Outlook

#2024-0257 Wake Robin LLC Special Exception Application

From Terri Carlson
on behalf of
Perley H. Grimes

Date Wed 11/27/2024 5:28 PM

To Land Use

Cc candres; jmackey; Abby Conroy; Miles Todaro

1 attachment (13 MB)

Letter2-WakeRobinInnAPREV-11-27-2024 wa.pdf;

Please file the attached report of REMA Ecological Services, LLC in the record. Thank you

This will certify that I have forwarded copies of the attached report via email to Attorney Andres and Attorney Mackey who represent the Salisbury Planning and Zoning Commission and Aradev LLC respectively.

Perley H. Grimes, Esq.
By Terri Carlson

Perley H. Grimes, Jr., Esq.
Cramer & Anderson LLP
46 West St., P.O. Box 278
Litchfield, CT 06759
Ph: 860-567-8718
Fx: 860-567-4531
Email: pgrimes@cramer-anderson.com

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November 27, 2024

VIA E-MAIL

Town of Salisbury
Planning & Zoning Commission
Attn.: Dr. Michael Klemens, Chairman
27 Main Street
Salisbury, CT 06068

RE: **APPLICATION REVIEW - *SUPPLEMENTAL***
#2024-0257 / Wake Robin LLC & Ms. Serena Granberry (ARADEV LLC) / 104 & 106 Sharon Road & 53 Wells Hill Road / Special Permit (Section 213.5) / Map 47 / Lot 2 & 2-1 / DOR: 08/05/2024

REMA Job No.: 24-2744-SLS4

Dear Attorney Grimes:

At your request, REMA ECOLOGICAL SERVICES, LLC (REMA), is submitting this review of a Special Permit application before the Salisbury Planning & Zoning Commission for the above-referenced proposal, which is for the redevelopment of the Wake Robin Inn site. This supplements our initial preliminary review of the application materials, dated November 11th, 2024, in which we pointed out two categories of deficiencies in data and analysis, as well as some of the applicable sections of the Town of Salisbury's Zoning Regulations. These are: (1) The lack of a robust stormwater management system that will be protective of the water quality of surface waters and groundwater, including Wononskopomuc Lake and the Aquifer Protection Area (APA), and (2) The lack of a robust ecological assessment of the subject property, including for the presence of CT-Listed Species (i.e., endangered, threatened, special concern).

As with our initial review, we relied on the submitted plans produced by SLR. It is worth noting that in the late afternoon of November 26th, 2024, we received several new documents through the applicant's legal representative, which included SLR plans, dated July 29, 2024, and revised through November 26, 2024. The SLR Drainage Report, dated August 1, 2024, and revised through November 6, 2024, were also reviewed. We also continued accessing online secondary-source data, such as archival aerial photographs (see Figures C through E, attached for example).

Regarding the November 26th, 2024 SLR revised plan, we note that the typical correspondence that details the changes to the plans was not submitted. Based on our review it appears that the only changes (additions) to the plans are the locations of several additional soil test pits that correspond to the locations of Water Quality Basins 120, 130, and 140. However, the requisite data logs for these test pits and well as data on any required in-field infiltration tests, were not included on the plans or on any other correspondence.

1.0 PROTECTION OF WATER QUALITY

1.1 Overview

The amount of total disturbance proposed at that subject site exceeds the 5.0 acre threshold, and triggers review by the CT DEEP under the State's Construction Stormwater General Permit, which *"requires developers and builders to implement a Stormwater Pollution Control Plan to prevent the movement of sediments off construction sites into nearby water bodies and to address the impacts of stormwater discharges from a project after construction is complete"* (Appendix A, 2024 Stormwater Quality Manual). Therefore, adherence to the guidelines, criteria, recommendations, and/or requirements of the Stormwater Quality Manual ("the Manual") is expected for the proposed development project.

In the following narrative, we will point out some of the guidance provided by the Manual and its applicability to post-construction stormwater controls that are protective of water quality. Chapter 4 of the Manual *"Stormwater Management Standards and Performance Criteria"* outlines the process to be utilized for achieving the cardinal principle of the Manual which is Stormwater Management Standard 1 – Runoff Volume and Pollutant Reduction (see Attachment A, excerpts from Chapter 4 of the Manual). Standard 1 provides for the preservation of pre-development hydrology and pollutant loads to protect water quality and maintain groundwater recharge.

According to the Manual adherence to Standard 1 is to follow a specific process whose *elements* are: (1) LID[1] Site Planning and Design (non-structural), followed by (2) Stormwater Retention (Structural BMPs), followed by (3) Stormwater Treatment (Structural BMPs).

Regarding LID Site Planning and Design, the applicant has attempted to comply with this element. However, the sheer magnitude of the proposed development, which will touch roughly 8.5 acres of the 13.8 acre parcel, makes it difficult to maintain, mimic, or replicate pre-development hydrology, using small-scale structural best management practices (BMPs), distributed throughout the site, allowing for the management of runoff volume and water quality at its source.

Some attempts have been made, such as the provision of "water quality basins" (i.e., Basins 120, 130, and 140), as well as providing parking spaces with permeable concrete interlocking pavers (PCIP). Also, much of the internal roadway/driveway surfaces have been graded to pitch towards the permeable paver parking spaces, grassy areas, and/or to roadside swales which terminate at yard drains that tie back into the piped stormwater conveyance system.

The primary structural BMPs used to capture, infiltrate, and treat stormwater runoff associated with impervious surfaces are two infiltration basins (i.e., Detention Basins 210 and 220), as well as a hydrodynamic separator, used for pre-treatment of stormwater. The SLR Drainage Report provides calculations for the water quality volume (WQV)[2], which according to the Manual should be infiltrated to the ground per Standard 1.

In the following subsections of the report, we will provide some analysis of each of the structural BMPs of the stormwater management system for their compliance with the Stormwater Management Standards put forth in the Manual, and provide a conclusion as to the effectiveness of the overall proposed stormwater management system to protect surface water and groundwater resources.

1.2 Water Quality Basins

Three "water quality basins" are proposed. Two in the eastern section of the site, associated with the proposed "cottages" (i.e., Basins 120 and 130). The plans show that at minimum the

[1] LID – Low Impact Development practices
[2] The WQV is associated with the runoff generated over the contributing area during a 1.3-inch precipitation event.

roof drainage is conveyed to these two basins. Water quality basin No. 140 is located adjacent to a proposed Spa, but there is no indication that roof water is being conveyed here from the adjacent proposed building, just from a catchment area to the north of the basin.

All three basins should be used for infiltrating 100% of the WQV per Standard 1 of the Manual. To ensure that this is the case, both Soil Test pits and in-field infiltration testing should be provided per the Manual. Based on the most recently revised plans (11/26/24), additional soil test pits were located, as required at each of the three water quality basins. However, the data logs for these new test pits were not provided as of the writing of this report. Therefore, we use the data provided in the previous revision of the plans (i.e., 11/6/24).

Soil test pit TP-3 located just to the south of water quality basin 130 has redoximorphic features (i.e., mottles) at 24 inches of the soil surface, indicating a seasonal high groundwater table. If conditions are similar just a few feet to the north, then water quality basin 130 is 2 to 2.5 feet into the seasonal high groundwater table. Per the Manual for infiltration practices a separation of 3 feet above seasonal high groundwater and/or bedrock is prescribed.

Also, if TP-4 to the south of water quality basin 120 is indicative of conditions in this general location, then it is likely that this basin also would be either within the seasonal high groundwater table or just above it. Therefore, it appears more likely than not that both of the water quality basins associated with the "cottages" at the eastern portion of the subject site would not be able to infiltrate the water quality volume (WQV) from the impervious surfaces draining to them, calculated at roughly 1,100 cubic feet.

It should also be noted that the plans show a detail for a "rain garden" (Plan SD-6). However, there is no indication that the water quality basins are designed as rain gardens. Even if they were, they do not comply with the Manual specifications if the subsurface conditions are as expected.

1.3 Infiltration (Detention) Basins

Two major structural-BMPs are provided on the plans, that is, Detention Basins 210 and 220. These are also infiltration practices that are to retain the water quality volume allowing it to recharge the local groundwater table, per Standard 1 of the Manual.

Detention Basin 220, located at the northwest section of the subject site is the principal parking area for the proposed development. This area will receive significant fill in order to accommodate a relatively level parking lot, up to 14 feet in depth at the far end towards the property boundary. All of the parking spaces will be constructed with permeable concrete interlocking pavers (PCIP). Since this area including the detention basin will be constructed on select fill, infiltration of the WQV may not be an issue. However, the data for soil test pit #8 has not been provided. Additionally, a swale with underdrain that ties back into Basin 220 is specified at the far northwestern edge of the parking lot, but a detail has not been provided on the plans.

We should note that in conformance with the Manual the rate at which the water quality volume is to be infiltrated based on what appears to be falling head infiltration testing (i.e., "tube samples" on the Plans) should be at *"50% of slowest field measured infiltration rate"* when the NRCS Hydrologic Soil Group (HSG) is C or D.

The SLR Drainage Report indicates that the soils at this location are HSG D soils[3] (also see Attachment B). However, all infiltration testing needs to be conducted in the field. The applicant has not provided sufficient documentation to show that the CT DEEP sanctioned methods have been conducted in the field. Conducting "falling head" infiltration tests in the laboratory is not the prescribed method. Moreover, we find that the infiltration rates provided appear to be "too fast" for HSG D soils.

The Manual also notes that if the surface at the bottom of an infiltration basin is topsoiled in order to grow an herbaceous cover (which is recommended), then the design infiltration rate should be 0.5 inches per hour. Ideally, the infiltration rate would be measured at the surface post-construction using a method such as a double-ring infiltrometer, but the 0.5 in/hr. rate could be used in designing for the infiltration of the water quality volume.

While Detention Basin 220 may be in general conformance with the Manual, pending the aforementioned infiltration testing, Detention Basin 210 presents us with several issues. This

[3] According to the NRSC Web Soil Survey, attached to the SLR Drainage Report, Group D soils are defined "as those soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission." The Group D designation at the subject site is mostly due to the presence of bedrock in the Farmington soils series, typically within 10 to 20 inches of the soil surface. Bedrock outcrops are evident on the submitted plans.

basin receives runoff from 2.68 acres of which 47% is impervious surfaces (i.e., 1.25 acres)[4]. The bottom of the basin is set at elevation 814.0 feet. Data for two soil test pits are provided (i.e., TP-1 and TP-2), which include "tube samples" at specified depths for conducting infiltration testing, but no indication of whether or not these were done in the field, as required. The sample taken at TP-1 was taken at 32" inches below the surface which at the level or slightly above the proposed basin bottom elevation. The sample taken at TP-2 was taken 60" below the surface, or at elevation +/- 815.0 feet, which is above proposed basin bottom elevation of 814.0 feet. Moreover, TP-2 data indicates that ledge is encountered at elevation +/- 813.4 feet, just below the proposed basin bottom elevation.

The test pit data for Detention Basin 210 show that it is <u>not</u> possible to comply with the Manual or to infiltrate the required water quality volume. The Manual explicitly indicates that the separation from the bottom of this type of infiltration practice and the seasonal groundwater table or bedrock is a minimum of 3 feet.

We also note that although not labeled, there appears to be a low flow channel that connects to the basin's outlet control structure. Yet, such a connection does not appear in the detail of the outlet control structure for this basin on SLR Plan SD-6. According to the Manual an infiltration basin bottom needs to be level flat and not be used with underdrain systems. That would negate the efficiency of such a BMP to infiltrate and renovate the water quality volume (see Attachment C for information on Infiltration Basins).

As mentioned above for Detention Basin 220, an infiltration rate of 0.5 inches per hour should be used if the basin bottom is loamed and seeded.

1.4 <u>Permeable Concrete Interlocking Pavers (PCIP)</u>

A proposed LID structure practice is the proposal of roughly 91 parking spaces with permeable pavers. Forty one (41) of those parking spaces are on soils identified as being in Hydrologic Soil Group D, which are considered generally *unsuitable* for this type of BMP per the Manual (see Attachment D, Tables 8-2 to 8-5).

According to the Manual for this BMP to work it should also be at least three feet above seasonal high groundwater table and/or bedrock. As many of these parking fields, especially

[4] According to the SLR documentation the total impervious surfaces proposed is 2.7 acres.

along the main east-west oriented driveway are on Hydrologic Soil Group D, soil exploration is required, and depending on that data, an underdrain system may be necessary. Also, according to the Manual, the size of the filter and reservoir course needs to retain the Required Retention Volume, which is 100% of the water quality volume, and fully drain within 48 hours after the end of a design storm (see Attachment E, for further information). The contributing watershed area should not exceed 3 times the area of the permeable pavers. Finally, according to the Manual (Attachment D, Table 8-6) in Aquifer Protection Areas (APAs) and other groundwater drinking supply areas infiltration should be limited to clear roof runoff <u>only</u>. Therefore, those parking spaces proposed for the "cottage" area, as well as any other ones within the APA, should be removed (see Figures A and B, attached).

In the November 26th, 2024, Comment Response Letter by SLR to the third-party engineering review, on the matter of the necessary soil and permeability testing at the location of the permeable pavers, SLR responded that they had revised their drainage report as if these areas were in fact non-permeable and, therefore, no soil and permeability data would be needed. This begs the question, why was this LID component included as part of the overall stormwater management strategy if no benefit would be derived from them?

1.5 <u>Compliance with Standard 2</u>

The Manual's Stormwater Management <u>Standard 2</u> – Runoff Quantity Control, is intended to *"manage the volume and timing of runoff to prevent downstream flooding, channel erosion, and other adverse impacts, and safely convey flows into, though, and from structural BMPs."* One of the performance criteria reads as follows:

> *"Control the 2-year, 24-hour post-development peak flow rate to 50% of the 2-year, 24-hour pre-development peak flow rate for each point at which stormwater discharges from a site using structural stormwater BMPs."*

In reviewing the SLR Drainage Report for Analysis Point A (Wells Hill Road) the post-development peak runoff rate is 7.5 cubic feet per second (CFS), while the pre-development peak runoff rate is 8.1 CFS. To comply with this requirement or "overcontrol" the post-development peak runoff rate should be approximately 4 CFS. The additional volume of water generated at the calculated rate will result in the eroding of the intermittent stream channel both on-site and off-site and downstream. This unreasonable adverse impact needs to be rectified.

For Analysis Point B, the Sharon Road existing storm drainage system to which a connection is proposed, nearly meets the "overcontrol" with 3.4 CFS provided instead of 3.05, per Standard 2. However, another potential issue has become evident, which has not been discussed or analyzed to date by the applicant's engineering consultant. While the "overcontrol" has just about been met for the 2-year, 24-hour storm, it is obvious that the total volume of runoff generated to the Sharon Road drainage system will increase. This is not only due to the increase of impervious surfaces within the contributing watershed from 0.7 acres under existing conditions to 1.8 under proposed conditions, but also due to the increase of the contributing watershed itself, from 5.0 acres to 6.28 acres.

The discharge of runoff from the site will be conveyed via a new catch basin and pipe within the roadway right-of-way, to an existing catch basin on the west side of the roadway that discharges westerly via a 24-inch RCP. It is not clear whether or not this pipe runs all the way to the edge of the Wononskopomuc Lake or if it discharges to a swale further downgradient of the catch basin. Whatever the case the additional volume may have the effect of eroding a channel or the area at the discharge point and releasing sediment into the lake environment resulting in an adverse effect upon water quality.

1.6 Pollutant Reduction

In order to demonstrate compliance with Standard 1 of the Manual, the stormwater management systems employed at the subject site should achieve the minimum average annual pollutant reductions required, which are: 90% Total Suspended Solids (TSS); 60% Total Phosphorus (TP); 40% Total Nitrogen (TN).[5] This might not be necessary if it can be shown that the Required Retention volume is achieved and can be infiltrated to the ground following the specifications promulgated by the Manual. Based our analysis, this cannot be achieved by the current proposal.

1.7 Conclusion

The above analysis shows that as proposed the stormwater management system for the subject site does not meet the 2024 Stormwater Manual's guidelines, criteria, recommendations, and/or requirements. At a minimum Standard 1 and Standard 2 are not met, and many other

[5] Unfortunately, these nutrient renovation standards are in all likelihood too low for the protection of the lake's water quality, since it a relatively low nutrient environment (Nutrient Status: early-mesotrophic to mesotrophic).

deficiencies have been pointed out. Therefore, in our professional opinion, as submitted the proposed development is reasonably likely to have the effect of unreasonably polluting surface and groundwater quality, both on-site and also off-site.

