Industrial	45.2	316.3	57.8	15.8	435.1
Developed, Low Intensity	All Residential	918.1	909.9	525.5	616.4	2,969.8
Developed, Medium Intensity	Commercial and Industrial	194.0	483.2	111.6	125.1	913.8
Developed, Open Space	Open Land	1,187.5	871.9	995.4	1,034.4	4,089.2
Emergent Herbaceous Wetlands	Forest	355.1	335.0	134.7	283.7	1,108.4
Evergreen Forest	Forest	4,329.6	1,042.0	4,907.3	3,384.1	13,663.0
Hay/Pasture	Agriculture	2,159.3	322.0	1,576.5	982.3	5,040.1
Herbaceous	Open Land	422.8	43.7	328.7	261.6	1,056.9
Mixed Forest	Forest	7,031.8	1,204.8	9,788.4	6,249.0	24,274.0
Open Water	Water	228.7	1,831.2	136.9	336.9	2,533.7
Shrub/Scrub	Forest	226.0	33.6	322.8	146.4	728.9
Woody Wetlands	Forest	5,533.8	1,368.5	3,251.0	3,273.2	13,426.5



Table 4 – New Hampshire Land Use Details

		Total Area (acres)														
LU4	LU4_Desc		Dover	Durham	Epping	Exeter	Milton	Newfields	Newington	Newmarket	Pease	Portsmouth	Rochester	Rollinsford	Somersworth	NH Total
	Total		18,567	15,852	16,776	12,813	21,931	4,647	6,534	9,080	3,036	9,116	29,062	4,841	6,397	158,653
	Impervious		2,445	924	933	1,227	695	214	546	579	868	2,147	2,859	281	1,016	14,733
	% Impervious		13%	6%	6%	10%	3%	5%	8%	6%	29%	24%	10%	6%	16%	9%
1110	Multi-family, medium to high rise apartments and condominiums (4 or more stories)	Resid.	-	-	-	21.7	-	-	-	-	-	6.5	5.2	-	-	33.4
1120	Multi-family, low rise apartments and townhouses, but not duplexes (1 - 3 stories)	Resid.	592.5	93.6	48.7	116.8	3.5	1.9	0.9	128.0	-	297.2	388.1	14.4	185.1	1,870.5
1130	Single family/duplex	Resid.	4,319.7	2,024.2	2,053.2	2,065.7	1,876.7	787.5	419.0	1,667.2	2.5	1,633.9	5,343.9	780.6	1,339.5	24,313.7
1140	Mobile home parks	Resid.	8.5	0.0	28.7	197.3	34.5	-	-	32.4	-	55.4	465.8	-	101.0	923.6
1150	Group and transient quarters	Resid.	5.2	69.4	-	0.5	7.2	-	-	4.4	-	-	2.9	-	-	89.6
1190	Other residential	Resid.	-	-	-	13.4	-	-	-	-	-	36.4	-	-	-	49.9
1210	Commercial retail	Comm/Ind	176.6	9.3	113.2	95.2	11.1	6.5	73.1	12.9	3.3	204.2	358.4	22.3	176.2	1,262.3
1220	Commercial wholesale	Comm/Ind	31.5	-	41.6	26.7	29.4	-	68.7	-	21.3	131.7	21.2	-	10.5	382.5
1230	Services	Comm/Ind	199.3	11.1	76.2	90.4	45.9	20.4	18.1	14.3	104.3	246.9	146.3	23.5	92.4	1,089.1
1240	Lodging	Comm/Ind	5.5	9.1	1.7	1.5	26.6	-	-	-	4.2	33.3	16.8	-	0.5	99.1
1250	Government	Comm/Ind	70.7	17.5	13.7	17.7	5.6	10.2	104.9	3.0	320.8	80.3	53.4	7.7	33.2	738.9
1260	Institutional	Comm/Ind	44.5	11.9	12.7	118.8	2.3	0.9	4.5	1.3	11.6	75.0	94.8	4.5	25.9	408.7
1270	Educational	Comm/Ind	93.9	141.7	44.2	212.7	12.4	6.6	14.2	16.9	19.6	67.9	36.7	4.6	31.0	702.4
1280	Indoor cultural/public assembly	Comm/Ind	8.2	-	2.1	10.0	3.0	-	3.8	3.3	-	23.9	17.4	1.2	8.6	81.5

1290	Other commercial, services, and institutional	Comm/Ind	-	10.4	14.5	9.7	0.4	-	-	1.3	7.5	-	-	-	-	43.7
1300	Industrial	Comm/Ind	216.7	9.7	46.2	82.2	-	34.3	56.0	16.9	81.3	196.6	308.7	-	138.7	1,187.2
1370	Mining	Comm/Ind	163.9	11.7	-	22.9	1.5	-	-	72.7	-	-	59.1	-	-	331.9
1410	Air transportation	Comm/Ind	-	-	-	-	-	-	1.5	-	806.7	0.5	148.8	-	-	957.5
1420	Rail transportation	Comm/Ind	12.5	16.5	-	15.9	23.0	9.3	4.4	7.8	-	25.7	28.2	15.6	12.9	171.9
1430	Water transportation	Comm/Ind	-	-	-	-	-	-	3.8	-	-	-	-	-	-	3.8
1441	Limited & controlled highway right-of-way	Highway	79.6	-	60.6	67.7	26.3	-	36.0	-	19.4	141.7	106.7	-	-	538.1
1442	Road right-of-way	Highway	493.9	261.0	245.1	307.7	190.5	62.5	89.1	146.2	78.1	446.1	598.5	77.9	190.3	3,186.9
1445	Park & ride lot	Comm/Ind	12.5	-	-	-	-	-	-	-	8.0	0.6	4.0	-	-	25.1
1446	Parking structure/lot	Comm/Ind	19.3	35.8	4.6	3.1	0.7	0.7	1.2	5.1	22.9	22.4	7.0	0.7	15.5	139.1
1447	Auxiliary transportation	Comm/Ind	141.9	40.0	96.8	157.7	132.3	1.7	18.6	5.0	18.5	123.4	187.6	1.4	6.8	931.6
1449	Other road transportation	Highway	0.7	-	-	-	10.6	-	0.8	-	-	-	-	-	4.9	17.1
1450	Communication	Comm/Ind	0.4	0.9	10.2	1.4	3.2	0.7	-	-	5.3	4.5	1.0	-	-	27.6
1460	Electric, gas and other utilities	Comm/Ind	112.7	106.2	54.8	123.3	56.7	6.7	56.4	18.3	15.2	185.8	337.5	16.5	50.4	1,140.5
1470	Water and wastewater utilities	Comm/Ind	12.7	12.6	17.0	45.6	7.8	6.9	1.3	3.6	2.5	7.1	120.2	2.0	12.8	252.3
1480	Solid waste utilities	Comm/Ind	-	4.2	-	-	29.4	-	1.8	-	-	-	469.9	6.4	-	511.8
1490	Other transportation, communications, and utilities	Comm/Ind	0.9	5.1	-	-	-	-	-	-	8.2	1.0	-	-	-	15.2
1510	Industrial park	Comm/Ind	-	-	-	-	-	-	-	22.2	-	18.9	-	-	-	41.1
1520	Office park	Comm/Ind	42.4	0.0	-	7.1	-	-	1.3	1.4	89.2	19.0	4.0	4.9	-	169.2
1530	Shopping mall	Comm/Ind	-	-	-	10.2	-	-	51.7	-	-	-	18.4	-	-	80.2
1580	Other industrial complexes	Comm/Ind	-	28.7	-	14.8	-	-	65.0	-	19.8	4.5	22.1	-	-	155.0

1590	Other commercial complexes	Comm/Ind	-	-	5.6	13.7	-	-	38.2	3.0	22.3	101.0	-	-	-	183.8
1610	Multiple stories, residential in upper stories only	Comm/Ind	5.3	0.8	-	0.2	-	-	-	4.7	-	0.3	2.7	-	3.8	17.7
1690	Other mixed uses	Comm/Ind	0.7	-	-	-	-	-	-	-	-	-	0.6	-	-	1.3
1710	Outdoor cultural	Open Land	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1720	Outdoor public assembly	Open Land	-	-	171.3	-	0.8	-	-	-	-	-	50.0	-	-	222.1
1730	Outdoor recreation	Open Land	204.4	80.4	72.4	117.2	21.8	28.5	26.5	72.1	159.5	152.4	277.4	14.6	217.6	1,444.8
1740	Cemeteries	Open Land	103.3	5.4	10.6	33.3	8.3	5.2	10.3	22.2	-	55.7	67.3	19.7	40.6	381.8
1780	Maintained Open Areas	Open Land	370.7	229.2	-	-	246.0	-	-	145.3	-	-	280.7	80.7	122.7	1,475.3
1790	Other outdoor and other urban or built-up land	Comm/Ind	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1800	Vacant Land	Open Land	1.8	23.2	3.1	-	-	0.1	2.6	11.9	1.1	4.2	4.8	-	3.6	56.4
2000	Agricultural Land	Agriculture	1,411.5	1,283.9	980.6	334.2	339.7	221.6	411.4	625.9	7.4	69.1	1,619.2	992.2	172.0	8,468.8
2900	Other Agricultural Land	Agriculture	28.0	47.9	119.4	21.3	9.1	19.1	14.4	21.9	-	10.4	17.7	29.0	8.8	346.9
3000	Brush or Transitional Between Open and Forested	Forest	378.1	188.9	635.2	356.5	515.7	165.8	281.3	110.0	292.8	351.7	554.9	117.4	103.6	4,051.9
4000	Forest Land	Forest	6,307.0	8,283.6	9,356.1	5,745.5	15,395.2	2,641.7	1,724.8	3,641.4	549.9	1,705.9	13,154.3	2,042.4	2,194.5	72,742.2
5000	Water	Water	1,439.2	1,544.8	338.1	242.2	978.8	92.7	2,572.6	1,026.8	4.5	782.9	489.9	154.4	184.8	9,851.7
6000	Wetlands	Forest	1,138.4	1,110.1	1,850.3	2,042.7	1,285.1	496.2	317.6	1,085.8	301.9	1,765.6	2,438.8	374.9	674.2	14,881.6
7200	Beaches and River Banks	Open Land	-	1.1	-	-	0.9	-	6.9	-	-	5.1	2.8	-	-	16.8
7300	Sandy Areas (non-beaches)	Open Land	1.6	-	-	-	-	-	-	-	-	-	-	-	-	1.6

7400	Bare/Exposed Rock	Open Land	42.6	46.5	-	-	-	-	-	18.6	-	-	-	0.6	-	108.4
7500	Strip Mine/Quarry or Gravel Pit	Comm/Ind	-	-	62.0	-	49.3	-	-	-	-	-	40.6	-	-	151.9
7600	Disturbed Land	Open Land	253.8	74.8	185.2	48.5	535.3	18.9	30.6	104.2	26.8	21.6	612.2	29.2	161.5	2,102.6
7900	Other Barren Lands	Open Land	14.3	0.9	-	-	3.9	-	0.5	2.5	-	-	76.2	2.1	72.6	173.2

## 2. Pollutant Load Analysis

### 2.1. Stormwater Runoff

The volume and quality of stormwater runoff generated from each major land use within the study watershed was characterized through the use of modeling of hydrologic response units (HRUs). HRUs are idealized catchments, 1 acre in size, which represent a land use cover, one of four hydrologic soil groups (HSG) and an imperviousness condition, either 100% impervious or 100% pervious. HRUs can be used as sub-elements to represent the various combinations of land use, land cover, imperviousness, and soil type within a watershed.

Each HRU was modeled in the EPA Stormwater Management Model (SWMM)<sup>3</sup> as a subcatchment. Subcatchments are defined as hydrologic units of land whose topography and drainage system elements direct surface runoff to a single discharge point. SWMM calculates estimated rates at which rainfall infiltrates into the upper soil zone of a subcatchment's pervious area. Infiltration is estimated for each HRU using the Curve Number (CN) Method. The CN Method is adopted from the NRCS<sup>4</sup> (SCS) and assumes that the total infiltration capacity of a soil can be found from the soil's tabulated Curve Number. During a rain event this capacity is depleted as a function of the cumulative rainfall and remaining capacity. The input parameters for this method are the Curve Number and the time it takes a fully saturated soil to completely dry (used to compute the recovery of infiltration capacity during dry periods). Curve numbers were assigned to HRUs based on the soil type and impervious cover.

After the stormwater runoff volumes were determined by HRU analysis, the pollutant load analysis was conducted. This was accomplished by using event mean concentrations (EMCs), the flow weighted average concentration of a pollutant throughout a storm event. EMCs for nitrogen are available for a wide range of land uses. Pollutant load export rates (PLERs) are the mass of pollutant load that is expected to be produced by a specific land use and soil type combination for a given period of time. PLERs for nitrogen were developed previously using this method in prior efforts and studies and published in the 2017 NH Small MS4 permit<sup>5</sup>, as shown in Table 5.

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<sup>3</sup> EPA (2010b)

<sup>4</sup> NRCS (1986)

<sup>5</sup> EPA (2017). Appendix F: Requirements Of Approved Total Maximum Daily Loads, 2017 NH Small MS4. General Permits for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems. Boston, MA, Office of Ecosystem Protection, United States Environmental Protection Agency.



*Table 5 - Average Annual Nitrogen Load Export Rates from 2017 NH MS4 General Permit*

<b>Land Use Category</b>	<b>Nitrogen Load Export Rate, lbs/acre/year</b>
Commercial and Industrial (impervious)	15.0
All Residential (impervious)	14.1
Highway (impervious)	10.5
Forest (impervious)	11.3
Forest (pervious)	0.5
Open Land (impervious)	11.3
Agriculture (impervious)	11.3
Agriculture (pervious)	2.6
Developed-Pervious, HSG A	0.3
Developed-Pervious, HSG B	1.2
Developed-Pervious, HSG C	2.4
Developed-Pervious, HSG C/D	3.1
Developed-Pervious, HSG D	3.6

## **2.2. Septic Systems**

The annual load derived from the use of septic systems was based on calculations provided by NHDES in the GBNNPSS. The process used to arrive at estimates of septic system loads is explained in Appendix G of GBNNPSS. NHDES delineated regions serviced by municipal sewer systems based on direct information from regional municipalities and information in the USGS Water Demand Model for New Hampshire Towns. The population outside of these service areas, as determined by 2010 US Census block data, was assumed to use septic systems for waste disposal. A per-capita excretion rate of 10.6 lb N per year was multiplied by the population using septic systems to calculate a nitrogen load to groundwater from septic systems.

## **3. Hydrologic Analysis**

LiDAR data<sup>6</sup> was used to perform a hydrologic analysis to identify flow accumulation pathways within the downtown area of each of the 17 Great Bay Estuary Watershed towns of interest. This was conducted as an example of the sub-watershed delineation, source identification, targeting, and implementation plan development required by the MS4. By overlaying these pathways with land use and land cover data, it is possible to identify an idealized set of locations for construction of stormwater management BMPs.

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<sup>6</sup> USGS NRCS Maine Lidar, 2013, LiDAR for the North East, 2011  
 Technical Methods  
 Feasibility Analysis for EPA’s Draft Great Bay Total Nitrogen General Permit  
 May 2020

#### 4. Best Management Practices: Structural and Non-Structural

To assess an optimal nitrogen control strategy the evaluation included both structural and non-structural stormwater best management practices (BMPs). The BMPs considered in this analysis, along with their applicable land use types are listed in Table 6, below. Not all BMPs are applied to each land use. For example, the non-structural BMP of leaf litter collection is limited to residential land uses because of the regulatory guidance from the 2017 MS4 and WDNR (2018). Individual BMPs are described in the following section.

*Table 6 –Structural and Non-Structural BMP by Land Use Types*

BMP Type	Residential	Commercial	Institutional	Road	Industrial	Outdoor	Agriculture
Rain Garden	x						
High Efficiency Bioretention	x	x	x		x	x	
Dry Well	x	x	x		x		
Redevelopment Permeable Pavement	x	x	x		x	x	
Bioretention		x	x	x	x	x	
Gravel Wetland		x	x	x	x	x	
Wet Pond		x	x	x	x		
Subsurface Infiltration		x	x		x	x	
Sand Filter		x	x		x	x	
Tree Box Filter		x	x			x	
Cover Crop							x
Slow Release Fertilizer							x
Septic Sludgehammer							
Street Sweeping	x	x	x	x	x		
Leaf Litter Removal	x						
Catch Basin Cleaning	x	x	x	x	x		
Urban Fertilizer Reduction	x					x	

Table 7 lists values and sources for all model inputs for each structural and non-structural control considered in this analysis. The sources drawn on represent the most current available analyses related to structural and non-structural BMP performance and cost. Where possible, information was drawn from analyses local to Great Bay. Structural control BMP performance is from the 2017 NH Small MS4 and WISE 2015. BMP performance is typically a function of soil type and capture depth for each specific BMP.

**Table 7 – BMP Model Parameterization**

		<b>Cost</b>	<b>Input Loads</b>	<b>BMP Performance and Output Loads</b>	<b>Groundwater Load</b>	<b>Max Land Use Areas</b>
<b>Structural Controls</b>	Model Input	See Table 7	per-acre loads based on LULC as shown in Table 3	See BMP Performance Curves as a function of soil type and capture depth, % reductions applied to input loads; see Table 6	% of input load; see Table 6	Varies, see Table 4
	Source	WISE, 2015	2017 NH MS4 General Permit	2017 NH MS4, WISE, 2015	WISE, 2015	WISE, 2015
<b>Septic</b>	Model Input	\$4,000 per system	[10.6 lbs/person/yr] x [3 persons/system] = 31.8 lbs/system/year	60% reduction of input load	N/A	[population on septic] / 3
	Source	SludgeHammer Specs	GBNNPSS	SludgeHammer Specs	-	GNNPSS
<b>Street Sweeping</b>	Model Input	\$32 per acre	per-acre loads based on LULC as shown in Table 3	10% reduction of input load	N/A	impervious roadways
	Source	BIP, 2019	2017 NH MS4	BIP, 2019; 2017 NH MS4	-	BIP, 2019
<b>Leaf Litter</b>	Model Input	\$11 per acre	per-acre loads based on LULC as shown in Table 3	5% reduction	N/A	pervious Residential areas
	Source	BIP, 2019	2017 NH MS4	2017 NH MS4	-	WDNR, 2018 BIP, 2019
<b>Catch Basin Cleaning</b>	Model Input	\$320 per acre	per-acre loads based on LULC as shown in Table 3	6% reduction	N/A	Estimate varies by town; detailed in 'assumptions'
	Source	BIP, 2019	2017 NH MS4	BIP, 2019; 2017 NH MS4	-	BIP, 2019
<b>Urban Fertilizer Control</b>	Model Input	\$74 per acre	2.4 lbs-N/acre as per the 'Developed Pervious, HSG C' land use category shown in Table 3	9% reduction of input load	N/A	Residential lawns, golf courses, school fields, town rec. fields
	Source	BIP, 2019	2017 NH MS4	Chesapeake Stormwater Network, 2013	-	GBNNPSS

BMP performance data sources are detailed in Table 7. This generally includes the NH MS4, the UNHSC, or WISE BMP performance curves. The summary range of BMP pollutant load reduction is shown in Table 8. This range varies as a function of BMP size and soil type and is detailed in the respective performance curves. ‘Output Load Range’ represents the percentage reduction of the influent nitrogen load for each BMP at discharge.

*Table 8 – Summary of BMP Nitrogen Load Reduction for Linear Optimization Analysis*

<b>BMP</b>	<b>Removal Efficiency Low</b>	<b>Removal Efficiency High</b>	<b>Output Load Range</b>
Bioretention	29%	91%	2-71%
Dry Well	72%	90%	0-20%
Gravel Wetland	75%	94%	6-25%
Bioretention-ISR	57%	95%	1-43%
Raingarden	42%	91%	2-58%
Permeable Pavement	87%	93%	1-4%
Sand Filter	19%	90%	4-81%
Subsurface Infiltration	13%	90%	0-87%
Tree Box Filter	21%	89%	5-79%
Wet Pond	32%	88%	12-68%

#### **4.1. Structural Control BMPs**

There is a wide range of BMPs that can be used in the municipal, commercial, industrial, and residential areas to manage runoff from roof tops, impervious surfaces and pervious surfaces. This includes dry wells, subsurface infiltration, gravel wetlands, porous pavements, biofiltration, and high efficiency bioretention.

#### **4.2. Non-Structural BMPs**

Non-structural controls (NSC) are institutional, educational, and other pollution-prevention practices designed to limit the amount of stormwater runoff or pollutants generated by a landscape. NSCs considered in this study are street sweeping, leaf litter control, catch basin cleaning, septic system retrofits, and fertilizer reduction programs. Other NSCs exist that could be similarly considered. Those included here were chosen due to their inclusion in the 2017 MS4 or their successful usage elsewhere.

##### **4.2.1. Septic Systems Retrofits**

The anticipated N-reduction and cost to implement were based on reported performance data from the Massachusetts Septic System Test Center<sup>7</sup> and sales for a commercially available septic system retrofit for residential applications. The retrofit is an aerobic bacterial generator that costs

<sup>7</sup> MASSTC (2002). SludgeHammer Test Results. Buzzards Bay, MA, Massachusetts Advanced Septic System Test Center: 1.

typically \$4,000 for a residential installation and has been demonstrated to achieve a 60% N load reductions.

An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic are based on GBNNPSS population estimates for septic systems. No septic system estimates were available for Pease, so the number of septic systems for Pease was determined by multiplying the relative area that Pease makes up within Newington and Portsmouth by the number of septic systems in those towns.

#### ***4.2.1. Street Sweeping***

The range in expected nitrogen reduction associated with street sweeping varies depending on whether a traditional mechanical broom sweeper is being deployed versus a more advanced regenerative vacuum sweeper using water and suction along with sweeping. A 2007 USGS study<sup>8</sup> evaluated the performance of three street-sweeper technologies (regenerative-air, vacuum-assisted, and mechanical-broom street sweepers) to help environmental managers meet the NPDES permit requirements. The study was inconclusive due to the variability in stormwater quality loads. They found the use of the regenerative-air and vacuum-assist sweepers resulted in the greatest total reductions in average basin street-dirt yield of 76 and 63 percent, respectively. Use of the mechanical broom sweeper at high frequency resulted in a 20-percent reduction on average. However, in application the regenerative-air, vacuum assist sweepers, and mechanical broom averaged removal efficiencies of 25 and 30, and 5 percent, respectively. The Chesapeake Stormwater Group states that regular street sweeping can reduce nitrogen loading by up to 4%, and TSS loading by up to 21% depending on the frequency of sweeping and technology being used. The 2017 New Hampshire Small MS4 General Permit, Appendix F details expected reductions in nitrogen (up to 10%) associated with street sweeping programs.

#### ***4.2.2. Leaf Litter Control***

Leaf litter control programs focus on removing leaves from urban areas before they enter the stormwater system. Studies suggest that a significant amount of annual nitrogen loading from closed drainage systems comes from leaf litter during the fall season, and that leaf removal programs can reduce phosphorus concentrations in stormwater by up to 74%.<sup>9</sup> The 2017 New Hampshire Small MS4 General Permit, Appendix F outlines a method for assigning nitrogen-removal credits for leaf litter control programs.

#### ***4.2.1. Catch Basin Cleaning***

Expanding programs to clean debris and litter buildup in catch basins has been shown to be an effective means of reducing nitrogen in stormwater runoff. The 2017 New Hampshire Small MS4 General Permit, Appendix F outlines a method for assigning nitrogen-removal credits for catch basin cleaning programs, offering a 6% reduction in nitrogen loading.

Catchbasins were determined on a per town basis by a number of approaches. Specific approaches for each town are listed in Table 9. The approaches used either reporting of actual

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<sup>8</sup> Selbig, W. R. and R. T. Bannerman (2007). Evaluation of street sweeping as a stormwater-quality-management tool in three residential basins in Madison, Wisconsin: Scientific Investigations Report, 2007–5156, U.S. Geological Survey: 103p.

<sup>9</sup>Selbig, 2016



numbers, or estimates based on population using a method used by a 2017 EPA MS4 Costing Study<sup>10</sup>

*Table 9 – Catch Basin Estimation Method By Town*

Town	# of CBs	Outfalls	Source	Approach	Population	Year
Dover	2620	210	2018 MS4 Annual Report	Calculated based on annual report estimate	31,398	2010
Rochester	4380	438	2017 EPA MS4 Costing Study	Calculated based on reported # of outfalls X 10 from EPA costing study	30,797	2017
Portsmouth	3700	317	7/19 MS4 SWMP	Reported	21,796	2017
Durham	600	60	2017 EPA MS4 Costing Study	Calculated based on reported # of outfalls X 10 from EPA costing study	14,638	2010
Exeter	5366	65	Stormwater Resource Binder		14,306	2010
Somersworth	1012		2016 MS4 Annual Report	estimated from reported # cleaned x frequency of every 4 years	11,766	2010
Kittery	892		2018 MS4 Annual Report	Reported	9,722	2017
Newmarket	1477		N/A	Calculated from trendline based on population	9,073	2017
South Berwick	68		2018 MS4 Annual Report	Reported	7,464	2017
Berwick	97		2018 MS4 Annual Report	Reported	7,246	2017
Epping	887		N/A	Calculated from trendline based on population	6,411	2010
Milton	323		N/A	Calculated from trendline based on population	4,598	2010
North Berwick	315			Calculated from trendline based on population	4,576	2010
Rollinsford	104	30	2019 Rollinsford CB Listing	Reported	2,527	2010
Newfields	10	1	N/A	Calculated based on estimated # of outfalls X 10 from EPA costing study	1,719	2017
Newington	250		N/A	Estimated from EPA Costing Study	789	2017
Pease	1297		1989 SWI Inventory	Estimated from 1989 Stormwater Infrastructure Inventory		

#### **4.2.2. Urban Fertilizer Runoff Reduction**

There are a number of methods for reducing runoff from urban fertilizer use, from state-level legislation to local requirements for nutrient management planning. Depending on a variety of factors, these programs have been shown to reduce pollutant loading from fertilized areas by up

<sup>10</sup> EPA (2017). Stormwater Program Cost Evaluation for New Hampshire. Boston, MA, WaterVision, LLC. Technical Methods Feasibility Analysis for EPA’s Draft Great Bay Total Nitrogen General Permit May 2020

to 50%.<sup>11,12,13</sup> In 2013, New Hampshire passed State Statute (RSA: 431)<sup>14</sup>, regulating the application and retail display of fertilizer intended for commercial and residential use. This act prohibits use of fertilizers with a total nitrogen content of greater than 0.9lbs per 1,000 sq-ft when applied according to the instructions on the label. Reducing urban fertilizer runoff can reduce stormwater nitrogen loads by up to 20% depending on the management actions taken, according to the Chesapeake Stormwater Network.<sup>13</sup>

For this analysis, rather than determine different performance functions for fertilized areas of different soil types, all areas were assigned performance functions relating to C-type soils. If this NSC were broken down by soil type, the linear optimization results would favor implementing the NSC on D-type soils, however in reality there is no way to target only D soils with this NSC, thus the nitrogen loading rates for C-type soils were used. In order to determine the area of residential lawns, a multiplier of 20% was used which represents the average ‘% lawn’ for medium density residential areas.

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<sup>11</sup>EPA, 2015

<sup>12</sup>EPA, 2016

<sup>13</sup>Chesapeake Stormwater Network, 2013

<sup>14</sup> <http://www.gencourt.state.nh.us/rsa/html/XL/431/431-mrg.htm>

## 5. BMP Optimization Analysis

A BMP optimization analysis was performed using the results of the pollutant load and hydrologic analyses to assess the potential to mitigate nitrogen loading via structural and non-structural stormwater best management practices.

The 2017 NH MS4 permit includes the requirement for BMPs to be optimized for pollutant removal<sup>15</sup>. Optimization is especially valuable for retrofitting and redevelopment because it involves sizing of a BMP to achieve the greatest performance for least cost. Results are influenced by pollutant type, soils, land use, BMP performance and cost, and application constraints (i.e. prohibiting certain BMPs for certain land uses). Optimization can occur at multiple scales. In its simplest sense optimization is done at the BMP level for sizing an individual system. At its most complex it can be used at the watershed-scale to determine a menu of lowest cost highest performance BMPs by type and size while factoring in multiple land uses, soils, performance, cost, and constraints.

The optimization analysis was conducted using a previously developed optimization model<sup>16</sup> developed in collaboration with and approved by EPA, and a related EPA optimization tool<sup>17</sup>. The model selects the most cost-effective management measures for a range of increasing runoff reduction. The optimization model runs repeatedly, changing the target volume reduction with each iteration. It evaluates the runoff control strategies based upon user defined constraints including available land for implementation, volume reduction capability based on capture depth of the BMP, and cost to implement the strategy. This model was first applied at the system level to develop a series of BMP performance curves. It was next applied at the land use scale to identify the most cost-effective options for each particular land use. For this analysis, the optimization tool was focused on the study area described in previous sections for the range of feasible runoff control measures, and the range of land uses.

### 5.1. Linear Optimization Analysis

This section is excerpted from the study by Roseen et al 2015. A linear optimization (LO) model utilizes a series of linear equations to minimize or maximize a given function. The model consists of the objective function (the mathematical relationship being optimized) and a set of constraints (equations describing the physical limits and/or minimum required performances of the system being modeled).

The objective function of the LO is a function that describes the total cost of a given NPS management strategy. The goal is to minimize this cost for a given target nutrient load reduction. If  $C_{BMP1}$  is the total cost associated with the implementation of BMP1, then the objective function for the LO model is:

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<sup>15</sup> Appendix H. Part I, 1.a Additional or Enhanced BMPs.i.2

<sup>16</sup> Roseen, R., Watts, A., Bourdeau, R., Stacey, P., Sinnott, C., Walker, T., Thompson, D., Roberts, E., and Miller, S. (2015). Water Integration for Squamscott Exeter (WISE), Preliminary Integrated Plan, Final Technical Report. Portsmouth, NH, Geosyntec Consultants, University of New Hampshire, Rockingham Planning Commission, Great Bay National Estuarine Research Reserve, Consensus Building Institute.

<sup>17</sup> EPA (2015). Opti-Tool for Stormwater and Nutrient Management. Boston, MA, U.S. Environmental Protection Agency, Region 1, New England Tetra Tech.

The objective function of the optimization model was:

$$\text{Min. } Z = \sum_{j=1}^n C_{BMP_j} A_{BMP_j} = C_{BMP_1} A_{BMP_1} + C_{BMP_2} A_{BMP_2} + \dots + C_{BMP_n} A_{BMP_n}$$

where:  $Z$  =total cost (\$);  $BMP_j$  = BMP type;  $A_{BMP_j}$  = Acres treated by  $BMP_j$ ; and  $C_{BMP_j}$  = capital cost of  $A_{BMP_j}$  (\$/acre treated by  $BMP_j$ ).

The decision variables of the model were  $A_{BMP_j} = A_{BMP_1}, A_{BMP_2}, \dots, A_{BMP_n}$  (i.e. the goals was to find the optimal number of each of these variables).

The constraints of the model included:

$$A_{BMP_j} \geq 0$$

$$\sum_{j=1}^n A_{BMP_j} T_{BMP_j} = A_{BMP_1} T_{BMP_1} + A_{BMP_2} T_{BMP_2} + \dots + A_{BMP_n} T_{BMP_n} = P$$

$$\sum_{j=1}^n A_{BMP_j LUC_x} \leq A_{MaxLUC_x}$$

where:  $A_{BMP_j}$  = Acres treated by  $BMP_j$ ;  $T_{BMP_j}$  = treatment with  $BMP_j$  (lb/acre/year);  $P$  = total target treatment for watershed (lb/year);  $LUC_x$  = Landuse/Cover type;  $A_{BMP_j LUC_x}$  = Area of  $BMP_j$  with  $LUC_x$  (acres); and  $A_{MaxLUC_x}$  = Total area of Landuse/Cover type in watershed.

Constraint functions used in the LO model will fall into 6 categories:

1. Total cost associated with implementation of a given BMP of known capture depth;
2. Total load reduction associated with implementation of a given BMP of known capture depth;
3. Summation of costs associated with implementation of a given BMP type across all sizes
4. Summation of load reductions associated with implementation of a given BMP type across all sizes;
5. Total area available for treatment
6. Total target load reduction

Constraint type 1 describes the cost of implementing a given BMP type of a single size. Costs have been summarized in \$/acre treated for each BMP type and size. Therefore, to describe the total implementation cost for a given BMP of a single size, type 1 constraints will follow the format:

$$(Cost/area)(Area Treated) - (Total Cost) = 0$$

As an example, a wet pond with capture depth of 0.25” costs \$1425 per acre treated. The constraint to describe this BMP type of this size would be written as:

$$(1425)WPA_{0.25} - WPC_{0.25} = 0$$

Where  $WPA_{0.25}$  is the area treated using wet ponds of capture depth 0.25”, and  $WPC_{0.25}$  is the total cost associated with implementing wet ponds of capture depth 0.25”.

Constraint type 2 is similar to constraint type 1, except it describes load reduction associated with the given practice, rather than cost. To continue the example above, a wet pond with capture depth 0.25” will reduce nitrogen loads by 0.2234 lb N per acre treated. This constraint would be written as:

$$(0.2234)WPA_{0.25} - WPL_{0.25} = 0$$

Where  $WPA_{0.25}$  is the area treated using wet ponds of capture depth 0.25”, and  $WPL_{0.25}$  is the total load reduction associated with implementing wet ponds of capture depth 0.25”.

Constraint type 3 and 4 will summarize the costs and load reductions modeled by constraint types 1 and 2, respectively. If  $WPC_{0.25}$  is the total cost associated with implementing wet ponds of capture depth 0.25”, the total cost for wet ponds of all sizes is:

$$WPC_{0.25} + WPC_{0.50} + \dots + WPC_{1.50} - WPC_{tot} = 0$$

where  $WPC_{tot}$  is the total cost associated with implementation of wet ponds of all sizes.

A similar method is used to determine the sum of load reduction associated with wet ponds of all sizes (constraint type 4):

$$WPL_{0.25} + WPL_{0.50} + \dots + WPL_{1.50} - WPL_{tot} = 0$$

Where  $WPL_{tot}$  is the total load reduction associated with implementation of wet ponds of all sizes.

Constraints 1-4 are applied to each BMP type of each capture depth for each land use/cover type. The model is limited to only using BMP/land use combinations that are listed in Table 6.

Constraint type 5 describes the available area of a given land use type within the watershed. Until now, notation described in this methodology has not indicated land use; now we will consider land use in the notation. Let  $WPA_{0.25-com-i}$  be the area of commercial impervious treated with wet ponds of 0.25” capture depth, and  $GWA_{0.25-com-l}$  be the area of commercial impervious treated with gravel wetlands of 0.25” capture depth, and so on. Since we cannot possibly treat more acres of land with a suite of BMPs than what is available in the watershed, the total area of a given land use type is described by:

$$WPA_{0.25-com-i} + WPA_{0.50-com-i} + \dots + WPA_{1.50-com-i} + GWA_{0.25-com-i} + \dots < 143.9$$

In this constraint example, there are a total of 143.9 acres of commercial impervious surface within the watershed. The constraint states that the total area of this land use treated by each bmp type of each size cannot exceed 143.9 acres. This type of constraint is added for each land use which is suitable for NPS treatment (e.g. commercial impervious, commercial roof, commercial pervious with soil type A, commercial pervious with soil type B, etc.).

Constraint type 6 allows for a target load reduction to be specified. For this given target load reduction, the model will determine the mixture of BMP types, sizes, and acreages of each land use treated which will result in a minimum cost. The constraint is written as:

$$WPL_{tot-com-i} + WPL_{tot-com-r} + \dots + BMP_{tot-LU} = X$$

Where each item in the summation refers to the total load reduction associated with a given BMP type treating a given land use/cover type (as determined in constraint type 4) and X represents the target load reduction.

### 5.2. Optimization Model Setup

The Linear Optimization Analysis (LOA) model evaluates the runoff control strategies based upon user defined constraints, including available land for implementation, nitrogen load reduction capability based on capture depth of the BMP, and cost to implement the strategy. This section describes the model parameterization. The model examines water quality treatment of pollutants through settling, filtration, and biological activity, represented in the storage unit. Using a mathematical treatment expression that describes the changes in pollutant concentration at the storage unit, the treatment is modeled as a first-order decay process. This process estimates the concentration of pollutants removed by the BMP.

BMP performance data includes a wide range of sources as detailed in Table 7. Structural control BMP performance estimates come from WISE 2015. BMP performance is typically a function of soil type and capture depth for each specific BMP. Using this data, the average reduction of pollutant concentration for total nitrogen (TN) for the structural management measures was estimated, as shown in Table 10. ‘Output Load Range’ represents the % of the input nitrogen load for each BMP that emerges from the BMP in the effluent. ‘Groundwater Load Range’ represents the % of the input nitrogen load for each BMP that is infiltrated. A range of values is provided to represent the performance of BMPs of various sizes. Detailed BMP performance estimates are shown in tabular and graphical format in [Appendix X](#).

*Table 10 - BMP Performance Inputs for Linear Optimization Analysis*

	<b>Output Load Range</b>	<b>Groundwater Load Range</b>
Bioretention	2-71%	0-70%
Dry Well	0-20%	80-100%
Gravel Wetland	6-25%	0%
HE Bioretention	1-43%	0-43%
Rain Garden	2-58%	0-67%
Red Permeable Pavement	1-4%	50-93%
Sand Filter	4-81%	0-78%
Subsurface Infiltration	0-87%	0-100%
Tree Box Filter	5-79%	0-77%
Wet Pond	12-68%	0%

### 5.3. BMP Costing

The cost to implement and maintain each structural control was characterized according to their estimated capital cost scaled to relative size by water quality volume. Sources for BMP capital costs information included local reports, compilations of studies from national literature, and professional judgement (EPA 1999; Narayanan, A. and R. Pitt, 2006; FB Environmental, 2009; Tetra Tech, 2009; UNHSC, 2012; Houle et al, 2013; CRWA, 2014; Geosyntec, 2014; and, Roseen, R. et al., 2015).

Capital cost data from these studies were normalized to represent the cost of treating the runoff from one acre of land (the standard size of an HRU) for a given capture depth (ranging from 0.25



– 1.5 inches). By normalizing the costs in this manner, the cost data was directly related to BMP performance as a function of capture depth.

Table 11 lists the range of per-acre capital costs for structural BMPs and non-structural BMPs that were used in this analysis.

*Table 11 - Modeled Costs of Structural and Non-Structural Controls*

<b>BMP</b>	<b>Size</b>	<b>Cost</b>	<b>Unit</b>
Bioretention	0.25" – 1.5" WQV	\$11,400 - \$48,300	per acre
Raingarden	0.25" – 1.5" WQV	\$4,500 - \$18,000	per acre
HE Bioretention	0.25" – 1.5" WQV	\$12,255 - \$51,923	per acre
Tree Box Filter	0.25" – 1" WQV	\$11,800 - \$41,100	per acre
Dry Well	0.25" – 1.5" WQV	\$4,000 - \$20,000	per acre
Red Permeable Pavement	-	\$186,300	per acre
New Permeable Pavement	-	\$29,700	per acre
Gravel Wetland	0.25" – 1.5" WQV	\$5,900 - \$35,300	per acre
Wet Pond	0.25" – 1.5" WQV	\$5,500 - \$22,400	per acre
Infiltration Trench	0.25" – 1.5" WQV	\$4,000 - \$19,000	per acre
Subsurface Infiltration	0.25" – 1.5" WQV	\$18,500 - \$77,800	per acre
Sand Filter	0.25" – 1.5" WQV	\$30,000 - \$180,000	per acre
Septic SludgeHammer	-	\$4,000	per system
Street Sweeping	-	\$32	per acre
Leaf Litter Control	-	\$11	per acre
Catch Basin Cleaning	-	\$320	per acre
Urban Fertilizer Reduction	-	\$74	per acre

### **5.3.1. Assumptions and Limitations**

There are a number of assumptions and limitations to note when interpreting the results of this analysis.

#### *Overlapping Non-Structural Controls (NSCs)*

The optimization analysis has not accounted for how overlapping NSCs would impact each other's performance. In some cases, implementing two NSCs in the same area could reduce the potential for nitrogen load reduction provided by either NSC. For example, it is possible (though unproven as of yet) that increased street sweeping or leaf litter control would reduce the importance of catch basin cleaning by removing a significant portion of the nitrogen load before it reached the sewer system. Similar interactions could be imagined between other NSCs, or between NSCs and traditional structural controls. However, these interactions are unproven and require further analysis.

Similarly, in some cases, implementation of one NSC might preclude future implementation of another, but this interaction was not be accounted for in the feasibility analysis of this effort. This unaccounted for interactive effect between NSCs should not impact the usefulness of the analysis unless very high adoption percentages were being considered amongst multiple overlapping NSCs. As long as potential areas are not limited, it should be possible to implement NSCs in a distributed fashion.

It should also be noted that it is also reasonable to assume that, in many cases, multiple NSCs could be implemented over the same geographic area without impacting the nitrogen load reduction performance of any of them.

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#### *GIS Analysis Land Use / Land Cover Generalizations*

While a highly-refined land use dataset was used for this analysis, it still represents a generalization of a much more complex reality. NSC implementation feasibility was assessed based on land use categories that were subdivided into land cover classes, resulting in land use/land cover categories. Still, there is inherent variability within each of these categories that cannot be fully captured on the scale required for this effort. Consequently, the ‘feasible areas of application’ for each BMP should be considered the *maximum* feasible areas. Site-specific analyses would be required to determine the suitability of each site for actual NSC implementation.

#### *Pollutant Load Analysis*

Section 4.1.3 of Appendix B (page 27) from WISE, 2015 describes how nitrogen load attenuation is accounted for in their analysis. They used an estimate from GBNNPSS that states that 87% of nitrogen traveling in stormwater and surface water pathways will be transported from its origin to the receiving waters. The WISE approach also takes this a step farther, generating a weighted average annual load from impervious surfaces based on what percent of impervious surfaces are disconnected. DCIA estimates were not available for this analysis, so it was not possible to perform this step. However, this should result in no impact to the final recommended implementation strategy as the goal is based on a percent-reduction, not specific load targets.

#### *Hydrologic Analysis*

The approach used to delineate subwatersheds does not account for sewersheds, which might significantly impact drainage areas. Additionally, the potential BMP locations identified through this analysis do not consider any site-specific feasibility assessments. Detailed, site-specific analysis would be required to refine subwatershed boundaries and determine an optimal, feasible BMP implementation strategy.

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## **Modeling Appendix A: Linear Optimization BMP Performance Inputs**



LAND USE	COVER	BMP	SIZE	BMP AND SIZE	Output Load	GW Load
RESIDENTIAL	I	RAINGARDEN	0.25	RAINGARDEN0.25	49%	10%
RESIDENTIAL	I	RAINGARDEN	0.5	RAINGARDEN0.5	34%	18%
RESIDENTIAL	I	RAINGARDEN	0.75	RAINGARDEN0.75	24%	24%
RESIDENTIAL	I	RAINGARDEN	1	RAINGARDEN1	18%	30%
RESIDENTIAL	I	RAINGARDEN	1.25	RAINGARDEN1.25	13%	34%
RESIDENTIAL	I	RAINGARDEN	1.5	RAINGARDEN1.5	11%	37%
RESIDENTIAL	R	RAINGARDEN	0.25	RAINGARDEN0.25	48%	5%
RESIDENTIAL	R	RAINGARDEN	0.5	RAINGARDEN0.5	33%	9%
RESIDENTIAL	R	RAINGARDEN	0.75	RAINGARDEN0.75	24%	12%
RESIDENTIAL	R	RAINGARDEN	1	RAINGARDEN1	17%	15%
RESIDENTIAL	R	RAINGARDEN	1.25	RAINGARDEN1.25	13%	18%
RESIDENTIAL	R	RAINGARDEN	1.5	RAINGARDEN1.5	10%	21%
RESIDENTIAL	A	RAINGARDEN	0.25	RAINGARDEN0.25	32%	31%
RESIDENTIAL	A	RAINGARDEN	0.5	RAINGARDEN0.5	15%	46%
RESIDENTIAL	A	RAINGARDEN	0.75	RAINGARDEN0.75	7%	55%
RESIDENTIAL	A	RAINGARDEN	1	RAINGARDEN1	4%	62%
RESIDENTIAL	A	RAINGARDEN	1.25	RAINGARDEN1.25	3%	65%
RESIDENTIAL	A	RAINGARDEN	1.5	RAINGARDEN1.5	2%	67%
RESIDENTIAL	B	RAINGARDEN	0.25	RAINGARDEN0.25	51%	8%
RESIDENTIAL	B	RAINGARDEN	0.5	RAINGARDEN0.5	38%	14%
RESIDENTIAL	B	RAINGARDEN	0.75	RAINGARDEN0.75	29%	19%
RESIDENTIAL	B	RAINGARDEN	1	RAINGARDEN1	22%	23%
RESIDENTIAL	B	RAINGARDEN	1.25	RAINGARDEN1.25	17%	27%
RESIDENTIAL	B	RAINGARDEN	1.5	RAINGARDEN1.5	13%	30%
RESIDENTIAL	C	RAINGARDEN	0.25	RAINGARDEN0.25	58%	0%
RESIDENTIAL	C	RAINGARDEN	0.5	RAINGARDEN0.5	47%	1%
RESIDENTIAL	C	RAINGARDEN	0.75	RAINGARDEN0.75	39%	2%
RESIDENTIAL	C	RAINGARDEN	1	RAINGARDEN1	33%	3%
RESIDENTIAL	C	RAINGARDEN	1.25	RAINGARDEN1.25	28%	4%
RESIDENTIAL	C	RAINGARDEN	1.5	RAINGARDEN1.5	25%	4%
RESIDENTIAL	D	RAINGARDEN	0.25	RAINGARDEN0.25	58%	0%
RESIDENTIAL	D	RAINGARDEN	0.5	RAINGARDEN0.5	48%	0%
RESIDENTIAL	D	RAINGARDEN	0.75	RAINGARDEN0.75	40%	1%
RESIDENTIAL	D	RAINGARDEN	1	RAINGARDEN1	34%	1%
RESIDENTIAL	D	RAINGARDEN	1.25	RAINGARDEN1.25	29%	1%
RESIDENTIAL	D	RAINGARDEN	1.5	RAINGARDEN1.5	26%	2%
RESIDENTIAL	I	HE BIORETENTION	0.25	HE BIORETENTION0.25	30%	6%
RESIDENTIAL	I	HE BIORETENTION	0.5	HE BIORETENTION0.5	21%	11%
RESIDENTIAL	I	HE BIORETENTION	0.75	HE BIORETENTION0.75	15%	15%
RESIDENTIAL	I	HE BIORETENTION	1	HE BIORETENTION1	11%	18%
RESIDENTIAL	I	HE BIORETENTION	1.25	HE BIORETENTION1.25	8%	21%
RESIDENTIAL	I	HE BIORETENTION	1.5	HE BIORETENTION1.5	7%	23%
RESIDENTIAL	R	HE BIORETENTION	0.25	HE BIORETENTION0.25	30%	3%
RESIDENTIAL	R	HE BIORETENTION	0.5	HE BIORETENTION0.5	21%	5%
RESIDENTIAL	R	HE BIORETENTION	0.75	HE BIORETENTION0.75	15%	8%
RESIDENTIAL	R	HE BIORETENTION	1	HE BIORETENTION1	11%	10%
RESIDENTIAL	R	HE BIORETENTION	1.25	HE BIORETENTION1.25	8%	12%
RESIDENTIAL	R	HE BIORETENTION	1.5	HE BIORETENTION1.5	7%	13%
RESIDENTIAL	A	HE BIORETENTION	0.25	HE BIORETENTION0.25	20%	19%
RESIDENTIAL	A	HE BIORETENTION	0.5	HE BIORETENTION0.5	9%	28%
RESIDENTIAL	A	HE BIORETENTION	0.75	HE BIORETENTION0.75	4%	34%
RESIDENTIAL	A	HE BIORETENTION	1	HE BIORETENTION1	3%	38%
RESIDENTIAL	A	HE BIORETENTION	1.25	HE BIORETENTION1.25	2%	40%
RESIDENTIAL	A	HE BIORETENTION	1.5	HE BIORETENTION1.5	1%	41%
RESIDENTIAL	B	HE BIORETENTION	0.25	HE BIORETENTION0.25	32%	5%
RESIDENTIAL	B	HE BIORETENTION	0.5	HE BIORETENTION0.5	24%	9%
RESIDENTIAL	B	HE BIORETENTION	0.75	HE BIORETENTION0.75	18%	12%
RESIDENTIAL	B	HE BIORETENTION	1	HE BIORETENTION1	14%	14%
RESIDENTIAL	B	HE BIORETENTION	1.25	HE BIORETENTION1.25	11%	17%
RESIDENTIAL	B	HE BIORETENTION	1.5	HE BIORETENTION1.5	9%	19%
RESIDENTIAL	C	HE BIORETENTION	0.25	HE BIORETENTION0.25	36%	0%
RESIDENTIAL	C	HE BIORETENTION	0.5	HE BIORETENTION0.5	29%	1%
RESIDENTIAL	C	HE BIORETENTION	0.75	HE BIORETENTION0.75	24%	1%
RESIDENTIAL	C	HE BIORETENTION	1	HE BIORETENTION1	21%	2%
RESIDENTIAL	C	HE BIORETENTION	1.25	HE BIORETENTION1.25	18%	2%
RESIDENTIAL	C	HE BIORETENTION	1.5	HE BIORETENTION1.5	16%	3%
RESIDENTIAL	D	HE BIORETENTION	0.25	HE BIORETENTION0.25	36%	0%
RESIDENTIAL	D	HE BIORETENTION	0.5	HE BIORETENTION0.5	30%	0%
RESIDENTIAL	D	HE BIORETENTION	0.75	HE BIORETENTION0.75	25%	1%
RESIDENTIAL	D	HE BIORETENTION	1	HE BIORETENTION1	22%	1%
RESIDENTIAL	D	HE BIORETENTION	1.25	HE BIORETENTION1.25	19%	1%
RESIDENTIAL	D	HE BIORETENTION	1.5	HE BIORETENTION1.5	17%	1%
RESIDENTIAL	R	DRY WELL	0.25	DRY WELLO.25	20%	80%
RESIDENTIAL	R	DRY WELL	0.5	DRY WELLO.5	5%	95%
RESIDENTIAL	R	DRY WELL	0.75	DRY WELLO.75	1%	99%

RESIDENTIAL	R	DRY WELL	1	DRY WELL1	0%	100%
RESIDENTIAL	R	DRY WELL	1.25	DRY WELL1.25	0%	100%
RESIDENTIAL	R	DRY WELL	1.5	DRY WELL1.5	0%	100%
RESIDENTIAL	I	RED PERMEABLE PAVEMENT 18 RES		RED PERMEABLE PAVEMENT 18 RES	1%	75%
COMMERCIAL	I	BIORETENTION	0.25	BIORETENTION0.25	48%	5%
COMMERCIAL	I	BIORETENTION	0.5	BIORETENTION0.5	33%	9%
COMMERCIAL	I	BIORETENTION	0.75	BIORETENTION0.75	24%	12%
COMMERCIAL	I	BIORETENTION	1	BIORETENTION1	17%	15%
COMMERCIAL	I	BIORETENTION	1.25	BIORETENTION1.25	13%	18%
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COMMERCIAL	R	BIORETENTION	0.25	BIORETENTION0.25	49%	10%
COMMERCIAL	R	BIORETENTION	0.5	BIORETENTION0.5	34%	18%
COMMERCIAL	R	BIORETENTION	0.75	BIORETENTION0.75	24%	24%
COMMERCIAL	R	BIORETENTION	1	BIORETENTION1	18%	30%
COMMERCIAL	R	BIORETENTION	1.25	BIORETENTION1.25	13%	34%
COMMERCIAL	R	BIORETENTION	1.5	BIORETENTION1.5	11%	37%
COMMERCIAL	A	BIORETENTION	0.25	BIORETENTION0.25	32%	31%
COMMERCIAL	A	BIORETENTION	0.5	BIORETENTION0.5	15%	46%
COMMERCIAL	A	BIORETENTION	0.75	BIORETENTION0.75	7%	55%
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COMMERCIAL	B	BIORETENTION	0.25	BIORETENTION0.25	51%	8%
COMMERCIAL	B	BIORETENTION	0.5	BIORETENTION0.5	38%	14%
COMMERCIAL	B	BIORETENTION	0.75	BIORETENTION0.75	29%	19%
COMMERCIAL	B	BIORETENTION	1	BIORETENTION1	22%	23%
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COMMERCIAL	C	BIORETENTION	0.75	BIORETENTION0.75	39%	2%
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COMMERCIAL	D	BIORETENTION	0.75	BIORETENTION0.75	40%	1%
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COMMERCIAL	I	HE BIORETENTION	0.25	HE BIORETENTION0.25	30%	3%
COMMERCIAL	I	HE BIORETENTION	0.5	HE BIORETENTION0.5	21%	5%
COMMERCIAL	I	HE BIORETENTION	0.75	HE BIORETENTION0.75	15%	8%
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COMMERCIAL	I	HE BIORETENTION	1.25	HE BIORETENTION1.25	8%	12%
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COMMERCIAL	R	HE BIORETENTION	0.25	HE BIORETENTION0.25	30%	6%
COMMERCIAL	R	HE BIORETENTION	0.5	HE BIORETENTION0.5	21%	11%
COMMERCIAL	R	HE BIORETENTION	0.75	HE BIORETENTION0.75	15%	15%
COMMERCIAL	R	HE BIORETENTION	1	HE BIORETENTION1	11%	18%
COMMERCIAL	R	HE BIORETENTION	1.25	HE BIORETENTION1.25	8%	21%
COMMERCIAL	R	HE BIORETENTION	1.5	HE BIORETENTION1.5	7%	23%
COMMERCIAL	A	HE BIORETENTION	0.25	HE BIORETENTION0.25	20%	19%
COMMERCIAL	A	HE BIORETENTION	0.5	HE BIORETENTION0.5	9%	28%
COMMERCIAL	A	HE BIORETENTION	0.75	HE BIORETENTION0.75	4%	34%
COMMERCIAL	A	HE BIORETENTION	1	HE BIORETENTION1	3%	38%
COMMERCIAL	A	HE BIORETENTION	1.25	HE BIORETENTION1.25	2%	40%
COMMERCIAL	A	HE BIORETENTION	1.5	HE BIORETENTION1.5	1%	41%
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COMMERCIAL	B	HE BIORETENTION	1	HE BIORETENTION1	14%	14%
COMMERCIAL	B	HE BIORETENTION	1.25	HE BIORETENTION1.25	11%	17%
COMMERCIAL	B	HE BIORETENTION	1.5	HE BIORETENTION1.5	9%	19%
COMMERCIAL	C	HE BIORETENTION	0.25	HE BIORETENTION0.25	36%	0%
COMMERCIAL	C	HE BIORETENTION	0.5	HE BIORETENTION0.5	29%	1%
COMMERCIAL	C	HE BIORETENTION	0.75	HE BIORETENTION0.75	24%	1%
COMMERCIAL	C	HE BIORETENTION	1	HE BIORETENTION1	21%	2%
COMMERCIAL	C	HE BIORETENTION	1.25	HE BIORETENTION1.25	18%	2%
COMMERCIAL	C	HE BIORETENTION	1.5	HE BIORETENTION1.5	16%	3%
COMMERCIAL	D	HE BIORETENTION	0.25	HE BIORETENTION0.25	36%	0%
COMMERCIAL	D	HE BIORETENTION	0.5	HE BIORETENTION0.5	30%	0%
COMMERCIAL	D	HE BIORETENTION	0.75	HE BIORETENTION0.75	25%	1%
COMMERCIAL	D	HE BIORETENTION	1	HE BIORETENTION1	22%	1%
COMMERCIAL	D	HE BIORETENTION	1.25	HE BIORETENTION1.25	19%	1%
COMMERCIAL	D	HE BIORETENTION	1.5	HE BIORETENTION1.5	17%	1%

