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CHAPTER 272

STORMWATER MANAGEMENT BYLAW

GUIDANCE DOCUMENT

(JUNE 22, 2022)

Chapter 272
Stormwater Management Bylaw

§ 272-1. **Purpose and Objectives**

A. The purpose of this Bylaw is to protect, maintain, and enhance public health, safety, environment, and general welfare of the Town by preventing or diminishing adverse effects of construction-site and post-construction stormwater runoff. Proper management of stormwater runoff will minimize damage to public and private property and infrastructure, safeguard the health, safety, environment, and general welfare of the public, protect water and aquatic resources, protect and enhance wildlife habitat, and promote groundwater recharge to protect surface and groundwater drinking supplies. This Bylaw seeks to meet that purpose through the following objectives:

Establish minimum stormwater management standards and design criteria for the regulation and control of stormwater runoff quantity and quality;

Encourage the use of nonstructural stormwater management, better site design, and low impact development practices such as preserving natural resources and open space, reducing impervious surface area, and increasing infiltration;

Establish provisions for the long-term responsibility for, and maintenance of, structural stormwater control facilities and nonstructural stormwater best management practices to ensure that they continue to function as designed and pose no threat to public safety;

Establish provisions to ensure there is an adequate funding mechanism, including surety, for the proper review, inspection, and long-term maintenance of stormwater facilities implemented as part of this Bylaw;

Establish the Town of Brewster's legal authority to ensure compliance with the provisions of this bylaw through permitting, inspection, monitoring, and enforcement; and

Comply with state and federal statutes and regulations relating to stormwater discharges including Total Maximum Daily Load requirements and with the General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts (MS4 Permit), issued by the U.S. Environmental Protection Agency and the Massachusetts Department of Environmental Protection.

§ 272-2. **Definitions**

The following definitions shall apply in the interpretation and implementation of this Bylaw. Additional definitions may be adopted by separate regulation.

ALTERATION OF DRAINAGE CHARACTERISTICS: Any activity on an area of land that changes the water quality, force, direction, timing, or location of runoff flowing from the area. Such changes include: change from distributed runoff to confined or discrete discharge; change in the volume of runoff from the area; change in the peak rate of runoff from the area; and change in the recharge to groundwater on the area.

APPLICANT: Any person, individual, partnership, association, firm, company, corporation, trust, authority, agency, department, or political subdivision, of the Commonwealth or the Federal government, to the extent permitted by law, requesting a Stormwater Permit.

BEST MANAGEMENT PRACTICE (BMP): Schedules of activities, practices (and prohibitions of practices), structures, vegetation, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to Waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

CLEAN WATER ACT: The Federal Water Pollution Control Act (33 U.S.C. § 1251 et seq.) as hereafter amended.

CLEARING: Any activity that removes the vegetative surface cover.

COMMON PLAN OF DEVELOPMENT: - A "larger common plan of development or sale" is a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules under one plan.

EROSION: The wearing away of the land surface by natural or artificial forces such as wind, water, ice, gravity, or vehicle traffic and the subsequent detachment and transportation of soil particles.

GRADING: Changing the level or shape of the ground surface.

GRUBBING: The act of clearing land surface by digging up roots and stumps.

IMPERVIOUS SURFACE: Any surface that prevents or significantly impedes the infiltration of water into the underlying soil. This can include but is not limited to: roads, driveways, parking areas and other areas created using nonporous material; buildings, rooftops, structures, solar panels, artificial turf, and compacted gravel or soil.

INFILTRATION: The act of conveying surface water into the ground to permit groundwater recharge and the reduction of stormwater runoff from a project site.

LAND DISTURBANCE ACTIVITY: Any activity that causes a change in the position or location of soil, sand, rock, gravel, or similar earth material; results in an increased amount of runoff or pollutants; measurably changes the ability of a ground surface to absorb waters; involves clearing, grading, or excavating, including grubbing; or results in an alteration of drainage characteristics.

LOW IMPACT DEVELOPMENT (LID): site planning and design strategies that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat.

MS4 PERMIT: General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts.

MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) or MUNICIPAL STORM DRAIN SYSTEM: The system of conveyances designed or used for collecting or conveying stormwater, including any road with a drainage system, street, gutter, curb, inlet, piped storm drain, pumping facility, retention or detention basin, natural or man-made or altered drainage channel, reservoir, and other drainage structure that together comprise the storm drainage system owned or operated by the Town of Brewster.

NEW DEVELOPMENT: Any construction activities or land alteration on an area that has not previously been developed to include impervious surface.

OPERATION AND MAINTENANCE PLAN: A plan setting up the functional, financial and organizational mechanisms for the ongoing operation and maintenance of a stormwater management system to ensure that it continues to function as designed.

OWNER: A person with a legal or equitable interest in property.

PERSON: An individual, partnership, association, firm, company, trust, corporation, agency, authority, department or political subdivision of the Commonwealth or the federal government, to the extent permitted by law, and any officer, employee, or agent of such person.

RECHARGE: The process by which groundwater is replenished by precipitation through the percolation of runoff and surface water through the soil.

RECORD: Recorded in the Barnstable County Registry of Deeds; if registered land is affected, filed with the recorder of the Land Court of Massachusetts.

REDEVELOPMENT: Development, rehabilitation, expansion, demolition, construction, land alteration, or phased projects that disturb the ground surface, including impervious surfaces, on previously developed sites.

RUNOFF: Rainfall, snowmelt, or irrigation water flowing over the ground surface.

SEDIMENT: Mineral or organic soil material that is transported by wind or water, from its origin to another location; the product of erosion processes.

SEDIMENTATION: The process or act of deposition of sediment.

SITE: The areal extent of construction and land disturbance activities, including but not limited to the creation of new impervious surface and improvement of existing impervious surface.

STORMWATER AUTHORITY: The Town of Brewster Planning Board or its authorized agent(s), acting pursuant to this Bylaw to administer, implement, and enforce this Bylaw and to adopt regulations pursuant to it.

STORMWATER PERMIT: A permit issued by the Stormwater Authority, after review of an application, plans, calculations, and other supporting documents, in accordance with the provisions of this Bylaw.

TOTAL MAXIMUM DAILY LOAD (TMDL): A regulatory plan (authorized by the Clean Water Act) that identifies the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant.

WATERCOURSE: A natural or man-made channel through which water flows or a stream of water, including a river, brook, or underground stream.

WATERS OF THE COMMONWEALTH: All waters within the jurisdiction of the Commonwealth, including, without limitation, rivers, streams, lakes, ponds, springs, impoundments, estuaries, wetlands, coastal waters, groundwater, and Waters of the United States as defined under the Federal Clean Water Act as hereafter amended.

§ 272-3. **Authority**

This Bylaw is adopted under authority granted by the Home Rule Amendment of the Massachusetts Constitution and the Massachusetts home rule statutes, and pursuant to the regulations of the federal Clean Water Act found at 40 CFR 122.34.

§ 272-4. **Administration**

A. The Stormwater Authority shall administer, implement, and enforce this Bylaw. Any powers granted to or duties imposed upon the Stormwater Authority may be delegated in writing by the Stormwater Authority to its employees or agents.

B. The Brewster Planning Board shall be the Stormwater Authority. For projects that fall within the jurisdiction of the Brewster Wetlands Protection Bylaw (Brewster General Bylaw Chapter 172), the Conservation Commission shall be the authority to implement and enforce this Bylaw. The Stormwater Authority may designate an agent to enforce this Bylaw.

C. This Bylaw is not intended to interfere with, abrogate, or annul any other Town of Brewster bylaw, rule or regulation, statute, or other provision of law. The requirements of this Bylaw should be considered minimum requirements, and where any provision of this Bylaw imposes restrictions different from those imposed by any other bylaw, rule or regulation, or other provision of law, whichever provisions are more restrictive or impose higher protective standards for human health or the environment shall be considered to take precedence.

§ 272-5. **Applicability**

A Stormwater Permit shall be required for any of the following, except for an activity exempted under Section 6 of this Bylaw:

A. Any land disturbance activity that will disturb 10,000 square feet or more, or smaller land disturbance activities that are part of a larger common plan of alteration or development that will disturb 10,000 square feet or more;

B. Any new development or redevelopment that will result in a net increase in impervious surface area by 500 square feet or more, or smaller activities that are part of a larger common plan of alteration or development that will result in a net increase in impervious surface area by 500 square feet or more; or

C. Any land disturbance activity, new development, or redevelopment that, over a two-year period, will result in a cumulative land disturbance of more than 10,000 square feet and/or a cumulative net increase in impervious surface area of more than 500 square feet to land that is part of a larger parcel held in common ownership or control at any time since said date. For the purposes of this Section, ownership by related or jointly controlled persons or entities shall be considered common ownership. In such cases, the new activity is prohibited until either:

   (1) All activities that previously disturbed land and/or increased impervious surface area as described in this Section are brought into full compliance with the requirements and standards of this Bylaw, or

   (2) The application for permit under this Bylaw for the new activity includes bringing the land previously disturbed and/or the impervious surface area

previously increased into full compliance with the requirements and standards of this Bylaw. If the involved land is not currently held in common ownership, all owners of the involved land must jointly apply for the permit.

D. A development or alteration of land shall not be segmented or phased in a manner to avoid compliance with this Bylaw.

§ 272-6. **Exemptions**

The following activities are exempt from the requirements of this Bylaw, provided that such activities utilize the best practical measures to avoid any negative impacts on stormwater quality, runoff rate, and volume.

A. Any work or projects for which all necessary approvals and permits, including building permits, have been issued before the effective date of this Bylaw.

B. Maintenance and improvement of land in agricultural or aquacultural use, as defined by the Massachusetts Wetlands Protection Act regulation 310 CMR 10.04.

C. Maintenance of existing landscaping, gardens, or lawn areas associated with a residential dwelling conducted in such a way as to not cause a nuisance.

D. Construction of fencing that will not substantially alter existing terrain or drainage patterns.

E. Construction of utilities other than drainage (gas, water, electric, telephone, etc.) that will not alter terrain, ground cover, or drainage patterns or result in discharge of sediment or other pollutants to the MS4 or to a Watercourse or Waters of the Commonwealth.

F. Emergency repairs to existing utilities (gas, water, electric, telephone, drainage, etc.) or emergency repairs to any stormwater management facility that poses a threat to public health or safety, as determined by the Stormwater Authority.

G. Maintenance or resurfacing (not including reconstruction) of an existing public or private way, parking area, or driveway, provided that such activity does not increase impervious surface area and that resurfacing does not disturb the pavement subbase.

§ 272-7. **Stormwater Management Regulations**

A. The Stormwater Authority shall promulgate and periodically amend Stormwater Management Regulations relating to the terms, conditions, definitions, enforcement, fees (including application, inspection, and/or consultant fees), delegation of authority, procedures, and administration of this Bylaw. Failure of the Stormwater Authority to issue such regulations, or a legal declaration of their invalidity by a court, shall not act to suspend or invalidate the effect of this Bylaw.

B. The Stormwater Authority may establish a Minor Stormwater Permit for specific activities.

(1) The purpose of the Minor Stormwater Permit is to simplify the permitting process under this Bylaw by waiving certain submission requirements, provided a set of predetermined eligibility criteria and performance standards are met.

(2) The eligibility criteria, performance standards, and submission requirements for Minor Stormwater Permits shall be outlined in the Stormwater Management Regulations promulgated in accordance with this Bylaw.

(3) The Stormwater Authority may allow Minor Stormwater Permits to be approved by one or more agents of the Stormwater Authority rather than by a majority of Stormwater Authority members.

C. The Stormwater Authority may establish criteria, procedures, and standards for off-site compliance with post-construction stormwater management performance standards established in the Stormwater Management Regulations promulgated under this Bylaw.

§ 272-8. **Performance Standards**

A. Performance standards shall be defined as part of the Stormwater Management Regulations promulgated under this Bylaw.

B. Unless specifically altered by this Bylaw or its regulations, the Stormwater Authority will use the latest accepted versions of the Massachusetts Stormwater Management Regulations as contained in the Massachusetts Wetlands Protection Act Regulations at 310 CMR 10.05 (6)(k) and the Massachusetts Stormwater Handbook as issued by the Massachusetts Department of Environmental Protection for criteria, policy, standards, stormwater systems design and engineering, compliance documentation requirements, and general information for the execution of the provisions of this Bylaw.

C. Unless specifically altered in this Bylaw and its regulations, the Stormwater Authority shall presume that stormwater management practices designed, constructed, and maintained in accordance with the Massachusetts Stormwater Management Handbook meet the performance standards of this Bylaw. For requirements that are inconsistent between the Massachusetts Stormwater Management Handbook and the MS4 Permit, the Stormwater Authority will enforce the more stringent of the requirements.

§ 272-9. **Procedures**

A. A Stormwater Permit must be obtained prior to the commencement of any construction or land disturbance activity for which such a permit is required. An Applicant seeking a permit shall file an appropriate application with the Stormwater Authority in a form and containing information as specified in this Bylaw and in regulations adopted by the Stormwater Authority.

B. Each application must be accompanied by the appropriate application fee as established by the Stormwater Authority. Applicants shall pay the application fee before the review process commences. The Stormwater Authority, or its

designated agent, is authorized to retain a Registered Professional Engineer (PE) or other professional consultant to advise the Stormwater Authority on any or all aspects of the application and/or the project's compliance with conditions of a Stormwater Permit. The Stormwater Authority may require the applicant to pay reasonable costs to be incurred by the Stormwater Authority for the employment of outside consultants pursuant to Stormwater Authority regulations as authorized by M.G.L. c. 44, §53G.

C. To obtain a Stormwater Permit, the applicant must show that site design, construction-site stormwater management, and post-construction stormwater management will meet the standards established by the Stormwater Authority in its regulations, which shall be at least as stringent as the relevant requirements of the MS4 Permit and the Massachusetts Stormwater Handbook.

D. The Stormwater Permit shall include measures to ensure adequate long-term operation and maintenance of stormwater management design features and BMPs.

E. The Stormwater Authority may impose requirements, including but not limited to the following:

(1) A requirement that funds for future operation and maintenance be set aside in a dedicated fund or escrow account;

(2) A permanent permit condition requiring compliance with an Operation and Maintenance Plan;

(3) A permanent permit condition requiring that the property owner submit an annual report or certification regarding operation and maintenance;

(4) A requirement to record the Operation and Maintenance Plan (or notice thereof);

(5) A requirement that a legal instrument be put in place establishing responsibility for operation and maintenance of a stormwater BMP serving more than one lot.

§ 272-10. **Consent to Entry onto Property**

By signing the permit application, the Applicant consents to the entry of members of the Stormwater Authority or its authorized agents on the property while the application is under review to verify the information in the application, and at any time after a Stormwater Permit is issued to inspect for compliance with Stormwater Permit conditions.

§ 272-11. **Inspection and Site Supervision**

The Stormwater Authority or its designated agent shall make inspections to verify and document compliance with the Stormwater Permit.

§ 272-12. **Surety**

The Stormwater Authority may require the applicant to post surety before the start of land disturbance or construction activity. The form of the surety shall be approved by the Stormwater Authority and be in an amount deemed sufficient by the Stormwater Authority to ensure that the work will be completed in accordance with the permit. If the project is phased, the Stormwater

Authority may release part of the surety as each phase is completed in compliance with the permit.

Funds held pursuant to this Section shall be deposited in a separate account pursuant to M.G.L. c. 44, §53G1/2. Surety shall be in the form of a surety bond, irrevocable letter of credit, or cash. All interest shall be held within said account; surety shall be released upon satisfaction of all Permit requirements; upon satisfaction of all Permit requirements, applicant shall request, in writing, to the Town Treasurer, that the funds be released, the funds shall not be released until the Stormwater Authority certifies, in writing, that all requirements of the Permit have been met. If the permittee defaults on any obligations imposed by the Permit, the Stormwater Authority may (after notification of the permittee) inform the holder of the security (and the municipal treasurer if the treasurer is not holding the funds) of the default, in which event the Town shall be entitled to the security funds to complete the outstanding permit requirements.

§ 272-13. **Waivers**

A. The Stormwater Authority, or its authorized agent, may waive strict compliance with any requirement of this Bylaw if it finds that:

   (1) Application of some of the requirements is unnecessary or impracticable because of the size or character of the development activity or because of the natural conditions at the site;

   (2) The project is consistent with the purposes and intent of this Bylaw; and

   (3) The project provides substantially the same level of protection to the public health, safety, environment, and general welfare of the Town as required by this Bylaw.

B. Any person seeking a waiver shall submit a written waiver request. Such a request shall be accompanied by an explanation or documentation supporting the waiver request.

C. Waiver requests, except those for activities eligible for Minor Stormwater Permits, shall be discussed and voted on at a public meeting for the project.

D. Waiver requests for Minor Stormwater Permits may be approved by one or more agents of the Stormwater Authority rather than by a majority of Stormwater Authority members.

E. If in the opinion of the Stormwater Authority or its authorized agent, additional time or information is required for review of a waiver request, the Stormwater Authority may continue a meeting to a date announced at the meeting. In the event the Applicant objects to a continuance or postponement, or fails to provide requested information, the waiver request shall be denied.

§ 272-14. **Enforcement**

The Stormwater Authority or its authorized agent shall enforce this Bylaw, and any associated regulations, orders, violation notices, and enforcement orders and may pursue all civil and criminal remedies for such violations.

A. Criminal and Civil Relief.

(1) Any person who violates the provisions of this Bylaw, or any associated regulations, permit, or order issued thereunder, may be subject to criminal penalties and prosecution in a court of competent jurisdiction and/or a fine of not more than $300 per violation. Each day or part thereof that such violation occurs or continues shall constitute a separate offense.

(2) The Stormwater Authority may seek injunctive relief in a court of competent jurisdiction restraining the person from activities which would create further violations or compelling the person to perform abatement or remediation of the violation.

B. Orders.

(1) The Stormwater Authority's authorized agent may issue a written order to enforce the provisions of this Bylaw or any associated regulations or permit. Violations include, without limitation, failure to obtain a Stormwater Permit for an activity subject to this Bylaw, or failure to follow the requirements of a Stormwater Permit, or any other authorization issued pursuant to this Bylaw or regulations issued hereunder. The written order may require the violator to remediate the non-compliance and/or any adverse impact caused by it, including without limitation:

(a) A requirement to cease and desist from the land-disturbing activity until there is compliance with this Bylaw and provisions of the Stormwater Permit or other authorization;

(b) Maintenance, installation, or performance of additional erosion and sediment control measures;

(c) Monitoring, analyses, and reporting;

(d) Remediation of erosion and sedimentation resulting directly or indirectly from the land-disturbing activity;

(e) Construction, reconstruction, repair, or maintenance of stormwater BMPs or any other aspect of the post-construction stormwater management system;

(f) Remediation of adverse impacts resulting from improper construction or operation of the post-construction stormwater management system; and/or

(g) A requirement to eliminate discharges, directly or indirectly, into the MS4, a watercourse, or into the Waters of the Commonwealth.

(2) Any order under this section may be appealed to the Stormwater Authority within five (5) days of the date of said order. All appeals shall be heard and decided within thirty (30) days. The decision of the Stormwater Authority shall be final.

(3) If the Stormwater Authority or its authorized agent determines that abatement or remediation of contamination is required, the order shall set

forth a deadline by which such abatement or remediation must be completed. Said order shall further provide that, should the violator or property owner fail to abate or perform remediation within the specified deadline, the Town of Brewster may, at its option, undertake such work, and expenses thereof shall be charged to the violator.

(4) Within 30 days after completing all measures necessary to abate the violation or to perform remediation, the violator and the property owner will be notified of the costs incurred by the Town, including administrative costs. The violator or property owner may file a written protest objecting to the amount or basis of costs with the Stormwater Authority within 30 days of receipt of the notification of the costs incurred. If the amount due is not received by the expiration of the time in which to file a protest or within 30 days following a decision of the Stormwater Authority affirming or reducing the costs, or from a final decision of a court of competent jurisdiction affirming or reducing the costs, the costs shall constitute a municipal charge for purposes of M.G.L. c.40, §58, and a lien may be imposed on the property for the amount of the unpaid charge, pursuant to M.G.L. c.40, §58. Interest shall begin to accrue on any unpaid costs at the statutory rate provided in M.G.L. c. 59, §57 on the 31st day after the costs first become due.

C. Noncriminal disposition. As an alternative to criminal prosecution or civil action, the Town may elect to utilize the noncriminal disposition procedure set forth in M.G.L. c. 40, §21D, in which case designated agents of the Stormwater Authority shall be the enforcing persons. The penalty for the first violation shall be a warning. The penalty for the second violation shall be $100. The penalty for the third and subsequent violations shall be $300. Each day or part thereof that such violation occurs or continues shall constitute a separate offense.

D. Entry to perform duties under this Bylaw. To the extent permitted by local, state or federal law, or if authorized by the owner or other party in control of the property, the Stormwater Authority, its agents, officers, and employees may enter upon privately owned property for the purpose of performing their duties under this Bylaw and regulations and may make or cause to be made such examinations, surveys or sampling as the Stormwater Authority deems reasonably necessary.

E. Appeals. The decisions or orders of the Stormwater Authority shall be final. Further relief shall be appealed to a court of competent jurisdiction.

F. Remedies not exclusive. The remedies listed in this section are not exclusive of any other remedies available under any applicable federal, state, or local law.

§ 272-15. **Severability**

The provisions of this Bylaw are hereby declared to be severable. If any provision, paragraph, sentence, or clause of this Bylaw or the application thereof to any person, establishment, or circumstances shall be held invalid, such invalidity shall not affect the other provisions or application of this Bylaw.

Town of Brewster
Stormwater Management Regulations

Adopted Date: February 23, 2022
Effective Date: March 4, 2022

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Section 1. Purpose

The purpose of these Regulations is to protect, maintain, and enhance public health, safety, environment, and general welfare by establishing minimum requirements and procedures to mitigate the adverse effects of stormwater runoff, decreased groundwater recharge, erosion and sedimentation, and nonpoint source pollution, as more specifically addressed in the Town of Brewster Stormwater Management Bylaw (Chapter 272).

Section 2. Definitions

2.1. The definitions contained herein apply to the Brewster Stormwater Management Bylaw and the Regulations adopted thereunder. Terms not defined in this section shall be construed according to their customary and usual meaning unless the context indicates a special or technical meaning.

2.2. Definitions are provided in Appendix A of these Regulations.

Section 3. Authority

3.1. The regulations contained herein have been adopted by the Stormwater Authority in accordance with § 272-7 of the Stormwater Management Bylaw.

3.2. Pursuant to § 272-4 of the Stormwater Management Bylaw, the Brewster Planning Board is the Stormwater Authority. For projects that fall within the jurisdiction of the Brewster Wetlands Protection Bylaw (Chapter 172), the Conservation Commission shall be the authority to implement and enforce this Bylaw. The Stormwater Authority may designate an agent(s) to enforce this Bylaw.

3.3. The Stormwater Authority may periodically amend these regulations pursuant to § 272-7 of the Stormwater Management Bylaw.

