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Rev.July 27, 2022

Ms. Maureen FitzGerald
Environmental Planner
15 Rope Ferry Road
Waterford, CT 06385
United States

RE: Gurley Rd
Waterford
GSD 60

To the Commission:

CLA has investigated the referenced site for inland wetlands and watercourses and assessed the potential for impact due to the proposed development of a business park. This report documents the wetland and soil types found at the site and provides an assessment of the potential for wetland impacts.

Existing Conditions

The site is located on Gurley Rd and Oil Mill Rd, CT and is bordered to the north by Route I-95. This site is currently undeveloped and has cover types including wooded uplands, wooded wetlands, scrub shrub uplands, early successional meadow, perennial stream and manmade pond. Traces of past development and use of the site are still evident.

The site has gentle to moderately steep slopes. Starting on the western (Oil Mill Rd) side, the slopes are nearly flat to moderate and drain into an un-named perennial stream that enters the site from a culvert under I-95 and exits the site to the south through a culvert under Gurley Rd. It also receives stormwater runoff from paved swales from I-95. This stream has an on-site manmade pond and eventually flows into the Niantic River. The easterly slopes of this watershed are steep and reflect past sand and gravel removal. Continuing eastward on the site the elevation climbs gradually there are alternating wetland and upland areas. The two wetland systems also flow southward under Gurley Rd via culverts and are tributary to the Niantic River. The wetlands also shown signs of human manipulation including a manmade pond in the easterly wetland.

Past land uses include farming and sand & gravel mining. The 1934 Connecticut Fairchild aerial photos (http://magic.lib.uconn.edu/mash_up/1934.html) show the site in agricultural use with a house and three outbuildings located over 1000 feet east of Oil Mill Rd. There are also two manmade ponds, one on the perennial stream

In the 1934 photo, no gravel mining is evident. In the 1961 photo, gravel mining is evident in the central portion of the site. In the 1990 photo the gravel mining area has already been re-vegetated and the buildings are still present. By 2004 it appears that the site may be no longer occupied or maintained. The information gleaned from the aerial photograph review substantiates that the site was previously farmed, ponds were created and the area of wetland flags 3-1 to 3-32 was excavated for gravel prior to 1961.

Wetland and Soil Types

Robert Russo, C.S.S. performed the wetland delineation in May of 2021and the table below provides wetland flag numbers, soil type, and wetland type.

Table 1 – Wetland Flag Numbers, Soil Types and Wetland Types

Flag Numbers	**Soil Parent Material**	**Wetland Type**
WF 1series	alluvial	Perennial stream, pond, wooded riverine floodplain
WF 2 series	Glacial till	Wooded swamp
WF 3 series	Excavated glacial outwash	Wooded swamp
WF 4 series	Glacial till	Wooded swamp, vernal pools

As shown on the project plans, the un-named perennial stream (Wetland system 1) and its associated floodplain are on the western side of the site. This reach of the stream has a cobble and gravel bottom and a manmade pond. There are rock piles and evidence of altered soils however the vegetation is predominantly hardwoods such as red maple (*Acer rubrum*) and shrubs such as multiflora rose (*Rosa multiflora*) and highbush blue berry (*Vaccinium corymbosum)*. The surrounding upland has dense stands of autumn olive (*Eleagnus umbelatta*). This wetland has hydrology fed by shallow groundwater discharge from the local glacial outwash and the upstream watershed. It receives storm water from the nearby roads

The perennial stream in wetland system 1 enters the site via a culvert under I-95 (refer to photograph 1 in Appendix C). Field inspection of the stream revealed that the channel is stable with no signs of ongoing erosion. Photograph 1 in Appendix C does show accumulation of cobbles and stones downstream of the culvert which may be due to recent extreme rainfall events (i.e. September of 2021). The channel below the rock accumulation is approximately 6-12 inches deep and 10-12 feet wide for a cross sectional area of 5 to 12 square feet. Downstream, at a location approximately 350' north of Gurley Rd. the channel is also stable, with a depth 0--6 inches and a width of 4-5 feet for a cross sectional area of approximately 2.5 square feet.. The stream banks are well vegetated with alder (*Alnus sp.*) and red maple (*Acer rubrum*).

Wetland system 2 is shown on the project plans in the center of the site. This wetland is a wooded swamp with a mucky substrate. There are rock piles and evidence of altered soils here as well. The vegetation is predominantly hardwoods such as red maple and shrubs such as multiflora rose and highbush blue berry. The surrounding upland has dense stands of rose and green brier. This wetland has hydrology is fed by shallow groundwater discharge from the local glacial till. Wood frog egg masses were found here as well as tadpoles, but by mid-May of 2021, the water had dried and the tadpoles died. The vernal pool investigation of March and April of 2022 revealed a total of 23 wood frog egg masses in this wetland. There were no spotted salamander egg masses. The egg mass count suggests that the hydro period of the wetland is too short for it to function as a vernal pool and wood frogs occasionally stray from wetland 4/5 and lay eggs here. The wetland receives storm water from the nearby roads.

Wetland system 3 is shown on the project plans in the west/center of the site. This wetland is a wooded swamp with a mineral substrate. There are rock piles, soil spoil piles and evidence of altered soils here as well. As noted above, this wetland was created prior to 1961 by excavation of fill material for I-95 .The vegetation is predominantly hardwoods such as red maple and shrubs such as multiflora rose (*Rosa multiflora*) and highbush blue berry. The surrounding upland has dense stands of rose, autumn olive and green brier. This wetland has hydrology fed by shallow groundwater discharge from the interface of the past gravel excavation with the local glacial till.

Wetland system 4/5 is shown on the project plans on the east side of the site. This wetland is a wooded swamp with both a mineral and mucky substrate. It contains a manmade pond (which functions as a vernal pool), an intermittent watercourse and a second vernal pool. There are rock piles, a farm crossing of the intermittent watercourse and evidence of altered soils here as well. The vegetation is predominantly hardwoods such as red maple and shrubs such as multiflora rose and highbush blue berry .The surrounding upland has dense stands of rose and green brier. This wetland has hydrology fed by shallow groundwater discharge from the local glacial till. Wood frog and spotted salamander egg masses were found here as well as tadpoles. The pond had greater than 25 wood frog egg masses and greater than 25 spotted salamander egg masses in March and April of 2022. The second vernal pool had 63 spotted salamander egg masses and 71 wood frog egg masses in March and April of 2022. The hydro period of this pool is long enough to provide breeding success for these species were present into July and August of 2021. The wetland receives storm water from the nearby roads.

The soils present on the site are document in the table below and further detail is provided in Appendix A.

Table 2, Soils at the Gurley Rd. Site

Soil Series	**Parent Material**	**Drainage Class**	**Texture/Characteristics**

Ridgebury Leicester Whitman (3)*	Glacial till	Poorly drained	Stony sandy loam
Agawam (29)	Glaciofluvial	Well drained	Sandy loam over sand and gravel
Hinckley (38)	Glaciofluvial	Excessively drained	Loamy sand
Canton and Charlton (61)	Glacial till	Well Drained	Sandy loam
Ripppowam (103)*	Alluvial	Well drained	Fine sandy loam
Udorthents (306)*	Varies – cut and fill material	Moderately well to poorly on site	Typically sandy loam

* Wetland soil type

The upland soils, as found during the soil investigation are a combination of Canton/Charlton, Agawam, Hinckley and Udorthetns/Urban land. The Udrothents/Urban land designation indicates extensive alteration of the soils and the presence of non-native soils. In this case, it indicated the presence of both areas that have been mined for gravel and the farm stream crossing. There are no set characteristics for Udorthents land, the soils reflect the properties of the non-native material and any artificial grading or drainage.

Hinckley and Agawam soils are formed in glacial outwash, i.e. well sorted sand and gravel. These soils occupy the wide, flat areas that cover most of the western part of the site. Floodplain and alluvial soils (Rippowam series) were found in a narrow floodplain parallel to the perennial stream.

Canton and Charlton soils are formed in glacial till and comprise the eastern portion of the site. They are unsorted silt, gravel stones and boulders and typically have greater than 6 feet to bedrock. The adjacent wetland soils are of the Ridgebury series which are also formed in glacial till and often have perched water tables.

NDDB Coordination

CLA has coordinated with the CTDEEP NDDB and the correspondence is attached. There are species of concern located at the site and CLA will continue to coordinate with the CTDEEP to properly protect those species. At present, CLA has included measures on the project plans to protect these species. These measures include excluding the species from work zones through use of barriers such as silt fence, regular inspections by a biologist to relocate any individuals encountered and education of the contractor and workers.

Potential Impacts

CLA has considered potential impacts at several levels. Each of the types of impacts considered are discussed in the following sections.

Water discharge and stream channel stability

The onsite perennial stream has a channel that appears stable as viewed in the field. There is the potential for channel erosion and degradation if it were to experience increased flows from the proposed development. The Drainage Hydrology and Hydraulics Report shows that the peak flows into the perennial stream will be reduced based on the drainage design. This reduction is a result of use of underground stormwater infiltration, installation of rain gardens, and use of stormwater treatment basins. CLA believes that there will be no negative impacts to the stream channel.

Construction related impacts

The site plan contains a detailed erosion and sedimentation control narrative that is consistent with the CTDEP 2002 Manual. Provisions to protect both onsite and offsite resources are included. The onsite construction will be phased with ongoing stabilization required. Temporary sediment traps, sediment barrier and soil stabilization are all shown on the E&S plans. The offsite utility construction (the water line) will employ silt fence barrier and a dirt bag for dewatering to protect the Niantic River and Oil Mill Brook. The utility installation will occur trenched within in the roadway and have limited potential for erosion as it will proceed sequentially with only a short run of trench open at any time.

Water quality

The CTDEEP 2004 Stormwater Manual prescribes means by which stormwater runoff from developed sites can be adequately treated. The method outlined in section 7.4.1 of the 2004 Manual, treating the WQV is employed on this site. As indicated in the calculations of Water Quality Volume (WQV) within the Drainage Hydrology and Hydraulics Report, the stormwater treatment design exceeds treatment of the WQV required by the 2004 Manual for each stormwater treatment basin. The range of over-treatment runs from three times that required for Basin 2 to nine times that required for Basin 1. Thus it is anticipated that the stormwater basins will provide a higher level of water quality renovation than required by CTDEEP. All of the basins are designed as wet bottom basins that will function as stormwater wetlands.

Also note that per the calculations in the Drainage Hydrology and Hydraulics Report, none of the stormwater basins will discharge in the 2 year storm event. Appendix D of this report includes data from the University of New Hampshire Stormwater Center (https://www.unh.edu/unhsc/) that indicate that retaining the two year storm provides extremely high levels of removal of pollutants of concern for commercial and industrial sites. Based on the UNH data, CLA anticipates levels of renovation that will be protective of water quality within local water bodies as well as the Niantic River, CLA has reviewed the Niantic River watershed management plans to ensure that the site plans are consistent with those documents. Based on that review, additional measures beyond the water quality basins described above have been incorporated into the site plans.

1. There will be a 50 foot undisturbed vegetative buffer left in place around all wetlands and watercourses on the site. This will provide shade over streams, wildlife habitat and further treat discharge from the treatment basins.
2. Low Impact Development (LID) measures such as rain gardens have been incorporated. In total, nine rain gardens are proposed and each will provide bio-filtration to stormwater runoff before is enters the ground. This will provide treatment not accounted for in the WQV calculations.
3. Infiltration of stormwater is used whenever practical, in infiltrations chamber systems for roof drainage, rain gardens and Basin 1, 2, and 3.
4. To minimize the potential for metal leachate from roofs, they will be treated with elastomeric coating.
5. The plans are consistent with the CTDEEP 2002 and 2004 Manuals.

Based on the stormwater treatment design and the measures incorporated to be consistent with the watershed management plans, CLA believes that the design is protective of both onsite resources and the Niantic River.

Summary

Note that CLA submitted the plans to town staff for two pre-application reviews and significant revisions that are protective of wetland and watercourses were made as a result of that review. Prior to the review, CLA's design kept all infrastructure at least 50 feet from regulated resources. Based on the feedback from staff, CLA has re-designed the site to maintain a minimum of 50 feet of undisturbed vegetation around all wetlands and watercourses. However infrastructure such as storm water treatment are still shown as eventually discharging to the wetlands and watercourse via overland flow and CLA has considered the potential impact to the wetlands and watercourses, CLA's drainage report shows that for all storm events (2 year through 100 year) peak flows are reduced at each point of analysis. Due to the volume of storm water being infiltrated CLA believes that the stream and wetlands will not be adversely impacted.

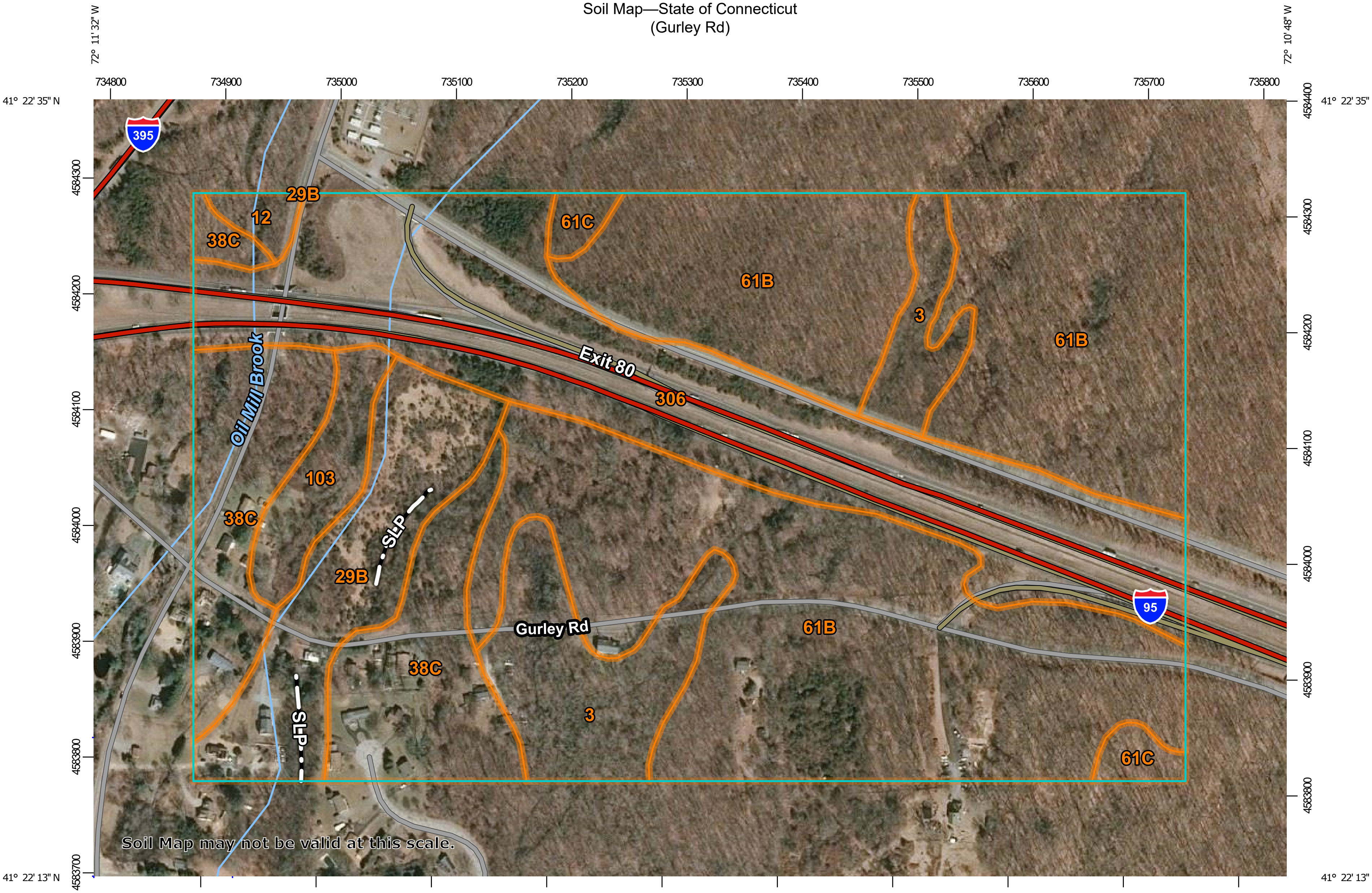
As was the case prior to the re-design, no filling or direct impact of wetland is proposed. CLA has examined the potential for secondary wetland impacts both construction related and post-construction. The main concern during construction is for water quality. In order to protect the aquatic life and water quality within the stream, proper erosion and sedimentation control has been provided on the Site Improvement Plan. Post construction, water that runs off of the developed surfaces will be treated in water treatment basins and via infiltration as shown on the plan. The site has been designed per both the 2002 and 2004 CTDEEP Manuals. CLA believes that if the project is constructed per plan, there will be no adverse wetland impacts.

Sincerely,

Robert C Russo

Robert C. Russo
Soil Scientist

Appendix A Soils Data



Map Scale: 1:4,730 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: State of Connecticut
Survey Area Data: Version 20, Jun 9, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 20, 2019—Mar 27, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	8.8	8.1%
12	Raypol silt loam	0.7	0.7%
29B	Agawam fine sandy loam, 3 to 8 percent slopes	8.1	7.5%
38C	Hinckley loamy sand, 3 to 15 percent slopes	13.2	12.2%
61B	Canton and Charlton fine sandy loams, 0 to 8 percent slopes, very stony	49.9	46.0%
61C	Canton and Charlton fine sandy loams, 8 to 15 percent slopes, very stony	1.4	1.3%
103	Rippowam fine sandy loam	2.8	2.6%
306	Udorthents-Urban land complex	23.5	21.7%
Totals for Area of Interest		**108.4**	**100.0%**

U.S.A.