COMMERCIAL	I	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	20%	0%
COMMERCIAL	I	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	16%	0%
COMMERCIAL	I	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	13%	0%
COMMERCIAL	I	GRAVEL WETLAND	1	GRAVEL WETLAND1	11%	0%
COMMERCIAL	I	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	10%	0%
COMMERCIAL	I	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	8%	0%
COMMERCIAL	A	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	18%	0%
COMMERCIAL	A	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	14%	0%
COMMERCIAL	A	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	11%	0%
COMMERCIAL	A	GRAVEL WETLAND	1	GRAVEL WETLAND1	9%	0%
COMMERCIAL	A	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	7%	0%
COMMERCIAL	A	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	6%	0%
COMMERCIAL	B	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	20%	0%
COMMERCIAL	B	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	16%	0%
COMMERCIAL	B	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	13%	0%
COMMERCIAL	B	GRAVEL WETLAND	1	GRAVEL WETLAND1	11%	0%
COMMERCIAL	B	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	9%	0%
COMMERCIAL	B	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	8%	0%
COMMERCIAL	C	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
COMMERCIAL	C	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	17%	0%
COMMERCIAL	C	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	15%	0%
COMMERCIAL	C	GRAVEL WETLAND	1	GRAVEL WETLAND1	12%	0%
COMMERCIAL	C	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	11%	0%
COMMERCIAL	C	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	9%	0%
COMMERCIAL	D	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
COMMERCIAL	D	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	18%	0%
COMMERCIAL	D	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	15%	0%
COMMERCIAL	D	GRAVEL WETLAND	1	GRAVEL WETLAND1	13%	0%
COMMERCIAL	D	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	11%	0%
COMMERCIAL	D	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	10%	0%
COMMERCIAL	R	DRY WELL	0.25	DRY WELL0.25	12%	88%
COMMERCIAL	R	DRY WELL	0.5	DRY WELL0.5	3%	98%
COMMERCIAL	R	DRY WELL	0.75	DRY WELL0.75	1%	99%
COMMERCIAL	R	DRY WELL	1	DRY WELL1	0%	100%
COMMERCIAL	R	DRY WELL	1.25	DRY WELL1.25	0%	100%
COMMERCIAL	R	DRY WELL	1.5	DRY WELL1.5	0%	100%
COMMERCIAL	I	RED PERMEABLE PAVEMENT 24 COM 1		RED PERMEABLE PAVEMENT 24 COM 1	1%	59%
COMMERCIAL	I	RED PERMEABLE PAVEMENT 24 COM 4		RED PERMEABLE PAVEMENT 24 COM 4	2%	50%
COMMERCIAL	A	WET POND	0.25	WET POND0.25	47%	0%
COMMERCIAL	A	WET POND	0.5	WET POND0.5	29%	0%
COMMERCIAL	A	WET POND	0.75	WET POND0.75	24%	0%
COMMERCIAL	A	WET POND	1	WET POND1	21%	0%
COMMERCIAL	A	WET POND	1.25	WET POND1.25	18%	0%
COMMERCIAL	A	WET POND	1.5	WET POND1.5	15%	0%
COMMERCIAL	B	WET POND	0.25	WET POND0.25	52%	0%
COMMERCIAL	B	WET POND	0.5	WET POND0.5	34%	0%
COMMERCIAL	B	WET POND	0.75	WET POND0.75	27%	0%
COMMERCIAL	B	WET POND	1	WET POND1	23%	0%
COMMERCIAL	B	WET POND	1.25	WET POND1.25	19%	0%
COMMERCIAL	B	WET POND	1.5	WET POND1.5	17%	0%
COMMERCIAL	C	WET POND	0.25	WET POND0.25	53%	0%
COMMERCIAL	C	WET POND	0.5	WET POND0.5	35%	0%
COMMERCIAL	C	WET POND	0.75	WET POND0.75	29%	0%
COMMERCIAL	C	WET POND	1	WET POND1	24%	0%
COMMERCIAL	C	WET POND	1.25	WET POND1.25	20%	0%
COMMERCIAL	C	WET POND	1.5	WET POND1.5	18%	0%
COMMERCIAL	D	WET POND	0.25	WET POND0.25	54%	0%
COMMERCIAL	D	WET POND	0.5	WET POND0.5	36%	0%
COMMERCIAL	D	WET POND	0.75	WET POND0.75	29%	0%
COMMERCIAL	D	WET POND	1	WET POND1	25%	0%
COMMERCIAL	D	WET POND	1.25	WET POND1.25	21%	0%
COMMERCIAL	D	WET POND	1.5	WET POND1.5	18%	0%
COMMERCIAL	I	WET POND	0.25	WET POND0.25	41%	0%
COMMERCIAL	I	WET POND	0.5	WET POND0.5	27%	0%
COMMERCIAL	I	WET POND	0.75	WET POND0.75	21%	0%
COMMERCIAL	I	WET POND	1	WET POND1	17%	0%
COMMERCIAL	I	WET POND	1.25	WET POND1.25	14%	0%
COMMERCIAL	I	WET POND	1.5	WET POND1.5	12%	0%
COMMERCIAL	R	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	59%	41%
COMMERCIAL	R	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	34%	66%
COMMERCIAL	R	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	20%	80%
COMMERCIAL	R	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	13%	87%
COMMERCIAL	R	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	8%	92%
COMMERCIAL	R	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	5%	94%
COMMERCIAL	I	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	67%	33%
COMMERCIAL	I	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	42%	58%

COMMERCIAL	I	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	27%	73%
COMMERCIAL	I	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	18%	82%
COMMERCIAL	I	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	12%	88%
COMMERCIAL	I	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	9%	91%
COMMERCIAL	A	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	40%	60%
COMMERCIAL	A	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	19%	81%
COMMERCIAL	A	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	7%	93%
COMMERCIAL	A	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	0%	100%
COMMERCIAL	A	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	0%	100%
COMMERCIAL	A	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	0%	100%
COMMERCIAL	B	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	63%	36%
COMMERCIAL	B	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	42%	58%
COMMERCIAL	B	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	31%	69%
COMMERCIAL	B	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	23%	77%
COMMERCIAL	B	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	17%	83%
COMMERCIAL	B	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	13%	87%
COMMERCIAL	C	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	77%	0%
COMMERCIAL	C	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	60%	39%
COMMERCIAL	C	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	47%	52%
COMMERCIAL	C	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	37%	61%
COMMERCIAL	C	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	29%	69%
COMMERCIAL	C	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	23%	75%
COMMERCIAL	D	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	85%	0%
COMMERCIAL	D	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	70%	0%
COMMERCIAL	D	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	59%	0%
COMMERCIAL	D	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	49%	48%
COMMERCIAL	D	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	40%	57%
COMMERCIAL	D	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	32%	65%
COMMERCIAL	I	SAND FILTER	0.25	SAND FILTER0.25	45%	3%
COMMERCIAL	I	SAND FILTER	0.5	SAND FILTER0.5	28%	5%
COMMERCIAL	I	SAND FILTER	0.75	SAND FILTER0.75	19%	8%
COMMERCIAL	I	SAND FILTER	1	SAND FILTER1	14%	10%
COMMERCIAL	I	SAND FILTER	1.25	SAND FILTER1.25	11%	12%
COMMERCIAL	I	SAND FILTER	1.5	SAND FILTER1.5	8%	13%
COMMERCIAL	A	SAND FILTER	0.25	SAND FILTER0.25	38%	24%
COMMERCIAL	A	SAND FILTER	0.5	SAND FILTER0.5	21%	35%
COMMERCIAL	A	SAND FILTER	0.75	SAND FILTER0.75	12%	44%
COMMERCIAL	A	SAND FILTER	1	SAND FILTER1	7%	51%
COMMERCIAL	A	SAND FILTER	1.25	SAND FILTER1.25	5%	57%
COMMERCIAL	A	SAND FILTER	1.5	SAND FILTER1.5	5%	60%
COMMERCIAL	B	SAND FILTER	0.25	SAND FILTER0.25	52%	5%
COMMERCIAL	B	SAND FILTER	0.5	SAND FILTER0.5	36%	10%
COMMERCIAL	B	SAND FILTER	0.75	SAND FILTER0.75	26%	13%
COMMERCIAL	B	SAND FILTER	1	SAND FILTER1	19%	16%
COMMERCIAL	B	SAND FILTER	1.25	SAND FILTER1.25	15%	18%
COMMERCIAL	B	SAND FILTER	1.5	SAND FILTER1.5	13%	21%
COMMERCIAL	C	SAND FILTER	0.25	SAND FILTER0.25	56%	0%
COMMERCIAL	C	SAND FILTER	0.5	SAND FILTER0.5	41%	0%
COMMERCIAL	C	SAND FILTER	0.75	SAND FILTER0.75	33%	1%
COMMERCIAL	C	SAND FILTER	1	SAND FILTER1	26%	2%
COMMERCIAL	C	SAND FILTER	1.25	SAND FILTER1.25	22%	2%
COMMERCIAL	C	SAND FILTER	1.5	SAND FILTER1.5	19%	3%
COMMERCIAL	D	SAND FILTER	0.25	SAND FILTER0.25	57%	0%
COMMERCIAL	D	SAND FILTER	0.5	SAND FILTER0.5	42%	0%
COMMERCIAL	D	SAND FILTER	0.75	SAND FILTER0.75	33%	0%
COMMERCIAL	D	SAND FILTER	1	SAND FILTER1	27%	0%
COMMERCIAL	D	SAND FILTER	1.25	SAND FILTER1.25	23%	1%
COMMERCIAL	D	SAND FILTER	1.5	SAND FILTER1.5	19%	1%
COMMERCIAL	I	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	53%	5%
COMMERCIAL	I	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	36%	9%
COMMERCIAL	I	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	26%	13%
COMMERCIAL	I	TREE BOX FILTER	1	TREE BOX FILTER1	19%	17%
COMMERCIAL	A	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	35%	34%
COMMERCIAL	A	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	17%	50%
COMMERCIAL	A	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	7%	62%
COMMERCIAL	A	TREE BOX FILTER	1	TREE BOX FILTER1	5%	69%
COMMERCIAL	B	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	57%	9%
COMMERCIAL	B	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	42%	15%
COMMERCIAL	B	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	31%	21%
COMMERCIAL	B	TREE BOX FILTER	1	TREE BOX FILTER1	24%	25%
COMMERCIAL	C	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	63%	0%
COMMERCIAL	C	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	51%	2%
COMMERCIAL	C	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	42%	2%
COMMERCIAL	C	TREE BOX FILTER	1	TREE BOX FILTER1	36%	3%
COMMERCIAL	D	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	64%	0%
COMMERCIAL	D	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	52%	0%

COMMERCIAL	D	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	44%	1%
COMMERCIAL	D	TREE BOX FILTER	1	TREE BOX FILTER1	37%	1%
INSTITUTIONAL	I	WET POND	0.25	WET POND0.25	49%	0%
INSTITUTIONAL	I	WET POND	0.5	WET POND0.5	40%	0%
INSTITUTIONAL	I	WET POND	0.75	WET POND0.75	35%	0%
INSTITUTIONAL	I	WET POND	1	WET POND1	33%	0%
INSTITUTIONAL	I	WET POND	1.25	WET POND1.25	31%	0%
INSTITUTIONAL	I	WET POND	1.5	WET POND1.5	29%	0%
INSTITUTIONAL	A	WET POND	0.25	WET POND0.25	46%	0%
INSTITUTIONAL	A	WET POND	0.5	WET POND0.5	27%	0%
INSTITUTIONAL	A	WET POND	0.75	WET POND0.75	21%	0%
INSTITUTIONAL	A	WET POND	1	WET POND1	18%	0%
INSTITUTIONAL	A	WET POND	1.25	WET POND1.25	16%	0%
INSTITUTIONAL	A	WET POND	1.5	WET POND1.5	13%	0%
INSTITUTIONAL	B	WET POND	0.25	WET POND0.25	52%	0%
INSTITUTIONAL	B	WET POND	0.5	WET POND0.5	32%	0%
INSTITUTIONAL	B	WET POND	0.75	WET POND0.75	24%	0%
INSTITUTIONAL	B	WET POND	1	WET POND1	20%	0%
INSTITUTIONAL	B	WET POND	1.25	WET POND1.25	16%	0%
INSTITUTIONAL	B	WET POND	1.5	WET POND1.5	13%	0%
INSTITUTIONAL	C	WET POND	0.25	WET POND0.25	53%	0%
INSTITUTIONAL	C	WET POND	0.5	WET POND0.5	34%	0%
INSTITUTIONAL	C	WET POND	0.75	WET POND0.75	26%	0%
INSTITUTIONAL	C	WET POND	1	WET POND1	21%	0%
INSTITUTIONAL	C	WET POND	1.25	WET POND1.25	17%	0%
INSTITUTIONAL	C	WET POND	1.5	WET POND1.5	15%	0%
INSTITUTIONAL	D	WET POND	0.25	WET POND0.25	54%	0%
INSTITUTIONAL	D	WET POND	0.5	WET POND0.5	35%	0%
INSTITUTIONAL	D	WET POND	0.75	WET POND0.75	27%	0%
INSTITUTIONAL	D	WET POND	1	WET POND1	22%	0%
INSTITUTIONAL	D	WET POND	1.25	WET POND1.25	18%	0%
INSTITUTIONAL	D	WET POND	1.5	WET POND1.5	15%	0%
INSTITUTIONAL	I	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
INSTITUTIONAL	I	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	18%	0%
INSTITUTIONAL	I	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	16%	0%
INSTITUTIONAL	I	GRAVEL WETLAND	1	GRAVEL WETLAND1	15%	0%
INSTITUTIONAL	I	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	14%	0%
INSTITUTIONAL	I	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	13%	0%
INSTITUTIONAL	A	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	18%	0%
INSTITUTIONAL	A	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	14%	0%
INSTITUTIONAL	A	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	11%	0%
INSTITUTIONAL	A	GRAVEL WETLAND	1	GRAVEL WETLAND1	9%	0%
INSTITUTIONAL	A	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	7%	0%
INSTITUTIONAL	A	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	6%	0%
INSTITUTIONAL	B	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
INSTITUTIONAL	B	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	16%	0%
INSTITUTIONAL	B	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	13%	0%
INSTITUTIONAL	B	GRAVEL WETLAND	1	GRAVEL WETLAND1	11%	0%
INSTITUTIONAL	B	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	9%	0%
INSTITUTIONAL	B	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	7%	0%
INSTITUTIONAL	C	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
INSTITUTIONAL	C	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	18%	0%
INSTITUTIONAL	C	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	15%	0%
INSTITUTIONAL	C	GRAVEL WETLAND	1	GRAVEL WETLAND1	12%	0%
INSTITUTIONAL	C	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	10%	0%
INSTITUTIONAL	C	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	9%	0%
INSTITUTIONAL	D	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
INSTITUTIONAL	D	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	18%	0%
INSTITUTIONAL	D	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	15%	0%
INSTITUTIONAL	D	GRAVEL WETLAND	1	GRAVEL WETLAND1	13%	0%
INSTITUTIONAL	D	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	11%	0%
INSTITUTIONAL	D	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	10%	0%
INSTITUTIONAL	I	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	59%	41%
INSTITUTIONAL	I	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	34%	66%
INSTITUTIONAL	I	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	20%	80%
INSTITUTIONAL	I	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	13%	87%
INSTITUTIONAL	I	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	8%	92%
INSTITUTIONAL	I	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	5%	94%
INSTITUTIONAL	R	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	59%	41%
INSTITUTIONAL	R	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	34%	66%
INSTITUTIONAL	R	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	20%	80%
INSTITUTIONAL	R	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	13%	87%
INSTITUTIONAL	R	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	8%	92%
INSTITUTIONAL	R	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	5%	94%
INSTITUTIONAL	A	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	46%	54%
INSTITUTIONAL	A	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	22%	78%

INSTITUTIONAL	A	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	8%	92%
INSTITUTIONAL	A	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	0%	100%
INSTITUTIONAL	A	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	0%	100%
INSTITUTIONAL	A	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	0%	100%
INSTITUTIONAL	B	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	69%	31%
INSTITUTIONAL	B	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	48%	52%
INSTITUTIONAL	B	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	35%	65%
INSTITUTIONAL	B	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	26%	74%
INSTITUTIONAL	B	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	20%	80%
INSTITUTIONAL	B	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	15%	85%
INSTITUTIONAL	C	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	81%	0%
INSTITUTIONAL	C	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	65%	34%
INSTITUTIONAL	C	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	51%	47%
INSTITUTIONAL	C	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	41%	57%
INSTITUTIONAL	C	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	33%	66%
INSTITUTIONAL	C	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	27%	72%
INSTITUTIONAL	D	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	87%	0%
INSTITUTIONAL	D	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	74%	0%
INSTITUTIONAL	D	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	63%	0%
INSTITUTIONAL	D	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	53%	45%
INSTITUTIONAL	D	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	44%	54%
INSTITUTIONAL	D	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	36%	62%
INSTITUTIONAL	I	SAND FILTER	0.25	SAND FILTER0.25	51%	7%
INSTITUTIONAL	I	SAND FILTER	0.5	SAND FILTER0.5	34%	14%
INSTITUTIONAL	I	SAND FILTER	0.75	SAND FILTER0.75	25%	20%
INSTITUTIONAL	I	SAND FILTER	1	SAND FILTER1	19%	25%
INSTITUTIONAL	I	SAND FILTER	1.25	SAND FILTER1.25	15%	28%
INSTITUTIONAL	I	SAND FILTER	1.5	SAND FILTER1.5	12%	31%
INSTITUTIONAL	A	SAND FILTER	0.25	SAND FILTER0.25	39%	18%
INSTITUTIONAL	A	SAND FILTER	0.5	SAND FILTER0.5	21%	29%
INSTITUTIONAL	A	SAND FILTER	0.75	SAND FILTER0.75	12%	37%
INSTITUTIONAL	A	SAND FILTER	1	SAND FILTER1	6%	45%
INSTITUTIONAL	A	SAND FILTER	1.25	SAND FILTER1.25	5%	51%
INSTITUTIONAL	A	SAND FILTER	1.5	SAND FILTER1.5	4%	56%
INSTITUTIONAL	B	SAND FILTER	0.25	SAND FILTER0.25	52%	4%
INSTITUTIONAL	B	SAND FILTER	0.5	SAND FILTER0.5	35%	7%
INSTITUTIONAL	B	SAND FILTER	0.75	SAND FILTER0.75	25%	9%
INSTITUTIONAL	B	SAND FILTER	1	SAND FILTER1	18%	11%
INSTITUTIONAL	B	SAND FILTER	1.25	SAND FILTER1.25	14%	13%
INSTITUTIONAL	B	SAND FILTER	1.5	SAND FILTER1.5	12%	15%
INSTITUTIONAL	C	SAND FILTER	0.25	SAND FILTER0.25	56%	0%
INSTITUTIONAL	C	SAND FILTER	0.5	SAND FILTER0.5	40%	0%
INSTITUTIONAL	C	SAND FILTER	0.75	SAND FILTER0.75	30%	1%
INSTITUTIONAL	C	SAND FILTER	1	SAND FILTER1	23%	1%
INSTITUTIONAL	C	SAND FILTER	1.25	SAND FILTER1.25	18%	1%
INSTITUTIONAL	C	SAND FILTER	1.5	SAND FILTER1.5	15%	2%
INSTITUTIONAL	D	SAND FILTER	0.25	SAND FILTER0.25	57%	0%
INSTITUTIONAL	D	SAND FILTER	0.5	SAND FILTER0.5	41%	0%
INSTITUTIONAL	D	SAND FILTER	0.75	SAND FILTER0.75	31%	0%
INSTITUTIONAL	D	SAND FILTER	1	SAND FILTER1	24%	0%
INSTITUTIONAL	D	SAND FILTER	1.25	SAND FILTER1.25	19%	1%
INSTITUTIONAL	D	SAND FILTER	1.5	SAND FILTER1.5	16%	1%
INSTITUTIONAL	I	BIORETENTION	0.25	BIORETENTION0.25	49%	10%
INSTITUTIONAL	I	BIORETENTION	0.5	BIORETENTION0.5	34%	18%
INSTITUTIONAL	I	BIORETENTION	0.75	BIORETENTION0.75	24%	24%
INSTITUTIONAL	I	BIORETENTION	1	BIORETENTION1	18%	30%
INSTITUTIONAL	I	BIORETENTION	1.25	BIORETENTION1.25	13%	34%
INSTITUTIONAL	I	BIORETENTION	1.5	BIORETENTION1.5	11%	37%
INSTITUTIONAL	R	BIORETENTION	0.25	BIORETENTION0.25	49%	10%
INSTITUTIONAL	R	BIORETENTION	0.5	BIORETENTION0.5	34%	18%
INSTITUTIONAL	R	BIORETENTION	0.75	BIORETENTION0.75	24%	24%
INSTITUTIONAL	R	BIORETENTION	1	BIORETENTION1	18%	30%
INSTITUTIONAL	R	BIORETENTION	1.25	BIORETENTION1.25	13%	34%
INSTITUTIONAL	R	BIORETENTION	1.5	BIORETENTION1.5	11%	37%
INSTITUTIONAL	A	BIORETENTION	0.25	BIORETENTION0.25	35%	26%
INSTITUTIONAL	A	BIORETENTION	0.5	BIORETENTION0.5	17%	40%
INSTITUTIONAL	A	BIORETENTION	0.75	BIORETENTION0.75	7%	52%
INSTITUTIONAL	A	BIORETENTION	1	BIORETENTION1	4%	59%
INSTITUTIONAL	A	BIORETENTION	1.25	BIORETENTION1.25	3%	63%
INSTITUTIONAL	A	BIORETENTION	1.5	BIORETENTION1.5	2%	66%
INSTITUTIONAL	B	BIORETENTION	0.25	BIORETENTION0.25	53%	6%
INSTITUTIONAL	B	BIORETENTION	0.5	BIORETENTION0.5	40%	10%
INSTITUTIONAL	B	BIORETENTION	0.75	BIORETENTION0.75	30%	15%
INSTITUTIONAL	B	BIORETENTION	1	BIORETENTION1	23%	18%
INSTITUTIONAL	B	BIORETENTION	1.25	BIORETENTION1.25	18%	21%
INSTITUTIONAL	B	BIORETENTION	1.5	BIORETENTION1.5	13%	24%



INSTITUTIONAL	C	BIORETENTION	0.25	BIORETENTION0.25	58%	0%
INSTITUTIONAL	C	BIORETENTION	0.5	BIORETENTION0.5	47%	1%
INSTITUTIONAL	C	BIORETENTION	0.75	BIORETENTION0.75	38%	1%
INSTITUTIONAL	C	BIORETENTION	1	BIORETENTION1	32%	2%
INSTITUTIONAL	C	BIORETENTION	1.25	BIORETENTION1.25	27%	2%
INSTITUTIONAL	C	BIORETENTION	1.5	BIORETENTION1.5	23%	3%
INSTITUTIONAL	D	BIORETENTION	0.25	BIORETENTION0.25	59%	0%
INSTITUTIONAL	D	BIORETENTION	0.5	BIORETENTION0.5	48%	0%
INSTITUTIONAL	D	BIORETENTION	0.75	BIORETENTION0.75	40%	1%
INSTITUTIONAL	D	BIORETENTION	1	BIORETENTION1	33%	1%
INSTITUTIONAL	D	BIORETENTION	1.25	BIORETENTION1.25	28%	1%
INSTITUTIONAL	D	BIORETENTION	1.5	BIORETENTION1.5	24%	1%
INSTITUTIONAL	I	HE BIORETENTION	0.25	HE BIORETENTION0.25	30%	6%
INSTITUTIONAL	I	HE BIORETENTION	0.5	HE BIORETENTION0.5	21%	11%
INSTITUTIONAL	I	HE BIORETENTION	0.75	HE BIORETENTION0.75	15%	15%
INSTITUTIONAL	I	HE BIORETENTION	1	HE BIORETENTION1	11%	18%
INSTITUTIONAL	I	HE BIORETENTION	1.25	HE BIORETENTION1.25	8%	21%
INSTITUTIONAL	I	HE BIORETENTION	1.5	HE BIORETENTION1.5	7%	23%
INSTITUTIONAL	R	HE BIORETENTION	0.25	HE BIORETENTION0.25	30%	6%
INSTITUTIONAL	R	HE BIORETENTION	0.5	HE BIORETENTION0.5	21%	11%
INSTITUTIONAL	R	HE BIORETENTION	0.75	HE BIORETENTION0.75	15%	15%
INSTITUTIONAL	R	HE BIORETENTION	1	HE BIORETENTION1	11%	18%
INSTITUTIONAL	R	HE BIORETENTION	1.25	HE BIORETENTION1.25	8%	21%
INSTITUTIONAL	R	HE BIORETENTION	1.5	HE BIORETENTION1.5	7%	23%
INSTITUTIONAL	A	HE BIORETENTION	0.25	HE BIORETENTION0.25	22%	16%
INSTITUTIONAL	A	HE BIORETENTION	0.5	HE BIORETENTION0.5	10%	25%
INSTITUTIONAL	A	HE BIORETENTION	0.75	HE BIORETENTION0.75	4%	32%
INSTITUTIONAL	A	HE BIORETENTION	1	HE BIORETENTION1	3%	36%
INSTITUTIONAL	A	HE BIORETENTION	1.25	HE BIORETENTION1.25	2%	39%
INSTITUTIONAL	A	HE BIORETENTION	1.5	HE BIORETENTION1.5	1%	40%
INSTITUTIONAL	B	HE BIORETENTION	0.25	HE BIORETENTION0.25	33%	4%
INSTITUTIONAL	B	HE BIORETENTION	0.5	HE BIORETENTION0.5	25%	7%
INSTITUTIONAL	B	HE BIORETENTION	0.75	HE BIORETENTION0.75	19%	9%
INSTITUTIONAL	B	HE BIORETENTION	1	HE BIORETENTION1	15%	11%
INSTITUTIONAL	B	HE BIORETENTION	1.25	HE BIORETENTION1.25	11%	13%
INSTITUTIONAL	B	HE BIORETENTION	1.5	HE BIORETENTION1.5	9%	15%
INSTITUTIONAL	C	HE BIORETENTION	0.25	HE BIORETENTION0.25	36%	0%
INSTITUTIONAL	C	HE BIORETENTION	0.5	HE BIORETENTION0.5	30%	1%
INSTITUTIONAL	C	HE BIORETENTION	0.75	HE BIORETENTION0.75	25%	1%
INSTITUTIONAL	C	HE BIORETENTION	1	HE BIORETENTION1	21%	1%
INSTITUTIONAL	C	HE BIORETENTION	1.25	HE BIORETENTION1.25	18%	2%
INSTITUTIONAL	C	HE BIORETENTION	1.5	HE BIORETENTION1.5	15%	2%
INSTITUTIONAL	D	HE BIORETENTION	0.25	HE BIORETENTION0.25	37%	0%
INSTITUTIONAL	D	HE BIORETENTION	0.5	HE BIORETENTION0.5	30%	0%
INSTITUTIONAL	D	HE BIORETENTION	0.75	HE BIORETENTION0.75	25%	0%
INSTITUTIONAL	D	HE BIORETENTION	1	HE BIORETENTION1	21%	0%
INSTITUTIONAL	D	HE BIORETENTION	1.25	HE BIORETENTION1.25	18%	1%
INSTITUTIONAL	D	HE BIORETENTION	1.5	HE BIORETENTION1.5	16%	1%
INSTITUTIONAL	I	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	54%	11%
INSTITUTIONAL	I	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	37%	20%
INSTITUTIONAL	I	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	26%	27%
INSTITUTIONAL	I	TREE BOX FILTER	1	TREE BOX FILTER1	19%	33%
INSTITUTIONAL	A	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	38%	28%
INSTITUTIONAL	A	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	18%	45%
INSTITUTIONAL	A	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	8%	57%
INSTITUTIONAL	A	TREE BOX FILTER	1	TREE BOX FILTER1	5%	65%
INSTITUTIONAL	B	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	58%	6%
INSTITUTIONAL	B	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	43%	11%
INSTITUTIONAL	B	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	32%	16%
INSTITUTIONAL	B	TREE BOX FILTER	1	TREE BOX FILTER1	24%	20%
INSTITUTIONAL	C	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	64%	0%
INSTITUTIONAL	C	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	51%	1%
INSTITUTIONAL	C	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	42%	2%
INSTITUTIONAL	C	TREE BOX FILTER	1	TREE BOX FILTER1	34%	2%
INSTITUTIONAL	D	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	64%	0%
INSTITUTIONAL	D	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	52%	0%
INSTITUTIONAL	D	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	43%	1%
INSTITUTIONAL	D	TREE BOX FILTER	1	TREE BOX FILTER1	36%	1%
INSTITUTIONAL	R	DRY WELL	0.25	DRY WELL0.25	12%	88%
INSTITUTIONAL	R	DRY WELL	0.5	DRY WELL0.5	3%	98%
INSTITUTIONAL	R	DRY WELL	0.75	DRY WELL0.75	1%	99%
INSTITUTIONAL	R	DRY WELL	1	DRY WELL1	0%	100%
INSTITUTIONAL	R	DRY WELL	1.25	DRY WELL1.25	0%	100%
INSTITUTIONAL	R	DRY WELL	1.5	DRY WELL1.5	0%	100%
INSTITUTIONAL	I	RED PERMEABLE PAVEMENT 24 COM 1		RED PERMEABLE PAVEMENT 24 COM 1	1%	74%
INSTITUTIONAL	I	RED PERMEABLE PAVEMENT 24 COM 4		RED PERMEABLE PAVEMENT 24 COM 4	3%	70%

ROAD	I	WET POND	0.25	WET POND0.25	68%	0%
ROAD	I	WET POND	0.5	WET POND0.5	68%	0%
ROAD	I	WET POND	0.75	WET POND0.75	68%	0%
ROAD	I	WET POND	1	WET POND1	68%	0%
ROAD	I	WET POND	1.25	WET POND1.25	67%	0%
ROAD	I	WET POND	1.5	WET POND1.5	67%	0%
ROAD	I	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	25%	0%
ROAD	I	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	24%	0%
ROAD	I	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	24%	0%
ROAD	I	GRAVEL WETLAND	1	GRAVEL WETLAND1	24%	0%
ROAD	I	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	24%	0%
ROAD	I	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	24%	0%
ROAD	I	BIORETENTION	0.25	BIORETENTION0.25	56%	16%
ROAD	I	BIORETENTION	0.5	BIORETENTION0.5	42%	30%
ROAD	I	BIORETENTION	0.75	BIORETENTION0.75	32%	40%
ROAD	I	BIORETENTION	1	BIORETENTION1	24%	48%
ROAD	I	BIORETENTION	1.25	BIORETENTION1.25	19%	53%
ROAD	I	BIORETENTION	1.5	BIORETENTION1.5	15%	57%
INDUSTRIAL	I	BIORETENTION	0.25	BIORETENTION0.25	48%	5%
INDUSTRIAL	I	BIORETENTION	0.5	BIORETENTION0.5	33%	9%
INDUSTRIAL	I	BIORETENTION	0.75	BIORETENTION0.75	24%	12%
INDUSTRIAL	I	BIORETENTION	1	BIORETENTION1	17%	15%
INDUSTRIAL	I	BIORETENTION	1.25	BIORETENTION1.25	13%	18%
INDUSTRIAL	I	BIORETENTION	1.5	BIORETENTION1.5	10%	21%
INDUSTRIAL	R	BIORETENTION	0.25	BIORETENTION0.25	49%	10%
INDUSTRIAL	R	BIORETENTION	0.5	BIORETENTION0.5	34%	18%
INDUSTRIAL	R	BIORETENTION	0.75	BIORETENTION0.75	24%	24%
INDUSTRIAL	R	BIORETENTION	1	BIORETENTION1	18%	30%
INDUSTRIAL	R	BIORETENTION	1.25	BIORETENTION1.25	13%	34%
INDUSTRIAL	R	BIORETENTION	1.5	BIORETENTION1.5	11%	37%
INDUSTRIAL	A	BIORETENTION	0.25	BIORETENTION0.25	32%	31%
INDUSTRIAL	A	BIORETENTION	0.5	BIORETENTION0.5	15%	46%
INDUSTRIAL	A	BIORETENTION	0.75	BIORETENTION0.75	7%	55%
INDUSTRIAL	A	BIORETENTION	1	BIORETENTION1	4%	62%
INDUSTRIAL	A	BIORETENTION	1.25	BIORETENTION1.25	3%	65%
INDUSTRIAL	A	BIORETENTION	1.5	BIORETENTION1.5	2%	67%
INDUSTRIAL	B	BIORETENTION	0.25	BIORETENTION0.25	51%	8%
INDUSTRIAL	B	BIORETENTION	0.5	BIORETENTION0.5	38%	14%
INDUSTRIAL	B	BIORETENTION	0.75	BIORETENTION0.75	29%	19%
INDUSTRIAL	B	BIORETENTION	1	BIORETENTION1	22%	23%
INDUSTRIAL	B	BIORETENTION	1.25	BIORETENTION1.25	17%	27%
INDUSTRIAL	B	BIORETENTION	1.5	BIORETENTION1.5	13%	30%
INDUSTRIAL	C	BIORETENTION	0.25	BIORETENTION0.25	58%	0%
INDUSTRIAL	C	BIORETENTION	0.5	BIORETENTION0.5	47%	1%
INDUSTRIAL	C	BIORETENTION	0.75	BIORETENTION0.75	39%	2%
INDUSTRIAL	C	BIORETENTION	1	BIORETENTION1	33%	3%
INDUSTRIAL	C	BIORETENTION	1.25	BIORETENTION1.25	28%	4%
INDUSTRIAL	C	BIORETENTION	1.5	BIORETENTION1.5	25%	4%
INDUSTRIAL	D	BIORETENTION	0.25	BIORETENTION0.25	58%	0%
INDUSTRIAL	D	BIORETENTION	0.5	BIORETENTION0.5	48%	0%
INDUSTRIAL	D	BIORETENTION	0.75	BIORETENTION0.75	40%	1%
INDUSTRIAL	D	BIORETENTION	1	BIORETENTION1	34%	1%
INDUSTRIAL	D	BIORETENTION	1.25	BIORETENTION1.25	29%	1%
INDUSTRIAL	D	BIORETENTION	1.5	BIORETENTION1.5	26%	2%
INDUSTRIAL	I	HE BIORETENTION	0.25	HE BIORETENTION0.25	30%	3%
INDUSTRIAL	I	HE BIORETENTION	0.5	HE BIORETENTION0.5	21%	5%
INDUSTRIAL	I	HE BIORETENTION	0.75	HE BIORETENTION0.75	15%	8%
INDUSTRIAL	I	HE BIORETENTION	1	HE BIORETENTION1	11%	10%
INDUSTRIAL	I	HE BIORETENTION	1.25	HE BIORETENTION1.25	8%	12%
INDUSTRIAL	I	HE BIORETENTION	1.5	HE BIORETENTION1.5	7%	13%
INDUSTRIAL	R	HE BIORETENTION	0.25	HE BIORETENTION0.25	30%	6%
INDUSTRIAL	R	HE BIORETENTION	0.5	HE BIORETENTION0.5	21%	11%
INDUSTRIAL	R	HE BIORETENTION	0.75	HE BIORETENTION0.75	15%	15%
INDUSTRIAL	R	HE BIORETENTION	1	HE BIORETENTION1	11%	18%
INDUSTRIAL	R	HE BIORETENTION	1.25	HE BIORETENTION1.25	8%	21%
INDUSTRIAL	R	HE BIORETENTION	1.5	HE BIORETENTION1.5	7%	23%
INDUSTRIAL	A	HE BIORETENTION	0.25	HE BIORETENTION0.25	20%	19%
INDUSTRIAL	A	HE BIORETENTION	0.5	HE BIORETENTION0.5	9%	28%
INDUSTRIAL	A	HE BIORETENTION	0.75	HE BIORETENTION0.75	4%	34%
INDUSTRIAL	A	HE BIORETENTION	1	HE BIORETENTION1	3%	38%
INDUSTRIAL	A	HE BIORETENTION	1.25	HE BIORETENTION1.25	2%	40%
INDUSTRIAL	A	HE BIORETENTION	1.5	HE BIORETENTION1.5	1%	41%
INDUSTRIAL	B	HE BIORETENTION	0.25	HE BIORETENTION0.25	32%	5%
INDUSTRIAL	B	HE BIORETENTION	0.5	HE BIORETENTION0.5	24%	9%
INDUSTRIAL	B	HE BIORETENTION	0.75	HE BIORETENTION0.75	18%	12%
INDUSTRIAL	B	HE BIORETENTION	1	HE BIORETENTION1	14%	14%

INDUSTRIAL	B	HE BIORETENTION	1.25	HE BIORETENTION1.25	11%	17%
INDUSTRIAL	B	HE BIORETENTION	1.5	HE BIORETENTION1.5	9%	19%
INDUSTRIAL	C	HE BIORETENTION	0.25	HE BIORETENTION0.25	36%	0%
INDUSTRIAL	C	HE BIORETENTION	0.5	HE BIORETENTION0.5	29%	1%
INDUSTRIAL	C	HE BIORETENTION	0.75	HE BIORETENTION0.75	24%	1%
INDUSTRIAL	C	HE BIORETENTION	1	HE BIORETENTION1	21%	2%
INDUSTRIAL	C	HE BIORETENTION	1.25	HE BIORETENTION1.25	18%	2%
INDUSTRIAL	C	HE BIORETENTION	1.5	HE BIORETENTION1.5	16%	3%
INDUSTRIAL	D	HE BIORETENTION	0.25	HE BIORETENTION0.25	36%	0%
INDUSTRIAL	D	HE BIORETENTION	0.5	HE BIORETENTION0.5	30%	0%
INDUSTRIAL	D	HE BIORETENTION	0.75	HE BIORETENTION0.75	25%	1%
INDUSTRIAL	D	HE BIORETENTION	1	HE BIORETENTION1	22%	1%
INDUSTRIAL	D	HE BIORETENTION	1.25	HE BIORETENTION1.25	19%	1%
INDUSTRIAL	D	HE BIORETENTION	1.5	HE BIORETENTION1.5	17%	1%
INDUSTRIAL	I	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	20%	0%
INDUSTRIAL	I	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	16%	0%
INDUSTRIAL	I	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	13%	0%
INDUSTRIAL	I	GRAVEL WETLAND	1	GRAVEL WETLAND1	11%	0%
INDUSTRIAL	I	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	10%	0%
INDUSTRIAL	I	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	8%	0%
INDUSTRIAL	A	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	18%	0%
INDUSTRIAL	A	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	14%	0%
INDUSTRIAL	A	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	11%	0%
INDUSTRIAL	A	GRAVEL WETLAND	1	GRAVEL WETLAND1	9%	0%
INDUSTRIAL	A	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	7%	0%
INDUSTRIAL	A	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	6%	0%
INDUSTRIAL	B	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	20%	0%
INDUSTRIAL	B	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	16%	0%
INDUSTRIAL	B	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	13%	0%
INDUSTRIAL	B	GRAVEL WETLAND	1	GRAVEL WETLAND1	11%	0%
INDUSTRIAL	B	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	9%	0%
INDUSTRIAL	B	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	8%	0%
INDUSTRIAL	C	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
INDUSTRIAL	C	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	17%	0%
INDUSTRIAL	C	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	15%	0%
INDUSTRIAL	C	GRAVEL WETLAND	1	GRAVEL WETLAND1	12%	0%
INDUSTRIAL	C	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	11%	0%
INDUSTRIAL	C	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	9%	0%
INDUSTRIAL	D	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
INDUSTRIAL	D	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	18%	0%
INDUSTRIAL	D	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	15%	0%
INDUSTRIAL	D	GRAVEL WETLAND	1	GRAVEL WETLAND1	13%	0%
INDUSTRIAL	D	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	11%	0%
INDUSTRIAL	D	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	10%	0%
INDUSTRIAL	R	DRY WELL	0.25	DRY WELL0.25	12%	88%
INDUSTRIAL	R	DRY WELL	0.5	DRY WELL0.5	3%	98%
INDUSTRIAL	R	DRY WELL	0.75	DRY WELL0.75	1%	99%
INDUSTRIAL	R	DRY WELL	1	DRY WELL1	0%	100%
INDUSTRIAL	R	DRY WELL	1.25	DRY WELL1.25	0%	100%
INDUSTRIAL	R	DRY WELL	1.5	DRY WELL1.5	0%	100%
INDUSTRIAL	I	RED PERMEABLE PAVEMENT 24 COM 1		RED PERMEABLE PAVEMENT 24 COM 1	1%	59%
INDUSTRIAL	I	RED PERMEABLE PAVEMENT 24 COM 4		RED PERMEABLE PAVEMENT 24 COM 4	2%	50%
INDUSTRIAL	A	WET POND	0.25	WET POND0.25	47%	0%
INDUSTRIAL	A	WET POND	0.5	WET POND0.5	29%	0%
INDUSTRIAL	A	WET POND	0.75	WET POND0.75	24%	0%
INDUSTRIAL	A	WET POND	1	WET POND1	21%	0%
INDUSTRIAL	A	WET POND	1.25	WET POND1.25	18%	0%
INDUSTRIAL	A	WET POND	1.5	WET POND1.5	15%	0%
INDUSTRIAL	B	WET POND	0.25	WET POND0.25	52%	0%
INDUSTRIAL	B	WET POND	0.5	WET POND0.5	34%	0%
INDUSTRIAL	B	WET POND	0.75	WET POND0.75	27%	0%
INDUSTRIAL	B	WET POND	1	WET POND1	23%	0%
INDUSTRIAL	B	WET POND	1.25	WET POND1.25	19%	0%
INDUSTRIAL	B	WET POND	1.5	WET POND1.5	17%	0%
INDUSTRIAL	C	WET POND	0.25	WET POND0.25	53%	0%
INDUSTRIAL	C	WET POND	0.5	WET POND0.5	35%	0%
INDUSTRIAL	C	WET POND	0.75	WET POND0.75	29%	0%
INDUSTRIAL	C	WET POND	1	WET POND1	24%	0%
INDUSTRIAL	C	WET POND	1.25	WET POND1.25	20%	0%
INDUSTRIAL	C	WET POND	1.5	WET POND1.5	18%	0%
INDUSTRIAL	D	WET POND	0.25	WET POND0.25	54%	0%
INDUSTRIAL	D	WET POND	0.5	WET POND0.5	36%	0%
INDUSTRIAL	D	WET POND	0.75	WET POND0.75	29%	0%
INDUSTRIAL	D	WET POND	1	WET POND1	25%	0%
INDUSTRIAL	D	WET POND	1.25	WET POND1.25	21%	0%
INDUSTRIAL	D	WET POND	1.5	WET POND1.5	18%	0%

INDUSTRIAL	I	WET POND	0.25	WET POND0.25	41%	0%
INDUSTRIAL	I	WET POND	0.5	WET POND0.5	27%	0%
INDUSTRIAL	I	WET POND	0.75	WET POND0.75	21%	0%
INDUSTRIAL	I	WET POND	1	WET POND1	17%	0%
INDUSTRIAL	I	WET POND	1.25	WET POND1.25	14%	0%
INDUSTRIAL	I	WET POND	1.5	WET POND1.5	12%	0%
INDUSTRIAL	R	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	59%	41%
INDUSTRIAL	R	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	34%	66%
INDUSTRIAL	R	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	20%	80%
INDUSTRIAL	R	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	13%	87%
INDUSTRIAL	R	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	8%	92%
INDUSTRIAL	R	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	5%	94%
INDUSTRIAL	I	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	67%	33%
INDUSTRIAL	I	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	42%	58%
INDUSTRIAL	I	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	27%	73%
INDUSTRIAL	I	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	18%	82%
INDUSTRIAL	I	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	12%	88%
INDUSTRIAL	I	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	9%	91%
INDUSTRIAL	A	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	40%	60%
INDUSTRIAL	A	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	19%	81%
INDUSTRIAL	A	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	7%	93%
INDUSTRIAL	A	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	0%	100%
INDUSTRIAL	A	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	0%	100%
INDUSTRIAL	A	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	0%	100%
INDUSTRIAL	B	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	63%	36%
INDUSTRIAL	B	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	42%	58%
INDUSTRIAL	B	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	31%	69%
INDUSTRIAL	B	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	23%	77%
INDUSTRIAL	B	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	17%	83%
INDUSTRIAL	B	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	13%	87%
INDUSTRIAL	C	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	77%	0%
INDUSTRIAL	C	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	60%	39%
INDUSTRIAL	C	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	47%	52%
INDUSTRIAL	C	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	37%	61%
INDUSTRIAL	C	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	29%	69%
INDUSTRIAL	C	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	23%	75%
INDUSTRIAL	D	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	85%	0%
INDUSTRIAL	D	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	70%	0%
INDUSTRIAL	D	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	59%	0%
INDUSTRIAL	D	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	49%	48%
INDUSTRIAL	D	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	40%	57%
INDUSTRIAL	D	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	32%	65%
INDUSTRIAL	I	SAND FILTER	0.25	SAND FILTER0.25	45%	3%
INDUSTRIAL	I	SAND FILTER	0.5	SAND FILTER0.5	28%	5%
INDUSTRIAL	I	SAND FILTER	0.75	SAND FILTER0.75	19%	8%
INDUSTRIAL	I	SAND FILTER	1	SAND FILTER1	14%	10%
INDUSTRIAL	I	SAND FILTER	1.25	SAND FILTER1.25	11%	12%
INDUSTRIAL	I	SAND FILTER	1.5	SAND FILTER1.5	8%	13%
INDUSTRIAL	A	SAND FILTER	0.25	SAND FILTER0.25	38%	24%
INDUSTRIAL	A	SAND FILTER	0.5	SAND FILTER0.5	21%	35%
INDUSTRIAL	A	SAND FILTER	0.75	SAND FILTER0.75	12%	44%
INDUSTRIAL	A	SAND FILTER	1	SAND FILTER1	7%	51%
INDUSTRIAL	A	SAND FILTER	1.25	SAND FILTER1.25	5%	57%
INDUSTRIAL	A	SAND FILTER	1.5	SAND FILTER1.5	5%	60%
INDUSTRIAL	B	SAND FILTER	0.25	SAND FILTER0.25	52%	5%
INDUSTRIAL	B	SAND FILTER	0.5	SAND FILTER0.5	36%	10%
INDUSTRIAL	B	SAND FILTER	0.75	SAND FILTER0.75	26%	13%
INDUSTRIAL	B	SAND FILTER	1	SAND FILTER1	19%	16%
INDUSTRIAL	B	SAND FILTER	1.25	SAND FILTER1.25	15%	18%
INDUSTRIAL	B	SAND FILTER	1.5	SAND FILTER1.5	13%	21%
INDUSTRIAL	C	SAND FILTER	0.25	SAND FILTER0.25	56%	0%
INDUSTRIAL	C	SAND FILTER	0.5	SAND FILTER0.5	41%	0%
INDUSTRIAL	C	SAND FILTER	0.75	SAND FILTER0.75	33%	1%
INDUSTRIAL	C	SAND FILTER	1	SAND FILTER1	26%	2%
INDUSTRIAL	C	SAND FILTER	1.25	SAND FILTER1.25	22%	2%
INDUSTRIAL	C	SAND FILTER	1.5	SAND FILTER1.5	19%	3%
INDUSTRIAL	D	SAND FILTER	0.25	SAND FILTER0.25	57%	0%
INDUSTRIAL	D	SAND FILTER	0.5	SAND FILTER0.5	42%	0%
INDUSTRIAL	D	SAND FILTER	0.75	SAND FILTER0.75	33%	0%
INDUSTRIAL	D	SAND FILTER	1	SAND FILTER1	27%	0%
INDUSTRIAL	D	SAND FILTER	1.25	SAND FILTER1.25	23%	1%
INDUSTRIAL	D	SAND FILTER	1.5	SAND FILTER1.5	19%	1%
OUTDOOR	I	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	25%	0%
OUTDOOR	I	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	24%	0%
OUTDOOR	I	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	24%	0%
OUTDOOR	I	GRAVEL WETLAND	1	GRAVEL WETLAND1	24%	0%

OUTDOOR	I	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	24%	0%
OUTDOOR	I	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	24%	0%
OUTDOOR	A	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	21%	0%
OUTDOOR	A	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	18%	0%
OUTDOOR	A	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	15%	0%
OUTDOOR	A	GRAVEL WETLAND	1	GRAVEL WETLAND1	13%	0%
OUTDOOR	A	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	10%	0%
OUTDOOR	A	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	8%	0%
OUTDOOR	B	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	23%	0%
OUTDOOR	B	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	21%	0%
OUTDOOR	B	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	19%	0%
OUTDOOR	B	GRAVEL WETLAND	1	GRAVEL WETLAND1	18%	0%
OUTDOOR	B	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	16%	0%
OUTDOOR	B	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	15%	0%
OUTDOOR	C	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	24%	0%
OUTDOOR	C	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	23%	0%
OUTDOOR	C	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	22%	0%
OUTDOOR	C	GRAVEL WETLAND	1	GRAVEL WETLAND1	21%	0%
OUTDOOR	C	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	20%	0%
OUTDOOR	C	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	19%	0%
OUTDOOR	D	GRAVEL WETLAND	0.25	GRAVEL WETLAND0.25	24%	0%
OUTDOOR	D	GRAVEL WETLAND	0.5	GRAVEL WETLAND0.5	23%	0%
OUTDOOR	D	GRAVEL WETLAND	0.75	GRAVEL WETLAND0.75	23%	0%
OUTDOOR	D	GRAVEL WETLAND	1	GRAVEL WETLAND1	22%	0%
OUTDOOR	D	GRAVEL WETLAND	1.25	GRAVEL WETLAND1.25	21%	0%
OUTDOOR	D	GRAVEL WETLAND	1.5	GRAVEL WETLAND1.5	20%	0%
OUTDOOR	I	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	55%	45%
OUTDOOR	I	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	31%	68%
OUTDOOR	I	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	19%	81%
OUTDOOR	I	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	12%	88%
OUTDOOR	I	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	8%	92%
OUTDOOR	I	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	5%	94%
OUTDOOR	A	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	23%	77%
OUTDOOR	A	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	10%	89%
OUTDOOR	A	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	4%	96%
OUTDOOR	A	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	0%	100%
OUTDOOR	A	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	0%	100%
OUTDOOR	A	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	0%	100%
OUTDOOR	B	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	45%	54%
OUTDOOR	B	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	27%	73%
OUTDOOR	B	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	18%	81%
OUTDOOR	B	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	13%	86%
OUTDOOR	B	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	10%	89%
OUTDOOR	B	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	8%	91%
OUTDOOR	C	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	66%	0%
OUTDOOR	C	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	46%	51%
OUTDOOR	C	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	33%	64%
OUTDOOR	C	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	25%	71%
OUTDOOR	C	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	19%	78%
OUTDOOR	C	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	15%	82%
OUTDOOR	D	SUBSURFACE INFILTRATION	0.25	SUBSURFACE INFILTRATION0.25	77%	0%
OUTDOOR	D	SUBSURFACE INFILTRATION	0.5	SUBSURFACE INFILTRATION0.5	59%	0%
OUTDOOR	D	SUBSURFACE INFILTRATION	0.75	SUBSURFACE INFILTRATION0.75	48%	0%
OUTDOOR	D	SUBSURFACE INFILTRATION	1	SUBSURFACE INFILTRATION1	38%	57%
OUTDOOR	D	SUBSURFACE INFILTRATION	1.25	SUBSURFACE INFILTRATION1.25	30%	66%
OUTDOOR	D	SUBSURFACE INFILTRATION	1.5	SUBSURFACE INFILTRATION1.5	23%	72%
OUTDOOR	I	SAND FILTER	0.25	SAND FILTER0.25	68%	14%
OUTDOOR	I	SAND FILTER	0.5	SAND FILTER0.5	53%	28%
OUTDOOR	I	SAND FILTER	0.75	SAND FILTER0.75	42%	40%
OUTDOOR	I	SAND FILTER	1	SAND FILTER1	33%	48%
OUTDOOR	I	SAND FILTER	1.25	SAND FILTER1.25	27%	55%
OUTDOOR	I	SAND FILTER	1.5	SAND FILTER1.5	22%	59%
OUTDOOR	A	SAND FILTER	0.25	SAND FILTER0.25	38%	48%
OUTDOOR	A	SAND FILTER	0.5	SAND FILTER0.5	21%	63%
OUTDOOR	A	SAND FILTER	0.75	SAND FILTER0.75	12%	71%
OUTDOOR	A	SAND FILTER	1	SAND FILTER1	8%	75%
OUTDOOR	A	SAND FILTER	1.25	SAND FILTER1.25	7%	77%
OUTDOOR	A	SAND FILTER	1.5	SAND FILTER1.5	5%	78%
OUTDOOR	B	SAND FILTER	0.25	SAND FILTER0.25	66%	17%
OUTDOOR	B	SAND FILTER	0.5	SAND FILTER0.5	51%	32%
OUTDOOR	B	SAND FILTER	0.75	SAND FILTER0.75	41%	42%
OUTDOOR	B	SAND FILTER	1	SAND FILTER1	33%	50%
OUTDOOR	B	SAND FILTER	1.25	SAND FILTER1.25	27%	55%
OUTDOOR	B	SAND FILTER	1.5	SAND FILTER1.5	22%	60%
OUTDOOR	C	SAND FILTER	0.25	SAND FILTER0.25	79%	0%
OUTDOOR	C	SAND FILTER	0.5	SAND FILTER0.5	76%	0%