3.4. Nothing in these Regulations is intended to replace or be in derogation of the requirements of any other Brewster bylaw. These Regulations should be considered minimum requirements, and where any provision of these Regulations impose restrictions different from those imposed by any other bylaw, rule or regulation, or other provision of law, whichever provisions are more restrictive or impose higher protective standards for human health or the environment shall be considered to take precedence.

Section 4. Applicability

All activities subject to the Stormwater Management Bylaw (as set forth in § 272-5 of the Stormwater Management Bylaw) shall obtain a Stormwater Permit before commencing construction or land-disturbance activities. Exemptions are established in § 272-6 of the Stormwater Management Bylaw. The following provides further guidance on activities that do not require a Stormwater Permit:

- Paving an existing gravel, crushed shell, or dirt driveway, road, or parking area, provided that the area of land disturbance is less than 10,000 square feet and the expansion of impervious surface area is less than 500 square feet. Gravel, crushed shell, and dirt driveways, roads, and parking areas are defined as impervious surfaces per Appendix A of these Regulations and § 272-2 of the Stormwater Management Bylaw. Therefore, paving of those surfaces does not constitute creation of new impervious surface area;
- Construction or repair of subsurface septic system components; and
- Replacement of an existing roof.

Proposed raised decks are excluded from the calculation of new impervious surface area if:

- The ground area beneath the proposed deck is presently bare ground or landscaped, including lawn, and is proposed to remain pervious,
- There will not be a roof constructed over the proposed deck, and
- The proposed deck will be constructed in such a manner to allow rainfall to pass through to the ground below. An example of this is the typical wooden deck with expansion spaces between the boards that form the deck surface.

The following criteria shall apply for determining eligibility for Minor Stormwater Permit and Major Stormwater Permit categories:

4.1. Minor Stormwater Permit

A. Any combination or series of construction or land disturbance activities that, over a two-year period, will result in a net increase in impervious area of 500 square feet to 2,500 square feet and/or will result in land disturbances of 10,000 square feet to 20,000 square feet.

4.2. Major Stormwater Permit

A. Any alteration, disturbance, development, or redevelopment that does not meet the eligibility criteria for Minor Stormwater Permit.

Section 5. Administration

5.1. Stormwater Permit applications shall be administered as follows:

A. Minor Stormwater Permit applications shall be reviewed and acted upon by the Designated Agent of the Stormwater Authority. The Town Planner, Conservation Administrator, Department of Public Works (DPW) Director, or Building Commissioner shall be the Designated Agent, depending on the other reviews and

approvals to which the project is subject. Review by the Stormwater Authority is not required for Minor Stormwater Permits.

B. Major Stormwater Permit applications shall be reviewed and acted upon by the Stormwater Authority.

5.2. Application Procedures

A. The Applicant shall submit to the Stormwater Authority (for a Major Permit) or Designated Agent (for a Minor Permit) a completed application for a Stormwater Permit. The Stormwater Permit Application package shall include:

(1) A completed Application Form with original signatures of all property owners;

(2) Digital and printed copies of the Stormwater Management Plan, prepared in accordance with the Stormwater Management Plan Checklist in Appendix B of these Regulations; and

(3) Payment of the Application Fee in accordance with the Fee Schedule in Appendix C of these Regulations.

B. The Stormwater Authority (for a Major Permit) or Designated Agent (for a Minor Permit) shall make a determination as to the completeness of the application and adequacy of the materials submitted. No review shall take place until the application is determined complete.

5.3. Fees

A. Each application shall be accompanied by the appropriate Application Fee, as detailed in Appendix C of these Regulations.

B. The Stormwater Authority or Designated Agent may, at the Applicant's expense, retain a registered Professional Engineer (PE) or other professional consultant to advise the Stormwater Authority on any or all aspects of the Application.

(1) Purpose. As provided by M.G.L. Ch. 44 §53G and the Stormwater Management Bylaw, the Stormwater Authority may impose reasonable fees for the employment of outside consultants, engaged by the Stormwater Authority, for specific expert services to assist the Stormwater Authority in its review of applications for Stormwater Permits and oversight of permit compliance.

(2) Consultant Services. Specific consultant services may include, but are not limited to, technical or legal review of the permit application and associated information, on-site monitoring during construction, or other services related to the project deemed necessary by the Stormwater Authority. The consultant shall be chosen by, and report only to, the Stormwater Authority or its staff.

(3) Notice. The Stormwater Authority shall give written notice to the Applicant of the selection of an outside consultant. Such notice shall state the identity of the consultant, the amount of the fee to be charged to the applicant, and a request for payment of said fee in its entirety. Such notice shall be deemed to have been given on the date it is mailed or delivered. No such costs or expenses

shall be incurred by the Applicant if the application or request is withdrawn within five (5) business days of the date notice is given.

(4) Payment of Fee. The fee must be received prior to the initiation of consulting services. The Stormwater Authority may request additional consultant fees if the review requires a larger expenditure than originally anticipated or new information requires additional consultant services. Failure by the Applicant to pay the consultant fee specified by the Stormwater Authority within ten (10) business days of the request for payment, or refusal of payment, shall be cause for the Stormwater Authority to deny the application based on lack of sufficient information to evaluate whether the project meets applicable performance standards. An appeal stops the clock on the above deadline; the countdown resumes on the first business day after the appeal is either denied or upheld.

(5) Special Account. Funds received pursuant to these Regulations shall be deposited with the municipal treasurer, who shall establish a special account for this purpose. Expenditures from this special account may be made at the direction of the Stormwater Authority without further appropriation as provided in M.G.L. Ch. 44 §53G. Expenditures from this account shall be made only in connection with a specific project or projects for which a consultant fee has been collected from the applicant. Expenditures of accrued interest may also be made for these purposes.

(6) Appeals. The Applicant may appeal the selection of the outside consultant to the Select Board, who may only disqualify the outside consultant selected on the grounds that the consultant has a conflict of interest or does not possess the minimum required qualifications. The minimum qualifications shall consist of either an educational degree or three or more years of practice in the field at issue or a related field. Such an appeal must be in writing and received by the Select Board and a copy received by the Stormwater Authority, so as to be received within ten (10) business days of the date consultant fees were requested by the Stormwater Authority. The required time limits for action upon the application shall be extended by the duration of the administrative appeal.

(7) Return of Unspent Fees. When the Stormwater Authority's review of a permit application and oversight of the permitted project is complete, any balance in the special account attributable to that project shall be returned within thirty (30) business days. The excess amount, including interest, shall be repaid to the Applicant or the Applicant's successor in interest. For the purpose of these Regulations, any person or entity claiming to be an Applicant's successor in interest shall provide the Stormwater Authority with appropriate documentation. A final report of said account shall be made available to the Applicant or Applicant's successor in interest.

5.4. Right of Entry

Filing an application for a permit grants the Stormwater Authority or its agent permission to enter the property to verify the information in the application and to inspect for

compliance with permit conditions. During the application process, the Stormwater Authority, its employees and agents (including consultants) may conduct site visits of the project site to review information presented in the application.

5.5. Public Meeting

A. A public meeting is not required for Minor Stormwater Permit applications.

B. For Major Stormwater Permit applications, the Stormwater Authority shall hold a meeting in accordance with the Massachusetts Open Meeting Law. For projects or activities that require issuance of a Stormwater Permit in addition to other approvals or permits, the Stormwater Authority shall hold a coordinated meeting on all jurisdictional project aspects in accordance with its own regulations and procedures.

5.6. Action by the Stormwater Authority or Designated Agent

A. Minor Stormwater Permit

(1) The Designated Agent shall act upon a Minor Stormwater Permit Application within thirty (30) business days of the date the Designated Agent determines the application is complete or after receipt of expert review by outside consultants if deemed necessary in accordance with Section 5.3.B.

(2) The Designated Agent may:

a. Approve the Minor Stormwater Permit Application and issue a permit if it finds that the performance standards and requirements set forth herein have been met;

b. Approve the Minor Stormwater Permit Application and issue a permit with conditions, modifications, or restrictions that the Designated Agent determines are required to ensure that the performance standards and requirements set forth herein are met;

c. Disapprove the Minor Stormwater Permit Application and deny the permit if it finds that the performance standards and requirements set forth herein have not been met; or

d. Disapprove the Minor Stormwater Permit Application "without prejudice" where an applicant fails to provide requested additional information or review fees that in the Designated Agent's opinion are needed to adequately describe or review the proposed project.

(3) Final approval, if granted, shall be endorsed on the Stormwater Permit by the signature of the Designated Agent.

(4) Appeal of Disapproved Applications

a. The Applicant may appeal a permit denial by the Designated Agent by requesting the Stormwater Authority review the application. Such review shall take place with a public meeting as described in Section 5.5 and shall be subject to any review fees or additional submittal requirements as specified in these Regulations.

B. Major Stormwater Permit

(1) The Stormwater Authority shall take final action within thirty (30) business days from the public meeting as described in Section 5.5, unless such time is extended by agreement between the Applicant and Stormwater Authority.

(2) The Water Quality Review Committee will provide comments on Major Stormwater Permit applications for those projects that require a Special Permit under the Water Quality Protection District (Chapter 179, Article XI).

(3) The Stormwater Authority may:

a. Approve the Major Stormwater Permit Application and issue a permit if it finds that the performance standards and requirements set forth herein have been met;

b. Approve the Major Stormwater Permit Application and issue a permit with conditions, modifications, or restrictions that the Stormwater Authority determines are required to ensure that the performance standards and requirements set forth herein are met;

c. Disapprove the Major Stormwater Permit Application and deny the permit if it finds that the performance standards and requirements set forth herein have not been met; or

d. Disapprove the Major Stormwater Permit Application "without prejudice" where an applicant fails to provide requested additional information or review fees that in the Stormwater Authority's opinion are needed to adequately describe or review the proposed project.

(4) Final approval, if granted, shall be endorsed on the Stormwater Permit by the signature of the majority of the Stormwater Authority or by the Stormwater Authority chair or other designated Stormwater Authority member, as consistent with the Stormwater Authority (Planning Board or Conservation Commission) standard procedures.

5.7. Project Delay

If the project associated with an approved Stormwater Permit has not been completed within three (3) years of permit issuance, the Permit shall expire. At the request of the Applicant, the Stormwater Authority or Designated Agent may extend the Permit or require the Applicant to apply for a new permit. Any request for extension shall be submitted in writing no later than thirty (30) business days prior to the expiration of the Stormwater Permit. The Stormwater Authority or Designated Agent may require updates to the project to comply with current regulations and standards as a condition of the permit extension.

5.8. Project Changes

The Permittee, or their agent, shall notify the Stormwater Authority or Designated Agent in writing of any change of a land-disturbing activity authorized in a Stormwater Permit before any change occurs. If the Stormwater Authority or Designated Agent determines that the change is significant, based on the performance standards in Section 6 and accepted construction practices, the Stormwater Authority or Designated Agent may

require that an amended Stormwater Permit application be filed and a public meeting held. If any change from the Stormwater Permit occurs during land disturbing activities, the Stormwater Authority or Designated Agent may require the installation of interim erosion and sedimentation control measures before approving the change.

5.9. Stormwater Management Certificate of Compliance (SMCC)

A. No SMCC is required for work approved under a Minor Stormwater Permit.

B. Within two (2) years after completion of construction or land disturbance activities permitted under a Major Stormwater Permit, the Permittee shall submit in writing a request for a SMCC. The Permittee must complete the following actions before the Stormwater Authority will consider the request for SMCC:

(1) Within six (6) months after completion of construction and land disturbance activities, the Permittee shall submit certified as-built plans from a registered Professional Engineer (PE), surveyor, or Certified Professional in Erosion and Sediment Control (CPESC). The as-built plans must depict all structural and non-structural stormwater management systems, including subsurface components, and impervious and pervious surface areas on site. Any discrepancies from the approved Stormwater Management Plan should be noted in the cover letter.

(2) The Permittee shall record the approved Operation and Maintenance Plan, including the as-built plans, with the Barnstable County Registry of Deeds.

(3) The Permittee shall complete and document the first year of stormwater best management practice (BMP) operation and maintenance, in accordance with the approved Operation and Maintenance Plan and Stormwater Permit conditions.

C. Upon written request by the Permittee, the Stormwater Authority shall assess whether the work has been completed in substantial conformance with the approved Stormwater Management Plan and any conditions of the Stormwater Permit. Upon determination that permit conditions have been met, the Stormwater Authority shall issue a SMCC.

D. It is the responsibility of the Permittee to request, in writing, the issuance of a SMCC. A Permittee who fails to request a SMCC within two (2) years after completion of construction and land disturbance activities may be found in noncompliance with the Stormwater Management Bylaw and face applicable enforcement actions.

E. After issuance of the SMCC, the Stormwater Authority may periodically review ongoing compliance with Stormwater Permit conditions, including long-term operation and maintenance. If it finds that permit conditions have not been met, the Stormwater Authority may revoke the SMCC and take action in accordance with § 272-14 of the Stormwater Management Bylaw. For projects that have been issued a Water Quality Certificate under the Water Quality Protection District (Chapter 179, Article XI), the Water Quality Review Committee will conduct a compliance review every three years and will work with the Stormwater Authority to ensure ongoing compliance with Stormwater Permit conditions.

5.10. Waivers

A. The Stormwater Authority or Designated Agent may waive strict compliance with any requirement of these Regulations, if it finds that:

(1) Application of some of the requirements is unnecessary or impracticable because of the size or character of the development activity or because of the natural conditions at the site;

(2) The project is consistent with the purposes and intent of the Stormwater Management Bylaw; and

(3) The project provides substantially the same level of protection to the public health, safety, environment, and general welfare of the Town as required by the Stormwater Management Bylaw.

B. Any Applicant seeking a waiver shall submit a written waiver request. Such a request shall be accompanied by an explanation or documentation supporting the waiver request.

C. Waiver requests for Minor Stormwater Permits may be approved by the Designated Agent rather than by a majority of Stormwater Authority members.

D. Waiver requests for Major Stormwater Permits shall be discussed and voted on at a public meeting for the project. If, in the opinion of the Stormwater Authority, additional time or information is required for review of a waiver request, the Stormwater Authority may continue a meeting to a date announced at the meeting. In the event the Applicant objects to a continuance or postponement, or fails to provide requested information, the waiver request shall be denied.

Section 6. Performance Standards

6.1. Construction-Site Stormwater Management

A. Projects eligible for Minor Stormwater Permits shall meet the construction-site stormwater management performance standards detailed in Section 6.1.B to the maximum extent practicable. At a minimum, controls for erosion, sediment, and construction wastes shall be implemented to prevent nuisance conditions, such as sediment or debris washouts onto abutting properties and public rights of way.

B. For Major Stormwater Permits, projects shall implement practices to control construction-related erosion, sedimentation, and wastes in accordance with the most recent versions of the Massachusetts Stormwater Handbook and the Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas, or more stringent standards as specified in these Regulations. The following performance standards shall be met.

(1) Natural Resource Protection: Before commencing land disturbance activities, the limits of permitted disturbance areas shall be marked with high-visibility flagging, fencing, and/or signage. Areas designated for revegetation and/or infiltration-based stormwater practices shall be marked with flagging, fencing, and/or signage to restrict use of heavy vehicles and equipment in these areas to

avoid soil compaction. Tree protection shall be installed around the dripline for all trees to be preserved. Buffers and other restricted areas shall be maintained as required in a wetlands protection authorization from the Brewster Conservation Commission or MassDEP.

(2) Area of Disturbance: Clearing and grading shall only be performed within areas needed to build the project, including structures, utilities, roads, recreational amenities, post-construction stormwater management facilities, and related infrastructure. Such areas shall be staked to ensure that the work is completed within the appropriate areas. Construction activities shall be phased to minimize the area of disturbed soil at any one time.

(3) Soil Stabilization: The time that soil is exposed shall be minimized by stabilizing dormant areas as work progresses. Exposed areas shall be vegetated, hydromulched, protected with erosion control blankets, or otherwise stabilized within 14 days after land disturbance activities have permanently ceased or will be temporarily inactive for 14 or more days. Vegetative cover shall be prepared in the fall to ensure that exposed areas have cover before the first freeze.

(4) Stockpiles: Materials shall not be stored or stockpiled near a storm drain or a wetland resource area. Stockpiled materials that will be unused for 14 or more days shall be covered with roof, tarp, or temporary seeding (of soil stockpiles). Perimeter controls shall be installed around stockpile and staging areas.

(5) Perimeter Controls: Perimeter sediment controls, such as silt fencing and filter tubes, shall be installed around downgradient boundaries, along all resource areas, and around stockpile and staging areas. Compost socks and straw bale shall be free of invasive species. Perimeter controls shall not be removed until the drainage areas have been permanently stabilized.

(6) Stabilized Construction Entrance: Track-out controls (e.g., gravel apron) shall be installed at each construction entrance to remove sediment from vehicles and prevent tracking onto public roads. Where sediment has been tracked-out from the site, paved roads, sidewalks, or other paved areas shall be swept or vacuumed at the end of the workday. Sediment shall not be swept, hosed, or otherwise deposited into any stormwater conveyance, storm drain inlet, or waterbody.

(7) Inlet Protection: Filter bags, filter tubes, or other inlet protection controls shall be installed to prevent sediment from entering downgradient storm drains. Inlet controls shall not be removed until the drainage areas have been permanently stabilized.

(8) Runoff Diversion: Runoff shall be intercepted and diverted away from disturbed areas with berms, swales, or pipes toward stabilized outlets. Conveyances shall be stabilized with vegetation, erosion control blankets, check dams, or similar practices to slow velocities and prevent erosion.

(9) Sediment Removal: Sediment traps and basins shall be used to remove suspended solids from runoff before it discharges from the site. Traps and

basins shall be designed to use baffles, multiple cells, and other practices to maximize the flow path and settling time. Sediment controls shall not be removed until the drainage areas have been permanently stabilized.

(10) Dewatering: Dewatering activities shall use tanks, filter bags, or other practices to remove sediment before discharge. Water shall not be discharged in a manner that causes erosion or flooding of the site or receiving waters.

(11) Outlet Protection: Pipe outlets shall have stone aprons, level spreaders, or other energy dissipation practices installed to prevent erosion.

(12) Construction Waste Management: Trash, debris, and sanitary wastes shall be removed from the site on a regular basis. Dumpsters shall be covered at the end of every workday and before rain events. Dumpsters shall not be allowed to leak or otherwise discharge to any stormwater conveyance, storm drain inlet, or waterbody. Concrete mixers shall be washed out only in designated areas with liners. Demolition debris, discarded building materials, concrete truck wash out, chemicals, litter, and sanitary wastes shall not be discharged to the MS4 and shall be disposed of in compliance with all local, state, and federal requirements.

(13) Post-Construction BMPs: Stormwater management facilities to be used after construction shall not be used as BMPs during construction unless otherwise approved by the Stormwater Authority. Many technologies are not designed to handle the high concentrations of sediments typically found in construction runoff, and thus must be protected from construction-related sediment loadings.

(14) Dust Control: Dust control shall be used during grading operations. Dust control methods may consist of grading fine soils on calm days only or dampening the ground with water.

(15) Inspection and Maintenance: Erosion and sediment controls shall be inspected as needed and at a minimum before and after rain events. Accumulated sediments shall be removed, and erosion and sediment controls shall be repaired or replaced as needed to ensure they perform as intended.

6.2. Post-Construction Stormwater Management

Projects that do not involve the development or redevelopment of impervious surfaces are exempt from meeting Post-Construction Stormwater Management performance standards.

A. Minor Stormwater Permits

(1) Projects eligible for Minor Stormwater Permits shall evaluate and, unless impracticable, implement Low Impact Development (LID) planning and design strategies. LID practices may include, but not be limited to, protection and restoration of natural resources, minimizing impervious surfaces, grading to direct runoff onto pervious surfaces, and soil decompaction and amendments

to improve infiltration capacity. Further guidance on LID practices may be found in the Massachusetts Stormwater Handbook.

(2) Projects shall implement at least one stormwater BMP to mitigate the impacts from stormwater runoff and pollutants generated from impervious surfaces on the property. The Applicant may select a BMP type including but not limited to:

i. Impervious area disconnection
ii. Rain barrel for roof runoff
iii. Rain garden
iv. Pervious pavement
v. Dry well
vi. Infiltration trench
vii. Vegetated swale

(3) Stormwater BMPs shall be designed in accordance with the Massachusetts Stormwater Handbook and shall have a storage volume equivalent to 1 inch multiplied by the net increase in impervious surface area or by 500 square feet of impervious surface area, whichever is greater. Sizing of infiltration BMPs may be adjusted using a BMP sizing tool provided by the Stormwater Authority.

B. Major Stormwater Permits

(1) At a minimum, Major Stormwater Permit projects shall comply with the Massachusetts Stormwater Standards and the MS4 Permit. Design of stormwater management systems shall be consistent with the requirements of the Massachusetts Stormwater Handbook, or more stringent standards as specified in these Regulations.

(2) Applicants shall evaluate and, unless infeasible, implement LID planning and design strategies. LID practices shall include, but not be limited to, protection and restoration of natural resources, minimizing impervious surfaces, grading to direct runoff onto pervious surfaces, and soil decompaction and amendments to improve infiltration capacity. Further guidance on LID practices may be found in the Massachusetts Stormwater Handbook. If the Applicant finds that LID practices are infeasible, the Applicant shall demonstrate which LID practices were evaluated and reasons why those practices were deemed infeasible.

(3) Selection and design of stormwater BMPs shall be optimized for the removal of phosphorus and nitrogen. Infiltration BMPs, bioretention, and constructed stormwater wetlands are recommended for reducing the concentration of nutrients in stormwater discharges. Additional guidance on BMP performance for phosphorus and nitrogen removal may be found in the MS4 Permit.

(4) Drainage analyses and design calculations shall use precipitation depths based on 90% of the NOAA Atlas 14[1] upper confidence interval for the project location, also known as "NOAA Plus". These "Plus" values are calculated by multiplying the NOAA Atlas 14 upper confidence interval by 0.9.

(5) BMPs located on commercial or industrial land use areas shall be designed to allow for shutdown and containment to isolate the drainage system in the event of an emergency spill or other unexpected event.

(6) New Development

a. Stormwater management systems for new development shall be designed to remove, at a minimum, 90% of the average annual load of Total Suspended Solids (TSS) and 60% of the average annual load of Total Phosphorus (TP) generated from the total post-construction impervious surface area on the site. Average annual pollutant removal requirements may be achieved through one of the following methods:

i. Installing stormwater BMPs that provide the required pollutant removal based on calculations developed using EPA Region 1's BMP Accounting and Tracking Tool (2016), the MS4 Permit methodology, or other BMP performance evaluation tool provided by the Stormwater Authority; or

ii. Retaining the volume of runoff equivalent to, or greater than, 1.0 inch multiplied by the total post-construction impervious surface area on the site; or

iii. Providing a combination of retention and treatment that achieves the above standards.

