# Model Stormwater Management Bylaw

## Prepared for the Towns of Duxbury, Marshfield, & Plymouth, MA

**Prepared by Horsley Witten Group**
**December 31, 2004**

**In collaboration with:**

**Massachusetts Office of Coastal Zone Management**
**North and South Rivers Watershed Association**
**Massachusetts Bays National Estuary Program**
**Buzzards Bay Project National Estuary Program**

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## Model Stormwater Management Bylaw Components:

- **Model Stormwater Bylaw**
- **Model Stormwater Regulations**
- **Appendix A: Method of Pollutant Load Calculation for Compliance with Water Quality Standards**
- **Appendix B: Example System of Stormwater Management Credits and Incentives**

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# MODEL STORMWATER BYLAW
**Duxbury, Marshfield, and Plymouth**
**December 31, 2004**

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## Introduction

It is hereby determined that:

Land development projects and other land use conversions, and their associated changes to land cover, permanently alter the hydrologic response of local watersheds and increase stormwater runoff rates and volumes, which in turn increase flooding, stream channel erosion, and sediment transport and deposition, and decrease groundwater recharge;

Land development projects and other land use conversions also contribute to increased nonpoint source pollution and degradation of receiving waters;

The impacts of post-development stormwater runoff quantity and quality can adversely affect public safety, public and private property, surface water drinking water supplies, groundwater resources, drinking water supplies, recreation, aquatic habitats, fish and other aquatic life, property values and other uses of lands and waters;

These adverse impacts can be controlled and minimized through the regulation of stormwater runoff quantity and quality from new development and redevelopment, by the use of both structural and nonstructural Best Management Practices;

Localities in the Commonwealth of Massachusetts are required to comply with a number of both State and Federal laws, regulations and permits which require a locality to address the impacts of post-development stormwater runoff quality and nonpoint source pollution.

Therefore, the *[Stormwater Authority]* has established this stormwater management bylaw to provide reasonable guidance for the regulation of post-development stormwater runoff for the purpose of protecting local water resources from degradation. This bylaw regulates the post-construction stormwater controls for both new and re-development projects.

It has been determined that it is in the public interest to regulate post-development stormwater runoff discharges in order to control and minimize increases in stormwater runoff rates and volumes, post-construction soil erosion and sedimentation, stream channel erosion, and nonpoint source pollution associated with post-development stormwater runoff.

## 1.0 PURPOSE

A) The purpose of this Bylaw is to protect, maintain and enhance the public health, safety, environment and general welfare by establishing minimum requirements and procedures to control the adverse effects of increased post-development stormwater runoff and nonpoint source pollution associated with new development and redevelopment. It has been determined that proper management of post-development stormwater runoff will minimize damage to public and private property and infrastructure, safeguard the public health, safety, environment and general welfare of the public, protect water and aquatic resources, and promote groundwater recharge to protect surface and groundwater drinking supplies. This Bylaw seeks to meet that purpose through the following objectives:

1. Establish decision-making processes surrounding land development activities that protect the

integrity of the watershed and preserve the health of water resources;

2. Require that new development, redevelopment and all land conversion activities maintain the after-development runoff characteristics as equal to or less than the pre-development runoff characteristics in order to reduce flooding, stream bank erosion, siltation, nonpoint source pollution, property damage, and to maintain the integrity of stream channels and aquatic habitats;

3. Establish minimum post-development stormwater management standards and design criteria for the regulation and control of stormwater runoff quantity and quality; Establish minimum design criteria for the protection of properties and aquatic resources downstream from land development and land conversion activities from damages due to increases in volume, velocity, frequency, duration, and peak flow rate of storm water runoff; Establish minimum design criteria for measures to minimize nonpoint source pollution from stormwater runoff which would otherwise degrade water quality;

4. Establish design and application criteria for the construction and use of structural stormwater control facilities that can be used to meet the minimum post-development stormwater management standards;

5. Encourage the use of nonstructural stormwater management, stormwater better site design practices or "low-impact development practices", such as reducing impervious cover and the preservation of greenspace and other natural areas, to the maximum extent practicable; Coordinate site design plans, which include greenspace, with the Town's greenspace protection plan;

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

7. 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;

8. Establish administrative procedures for the submission, review, approval or disapproval of stormwater management plans, and for the inspection of approved active projects, and long-term follow up; Establish certain administrative procedures and fees for the submission, review, approval, or disapproval of stormwater plans, and the inspection of approved projects.