OUTDOOR	C	SAND FILTER	0.75	SAND FILTER0.75	73%	6%
OUTDOOR	C	SAND FILTER	1	SAND FILTER1	69%	9%
OUTDOOR	C	SAND FILTER	1.25	SAND FILTER1.25	65%	12%
OUTDOOR	C	SAND FILTER	1.5	SAND FILTER1.5	61%	15%
OUTDOOR	D	SAND FILTER	0.25	SAND FILTER0.25	81%	0%
OUTDOOR	D	SAND FILTER	0.5	SAND FILTER0.5	79%	0%
OUTDOOR	D	SAND FILTER	0.75	SAND FILTER0.75	77%	0%
OUTDOOR	D	SAND FILTER	1	SAND FILTER1	74%	0%
OUTDOOR	D	SAND FILTER	1.25	SAND FILTER1.25	72%	4%
OUTDOOR	D	SAND FILTER	1.5	SAND FILTER1.5	70%	6%
OUTDOOR	I	BIORETENTION	0.25	BIORETENTION0.25	56%	16%
OUTDOOR	I	BIORETENTION	0.5	BIORETENTION0.5	42%	30%
OUTDOOR	I	BIORETENTION	0.75	BIORETENTION0.75	32%	40%
OUTDOOR	I	BIORETENTION	1	BIORETENTION1	24%	48%
OUTDOOR	I	BIORETENTION	1.25	BIORETENTION1.25	19%	53%
OUTDOOR	I	BIORETENTION	1.5	BIORETENTION1.5	15%	57%
OUTDOOR	A	BIORETENTION	0.25	BIORETENTION0.25	25%	49%
OUTDOOR	A	BIORETENTION	0.5	BIORETENTION0.5	12%	62%
OUTDOOR	A	BIORETENTION	0.75	BIORETENTION0.75	6%	67%
OUTDOOR	A	BIORETENTION	1	BIORETENTION1	4%	69%
OUTDOOR	A	BIORETENTION	1.25	BIORETENTION1.25	3%	70%
OUTDOOR	A	BIORETENTION	1.5	BIORETENTION1.5	2%	70%
OUTDOOR	B	BIORETENTION	0.25	BIORETENTION0.25	52%	20%
OUTDOOR	B	BIORETENTION	0.5	BIORETENTION0.5	40%	34%
OUTDOOR	B	BIORETENTION	0.75	BIORETENTION0.75	30%	43%
OUTDOOR	B	BIORETENTION	1	BIORETENTION1	23%	50%
OUTDOOR	B	BIORETENTION	1.25	BIORETENTION1.25	18%	54%
OUTDOOR	B	BIORETENTION	1.5	BIORETENTION1.5	15%	57%
OUTDOOR	C	BIORETENTION	0.25	BIORETENTION0.25	69%	0%
OUTDOOR	C	BIORETENTION	0.5	BIORETENTION0.5	66%	5%
OUTDOOR	C	BIORETENTION	0.75	BIORETENTION0.75	62%	9%
OUTDOOR	C	BIORETENTION	1	BIORETENTION1	58%	13%
OUTDOOR	C	BIORETENTION	1.25	BIORETENTION1.25	54%	16%
OUTDOOR	C	BIORETENTION	1.5	BIORETENTION1.5	51%	20%
OUTDOOR	D	BIORETENTION	0.25	BIORETENTION0.25	71%	0%
OUTDOOR	D	BIORETENTION	0.5	BIORETENTION0.5	69%	0%
OUTDOOR	D	BIORETENTION	0.75	BIORETENTION0.75	67%	3%
OUTDOOR	D	BIORETENTION	1	BIORETENTION1	65%	5%
OUTDOOR	D	BIORETENTION	1.25	BIORETENTION1.25	62%	7%
OUTDOOR	D	BIORETENTION	1.5	BIORETENTION1.5	60%	9%
OUTDOOR	I	HE BIORETENTION	0.25	HE BIORETENTION0.25	34%	10%
OUTDOOR	I	HE BIORETENTION	0.5	HE BIORETENTION0.5	26%	18%
OUTDOOR	I	HE BIORETENTION	0.75	HE BIORETENTION0.75	19%	25%
OUTDOOR	I	HE BIORETENTION	1	HE BIORETENTION1	15%	29%
OUTDOOR	I	HE BIORETENTION	1.25	HE BIORETENTION1.25	12%	32%
OUTDOOR	I	HE BIORETENTION	1.5	HE BIORETENTION1.5	9%	35%
OUTDOOR	A	HE BIORETENTION	0.25	HE BIORETENTION0.25	15%	30%
OUTDOOR	A	HE BIORETENTION	0.5	HE BIORETENTION0.5	7%	38%
OUTDOOR	A	HE BIORETENTION	0.75	HE BIORETENTION0.75	4%	41%
OUTDOOR	A	HE BIORETENTION	1	HE BIORETENTION1	3%	42%
OUTDOOR	A	HE BIORETENTION	1.25	HE BIORETENTION1.25	2%	43%
OUTDOOR	A	HE BIORETENTION	1.5	HE BIORETENTION1.5	1%	43%
OUTDOOR	B	HE BIORETENTION	0.25	HE BIORETENTION0.25	32%	12%
OUTDOOR	B	HE BIORETENTION	0.5	HE BIORETENTION0.5	24%	21%
OUTDOOR	B	HE BIORETENTION	0.75	HE BIORETENTION0.75	18%	26%
OUTDOOR	B	HE BIORETENTION	1	HE BIORETENTION1	14%	30%
OUTDOOR	B	HE BIORETENTION	1.25	HE BIORETENTION1.25	11%	33%
OUTDOOR	B	HE BIORETENTION	1.5	HE BIORETENTION1.5	9%	35%
OUTDOOR	C	HE BIORETENTION	0.25	HE BIORETENTION0.25	42%	0%
OUTDOOR	C	HE BIORETENTION	0.5	HE BIORETENTION0.5	40%	3%
OUTDOOR	C	HE BIORETENTION	0.75	HE BIORETENTION0.75	38%	5%
OUTDOOR	C	HE BIORETENTION	1	HE BIORETENTION1	35%	8%
OUTDOOR	C	HE BIORETENTION	1.25	HE BIORETENTION1.25	33%	10%
OUTDOOR	C	HE BIORETENTION	1.5	HE BIORETENTION1.5	31%	12%
OUTDOOR	D	HE BIORETENTION	0.25	HE BIORETENTION0.25	43%	0%
OUTDOOR	D	HE BIORETENTION	0.5	HE BIORETENTION0.5	42%	0%
OUTDOOR	D	HE BIORETENTION	0.75	HE BIORETENTION0.75	41%	2%
OUTDOOR	D	HE BIORETENTION	1	HE BIORETENTION1	39%	3%
OUTDOOR	D	HE BIORETENTION	1.25	HE BIORETENTION1.25	38%	4%
OUTDOOR	D	HE BIORETENTION	1.5	HE BIORETENTION1.5	37%	5%
OUTDOOR	I	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	62%	17%
OUTDOOR	I	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	47%	33%
OUTDOOR	I	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	35%	45%
OUTDOOR	I	TREE BOX FILTER	1	TREE BOX FILTER1	27%	53%
OUTDOOR	A	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	27%	55%
OUTDOOR	A	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	14%	69%



OUTDOOR	A	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	7%	75%
OUTDOOR	A	TREE BOX FILTER	1	TREE BOX FILTER1	5%	77%
OUTDOOR	B	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	58%	23%
OUTDOOR	B	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	44%	38%
OUTDOOR	B	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	33%	48%
OUTDOOR	B	TREE BOX FILTER	1	TREE BOX FILTER1	26%	55%
OUTDOOR	C	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	77%	0%
OUTDOOR	C	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	73%	6%
OUTDOOR	C	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	69%	10%
OUTDOOR	C	TREE BOX FILTER	1	TREE BOX FILTER1	65%	14%
OUTDOOR	D	TREE BOX FILTER	0.25	TREE BOX FILTER0.25	79%	0%
OUTDOOR	D	TREE BOX FILTER	0.5	TREE BOX FILTER0.5	76%	0%
OUTDOOR	D	TREE BOX FILTER	0.75	TREE BOX FILTER0.75	74%	4%
OUTDOOR	D	TREE BOX FILTER	1	TREE BOX FILTER1	72%	6%
OUTDOOR	I	RED PERMEABLE PAVEMENT 24 COM 1		RED PERMEABLE PAVEMENT 24 COM 1	1%	93%
OUTDOOR	I	RED PERMEABLE PAVEMENT 24 COM 4		RED PERMEABLE PAVEMENT 24 COM 4	4%	93%

# **APPENDIX B: NITROGEN CONTROL DETAILS BY TOWN**

- B 1. Dover**
- B 2. Durham**
- B 3. Epping**
- B 4. Exeter**
- B 5. Milton**
- B 6. Newfields**
- B 7. Newington**
- B 8. Newmarket**
- B 9. Pease**
- B 10. Portsmouth**
- B 11. Rochester**
- B 12. Rollinsford**
- B 13. Somersworth**
- B 14. Berwick**
- B 15. Kittery**
- B 16. North Berwick**
- B 17. South Berwick**

## B1. Dover

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



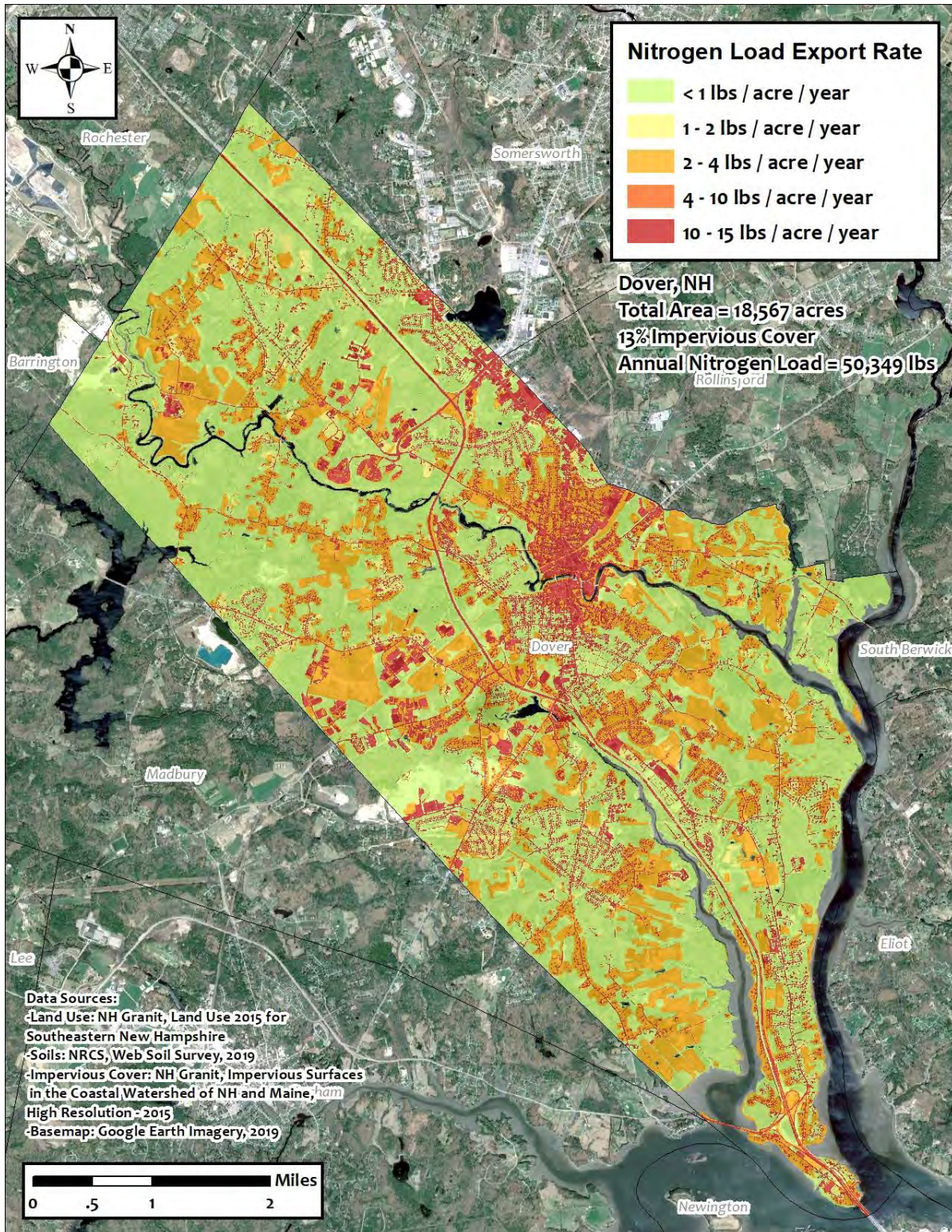


Figure 1 - Annual Nitrogen Load Export



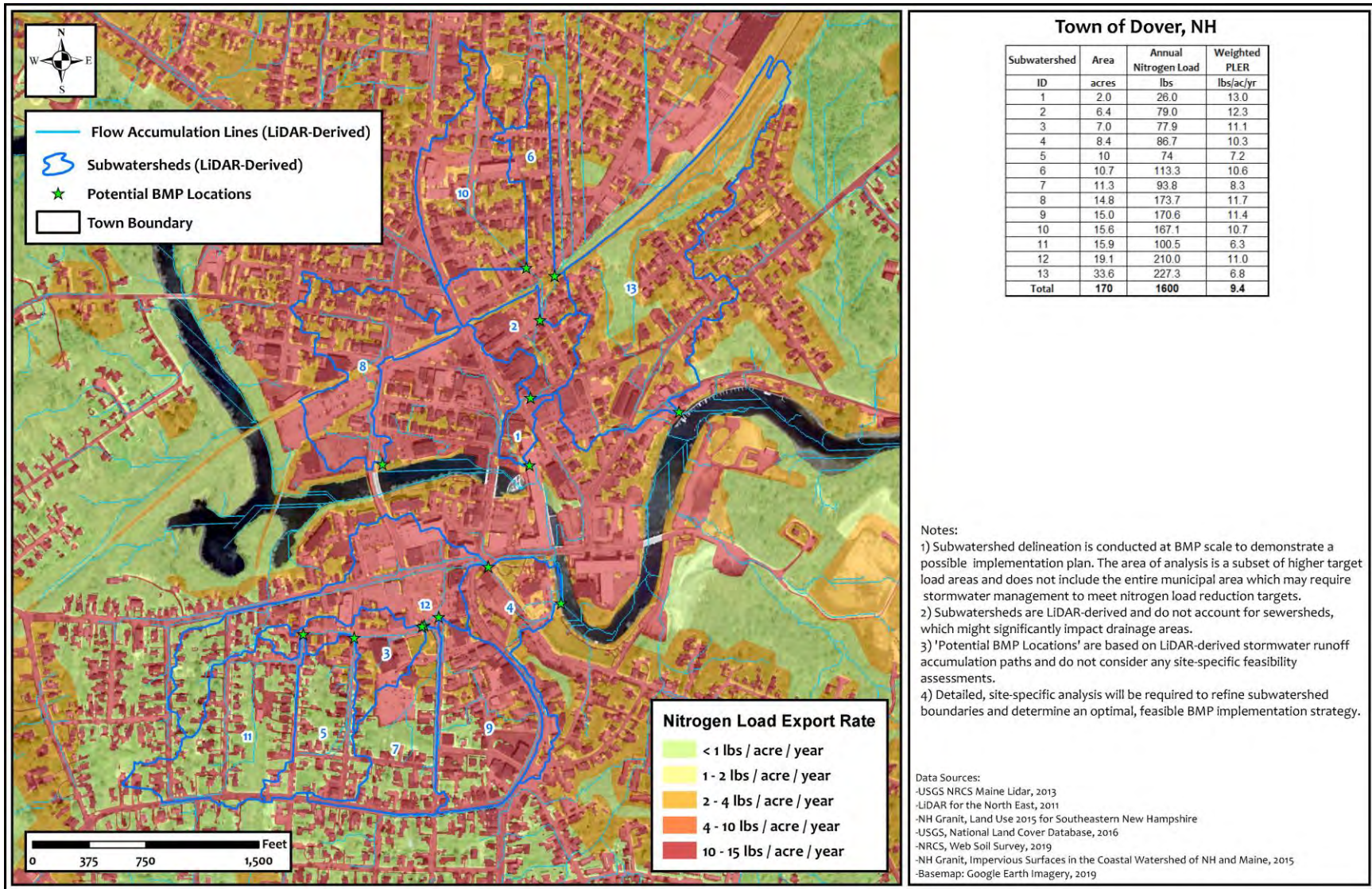


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	32,603				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		9,601.8	32,603.0	\$ 17,489,220	\$ 402
<b>Structural Controls</b>	7,552.5	2,136.6	20,126.1	\$ 10,579,206	\$ 496
<b>Non-Structural Controls</b>	9,040.8	9,040.8	12,476.9	\$ 6,910,014	\$ 316
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acres)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	627.91	627.9	4462.5	\$ 2,825,595	\$ 633
RESIDENTIAL R DRY WELLO.25	436.34	436.3	4402.9	\$ 1,745,360	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	270.43	270.4	3247.9	\$ 1,595,537	\$ 491
COMMERCIAL R DRY WELLO.25	67.61	67.6	803.3	\$ 270,440	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	105.63	105.6	1252.4	\$ 623,217	\$ 498
INSTITUTIONAL R DRY WELLO.25	26.41	26.4	313.8	\$ 105,640	\$ 337
ROAD I GRAVEL WETLAND0.25	567.35	346.9	2742.7	\$ 2,046,939	\$ 746
INDUSTRIAL I GRAVEL WETLAND0.25	136.92	136.9	1644.4	\$ 807,828	\$ 491
INDUSTRIAL R DRY WELLO.25	73.73	73.7	876.0	\$ 294,920	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	44.7	44.7	380.3	\$ 263,730	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	1,575.61	1575.6	10020.9	\$ 6,302,440	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	567.35	567.4	595.7	\$ 18,155	\$ 30
LEAF_LITTER_A LEAF_LITTER_A	1,543.08	1543.1	23.1	\$ 16,974	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	358.31	358.3	21.5	\$ 3,941	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	305.97	306.0	36.7	\$ 3,366	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	1654.26	1654.3	297.8	\$ 18,197	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	1310	1310.0	1108.3	\$ 419,200	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	1590.03	1590.0	343.4	\$ 117,662	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	86.84	86.8	18.8	\$ 6,426	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SCHOOL	31.4	31.4	6.8	\$ 2,324	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	17.96	18.0	3.9	\$ 1,329	\$ 343



Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

<b>Cost to Implement</b>	\$26,026	\$211,091	\$455,010	\$698,930	\$957,738	\$2,666,382	\$6,640,901	\$12,108,901	\$17,489,220	\$92,984,878
<b>Percent Reduction</b>	1%	2%	3%	4%	5%	11%	22%	34%	45%	65%
<b>Load Reduction Achieved (Lbs TN/Yr)</b>	725	1,449	2,174	2,898	3,623	7,970	15,939	24,633	32,603	47,093
<b>Load Reduction Target (Lbs TN/Yr)</b>	725	1,449	2,174	2,898	3,623	7,970	15,939	24,633	32,603	47,093
<b>Treated Area (Acres)</b>	1,283	2,928	2,989	3,050	5,140	6,441	7,039	7,039	9,602	15,018
<b>Implementation Period (yrs)</b>	<b>Yearly Rate of Area Treated-Total (AC/YR)</b>									
15	85.5	195.2	199.2	203.3	342.7	429.4	469.3	469.3	640.1	1001.2
16	80.2	183.0	186.8	190.6	321.3	402.6	439.9	439.9	600.1	938.6
17	75.5	172.2	175.8	179.4	302.4	378.9	414.1	414.1	564.8	883.4
18	71.3	162.7	166.0	169.4	285.6	357.8	391.1	391.1	533.4	834.3
19	67.5	154.1	157.3	160.5	270.5	339.0	370.5	370.5	505.4	790.4
20	64.1	146.4	149.4	152.5	257.0	322.1	352.0	352.0	480.1	750.9
21	61.1	139.4	142.3	145.2	244.8	306.7	335.2	335.2	457.2	715.1
22	58.3	133.1	135.9	138.6	233.6	292.8	320.0	320.0	436.4	682.6
23	55.8	127.3	129.9	132.6	223.5	280.0	306.1	306.1	417.5	652.9
24	53.5	122.0	124.5	127.1	214.2	268.4	293.3	293.3	400.1	625.7
25	51.3	117.1	119.5	122.0	205.6	257.6	281.6	281.6	384.1	600.7

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

<b>Cost to Implement</b>	\$26,026	\$211,091	\$455,010	\$698,930	\$957,738	\$2,666,382	\$6,640,901	\$12,108,901	\$17,489,220	\$92,984,878
<b>Percent Reduction</b>	1%	2%	3%	4%	5%	11%	22%	34%	45%	65%
<b>Load Reduction (Lbs TN/Yr)</b>	725	1,449	2,174	2,898	3,623	7,970	15,939	24,633	32,603	47,093
<b>Treated Area (Acres)</b>	1,283	2,928	2,989	3,050	5,140	6,441	7,039	7,039	9,602	15,018
<b>Implementation Period (yrs)</b>	<b>Yearly Cost to Implement Total (\$\$/Yr)</b>									
15	\$1,735	\$14,073	\$30,334	\$46,595	\$63,849	\$177,759	\$442,727	\$807,260	\$1,165,948	\$6,198,992
16	\$1,627	\$13,193	\$28,438	\$43,683	\$59,859	\$166,649	\$415,056	\$756,806	\$1,093,076	\$5,811,555
17	\$1,531	\$12,417	\$26,765	\$41,114	\$56,338	\$156,846	\$390,641	\$712,288	\$1,028,778	\$5,469,699
18	\$1,446	\$11,727	\$25,278	\$38,829	\$53,208	\$148,132	\$368,939	\$672,717	\$971,623	\$5,165,827
19	\$1,370	\$11,110	\$23,948	\$36,786	\$50,407	\$140,336	\$349,521	\$637,311	\$920,485	\$4,893,941
20	\$1,301	\$10,555	\$22,751	\$34,946	\$47,887	\$133,319	\$332,045	\$605,445	\$874,461	\$4,649,244
21	\$1,239	\$10,052	\$21,667	\$33,282	\$45,607	\$126,971	\$316,233	\$576,614	\$832,820	\$4,427,851
22	\$1,183	\$9,595	\$20,682	\$31,770	\$43,534	\$121,199	\$301,859	\$550,405	\$794,965	\$4,226,585
23	\$1,132	\$9,178	\$19,783	\$30,388	\$41,641	\$115,930	\$288,735	\$526,474	\$760,401	\$4,042,821
24	\$1,084	\$8,795	\$18,959	\$29,122	\$39,906	\$111,099	\$276,704	\$504,538	\$728,718	\$3,874,370
25	\$1,041	\$8,444	\$18,200	\$27,957	\$38,310	\$106,655	\$265,636	\$484,356	\$699,569	\$3,719,395

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$70	\$5.81	\$0.031	\$1,350
16	\$65	\$5.45	\$0.029	\$1,266
17	\$62	\$5.13	\$0.027	\$1,191
18	\$58	\$4.84	\$0.026	\$1,125
19	\$55	\$4.59	\$0.024	\$1,066
20	\$52	\$4.36	\$0.023	\$1,013
21	\$50	\$4.15	\$0.022	\$964
22	\$48	\$3.96	\$0.021	\$921
23	\$45	\$3.79	\$0.020	\$881
24	\$44	\$3.63	\$0.019	\$844
25	\$42	\$3.49	\$0.019	\$810
Population Est	31,398			
Persons per household	3			
# of Households Est.	10,466			
Typical household IC (SF)	2250	IC Normalize		
% IC Residential	44%	63%		
%IC Comm/Ind/Inst	26%	37%		
%IC Transportation	25%			
%IC Misc	5%			
Total		100%		

## **B2. Durham, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

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Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



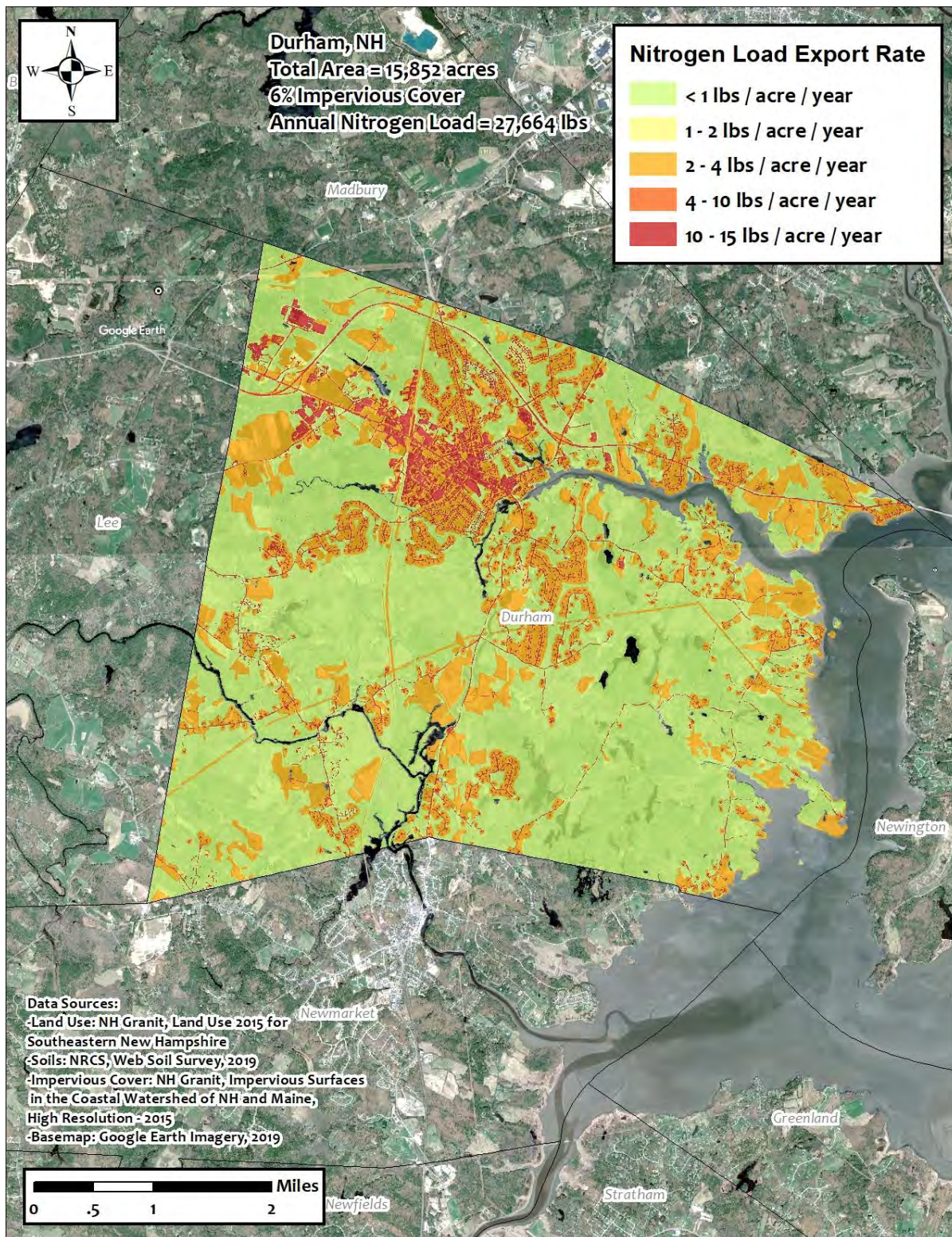


Figure 1 - Annual Nitrogen Load Export



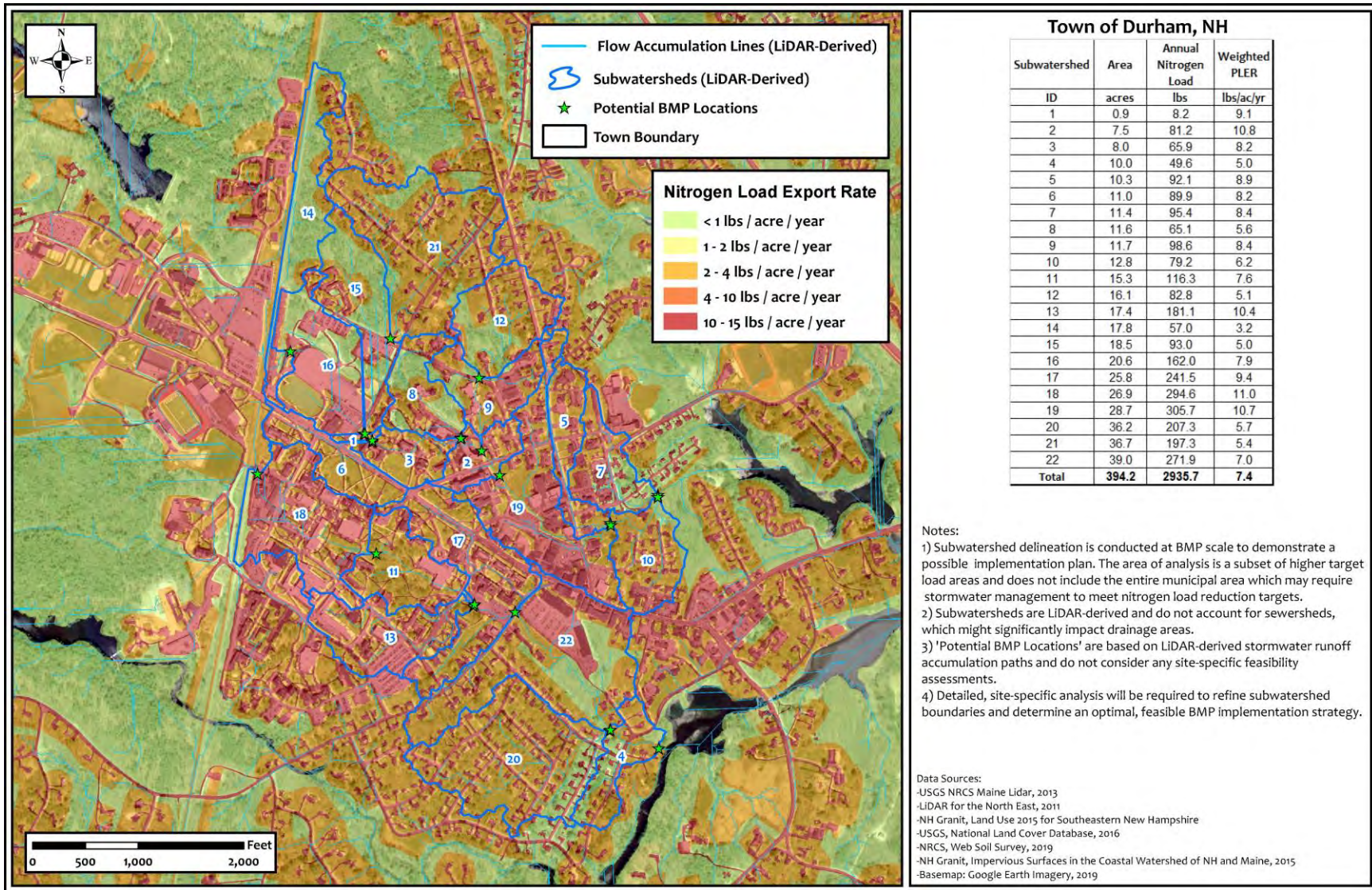


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 34% N-Load Reduction Target

PERCENT REDUCTION TARGET	34%				
TN LOAD REDUCTION TARGET (LBS/YR)	17,796				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		4,113.9	17,795.9	\$11,932,150	701
<b>Structural Controls</b>	3,269.7	1,133.0	9,297.7	\$ 7,006,407	\$ 978
<b>Non-Structural Controls</b>	4,169.9	4,169.9	8,498.3	\$ 4,925,743	\$ 313
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acres)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.5	221.37	221.4	2015.2	\$ 1,549,590	\$ 769
RESIDENTIAL R DRY WELLO.5	153.84	153.8	1850.7	\$ 1,076,880	\$ 582
COMMERCIAL I GRAVEL WETLAND0.25	44.67	44.7	536.5	\$ 263,553	\$ 491
COMMERCIAL D GRAVEL WETLAND0.25	13.33	13.3	37.8	\$ 78,647	\$ 2,080
COMMERCIAL R DRY WELLO.25	11.17	11.2	132.7	\$ 44,680	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	79.98	80.0	948.3	\$ 471,882	\$ 498
INSTITUTIONAL D GRAVEL WETLAND0.25	61.75	61.8	174.6	\$ 364,325	\$ 2,087
INSTITUTIONAL R DRY WELLO.25	19.99	20.0	237.5	\$ 79,960	\$ 337
ROAD I GRAVEL WETLAND0.25	255.24	255.2	2017.8	\$ 1,505,916	\$ 746
INDUSTRIAL I GRAVEL WETLAND0.25	31.38	31.4	376.9	\$ 185,142	\$ 491
INDUSTRIAL D GRAVEL WETLAND0.25	117.39	117.4	333.0	\$ 692,601	\$ 2,080
INDUSTRIAL R DRY WELLO.25	16.9	16.9	200.8	\$ 67,600	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	25.33	25.3	215.5	\$ 149,447	\$ 693
OUTDOOR D GRAVEL WETLAND0.25	248.21	80.7	220.5	\$ 476,184	\$ 2,160
SEPTIC SEPTIC SLUDGEHAMMER	1,189.06	1189.1	7562.4	\$ 4,756,240	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	255.24	255.2	268.0	\$ 8,168	\$ 30
LEAF_LITTER_A LEAF_LITTER_A	166.66	166.7	2.5	\$ 1,833	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	52.74	52.7	3.2	\$ 580	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	180.64	180.6	21.7	\$ 1,987	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	1412.02	1412.0	254.2	\$ 15,532	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	300	300.0	253.8	\$ 96,000	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	588.2	588.2	127.1	\$ 43,527	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	21.41	21.4	4.6	\$ 1,584	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	3.94	3.9	0.9	\$ 292	\$ 343



Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$23,814	\$194,538	\$386,029	\$593,516	\$801,003	\$2,423,624	\$6,044,700	\$11,932,150	\$49,102,379
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%
Load Reduction Achieved (Lbs TN/Yr)	523	1,047	1,570	2,094	2,617	5,758	11,515	17,796	23,553
Load Reduction Target (Lbs TN/Yr)	523	1,047	1,570	2,094	2,617	5,758	11,515	17,796	23,553
Treated Area (Acres)	1,678	1,943	2,869	2,921	2,973	3,172	3,172	4,114	6,251
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)								
15	111.8	129.5	191.3	194.7	198.2	211.5	211.5	274.3	416.7
16	104.9	121.4	179.3	182.5	185.8	198.3	198.3	257.1	390.7
17	98.7	114.3	168.8	171.8	174.9	186.6	186.6	242.0	367.7
18	93.2	107.9	159.4	162.3	165.1	176.2	176.2	228.5	347.3
19	88.3	102.2	151.0	153.7	156.4	167.0	167.0	216.5	329.0
20	83.9	97.1	143.4	146.0	148.6	158.6	158.6	205.7	312.5
21	79.9	92.5	136.6	139.1	141.5	151.1	151.1	195.9	297.6
22	76.3	88.3	130.4	132.8	135.1	144.2	144.2	187.0	284.1
23	72.9	84.5	124.7	127.0	129.2	137.9	137.9	178.9	271.8
24	69.9	80.9	119.5	121.7	123.9	132.2	132.2	171.4	260.4
25	67.1	77.7	114.8	116.8	118.9	126.9	126.9	164.6	250.0

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$23,814	\$194,538	\$386,029	\$593,516	\$801,003	\$2,423,624	\$6,044,700	\$11,932,150	\$49,102,379
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%
Load Reduction (Lbs TN/Yr)	523	1,047	1,570	2,094	2,617	5,758	11,515	17,796	23,553
Treated Area (Acres)	1,678	1,943	2,869	2,921	2,973	3,172	3,172	4,114	6,251
Implementation Period (yrs)	Yearly Cost to Implement Total (\$/Yr)								
15	\$1,588	\$12,969	\$25,735	\$39,568	\$53,400	\$161,575	\$402,980	\$795,477	\$3,273,492
16	\$1,488	\$12,159	\$24,127	\$37,095	\$50,063	\$151,477	\$377,794	\$745,759	\$3,068,899
17	\$1,401	\$11,443	\$22,708	\$34,913	\$47,118	\$142,566	\$355,571	\$701,891	\$2,888,375
18	\$1,323	\$10,808	\$21,446	\$32,973	\$44,500	\$134,646	\$335,817	\$662,897	\$2,727,910
19	\$1,253	\$10,239	\$20,317	\$31,238	\$42,158	\$127,559	\$318,142	\$628,008	\$2,584,336
20	\$1,191	\$9,727	\$19,301	\$29,676	\$40,050	\$121,181	\$302,235	\$596,608	\$2,455,119
21	\$1,134	\$9,264	\$18,382	\$28,263	\$38,143	\$115,411	\$287,843	\$568,198	\$2,338,209
22	\$1,082	\$8,843	\$17,547	\$26,978	\$36,409	\$110,165	\$274,759	\$542,370	\$2,231,926
23	\$1,035	\$8,458	\$16,784	\$25,805	\$34,826	\$105,375	\$262,813	\$518,789	\$2,134,886
24	\$992	\$8,106	\$16,085	\$24,730	\$33,375	\$100,984	\$251,862	\$497,173	\$2,045,932
25	\$953	\$7,782	\$15,441	\$23,741	\$32,040	\$96,945	\$241,788	\$477,286	\$1,964,095

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$444	\$36.97	\$0.197	\$8,589
16	\$416	\$34.66	\$0.185	\$8,052
17	\$391	\$32.62	\$0.174	\$7,579
18	\$370	\$30.81	\$0.164	\$7,158
19	\$350	\$29.19	\$0.156	\$6,781
20	\$333	\$27.73	\$0.148	\$6,442
21	\$317	\$26.41	\$0.141	\$6,135
22	\$302	\$25.21	\$0.134	\$5,856
23	\$289	\$24.11	\$0.129	\$5,602
24	\$277	\$23.11	\$0.123	\$5,368
25	\$266	\$22.18	\$0.118	\$5,153

Population Est	14,638
Persons per household	3
# of Households Est.	4,879
Typical household IC (SF)	2250 IC Normalized
% IC Residential	41%      66%
%IC Comm/Ind/Inst	21%      34%
%IC Transportation	29%
%IC Misc	9%
Total	100%

### **B3. Epping, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.

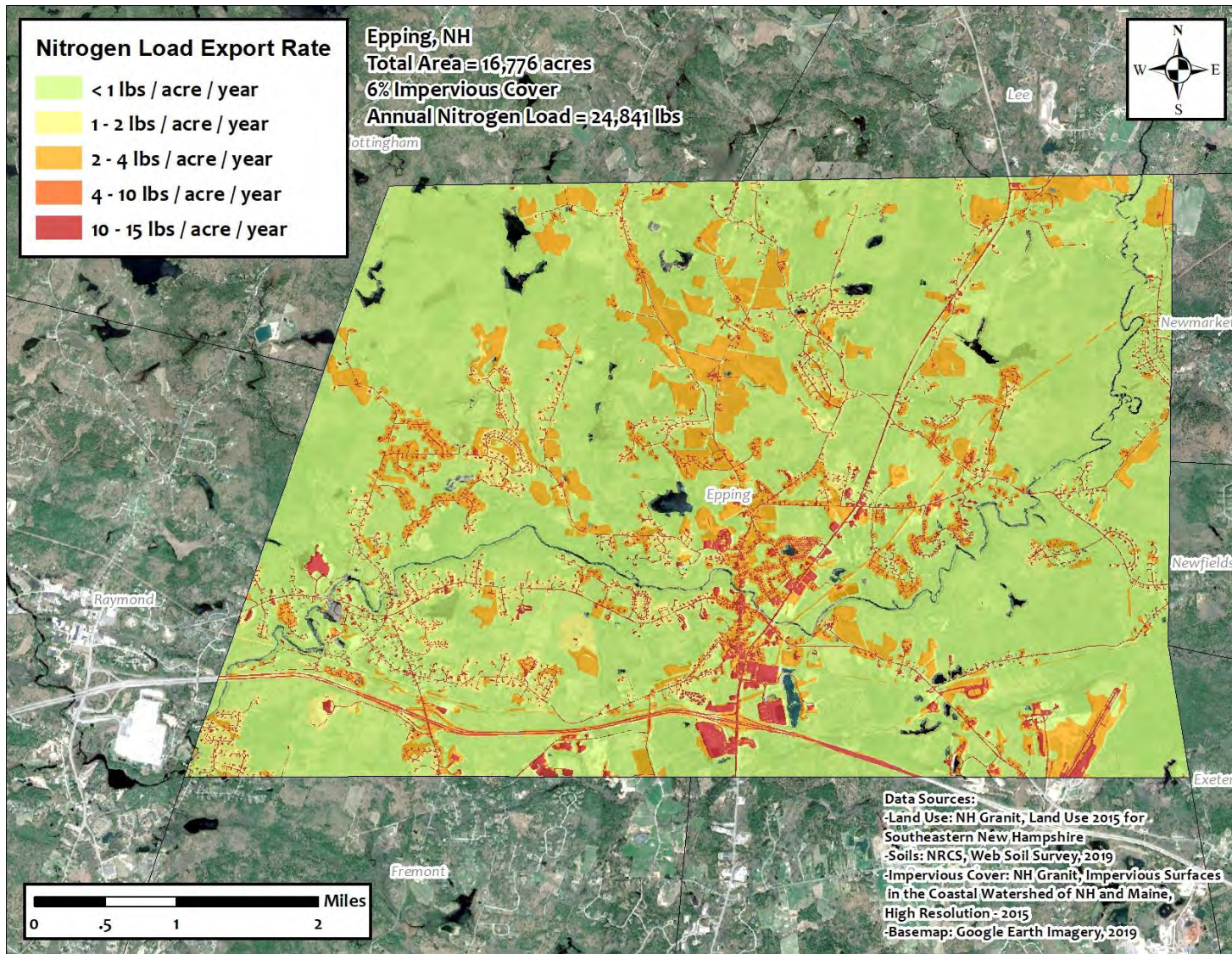


Figure 1 - Annual Nitrogen Load Export



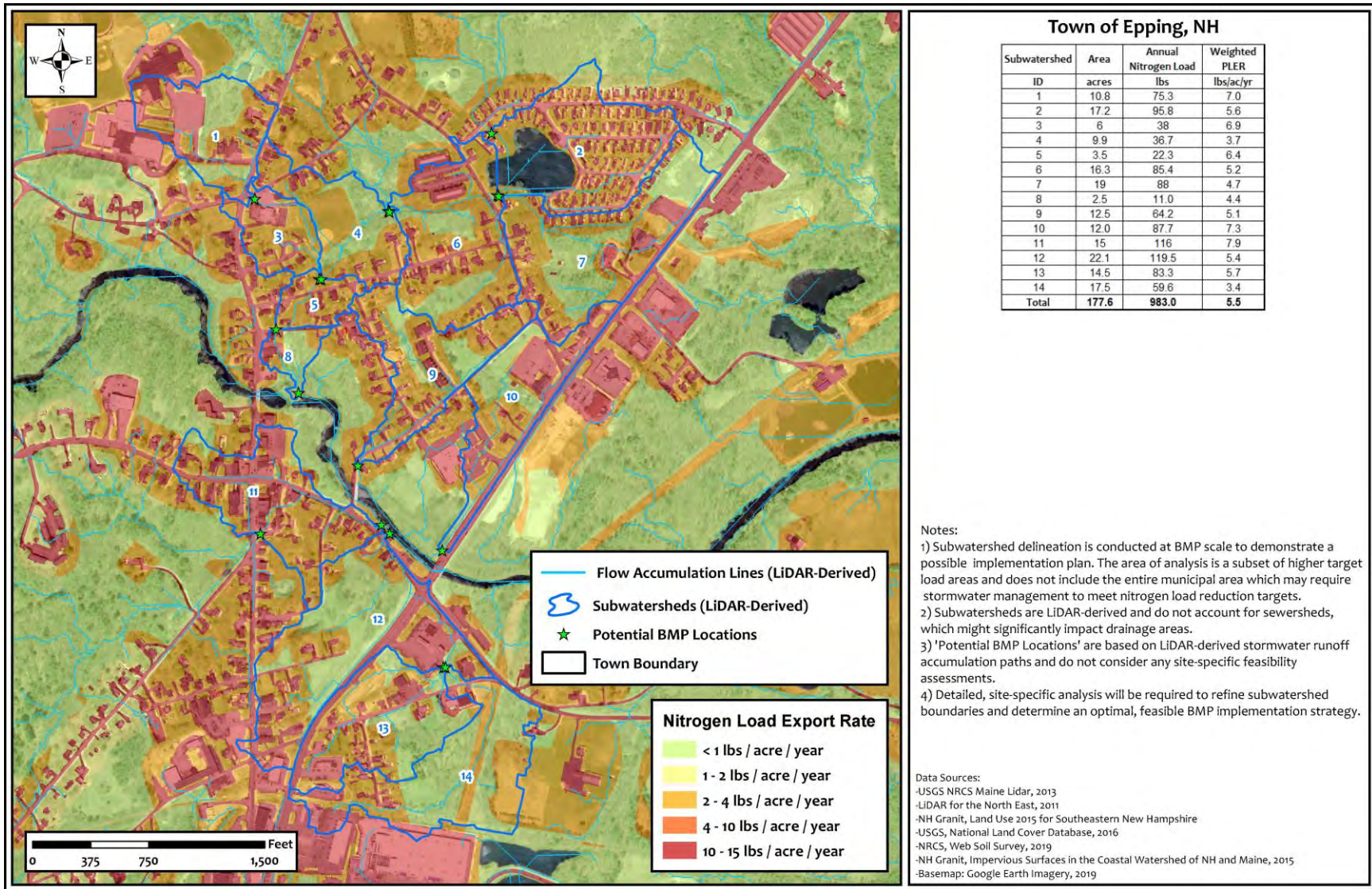


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	17,024				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		2,893.7	17,024.0	\$ 9,608,205	\$ 348
<b>Structural Controls</b>	3,310.8	501.0	4,983.3	\$ 2,401,504	\$ 440
<b>Non-Structural Controls</b>	4,662.6	4,146.4	12,040.7	\$ 7,206,701	\$ 267
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	181.29	159.4	1132.5	\$ 717,099	\$ 633
RESIDENTIAL R DRY WELLO.25	125.98	126.0	1271.2	\$ 503,920	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	119.26	119.3	1432.3	\$ 703,634	\$ 491
COMMERCIAL R DRY WELLO.25	29.81	29.8	354.2	\$ 119,240	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	25.75	25.8	305.3	\$ 151,925	\$ 498
INSTITUTIONAL R DRY WELLO.25	6.44	6.4	76.5	\$ 25,760	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	22.34	22.3	268.3	\$ 131,806	\$ 491
INDUSTRIAL R DRY WELLO.25	12.03	12.0	142.9	\$ 48,120	\$ 337
SEPTIC SEPTIC SLUDGEHAMMER	1,753.73	1753.7	11153.7	\$ 7,014,920	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	287.53	287.5	301.9	\$ 9,201	\$ 30
LEAF_LITTER_B LEAF_LITTER_B	638.33	638.3	38.3	\$ 7,022	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	425.64	425.6	51.1	\$ 4,682	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	243.16	243.2	43.8	\$ 2,675	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	443.69	443.7	375.4	\$ 141,981	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	340.5	340.5	73.5	\$ 25,197	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	5.41	5.4	1.2	\$ 400	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	8.43	8.4	1.8	\$ 624	\$ 343



Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$14,867	\$131,841	\$261,727	\$405,779	\$555,747	\$1,591,137	\$4,130,969	\$6,986,139	\$9,608,205	\$49,096,787
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	65%
Load Reduction Achieved (Lbs TN/Yr)	378	757	1,135	1,513	1,892	4,161	8,323	12,863	17,024	24,590
Load Reduction Target (Lbs TN/Yr)	378	757	1,135	1,513	1,892	4,161	8,323	12,863	17,024	24,590
Treated Area (Acres)	803	1,622	2,056	2,446	2,484	2,686	2,734	2,734	2,894	6,220
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)									
15	53.5	108.1	137.1	163.1	165.6	179.1	182.3	182.3	192.9	414.6
16	50.2	101.4	128.5	152.9	155.2	167.9	170.9	170.9	180.9	388.7
17	47.2	95.4	120.9	143.9	146.1	158.0	160.8	160.8	170.2	365.9
18	44.6	90.1	114.2	135.9	138.0	149.2	151.9	151.9	160.8	345.5
19	42.2	85.4	108.2	128.7	130.7	141.4	143.9	143.9	152.3	327.3
20	40.1	81.1	102.8	122.3	124.2	134.3	136.7	136.7	144.7	311.0
21	38.2	77.2	97.9	116.5	118.3	127.9	130.2	130.2	137.8	296.2
22	36.5	73.7	93.5	111.2	112.9	122.1	124.3	124.3	131.5	282.7
23	34.9	70.5	89.4	106.4	108.0	116.8	118.9	118.9	125.8	270.4
24	33.4	67.6	85.7	101.9	103.5	111.9	113.9	113.9	120.6	259.2
25	32.1	64.9	82.2	97.8	99.3	107.4	109.4	109.4	115.7	248.8

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$14,867	\$131,841	\$261,727	\$405,779	\$555,747	\$1,591,137	\$4,130,969	\$6,986,139	\$9,608,205	\$49,096,787
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	65%
Load Reduction (Lbs TN/Yr)	378	757	1,135	1,513	1,892	4,161	8,323	12,863	17,024	24,590
Treated Area (Acres)	803	1,622	2,056	2,446	2,484	2,686	2,734	2,734	2,894	6,220
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)									
15	\$991	\$8,789	\$17,448	\$27,052	\$37,050	\$106,076	\$275,398	\$465,743	\$640,547	\$3,273,119
16	\$929	\$8,240	\$16,358	\$25,361	\$34,734	\$99,446	\$258,186	\$436,634	\$600,513	\$3,068,549
17	\$875	\$7,755	\$15,396	\$23,869	\$32,691	\$93,596	\$242,998	\$410,949	\$565,189	\$2,888,046
18	\$826	\$7,325	\$14,540	\$22,543	\$30,875	\$88,397	\$229,498	\$388,119	\$533,789	\$2,727,599
19	\$782	\$6,939	\$13,775	\$21,357	\$29,250	\$83,744	\$217,419	\$367,692	\$505,695	\$2,584,041
20	\$743	\$6,592	\$13,086	\$20,289	\$27,787	\$79,557	\$206,548	\$349,307	\$480,410	\$2,454,839
21	\$708	\$6,278	\$12,463	\$19,323	\$26,464	\$75,768	\$196,713	\$332,673	\$457,534	\$2,337,942
22	\$676	\$5,993	\$11,897	\$18,445	\$25,261	\$72,324	\$187,771	\$317,552	\$436,737	\$2,231,672
23	\$646	\$5,732	\$11,379	\$17,643	\$24,163	\$69,180	\$179,607	\$303,745	\$417,748	\$2,134,643
24	\$619	\$5,493	\$10,905	\$16,907	\$23,156	\$66,297	\$172,124	\$291,089	\$400,342	\$2,045,699
25	\$595	\$5,274	\$10,469	\$16,231	\$22,230	\$63,645	\$165,239	\$279,446	\$384,328	\$1,963,871

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$180	\$14.99	\$0.080	\$3,482
16	\$169	\$14.05	\$0.075	\$3,264
17	\$159	\$13.22	\$0.071	\$3,072
18	\$150	\$12.49	\$0.067	\$2,901
19	\$142	\$11.83	\$0.063	\$2,749
20	\$135	\$11.24	\$0.060	\$2,611
21	\$128	\$10.71	\$0.057	\$2,487
22	\$123	\$10.22	\$0.054	\$2,374
23	\$117	\$9.77	\$0.052	\$2,271
24	\$112	\$9.37	\$0.050	\$2,176
25	\$108	\$8.99	\$0.048	\$2,089

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Population Est	6,411	
Persons per household	3	
# of Households Est.	2,137	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	33%	60%
% IC Comm/Ind/Inst	22%	40%
% IC Transportation	31%	
% IC Misc	14%	
		100%