RIPPOWAM SERIES

The Rippowam series consists of very deep, poorly drained loamy soils formed in alluvial sediments. They are nearly level soils on flood plains subject to frequent flooding. Slope ranges from 0 to 3 percent. Saturated hydraulic conductivity ranges from moderately high or high in the loamy upper part and high or very high in the underlying sandy materials. Mean annual temperature is about 50 degrees F., and mean annual precipitation is about 47 inches.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, nonacid, mesic Fluvaquentic Endoaquepts

TYPICAL PEDON: Rippowam fine sandy loam in woodland at an elevation of about 435 feet. (Colors are for moist soil.)

A--0 to 5 inches; very dark grayish brown (10YR 3/2) fine sandy loam; weak medium granular structure; friable; common fine and medium roots; very strongly acid; clear wavy boundary. (3 to 9 inches thick)

Bg1--5 to 12 inches; dark grayish brown (10YR 4/2) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; common medium prominent strong brown (7.5YR 5/6) masses of iron accumulation; very strongly acid; clear wavy boundary.

Bg2--12 to 19 inches; dark gray (10YR 4/1) fine sandy loam; weak medium subangular blocky structure; friable; few fine and medium roots; many medium prominent yellowish red (5YR 4/6) masses of iron accumulation; strongly acid; clear wavy boundary. (Combined thickness of the Bg horizons is 6 to 27 inches.)

BCg1--19 to 24 inches; grayish brown (10YR 5/2) sandy loam; massive; friable; few fine and medium roots; common medium prominent strong brown (7.5YR 5/6) masses of iron accumulation; strongly acid; clear wavy boundary.

BCg2--24 to 27 inches; very dark gray (10YR 3/1) sandy loam; massive; friable; few fine and medium roots; moderately acid; clear wavy boundary. (Combined thickness of the BCg horizons is 0 to 8 inches.)

Cg1--27 to 31 inches; dark gray (10YR 4/1) loamy sand; single grain; loose; moderately acid; clear wavy boundary.

Cg2--31 to 65 inches; grayish brown (10YR 5/2) very gravelly sand; single grain; loose; 35 percent gravel; moderately acid.

TYPE LOCATION: Fairfield County, Connecticut; town of Redding, 100 feet south of Cross Highway and 100 feet east of Little River. USGS Botsford Quadrangle; latitude 41 degrees 18 minutes 32 seconds N. and longitude 73 degrees 21 minutes 57 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 20 to 40 inches. The difference between mean summer soil temperature and mean winter soil temperature is at least 25 degrees F. or more. Depth to the coarse-textured substratum layers commonly is from 20 to 40 inches but can range to a depth of 45 inches. Gravel ranges from 0 to 15 percent by volume in the solum and from 0 to 40 percent in the sandy substratum. Some pedons have up to 10 percent cobbles in the coarse-textured substratum. Reaction ranges from very strongly acid to neutral with some subhorizon being moderately acid, slightly acid, or neutral within a depth of 40 inches.

Some pedons have an O horizon that is highly decomposed, moderately decomposed, or slightly decomposed plant material. It has hue of 5YR to 10YR and value and chroma of 3 or less.

The A or Ap horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 or 2. Texture is very fine sandy loam, fine sandy loam, or sandy loam. It typically has weak or moderate granular structure but some pedons have subangular blocky structure. Consistence is friable or very friable.

The Bg horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 or 2 and typically has redoximorphic features. Texture of the Bg horizon is dominantly fine sandy loam or sandy loam. The Bg horizon is massive or has weak granular or subangular blocky structure. Consistence is friable or very friable.

The BCg horizon, where present, has hue of 10YR to 5Y, value of 3 to 6, and chroma of 1 or 4 and typically has redoximorphic features. Texture of the BCg horizon is dominantly fine sandy loam or sandy loam. The BCg horizon is massive or has weak granular or subangular blocky structure. Consistence is friable or very friable.

Included in some pedons are thin Ab horizons with characteristics similar to the A horizon.

The C horizon or layer has hue of 10YR to 5Y, value of 3 to 6, and chroma of 1 to 4. Texture ranges from loamy fine sand to coarse sand in the fine-earth fraction. The C horizon is typically single grain and loose. Some pedons have thin loamy strata and/or extremely gravelly strata in the lower part of the C horizon.

COMPETING SERIES: There are no soils currently in the same family. Briscot, Holderton, and Lim soils are in related families. Briscot soils are from outside LRR R.

Briscot soils are dominantly fine sandy loam or finer to a 60-inch depth and the difference between mean summer soil temperature and mean winter soil temperature is less than 25 degrees F. Holderton soils have an active cation exchange activity class and have textures finer than loamy fine sand in the substratum. Lim soils have a texture to a depth of at least 18 inches that is commonly silt loam or very fine sandy loam but includes loam with more than 65 percent silt plus very fine sand.

GEOGRAPHIC SETTING: Rippowam soils are nearly level soils on flood plains along rivers and streams. They are in low areas. Slope ranges from 0 to 3 percent. The soils formed in recent alluvium derived mostly from granite, gneiss, and schist. Mean annual temperature ranges from 45 to 54 degrees F., mean annual precipitation ranges from 35 to 50 inches, and the growing season ranges from 115 to 190 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Agawam, Enfield, Hadley, Haven, Hinckley, Lim, Limerick, Merrimac, Ninigret, Occum, Pootatuck, Saco, Suncook, Tisbury, Windsor, and Winooski soils on nearby landscapes. The well drained Occum and the moderately well drained Pootatuck soils are associated in a drainage sequence. Agawam, Haven, Enfield, Hinckley, Merrimac, Ninigret, Tisbury, and Windsor soils are better drained soils on outwash terraces. Hadley soils are well drained silty floodplain associates. Suncook soils are excessively drained sandy soils on floodplains.

DRAINAGE AND PERMEABILITY: Poorly drained. Surface runoff is negligible to low. Saturated hydraulic conductivity ranges from moderately high or high in the loamy upper part and high or very high in the underlying sandy materials. These soils typically flood in the spring of each year. Rippowam soils have a water table at or near the surface much of this year.

USE AND VEGETATION: Most areas are in brushy woodland. Common trees are red maple, willow, and alder. A few areas are cleared and used for pasture or hay.

DISTRIBUTION AND EXTENT: Floodplains in Connecticut, Massachusetts, New Hampshire, eastern New York, Rhode Island, and Vermont; MLRAs 142, 144A, 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Fairfield County, Connecticut, 1979.

REMARKS: This revision reflects conformance to a change in soil taxonomy based on a revision to the definition of the cambic horizon made in 1999. Cation exchange activity class placement determined from a review of limited lab data and similar or associated soils.

Diagnostic horizons and features recognized in this pedon are:

1. Ochric epipedon - the zone from 0 to 5 inches (A horizon).
2. Cambic horizon - the zone from 5 to 27 inches (Bg1, Bg2, BCg1, and BCg2 horizons). Evidence of alteration is in the form of description of subangular blocky structure and inferred absence of rock structure to a depth of 27 inches.

AGAWAM SERIES

The Agawam series consists of very deep, well drained soils formed in sandy, water deposited materials. They are level to steep soils on outwash plains and high stream terraces. Slope ranges from 0 to 15 percent. Saturated hydraulic conductivity is moderately high or high in the upper solum and high or very high in the lower solum and substratum. Mean annual temperature is about 48 degrees F. and mean annual precipitation is about 47 inches.

TAXONOMIC CLASS: Coarse-loamy over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts

TYPICAL PEDON: Agawam fine sandy loam in a nearly level cultivated field at an elevation of about 124 feet. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 11 inches; dark grayish brown (10YR 4/2) fine sandy loam; light brownish gray (10YR 6/2) dry; weak medium and coarse subangular blocky structure; very friable; common fine and medium roots; strongly acid; abrupt smooth boundary. (5 to 14 inches thick)

Bw1--11 to 16 inches; dark yellowish brown (10YR 4/4) fine sandy loam; weak medium and coarse subangular blocky structure; very friable; common fine and medium roots; strongly acid; abrupt smooth boundary.

Bw2--16 to 26 inches; light olive brown (2.5Y 5/4) fine sandy loam; weak medium subangular blocky structure; very friable; common fine and medium roots; strongly acid; clear smooth boundary. (Combined thickness of the Bw horizons is 10 to 30 inches)

2C1--26 to 45 inches; olive(5Y 5/3) loamy fine sand; massive; very friable; few fine roots; strongly acid; clear smooth boundary.

2C2--45 to 55 inches; olive brown (2.5Y 4/4) loamy fine sand; massive; very friable; strongly acid; abrupt smooth boundary.

2C3--55 to 65 inches; olive (5Y 5/3) loamy sand; single grain; loose; strongly acid.

TYPE LOCATION: Hampshire County, Massachusetts; Town of Hatfield; 700 feet north of Elm Street at a point 1,600 feet west of its intersection with Prospect Street. USGS Mt. Holyoke quadrangle; Lat. 42 degrees 22 minutes 00 seconds N. and 72 degrees 36 minutes 42 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 15 to 35 inches. Coarse fragments range from 0 to 10 percent by volume in the surface, 0 to 30 percent in the B and C horizons above a depth of 40 inches and 0 to 60 percent below. The soil ranges from very strongly acid to slightly acid, unless limed.

The Ap horizon has hue of 7.5YR to 2.5Y, value of 3 or 4, and chroma of 2 to 4. Dry value is 6 or more. It is fine sandy loam, very fine sandy loam, or loam. Undisturbed pedons have an A horizon that has hue of 7.5YR to 2.5Y, value of 2 to 3, and chroma of 1 to 3. It is 1 to 4 inches thick. Some pedons have a thin E horizon directly below the A.

The upper part of the Bw horizon has hue of 5YR to 10YR, value of 4 to 7, and chroma of 3 to 8. The lower part has hue of 10YR to 5Y with value and chroma ranges the same as the upper part. Texture is fine sandy loam, very fine sandy loam, or loam in the upper part and fine sandy loam or very fine sandy loam in the lower part. Structure is very weak, weak or moderate granular or subangular blocky or the horizon is massive.

A BC horizon of sandy loam or loamy sand is present in some pedons. Color and texture ranges are the same as the lower part of the Bw. Structure is very weak, weak or moderate granular or the horizon is massive. It is up to 5 inches thick.

The C horizon has hue of 10YR to 5Y, value of 3 to 7, and chroma of 1 to 4. It is stratified loamy fine sand, loamy sand, fine sand, sand, or their gravelly analogues and is very gravelly below a depth of 40 inches in some pedons. Consistence is very friable or loose.

COMPETING SERIES: These are the Barnstable, Branford, Haven, and Narragansett series. Barnstable soils formed in till over outwash and have rock fragments in the solum that are dominantly angular. Branford soils have hue of 5YR or redder throughout the B and C horizons. Narragansett soils lack stratified layers and have coarse fragments that are dominantly angular. Haven soils typically have more than 40 percent silt in the lower part of the Bw horizon.

GEOGRAPHIC SETTING: Agawam soils are level to steep soils on outwash plains and high stream terraces. Most areas are on slopes that are less than 15 percent. Steeper slopes are on terrace escarpments and steep sides of gullies in dissected outwash plains. The soils formed in sandy water deposited material derived principally from schist, granite, gneiss, and phyllite. Mean annual precipitation ranges from 28 to 55 inches and mean annual air temperature from 45 degrees to 50 degrees F. The mean growing season ranges from 120 to 200 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Enfield, Hadley, Hartland, Hinckley, Merrimac, Ninigret, Occum, Walpole, and Windsor soils on nearby landscapes. The excessively drained Hinckley and Windsor, somewhat excessively drained Merrimac, and well drained Enfield and Hartland soils are on associated outwash terraces and glacial lake plains. Well drained Hadley and Occum soils are on nearby floodplains. The moderately well drained Ninigret and poorly drained Walpole soils are associated in a drainage sequence with Agawam soils.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Runoff and internal drainage are negligible to low. Saturated hydraulic conductivity is moderately high or high in the upper solum and high or very high in the lower solum and substratum.

USE AND VEGETATION: Most areas are used for growing cultivated hay, silage corn, tobacco, potatoes, and truck crops. Some areas are used for growing pasture. Native vegetation is forest composed mainly of white pine, gray birch, red maple, red, white, black, and scarlet oaks.

DISTRIBUTION AND EXTENT: Connecticut, Massachusetts, New Hampshire, eastern New York, and Rhode Island; MLRA's 101, 142, 144A, and 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Hampden and Hampshire Counties, Massachusetts, 1928.

REMARKS: It should be noted that as a competing series, Haven soils typically have soil temperatures that may be slightly warmer but a precise difference could not be quantified based on available data and historical use.

Diagnostic horizons and other features recognized in this pedon are:

1. Ochric epipedon - the zone from 0 to 11 inches (Ap horizon).
2. Cambic horizon - the zone from 11 to 26 inches (Bw horizons).
3. Contrasting particle-size - the coarse-loamy material contains less than 50 percent fine or coarser sand and the transition zone is less than 12.5 cm thick.

ADDITIONAL DATA: Reference samples from pedons S54MA023006, S58MA011002, S57NH013003, S70CT003001, S85VT027017, S85VT027018, S91MA011008, S93MA011003, S93MA011003, S93MA011004 from numerous counties and states, by NSSL, Lincoln, NE, various years. Pedon S70 CT-3-1 sampled in Hartford, Connecticut. Analysis by Beltsville soil survey laboratory.

CANTON SERIES

The Canton series consists of very deep, well drained soils formed in a loamy mantle underlain by sandy till. They are on nearly level to very steep moraines, hills, and ridges. Slope ranges from 0 to 45 percent. Saturated hydraulic conductivity is moderately high or high in the solum and high or very high in the substratum. The mean annual temperature is about 9 degrees C and the annual precipitation is about 1205 mm.

TAXONOMIC CLASS: Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Typic Dystrudepts

TYPICAL PEDON: Canton fine sandy loam on a west-facing, convex, 8 percent slope in an extremely stony forested area at an elevation of about 210 meters. (Colors are for moist soil unless otherwise noted.)

Oi-- 0 to 5 cm; slightly decomposed plant material; (0 to 13 cm thick.)

A-- 5 to 13 cm; very dark grayish brown (10YR 3/2) fine sandy loam; weak fine granular structure; friable; common fine roots; 5 percent gravel; very strongly acid (pH 4.6); abrupt smooth boundary. (3 to 10 cm thick.)

Bw1-- 13 to 30 cm; yellowish brown (10YR 5/6) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; 5 percent gravel; very strongly acid (pH 4.6); clear smooth boundary.

Bw2-- 30 to 41 cm; yellowish brown (10YR 5/4) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; 5 percent gravel; strongly acid (pH 5.1); clear smooth boundary.

Bw3-- 41 to 56 cm; yellowish brown (10YR 5/4) gravelly fine sandy loam; weak medium subangular blocky; friable; common fine and medium roots; 15 percent gravel; strongly acid (pH 5.1); abrupt smooth boundary. (Combined thickness of the Bw horizons is 43 to 84 cm.)

2C-- 56 to 170 cm; grayish brown (2.5Y 5/2) gravelly loamy sand; massive; friable; 25 percent gravel; moderately acid (pH 5.6).

TYPE LOCATION: Worcester County, Massachusetts; Town of Douglas; 150 feet south on Wallum Lake Road from the junction of Cedar and South West Main Streets, and 165 feet southwest of Wallum Lake Road. USGS Oxford, MA quadrangle; Latitude 42 degrees, 2 minutes, 43.2 seconds N., and Longitude 71 degrees, 45 minutes, 44.8 seconds W., NAD 83.

RANGE IN CHARACTERISTICS: Solum thickness is commonly 46 to 91 cm, but ranges to 36 cm. It corresponds closely to the depth to the sandy till. Rock fragment content consists of 0 to 20 percent gravel and 0 to 5 percent cobbles in the solum. Stones and boulders are 0 to 15 percent of the surface and solum. Gravel content is 10 to 30 percent, cobbles 5 to 10 percent, and stones 0 to 10 percent in the substratum. Rock fragments are dominantly granite, gneiss, and quartzite. The soil ranges from extremely acid to moderately acid.

The O horizons, where present, consist of slightly, moderately, and/or highly decomposed organic material.

The A horizon has hue of 7.5YR or 10YR, value of 2 to 4, and chroma of 1 to 3. Texture is sandy loam, fine sandy loam, loam, or very fine sandy loam in the fine-earth fraction. Some pedons have an Ap horizon with properties similar to the A horizon. It is up to 20 cm thick.

Some pedons have a thin E or AE horizon that has hue of 7.5YR or 10YR, value of 3 to 5 and chroma of 1 or 2 with similar textures to the A horizon. It is up to 8cm thick.

The upper Bw horizons commonly have hue of 10YR, and includes 7.5YR when a high ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron (greater than 0.15) exists, value of 4 or 5, and chroma of 4 to 8. The lower Bw horizons have hue of 10YR or 2.5Y, value of 4 to 7, and chroma of 4 to 8. Texture of the fine-earth fraction of the Bw horizons is commonly fine sandy loam and less commonly sandy loam, loam, and very fine sandy loam. Structure of the Bw horizons is granular or subangular blocky.

Some pedons have a Bs, Bh, or BC horizon with texture similar to the Bw horizons.

The 2C horizon typically has hue of 2.5Y or 5Y, value of 5 to 7, and chroma of 2 or 3. In some pedons hue is 10YR with chroma of 4 to 6. The texture of the fine-earth fraction is loamy fine sand or coarser. It is single grain or massive. Consistence is friable, very friable or loose. Thin lenses or small pockets of firm or very firm finer textured material are common below 91 cm.

COMPETING SERIES: There are no other soils currently in the same family.