(7) Redevelopment

a. Redevelopment activities that are exclusively limited to maintenance and improvement of existing roadways (including widening less than a single lane, adding shoulders, correcting substandard intersections, improving existing drainage systems, and repaving projects) shall improve existing conditions unless infeasible and are exempt from the requirements of Section 6.2.C(7)b.

b. Stormwater management systems for redevelopment shall be designed to remove, at a minimum, 80% of the average annual load of TSS and 50% of the average annual load of TP generated from the total post-construction impervious surface area on the site. Average annual pollutant removal requirements may be achieved through one of the following methods:

i. Installing stormwater BMPs that provide the required pollutant removal based on calculations developed using EPA Region 1's BMP Accounting and Tracking Tool (2016), the MS4 Permit methodology,

[1] NOAA Atlas 14 Precipitation Frequency Data Server https://hdsc.nws.noaa.gov/hdsc/pfds/

or other BMP performance evaluation tool provided by the Stormwater Authority; or

ii. Retaining the volume of runoff equivalent to, or greater than, 0.8 inch multiplied by the total post-construction impervious surface area on the site; or

iii. Providing a combination of retention and treatment that achieves the above standards.

Section 7. Construction Inspections

7.1. For Minor Stormwater Permit projects, inspection requirements will be determined by the Designated Agent based on the proposed project's scale and complexity.

7.2. For Major Stormwater Permit projects, the following inspection requirements shall apply:

A. The Stormwater Authority may, at its discretion, require a pre-construction meeting prior to the start of clearing, excavation, construction, or land disturbing activity by the Applicant. The Permittee's technical representative, general contractor, or other authorized person(s) shall meet with the Stormwater Authority to review the permitted plans and their implementation.

B. For projects subject to the NPDES Construction General Permit, construction may not commence until the Permittee has submitted EPA's approval of the Construction General Permit Notice of Intent to the Stormwater Authority and posted the final Stormwater Pollution Prevention Plan (SWPPP) at the site.

C. The approved Stormwater Management Plan bearing the signature of approval of the Stormwater Authority shall be maintained at the site during the progress of the work.

D. The Stormwater Authority or its designated agent may inspect the site at the following stages, at a minimum:

(1) Initial Site Inspection: An inspection may be made of erosion and sedimentation controls and signage prior to any land disturbance to assess overall effectiveness and functioning to protect resources.

(2) Stormwater Management System Excavation Inspection: An inspection may be made of the excavation for the stormwater management system to ensure adequate separation of the stormwater system from groundwater and presence of approved soil type.

(3) Stormwater Management System Inspection: An inspection may be made of the completed stormwater management system, prior to backfilling of any underground drainage or stormwater conveyance structures.

(4) Final Inspection: An inspection may be made of the completed stormwater management system and final site stabilization to confirm as-built features and other permit conditions.

E. Inspections will be conducted by a "qualified person" from the Stormwater Authority or a third party hired to conduct such inspections. A "qualified person" is a person

knowledgeable in the principles and practice of erosion and sediment controls and pollution prevention, who possesses the appropriate skills and training to assess conditions at the construction site that could impact stormwater quality, and the appropriate skills and training to assess the effectiveness of any stormwater controls selected and installed to meet the requirements of these Regulations.

F. The Permittee shall notify the Stormwater Authority at least five (5) business days before each of the following events, to keep the Stormwater Authority informed of construction progress and to facilitate timely inspections by the Stormwater Authority:

(1) Commencement of construction, with erosion and sedimentation control measures in place and stabilized;

(2) Site clearing has been substantially completed;

(3) Rough grading has been substantially completed;

(4) Excavation for stormwater BMPs has been completed;

(5) Subsurface components of stormwater BMPs have been installed, prior to backfilling;

(6) Stormwater BMP surface features have been substantially completed;

(7) Final grading has been substantially completed;

(8) Close of the construction season; and,

(9) Final landscaping (permanent stabilization) and project final completion.

G. Permittee Inspections. The Permittee, or their agent, shall conduct and document inspections of all erosion and sediment control measures no less than weekly or as specified in the permit, and prior to and following anticipated storm events. The purpose of such inspections will be to determine the overall effectiveness of the Erosion and Sedimentation Control Plan, and the need for maintenance or additional control measures as well as verifying compliance with the Stormwater Management Plan. The Permittee, or their agent, shall submit monthly reports to the Stormwater Authority or designated agent in a format approved by the Stormwater Authority.

Section 8. Long-Term Operation and Maintenance

8.1. For Minor Stormwater Permits, the Permittee shall maintain post-construction stormwater BMPs to ensure that they continue to function as intended.

8.2. For Major Stormwater Permits, the Permittee shall meet the following requirements:

A. The Permittee shall ensure that all components of the proposed Stormwater Management Plan are functioning according to manufacturer or design specifications for the life of the system. All components shall be maintained in good condition and promptly repaired, in accordance with the approved Operation and Maintenance Plan. This shall constitute a perpetual condition of any Major Stormwater Permit issued under these Regulations.

B. To ensure adequate long-term operation and maintenance of stormwater management practices, the Stormwater Authority or Designated Agent may require Permittees to implement one or more of the following procedures, depending on the scale and complexity of the project:

(1) Submit an annual certification documenting the work that has been done over the last 12 months to properly operate and maintain the stormwater control measures. The certification shall be signed by the person(s) or authorized agent of the person(s) named in the permit as being responsible for ongoing operation and management.

(2) Establish a dedicated fund or escrow account in the form of a Bond, Insurance Policy, or similar instrumentality, to be maintained for a number of years and for an amount specified by the Stormwater Authority. Such fund or account may be used by the applicant to perform its operation and maintenance responsibilities or, if the Stormwater Authority finds that the applicant has failed to comply with the Permit, by the Stormwater Authority to perform or cause to be performed the required operation and maintenance tasks.

(3) Pay to the Town an amount specified by the Stormwater Authority in compensation for its acceptance of ownership of privately constructed BMPs.

(4) Establish a maintenance contract between with the Stormwater Authority whereby the Stormwater Authority will perform or cause to be performed the required operation and maintenance tasks.

8.3. Recording

For Major Stormwater Permits, the Operation and Maintenance Plan shall be recorded with the Barnstable County Registry of Deeds prior to issuance of a Stormwater Management Certificate of Compliance by the Stormwater Authority pursuant to Section 5.9 of these Regulations.

8.4. Record Keeping

A. The Permittee shall keep records of all inspections, maintenance, and repairs and shall retain the records for at least five (5) years. These records shall be made available to the Stormwater Authority or Designated Agent during inspection of the stormwater management structure or system and at other reasonable times upon request.

B. The Stormwater Authority or Designated Agent may request written records documenting maintenance of the system, including receipts of inspection or cleaning services, and/or may physically inspect the systems to ensure that the proper maintenance has been carried out. Failure of the Permittee to maintain the stormwater management system in reasonable order and condition, in conformance with the approved Operation and Maintenance Plan, shall be considered a violation of these Regulations and shall be subject to enforcement action in accordance with § 272-14 of the Stormwater Management Bylaw.

8.5. Changes to Ownership and/or Operation and Maintenance Plans

A. The Permittee shall notify the Stormwater Authority or Designated Agent of changes in ownership or assignment of financial responsibility for O&M of the stormwater management system or any changes to the Operation and Maintenance Plan within thirty (30) business days of the change. The Permittee shall also be responsible for informing prospective new owners of the requirements of the existing Operation and Maintenance Plan. This shall be an on-going requirement of any Major Stormwater Permit issued.

Section 9. Surety

For Major Stormwater Permits, the Stormwater Authority may require the Applicant to post surety before the start of land disturbance or construction activity. The form of the surety shall be approved by the Stormwater Authority and be in an amount deemed sufficient by the Stormwater Authority to ensure that the work will be completed in accordance with the Permit. If the project is phased, the Stormwater Authority may release part of the surety as each phase is completed in compliance with the permit.

Funds held pursuant to this Section shall be deposited in a separate account pursuant to M.G.L. c. 44, §53G1/2. Surety shall be in the form of a surety bond, irrevocable letter of credit, or cash. All interest shall be held within said account; surety shall be released upon satisfaction of all Permit requirements; upon satisfaction of all Permit requirements, Applicant shall request, in writing, to the Town Treasurer, that the funds be released. The funds shall not be released until the Stormwater Authority certifies, in writing, that all requirements of the Permit have been met. If the Permittee defaults on any obligations imposed by the Permit, the Stormwater Authority may (after notification of the Permittee) inform the holder of the security (and the municipal treasurer if the treasurer is not holding the funds) of the default, in which event the Town shall be entitled to the security funds to complete the outstanding permit requirements.

Section 10. Severability

The invalidity of any section, provision, paragraph, sentence, or clause of these Regulations shall not invalidate any other section, provision, paragraph, sentence, or clause thereof, nor shall it invalidate any permit or determination that previously has been issued.

Appendix A. Definitions

ABUTTER: The owner(s) of land adjacent to regulated activity.

ALTERATION OF DRAINAGE CHARACTERISTICS: Any activity on an area of land that changes the water quality, force, direction, timing, or location of runoff flowing from the area. Such changes include: change from distributed runoff to confined or discrete discharge, change in the volume of runoff from the area; change in the peak rate of runoff from the area; and change in the recharge to groundwater on the area.

APPLICANT: Any person, individual, partnership, association, firm, company, corporation, trust, authority, agency, department, or political subdivision of the Commonwealth or the Federal government, to the extent permitted by law, requesting a Stormwater Permit.

BEST MANAGEMENT PRACTICE (BMP): Schedules of activities, practices (and prohibitions of practices), structures, vegetation, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to Waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

CERTIFIED PROFESSIONAL IN EROSION AND SEDIMENT CONTROL (CPESC): A certified specialist in soil erosion and sediment control. This certification program, sponsored by the Soil and Water Conservation Society in cooperation with the American Society of Agronomy, provides the public with evidence of professional qualifications.

CLEAN WATER ACT: The Federal Water Pollution Control Act (33 U.S.C. § 1251 et seq.) as hereafter amended.

CLEARING: Any activity that removes the vegetative surface cover.

COMMON PLAN OF DEVELOPMENT: A "larger common plan of development or sale" is a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules under one plan.

DESIGNATED AGENT: Staff of the Planning, Conservation, Public Works, and Building Departments designated by the Stormwater Authority to review and act upon Minor Stormwater Permit applications.

EROSION: The wearing away of the land surface by natural or artificial forces such as wind, water, ice, gravity, or vehicle traffic and the subsequent detachment and transportation of soil particles.

EROSION AND SEDIMENTATION CONTROL PLAN: A document containing narrative, drawings and details developed by a registered Professional Engineer (PE) or a Certified Professional in Erosion and Sedimentation Control (CPESC), which includes best management practices, or equivalent measures designed to control surface runoff, erosion, and sedimentation during pre-construction and construction related land disturbing activities.

EROSION CONTROL: The prevention or reduction of the movement of soil particles or rock fragments due to stormwater runoff.

GRADING: Changing the level or shape of the ground surface.

GRUBBING: The act of clearing land surface by digging up roots and stumps.

IMPERVIOUS SURFACE: Any surface that prevents or significantly impedes the infiltration of water into the underlying soil. This can include but is not limited to: roads, driveways, parking areas and other areas created using nonporous material; buildings, rooftops, structures, solar panels, artificial turf, and compacted gravel or soil.

INFILTRATION: The act of conveying surface water into the ground to permit groundwater recharge and the reduction of stormwater runoff from a project site.

LAND DISTURBANCE ACTIVITY: Any activity that causes a change in the position or location of soil, sand, rock, gravel, or similar earth material; results in an increased amount of runoff or pollutants; measurably changes the ability of a ground surface to absorb waters; involves clearing, grading, or excavating, including grubbing; or results in an alteration of drainage characteristics.

LOW IMPACT DEVELOPMENT (LID): Site planning and design strategies that use or mimic natural processes that result in the infiltration, evapotranspiration, or use of stormwater in order to protect water quality and associated aquatic habitat.

M.G.L.: Massachusetts General Laws.

MASSACHUSETTS STORMWATER MANAGEMENT STANDARDS: The performance standards as further defined by the Massachusetts Stormwater Handbook, issued by the Department of Environmental Protection, and as amended, that coordinate the requirements prescribed by state regulations promulgated under the authority of the Massachusetts Wetlands Protection Act M.G.L. c. 131 §. 40 and Massachusetts Clean Waters Act M.G.L. c. 21, §. 23-56 to prevent or reduce pollutants from reaching water bodies and control the quantity of runoff from a site.

MS4 PERMIT: General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts.

MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) or MUNICIPAL STORM DRAIN SYSTEM: The system of conveyances designed or used for collecting or conveying stormwater, including any road with a drainage system, street, gutter, curb, inlet, piped storm drain, pumping facility, retention or detention basin, natural or altered drainage channel, reservoir, and other drainage structure that together comprise the storm drainage system owned or operated by the Town of Brewster.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) STORMWATER DISCHARGE PERMIT: A permit issued by the Environmental Protection Agency that authorizes the discharge of pollutants to Waters of the United States.

NEW DEVELOPMENT: Any construction activities or land alteration on an area that has not previously been developed to include impervious surface.

NONPOINT SOURCE POLLUTION: Pollution from many diffuse sources caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away pollutants finally depositing them into a water resource area.

OPERATION AND MAINTENANCE PLAN: A plan setting up the functional, financial and organizational mechanisms for the ongoing operation and maintenance of a stormwater management system to ensure that it continues to function as designed.

OWNER: A person with a legal or equitable interest in property.

PERSON: An individual, partnership, association, firm, company, trust, corporation, agency, authority, department or political subdivision of the Commonwealth or the federal government, to the extent permitted by law, and any officer, employee, or agent of such person.

PUBLIC SHADE TREES: All trees within a public way or on the boundaries thereof, as defined within Massachusetts General Law Chapter 87 (Public Shade Tree Law).

RECHARGE: The process by which groundwater is replenished by precipitation through the percolation of runoff and surface water through the soil.

RECORD: Recorded in the Barnstable County Registry of Deeds; if registered land is affected, filed with the recorder of the Land Court of Massachusetts.

REDEVELOPMENT: Development, rehabilitation, expansion, demolition, construction, land alteration, or phased projects that disturb the ground surface, including impervious surfaces, on previously developed sites.

RUNOFF: Rainfall, snowmelt, or irrigation water flowing over the ground surface.

SEDIMENT: Mineral or organic soil material that is transported by wind or water, from its origin to another location; the product of erosion processes.

SEDIMENTATION: The process or act of deposition of sediment.

SITE: The areal extent of land disturbance and construction activities, including but not limited to the creation of new impervious surface and improvement of existing impervious surface.

STABILIZATION: The use, singly or in combination, of mechanical, structural, or vegetative methods, to prevent or retard erosion.

STORMWATER AUTHORITY: The Town of Brewster Planning Board or its authorized agent(s), acting pursuant to the Town of Brewster Stormwater Management Bylaw (Chapter 272) to administer, implement, and enforce the Bylaw and to adopt regulations pursuant to it.

STORMWATER: Stormwater runoff, snow melt runoff, and surface runoff and drainage.

STORMWATER MANAGEMENT CERTIFICATE OF COMPLIANCE (SMCC): A document issued by the Stormwater Authority which states that all conditions of an issued Stormwater Permit have been met and that a project is currently in compliance with the conditions set forth in the permit.

STORMWATER PERMIT: A permit issued by the Stormwater Authority, after review of an application, plans, calculations, and other supporting documents, in accordance with the provisions of the Town of Brewster Stormwater Management Bylaw (Chapter 272).

TOTAL MAXIMUM DAILY LOAD (TMDL): A regulatory plan (authorized by the Clean Water Act) that identifies the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant.

TOTAL SUSPENDED SOLIDS (TSS): A measure of undissolved organic or inorganic particles in water.

TOTAL PHOSPHORUS (TP): A measure of the total dissolved and particulate forms of phosphorus.

WATERCOURSE: A natural or man-made channel through which water flows or a stream of water, including a river, brook, or underground stream.

WATERS OF THE COMMONWEALTH: All waters within the jurisdiction of the Commonwealth, including, without limitation, rivers, streams, lakes, ponds, springs, impoundments, estuaries, wetlands, coastal waters, groundwater, and Waters of the United States as defined under the Federal Clean Water Act as hereafter amended.

WETLAND RESOURCE AREA: Areas specified in the Massachusetts Wetlands Protection Act M.G.L. c. 131, § 40 and in the Brewster Wetlands Protection Bylaw (Chapter 172).

Appendix B. Stormwater Management Plan Checklists

Minor Stormwater Permit Applications

The application for a Minor Stormwater Permit shall contain sufficient information for the Designated Agent to evaluate the environmental impact, effectiveness, and acceptability of the measures proposed by the Applicant to reduce adverse impacts from stormwater runoff during and after construction.

The Applicant shall submit one digital copy and two (2) printed copies of the Minor Permit application package. The Minor Permit application package shall include:

A. Completed Application Form with original signatures of all property owners;

B. Narrative describing the proposed work including:

(1) Existing and proposed site conditions (including structures, vegetation, and drainage),

(2) The square footage of the proposed land disturbance area, existing impervious surface area, and proposed impervious surface area,

(3) Proposed low impact development practices, and

(4) Proposed measures to control erosion, sediment, and wastes during construction and to mitigate any long-term stormwater impacts.

C. For proposed stormwater BMPs, if applicable, calculations for the stormwater volume to be managed. The volume may be calculated using the following formulas, or using a BMP sizing tool provided by the Stormwater Authority:

(1) Stormwater volume (cubic feet) = impervious surface area (square feet) x 1 inch x 1 foot / 12 inches

(2) Stormwater volume (gallons) = stormwater volume (cubic feet) x 7.48 gallons / cubic foot

D. For proposed stormwater BMPs, if applicable, a description of anticipated maintenance activities and schedule to ensure that the stormwater BMP continues to function as intended. A stormwater BMP maintenance guide, provided by the Stormwater Authority and customized as needed for the project, may be used to meet this requirement.

E. A drawing, map, or plan that shows:

(1) Existing site features including structures, pavement, trees, plantings, and stormwater management systems, etc.;

(2) Proposed work including proposed stormwater management systems and limits of disturbance; and

(3) Proposed erosion and sedimentation controls.

Major Stormwater Permit Applications

The Stormwater Management Plan shall contain sufficient information for the Stormwater Authority to evaluate the environmental impact, effectiveness, and acceptability of the site planning process and the measures proposed by the applicant to prevent adverse impacts from stormwater runoff during and after construction.

The applicant shall submit one digital copy and twelve (12) printed copies of the Stormwater Management Plan. Stormwater Management Plans submitted for consideration shall contain the following minimum components:

1. Site Plan;
2. Stormwater Management Report; and
3. Operation and Maintenance Plan.

More information than the minimum required herein may be required by the Stormwater Authority, provided such information is reasonably necessary for the proper evaluation of the Stormwater Management Plan. Additional plans, such as but not limited to utility plan, landscaping plan, etc., may be required for more complex projects.

Site Plan

The Site Plan shall be prepared to fully detail and explain the intentions of the Applicant. Site Plan sheets shall be prepared at a standard scale (1" = 20', 1" = 40', or 1" = 80', whichever is appropriate to the size of the proposal). All sheets shall include a reasonable numbering system with an appropriate title block, north arrow, signature block, and legend identifying any representative symbols used on the sheet in question.

Design Certification: Each plan sheet shall show the seal and signature of an Engineer, Landscape Architect, or Surveyor, as appropriate to the data.

The Site Plan shall include the following sheets (pages), at a minimum:

A. Existing Conditions Sheet

The Existing Conditions sheet shall contain all the necessary information to convey existing surface features and drainage patterns. It shall contain a topographical survey plan prepared by a Surveyor, including the following information:

1. Name, seal, and signature of the Surveyor who performed the survey.
2. Date(s) of the survey.
3. Reference to all deeds, plans of record, and other information used to establish the existing property lines, the layout of all streets and ways, and public and private easements, including deed references to the abutting lots.
4. Locus, prepared at a scale not smaller than 1" = 1200' and a minimum extent of

one mile diameter. Major streets, buildings, brooks, streams, rivers, or other landmarks should be shown on the Locus with sufficient clarity to be easily discernible.

5. Existing property lines, public and private easements, and road layouts with bearings and distances. All distances shall be in feet and decimals of a foot and all bearings shall be given to the nearest ten seconds. The error of closure shall not exceed one to ten thousand.
6. Boundary of the entire property held in common ownership by the Applicant regardless of whether all or part is being developed at this time.
7. Acreage of the property to the nearest tenth of an acre.
8. Existing monuments.
9. Location and name of all abutters as they appear on the most recent tax list, including owners of the property on the opposite side of all streets abutting the property.
10. Location, names, status (i.e., public or private), and present widths of streets and sidewalks bounding, approaching, or within reasonable proximity of the property, showing both roadway widths and right-of-way width.
11. Location of all test pits, borings, percolation tests, or similar, in or adjacent to the development. Logs of observed groundwater elevations and other test data shall be included in the Stormwater Management Report.
12. Location of all existing buildings and structures on the property and within reasonable proximity of the perimeter of the property.
13. Location of all existing wells and septic systems that can be observed and/or are on file with the Health Department, on the property and within reasonable proximity of the perimeter of the property.
14. Features within and abutting the property, including but not limited to, waterways, water bodies, drainage ditches, streams, brooks, stone walls, fences, curbing, walkways and other paths (paved or unpaved), utility and light poles, buildings and other structures, ledge outcrops, wooded areas, public shade trees and all other trees greater than four (4) inches in diameter at breast height (4½ feet above grade), and historic sites.
15. Location and identification of resource areas regulated under the Massachusetts Wetlands Protection Act or the Brewster Wetlands Protection Bylaw, including areas located within the property and areas outside of the property with buffer zones or offsets that may intersect the property. This shall include wetlands and associated offsets and buffer zones, isolated lands subject to flooding (ILSF), bordering land subject to flooding (BLSF), and riverfront protection areas. If a currently valid delineation for the property does not exist, wetland boundaries shall be delineated in the field with numbered flags by a qualified wetlands specialist, surveyed, and shown on the plan(s) with reference to the flag numbers. The date of any Resource Area Delineation, Determination of Applicability, Order of Conditions, or other applicable decision from the Brewster Conservation Commission shall be indicated on the plans.
16. Location of aquifer protection zones, including Zone 1 and Zone II as defined in

the Brewster Water Quality Protection Bylaw, Chapter 179 Article XI.

17. Location of all existing above- and below-ground utilities and all associated appurtenances within and abutting the property. All utility pipe types, sizes, lengths, and slopes shall be provided, as well as utility structure information, including rim and invert elevations.
18. Existing topography within the property and within reasonable proximity of the perimeter of the property. Topography shall be provided at a minimum one-foot contour intervals. The plan survey datum shall be the National American Vertical Datum 1988 (NAVD88), and this reference shall be identified on the plans.
19. Stormwater flow direction.