2.0 ECOLOGICAL ASSESSMENT

2.1 Introduction

This proposal calls for extensive grading, filling, and tree cutting. Approximately 8.5 acres of this roughly 13.8 acre site is to be disturbed. Although described as a "redevelopment," most of the site is currently naturally vegetated under existing conditions, with a high proportion of mature and maturing trees, as shown in the Bartlett Tree inventory. Review of the aerial photo record shows 4.1 acres of forest in the northerly portion, and a contiguous 5.1-acre block of old-growth forest in the southerly portion of the site, that has remained intact at least since 1934 (see Figures C and E, attached). This is consistent with the many large trees in the Bartlet inventory: of the 800 trees tallied, 146 have a dbh (diameter at breast height) of 18 inches or more; 15 have a dbh of 30 inches or more.

Therefore, the project far exceeds the five-acre-disturbance threshold, that triggers CTDEEP stormwater and NDDB reviews, to secure a CTDEEP general permit. This means a stormwater management system consistent with the state guidance must be prepared, as analyzed above in Section 1.0 of this review report. Moreover, as part of the review under the CT DEEP general permit, the applicant is required to conduct thorough rare species and habitat surveys and to prepare a report that includes plans for their protection, if present or potentially present.

Four rare plants and one rare mammal have been found in the project vicinity in the past, per the CTDEEP Natural Diversity database (attached to the REMA preliminary application review, dated 11/11/24). The types of plant and wildlife communities on a site, and their quality and diversity depends on the site's ecological characteristics, landscape setting, and disturbance history: soil types and topography, bedrock geology, landscape setting, ecological integrity, forest maturity, and disturbance history.

It is worth noting, that just prior to the release of this application review (i.e., late afternoon on 11/26/24) we received the "NDDB State-Listed Plants Survey Report" by SLR, dated November 22nd, 2024. In the last sub-section of our Ecological Review (Section 2.5), we will provide some comments on this survey, but we question why this was released at this late date, when the survey had been completed in June and July of 2024.

2.1 Northern long-eared bat (*Myotis septentrioalis)*

This species is federally endangered. During summer it roosts in cavities of both live and dead trees under loose bark, like that found on mature sugar maples, shagbark hickory, and also on dead trees, only rarely in structures. It over winters in caves, which do occur in the marble district. The tree study categorized trees by condition, to prepare for extensive culling of dead or ailing trees. Not only this rare bat, but many other wildlife species and overwintering insects depend on the cavities that develop in dead trees or branches. This site is suitable for the rare bat.

2.2 Rare Plant Habitats

Bedrock

All four rare plants are "calciphiles," growing where the substrate is rich in calcium. To understand the habitat requirements of these species, background on bedrock geology is needed.

The SLR Soil Scientist report does not mention the unusual bedrock geology of the site. They provide a list and map of the soil series on the site, but they are not described, and their ecological significance is not explained. The bedrock under this site is a large area of Stockbridge marble with several contiguous units (Csc, Csb, Ose) (see Figure F, attached). Marble is metamorphosed limestone and occurs only in the far western portion of Connecticut, often just a narrow, north-south oriented band. Glacial till deposited on the site also includes fragments from bedrock to the north and north (Walloomsac schist, Unit OW unit) that also weathers into relatively mineral-rich soil.

Soils

The upland soils on the site – Stockbridge loam, and Farmington-Nellis complex - are all derived from these calcium-rich and mineral-rich rocks, which is consistent with the preponderance of sugar maples and the presence of tree species like hop hornbeam and basswood, and the many large trees. Because sub-acidic soils derived from marble and a few other rock types like traprock and gabbro, occupy such a small fraction of our state, various "calciphile" plant species are also uncommon to rare, including the four target plants for this site, per the Natural Diversity database (NDDB). A distinctive suite of mosses and lichens also prefer calcium-rich habitats.

The soils on the site all have a loamy soil texture, which increases moisture holding capacity and cation exchange capacity (CEC) to adsorb positively charged minerals. They also include a high proportion to moderate to steep slopes, exposed rock, and shallow to bedrock soil, (i.e., the Farmington series in the 95E and 94C soil mapping units) which are also habitat properties needed by certain rare species, including the Eastern few-fruited sedge, a target species. Shallow-to-bedrock soils prevent or limit growth of trees, allowing a different suite of herbaceous species to grow in those areas, often including rare species. As an aside, each of these three soil characteristics also foster soil erosion: steepness, fine texture, and shallow soil depth. Shallow soils become saturated relatively early in a rain event due to low volume, and are highly erodible when saturated.

The western portion of this site is shown on the soils map as the 95E mapping unit, a complex of shallow Farmington loams and rock outcrops. It has steep rocky areas with open ledge, cliffs, outcrops, and patchy tree canopy. These are key habitat elements for two of the four rare plants potentially occurring at this site: Eastern few-fruited sedge and wall rue spleenwort.

Shallow calcareous soil, partly shaded, is the habitat needed by the Eastern few-fruited sedge. At this site this type of soil occurs not only on west side but a is also a major component of the predominant 94C mapping unit, a complex of shallow Farmington and deeper Nellis loam.

The fourth rare plant, handsome sedge grows on deep moist soil, moist calcareous soil, moist inclusions in Nellis loam or better drained inclusions in the Mudgepond soil mapping unit, the latter being a poorly drained, wetland type soil.

Rare Cliff Ferns

Two plants are delicate ferns of rocky habitats. The CT-endangered smooth cliff-brake (*Pellaea glabella*), and the CT-threatened wallrue spleenwort (*Asplenium ruta-muraria*).

Smooth cliff brake – grows about eight inches tall, on rocky slopes, cliffs, and ledges. Often partly shaded. It has a smooth reddish brown stipe, and gray-green fronds, up to seven inches long. Leaflets are mostly in threes.

Wallrue spleenwort – prefers shaded or semi-shaded, high-pH rock-faces or walls, growing from mossy crevices. Widely spaced, stalked, fan-shaped pinnules (leaves) are light green and up to seven inches long, and the smooth green stipe (stem) is grooved in front.
The preferred habitat of both rare ferns occurs in the Farmington – rock outcrop soil mapping unit along the western edge of the site (15-45% slopes). This narrow rocky ridge top is five hundred feet long, and sixty to eighty feet wide.

Not only calcium-rich ridgetops, summits, and outcrops, but all summits, regardless of bedrock type, are classified as CTDEEP critical habitats, with an elevated probability of supporting rare and uncommon species.

Sedges

Two of the rare plants were searched for are CT Special Concern sedges, the Eastern few-fruit sedge (*Carex oligocarp*a) and the handsome sedge (*Carex formosa*).

Eastern Few-fruited sedge - This sedge grows in small clumps, which may be clustered in larger patches. With a sharply triangular stem, it grows about two and a half feet tall, leaves are flat, 2-5 mm wide, and the 4-5 fruiting stalks have short, low-density seed spikes, and a separate male (staminate) spike. The peregynia (seed sacs) have rough awns. It grows in shallow-to-bedrock, calcareous soil, both on both marble and traprock ridges, preferring partial shade.

Handsome sedge - Strongly purplish at the base, this sedge grows up to 30 inches tall. Its leaves are very narrow, and sheaths are hairy on the back. The short seed spikes have slender culms, and the peregynia are strongly trigonous (three-sided). This species needs moist, calcareous soils, but not necessarily wetland soils. It needs moderately well-lit conditions, grows in oak-hickory forest with few tall saplings or shrubs, but not in a dense hemlock forest or beech grove[6]. It grows in woods, meadows, thickets, seepage fens, and open swamps.

[6] Smith, W.R. 2020. Rare Species Guide: Handsome Sedge (Carex formosa). Minesota Deparment of Natural Resources.

2.3 Overall Ecological Value

The largest trees are white pines, sugar maples, red oaks, and tulip poplars. As shown in the landscape setting figure (see Figure G, attached), the highest proportion of intact, unfragmented forest on the perimeter of Lake Wononskopomuc lies on the east side of the lake, including the southern portion of this site. This increases wildlife potential and potential for rare species on the site.

Wononskopomuc Lake is the deepest natural lake in Connecticut, with a very uncommon clay-marl substrate, which increases the importance of protecting its water quality. The proposed project will also not be protective of the water quality in Factory Brook, Salmon Brook, and the Housatonic River, to which the eastern portion of the subject site drains.

2.4 Conclusion

This site has habitat suitable for each of these rare species, and existing natural vegetation cover is of high quality. The site design does not preserve any forested open areas and all *Carex oligocarpa* plants would need to be transplanted. Soils data on transplanting destinations has not been provided, or information on natural site illumination in the proposed mitigation area. It significantly reduces habitat available for wildlife and connectivity between wetlands. Moreover, it eliminates large-diameter den trees, trees with loose bark, and snags needed by many wildlife species such as flying squirrel, pileated woodpecker, and several own species. This could include, potentially, the federally endangered Eastern long-eared bat.

The herb stratum on marble-derived soils is also typically diverse, overall, but only a limited inventory of certain habitats has been provided with the application, until November 26, 2024. Calciphile plants include mosses, ferns, sedges, and wildflowers. Sugar maples and a suite of special, less common "rich site" wildflowers and ferns are more widespread in the marble district, not limited to a narrow slope-base zone of rich soil, where groundwater has picked up additional minerals as it flows downslope. We know from the Barlett tree inventory that tree diversity is high.

An alternative plan for this hospitality facility could reduce the roadway network, and the density of development. The many existing very tall trees would reduce the offensiveness to neighbors of three story buildings, if fewer were felled. Walking trails through the southern, especially mature, scenic forested Penn sedge glade, and along the southern portion of the site and the western linear, rock ridge would enhance the facility for resort visitors, views of the lake, and opportunities to observe stately massive trees in their natural setting, and uncommon plants and wildlife. The proposed plan calls for removing and grading the western ridge and most of the southern portion of the site, where the few-fruited sedge grows. It does not set any forest areas aside as open space.

2.5 Review of SLR's NDDB State-Listed Plants Survey Report

This report, dated November 22, 2024, and received November 26, 2024, was reviewed by REMA for its robustness and consistency with the required CT DEEP NDDB protocols. We also provide additional perspectives on potential impacts to the listed plants, one found, and three which may still be present on the subject site.

Based on the SLR report it is likely that *Carex formosa* (handsome sedge) is just off-site to the south and downslope, in what remains of the mesic, Penn sedge community, in an area where according to the report, more *Carex oligocarpa* (Eastern few-fruited sedge) was also expected to occur. The proposed upslope grading will change this area's hydrologic regime, interrupting and reducing the supply of mineral rich seepage to the downgradient, offsite calcareous glade critical habitat. Forest removal will encourage spread of invasives into that area as well as into the regraded onsite areas near the proposed southern storage building. There is a reasonable likelihood of these two adverse impacts on *Carex oligocarpa,* and potentially on *Carex formosa* and other rare species that may inhabit the glade critical habitat.

The small, rare ferns could be on the east or north side is (sheltered) on the eastern cliffs and rocky steep slopes, which may be difficult to search. One cannot say with confidence that they are not present. If present, they are very much at risk from the proposed earthwork, both from direct impacts as well as from changes in patterns of seepage down the rock formation.

We question the SLR botanist's qualifications to find the rare sedges, as too few sedges are included on the species list. At least 6-8 should have been recorded based on the experience of consulting REMA botanist Sigrun Gadwa in similar mesic, sub-acidic habitats (e.g., in Berlin, near Ragged Mountain). There may also be stunted, non-fertile residual individuals in successional mesic forest on the north side, that are difficult for botanists not familiar with this genus to find and recognize due to the dense, invasives-infested understory.

By contrast the botanist's herb list is very good, for the wildflower species of calcareous glade and forest habitats that are best identified in late spring and early summer, though it lacks spring ephemerals and fall species, that a more experienced botanist would have recognized from the foliage. *Dryopteri*s ferns and goldenrods are on the list as *Dryopteris spp.* and *Solidago spp.*, and not keyed out to species.

However, in combination with the good photo-record and impressive Bartlett tree inventory, the late-spring-early summer forb list shows that at least the southern portion of the site does indeed include non-impaired examples of "old growth" mixed hardwood forest and sub-acidic glade worthy of protection. The Salisbury Planning & Zoning Commission should recommend that impacts to these valuable natural resource be reduced by modifying the site design.

The SLR report provides insufficient information on the plant community and habitat characteristics in the northern and western portions of the site. The extent and distribution of tree cover is unclear for the long western unit of rocky habitat. How much of the area is open habitat? The suite of herb species found in dry rocky habitat in open areas along the western ridge is entirely absent from the species list. An example is low native rosette panic grasses (*Dicanthelium* spp.), a genus which includes very common species as well as several rare species. Is this because there is minimal unshaded habitat? If the western ridge is a woodland, defined by ecologists as a tree community with <65 % canopy cover, it is highly suitable for both *Carex oligocarpa* and the two *target ferns*, which need shelter and relatively moist rocky habitat, but also sunlight. The ferns can grow on boulders as well as cliffs. If the western ridge is a largely open, and mostly relatively xeric, the target ferns could on the north or east side of boulders in partial shade. The target sedges could grow in local partly shaded, concave areas with shallow, mesic calcareous soil.

Note that the NDDB protocols call for identifying all the species throughout the search area. One of the reasons is that this increases the likelihood that other rare species in critical habitats will be detected. Plant population distributions are always shifting, with ongoing colonization and extinction. Similarly, the wetlands should have been searched and inventoried because they would have inclusions of mesic habitat. Wetland characterization in the prior report was not sufficient in regard to floristic composition. Finally, the report does not include the survey path which is required by the NDDB protocols.

Please feel free to contact us if you have any questions.

Respectfully submitted,

REMA ECOLOGICAL SERVICES, LLC

George T. Logan, MS, PWS, CSE
Professional Wetland Scientist
Registered Soil Scientist, Certified Senior Ecologist

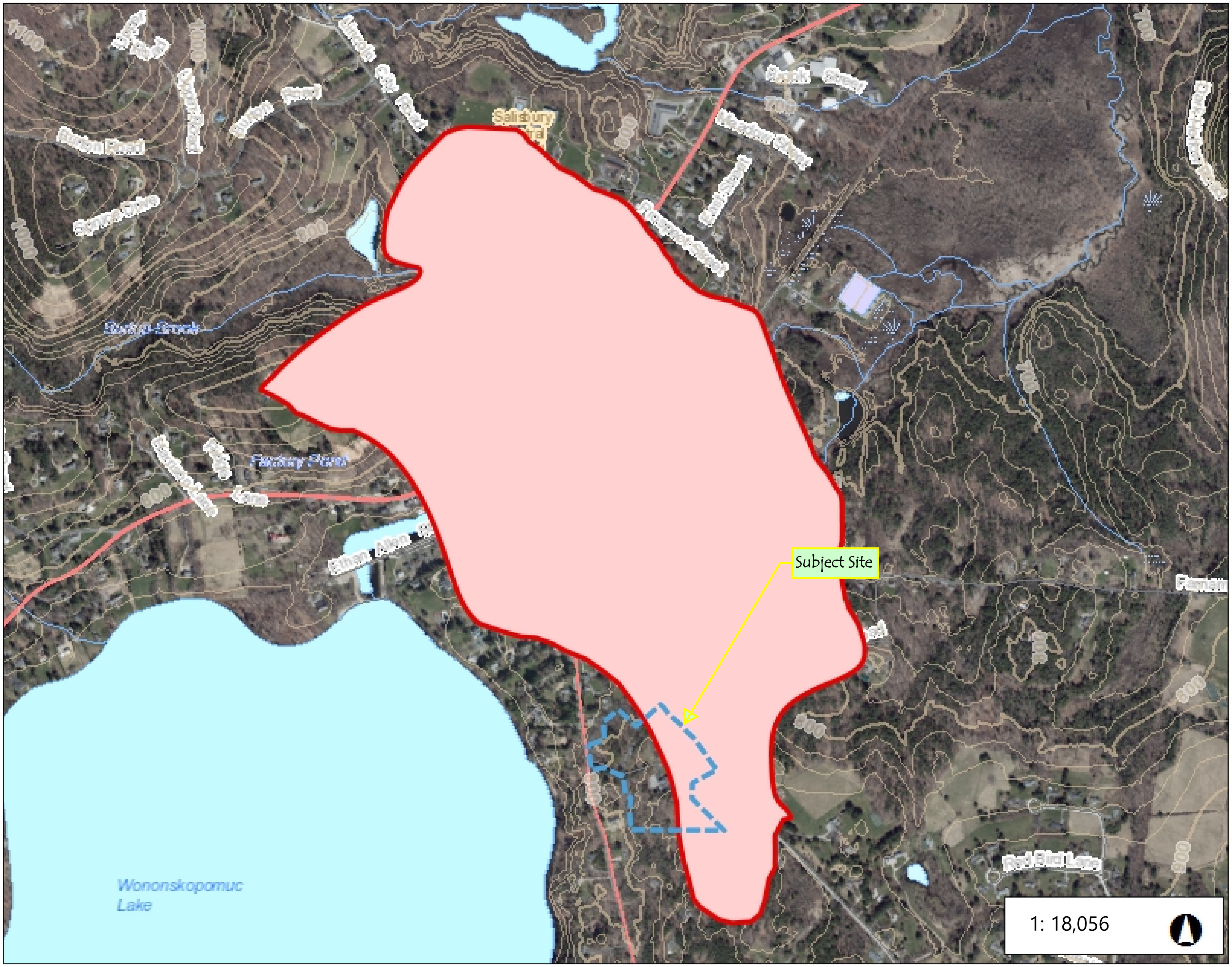
Sigrun N. Gadwa, MS, PWS
Ecologist, Registered Soil Scientist
Professional Wetland Scientist