The Agawam, Barnstable, Branford, Brookfield, Charlton, Haven, and Narragansett series are in closely related families. The Agawam, Branford, and Haven soils have stratified sand or sand and gravel in the series control section. In addition, the Branford soils have hues redder than 7.5YR throughout the B horizon. Barnstable soils formed in till over outwash and have less than 30 percent fine sand in the lower part of the Bw horizon. Brookfield soils formed in sulfur bearing parent materials and have a ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron less than 0.15 and have pedogenic iron contents greater than 1 percent throughout the pedon. Charlton soils lack a lithologic discontinuity of abrupt change in sand distribution. Narragansett soils have more than 55 percent silt and very fine sand in the solum.

GEOGRAPHIC SETTING: Canton soils are on moraines and glaciated upland hills and ridges. Slope ranges from 0 to 45 percent. The soils formed in an acid coarse loamy supraglacial melt out till over loose sandy till of Wisconsin age derived from gneiss, granite and schist along with some fine-grained sandstone in some pedons. The loamy mantle in some pedons is influenced or derived from eolian sources. The climate is humid temperate. The mean annual air temperature is 7 to 11 degrees C, and the mean annual precipitation ranges from 1016 to 1295 mm.

GEOGRAPHICALLY ASSOCIATED SOILS: The Newfields series is the moderately well drained member of the same toposequence. The Agawam, Haven, Merrimac, and Warwick soils are on nearby glacial outwash kames and plains. The Barnstable, Brookfield, Charlton, Cheshire, Dutchess, Gloucester, Hollis, Montauk, Narragansett, and Paxton soils are on nearby glaciated uplands. Brookfield, Charlton, Cheshire, Dutchess, Gloucester, Hollis, Montauk, and Paxton soils do not have a contrasting particle size in the control section.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Runoff is negligible to medium. Internal drainage is medium. Saturated hydraulic conductivity is moderately high or high in the solum and high or very high in the substratum.

USE AND VEGETATION: Mostly forested. Some areas have been cleared of surface stones and are used for crops and pasture. Native vegetation is forest composed of eastern white pine, northern red, white, and black oaks, hickory, red maple, sugar maple, gray birch, yellow birch, beech, eastern hemlock, and white ash.

DISTRIBUTION AND EXTENT: Glaciated uplands in Connecticut, Massachusetts, New Hampshire, eastern New York, and Rhode Island, also in the Massachusetts Coastal Islands; MLRAs 144A, 145, and 149B. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Herkimer County, New York, 1969.

REMARKS:

Diagnostic horizons and features recognized in this pedon are:
1) Ochric epipedon - the zone from 0 to 13 cm (Oi and A horizons).
2) Cambic horizon - the zone from 13 to 56 cm (Bw1, Bw2, and Bw3 horizons).
3) Contrasting particle size - the coarse-loamy material contains less than 50 percent fine sand or coarser, and the transition zone between the two parts of the particle-size control section is less than 12 cm thick. (Coarse-loamy over sandy or sandy skeletal).
4) Lithologic discontinuity - abrupt change in sand distribution at 56 cm (2C horizon).
6) Particle-size control section - the zone from 30 to 105 cm (Bw1, Bw2, Bw3, and 2C horizons).

ADDITIONAL DATA: M.S. Thesis work by Shawn McVey, University of Connecticut, 2006. Full characterization data for sample no. S1982CT007001, S1999CT013001, S1999CT013004, S2000CT007003, S2004CT011003, and pedons of similar soils is available through the National Cooperative Soil Survey Soil Characterization Database: http://ncsslabdatamart.sc.egov.usda.gov/

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CHARLTON SERIES

The Charlton series consists of very deep, well drained soils formed in loamy melt-out till. They are nearly level to very steep soils on moraines, hills, and ridges. Slope ranges from 0 to 60 percent. Saturated hydraulic conductivity is moderately high or high. Mean annual temperature is about 9 degrees C and mean annual precipitation is about 1205 mm.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, mesic Typic Dystrudepts

TYPICAL PEDON: Charlton fine sandy loam - forested, very stony, at an elevation of about 170 meters. (Colors are for moist soil unless otherwise noted.)

Oe -- 0 to 4 cm; black (10YR 2/1) moderately decomposed forest plant material. (0 to 5 cm thick.)

A -- 4 to 10 cm; dark brown (10YR 3/3) fine sandy loam; weak fine granular structure; very friable; many fine roots; 5 percent gravel; very strongly acid; abrupt smooth boundary. (2 to 15 cm thick.)

Bw1 -- 10 to 18 cm; brown (7.5YR 4/4) fine sandy loam; weak coarse granular structure; very friable; many fine and medium roots; 5 percent gravel; very strongly acid; clear wavy boundary.

Bw2 -- 18 to 48 cm; yellowish brown (10YR 5/6) fine sandy loam; weak medium subangular blocky structure; very friable; common fine and medium roots; 10 percent gravel and cobbles; very strongly acid; clear wavy boundary.

Bw3 -- 48 to 69 cm; light olive brown (2.5Y 5/4) gravelly fine sandy loam; massive; very friable; few medium roots; 15 percent gravel and cobbles; very strongly acid; abrupt wavy boundary. (Combined thickness of the Bw horizons is 35 to 91 cm.)

C -- 69 to 165 cm; grayish brown (2.5Y 5/2) gravelly fine sandy loam with thin lenses of loamy sand; massive; friable, some lenses firm; few medium roots; 25 percent gravel and cobbles; strongly acid.

TYPE LOCATION: New Haven County, Connecticut; town of Middlebury, 3800 feet along Long Meadow Road from the intersection with South Street, 450 feet southeast along a gravel road and 50 feet west of the gravel road, 400 feet northeast of Long Meadow Pond, in a wooded area. USGS Naugatuck topographic quadrangle, Latitude 41 degrees 29 minutes 48.40 seconds N., Longitude 73 degrees 7 minutes 04.59 seconds W., NAD 1983.

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from 31 to 109 cm. Depth to bedrock is commonly more than 180 cm. Rock fragments range from 5 to 35 percent by volume to a depth of 100 cm and up to 50 percent below 100 cm. Except where the surface layer is stony, the fragments are mostly subrounded gravel and typically make up 60 percent or more of the total rock fragments. Unless limed, reaction ranges from extremely acid to moderately acid.

The O horizon, where present, ranges from slightly decomposed to highly decomposed plant material.

The A horizon has hue of 7.5YR or 10YR, value of 2 or 3, and chroma of 1 to 3. Disturbed pedons have an Ap horizon with value of 3 or 4 and chroma of 2 to 4. The A or Ap horizon is sandy loam, fine sandy loam, or loam in the fine-earth fraction. It has weak or moderate granular structure and is friable or very friable.

Some pedons have a thin AE or E horizon below the O horizon or a thin E horizon below the A horizon. It has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 3. Texture, structure, and consistence are like the A horizon.

The upper part of the Bw horizon has commonly hue of 7.5YR or 10YR, and includes 7.5YR when a high ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron (greater than 0.15) exists, and value and chroma of 4 to 6. The lower part of the Bw horizon has hue of 10YR or 2.5Y and value and chroma of 4 to 6. Texture of the Bw horizon is loam, fine sandy loam, or sandy loam with less than 65 percent silt plus very fine sand in the fine earth fraction. It has weak granular or subangular blocky structure. Consistence is friable or very friable.

Some pedons have a BC horizon with value and chroma like the lower part of the Bw horizon, but includes hue of 5Y. The BC horizon commonly has texture, structure, and consistence like the Bw horizon but the range includes geologically derived structure appearing in the form of thin plates.

The C horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 2 to 6. Texture is loam, fine sandy loam, or sandy loam in the fine-earth fraction, with pockets or thin lenses of loamy sand. The horizon is massive or has plates of geogenic origin. Consistence commonly is very friable or friable but in some pedons includes firm.

COMPETING SERIES: These are Chadakoin, Chatfield, Maplecrest, Riverhead, Stinger and Valois. Chadakoin and Valois soils formed in till derived primary from sedimentary rock parent materials. Chatfield soils have a lithic contact at 50 to 100 cm below the mineral soil surface. Maplecrest soils formed in till derived from red sedimentary rock parent materials. Riverhead soils formed in glacial outwash deposits and have sandy textures in the substratum. Stinger soils are moderately deep to a paralithic contact and formed in colluvium on mountain side slopes in Oregon.

GEOGRAPHIC SETTING: Charlton soils are nearly level to very steep soils on moraines and glaciated upland hills and ridges. Slope ranges from 0 to 60 percent. The soils formed in acid melt-out till derived mainly from schist, gneiss, or granite. Mean annual temperature ranges from 7 to 11 degrees C and mean annual precipitation commonly ranges from 940 to 1245 cm, but the range includes as low as 660 cm in some places east of the Adirondack Mountains in the Champlain Valley of New York. The growing season ranges from 115 to 185 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Acton, Brookfield, Chatfield, Essex, Hollis, Leicester, Rainbow, Ridgebury, Sutton, Wapping, Whitman, and Woodbridge soils on nearby landscapes. The moderately well drained Sutton and the poorly drained Leicester soils are associated in a drainage sequence. Acton and Wapping soils are moderately well drained. Brookfield soils formed in iron sulfide bearing parent materials and have a ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron less than 0.15 and have pedogenic iron contents greater than 1 percent throughout the pedon. Chatfield soils have bedrock within a depth of 50 to 100 cm. Essex soils have a sandy particle-size control section and a dense substratum. Hollis soils have bedrock within a depth of 25 to 50 cm. Rainbow and Woodbridge soils are moderately well drained with a dense substratum. Ridgebury soils are poorly drained and have a dense substratum. Whitman soils are very poorly drained with a dense substratum.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Runoff is negligible to medium. Saturated hydraulic conductivity is moderately high or high in the mineral soil.

USE AND VEGETATION: Areas cleared of stones are used for cultivated crops, specialty crops, hay, and pasture. Many scattered areas are used for community development. Stony areas are mostly wooded. Common trees are northern red, white, and black oak, hickory, sugar maple, red maple, black and gray birch, white ash, beech, white pine, and hemlock.

DISTRIBUTION AND EXTENT: Glaciated uplands in Connecticut, Massachusetts, New Hampshire, New York, and Rhode Island. MLRAs 142,144A, and 145. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts

SERIES ESTABLISHED: Worcester County, Massachusetts, 1922.

REMARKS: Diagnostic horizons and features recognized in this pedon include:
1. Ochric epipedon - the zone from 0 to 10 cm (Oe and A horizons).
2. Cambic horizon - the zone from 10 to 69 cm (Bw1, Bw2, and Bw3 horizons).
3. Particle-size class - coarse-loamy in the control section from 29 to 109 cm.

ADDITIONAL DATA: M.S. Thesis work by Shawn McVey, University of Connecticut, 2006. Full characterization data for sample numbers S1999NY005001 and S1999CT013003. Pedons analyzed by the KSSL, Lincoln, NE.

HINCKLEY SERIES

The Hinckley series consists of very deep, excessively drained soils formed in glaciofluvial materials. They are nearly level through very steep soils on outwash terraces, outwash plains, outwash deltas, kames, kame terraces, and eskers. Saturated hydraulic conductivity is high or very high. Slope ranges from 0 to 60 percent. Mean annual temperature is about 7 degrees C, and mean annual precipitation is about 1143 mm.

TAXONOMIC CLASS: Sandy-skeletal, mixed, mesic Typic Udorthents

TYPICAL PEDON: Hinckley loamy sand in woodland at an elevation of about 240 meters. (All colors are for moist soil.)

Oe -- 0 to 3 cm; moderately decomposed plant material derived from red pine needles and twigs. (0 to 5 cm thick.)

Ap -- 3 to 20 cm; very dark grayish brown (10YR 3/2) loamy sand; weak fine and medium granular structure; very friable; many fine and medium roots; 5 percent fine gravel; very strongly acid; abrupt smooth boundary. (3 to 25 cm thick.)

Bw1 -- 20 to 28 cm; strong brown (7.5YR 5/6) gravelly loamy sand; weak fine and medium granular structure; very friable; common fine and medium roots; 20 percent gravel; very strongly acid; clear smooth boundary.

Bw2 -- 28 to 41 cm; yellowish brown (10YR 5/4) gravelly loamy sand; weak fine and medium granular structure; very friable; common fine and medium roots; 25 percent gravel; very strongly acid; clear irregular boundary. (Combined thickness of the Bw horizon is 8 to 41 cm.)

BC -- 41 to 48 cm; yellowish brown (10YR 5/4) very gravelly sand; single grain; loose; common fine and medium roots; 40 percent gravel; strongly acid; clear smooth boundary. (0 to 13 cm thick)

C -- 48 to 165 cm; light olive brown (2.5Y 5/4) extremely gravelly sand consisting of stratified sand, gravel and cobbles; single grain; loose; common fine and medium roots in the upper 20 cm and very few below; 60 percent gravel and cobbles; moderately acid.

TYPE LOCATION: Worcester County, Massachusetts; Town of Petersham, Harvard Forest, 240 feet north of Tom Swamp Road at a point 1.15 miles east of the intersection of Athol Road and Tom Swamp Road. USGS Athol, MA topographic quadrangle, Latitude 42 degrees, 30 minutes, 41.8 seconds N., and Longitude 72 degrees, 12 minutes, 28.9 seconds W., NAD 1983.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 30 to 87 cm. Rock fragment content of the solum ranges from 5 through 50 percent gravel, 0 through 30 percent cobbles, and 0 through 3 percent stones. Rock fragment content of individual horizons of the substratum ranges from 10 through 55 percent gravel, 5 through 25 percent cobbles, and 0 through 5 percent stones. In some places gravel content throughout the soil ranges up through 75 percent. The soil ranges from extremely acid through moderately acid, except where limed.

The O horizons, where present, consist of slightly, moderately, and/or highly decomposed plant material. They have hue N or 2.5YR through 7.5YR, value of 2 or 3, and chroma of 0 through 3.

The Ap horizon has hue of 7.5YR or 10YR, value of 2 through 4, and chroma of 1 through 4. Texture of the fine-earth fraction is very fine sandy loam, fine sandy loam, sandy loam, coarse sandy loam, loamy fine sand, loamy sand, or loamy coarse sand. Structure is weak or moderate very fine through coarse granular or subangular blocky. Consistence is friable or very friable. Undisturbed areas have an A horizon that has hue of 10YR, value of 2 or 3, and chroma of 1 through 4.

Some pedons have thin E, Bhs, Bh, or Bs horizons below the A horizon.

The upper part of the Bw horizon has hue of 7.5YR or 10YR, value of 3 through 5, and chroma of 3 through 8. The lower part has hue of 7.5YR through 2.5Y, value of 3 through 6, and chroma of 3 through 8. Texture, to a depth of 25 cm from the surface, is fine sandy loam, sandy loam, coarse sandy loam, loamy fine sand, loamy sand, or loamy coarse sand in the fine-earth fraction. Below 25 cm it is loamy fine sand, loamy sand, loamy coarse sand, fine sand, sand, or coarse sand in the fine-earth fraction. Structure commonly is weak fine and/or medium granular or the horizon is structureless, but ranges through weak subangular blocky in some places. It is very friable, friable, or loose.

Some pedons have a BC horizon with characteristics similar to both the B and 2C horizons.

The C horizon has hue of 7.5YR through 5Y, value of 3 through 7, and chroma of 2 through 8. Texture is loamy fine sand, loamy sand, loamy coarse sand, fine sand, sand or coarse sand in the fine-earth fraction, and is stratified.

COMPETING SERIES: These are the Bonaparte, Manchester, Mecosta, Multorpor, Otisville, Quonset, and Rikers series. Mecosta and Multorpor soils are from outside Land Resource Region R. Bonaparte soils have carbonates within a depth of 100 cm. Manchester soils have 5YR or redder hue in the Bw and C horizons. Mecosta soils are calcareous and Multorpor soils do not have Bw horizons. Otisville soils have rock fragments dominated by sandstone, shale, and slate. Quonset soils have rock fragments dominated by phyllite, slate, and shale. Rikers soils have carboliths in the soil.

GEOGRAPHIC SETTING: Hinckley soils are nearly level through very steep soils on outwash terraces, outwash plains, outwash deltas, kames, kame terraces, and eskers. Slope is generally 0 through 8 percent on tops of the terraces, outwash plains and deltas. Slope of 8 through 60 percent or more are on the kames, eskers and margins of the outwash plains, deltas, and terraces. The soils formed in glaciofluvial sand and gravel derived principally from granite, gneiss, and schist. Mean annual temperature ranges from 7 to 13 degrees C, and mean annual precipitation ranges from 1016 to 1270 mm. Length of the growing season ranges from 140 through 240 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Agawam, Canton, Charlton, Deerfield, Essex, Gloucester, Horseneck, Mashpee, Massasoit, Merrimac, Paxton, Pompton, Riverhead, Scarboro, Sudbury, Walpole, Wareham, and Windsor soils on nearby landscapes. Horseneck, Pompton, and Riverhead soils are commonly associates in the extreme southern portions of MLRA 144A. Agawam, Merrimac, and Riverhead soils are similar to Hinckley soils, but have cambic horizons. Canton, Charlton, Essex, Gloucester, and Paxton soils formed in till. Deerfield, Horseneck, and Sudbury soils are moderately well drained and Horseneck and Sudbury soils have Cambic horizons. Pompton soils have Cambic horizons and are moderately well and somewhat poorly drained. Scarboro soils are very poorly drained. Windsor soils have less than 15 percent rock fragments. Mashpee and Massasoit soils are poorly drained with spodic horizons. Walpole and Wareham soils are poorly drained.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Excessively drained. Surface runoff is negligible through low. Saturated hydraulic conductivity is high or very high.

USE AND VEGETATION: Cleared areas are used for hay, pasture, and silage corn. In the southern Connecticut River Valley, Hinckley soils are used for growing tobacco and truck crops and in eastern Massachusetts, truck crops. Most areas are forested, brush land or used as urban land. Northern red, black, white, scarlet and scrub oak, eastern white and pitch pine, eastern hemlock, and gray birch are the common trees. Unimproved pasture and idle land support hardhack, little bluestem, bracken fern, sweet fern, and low bush blueberry.