B) Nothing in this Bylaw is intended to replace the requirements of either, the Town of *[_____]* Flood Plain Zoning Bylaw, the Town of *[_____]* General Wetlands Protection Bylaw, or any other Bylaw that may be adopted by the Town of *[_____]*. Any activity subject to the provisions of the above-cited Bylaws must comply with the specifications of each.

## 2.0 DEFINITIONS

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

ALTER: Any activity, which will measurably change the ability of a ground surface area to absorb water or will change existing surface drainage patterns. Alter may be similarly represented as "alteration of drainage characteristics," and "conducting land disturbance activities."

BEST MANAGEMENT PRACTICE (BMP): Structural, non-structural and managerial techniques that are recognized to be the most effective and practical means to prevent and/or reduce increases in stormwater volumes and flows, reduce point source and nonpoint source pollution, and promote stormwater quality and protection of the environment. "Structural" BMPs are devices that are engineered and constructed to provide temporary storage and treatment of stormwater runoff. "Nonstructural" BMPs use natural measures to reduce pollution levels, do not require extensive construction efforts, and/or promote pollutant reduction by eliminating the pollutant source.

BETTER SITE DESIGN: Site design approaches and techniques that can reduce a site's impact on the watershed through the use of nonstructural stormwater management practices. Better site design includes conserving and protecting natural areas and greenspace, reducing impervious cover, and using natural features for stormwater management.

GENERAL STORMWATER MANAGEMENT PERMIT (GSMP): A permit issued for an application that meets a set of pre-determined standards outlined in the Regulations to be adopted by the *[Stormwater Authority]* under Section 4 of this Bylaw. By meeting these pre-determined standards, the proposed project will be presumed to meet the requirements and intent of this Bylaw.

HOTSPOT: Land uses or activities with higher potential pollutant loadings, such as auto salvage yards, auto fueling facilities, fleet storage yards, commercial parking lots with high intensity use, road salt storage areas, commercial nurseries and landscaping, outdoor storage and loading areas of hazardous substances, or marinas.

MASSACHUSETTS STORMWATER MANAGEMENT POLICY: The Policy issued by the Department of Environmental Protection, and as amended, that coordinates the requirements prescribed by state regulations promulgated under the authority of the Massachusetts Wetlands Protection Act G.L. c. 131 § 40 and Massachusetts Clean Waters Act G.L. c. 21, §. 23-56. The Policy addresses stormwater impacts through implementation of performance standards to reduce or prevent pollutants from reaching water bodies and control the quantity of runoff from a site.

NEW DEVELOPMENT: Any construction or land disturbance of a parcel of land that is currently in a natural vegetated state and does not contain alteration by man-made activities.

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 natural and human-made pollutants, finally depositing them into water resource areas.

PERSON: Any individual, group of individuals, association, partnership, corporation, company, business organization, trust, estate, the Commonwealth or political subdivision thereof to the extent subject to Town Bylaws, administrative agency, public or quasi-public corporation or body, the Town of *[_____]*, and any other legal entity, its legal representatives, agents, or assigns.

PRE-DEVELOPMENT: The conditions that exist at the time that plans for the land development of a tract of land are submitted to the *[Stormwater Authority].* Where phased development or plan approval occurs (preliminary grading, roads and utilities, etc.), the existing conditions at the time prior to the first plan submission shall establish pre-development conditions.

POST-DEVELOPMENT: The conditions that reasonably may be expected or anticipated to exist after completion of the land development activity on a specific site or tract of land. Post-

development refers to the phase of a new development or redevelopment project after completion, and does not refer to the construction phase of a project.

RECHARGE: The replenishment of underground water reserves.

REDEVELOPMENT: Any construction, alteration, or improvement exceeding land disturbance of *[5,000]* square feet, where the existing land use is commercial, industrial, institutional, or multi-family residential.

STORMWATER AUTHORITY: the Town *of [_____] [Planning Board, Conservation Commission, Board of Health, or other specifically authorized Dept. or entity the Town decides is appropriate to administer, implement and enforce this bylaw, OR its authorized agent(s)]*. The *[Stormwater Authority]* is responsible for coordinating the review, approval and permit process as defined in this Bylaw. Other Boards and/or departments participate in the review process as defined in the Stormwater Regulations adopted by the *[Boards, Commissions and/or Departments of the Town of _____]*.

STORMWATER CREDITS: A form of incentive for developers to promote conservation of natural and open space areas. Projects that comply with prescribed requirements are allowed reductions in stormwater management requirements when they use techniques to reduce stormwater runoff at the site.