## B.4 Exeter, New Hampshire

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



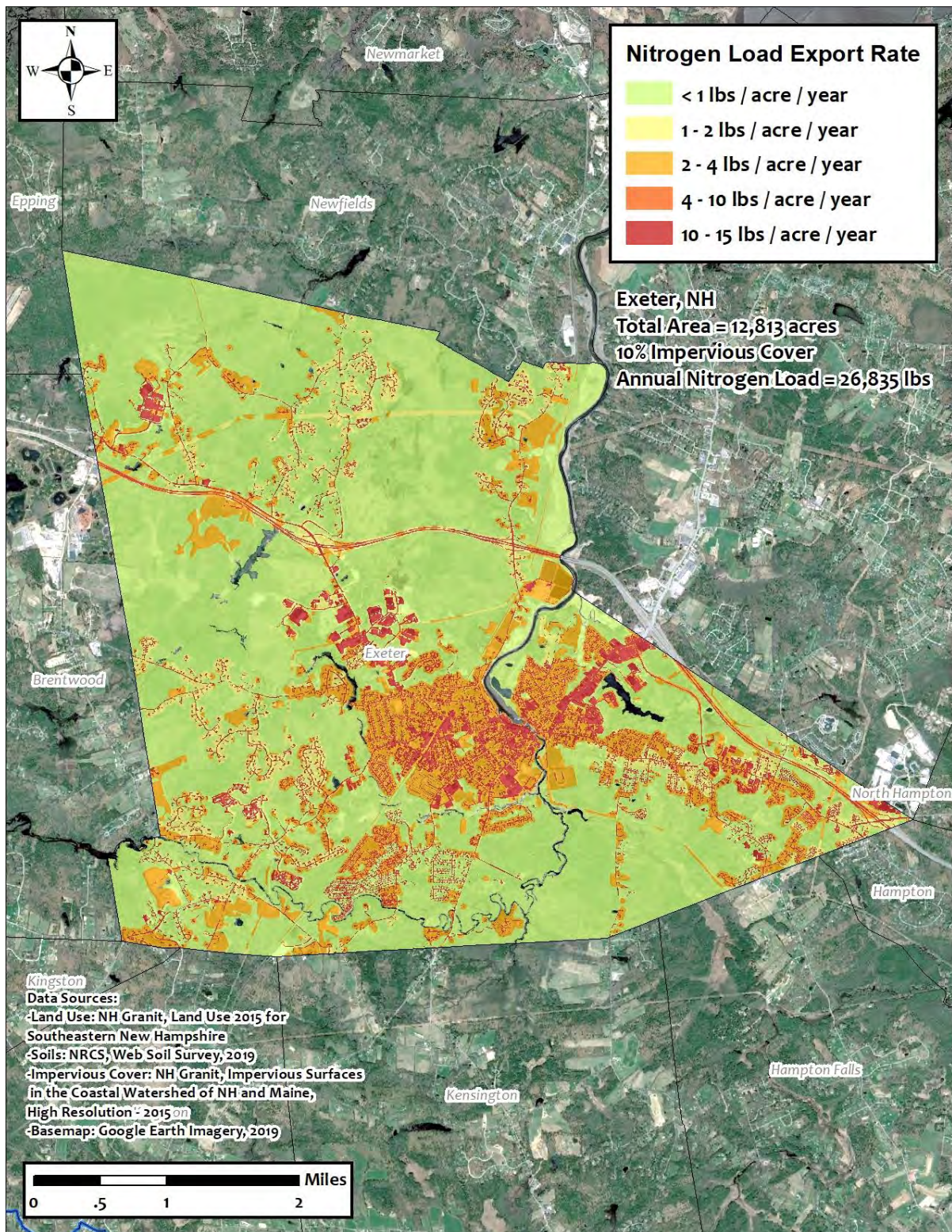


Figure 1 - Annual Nitrogen Load Export



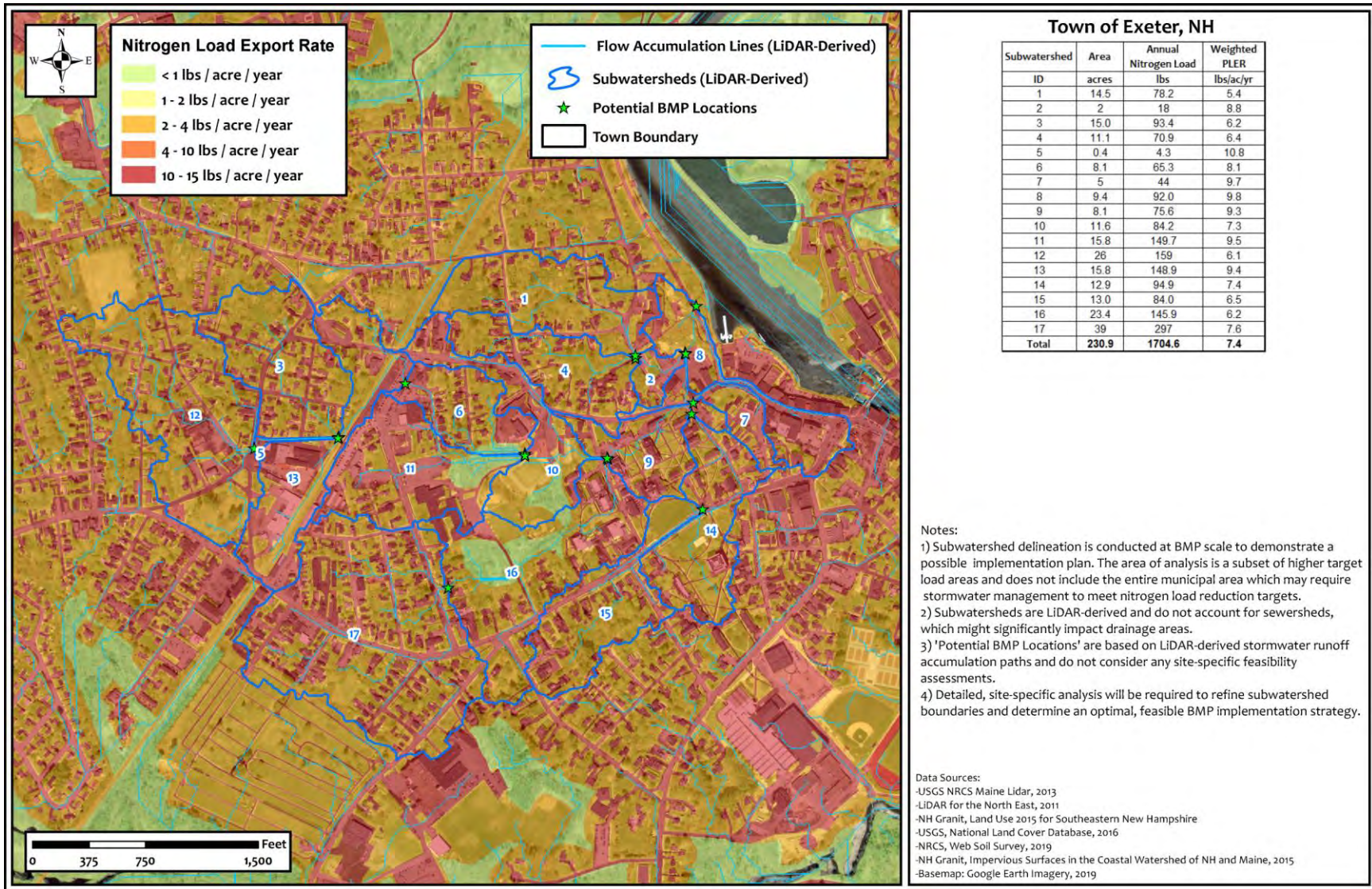


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	14,909				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		6,047.2	14,908.5	\$ 7,229,884	\$ 331
<b>Structural Controls</b>	4,022.3	561.7	6,375.2	\$ 2,811,860	\$ 412
<b>Non-Structural Controls</b>	6,919.4	6,352.8	8,533.3	\$ 4,418,024	\$ 274
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL R DRY WELLO.25	177.50	177.5	1791.1	\$ 710,000	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	130.6	130.6	1568.5	\$ 770,540	\$ 491
COMMERCIAL R DRY WELLO.25	32.7	32.7	388.5	\$ 130,800	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	123.8	123.8	1467.9	\$ 730,420	\$ 498
INSTITUTIONAL R DRY WELLO.25	30.9	30.9	367.1	\$ 123,600	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	43	43.0	516.4	\$ 253,700	\$ 491
INDUSTRIAL R DRY WELLO.25	23.2	23.2	275.6	\$ 92,800	\$ 337
SEPTIC SEPTIC SLUDGEHAMMER	1,069.00	867.3	5515.7	\$ 3,469,019	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	357.9	357.9	375.8	\$ 11,453	\$ 30
LEAF_LITTER_B LEAF_LITTER_B	607	607.0	36.4	\$ 6,677	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	416.6	416.6	50.0	\$ 4,583	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	594	594.0	106.9	\$ 6,534	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	2683	2683.0	2269.8	\$ 858,560	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	707.8	707.8	152.9	\$ 52,377	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	36.7	36.7	7.9	\$ 2,716	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	71.1	71.1	15.4	\$ 5,261	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	11.4	11.4	2.5	\$ 844	\$ 343



Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$10,097	\$60,716	\$172,254	\$283,792	\$395,662	\$1,143,179	\$2,717,875	\$4,937,871	\$7,229,884	\$20,896,676
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	75%
Load Reduction Achieved (Lbs TN/Yr)	331	663	994	1,325	1,657	3,644	7,289	11,264	14,909	24,848
Load Reduction Target (Lbs TN/Yr)	331	663	994	1,325	1,657	3,644	7,289	11,264	14,909	24,848
Treated Area (Acres)	316	1,983	2,011	2,039	2,322	5,094	5,870	6,047	6,047	8,324
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)									
15	21.0	132.2	134.1	135.9	154.8	339.6	391.4	403.1	403.1	554.9
16	19.7	124.0	125.7	127.4	145.1	318.4	366.9	378.0	378.0	520.3
17	18.6	116.7	118.3	119.9	136.6	299.7	345.3	355.7	355.7	489.6
18	17.5	110.2	111.7	113.3	129.0	283.0	326.1	336.0	336.0	462.4
19	16.6	104.4	105.9	107.3	122.2	268.1	309.0	318.3	318.3	438.1
20	15.8	99.2	100.6	102.0	116.1	254.7	293.5	302.4	302.4	416.2
21	15.0	94.4	95.8	97.1	110.6	242.6	279.5	288.0	288.0	396.4
22	14.3	90.2	91.4	92.7	105.5	231.5	266.8	274.9	274.9	378.4
23	13.7	86.2	87.4	88.7	101.0	221.5	255.2	262.9	262.9	361.9
24	13.1	82.6	83.8	85.0	96.7	212.3	244.6	252.0	252.0	346.8
25	12.6	79.3	80.5	81.6	92.9	203.8	234.8	241.9	241.9	333.0

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$10,097	\$60,716	\$172,254	\$283,792	\$395,662	\$1,143,179	\$2,717,875	\$4,937,871	\$7,229,884	\$20,896,676
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	75%
Load Reduction (Lbs TN/Yr)	331	663	994	1,325	1,657	3,644	7,289	11,264	14,909	24,848
Treated Area (Acres)	316	1,983	2,011	2,039	2,322	5,094	5,870	6,047	6,047	8,324
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)									
15	\$673	\$4,048	\$11,484	\$18,919	\$26,377	\$76,212	\$181,192	\$329,191	\$481,992	\$1,393,112
16	\$631	\$3,795	\$10,766	\$17,737	\$24,729	\$71,449	\$169,867	\$308,617	\$451,868	\$1,306,042
17	\$594	\$3,572	\$10,133	\$16,694	\$23,274	\$67,246	\$159,875	\$290,463	\$425,287	\$1,229,216
18	\$561	\$3,373	\$9,570	\$15,766	\$21,981	\$63,510	\$150,993	\$274,326	\$401,660	\$1,160,926
19	\$531	\$3,196	\$9,066	\$14,936	\$20,824	\$60,167	\$143,046	\$259,888	\$380,520	\$1,099,825
20	\$505	\$3,036	\$8,613	\$14,190	\$19,783	\$57,159	\$135,894	\$246,894	\$361,494	\$1,044,834
21	\$481	\$2,891	\$8,203	\$13,514	\$18,841	\$54,437	\$129,423	\$235,137	\$344,280	\$995,080
22	\$459	\$2,760	\$7,830	\$12,900	\$17,985	\$51,963	\$123,540	\$224,449	\$328,631	\$949,849
23	\$439	\$2,640	\$7,489	\$12,339	\$17,203	\$49,703	\$118,168	\$214,690	\$314,343	\$908,551
24	\$421	\$2,530	\$7,177	\$11,825	\$16,486	\$47,632	\$113,245	\$205,745	\$301,245	\$870,695
25	\$404	\$2,429	\$6,890	\$11,352	\$15,826	\$45,727	\$108,715	\$197,515	\$289,195	\$835,867

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$54	\$4.47	\$0.024	\$1,038
16	\$50	\$4.19	\$0.022	\$973
17	\$47	\$3.94	\$0.021	\$916
18	\$45	\$3.72	\$0.020	\$865
19	\$42	\$3.53	\$0.019	\$819
20	\$40	\$3.35	\$0.018	\$778
21	\$38	\$3.19	\$0.017	\$741
22	\$37	\$3.05	\$0.016	\$708
23	\$35	\$2.91	\$0.016	\$677
24	\$34	\$2.79	\$0.015	\$649
25	\$32	\$2.68	\$0.014	\$623

Population Est	14,306	
Persons per household	3	
# of Households Est.	4,769	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	35%	53%
%IC Comm/Ind/Inst	31%	47%
%IC Transportation	29%	
%IC Misc	5%	
		100%

## **B5. Milton, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



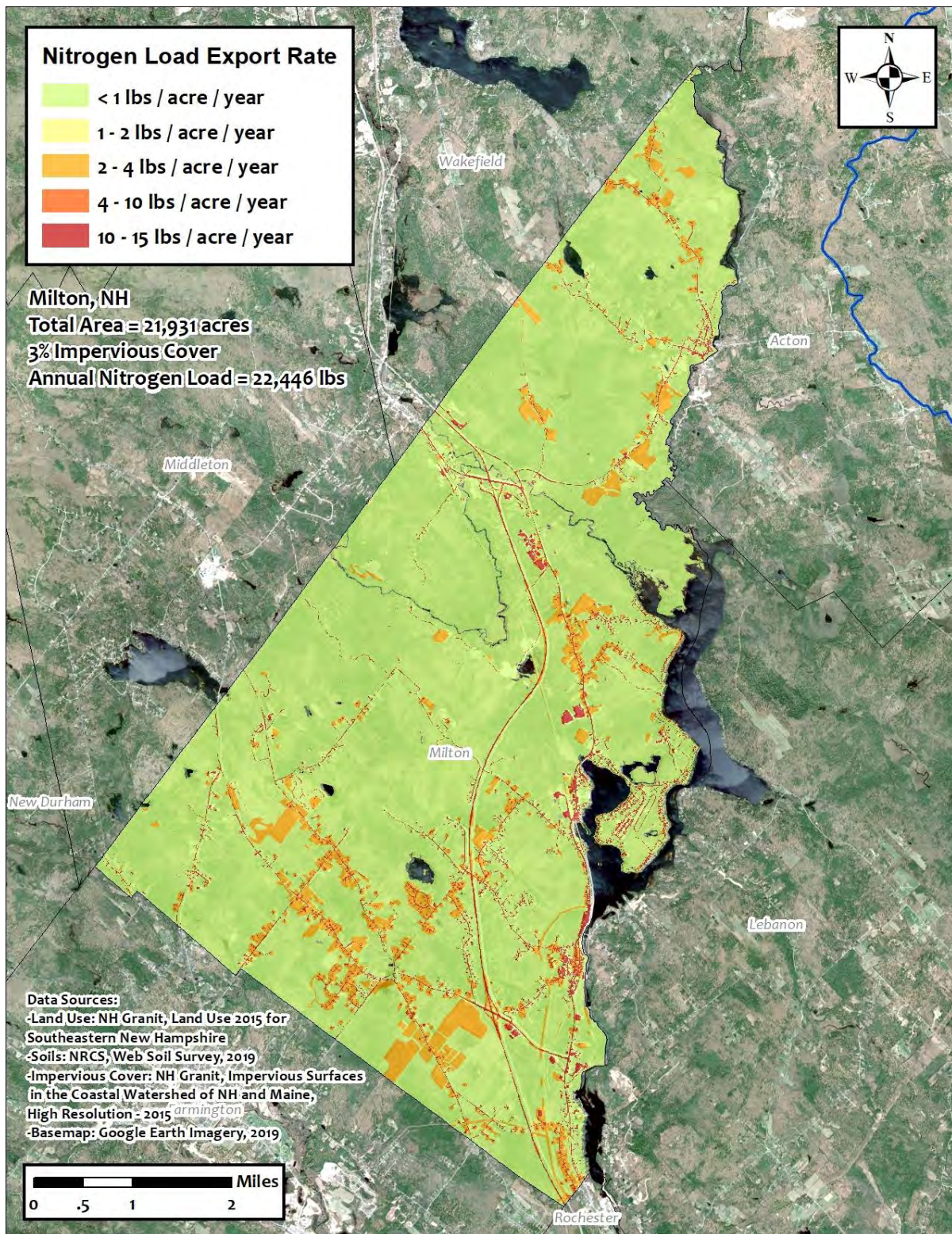


Figure 1 - Annual Nitrogen Load Export



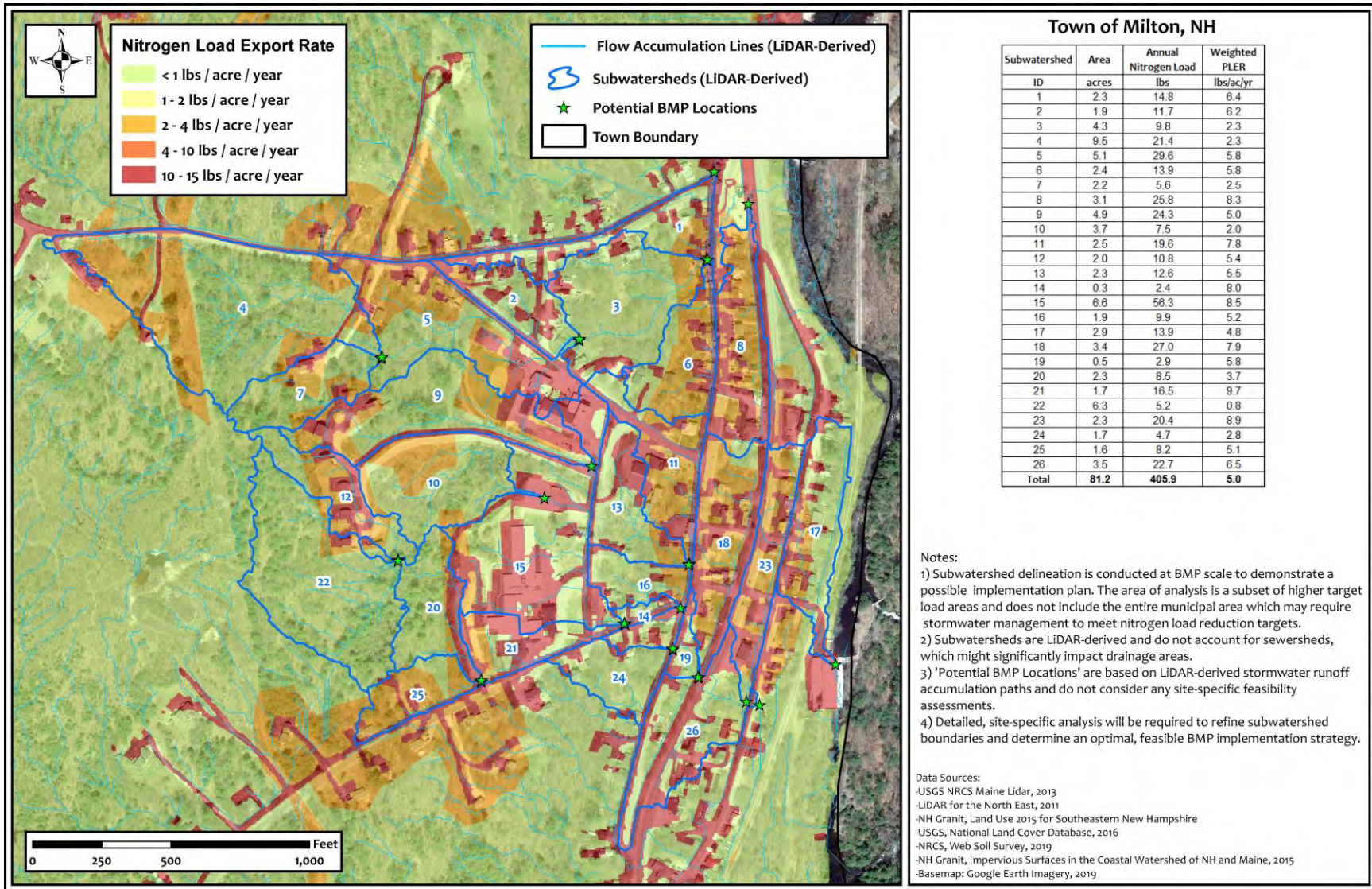


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme



Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	13,307				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		2,809.9	13,306.5	\$ 7,654,894	\$ 408
<b>Structural Controls</b>	2,866.9	459.1	4,195.4	\$ 2,174,328	\$ 496
<b>Non-Structural Controls</b>	3,695.3	3,695.3	9,111.1	\$ 5,480,565	\$ 310
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	177.45	177.5	1261.1	\$ 798,525	\$ 633
RESIDENTIAL R DRY WELLO.25	123.31	123.3	1244.3	\$ 493,240	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	44.43	44.4	533.6	\$ 262,137	\$ 491
COMMERCIAL R DRY WELLO.25	11.11	11.1	132.0	\$ 44,440	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	10.67	10.7	126.5	\$ 62,953	\$ 498
INSTITUTIONAL R DRY WELLO.25	2.67	2.7	31.7	\$ 10,680	\$ 337
ROAD I GRAVEL WETLAND0.25	212	43.7	345.4	\$ 257,755	\$ 746
INDUSTRIAL I GRAVEL WETLAND0.25	24.75	24.8	297.2	\$ 146,025	\$ 491
INDUSTRIAL R DRY WELLO.25	13.33	13.3	158.4	\$ 53,320	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	7.67	7.7	65.3	\$ 45,253	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	1,344.47	1344.5	8550.8	\$ 5,377,880	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	212	212.0	222.6	\$ 6,784	\$ 30
LEAF_LITTER_A LEAF_LITTER_A	911.99	912.0	13.7	\$ 10,032	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	7.33	7.3	0.4	\$ 81	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	274.67	274.7	33.0	\$ 3,021	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	427.23	427.2	76.9	\$ 4,700	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	161.64	161.6	136.7	\$ 51,725	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	352.03	352.0	76.0	\$ 26,050	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	3.96	4.0	0.9	\$ 293	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$11,251	\$101,614	\$208,411	\$325,631	\$442,850	\$1,280,186	\$3,325,909	\$5,557,607	\$7,654,894	\$19,671,050
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	60%
Load Reduction Achieved (Lbs TN/Yr)	296	591	887	1,183	1,479	3,253	6,505	10,054	13,307	17,742
Load Reduction Target (Lbs TN/Yr)	296	591	887	1,183	1,479	3,253	6,505	10,054	13,307	17,742
Treated Area (Acres)	618	943	1,468	1,497	1,526	1,669	1,669	1,669	2,810	3,936
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)									
15	41.2	62.9	97.9	99.8	101.8	111.3	111.3	111.3	187.3	262.4
16	38.6	58.9	91.7	93.6	95.4	104.3	104.3	104.3	175.6	246.0
17	36.4	55.5	86.3	88.1	89.8	98.2	98.2	98.2	165.3	231.5
18	34.3	52.4	81.5	83.2	84.8	92.7	92.7	92.7	156.1	218.7
19	32.5	49.6	77.3	78.8	80.3	87.8	87.8	87.8	147.9	207.2
20	30.9	47.1	73.4	74.9	76.3	83.5	83.5	83.5	140.5	196.8
21	29.4	44.9	69.9	71.3	72.7	79.5	79.5	79.5	133.8	187.4
22	28.1	42.9	66.7	68.1	69.4	75.9	75.9	75.9	127.7	178.9
23	26.9	41.0	63.8	65.1	66.4	72.6	72.6	72.6	122.2	171.1
24	25.8	39.3	61.2	62.4	63.6	69.5	69.5	69.5	117.1	164.0
25	24.7	37.7	58.7	59.9	61.1	66.8	66.8	66.8	112.4	157.4

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$11,251	\$101,614	\$208,411	\$325,631	\$442,850	\$1,280,186	\$3,325,909	\$5,557,607	\$7,654,894	\$19,671,050
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	60%
Load Reduction (Lbs TN/Yr)	296	591	887	1,183	1,479	3,253	6,505	10,054	13,307	17,742
Treated Area (Acres)	618	943	1,468	1,497	1,526	1,669	1,669	1,669	2,810	3,936
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)									
15	\$750	\$6,774	\$13,894	\$21,709	\$29,523	\$85,346	\$221,727	\$370,507	\$510,326	\$1,311,403
16	\$703	\$6,351	\$13,026	\$20,352	\$27,678	\$80,012	\$207,869	\$347,350	\$478,431	\$1,229,441
17	\$662	\$5,977	\$12,259	\$19,155	\$26,050	\$75,305	\$195,642	\$326,918	\$450,288	\$1,157,121
18	\$625	\$5,645	\$11,578	\$18,091	\$24,603	\$71,121	\$184,773	\$308,756	\$425,272	\$1,092,836
19	\$592	\$5,348	\$10,969	\$17,138	\$23,308	\$67,378	\$175,048	\$292,506	\$402,889	\$1,035,318
20	\$563	\$5,081	\$10,421	\$16,282	\$22,143	\$64,009	\$166,295	\$277,880	\$382,745	\$983,553
21	\$536	\$4,839	\$9,924	\$15,506	\$21,088	\$60,961	\$158,377	\$264,648	\$364,519	\$936,717
22	\$511	\$4,619	\$9,473	\$14,801	\$20,130	\$58,190	\$151,178	\$252,619	\$347,950	\$894,139
23	\$489	\$4,418	\$9,061	\$14,158	\$19,254	\$55,660	\$144,605	\$241,635	\$332,821	\$855,263
24	\$469	\$4,234	\$8,684	\$13,568	\$18,452	\$53,341	\$138,580	\$231,567	\$318,954	\$819,627
25	\$450	\$4,065	\$8,336	\$13,025	\$17,714	\$51,207	\$133,036	\$222,304	\$306,196	\$786,842

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$265	\$22.09	\$0.118	\$5,133
16	\$249	\$20.71	\$0.110	\$4,812
17	\$234	\$19.50	\$0.104	\$4,529
18	\$221	\$18.41	\$0.098	\$4,278
19	\$209	\$17.44	\$0.093	\$4,052
20	\$199	\$16.57	\$0.088	\$3,850
21	\$189	\$15.78	\$0.084	\$3,667
22	\$181	\$15.06	\$0.080	\$3,500
23	\$173	\$14.41	\$0.077	\$3,348
24	\$166	\$13.81	\$0.074	\$3,208
25	\$159	\$13.26	\$0.071	\$3,080

Population Est	4,598	
Persons per household	3	
# of Households Est.	1,533	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	43%	80%
% IC Comm/Ind/Inst	11%	20%
% IC Transportation	34%	
% IC Misc	12%	
Total		100%

## **B6. Newfields, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



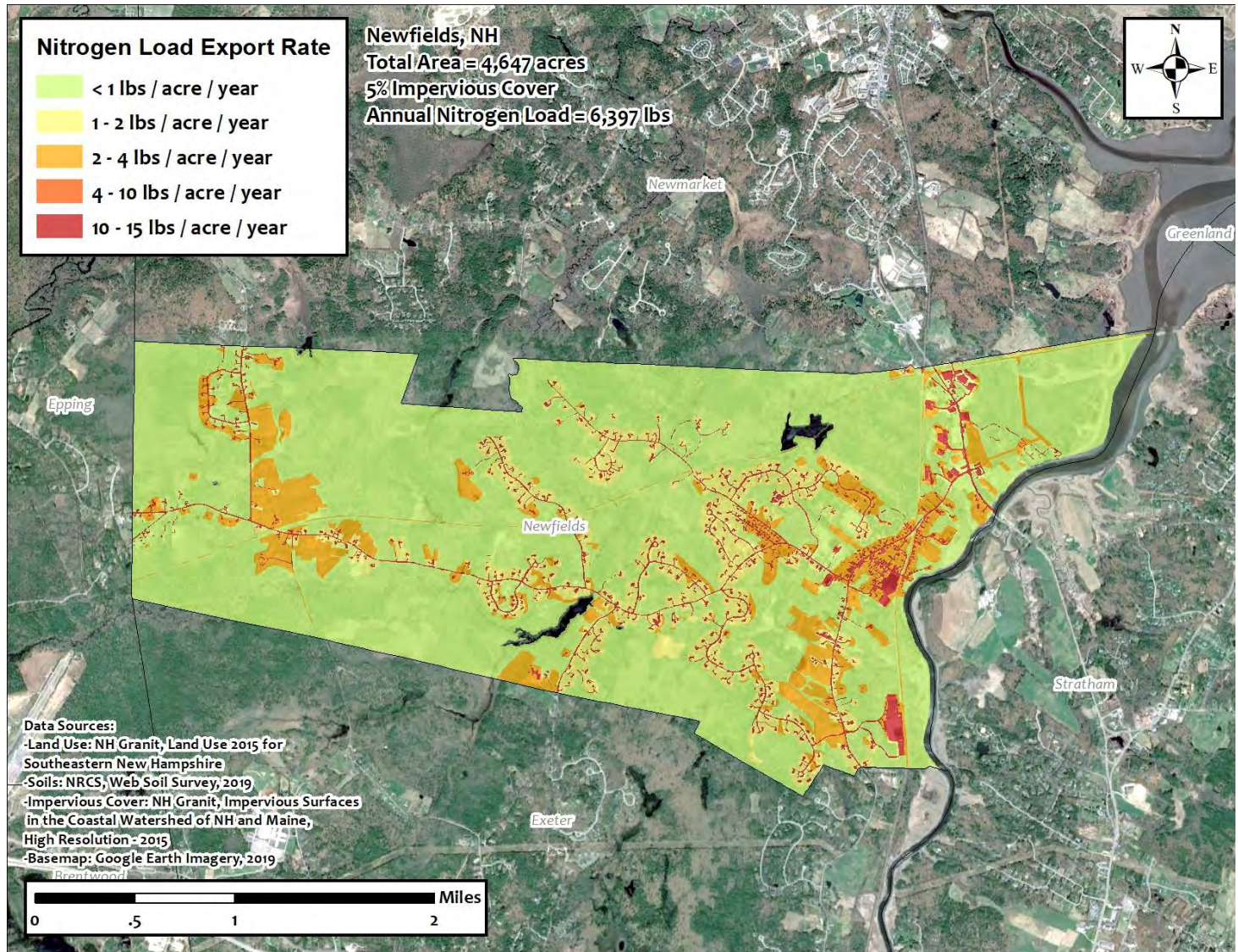


Figure 1 - Annual Nitrogen Load Export



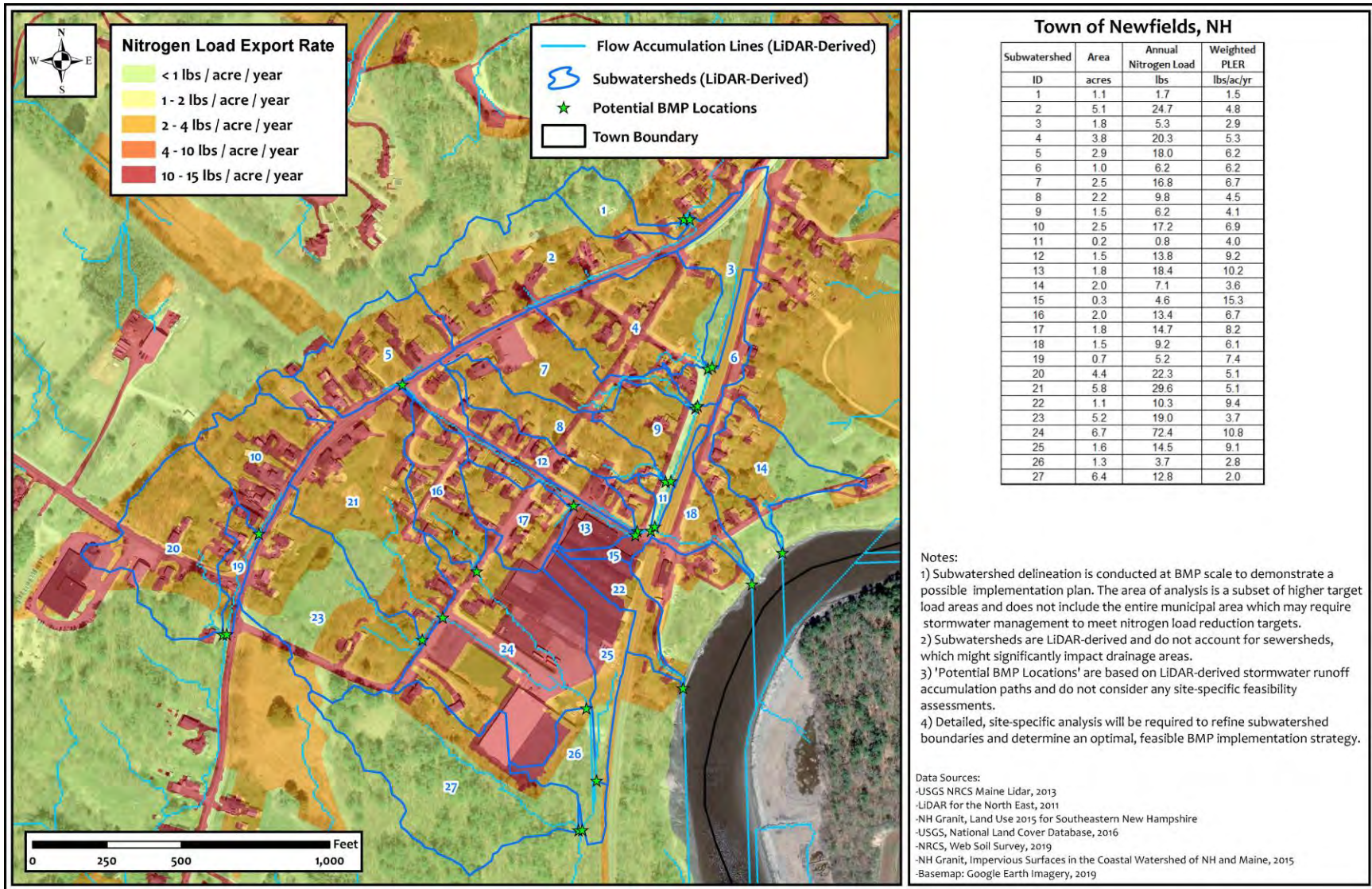


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	3,970				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		863.6	3,969.9	\$ 2,237,924	\$ 349
<b>Structural Controls</b>	990.7	104.9	1,073.6	\$ 488,678	\$ 440
<b>Non-Structural Controls</b>	1,264.7	1,192.1	2,896.3	\$ 1,749,246	\$ 257
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	57.83	21.7	154.1	\$ 97,590	\$ 633
RESIDENTIAL R DRY WELLO.25	40.19	40.2	405.5	\$ 160,760	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	9.36	9.4	112.4	\$ 55,224	\$ 491
COMMERCIAL R DRY WELLO.25	2.34	2.3	27.8	\$ 9,360	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	5.45	5.5	64.6	\$ 32,155	\$ 498
INSTITUTIONAL R DRY WELLO.25	1.36	1.4	16.2	\$ 5,440	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	15.91	15.9	191.1	\$ 93,869	\$ 491
INDUSTRIAL R DRY WELLO.25	8.57	8.6	101.8	\$ 34,280	\$ 337
SEPTIC SEPTIC SLUDGEHAMMER	433.34	433.3	2756.0	\$ 1,733,360	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	59.71	59.7	62.7	\$ 1,911	\$ 30
LEAF_LITTER_B LEAF_LITTER_B	433.17	433.2	26.0	\$ 4,765	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	37.95	38.0	4.6	\$ 417	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	147.65	147.7	26.6	\$ 1,624	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	5	5.0	4.2	\$ 1,600	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	72.75	72.8	15.7	\$ 5,384	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	2.5	2.5	0.5	\$ 185	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$3,471	\$27,780	\$57,481	\$91,445	\$126,417	\$362,688	\$961,129	\$1,626,940	\$2,237,924	\$13,139,440
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	70%
Load Reduction Achieved (Lbs TN/Yr)	88	176	265	353	441	970	1,941	2,999	3,970	6,175
Load Reduction Target (Lbs TN/Yr)	88	176	265	353	441	970	1,941	2,999	3,970	6,175
Treated Area (Acres)	202	683	691	778	786	834	842	842	864	1,822
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)									
15	13.4	45.5	46.0	51.8	52.4	55.6	56.1	56.1	57.6	121.5
16	12.6	42.7	43.2	48.6	49.1	52.2	52.6	52.6	54.0	113.9
17	11.9	40.2	40.6	45.7	46.3	49.1	49.5	49.5	50.8	107.2
18	11.2	38.0	38.4	43.2	43.7	46.4	46.8	46.8	48.0	101.2
19	10.6	36.0	36.4	40.9	41.4	43.9	44.3	44.3	45.5	95.9
20	10.1	34.2	34.5	38.9	39.3	41.7	42.1	42.1	43.2	91.1
21	9.6	32.5	32.9	37.0	37.4	39.7	40.1	40.1	41.1	86.8
22	9.2	31.1	31.4	35.3	35.7	37.9	38.3	38.3	39.3	82.8
23	8.8	29.7	30.0	33.8	34.2	36.3	36.6	36.6	37.5	79.2
24	8.4	28.5	28.8	32.4	32.8	34.8	35.1	35.1	36.0	75.9
25	8.1	27.3	27.6	31.1	31.5	33.4	33.7	33.7	34.5	72.9

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$3,471	\$27,780	\$57,481	\$91,445	\$126,417	\$362,688	\$961,129	\$1,626,940	\$2,237,924	\$13,139,440
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	70%
Load Reduction (Lbs TN/Yr)	88	176	265	353	441	970	1,941	2,999	3,970	6,175
Treated Area (Acres)	202	683	691	778	786	834	842	842	864	1,822
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)									
15	\$231	\$1,852	\$3,832	\$6,096	\$8,428	\$24,179	\$64,075	\$108,463	\$149,195	\$875,963
16	\$217	\$1,736	\$3,593	\$5,715	\$7,901	\$22,668	\$60,071	\$101,684	\$139,870	\$821,215
17	\$204	\$1,634	\$3,381	\$5,379	\$7,436	\$21,335	\$56,537	\$95,702	\$131,643	\$772,908
18	\$193	\$1,543	\$3,193	\$5,080	\$7,023	\$20,149	\$53,396	\$90,386	\$124,329	\$729,969
19	\$183	\$1,462	\$3,025	\$4,813	\$6,654	\$19,089	\$50,586	\$85,628	\$117,785	\$691,549
20	\$174	\$1,389	\$2,874	\$4,572	\$6,321	\$18,134	\$48,056	\$81,347	\$111,896	\$656,972
21	\$165	\$1,323	\$2,737	\$4,355	\$6,020	\$17,271	\$45,768	\$77,473	\$106,568	\$625,688
22	\$158	\$1,263	\$2,613	\$4,157	\$5,746	\$16,486	\$43,688	\$73,952	\$101,724	\$597,247
23	\$151	\$1,208	\$2,499	\$3,976	\$5,496	\$15,769	\$41,788	\$70,737	\$97,301	\$571,280
24	\$145	\$1,158	\$2,395	\$3,810	\$5,267	\$15,112	\$40,047	\$67,789	\$93,247	\$547,477
25	\$139	\$1,111	\$2,299	\$3,658	\$5,057	\$14,508	\$38,445	\$65,078	\$89,517	\$525,578

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$181	\$15.12	\$0.081	\$3,513
16	\$170	\$14.18	\$0.076	\$3,294
17	\$160	\$13.34	\$0.071	\$3,100
18	\$151	\$12.60	\$0.067	\$2,928
19	\$143	\$11.94	\$0.064	\$2,774
20	\$136	\$11.34	\$0.060	\$2,635
21	\$130	\$10.80	\$0.058	\$2,510
22	\$124	\$10.31	\$0.055	\$2,395
23	\$118	\$9.86	\$0.053	\$2,291
24	\$113	\$9.45	\$0.050	\$2,196
25	\$109	\$9.07	\$0.048	\$2,108

Population Est	1,719	
Persons per household	3	
# of Households Est.	573	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	46%	70%
% IC Comm/Ind/Inst	20%	30%
% IC Transportation	28%	
% IC Misc	6%	
Total		100%

## **B7. Newington, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified. It is important to note that the costs for Newington and Portsmouth include Pease International Tradeport, as per the Great Bay Nitrogen Non-Point Source Study (GBNPSS) PLA allocation. A total of 46% and 54% of Pease International Tradeport areas are allocated to Newington and Portsmouth respectively. Presumably those costs would be subtracted simply from Newington and Portsmouth based on the MS4 coverage boundaries.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

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BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



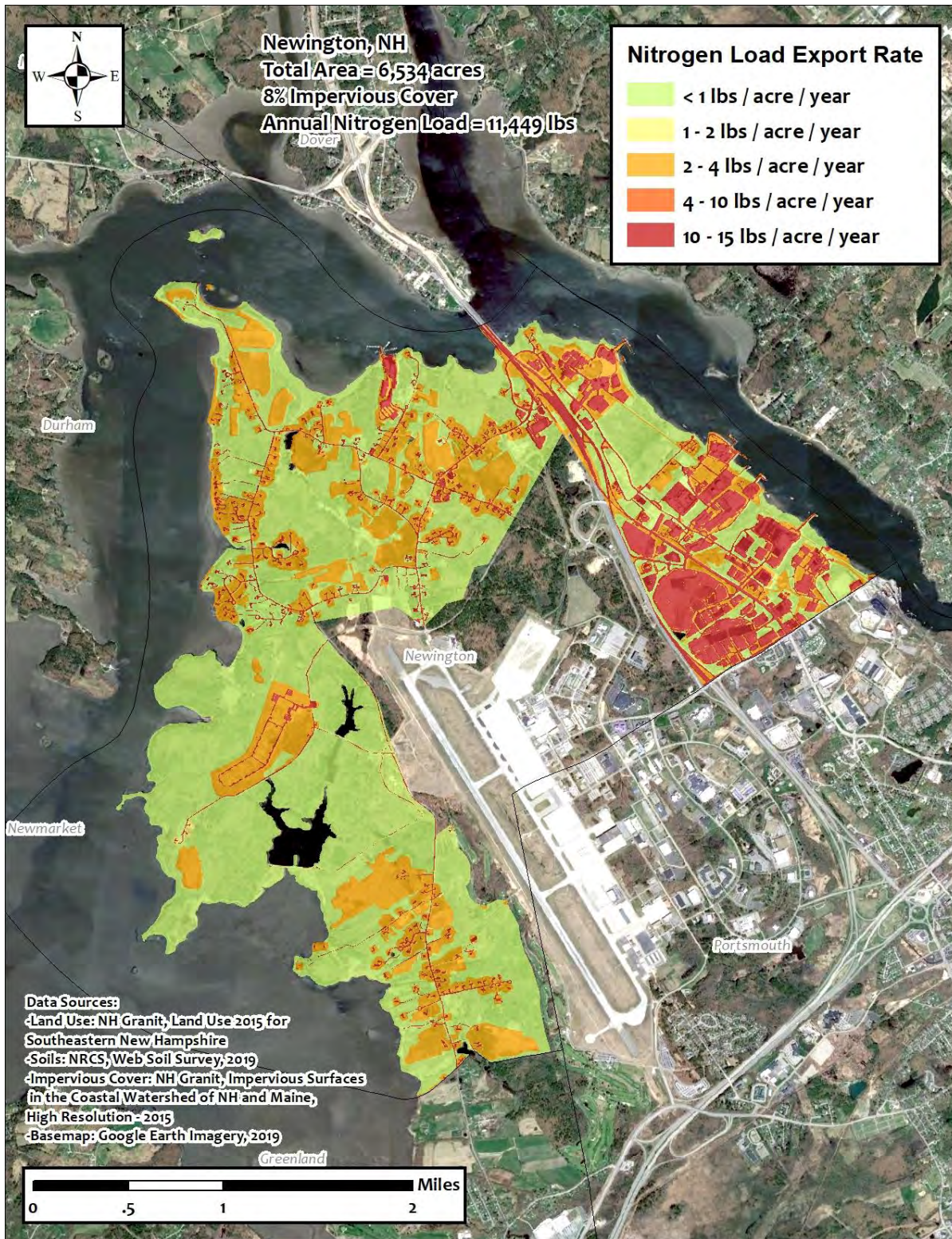


Figure 1 - Annual Nitrogen Load Export



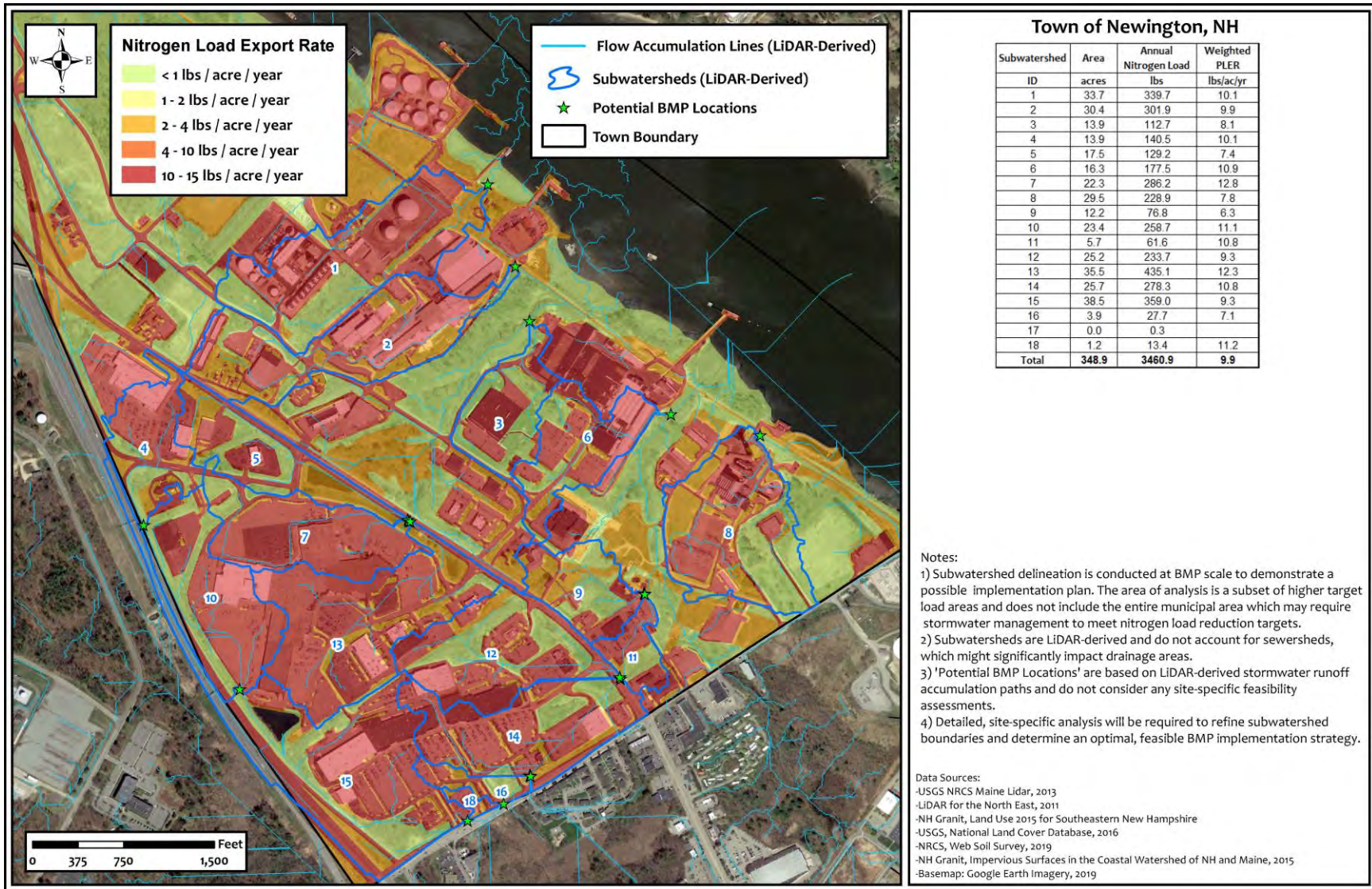


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	12,346				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		2,304.8	12,345.8	\$ 6,476,901	\$ 637
<b>Structural Controls</b>	2,023.9	960.5	10,239.1	\$ 5,392,634	\$ 887
<b>Non-Structural Controls</b>	1,571.9	1,571.9	2,106.6	\$ 1,084,267	\$ 313
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.5	35.30791832	35.3	321.4	\$ 247,155	\$ 769
RESIDENTIAL R DRY WELLO.5	24.54	24.5	295.2	\$ 171,752	\$ 582
COMMERCIAL I GRAVEL WETLAND0.25	206.3787731	206.4	2478.6	\$ 1,217,635	\$ 491
COMMERCIAL D GRAVEL WETLAND0.25	21.46233683	21.5	60.9	\$ 126,628	\$ 2,080
COMMERCIAL R DRY WELLO.25	51.59469328	51.6	613.0	\$ 206,379	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	101.0814429	101.1	1198.5	\$ 596,381	\$ 498
INSTITUTIONAL D GRAVEL WETLAND0.25	15.12726201	0.9	2.6	\$ 5,337	\$ 2,087
INSTITUTIONAL R DRY WELLO.25	25.27036072	25.3	300.2	\$ 101,081	\$ 337
ROAD I GRAVEL WETLAND0.25	158.0038951	158.0	1249.1	\$ 932,223	\$ 746
INDUSTRIAL I GRAVEL WETLAND0.25	189.5360067	189.5	2276.3	\$ 1,118,262	\$ 491
INDUSTRIAL D GRAVEL WETLAND0.25	25.82666875	25.8	73.3	\$ 152,377	\$ 2,080
INDUSTRIAL R DRY WELLO.25	102.0578498	102.1	1212.6	\$ 408,231	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	18.50724688	18.5	157.5	\$ 109,193	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	227.55	227.6	1447.2	\$ 910,214	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	158.0038951	158.0	165.9	\$ 5,056	\$ 30
LEAF_LITTER_A LEAF_LITTER_A	68.11	68.1	1.0	\$ 749	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	3.28965	3.3	0.2	\$ 36	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	72.98483281	73.0	8.8	\$ 803	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	216.7960015	216.8	39.0	\$ 2,385	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	422.5981929	422.6	357.5	\$ 135,231	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	372.942604	372.9	80.6	\$ 27,598	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	27.99470226	28.0	6.0	\$ 2,072	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SCHOOL	1.665058872	1.7	0.4	\$ 123	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$28,637	\$121,002	\$213,367	\$305,732	\$398,097	\$981,629	\$2,462,839	\$4,134,925	\$6,476,901	\$21,943,616
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	55%
Load Reduction Achieved (Lbs TN/Yr)	274	549	823	1,097	1,372	3,018	6,036	9,328	12,346	15,089
Load Reduction Target (Lbs TN/Yr)	274	549	823	1,097	1,372	3,018	6,036	9,328	12,346	15,089
Treated Area (Acres)	456	479	502	525	549	1,478	1,730	1,977	2,305	3,225
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)									
15	30.4	32.0	33.5	35.0	36.6	98.6	115.3	131.8	153.7	215.0
16	28.5	30.0	31.4	32.8	34.3	92.4	108.1	123.5	144.1	201.5
17	26.8	28.2	29.5	30.9	32.3	87.0	101.8	116.3	135.6	189.7
18	25.3	26.6	27.9	29.2	30.5	82.1	96.1	109.8	128.0	179.1
19	24.0	25.2	26.4	27.7	28.9	77.8	91.0	104.0	121.3	169.7
20	22.8	24.0	25.1	26.3	27.4	73.9	86.5	98.8	115.2	161.2
21	21.7	22.8	23.9	25.0	26.1	70.4	82.4	94.1	109.8	153.6
22	20.7	21.8	22.8	23.9	24.9	67.2	78.6	89.9	104.8	146.6
23	19.8	20.8	21.8	22.8	23.8	64.3	75.2	85.9	100.2	140.2
24	19.0	20.0	20.9	21.9	22.9	61.6	72.1	82.4	96.0	134.4
25	18.2	19.2	20.1	21.0	21.9	59.1	69.2	79.1	92.2	129.0

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$28,637	\$121,002	\$213,367	\$305,732	\$398,097	\$981,629	\$2,462,839	\$4,134,925	\$6,476,901	\$21,943,616
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	55%
Load Reduction (Lbs TN/Yr)	274	549	823	1,097	1,372	3,018	6,036	9,328	12,346	15,089
Treated Area (Acres)	456	479	502	525	549	1,478	1,730	1,977	2,305	3,225
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)									
15	\$1,909	\$8,067	\$14,224	\$20,382	\$26,540	\$65,442	\$164,189	\$275,662	\$431,793	\$1,462,908
16	\$1,790	\$7,563	\$13,335	\$19,108	\$24,881	\$61,352	\$153,927	\$258,433	\$404,806	\$1,371,476
17	\$1,685	\$7,118	\$12,551	\$17,984	\$23,417	\$57,743	\$144,873	\$243,231	\$380,994	\$1,290,801
18	\$1,591	\$6,722	\$11,854	\$16,985	\$22,116	\$54,535	\$136,824	\$229,718	\$359,828	\$1,219,090
19	\$1,507	\$6,369	\$11,230	\$16,091	\$20,952	\$51,665	\$129,623	\$217,628	\$340,890	\$1,154,927
20	\$1,432	\$6,050	\$10,668	\$15,287	\$19,905	\$49,081	\$123,142	\$206,746	\$323,845	\$1,097,181
21	\$1,364	\$5,762	\$10,160	\$14,559	\$18,957	\$46,744	\$117,278	\$196,901	\$308,424	\$1,044,934
22	\$1,302	\$5,500	\$9,698	\$13,897	\$18,095	\$44,619	\$111,947	\$187,951	\$294,405	\$997,437
23	\$1,245	\$5,261	\$9,277	\$13,293	\$17,309	\$42,680	\$107,080	\$179,779	\$281,604	\$954,070
24	\$1,193	\$5,042	\$8,890	\$12,739	\$16,587	\$40,901	\$102,618	\$172,289	\$269,871	\$914,317
25	\$1,145	\$4,840	\$8,535	\$12,229	\$15,924	\$39,265	\$98,514	\$165,397	\$259,076	\$877,745