DISTRIBUTION AND EXTENT: Connecticut, southern Maine, Massachusetts, New

Hampshire, northern New Jersey, New York, Rhode Island, and Vermont. MLRA's 101, 141, 142, 144A, 145, and 149B. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Oneida County, New York, 1913.

REMARKS: The use of the Hinckley series in frigid areas of Maine, and in MLRA 143 and 144B, is relict to before temperature classes. These have been removed from the SC file.

Diagnostic horizons and features recognized in this pedon are:
1. Ochric epipedon - the zone from 3 to 20 cm (Ap horizon).
2. Sandy-skeletal feature - the zone from 25 to 100 cm has a weighted average content of rock fragments of 51 percent and a particle size of the fine-earth fraction is sandy (Bw, BC, and C horizons).

ADDITIONAL DATA: Reference samples from pedons S55NH015002, S56MA011002, S56MA011003, S57MA023005, S58NH015002, S73MA009001, S73MA005002, S73MA009004, S73MA005005, S96NH013003 from Massachusetts and New Hampshire, samples by NSSL, Lincoln, NE, various dates.

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RIDGEBURY SERIES

The Ridgebury series consists of very deep, somewhat poorly and poorly drained soils formed in lodgment till derived mainly from granite, gneiss and/or schist. They are commonly shallow to a densic contact. They are nearly level to gently sloping soils in depressions in uplands. They also occur in drainageways in uplands, in toeslope positions of hills, drumlins, and ground moraines, and in till plains. Slope ranges from 0 to 15 percent. Saturated hydraulic conductivity is moderately high or high in the solum and very low to moderately low in the substratum. Mean annual temperature is about 9 degrees C. and the mean annual precipitation is about 1143 mm.

TAXONOMIC CLASS: Loamy, mixed, superactive, acid, mesic, shallow Aeric Endoaquepts

TYPICAL PEDON: Ridgebury sandy loam - on a 3 to 8 percent slope in an extremely stony wooded area at an elevation of about 334 m. (Colors are for moist soil.)

A--0 to 13 cm; black (N 2/0) fine sandy loam; weak medium and coarse granular structure; friable; many very fine, fine and medium tree roots; 5 percent gravel and 5 percent cobbles; very strongly acid; abrupt smooth boundary. (5 to 25 cm thick)

Bw--13 to 23 cm; brown (10YR 4/3) sandy loam; weak medium subangular blocky structure; friable; few fine tree roots; 5 percent gravel and 5 percent cobbles; very strongly acid; abrupt wavy boundary. (8 to 22 cm thick)

Bg--23 to 46 cm; dark gray (10YR 4/1) gravelly sandy loam; massive; friable; 10 percent gravel and 5 percent cobbles; common fine prominent yellowish brown (10YR 5/6) and common medium distinct reddish brown (5YR 4/4) masses of iron accumulation; very strongly acid; gradual wavy boundary. (10 to 43 cm thick)

Cd--46 to 165 cm; gray (5Y 5/1) gravelly sandy loam; massive; firm; 10 percent gravel and 5 percent cobbles; common fine prominent reddish yellow (7.5YR 6/8) masses of iron accumulation; very strongly acid.

TYPE LOCATION: Hampshire County, Massachusetts; Town of Pelham; 1,600 feet east of Route 202 at a point 3,950 feet south of its junction with Amherst Road; USGS Shutesbury quadrangle; latitude 42 degrees 22 minutes 53 seconds N. and longitude 72 degrees 23 minutes 45 second W., NAD 27.

RANGE IN CHARACTERISTICS: Depth to the dense till commonly is 36 to 49 cm. The A horizon has 5 to 25 percent gravel, 0 to 10 percent cobbles, and 0 to 25 percent stones by volume. The B and C horizons have 5 to 25 percent gravel, 0 to 5 percent cobbles and 0 to 5 percent stones. Rock fragments within the soil range from 5 to 35 percent by volume and are subangular fragments. The unlimed soil ranges from very strongly acid to slightly acid.

The O horizon, where present, has hue of 7.5YR to 2.5Y, value of 2, 2.5, or 3 and chroma of 0 to 2.

The A or Ap horizon is neutral or has hue of 10YR to 5Y, value of 2, 2.5, or 3 and chroma of 0 to 2. Texture is sandy loam, fine sandy loam or loam in the fine-earth fraction.

Some pedons have a thin E horizon with hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 or 2. Texture is the same as the A horizon.

The B horizon is neutral or has hue of 7.5YR to 5Y, value of 4 to 6, and chroma of 0 to 3.

The chroma is 4 in some places. Chroma of 3 or 4 is restricted to subhorizons. Redoximorphic features are few to many and are distinct or prominent. Texture is sandy loam, fine sandy loam, very fine sandy or loam in the fine earth fraction with fifteen percent or more fine sand or coarser and clay content less than 18 percent. The B horizon has subangular blocky structure, weak to moderate very thin to medium platy structure or is massive. It is very friable or friable.

The Cd horizon has hue of 10YR to 5Y, value of 3 to 6, and chroma of 1 to 4. It commonly has distinct or prominent redoximorphic features which generally become less abundant with depth but the range includes faint. Texture is coarse sandy loam, sandy loam, fine sandy loam, very fine sandy or loam in the fine-earth fraction. Consistence is firm or very firm and brittle. It is massive or has plates. Any physical aggregation is considered to not be pedogenic.

Some pedons have a C horizon below the Cd that is firm but not brittle.

COMPETING SERIES: There are no series currently in the same family.

The Painesville, Punsit, and Sun series are in a closely related family. Painesville soils lack a densic contact. Punsit soils have more than 60 percent silt plus very fine sand in the particle size control section. Sun soils formed in till derived from limestone and sandstone.

GEOGRAPHIC SETTING: The nearly level to gently sloping Ridgebury soils are in depressions and drainageways of till uplands. They also occur in toeslope positions and concave microfeatures of hills, drumlins, and ground moraines, and in till plains. Slope ranges from 0 to 15 percent. The soils formed in loamy lodgment till derived mainly from granite, gneiss and schist. Mean annual air temperature ranges from 7 to 11 degrees C and mean annual precipitation ranges from 1016 to 1270 mm. Mean growing season ranges from 100 to 195 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These include the Charlton, Chatfield, Hollis, Leicester, Paxton and Sutton, Whitman and Woodbridge soils. Ridgebury is a member of a drainage sequence that includes the well drained Paxton, moderately well drained Woodbridge, and very poorly drained Whitman soils. Charlton and Sutton soils are better drained and have friable substrata. Chatfield and Hollis soils have bedrock within depths of 100 and 50 cm respectively. Leicester soils do not have a densic contact.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Commonly poorly drained but the range includes the wetter part of somewhat poorly drained. Runoff is negligible to medium. Saturated hydraulic conductivity is moderately high or high in the solum and very low to moderately low in the substratum. A perched, fluctuating water table above the dense till saturates the solum to or near the surface for 7 to 9 months of the year.

USE AND VEGETATION: Largely forested to gray birch, yellow birch, red maple, hemlock, elm, spruce and balsam fir. Cleared areas are used mainly for hay and pasture.

DISTRIBUTION AND EXTENT: Glaciated landforms in Connecticut, Massachusetts, New Hampshire, New Jersey, New York, and Rhode Island. (MLRAs 142, 144A, 145, and 149B) The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Franklin County, Vermont, 1948.

REMARKS: An analysis of Ridgebury soils in 2002 for 38 surveys showed that this series most commonly has a densic contact at 40 to 60 cm including 8 surveys with the depth to a densic contact at 50 cm. The average depth to a densic contact was 50 cm - the data showed an almost even split between depth class occurrences. A review of characterization data for Ridgebury soils shows a very slight dominance in the acid reaction class. Any physical aggregation in the Cd is considered to not be pedogenic. The type location is currently within the officially designated mesic zone in Massachusetts. Previous revision of this series was 12/2005.

Diagnostic horizons and features in this pedon include:

1. Ochric epipedon - the zone from 0 to 13 cm (A horizon).
2. Aeric feature 100 percent of the zone from 13 to 23 cm has hue of 10YR and both color value moist of 4 and chroma moist of 3 (Bw1 horizon).
3. Cambic horizon - the zone from 13 to 46 cm (Bw and Bg horizons).
3. Densic contact root limiting material begins at 46 cm (Cd horizon).
4. Endosaturation the zone from 23 to 46 cm is saturated above the densic contact (Bw2 horizon). A seasonal high water table is perched above the densic materials.
5. Reaction - the pH in the zone from 25 to 46 cm (control section for reaction) is presumed less than 5.0 in 0.01 M CaCl2 (1:2) (see remarks).
6. Series control section - the zone from 0 to 71 cm.

ADDITIONAL DATA: Reference samples from pedons with User Pedon IDs of S2000CT013002, S1995NH013005, and S1996NH013002
from Connecticut and New Hampshire, samples by NSSL, Lincoln, NE, various years. The laboratory data for these pedons and similar soils is available through the National Cooperative Soil Survey Soil Characterization Database:
http://ncsslabdatamart.sc.egov.usda.gov/

National Cooperative Soil Survey
U.S.A.

Appendix B NDDB Coordination

79 Elm Street • Hartford, CT 06106-5127 www.ct.gov/deep Affirmative Action/Equal Opportunity Employer

September 14, 2021

Bob Russo
CLA Engineers
317 Main St
Norwich, CT 06360
brusso@claengineers.com

Project: Preliminary Assessment of Stone Ridge Business Park, 21 Gurley Rd in Waterford, CT
NDDB Preliminary Assessment No.: 202109516

Dear Mr. Russo,

I have reviewed Natural Diversity Database maps and files regarding the area delineated on the map provided for a preliminary assessment of the proposed Stone Ridge Business Park at 21 Gurley Road in Waterford, Connecticut.

According to our records there are known extant populations of State Listed Species that occur in the vicinity of this property. I have attached a list of species known from this area. We have not visited this site. Depending on the habitat available, these or other species may be present. Please be advised that this is a preliminary review and not a final determination. A more detailed review will be necessary to move forward with any environmental permit applications submitted to DEEP for the proposed project. **This preliminary assessment letter cannot be used or submitted with permit applications at DEEP**. This letter is valid for one year.

To better evaluate the property and to plan for management activities that may enhance habitat or prevent impacts to State-listed species, field surveys of the site should be performed by a qualified biologist(s) with the appropriate scientific collecting permits at a time when these target species are identifiable. A report summarizing the results of such surveys should include:

1. Survey date(s) and duration
2. Site descriptions and photographs
3. List of component vascular plant and animal species within the survey area (including scientific binomials)
4. Data regarding population numbers and/or area occupied by State-listed species
5. Detailed maps of the area surveyed including the survey route and locations of State listed species
6. Conservation strategies or protection plans that indicate how impacts may be avoided for all state listed species present on the site
7. Statement/résumé indicating the biologist's qualifications. Please be sure when you hire a consulting qualified biologist to help conduct this site survey that they have the proper experience with target taxon and have a CT scientific collectors permit to work with state listed species for this specific project.

The site surveys report should be sent to our CT DEEP-NDDB Program (deep.nddbrequest@ct.gov) for further review by our program biologists along with an updated request for another NDDB review. Incomplete reports may not be accepted.

If you do not intend to do site surveys to determine the presence or absence of state-listed species, then you should presume species are present and let us know how you will protect the state-listed species from being impacted by this project. You may submit these best management practices or protection plans with your new request for an NDDB review. After reviewing your new NDDB request form and the documents describing how you will protect this species from project impacts we will make a final determination and provide you with a letter from our program to use with DEEP-Permits.

Natural Diversity Database information includes all information regarding critical biological resources available to us at the time of the request. This information is a compilation of data collected over the years by the Department of Energy and Environmental Protection's Natural History Survey, cooperating units of DEEP, landowners, private conservation groups and the scientific community. This information is not necessarily the result of comprehensive or site-specific field investigations. Consultations with the NDDB should not be substitutes for onsite surveys necessary for a thorough environmental impact assessment. The result of this review does not preclude the possibility that listed species may be encountered on site and that additional action may be necessary to remain in compliance with certain state permits.

Please contact me if you have further questions at (860) 424-3378, or karen.zyko@ct.gov . Thank you for consulting the Natural Diversity Data Base.

Sincerely,

Karen Zyko

Karen Zyko
Environmental Analyst

Species List for NDDB Request

Scientific Name	Common Name	State Status
Vertebrate Animal		
Opheodrys vernalis	Smooth green snake	SC
Thamnophis sauritus	Eastern ribbon snake	SC
Terrapene carolina carolina	Eastern box turtle	SC
Icteria virens	Yellow-breasted chat	E
Toxostoma rufum	Brown thrasher	SC

E = State Endangered, T = State Threatened, SC = State Special Concern
FE = Federally Endangered, FT = Federally Threatened

Appendix C
Photographs

Photograph1 – Wetland 1. Culvert that carries perennial stream under I-95, looking upstream. Note the cobbles and stones collected in the channel, presumably from previous extreme floods as the channel itself does not show erosion. The channel here is 6-8 inches deep and 10-12 feet wide.

Photograph 2 – Wetland 1. Perennial stream approximately 350 feet upstream from Gurley Rd, taken looking downstream. Note the gravel and cobble substrate. The channel here is less than 6 inches deep and 5-6 feet wide.

Photograph 3 – Wetland 4/5. This is the vernal pool in the eastern most part of the wetland. .

Photograph 4 – Wetland 4/5. This man made pond also functions as a vernal pool. This photograph was taken from the driveway/dam.

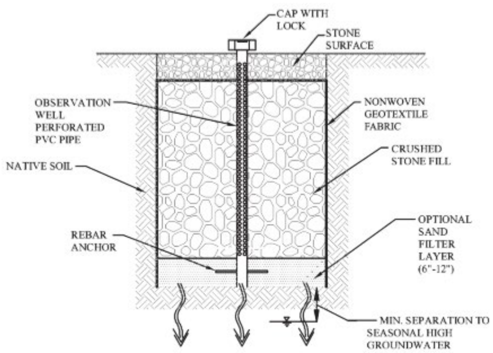
Appendix D
University of New Hampshire
Water Quality Data

Infiltration Trench Factsheet

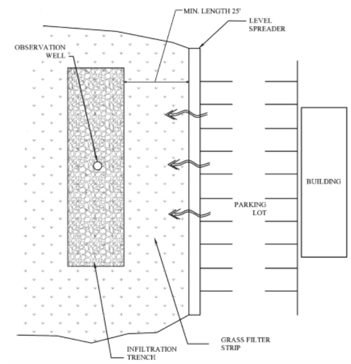
Infiltration Trench is a practice that provides temporary storage of runoff using the void spaces within the soil/sand/gravel mixture that is used to backfill the trench for subsequent infiltration into the surrounding sub-soils. Performance results for the infiltration trench can be used for all subsurface infiltration practices including systems that include pipes and/or chambers that provide temporary storage. Also, the results for this BMP type can be used for bio-retention systems that rely on infiltration when the majority of the temporary storage capacity is provided in the void spaces of the soil filter media and porous pavements that allow infiltration to occur. General design specifications for infiltration trench systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Cross Section



Plan View



Examples images from the *New Hampshire Stormwater Manual, Volume 2,* p. 86

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft^3) (2020)	Design Cost ($/ft^3) (2020)	Total Cost ($/ft^3) (2020)[1,2]
Rural	8.33	4.49	12.82
Mixed	16.67	8.97	25.64
Urban	25.00	13.46	38.46

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

Prepared By:
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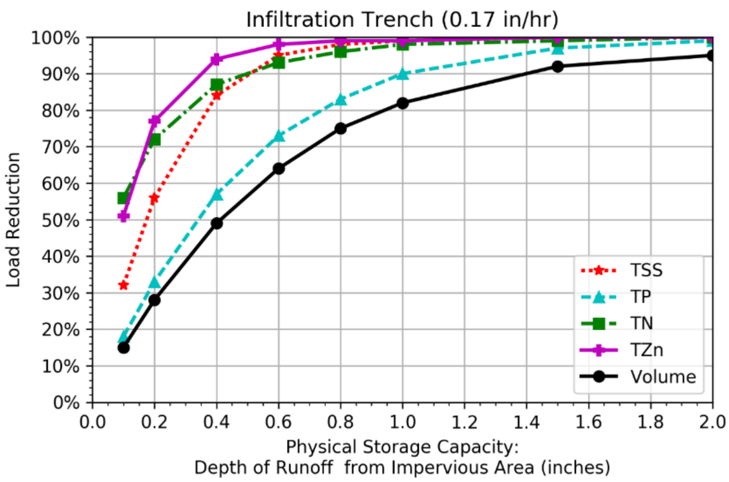
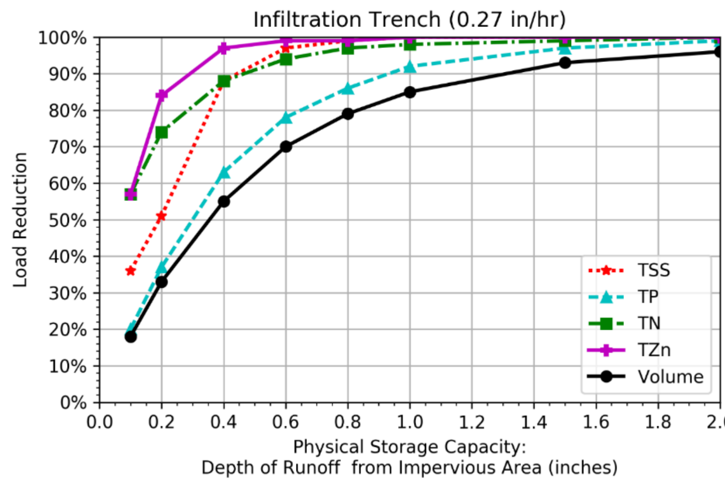
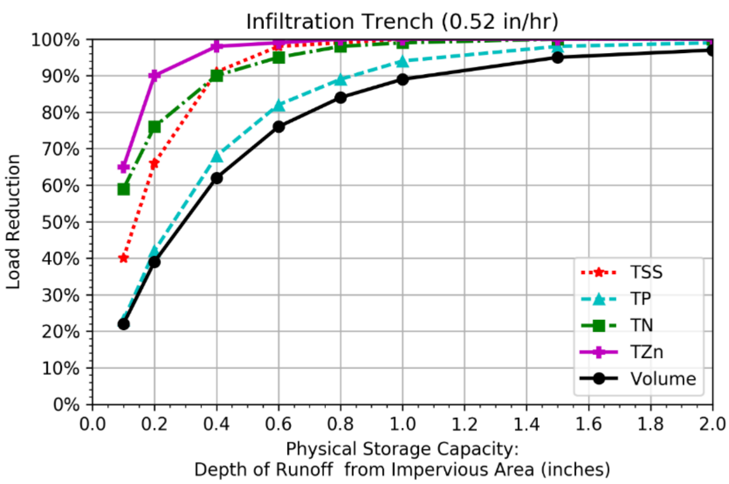
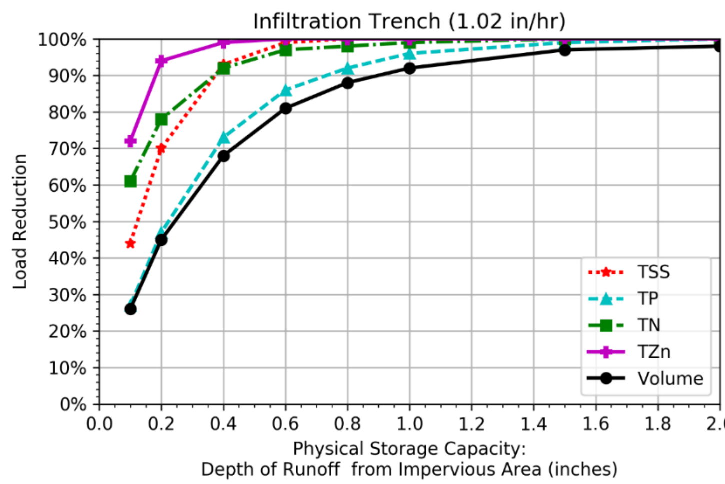
Stormwater Center
Durham, NH
www.unh.edu/unhsc
January 2020