Attachments: Figures A through F
A through E (water quality related, excerpts from 2024 Stormwater Quality Manual)
Reviewers Professional Resumes

CT Environmental Conditions Online

FIGURE A: AQUIFER PROTECTION AREA (APA) IN RELATION TO SUBJECT SITE

Wake Robin Inn, Sharon Road and Wells Hill Road, Salisbury, CT



Legend

Aquifer Protection Area
- Final Adopted Aquifer Protection
- Final Aquifer Protection
- Preliminary Aquifer Protection

Wellhead Protection Areas - A

- MA Wellfield
- RI Wellfield

Geographic Names7

Geographic Place 3

Airport
- Airport
- Heliport

Railroad

Streets
- Interstate Highway
- US Highway
- State Highway
- Primary limited-access
- Ramp
- Street
- Ferry crossing

County Line
- State Boundary
- County Boundary
- Coastline

County Name

Notes

0.6 0 0.28 0.6 Miles

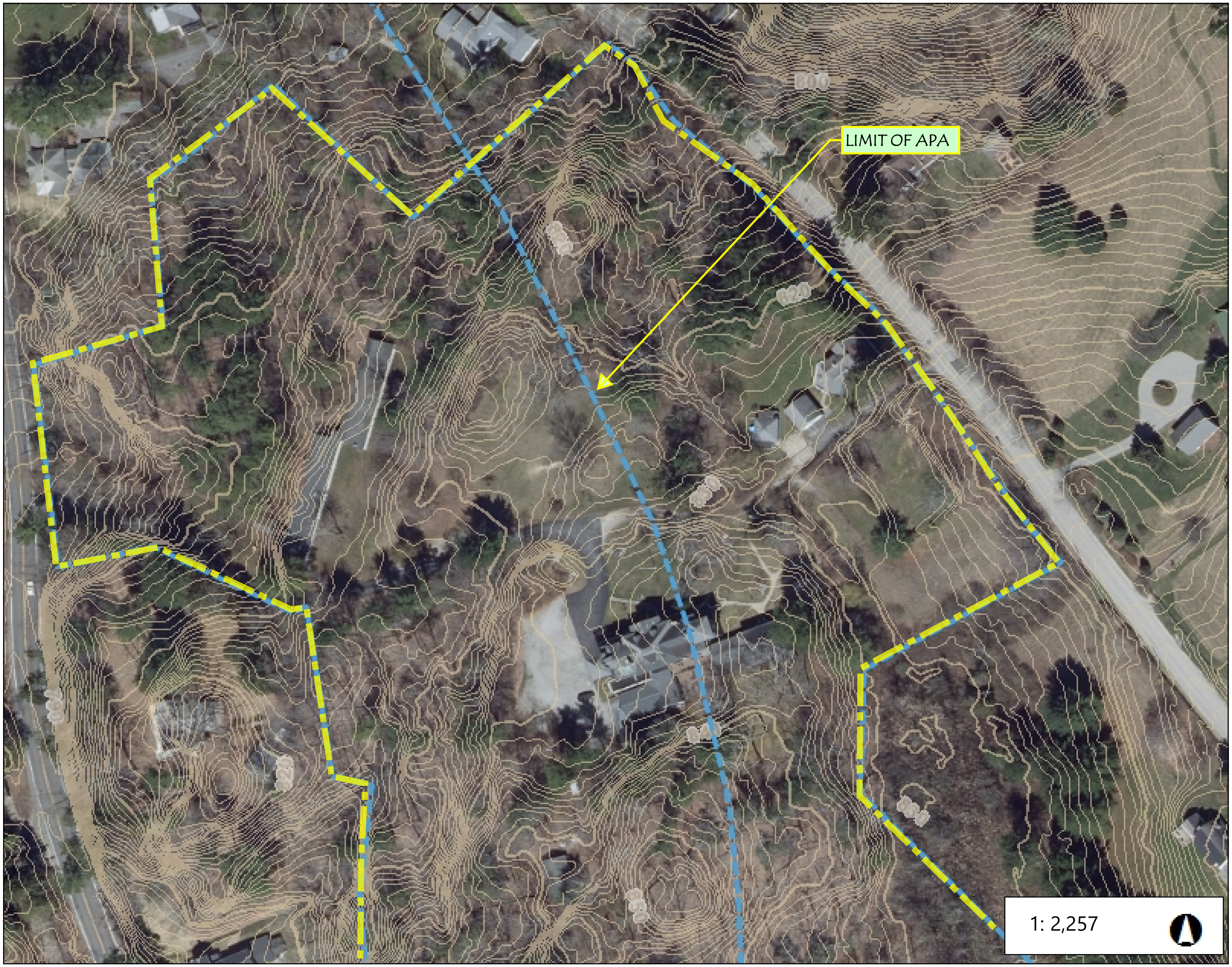
This map is intended for general planning, management, education, and research purposes only. Data shown on this map may not be complete or current. The data shown may have been compiled at different times and at different map scales, which may not match the scale at which the data is shown on this map.

THIS MAP IS NOT TO BE USED FOR NAVIGATION

CT Environmental Conditions Online

FIGURE B: LIMIT OF AQUIFER PROTECTION AREA ON SUBJECT SITE

Wake Robin Inn, Sharon Road and Wells Hill Road, Salisbury, CT



Legend

Light Gray Canvas Base

Notes

0.1 | 0 | 0.04 | 0.1 Miles

This map is intended for general planning, management, education, and research purposes only. Data shown on this map may not be complete or current. The data shown may have been compiled at different times and at different map scales, which may not match the scale at which the data is shown on this map.

THIS MAP IS NOT TO BE USED FOR NAVIGATION

FIGURE C: 1934 AERIAL OF SUBJECT SITE
Wake Robin Inn, Sharon Road and Wells Hill Road, Salisbury, CT

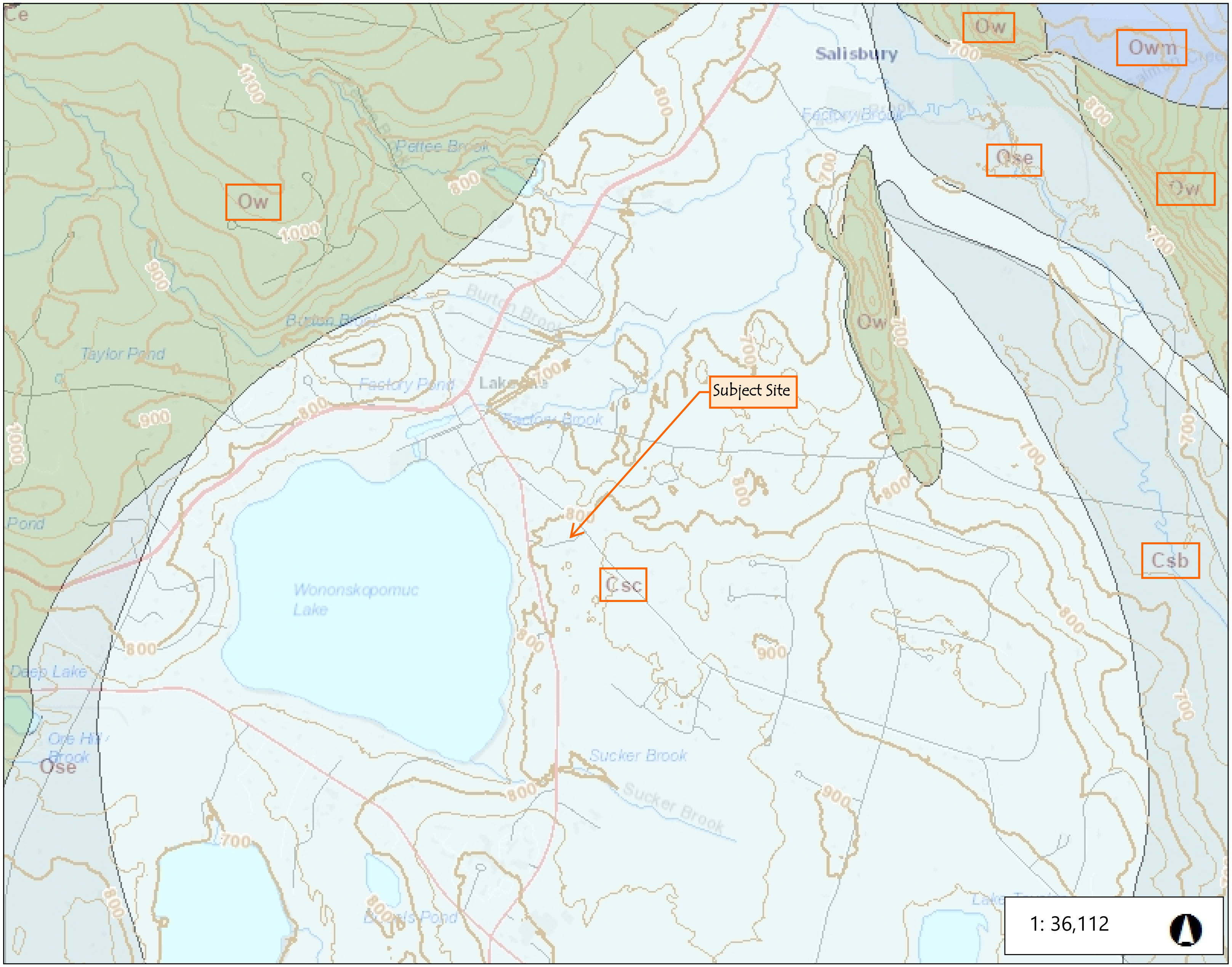
FIGURE D: 1951 AERIAL OF SUBJECT SITE
Wake Robin Inn, Sharon Road and Wells Hill Road, Salisbury, CT

FIGURE E: 1965 AERIAL OF SUBJECT SITE
Wake Robin Inn, Sharon Road and Wells Hill Road, Salisbury, CT

CT ECO CT Environmental Conditions Online

FIGURE F: BEDROCK GEOLOGY OF SUBJECT SITE

Wake Robin Inn, Sharon Road and Wells Hill Road, Salisbury, CT



Legend

Csc-Unit c of Stockbridge marble
Ose-Units e and d of " "
Csb-Unit b of Stockbridge marble
Owm-Basal marble unit of Walloomsac Schist
Ow-Walloomsac Schist

Notes

1.1 0 0.57 1.1 Miles

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THIS MAP IS NOT TO BE USED FOR NAVIGATION

CT Environmental Conditions Online

FIGURE G: LOCAL LANDSCAPE SETTING

Wake Robin Inn, Sharon Road and Wells Hill Road, Salisbury, CT

Legend

Geographic Names7

Geographic Place 3

Airport

- Airport
- Heliport

Railroad

Streets

- Interstate Highway
- US Highway
- State Highway
- Primary limited-access
- Ramp
- Street
- Ferry crossing

County Line

- State Boundary
- County Boundary
- Coastline

County Name

Town Line

- State Boundary
- Town Boundary
- Coastline

CT Town Name

Waterbody Line 7

- Water

Notes

0.6 0 0.28 0.6 Miles

This map is intended for general planning, management, education, and research purposes only. Data shown on this map may not be complete or current. The data shown may have been compiled at different times and at different map scales, which may not match the scale at which the data is shown on this map.

THIS MAP IS NOT TO BE USED FOR NAVIGATION

Chapter 4 – Stormwater Management Standards and Performance Criteria

Introduction

This chapter presents stormwater management standards and performance criteria for land development projects in Connecticut. The standards and performance criteria apply to all new development, redevelopment, retrofits, and other land disturbance activities, whether considered individually or collectively as part of a larger common plan, which are subject to local, state, or federal regulatory requirements to address post-construction stormwater management.

What's New in this Chapter?

- Updated stormwater management standards and performance criteria
- Consistency with stormwater retention and treatment requirements in the CT DEEP stormwater general permits
- Updated design storm precipitation for stormwater quality and quantity control
- Use of EPA stormwater BMP performance curves and pollutant-specific load reduction targets

Project proponents are required to meet and demonstrate compliance with the management standards and performance criteria using non-structural Low Impact Development (LID) site planning and design techniques and structural stormwater Best Management Practices (BMPs), in addition to operational source controls and pollution prevention. The management standards and performance criteria are intended to help preserve pre-development site hydrology and pollutant loads to the maximum extent possible to protect water quality, maintain groundwater recharge, and prevent flooding.

The performance criteria address the full spectrum of storm flows and their associated water quality and quantity impacts. These range from smaller more frequent storms that are responsible for a majority of the annual runoff volume and pollutant loads, to larger less frequent events that can cause flooding. Given the observed and anticipated future increases in precipitation as a result of climate change, the performance criteria include updated design storm precipitation amounts and intensities for more resilient stormwater management designs.

The management standards and performance criteria presented in this Manual are intended to be consistent with the post-construction stormwater management requirements of the CT DEEP stormwater general permits, as well as local requirements within municipal planning, zoning, and stormwater ordinances and regulations. Some differences may exist between the standards and performance criteria in this Manual and local requirements. For example a local Inland Wetlands and Watercourses authority may require to maintain certain flow levels with respect to a downstream wetland, shallow water body, vernal pool, or small watercourse, etc. Where local requirements are less stringent than noted in this Manual, the intent of this Manual is to provide recommended guidance based on the most relevant science at the time of its publication.

Table 4-1 summarizes the stormwater management standards and performance criteria, which are described in more detail in the following sections.

KEY TERM:

Maximum Extent Achievable (MEA)

This term is meant to indicate the site design has incorporated that element as completely as possible for the given site parameters. The justification and documentation of achieving this extent is described further in each of the sub sections below.

Maximum Extent Achievable (MEA) - LID Site Planning and Design

Maximum Extent Achievable (MEA) – Stormwater Treatment

Maximum Extent Achievable (MEA) – Stormwater Retention

***Note:** The term MEA is used, but not specifically defined, in the current MS4 General Permit. The concepts described here are synonymous with the term Maximum Extent Practicable (MEP) of the MS4 General Permit.

Table 4-1. Stormwater Management Standards and Performance Criteria Summary

Stormwater Management Standard	Performance Criteria
Standard 1 – Runoff Volume and Pollutant Reduction Preserve pre-development hydrology and pollutant loads to protect water quality and maintain groundwater recharge.	**LID Site Planning and Design (non-structural)** Consider the use of non-structural LID site planning and design strategies, to the maximum extent achievable, prior to the consideration of other practices, including structural stormwater BMPs. Refer to Chapter 5 - Low Impact Development Site Planning and Design Strategies for impervious surface disconnection and other non-structural LID Site Planning and Design techniques that can reduce post-development impervious area and stormwater runoff volumes. **Stormwater Retention and Treatment (structural)** After application of non-structural LID site planning and design techniques, use structural stormwater BMPs to retain and/or treat the remaining post-development stormwater runoff volume: ➢ Retention: Retain on-site the following post-development stormwater runoff volume for the site (Required Retention Volume) to the Maximum Extent Achievable using structural stormwater BMPs: Required Retention Volume (RRV): ○ 100% of the site's Water Quality Volume (WQV) ▪ All new development ▪ Redevelopment or retrofit of sites that are currently developed with existing DCIA[42] of less than 40% ▪ Any new stormwater discharges located within 500 feet of tidal wetlands ○ 50% of the site's WQV ▪ Redevelopment or retrofit of sites that are currently developed with existing DCIA of 40% or more ➢ Additional Treatment without Retention: If the post-development stormwater runoff volume retained on-site does not meet the Required Retention Volume for the site, provide stormwater treatment without retention to the Maximum Extent Achievable for the volume above that which can be retained, up to 100% of the site's WQV. The additional stormwater treatment should be provided using structural stormwater BMPs to achieve annual average pollutant load reduction targets for sediment, floatables, and nutrients, per Table 4-3. Refer to Chapters 7 through 13 for selection and design of structural stormwater BMPs for meeting the Stormwater Retention and Treatment requirements.

[42] Note DCIA is not equivalent to the impervious area, see the distinction noted in Chapter 2.