B. Proposed Conditions Sheet

The Proposed Conditions sheet shall indicate all proposed site improvements, including but not limited to structures, buildings, sidewalks, handicap ramps, parking areas, curb type and limits, walls, fences, landscaped areas, and the proposed location of all utilities, as described below:

1. All applicable information from the Existing Conditions sheet. The proposed improvements shall be overlaid on the existing conditions and shown in a darker line weight.
2. The boundaries of the site, the outline or footprint of all proposed buildings, structures, parking areas, walkways, loading facilities, or significant landscaping features shall be shown.
3. All means of vehicular access for ingress and egress to and from the site onto the public streets. Plans should show the size and location of driveways and curb cuts.
4. The location of all public shade trees and all other trees over four (4) inches in diameter at breast height (4½ feet above grade) to be removed.
5. The location and type of all above-ground and below-ground utilities.
6. The existing and proposed above- and below-ground stormwater management system, with pipe sizes, lengths, slopes, and materials including conveyances, catch basins, manholes, culverts, headwalls, detention and/or retention basins, treatment units, infiltration systems, and outlet pipes/structures. Rim and invert elevations shall be provided for all structures and other appurtenant features.
7. Proposed contours indicating the finished grades of all proposed construction in the site. The plan shall show how the proposed grades will tie in to the existing grades within and outside of the limit of disturbance. The grades should be provided at a minimum one-foot contour intervals. Walls, curbing and any other features creating a break in grade shall be shown, including proposed top and bottom grades.
8. Stormwater flow direction.

C. Erosion and Sediment Control Sheet

The Erosion and Sediment Control sheet shall contain sufficient information to demonstrate that erosion will be minimized and sediment contained as part of a land disturbance activity,

including the following:

1. All applicable information from both the Existing and Proposed Conditions sheets. The proposed development information shall be shown in a darker line weight.
2. Location of the proposed limit of land disturbance activity, to be lined by perimeter sediment controls in downgradient areas and along all resource areas.
3. Location of anti-tracking area at each construction entrance.
4. Inlet and outlet erosion and sediment controls at all existing and proposed drainage structures.
5. Tree protection for all public shade trees and all other trees over six inches in caliper proposed to remain.
6. Seeding, sodding, or revegetation plans and specifications for all unprotected or unvegetated areas.
7. Location and design of all structural erosion and sediment control measures, such as grade stabilization practices, temporary drainage swales, dewatering devices, and temporary sedimentation basins.
8. Location of all proposed construction stockpiling and staging areas with appropriate erosion and sediment control measures.
9. Location of areas designated for revegetation or infiltration-based BMPs, with notes indicating that soil compaction shall be avoided in those areas.
10. Notes detailing the proposed operation, maintenance, and inspection schedule for all erosion and sedimentation control measures, including proposed schedule for street sweeping of adjacent roadways and paved areas.
11. Notes indicating that demolition debris, discarded building materials, concrete truck wash out, chemicals, litter, and sanitary wastes may not be discharged to the MS4 and must be legally disposed of.
12. Where a site is located in whole or in part within the floodplain, a Floodplain Contingency Plan shall be included. The Floodplain Contingency Plan shall describe the steps necessary to stabilize the site during construction in the event that a flood watch is declared by the National Weather Service.
13. Where a project is also subject to coverage under a National Pollutant Discharge Elimination System (NPDES) Construction General Permit issued by the EPA, submission of the Stormwater Pollution Prevention Plan (SWPPP) shall be required prior to commencement of land disturbance activities.

D. Construction Details Sheet

The Construction Details sheet should provide information regarding the component parts of the construction, illustrating how they fit together. The sheet shall show the following:

1. Typical construction details of all proposed stormwater management system devices, including but not limited to conveyances, catch basins, manholes, headwalls, sub-drains, detention and retention systems, and other stormwater management system structures.

2. Landscaping details including, but not limited to, tree plantings, shrubs, perennials, fences, walls, guard rails, street furniture, and other specialty items, if applicable.
3. Construction details for all hard surfaces, including but not limited to, roadways, sidewalks, driveways, loading docks, handicap ramps, permeable pavers, and curbing.
4. Erosion and sediment control details that for components included in the Erosion and Sediment Control Plan.
5. Where site constraints or differing conditions require work that deviates from "typical details," specific construction details shall be provided.
6. All proposed work within the public right-of-way shall conform to Town of Brewster and/or MassDOT Standard Details, where applicable.

Stormwater Management Report

A separate Stormwater Management Report shall be submitted with the Stormwater Permit Application. It shall be prepared and stamped by an Engineer, and shall contain the following information:

1. Contact Information. The name, address, and telephone number of all persons having a legal interest in the property and the tax reference number and parcel number of the property or properties affected.
2. Description of the watershed that the site is located in, the immediate downgradient waterbody(s) that stormwater runoff from the site discharges to, the impairment status and Total Maximum Daily Load (TMDL), if applicable, of the watershed and waterbody(s), and the pollutant(s) of concern.
3. Description of the existing and proposed soil conditions (including Hydrologic Soils Group [HSG] classification published by the National Resources Conservation Service [NRCS]), land use, land cover, estimated high groundwater elevations, design points, drainage patterns, and proposed stormwater management practices.
4. Description of proposed work within proximity of regulated wetland resources, aquifer protection zones, earthwork within 4 feet of seasonal high groundwater elevations, and other sensitive environmental areas.
5. Description of the low impact development (LID) site planning and design techniques considered for the project and an explanation as to why they were included or excluded from the project.
6. Description of the existing and proposed stormwater management system, including all proposed BMPs incorporated in the project design.
7. Description of all soil testing conducted in the study area, including sieve analyses, tests for saturated hydraulic conductivity, test pits, or soil borings. Soils information shall be based on field investigations by a Soil Evaluator approved by the Commonwealth of Massachusetts, or by an Engineer. Testing shall be performed in accordance with Volume 3 of the Massachusetts Stormwater Handbook (dated February 2008, as amended) and these Rules and Regulations.

Raw test data shall be provided in an appendix to the report.

8. Narrative describing the methodology used to conduct the hydrologic and hydraulic analyses of the site and the design of the proposed stormwater management system.
9. Tables comparing existing and proposed impervious areas, peak stormwater runoff rates, and total stormwater runoff volumes for each design point and for the 2-, 10-, 25-, and 100-year design storms.
10. Narrative and calculations demonstrating compliance with the Massachusetts Stormwater Management Standards.
11. Narrative and calculations demonstrating compliance with the requirements of Section 6 of these Regulations, including estimated reductions to annual average load of total suspended solids (TSS) and annual average load of total phosphorus (TP). Calculations shall be completed using the Environmental Protection Agency (EPA) Region 1's BMP Accounting and Tracking Tool (2016), the Massachusetts MS4 Permit methodology, or other BMP performance evaluation tool provided by the Stormwater Authority.
12. Description of any impacts to the floodplain and floodway and a summary of compensatory flood storage calculations, if appropriate.
13. Description of existing and proposed groundwater recharge on the site, including quantitative summary of existing and proposed recharge volumes, and summary of groundwater mounding analysis, if applicable.
14. Plans showing existing and proposed drainage areas, including any off-site contributions, and time of concentration travel flow-paths. Study design points should be indicated on the plan.
15. If applicable, a map showing the location of the site overlaid on the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Map (FIRM) for the Town of Brewster, or other appropriate information pertaining to location of the floodplain and floodway boundaries in relation to the site.
16. Appendix containing all drainage calculations for existing and proposed conditions, including hydrologic analysis of the site, hydraulic analysis of the proposed drainage system, and calculations supporting the design of all BMPs that will control stormwater runoff pollutants, peak rates, and volumes.
17. Massachusetts Department of Environmental Protection (MassDEP) Checklist for Stormwater Report, stamped and signed by a registered Professional Engineer (PE) licensed in the Commonwealth of Massachusetts to certify that the Stormwater Management Plan is in accordance with the criteria established in the Massachusetts Stormwater Management Standards, Brewster Stormwater Management Bylaw, and these Regulations.

Operation and Maintenance Plan

An Operation and Maintenance (O&M) Plan, in accordance with the Massachusetts Stormwater Management Standards, shall be included with the Stormwater Management Plan. The purpose of the plan is to identify the actions necessary to ensure that stormwater management systems and BMPs function as designed, in perpetuity.

At a minimum, the O&M Plan shall contain:

1. The name(s) of the Owner of all components of the system, and the name(s) and address(es) of the Responsible Party for O&M of each component, if different from the Owner.
2. A plan that is prepared to scale and shows the location of all stormwater management system components and all discharge points.
3. A description of all BMPs, including proper operating parameters and how the Owner will determine if a BMP is not functioning properly.
4. A description of long-term source control and pollution prevention measures.
5. An inspection log and a description of all inspection and maintenance procedures, responsibilities, and frequencies. Where applicable, this schedule shall refer to the Maintenance Criteria provided in the Stormwater Handbook or the EPA National Menu of Stormwater Best Management Practices or equivalent;
6. An inspection and maintenance schedule for all routine and non-routine maintenance tasks to be performed.
7. Minimum qualifications for personnel that will perform inspections and maintenance.
8. Snow storage procedures and locations in accordance with the MassDEP Snow Disposal Guidance, dated December 11, 2020, as amended. Snow shall not be stored or disposed of in any proposed stormwater BMP.
9. A list of easements held to access any BMPs.
10. An estimated O&M budget.
11. A copy of the As-built Plan prepared in accordance with Section 5.9 of these Regulations, upon project completion.

Appendix C. Fee Schedule

	Fee
Minor Stormwater Permit Application	$50
Major Stormwater Permit Application	$100
Consultant Services and Technical Review	Determined on a case-by-case basis

Brewster Stormwater Management Bylaw
Frequently Asked Questions

What is stormwater and why does it matter?

Stormwater is rain and snow melt that doesn't soak into the ground but instead flows over impervious surfaces such as roofs, pavement, and gravel driveways. As stormwater flows, it picks up soil, animal waste, road salt, fertilizer, trash, and other pollutants that can impact our ponds, coastal waters, and drinking water.

Land disturbance activities, such as clearing, construction, and creation of impervious surfaces, can increase stormwater runoff and pollutants if not managed properly. Runoff from disturbed lands also impacts the town's storm drainage systems, exacerbating road flooding during large storms and necessitating more frequent maintenance and upgrades.

What activities trigger the bylaw?

With some exceptions, the bylaw applies to projects that will, over a 2-year period:

1) Disturb over 10,000 square feet of land.

   And/or

2) Increase impervious surface area by over 500 square feet.

A project that meets either of these thresholds must apply for a Stormwater Permit.

Commonly Used Terms

Land disturbance: Any activity that causes a change in the position or location of soil, sand, rock, gravel, or similar earth material; results in an increased amount of runoff or pollutants; measurably changes the ability of a ground surface to absorb waters; involves clearing, grading, or excavating, including grubbing; or results in an alteration of drainage characteristics.

Impervious surface: Any surface that prevents water from soaking into the underlying soil. This can include roofs, solar panels, artificial turf, and paved, gravel, or crushed-shell roads, driveways, parking areas, and sidewalks.

Would a Stormwater Permit be required for these projects?

Yes	No
• Clearing a quarter-acre forest to create a landscaped yard. • Building a 600-square-foot addition onto an existing house. • Expanding an existing parking lot to add 4 parking spaces. • Constructing a new home on a vacant lot. • Building a 400 square-foot garage and then adding a 400 square-foot patio the next year. • Reconstructing a 1,000-foot length of road. • Installing a large solar array in a field.	• Paving an existing gravel driveway (< 10,000 sq. ft.) without expanding it. • Installing or repairing a septic system. • Demolishing a structure and reconstructing it within the same footprint (assuming construction disturbs < 10,000 sq. ft. land area). • Maintaining an existing landscaped property. • Building a new 600-square-foot driveway and converting the old 400-square-foot driveway into lawn. (This would only increase impervious surface area by 200 square feet). • Installing solar panels on a roof or over an existing parking lot.

What does the Stormwater Management Bylaw require?

As described in the Brewster Stormwater Management Regulations, the size of a project will determine the stormwater permitting requirements that must be met. Small projects may qualify for a minor permit, which has simpler procedures and requirements than for a major permit.

Minor Permits. Small projects that will disturb between 10,000 – 20,000 square feet of land or will increase impervious surface area by 500 - 2,500 square feet will require a minor permit. These projects can use simple, non-engineered practices to prevent sediment from washing offsite during construction and to soak rain into the ground after construction. Minor permit applications can be approved administratively by the Town Planner, Building Commissioner, Conservation Agent, or DPW Director.

Rain Barrel

Drywell

Rain Garden

Major Permits. Larger projects (above 20,000 square feet of land disturbance or 2,500 square feet increase in impervious surface area) will need to provide construction-site and post-construction stormwater management in accordance with the Massachusetts Stormwater Handbook and the Massachusetts MS4 General Permit. These requirements are similar to those for projects under Conservation Commission jurisdiction. Major permit applications will be acted upon by the Conservation Commission if the project is within jurisdiction of the Wetlands Protection Bylaw, or by the Planning Board for all other projects.

Bioretention Basin

Permeable Pavement

Brewster Stormwater Management Bylaw
Guide for Minor Stormwater Permit Applicants

This fact sheet provides guidance to applicants for a Minor Stormwater Permit under the Brewster Stormwater Management Bylaw. Please refer to the Stormwater Management Regulations for more detail.

Does my project qualify for a Minor Permit?

You can apply for a Minor Stormwater Permit if your project falls within or below the following thresholds:

- Cumulative area of land disturbance between 10,000 and 20,000 square feet over a 2-year period, and
- Net increase of impervious surface area between 500 and 2,500 square feet over a 2-year period.

If your project's land disturbance or net impervious surface area are above those thresholds, you will need to apply for a Major Stormwater Permit.

TIP

Is your project just barely above the 500 or 2,500-square-foot thresholds for net impervious surface area? With good design, you might be able to get below those thresholds. Look for ways to reduce the area of existing and new impervious surfaces. For example, can you make the new driveway narrower? Revegetate unused parking spaces?

How do I apply for a Minor Permit?

Download and fill out the Town of Brewster Stormwater Management Permit Application. In the space provided for "Detailed Project Description", include the following information:

- A description of the proposed work,
- The square footage of the proposed area of land disturbance, the existing impervious surface area, and the proposed impervious surface area,
- Low-impact development strategies that will be incorporated into the project,
- Proposed measures to control erosion, sediment, and wastes during construction, and
- Proposed stormwater practices to manage runoff after construction.

Commonly Used Terms

Land disturbance: Any activity that causes a change in the position or location of soil, sand, rock, gravel, or similar earth material; results in an increased amount of runoff or pollutants; measurably changes the ability of a ground surface to absorb waters; involves clearing, grading, or excavating, including grubbing; or results in an alteration of drainage characteristics.

Impervious surface: Any surface that prevents water from soaking into the underlying soil. This can include roofs, solar panels, artificial turf, and paved, gravel, or crushed-shell roads, driveways, parking areas, and sidewalks.

Attach the following to your application form:

- A drawing, map, or plan that shows existing site features, proposed site features, limits of land disturbance, proposed construction-site erosion and sedimentation controls, and proposed post-construction stormwater practices,
- A page showing your calculations for the stormwater volume to be managed and sizing of the proposed post-construction stormwater practices, and
- A page describing the anticipated maintenance activities and schedule to ensure that the stormwater practices continue to function as intended.

If your project is subject to the Wetlands Protection Bylaw (i.e., if it is within 100 feet of a wetland), submit your application to the Conservation Department. Otherwise, submit your application to the Planning Department.

Where can I go for help?

Please reach out to the Planning Department, Conservation Department, or the Department of Public Works for guidance on the Stormwater Management Regulations, application process, resources, and examples. You can also hire an engineer or landscape architect to assist you with the design and permit application.

What are low impact development strategies?

Low impact development (LID) planning and design strategies aim to enhance a landscape's ability to slow, filter, and soak in rain. Applicants for Minor Permits must evaluate and implement LID strategies unless it is impracticable due to cost or site constraints. Some strategies that you might consider include:

- Minimize the area of impervious surfaces on your property,
- Slope new impervious surfaces toward vegetated areas, where runoff can soak in,
- Till, amend, and densely seed your lawn to improve drainage and reduce erosion,
- Protect and care for trees on your property, and
- Plant trees and native plants to replace mowed lawn.

Association to Preserve Cape Cod meadow in Dennis, MA

What is construction-site stormwater management?

The Regulations list best practices for construction-site stormwater management in Section 6.1. Minor Permit projects must implement these practices unless they are impracticable due to cost or site constraints. At a minimum, projects must control erosion, sediment, and construction wastes to prevent nuisance conditions, such as sediment or debris washouts onto abutting properties and public rights of way.

Inlet Protection

Tree Protection

Covered and Contained Stockpiles

What are post-construction stormwater practices?

Minor Permit projects must install at least one stormwater practice (also known as stormwater best management practice, or BMP) to mitigate the impacts of stormwater runoff and pollutants generated from impervious surfaces on the property. Some common practices to consider are rain barrels, dry wells, rain gardens, permeable pavers, and directing runoff toward vegetated areas (impervious area disconnection).

Rain Barrel

Drywell

Rain Garden

Permeable Pavers

How do I select and design my stormwater practices?

Step 1. Understand Your Site Conditions

Before selecting a stormwater practice, it is helpful to first understand conditions on your property and which stormwater practices are suitable for those conditions.

Commonly Used Terms

Stormwater practice: Sometimes referred to as best management practice (BMP), methods used to collect, cleanse, and infiltrate stormwater.

Impervious surface: Any surface that prevents water from soaking into the underlying soil. This can include roofs, solar panels, artificial turf, and paved, gravel, and crushed-shell roads, driveways, parking areas, and sidewalks.

Infiltration: Soaking water into the ground.

Permeability: Soil characteristic that describes how easily water can drain through it.

Soils

- Most properties in Brewster have sandy soils that allow water to soak in quickly. These are called “high permeability” soils. Disconnection and infiltration practices work best in permeable soils.
- Some properties in Brewster have clay soils that drain water slowly. These are called “low permeability” soils. Rain barrels and rain gardens work best in these conditions but may require simple soil amendments.
- If you are not sure if your property has high or low permeability soils, view the soils map on the Town of Brewster GIS Map Viewer. Areas shown as Hydrologic Soil Group (HSG) A or HSG B have high permeability; areas shown as HSG C or HSG D have low permeability.

Groundwater Table

- Stormwater practices that soak water into the ground should be located in areas that are dry in the springtime. If you have frequent spring ponding or basement flooding when it has not been raining, the groundwater table on your property might be too high for stormwater to infiltrate.

Slope

- Most stormwater practices should be in an area that is flat or gently sloped (i.e., a vertical drop of 5 feet over horizontal distance of 100 feet).

Available Space

- It may be helpful to measure the area on your property to see if you have enough space for your desired practice. Stormwater infiltration practices should be placed at least 10 feet from building foundations and property lines, 50 feet from septic system leach fields and surface waters, and 100 feet from private wells.

Step 2. Select Your Stormwater Practice

Use the matrix below to identify stormwater practices that might be suitable for your property.

Stormwater Practices	Source of Stormwater			Soils and Groundwater		Slope		Available Space	
	Roof	Driveway /Parking	Patio	High Permeability, Dry Area	Low Permeability or Wet Area	Flat or Gently Sloping	Steep Slopes	< 100 ft²	> 100 ft²
Dry Well	X			X		X		X	
Permeable Pavers		X	X	X		X		X	X
Rain Garden	X	X	X	X	*	X			X
Infiltration Trench	X	X	X	X		X			X
Rain Barrel	X			X	X		X	X	
Impervious Area Disconnection	X	X	X	X	X	X			X

*Low permeability soils can be amended to improve permeability, and the system size is increased to account for poor soils

Step 3. Calculate the Volume of Stormwater to Manage

For Minor Permits, the Brewster Stormwater Management Regulations require that an applicant install one or more stormwater practices that are sized to manage 1 inch of runoff from the net impervious surface area (proposed minus existing impervious surface area) or 500 square feet, whichever is greater. Impervious surface area is the square footage of land covered by roof, driveway, parking area, patio, and other hardscapes on your property.

ft = feet
ft^2 = square feet
ft^3 = cubic feet
gal = gallons

To calculate the volume of runoff to manage, use the following equation:

STORMWATER VOLUME TO MANAGE (ft^3) = IMPERVIOUS SURFACE AREA (ft^2) × 0.083 (ft)

If the stormwater practice is designed to infiltrate runoff and will be located in an area with very sandy soils where water soaks in immediately, you may apply a 20% reduction to the required stormwater volume and calculate volume using the following equation.

STORMWATER VOLUME FOR SANDY SOIL INFILTRATION (ft^3) = STORMWATER VOLUME (ft^3) × 0.8

Step 4. Design your Stormwater Practice

Refer to the fact sheet for your selected stormwater practice for instructions on where to place your practice and how to design it.

Step 5. Plan for Maintenance

Stormwater practices must be maintained to ensure that they continue to function as intended. Maintenance typically includes periodic inspections of the stormwater practice, cleaning out accumulated sediment, leaves, and other debris, and taking care of plants (e.g., for rain gardens). For more information about the maintenance activities and schedule, refer to the fact sheet for your selected stormwater practice.