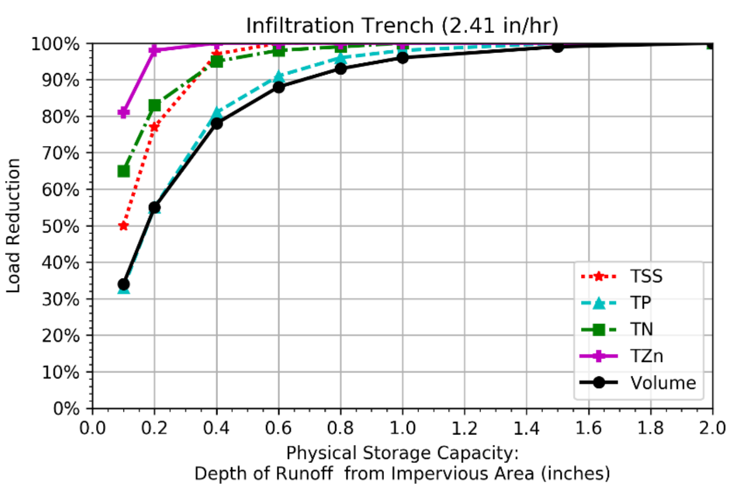
BMP Performance Curves for Soil Infiltration Rate: Infiltration Trench

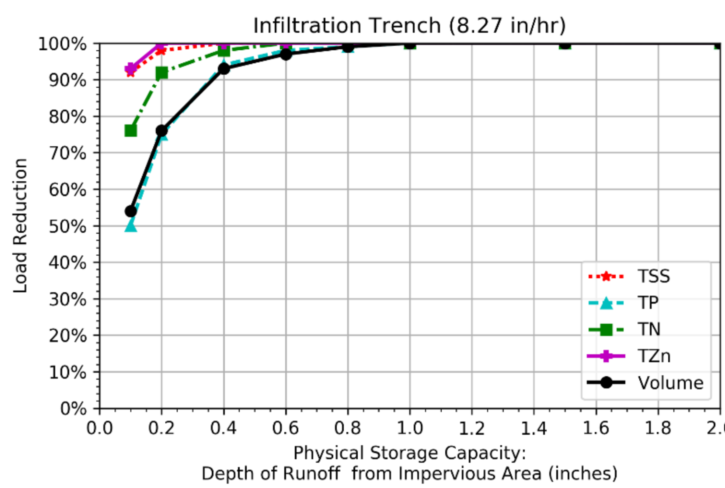












BMP Performance Tables for Soil Infiltration Rate: Infiltration Trench

		Cumulative Load Reduction				
Infiltration Rate (in/hr)	Depth of Runoff from Impervious Area (inches)	TSS	Phosphorus	Nitrogen	Zinc	Runoff Volume
0.17	0.1	32%	18%	56%	51%	15%
	0.2	56%	33%	72%	77%	28%
	0.4	84%	57%	87%	94%	49%
	0.6	95%	73%	93%	98%	64%
	0.8	98%	83%	96%	99%	75%
	1.0	99%	90%	98%	99%	82%
	1.5	100%	97%	99%	100%	92%
	2.0	100%	99%	100%	100%	95%
0.27	0.1	36%	20%	57%	57%	18%
	0.2	51%	37%	74%	84%	33%
	0.4	88%	63%	88%	97%	55%
	0.6	97%	78%	94%	99%	70%
	0.8	99%	86%	97%	99%	79%
	1.0	100%	92%	98%	100%	85%
	1.5	100%	97%	99%	100%	93%
	2.0	100%	99%	100%	100%	96%
0.52	0.1	40%	23%	59%	65%	22%
	0.2	66%	42%	76%	90%	39%
	0.4	91%	68%	90%	98%	62%
	0.6	98%	82%	95%	99%	76%
	0.8	99%	89%	98%	100%	84%
	1.0	100%	94%	99%	100%	89%
	1.5	100%	98%	100%	100%	95%
	2.0	100%	99%	100%	100%	97%

BMP Performance Tables for Soil Infiltration Rate: Infiltration Trench

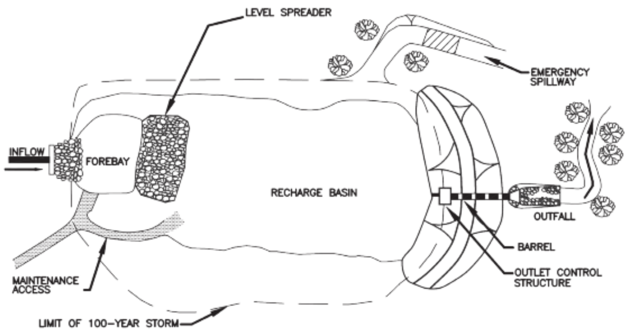
		Cumulative Load Reduction				
Infiltration Rate (in/hr)	Depth of Runoff from Impervious Area (inches)	TSS	Phosphorus	Nitrogen	Zinc	Runoff Volume
1.02	0.1	44%	27%	61%	72%	26%
	0.2	70%	47%	78%	94%	45%
	0.4	93%	73%	92%	99%	68%
	0.6	99%	86%	97%	100%	81%
	0.8	100%	92%	98%	100%	88%
	1.0	100%	96%	99%	100%	92%
	1.5	100%	99%	100%	100%	97%
	2.0	100%	100%	100%	100%	98%
2.41	0.1	50%	33%	65%	81%	34%
	0.2	77%	55%	83%	98%	55%
	0.4	97%	81%	95%	100%	78%
	0.6	100%	91%	98%	100%	88%
	0.8	100%	96%	99%	100%	93%
	1.0	100%	98%	100%	100%	96%
	1.5	100%	100%	100%	100%	99%
	2.0	100%	100%	100%	100%	100%
8.27	0.1	92%	50%	76%	93%	54%
	0.2	98%	75%	92%	100%	76%
	0.4	100%	94%	98%	100%	93%
	0.6	100%	98%	100%	100%	97%
	0.8	100%	99%	100%	100%	99%
	1.0	100%	100%	100%	100%	100%
	1.5	100%	100%	100%	100%	100%
	2.0	100%	100%	100%	100%	100%

Infiltration Basin Factsheet

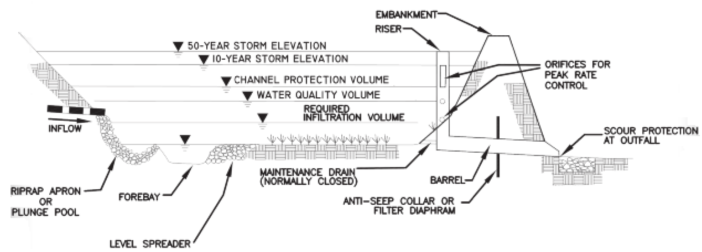
Infiltration Basin represents a practice that provides temporary surface storage of runoff (e.g. ponding) for subsequent infiltration into the ground. Appropriate practices for use of the surface infiltration performance estimates include infiltration basins, infiltration swales (not conveyance swales), rain gardens, and bio-retention systems that rely on infiltration and provide the majority of storage capacity through surface-ponding. If an infiltration system includes both surface storage through ponding and a lesser storage volume within the void spaces of a coarse filter media, then the physical storage volume capacity used to determine the long-term cumulative phosphorus removal efficiency from the infiltration basin performance curves would be equal to the sum of the surface storage volume and the void space storage volume. General design specifications for infiltration basin systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Plan View



Profile View



Examples images from the *New Hampshire Stormwater Manual, Volume 2*, p. 90

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft³) (2020)	Design Cost ($/ft³) (2020)	Total Cost ($/ft³) (2020)[1,2]
Rural	4.17	2.24	6.41
Mixed	8.33	4.49	12.82
Urban	12.50	6.73	19.23

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

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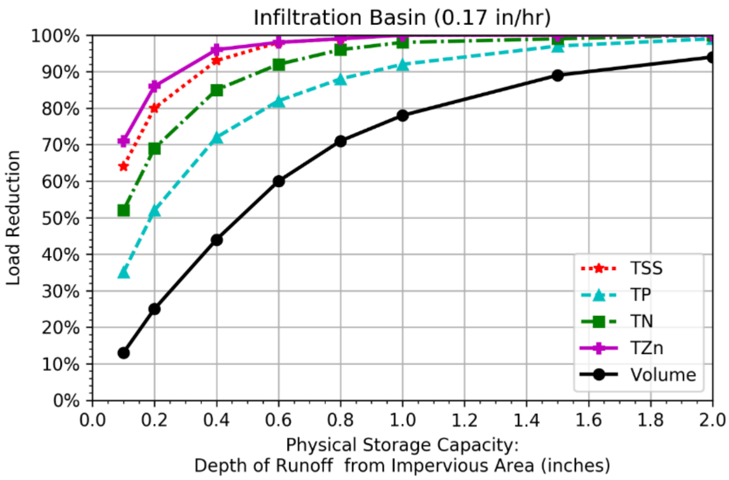
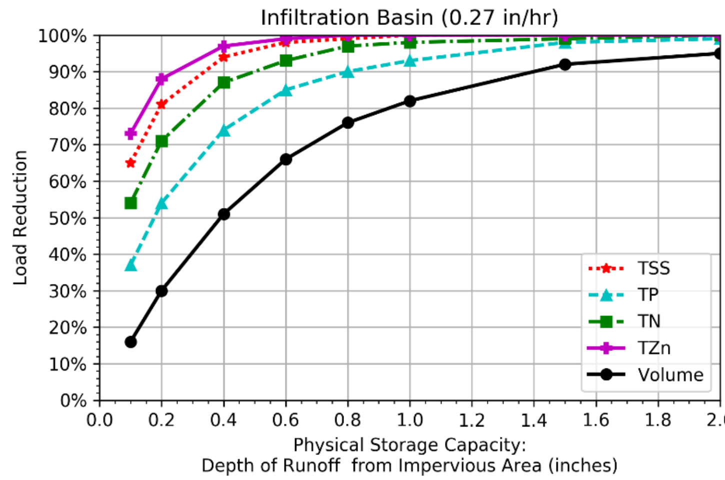
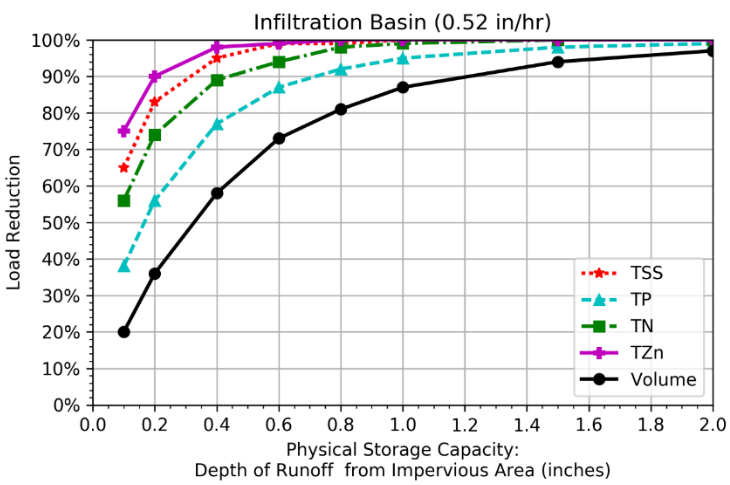
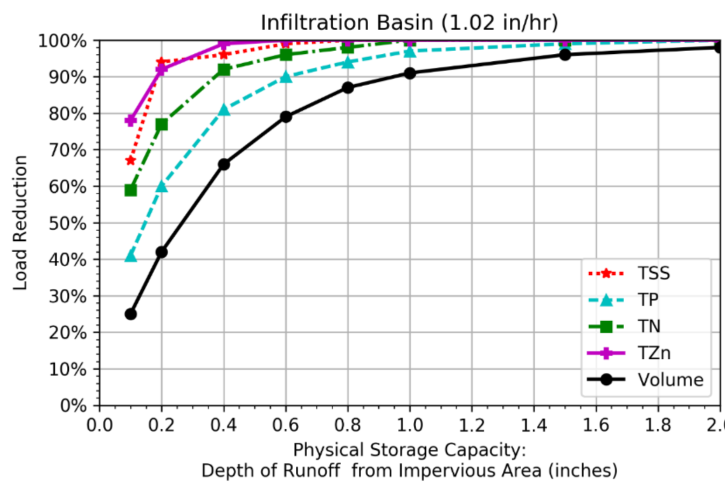
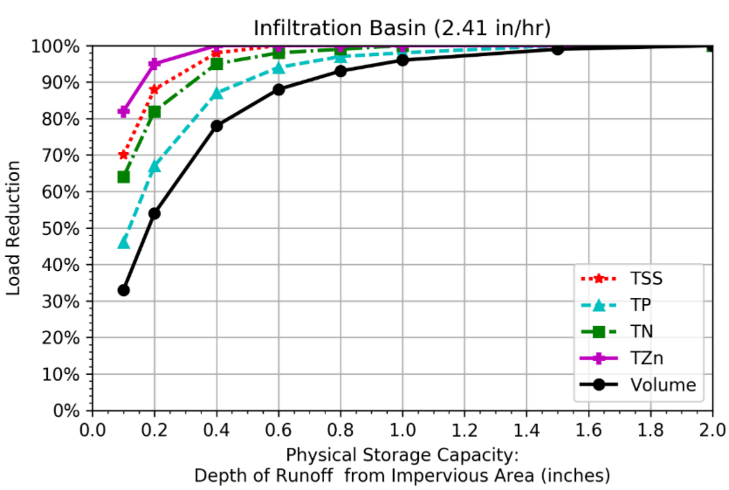
BMP Performance Curves for Soil Infiltration Rate: Infiltration Basin

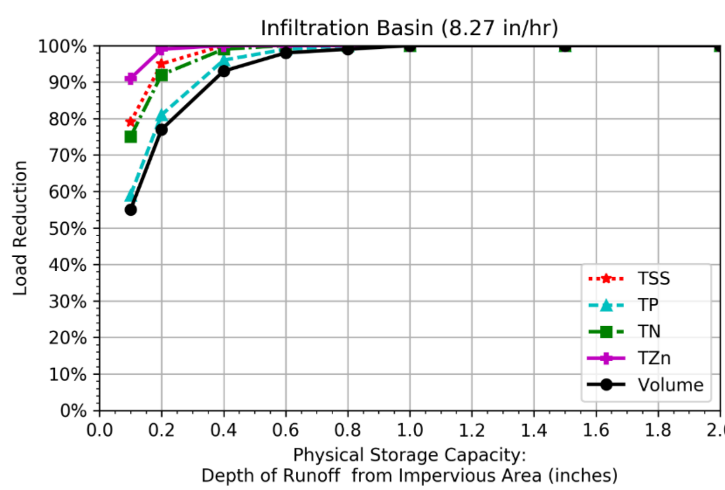












BMP Performance Tables for Soil Infiltration Rate: Infiltration Basin

		Cumulative Load Reduction				
Infiltration Rate (in/hr)	Depth of Runoff from Impervious Area (inches)	TSS	Phosphorus	Nitrogen	Zinc	Runoff Volume
0.17	0.1	64%	35%	52%	71%	13%
	0.2	80%	52%	69%	86%	25%
	0.4	93%	72%	85%	96%	44%
	0.6	98%	82%	92%	98%	60%
	0.8	99%	88%	96%	99%	71%
	1.0	100%	92%	98%	100%	78%
	1.5	100%	97%	99%	100%	89%
	2.0	100%	99%	100%	100%	94%
0.27	0.1	65%	37%	54%	73%	16%
	0.2	81%	54%	71%	88%	30%
	0.4	94%	74%	87%	97%	51%
	0.6	98%	85%	93%	99%	66%
	0.8	99%	90%	97%	100%	76%
	1.0	100%	93%	98%	100%	82%
	1.5	100%	98%	99%	100%	92%
	2.0	100%	99%	100%	100%	95%
0.52	0.1	65%	38%	56%	75%	20%
	0.2	83%	56%	74%	90%	36%
	0.4	95%	77%	89%	98%	58%
	0.6	99%	87%	94%	99%	73%
	0.8	99%	92%	98%	100%	81%
	1.0	100%	95%	99%	100%	87%
	1.5	100%	98%	100%	100%	94%
	2.0	100%	99%	100%	100%	97%