Stormwater Management Standard	Performance Criteria
Standard 2 – Stormwater Runoff Quantity Control[43] Do not exceed pre-development peak flow rates and manage the volume and timing of runoff to prevent downstream flooding, channel erosion, and other adverse impacts, and safely convey flows into, through, and from structural stormwater BMPs.	**Peak Runoff Attenuation for Site Development / Redevelopment** Control the 2-year, 24-hour post-development peak flow rate to 50% of the 2-year, 24-hour pre-development peak flow rate for each point at which stormwater discharges from a site using structural stormwater BMPs. Control the 10-year, 24-hour post-development peak flow rate to the 10-year, 24-hour pre-development peak flow rate for each point at which stormwater discharges from a site using structural stormwater BMPs. Potentially control the 100-year, 24-hour post-development peak flow rate to the 100-year, 24-hour pre-development peak flow rate for each point at which stormwater discharges from a site using structural stormwater BMPs, as required by the review authority. Demonstrate that any increased volume or change in timing of stormwater runoff will not result in adverse effects such as increased flooding downstream of the site or at other off-site locations, as required by the review authority. **Conveyance Protection** Design the conveyance system leading to, from, and through structural stormwater BMPs based on the post-development peak flow rate associated with the 10-year, 24-hour or larger magnitude design storm. **Emergency Outlet Sizing** Size the emergency outlet of stormwater quantity control structures to safely pass the post-development peak runoff from the 100-year, 24-hour or larger magnitude design storm in a controlled manner without eroding the outlet and downstream drainage systems. Refer to Chapters 7 through 13 for selection and design of structural stormwater BMPs for meeting the Stormwater Runoff Quantity Control requirements.

[43] Per the CTDOT MS4 Permit, linear projects have alternative standards and may take an alternative approach to address constraints that are different than those that affect traditional parcel development projects. These alternative linear project standards can be found in the CTDOT drainage manual, the CTDOT MS4 General Permit, the General Construction Permit and in the supporting materials that CTDOT has developed.

Stormwater Management Standard	Performance Criteria
Standard 3 – Construction Soil Erosion and Sediment Control Design, install, and maintain effective soil erosion and sedimentation control measures during construction and land disturbance activities. Consideration for final site stabilization should also be included during the development of a SESC Plan.	Develop and implement a Soil Erosion and Sediment Control (SESC) Plan in accordance with local and/or state regulatory requirements, the Connecticut Guidelines for Soil Erosion and Sediment Control Guidelines (as amended), and the requirements of the CT DEEP Construction Stormwater General Permit.
Standard 4 – Post-Construction Operation and Maintenance Perform long-term maintenance of structural stormwater management systems to ensure that they continue to function as designed and implement operational source control and pollution prevention measures.	Develop and implement a long-term Operation and Maintenance (O&M) Plan, which identifies required inspection and maintenance activities for structural stormwater BMPs. Operational source control and pollution prevention practices (see Chapter 6 - Source Control Practices and Pollution Prevention) should be included in the O&M Plan. Refer to Chapter 7 – Overview of Structural Stormwater Best Management Practices for general maintenance guidelines for stormwater BMPs, Chapter 13 – Structural Stormwater BMP Design Guidance for recommended maintenance for specific stormwater BMPs, and Appendix B for BMP-specific maintenance inspection checklists.

Stormwater Management Standard	Performance Criteria
Standard 5 – Stormwater Management Plan Document how the proposed stormwater management measures meet the stormwater management standards, performance criteria, and design guidelines.	Prepare a Stormwater Management Plan (see Chapter 12 – Stormwater Management Plan) to document how the proposed stormwater management measures for a specific land development project or activity meet the stormwater management standards, performance criteria, and design guidelines contained in the Connecticut Stormwater Quality Manual, as well as other local, state, and federal stormwater requirements.

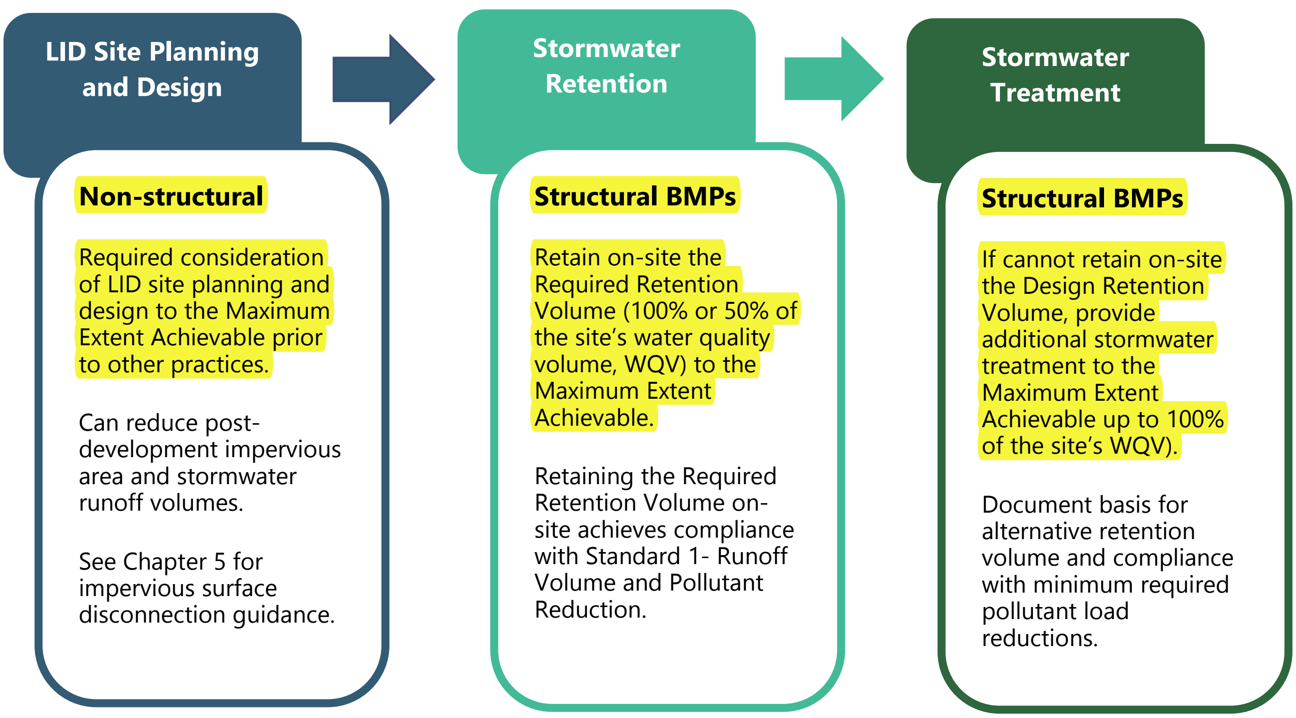
Note: Consult local and state regulations for additional stormwater management requirements. The above standards and criteria are recommended where local or state regulations are less stringent.

Standard 1 – Runoff Volume and Pollutant Reduction

Standard 1 (Runoff Volume and Pollutant Reduction) is intended to preserve pre-development hydrology (runoff duration, rate, and volume) and pollutant loads to protect water quality and maintain groundwater recharge by retaining and/or treating stormwater runoff from smaller, more frequent storms.

Standard 1 requires consideration of non-structural LID site planning and design techniques to reduce and disconnect post-development impervious areas on a site prior to consideration of structural stormwater BMPs. Once LID site planning and design techniques have been applied, structural stormwater BMPs should be used to retain on-site the required post-development stormwater runoff volume (i.e., retention volume) primarily through stormwater infiltration or reuse. If the retention volume for the site cannot be fully retained on-site, additional stormwater BMPs should be used to treat the volume above that which can be retained. Figure 4-1 illustrates schematically the major elements of and general process for complying with Standard 1.

Figure 4-1. Runoff Volume and Pollutant Reduction (Standard 1) Elements and Process



If the results of the initial screening step as determined by a Qualified Professional show that an infiltration rate greater than the minimum required infiltration rate (see General Design Guidance) is probable, the project proponent should proceed with test pits/soil borings and, under certain conditions, field infiltration testing, as discussed below. Initial screening results cannot be used in place of test pits/soil borings and field infiltration (or conductivity) testing.

Test Pits and Soil Borings

Test pits or soil borings are required for ALL proposed stormwater infiltration systems (and all other structural stormwater BMPs) to verify soil type, USDA soil textural class, and NRCS HSG soil classifications.

- Perform test pits or soil borings to a minimum depth of 3 feet below the elevation of the bottom of the proposed infiltration system (i.e., the portion of the system in contact with the underlying soil) and within 20 feet horizontally of the proposed system.
- Excavate test pits or install encased soil or hollow stem auger borings at a frequency of:
    - 1 test pit or boring per 2,000 square feet of infiltration area, but no fewer than 1 test pit or boring per location where infiltration is proposed
    - 1 test pit or boring per 5,000 square feet of permeable paving surface for permeable pavement installations, but no fewer than 2 test pits or borings per location where permeable pavement is proposed
    - 1 test pit or boring per 100 linear feet of linear BMP (infiltration trench, linear underground infiltration system, linear bioretention system, and water quality swale) but no fewer than 1 test pit or boring per linear BMP
    - Minimum test pit or soil boring frequencies for other structural stormwater BMPs are addressed in Chapter 13 - Structural Stormwater BMP Design Guidance
    - Sites with historic fill (due to the highly variable subsurface) should include additional borings and/or assure infiltration proceeds below the elevation of the fill and into natural subsoil.
- Test pit/soil boring stakes are to be left in the field for inspection purposes and survey and should be clearly labeled as such.
- Test pits should be of adequate size, depth, and construction to allow a person to enter and exit the pit and complete a soil profile description.
- If borings are drilled, continuous soil borings should be taken using a probe, split-spoon sampler, Shelby tube, or equivalent device. Samples should have a minimum 2-inch diameter.

- Determine USDA soil textural class at the bottom of the proposed infiltration system and 3ft below the bottom of the proposed infiltration system through visual field inspection by a Qualified Professional. Soil textural class represents the relative composition of sand, silt, and clay in soil. Classification of soil texture should be consistent with the USDA Textural Triangle. Geotechnical lab testing (grain-size sieve analysis and hydrometer tests) of soil samples collected from the test pits or soil borings may be used for the soil textural analysis and USDA textural soil classification. Soils must not be composited from one test pit or bore hole with soils from another test pit or bore hole for purposes of the textural analysis.

- The soil description should include all soil horizons in the test pit or soil boring.

- Determine depth to seasonal high groundwater table (SHGT) (if within 3 feet of the bottom of the proposed infiltration system). Depth to SHGT may be identified based on redoximorphic features in the soil. When redoximorphic features are not available, installation of temporary push point wells or piezometers should be considered. Ideally, such wells should be monitored in the spring when groundwater is typically highest and the results should be compared to nearby groundwater wells monitored by the USGS to estimate whether regional groundwater is below normal, normal, or above normal.

- Determine depth to bedrock (if within 3 feet of the bottom of the proposed infiltration system).

Field Infiltration Testing

Field infiltration testing is required when one or more of the following conditions exist:

- Stormwater infiltration is proposed in HSG C or D soils, as field verified through test pits or soil boring

- The Dynamic Method is used for infiltration system sizing (see below for sizing methods) regardless of USDA soil textural class or Hydrologic Soil Group

- Highly compacted soils are observed indicated or in areas of sand/gravely soils

In general, field infiltration testing is not required for infiltration systems proposed in HSG A or B soils, as field verified through test pits or soil borings, when the Static Method is used for system sizing; default infiltration rates based on the field verified USDA soil textural class may be used as the design infiltration rate. Field infiltration testing is not required for Filtering BMPs or Dry Water Quality Swales that are not designed for infiltration (i.e., designed with an impermeable liner). However, these exclusions from testing do not apply to coastal areas.

The field infiltration test method should be representative of vertical water infiltration through the soil, excluding lateral flows, under field saturated conditions. The testing should be performed by a Qualified Professional. Acceptable test methods include:

- If it is determined that the minimum required infiltration rate is not possible at the location of the proposed infiltration system, other potential on-site locations should be evaluated for infiltration feasibility.

Design Infiltration Rate

The infiltration rate used for the design of a stormwater infiltration system (i.e., design infiltration rate) should be determined from the soil evaluation results as described in Soil Evaluation Guidance section.

- Table 10- 1 summarizes the appropriate approach for determining the design infiltration rate depending on: 1) the field-verified soil textural class and corresponding NRCS Hydrologic Soil Group classification at the location of the proposed infiltration system, and 2) the infiltration system sizing method.

Table 10- 1 Determining Design Infiltration Rates[4] for Stormwater Infiltration Systems

Sizing Method	NRCS Hydrologic Soil Group (HSG)			
	A	B	C	D
Static Method	Default Infiltration Rate[1] (Table 10-2) USDA Soil Textural Class[3]	Default Infiltration Rate[1] (Table 10-2) USDA Soil Textural Class[3]	50% of Slowest Field Measured Infiltration Rate[2] Field Infiltration Testing	50% of Slowest Field Measured Infiltration Rate[2] Field Infiltration Testing
Dynamic Method	50% of Slowest Field Measured Infiltration Rate[2] Field Infiltration Testing	50% of Slowest Field Measured Infiltration Rate[2] Field Infiltration Testing	50% of Slowest Field Measured Infiltration Rate[2] Field Infiltration Testing	50% of Slowest Field Measured Infiltration Rate[2] Field Infiltration Testing

Notes:

[1] Default infiltration rate of the most restrictive USDA soil textural class below the bottom of the proposed infiltration system.

[2] 50% of the most restrictive (i.e., slowest) field measured infiltration rate below the bottom of the proposed infiltration system.

[3] USDA soil textural class as determined from test pits or soil borings and textural analysis.

[4] If a loam surface is proposed for a surface infiltration system, use a design infiltration rate of 0.5 inch per hour (1 foot per day) for the loam surface when considering the most restrictive layer and the appropriate design infiltration rate. For Filtering BMPs (bioretention, tree filters, and sand filters) that rely on infiltration and for dry water quality swales, the design infiltration rate should be equal to 50% of the slowest field measured infiltration rate of the soils beneath the filtering system or the infiltration rate of the bioretention soil media (0.5 inches per hour, which is typical for bioretention soil) or sand filter media (1.75 inches per hour for a typical sand filter), whichever is lower.

Infiltration Basin

Stormwater BMP Type

Pretreatment BMP	☐
Infiltration BMP	■
Filtering BMP	☐
Stormwater Pond BMP	☐
Stormwater Wetland BMP	☐
Water Quality Conveyance BMP	☐
Stormwater Reuse BMP	☐
Proprietary BMP	☐
Other BMPs and Accessories	☐

Stormwater Management Suitability

Retention	■
Treatment	■
Pretreatment	☐
Peak Runoff Attenuation*	■

*On-line systems only

Pollutant Removal

Sediment*	**High**
Phosphorus	**High**
Nitrogen	**Low**
Bacteria	**High**

*Includes sediment-bound pollutants and floatables (with pretreatment)

Implementation

Capital Cost	**Low**
Maintenance Burden	**Low**
Land Requirement	**Medium**

Description

Infiltration basins are open stormwater impoundments designed to capture and infiltrate the stormwater over several days but do not retain a permanent pool of water. The bottom of an infiltration basin typically contains vegetation to increase the infiltration capacity of the basin, allow for vegetative uptake, and reduce soil erosion and scouring of the basin. This BMP can receive both sheet flow and piped runoff discharged directly into the basin. Runoff gradually infiltrates into the underlying soil through the bottom of the basin, removing pollutants through sorption, trapping, straining, and bacterial degradation, or transformation. Infiltration basins may also be used to provide stormwater quantity control when designed as on-line facilities.

Infiltration basins are a cost-effective approach to managing stormwater where there is adequate space. Water is stored above the bottom of the basin rather than in subsurface storage media, which is more cost-effective than other infiltration approaches.

Advantages

- Cost-effective approach to recharge stormwater as it does not require subsurface storage media and stormwater can be temporarily stored aboveground.
- Naturally can take advantage of topographic low areas.
- High solids, phosphorus, and bacteria removal efficiency.
- Can provide stormwater retention, runoff volume reduction, groundwater recharge, and some peak runoff attenuation when designed as an on-line system

Limitations

- Require adequate space to store stormwater aboveground. Difficult to site in urban and fully developed locations.
- System clogging would require replacement of basin surface.
- Lower removal of dissolved pollutants especially in coarse soils.
- Should not be used with underdrain systems.

Siting Considerations

- **Potential Locations:** Best located where there is adequate surface area to temporarily store stormwater. Infiltration basins are suitable in urban and rural settings, but require adequate space, which makes their use limited in urban areas. Locate where:
    - The topography allows the design of the infiltration basin bottom to be level
    - Snow storage will not occur atop the basin
    - There is a low likelihood that pedestrian traffic will cut across the basin.

- **Drainage Area:** The maximum contributing drainage area for infiltration basins is 10 acres.

- **General:** Meet the soils, water table, bedrock, and horizontal setback requirements specified in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems. Infiltration basins can be designed as on-line or off-line practices.

Soil Evaluation

- Conduct an evaluation of the soil characteristics and subsurface conditions at the location of the proposed system including soil type, depth to the seasonal high groundwater table, depth to bedrock, and soil infiltration rate. Refer to Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for soil evaluation guidance.

Design Recommendations

Pretreatment

- Incorporate pretreatment measures at locations where runoff enters the infiltration basin in accordance with the Pretreatment BMPs section of this Manual.