STORMWATER MANAGEMENT PERMIT (SMP): A permit issued by the *[Stormwater Authority]*, after review of an application, plans, calculations, and other supporting documents, which is designed to protect the environment of the Town from the deleterious affects of uncontrolled and untreated stormwater runoff.

STORMWATER UTILITY: A special assessment district set up to generate funding specifically for stormwater management. Users within the district pay a stormwater fee, and the revenue thus generated directly supports maintenance and upgrade of existing storm drain systems; development of drainage plans, flood control measures, and water-quality programs; administrative costs; and sometimes construction of major capital improvements.

## 3.0 AUTHORITY

This Bylaw is adopted under authority granted by the Home Rule Amendment of the Massachusetts Constitution, the Home Rule statutes, and pursuant to the regulations of the federal Clean Water Act found at 40 CFR 122.34, and as authorized by the residents of the Town of *[_____]* at Town Meeting, dated *[_____]*.

## 4.0 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) Stormwater Regulations. The *[Stormwater Authority]* may adopt, and periodically amend, rules and regulations relating to the terms, conditions, definitions, enforcement, fees (including application, inspection, and/or consultant fees), procedures and administration of this Stormwater Management Bylaw by majority vote of the *[Stormwater Authority]*, after conducting a public hearing to receive comments on any proposed revisions. Such hearing dates shall be advertised in a newspaper of general local circulation, at least seven (7) days prior to the hearing date. After public notice and public hearing, the *[Stormwater Authority]* may promulgate rules and regulations

to effectuate the purposes of this Bylaw. Failure by the *[Stormwater Authority]* to promulgate such rules and regulations or a legal declaration of their invalidity by a court shall not act to suspend or invalidate the effect of this Bylaw.

C) Stormwater Management Manual. The *[Stormwater Authority]* will utilize the policy, criteria and information including specifications and standards of the latest edition of the Massachusetts Stormwater Management Policy, *[or approved local equivalent]*, for execution of the provisions of this Bylaw. This Policy includes a list of acceptable stormwater treatment practices, including the specific design criteria for each stormwater practice. The Policy may be updated and expanded periodically, based on improvements in engineering, science, monitoring, and local maintenance experience. Unless specifically altered in the Stormwater Regulations, stormwater management practices that are designed, constructed, and maintained in accordance with these design and sizing criteria will be presumed to be protective of Massachusetts water quality standards.

D) General Permit. The *[Stormwater Authority]* shall have the authority to develop a General Stormwater Management Permit (GSMP) for specific types of projects, such as, without limitation Construction of a *[Deck, Patio, Retaining Wall, Existing Driveway Expansion, Shed, Swimming Pool, Tennis or Basketball Court]*. Any such General Stormwater Management Permit Requirements shall be defined and included as part of any Stormwater Regulations promulgated as a result of this Bylaw.

E) Actions by the *[Stormwater Authority]*. The *[Stormwater Authority]* may take any of the following actions as a result of an application for a Stormwater Management Permit as more specifically defined as part of Stormwater Regulations promulgated as a result of this Bylaw: Approval, Approval with Conditions, Disapproval, or Disapproval without Prejudice.

F) Appeals of Action by the *[Stormwater Authority]*. A decision of the *[Stormwater Authority]* shall be final. Further relief of a decision by the *[Stormwater Authority]* made under this Bylaw shall be reviewable in the Superior Court in and action filed within *[60 days]* thereof, in accordance with M.G.L. Ch 249 § 4.

G) Stormwater Credit System. The *[Stormwater Authority]* may adopt, through the Regulations authorized by this Stormwater Management Bylaw, a Stormwater Credit System. This credit system will allow applicants the option, if approved by the *[Stormwater Authority],* to take credit for the use of stormwater better site design practices to reduce some of the requirements specified in the criteria section of the Regulations. Failure by the *[Stormwater Authority]* to promulgate such a credit system through its Regulations or a legal declaration of its invalidity by a court shall not act to suspend or invalidate the effect of this Bylaw.

H) Stormwater Utility. The *[Stormwater Authority]* may adopt, through the Regulations authorized by this Stormwater Management Bylaw, a Stormwater Utility pursuant to M.G.L. Chapter 83 Section 16 and Chapter 40 Section 1A. The *[Stormwater Authority]* shall administer, implement and enforce this Utility. Failure by the *[Stormwater Authority]* to promulgate such a Stormwater Utility through its Regulations or a legal declaration of its invalidity by a court shall not act to suspend or invalidate the effect of this Bylaw.