BMP Performance Tables for Soil Infiltration Rate: Infiltration Basin

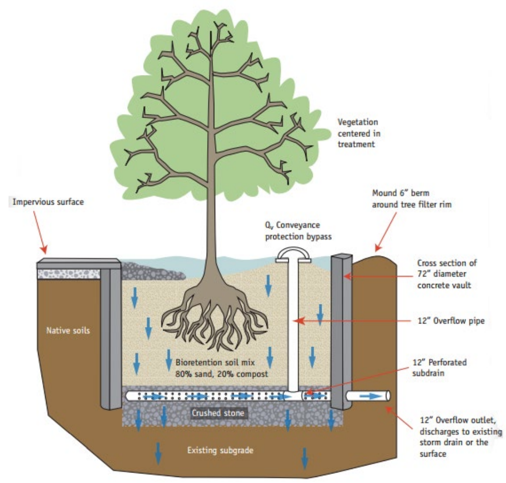
		Cumulative Load Reduction				
Infiltration Rate (in/hr)	Depth of Runoff from Impervious Area (inches)	TSS	Phosphorus	Nitrogen	Zinc	Runoff Volume
1.02	0.1	67%	41%	59%	78%	25%
	0.2	94%	60%	77%	92%	42%
	0.4	96%	81%	92%	99%	66%
	0.6	99%	90%	96%	100%	79%
	0.8	100%	94%	98%	100%	87%
	1.0	100%	97%	100%	100%	91%
	1.5	100%	99%	100%	100%	96%
	2.0	100%	100%	100%	100%	98%
2.41	0.1	70%	46%	64%	82%	33%
	0.2	88%	67%	82%	95%	54%
	0.4	98%	87%	95%	100%	78%
	0.6	100%	94%	98%	100%	88%
	0.8	100%	97%	99%	100%	93%
	1.0	100%	98%	100%	100%	96%
	1.5	100%	100%	100%	100%	99%
	2.0	100%	100%	100%	100%	100%
8.27	0.1	79%	59%	75%	91%	55%
	0.2	95%	81%	92%	99%	77%
	0.4	100%	96%	99%	100%	93%
	0.6	100%	99%	100%	100%	98%
	0.8	100%	100%	100%	100%	99%
	1.0	100%	100%	100%	100%	100%
	1.5	100%	100%	100%	100%	100%
	2.0	100%	100%	100%	100%	100%

Biofiltration Factsheet

Biofiltration is a practice that provides temporary storage of runoff for filtering through an engineered soil media. The storage capacity is typically made of void spaces in the filter media and temporary ponding at the surface of the practice. Once the runoff has passed through the filter media it is collected by an under-drain pipe for discharge. The performance curve for this control practice assumes zero infiltration. If a filtration system has subsurface soils that are suitable for infiltration, then user should use either the performance curves for the infiltration trench or the infiltration basin depending on the predominance of storage volume made up by free standing storage or void space storage. Depending on the design of the manufactured or packaged bio-filter systems such as tree box filters may be suitable for using the bio-filtration performance results. Design specifications for biofiltration systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Profile view of a Tree Box Filter. The underdrain makes the system one example of a biofiltration system.



Examples images from the *New Hampshire Stormwater Manual, Volume 2,* p. 116

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft^3) (2020)	Design Cost ($/ft^3) (2020)	Total Cost ($/ft^3) (2020)[1,2]
Rural	10.32	5.55	15.87
Mixed	20.63	11.11	31.74
Urban	30.95	16.66	47.61

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

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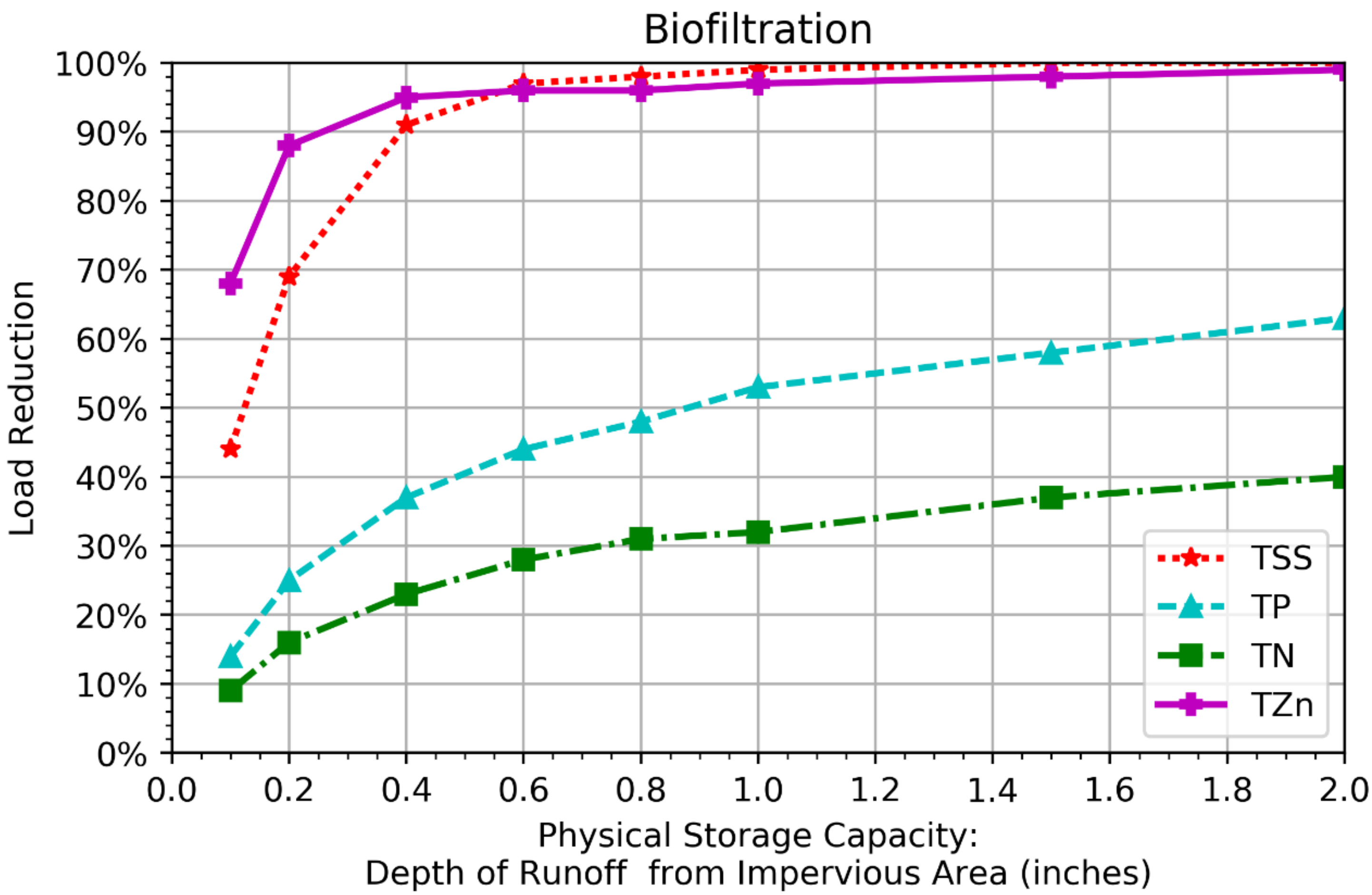
January 2020

BMP Performance Curve for Biofiltration



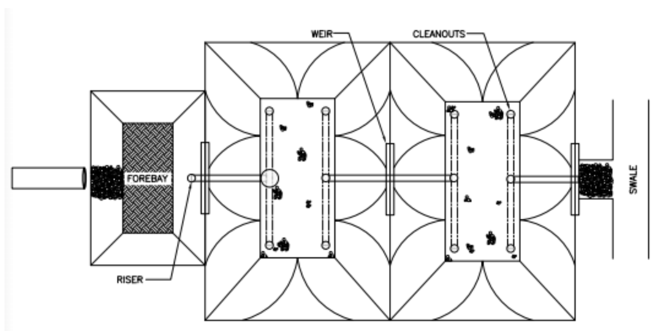
Biofiltration BMP Performance Table								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative TSS Phosphorus Load Reduction	44%	69%	91%	97%	98%	99%	100%	100%
Cumulative Phosphorus Load Reduction	14%	25%	37%	44%	48%	53%	58%	63%
Cumulative Nitrogen Load Reduction	9%	16%	23%	28%	31%	32%	37%	40%
Cumulative Zinc Phosphorus Load Reduction	68%	88%	95%	96%	96%	97%	98%	99%

Gravel Wetlands Factsheet

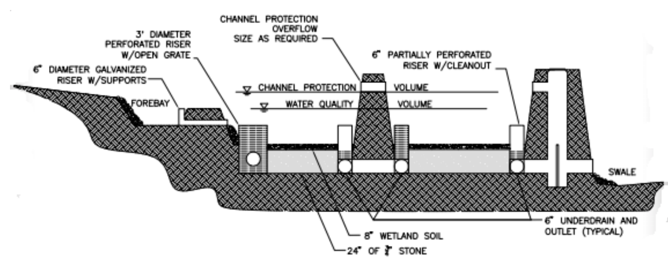
Gravel Wetlands consists of one or more flow-through constructed wetland cells, preceded by a forebay. The cells are filled with a gravel media, supporting an organic substrate that is planted with wetland vegetation. During low-flow storm events, the systems is designed to promote subsurface horizontal flow through the gravel media, allowing contact with the root zone of the wetland vegetation. The gravel and planting media support a community of soil microorganisms. Water quality treatment occurs through microbial, chemical, and physical processes within this media. Treatment may also be enhanced by vegetative uptake.. General design specifications for infiltration basin systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Plan View



Profile View



Examples images from the *New Hampshire Stormwater Manual, Volume 2,* p. 80

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft³) (2020)	Design Cost ($/ft³) (2020)	Total Cost ($/ft³) (2020)[1,2]
Rural	5.86	3.15	9.01
Mixed	11.71	6.31	18.02
Urban	17.57	9.46	27.03

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

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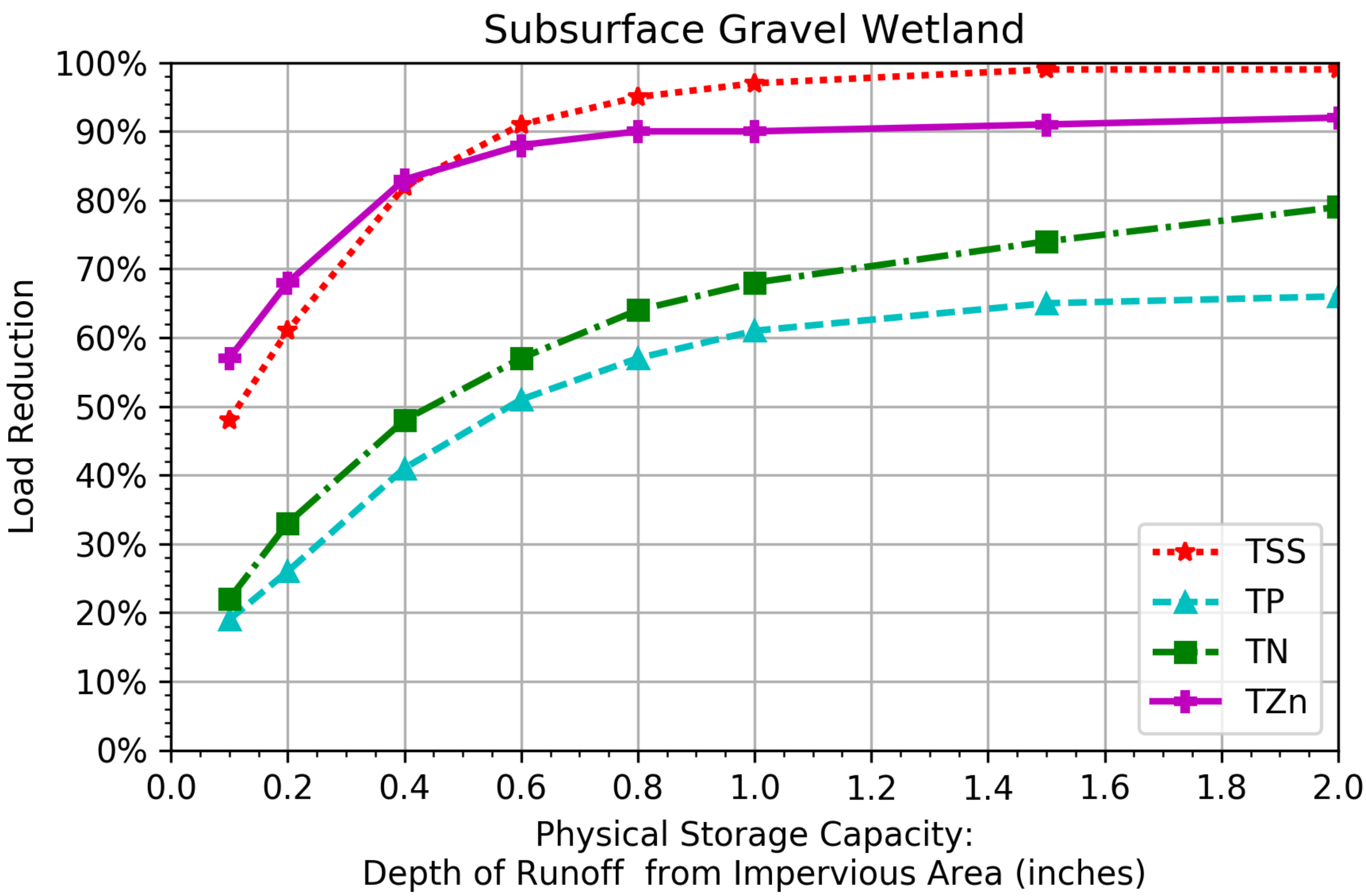
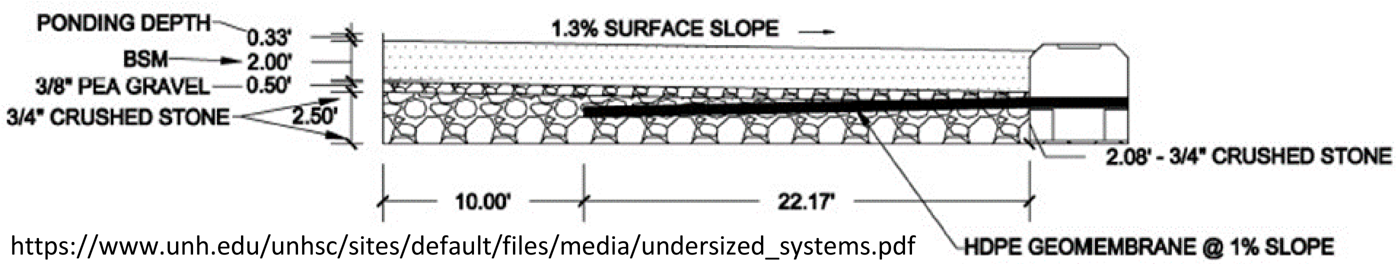
BMP Performance Curve for Gravel Wetlands



Gravel Wetland BMP Performance Table								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative TSS Phosphorus Load Reduction	48%	61%	82%	91%	95%	97%	99%	99%
Cumulative Phosphorus Load Reduction	19%	26%	41%	51%	57%	61%	65%	66%
Cumulative Nitrogen Load Reduction	22%	33%	48%	57%	64%	68%	74%	79%
Cumulative Zinc Phosphorus Load Reduction	57%	68%	83%	88%	90%	90%	91%	92%

Enhanced Biofiltration with Internal Storage Reservoir (ISR) Factsheet

Enhanced Biofiltration is a practice the provides temporary storage of runoff for filtering through an engineered soil media, augmented for enhanced phosphorus removal, followed by detention and denitrification in a subsurface internal storage reservoir (ISR) comprised of gravel. Runoff flows are routed through filter media and directed to the underlying ISR via an impermeable membrane for temporary storage. An elevated outlet control at the top of the ISR is designed to provide a retention time of at least 24 hours in the system to allow for sufficient time for denitrification and nitrogen reduction to occur prior to discharge. The design storage capacity for using the cumulative performance curves is comprised of void spaces in the filter media, temporary ponding at the surface of the practice and the void spaces in the gravel ISR. The cumulative phosphorus load reduction curve for this control is intended to be used for systems in which the filter media has been augmented with materials designed and/or known to be effective at capturing phosphorus. If the filter media is not augmented to enhance phosphorus capture, then the phosphorus performance curve for the Bio-Filter should be used for estimating phosphorus load reductions. The University of New Hampshire Stormwater Center (UNHSC) developed the design of this control practice and a design templated can be found at UNHSC's website.



https://www.unh.edu/unhsc/sites/default/files/media/undersized_systems.pdf

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft^3) (2020)	Design Cost ($/ft^3) (2020)	Total Cost ($/ft^3) (2020)[1,2]
Rural	10.42	5.61	16.02
Mixed	20.83	11.22	32.05
Urban	31.25	16.83	48.07