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$254	\$21.20	\$0.113	\$4,924
16	\$238	\$19.87	\$0.106	\$4,617
17	\$224	\$18.70	\$0.100	\$4,345
18	\$212	\$17.66	\$0.094	\$4,104
19	\$201	\$16.73	\$0.089	\$3,888
20	\$191	\$15.90	\$0.085	\$3,693
21	\$182	\$15.14	\$0.081	\$3,517
22	\$173	\$14.45	\$0.077	\$3,358
23	\$166	\$13.82	\$0.074	\$3,212
24	\$159	\$13.25	\$0.071	\$3,078
25	\$153	\$12.72	\$0.068	\$2,955

Population Est	789	
Persons per household	3	
# of Households Est.	263	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	11%	15%
%IC Comm/Ind/Inst	60%	85%
%IC Transportation	22%	
%IC Misc	7%	
Total		100%



## **B8. Newmarket, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.

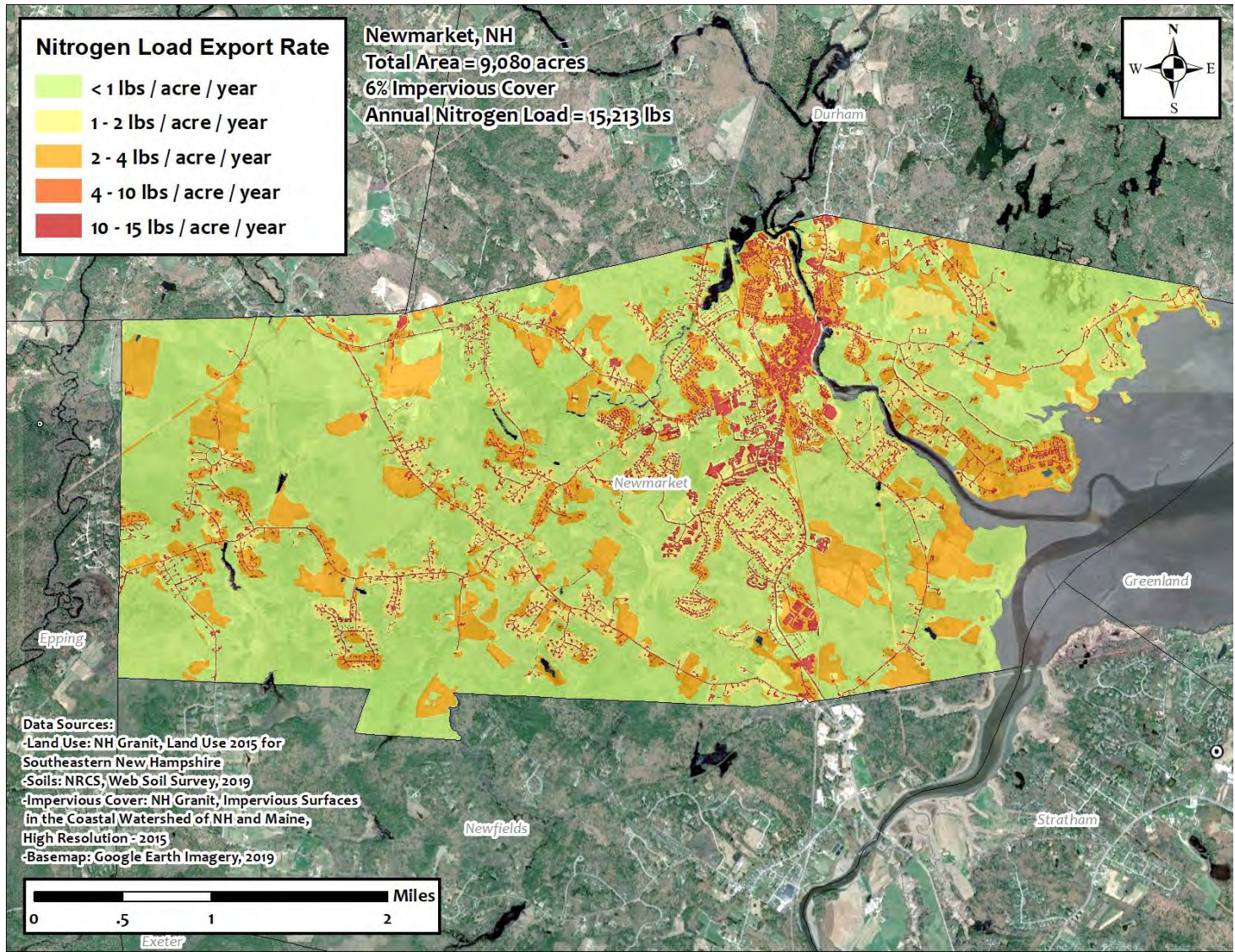


Figure 1 - Annual Nitrogen Load Export



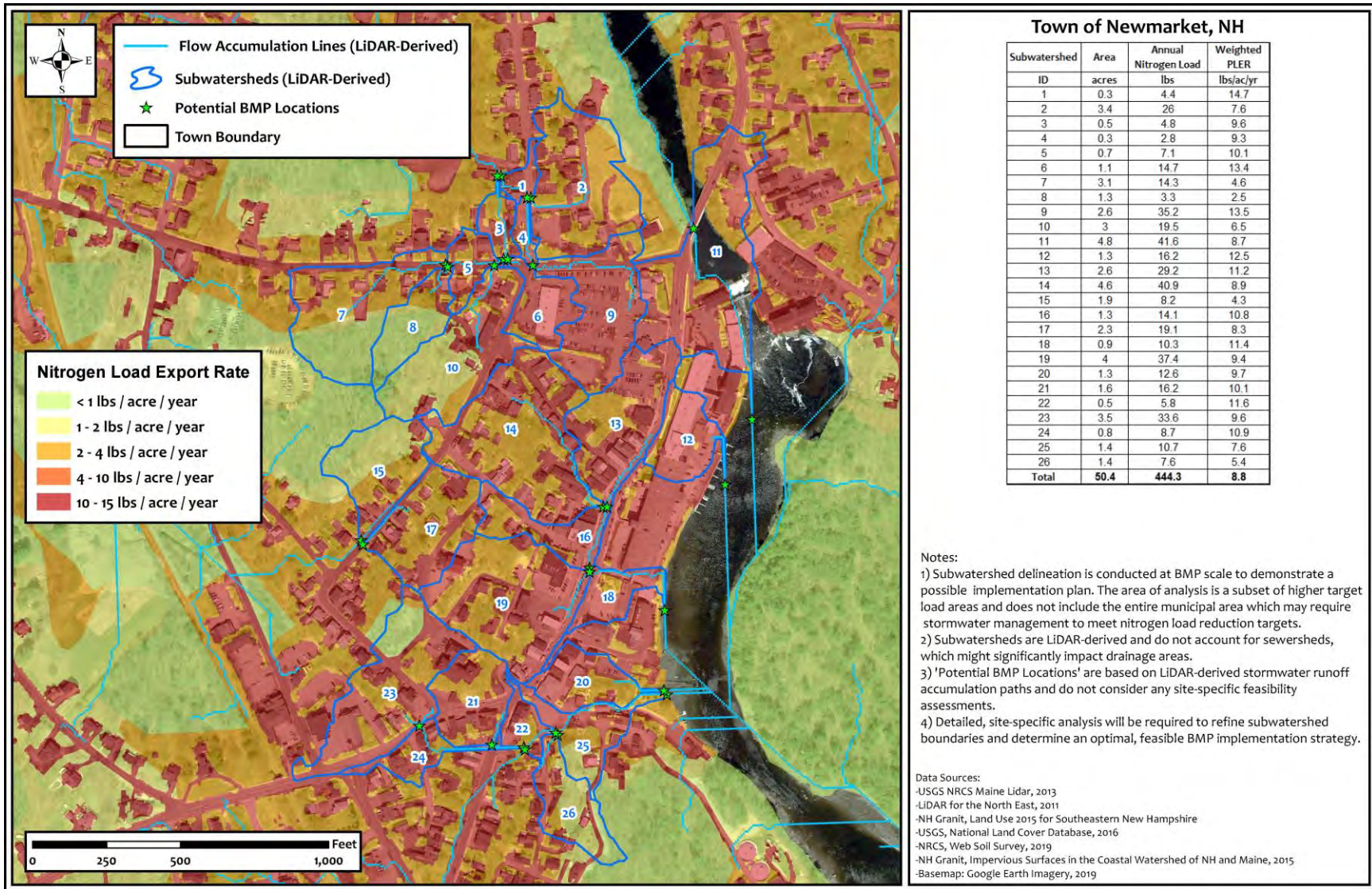


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	11,000				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		3,286.6	11,000.3	\$ 6,409,285	\$ 418
<b>Structural Controls</b>	2,443.2	558.4	5,057.8	\$ 3,006,075	\$ 521
<b>Non-Structural Controls</b>	3,508.1	3,508.1	5,942.5	\$ 3,403,210	\$ 316
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	199.1	85.3	606.0	\$ 383,710	\$ 633
RESIDENTIAL I RAINGARDEN0.5	199.1	113.8	1036.2	\$ 796,748	\$ 769
RESIDENTIAL R DRY WELLO.25	138.4	138.4	1396.0	\$ 553,400	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	21.8	21.8	262.1	\$ 128,738	\$ 491
COMMERCIAL R DRY WELLO.25	5.5	5.5	64.8	\$ 21,800	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	13.0	13.0	154.6	\$ 76,936	\$ 498
INSTITUTIONAL R DRY WELLO.25	3.3	3.3	38.7	\$ 13,040	\$ 337
ROAD I GRAVEL WETLAND0.25	144.0	144.0	1138.4	\$ 849,659	\$ 746
INDUSTRIAL I GRAVEL WETLAND0.25	14.5	14.5	174.1	\$ 85,550	\$ 491
INDUSTRIAL R DRY WELLO.25	7.8	7.8	92.8	\$ 31,240	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	11.1	11.1	94.1	\$ 65,254	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	780.0	780.0	4960.6	\$ 3,119,880	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	144.0	144.0	151.2	\$ 4,608	\$ 30
LEAF_LITTER_A LEAF_LITTER_A	228.1	228.1	3.4	\$ 2,509	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	764.8	764.8	45.9	\$ 8,413	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	158.7	158.7	19.0	\$ 1,745	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	342.9	342.9	61.7	\$ 3,772	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	738.4	738.4	624.7	\$ 236,285	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	300.6	300.6	64.9	\$ 22,244	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	41.5	41.5	9.0	\$ 3,073	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	6.5	6.5	1.4	\$ 483	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	2.7	2.7	0.6	\$ 198	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$12,414	\$89,677	\$179,961	\$272,425	\$365,752	\$958,386	\$2,585,466	\$4,431,178	\$6,409,285	\$28,728,531
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	60%
Load Reduction Achieved (Lbs TN/Yr)	244	489	733	978	1,222	2,689	5,378	8,311	11,000	14,667
Load Reduction Target (Lbs TN/Yr)	244	489	733	978	1,222	2,689	5,378	8,311	11,000	14,667
Treated Area (Acres)	854	1,495	1,995	2,284	2,521	2,665	2,704	2,731	3,287	5,171
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)									
15	56.9	99.7	133.0	152.3	168.1	177.7	180.3	182.1	219.1	344.8
16	53.3	93.5	124.7	142.7	157.6	166.6	169.0	170.7	205.4	323.2
17	50.2	88.0	117.3	134.3	148.3	156.8	159.1	160.6	193.3	304.2
18	47.4	83.1	110.8	126.9	140.1	148.0	150.2	151.7	182.6	287.3
19	44.9	78.7	105.0	120.2	132.7	140.3	142.3	143.7	173.0	272.2
20	42.7	74.8	99.7	114.2	126.1	133.2	135.2	136.5	164.3	258.6
21	40.6	71.2	95.0	108.8	120.1	126.9	128.8	130.0	156.5	246.3
22	38.8	68.0	90.7	103.8	114.6	121.1	122.9	124.1	149.4	235.1
23	37.1	65.0	86.7	99.3	109.6	115.9	117.6	118.7	142.9	224.8
24	35.6	62.3	83.1	95.2	105.1	111.0	112.7	113.8	136.9	215.5
25	34.1	59.8	79.8	91.4	100.9	106.6	108.2	109.2	131.5	206.9

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$12,414	\$89,677	\$179,961	\$272,425	\$365,752	\$958,386	\$2,585,466	\$4,431,178	\$6,409,285	\$28,728,531
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	60%
Load Reduction (Lbs TN/Yr)	244	489	733	978	1,222	2,689	5,378	8,311	11,000	14,667
Treated Area (Acres)	854	1,495	1,995	2,284	2,521	2,665	2,704	2,731	3,287	5,171
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)									
15	\$828	\$5,978	\$11,997	\$18,162	\$24,383	\$63,892	\$172,364	\$295,412	\$427,286	\$1,915,235
16	\$776	\$5,605	\$11,248	\$17,027	\$22,859	\$59,899	\$161,592	\$276,949	\$400,580	\$1,795,533
17	\$730	\$5,275	\$10,586	\$16,025	\$21,515	\$56,376	\$152,086	\$260,658	\$377,017	\$1,689,914
18	\$690	\$4,982	\$9,998	\$15,135	\$20,320	\$53,244	\$143,637	\$246,177	\$356,071	\$1,596,030
19	\$653	\$4,720	\$9,472	\$14,338	\$19,250	\$50,441	\$136,077	\$233,220	\$337,331	\$1,512,028
20	\$621	\$4,484	\$8,998	\$13,621	\$18,288	\$47,919	\$129,273	\$221,559	\$320,464	\$1,436,427
21	\$591	\$4,270	\$8,570	\$12,973	\$17,417	\$45,637	\$123,117	\$211,008	\$305,204	\$1,368,025
22	\$564	\$4,076	\$8,180	\$12,383	\$16,625	\$43,563	\$117,521	\$201,417	\$291,331	\$1,305,842
23	\$540	\$3,899	\$7,824	\$11,845	\$15,902	\$41,669	\$112,412	\$192,660	\$278,665	\$1,249,067
24	\$517	\$3,737	\$7,498	\$11,351	\$15,240	\$39,933	\$107,728	\$184,632	\$267,054	\$1,197,022
25	\$497	\$3,587	\$7,198	\$10,897	\$14,630	\$38,335	\$103,419	\$177,247	\$256,371	\$1,149,141



Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$119	\$9.90	\$0.053	\$2,299
16	\$111	\$9.28	\$0.049	\$2,155
17	\$105	\$8.73	\$0.047	\$2,029
18	\$99	\$8.25	\$0.044	\$1,916
19	\$94	\$7.81	\$0.042	\$1,815
20	\$89	\$7.42	\$0.040	\$1,724
21	\$85	\$7.07	\$0.038	\$1,642
22	\$81	\$6.75	\$0.036	\$1,568
23	\$77	\$6.45	\$0.034	\$1,499
24	\$74	\$6.19	\$0.033	\$1,437
25	\$71	\$5.94	\$0.032	\$1,380

Population Est	9,073	
Persons per household	3	
# of Households Est.	3,024	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	58%	84%
% IC Comm/Ind/Inst	11%	16%
% IC Transportation	25%	
% IC Misc	6%	
Total		100%

## **B9. Pease International Tradeport, New Hampshire**

In this study, Pease ITP was not examined individually because the EPA and DES calculations in the Great Bay Nitrogen Non-Point Source Study do not examine an individual NPS load for Pease ITP and instead combine it with Newington and Portsmouth. On January 1, 2019 Pease ITP agreed to apply for coverage of discharges subject to the NH Small MS4 Permit, either under the general permit or an individual permit.<sup>1</sup> The agreement specifies specific removal or treatment of impervious surfaces in addition to the standard MS4 requirements. It is important to note that the costs for Newington and Portsmouth include Pease International Tradeport, as per the Great Bay Nitrogen Non-Point Source Study (GBNPSS) PLA allocation. A total of 46% and 54% of Pease International Tradeport areas are allocated to Newington and Portsmouth respectively. Presumably those costs would be subtracted simply from Newington and Portsmouth based on the MS4 coverage boundaries.

A pollutant load analysis was conducted to determine the nitrogen load Pease. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

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<sup>1</sup> Irwin, T, Z. Griefen, et al. (2019). Settlement Agreement between Conservation Law Foundation v. Pease Development Authority, US District Court for NH. Case No 1:16-cv-00493-SM.

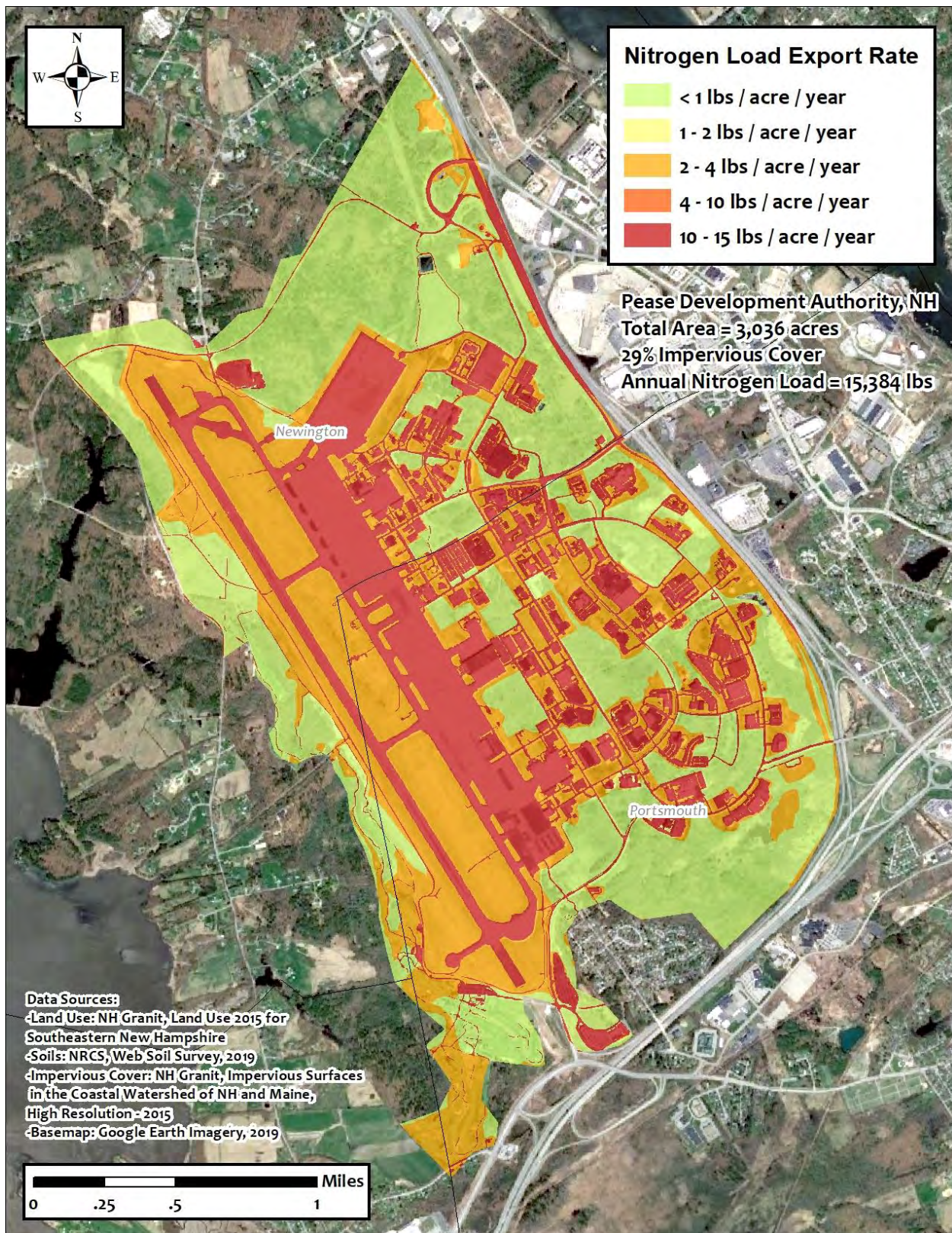


Figure 1 - Annual Nitrogen Load Export



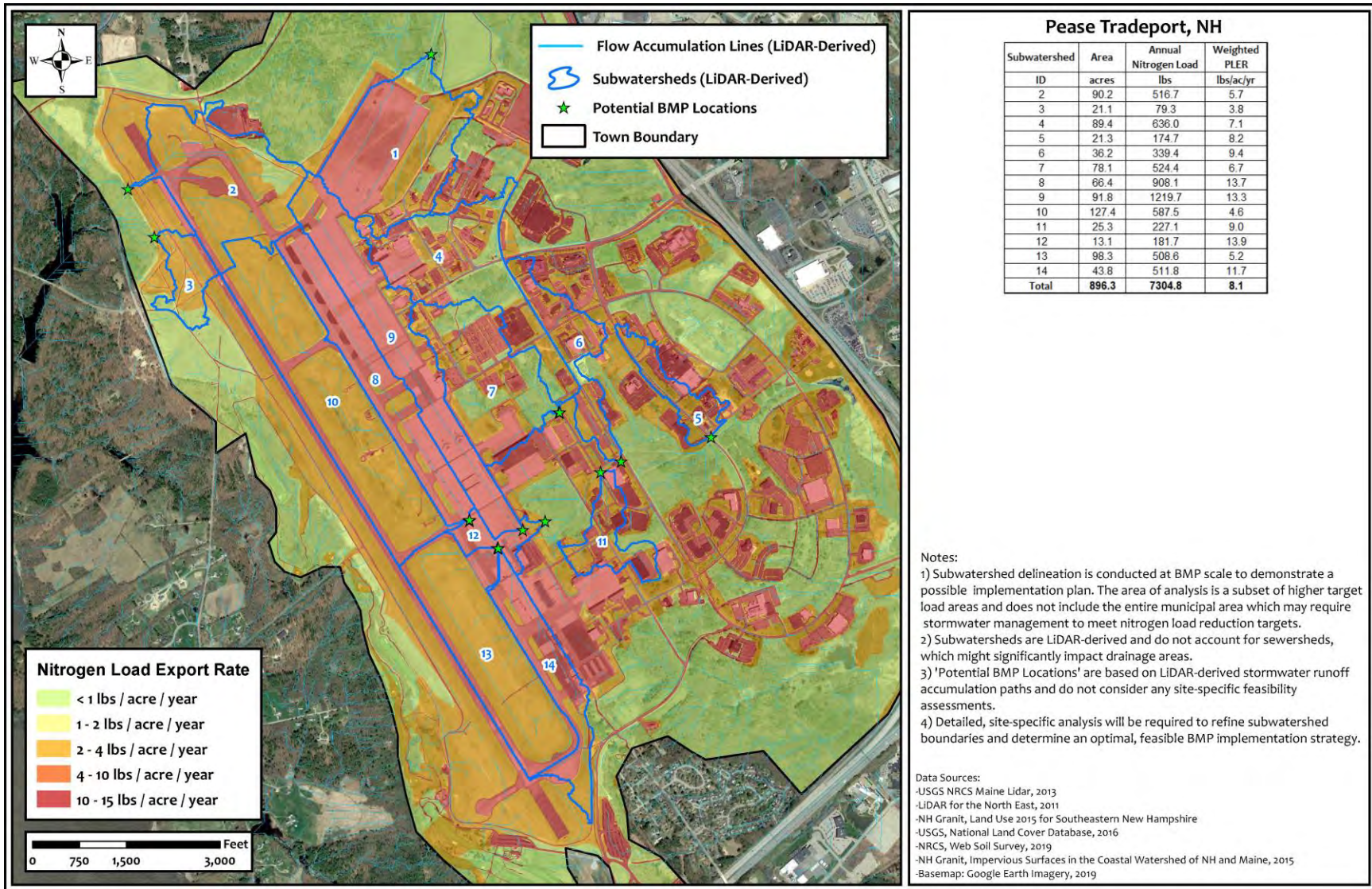


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

## **B10. Portsmouth, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified. It is important to note that the costs for Newington and Portsmouth include Pease International Tradeport, as per the Great Bay Nitrogen Non-Point Source Study (GBNPSS) PLA allocation. A total of 46% and 54% of Pease International Tradeport areas are allocated to Newington and Portsmouth respectively. Presumably those costs would be subtracted simply from Newington and Portsmouth based on the MS4 coverage boundaries.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



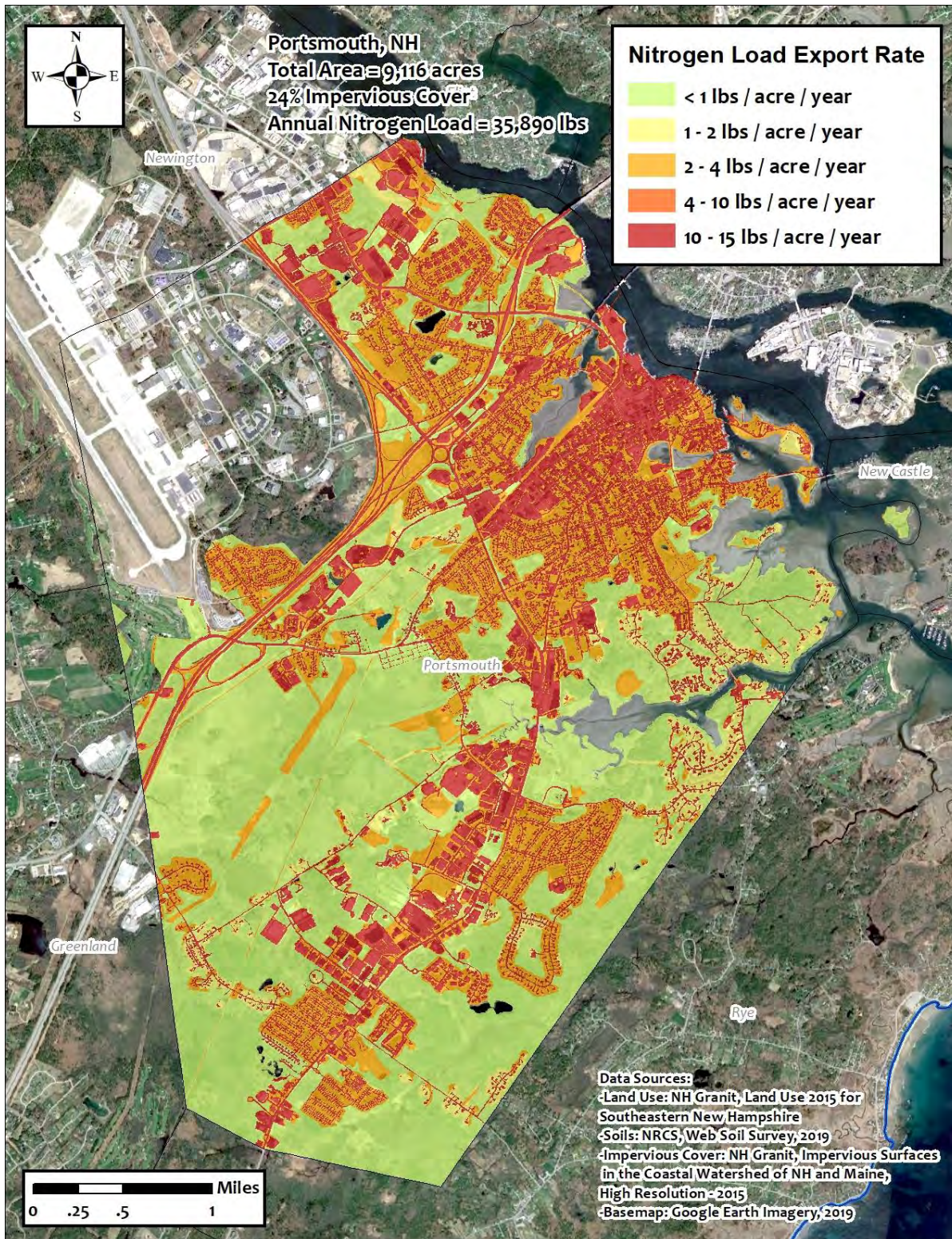


Figure 1 - Annual Nitrogen Load Export



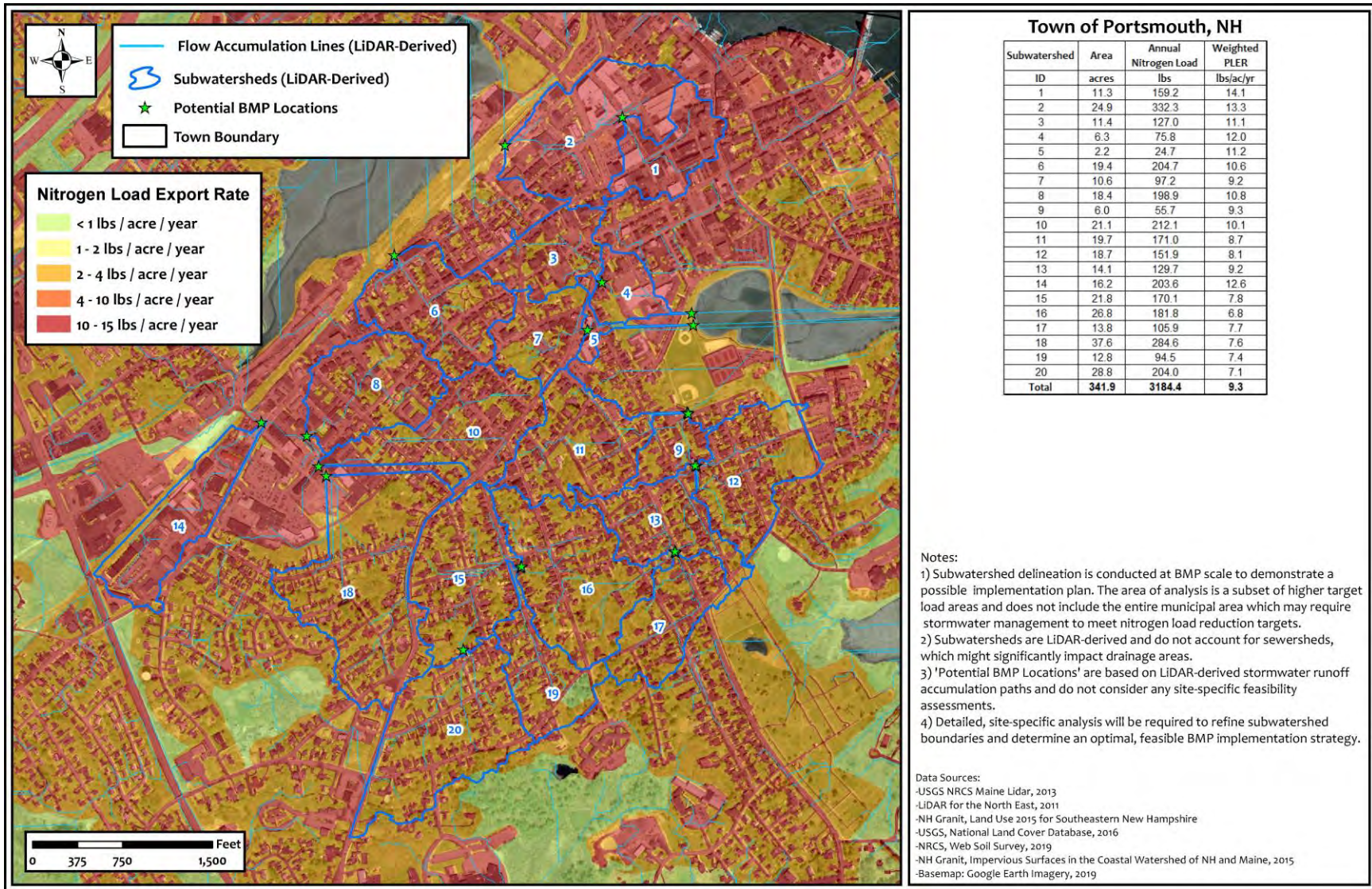


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	21,616				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		7,261.6	21,615.8	\$ 9,266,590	\$ 331
<b>Structural Controls</b>	5,407.2	1,548.1	18,029.4	\$ 8,044,536	\$ 412
<b>Non-Structural Controls</b>	6,233.6	5,806.0	3,586.3	\$ 1,222,053	\$ 274
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL R DRY WELLO.25	254.70	254.7	2570.0	\$ 1,018,792	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	494.6859509	494.7	5941.2	\$ 2,918,647	\$ 491
COMMERCIAL R DRY WELLO.25	123.6714877	123.7	1469.4	\$ 494,686	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	220.1032715	220.1	2609.8	\$ 1,298,609	\$ 498
INSTITUTIONAL R DRY WELLO.25	55.02581788	55.0	653.8	\$ 220,103	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	259.962559	260.0	3122.2	\$ 1,533,779	\$ 491
INDUSTRIAL R DRY WELLO.25	139.9798395	140.0	1663.1	\$ 559,919	\$ 337
SEPTIC SEPTIC SLUDGEHAMMER	482.55	92.6	588.8	\$ 370,328	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	621.2772183	621.3	652.3	\$ 19,881	\$ 30
LEAF_LITTER_B LEAF_LITTER_B	297.0536709	297.1	17.8	\$ 3,268	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	939.3589773	939.4	112.7	\$ 10,333	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	135.5131178	135.5	24.4	\$ 1,491	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	2201.043901	2201.0	1862.1	\$ 704,334	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	1400.772227	1400.8	302.6	\$ 103,657	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	90.48564362	90.5	19.5	\$ 6,696	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	17.3235256	17.3	3.7	\$ 1,282	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	10.60146251	10.6	2.3	\$ 785	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

<b>Cost to Implement</b>	\$14,639	\$86,624	\$248,342	\$410,061	\$571,779	\$1,559,094	\$3,741,570	\$6,573,253	\$9,266,590	\$25,600,254
<b>Percent Reduction</b>	1%	2%	3%	4%	5%	11%	22%	34%	45%	75%
<b>Load Reduction Achieved (Lbs TN/Yr)</b>	480	961	1,441	1,921	2,402	5,284	10,568	16,332	21,616	36,026
<b>Load Reduction Target (Lbs TN/Yr)</b>	480	961	1,441	1,921	2,402	5,284	10,568	16,332	21,616	36,026
<b>Treated Area (Acres)</b>	457	2,006	2,047	2,087	2,127	4,259	6,388	6,868	7,262	9,289
<b>Implementation Period (yrs)</b>	<b>Yearly Rate of Area Treated-Total (AC/YR)</b>									
15	30.5	133.7	136.4	139.1	141.8	283.9	425.9	457.9	484.1	619.3
16	28.6	125.4	127.9	130.4	133.0	266.2	399.2	429.2	453.8	580.6
17	26.9	118.0	120.4	122.8	125.1	250.5	375.8	404.0	427.2	546.4
18	25.4	111.5	113.7	115.9	118.2	236.6	354.9	381.5	403.4	516.1
19	24.1	105.6	107.7	109.8	112.0	224.2	336.2	361.5	382.2	488.9
20	22.9	100.3	102.3	104.3	106.4	213.0	319.4	343.4	363.1	464.5
21	21.8	95.5	97.5	99.4	101.3	202.8	304.2	327.0	345.8	442.3
22	20.8	91.2	93.0	94.9	96.7	193.6	290.4	312.2	330.1	422.2
23	19.9	87.2	89.0	90.7	92.5	185.2	277.7	298.6	315.7	403.9
24	19.1	83.6	85.3	87.0	88.6	177.5	266.2	286.2	302.6	387.0
25	18.3	80.2	81.9	83.5	85.1	170.4	255.5	274.7	290.5	371.6

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

<b>Cost to Implement</b>	\$14,639	\$86,624	\$248,342	\$410,061	\$571,779	\$1,559,094	\$3,741,570	\$6,573,253	\$9,266,590	\$25,600,254
<b>Percent Reduction</b>	1%	2%	3%	4%	5%	11%	22%	34%	45%	75%
<b>Load Reduction (Lbs TN/Yr)</b>	480	961	1,441	1,921	2,402	5,284	10,568	16,332	21,616	36,026
<b>Treated Area (Acres)</b>	457	2,006	2,047	2,087	2,127	4,259	6,388	6,868	7,262	9,289
<b>Implementation Period (yrs)</b>	<b>Yearly Cost to Implement Total (\$\$/Yr)</b>									
15	\$976	\$5,775	\$16,556	\$27,337	\$38,119	\$103,940	\$249,438	\$438,217	\$617,773	\$1,706,684
16	\$915	\$5,414	\$15,521	\$25,629	\$35,736	\$97,443	\$233,848	\$410,828	\$579,162	\$1,600,016
17	\$861	\$5,096	\$14,608	\$24,121	\$33,634	\$91,711	\$220,092	\$386,662	\$545,094	\$1,505,897
18	\$813	\$4,812	\$13,797	\$22,781	\$31,766	\$86,616	\$207,865	\$365,181	\$514,811	\$1,422,236
19	\$770	\$4,559	\$13,071	\$21,582	\$30,094	\$82,058	\$196,925	\$345,961	\$487,715	\$1,347,382
20	\$732	\$4,331	\$12,417	\$20,503	\$28,589	\$77,955	\$187,079	\$328,663	\$463,329	\$1,280,013
21	\$697	\$4,125	\$11,826	\$19,527	\$27,228	\$74,243	\$178,170	\$313,012	\$441,266	\$1,219,060
22	\$665	\$3,937	\$11,288	\$18,639	\$25,990	\$70,868	\$170,071	\$298,784	\$421,209	\$1,163,648
23	\$636	\$3,766	\$10,797	\$17,829	\$24,860	\$67,787	\$162,677	\$285,794	\$402,895	\$1,113,055
24	\$610	\$3,609	\$10,348	\$17,086	\$23,824	\$64,962	\$155,899	\$273,886	\$386,108	\$1,066,677
25	\$586	\$3,465	\$9,934	\$16,402	\$22,871	\$62,364	\$149,663	\$262,930	\$370,664	\$1,024,010

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$35	\$2.94	\$0.016	\$682
16	\$33	\$2.75	\$0.015	\$639
17	\$31	\$2.59	\$0.014	\$602
18	\$29	\$2.45	\$0.013	\$568
19	\$28	\$2.32	\$0.012	\$538
20	\$26	\$2.20	\$0.012	\$511
21	\$25	\$2.10	\$0.011	\$487
22	\$24	\$2.00	\$0.011	\$465
23	\$23	\$1.91	\$0.010	\$445
24	\$22	\$1.83	\$0.010	\$426
25	\$21	\$1.76	\$0.009	\$409

Population Est	21,796	
Persons per household	3	
# of Households Est.	7,265	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	29%	41%
% IC Comm/Ind/Inst	41%	59%
% IC Transportation	27%	
% IC Misc	3%	
Total		100%



## **B11. Rochester, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.

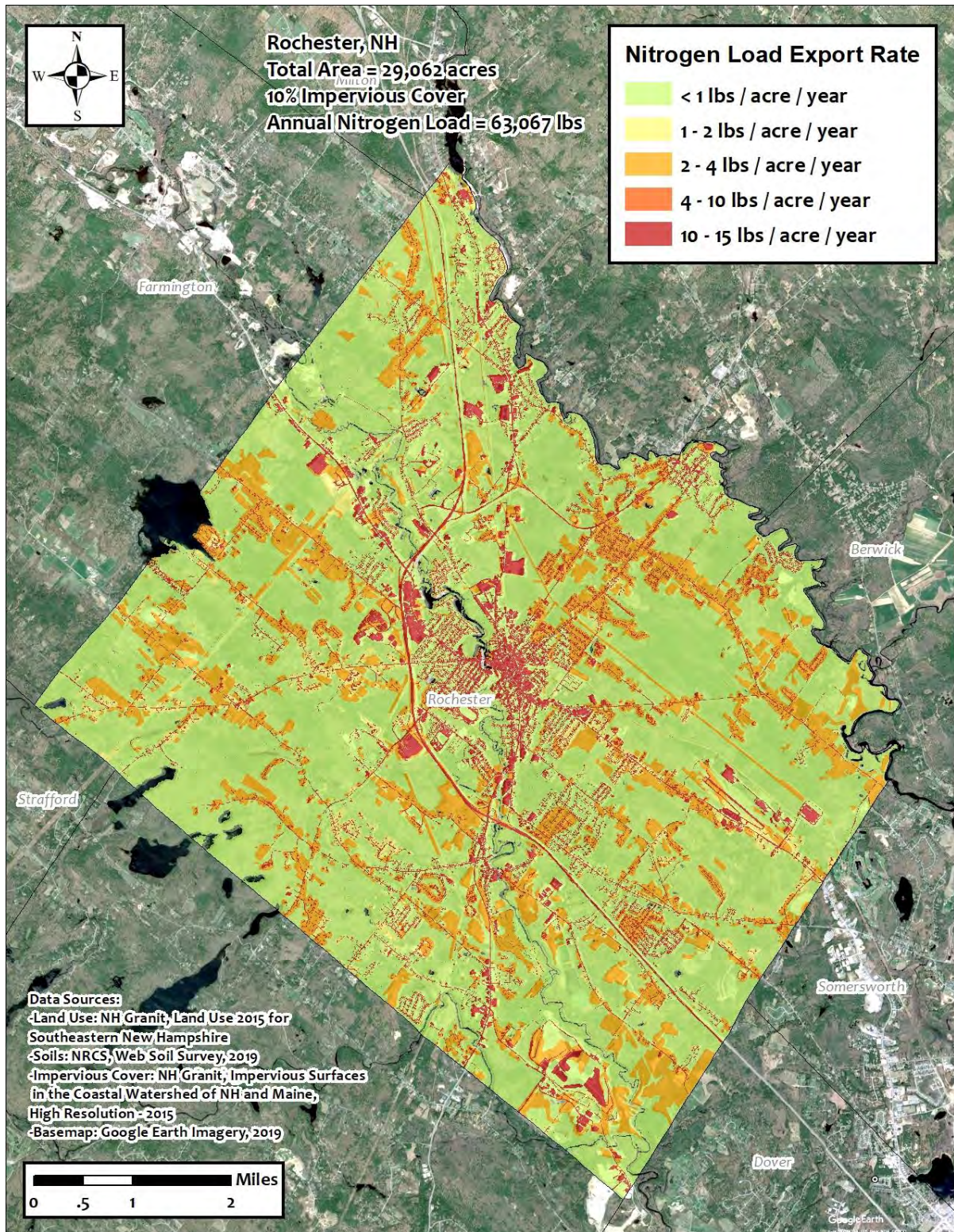


Figure 1 - Annual Nitrogen Load Export



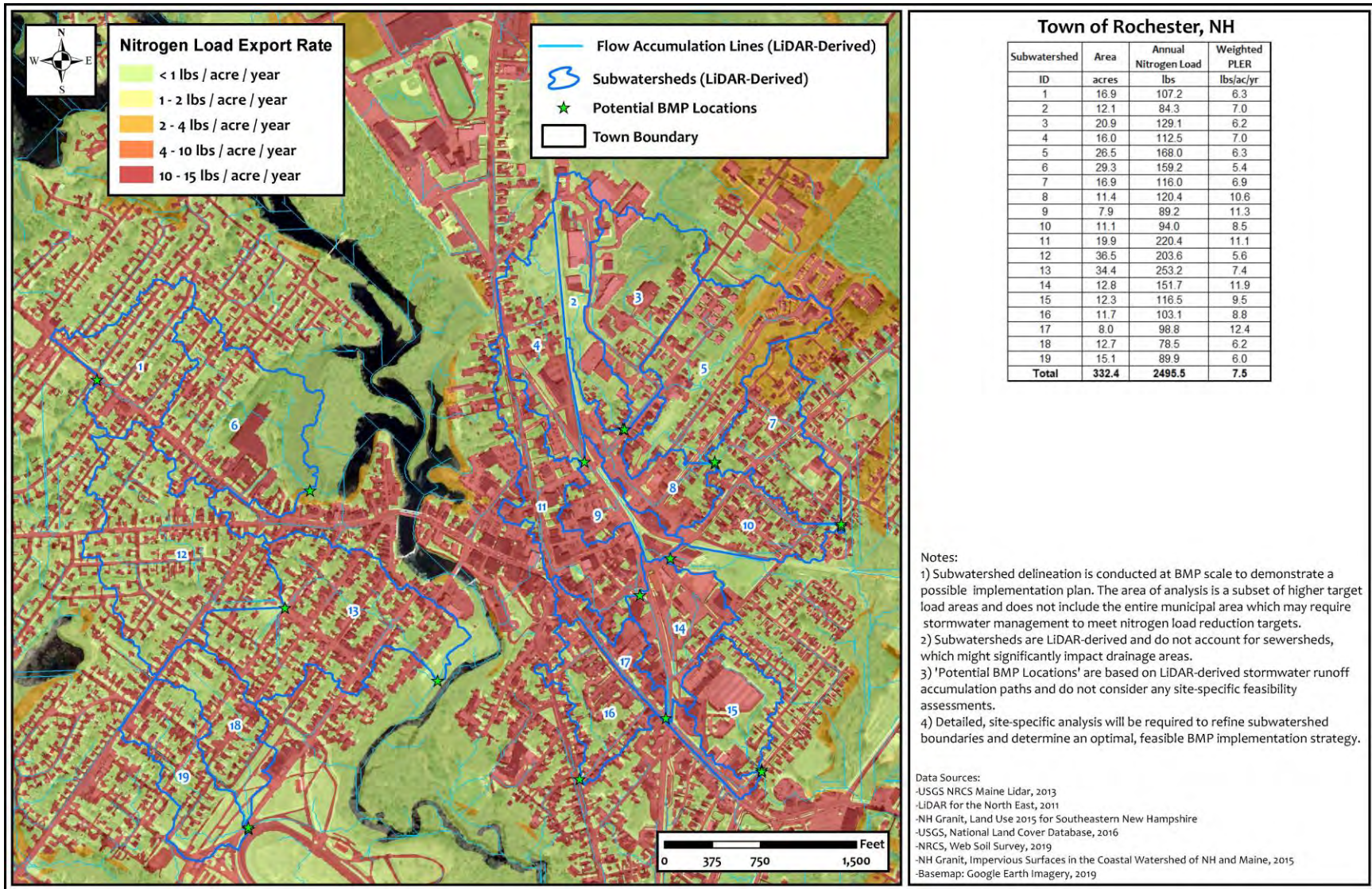


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	42,151				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		8,946.0	42,150.6	\$ 22,309,237	\$ 331
<b>Structural Controls</b>	10,096.4	1,343.1	15,193.2	\$ 6,595,115	\$ 412
<b>Non-Structural Controls</b>	14,275.2	11,306.4	26,957.4	\$ 15,714,122	\$ 274
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL R DRY WELLO.25	465.24	465.2	4694.5	\$ 1,860,960	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	292.3	292.3	3510.6	\$ 1,724,570	\$ 491
COMMERCIAL R DRY WELLO.25	73.07	73.1	868.2	\$ 292,280	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	96.04	96.0	1138.7	\$ 566,636	\$ 498
INSTITUTIONAL R DRY WELLO.25	24.01	24.0	285.3	\$ 96,040	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	255.11	255.1	3063.9	\$ 1,505,149	\$ 491
INDUSTRIAL R DRY WELLO.25	137.37	137.4	1632.1	\$ 549,480	\$ 337
SEPTIC SEPTIC SLUDGEHAMMER	4,343.66	3703.5	23554.5	\$ 14,814,158	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	681.21	681.2	715.3	\$ 21,799	\$ 30
LEAF_LITTER_B LEAF_LITTER_B	520.45	520.5	31.2	\$ 5,725	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	433.07	433.1	52.0	\$ 4,764	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	1788.98	1789.0	322.0	\$ 19,679	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	2190	2190.0	1852.7	\$ 700,800	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	1837.58	1837.6	396.9	\$ 135,981	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	96.03	96.0	20.7	\$ 7,106	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	15.17	15.2	3.3	\$ 1,123	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	40.38	40.4	8.7	\$ 2,988	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$35,329	\$305,436	\$620,786	\$936,136	\$1,268,491	\$3,469,033	\$8,759,778	\$15,829,061	\$22,309,237	\$92,356,293
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	75%
Load Reduction Achieved (Lbs TN/Yr)	937	1,873	2,810	3,747	4,683	10,303	20,607	31,847	42,151	70,251
Load Reduction Target (Lbs TN/Yr)	937	1,873	2,810	3,747	4,683	10,303	20,607	31,847	42,151	70,251
Treated Area (Acres)	1,911	3,487	3,566	3,645	6,058	8,245	8,946	8,946	8,946	16,522
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)									
15	127.4	232.5	237.7	243.0	403.9	549.7	596.4	596.4	596.4	1101.4
16	119.5	217.9	222.9	227.8	378.6	515.3	559.1	559.1	559.1	1032.6
17	112.4	205.1	209.8	214.4	356.4	485.0	526.2	526.2	526.2	971.9
18	106.2	193.7	198.1	202.5	336.6	458.1	497.0	497.0	497.0	917.9
19	100.6	183.5	187.7	191.8	318.9	434.0	470.8	470.8	470.8	869.6
20	95.6	174.4	178.3	182.2	302.9	412.3	447.3	447.3	447.3	826.1
21	91.0	166.1	169.8	173.6	288.5	392.6	426.0	426.0	426.0	786.7
22	86.9	158.5	162.1	165.7	275.4	374.8	406.6	406.6	406.6	751.0
23	83.1	151.6	155.0	158.5	263.4	358.5	389.0	389.0	389.0	718.3
24	79.6	145.3	148.6	151.9	252.4	343.5	372.8	372.8	372.8	688.4
25	76.5	139.5	142.6	145.8	242.3	329.8	357.8	357.8	357.8	660.9

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$35,329	\$305,436	\$620,786	\$936,136	\$1,268,491	\$3,469,033	\$8,759,778	\$15,829,061	\$22,309,237	\$92,356,293
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	75%
Load Reduction (Lbs TN/Yr)	937	1,873	2,810	3,747	4,683	10,303	20,607	31,847	42,151	70,251
Treated Area (Acres)	1,911	3,487	3,566	3,645	6,058	8,245	8,946	8,946	8,946	16,522
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)									
15	\$2,355	\$20,362	\$41,386	\$62,409	\$84,566	\$231,269	\$583,985	\$1,055,271	\$1,487,282	\$6,157,086
16	\$2,208	\$19,090	\$38,799	\$58,509	\$79,281	\$216,815	\$547,486	\$989,316	\$1,394,327	\$5,772,268
17	\$2,078	\$17,967	\$36,517	\$55,067	\$74,617	\$204,061	\$515,281	\$931,121	\$1,312,308	\$5,432,723
18	\$1,963	\$16,969	\$34,488	\$52,008	\$70,472	\$192,724	\$486,654	\$879,392	\$1,239,402	\$5,130,905
19	\$1,859	\$16,076	\$32,673	\$49,270	\$66,763	\$182,581	\$461,041	\$833,108	\$1,174,170	\$4,860,858
20	\$1,766	\$15,272	\$31,039	\$46,807	\$63,425	\$173,452	\$437,989	\$791,453	\$1,115,462	\$4,617,815
21	\$1,682	\$14,545	\$29,561	\$44,578	\$60,404	\$165,192	\$417,132	\$753,765	\$1,062,345	\$4,397,919
22	\$1,606	\$13,883	\$28,218	\$42,552	\$57,659	\$157,683	\$398,172	\$719,503	\$1,014,056	\$4,198,013
23	\$1,536	\$13,280	\$26,991	\$40,702	\$55,152	\$150,828	\$380,860	\$688,220	\$969,967	\$4,015,491
24	\$1,472	\$12,727	\$25,866	\$39,006	\$52,854	\$144,543	\$364,991	\$659,544	\$929,552	\$3,848,179
25	\$1,413	\$12,217	\$24,831	\$37,445	\$50,740	\$138,761	\$350,391	\$633,162	\$892,369	\$3,694,252



Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$85	\$7.10	\$0.038	\$1,650
16	\$80	\$6.66	\$0.036	\$1,547
17	\$75	\$6.27	\$0.033	\$1,456
18	\$71	\$5.92	\$0.032	\$1,375
19	\$67	\$5.61	\$0.030	\$1,303
20	\$64	\$5.33	\$0.028	\$1,237
21	\$61	\$5.07	\$0.027	\$1,179
22	\$58	\$4.84	\$0.026	\$1,125
23	\$56	\$4.63	\$0.025	\$1,076
24	\$53	\$4.44	\$0.024	\$1,031
25	\$51	\$4.26	\$0.023	\$990

Population Est	30,797	
Persons per household	3	
# of Households Est.	10,266	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	40%	59%
%IC Comm/Ind/Inst	28%	41%
%IC Transportation	25%	
%IC Misc	7%	
Total		100%