Bioretention Areas & Rain Gardens

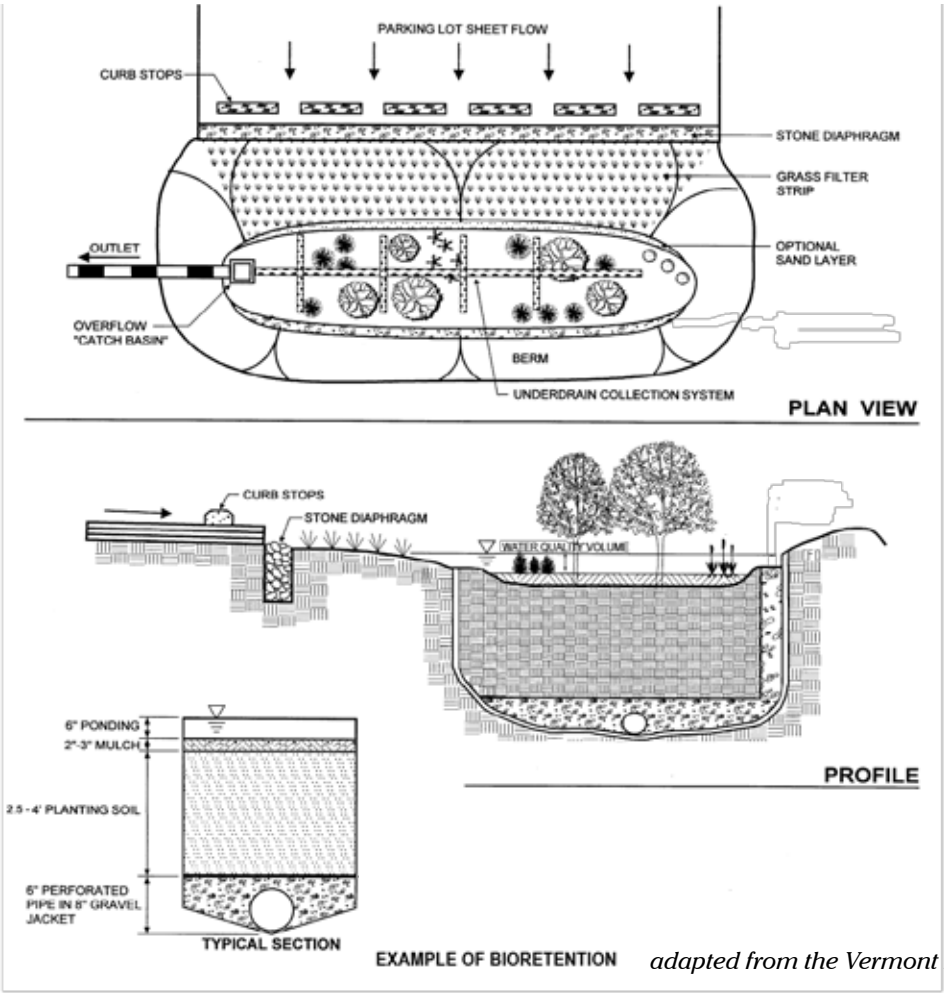
Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Stormwater runoff is directed into the cell via piped or sheet flow. The runoff percolates through the soil media that acts as a filter.
There are two types of bioretention cells: those that are designed solely as an organic filter filtering bioretention areas and those configured to recharge groundwater in addition to acting as a filter exfiltrating bioretention areas. A filtering bioretention area includes an impermeable liner and underdrain that intercepts the runoff before it reaches the water table so that it may be conveyed to a discharge outlet, other best management practices, or the municipal storm drain system. An exfiltrating bioretention area has an underdrain that is designed to enhance exfiltration of runoff into the groundwater.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	An exfiltrating bioretention area provides groundwater recharge.
4 - TSS Removal	90% TSS removal credit with adequate pretreatment
5 - Higher Pollutant Loading	Can be used for certain land uses with higher potential pollutant loads if lined and sealed until adequate pretreatment is provided. Adequate pretreatment must include 44% TSS removal prior to infiltration. For land uses that have the potential to generate runoff with high concentrations of oil and grease such as high intensity use parking lots and gas stations, adequate pretreatment may also include an oil grit separator, sand filter or equivalent. In lieu of an oil grit separator or sand filter, a filtering bioretention area also may be used as a pretreatment device for infiltration practices exfiltrating runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.
6 - Discharges near or to Critical Areas	Good option for discharges near cold-water fisheries. Should not be used near bathing beaches and shellfish growing areas.
7 - Redevelopment	Suitable with appropriate pretreatment

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) — 90% with vegetated filter strip or equivalent
- Total Nitrogen — 30% to 50% if soil media at least 30 inches
- Total Phosphorus — 30% to 90%
- Metals (copper, lead, zinc, cadmium) — 40% to 90%
- Pathogens (coliform, e coli) — Insufficient data



EXAMPLE OF BIORETENTION *adapted from the Vermont Stormwater Manual*

Special Features:

- Can be lined and sealed to prevent recharge where appropriate
- Adequate pretreatment is essential
- Not recommended in areas with steep slope
- Depth of soil media depends on type of vegetation that is proposed
- Soil media must be 30 inches deep to achieve removal of nitrogen

Advantages/Benefits:

- Can be designed to provide groundwater recharge and preserves the natural water balance of the site
- Can be designed to prevent recharge where appropriate
- Supplies shade, absorbs noise, and provides windbreaks
- Can remove other pollutants besides TSS including phosphorus, nitrogen and metals
- Can be used as a stormwater retrofit by modifying existing landscape or if a parking lot is being resurfaced
- Can be used on small lots with space constraints
- Small rain gardens are mosquito death traps
- Little or no hazard for amphibians or other small animals

Disadvantages/Limitations:

- Requires careful landscaping and maintenance
- Not suitable for large drainage areas

Maintenance

Activity	Frequency
Inspect and remove trash	Monthly
Mow	2 to 12 times per year
Mulch	Annually
Fertilize	Annually
Remove dead vegetation	Annually
Prune	Annually

Bioretention Areas & Rain Gardens

Not all bioretention cells are designed to exfiltrate. Only the infiltration requirements are applicable to bioretention cells intended to exfiltrate.

Applicability

Bioretention areas can provide excellent pollutant removal for the "first flush" of stormwater runoff. Properly designed and maintained cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as "rain gardens" and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Bioretention systems can be applied to a wide range of commercial, residential, and industrial developments in many geologic conditions; they work well on small sites and on large sites divided into multiple small drainage areas. Bioretention systems are often well suited for ultra-urban settings where little pervious area exists. Although they require significant space (approximately 5% to 7% of the area that drains to them), they can be integrated into parking lots, parking lot islands, median strips, and traffic islands. Sites can be retrofitted with bioretention areas by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites, they are commonly used for rooftop and driveway runoff.

Effectiveness

Bioretention areas remove pollutants through filtration, microbe activity, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove from 80% to 90% of TSS. If properly designed and installed, bioretention areas remove phosphorus, nitrogen, metals, organics, and bacteria to varying degrees.

Bioretention areas help reduce stress in watersheds that experience severe low flows due to excessive impervious cover. Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe. Decentralized bioretention cells can also reduce the size of storm drain pipes, a major component of stormwater treatment costs. Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide windbreaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Planning Considerations

Filtering bioretention areas are designed with an impermeable liner and underdrain so that the stormwater may be transported to additional BMPs for treatment and/or discharge. Exfiltrating bioretention areas are designed so that following treatment by the bioretention area the stormwater may recharge the groundwater.

Both types of bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads. However, exfiltrating bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads, only if pretreatment has been provided to achieve TSS removal of at least 44%. If the land use has the potential to generate runoff with high concentrations of oil and grease, other types of pretreatment, i.e., a deep sump catch basin and oil grit separator or a sand filter, is required prior to discharge of runoff to an exfiltrating bioretention area. A filtering bioretention area may also be used as a pretreatment device for an exfiltrating bioretention area or other infiltration practice that exfiltrates runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.

To receive 90% TSS removal credit, adequate pretreatment must be provided. If the flow is piped to the bioretention area a deep sump catch catch basin and sediment forebay should be used to provide pretreatment. For sheet flow, there are a number or pretreatment options. These options include:

- A vegetated filter strip, grass channel or water quality swale designed in accordance with the specifications set forth in Chapter 2.
- A grass and gravel combination. This should consist of at least 8 inches of gravel followed by 3 to 5 feet of sod. (source: North Carolina Stormwater Manual, 2007, http://h2o.enr.state.nc.us/su/documents/Ch12-Bioretention_001.pdf)
- Pea diaphragm combined with a vegetated filter strip specially designed to provide pretreatment for a bioretention area as set forth in the following table. (source: Georgia Stormwater Manual and Claytor and Schuler 1996)

Dimensions for Filter Strip Designed Specially to Provide Pretreatment for Bioretention Area

Parameter	Impervious Area				Pervious Areas (lawns, etc.)			
Maximum inflow approach length (feet)	35		75		75		100	
Filter strip slope (max=6%)	<2%	>2%	<2%	>2%	<2%	>2%	<2%	>2%
Filter strip minimum length (feet)	10	15	20	25	10	12	15	18

Bioretention areas must not be located on slopes greater than 20%. When the bioretention area is designed to exfiltrate, the design must ensure vertical separation of at least 2 feet from the seasonal high groundwater table to the bottom of the bioretention cell.

For residential rain gardens, pick a low spot on the property, and route water from a downspout or sump pump into it. It is best to choose a location with full sun, but if that is not possible, make sure it gets at least a half-day of sunlight.

Do not excavate an extensive rain garden under large trees. Digging up shallow feeder roots can weaken or kill a tree. If the tree is not a species that prefers moisture, the additional groundwater could damage it. Size the bioretention area using the methodology set forth in Volume 3.

Design

Size the bioretention area to be 5% to 7% of the area draining to it. Determine the infiltrative capacity of the underlying native soil by performing a soil evaluation in accordance with Volume 3. Do not use a standard septic system (i.e., Title 5) percolation test to determine soil permeability.

The depth of the soil media must be between 2 and 4 feet. This range reflects the fact that most of the pollutant removal occurs within the first 2 feet of soil and that excavations deeper than 4 feet become expensive. The depth selected should accommodate the vegetation. If the minimum depth is used, only shallow rooted plants and grasses my be used. If there is a Total Maximum Daily Load that requires nitrogen to be removed from the stormwater dischrges, the bioretention area should have a soil media with a depth of at least 30 inches, because nitrogen removal takes place 30 inches below the ground surface. If trees and shrubs are to be planted, the soil media should be at least 3 feet.

Size the cells (based on void space and ponding area) at a minimum to capture and treat the required water quality volume (the first 0.5 inch or 1 inch of runoff) if intended to be used for water quality treatment (Stormwater Standard No. 4), the required recharge volume if used for recharge (Stormwater Standard No. 3), or the larger of the two volumes if used to achieve compliance with both Stormwater Standards 3 and 4.

Cover the bottom of the excavation with coarse gravel, over pea gravel, over sand. Earlier designs used filter fabric as a bottom blanket, but more recent experiences show that filter fabric is prone to clogging. Consequently, do not use fabric filters or sand curtains. Use the Engineered Soil Mix below.

Engineered Soil Mix for Bioretention Systems Designed to Exfiltrate

- The soil mix for bioretention areas should be a mixture of sand compost and soil.
  - o 40 % sand,
  - o 20-30% topsoil, and
  - o 30-40% compost.

- The soil mix must be uniform, free of stones, stumps, roots or similar objects larger than 2 inches. Clay content should not exceed 5%.
- Soil pH should generally be between 5.5-6.5, a range that is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants.
- Use soils with 1.5% to 3% organic content and maximum 500-ppm soluble salts.
- The sand component should be gravelly sand that meets ASTM D 422.

Sieve Size	**Percent Passing**
2-inch	100
¾-inch	70-100
¼-inch	50-80
U.S. No. 40	15-40
U.S. No. 200	0-3

- The topsoil component shall be a sandy loam, loamy sand or loam texture.
- The compost component must be processed from yard waste in accordance with MassDEP Guidelines (see http://www.mass.gov/dep/recycle/reduce/leafguid.doc). The compost shall not contain biosolids.

On-site soil mixing or placement is not allowed if soil is saturated or subject to water within 48 hours. Cover and store soil to prevent wetting or saturation.

Test soil for fertility and micro-nutrients and, only if necessary, amend mixture to create optimum conditions for plant establishment and early growth.

Grade the area to allow a ponding depth of 6 to 8 inches; depending on site conditions, more or less ponding may be appropriate.

Cover the soil with 2 to 3 inches of fine-shredded hardwood mulch.

The planting plan shall include a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding, occasional saline conditions due to road salt, and extended dry periods. A list of plants that are suitable for bioretention areas can be found at the end of this section. To avoid a monoculture, it is a good practice to include one tree or shrub per 50 square feet of bioretention area, and at least 3 species each of herbaceous perennials and shrubs. Invasive and exotic species are prohibited. The planting plan should also meet any applicable local landscaping requirements.

All exfiltrating bioretention areas must be designed to drain within 72 hours. However, rain gardens are typically designed to drain water within a day and are thus unlikely to breed mosquitoes.

Bioretention cells, including rain gardens, require pretreatment, such as a vegetated filter strip. A stone or pea gravel diaphragm or, even better, a concrete level spreader upstream of a filter strip will enhance sheet flow and sediment removal.
Bioretention cells can be dosed with sheet flow, a surface inlet, or pipe flow. When using a surface inlet, first direct the flow to a sediment forebay. Alternatively, piped flow may be introduced to the bioretention system via an underdrain.

For bioretention cells dosed via sheet flow or surface inlets, include a ponding area to allow water to pond and be stored temporarily while stormwater is exfiltrating through the cell. Where bioretention areas are adjacent to parking areas, allow three inches of freeboard above the ponding depth to prevent flooding.

Most bioretention cells have an overflow drain that allows ponded water above the selected ponding depth to be dosed to an underdrain. If the bioretention system is designed to exfiltrate, the underdrain is not connected to an outlet, but instead terminates in the bioretention cell. If the bioretention area is not designed to exfiltrate, the underdrain is connected to an outlet for discharge or conveyance to additional best management practices.

Construction

During construction, avoid excessively compacting soils around the bioretention areas and accumulating silt around the drain field. To minimize sediment loading in the treatment area, direct runoff to the bioretention area only from areas that are stabilized; always divert construction runoff elsewhere.

To avoid compaction of the parent material, work from the edge of the area proposed as the location of an exfiltrationg bioretention cell. Never direct runoff to the cell until the cell and the contributing drainage areas are fully stabilized.

Place planting soils in 1-foot to 2-foot lifts and compact them with minimal pressure until the desired elevation is reached. Some engineers suggest flooding the cell between each lift placement in lieu of compaction.

Maintenance

Premature failure of bioretention areas is a significant issue caused by lack of regular maintenance. Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately owned cells. Bioretention areas require careful attention while plants are being established

Bioretention Maintenance Schedule

Activity	*Time of Year*	*Frequency*
Inspect & remove trash	Year round	Monthly
Mulch	Spring	Annually
Remove dead vegetation	Fall or Spring	Annually
Replace dead vegetation	Spring	Annually
Prune	Spring or Fall	Annually
Replace entire media & all vegetation	Late Spring/early Summer	As needed*

** Paying careful attention to pretreatment and operation & maintenance can extend the life of the soil media*

and seasonal landscaping maintenance thereafter.

In many cases, a landscaping contractor working elsewhere on the site can complete maintenance tasks. Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.

Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly. Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall).

Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides. Remove invasive species as needed to prevent these species from spreading into the bioretention area. Replace mulch every two years, in the early spring. Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch. A summary of maintenance activities can be found on the previous page.

Because the soil medium filters contaminants from runoff, the cation exchange capacity of the soil media will eventually be exhausted. When the cation exchange capacity of the soil media decreases, change the soil media to prevent contaminants from migrating to the groundwater, or from being discharged via an underdrain outlet. Using small shrubs and plants instead of larger trees will make it easier to replace the media with clean material when needed.

Plant maintenance is critical. Concentrated salts in roadway runoff may kill plants, necessitating removal of dead vegetation each spring and replanting. The operation and maintenance plan must include measures to make sure the plants are maintained. This is particularly true in residential subdivisions, where the operation and maintenance plan may assign each homeowner the legal responsibility to maintain a bioretention cell or rain garden on his or her property. Including the requirement in the property deed for new subdivisions may alert residential property owners to their legal responsibilities regarding the bioretention cells constructed on their lot.

Cold Climate Considerations

Never store snow in bioretention areas. The Operation and Maintenance plan must specify where on-site snow will be stored. All snow dumps must comply with MassDEP's guidance. When bioretention areas are located along roads, care must be taken during plowing operations to prevent snow from being plowed into the bioretention areas. If snow is plowed into the cells, runoff may bypass the cell and drain into downgradient wetlands without first receiving the required water quality treatment, and without recharging the groundwater.

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Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Agrostis alba redtop	FAC	Mesic-Xeric	1-2	H	–	H	H	Shade	Grass	2-3'	Fiberous Shallow	Yes	High	–
Andropogon gerardi bluejoint	FAC	Dry Mesic-Mesic	1-2	–	–	–	–	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	–
Andropogon virginicus broomsedge	–	Wet meadow	1-2	L	–			Full sun	Grass	1-3'		Yes	High	Tolerant of fluctuating water levels and drought.
Carex vulpinoidea fox sedge	OBL	Freshwater marsh	2-4	L	–			Sun to partial sun	Grass	2-3.5'	Rhizome	Yes	High	–
Chelone glabra														
Deschampsia caespitosa tufted hairgrass	FACW	Mesic to wet Mesic	2-4	H	–	H	H	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	May become invasive.
Glyceria striata fowl mannagrass, nerved mannagrass	OBL	Freshwater marsh, seeps	1-2	L	–			Partial shade to full shade	Grass	2-4'	Rhizome	Yes	High	–
Hedera helix English Ivy	FACU	Mesic	1-2	–	–	–	H	Sun	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Hibiscus palustris														
Iris kaempferi														

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FAC Facultative - Equally likely to occur in wetlands and non-wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Occur almost always in wetlands

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Lobelia siphilitica														
Lotus Corniculatus birdsfoot-trefoil	FAC	Mesic-Xeric	1-2	H	L	H	H	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	Member of the legume family.
Onoclea sensibilis sensitive fern, beadfern	FACW							Shade		1-3.5'			H	
Pachysandra terminalis Japanese pachysandra	FACU	Mesic	1-2	–	–	–	M	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Panicum virgatum switch grass	FAC to FACU	Mesic	2-4	H	–	–	H	Sun or Shade	Grass	4-5'	Fiberous Shallow	Yes	High	Can spread fast and reach height of 6'
Vinca major large periwinkle	FACU	Mesic	1-2	–	–	–	H	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	Sensitive to soil compaction and pH changes.
Vinca minor common periwinkle	FACU	Mesic	1-2	–	–	–	H	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Indian grass														
Little bluestem														
Deer tongue														
Green coneflower														

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Aronia arbutifolia (Pyrus arbutifolia) red chokeberry	FACW	Mesic	1-2	H	_	H	M	Sun to partial sun	Deciduous shrub	6-12'	_	Yes	High	Good bank stabilizer. Tolerates drought.
Clethra alnifolia sweet pepperbush	FAC	Mesic to wet Mesic	2-4	H	_	_	H	Sun to partial sun	Ovoid shrub	6-12'	Shallow	Yes	Med	Coastal plain species.
Cornus Stolonifera (Cornus sericea) red osier dogwood	FACW	Mesic-Hydric	2-4	H	H	H	M	Sun or shade	Arching, spreading shrub	8-10'	Shallow	Yes	High	Needs more consistent moisture levels.
Cornus amomum silky dogwood	FAC	Mesic	1-2	L	_	_	M	Sun to partial sun	Broad-leaved	6-12'	_	Yes	High	Good bank stabilizer
Euonymous europaeus spindle-tree	FAC	Mesic	1-2	M	M	M	M	Sun to partial sun	Upright dense oval shrub	10-12'	Shallow	No	No	_
Hamamelis virginiana witch hazel	FAC	Mesic	2-4	M	M	M	M	Sun or shade	Vase-like compact shrub	4-6'	Shallow	Yes	Low	_
Hypericum densiflorum common St. John's wort	FAC	Mesic	2-4	H	M	M	H	Sun	Ovoid shrub	3-6'	Shallow	Yes	Med	_
Ilex glabra inkberry	FACW	Mesic to wet Mesic	2-4	H	H	_	H	Sun to partial sun	Upright dense shrub	6-12'	Shallow	Yes	High	Coastal plain species.
Ilex verticillata winterberry	FACW	Mesic to wet Mesic	2-4	L	M	_	H	Sun to partial sun	Spreading shrub	6-12'	Shallow	Yes	High	_

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Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Itea virginica tassel-white, Virginia sweetspire	OBL	Mesic	1-2	M	–	–	M	Sun or shade	Broad-leaved, deciduous shrub	6-12'	–	Yes	Low	–
Juniperus communis "compressa" common juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Mounded shrub	3-6'	Deep taproot	No	High	Evergreen
Juniperus horizontalis "Bar Harbor" creeping juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Matted shrub	0-3'	Deep taproot	No	High	Evergreen
Lindera benzoin spicebush	FACW	Mesic to wet Mesic	2-4	H	–	–	H	Sun	Upright shrub	6-12'	Deep	Yes	High	–
Myrica pennsylvanica bayberry	FAC	Mesic	2-4	H	M	M	H	Sun to partial sun	Rounded, compact shrub	6-8'	Shallow	Yes	High	Coastal plain species.
Physocarpus opulifolius ninebark	FAC	Dry Mesic to wet Mesic	2-4	M	–	–	H	Sun	Upright shrub	6-12'	Shallow	Yes	Med	May be difficult to locate.
Viburnum cassinoides northern wild raisin	FACW	Mesic	2-4	H	H	H	H	Sun to partial sun	Rounded, compacted shrub	6-8'	Shallow	Yes	High	–
Viburnum dentatum arrow-wood	FAC	Mesic to wet	2-4	H	H	H	H	Sun to partial sun	Upright, multi-stemmed shrub	8-10'	Shallow	Yes	High	–
Viburnum lentago nannyberry	FAC	Mesic	2-4	H	H	H	H	Sun to partial sun	Upright, mlti-stemmed shrub	8-10'	Shallow	Yes	High	–

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Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Acer rubrum red maple	FAC	Mesic-Hydric	4-6	H	H	H	H	Partial sun	Single to multi-stem tree	50-70'	Shallow	Yes	High	-
Amelanchier canadensis shadbush	FAC	Mesic	2-4	H	M	-	H	Partial sun	Single to multi-stem tree	35-50'	Shallow	Yes	High	Not recommended for full sun.
Betula nigra river birch	FACW	Mesic-Hydric	4-6	-	M	M	H	Partial sun	Single to multi-stem tree	50-75'	Shallow	Yes	High	Not susceptible to bronze birch borer.
Betula populifolia gray birch	FAC	Xeric-Hydric	4-6	H	H	M	H	Partial sun	Single to multi-stem tree	35-50'	Shallow to deep	No	High	Native to New England area.
Fraxinus americana white ash	FAC	Mesic	2-4	M	H	H	H	Sun	Large tree	50-80'	Deep	Yes	Low	-
Fraxinus Pennsylvanica green ash	FACW	Mesic	4-6	M	H	H	H	Partial sun	Large tree	40-65'	Shallow to deep	Yes	Low	-
Ginko biloba Maidenhair tree	FAC	Mesic	2-4	H	H	H	H	Sun	Large tree	50-80'	Shallow to deep	No	Low	Avoid female species-offensive odor from fruit.
Gleditsia triacanthos honeylocust	FAC	Mesic	2-4	H	M	-	M	Sun	Small caopied large tree	50-75'	Shallow to deep variable taproot	Yes	Low	Select thornless variety.
Juniperus virginiana eastern red cedar	FACU	Mesic-Xeric	2-4	H	H	-	H	Sun	Dense single stem tree	50-75'	Taproot	Yes	Very high	Evergreen
Liquidambar styraciflua sweet gum	FAC	Mesic	4-6	H	H	H	M	Sun	Large tree	50-70'	Deep taproot	Yes	High	Edge and perimeter; fruit is a maintenance problem.
Nyssa sylvatica black gum	FACW	Mesic-Hydric	4-6	H	H	H	H	Sun	Large tree	40-70'	Shallow to deep taproot	Yes	High	-

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in non-wetlands and wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Almost always occur in wetlands.