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

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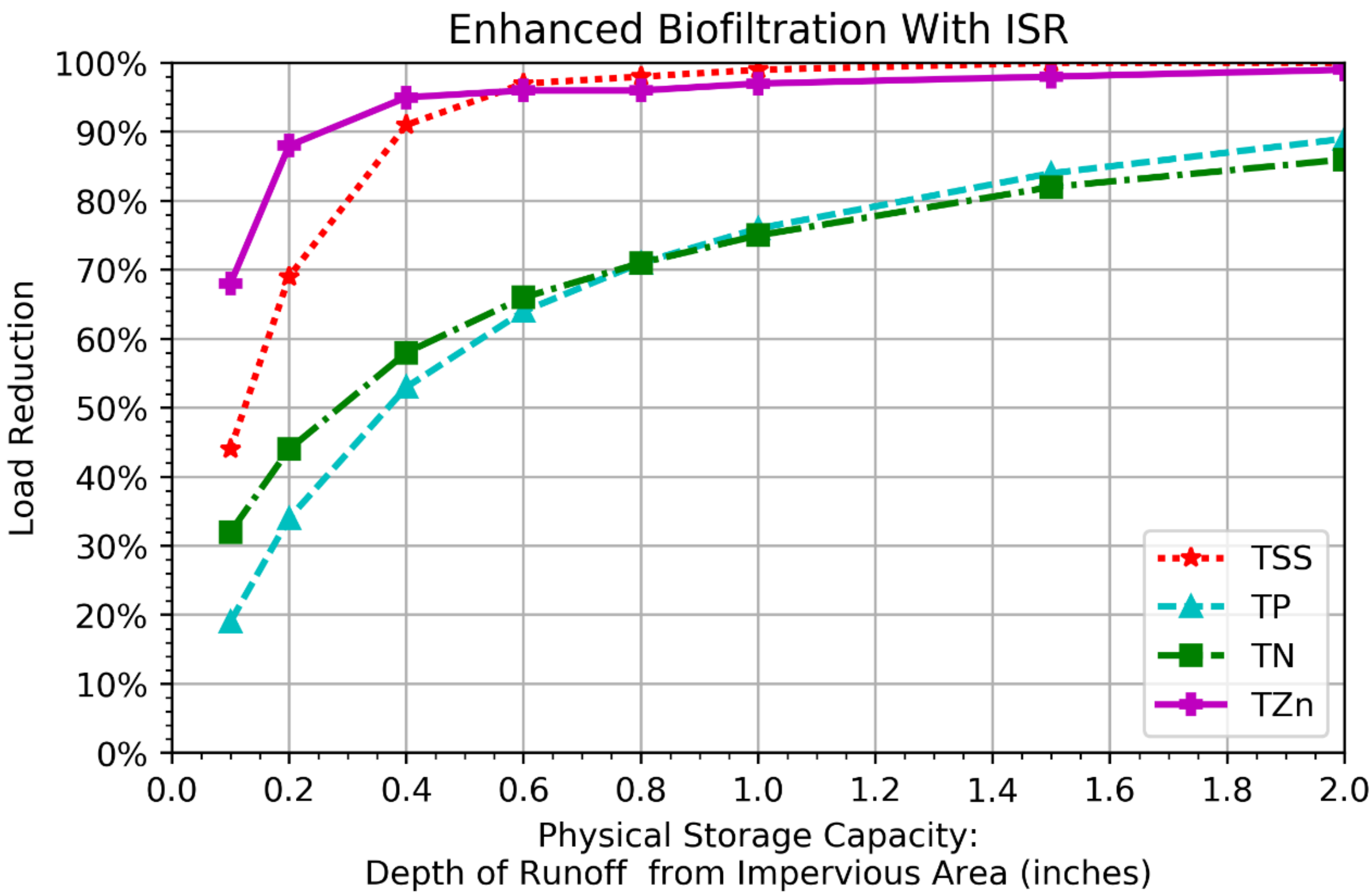
BMP Performance Curve for Enhanced Biofiltration w/ ISR



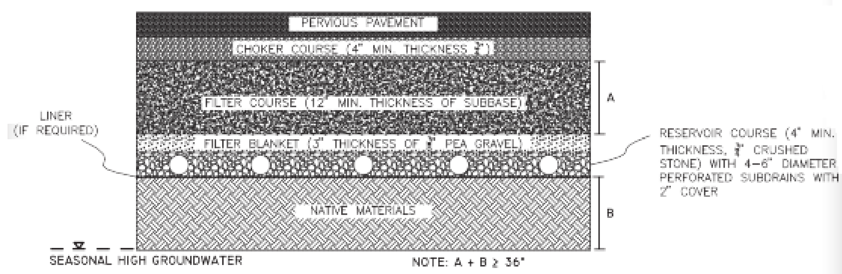
Enhanced Biofiltration w/ ISR BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative TSS Phosphorus Load Reduction	44%	69%	91%	97%	98%	99%	100%	100%
Cumulative Phosphorus Load Reduction	19%	34%	53%	64%	71%	76%	84%	89%
Cumulative Nitrogen Load Reduction	32%	44%	58%	66%	71%	75%	82%	86%
Cumulative Zinc Phosphorus Load Reduction	68%	88%	95%	96%	96%	97%	98%	99%

Porous Pavement Factsheet

Porous Pavement consists of a porous surface, base, and sub-base materials which allow penetration of runoff through the surface into underlying soils. The surface materials for porous pavements can consist of paving blocks or grids, pervious asphalt, or pervious concrete. These materials are installed on a base which serves as a filter course between the pavement surface and the underlying sub-base material. The sub-base material typically comprises a layer of crushed stone that not only supports the overlying pavement structure, but also serves as a reservoir to store runoff that penetrates the pavement surface until it can percolate into the ground. General design specifications for porous pavement systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Profile View



Examples images from the *New Hampshire Stormwater Manual, Volume 2,* p. 120

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft³) (2020)		Design Cost ($/ft³) (2020)		Total Cost ($/ft³) (2020)[1,2]	
	Porous Asphalt	Porous Concrete	Porous Asphalt	Porous Concrete	Porous Asphalt	Porous Concrete
Rural	3.55	12.06	1.91	6.49	5.46	18.55
Mixed	7.10	24.12	3.82	12.99	10.92	37.11
Urban	10.65	36.18	5.73	19.48	16.38	55.66

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

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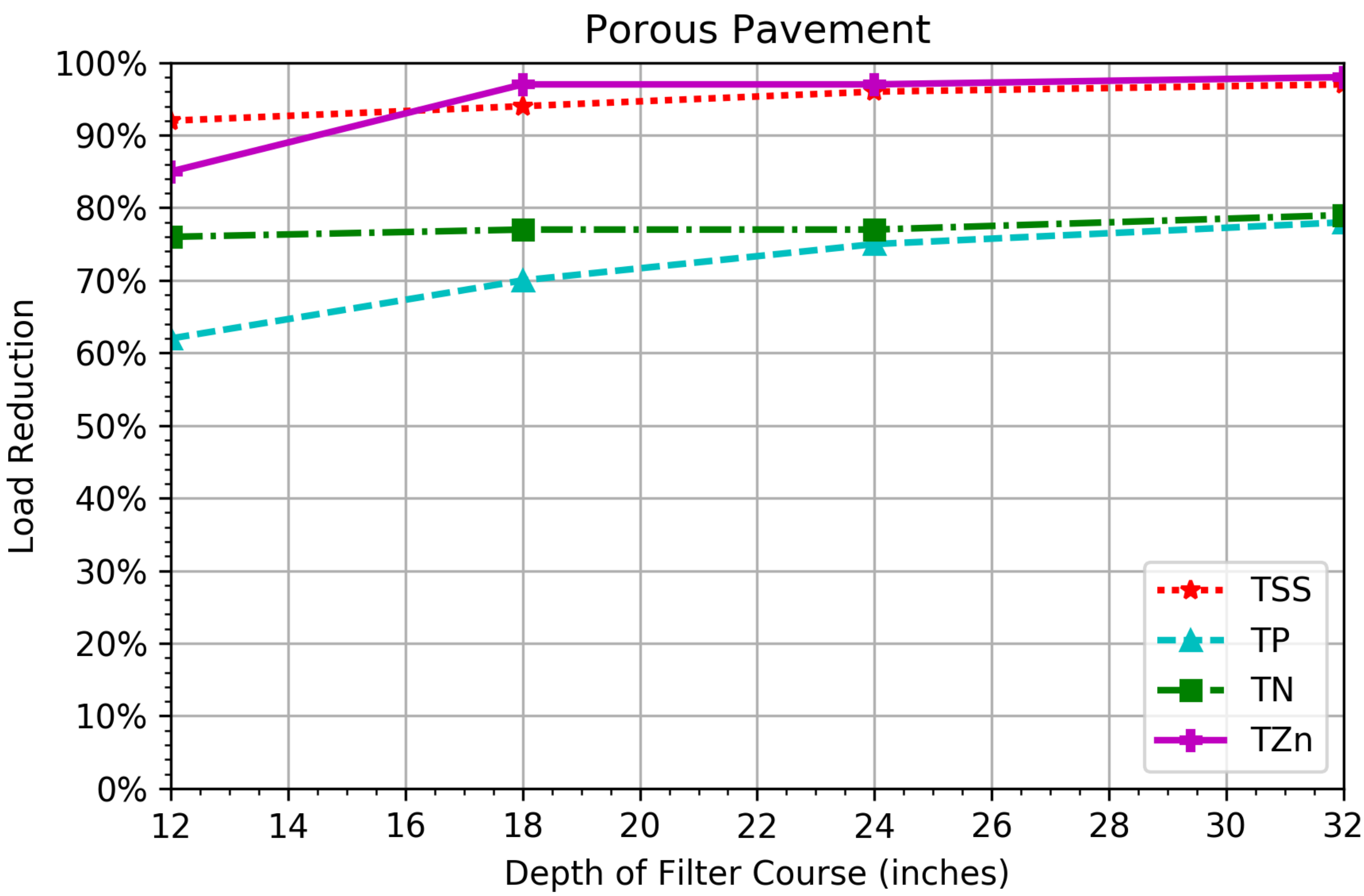
BMP Performance Curve for Porous Pavement



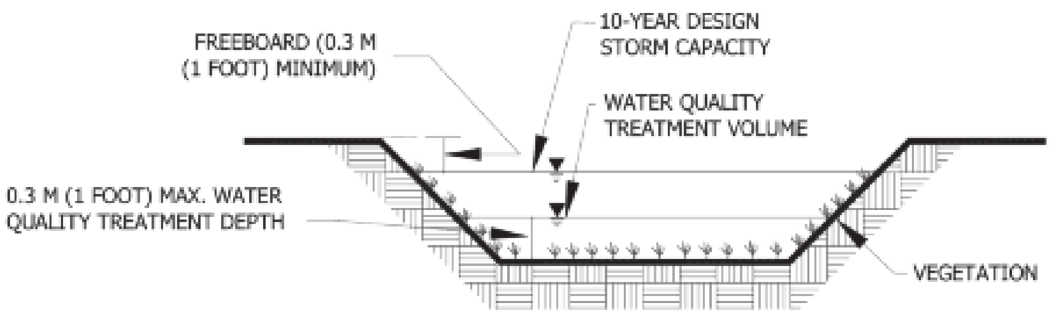
Porous Pavement BMP Performance Table				
BMP Capacity: Depth of Filter Course Area (inches)	12	18	24	32
Cumulative TSS Phosphorus Load Reduction	92%	94%	96%	97%
Cumulative Phosphorus Load Reduction	62%	70%	75%	78%
Cumulative Nitrogen Load Reduction	76%	77%	77%	79%
Cumulative Zinc Phosphorus Load Reduction	85%	97%	97%	98%

Grass Swale Factsheet

Grass Swale is a system which consists of a vegetated channel with check dams designed to convey and treat stormwater runoff. The design of allows filtration through the vegetation and check dams and infiltration through the subsurface soil media. Vegetation for the swale is selected based on mowing requirements, expected design flow, and site soil conditions. The channel should be designed to carry the max design flow within the design depth while preventing erosion within the channel. General design specifications for grass swale systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Profile View



Examples images from the *New Hampshire Stormwater Manual, Volume 2,* p. 145

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016

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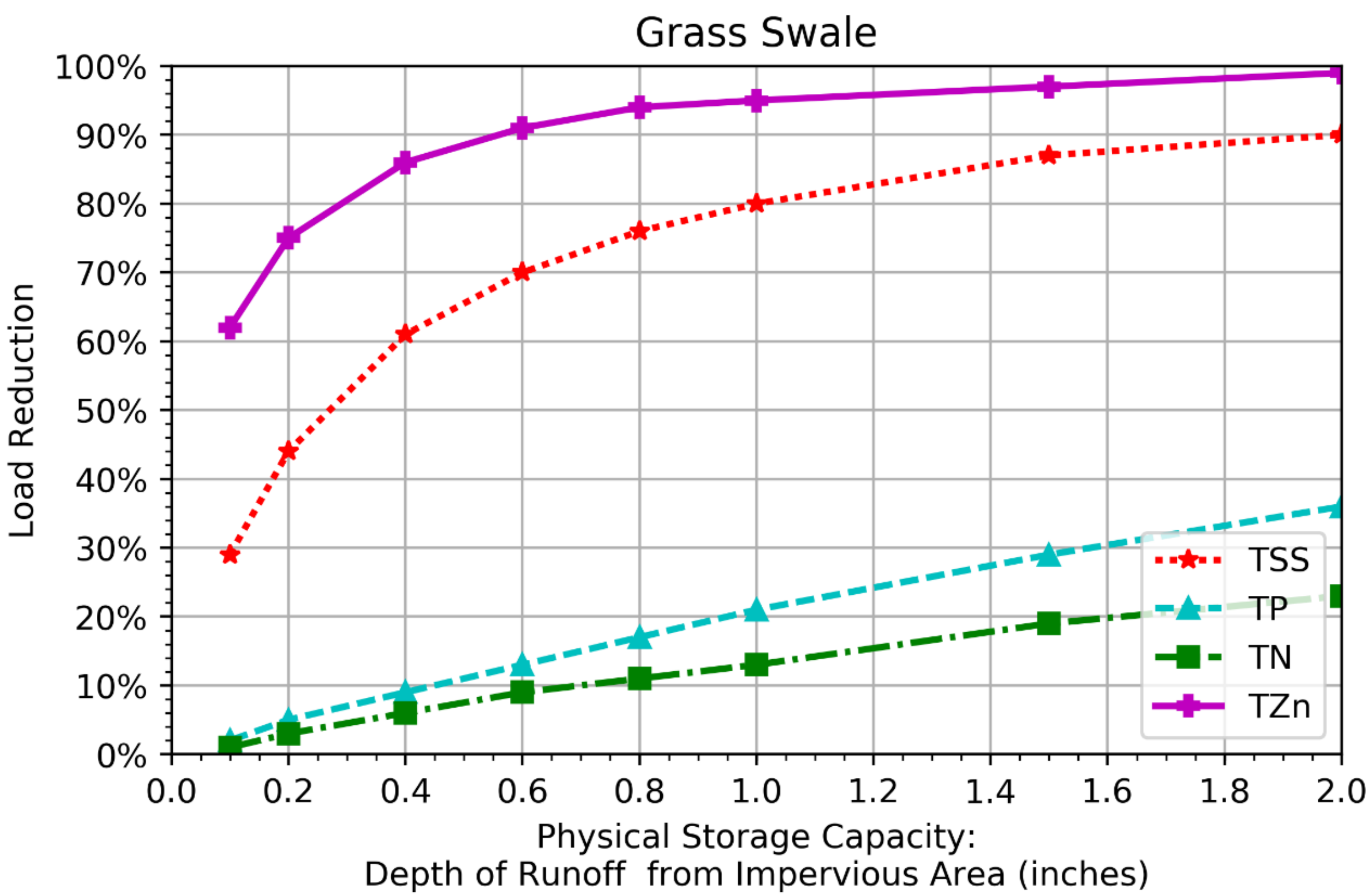
January 2020

BMP Performance Curve for Grass Swale



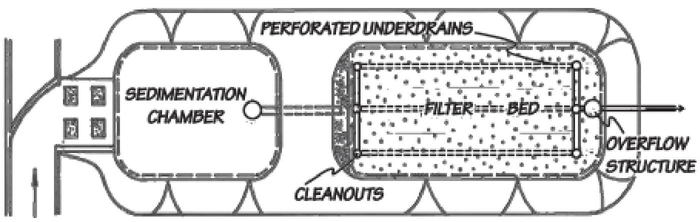
Grass Swale BMP Performance Table								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative TSS Phosphorus Load Reduction	29%	44%	61%	70%	76%	80%	87%	90%
Cumulative Phosphorus Load Reduction	2%	5%	9%	13%	17%	21%	29%	36%
Cumulative Nitrogen Load Reduction	1%	3%	6%	9%	11%	13%	19%	23%
Cumulative Zinc Phosphorus Load Reduction	62%	75%	86%	91%	94%	95%	97%	99%

Sand Filter Factsheet

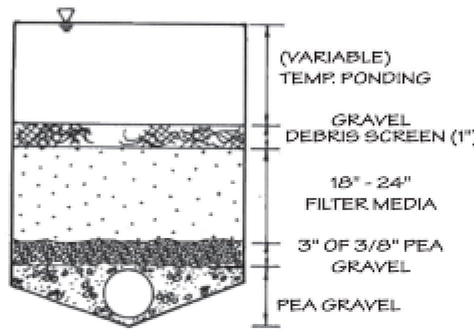
Sand Filter is a system which provides filtering of runoff through a sand filter media and temporary storage of runoff within the void spaces prior to discharge by way of an underdrain. Sand filters are generally used for overflow conditions of the primary BMP, and as such often include a pretreatment device to allow coarse settlements to settle out of the water. The top surface of the filter is kept clear of vegetation. General design specifications for sand filter systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Plan View