## 5.0 APPLICABILITY

A) This bylaw shall be applicable to all new development and redevelopment, including, but not limited to, site plan applications, subdivision applications, grading applications, land use conversion applications, any activity that will result in an increased amount of stormwater runoff or pollutants flowing from the a parcel of land, or any activity that will alter the drainage characteristics of a parcel of land, unless exempt pursuant to Section 5.B) of this Bylaw. All new development and redevelopment under the jurisdiction of this Bylaw as prescribed in this Bylaw

shall be required to obtain a Stormwater Management Permit.

B) Exemptions

No person shall alter land within the Town of *[_____]* without having obtained a Stormwater Management Permit (SMP) for the property with the following exceptions:

1. Any activity that will disturb an area less than *[5000]* square feet or less than *[25%]* of a contiguous property, whichever is less. This exception may not be applied for contiguous properties held in common ownership at the time of adoption of this Bylaw that may have been previously subdivided and/or are attributed to multiple separate owners;

   *Another option could be based on impervious area such as "Any activity that will increase a contiguous impervious area of less than [5000] square feet.*

2. Normal maintenance and improvement of land in agricultural use as defined by the Wetlands Protection Act regulation 310 CMR 10.04 and MGL Chapter 40A Section 3.

3. Maintenance of existing landscaping, gardens or lawn areas associated with a single family dwelling;

4. Repair or replacement of an existing roof of a single-family dwelling;

5. The construction of any fence that will not alter existing terrain or drainage patterns;

6. Construction of utilities (gas, water, electric, telephone, etc.) other than drainage, which will not alter terrain, ground cover, or drainage patterns;

7. Emergency repairs to any stormwater management facility or practice that poses a threat to public health or safety, or as deemed necessary by the *[Stormwater Authority]*;

8. Any work or projects for which all necessary approvals and permits have been issued before the effective date of this Bylaw;

9. Redevelopment projects are presumed to meet the specified stormwater management requirements described in the Stormwater Regulations of the Town of *[_____]* if the total impervious cover is reduced by *[40%]* from existing conditions. Where site conditions prevent the reduction in impervious cover, stormwater management practices shall be implemented to provide stormwater controls for at least *[40%]* of the site's impervious area. When a combination of impervious area reduction and stormwater management practice implementation is used for redevelopment projects, the combination of impervious area reduction and the area controlled by a stormwater management practice shall equal or exceed *[40%].*

10. An alteration, redevelopment, or conversion of land use to a hotspot such as, without limitation: auto salvage yards, auto fueling facilities, fleet storage yards, commercial parking lots with high intensity use, road salt storage areas, commercial nurseries and landscaping, outdoor storage and loading areas of hazardous substances, or marinas, shall require a Stormwater Management Permit.

## 6.0 PROCEDURES

Permit Procedures and Requirements shall be defined and included as part of any rules and regulations promulgated as permitted under Section 4 of this Bylaw.

## 7.0 ENFORCEMENT

The *[Stormwater Authority],* or an authorized agent of the *[Stormwater Authority]* shall enforce this Bylaw, regulations, orders, violation notices, and enforcement orders, and may pursue all civil and criminal remedies for such violations. Enforcement shall be further defined and included as part of any Stormwater regulations promulgated as permitted under Section 4 of this Bylaw.

## 8.0 SEVERABILITY

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

# MODEL STORMWATER REGULATIONS

**Duxbury, Marshfield, and Plymouth**
**December 31, 2004**

## 1.0 PURPOSE

The purpose of these Stormwater Regulations is to protect, maintain and enhance the public health, safety, environment, and general welfare by establishing minimum requirements and procedures to control the adverse effects of increased post-development stormwater runoff, decreased groundwater recharge, and nonpoint source pollution associated with new development and redevelopment, as more specifically addressed in the Stormwater Management Bylaw of the Town of *[_____]*.

## 2.0 DEFINITIONS

The definitions contained herein apply to issuance of a Stormwater Management Permit (SMP) established by the Town of *[_____]* Stormwater Management Bylaw and implemented through these Stormwater Regulations. 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.

ALTER: Any activity, which will measurably change the ability of a ground surface area to absorb water or will change existing surface drainage patterns. Alter may be similarly represented as "alteration of drainage characteristics," and "conducting land disturbance activities."

APPLICANT: A property owner or agent of a property owner who has filed an application for a stormwater management permit.