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Platanus acerifolia London plane-tree	FACW	Mesic	2-4	H	–	–	M	Sun	Large tree	70-80'	Shallow	No	Low	Tree roots can heave sidewalks.
Platanus occidentalis sycamore	FACW	Mesic-Hydric	4-6	M	M	M	M	Sun	Large tree	70-80'	Shallow	Yes	Med	Edge and perimeter; fruit is a maintennance problem; tree is also prone to windthrow.
Populus deltoides eastern cottonnwood	FAC	Xeric-Mesic	4-6	H	H	H	L	Sun	Large tree with spreading branches	75-100'	Shallow	Yes	High	Short lived.
Quercus bicolor Swamp white oak	FACW	Mesic to wet Mesic	4-6	H	–	H	H	Sun to partial sun	Large tree	75-100'	Shallow	Yes	High	One of the faster growing oaks.
Quercus coccinea scarlet oak	FAC	Mesic	1-2	H	M	M	M	Sun	Large tree	50-75'	Shallow to deep	Yes	High	–
Quercus macrocarpa bur oak	FAC	Mesic to wet Mesic	2-4	H	H	H	M	Sun	Large spreading tree	75-100"	Taproot	No	High	Native to Midwest.
Quercus palustris pin oak	FACW	Mesic-Hydric	4-6	H	H	H	M	Sun	Large tree	60-80'	Shallow to deep taproot	Yes	High	–
Quercus phellos willow oak	FACW	Mesic to wet Mesic	4-6	H	–	–	H	Sun	Large tree	55-75'	Shallow	Yes	High	Fast growing oak.
Quercus rubra red oak	FAC	Mesic	2-4	M	H	M	M	Sun to partial sun	Large spreading tree	60-80'	Deep taproot	Yes	High	–
Quercus shumardii Shumard's red oak	FAC	Mesic	2-4	H	H	H	M	Sun to partial sun	Large spreading tree	60-80'	Deep taproot	No	High	Native to Southeast.

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Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Sophora japonica Japanese pagoda tree	FAC	Mesic	1-2	M	M	_	M	Sun	Shade tree	40-70'	Shallow	No	Low	Fruit stains sidewalk.
Taxodium distichum bald cypress	FACW	Mesic-Hydric	4-6	_	_	M	H	Sun to partial sun	Typically single stem tree	75-100'	Shallow	Yes	Low	Not well documented for planting in urban areas.
Thuja occidentalis arborvitae	FACW	Mesic to wet Mesic	2-4	M	M	M	H	Sun to partial sun	Dense single stem tree	50-75'	Shallow	No	Low	Evergreen
Zelkova serrata Japanese zelkova	FACU	Mesic	1-2	M	M	_	H	Sun	Dense shade tree	60-70'	Shallow	No	Low	Branches can split easily in storms.

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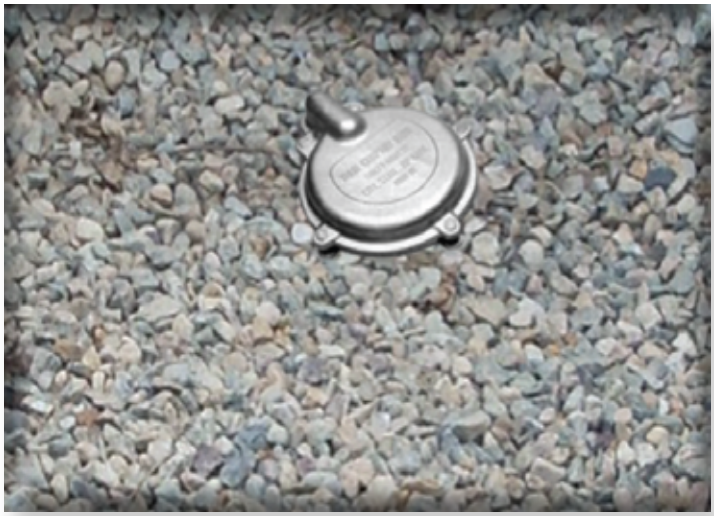
Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Dry Wells



Description: Dry wells are small excavated pits, backfilled with aggregate, and used to infiltrate uncontaminated runoff from non-metal roofs or metal roofs located outside the Zone II or Interim Wellhead Protection Area of a public water supply and outside an industrial site. Do not use dry wells to infiltrate any runoff that could be significantly contaminated with sediment and other pollutants. Never use dry wells to infiltrate runoff from land uses with higher potential pollutant loads, including parking lot runoff.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	Provides groundwater recharge.
4 - TSS Removal	80% TSS removal for runoff from non-metal roofs and runoff from metal roofs that are located outside the Zone II or Interim Wellhead Protection Area of a public water supply and outside an industrial site.
5 - Higher Pollutant Loading	May not be used for runoff from land uses with higher potential pollutant loads, May not be used for runoff from metal roofs located at industrial sites.
6 - Discharges near or to Critical Areas	Within a Zone II or IWPAmay be used only for runoff from nonmetal roofs. Outside a Zone II or Interim Wellhead Protection Area, may be used for both metal and nonmetal roofs provided the roof is not located on an industrial site.
7 - Redevelopment	For rooftop runoff from non-metal roofs and from metal roofs located outside a Zone II or IWPA and outside industrial sites.

Advantages/Benefits:

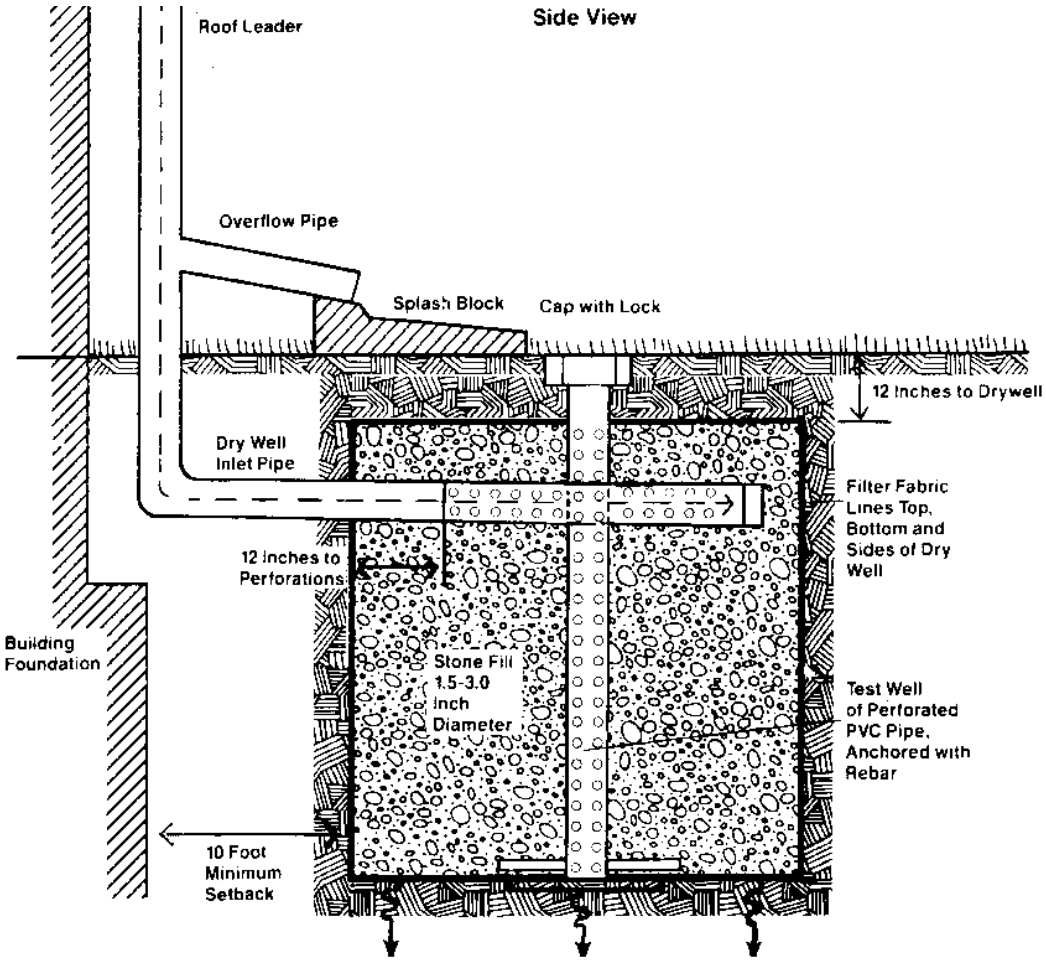
- Applicable for runoff from non-metal roofs and metal roofs located outside of the Zone IIs or IWPA of a public water supply, and outside industrial sites
- Can reduce the size and cost of downstream BMPs and/or storm drains.
- Feasible for new development and retrofit areas
- Provides groundwater recharge

Disadvantages/Limitations:

- Clogging likely when used for runoff other than that from residential rooftops.
- May experience high failure rate due to clogging.
- Only applicable in small drainage areas of one acre or less.
- When located near buildings, potential issues with water seeping into cellars or inducing cracking or heaving in slabs
- Overflow from roof leader must be directed away from sidewalks or driveways

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) 80%
- Nutrients (Nitrogen, phosphorus) Insufficient data
- Metals (copper, lead, zinc, cadmium) Insufficient data
- Pathogens (coliform, e coli) Insufficient data



adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Inspect dry wells.	After every major storm in the first few months after construction to ensure proper stabilization and function. Thereafter, inspect annually.
Measure the water depth in the observation well at 24- and 48-hour intervals after a storm. Calculate clearance rates by dividing the drop in water level (inches) by the time elapsed (hr).	See activity

Special Features

For uncontaminated runoff from non-metal roofs. May be used for runoff from metal roofs located outside the Zone II or Interim Wellhead Protection Area of a public water supply and outside an industrial site. A metal roof is a roof made of galvanized steel or copper.

LID Alternative

Take advantage of LID site design credit and direct runoff from non-metal roofs to a qualifying pervious area. See Volume 3 for information on disconnecting roof runoff.
Consider green roof.

Infiltration Trenches

Description: Infiltration trenches are shallow excavations filled with stone. They can be designed to capture sheet flow or piped inflow. The stone provides underground storage for stormwater runoff. The stored runoff gradually exfiltrates through the bottom and/or sides of the trench into the subsoil and eventually into the water table.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Full exfiltration trench systems may be designed for peak rate attenuation
3 - Recharge	Provides groundwater recharge.
4 - TSS Removal	80% TSS removal credit when combined with one or more pretreatment BMPs.
5 - Higher Pollutant Loading	May be used if 44% of TSS is removed with a pretreatment BMP prior to infiltration. For some land uses with higher potential pollutant load an oil grit separator or equivalent must be used prior to discharge to the infiltration structure. Infiltration must be done in compliance with 314 CMR 5.00.
6 - Discharges near or to Critical Areas	Highly recommended with pretreatment to remove at least 44% TSS removal prior to discharge.
7 - Redevelopment	Suitable with pretreatment.

Advantages/Benefits:

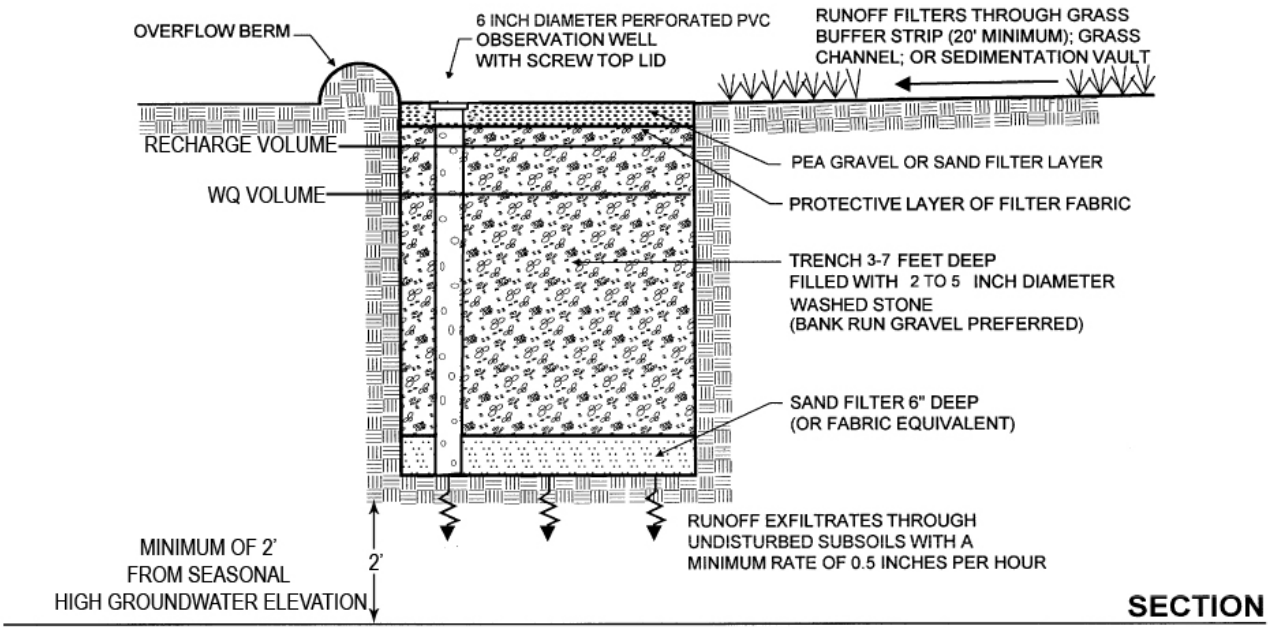
- Provides groundwater recharge.
- Reduces downstream flooding and protects stream bank integrity for small storms.
- Preserves the natural water balance of the site.
- Provides a high degree of runoff pollution control when properly designed and maintained.
- Reduces the size and cost of downstream stormwater control facilities and/or storm drain systems by infiltrating stormwater in upland areas.
- Suitable where space is limited.

Disadvantages/Limitations:

- High failure rates due to improper siting, inadequate pollution prevention and pretreatment, poor design, construction and maintenance.
- Use restricted to small drainage areas.
- Depending on runoff quality, potential risk of groundwater contamination.
- Requires frequent maintenance.
- Susceptible to clogging with sediment.

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) — 80% with pretreatment
- Total Nitrogen — 40% to 70%
- Total Phosphorus — 40% to 70%
- Metals (copper, lead, zinc, cadmium) — 85% to 90%
- Pathogens (coliform, e coli) — Up to 90%



Example of Infiltration Trench

adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Inspect units and remove debris	Every 6 months and after every major storm
Remove sediment from pretreatment BMPs	Every 6 months and after every major storm

Special Features:

High failure rate without adequate pretreatment and regular maintenance

LID Alternative:

Reduce impervious areas
Bioretention areas

Infiltration Trenches

Infiltration trenches can be designed for complete exfiltration or partial exfiltration, where a portion of the runoff volume is directed to the trench and the remainder is conveyed to other BMPs.

Full Exfiltration Trench Systems

Infiltration trenches must be sized to provide storage and exfiltration of the required water quality volume. Full exfiltration systems also provide control of peak discharges and water quality treatment for all storm events equal to or less than the design storm selected. In selecting the design storm, the minimum peak rate attenuation storm event must include the 2- and 10-year 24-hour storm events and may include the 100-year 24-hour storm event, if the runoff from that storm will increase flooding up- or downstream of the site. An emergency overflow channel is required to discharge runoff volumes in excess of the design storm. Economic and physical constraints can restrict the use of full exfiltration systems. Generally, it is not practical to provide storage for large infrequent storms, such as the 100-year storm.

Partial or Water Quality Exfiltration Trench Systems

These systems exfiltrate a portion of the runoff, while the remainder is conveyed to other BMPs. At a minimum, they must be sized to exfiltrate the recharge volume required by Stormwater Management Standard 3. There are two methods of partial infiltration. The first relies on off-line treatment where a portion of the runoff, or the "first-flush," is routed from the main channel to the trench by means of a weir or other diversion structure. The second method is on-line, and uses a perforated pipe at the top of the trench. This underdrain must be placed near the top of the trench. Refer to the design section below. After the trench fills to capacity, excess runoff is discharged through the perforated pipe and directed to other BMPs.

Applicability

Infiltration trenches always require a pretreatment BMP. For sheet flow, pretreatment BMP structures that may be used include vegetated filter strips and pea stone gravel diaphragms. For piped flow, a sediment forebay should be used.

Infiltration trenches are feasible at sites with gentle slopes, permeable soils, and where seasonal high groundwater levels are at least two feet below the bottom of the trench. MassDEP recommends providing greater depths from the bottom of the trench to seasonal high groundwater elevation to reduce the potential for failure. Depth to bedrock will need to be evaluated to determine if use of an infiltration trench is feasible.

Contributing drainage areas must be relatively small and not exceed 5 acres. Infiltration trenches are suitable for parking lots, rooftop areas, local roads, highways, and small residential developments.

Infiltration trenches are adaptable to many sites because of their thin profile. Table IT.1 lists the recommended site criteria. Infiltration trenches can be used in upland areas of larger sites to reduce the overall amount of runoff and improve water quality while reducing the size and costs of downgradient BMPs.

Infiltration trenches are effective at mimicking the natural, pre-development hydrological regime at a site. Full exfiltration systems that have been carefully designed may be capable of controlling peak discharges from the 2-year and 10-year 24-hour storm.

Planning Considerations

MassDEP highly recommends using infiltration trenches near Critical Areas. They may be used to treat stormwater discharges from areas of higher potential pollutant loads, provided 44% of TSS is removed prior to infiltration. For some land uses with higher potential pollutant load, an oil grit separator or equivalent device may be required prior to discharge to the infiltration trench. When an oil/grit separator is used, pipe the runoff to the infiltration trench. Discharges from land uses with higher potential pollutant loads require compliance with 314 CMR 5.00.

Before planning infiltration trenches, carefully evaluate the subsurface of the site including soils, depth to bedrock, and depth to the water table. Make sure soils have a minimum percolation rate of 0.17 inches per hour.

Make the slopes of the contributing drainage area less than 5%. Infiltration trenches have extremely high failure rates, usually due to clogging, so pretreatment is essential. Infiltration trenches are not intended to remove coarse particulate pollutants, and generally are difficult to rehabilitate once clogged. Typical pretreatment BMPs for infiltration trenches

Table IT.1 - Site Criteria for Infiltration Trenches
1. The contributing drainage area to any individual infiltration trench should be restricted to 5 acres or less.
2. The minimum depth to the seasonal high water table, bedrock, and/or impermeable layer should be 2 ft. from the bottom of the trench.
3. The minimum acceptable soil infiltration rate is 0.17 inches per hour. Infiltration trenches must be sized in accordance with the procedures set forth in Volume 3.
4. A minimum of 2 soil borings should be taken for each infiltration trench. Infiltration trenches over 100 ft. in length should include at least one additional boring location for each 50 ft. increment. Borings should be taken at the actual location of the proposed infiltration trench so that any localized soil conditions are detected.
5. Infiltration trenches should not be used at sites where soils have 30% or greater clay content, or 40% or greater silt clay content. Infiltration trenches will not function adequately in areas with hydrologic soils in group D and infiltration will be limited for hydrologic soils in group C.
6. Infiltration trenches should not be placed over fill materials.
7. The following setback requirements apply to infiltration trench installations: • Distance from any slope greater than 5% to any surface exposed trench: minimum of 100 ft. • Distance from any slope greater than 20% to any underground trench: minimum of 100 ft. • Distance from septic system soil absorption system: minimum of 50 ft. • Distance from any private well: minimum of 100 feet, additional setback distance may be required depending on hydrogeological conditions. • Distance from any public groundwater drinking water supplies: Zone I radius, additional setback distance may be required depending on hydrogeological conditions. • Distance from any surface water supply and its tributaries: Zone A
8. Distance from any surface water of the Commonwealth (other than surface drinking water supplies and their tributaries): minimum of 150 ft downslope and 100 ft upslope.
9. Distance from any building foundations including slab foundations without basements: minimum of 20 ft.

include oil grit separators, deep sump catch basins, vegetated filter strips, pea stone gravel diaphragms, or sediment forebays.
Clogging can be an issue even when infiltrating uncontaminated rooftop runoff as well, so it is important to implement some form of pretreatment to remove sediments, leaf litter, and debris to ensure the proper functioning of the trench and allow for longer periods between maintenance.

Consider the impacts of infiltrating stormwater on nearby resources. Infiltration trenches need to be set back outside Zone Is and Zone As for public drinking water supplies. Finally, avoid creating groundwater mounds near Chapter 21e sites that could alter subsurface flow patterns and spread groundwater pollution.

Design

See the following for complete design references:
Maryland Stormwater Design Manual, Volumes I and II. October 2000. Maryland Department of Environment. Baltimore, MD.

The volume and surface area of an infiltration trench relate to the quantity of runoff entering the trench from the contributing area, the void space, and the infiltration rate. Because the infiltration trench is filled with stone, only the space between the stone is available for runoff storage. Effective designs call for infiltration trenches to be filled with 1.5-inch to 3.0-inch diameter clean washed stone. Conduct a geotechnical study to determine the final soil infiltration rate below the trench. For sizing purposes, assume a void ratio of 0.4.

Take a minimum of two borings or observation pits for each infiltration trench. For trenches over 100 feet long, include at least one additional boring or pit for each 50-foot increment. Take borings or dig observation pits at the actual location of the proposed infiltration trench to determine localized soil conditions.

Base the design of the infiltration trench on the soil evaluation set forth in Volume 3. The minimum acceptable rate is 0.17 inches per hour. Never use the results of a Title 5 percolation test to estimate an infiltration rate, as these tend to greatly overestimate the rate that water will infiltrate into the subsurface.

Place the maximum depth of the trench at least two feet above the seasonal high water table or bedrock, and below the frost line.

Include vegetated buffers (20-foot minimum) around surface trenches. Place permeable filter fabric 6 to 12 inches below the surface of the trench, along the sides, and at the bottom of the trench. Use filter fabric, especially at the surface to prevent clogging; if failure does occur, it can be alleviated without reconstructing the infiltration trench. Another option is to place twelve inches of sand at the bottom of the trench.

Install an observation well at the center of the trench to monitor how quickly runoff is clearing the system. Use a well-anchored, vertical perforated PVC pipe with a lockable above-ground cap.

The visible surface of the trench may either be stone or grassed. Stone is easier to rake out when clogged. If it is vegetated with grasses, use fabric above the stone to keep the soil that serves as the planting medium from clogging the stone. When trenches are designed to accept sheet flow, take into account the grass surface when determining how much of the runoff will exfiltrate into the trench.

A perforated pipe underdrain is sometimes used as part of the design. The purpose of the underdrain is to facilitate exfiltration into the parent soil. Except for underdrains placed between different trench cells, MassDEP does not allow underdrains placed near the bottom of the trench. Placement of an underdrain near the bottom of the trench reduces the amount of treatment and exfiltration, because more water is conveyed through the underdrain to the outlet point when it rains than exfiltrates into the surrounding soils.

Construction

Table IT.2 presents the minimum construction criteria for infiltration trenches. Take precautions before and during construction to minimize the risk of premature failure of the infiltration trench. First, prevent heavy equipment from operating at the locations where infiltration trenches are planned. Heavy equipment will compact soil and adversely affect the performance of the trench. Isolate the areas where the trenches will be located by roping them off and flagging them.

Construct infiltration trenches only after the site has been stabilized. Never use trenches as temporary sediment traps during construction. Use diversion berms or staked and lined hay bales around the perimeter of the trenches during their construction. Excavate and build the trench manually or with light earth-moving equipment. Deposit all excavated material downgradient of the trench to prevent re-deposition during runoff events.