Section View



Examples images from the *New Hampshire Stormwater Manual, Volume 2,* p. 104

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft^3) (2020)	Design Cost ($/ft^3) (2020)	Total Cost ($/ft^3) (2020)[1,2]
Rural	11.97	6.44	18.41
Mixed	23.93	12.89	36.82
Urban	35.90	19.33	55.23

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

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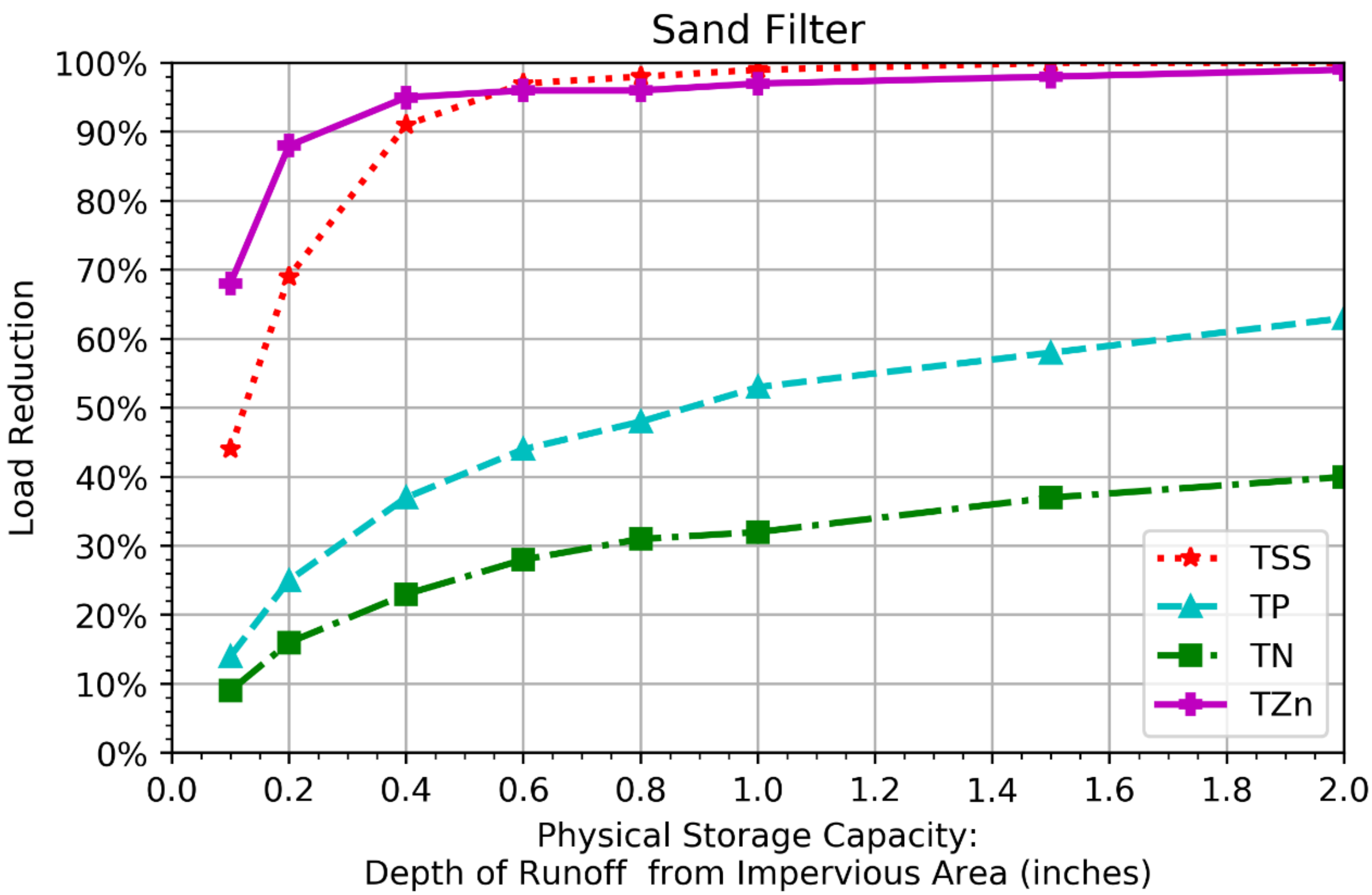
January 2020

BMP Performance Curve for Sand Filter



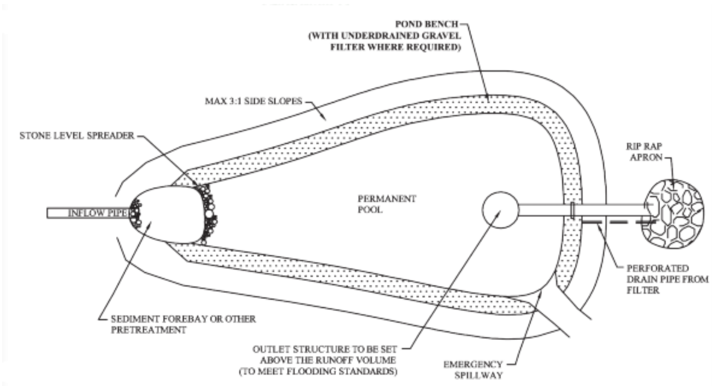
Sand Filter BMP Performance Table								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative TSS Phosphorus Load Reduction	44%	69%	91%	97%	98%	99%	100%	100%
Cumulative Phosphorus Load Reduction	14%	25%	37%	44%	48%	53%	58%	63%
Cumulative Nitrogen Load Reduction	9%	16%	23%	28%	31%	32%	37%	40%
Cumulative Zinc Phosphorus Load Reduction	68%	88%	95%	96%	96%	97%	98%	99%

Wet Pond Factsheet

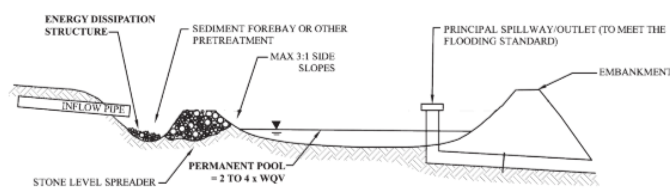
Wet Pond is a class of systems designed to maintain a permanent pool of water year-round. The pool allows for pollutant removal via settling, biological uptake, and decomposition. This allows the system to treat both sediment loads and its commonly associated pollutants along with treating dissolved nutrients through the pond's biological processes. For areas where water temperature is a concern, an underdrained gravel trench in the bench area around the permanent pool can allow for the extended release of stormwater, minimizing risk of clogging. General design specifications for wet pond systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Plan View



Profile View



Examples images from the *New Hampshire Stormwater Manual, Volume 2,* p. 61

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft^3) (2020)	Design Cost ($/ft^3) (2020)	Total Cost ($/ft^3) (2020)[1,2]
Rural	4.54	2.44	6.98
Mixed	9.07	4.89	13.96
Urban	13.61	7.33	20.94

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

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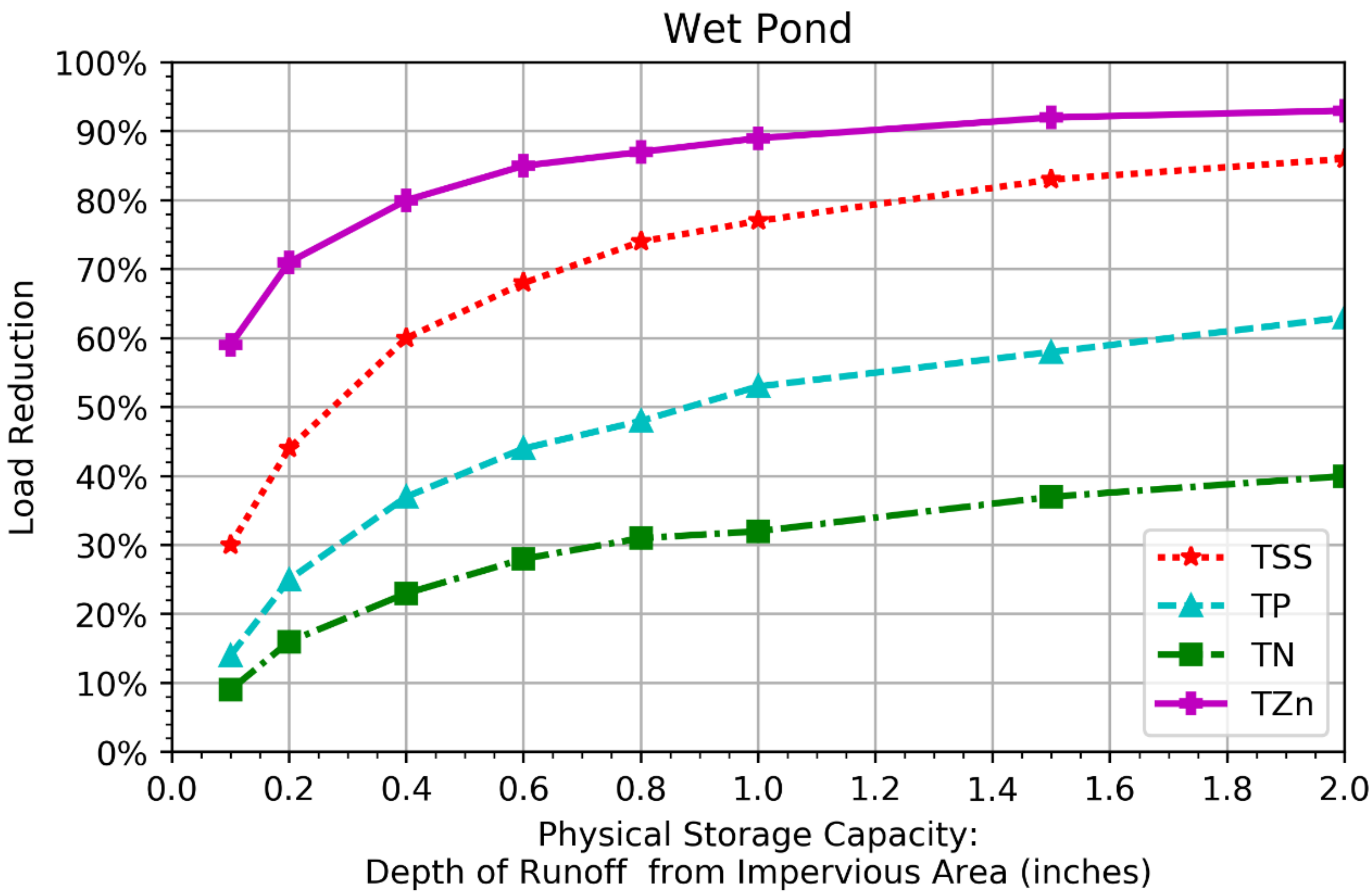
BMP Performance Curve for Wet Pond



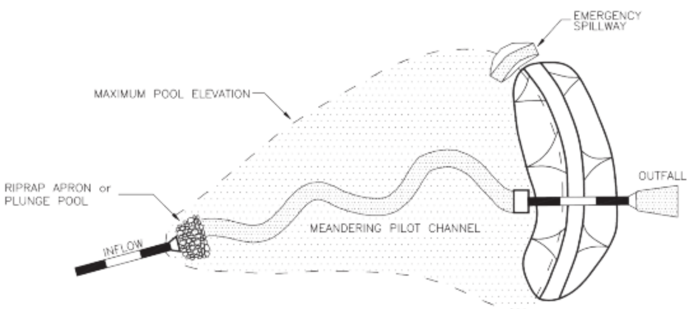
Wet Pond BMP Performance Table								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative TSS Phosphorus Load Reduction	30%	44%	60%	68%	74%	77%	83%	86%
Cumulative Phosphorus Load Reduction	14%	25%	37%	44%	48%	53%	58%	63%
Cumulative Nitrogen Load Reduction	9%	16%	23%	28%	31%	32%	37%	40%
Cumulative Zinc Phosphorus Load Reduction	59%	71%	80%	85%	87%	89%	92%	93%

Extended Dry Detention Basin Factsheet

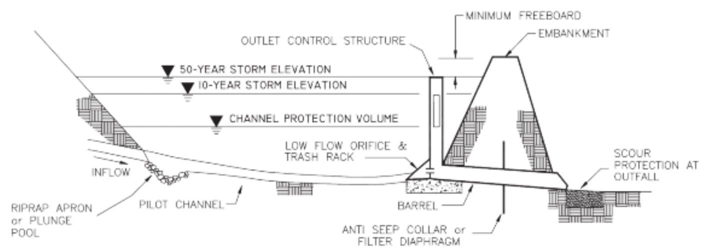
Detention Basin consists of a type of system which is primarily intended to provide flood protection by containing the flow within an excavated area and gradually releasing it over the course of a design length of time, with extended dry detention basins typically having a detention time of 24 hours. This reduces the intensity of peak flows, and the detention time allows the treatment of some pollutants, particularly those associated with suspended solids. A detention basin may be combined with other BPMs to combine detention with other treatment methods. Dry detention basins are often referred to as dry ponds, due to their similarity in design to wet ponds. General design specifications for detention basin systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design*.

Sample Design

Plan View



Profile View



Examples images from the *New Hampshire Stormwater Manual, Volume 2,* p. 159

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor[1]
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

	Materials and Installation Cost ($/ft^3) (2020)	Design Cost ($/ft^3) (2020)	Total Cost ($/ft^3) (2020)[1,2]
Rural	4.54	2.44	6.98
Mixed	9.07	4.89	13.96
Urban	13.61	7.33	20.94

[1] EPA Memorandum "Methodology for developing cost estimates for Opti-Tool." Februrary 20, 2016
[2] Converted from 2010 to 2020 dollars using U.S. Department of Labor (USDOL). (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

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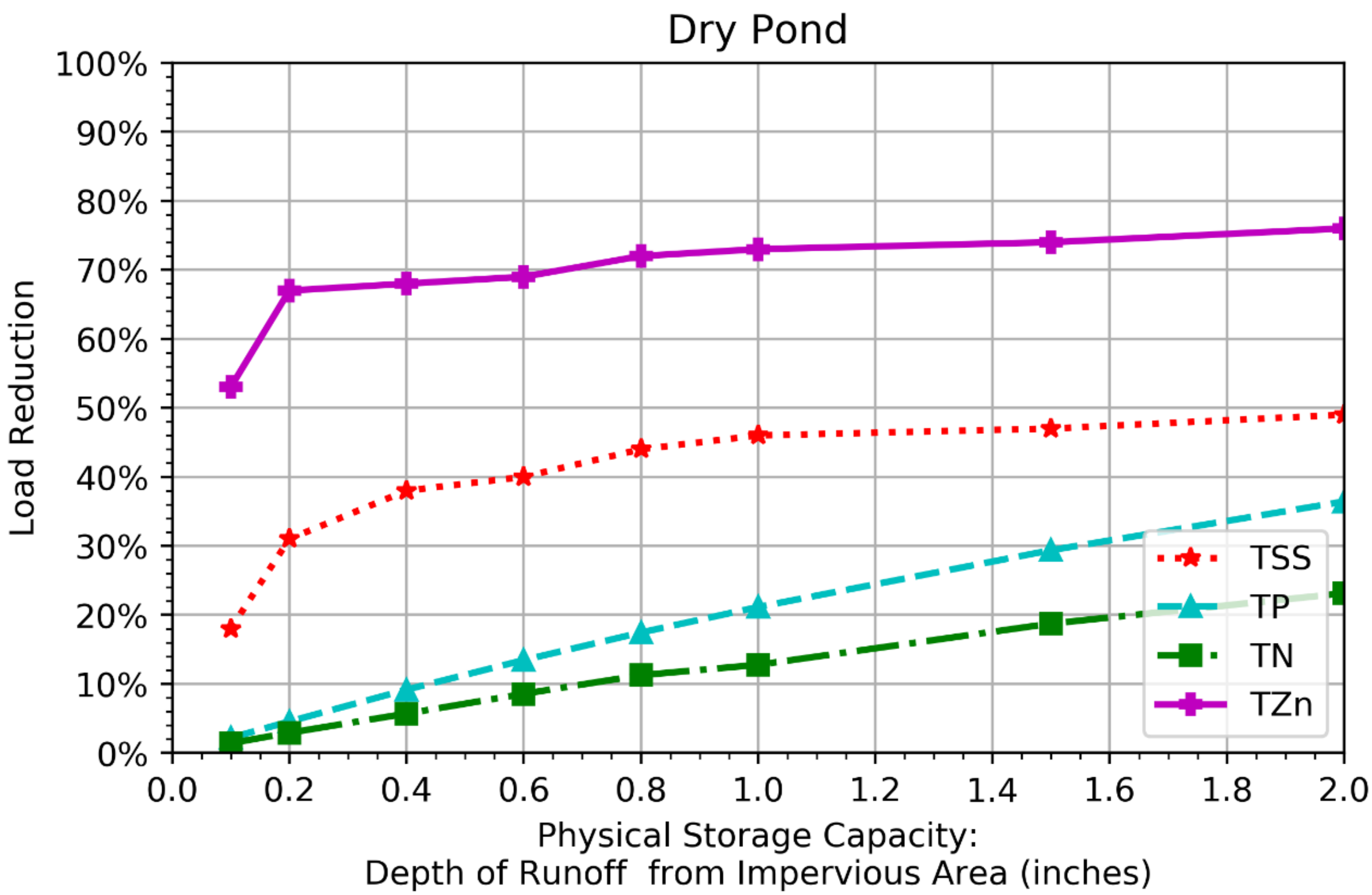
BMP Performance Curve for Extended Dry Detention Basin



Dry Pond BMP Performance Table								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative TSS Phosphorus Load Reduction	18%	31%	38%	40%	44%	46%	47%	49%
Cumulative Phosphorus Load Reduction	2%	5%	9%	13%	17%	21%	29%	36%
Cumulative Nitrogen Load Reduction	1%	3%	6%	9%	11%	13%	19%	23%
Cumulative Zinc Phosphorus Load Reduction	53%	67%	68%	69%	72%	73%	74%	76%