- Acceptable pretreatment measures include vegetative filter strips, sediment forebays, pretreatment swales, deep sump hooded catch basins,[83] oil grit separators, and proprietary pretreatment devices.

- Sediment forebays should have a minimum storage volume of 25% of the Water Quality Volume (WQV), while flow-through Pretreatment BMPs should treat at least the equivalent Water Quality Flow (WQF). A minimum sediment forebay storage volume of 10% of the

[83] Only recommended for space constrained sites where no other Pretreatment BMPs are feasible.

WQV may be used in urban settings, space constrained sites, and as retrofits, with the approval of the review authority.

Sizing and Dimensions

- Basin Surface Area
    - Basin should be designed by either the Static or Dynamic Methods as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.
    - Basin should completely drain in 48 hours or less after the end of the design storm as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.

- Ponding Depth
    - Maximum depth of water above the basin bottom: 36 inches

- Bottom Slope
    - Bottom slope of the basin should be level.

- Side Slopes
    - Side slopes should be 3(H):1(V) or flatter especially on grassed slopes where mowing is required.
    - In ultra-urban locations or space constrained areas; side slopes of 2(H):1(V) may be utilized if properly designed to account for erosion and slope stability. Stabilize the slope with turf reinforcement matting or equivalent if the slope could potentially erode.
    - If site topography does not allow for 3(H):1(V) slopes or adequately stabilized 2(H):1(V) slopes, vertical concrete walls with a maximum height of 30 inches can be used. Drop curbs or similar precast structures can also be used to create stable, vertical side walls.

Inlet

- Design the inlet in accordance with the Inlet and Outlet Controls section of this Manual.

- Runoff can be introduced through overland flow, curb cuts, inlet structures, swales/channels, and/or pipes.

- Design in an off-line configuration to the extent feasible if runoff is delivered by a storm drainpipe or is along the main storm conveyance system.

Outlet & Overflow

- Design the outlet in accordance with the Inlet and Outlet Controls section of this Manual.

- Outlets are typically a stabilized spillway, gabion berm, concrete weir, curb cut opening, precast concrete structure, or polyethylene/polyvinyl chloride riser structure.

- On-line systems should have a primary outlet sized to convey the 10-year, 24-hour storm event, at a minimum, to the storm drainage system or stabilized channel. An emergency spillway is required to convey the 100-year storm event (assuming the primary outlet is not designed to pass the 100-year storm event).

- Off-line systems should be designed with a bypass or overflow for flows in excess of the water quality storm.

Materials

- Surface Cover
    - Should use 4 to 6 inches of loam/topsoil and seed to establish stabilized permanent vegetative cover as desired for the site and application. Select vegetation with the guidance provided in Appendix F of this Manual.
    - Alternatively, the bottom of the basin can be landscaped utilizing plant materials suitable for the site and application. Select plants with the guidance provided in Appendix F of this Manual.
    - Mulch can be 2 to 4 inches of shredded hardwood bark mulch, aged for 6 month or 3 inches of 3/8" to ¾" size pea gravel conforming to AASHTO No. 8 or No. 5 stone. Pea gravel should be clean (washed and free from dirt and debris) and rounded in shape. Mulch may be used directly around the plants, but mulch should NOT be used to cover the entire bottom of the infiltration basin.
    - Do not plant any woody vegetation (e.g., shrubs and trees) on embankments that are used to retain water in the basin. Those embankments should be stabilized with a grass cover.

Winter Operations

- Infiltration basins should not be used for storage of plowed snow. To the extent feasible, locate and design the system to avoid snow storage areas and potential damage from snow plowing activities. Refer to Chapter 7 - Overview of Structural Stormwater Best Management Practices for general design considerations related to winter operations.

Construction Recommendations

- The designing qualified professional should develop a detailed, site-specific construction sequence.

- The designing qualified professional should inspect the installation during the following stages of construction, at a minimum:
    - After excavation of the infiltration basin and scarification of bottom and side slopes of excavation
    - After installation of bypass, outlet/overflow, and inlet controls
    - After pea gravel or loam/topsoil and grass surface cover have been installed

- The designing qualified professional should provide an as-built plan of the completed infiltration basin along with a certification that the system was designed in accordance with the guidance contained in this Manual and other local or state requirements and that the system was installed in accordance with the approved plans.
- The entire contributing drainage area should be completely stabilized prior to directing any flow to the system. Adequate vegetative cover must be established over any pervious area adjacent or contributing to the system before runoff can be accepted.
- Erosion and sediment controls should be in place during construction in accordance with the Connecticut Guidelines for Soil Erosion and Sediment Control and the Soil Erosion and Sediment Control (SESC) Plan developed for the project.
- Infiltration basins should not be used as temporary sediment traps for construction erosion and sediment control.
- During clearing and grading of the site, measures should be taken to avoid soil compaction at the location of the proposed system.
- The system should be fenced off during the construction period to prevent disturbance of the soils.
- The infiltration basin should be excavated to the dimensions, side slopes, and elevations shown on the plans. The method of excavation should avoid compaction of the bottom of the system. A hydraulic excavator or backhoe loader, operating outside the limits of the infiltration basin, should be used to excavate the system. Excavation equipment should not be allowed within the limits of the system.
- The pea gravel layer (if used) should be placed in the excavation by a hydraulic excavator or backhoe loader located outside the limits of the infiltration basin and then hand-raked to the desired elevation.
- Install vegetation (e.g., drought tolerant grass) on the side slopes and surface of the infiltration basin (if grass is used instead of pea gravel) in accordance with the planting plan and plant schedule on the plans. Water vegetation thoroughly immediately after planting and as necessary until fully established.

Maintenance Needs

- Infiltration basins should be designed with easy access to all components of the system for maintenance purposes. Refer to Chapter 7 - Overview of Structural Stormwater Best Management Practices for general design considerations to reduce and facilitate system maintenance.

- Detailed inspection and maintenance requirements, inspection and maintenance schedules, and those parties responsible for maintenance should be identified on the plans and in the Site Stormwater Management Plan.
- Maintenance should be detailed in a legally binding maintenance agreement.
- Maintenance activities such as sediment removal, mowing, and repairs should be performed with rakes and light-weight equipment rather than heavy construction equipment to avoid compaction of the filter media and underlying soils. Heavy equipment may be used for sediment removal and other maintenance activities if the equipment is positioned outside the limits of the system. Heavy construction equipment should not be allowed within the limits of the system for maintenance purposes.

Recommended Maintenance Activities

- Inspect after major storms (1 inch or more of precipitation) in the first few months following construction.
- Inspect the sediment forebay or other pretreatment area twice a year.
- Inspect the remainder of the infiltration basin annually.
- Refer to Appendix B for maintenance inspection checklists, including items to focus on during inspections.
- Remove trash and organic debris (leaves) in the Spring and Fall.
- Remove sediment from the sediment forebay or other pretreatment area when it accumulates to a depth of more than 12 inches or 50% of the design depth. Clean outlet of sediment forebay or other pretreatment measures when drawdown time exceeds 36 hours after the end of a storm event.
- Remove sediment from the infiltration basin surface when the sediment accumulation exceeds 2 inches or when drawdown time exceeds 48 hours after the end of a storm event, indicating that the system is clogged.
- Weed as necessary. Mow grass within infiltration basin to a height of 3 to 6 inches. Maintain a healthy, vigorous stand of grass cover; re-seed as necessary.
- Maintain vegetated filter strips or grassed side slopes of infiltration basin in accordance with maintenance recommendations in the Pretreatment BMPs section of this Manual.
- Periodically remove grass clippings to prevent clogging of the surface of the infiltration basin.

Table 8-2. Physical Feasibility – Contributing Drainage Area

BMP Category	BMP Type	Contributing Drainage Area				
		< 0.5 ac	0.5 - 1 ac	1 - 5 ac	5 - 10 ac	> 10 ac
Infiltration BMPs	Infiltration Trench	●	●	●		
	Underground Infiltration System	●	●	●		
	Infiltration Basin	●	●	●	●	
	Dry Well	●	●	Multiple connected		
	Infiltrating Catch Basin	●	●	Multiple connected		
	Porous Asphalt	Not Cost Effective	(1)	(1)	(1)	(1)
	Pervious Concrete	(1)	(1)	(1)	(1)	(1)
	Permeable Concrete Interlocking Pavers	(1)	(1)	(1)	(1)	(1)
Filtering BMPs	Bioretention	(2)	●	●		
	Sand Filter	●	●	●		
	Tree Filter	●	Multiple connected			
Stormwater Pond BMPs	Wet Pond	(4)	(4)	(4)	(4)	●
	Micropool Extended Detention Pond	(4)	(4)	(4)	(4)	●
	Wet Extended Detention Pond	(4)	(4)	(4)	(4)	●
	Multiple Pond System	(4)	(4)	(4)	(4)	●
Stormwater Wetland BMPs	Subsurface Gravel Wetland	(4)	(4)	(4)	●	●
	Shallow Wetland	(4)	(4)	(4)	(4)	●
	Extended Detention Shallow Wetland	(4)	(4)	(4)	(4)	●

BMP Category	BMP Type	Contributing Drainage Area				
		< 0.5 ac	0.5 - 1 ac	1 - 5 ac	5 - 10 ac	> 10 ac
	Pond/Wetland System	(4)	(4)	(4)	(4)	💧
Water Quality Conveyance BMPs	Dry Water Quality Swale	(3)	(3)	(3)		
	Wet Water Quality Swale	(3)	(3)	(3)		
Stormwater Reuse BMPs	Rain Barrel	Small roof areas only				
	Cistern	💧	💧	Larger systems based on water demand		
Proprietary BMPs	Manufactured Treatment System	💧	💧	💧	Larger systems if allowed by manufacturer	
Other BMPs and BMP Accessories	Green Roof	💧	💧	💧	💧	💧
	Dry Extended Detention Basin			(5)	(5)	💧
	Underground Detention (no infiltration)	💧	💧	💧	💧	Max 25 AC

Notes:

(1) Contributing drainage area should not exceed 3 times area of permeable pavement.
(2) Rain gardens and other small-scale bioretention systems. For curb inlet planters, the recommended maximum ratio of contributing impervious drainage area to planter bed area is 10:1.
(3) No limit if runoff enters swale as sheet flow. May be suitable for larger areas, but limitations are most often associated with linear projects. The aid of a level spreader and larger filter strips will enhance these practices.
(4) Smaller drainage areas may be suitable if intercepting groundwater or with sufficient surface runoff to support permanent pool, required wetland depths, or submerged gravel bed. An impermeable liner may be required if the system is located in permeable soils and the bottom of the system does not intercept groundwater.
(5) Drainage areas smaller than 10 acres may require an excessively small outlet structure susceptible to clogging.

Legend		
	💧	Suitable
	(See notes)	Suitable under certain conditions or with design restrictions as noted
		Generally not suitable

Table 8-3. Physical Feasibility – Site Slope

BMP Category	BMP Type	Site Ground Slope (1)		
		Less than 2%	2% - 6%	6% - 10%
Infiltration BMPs	Infiltration Trench	💧	💧	💧
	Underground Infiltration System	💧	💧	💧
	Infiltration Basin	💧	💧	💧
	Dry Well	💧	💧	💧
	Infiltrating Catch Basin	💧	💧	💧
	Porous Asphalt	💧	5% max	
	Pervious Concrete	💧	5% max	
	Permeable Concrete Interlocking Pavers	💧	5% max	
Filtering BMPs	Bioretention	💧	💧	💧
	Sand Filter	💧	💧	💧
	Tree Filter	💧	💧	💧
Stormwater Pond BMPs	Wet Pond	💧	💧	(2)
	Micropool Extended Detention Pond	💧	💧	(2)
	Wet Extended Detention Pond	💧	💧	(2)
	Multiple Pond System	💧	💧	(2)
Stormwater Wetland BMPs	Subsurface Gravel Wetland	💧	💧	(2)
	Shallow Wetland	💧	💧	(2)
	Extended Detention Shallow Wetland	💧	💧	(2)
	Pond/Wetland System	💧	💧	(2)

BMP Category	BMP Type	Site Ground Slope (1)		
		Less than 2%	2% - 6%	6% - 10%
Water Quality Conveyance BMPs	Dry Water Quality Swale	💧	Check dams required	
	Wet Water Quality Swale	💧	Check dams required	
Stormwater Reuse BMPs	Rain Barrel	Not Applicable		
	Cistern	Not Applicable		
Proprietary BMPs	Manufactured Treatment System	Not Applicable		
Other BMPs and BMP Accessories	Green Roof	Ground Slope Not Applicable (max 20% roof slope)		
	Dry Extended Detention Basin	💧	💧	(2)
	Underground Detention (no infiltration)	💧	💧	💧

Notes:
(1) Refers to post-construction slope at the BMP site.
(2) More difficult and costly installation for site slopes of greater than 6% due to the need for a potentially large embankment and other design modifications. Limited to 9.4% resultant slope. Embankment slope may be 2-33% with a level spreader and 2-15% without.

Legend	💧	Suitable
	(See notes)	Suitable under certain conditions or with design restrictions as noted
		Generally not suitable

Table 8-4. Physical Feasibility – Soil Infiltration Capacity (Hydrologic Soil Group)

BMP Category	BMP Type	Hydrologic Soil Group (HSG)			
		A	B	C	D
Infiltration BMPs	Infiltration Trench	💧	💧	(4)(5)	
	Underground Infiltration System	💧	💧	(4)(5)	
	Infiltration Basin	💧	💧	(4)(5)	
	Dry Well	💧	💧	(4)(5)	
	Infiltrating Catch Basin	💧	💧	(4)(5)	
	Porous Asphalt	💧	💧	(4)(5)	
	Pervious Concrete	💧	💧	(4)(5)	
	Permeable Concrete Interlocking Pavers	💧	💧	(4)(5)	
Filtering BMPs	Bioretention	💧	💧	(4)(5)	(4)(5)
	Sand Filter	💧	💧	(4)(5)	(4)(5)
	Tree Filter	💧	💧	(4)(5)	(4)(5)
Stormwater Pond BMPs	Wet Pond	(1)	(1)	(1)	💧
	Micropool Extended Detention Pond	(1)	(1)	(1)	💧
	Wet Extended Detention Pond	(1)	(1)	(1)	💧
	Multiple Pond System	(1)	(1)	(1)	💧
Stormwater Wetland BMPs	Subsurface Gravel Wetland	(2)	(2)	(2)	💧
	Shallow Wetland	(1)	(1)	(1)	💧
	Extended Detention Shallow Wetland	(1)	(1)	(1)	💧
	Pond/Wetland System	(1)	(1)	(1)	💧

BMP Category	BMP Type	Hydrologic Soil Group (HSG)			
		A	B	C	D
Water Quality Conveyance BMPs	Dry Water Quality Swale	💧	💧	(4)(5)	(4)(5)
	Wet Water Quality Swale	(3)	(3)	💧	💧
Stormwater Reuse BMPs	Rain Barrel	Not Applicable			
	Cistern	Not Applicable			
Proprietary BMPs	Manufactured Treatment System	Not Applicable			
Other BMPs and BMP Accessories	Green Roof	Not Applicable			
	Dry Extended Detention Basin	💧	💧	Liner recommended to prevent groundwater inflow	
	Underground Detention (no infiltration)	💧	💧	💧	💧

Notes:

NRCS Hydrologic Soil Group (HSG) as determined from field-verified soil textural class of the soil (refer to Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for soil evaluation methods).