BEST MANAGEMENT PRACTICE (BMP): Structural, non-structural and managerial techniques that are recognized to be the most effective and practical means to prevent and/or reduce increases in stormwater volumes and flows, reduce point source and nonpoint source pollution, and promote stormwater quality and protection of the environment. "Structural" BMPs are devices that are engineered and constructed to provide temporary storage and treatment of stormwater runoff. "Nonstructural" BMPs use natural measures to reduce pollution levels, do not require extensive construction efforts, and/or promote pollutant reduction by eliminating the pollutant source.

BETTER SITE DESIGN: Site design approaches and techniques that can reduce a site's impact on the watershed through the use of nonstructural stormwater management practices. Better site design includes conserving and protecting natural areas and greenspace, reducing impervious cover, and using natural features for stormwater management.

CERTIFICATE OF COMPLETION (COC): A document issued by the *[Stormwater Authority]* after all construction activities have been completed which states that all conditions of an issued Stormwater Management Permit (SMP) have been met and that a project has been completed in compliance with the conditions set forth in a SMP.

CONVEYANCE: Any structure or device, including pipes, drains, culverts, curb breaks, paved swales or man-made swales of all types designed or utilized to move or direct stormwater runoff or existing water flow.

DEVELOPER: A person who undertakes or proposes to undertake land disturbance activities.

DEVELOPMENT: The modification of land to accommodate a new use or expansion of use, usually involving construction.

DISTURBANCE OF LAND: Any action that causes a change in the position, location, or arrangement of soil, sand, rock, gravel of similar earth material.

DRAINAGE EASEMENT: A legal right granted by a landowner to a grantee allowing the use of private land for stormwater management purposes.

GENERAL STORMWATER MANAGEMENT PERMIT (GSMP): A permit for projects in the categories and meeting the standards and defined herein and as authorized in the Town of *[_____]* Stormwater Management Bylaw. Projects in these categories that meet these generic standards and are properly implemented are assumed to meet the requirements and intent of the Town of *[_____]* Stormwater Management Bylaw.

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

EROSION CONTROL: The prevention or reduction of the movement of soil particles or rock fragments.

EROSION CONTROL PLAN: A plan that shows the location and construction detail(s) of the erosion and sediment reduction controls to be utilized for a construction site.

FLOOD CONTROL: The prevention or reduction of flooding and flood damage.

FLOODING: A local and temporary inundation or a rise in the surface of a body of water, such that it covers land not usually under water.

GROUNDWATER: All water beneath any land surface including water in the soil and bedrock beneath water bodies.

HOTSPOT: Land uses or activities with higher potential pollutant loadings, such as auto salvage yards, auto fueling facilities, fleet storage yards, commercial parking lots with high intensity use, road salt storage areas, commercial nurseries and landscaping, outdoor storage and loading areas of hazardous substances, or marinas.

IMPERVIOUS SURFACE: Any material or structure on or above the ground that prevents water from infiltrating through the underlying soil. Impervious surface is defined to include, without limitation: paved parking lots, sidewalks, roof tops, driveways, patios, and paved, gravel and compacted dirt surfaced roads.

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

MASSACHUSETTS STORMWATER MANAGEMENT POLICY: The Policy issued by the Department of Environmental Protection, and as amended, that coordinates the requirements prescribed by state regulations promulgated under the authority of the Massachusetts Wetlands Protection Act G.L. c. 131 § 40 and Massachusetts Clean Waters Act G.L. c. 21, §. 23-56. The Policy addresses stormwater impacts through implementation of performance standards to reduce or prevent pollutants from reaching water bodies and control the quantity of runoff from a site.

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 *[_____].*

NEW DEVELOPMENT: Any construction or land disturbance of a parcel of land that is currently in a natural vegetated state and does not contain alteration by man-made activities.

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 natural and human-made pollutants, finally depositing them into water resource areas.

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

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

PERSON: Any individual, group of individuals, association, partnership, corporation, company, business organization, trust, estate, the Commonwealth or political subdivision thereof to the extent subject to Town Bylaws, administrative agency, public or quasi-public corporation or body, the Town of *[_____]*, and any other legal entity, its legal representatives, agents, or assigns.

PRE-DEVELOPMENT: The conditions that exist at the time that plans for the land development of a tract of land are submitted to the *[Stormwater Authority].* Where phased development or plan approval occurs (preliminary grading, roads and utilities, etc.), the existing conditions at the time prior to the first plan submission shall establish pre-development conditions.

POINT SOURCE: Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, or container from which pollutants are or may be discharged.