Line the sides and bottom of the trench with permeable geotextile fabric. Twelve inches of sand (clean, fine aggregate) may be substituted or used in addition on the bottom. Place one to three inches of clean, washed stone in the lined trench and lightly compact the stone with plate compactors, to within approximately one foot of the surface. Place fabric filter over the top, with at least a 12-inch overlap on both sides. An underground trench may be filled with topsoil and planted. A surface trench may be filled with additional aggregate stone.

Divert drainage away from the infiltration trench until the contributing drainage area is fully stabilized, including full establishment of any vegetation.

Table IT.2 - Construction Criteria for Infiltration Trenches
1. Infiltration trenches should never serve as temporary sediment traps for construction.
2. Before the development site is graded, the area of the infiltration trench should be roped off and flagged to prevent heavy equipment from compacting the underlying soils.
3. Infiltration trenches should not be constructed until the entire contributing drainage area has been stabilized. Diversion berms should be placed around the perimeter or the infiltration trench during all phases of construction. Sediment and erosion controls should be used to keep runoff and sediment away from the trench area.
4. During and after excavation, all excavated materials should be placed downstream, away from the infiltration trench, to prevent redeposition of these materials during runoff events. These materials should be properly handled and disposed of during and after construction.
Light earth-moving equipment should be used to excavate the infiltration trench. Use of heavy equipment causes compaction of the soils in the trench floor, resulting in reduced infiltration capacity.

Maintenance

Because infiltration trenches are prone to failure due to clogging, it is imperative that they be aggressively maintained on a regular schedule. Using pretreatment BMPs will significantly reduce the maintenance requirements for the trench itself. Removing accumulated sediment from a deep sump catch basin or a vegetated filter strip is considerably less difficult and less costly than rehabilitating a trench. Eventually, the infiltration trench will have to be rehabilitated, but regular maintenance will prolong its operational life and delay the day when rehabilitation is needed. With appropriate design and aggressive maintenance, rehabilitation can be delayed for a decade or more. Perform preventive maintenance at least twice a year.

Inspect and clean pretreatment BMPs every six months and after every major storm event (2 year return frequency). Check inlet and outlet pipes to determine if they are clogged. Remove accumulated sediment, trash, debris, leaves and grass clippings from mowing. Remove tree seedlings, before they become firmly established.

Inspect the infiltration trench after the first several rainfall events, after all major storms, and on regularly scheduled dates every six months. If the top of the trench is grassed, it must be mowed on a seasonal basis. Grass height must be maintained to be no more than four inches. Routinely remove grass clippings leaves and accumulated sediment from the surface of the trench.

Inspect the trench 24 hours or several days after a rain event, to look for ponded water. If there is ponded water at the surface of the trench, it is likely that the trench surface is clogged. To address surface clogging, remove and replace the topsoil or first layer of stone aggregate and the filter fabric. If water is ponded inside the trench, it may indicate that the bottom of the trench has failed. To rehabilitate a failed trench, all accumulated sediment must be stripped from the bottom, the bottom of the trench must be scarified and tilled to induce infiltration, and all of the stone aggregate and filter fabric or media must be removed and replaced.

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U.S. EPA, 1999, Stormwater Technology Fact Sheet, Infiltration Trench, EPA 832-F-99-019, http://www.epa.gov/owm/mtb/infltrenc.pdf

Porous Pavement

Description: Porous pavement is a paved surface with a higher than normal percentage of air voids to allow water to pass through it and infiltrate into the subsoil. This porous surface replaces traditional pavement, allowing parking lot, driveway, and roadway runoff to infiltrate directly into the soil and receive water quality treatment. All permeable paving systems consist of a durable, load-bearing, pervious surface overlying a stone bed that stores rainwater before it infiltrates into the underlying soil. Permeable paving techniques include porous asphalt, pervious concrete, paving stones, and manufactured "grass pavers" made of concrete or plastic. Permeable paving may be used for walkways, patios, plazas, driveways, parking stalls, and overflow parking areas.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides peak flow attenuation for small storms.
3 - Recharge	Provides groundwater recharge.
4 - TSS Removal	80% TSS Removal credit if storage bed is sized to hold ½-inch or 1-inch Water Quality Volume, and designed to drain within 72 hours.
5 - Higher Pollutant Loading	Not suitable.
6 - Discharges near or to Critical Areas	Not suitable especially within Zone IIs or Zone A's of public water supplies.
7 - Redevelopment	Suitable.

Advantages/Benefits:

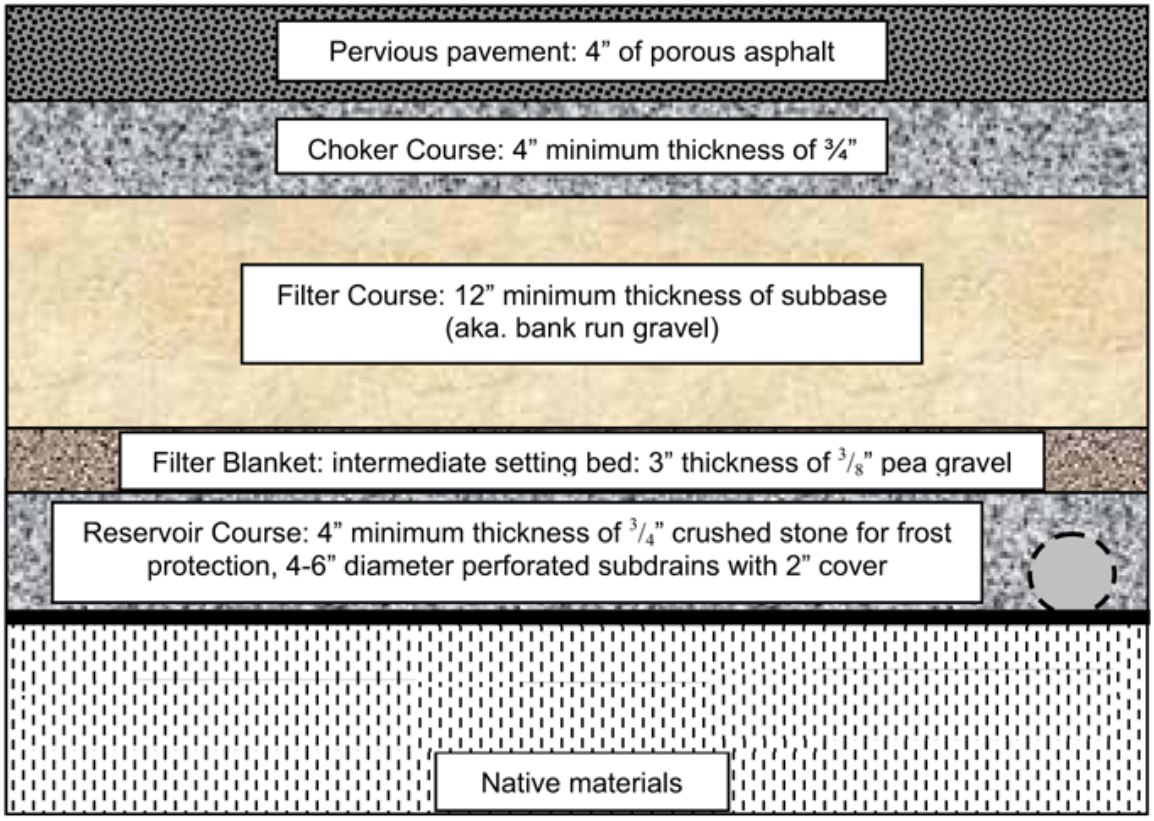
- Reduce stormwater runoff volume from paved surfaces
- Reduce peak discharge rates.
- Increase recharge through infiltration.
- Reduce pollutant transport through direct infiltration.
- Can last for decades in cold climates if properly designed, installed, and maintained
- Improved site landscaping benefits (grass pavers only).
- Can be used as a retrofit when parking lots are replaced.

Disadvantages/Limitations:

- Prone to clogging so aggressive maintenance with jet washing and vacuum street sweepers is required.
- No winter sanding is allowed.
- Winter road salt and deicer runoff concern near drinking water supplies for both porous pavements and impervious pavements.
- Soils need to have a permeability of at least 0.17 inches per hour.
- Special care is needed to avoid compacting underlying parent soils.

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) — 80%
- Nutrients (Nitrogen, phosphorus) — Insufficient data
- Metals (copper, lead, zinc, cadmium) — Insufficient data
- Pathogens (coliform, e coli) — Insufficient data



adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Monitor to ensure that the paving surface drains properly after storms	As needed
For porous asphalts and concretes, clean the surface using power washer to dislodge trapped particles and then vacuum sweep the area. For paving stones, add joint material (sand) to replace material that has been transported.	As needed
Inspect the surface annually for deterioration	Annually
Assess exfiltration capability at least once a year. When exfiltration capacity is found to decline, implement measures from the Operation and Maintenance Plan to restore original exfiltration capacity.	As needed, but at least once a year
Reseed grass pavers to fill in bare spots.	As needed

Special Features

Most appropriate for pedestrian-only areas and for low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, and parking stalls.

Porous Pavement

Applicability

Porous pavement, also known as permeable paving, is appropriate for pedestrian-only areas and for low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, parking stalls, bikepaths, walkways, and patios. It can be constructed where the underlying soils have a permeability of at least 0.17 inches per hour. Porous paving is an excellent technique for dense urban areas, because it does not require any additional land. Porous pavement can be successfully installed in cold climates as long as the design includes features to reduce frost heaving.

Porous paving is not appropriate for high traffic/ high speed areas, because it has lower load-bearing capacity than conventional pavement. Do not use porous pavement in areas of higher potential pollutant loads, because stormwater cannot be pretreated prior to infiltration. Heavy winter sanding will clog joints and void spaces. On some highways, MassHighway Department uses an Open Graded Friction Course (OGF) that has a permeable top coat but an impermeable base course. MassDEP provides no Water Quality or Recharge Credit for OGC, because it does not provide treatment or recharge. The primary benefit of OGF pavements is reductions in noise and hydroplaning.

Effectiveness

Porous pavement provides groundwater recharge and reduces stormwater runoff volume. Depending on design, paving material, soil type, and rainfall, porous paving can infiltrate as much as 70% to 80% of annual rainfall. To qualify for the Water Quality and Recharge Credits, size the storage layer to hold the Required Water Quality or Required Recharge Volume, whichever is larger, using the Static Method, and design the system to dewater within 72 hours. Porous pavement may reduce peak discharge rates significantly by diverting stormwater into the ground and away from pipe-and-basin stormwater management systems, up to the volume housed in the storage layer. Grass pavers can improve site appearance by providing vegetation where there would otherwise be pavement. Porous paving can increase the effective developable area of a site, because the infiltration provided by permeable paving can significantly reduce the need for large stormwater management structures.

Planning considerations

Porous paving must not receive stormwater from other drainage areas, especially any areas that are not fully stabilized.

Use porous paving only on gentle slopes (less than 5%). Do not use it in high-traffic areas or where it will be subject to heavy axle loads.

Consider the setback requirements when considering porous pavement:

Considerations	Setback Requirements
Slope	Less than 5%
Septic system soil absorption system	50 feet
Private well	100 feet
Public well	Outside the Zone 1
Public reservoir	Outside the Zone A
Surface Waters	100 feet
Cellar Foundations	20 feet
Slab Foundations	10 feet
Property Lines	10 feet
Minimum depth	2 feet vertical separation above seasonal high groundwater from bottom of storage layer
Frost Line	Below frost line
Bedrock	As with any stormwater exfiltration system, determine if it is feasible in locations with high bedrock. Presence of bedrock near land surface reduces the ability of soils to exfiltrate to groundwater.

Porous paving reduces the need for other stormwater conveyances and treatment structures, resulting in cost savings.

Permeable paving also reduces the amount of land needed for stormwater management.

Design

There are three major types of permeable paving:

- Porous asphalt and pervious concrete. Although it appears to be the same as traditional asphalt or concrete pavement, it is mixed with a very low content of fine sand, so that it has from 10%-25% void space.

- Paving stones (also known as unit pavers) are impermeable blocks made of brick, stone, or concrete, set on a prepared sand base. The joints between the blocks are filled with sand or stone dust to allow water to percolate to the subsurface. Some concrete paving stones have an open cell design to increase permeability.

- Grass pavers (also known as turf blocks) are a type of open-cell unit paver in which the cells are filled with soil and planted with turf. The pavers, made of concrete or synthetic material, distribute the weight of traffic and prevent compression of the underlying soil.

Each of these products is constructed over a storage bed.

Storage Bed Design
The University of New Hampshire has developed specifications for storage beds used in connection with porous asphalt or pervious concrete. According to UNH, the storage bed should be constructed as indicated in Figure PP 1 with the following components from top to bottom:

- a 4-inch choker course comprised of uniformly graded crushed stone,
- a filter course, at least 12 inches thick, of poorly graded sand or bankrun gravel to provide enhanced filtration and delayed infiltration
- a filter blanket, at least 3 inches thick, of pea stone gravel to prevent material from entering the reservoir course, and
- a reservoir course of uniformly graded crushed stone with a high void content to maximize the storage of infiltrated water and to create a capillary barrier to winter freeze thaw. The bottom of the stone reservoir must be completely flat so that runoff can infiltrate through the entire surface.

The size of the storage bed may have to be increased to accommodate the larger of the Required Water Quality and the Required Recharge Volume.

If paving stones or grass pavers are used, a top course of sand that is one inch thick should be placed above the choker coarse.

Overflow Edge
Some designs incorporate an "overflow edge," which is a trench surrounding the edge of the pavement. The trench connects to the stone reservoir below the surface of the pavement and acts as a backup in case the surface clogs.

Preparation of Porous Asphalt
Care must be taken in batching and placing porous asphalt. Unless batched and installed properly, porous pavement may have a reduced exfiltration ability. At Walden Pond State Reservation, several of the areas paved with porous asphalt did not meet the target exfiltration rate. Cores were taken and it was found that the batches had more sand and/or asphalt than was specified, and those sections had to be removed and repaved.

It is critical to minimize the amount of asphalt binder. Using greater amounts of asphalt binder could lead to a greater likelihood of "binder" or asphalt drawdown and clogging of voids. Sun light heating can liquefy the asphalt. The liquefied asphalt then drains into the voids, clogging them. Such clogging is not remedied by power washing and vacuuming. The topcoat in such instances needs to be scarified and resurfaced. The University of New Hampshire has prepared detailed specifications for preparing and installing pourous asphalt that are intended to prevent asphalt problems.

Additional Design Considerations

- Provide an open-graded subbase with minimum 40% void space.
- Use surface and stone beds to accommodate design traffic loads
- Generally, do not use porous pavement for slopes greater than 5 %.
- Do not place bottom on compacted fill.
- Provide perforated pipe network along bed bottoms for distribution
- Provide a three-foot buffer between the bed bottom and the seasonal high groundwater elevation, and a two-foot buffer for bedrock.

Cold Weather Design Considerations

Porous pavement performs well in cold climates. Porous pavement can reduce meltwater runoff and avoid excessive water on the road during the snowmelt period.

In cold climates, the major concern is the potential for frost heaving. The storage bed specifications prepared by the University of New Hampshire address this concern.

Maintenance

In most porous pavement designs, the pavement itself acts as pretreatment to the stone reservoir below. Consequently, frequent cleaning and maintenance of the pavement surface is critical to prevent clogging. To keep the surface clean, frequent vacuum sweeping along with jet washing of asphalt and concrete pavement is required. No winter sanding shall be conducted on the porous surface.
As discussed, designs that include an "overflow edge" provide a backup in case the surface clogs. If the surface clogs, stormwater will flow over the surface and into the trench, where some infiltration and treatment will occur. For proper maintenance:

- Post signs identifying porous pavement areas.
- Minimize salt use during winter months. If drinking water sources are located nearby (see setbacks), porous pavements may not be allowed.
- No winter sanding is allowed.
- Keep landscaped areas well maintained to prevent soil from being transported onto the pavement.
- Clean the surface using vacuum sweeping machines monthly. For paving stones, periodically add joint material (sand) to replace material that has been transported.
- Regularly monitor the paving surface to make sure it drains properly after storms.
- Never reseal or repave with impermeable materials.
- Inspect the surface annually for deterioration or spalling.
- Periodically reseed grass pavers to fill in bare spots.
- Attach rollers to the bottoms of snowplows to prevent them from catching on the edges of grass pavers and some paving stones.

Adapted from:
MassDEP, Massachusetts Nonpoint Source Pollution Management Manual, 2006.

References

Ferguson, Bruce, K., Porous Pavements, 2005, CRC Press. Taylor and Francis Group, Boca Raton

UNH, 2007, UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds, Revised October 2007, http://www.unh.edu/erg/cstev/pubs_specs_info/unhsc_pa_apec_07_07_final.pdf

Asphalt Pavement for Stormwater Management, http://www.unh.edu/erg/cstev/pubs_specs_info/porous_ashpalt_fact_sheet.pdf

University of New Hampshire Center for Stormwater Technology Evaluation and Verification; this research group tests and evaluates stormwater BMPs on the UNH campus.

- An article about the use of permeable pavers at the Westfarms Mall in Connecticut.
- Case Studies from Uni-Group USA, a block paver manufacturer.
- The Nonpoint Education For Municipal Officials program at the University of Connecticut has been involved in numerous permeable paving pilot projects.
- Permeable paver specifications courtesy of the Low Impact Development Center.
- Porous pavement design and operational criteria from the US Environmental Protection Agency, which also publishes a Low Impact Development Page. Also see this report on a Field Evaluation of Permeable Pavements for Stormwater Management (PDF.)
- New Jersey Stormwater Best Management Practices Manual February 2004.

Rain Barrels & Cisterns

Description: Cisterns and rain barrels are structures that store rooftop runoff and reuse it for landscaping and other non-potable uses. Instead of a nuisance to get rid of, consider rooftop runoff as a resource that can be reused or infiltrated. In contrast, conventional stormwater management strategies take rooftop runoff, which is often relatively free of pollutants, and direct it into the stormwater treatment system along with runoff from paved areas.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides peak flow attenuation for small storms.
3 - Recharge	Provides no groundwater recharge.
4 - TSS Removal	The roof surface can be deducted from the impervious area used to calculate the Required Water Quality Volume for sizing other structural treatment BMPs, a) when rain barrel or cistern is sized to store the Required Water Quality Volume for the roof surface (0.5 inch or 1.0 inch), b) stored water is used within 72-hours or discharged to an infiltration BMP, and c) the system is designed to operate year round.
5 - Higher Pollutant Loading	Not applicable.
6 - Discharges near or to Critical Areas	Not applicable.
7 - Redevelopment	Suitable.

Pollutant Removal Efficiencies

- Offers no primary pollutant removal benefits
- Rooftop Runoff presumed to be clean[1]

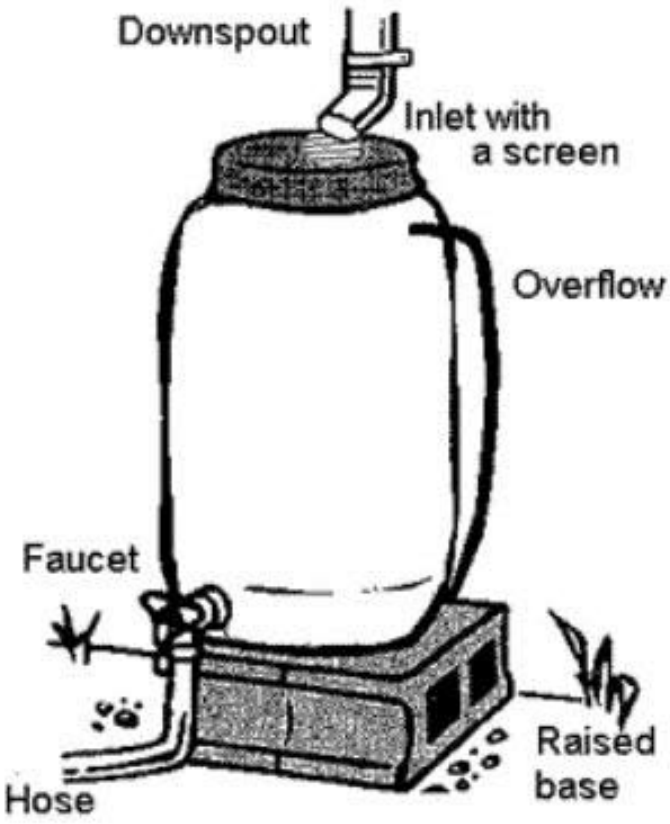
Advantages/Benefits:

- Can reduce water demand for irrigation or other non-potable uses.
- Property owners save money on water bills by using stored water for landscape purposes.
- Public water systems may experience lower peak demand in summer.
- When properly installed, rain barrels and cisterns reduce stormwater runoff volume for small storms.

Disadvantages/Limitations:

- Provides mosquito-breeding habitat unless properly sealed.
- May need to be disconnected and drained in winter to avoid cracking of storage structure

[1]Although MassDEP presumes rooftop runoff to be clean for purposes of the Stormwater Management Standards, research indicates higher PAHs in runoff from asphalt shingled roofs and zinc from metal roofs. USGS research in Texas indicates rooftop runoff contains mercury. Before using rooftop runoff for vegetable gardens, investigate the quality of the runoff, especially when using larvicides in rain barrels or cisterns for mosquito control.



Maintenance

Activity	Frequency
Maintenance requirements for cisterns and rain barrels are minimal. These requirements include the following: Inspecting the unit twice a year, larviciding for mosquito control, disconnecting and draining the system prior to winter to prevent cracking, and replacing or repairing any worn-out pieces.	

Special Features

Direct overflow from rain barrels and cisterns to a dry well, infiltration trench, rain garden, bioretention area, or other infiltration BMP sized to recharge the overflow volume.

Rain Barrels & Cisterns

Applications and Design Principles

The most common approach to roof runoff storage involves directing each downspout to a 55-gallon rain barrel. A hose is attached to a faucet at the bottom of the barrel and water is distributed by gravity pressure. A more sophisticated and effective technique is to route multiple downspouts to a partially or fully buried cistern with an electric pump for distribution. Where site designs permit, cisterns may be quite large, and shared by multiple households, achieving economies of scale. Stored rainwater can be used for lawn irrigation, vegetable and flower gardens, houseplants, car washing, and cleaning windows.

The roof surface can be deducted from the impervious surfaces used to determine the Required Water Quality Volume for sizing other structural treatment practices, only when a) the cistern or barrel can store the required water quality volume for the roof surface, b) the stored water is used or discharged to an infiltration BMP within 72-hours, and c) the system is designed to operate 365 days a year.

Cisterns and rain barrels can provide benefits by reducing the required water quality volume and peak discharge rates depending on the amount of storage available at the beginning of each storm. One rain barrel may provide a useful amount of water for garden irrigation, but it will have little effect on overall runoff volumes, especially if the entire tank is not drained between storms. Improve effectiveness by having more storage volume and by designing the system with a continuous discharge to an infiltration structure, so that there is always storage available for retention. To operate the system year-round, bury or insulate the unit. State Plumbing Code requirements apply to cisterns and rain barrels located within 10 feet of a building. All applicable requirements of the Massachusetts State Plumbing or State Building Codes must be met.