## **B12. Rollinsford, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.

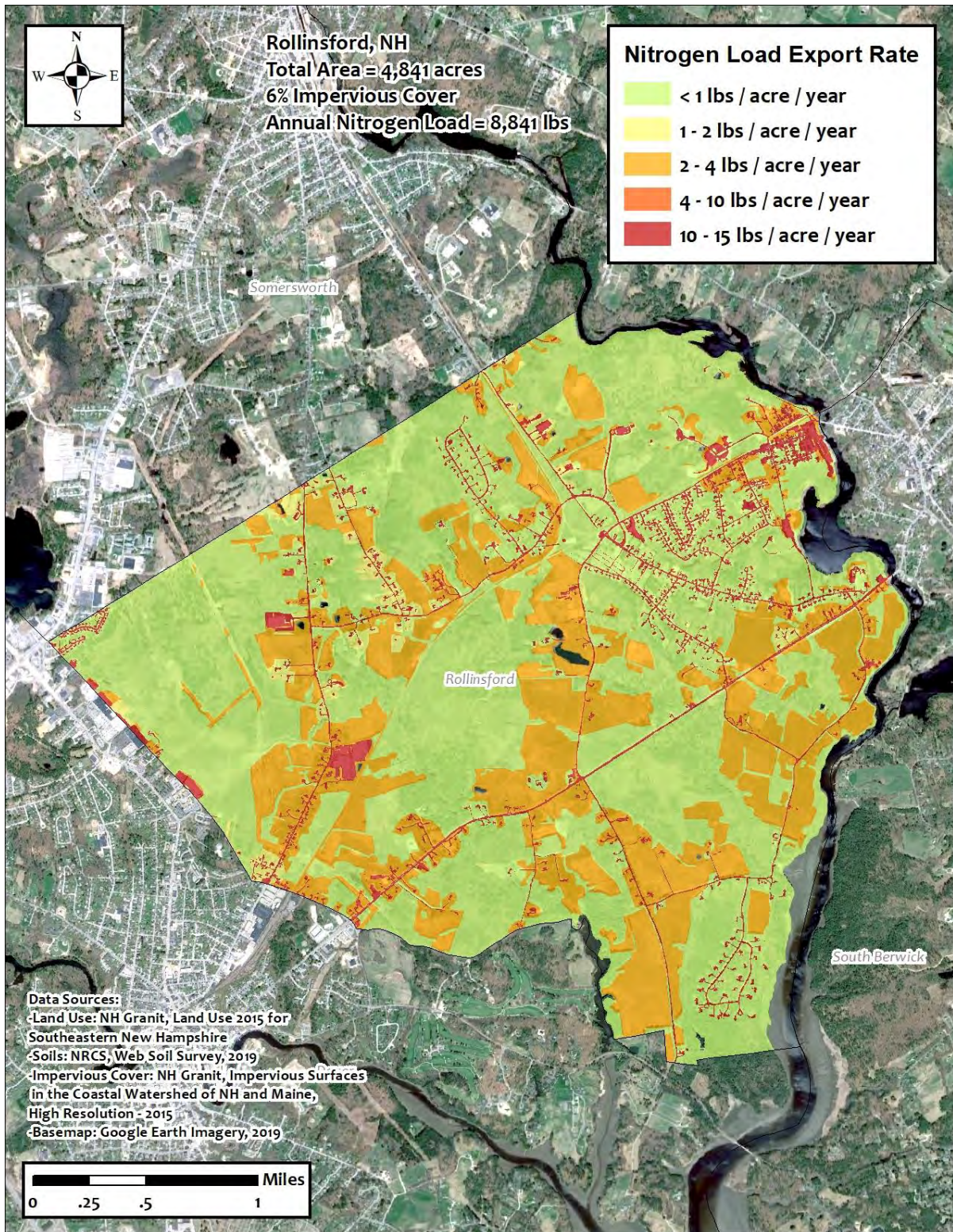


Figure 1 - Annual Nitrogen Load Export



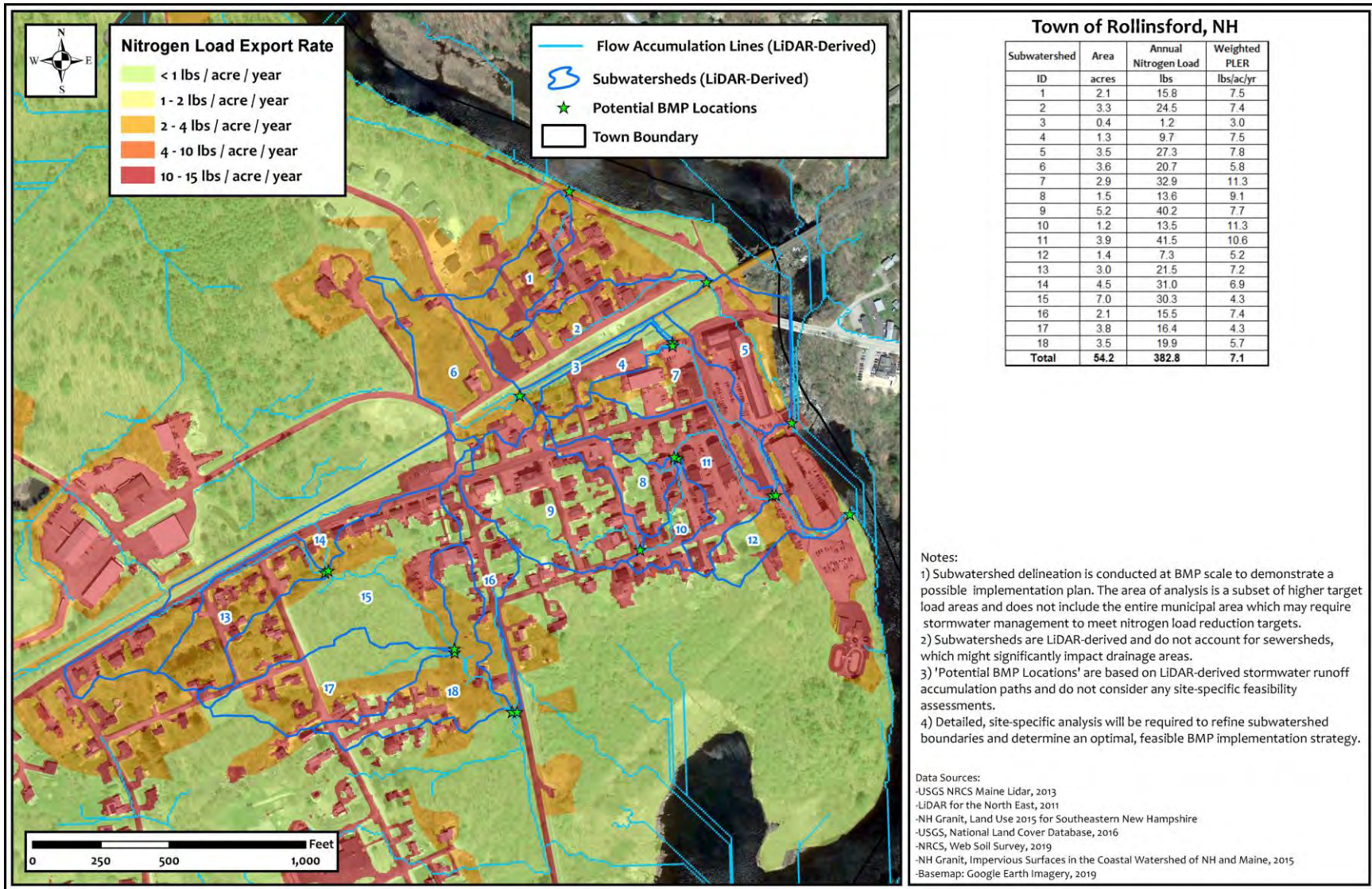


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme



Table 1 - BMP Menu for 34% N-Load Reduction Target

PERCENT REDUCTION TARGET	34%				
TN LOAD REDUCTION TARGET (LBS/YR)	5,396				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		1,270.6	5,396.1	\$ 3,108,501	\$ 405
<b>Structural Controls</b>	1,099.3	200.2	1,812.9	\$ 955,278	\$ 496
<b>Non-Structural Controls</b>	1,597.0	1,597.0	3,583.3	\$ 2,153,223	\$ 313
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	76.94	76.9	546.8	\$ 346,230	\$ 633
RESIDENTIAL R DRY WELLO.25	53.46	53.5	539.4	\$ 213,840	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	24.04	24.0	288.7	\$ 141,836	\$ 491
COMMERCIAL R DRY WELLO.25	6.01	6.0	71.4	\$ 24,040	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	8.44	8.4	100.1	\$ 49,796	\$ 498
INSTITUTIONAL R DRY WELLO.25	2.11	2.1	25.1	\$ 8,440	\$ 337
ROAD I GRAVEL WETLAND0.25	75.97	22.7	179.2	\$ 133,764	\$ 746
INDUSTRIAL I GRAVEL WETLAND0.25	1.22	1.2	14.7	\$ 7,198	\$ 491
INDUSTRIAL R DRY WELLO.25	0.66	0.7	7.8	\$ 2,640	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	4.66	4.7	39.6	\$ 27,494	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	526.57	526.6	3349.0	\$ 2,106,280	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	75.97	76.0	79.8	\$ 2,431	\$ 30
LEAF_LITTER_A LEAF_LITTER_A	342.17	342.2	5.1	\$ 3,764	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	74.25	74.3	4.5	\$ 817	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	62.59	62.6	7.5	\$ 688	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	185.58	185.6	33.4	\$ 2,041	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	52	52.0	44.0	\$ 16,640	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	262.74	262.7	56.8	\$ 19,443	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	12.27	12.3	2.7	\$ 908	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	2.85	2.9	0.6	\$ 211	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$17,280	\$72,230	\$134,854	\$197,769	\$260,683	\$786,228	\$1,884,222	\$3,108,501	\$8,385,860
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%
Load Reduction Achieved (Lbs TN/Yr)	159	317	476	635	794	1,746	3,492	5,396	7,142
Load Reduction Target (Lbs TN/Yr)	159	317	476	635	794	1,746	3,492	5,396	7,142
Treated Area (Acres)	401	718	751	767	783	824	824	1,271	1,758
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)								
15	26.7	47.9	50.1	51.1	52.2	54.9	54.9	84.7	117.2
16	25.1	44.9	46.9	47.9	48.9	51.5	51.5	79.4	109.8
17	23.6	42.2	44.2	45.1	46.0	48.5	48.5	74.7	103.4
18	22.3	39.9	41.7	42.6	43.5	45.8	45.8	70.6	97.6
19	21.1	37.8	39.5	40.4	41.2	43.4	43.4	66.9	92.5
20	20.1	35.9	37.6	38.3	39.1	41.2	41.2	63.5	87.9
21	19.1	34.2	35.8	36.5	37.3	39.2	39.2	60.5	83.7
22	18.2	32.6	34.1	34.9	35.6	37.5	37.5	57.8	79.9
23	17.4	31.2	32.7	33.3	34.0	35.8	35.8	55.2	76.4
24	16.7	29.9	31.3	32.0	32.6	34.3	34.3	52.9	73.2
25	16.0	28.7	30.0	30.7	31.3	33.0	33.0	50.8	70.3

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$17,280	\$72,230	\$134,854	\$197,769	\$260,683	\$786,228	\$1,884,222	\$3,108,501	\$8,385,860
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%
Load Reduction (Lbs TN/Yr)	159	317	476	635	794	1,746	3,492	5,396	7,142
Treated Area (Acres)	401	718	751	767	783	824	824	1,271	1,758
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)								
15	\$1,152	\$4,815	\$8,990	\$13,185	\$17,379	\$52,415	\$125,615	\$207,233	\$559,057
16	\$1,080	\$4,514	\$8,428	\$12,361	\$16,293	\$49,139	\$117,764	\$194,281	\$524,116
17	\$1,016	\$4,249	\$7,933	\$11,633	\$15,334	\$46,249	\$110,837	\$182,853	\$493,286
18	\$960	\$4,013	\$7,492	\$10,987	\$14,482	\$43,679	\$104,679	\$172,695	\$465,881
19	\$909	\$3,802	\$7,098	\$10,409	\$13,720	\$41,380	\$99,170	\$163,605	\$441,361
20	\$864	\$3,612	\$6,743	\$9,888	\$13,034	\$39,311	\$94,211	\$155,425	\$419,293
21	\$823	\$3,440	\$6,422	\$9,418	\$12,413	\$37,439	\$89,725	\$148,024	\$399,327
22	\$785	\$3,283	\$6,130	\$8,989	\$11,849	\$35,738	\$85,646	\$141,296	\$381,175
23	\$751	\$3,140	\$5,863	\$8,599	\$11,334	\$34,184	\$81,923	\$135,152	\$364,603
24	\$720	\$3,010	\$5,619	\$8,240	\$10,862	\$32,760	\$78,509	\$129,521	\$349,411
25	\$691	\$2,889	\$5,394	\$7,911	\$10,427	\$31,449	\$75,369	\$124,340	\$335,434

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$500	\$41.71	\$0.222	\$9,690
16	\$469	\$39.10	\$0.209	\$9,084
17	\$442	\$36.80	\$0.196	\$8,550
18	\$417	\$34.76	\$0.185	\$8,075
19	\$395	\$32.93	\$0.176	\$7,650
20	\$375	\$31.28	\$0.167	\$7,267
21	\$357	\$29.79	\$0.159	\$6,921
22	\$341	\$28.44	\$0.152	\$6,607
23	\$326	\$27.20	\$0.145	\$6,319
24	\$313	\$26.07	\$0.139	\$6,056
25	\$300	\$25.02	\$0.133	\$5,814

Population Est	2,527	
Persons per household	3	
# of Households Est.	842	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	46%	75%
%IC Comm/Ind/Inst	15%	25%
%IC Transportation	27%	
%IC Misc	12%	
Total		100%

### **B13. Somersworth, New Hampshire**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



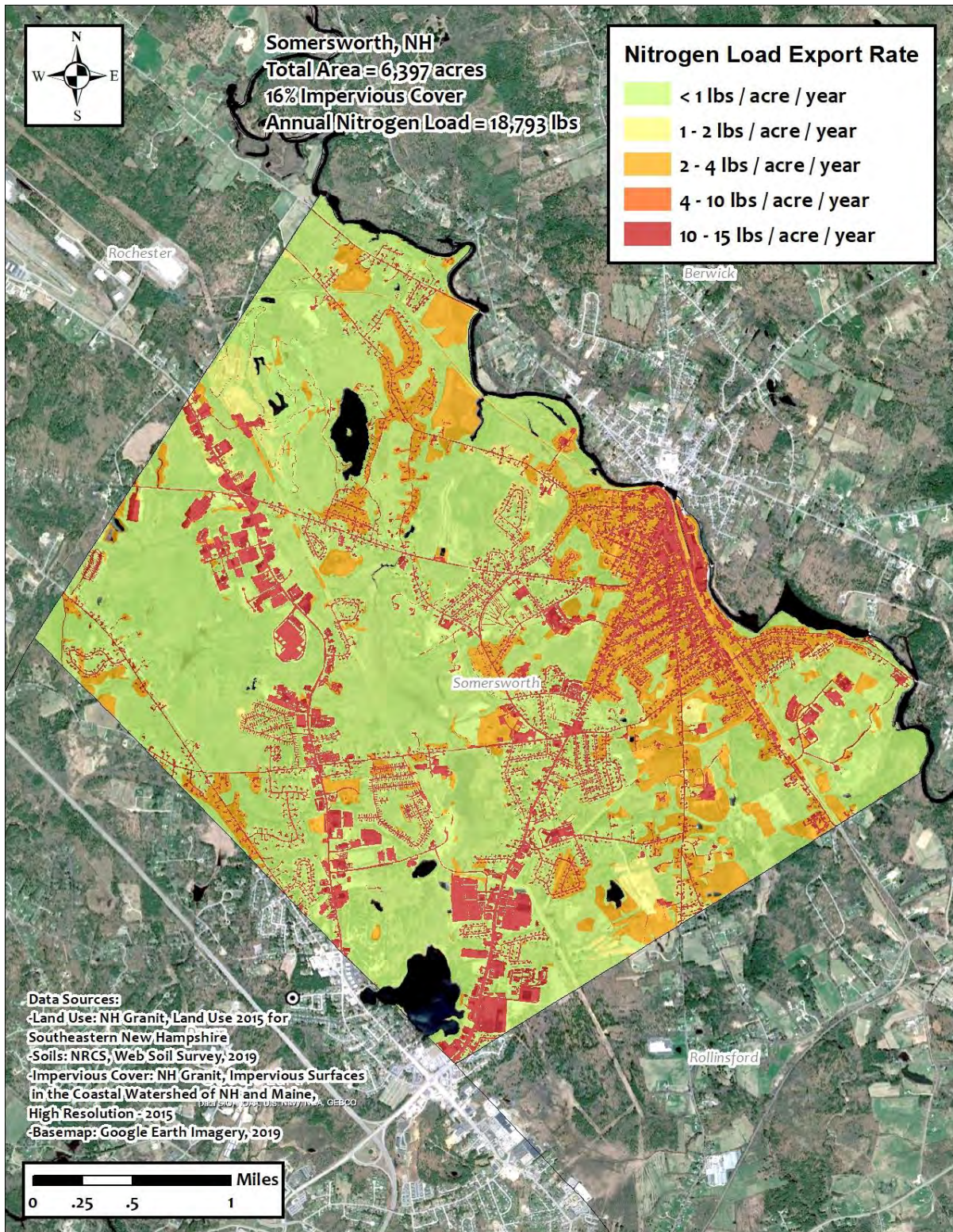


Figure 1 - Annual Nitrogen Load Export



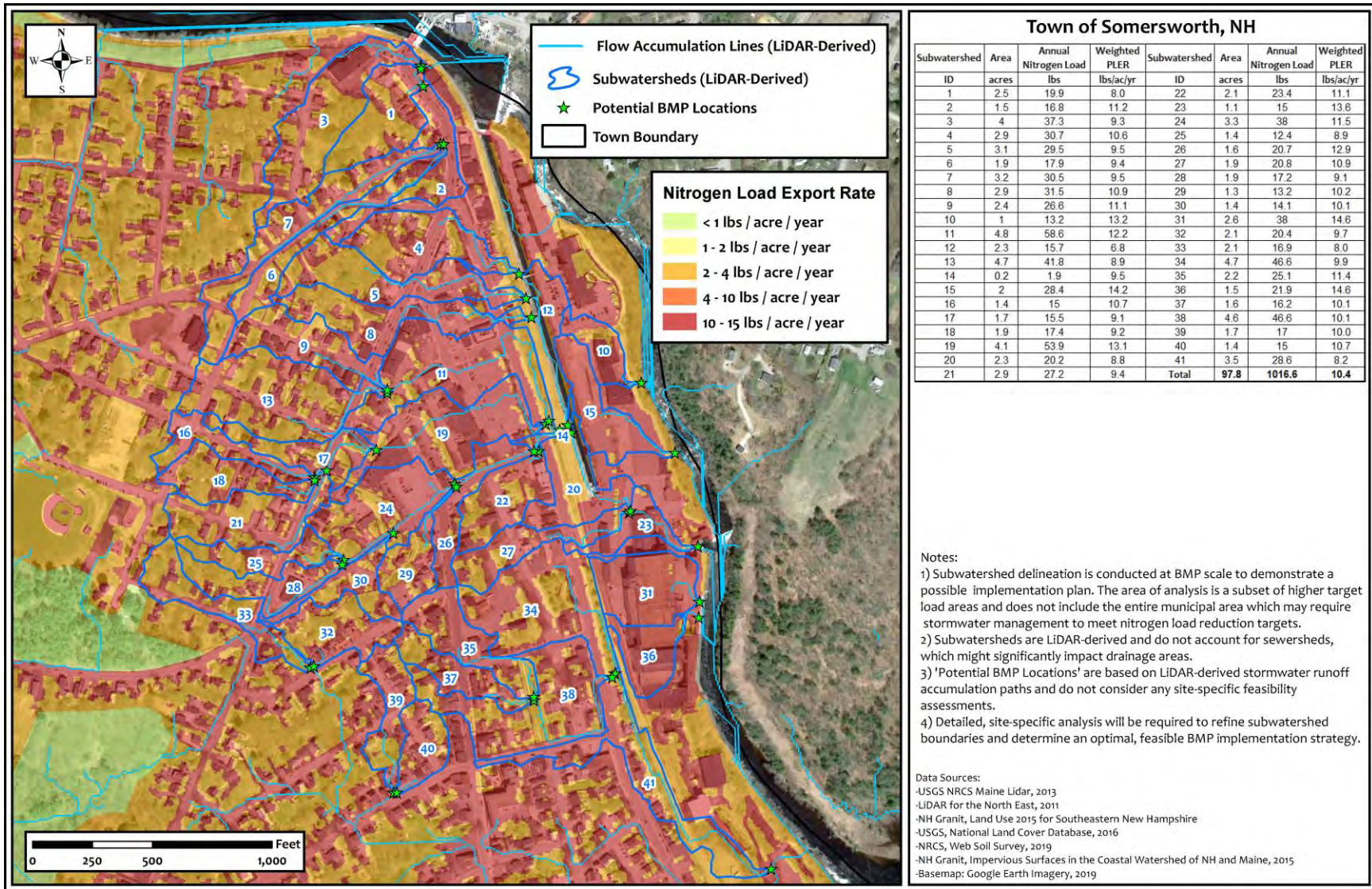


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	10,721				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		2,616.4	10,721.3	\$ 5,252,508	\$ 331
<b>Structural Controls</b>	2,824.7	538.1	6,136.6	\$ 2,698,084	\$ 412
<b>Non-Structural Controls</b>	3,750.6	2,658.2	4,584.6	\$ 2,554,424	\$ 274
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL R DRY WELLO.25	159.97	160.0	1614.2	\$ 639,880	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	172.08	172.1	2066.7	\$ 1,015,272	\$ 491
COMMERCIAL R DRY WELLO.25	43.02	43.0	511.1	\$ 172,080	\$ 337
INSTITUTIONAL I GRAVEL WETLAND0.25	48.51	48.5	575.2	\$ 286,209	\$ 498
INSTITUTIONAL R DRY WELLO.25	12.13	12.1	144.1	\$ 48,520	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	66.57	66.6	799.5	\$ 392,763	\$ 491
INDUSTRIAL R DRY WELLO.25	35.84	35.8	425.8	\$ 143,360	\$ 337
SEPTIC SEPTIC SLUDGEHAMMER	996.67	579.9	3688.0	\$ 2,319,512	\$ 629
STREET_SWEEPING_HWY STREET_SWEEPING_HWY	192.55	192.6	202.2	\$ 6,162	\$ 30
LEAF_LITTER_B LEAF_LITTER_B	66.23	66.2	4.0	\$ 729	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	59.65	59.7	7.2	\$ 656	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	433.99	434.0	78.1	\$ 4,774	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	506	506.0	428.1	\$ 161,920	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	649.94	649.9	140.4	\$ 48,096	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	149.8	149.8	32.4	\$ 11,085	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	7.91	7.9	1.7	\$ 585	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	12.24	12.2	2.6	\$ 906	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

<b>Cost to Implement</b>	\$8,366	\$74,628	\$154,839	\$235,050	\$315,262	\$853,800	\$2,049,155	\$3,604,238	\$5,252,508	\$10,982,104
<b>Percent Reduction</b>	1%	2%	3%	4%	5%	11%	22%	34%	45%	75%
<b>Load Reduction Achieved (Lbs TN/Yr)</b>	238	477	715	953	1,191	2,621	5,242	8,101	10,721	17,869
<b>Load Reduction Target (Lbs TN/Yr)</b>	238	477	715	953	1,191	2,621	5,242	8,101	10,721	17,869
<b>Treated Area (Acres)</b>	393	768	788	808	828	2,233	2,467	2,616	2,616	3,855
<b>Implementation Period (yrs)</b>	<b>Yearly Rate of Area Treated-Total (AC/YR)</b>									
15	26.2	51.2	52.5	53.9	55.2	148.9	164.4	174.4	174.4	257.0
16	24.6	48.0	49.3	50.5	51.8	139.6	154.2	163.5	163.5	240.9
17	23.1	45.2	46.4	47.5	48.7	131.4	145.1	153.9	153.9	226.8
18	21.8	42.7	43.8	44.9	46.0	124.1	137.0	145.4	145.4	214.2
19	20.7	40.4	41.5	42.5	43.6	117.5	129.8	137.7	137.7	202.9
20	19.6	38.4	39.4	40.4	41.4	111.7	123.3	130.8	130.8	192.8
21	18.7	36.6	37.5	38.5	39.4	106.3	117.5	124.6	124.6	183.6
22	17.9	34.9	35.8	36.7	37.6	101.5	112.1	118.9	118.9	175.2
23	17.1	33.4	34.3	35.1	36.0	97.1	107.2	113.8	113.8	167.6
24	16.4	32.0	32.8	33.7	34.5	93.0	102.8	109.0	109.0	160.6
25	15.7	30.7	31.5	32.3	33.1	89.3	98.7	104.7	104.7	154.2

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

<b>Cost to Implement</b>	\$8,366	\$74,628	\$154,839	\$235,050	\$315,262	\$853,800	\$2,049,155	\$3,604,238	\$5,252,508	\$10,982,104
<b>Percent Reduction</b>	1%	2%	3%	4%	5%	11%	22%	34%	45%	75%
<b>Load Reduction (Lbs TN/Yr)</b>	238	477	715	953	1,191	2,621	5,242	8,101	10,721	17,869
<b>Treated Area (Acres)</b>	393	768	788	808	828	2,233	2,467	2,616	2,616	3,855
<b>Implementation Period (yrs)</b>	<b>Yearly Cost to Implement Total (\$\$/Yr)</b>									
15	\$558	\$4,975	\$10,323	\$15,670	\$21,017	\$56,920	\$136,610	\$240,283	\$350,167	\$732,140
16	\$523	\$4,664	\$9,677	\$14,691	\$19,704	\$53,362	\$128,072	\$225,265	\$328,282	\$686,381
17	\$492	\$4,390	\$9,108	\$13,826	\$18,545	\$50,224	\$120,539	\$212,014	\$308,971	\$646,006
18	\$465	\$4,146	\$8,602	\$13,058	\$17,515	\$47,433	\$113,842	\$200,235	\$291,806	\$610,117
19	\$440	\$3,928	\$8,149	\$12,371	\$16,593	\$44,937	\$107,850	\$189,697	\$276,448	\$578,005
20	\$418	\$3,731	\$7,742	\$11,753	\$15,763	\$42,690	\$102,458	\$180,212	\$262,625	\$549,105
21	\$398	\$3,554	\$7,373	\$11,193	\$15,012	\$40,657	\$97,579	\$171,630	\$250,119	\$522,957
22	\$380	\$3,392	\$7,038	\$10,684	\$14,330	\$38,809	\$93,143	\$163,829	\$238,750	\$499,187
23	\$364	\$3,245	\$6,732	\$10,220	\$13,707	\$37,122	\$89,094	\$156,706	\$228,370	\$477,483
24	\$349	\$3,110	\$6,452	\$9,794	\$13,136	\$35,575	\$85,381	\$150,177	\$218,855	\$457,588
25	\$335	\$2,985	\$6,194	\$9,402	\$12,610	\$34,152	\$81,966	\$144,170	\$210,100	\$439,284



Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$45	\$3.77	\$0.020	\$876
16	\$42	\$3.53	\$0.019	\$821
17	\$40	\$3.33	\$0.018	\$773
18	\$38	\$3.14	\$0.017	\$730
19	\$36	\$2.98	\$0.016	\$691
20	\$34	\$2.83	\$0.015	\$657
21	\$32	\$2.69	\$0.014	\$626
22	\$31	\$2.57	\$0.014	\$597
23	\$30	\$2.46	\$0.013	\$571
24	\$28	\$2.36	\$0.013	\$547
25	\$27	\$2.26	\$0.012	\$525

Population Est	11,766	
Persons per household	3	
# of Households Est.	3,922	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	38%	51%
%IC Comm/Ind/Inst	37%	49%
%IC Transportation	19%	
%IC Misc	6%	
Total		100%

## **B14. Berwick, Maine**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.

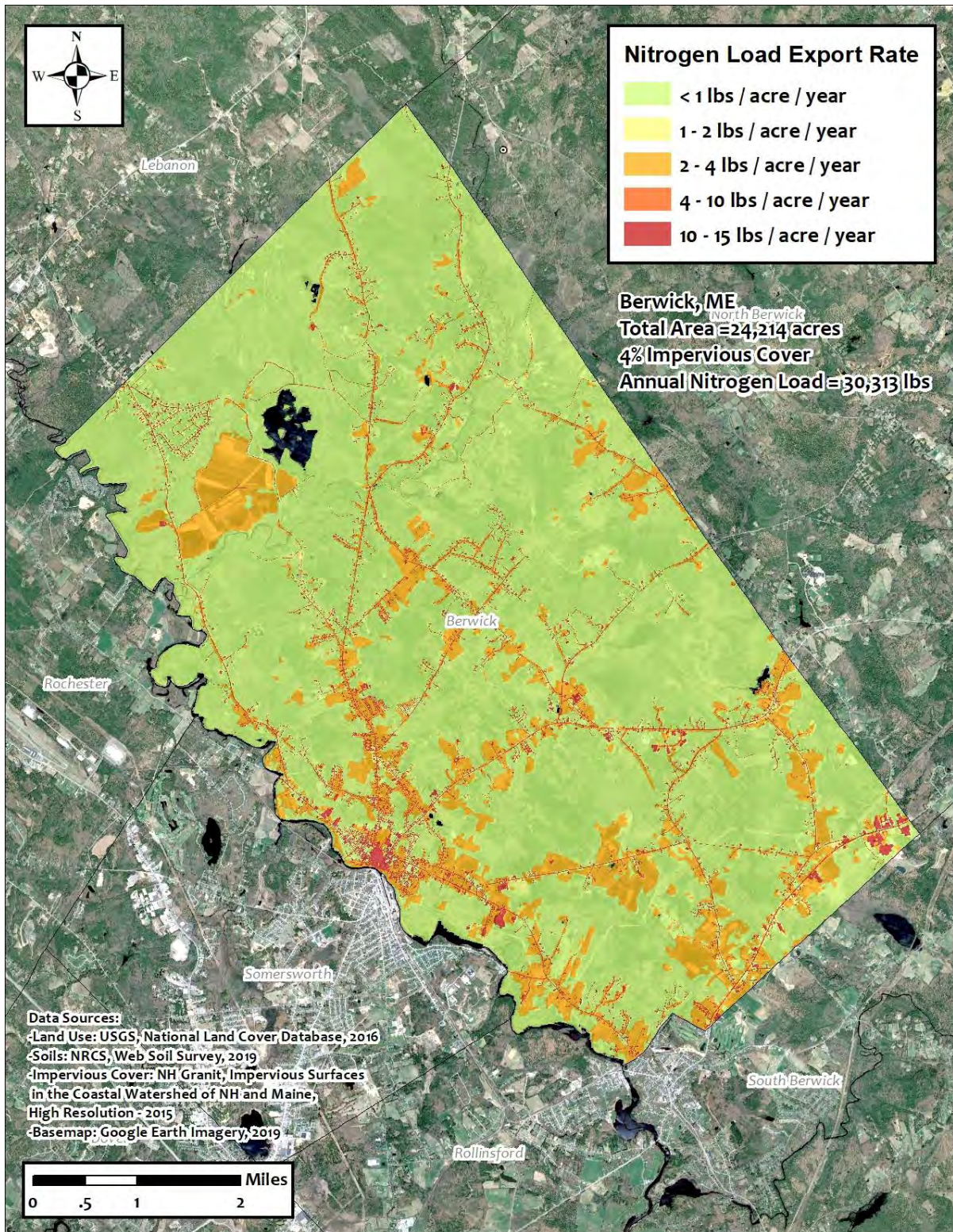


Figure 1 - Annual Nitrogen Load Export



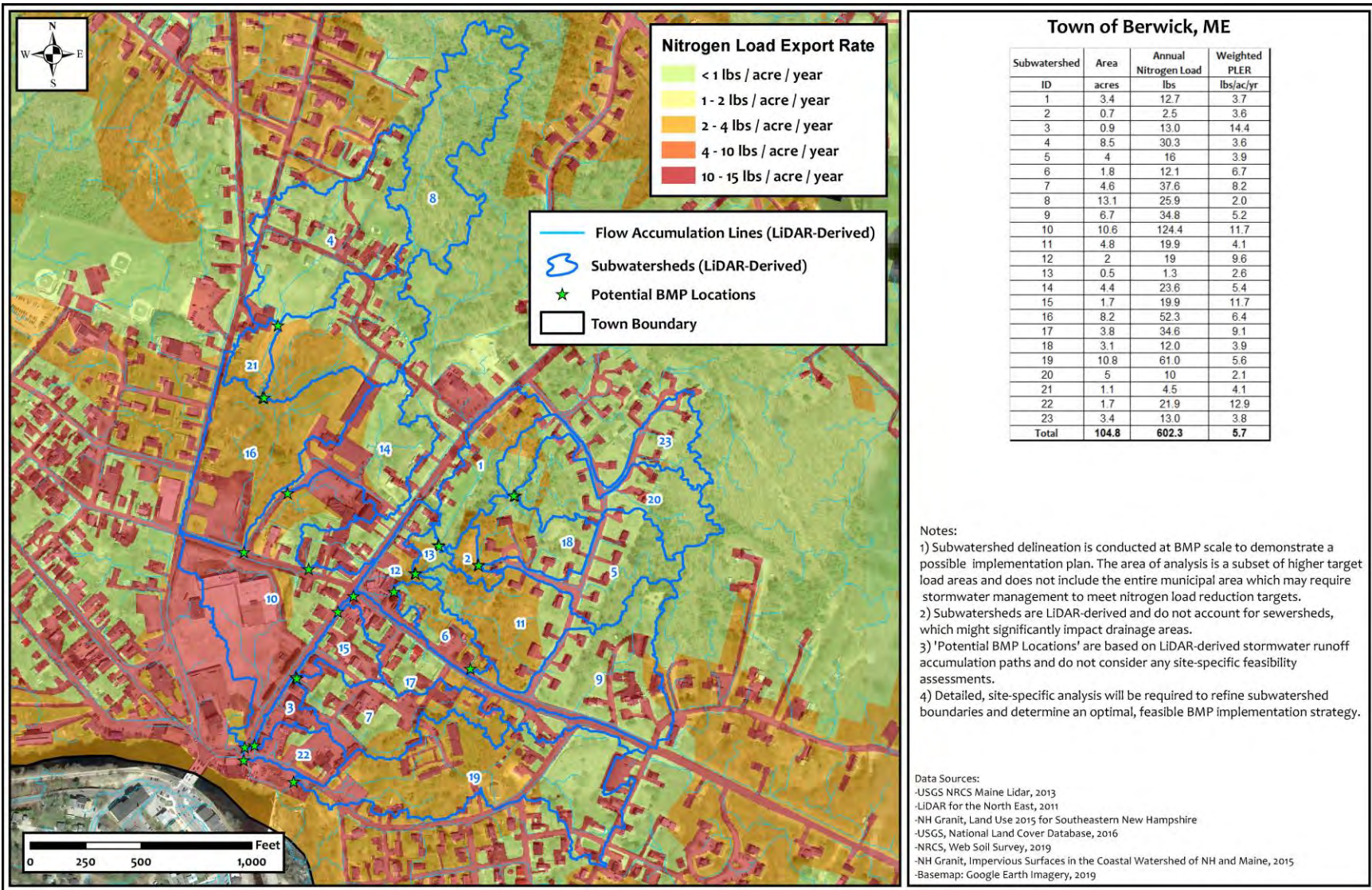


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme



Table 1 - BMP Menu for 34% N-Load Reduction Target

PERCENT REDUCTION TARGET	34%				
TN LOAD REDUCTION TARGET (LBS/YR)	17,757				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		2,547.6	17,756.8	\$ 13,412,688	\$ 614
<b>Structural Controls</b>	2,344.7	1,090.3	7,319.3	\$ 7,136,596	\$ 995
<b>Non-Structural Controls</b>	3,009.5	3,009.5	10,437.5	\$ 6,276,092	\$ 264
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.75	147.8	147.8	1534.0	\$ 1,477,600	\$ 963
RESIDENTIAL R DRY WELLO.5	102.7	102.7	1235.2	\$ 718,760	\$ 582
COMMERCIAL I GRAVEL WETLAND0.25	73.3	73.3	880.7	\$ 432,647	\$ 491
COMMERCIAL D GRAVEL WETLAND0.25	32.3	32.3	91.6	\$ 190,511	\$ 2,080
COMMERCIAL R DRY WELLO.25	18.3	16.4	194.9	\$ 65,627	\$ 337
COMMERCIAL R DRY WELLO.5	18.3	1.9	25.3	\$ 13,462	\$ 532
INDUSTRIAL I GRAVEL WETLAND0.25	24.2	24.2	291.0	\$ 142,957	\$ 491
INDUSTRIAL D GRAVEL WETLAND0.25	1.6	1.6	4.5	\$ 9,440	\$ 2,080
INDUSTRIAL R DRY WELLO.5	13.1	13.1	171.7	\$ 91,350	\$ 532
OUTDOOR I GRAVEL WETLAND0.25	180.3	180.3	1533.7	\$ 1,063,593	\$ 693
OUTDOOR D GRAVEL WETLAND0.25	496.7	496.7	1356.8	\$ 2,930,648	\$ 2,160
SEPTIC SEPTIC SLUDGEHAMMER	1552.2	1552.2	9871.8	\$ 6,208,680	\$ 629
STREET_SWEEPING_RES STREET_SWEEPING_RES	147.8	147.8	208.3	\$ 4,728	\$ 23
STREET_SWEEPING_COM STREET_SWEEPING_COM	73.3	73.3	110.0	\$ 2,347	\$ 21
STREET_SWEEPING_IND STREET_SWEEPING_IND	24.2	24.2	36.3	\$ 775	\$ 21
LEAF_LITTER_A LEAF_LITTER_A	302.4	302.4	4.5	\$ 3,326	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	27.6	27.6	1.7	\$ 303	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	68.6	68.6	8.2	\$ 754	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	269.1	269.1	48.4	\$ 2,960	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	48.5	48.5	41.0	\$ 15,520	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	478.3	478.3	103.3	\$ 35,392	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	1.8	1.8	0.4	\$ 131	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SCHOOL	15.9	15.9	3.4	\$ 1,175	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$48,651	\$233,424	\$440,455	\$658,769	\$915,331	\$2,813,089	\$6,426,208	\$13,412,688	\$17,448,210
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	36%
Load Reduction Achieved (Lbs TN/Yr)	522	1,045	1,567	2,089	2,611	5,745	11,490	17,757	18,801
Load Reduction Target (Lbs TN/Yr)	522	1,045	1,567	2,089	2,611	5,745	11,490	17,757	18,801
Treated Area (Acres)	620	1,197	1,249	1,299	1,342	1,387	1,387	2,548	3,026
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)								
15	41.3	79.8	83.3	86.6	89.5	92.4	92.4	169.8	201.8
16	38.7	74.8	78.1	81.2	83.9	86.7	86.7	159.2	189.2
17	36.5	70.4	73.5	76.4	79.0	81.6	81.6	149.9	178.0
18	34.4	66.5	69.4	72.2	74.6	77.0	77.0	141.5	168.1
19	32.6	63.0	65.7	68.4	70.7	73.0	73.0	134.1	159.3
20	31.0	59.9	62.5	64.9	67.1	69.3	69.3	127.4	151.3
21	29.5	57.0	59.5	61.9	63.9	66.0	66.0	121.3	144.1
22	28.2	54.4	56.8	59.0	61.0	63.0	63.0	115.8	137.6
23	26.9	52.1	54.3	56.5	58.4	60.3	60.3	110.8	131.6
24	25.8	49.9	52.0	54.1	55.9	57.8	57.8	106.2	126.1
25	24.8	47.9	50.0	52.0	53.7	55.5	55.5	101.9	121.1

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$48,651	\$233,424	\$440,455	\$658,769	\$915,331	\$2,813,089	\$6,426,208	\$13,412,688	\$17,448,210
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	36%
Load Reduction (Lbs TN/Yr)	522	1,045	1,567	2,089	2,611	5,745	11,490	17,757	18,801
Treated Area (Acres)	620	1,197	1,249	1,299	1,342	1,387	1,387	2,548	3,026
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)								
15	\$3,243	\$15,562	\$29,364	\$43,918	\$61,022	\$187,539	\$428,414	\$894,179	\$1,163,214
16	\$3,041	\$14,589	\$27,528	\$41,173	\$57,208	\$175,818	\$401,638	\$838,293	\$1,090,513
17	\$2,862	\$13,731	\$25,909	\$38,751	\$53,843	\$165,476	\$378,012	\$788,982	\$1,026,365
18	\$2,703	\$12,968	\$24,470	\$36,598	\$50,852	\$156,283	\$357,012	\$745,149	\$969,345
19	\$2,561	\$12,285	\$23,182	\$34,672	\$48,175	\$148,057	\$338,221	\$705,931	\$918,327
20	\$2,433	\$11,671	\$22,023	\$32,938	\$45,767	\$140,654	\$321,310	\$670,634	\$872,411
21	\$2,317	\$11,115	\$20,974	\$31,370	\$43,587	\$133,957	\$306,010	\$638,699	\$830,867
22	\$2,211	\$10,610	\$20,021	\$29,944	\$41,606	\$127,868	\$292,100	\$609,668	\$793,100
23	\$2,115	\$10,149	\$19,150	\$28,642	\$39,797	\$122,308	\$279,400	\$583,160	\$758,618
24	\$2,027	\$9,726	\$18,352	\$27,449	\$38,139	\$117,212	\$267,759	\$558,862	\$727,009
25	\$1,946	\$9,337	\$17,618	\$26,351	\$36,613	\$112,524	\$257,048	\$536,508	\$697,928

Table 4 - Stormwater Utility Funding Annual Fee – Equivalent Resident Units (ERU) for 15-25 Year Implementation Periods at 34% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$132	\$11.02	\$0.059	\$2,560
16	\$124	\$10.33	\$0.055	\$2,400
17	\$117	\$9.72	\$0.052	\$2,259
18	\$110	\$9.18	\$0.049	\$2,133
19	\$104	\$8.70	\$0.046	\$2,021
20	\$99	\$8.26	\$0.044	\$1,920
21	\$94	\$7.87	\$0.042	\$1,828
22	\$90	\$7.51	\$0.040	\$1,745
23	\$86	\$7.19	\$0.038	\$1,669
24	\$83	\$6.89	\$0.037	\$1,600
25	\$79	\$6.61	\$0.035	\$1,536

Population Est	7,246	
Persons per household	3	
# of Households Est.	2,415	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	15%	36%
%IC Comm/Ind/Inst	27%	64%
%IC Transportation	20%	
%IC Misc	38%	
Total		100%

## **B15. Kittery, Maine**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



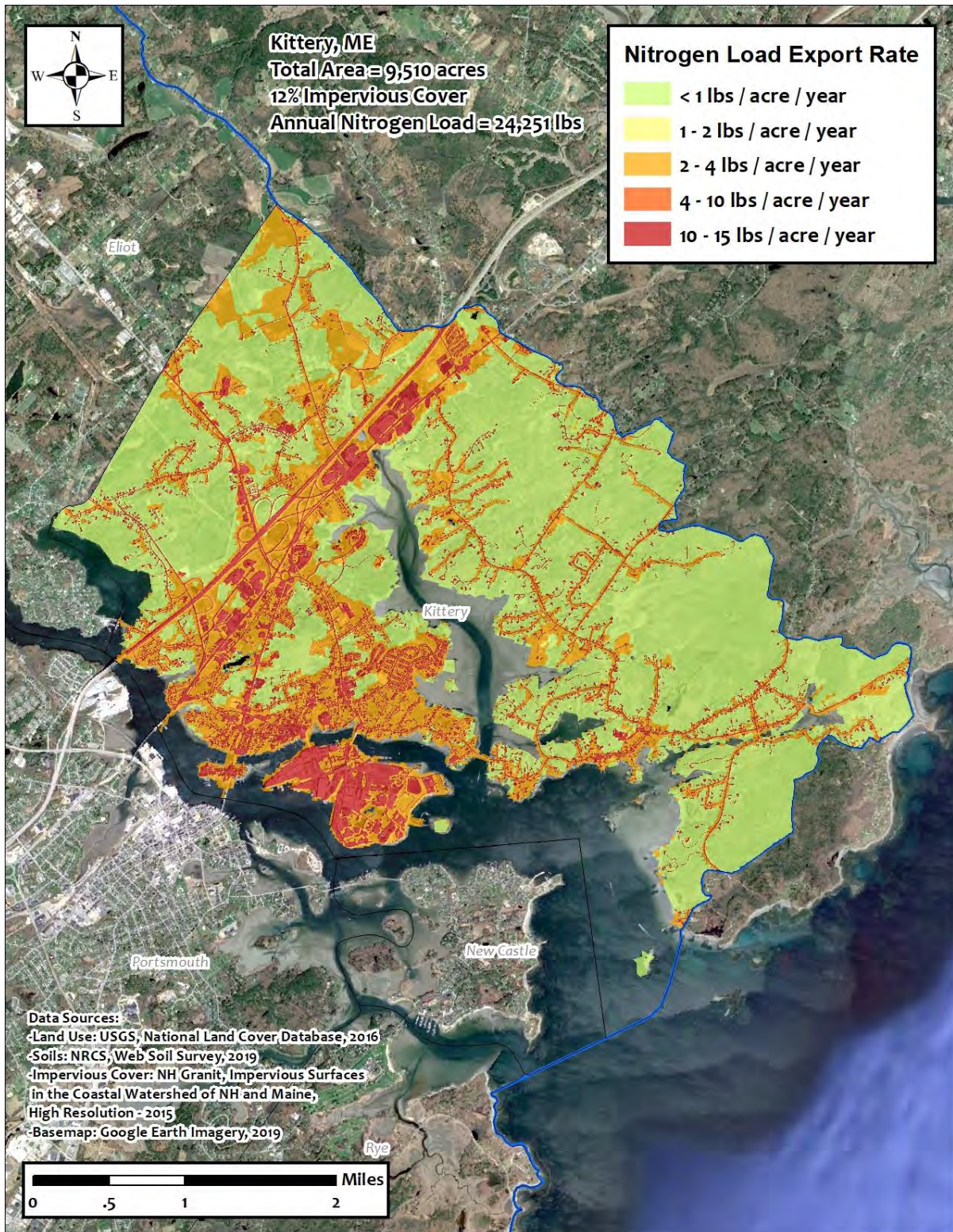


Figure 1 - Annual Nitrogen Load Export



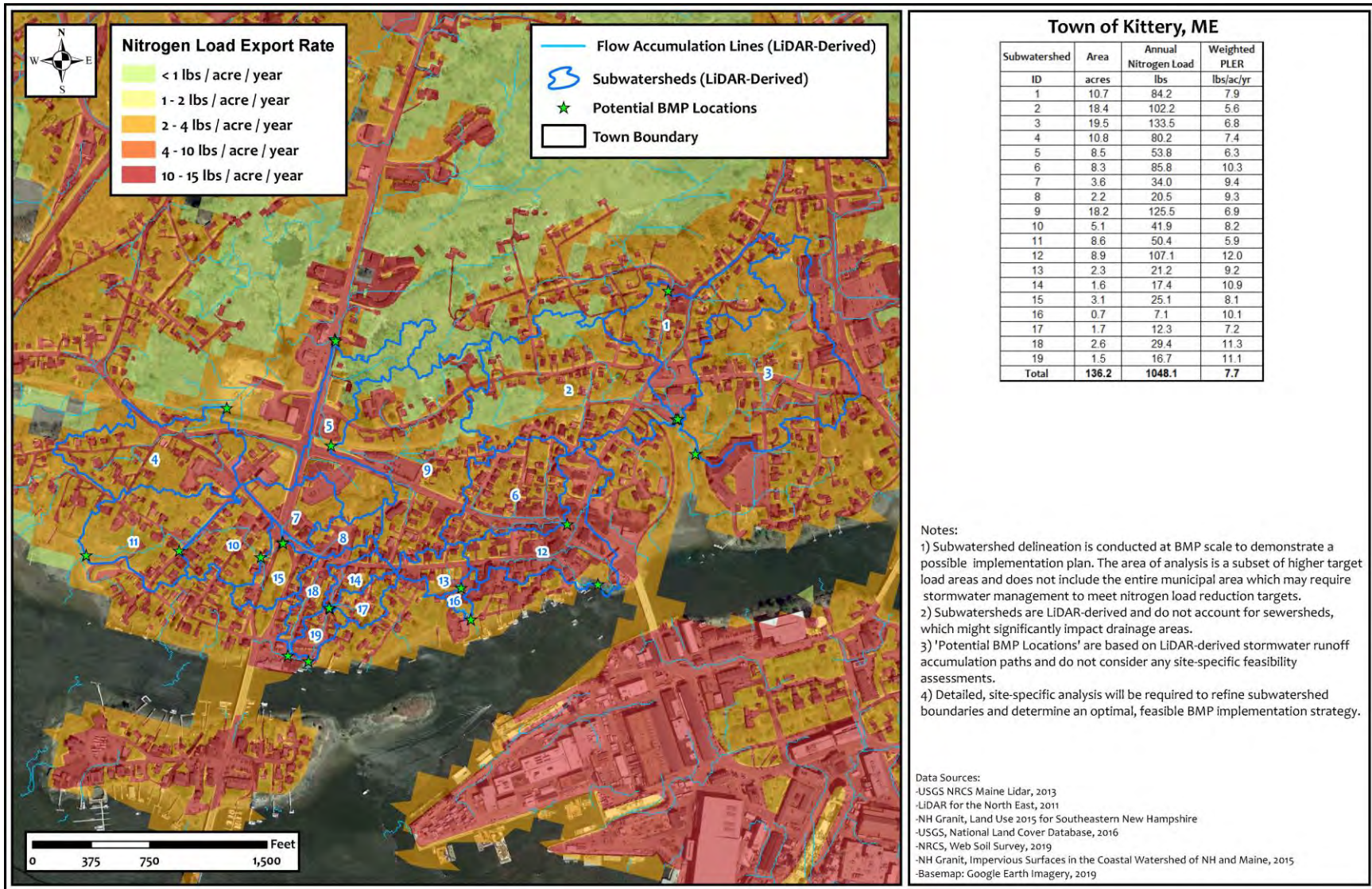


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 45% N-Load Reduction Target

PERCENT REDUCTION TARGET	45%				
TN LOAD REDUCTION TARGET (LBS/YR)	16,361				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		3,117.1	16,360.7	\$ 8,374,193	\$ 367
<b>Structural Controls</b>	2,581.2	967.6	10,247.6	\$ 5,215,570	\$ 518
<b>Non-Structural Controls</b>	2,887.5	2,887.5	6,113.0	\$ 3,158,623	\$ 257
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	176.68	69.7	495.1	\$ 313,522	\$ 633
RESIDENTIAL I RAINGARDEN0.5	176.68	107.0	974.1	\$ 749,059	\$ 769
RESIDENTIAL R DRY WELLO.25	122.78	122.8	1238.9	\$ 491,120	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	212.65	212.7	2553.9	\$ 1,254,635	\$ 491
COMMERCIAL R DRY WELLO.25	53.16	53.2	631.6	\$ 212,640	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	175.05	175.1	2102.4	\$ 1,032,795	\$ 491
INDUSTRIAL R DRY WELLO.25	94.26	94.3	1119.9	\$ 377,040	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	133.01	133.0	1131.6	\$ 784,759	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	738.00	738.0	4693.7	\$ 2,952,000	\$ 629
STREET_SWEEPING_RES STREET_SWEEPING_RES	176.68	176.7	249.1	\$ 5,654	\$ 23
STREET_SWEEPING_COM STREET_SWEEPING_COM	212.65	212.7	319.0	\$ 6,805	\$ 21
STREET_SWEEPING_IND STREET_SWEEPING_IND	175.05	175.1	262.6	\$ 5,602	\$ 21
LEAF_LITTER_A LEAF_LITTER_A	32.33	32.3	0.5	\$ 356	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	0.99	1.0	0.1	\$ 11	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	121.03	121.0	14.5	\$ 1,331	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	456.04	456.0	82.1	\$ 5,016	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	446	446.0	377.3	\$ 142,720	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	523.32	523.3	113.0	\$ 38,726	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	5.45	5.5	1.2	\$ 403	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$7,756	\$15,711	\$79,421	\$201,823	\$324,225	\$1,124,528	\$3,050,297	\$5,647,310	\$8,374,194	\$32,194,697
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	60%
Load Reduction Achieved (Lbs TN/Yr)	364	727	1,091	1,454	1,818	3,999	7,999	12,361	16,361	21,814
Load Reduction Target (Lbs TN/Yr)	364	727	1,091	1,454	1,818	3,999	7,999	12,361	16,361	21,814
Treated Area (Acres)	242	491	1,156	1,187	1,217	2,347	2,686	2,775	3,117	4,652
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)									
15	16.2	32.7	77.1	79.1	81.2	156.5	179.1	185.0	207.8	310.1
16	15.1	30.7	72.3	74.2	76.1	146.7	167.9	173.4	194.8	290.7
17	14.3	28.9	68.0	69.8	71.6	138.0	158.0	163.2	183.4	273.6
18	13.5	27.3	64.2	65.9	67.6	130.4	149.2	154.2	173.2	258.4
19	12.8	25.8	60.9	62.5	64.1	123.5	141.4	146.1	164.1	244.8
20	12.1	24.5	57.8	59.3	60.9	117.3	134.3	138.8	155.9	232.6
21	11.5	23.4	55.1	56.5	58.0	111.8	127.9	132.1	148.4	221.5
22	11.0	22.3	52.6	53.9	55.3	106.7	122.1	126.1	141.7	211.4
23	10.5	21.3	50.3	51.6	52.9	102.0	116.8	120.7	135.5	202.3
24	10.1	20.5	48.2	49.4	50.7	97.8	111.9	115.6	129.9	193.8
25	9.7	19.6	46.2	47.5	48.7	93.9	107.5	111.0	124.7	186.1

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$7,756	\$15,711	\$79,421	\$201,823	\$324,225	\$1,124,528	\$3,050,297	\$5,647,310	\$8,374,194	\$32,194,697
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	45%	60%
Load Reduction (Lbs TN/Yr)	364	727	1,091	1,454	1,818	3,999	7,999	12,361	16,361	21,814
Treated Area (Acres)	242	491	1,156	1,187	1,217	2,347	2,686	2,775	3,117	4,652
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)									
15	\$517	\$1,047	\$5,295	\$13,455	\$21,615	\$74,969	\$203,353	\$376,487	\$558,280	\$2,146,313
16	\$485	\$982	\$4,964	\$12,614	\$20,264	\$70,283	\$190,644	\$352,957	\$523,387	\$2,012,169
17	\$456	\$924	\$4,672	\$11,872	\$19,072	\$66,149	\$179,429	\$332,195	\$492,600	\$1,893,806
18	\$431	\$873	\$4,412	\$11,212	\$18,013	\$62,474	\$169,461	\$313,739	\$465,233	\$1,788,594
19	\$408	\$827	\$4,180	\$10,622	\$17,064	\$59,186	\$160,542	\$297,227	\$440,747	\$1,694,458
20	\$388	\$786	\$3,971	\$10,091	\$16,211	\$56,226	\$152,515	\$282,365	\$418,710	\$1,609,735
21	\$369	\$748	\$3,782	\$9,611	\$15,439	\$53,549	\$145,252	\$268,920	\$398,771	\$1,533,081
22	\$353	\$714	\$3,610	\$9,174	\$14,738	\$51,115	\$138,650	\$256,696	\$380,645	\$1,463,395
23	\$337	\$683	\$3,453	\$8,775	\$14,097	\$48,893	\$132,622	\$245,535	\$364,095	\$1,399,769
24	\$323	\$655	\$3,309	\$8,409	\$13,509	\$46,855	\$127,096	\$235,305	\$348,925	\$1,341,446
25	\$310	\$628	\$3,177	\$8,073	\$12,969	\$44,981	\$122,012	\$225,892	\$334,968	\$1,287,788



Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 45% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$70	\$5.82	\$0.031	\$1,351
16	\$65	\$5.45	\$0.029	\$1,267
17	\$62	\$5.13	\$0.027	\$1,192
18	\$58	\$4.85	\$0.026	\$1,126
19	\$55	\$4.59	\$0.024	\$1,067
20	\$52	\$4.36	\$0.023	\$1,013
21	\$50	\$4.15	\$0.022	\$965
22	\$48	\$3.96	\$0.021	\$921
23	\$46	\$3.79	\$0.020	\$881
24	\$44	\$3.63	\$0.019	\$844
25	\$42	\$3.49	\$0.019	\$811

Population Est	9,722	
Persons per household	3	
# of Households Est.	3,241	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	32%	41%
%IC Comm/Ind/Inst	47%	59%
%IC Transportation	1%	
%IC Misc	20%	
Total		100%

## **B16. North Berwick, Maine**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.

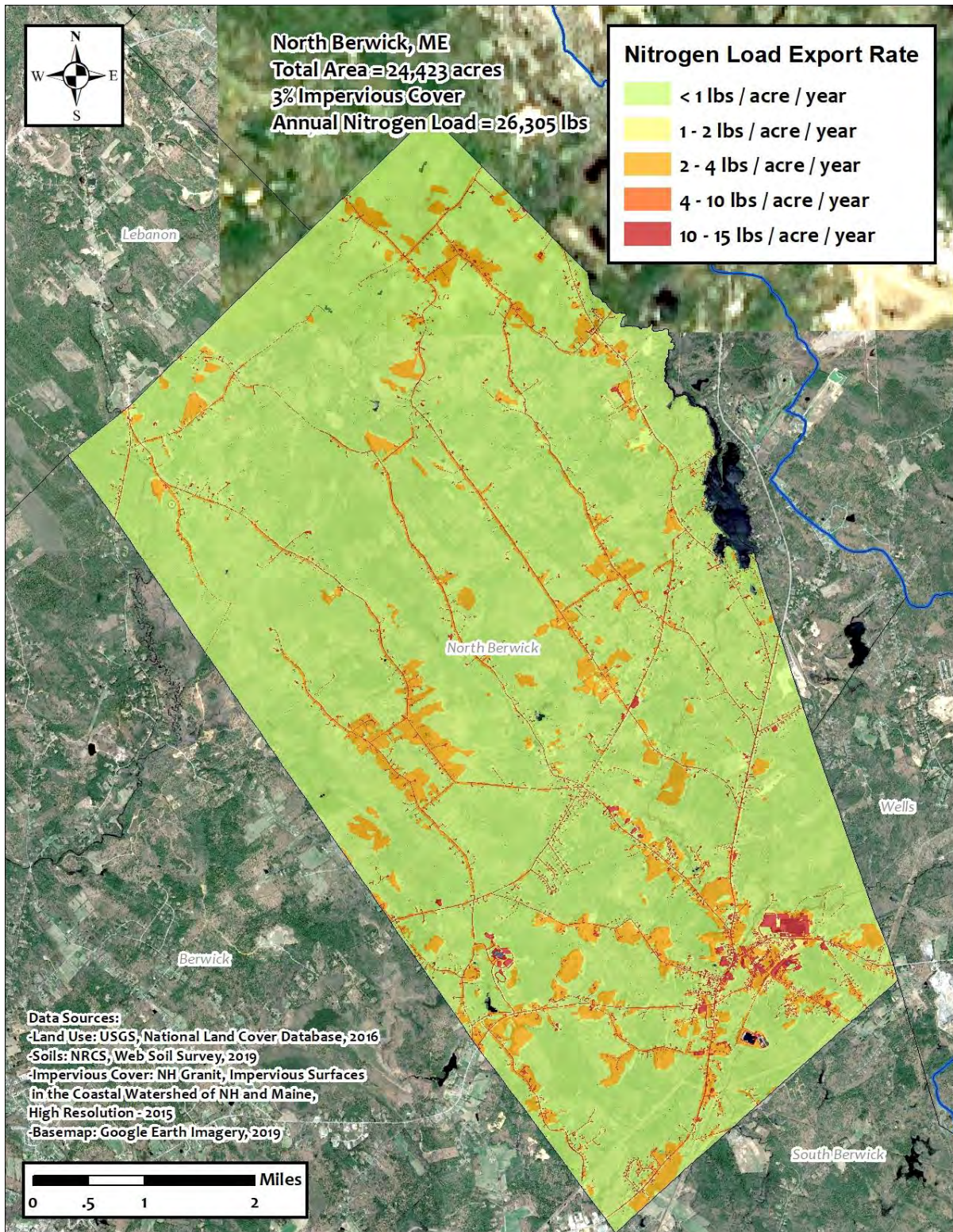


Figure 1 - Annual Nitrogen Load Export



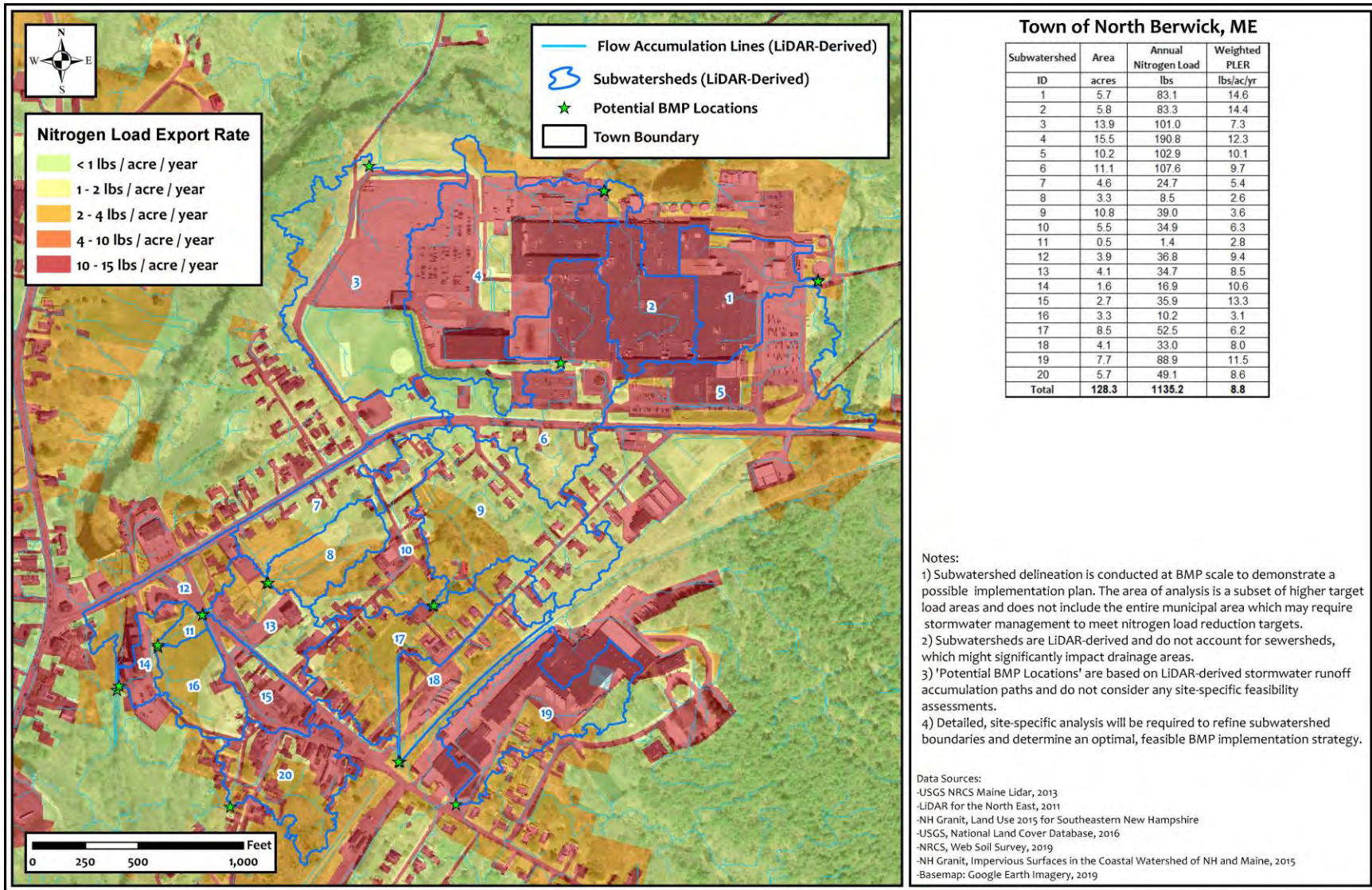


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme



Table 1 - BMP Menu for 34% N-Load Reduction Target

PERCENT REDUCTION TARGET	34%				
TN LOAD REDUCTION TARGET (LBS/YR)	11,720				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		1,202.9	11,720.5	\$ 6,820,648	\$ 322
<b>Structural Controls</b>	1,690.3	395.2	3,746.0	\$ 2,026,556	\$ 483
<b>Non-Structural Controls</b>	2,178.8	1,986.4	7,974.5	\$ 4,794,092	\$ 209
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	89.89	89.9	638.8	\$ 404,505	\$ 633
RESIDENTIAL R DRY WELLO.25	62.47	62.5	630.4	\$ 249,880	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	51.87	51.9	623.0	\$ 306,033	\$ 491
COMMERCIAL R DRY WELLO.25	12.97	13.0	154.1	\$ 51,880	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	34.91	34.9	419.3	\$ 205,969	\$ 491
INDUSTRIAL R DRY WELLO.25	18.8	18.8	223.4	\$ 75,200	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	181.17	124.3	1057.1	\$ 733,089	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	1,178.59	1178.6	7495.8	\$ 4,714,360	\$ 629
STREET_SWEEPING_RES STREET_SWEEPING_RES	89.89	89.9	126.7	\$ 2,876	\$ 23
STREET_SWEEPING_COM STREET_SWEEPING_COM	51.87	51.9	77.8	\$ 1,660	\$ 21
STREET_SWEEPING_IND STREET_SWEEPING_IND	34.91	34.9	52.4	\$ 1,117	\$ 21
LEAF_LITTER_B LEAF_LITTER_B	47.43	47.4	2.8	\$ 522	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	27.16	27.2	3.3	\$ 299	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	106.13	106.1	19.1	\$ 1,167	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	157.57	157.6	133.3	\$ 50,422	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	268.38	268.4	58.0	\$ 19,860	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	24.43	24.4	5.3	\$ 1,808	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$28,716	\$144,949	\$277,382	\$414,034	\$573,173	\$1,763,156	\$4,148,011	\$6,820,648	\$24,491,572
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	43%
Load Reduction Achieved (Lbs TN/Yr)	345	689	1,034	1,379	1,724	3,792	7,584	11,720	14,823
Load Reduction Target (Lbs TN/Yr)	345	689	1,034	1,379	1,724	3,792	7,584	11,720	14,823
Treated Area (Acres)	363	527	857	891	922	989	989	1,203	2,691
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)								
15	24.2	35.2	57.1	59.4	61.5	65.9	65.9	80.2	179.4
16	22.7	33.0	53.6	55.7	57.6	61.8	61.8	75.2	168.2
17	21.3	31.0	50.4	52.4	54.2	58.2	58.2	70.8	158.3
18	20.1	29.3	47.6	49.5	51.2	54.9	54.9	66.8	149.5
19	19.1	27.8	45.1	46.9	48.5	52.0	52.0	63.3	141.6
20	18.1	26.4	42.9	44.6	46.1	49.4	49.4	60.1	134.5
21	17.3	25.1	40.8	42.4	43.9	47.1	47.1	57.3	128.1
22	16.5	24.0	39.0	40.5	41.9	44.9	44.9	54.7	122.3
23	15.8	22.9	37.3	38.8	40.1	43.0	43.0	52.3	117.0
24	15.1	22.0	35.7	37.1	38.4	41.2	41.2	50.1	112.1
25	14.5	21.1	34.3	35.7	36.9	39.6	39.6	48.1	107.6

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$28,716	\$144,949	\$277,382	\$414,034	\$573,173	\$1,763,156	\$4,148,011	\$6,820,648	\$24,491,572
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	43%
Load Reduction (Lbs TN/Yr)	345	689	1,034	1,379	1,724	3,792	7,584	11,720	14,823
Treated Area (Acres)	363	527	857	891	922	989	989	1,203	2,691
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)								
15	\$1,914	\$9,663	\$18,492	\$27,602	\$38,212	\$117,544	\$276,534	\$454,710	\$1,632,771
16	\$1,795	\$9,059	\$17,336	\$25,877	\$35,823	\$110,197	\$259,251	\$426,290	\$1,530,723
17	\$1,689	\$8,526	\$16,317	\$24,355	\$33,716	\$103,715	\$244,001	\$401,215	\$1,440,681
18	\$1,595	\$8,053	\$15,410	\$23,002	\$31,843	\$97,953	\$230,445	\$378,925	\$1,360,643
19	\$1,511	\$7,629	\$14,599	\$21,791	\$30,167	\$92,798	\$218,316	\$358,981	\$1,289,030
20	\$1,436	\$7,247	\$13,869	\$20,702	\$28,659	\$88,158	\$207,401	\$341,032	\$1,224,579
21	\$1,367	\$6,902	\$13,209	\$19,716	\$27,294	\$83,960	\$197,524	\$324,793	\$1,166,265
22	\$1,305	\$6,589	\$12,608	\$18,820	\$26,053	\$80,143	\$188,546	\$310,029	\$1,113,253
23	\$1,249	\$6,302	\$12,060	\$18,001	\$24,921	\$76,659	\$180,348	\$296,550	\$1,064,851
24	\$1,196	\$6,040	\$11,558	\$17,251	\$23,882	\$73,465	\$172,834	\$284,194	\$1,020,482
25	\$1,149	\$5,798	\$11,095	\$16,561	\$22,927	\$70,526	\$165,920	\$272,826	\$979,663

Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 34% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$96	\$7.98	\$0.043	\$1,855
16	\$90	\$7.49	\$0.040	\$1,739
17	\$85	\$7.05	\$0.038	\$1,637
18	\$80	\$6.65	\$0.035	\$1,546
19	\$76	\$6.30	\$0.034	\$1,465
20	\$72	\$5.99	\$0.032	\$1,391
21	\$68	\$5.70	\$0.030	\$1,325
22	\$65	\$5.44	\$0.029	\$1,265
23	\$62	\$5.21	\$0.028	\$1,210
24	\$60	\$4.99	\$0.027	\$1,159
25	\$57	\$4.79	\$0.026	\$1,113

Population Est	4,576	
Persons per household	3	
# of Households Est.	1,525	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	9%	32%
% IC Comm/Ind/Inst	19%	68%
% IC Transportation	30%	
% IC Misc	42%	
Total		100%

## **B17. South Berwick, Maine**

A pollutant load analysis was conducted to determine the nitrogen load for each community. A map of nitrogen load export rates is shown in Figure 1 that illustrates the areas of highest loading concern for prioritization of structural BMPs. From this heat map, areas of greatest nitrogen loading can be clearly identified.

Figure 2 is a subwatershed delineation and potential BMP siting scheme for an LTCP and implementation plan development. This figure illustrates how BMP prioritization and ranking could be accomplished. BMP catchments (subwatersheds) are listed by area, total load, and weighted pollutant load export rates for ease of prioritization. BMPs can then be prioritized by drainage area, total load reduced, or most importantly by pollutant load export rate. This analyses would need to be extended to additional areas until the necessary load reduction was achieved.

Analyses for each community include an assessment of land use, soils, and a range of structural and non-structural BMPs in order to achieve the lowest cost and greatest performance (unit cost). Table 1 is a menu of BMPs optimized by cost. A mix of structural and non-structural controls are used with a total and average unit cost for structural and non-structural controls. Limited small-sized structural BMPs are used, such as rain gardens, dry wells, and gravel wetlands. Non-structural controls are widely used and are the most cost-effective management solution and include catch basin cleaning, leaf litter collection, and fertilizer reduction. Septic system retrofits account for the single largest load reduction. For this study, septic system retrofits were based on an aerobic bacterial generator that costs, on average, \$4,000 for a residential installation and demonstrated to achieve 60% nitrogen load reduction for residential applications (see Appendix D). An average septic system was assumed to serve three people. Estimates for the number of people in each town who are served by septic systems are based on GBNNPSS population estimates for septic systems.

BMPs listed here represent strategies evaluated as part of the development of the nutrient control planning for the various communities. Other BMP combinations may be feasible; additionally, some BMPs considered here may not be appropriate for some communities, due to concerns about program implementation or otherwise. The menu of BMPs ultimately selected for nutrient control planning represent one low cost option of many.

Table 2 provides summary information for the amount of area to be treated by structural and non-structural BMPs (in acres) combined annually, and with implementation periods ranging from 15-25 years.

Table 3 presents the costs for varying degrees of pollutant load reduction over 15-25 years implementation periods.

Table 4 presents the estimated annual fee for a stormwater utility as measured in ERUs for implementation periods ranging from 15-25 years, or 3-5 permit cycles. For this study, stormwater fees were based on an estimated number of community households, a standard equivalent residential unit (ERU) of 2,250SF of impervious cover, and the distribution of land cover as residential, commercial, industrial, or institutional, all which are listed below.



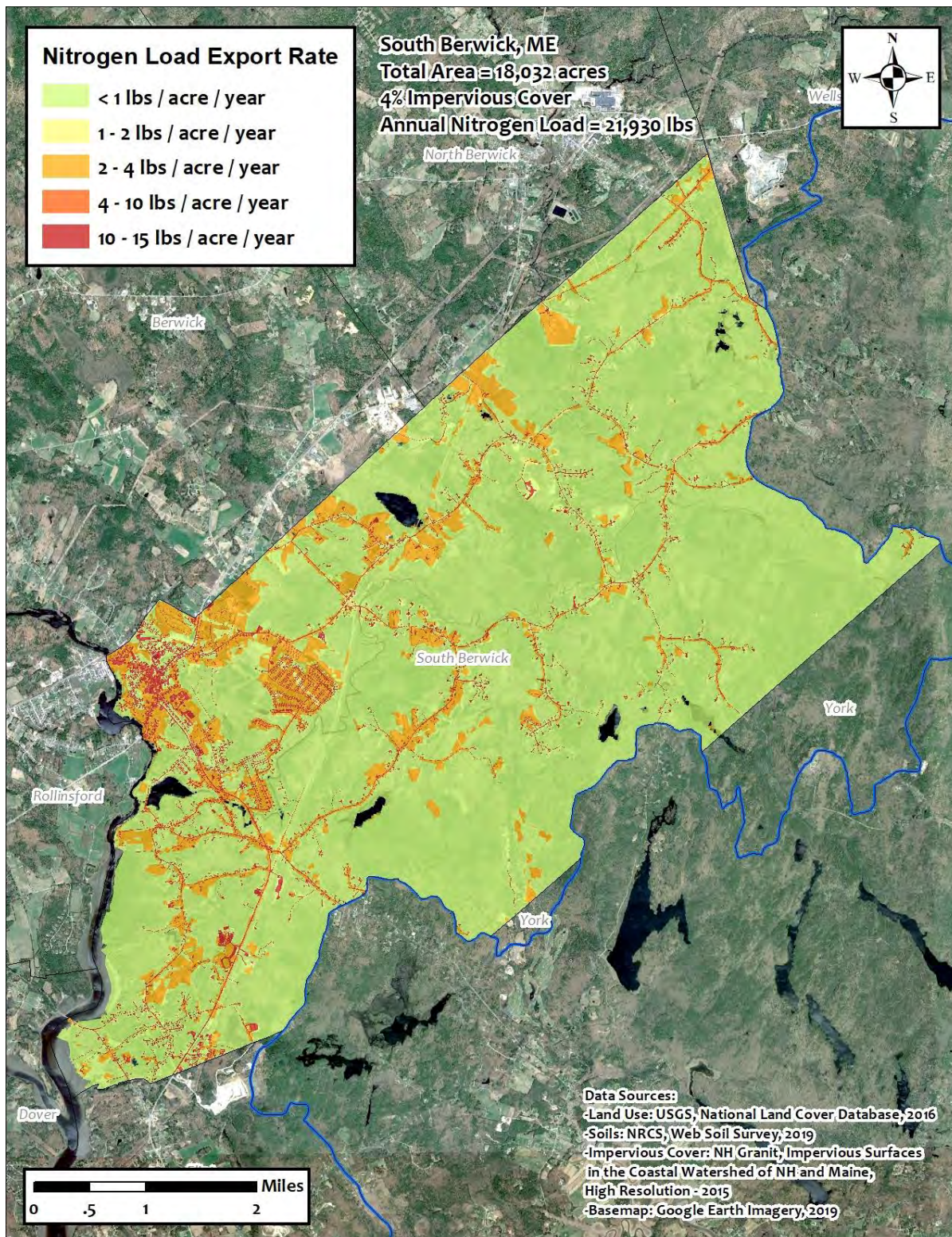


Figure 1 - Annual Nitrogen Load Export



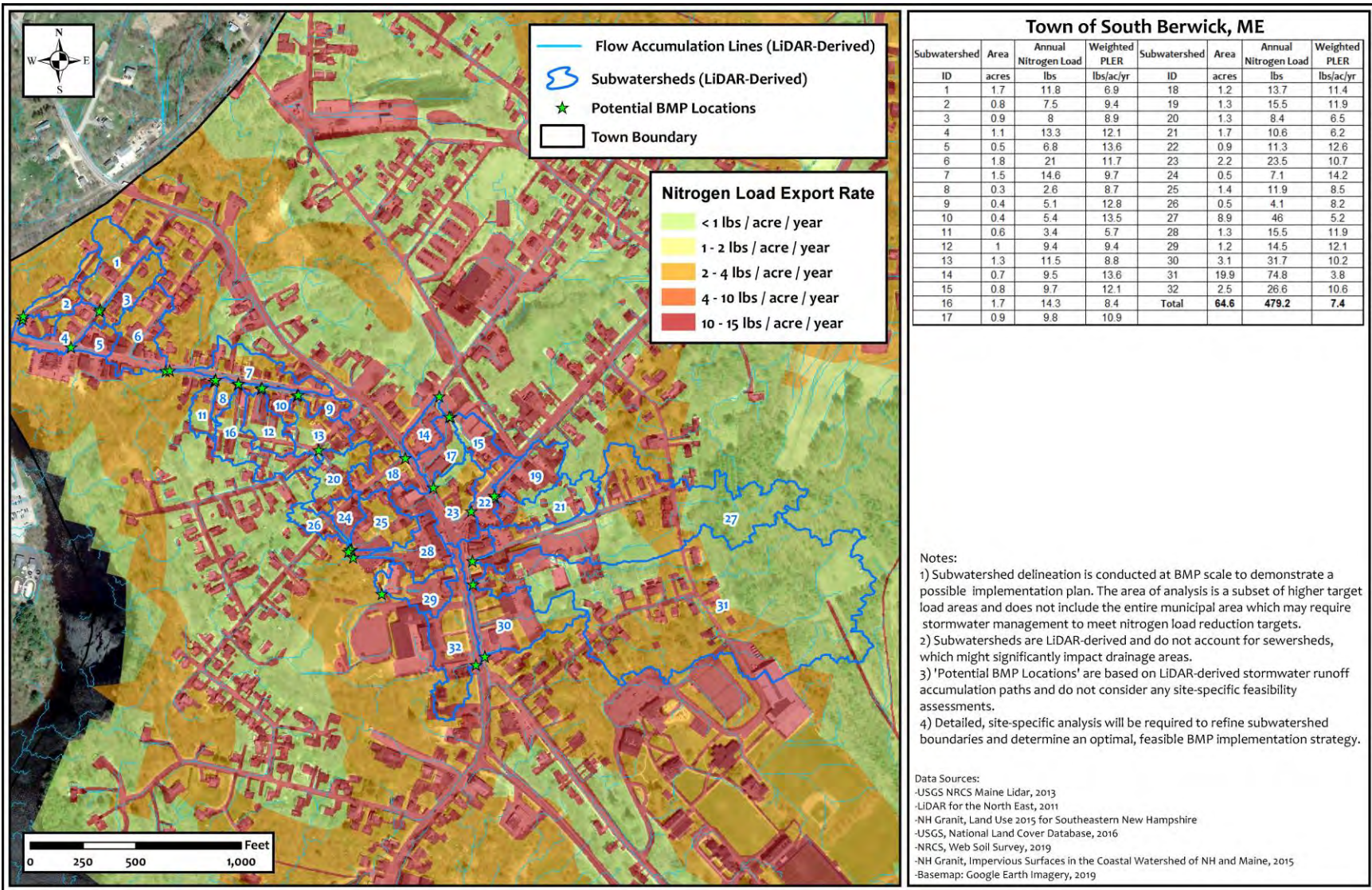


Figure 2 - Subwatershed Delineation and Potential BMP Siting Scheme

Table 1 - BMP Menu for 34% N-Load Reduction Target

PERCENT REDUCTION TARGET	34%				
TN LOAD REDUCTION TARGET (LBS/YR)	12,268				
	Potential Area (acres)	Treated Area (acres)	Load Reduction (lbs)	Cost (\$)	Unit Cost (\$/lb)
<b>Total</b>		1,546.4	12,268.2	\$ 7,276,758	\$ 365
<b>Structural Controls</b>	1,791.6	453.2	4,229.1	\$ 2,443,448	\$ 518
<b>Non-Structural Controls</b>	2,287.7	2,287.7	8,039.1	\$ 4,833,310	\$ 270
Landuse & BMP Type and Depth	Potential Area (acres)	Treated Area (acre)	Load Reduction (lb)	Cost (\$)	Unit Cost (\$/lb)
RESIDENTIAL I RAINGARDEN0.25	121.85	66.7	474.4	\$ 300,369	\$ 633
RESIDENTIAL I RAINGARDEN0.5	121.85	55.1	501.6	\$ 385,710	\$ 769
RESIDENTIAL R DRY WELLO.25	84.68	84.7	854.5	\$ 338,720	\$ 396
COMMERCIAL I GRAVEL WETLAND0.25	57.84	57.8	694.7	\$ 341,256	\$ 491
COMMERCIAL R DRY WELLO.25	14.46	14.5	171.8	\$ 57,840	\$ 337
INDUSTRIAL I GRAVEL WETLAND0.25	9.13	9.1	109.7	\$ 53,867	\$ 491
INDUSTRIAL R DRY WELLO.25	4.92	4.9	58.5	\$ 19,680	\$ 337
OUTDOOR I GRAVEL WETLAND0.25	160.34	160.3	1364.1	\$ 946,006	\$ 693
SEPTIC SEPTIC SLUDGEHAMMER	1,194.45	1194.5	7596.7	\$ 4,777,800	\$ 629
STREET_SWEEPING_RES STREET_SWEEPING_RES	121.85	121.9	171.8	\$ 3,899	\$ 23
STREET_SWEEPING_COM STREET_SWEEPING_COM	57.84	57.8	86.8	\$ 1,851	\$ 21
STREET_SWEEPING_IND STREET_SWEEPING_IND	9.13	9.1	13.7	\$ 292	\$ 21
LEAF_LITTER_A LEAF_LITTER_A	152.99	153.0	2.3	\$ 1,683	\$ 733
LEAF_LITTER_B LEAF_LITTER_B	20.76	20.8	1.2	\$ 228	\$ 183
LEAF_LITTER_C LEAF_LITTER_C	69.04	69.0	8.3	\$ 759	\$ 92
LEAF_LITTER_D LEAF_LITTER_D	167.05	167.1	30.1	\$ 1,838	\$ 61
CATCH_BASIN_RES CATCH_BASIN_RES	34	34.0	28.8	\$ 10,880	\$ 378
URBAN_FERTILIZER_RES URBAN_FERTILIZER_RES	332.03	332.0	71.7	\$ 24,570	\$ 343
URBAN_FERTILIZER_GOLF URBAN_FERTILIZER_GOLF	98.96	99.0	21.4	\$ 7,323	\$ 343
URBAN_FERTILIZER_SCHOOL URBAN_FERTILIZER_SC	22.44	22.4	4.8	\$ 1,661	\$ 343
URBAN_FERTILIZER_PARK URBAN_FERTILIZER_PARK	7.11	7.1	1.5	\$ 526	\$ 343

Table 2 - Yearly Rate of Area Treated for Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$25,353	\$151,684	\$294,722	\$437,760	\$607,289	\$1,896,633	\$4,392,941	\$7,276,758	\$28,164,686
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	43%
Load Reduction Achieved (Lbs TN/Yr)	361	722	1,082	1,443	1,804	3,969	7,938	12,268	15,516
Load Reduction Target (Lbs TN/Yr)	361	722	1,082	1,443	1,804	3,969	7,938	12,268	15,516
Treated Area (Acres)	450	965	1,000	1,036	1,068	1,111	1,111	1,546	2,885
Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)								
15	30.0	64.3	66.7	69.1	71.2	74.1	74.1	103.1	192.3
16	28.1	60.3	62.5	64.8	66.7	69.5	69.5	96.7	180.3
17	26.5	56.7	58.8	61.0	62.8	65.4	65.4	91.0	169.7
18	25.0	53.6	55.6	57.6	59.3	61.7	61.7	85.9	160.3
19	23.7	50.8	52.7	54.5	56.2	58.5	58.5	81.4	151.8
20	22.5	48.2	50.0	51.8	53.4	55.6	55.6	77.3	144.2
21	21.4	45.9	47.6	49.3	50.8	52.9	52.9	73.6	137.4
22	20.4	43.8	45.5	47.1	48.5	50.5	50.5	70.3	131.1
23	19.6	41.9	43.5	45.1	46.4	48.3	48.3	67.2	125.4
24	18.7	40.2	41.7	43.2	44.5	46.3	46.3	64.4	120.2
25	18.0	38.6	40.0	41.4	42.7	44.4	44.4	61.9	115.4

Table 3 - Yearly Cost to Implement Varying N-Load Reduction Targets for 15-25 Year Implementation Periods

Cost to Implement	\$25,353	\$151,684	\$294,722	\$437,760	\$607,289	\$1,896,633	\$4,392,941	\$7,276,758	\$28,164,686
Percent Reduction	1%	2%	3%	4%	5%	11%	22%	34%	43%
Load Reduction (Lbs TN/Yr)	361	722	1,082	1,443	1,804	3,969	7,938	12,268	15,516
Treated Area (Acres)	450	965	1,000	1,036	1,068	1,111	1,111	1,546	2,885
Implementation Period (yrs)	Yearly Cost to Implement Total (\$\$/Yr)								
15	\$1,690	\$10,112	\$19,648	\$29,184	\$40,486	\$126,442	\$292,863	\$485,117	\$1,877,646
16	\$1,585	\$9,480	\$18,420	\$27,360	\$37,956	\$118,540	\$274,559	\$454,797	\$1,760,293
17	\$1,491	\$8,923	\$17,337	\$25,751	\$35,723	\$111,567	\$258,408	\$428,045	\$1,656,746
18	\$1,409	\$8,427	\$16,373	\$24,320	\$33,738	\$105,368	\$244,052	\$404,264	\$1,564,705
19	\$1,334	\$7,983	\$15,512	\$23,040	\$31,963	\$99,823	\$231,207	\$382,987	\$1,482,352
20	\$1,268	\$7,584	\$14,736	\$21,888	\$30,364	\$94,832	\$219,647	\$363,838	\$1,408,234
21	\$1,207	\$7,223	\$14,034	\$20,846	\$28,919	\$90,316	\$209,188	\$346,512	\$1,341,176
22	\$1,152	\$6,895	\$13,396	\$19,898	\$27,604	\$86,211	\$199,679	\$330,762	\$1,280,213
23	\$1,102	\$6,595	\$12,814	\$19,033	\$26,404	\$82,462	\$190,997	\$316,381	\$1,224,552
24	\$1,056	\$6,320	\$12,280	\$18,240	\$25,304	\$79,026	\$183,039	\$303,198	\$1,173,529
25	\$1,014	\$6,067	\$11,789	\$17,510	\$24,292	\$75,865	\$175,718	\$291,070	\$1,126,587



Table 4 - Stormwater Utility Proof of Concept Calculations to Support NCP Implementation at 34% N-Load Reduction

Implementation Period (yrs)	Equivalent Residential Unit (ERU) \$\$/Yr	Equivalent Residential Unit (ERU) \$\$/Month	Equivalent Residential Unit (ERU) \$\$/IC SF per Yr	ERU \$\$ per Acre IC per Yr
15	\$71	\$5.88	\$0.031	\$1,367
16	\$66	\$5.52	\$0.029	\$1,281
17	\$62	\$5.19	\$0.028	\$1,206
18	\$59	\$4.90	\$0.026	\$1,139
19	\$56	\$4.64	\$0.025	\$1,079
20	\$53	\$4.41	\$0.024	\$1,025
21	\$50	\$4.20	\$0.022	\$976
22	\$48	\$4.01	\$0.021	\$932
23	\$46	\$3.84	\$0.020	\$891
24	\$44	\$3.68	\$0.020	\$854
25	\$42	\$3.53	\$0.019	\$820

Population Est	7,464	
Persons per household	3	
# of Households Est.	2,488	
Typical household IC (SF)	2250	IC Normalized
% IC Residential	21%	36%
%IC Comm/Ind/Inst	37%	64%
%IC Transportation	10%	
%IC Misc	32%	
Total		100%

# **APPENDIX C: CREDIT TRADING FACTSHEETS**

- **Innovations In Water Quality Trading: Significant Tools, Significant Progress  
Fact Sheet by the Willamette Partnership, USDA Natural Resources  
Conservation Service, 2017**
- **EPA Watershed-Based Permitting Case Study: Tualatin River Watershed,  
Oregon**
- **Building a Water Quality Trading Program: Options and Considerations by  
the National Network on Water Quality Trading, 2015.**

# INNOVATIONS IN WATER QUALITY TRADING: SIGNIFICANT TOOLS, SIGNIFICANT PROGRESS

**PROJECT SUMMARY:** In 2013, Willamette Partnership and its partners from The Freshwater Trust, the States of Idaho, Oregon, and Washington, and US EPA Region 10 received an Natural Resources Conservation Service (NRCS) Conservation Innovation Grant to make it faster and easier for states to support water quality trading (WQT)—a flexible approach for permitted entities (e.g., stormwater and wastewater utilities, transportation infrastructure) to save money, meet clean water goals, and support a vibrant local economy.

We’ve done that—locally, and nationally. Clear, practical, and defensible policy at the state level gives regulatory agencies what they need to write permits that allow trading to occur, and gives permittees the confidence that they need to invest rate payer dollars in a green infrastructure option. The project team built policy and technical approaches that have been shared across the state agencies in the Pacific Northwest and across the country. In the last four years:

- Four states have used products from this project to build state trading policies;
- The National Network on Water Quality Trading formed and published a comprehensive guidebook on trading program design; and

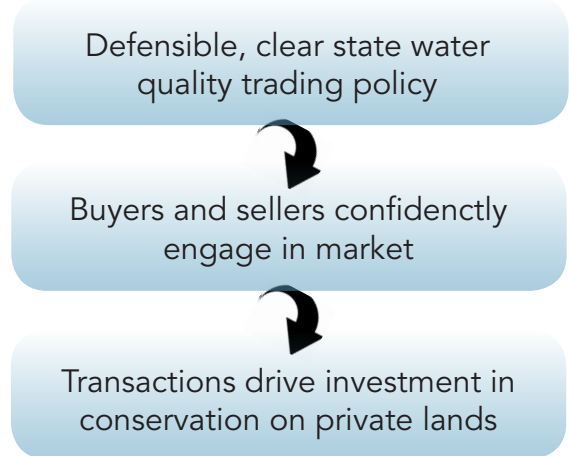


Figure 1. Logic model for project impact

- The Association of Clean Water Administrators (ACWA) with Willamette Partnership released a toolkit of WQT policy templates for states.

These policy innovations have made it easier for regulators, permittees, and landowners to build programs that invest compliance dollars in conservation that gets results, saves money for rate payers, supports local economies, and provides multiple additional benefits to soil, air, and wildlife.

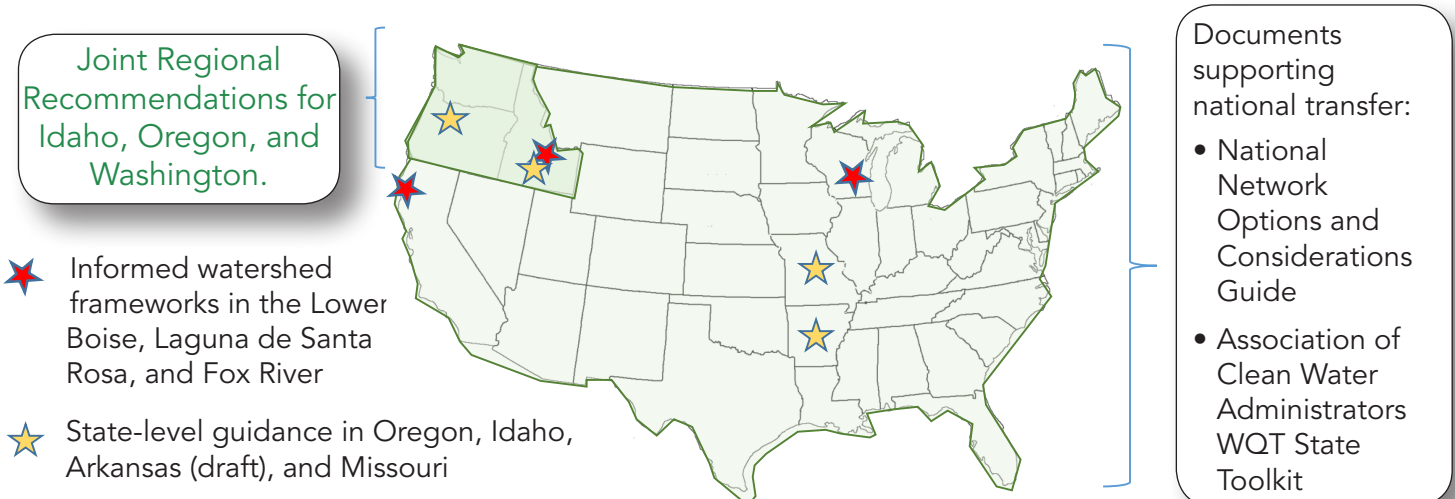


Figure 2. Map of the project’s products and impacts of the policy and process innovations.

# Water Quality Trading

## What is Water Quality Trading?

Water quality trading is a mechanism to help achieve local water quality improvements. Trading allows sources with very high costs of reducing pollution to negotiate equal or greater pollution reductions from sources with lower cost. For example, in a water quality trading program, a city's waste water facility can work with farmers and landowners to reduce sediment by implementing conservation practices such as installing livestock exclusion fencing along stream banks. Facilities then pay for the water quality benefits resulting from these practices as a way to meet their own clean water requirements.

This is the most basic value proposition for water quality trading, economic efficiency – cleaner water at a lower cost.

## One Tool, Multiple Benefits

Water quality trading programs provide multiple benefits. For permittees, trading provide flexibility in how they achieve pollution reduction targets and cost savings to their rate payers. For landowners, trading provides an opportunity to fund conservation measures that go above and beyond what is required, supporting the rural economy and stewardship of the land. Trading also provides “co-benefits” to the environment, like habitat for fish and bird species and reduced streambank erosion.

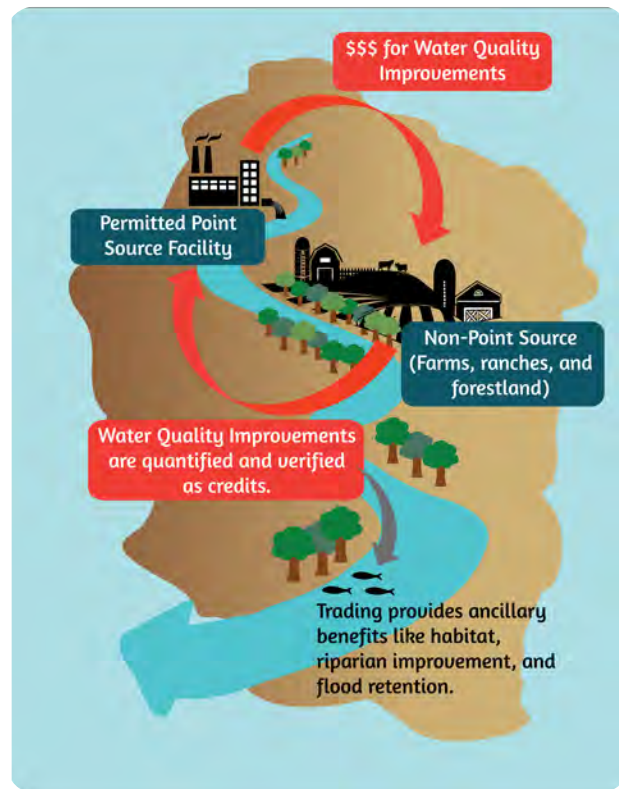


Figure 3. Basics of water quality trading.



**WILLAMETTE  
PARTNERSHIP**

## Who is Willamette Partnership?

Willamette Partnership is a conservation nonprofit dedicated to solving complex environmental problems in ways that work for people. We are known for helping state and federal natural resource agencies, businesses, and conservation interests take advantage of opportunities to achieve conservation and economic outcomes. We work throughout the western U.S. with a focus on the Pacific Northwest.

## NRCS Conservation Innovations Grant Program

This project was funded through NRCS Conservation Innovation Grants (CIG). CIG is a competitive grant program that stimulates the development and adoption of innovative approaches and technologies for conservation on agricultural lands. Through CIG, NRCS partners with public and private entities to accelerate technology transfer and adopt promising technologies.



**United States  
Department of  
Agriculture**

**Natural Resources Conservation Service**



# The Process

We believe the regional recommendations could result in the states developing regionally consistent and robust guidance to help ensure water quality trading programs have the quality, credibility, and transparency necessary to ensure water quality improvements are achieved.

--Dan Opalski, Director of Office of Water and Watersheds, EPA Region 10

## Timeline

### Action

### Impacts

2012

Project kickoff and convening state agency partners

2013

Convene Northwest and National partners to develop shared WQT tools and policy recommendations

Build common language, sources of information, and understanding of WQT between states and EPA.

2014

Joint Regional Recommendations released:

- Oregon and Idaho begin updating state policy.
- Idaho begins revising the Lower Boise River WQT Framework.

States are supported for faster, defensible updates to WQT policy.

Common playbook, vetted with diverse stakeholders, for states to build trading programs.

2015

National Network releases Options and Considerations Guide. Stakeholders apply the guide in program development in CA, MO, ID, WI.

Strengthen Oregon's regulatory framework, give certainty to buyers and landowners.

Oregon finalizes WQT rule.

2016

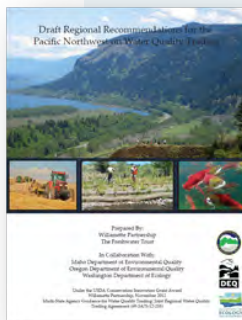
ACWA and Willamette Partnership release state WQT toolkit. CA and AK apply toolkit.

Faster and easier to develop defensible state policy supporting trades.

Idaho finalizes state guidance.

Strengthen Idaho regulatory framework, give certainty to buyers and landowners.

# The Products



## Joint Regional Recommendations

Recommendations on the development of water quality trading in the Pacific Northwest. These recommendations were piloted in ID and OR and became a starting point for the National Network guide.



## National Network Guide

A dialogue of producers, environmental groups, regulatory agencies, utilities, and practitioners built a comprehensive reference guidebook for each of the elements important to trading. The National Network Guide includes thorough references and represents exhaustive conversations on the details of each element from different viewpoints.



## ACWA & Willamette Partnership State WQT Toolkit

The Association of Clean Water Administrators and Willamette Partnership built a toolkit that lets states easily translate the National Network Guide into state policy documents, including:

- State rules and guidance,
- Permits and trading plans,
- Watershed trading frameworks.

I can't tell you how appreciative I am of the work you have done (and continue to do) with the National Network and ACWA. I feel I may be the epitome of your target audience. The Toolkit and the Options and Considerations documents are such excellent resources. The fact that I am relying on them to develop the next generation of our Laguna framework is a source of comfort for my management team and board members.

-- David Kuszmar, North Coast Regional Water Quality Control Board, Watershed Protection Division, TMDL Unit

## RESULTS:

### State Policies based on Recommendations, Guide, and Toolkit

There are now several examples of states using these policy innovations to advance trading in OR, ID, CA, WI, and MO. Other states are actively using the tools to form their policies and trading programs.

# Looking Ahead

## Remaining Challenges

### Is the juice worth the squeeze?

This project did a lot to clarify the steps, language, and elements of trading, but there are a lot of local decisions that need to be made and skepticism about trading to overcome.

Oregon's rulemaking process was met with skepticism from environmental groups seeking strict nonpoint source baselines, utilities who worried about complex reporting, and producers wanting to ensure trading didn't impose new regulatory expectations.

Trading programs need and want to be responsive to local environmental, economic, and social conditions, which means that it is still hard to launch and sustain programs. The tools and resources developed here have made it faster and easier to develop a trading program, but it will still take time and effort by local stakeholders. That effort may be difficult to justify for the sake of lower cost regulatory compliance without additional water quality improvements and economic benefits.

### Making trading normal

There are continued barriers to making trading a normal part of a permittee's compliance options. We were not able to establish a go-to regional quantification tool for nutrients or temperature, and the use of trading for Clean Water Act compliance has not been affirmed in the courts.

## Recommendations

### States need to be leaders

Opportunities for trading will be built at the state level. State agencies need support from their utilities and agencies, like USDA, to make time within hectic jobs and limited budgets to advance trading.

### Quantification is next choke point

States have policy and process templates. Applicable, defensible, and usable quantification tools are the next place to reduce start-up costs and increase consistency.

### Whole watershed solutions are cool

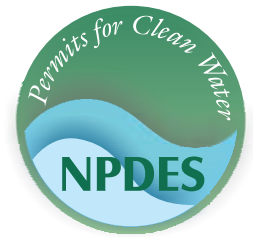
Talking about significant progress to water quality goals brings stakeholders together more effectively than talking about cheaper regulatory compliance alone. If we can link trading with watershed-scale water quality goals, regulatory certainty for landowners, and conservation finance, we may get much more energized stakeholders. Similarly, targeting BMPs that create multiple environmental, economic, and social benefits may help rise above some of the legal quarrels related to trading under the Clean Water Act.



**WILLAMETTE  
PARTNERSHIP**

Learn more at Willamette Partnership:

**[www.willamettepartnership.org](http://www.willamettepartnership.org)  
[info@willamettepartnership.org](mailto:info@willamettepartnership.org)**



# Tualatin River Watershed, Oregon

Clean Water Services Integrated Municipal Permit

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**Permit Type:**

Integrated municipal permit (integration of NPDES permits for four advanced wastewater treatment facilities, two industrial storm water permits, and permit for Municipal Separate Storm Sewer System)

**Permit Information:**

[www.deq.state.or.us/wq/wqpermit/cwsp permit.htm](http://www.deq.state.or.us/wq/wqpermit/cwsp permit.htm)

**Pollutants of Concern in Watershed:**

Temperature, bacteria, low dissolved oxygen (DO), chlorophyll a, toxics (arsenic, iron, and manganese), biological criteria, and low pH

**Pollutants Addressed in Permit:**

Temperature, bacteria, DO, ammonia, and phosphorus

**Permit Issued:** February 26, 2004

**Modified:** July 27, 2005

**Watershed:** Tualatin River, Oregon

**Key Water Quality Concerns:** Temperature, bacteria, low DO, chlorophyll a, arsenic, iron, manganese, low pH, and biological criteria

**Stakeholder Involvement Techniques:**

- Permittee and permitting authority motivated by opportunities to protect the river while streamlining requirements through integrated permitting
- Public notice and public meetings
- General public outreach on water quality trading
- Outreach to stakeholders regarding participation in water quality trading

**Case Study Issues of Interest**

Type of Point Sources	POTW Discharges	✓
	Industrial Process/Nonprocess Wastewater Discharges	
	Concentrated Animal Feeding Operations	
	Municipal Separate Storm Sewer System Discharges	✓
	Construction Site Stormwater Discharges	
	Industrial Facility Stormwater Discharges	✓
Highlighted Approach(es)	Combined Sewer Overflows	
	Statewide Watershed Approach	
	Implementation of Water Quality Standards	✓
	Implementation of Total Maximum Daily Loads or Other Watershed Pollutant Reduction Goals	✓
	Permit Coordination/Synchronization	✓
	Integrated Municipal Requirements	✓
	Point Source – Point Source Water Quality Trading	✓
	Point Source – Nonpoint Source Water Quality Trading	✓
Discharger Association		
Coordinated Watershed Monitoring		

## Overview

Clean Water Services (CWS) is a public utility (special services district) that operates four municipal wastewater treatment facilities, each with its own permit under the National Pollutant Discharge Elimination System (NPDES). CWS also has two industrial stormwater permits and is a co-permittee on a Municipal Separate Storm Sewer System (MS4) permit. The Tualatin River is the receiving stream for each of these permitted discharges. Oregon’s Department of Environmental Quality (OR DEQ) issued total maximum daily loads (TMDLs) for the Tualatin River for ammonia, phosphorus, temperature, bacteria, and tributary dissolved oxygen (DO). In February 2004, OR DEQ issued a single watershed-based, integrated municipal permit to CWS. This permit incorporates the NPDES requirements for all four of CWS’s advanced wastewater treatment facilities, its two industrial storm water permits, and its MS4 permit. A significant feature of the integrated permit is its inclusion of provisions for water quality credit trading involving temperature (thermal load), biochemical oxygen demand (BOD), and ammonia.

The watershed-based permit has resulted in various benefits to CWS, the permitting authority (OR DEQ), and the environment. For both CWS and OR DEQ, one permit is easier to administer and implement. The integrated permit provides economies of scale for both CWS and OR DEQ



in terms of resource use. Both organizations are now better able to focus their resources on the most critical resource problems, and the integrated permit provides greater protections for the environment than what might have been realized under the previous array of permits. Since the integrated watershed based permit was issued, CWS has planted nearly 10 miles of riparian shading, preventing 101 million kilocalories (Kcal) per day of thermal energy from impacting the Tualatin River.

This case study focuses on the components of the watershed-based permit issued to CWS. It also summarizes key components of CWS's thermal load trading program.

## Permitting Background

CWS operates four municipal wastewater treatment facilities that provide advanced wastewater treatment for the cities of Banks, Beaverton, Cornelius, Forest Grove, Gaston, Hillsboro, North Plains, Tigard, Sherwood and Tualatin, the communities of Durham and King City, and some unincorporated areas of Clackamas, Multnomah, and Washington Counties. Prior to issuance of the integrated watershed-based permit, CWS had four individual NPDES permits for these facilities. It also had two general industrial NPDES stormwater permits for its Durham and Rock Creek advanced wastewater treatment facilities (AWTF) and was a co-permittee on an NPDES permit for a MS4 with Washington County Department of Land Use and Transportation (DLUT) and the Oregon Department of Transportation (ODOT) covering the urbanized area of Washington County.

The Tualatin River subbasin has stream segments listed on Oregon's 1998 Clean Water Act section 303(d) list for temperature, bacteria, dissolved oxygen, chlorophyll a, arsenic, iron, manganese, biological criteria, and low pH. The state established TMDLs in 1988 for ammonia and phosphorus to address low dissolved oxygen and elevated pH and chlorophyll a in the mainstem. OR DEQ later revised the TMDLs for ammonia and phosphorus and established new TMDLs for temperature, bacteria and tributary dissolved oxygen. EPA approved the state's TMDL Water Quality Management Plan for the Tualatin River in August 2001.

## Permit Strategy

For years, CWS had been very interested in implementing a watershed-based approach to managing the water resources within the Tualatin River basin. Beginning in 2000, several events occurred that allowed CWS to pursue development of a single integrated municipal NPDES permit. The individual NPDES permits for its four wastewater facilities expired in 1995 and were administratively extended pending the development of the revised Tualatin TMDL, the original of which was issued in 1988. CWS's MS4 permit, under which it was a co-permittee, expired in early 2001. These circumstances, along with the release of guidance documents and encour-

agement from EPA regarding the watershed-based permitting approach, allowed CWS to propose the development of an integrated municipal permit to OR DEQ. At the time, OR DEQ had a large permit reissuance backlog. Therefore, the state was open to the approach of consolidating permits for CWS's five discharges (four wastewater treatment plants, including its stormwater discharges, and the MS4) into a single permit.

CWS was in a position to benefit from an integrated water resources management approach. It is the only major discharger in the Tualatin River watershed; it owns one quarter of the stored water in the basin, which is released for instream flow management; it has a significant amount of facility and ambient data; and it has long been responsible for managing surface water and stormwater in the basin.

CWS was issued a Clean Water Act section 104(b)(3) grant to begin developing the framework for an integrated municipal NPDES permit and a stakeholder outreach and education program. The intent of the outreach program was to build stakeholder support and understanding of CWS's integrated water resources management approach. CWS viewed the outreach as critical, especially because the Tualatin basin is home to a number of organisms that are listed as species of concern under the Endangered Species Act (ESA).