POST-DEVELOPMENT: The conditions that reasonably may be expected or anticipated to exist after completion of the land development activity on a specific site or tract of land. Post-development refers to the phase of a new development or redevelopment project after completion, and does not refer to the construction phase of a project.

RECHARGE: The replenishment of underground water reserves.

REDEVELOPMENT: Any construction, alteration, or improvement exceeding land disturbance of *[5,000]* square feet, where the existing land use is commercial, industrial, institutional, or multi-family residential.

RESOURCE AREA: Any area protected under including without limitation: the Massachusetts Wetlands Protection Act, Massachusetts Rivers Act, or Town of *[_____]* Wetlands Protection Bylaw.

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

SEDIMENTATION: A process of depositing material that has been suspended and transported in water.

SITE: The parcel of land being developed, or a designated planning area in which the land development project is located.

STORMWATER AUTHORITY: Town of *[_____]* [*Planning Board, Conservation Commission, Board of Health or other duly authorized Town entity that has the authority to administer, implement, and enforce these Stormwater Regulations].* The *[Stormwater Authority]* is responsible for coordinating the review, approval and permit process as defined in this Bylaw. Other Boards and/or departments participate in the review process as defined in Section 5 of these Stormwater Regulations.

STORMWATER MANAGEMENT: The use of structural or non-structural practices that are designed to reduce storm water runoff pollutant loads, discharge volumes, and/or peak flow discharge rates.

STORMWATER MANAGEMENT PERMIT (SMP): A permit issued by the *[Stormwater Authority]*, after review of an application, plans, calculations, and other supporting documents, which is designed to protect the environment of the Town from the deleterious affects of uncontrolled and untreated stormwater runoff.

STOP WORK ORDER: An order issued which requires that all construction activity on a site be stopped.

TSS: Total Suspended Solids**.**

WATER QUALITY VOLUME ($WQ_v$): The storage needed to capture a specified average annual stormwater runoff volume. Numerically (WQv) will vary as a function of drainage area or impervious area.

## 3.0 AUTHORITY

A) The Rules and Regulations contained herein have been adopted by the [*applicable town boards, commissions and/or departments]* in accordance with the Town of [*_____]* Stormwater Bylaw.

B) Nothing in these Rules and Regulations is intended to replace or be in derogation of the requirements of the Town of [*Town General Wetlands Protection Bylaw*] or the Town of *[_____] Floodplain Zoning Bylaw*] or any Rules and Regulations adopted thereunder.

C) These Stormwater Regulations may be periodically amended by the *[Stormwater Authority]* in accordance with the procedures outlined in Section 4.0 of the Town of *[_____]* Stormwater Bylaw.

## 4.0 ADMINISTRATION

A) The *[Stormwater Authority]* shall administer, implement and enforce these Regulations. Town Boards, including, but not limited to *[the Conservation Commission, Planning Board, Zoning Board of Appeals, Department of Public Works, Building Department, Board of Health, and insert any other applicable town board or department]* who have formally adopted these regulations, either directly, or by reference, and who issue permits and/or approvals for projects and/or activities under their specific jurisdiction and in accordance with their specific jurisdictional requirements regarding public notice, hearings and actions shall have approval authority under these Stormwater Regulations. Projects or activities approved by *[insert applicable board and/or department]* shall be deemed in compliance with the intent and provisions of these Stormwater

Regulations. Each approving *[insert board, commission or department]* must forward written documentation of said approval and all conditions of approval to the *[Stormwater Authority]* within *[10 business days]* of said approval. Upon receipt of written approval from *[insert board, commission or department]*, the *[Stormwater Authority]* shall issue a Stormwater Management Permit to the applicant within *[10 business days]*.

*Note: The above provision is designed to allow existing Town Boards, Commissions and/or Departments who have current jurisdiction over project approval activities to continue their current review procedures, but to add a provision that would authorize these entities to review and approve stormwater management facilities designed in accordance with this Regulation. In order for this authority to be granted, each applicable Town entity must adopt these regulations either directly, or by reference which would allow applicants to receive stormwater approval for projects without making a separate application to the designative Stormwater Authority. If certain Town Boards, Commissions and/or Departments fail to adopt these Regulations they would not have review authority for stormwater management applications.*