(1) An impermeable liner is required if the bottom of the system does not intercept groundwater.
(2) The system should be lined with an impermeable liner to prevent groundwater exchange with runoff in the subsurface gravel bed.
(3) Feasible if constructed with an impermeable liner but wet water quality swales are generally impractical in HSG A and B soils
(4) Underdrain Recommended
(5) Dispersed/Sheet flow

Legend	💧	Suitable
	(See notes)	Suitable under certain conditions or with design restrictions as noted
		Generally not suitable or very limited suitability

Table 8-5. Physical Feasibility – Depth to Seasonal High Groundwater Table and Bedrock

BMP Category	BMP Type	Depth to Seasonal High Groundwater Table (1)				Depth to Bedrock		
		< 1 ft	1 – 2 ft	2 – 3 ft	> 3 ft	< 2 ft	2 – 3 ft	> 3 ft
Infiltration BMPs	Infiltration Trench			(2)	💧		(2)	💧
	Underground Infiltration System			(2)	💧		(2)	💧
	Infiltration Basin			(2)	💧		(2)	💧
	Dry Well			(2)	💧		(2)	💧
	Infiltrating Catch Basin			(2)	💧		(2)	💧
	Porous Asphalt			(2)	💧		(2)	💧
	Pervious Concrete			(2)	💧		(2)	💧
	Permeable Concrete Interlocking Pavers			(2)	💧		(2)	💧
Filtering BMPs	Bioretention		(3)	(2)	💧	(3)	(2)	💧
	Sand Filter		(3)	(2)	💧	(3)	(2)	💧
	Tree Filter		(3)	(2)	💧	(3)	(2)	💧
Stormwater Pond BMPs	Wet Pond	💧	💧	(4)		💧	💧	💧
	Micropool Extended Detention Pond	💧	💧	(4)		💧	💧	💧
	Wet Extended Detention Pond	💧	💧	(4)		💧	💧	💧
	Multiple Pond System	💧	💧	(4)		💧	💧	💧
Stormwater Wetland BMPs	Subsurface Gravel Wetland	💧	💧	(4)		💧	💧	💧
	Shallow Wetland	💧	💧	(4)		💧	💧	💧
	Extended Detention Shallow Wetland	💧	💧	(4)		💧	💧	💧
	Pond/Wetland System	💧	💧	(4)		💧	💧	💧

BMP Category	BMP Type	Depth to Seasonal High Groundwater Table (1)				Depth to Bedrock		
		< 1 ft	1 – 2 ft	2 – 3 ft	> 3 ft	< 2 ft	2 – 3 ft	> 3 ft
Water Quality Conveyance BMPs	Dry Water Quality Swale			(2)	💧		(2)	💧
	Wet Water Quality Swale	💧	💧	(4)		💧	💧	💧
Stormwater Reuse BMPs	Rain Barrel	Not Applicable				Not Applicable		
	Cistern	Not Applicable				Not Applicable		
Proprietary BMPs	Manufactured Treatment System	Not Applicable				Not Applicable		
Other BMPs and BMP Accessories	Green Roof	Not Applicable				Not Applicable		
	Dry Extended Detention Basin	(6)	💧	💧	💧	(5)	💧	💧
	Underground Detention (no infiltration)	💧	💧	💧	💧	💧	💧	💧

Notes:

Depth from bottom of infiltration systems or top of filtering systems to seasonal high groundwater table and bedrock or other impermeable material or subsurface layer as determined from test pits or soil borings (refer to Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for soil evaluation methods).

(1) Stormwater BMPs designed with an underdrain system and impermeable liner may be used in areas where the required vertical separation to SHGT and bedrock cannot be met. Such systems are suitable for providing treatment but do not provide retention credit.
(2) Strictly residential uses or for stormwater retrofits where the minimum 3-foot separation cannot be met due to existing site constraints and there is little risk to groundwater quality, or where groundwater is already impacted (classified as GB) and there is little risk to groundwater quality from the infiltrated stormwater.
(3) For unlined filtering systems, the bottom of the filtering system should be at least 1 foot above SHGT and bedrock.
(4) Liner required in permeable soils.
(5) At least 1 foot of separation required.
(6) Liner recommended.

Legend	💧	💧	Suitable
	(See notes)	(See notes)	Suitable under certain conditions or with design restrictions as noted
			Generally not suitable

Table 8-6. High Risk Sites and Drinking Water Supply Area Suitability

BMP Category	BMP Type	Land Uses with Higher Potential Pollutant Loads	Contaminated Sites (2)	Groundwater Drinking Water Supply Areas (3)	Surface Drinking Water Supply Areas (4)
Infiltration BMPs	Infiltration Trench	(1)		Clean roof runoff only	(5)
	Underground Infiltration System	(1)		Clean roof runoff only	(5)
	Infiltration Basin	(1)		🌢	(5)
	Dry Well	(1)		Clean roof runoff only	(5)
	Infiltrating Catch Basin	(1)		Clean roof runoff only	(5)
	Porous Asphalt	(6)	(6)	🌢	(5)
	Pervious Concrete	(6)	(6)	🌢	(5)
	Permeable Concrete Interlocking Pavers	(6)	(6)	🌢	(5)
Filtering BMPs	Bioretention	(1)	(6)	🌢	(5)
	Sand Filter	(1)	(6)	🌢	(5)
	Tree Filter	(1)	(6)	🌢	(5)
Stormwater Pond BMPs	Wet Pond	Liner required	Liner required	🌢	(5)
	Micropool Extended Detention Pond	Liner required	Liner required	🌢	(5)
	Wet Extended Detention Pond	Liner required	Liner required	🌢	(5)
	Multiple Pond System	Liner required	Liner required	🌢	(5)
Stormwater Wetland BMPs	Subsurface Gravel Wetland	Liner required	Liner required	🌢	(5)
	Shallow Wetland	Liner required	Liner required	🌢	(5)
	Extended Detention Shallow Wetland	Liner required	Liner required	🌢	(5)

BMP Category	BMP Type	Land Uses with Higher Potential Pollutant Loads	Contaminated Sites (2)	Groundwater Drinking Water Supply Areas (3)	Surface Drinking Water Supply Areas (4)
	Pond/Wetland System	Liner required	Liner required	💧	(5)
Water Quality Conveyance BMPs	Dry Water Quality Swale	(1)	(6)	💧	(5)
	Wet Water Quality Swale	Liner required	Liner required	💧	(5)
Stormwater Reuse BMPs	Rain Barrel	💧	💧	💧	💧
	Cistern	💧	💧	💧	💧
Proprietary BMPs	Manufactured Treatment System	💧	💧	💧	(5)
Other BMPs and BMP Accessories	Green Roof	💧	💧	💧	💧
	Dry Extended Detention Basin	Liner required	Liner required	💧	(5)
	Underground Detention (no infiltration)	💧	💧	💧	(5)

Notes:

(1) Infiltration of stormwater from Land Uses with Higher Potential Pollutant Loads (LUHPPLs) is only allowed for the specific LUHPPLs listed in Table 10-4, at the discretion of the review authority and under the conditions listed in Chapter 10 (i.e., receive treatment by another BMP prior to infiltration).

(2) Infiltration BMPs should not be used where site contamination is present unless contaminated soil is removed and the site is remediated, or if approved by CT DEEP on a case-by-case basis. An impermeable liner may also be required.

(3) Aquifer Protection Areas and other groundwater drinking water supply areas. Infiltration within public or private wellhead protection areas should be limited to clean roof runoff only.

(4) Infiltration systems should be located a minimum distance horizontally from surface drinking water supplies as described in Table 10-3. Infiltration of clean roof runoff is allowed within the horizontal setback distances.

(5) Outlets of stormwater BMPs should be located at least 200 feet from a public water supply reservoir and 100 feet from streams tributary to a public water supply reservoir.

(6) Liner and underdrain required.

Legend		
	💧	Suitable
	(See notes)	Suitable under certain conditions or with design restriction as noted
		Generally not suitable

Permeable Pavement

Source: UConn NEMO Program

Stormwater BMP Type

Pretreatment BMP	□
Infiltration BMP	■
Filtering BMP	□
Stormwater Pond BMP	□
Stormwater Wetland BMP	□
Water Quality Conveyance BMP	□
Stormwater Reuse BMP	□
Proprietary BMP	□
Other BMPs and Accessories	□

Stormwater Management Suitability

Retention*	■
Treatment	■
Pretreatment	□
Peak Runoff Attenuation	■

*Exfiltration systems only

Pollutant Removal

Sediment*	**High**
Phosphorus	**Moderate**
Nitrogen	**Moderate**
Bacteria	**High**

*Includes sediment-bound pollutants

Implementation

Capital Cost	**High**
Maintenance Burden	**High**
Land Requirement	**Low**

Description

Permeable pavement is an alternative paved surface and stormwater management facility designed to capture stormwater runoff and snowmelt and allow it to move through void spaces in the surface course or through the joints in paver units. The captured stormwater is filtered as it moves vertically through the surface course, a transition and filter course, and a storage bed of open-graded aggregate where it is temporarily stored. The stormwater is discharged from the system through infiltration into the underlying soil or using an optional underdrain. Permeable pavement can be used to manage stormwater that falls on the pavement surface, but it may also accept some runoff from adjacent impervious areas.

When design for infiltration, permeable pavement can provide retention of stormwater, reducing runoff volumes and recharging groundwater. Filtration of stormwater is the primary pollutant removal mechanism in permeable pavement systems, although hydrocarbons and other pollutants can biodegrade in the system. Permeable pavement can be designed to store larger volumes of water and provide peak runoff attenuation for larger storms. Similar to other Infiltration BMPs, permeable pavement systems should be lined for certain applications.

There are many types of permeable pavement systems, but the most common are porous asphalt, pervious concrete, and permeable interlocking concrete pavers (PICP). The following photographs show common types of permeable pavement installations in Connecticut.

- Other benefits include improved traction while wet, reduced surface ponding, reduced freeze-thaw, and reduced need for de-icing due to well drained base.

Limitations

- Susceptible to clogging by sediment.
- Not recommended in areas with high traffic volumes. Should only be used in low speed and low traffic areas or outside main travel lanes.
- Avoid areas of excessive sediment loading.
- Do not apply sand in winter months, as sand increases need for vacuum sweeping.
- Some permeable pavement surfaces (i.e., pavers) may be damaged by snow removal without modified equipment such as special plow blades.
- Quality control for material production and installation are essential for success.
- Accidental seal-coating or similar surface treatment will result in failure of porous asphalt installations.
- Successful long-term functioning of permeable pavement systems is highly dependent on regular and appropriate maintenance (routine vacuum sweeping).
- Higher material cost than conventional pavement (although ay be offset by reduced stormwater infrastructure costs).

Siting Considerations

- **Potential Locations:** Low traffic areas such as within the roadway outside of the travel way (roadside rights-of-way and emergency access lanes), parking stalls and other low traffic areas of parking lots, driveways for residential and light commercial use, walkways, plazas, bike paths, and patios, where sanding will not occur within the contributing drainage area. Useful in stormwater retrofit applications where space is limited and where additional runoff control is required.
- **Drainage Area:** Contributing drainage area to the permeable pavement should not exceed three times the surface area of the permeable pavement. Runoff from upgradient permeable surfaces should be minimal. Porous asphalt installations of 0.5 acre or less are generally not cost effective.
- **Slopes:** Locate where pavement slopes do not exceed 5%.
- **General:** Meet the soils, water table, bedrock, and horizontal setback requirements specified in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems (General Design Guidance for Stormwater Infiltration Systems).

Soil Evaluation

- Conduct an evaluation of the soil characteristics and subsurface conditions at the location of the proposed system including soil type, depth to the seasonal high groundwater table, depth to bedrock, and soil infiltration rate. Refer to Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for soil evaluation guidance.

Design Recommendations

General Considerations

This section addresses design considerations for the most common types of permeable pavement systems.

- **Porous Asphalt:** Porous asphalt consists of a contiguous permeable asphalt surface course installed over a filter course and a base course that serves as a storage reservoir. Stormwater runoff moves vertically through the interconnected void spaces (10-25%) of the surface course and the filter course and temporarily accumulates in the underlying storage reservoir until it is discharged from the system or infiltrated into the underlying soil. The high infiltration rate through the surface course is achieved by eliminating the finer aggregates that are typically used in conventional asphalt. The remaining aggregates are bound together with an asphalt or Portland cement binder.

- **Pervious Concrete:** Like porous asphalt, pervious concrete consists of a contiguous permeable concrete surface course installed over a filter course and a base course that serves as a storage reservoir. Pervious concrete is like conventional concrete except the fine particles are absent from the mix, creating the interconnected void space and high infiltration capacity.

- **Permeable Interlocking Concrete Pavers (PICP):** This system uses concrete pavers that come in a variety of shapes, sizes, and many possible interlocking arrangements. Stormwater infiltrates vertically through the permeable joints between the paver units, or through voids in the permeable concrete units (similar to pervious concrete), then through the bedding layer, choker course, and an underlying storage reservoir.

Figure 13-15. is a typical section of porous asphalt and pervious concrete, and a typical section of permeable interlocking concrete pavers designed for vehicle and non-vehicle loads. Other open course paver systems are available that can be filled with pea gravel or topsoil and seeded with grass, ranging from plastic turf reinforcing grids to concrete grid pavers.

All types of permeable pavement systems can be used with an impermeable liner and underdrain. A liner and underdrain system are required for use with Land Uses with Higher Potential Pollutant Loads (LUHPPLs) (see Chapter 10 - General Design Guidance for Stormwater Infiltration Systems), in locations where contaminated soils exist, where the required vertical separation to SHGT cannot be met, or in locations with unacceptable horizontal setbacks for infiltration. Such systems are suitable for providing treatment and peak runoff attenuation but do not provide retention credit.

Pretreatment

- Pretreatment is not required for permeable pavement but may be appropriate if system receives stormwater runoff from pervious surfaces.

Inlet

- An inlet structure is not required if porous pavement receives evenly distributed sheet flow. Provide a level spreader or other feature to convert concentrated flow to sheet flow in accordance with the Inlet and Outlet Controls section of this Manual.

- Conveyance to porous pavement is typically overland and must be sheet flow; avoid concentrating flows due to features such as raised islands. Porous pavement receiving concentrated flow is more likely to clog and require additional maintenance.

Sizing and Dimensions

Surface Area and Volume

- Permeable pavement should be designed by either the Static or Dynamic Methods as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.

- Size the filter and reservoir course to retain the Required Retention Volume (100% or 50% of the Water Quality Volume or WQV) and fully drain within 48 hours after the end of the design storm as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.

- Assume a porosity of 40% when computing the amount of available storage within the aggregate courses.

- Size the permeable pavement surface area such that the contributing drainage area to the permeable pavement does not exceed three times the surface area of the permeable pavement.

Porous Asphalt and Pervious Concrete

- Surface Course
  - Porous Asphalt:
    - Thickness: 4 to 6 inches
  - Pervious Concrete
    - Thickness: 4 inches (minimum)
  - Design the surface course to support anticipated traffic and other design loads, including additional stresses that may be anticipated at the edges of the installation.

- Choker Course
  - Thickness: 4 to 8 inches
- Filter Course
  - Thickness: 8 to 12 inches; increase to 18 inches if an underdrain is used or there is inadequate separation from SHGT/bedrock.
- Filter Blanket
  - Thickness: 3 inches
- Reservoir Course
  - Thickness (without underdrain): 4 inches minimum
  - Thickness (with underdrain system): 8 inches minimum
  - Thicker reservoir course may be needed to retain the Required Retention Volume (100% or 50% of the WQV) or larger storms for stormwater quantity control
  - Ensure the reservoir course depth is sufficient to prevent winter freeze-thaw and heaving.
    - Combined pavement system and subbase thickness should exceed 0.65 times the design frost depth for the area.

Permeable Interlocking Concrete Pavers

- Surface Course
  - Pavers
    - Thickness: Per manufacturer
    - Gap Width: Per manufacturer
  - Design the surface course to support anticipated traffic and other design loads, including additional stresses that may be anticipated at the edges of the installation.
- Bedding Course
  - Thickness: 2 inches
- Base Reservoir Course
  - Thickness: 6 inches
- Subbase Reservoir Course
  - Thickness (without underdrain): 6 inches (non-vehicle loads), 8 inches (vehicle loads)
  - Thickness (with underdrain system): 8 inches minimum

Underdrain System

- Install an underdrain system when a proposed permeable pavement installation meets one or more of the following conditions:

  - Is in native soil that has an infiltration rate less than 0.3 inch per hour (HSG C and D soils)
  - Does not meet vertical separation distance to SHGT or bedrock (Chapter 10 - General Design Guidance for Stormwater Infiltration Systems) and should be lined
  - Does not meet minimum horizontal setback distances (Chapter 10 - General Design Guidance for Stormwater Infiltration Systems) and should be lined
  - Is within a Land Use with Higher Potential Pollutant Loads (LUHPPL) (Chapter 10 - General Design Guidance for Stormwater Infiltration Systems) or area of contaminated soils and should be lined.

- Minimum underdrain pipe diameter: 4 inches

- Minimum underdrain pipe slope: 0.5%

- Install perforated underdrains within a minimum 8-inch-thick reservoir course with a minimum of 2 inches of crushed stone above and below the underdrain.

- For unlined systems, install the perforated underdrain pipe 2 inches below the top of the reservoir course to promote infiltration. For systems that are lined with an impermeable liner to prevent infiltration, install the underdrain pipe 2 inches above the bottom of the reservoir course so the system can drain between storm events.

- Lay underdrain such that perforations are on the bottom of the pipe.

- Use solid (non-perforated) pipe sections and watertight joints wherever the underdrain system passes below berms, extends down steep slopes, connects to a drainage structure, and/or daylights.

- Other considerations when designing/installing underdrains:
  - Provide a marking stake and an animal guard for underdrains that daylight at grade.
  - If designed with laterals, space collection laterals every 25 feet or less.

- Include a minimum of two observation wells/cleanouts for each underdrain, one at the upstream end and one at the downstream end.
  - Cleanouts should be at least 4 inches in diameter, be nonperforated, and extend to the surface (flush with the surface). Cap cleanouts with a watertight removable cap. The cleanout should be highly visible.
  - Provide one cleanout for every 1,000 square feet of surface area (at a minimum) or for every 250 linear feet of total pipe length in larger systems.