OR DEQ revised and expanded the TMDL for the Tualatin River to include temperature and bacteria in August 2001. In February 2004, OR DEQ issued a single watershed-based, integrated municipal permit to CWS covering all four advanced wastewater treatment facilities, the two industrial storm water permits for the Rock Creek and Durham AWTFs, and the MS4 for the urbanized areas of Washington County. OR DEQ included a unique feature in the permit. It included provisions for CWS to engage in water quality credit trading involving temperature (thermal load), biochemical oxygen demand (BOD), and ammonia.

OR DEQ noted in the permit fact sheet that the single watershed-based, integrated municipal permit does not reduce any of the requirements that had previously been contained in the separate permits. Instead, it provides a number of advantages and efficiencies for both the OR DEQ and CWS, including:

- ◆ Enhanced opportunities for environmental results
- ◆ Targeted and maximized use of resources to achieve greatest environmental results
- ◆ Administrative efficiencies
- ◆ Opportunities for more effective watershed-wide monitoring programs
- ◆ Opportunities for water quality trading programs

- ◆ Achieving water quality goals in a more cost-effective and efficient manner.

In addition, an Intergovernmental Cooperative Agreement was drafted between CWS and the OR DEQ in order to “provide for the continuation of the development and implementation of a watershed based regulatory framework in the Tualatin River watershed.” The agreement outlines pending issues and commits the parties to continue to work on them.

## Permit Highlights

The TMDL temperature standard states that no measurable increase in water temperature is allowed from dischargers. (See highlight box below for further details.) Using methods outlined in the TMDL, the permit (Provision 10 of Schedule D) includes the thermal load each of CWS’s two AWWTFs must offset. The loads specified are as follows:  $2.0 \times 10^8$  kcal/day (Durham AWWTF) and  $7.2 \times 10^8$  kcal/day (Rock Creek AWWTF). The permit authorizes CWS to implement mitigation measures from its Temperature Management Plan (TMP) and engage in riparian shade trading (i.e., planting vegetation to shade stream) to meet these offsets. The offset period is May 1–October 31 each year; however, the critical period for the offsets is July–August. The flow CWS releases during this latter time period defines the shade goals CWS must meet during the offset season (May 1–October 31). The permit states that if CWS achieves the thermal load offset goals for July–August (the critical period), OR DEQ will deem CWS to be in compliance with its thermal load requirements for the entire season (May 1–October 31).

## Temperature Management Plan (TMP)

CWS submitted a revised Temperature Management Plan to OR DEQ on February 25, 2005. In the plan, CWS proposes three methods for reducing stream temperatures. These include wastewater reuse, flow augmentation, and the creation of stream shade. CWS is currently developing a Reclaimed Water Master Plan, which will address future reuse needs and opportunities for expansion.

Augmenting flow and increasing stream shading will allow CWS to obtain tradable thermal load credits. CWS notes in its TMP that augmenting flow and providing stream shading will eliminate the need for the organization to employ more burdensome alternatives, such as the installation of refrigeration equipment at its wastewater treatment facilities or piping treatment facility effluent to another river basin. CWS estimated that it would cost the organization \$60–\$150 million to install the necessary refrigeration equipment at both AWWTFs, and the electricity necessary would increase air pollution and contribute to global warming. CWS further estimated that its yearly costs to operate the refrigeration equipment or pipe treated effluent to another river basin would be between \$2.5 and \$6 million.

### **Tualatin TMDL Temperature Standard (2001)**

The applicable temperature standard for the Tualatin River and tributaries, set to protect salmonid fish rearing, is “no measurable surface water temperature increase resulting from anthropogenic activities.” The treatment facilities wasteload allocations are based on achieving “no measurable increase” in stream temperature at the edge of the mixing zones. OR DEQ defines a measurable increase as greater than a 0.25 degrees Fahrenheit (°F) increase at the edge of the mixing zone using the applicable stream temperature standard. Additionally, the discharges may not cause the receiving water within the mixing zone to exceed 77 °F at any time. Temperatures above 77 °F are considered acutely harmful to salmonids. Based on this standard, the CWS wastewater treatment plants were given wasteload allocations that are less than 10% of their current heat load. The magnitude of the difference between their current heat load and the waste load allocation in the TMDL report provides significant impetus for trading. This allocation, modified as allowed by the TMDL document has been included in the watershed-based permit as a thermal load to be offset ([www.deq.state.or.us/WQ/tmdls/docs/willamettebasin/tualatin/tmdlwqmp.pdf](http://www.deq.state.or.us/WQ/tmdls/docs/willamettebasin/tualatin/tmdlwqmp.pdf)). The integrated permit also requires CWS to develop a Temperature Management Plan. The plan is to indicate how CWS will address temperature concerns at its wastewater treatment facilities.

## Riparian Shading Trading

According to the TMP, solar radiation (sunlight) accounts for about 40 percent of the thermal energy input to the Tualatin River during the summer months. Since sunlight is easily blocked by vegetation, CWS argued in its TMP that if the watershed’s streams were better shaded, total thermal energy inputs would be smaller and the streams would be cooler.

The number of thermal credits that CWS is required to achieve via stream shading is based on the amount of thermal reductions CWS could achieve via other means (e.g., with refrigeration equipment). OR DEQ has limited the duration of each credit to 20 years, which is approximately equal to the useful life of mechanical refrigeration equipment. The magnitude of each credit will depend on the amount of shaded stream surface that CWS is able to achieve. The amount of energy that is blocked by shade along a particular stream is a function of stream width, tree height, and vegetation density.

CWS took all of these factors for determining shade credit into consideration when developing its TMP. To account for the fact that shade can take a significant amount of time to establish, CWS proposed that a trading ratio of 0.5 be applied when determining the shade credit associated with a particular project. Using this trading ratio means that, in

20 years, CWS will have offset twice as much heat through shading as the excess thermal load its treatment plants add to the Tualatin. This reduction is significantly larger than what would be accomplished using other methods, such as refrigeration equipment. In other words, OR DEQ is allowing CWS to not entirely offset its excess heat load within 5 years, in exchange for the fact that over 20 years it will offset twice its excess heat load.

Vegetation planted during a single permit term (5 years) will not by itself be of a sufficient height or maturity to offset CWS's excess thermal load. The integrated watershed-based permit allows CWS to undertake other activities to offset its thermal load. In order to determine CWS's energy inputs and credits from thermal load offset activities, the TMP includes a process for developing a thermal energy budget. The procedures to create the thermal energy budget, which accounts for all thermal inputs to the river from CWS activities, and how to determine the thermal credits generated via flow augmentation and riparian restoration/protection projects are detailed in Appendix B of the TMP.

The thermal energy budget submitted in Appendix B estimates that CWS's annual thermal load after flow augmentation is about 330 million kcal/day. To offset this load, about 35 miles of riparian restoration/protection is required over the five-year permit period. This is the Shade Credit Goal.

The integrated permit requires CWS to annually calculate and report a thermal energy budget (using flow augmentation, shade credits, and other OR DEQ projects) to the state. The permit also requires CWS to annually report on its progress toward achieving the thermal offset requirements. OR DEQ will use the thermal load budget calculated in the fifth year of the permit term to determine CWS's compliance with the permit's temperature requirements. If flow augmentation, the cumulative total of shade created, and all other DEQ-approved temperature management measures combine to offset the excess thermal load, CWS will have met its permitted temperature requirements. Prior to the five-year mark, OR DEQ will determine CWS compliance on the basis of the milestones CWS achieves in its approved TMP.

To remain consistent with the basic principles of trading, credits for creating shade will be generated only for those activities that go beyond regulatory requirements, such as the Forest Practices Act, local water quality management rules developed by the Oregon Department of Agriculture (also known as SB 1010), and CWS's own Design and Construction Standards. Therefore, re-vegetation projects implemented for creating shade credits will need to exceed the minimum requirements established in these regulations.

CWS will develop and implement "shade programs" aimed at increasing riparian shade. Programs intended primarily for use on private lands will be incentive based. Most projects on public lands will be conducted under CWS's Urban

Stream Enhancement Program. CWS will rely on various stream restoration partners—the U.S. Department of Agriculture (USDA), Oregon Department of Forestry (ODF), and Soil and Water Conservation Districts (SWCDs)—in order to meet the temperature requirements in its permit. CWS will set up the planting programs, help with the funding, and make sure that its partners perform in accordance with individual project contract requirements. The TMP includes a detailed "shade implementation plan," which describes how planting, maintenance, and monitoring will be accomplished for each project undertaken.

CWS will calculate shade credit for each project using a computer model developed by OR DEQ. To run the model, site-specific data must first be collected, including the size of the site, width of the stream, orientation of the site to the sun, and the estimated canopy height and density 20 years after planting. The model uses these data to determine the effective shade produced by the project. "Effective shade" is a measure of the amount of sunlight blocked by shade. The blocked sunlight is then converted to kilocalories per square foot of stream surface.

More information on the Clean Water Services and water quality trading in Oregon may be found at:

[www.deq.state.or.us/WQ/trading/faqs.htm](http://www.deq.state.or.us/WQ/trading/faqs.htm)

## Permit Components

### Effluent Limits

Schedule A of the CWS watershed-based permit contains all effluent limitations for the facilities covered under the permit for the following parameters: carbonaceous biochemical oxygen demand (CBOD), pH, total suspended solids (TSS), bacteria, residual chlorine, temperature, ammonia, and phosphorus. The outfall-specific limits are based on the approved TMDLs for the Tualatin River basin, technology-based effluent limitations (TBELs), the maximum extent practicable (MEP) standard for the MS4 covered, and pollutant benchmarks for industrial storm water discharged under the permit. Schedule A also contains a methodology for CWS to use for trading oxygen-demanding parameters (CBOD and ammonia) between the Durham and Rock Creek advanced wastewater treatment facilities. OR DEQ based the methodology on a combined Rock Creek and Durham oxygen demand load limitation expressed at Oswego Dam.

The effluent temperature limitations, the temperature monitoring requirements (in Schedule B), CWS's Temperature Management Plan (TMP), including a Thermal Load Credit Trading Plan (TLCTP), (in Schedule C), and the thermal load to offset and water quality trading provisions (in Schedule D) constitute the primary elements of the approved surface

water TMP. The permittee is deemed to be in compliance with in-stream water quality standards and is not deemed to be causing or contributing to a violation of the Tualatin Basin temperature TMDL or water quality standards for temperature if the permittee is in compliance with this approved surface water temperature management plan.

### Monitoring and Reporting Requirements

Schedule B of the permit includes a requirement for CWS to develop a watershed monitoring plan. The plan is to be designed as “a comprehensive and integrated approach to watershed assessment, to address CWS’s long-term progress towards achieving the goals of the Clean Water Act and, where appropriate, the Endangered Species Act.” CWS is responsible for all end-of-pipe monitoring activities covering the wastewater treatment facilities, the MS4, and industrial storm water facilities. CWS is also responsible for evaluating and assessing the MS4 stormwater management plan (SWMP). Schedule B also includes a schedule and description of the various reports and deadlines for all facilities covered under the watershed-based permit.

### Special Conditions

The permit contains special conditions under Schedules C and D. Schedule C contains compliance conditions and schedules, while Schedule D contains trading and other special conditions.

### Compliance Conditions and Schedules

This section includes the requirements for the MS4 SWMP, facility-specific stormwater pollution control plans (SWP-CPs), and the required components of the TMP and the Thermal Load Credit Trading Plan.

Schedule C.1 outlines the elements required in the TMP. The TMP is to describe and explain how CWS will manage and implement measures to offset the thermal load from its various wastewater treatment facilities to the Tualatin River. The required elements of the TMP include the following:

- (1) A description of the cooling benefits of flow augmentation.
- (2) A description of CWS’s long range plans for increasing in-stream water supply within the watershed.
- (3) An explanation of how an increase in stream shade that will result from riparian revegetation will offset thermal load discharges from CWS’s facilities.
- (4) A description of how CWS will protect and use stream shade in existing high quality riparian areas to offset thermal load discharges from its facilities.
- (5) An explanation of how and when CWS will accomplish stream surface area shading via riparian revegetation. OR DEQ will use this information to form the basis for

compliance with the permit during the time it takes for shade to become established.

- (6) A methodology for prioritizing areas throughout the Tualatin Basin where riparian revegetation/protection could take place in order to maximize the benefits of the proposed projects for the protection of the most sensitive beneficial uses. OR DEQ notes that the *receipt of credit for riparian re-vegetation/protection will not be affected by whether these actions occur in priority areas.*
- (7) CWS’s criteria for plant selection and a copy of the plant list. The plants on the list must be appropriate given the native plant communities found in the Tualatin Basin.
- (8) CWS’s approach for working with potential growers and contractors involved in riparian restoration so that adequate plant materials will be available and that contractors will have adequate time to mobilize resources.
- (9) A description of the kinds of approaches CWS will use to reach the target increase in stream shade.
- (10) A copy of CWS’s planting plan. The plan should include expected plant survival rates and justification for planting densities, and should reflect natural succession.
- (11) A monitoring plan to assess plant survival.
- (12) A monitoring plan to assess the amount of shade that is created.
- (13) A maintenance plan that will promote plant survival and reduce the impact of invasive species.

Schedule C.2. of the permit outlines the requirements of the TLCTP, which are to be included in the TMP. The TLCTP is to describe the mechanisms through which CWS will use water quality trading to offset the thermal loads from the treatment facilities. In particular, this plan is to include details of how CWS will create thermal credits through river flow augmentation and stream surface shading and include the methodologies CWS will use for calculating these credits. The elements to be included in the TLCTP include the following:

- (1) A description of the thermal load to be offset based on Schedule D.10 of the permit. Any reuse of reclaimed water will directly reduce the thermal load discharged by the facilities. The TLCTP will specify a baseline for thermal credit trading.
- (2) A discussion of how CWS will create, purchase, or otherwise arrange for thermal credits generated by the following types of actions, activities, and projects:



- (a) Thermal loadings relative to applicable baselines
- (b) Flow augmentation resulting from CWS's voluntary purchase and release of stored water to the Tualatin Basin
- (c) Stream surface area shading.
- (3) The methodology for calculating the amount of thermal credits generated by flow augmentation that can be applied to offset the thermal load.
- (4) The methodology for calculating the amount of thermal credit that will be generated by stream surface water shading through riparian re-vegetation and high quality area protection that can be applied to offset the thermal load.
- (5) Other thermal credit trading options proposed by CWS for consideration by OR DEQ, along with a technical justification for how much thermal credit should be granted for such actions.
- (6) Reporting requirements for thermal load trading credits.

**Trading and other special conditions**

Schedule D outlines all of the additional special conditions included in the watershed-based permit. Provision 7 describes the fundamental requirements of any water quality trading plans implemented under the watershed-based permit, such as:

- ◆ General authority.
- ◆ Authorized parameters for trading (oxygen demanding parameters such as CBOD5 and ammonia-nitrogen, temperature, and other parameters approved by OR DEQ)
- ◆ Trading baselines for both authorized parameters (temperature and oxygen-demanding materials)
- ◆ Definition of a *water quality credit* and how to apply credits for compliance purposes
- ◆ Requirements for Thermal Credit Trading Agreements between CWS and a conservation entity (defined as a “reputable land or water conservation organization or governmental entity”) charged with implementing a component of the TMP to include:
  - ◆ A commitment by the Conservation Entity to fully implement the Trading Agreement in accordance with its terms, including terms for initial planting and long-term maintenance, monitoring, and reporting

- ◆ A provision that the Credit Trading Agreement is enforceable by CWS and the OR DEQ and any successor agency. A breach of the Credit Trading Agreement by the Conservation Entity is not deemed a violation of the permit by CWS. In the event of a breach, CWS will be required to update its Clean Water Services Temperature Management Plan to demonstrate it still will be able to offset the thermal load.

- ◆ Conditions of compliance and enforcement provisions.
- ◆ Reporting and evaluation requirements.

**Permit Effectiveness  
Environmental Benefits**

The TMP establishes benchmarks against which CWS will demonstrate its progress toward meeting the Shade Credit Goal. Each benchmark will apply to the collective group of shade programs, rather than individually. This approach will allow CWS to meet the benchmark using whatever combination of shade programs is optimal. The TMP describes a benchmark as the annual increase in the percentage of the average excess thermal load that is offset by shade after accounting for flow augmentation and any other OR DEQ-approved temperature management measure. OR DEQ will evaluate CWS's progress toward achieving the benchmarks annually. Benchmarks are a means of measuring progress but are not requirements.

In the event the shade credit created in any year is less than 50 percent of the benchmark for that year, CWS must prepare and submit to OR DEQ a written memorandum that contains a list of measures that will be undertaken to meet benchmarks in subsequent years.

As of March 2006, CWS has met Year Two's goals by having planted more than 9.5 miles of streams. CWS has a contract in place with the Natural Resource Conservation Service (NRCS) to register landowners for incentive programs developed by CWS. According to project contact, Charles Logue, the permit, with its provision for water quality trading, has significantly increased the pace and quantity of riparian area restoration in the Tualatin Basin. The additional miles of stream planted will result in the prevention of 101 million/Kcal/day from reaching the Tualatin River tributaries that would otherwise result in additional increases in water temperature. Also, CWS has adjusted the release of stored water to develop temperature credits in the July-August time frame while continuing to release stored water in the fall to ensure assimilative capacity for oxygen demand in that time period.

Mr. Logue believes that the integration of the stormwater permits into the watershed-based wastewater discharge permit, has increased the public's awareness of stormwater

related impacts and activities on the overall water quality in the basin.

No trades of oxygen-demanding parameters have occurred to date. CWS's Operations staff is continuing to evaluate operating scenarios that would take advantage of this element of the permit. CWS currently is updating its Facilities Plan. A key element of this update is to make use of a "systems" approach to future operations of the CWS facilities to take full advantage of the water quality trading elements for biochemical oxygen demand and ammonia to optimize the wastewater treatment facilities.

### Benefits to the Permittee

CWS' Mr. Logue believes that one of the primary benefits of the watershed-based permit is that it has allowed CWS to spend resources where the greatest environmental benefit is realized. CWS has restored riparian areas and improved channel morphology, through utilizing "sanitary user fees" in areas outside the service boundaries, through the nexus created in an integrated watershed-based permit. The new watershed-based permit extends the purview of CWS to stormwater discharges that occur outside of the service area but that are within the urban growth boundary of Washington County. Also, the integrated permit has enabled CWS to redirect capital funds from traditional concrete and steel engineered solutions to more natural solutions (stream plantings), which provide significantly greater environmental benefit without increasing the sewer or stormwater user fee rate structure. By applying the capital savings from averting a construction-based solution to thermal load reduction, CWS has directed its capital funding towards stream restoration projects, which results in far greater benefits to the basic ecosystem services of the basin.

Since issuance of the integrated permit, CWS has reorganized to centralize its various regulatory affairs related activities into one department. According to the CWS contact, Mr. Logue, this action was a direct result of the integrated, watershed-based approach and heightened awareness of watershed issues within the District. The single watershed-based permit has also streamlined CWS's annual reporting requirements, thereby saving staff time and resources.

The success of the CWS water quality trading program has led to the formation of other watershed based approaches in Oregon. For example, the Willamette Partnership, a coalition of conservation, city, county, business, farm, and scientific leaders formed to protect the Willamette Basin. The goal of the Willamette Partnership is to accelerate and expand restoration of the Willamette River Basin through water quality and conservation trading. EPA is helping fund this effort with a matching grant of nearly \$800,000. By using conservation credits as a form of environmental currency, the Willamette Partnership intends to create an Ecosystem Marketplace that will focus public and private ecological investments across

the entire Willamette River Basin to improve water quality, restore fish and wildlife habitat, and protect endangered species ([www.willamettepartnership.org](http://www.willamettepartnership.org)).

### Benefits to the Permitting Authority

Sonja Biorn-Hansen, OR DEQ Environmental Engineer, stated that this permitting effort "was truly about achieving environmental gain instead of just dotting I's and crossing T's." Issuing the watershed-based permit to CWS was very time and resource intensive for the permitting authority, however. The permit writer, Lyle Christensen, believes that

After the permit with Clean Water Services was negotiated, Oregon DEQ used the experience gained to develop an Internal Management Directive to guide future trading efforts in the state. This document may be found at: [www.deq.state.or.us/wq/pubs/imds/wqtrading.pdf](http://www.deq.state.or.us/wq/pubs/imds/wqtrading.pdf)

future iterations will be much easier to issue in a timely manner and that working with one permit, rather than multiple permits, will save time and resources as well.

### Lessons Learned

The project contact, Mr. Charles Logue, was asked a number of questions to ascertain "lessons learned" from the CWS's watershed-based permitting project. The questions asked and Mr. Logue's responses to them are reported below.

- What has been the most challenging part of the project?

*The most challenging part of the project has been the lack of other similar work to build upon. At the same time, this has been the greatest asset of the project in that the development was not impeded or restricted by work precedents done elsewhere. CWS continues to advocate this approach across the country so as to gain from others' experience. An issue that continues is the development of the permitting accounting and tracking systems which were not designed to accommodate integrated NPDES permits. While issued as a "single" permit, the permit numbers are still administratively being tracked individually in the OR DEQ system. An additional problematic issue is the traditional enforcement response matrix accounting mechanism for permit violations. Many potential candidates for an integrated permit are concerned with the potential for accelerated movement through a regulatory agency enforcement response matrix with multiple facilities/outfalls covered under a single permit. In the CWS case, the individual facilities are still treated as individual discharges from an enforcement response perspective.*

Another challenge is combining the different individual permit approaches, language, requirements, reporting elements and schedules into a more comprehensive single format. In the CWS permit, there was not time to fully develop true “integrated” permit language and schedules. This is the major work to be accomplished in the renewal process.

- What could have been done differently to resolve the challenges more easily?

*I am not sure that the process could have moved any faster. For an innovative permitting action, the process went very fast. Both the state and federal agencies were highly supportive and willing to make this happen.*

- Would this approach be applicable to other watersheds? What characteristics would define other candidate watersheds?

*Absolutely, this approach is applicable to other watersheds. There are numerous other instances where one jurisdiction or utility with multiple facilities are the major dischargers to a stream or river segment. These are the obvious candidates for an integrated permit.*

- If the approach were to be applied in another area, what changes should be made?

*I am not sure that there need to be any changes, if the same situation occurs elsewhere. If you have the same level of system understanding, same degree of data available, same willingness by the parties, the approach should work anywhere.*

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## Resources

**Clean Water Services.** 2005. *Revised Temperature Management Plan*. February 18, 2005.  
[www.deq.state.or.us/wq/wqpermit/cwspermit.htm](http://www.deq.state.or.us/wq/wqpermit/cwspermit.htm)

**Oregon Department of Environmental Quality.** Clean Water Services NPDES Watershed-based Discharge Permit (ORS108014) Evaluation Report and Fact Sheet. Modified on July 27, 2005.  
[www.deq.state.or.us/wq/wqpermit/cwspermit.htm](http://www.deq.state.or.us/wq/wqpermit/cwspermit.htm)

**Oregon Department of Environmental Quality.** 2005. *Water Quality Trading Internal Management Directive*. January 13, 2005.  
[www.deq.state.or.us/wq/pubs/imds/wqtrading.pdf](http://www.deq.state.or.us/wq/pubs/imds/wqtrading.pdf)

**Oregon Department of Environmental Quality.** “Water Quality Credit Trading in Oregon: A Case Study Report”. Report submitted to USEPA Region 10 documenting results of the OPEI grant project entitled: Effluent Trading in Oregon - #CP-970211-01.  
[www.deq.state.or.us/wq/trading/docs/wqtradingcasestudy.pdf](http://www.deq.state.or.us/wq/trading/docs/wqtradingcasestudy.pdf)

*Note: All Web references current as of July 6, 2007.*



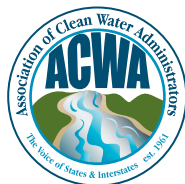
# Building a Water Quality Trading Program: Options and Considerations

Version 1.0 | June 2015: Point-Nonpoint Trades

A Product of the National Network on Water Quality Trading



The logos represent groups and organizations serving as National Network participants with the USDA as a technical advisor.



DISCLAIMER: The contributors to the National Network engaged in an extensive dialogue to develop the publication, *Building a Water Quality Trading Program: Options and Considerations*, and believe that it represents a comprehensive, contextual, balanced, and robust collection of information on different, representative water quality trading programs. New and evolving water quality trading programs should look to this document as an important source of information as they build and update their trading programs.

This document does not represent a consensus opinion, endorsement, or particular recommendation from any one National Network contributor. It seeks to cover the broad range of topics related to water quality trading to assist local stakeholders to develop and implement trading frameworks that meet local needs and conditions. This document does not create any binding requirements or standards of practice. Ultimately, local stakeholders, state regulators, and/or U.S. EPA will clarify those requirements that apply to any particular trading programs or trading program participants.



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## WEBSITE AVAILABILITY

All information contained in this document is available at [www.wri.org/nn-wqt](http://www.wri.org/nn-wqt).

Information on the National Network is available at [www.willamettepartnership.org/nn-wqt](http://www.willamettepartnership.org/nn-wqt).

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Cover photos courtesy of (in order from left to right) USDA, Willamette Partnership, US Army Corps of Engineers, Creative Commons, and Chesapeake Bay Program.

# **APPENDIX D: SEPTIC SYSTEM RETROFIT INFORMATION**

- **Septic Upgrade Incentive Program – Factsheet, Florida Department of Environmental Protection**
- **Septic System Retrofit for Advanced Nitrogen Reduction – Product Information**



Florida Department of Environmental Protection  
Division of Water Restoration Assistance  
**SEPTIC UPGRADE INCENTIVE PROGRAM**

**PROGRAM OVERVIEW**

The Department of Environmental Protection (Department) created this Septic Upgrade Incentive Program (Program) to encourage homeowners to voluntarily remediate existing conventional Onsite Sewage Treatment and Disposal Systems (OSTDS) to include nitrogen reducing enhancements.

The Program offers subsidies, only in designated areas within a county – identified and delineated by the Department as Priority Focus Areas (PFAs), in amounts up to \$10,000 per system. The subsidies are available for payment directly to septic system installers and licensed plumbers retained by homeowners to update existing conventional systems, and must be pre-approved by the Department prior to the commencement of work.

Septic system installers and licensed plumbers may apply to participate in and receive reimbursement for eligible upgrades under the Program by completing and submitting this Application (including all required attachments), registering as a vendor with the state at <https://vendor.myfloridamarketplace.com/>, and completing a Florida Substitute W-9 at <https://flvendor.myfloridacfo.com/>.

An application must be submitted to the Department, either electronically to [SepticProgram@FloridaDEP.gov](mailto:SepticProgram@FloridaDEP.gov) or by mail to the Department of Environmental Protection, Division of Water Restoration Assistance, Water and Springs Restoration Program, 3900 Commonwealth Boulevard, MS 3602, Tallahassee, Florida 32399.

Vendors may also contact program staff regarding this Program at 1-866-601-6910. Please see [FloridaDEP.gov/SepticUpgrade](http://FloridaDEP.gov/SepticUpgrade) for more information.

The Program is contingent upon appropriation by the Legislature and, if required, an authorized release of the funds by the Legislative Budget Commission. In the event of a state revenue shortfall, funding for the Program may be reduced. The Department, in accordance with direction from the Governor and/or Legislature, shall make the final determination of the availability of funds to continue subsidies under the Program.

**PROGRAM QUESTIONS & ANSWERS**

**Who is eligible for this Program?**

Contractors who are licensed or registered to install OSTDS.

**Are there specific areas of the state that are covered by the Program?**

Yes. Work must be done within the Priority Focus Area <https://floridadep.gov/PFAmap> in any of the following counties: Citrus, Hernando, Leon, Marion, Orange, Pasco, Seminole, Volusia and Wakulla.

**What OSTDS is eligible under this Program?**

Funds are only available for installations of nitrogen reducing OSTDS enhancements in an eligible single or multi-family residence with an existing conventional (non-nitrogen-reducing) system (Work). A list of the eligible features achieving enhanced treatment of nitrogen is available on the Department of Health (DOH) website <http://www.floridahealth.gov/environmental-health/onsite-sewage/index.html>.

Work must be permitted by, and receive final installation approval from, the DOH.

No work performed prior to issuance of a purchase order (PO) (see How does a contractor apply for this Program, below) will be eligible for reimbursement.

**How does a contractor apply for this Program?**

A contractor must:

- Complete an Application and provide required attachments, including a signed copy of the Disclaimers and Waiver for Homeowner Form and required registrations.
- Applications that are not approved within 30 days shall be deemed rejected.
- Approved Applicants will receive a purchase order for Work issued through MyFlorida Marketplace within 30 days of submitting a complete Application.
- No Work prior to issuance of a PO will be eligible for reimbursement.

**Is there a timeframe by which work must be completed?**

Yes. Work shall be completed within 30 days of the Application's estimated date of installation, unless delayed by weather, logistical or material shortage.

**How does a contractor get reimbursed through this Program?**

Within 30 days of completing the installation, the contractor must submit a reimbursement request. Work expenditures must be supported by accurate, legible and verifiable documentation.

Payment requests must include the following:

- A copy of the invoice to the homeowner showing the address of the residence, identifying the equipment, materials and labor performed, and the homeowner's share of the cost (reflecting the reduction of the incentive amount requested);
- A photograph representative of the installation prior to the inspection by the county health department;
- A copy of the inspection report issued by the county health department showing satisfactory completion of the Work;
- A reference to the PO number;
- Explanation for delay in installation, if any; and
- Any other documentation requested by Department to substantiate performance.

The Department will not process the invoice until all documentation required above is received and approved.

**How much funding is available?**

Subject to acceptance in the Program, funds are available on a first come, first served basis, until funds are exhausted. Reimbursement is limited to \$10,000 per residence.

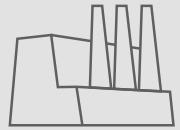




# SludgeHammer®

nature called. we answered.

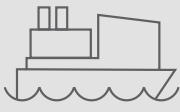
Model S-400/600  
Tested to  
NSF/ANSI Standard #40



commercial  
& industrial



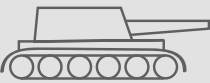
communities



marine



residential



military

231.348.5866  
SludgeHammer.net

The latest  
advance in  
wastewater  
treatment

Our biotechnology revolutionized the industry, providing a highly effective, all natural, non-toxic wastewater solution.

Now the second generation aerobic bacterial generator is here, the SludgeHammer®. Tried, tested, and reengineered for commercial and industrial applications. (More power for residential use, too)





# SludgeHammer®

nature called. we answered.

SludgeHammer® Group Ltd.  
336 S. Division Rd.  
Petoskey, MI 49770

Ph: 1.231.348.5866  
Fax: 1.720.834.3102  
www.SludgeHammer.net



## SludgeHammer® Specifications

The SludgeHammer® represents the first significant advance in Aerobic Bacterial Generator biotechnology since we presented our original technology over five years ago. During that period, this technology has been installed in thousands of units. Drawing on this extensive experience coupled with an active R&D program directed by the originator of the ABG concept, Dr. Daniel Wickham, we have dramatically improved on the original with the SludgeHammer®.

the results are clear



The SludgeHammer® continues to meet UPC code and the IAPMO IGC 180-2003 standard for Aerobic Bacterial Generators.

SludgeHammer® Group Ltd. provides design consultation and engineering for industrial applications and community scale systems.

Visit [www.SludgeHammer.net](http://www.SludgeHammer.net) for information on availability in your area as well as for dealership opportunities.

### specifications

Dimensions:  
Column diameter at top: 12"  
Column diameter at base: 15"  
Total height: 36"

Electrical Service\*: 110 V, 60 hz. - 15 amp.  
Power draw: 60 watts ~ 1 amp  
Air delivery rate: 3.5 CFM @ 2.0 psi  
Liquid mixing rate: 30,000 gpd @ 4 foot depth  
Fixed film utilization factor: 350 gal./ft2/day  
Organic digestion rate: 3-6 lb/BOD/day

Minimum depth of tank: 40 inches >w/60 watt pump  
Maximum depth of tank: 60 inches >w/60 watt pump  
Single chamber tanks: Minimum 800 gal.  
Maximum 2,500 gal.

Multi-family or commercial installations:

Domestic headworks strength:

High strength loads:

\*These are U.S. Standards. SludgeHammer Group, Ltd. can adapt to the electrical requirements/standards of any country in the world.



**S-86 unit**  
Recommended for larger residences and commercial applications



**S-46 unit**  
Recommended for single-family residences up to 4 bedrooms.

110 V, 60 hz. - 15 amp.  
60 watts ~ 1 amp  
3.5 CFM @ 2.0 psi  
22,600 gpd @ 4 foot depth  
240 gal/ft2/day  
1.5-3.0 lb/BOD/day

40 inches >w/60 watt pump  
60 inches >w/60 watt pump  
Minimum 500 gal.  
Maximum 1,500 gal.

S-86 Sludgehammers® can be installed in multiples with supplemental air diffusers.

5-10 lb/BOD/day for single S-86 with supplemental air.

Contact your local dealer for design details.

dealer info

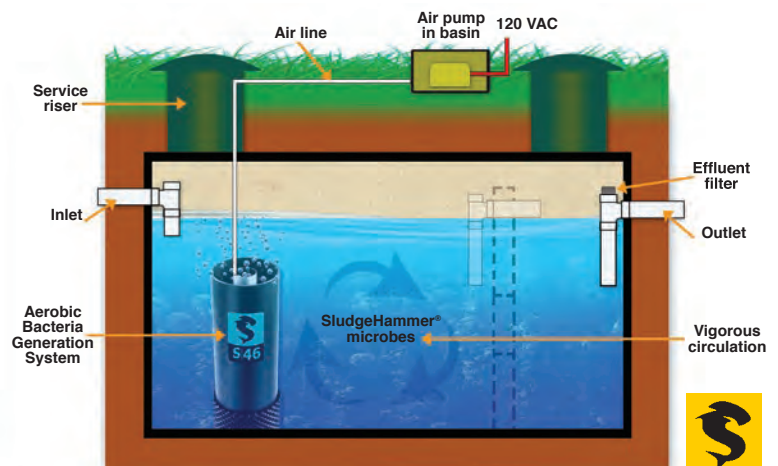


Model S-400/600  
Tested to  
NSF/ANSI Standard #40

IMO - MARPOL  
MEPC-159 (55)  
International



IAPMO STANDARD  
IGC 180-2003



# The SludgeHammer Breathes New Life Into Septic Systems Technology

## THE SLUDGEHAMMER PUTS NATURE TO WORK

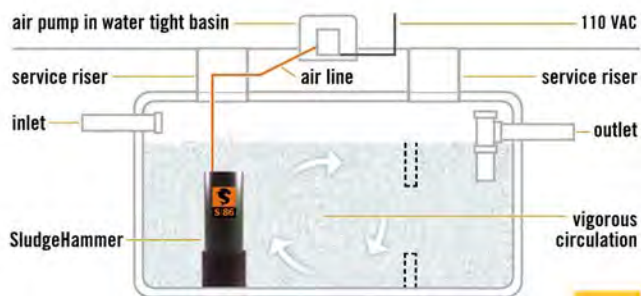
After installing the SludgeHammer into any single volume tank, or either chamber of a two compartment septic tank, the SludgeHammer Blend of powerful biological agents immediately begins processing wastes (including nitrates) within the tank and continues its work throughout the leach field system.

The SludgeHammer aerates, circulates and inoculates the entire contents of a septic chamber at the rate of over 25,000 gallons a day.

Within the SludgeHammer, circulating septic tank liquids pass over 150 ft<sup>2</sup> of surface in which a dense colony of SludgeHammer Blend bacteria attach and thrive.

As the septic liquid passes over the bacteria, organic wastes are rapidly digested. In single volume tanks, cesspools and inlet chambers of septic tanks, this digestion is so complete that regular pumping is significantly reduced.

## SludgeHammer Keeps All Systems Clean Naturally



Bacteria in the SludgeHammer Blend are so aggressive ("the SludgeHammer Effect") they starve out the resident slime-producing, anaerobic bacteria that produce "biomat" clogging. Leach fields are quickly opened up, further increasing the efficiency of the entire system.

The EPA estimates that 95% of septic system failures (over 1 million per year) are caused by "biomat" clogging, which simply cannot reoccur where the SludgeHammer is in operation.

The nitrification phase of treated effluent is virtually eliminated, resulting in **direct denitrification!**



## GO FROM SLUDGE TO CLEAR WATER WITH THE SLUDGEHAMMER!



## TIME PROVEN TECHNOLOGY

The two components of the system include the SludgeHammer Blend bacterial culture and the SludgeHammer device.

Experience with the use of these bacterial agents in wastewater treatment goes back over 15 years and includes extensive application in bioremediation of contaminated soil, manure ponds, and municipal treatment plants.

The SludgeHammer has been used in homes, and in commercial and industrial applications with a broad array of septic-based treatment systems, situated in a wide variety of site configurations and soil types across the country.

**Local Authorized Dealers:**





## Biological Questions and Answers

### **1. Why is SludgeHammer so unique? or How is it different from all the other similar units, ATU's in general?**

SludgeHammer is unique in several respects. First, the SludgeHammer is not an Air Treatment Unit (ATU). It is an Aerobic Bacteria Generator (ABG). It functions by efficiently converting organic matter in a septic tank into a rich colony of specific bacteria introduced and grown within the SludgeHammer unit. The species of bacteria in the SludgeHammer Blend™ have an aggressive appetite not only for the organic material within the tank, but also for the mucous coating that clogs the biomat that forms in a standard leach trench. Installation of a SludgeHammer System in septic tanks that are failing because of this type of clogging are quickly restored to full function as these bacteria digest the slime in the biomat.

These bacteria differ from those in a conventional ATU by being “facultative” organisms. This means that they can survive both aerobically (with oxygen) and anaerobically (without oxygen). Unlike the strict aerobes of an ATU, which die when they get into the anaerobic zone of a leach trench, the SludgeHammer bacteria survive while they move out into the aerobic zone of the soil where they continue to thrive.

The SludgeHammer device itself is unique by being an accessory rather than a system. A SludgeHammer converts any existing septic system to an advanced treatment unit capable of meeting most of the performance parameters associated with ATU's. It goes beyond ATU's, however, in the active behavior of the bacteria downstream of the device.

### **2. How does it deal with: Nitrate, Ammonia, and Pathogens?**

The SludgeHammer is completely different from typical ATU's in nitrogen dynamics. Even with high DO's (dissolved oxygen in the water) and extensive aeration, the ammonia in the tank cannot be converted to nitrate because the SludgeHammer Blend™ keeps nitrifying bacteria from the system through competitive exclusion. All nitrogen stays in ammonia form until it reaches the soil surrounding the leach field. There, a unique and unprecedented reaction occurs which results in an almost complete denitrification of the effluent as it passes through the SludgeHammer soil biomat. Concentrations of ammonia, nitrite and



nitrate all are typically less than 1 mg/L after passage through just 6-12" of the SludgeHammer biomat in the soil.

Pathogen removal is amplified by virtue of a two-stage biomat in a SludgeHammer system. The first is the dense 150 sq.ft. biomat existing as a fixed film within the SludgeHammer device itself. The contents of a septic tank are passed through this highly aerobic biomat as many as 20-30 times a day before the effluent leaves the tank. Experiments have shown a 2-log reduction in fecal coliform levels in the septic tank, even where no trash tank exists in front of the SludgeHammer to settle pathogens, as is the case with NSF-40 approved ATU's.

The second biomat is the facultative bacterial community that settles the soil of the leach system. Testing at the Buzzard's Bay ETV test site in Massachusetts has shown a SludgeHammer system has the same level of pathogen removal in the soil that a standard septic control tank with a typical clogging anaerobic biomat even when operated with 4 times the loading to the trenches. This despite the fact that the SludgeHammer Blend™ had restored soil porosity to the point where no ponding occurred in the trenches, as was the case with the control tank. The widespread notion that the clogging biomat in a standard leach trench is essential for pathogen removal is no longer valid.

### **3. What is the chemistry or methodology of the reactions that occur in a standard septic tank, ATU, and a SludgeHammer?**

The chemicals of most concern inherent in septic effluent are three compounds: ammonia, nitrate and phosphate. Ammonia and nitrate, relating to the SludgeHammer system, are discussed in section (2) above. With conventional ATUs, bio-filters, mounds or sand filters ammonia will be converted almost completely to nitrate. The removal of the nitrate then becomes a serious and problematic issue.

The phosphates become incorporated into the bodies of the SludgeHammer Blend™ bacteria. A portion of the SludgeHammer Blend™ bacteria become entrained in the effluent to the disposal area. When they die in the disposal area, the phosphates are released and bound up in the soil. This process removes a portion of the phosphate load in the tank. Phosphate is a mineral so it cannot be digested to a gas like nitrate can. However, phosphate is easily bound to the soil and is not an issue with on-site systems, except where failed leach lines allow effluent to reach the surface where phosphate can then wash into streams and lakes. The restoration of soil percolation is how the SludgeHammer prevents phosphate pollution.

Nitrogen dynamics are where the SludgeHammer differs most importantly from conventional septic treatment, or conventional aerobic treatment in ATU's, sand-filters, fiber filters, etc. A comparison of the systems is necessary to understand the SludgeHammer process:

- a. Anaerobic (without air) Septic System (standard septic tank and leach field);

Tank - Nitrogen stays in ammonia form;

Soil - Ammonia oxidized to nitrite (NO<sub>2</sub>) by Nitrosomonas species, Nitrite oxidized to nitrate (NO<sub>3</sub>) by Nitrobacter species;

Denitrification - Some denitrification will occur in the mixed aerobic-anaerobic biomat as the effluent passes through, however, typically no more than 10-30% is converted to nitrogen gas through denitrification.

b. Aerobic (with air) Treatment Unit (ATU, Sand Filter, etc.);

Tank - Over time spores of aerobic bacteria will enter the liquid with the air pumped into the tank. Ammonia in tank will kill most species except Nitrosomonas which use ammonia for energy. Nitrosomonas will grow and begin to oxidize ammonia to nitrite. Nitrobacter will then be able to survive and start converting nitrite to nitrate. When these combined bacteria have converted all ammonia to nitrate, other carbon consuming bacteria can begin to grow in the tank. It takes about 3-6 months to develop this type of colony in an ATU.

Soil - There is too little carbon left in the effluent for any denitrification to occur so virtually all nitrate is released. Nitrate migrates over long distances and causes health and environmental problems in ground water and receiving waters.

Denitrification - The only way any denitrification can occur in ATU's is by recirculating a portion of the treated effluent back to the anaerobic trash tank in front of the aeration chamber. This is very inefficient because you are completely treating the effluent all over again, several times where 2-3 recycles are necessary to get below the Federal 10 mg/L drinking water standard.

c. SludgeHammer

Tank - Bacillus species introduced in the SludgeHammer Blend™ culture prevent ammonia oxidizers or nitrifiers from surviving. Proteins and urea are converted only to ammonia, even though the system has high DO and aggressive aeration.

Soil - When SludgeHammers are installed in failed existing systems there will already be an established colony of Nitrosomonas and Nitrobacter in the soil. SludgeHammer effluent sends out the ammonia along with a dense colony of Bacillus. The Nitrosomonas do not compete with Bacillus so they will convert ammonia to nitrite. Bacillus does compete with Nitrobacter, because they want the oxygen that is now on the nitrite molecule. Our effluent contains so many more Bacillus that they overwhelm the Nitrobacter and that species dies out. In the process the Bacillus strips the oxygen from nitrite producing nitrogen gas that escapes harmlessly to the atmosphere.

Denitrification - The denitrification with the SludgeHammer typically occurs in the soil, without and almost total conversion to nitrogen gas within the first 3-6 inches of percolation through the new SludgeHammer enhanced biomat. Where desired, the denitrification can take place in the SludgeHammer tank itself. This is done by modifying the sequence of introduction of bacteria into the tank when the system is started. To date, the SludgeHammer is the only system in the world demonstrated to reduce nitrogen in a septic tank by over 95%.

**4. What is the difference between the clogging biomat and the biomat that our bacillus leaves?**

The clogging biomat, typical of conventional septic systems, is an anaerobic biomat composed primarily of a mucus slime. The intestinal bacteria that dominate the load to a septic tank need to produce this mucus to protect themselves in the intestinal tract. This mucus eventually fills the pore spaces between the soil particles, retarding the absorption of liquid into the soil. At some point the soil becomes so restricted that the system fails. The SludgeHammer Blend bacteria are facultative soil species capable of surviving anaerobically as they pass through the leach trench. When they colonize the aerobic zone of the soil they are "back home". These bacteria will actually consume the excess mucus removing the barrier that retards absorption of liquid into the soil.

**5. Is the bacillus biomat self-regulating or will it eventually clog the field or trench also?**

Within the SludgeHammer unit, the SludgeHammer Blend™ bacteria consume the basic organic load of the septic system. There is little organic material (food) in the effluent leaving the septic tank for the disposal area to maintain a clogging anaerobic biomat. The SludgeHammer Blend™ bacteria will also digest the mucus in the anaerobic biomat. If the amount of organic material (food) increases and decreases in the effluent to the disposal area, the aerobic biomat will increase and decrease in thickness with these changes in available food. Even with this change, the aerobic biomat will not clog the soil.

**6. How long do our microbes live anaerobically?**

The SludgeHammer Blend™ bacteria are able to survive periods up to 4 days in the absence of air. They can multiply under anaerobic conditions but are more vigorous with air. In anaerobic conditions where there is a significant amount of nitrate (or other oxygenated molecules) present, the SludgeHammer Blend™ bacteria will strip the nitrate of the ionized oxygen and use it aerobically. The reproductive capacity of the SludgeHammer Blend bacteria in this environment is very near that of fully aerobic conditions.

**7. What is the shelf life of our inoculants when in the envelopes?**

When properly stored as per the supplier's instruction, the SludgeHammer Blend™ bacteria stick should have a reasonable shelf life of up to 24 months. The SludgeHammer Blend™ bacteria sticks should be stored in a dark, cool, dry environment.

## **8. What is the tank life of our inoculants if food is present?**

The first SludgeHammer units were installed in the latter part of 2000. These systems were part of our R&D program. To date, unless we had toxic materials ( chemotherapy by-products , prolonged periods on strong antibiotics) introduced into the septic tanks, we have not had to re-inoculate these early systems. The SludgeHammer Blend™ bacteria should maintain a viable colony within the SludgeHammer unit indefinitely. We do, however, recommend replacing the SludgeHammer Blend™ bacteria stick on an annual basis to insure that the bacterial community stays healthy, and to encourage routine site inspection by a qualified installer.

This conservative approach is not costly and guarantees a vigorous SludgeHammer Blend bacteria community.

## **9. What do the enzymes that pumpers put into the tanks for clogged fields do? Positives and Negatives. How are we different?**

Enzymes are proteins produced by living cells that catalyze biochemical reactions. The enzymes that pumpers use are artificially produced and introduced in concentrations that will break down and dissolve (make soluble) the organic material in waste. The organic load is changed in form but not removed from the system by digestion. This includes the solids that are referred to as “scum” in septic tanks.

This may clean a tank of some organic material but the problem is passed down stream to the disposal area where it will hasten the failure of the disposal area. Standard septic tanks are designed to store organic material for future removal by pumping. Enzymes defeat this purpose. In commercial grease traps tied to municipal waste plants enzymes may help reduce the fat, oil and grease (FOG) load in grease traps, requiring less frequent and costly pumping, but the now soluble FOG will pass out of the grease trap and clog the sewer lines. If the grease trap is part of an onsite waste disposal system enzymes are guaranteed to dramatically shorten the life of the disposal area. The SludgeHammer is different because enzymes are being produced by living bacteria. Any food that is hydrolyzed by these enzymes is immediately consumed by the bacteria. In fact, these living bacteria pass with the effluent downstream to digest residual organic material that may have built up in the past.

## **10. At what temperature do the bacillus stop ramping up or become inert in the tanks?**

Temperatures of 40 degrees F and below will significantly reduce the biological activity of all bacteria. A properly functioning septic tank maintains an inside temperature ranging from 48 to 52 degrees in northern climates during the winter. Although the bacterial activity decreases in the winter it does not stop. The temperature of the input effluent and the activity of the bacteria in the tank



maintain functional temperatures.

**11. How do we know when the microbes have 'taken' in the tank?**

Within 24 hours of installing the SludgeHammer unit, with the SludgeHammer Blend bacteria stick properly placed within the SludgeHammer, there will be a dramatic reduction in odors commonly associated with septic tanks. The common odor that replaces the septic tank odor is one usually associated with wastewater plants. This odor is comprised of the various "musks" found in the many perfumed products we use in our modern daily lives. (soaps, deodorant, perfume and cologne, shampoo etc.) This "new" odor is very light and is normally not unpleasant. Very few residents notice this odor unless they open the septic tank. Within this time frame, there should be a measurable decrease in any scum layer if the SludgeHammer unit is placed in the inlet chamber of a septic tank. Should the SludgeHammer unit be placed in the outlet chamber of a septic tank, the effluent quality will be noticeably higher and the clarity of the effluent will be markedly improved. Additionally, there should be some evidence of bacteria colonization on parts of the piping and other accoutrements of the SludgeHammer unit.

**12. Drugs: which kind and how much will affect the function of the SludgeHammer? How long do we wait before we replace the inoculants?**

Any ongoing pharmaceutical drug treatment (10 days or more) by any occupant of a residence being served by the SludgeHammer System should be brought to the attention of the local SludgeHammer representative. This includes houseguests. Pharmaceuticals create toxic compounds after being utilized in the human body. They are typically excreted in the urine. When allowed to remain in sufficient concentrations within a septic tank, these compounds can kill the entire bacteria community. These compounds will seriously diminish the capacity of any bacteria community within the septic tank. We have found chemotherapeutic drugs, antibiotics and immune suppression drugs to be the most toxic. Combinations of many different pharmaceuticals can also be toxic. When confronted with this situation, the installer should discuss the problem with the occupants of the residence immediately. The names and purpose of the pharmaceuticals should be obtained. With this information we can develop a program to overcome the toxicity of the drugs. Some experimentation may be necessary but we have never failed to find a solution. The most important thing to remember, the longer the problem exists without correction, the time and costs to correct the problem typically increases. A point should be made at this time that the toxicity of these drugs affect every system. SludgeHammer enables early detection and correction.



December 22, 2002

## **Report on Fecal Coliform Reductions in SludgeHammer Test Installations**

SludgeHammer devices have been installed in septic tanks at two municipal waste water treatment plants (WWTP), one in Buzzard's Bay, Mass. and the other at the Comax-Squamish WWTP in British Columbia.

In both instances the septic tanks are loaded using the NSF protocol for testing. Raw influent into the WWTP is fed to the septic tanks at a rate of 330 gpd and timed to mimic a standard household load schedule.

At Buzzard's Bay two separate systems were studied. In one a single septic tank with a SludgeHammer installed was used to load 14-foot long leach trenches using tire chips in place of aggregate. This system is designated as TC in the spread sheet. The other system consists of three septic tanks, F1, F2, and F3. A SludgeHammer is installed in F2 while the others act as septic controls. Each tank discharges to a 14-foot standard aggregate filled leach trench with a washed sand bottom. Beneath the sand layer of each trench at 2 feet below the bottom of the trench is a pan that captures percolate from the trench, and at 4-foot depth below the entire system is an impermeable membrane leading to a sump where effluent from the three trenches is collected. Percolate from the TC system is collected from a pan 12" beneath the washed sand bottom of the trenches.

The septic tanks are 1,000-gallon single chambers without a baffle. They flow to a D-box that can split loads so the load to the trenches can be varied. At the onset of the experiment all trenches received  $\frac{1}{4}$  the daily load or 82.5 gpd. The control trenches were maintained at that load throughout the trial. The SludgeHammer tank (F2) received incremental flow increases until it was finally loaded with the entire daily load of 330 gpd to just a 14 foot leach trench.

Fecal coliform was measured as MPN/100 ml and is presented in the following tables. Sample points include the raw influent, readings at the D-box, readings from the 2-foot pan beneath the leach trenches, and the 4-foot sump, and in the TC system from pans 12" below the leach trench bottom. Daily effluent loads to the leach trenches are included in the table for comparison.



## Massachusetts Alternative Septic Systems Test Center

Two SludgeHammer biological incubators were inserted into existing mature septic tanks at the Massachusetts Alternative Septic Systems Test Center (MASSTC) in May 2002. Ponded septic trenches received the effluent. Daily loading of 330 gallons a day follow an ETV protocol with all operations and sampling managed by full time test facility staff. Laboratory analysis by a certified lab followed NSF/EPA QA/QC requirements.

Hydraulic acceptance rates increased dramatically as ponding dropped, eventually leading to flux rates (Q/wetted area) of three to almost eight gallons per day per square foot. In the winter of 2003 these levels dropped slightly. Pathogen reduction was significant as the biological mat created by the new ecology maintained unsaturated flow.

Weekly, then biweekly samples revealed a progressive reduction in nitrogen. This was the result of the conversion of residual solids in the tank and the sand fill to a new ecology by facultative aerobes. These aerobes were generated in the tank and discharged into the sand soil by the SludgeHammer technology. One system showed an average total nitrogen reduction of 60 percent with average concentration of 14.7 mg/l after the tank was pumped. A second former Title 5 system exhibited a low of 2.1-mg/l total nitrogen, with concentrations in a two-foot pan dropping to less than 20 mg/l in the fall. A mass balance analysis of the sump concentrations strongly suggests that the SludgeHammer system enables the soil to reduce nitrogen levels to less than 10 mg/l. Cold temperatures do not appear to affect the reaction rates or loss of nitrogen even with the higher than normal loading rates.

Field-testing at a 25-year-old residence confirmed hydraulic efficiency following the upgrade to the septic tank after 60 days of operation. COD measurement from this site showed a drop from over 200 to less than 30 ppm

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Void After: August 2017

Product: Aerobic Bacterial Generator

File No. 4500

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Identification: The main body of each Aerobic Bacterial Generator shall be permanently and legibly marked with the manufacturer's name or trademark so as to be visible before installation. All other components, including the air pump and diffuser, shall be permanently and legibly marked with the name or trademark of the Aerobic Bacterial Generator manufacturer or the name or trademark of the manufacturer of the component. The product shall also bear the UPC® certification mark.

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