## 5.0 APPLICABILITY

A) These Stormwater Regulations apply to all activities in accordance with the applicability section of the Town of *[_____]* Stormwater Management Bylaw and further described in this section. Projects and/or activities not specifically under the currently regulated jurisdiction of any of the Town of *[_____]* boards, commissions or departments but still within the jurisdiction of the Town of *[_____]* Stormwater Management Bylaw must obtain a Stormwater Management Permit from the *[Stormwater Authority]* in accordance with the permit procedures and requirements defined in Section 6 of these Regulations. For projects and/or activities within the currently regulated jurisdiction of any of the Town of *[_____]* boards, commission or departments, the specific application submission requirements, public notices, and fee requirements of the applicable board, commission and/or department shall govern. Not withstanding these requirements, the Stormwater Management Plan Contents, Operation and Maintenance Plan Contents, and Stormwater Review Fee, under Section 6.0 L) and Section 6.0 M) of these Regulations must also be met.

B) If a portion of a project or activity is within the specific jurisdiction of *[insert applicable town board, commission and department]* then the entire project and all related projects required as a result of the activity proposed by the applicant shall be within the specific jurisdiction of that *[insert applicable town board, commission and department]* and subject to the provisions of these Regulations.

## 6.0 PERMIT PROCEDURES AND REQUIREMENTS

A) Projects requiring a stormwater management permit shall be required to submit the materials as specified in this section, and are required to meet the stormwater management criteria as specified in Section 7. Applicants filing a stormwater permit application under the currently regulated jurisdiction of the Town of *[_____] [insert applicable town board, commission and department]* need only to comply with Subsections 6.0 L, and 6.0 M of these Regulations.

B) Permit Required

1. No land owner or land operator shall receive any of the building, grading or other land development permits required for land disturbance activities without first meeting the requirements of this Bylaw prior to commencing the proposed activity.

2. Should a land-disturbing activity associated with an approved plan in accordance with this section not begin during the [*180-day]* period following permit issuance, the *[Stormwater Authority]* may evaluate the existing stormwater management plan to determine whether the plan still satisfies local program requirements and to verify that all design factors are still valid. If the authority finds the previously filed plan to be inadequate, a modified plan shall be submitted and approved prior to the commencement of land-disturbing activities.

C) Filing Application

1. The applicant shall file with the *[Stormwater Authority]*, *[three (3)]* copies of a completed application package for a Stormwater Management Permit (SMP). Permit issuance is required prior to any site altering activity. While the applicant can be a representative, the permittee must be the owner of the site. The SMP Application package shall include:

   a) A completed *[Application Form]* with original signatures of all owners;
   b) A list of abutters, certified by the Assessors Office; (abutters at their mailing addresses shown on the most recent applicable tax list of the assessors, including owners of land directly opposite on any public or private street or way, and abutters to the abutters within 300 feet of the property line of the applicant, including any in another municipality or across a body of water);
   c) Stormwater Management Plan and project description;
   d) Operation and Maintenance Plan;
   e) Payment of the application and review fees;
   f) Inspection and Maintenance agreement;
   g) Erosion and Sediment Control Plan;
   h) Surety bond.

D) Entry

Filing an application for a permit grants the *[Stormwater Authority]*, or its agent, permission to enter the site to verify the information in the application and to inspect for compliance with the resulting permit.

E) Fees

The *[Stormwater Authority]* shall obtain with each submission an Application Fee established by the *[Stormwater Authority]* to cover expenses connected with the review of the Stormwater Management Permit and a technical review fee sufficient to cover professional review services for the project. The *[Stormwater Authority]* is authorized to retain a Registered Professional Engineer or other professional consultant to advise the *[Stormwater Authority]* on any or all aspects of these plans. Applicants must pay review fees before the review process may begin.

1. Rules

   a) Application fees are payable at the time of application and are non-refundable.

   b) Application fees shall be calculated by the *[Stormwater Authority]* in accordance with the fee schedule below.

   c) These fees are in addition to any other local or state fees that may be charged under any other law, Bylaw, or local ordinance.

d) The fee schedule may be reduced or increased by the *[Stormwater Authority]*. Any such change shall be made at a posted public hearing of the *[Stormwater Authority]* not less than [30] days prior to the date upon which the change is to be effective.

2. Application Fees

a) A non-refundable application fee of the larger of *[$30.00] or $0.0030]* per square foot of the parcel to which the permit will be issued shall be due and payable to the Town of *[_____]* at the time an application is filed.