Materials

Porous Asphalt and Pervious Concrete

- Porous Asphalt
  - Should conform to the latest version of the University of New Hampshire Stormwater Center Design Specifications for Porous Asphalt Pavement and Infiltration Beds.

- Pervious Concrete
  - Should conform to the latest version of the American Concrete Institute Specification for Pervious Concrete Pavement (ACI SPEC-522.1-13).

- Choker Course
  - Should consist of AASHTO No. 57 clean, washed stone.

- Filter Course
  - Should consist of washed concrete sand (ASTM C33 or AASHTO M-6) or coarse washed sand with a hydraulic conductivity of 10 to 60 feet per day at 95% Standard Proctor.

- Filter Blanket
  - Should consist of 3/8″ AASHTO No. 8 stone. Pea gravel should be clean (washed and free from dirt and debris) and rounded in shape.

- Reservoir Course
  - Should consist of 3/4″ AASHTO No. 5 stone. Gravel should be clean (washed and free from dirt and debris), crushed, and angular.

Permeable Interlocking Concrete Pavers

- Pavers
  - PCIP: Concrete pavers should conform to ASTM C936 and have a minimum thickness of 3.125 inches when subject to vehicular traffic.
  - Other open course paver systems should conform to manufacturer guidelines.

- Bedding Course
  - Non-vehicle Loads: washed concrete sand (ASTM C33 or AASHTO M-6)
  - Vehicle Loads: pea gravel, 3/8″ AASHTO No. 8 washed crushed stone

- Base Reservoir Course
  - Non-vehicle Loads: pea gravel, 3/8″ AASHTO No. 8 washed crushed stone
  - Vehicle Loads: AASHTO No. 57 washed crushed stone

- Subbase Reservoir Course
  - Non-vehicle Loads: 3/4″ AASHTO No. 5 washed crushed stone

  - Vehicle Loads: 1.5" AASHTO No. 4 washed crushed stone

General

- Filter Fabric
  - Use along sides of excavation; filter fabrics should not be used between aggregate courses or beneath the bottom course.
  - Where reservoir courses extend beneath conventional pavement, use filter fabric at the top of the reservoir course.
  - Use non-woven filter fabric that complies with State of Connecticut Department of Transportation Standard Specifications, Section M.08.01.19 (Drainage – Geotextiles).

- Underdrain (perforated and non-perforated pipe sections)
  - Polyethylene or polyvinyl pipe.

- Liner
  - If used, should consist of a 30 mil (minimum) HDPE or PVC liner, or one of the alternative liner systems described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems with the approval of the review authority.

Stormwater Quantity Control Design – Adjusted Runoff Curve Number

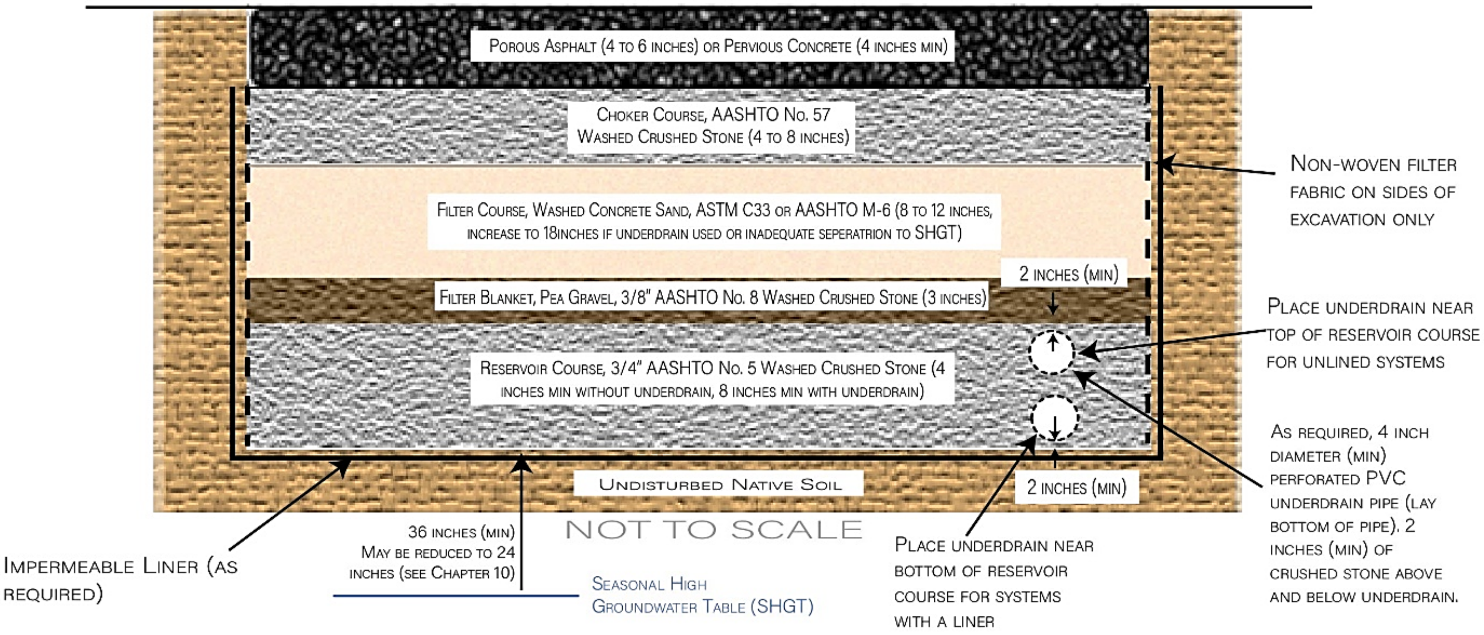
- Permeable pavement systems reduce the volume of runoff from the paved surface and therefore result in a reduced NRCS Runoff Curve Number (CN), which should be used for stormwater hydrologic and hydraulic routing calculations that are required for stormwater quantity control design.

- Determine adjusted CN values for the permeable pavement surface by the following method:

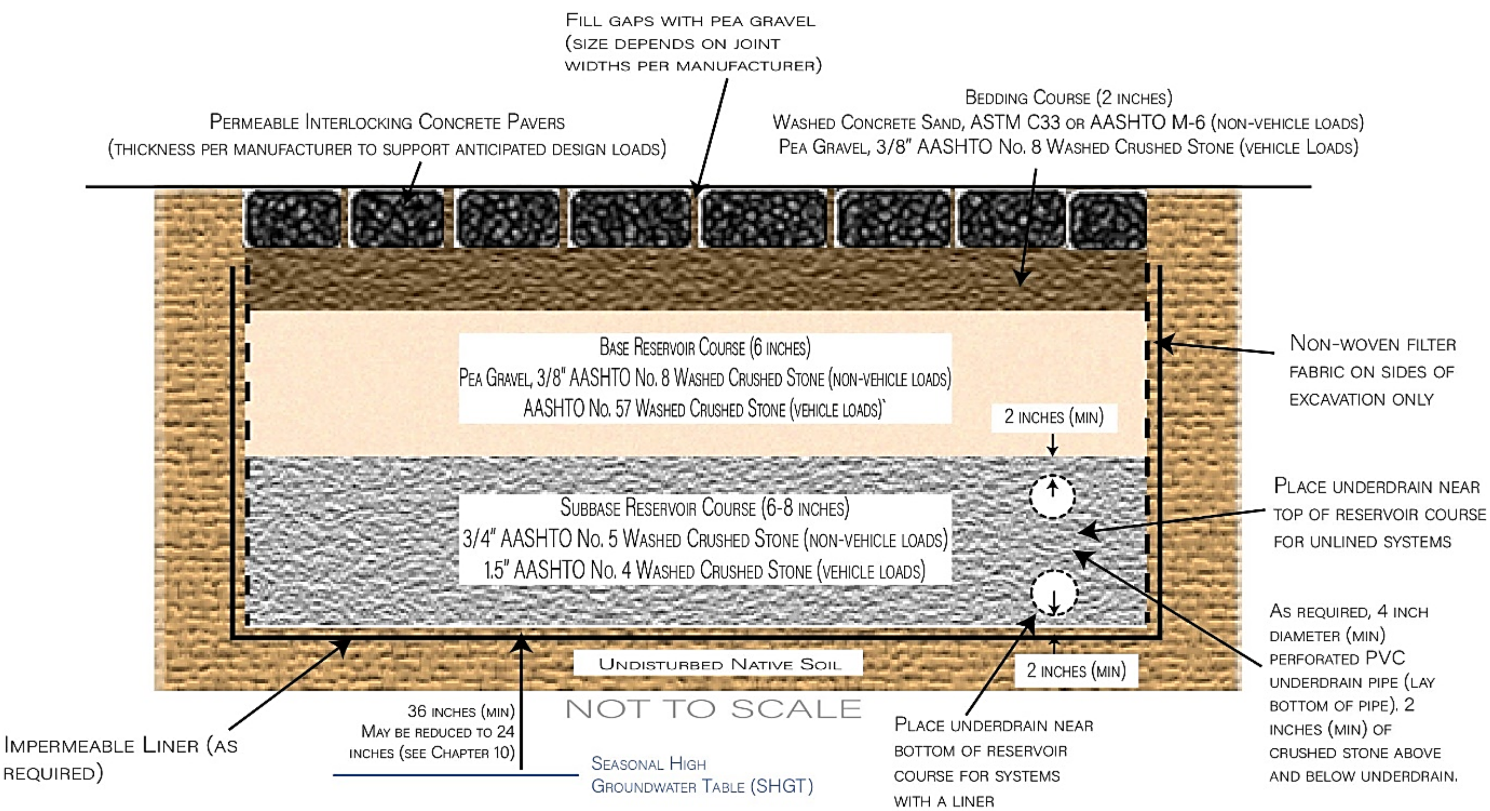
  1. Calculate the volume of stormwater retained by the permeable pavement system as described above.
  2. Calculate the stormwater runoff volume for the water quality storm and the 2-, 10-, and 100-year, 24-hour storms as described in Chapter 4 - Stormwater Management Standards and Performance Criteria of this Manual.
  3. Subtract the volume of stormwater retained by the permeable pavement system from the stormwater runoff volume for the various storm events. The result is the runoff volume that will be discharged from the permeable pavement during each storm event.
  4. Convert the volume of stormwater discharged from the permeable pavement system to an equivalent discharge depth (in inches) by dividing the volume discharged by the area of the permeable pavement surface.
  5. Using the calculated discharge depth described above and the precipitation for each design storm event, calculate the adjusted CN values using the equation or graphical

Figure 13-15.. Permeable Pavement – Typical Sections

Porous Asphalt or Pervious Concrete



Permeable Interlocking Concrete Pavers



CARYA ECOLOGICAL SERVICES, LLC, 183 GUINEVERE RIDGE, CHESHIRE, CONNECTICUT, 06410
& 164 EAST CENTER STREET, SUITE 9, MANCHESTER, CT 06040 • 203 537.1869
SIGRUN.N.GADWA@GMAIL.COM WWW.CARYAECOLOGICAL.COM

Curriculum vitae

Sigrun N. Gadwa, MS, PWS
Ecologist/Botanist/Wetland Scientist

EDUCATION:

M.S., Plant Ecology, University of Connecticut, Storrs, CT, 1997.

B.A., Biology, Brown University, Providence, R.I., 1975.

Continuing Education

16 credit hours in Soil Science and Geology, 1993 – 2001 University of Connecticut, Storrs
Five Plant Pathology courses, Cook College, Rutgers University, New Brunswick, N. J. 1978 - 1979
Graduate Phycology course. Pan American U. Brownsville, Texas, 1982
Arboriculture course, Quinnipiac College, Hamden, CT, 1984
CT DEEP training workshop Series: Rapid Bioassessment Techniques, & Stream Ecology Workshops. Bethany.1996 & 7.
Marking, Measuring & Planning Turtle Surveys. H. Gruner, CT Science Museum, workshop for QRWA Turtle Crossing Program. 1998.
Riparian Buffer Function, Performance & Limitations. Urban Riparian Buffers Conference & Technical Training Session. April 1999.
Sedimentation and Erosion Control Review Session. USDA Natural Resource Conservation Service and CPESC (Certified Professionals in Erosion Control), Concord, NH, September, 2001.
Freshwater Mussel Workshop. New Hampshire Department of Environmental Conservation. August 2004.
Moss Identification & Ecology,1-week course; Eagle Hill Institute. 2019

CERTIFICATIONS:

Registered Soil Scientist, Society of Soil Scientists of Southern New England
Certified Professional Wetland Scientist Society of Wetland Scientists
Organic land care professional. NOFA (NE Organic Farming Assoc)

EXPERIENCE:

As a plant ecologist Ms. Gadwa inventories, assesses, photographs, and monitors ecological communities, often in support of open space acquisition initiatives. She plans & guides control programs for invasive plants, and searches for listed plant and turtle populations and assesses their habitat. Botanical specialties include vascular plant identification and winter botany. She is experienced with third party reviews of development projects, assessments of functions & values, delineation of wetland and watercourse jurisdictional boundaries (CT and U.S. Army Corps of Engineers), planning wetland mitigation and restoration, vernal pools studies, water quality testing and data analysis, and in-stream bio-assessments.

Sigrun N. Gadwa, MS, PWS
Ecologist/Botanist/Wetland Scientist

EMPLOYMENT HISTORY:

1999 to present	**Carya Ecological Services, LLC**, **Principal** Ecological and wetland assessments, botany & habitat inventories, Vegetation planning. CTDEEP surveys for rare plants and turtles. Recent **Cary**a clients include the Berlin Land Trust, Hamden Land Conservation Trust, Avalonia Land Conservancy, East Lyme Land Trust, Brookfield North, LLC, Black & Veatch for the Town of West Haven, Mumford Cove Association, Town of Colebrook, SCS-Bethmour Rd., and private landowners.
1999 to present	**Carya Ecological Services, LLC**, **Principal,** *subcontractor* to **Rema Ecological Services**, LLC, Vernon, CT, an environmental science collaborative; Ecological fieldwork, planning, and reporting.
2015 to 2022	**Post University, Waterbury Campus** Adjunct Professor of Botany & Ecology.
2013 to 2018	**K & W Construction,** Southbury, CT, *subcontractor* Erosion & Sediment Control Inspections, Turbidity testing for CT DEEP
2014 to 2019	**South Central CT Regional Water Authority**, New Haven, CT Responsible for long term vegetation monitoring each fall, and reporting for compliance with CT DEEP Wellfield Diversion Permit.
2001 to 2004	**CT DEEP Wildlife Division,** *subcontractor* Vegetation and wetland inventories & mapping of large Wildlife Management Areas (WMAs).
2003 to May 2016	**Ships' Hole Farm Partnership,** Smithtown, Long Island, NY Responsible for vegetation management & invasive control; growing seed of native species on family farm, advised turtle monitors.
1995 to 2000	**Quinnipiac River Watershed Association Meriden, CT** Executive Director/Staff Scientist Led botany hikes and a volunteer monitoring program, including stream bio-assessments, turbidity testing, and bird/turtle surveys; site plan reviews of projects impacting the watershed; wrote testimony, grants, publicity, and educational materials; liaison with officials. Chair of Habitat Work Group of the **Watershed Partnership**, which identified and documented Quinnipiac watershed habitats in need of protection or restoration until 2003.

Curriculum vitae: *(continued)*

Sigrun N. Gadwa, MS, PWS
Ecologist/Botanist/Wetland Scientist

EMPLOYMENT HISTORY:
(continued)

Coordinator for **QRWA Turtle Crossing** monitoring program for Eastern box & wood turtles, which continued until 2018. Instructed citizens on preparing detailed accurate record forms for the Natural Diversity Database. Outreach on turtle behavior through the seasons, habitat usage, & conservation needs. > 50 records.

1991 to 1995 — **De Leuw-Cather, Inc.,** East Hartford, CT
Environmental Planner/Field Ecologist
Field data collection, analysis, and report preparation, mostly for high-way projects; specialties included listed plant searches, assessment of wetland functions, mitigation design, & wetland delineation (ACOE method).

1987 to 1991 — **Univ. of Connecticut Department of Civil Engineering,** Storrs, CT
Wetlands Researcher
Part of an interdisciplinary team, studying man-made replication wetlands and natural reference wetlands. Took part in research design; collected vegetation, soils, & hydrologic data; literature searches; data analysis. Research used for wetlands mitigation-related manual for the Connecticut Department of Transportation and for master's thesis.

1974 to 1975 — **Brown University,** Providence, RI
Teaching Assistant, Plant Systematics

1968 to 1975 — **Long Island Nature Conservancy,** Stewardship Volunteer
Nature trail development & maintenance, botanical inventories, wrote preserve descriptions & self-guided nature trail brochures.