Cisterns and rain barrels are applicable to most commercial and residential properties where there is a gutter and downspout system to direct roof runoff to the storage tank. They take up little room and can be used in dense urban areas. Rain barrels and cisterns are excellent retrofit techniques for almost any circumstance. Rain barrels are covered plastic tanks that can hold from 50 to 100 gallons with a hole in the top for downspout discharge, an overflow outlet, and a valve and hose adapter at the bottom. They are used almost exclusively on residential properties. Plastic rain barrels are typically installed above ground. They must be disconnected prior to the winter, and the barrel drained completely to prevent the barrel from cracking.

Because rain barrels rely on gravity flow, place them near, and slightly higher than, the point of use (whether a garden, flower bed, or lawn). Route the overflow outlet to a dry well, bioretention area, rain garden or other infiltration BMP. It is important for property owners to use the water in rain barrels on a regular basis, otherwise the barrels can fill up and prevent additional roof runoff from being stored. Each house should have the appropriate number of rain barrels or an appropriately sized cistern. A one-inch storm produces over 620 gallons of water from a 1,000 square foot roof. Assuming a rain barrel capacity of 55 gallons, it would take 11 rain barrels to store one inch of runoff from 1,000 square feet of roof.

Cisterns are partially or fully buried tanks with a secure cover and a discharge pump; they provide considerably more storage than barrels, as well as pressurized distribution. They are less susceptible to cracking induced by expansion of freezing water when buried below grade. Cisterns can collect water from multiple downspouts or even multiple roofs, and then distribute this water wherever it needs to go via an electric pump. Property owners may use one large tank or multiple tanks in series. Either way, direct the overflow for the systems to a dry well or other infiltration mechanism so that if the cistern is full, excess roof runoff is infiltrated, and not discharged to the stormwater treatment system. Some cisterns are designed to continuously discharge water into infiltration units at very slow rates, so that the tank slowly empties after a storm, providing more storage for the next storm. The cisterns must also be designed to dewater in 72 hours or less.

Design

Because of the low pressure of the discharge, rain barrels are most effectively used with a drip irrigation system. Secure rain barrels against disturbance by children or animals. Seal any openings with mosquito netting. If present, place the cistern's continuous discharge outlet so that the tank does not empty completely. This ensures water availability at all times, and provides some storage capacity for every storm. A diverter at the cistern inlet can redirect

the "first flush" of runoff, which is more likely to have particulates, leaves, and air-deposited contaminants washed off the roof. Keep leaves and debris out of the storage tank by placing a screen at the top of the downspout. Hide rain barrels and cisterns with shrubs or other landscaped features. Direct overflow from rain barrels and cisterns to a dry well, infiltration trench, rain garden, bioretention area, or other infiltration BMP sized to recharge the overflow volume. Use pond routing methods to design cisterns or rain barrels to account for retention of early runoff in the storage tank. Include access ports for any subsurface cisterns. Confined space entry training may be needed to enter large cisterns. MassDEP does not require treatment of runoff from non-metal roofs prior to infiltration.

Maintenance

Maintenance requirements for rain barrels are minimal and consist only of inspecting the unit as a whole and any of its constituent parts and accessories twice a year. The following components should be routinely inspected and either repaired or replaced as needed:

- *Roof catchment,* to ensure that trash and particulate matter are not entering the gutter and downspout to the rain barrel.
- *Gutters,* to ensure that no leaks or obstructions are occurring.
- *Downspouts,* to assure that no leaks or obstructions are occurring.
- *Entrance at rain barrel,* to ensure that there are no obstructions and/or leaks occurring.
- *Rain barrel,* to check for potential leaks, including barrel top and seal.
- *Runoff / overflow pipe,* to check that overflow is draining in non-erosive manner.
- *Spigot,* to ensure that it is functioning correctly.
- *Any accessories,* such as rain diverter, soaker hose, linking kit, and additional guttering.
- *Apply larvicides in strict accordance with all Mass. Department of Agricultural Resources Pesticide Bureau regulations* to prevent mosquitoes from reaching adulthood.
- *Add bleach or other chemicals annually to kill bacteria present in the system.* A qualified professional should determine appropriate treatment.
- *Drain the system before winter* if it is located above ground or partially exposed, to prevent cracking.
- *Disconnect the system from roof leaders in the fall,* if water is not intended to be used during the winter, unless the runoff is directed to a qualifying stormwater infiltration practice.
- *When the cistern or barrel is connected to a stormwater recharge system, remove particulates trapped in the cistern or rain barrel annually to limit clogging of the stormwater infiltration system.*

Adapted from:
MAPC Low Impact Development Toolkit. For more information, go to www.mapc.org/lid and www.arc-of-innovation.org.

Additional Information
http://www.rainwaterrecovery.com/about.html
www.crwa.org (Charles River Watershed Association)

Build it and Clean Water will Come!
A Rain Garden Guide for Homeowners

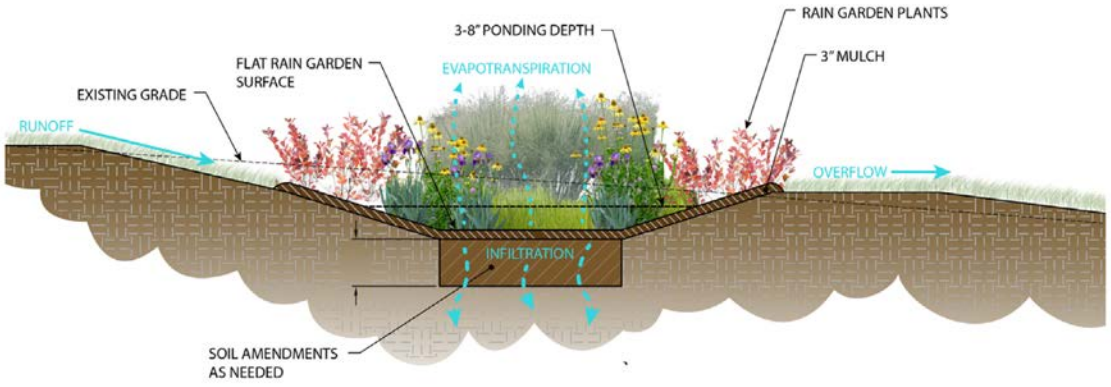
Michelle West, P.E.

Michelle is a senior water resources engineer with more than 18 years of professional experience. With a background in both engineering and natural resources, she is passionate about using her skills to restore the natural world while improving the human experience.

Have you joined the rain garden craze yet? Inspired by an article, your neighbor's rain garden, or our Rain Garden Wednesdays on Instagram? Want to do your part to improve your local water quality and wildlife habitat? It's easier than you think!

What is a Rain Garden?

Rain gardens are actually very simple. They are just shallow depressions – too shallow to even call a hole! – with plants. But, rain gardens are not just isolated depressions placed randomly out in a yard. They are specifically sized and placed to absorb ***stormwater runoff***, the water that flows from your built ***impervious surfaces*** such as rooftops, driveways, roads, parking lots, and even compacted lawn areas when it rains. And that's it! Well, not quite, since rain gardens do take a bit of planning and physical labor, which we will get to in a bit.

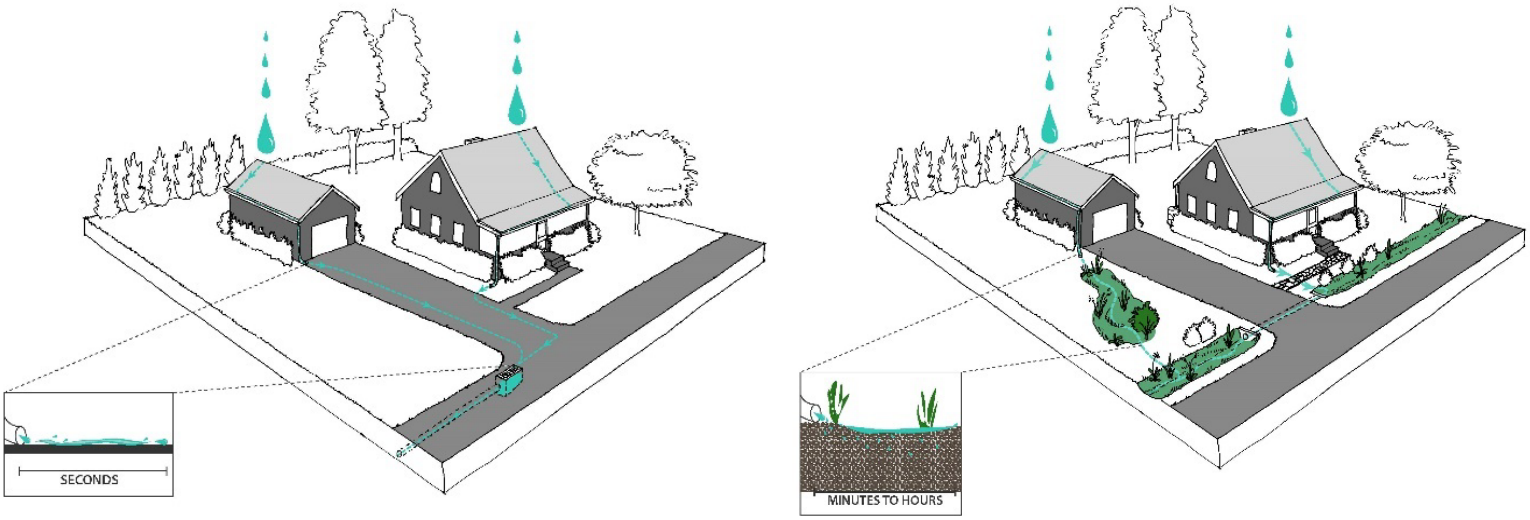


Cross-section of a typical rain garden

Maybe the better question to ask is "why a rain garden"? What's so bad about stormwater runoff? Why all the fuss? It's just rainwater straight from the sky – isn't that natural? Unfortunately, no. All of those impervious surfaces that we built for our shelter and transportation prevent the clean rainwater from soaking into the ground like it did before we developed the land. Dirt, fertilizer, soaps, oils, metals, and even animal poop build up on these hard surfaces and get carried away with the stormwater. In addition to creating water pollution, when your runoff joins up with your neighborhood's runoff, it can cause flooding and erosion, damage infrastructure, degrade aquatic ecosystems, and close shellfishing areas and beaches. While runoff from just your home or business may not cause much of a problem, the ***cumulative impact*** from everyone's home and business really does.

Rain gardens are one beautiful way to ***"break the impervious chain"*** of roof to downspout to driveway to road to stream, pond, or bay. They use soils and plants to filter pollutants and help water soak in rather than run off. Please remember that rain gardens are NOT ponds or wetlands - they should drain in less than 24 hours after a rainfall. Use the four-step process below to create one at your house!

 **Remember, this information is great for most sites, but if your property is really steep or you have complicated drainage issues, please do reach out to a professional to help you!*



These graphics show how "breaking the impervious chain" slows, cleans, and reduces the stormwater leaving a site.

Step 1 – Site Selection

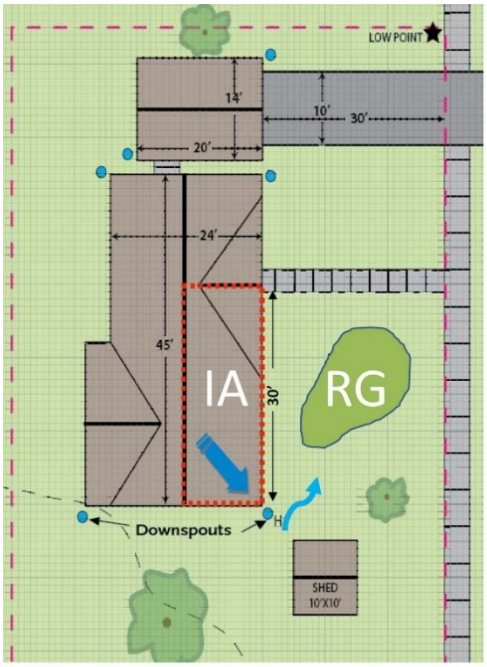
This step really is the most important. Choosing the wrong location for your rain garden can at best, waste your time and money, and at worst, cause drainage issues in your yard. So, take your time with Step 1!

- Walk your property to get the general lay of the land.
- Where does the water go? Determine existing stormwater flow paths.
- Note the location of underground pipes, trees, structures, property lines, septic systems, etc.
- What kind of soils do you have? (e.g., sand, clay, etc.) Areas of well-drained sand are ideal but not mandatory.
- Pick a good general location for your rain garden. Try to <u>avoid</u> areas that:
  - **X** Are within 10 ft of a wall or basement, 2 ft of a sidewalk/driveway; and 50 ft of a septic system
  - **X** Stay consistently wet
  - **X** Have high groundwater or bedrock
  - **X** Are under trees or on steep slopes or where getting water into and out of the rain garden is difficult.

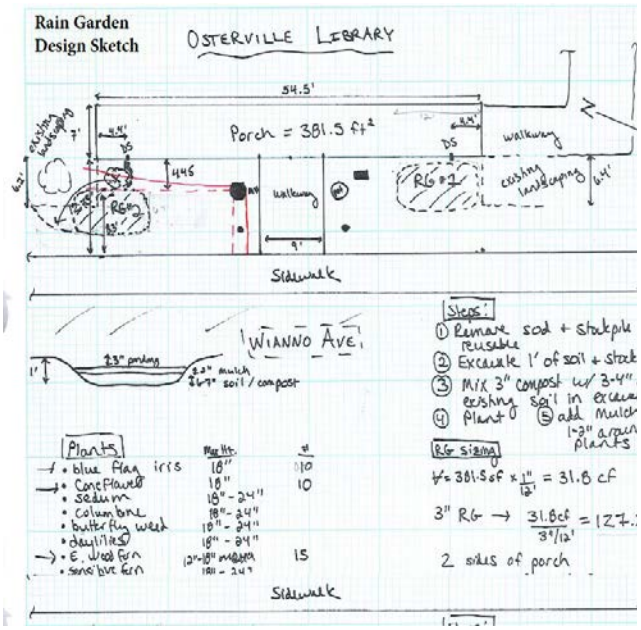
Helpful Tip - Existing flat areas are the best, at least on your shoulders and back if you are digging it by hand!

Step 2 - Design

Now that you have a general location, you can get to the fun part – designing your rain garden! You do not need to be an engineer to complete this step, I promise (although I understand how hollow that sounds coming from an engineer…)! While it is important to understand roughly how big your rain garden should be, this does not have to be an exact calculation - there is a lot of wiggle room here. Most importantly, have fun with the shape and look of your rain garden!



*Example plan showing rain garden (RG) that captures runoff from a portion of roof (IA)



Don't be afraid to make a sketch! You don't need to be an artist to jot down a meaningful sketch that helps you visualize your yard and find a great place for your rain garden.

- Estimate **impervious areas (IA)** draining to your rain garden. This is the size (ft^2) of your rooftops, driveways, patios, etc., that are uphill from your rain garden. So it may just be a portion of your roof or half of your driveway, while the other half drains to the other side of your yard. Don't over count!
- Size the **rain garden (RG)** surface area to hold at least **1 inch of rain (P=0.08 ft)**. One inch is a good target to shoot for since 90% of all storm events in the Northeast are 1 inch or less, causing the majority of all stormwater pollution. Typical rain gardens are 100-200 ft^2.
- Choose a **ponding depth (D)**. This is not a depth of permanent standing water, but instead, the maximum depth of water during and immediately after a rain event. Typical rain gardens are **6 inches deep (D=0.5 ft)** – you can go deeper for sandy soils (up to 8"), whereas tight soils (with a lot of silt or clay) require a larger surface area with shallower depths (minimum 3").

Now wait, you say, this is starting to sound like math! But you promised! Never fear – you can use the ***cheat sheet in Table 1*** to figure out your rain garden surface area. Just pick your ponding depth and size of impervious area, and we did the math for you! But if you love equations like I do, you can do your own calculations with the following equation:

$$RG\ (ft^2) = \frac{IA\ (ft^2) * P\ (ft)}{D\ (ft)}$$

 **Remember, this information is great for most sites, but if your property is really steep or you have complicated drainage issues, please do reach out to a professional to help you!*

Table 1. Approximate Rain Garden Size (ft^2) to meet rainfall target of 1 inch			
Impervious Drainage Area	Ponding Depth		
	3″ (.25 ft)	6″ (.50 ft)	8″ (.67 ft)
500 ft^2	170	85	65
750 ft^2	250	125	95
1000 ft^2	340	170	125
1500 ft^2	500	250	190
2000 ft^2	680	340	250

And that's it – now you now how big your rain garden needs to be! What's next?

- Amend soils <u>if necessary</u> to improve infiltration and provide organic matter for plants. Add a 3" layer of coarse sand for sites with clayey soils or 3" of leaf compost for really sandy sites.

Helpful Tip - For a 100 ft^2 rain garden, a 3" layer of amendments = 1 cubic yard

- Figure out how to get the water in your garden, and perhaps more importantly, how it will get out during really big storms. <u>For inlets,</u> consider using an extended downspout or pipe, vegetated or stone-lined swales, diversion berms, or just direct the surface flow over lawn. The key is to make sure you don't have erosion at the inlet location – use rock if you see erosion. <u>For overflows</u>, just make sure you know where the water will go if the rain garden overflows:
  - X Avoid directing overflow to other properties or structures
  - ✓ Make berms higher near buildings
  - ✓ Direct flows over lawns or into existing drain inlets or wherever the stormwater goes today.

Helpful Tip - Remember, you are not creating more water than you had before – the drainage area is the same. Rather, you are actually reducing the total amount of runoff with your rain garden. So as long as you are not redirecting runoff in a completely different direction, the rain garden should be improving conditions, not creating new problems!

- Pick your plants!
  - ✓ Use plant species tolerant to both wet and dry conditions.
  - ✓ Native species are preferred and DO NOT plant invasive vegetation
  - X Avoid using edible plants, particularly if treating driveway or road runoff
  - ✓ Provide for variable heights, color, leaf shape (trees, shrubs, herbaceous)
  - X Avoid placing woody vegetation at inflow/outflow locations to avoid clogging
  - ✓ Consider visual appeal and wildlife habitat in all seasons (e.g., fall flowers for pollinators; winter berries for birds, etc.)

But wait, which plants do I use? Don't worry if you are not a master gardener! You can usually ask at your local nursery or find a list online. There is probably a rain garden plant list for your location, but the recommended species are pretty similar throughout the Northeast, so don't worry if you can't find one for your specific area. Here are two example lists you can start with from UMASS and APCC:
https://ag.umass.edu/landscape/fact-sheets/rain-gardens-way-to-improve-water-quality
https://apcc.org/raingardens/apcc-rain-garden-plant-list.pdf

You can also find lists of invasive species to avoid in your area. Here is a sample list of the invasive species in Massachusetts:
https://www.mass.gov/service-details/invasive-plants

Step 3 – Install

Now that you've got your hand sketch of your rain garden location and design, it's time to get your hands dirty. Round up your friends and family, or even better, your neighbors (maybe they'll want one next!), to help you with the installation. Don't forget to do the following before you get started, though:

- Check with the Town or City to see if you need a permit and call for utility locations before you dig!
- Mark the excavation footprint with string or spray paint.

Spray-painted location of a rain garden – the solid line indicates bottom of bed and the dotted line is for the top of slope, leaving space to provide gentle side slopes rather than vertical walls.

- Install erosion & sediment controls if necessary (like silt fence or silt sock).
- Find a place to stockpile materials.
- Remove grass (reuse, if possible).

Helpful Tip – Use a tarp for stockpiling materials to make cleanup so much easier!

Now, you are ready for the actual work!

- Start digging! Dig to the desired ponding depth (3-8") along with another 2-3" if you are adding a mulch layer. May also need to over-dig another 3-6" to aerate compacted soils or for adding soil amendments. Use excavated material to create berms if needed.
- Mix any amendments into the native soil with shovels and rakes.
- Be sure to make the bottom of ponding area flat. This is the most important part of the install. The rain garden should fill up uniformly like a bathtub.

Helpful Tip - You can check this easily at home using two stakes, a string, a string level, and a measuring tape!

- Install inlet and overflow components.
- Plant! Arrange plants first, then remove from containers. Loosen root-bound plants and dig holes 2x wider than the root ball. Leave room for mulch layer if adding. Plugs can go in after mulch.
- Add mulch/organic surface layer (1-3") or just around plants (preferred). Protect small plants.

Helpful Tip - Don't be afraid to "decorate" with rocks, particularly any you found while you were digging! Looks cool and saves you time and effort to get rid of them.

- Turn on water to inspect flow path and to soak plants. If your inlet is a roof downspout, it is fun to spray water on your roof and watch the rain garden in action!
- Clean up site. Remove any erosion controls once area is stabilized (i.e., the plants and/or seed are well established!).
- Pat yourself on the back and enjoy your rain garden!

Table 2 – Sample rain garden supply list

Rain Garden Supply List	Qu	Unit	Notes
Materials			
Compost for 3 inches of soil amendments	1.5	cy	Mix compost with existing soil for bottom of RG
Mulch, 2 inches with extra for blending existing beds	1.5	cy	
Tarps for stockpiles	3-4	ea	
Plants	100	ea	See RG sketch for proposed layout
Washed stone for downspouts	1	cf	couple of bags should do
Non-woven filter fabric for use under the stone inlet and overflow – (roll 6' wide)	6	sf	only need a pretty small strip
Fabric staples	1	box	
Grass seed for stabilizing disturbed areas outside of rain garden	1	bag	or re-use sod
Erosion controls (silt fence or silt sock)	50	ft	~30 ft for downgradient of RG and ~20 ft for around soil stockpile if needed
Spray paint for marking garden footprint	1	can	
Tools			
Gloves	String level		
Tape measure	Hammer		
Shovels (both spade and flat)	Trowel		
Rake	Wheelbarrow		
Pitchfork	Utility knife for cutting fabric		
Stakes and string	Hose for watering		

Step 4 – Maintain

Unfortunately, yes, your rain garden will need to be maintained like everything else. But the level of effort required is really based on how "nice" you want it to look. If you are going for the more wild, natural look, maintenance will be pretty minimal. If you want it to be a more ornamental feature in your yard, then you will need to keep up with it just like your other ornamental beds.

- Inspect your rain garden after storms and during regular landscaping activities. Be sure to look for:
  - X Weeds and invasive plants
  - X Sediment build-up
  - X Debris and trash
  - X Dying plants and grasses
  - X Erosion/gullying
  - X Inlet/outlet clogging
  - X Standing water/drainage issues

- Maintenance activities will include:
  - ✓ Vegetation pruning and trimming
  - ✓ Debris and sediment removal
  - ✓ Plant and mulch replacement
  - ✓ Stabilization of any eroded areas with rock or plants
  - ✓ Soil amendments for areas that pond water >24 hours after rain
  - X No fertilization is recommended

We hope this helps you put a rain garden in at your house! If you want to use a downloadable rain garden App on your smart phone or tablet, we recommend the one that our friends at the University of Connecticut developed: http://nemo.uconn.edu/raingardens

Horsley Witten Group, Inc. **Remember, this information is great for most sites, but if your property is really steep or you have complicated drainage issues, please do reach out to a professional to help you!*