Carya E.S. clients have included Berlin Land Trust, Avalonia Land

PROFESSIONAL AFFILIATIONS:

Connecticut Botanical Soc. (Board Member, Chair of Ecology & Conservation Committee)
Connecticut Invasive Plant Working Group (CIPWG)
Connecticut Association of Wetland Scientists
Society of Soil Scientists of Southern New England
Connecticut Ornithological Society
Connecticut Entomological Society
Ecological Society of America
Native Plant Trust (PCV - Plant Conservation Volunteer Program)

Curriculum vitae: *(continued)*

Sigrun N. Gadwa, MS, PWS
Ecologist/Botanist/Wetland Scientist

PUBLICATIONS:

Lefor, M.W. Barklay, J.S. Cooke, R.S. Craig, S.N. Gadwa, T.S. Murray, April 1990. *Annotated Bibliography for Wetland Mitigation*.

August 1990. *Patterns of Herb Layer Species Association*. In Lefor, M.W. et al *Wetland Mitigation: Interim Report* No. CT-RD-JHR-90-8, The Transportation Institute, Storrs, Conn. 97 pp.

1994. *Forests.* In Chesanow et al. *Trails*. The Cheshire Land Trust and the Cheshire Environment Commission, Cheshire, CT 96 pp.

May 1995. *Wetland Mitigation: Botany*. Volume 1 of 6. Lefor, M.W. and S.N. Gadwa. Report No. JR95-241. Dept. Civil Engineering, Joint Highway Research Council, Transportation Institute, Storrs, Conn. 259 pp.

December 1997. *Plant Colonization Processes and Patterns along Shorelines of Man-made Mitigation Basins in Relation to Reproductive and Life History Traits.* MS Thesis. Dept. Ecology & Evolutionary Biology. Univ. of Connecticut, Storrs, CT. 181 pp.

River Resources Education Series, Quinnipiac River Watershed Association, Meriden, CT. May 1995 *New Haven Oysters;* June 1996 *What Good are Streamside Woods?* August 1996 *Taking a Close Look at Streamside Woods;* June 1997 *Foraging in the Quinnipiac Estuary;* March 1998 *Stream Biosurveys* (G.T. Logan & S. Gadwa) ; September 2000 *Muddy Waters.*

Logan, G.T. & S.N. Gadwa. *Quinnipiac River Watershed Assoc. Stream Study.* Water Quality in the Quinnipiac River. Proceedings of a Symposium on the Impact of Nonpoint Source Pollution in the Quinnipiac River Watershed, pp. 66-70.

October 2000. *A Report on the Water Quality of the Quinnipiac River.* M. Tyrell, C. Cappannari, D. Galt, S. Gadwa, L. MacMillan, R. Walters. Report to the Steering Committee of the Quinnipiac River Watershed Partnership. Q.R.W.P. Water Quality Workgroup, New Haven, CT. 19 pp.

Winter 2003. *Management of Invasive Plants: On-Site Open Space Management.* The Habitat 15(2):3-4 Connecticut Association of Conservation and Inland Wetland Commissions, Inc.

Spring 2003. *Management of Invasive Plants: Protecting Open Space and Wetlands, Tools for Land Use Boards and Town Staff.* The Habitat 15(3):4-5. Connecticut Association of Conservation and Inland Wetland Commissions, Inc.

July 2003. Interpreting Quinnipiac Songbird Surveys: Effects of Landscape Setting on Avian Community Composition. *The Connecticut Warbler*. 23(3): 81-114.

Sigrun N. Gadwa, MS, PWS
Ecologist/Botanist/Wetland Scientist

PUBLICATIONS, cont. :

June 2004. *Connecticut Turtles of Special Concern.* Quinnipiac River Watershed Association. 4 page pamphlet. (illustrations by Tony Ianello)
Fall 2005. S. N. Gadwa. *Preliminary Assessment of the Habitat & Historic Resources in North Cheshire, West of Route 10 & Recommended Protection Measures.* Cheshire Land Trust & Quinnipiac Watershed Partnership.

October 2011 S. N. Gadwa & G.T. Logan. *The Scientific Basis for Wetland & Watercourse Buffer Zones*. 23 pp. White Paper. Rema Ecological Services, LLC.

Spring 2014. Sigrun N. Gadwa. *The Invasive Threat to Connecticut's Upland Critical Habitats*. 3pp. Connecticut Botanical Society Newsletter 41: 1.

Spring 2020. Sigrun N. Gadwa. *Gabbro Habitats in Southeastern Connecticut.* Connecticut Botanical Society Newsletter 47: 1.

Fall 2020. Connecticut Botanical Society Ecology and Conservation Committee. *Recommendations for Electrical Utility Right-of-Way Vegetation Management* . See also website: www.caryaecological.com

WORKSHOPS & CONFERENCES *(selected)*:

SA Mid-Atlantic Chapter Symposium, Blacksburg Virginia
Lessons for Mitigation Design from Shoreline Seedling Colonization Patterns April 12-14. 2012. *(Poster presentation based on MS thesis)*

New England Invasive Plant Summit, Framingham Massachusetts: Wetlands permitting – a potentially powerful tool to control invasive plants. September 19-20. 2003. (*Poster Presentation)*.

Environmentally Sensitive Development along the Ten Mile River. Riverside Landscaping Conference. June 1998. Rivers Alliance of CT. (*Guest Lecturer*)

Water Quality in the Quinnipiac River: A Symposium on the Impact of Non-Point Source Pollution in the Quinnipiac River Watershed. Nov. 1998. *(Presenter)*

October, 2014. Documenting and Conserving Eastern Box Turtles in Central Connecticut: 19 years of Citizen Monitoring. Berlin Land Trust and Nature Center. Evening Membership Program. (*Guest Lecturer)*

2011 to 2119. For CT Botanical Society, have led 1-3 guided botany field trips and/or field botany workshops each year.

October 2016 Sigrun Gadwa, MS & Todd Mervosch, PHD. Connecticut Invasive Plant Working Group (CIPWG) Symposium, UConn College of Agriculture, Health, & Natural Resources. *Artemisia vulgaris (Mugwort): Overlooked Infiltrator of Meadow Habitats. (Poster Presentation).*

PROFESSIONAL RESUME

George T. Logan, MS, PWS, CSE

Principal Environmental Scientist/Senior Ecologist

EDUCATION:

M.S. Natural Resources, *Wildlife Management & Conservation Biology,* University of Rhode Island, Kingston, R.I., 1989.

B.S. Natural Resources, *Wildlife Management & Wetlands Ecology,* University of Rhode Island, Kingston, R.I., 1986.

Continuing Education

The Transportation Project Development Process: Training in the PennDOT Environmental Impact Statement Handbook, Harrisburg, PA, January 1994

Rapid Bioassessment Protocols of Aquatic Systems (EPA Protocols), Wetland Training Institute, Williamsport, PA, August 3-6, 1993

CERTIFICICATIONS:

Certified Senior Ecologist *(2005, 2014)* - Ecological Society of America

Certified Professional Wetland Scientist (No. 581) *(1994)* - Society of Wetland Scientists

Registered Soil Scientist *(1989)* - Society of Soil Scientists of Southern New England

Certified Associate Wildlife Biologist *(1989)* – The Wildlife Society

EXPERIENCE:

Mr. Logan is the Co-Owner and *Principal Environmental Scientist* and *Senior Ecologist* for Rema Ecological Services, LLC. He specializes in tidal and inland wetland delineations and evaluation, permitting, wetland mitigation design, implementation and monitoring, and the preparation of environmental compliance documents in accordance with national (NEPA), state (e.g., CEPA, MEPA), and local criteria and guidelines. He also provides design, construction supervision and implementation for a wide variety of habitat restoration and enhancement projects, and performs watershed-wide and surface water quality evaluations and provides guidance in the design of stormwater Best Management Practices (BMPs), including stormwater wetlands and bioretention basins, as well as for LID (low impact development) practices.

Mr. Logan has 35 years of experience as a wildlife biologist/ecologist conducting wildlife habitat evaluations and focused avian, mammalian, invertebrate, and herpetofaunal surveys using both active and passive methods. He frequently conducts targeted surveys for sensitive, rare, and "listed" species (i.e., endangered, threatened, special concern), and aquatic biosurveys to assess the biodiversity and biotic health of ponds, lakes, vernal pools, rivers, and streams. Mr. Logan has extensive experience in performing herpetological surveys, including nearly 300 vernal pool surveys and evaluations.

Mr. Logan provides 3rd party reviews for municipal land use boards, and has participated in nearly 3,100 individual projects in New England and the Mid-Atlantic States and in 163 of 169 municipalities in Connecticut.

George T. Logan, MS, PWS, CSE

PROFESSIONAL AFFILIATIONS:

Society of Soil Scientists of Southern New England
Society of Wetland Scientists
Ecological Society of America
The American Birding Association
The Wildlife Society
Soil & Water Conservation Society
Connecticut Association of Wetland Scientists (CAWS) *(Past-President, Charter member)*

PUBLICATIONS: *(selected)*

Logan, G.T. & S.N. Gadwa. 1999. Quinnipiac River Watershed Association Stream Study. Water Quality in the Quinnipiac River. Proceedings of a Symposium on the Impact of Nonpoint Source Pollution in the Quinnipiac River Watershed, pp. 66-70.

Logan, G.T. & S.N. Gadwa. 1998. Stream Biosurveys: *A Primer.* Quinnipiac River Watershed Association Educational Series for the Adopt-the-River Programs.

Pawlak, E.M. & G.T. Logan. 1996. Town of Cromwell Wetland Evaluation Project. Connecticut Association of Conservation and Inland Wetlands Commissions. The Habitat, Vol. 10:1

Logan, G.T., F.B. Titlow & D.G. Schall. 1995. The Scientific Basis for Protecting Buffer Zones. Proceedings of the 16th Annual Meeting of the Society of Wetland Scientists.

Pawlak, E.M. & G.T. Logan. 1995. Town of Cromwell Wetland Buffer Zone Designation Methodology. Proceedings of the 16th Annual Meeting of the Society of Wetland Scientists.

Logan, G.T., J.H. Brown, Jr., T.P. Husband & M.C. Nicholson. 1994. Conservation Biology of the Cretan Agrimi (*Capra aegagrus cretensis*). Biologia Gallo-Hellenica, Vol. 21, pp. 51-57.

Nicholson, M.C., T.P. Husband, J.H. Brown, Jr. and G.T. Logan. 1994. Implications of behavior on the management of the Cretan Agrimi (*Capra aegagrus cretensis*). Biologia Gallo-Hellenica, Vol. 21, pp. 45-50.

WORKSHOPS & CONFERENCES: *(selected)*

Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region. Corps Training Workshop. May 2011. *(sponsor & participant)*

Vernal Pools: *The Jewels of the Forest.* Technical Workshop for the Town of Southwick Conservation Commission. January 2005. *(Guest Lecturer)*

George T. Logan, MS, PWS, CSE

WORKSHOPS & CONFERENCES: *(selected)*

The Importance of Habitat Edges. Riverside Landscaping Conference. The Rivers Alliance of Connecticut. June 1998. (*Guest Lecturer*)

Riparian Buffer Function, Performance & Limitations. Urban Riparian Buffers Conference & Technical Training Session. April 1999. *(Guest Lecturer)*

Sedimentation and Erosion Control Review Session. USDA. Natural Resource Conservation Service and CPESC (Certified Professionals in Erosion Control), Concord, NH. September 2001.

Buffer Strips as Storm Water Quality Controls. EnviroExpo, Boston. May 1999. *(Guest Speaker)*

Identifying Wetland Soils, Fauna and Flora. Municipal Inland Wetland Staff Technical Workshops. June 1999. *(Guest Speaker)*

Water Quality in the Quinnipiac River: A Symposium on the Impact of Non Point Source Pollution in the Quinnipiac River Watershed. November 1998. *(Presenter)*

Our Hidden Wetlands: Vernal Pools in Connecticut. Co-sponsored by CT DEP and the Center for Coastal and Watershed Systems. November 1997 and January 1998 *(Workshop Leader)*

Aquatic Invertebrate & Stream Ecology Workshop. Quinnipiac River Watershed Association Workshop Series. September 1997, May 1998, June 1999, January 2000 (*Workshop Leader*)

The Massachusetts Association of Conservation Commissions Third Annual Conference: Wetland Buffer Zones, March 1996 (*Guest Lecturer*)

16th Annual Conference of the Society of Wetland Scientists: Wetland Understanding, Wetland Education, May 1995 (*Presenter*)

Quinnipiac River Watershed Association Forum on Non-Point Pollution: Significance of Wetlands and Wetland Buffers, October 1992 (*Guest Lecturer*)

The Massachusetts Association of Conservation Commissions Second Annual Conference, April 1995 (*Guest Lecturer*)

The Society of Soil Scientists of Southern New England Riparian Buffer Zone Conference, November 1994 (*Presenter*)

George T. Logan, MS, PWS, CSE

SUPPLEMENTARY INFORMATION:

1996 to present

Rema Ecological Services, LLC
Principal Environmental Scientist/Ecologist, Co-Owner

- Founded the company to provide natural resources management, environmental planning, compliance and permitting services, and client advocacy throughout the Northeast.
- Has participated in over 2,650 individual projects since the company's inception, including six gas-fired, combined-cycle power plant projects, 14 utility-scale solar projects, over 90 bridge projects, numerous municipal projects, including over 25 school projects, several higher education projects, numerous wetland replacement projects, several new golf courses, and many large residential, industrial and commercial endeavors, including distribution centers.
- Was the Interim Environmental Planner for the Town of Waterford, Connecticut, during a ten-month tenure. Responsibilities included providing procedural and technical support to the town's Conservation Commission (a.k.a. Inland Wetlands and Watercourses Agency), and working closely with Planning Department staff.

1994 to 1996

Fugro East, Inc. *(Currently AECOM)*
Senior Project Manager/Environmental Scientist

- Office Manager for the firm's Connecticut office, responsible for day-to-day operations, marketing, and business development.
- Wetland delineations in accordance with state and federal criteria.
- Natural resource inventories of upland, wetland and aquatic ecosystems, specializing in wildlife habitat assessments.
- Preparation of environmental compliance documentation for over 100 projects including large-scale commercial development.

1993 to 1994

A.D. Marble & Company, Inc.
Senior Environmental Planner/Wildlife Biologist

- Participated in the management of major transportation improvement projects and in the preparation of environmental documents in accordance with the National Environmental Policy Act (NEPA) while continuing involvement in the collection of baseline field data.
- Application of the Pennsylvania Department of Environmental Resources (PADER) hierarchical methodology for the selection of suitable wetland replacement sites.
- Field verification of Threatened, Endangered or Special Concern species listed by the Pennsylvania Game Commission.
- Wetland boundary identification in accordance with the unified PADER and U.S. Army Corps of Engineers (USACOE) methodology.
- Participated in nearly 30 projects, mostly for major transportation corridors, such as the rehabilitation of the I-95 corridor in PA.

SUPPLEMENTARY INFORMATION *(continued):*

1989 to 1993

Soil Science & Environmental Services, Inc.
Wildlife Biologist-Ecologist & Soil Scientist

- Project Manager responsible for field operations and report preparation for nearly 300 individual projects in over 75 towns in New England, including one town-wide wetland mapping, inventory and evaluation project (Town of Cromwell).
- Wetland boundary delineation according to state and federal criteria (e.g., Connecticut and Massachusetts Statutes, U.S. Army Corps of Engineers methodologies).
- Ecosystem analyses and biological inventories of upland areas, tidal and inland wetlands, estuaries, streams, rivers, ponds and lakes.
- Environmental impact evaluations, including site plan review, analyses of proposed impacts and design of mitigation strategies.
- Local, state and federal permitting for impacts to natural resources, including wetlands.
- Implementation of water quality monitoring programs for streams and rivers.
- Design, construction supervision, and monitoring of wetland enhancement, restoration and creation.
- Aquatic biosurveys of streams and rivers utilizing standardized methods (e.g., EPA Rapid Bioassessment Protocols).
- Detailed faunal surveys and censuses using both active and passive methods (e.g., direct and indirect observation, live-trapping, point count avian censuses, pellet counts, etc.).
- Expert witness testimony for court and administrative proceedings.

1988 to 1989

Independent Contracts
Soil & Wetland Scientist

- *Summer of 1988*: Was hired by the Town of Canton, CT, to identify, inventory, and evaluate wetlands and watercourses within the entire municipality. Was responsible for amending the municipality's *Official Wetland and Watercourses Map*.
- *Spring of 1988*: Was hired by the Connecticut Chapter of the Nature Conservancy to determine and report on the historic expansion of invasive plants (*Phragmites australis, Lythrum salicaria*) on eight TNC preserves. Scope included site visits, remote sensing using archived aerial photographs, and report.

TECHNICAL REPORTS:

Mr. Logan has completed several hundred comprehensive studies (e.g., Wetlands Assessments, Ecological Evaluations, Environmental Impact Analyses/Statements, Vernal Pool Investigations, Listed-Species Surveys & Management Plans, Aquatic Vegetation Surveys), and a variety of other specialized studies. A representative list, or examples of these technical reports can be provided upon request.