*Or, the [Stormwater Authority] may adopt reasonable administrative fees and technical review fees for site plan review.*

b) Application fees for permits issued under General Stormwater Management Permits (GSMP)s under Section 4 of the Town of *[_____]* Stormwater Bylaw shall be waived when such permits are issued for *[projects associated with existing single-family dwellings]* or *[for those projects that qualify].*

3. Engineering and Consultant Reviews and Fees

a) The *[Stormwater Authority]* is authorized to require an applicant to pay a fee for the reasonable costs and expenses for specific expert engineering and other consultant services deemed necessary by the *[Stormwater Authority]* to come to a final decision on the application. This fee is called the "Engineering and Consultant Review Fee."

b) Payment may be required at any point in the deliberations prior to a final decision.

c) Any application filed with the *[Stormwater Authority]* must be accompanied by a completed [*Engineering Consultant Fee Acknowledgement]* form.

d) Consultant fees shall be determined at the time of project review based on a specific scope of work, and shall be calculated at a rate of [*as the Stormwater Authority may determine].*

e) The services for which a fee may be utilized include, but are not limited to, wetland survey and delineation, hydrologic and drainage analysis, wildlife evaluation, stormwater quality analysis, site inspections, as-built plan review, and analysis of legal issues.

f) The *[Stormwater Authority]* is authorized to require an applicant to pay reasonable costs and expenses for certain activities which utilize the services of Town Staff. This includes such activities as inquiries concerning potential projects as well as site inspections not associated with a pending permit application.

g) The *[Stormwater Authority]* may require any applicant to pay an additional fee of [$30.00] per hour for review, inspection and monitoring services for any project filing that requires an excess of two (2) hours of review, inspection, and monitoring time by a Town Staff member.

h) Subject to applicable law, any unused portion of any fees collected shall be returned by the *[Stormwater Authority]* to the applicant within forty-five calendar days of a written request by the applicant, unless the *[Stormwater Authority]* decides in a public meeting that other action is necessary.

i) The Engineering and Consultant Review fees collected under this section shall be deposited in a revolving account. The *[Stormwater Authority]* shall include a full accounting of the revolving account as part of its annual report to the Town.

4. Revision Of Fee Schedules And Regulations Governing Fees

The *[Stormwater Authority]* may review and revise its regulations and fee schedules periodically as it sees fit.

a) Amendments shall be preceded by a public hearing.

b) A copy of the written decision will be filed with the town clerk within *[*10] days after final action is taken.

F) Public Hearings

The *[Stormwater Authority]* need not hold a public hearing for projects or activities outside the currently regulated jurisdiction of *[insert existing town boards, commissions and/or departments]*. For projects or activities within the currently regulated jurisdiction of *[insert existing town boards, commissions and/or departments], the applicable town board, commission and/or department* shall hold a public hearing in accordance with their own regulations and procedures.

G) Actions

The *[Stormwater Authority]*'s action, rendered in writing, shall consist of either:

1. Approval of the Stormwater Management Permit Application based upon determination that the proposed plan meets the Standards in Section 7 and will adequately protect the water resources of the community and is in compliance with the requirements set forth in this Bylaw;

2. Approval of the Stormwater Management Permit Application subject to any conditions, modifications or restrictions required by the *[Stormwater Authority]* which will ensure that the project meets the Standards in Section 7 and adequately protects water resources, set forth in this Bylaw;

3. Disapproval of the Stormwater Management Permit Application based upon a determination that the proposed plan, as submitted, does not meet the Standards in Section 7 or adequately protects water resources, as set forth in this Bylaw.

4. The *[Stormwater Authority]* may disapprove an application "without prejudice" where an applicant fails to provide requested additional information that in the *[Stormwater Authority's]* opinion is needed to adequately describe the proposed project. Information shall generally be limited to those items listed in Section 6.0 L) of these Regulations.

H) Failure of the *[Stormwater Authority]* to take final action upon an Application within *[30 calendar days]* of receipt of a complete application shall be deemed to be approval of said Application. Upon certification by the Town Clerk that the allowed time has passed without *[Stormwater Authority]* action, the *[Stormwater Authority]* must issue a Stormwater Management Permit.

I) Plan Changes

The permittee, must notify the *[Stormwater Authority]* in writing of any drainage change or alteration in the system authorized in a Stormwater Management Permit before any change or

alteration is made. If the *[Stormwater Authority]* determines that the change or alteration is significant, based on the Stormwater Management Standards in Section 7 and accepted construction practices, the *[Stormwater Authority]* may require that an amended application be filed.

J) Appeals of Actions of the *[Stormwater Authority]*

A decision of the *[Stormwater Authority]* shall be final. Further relief of a decision by the *[Stormwater Authority]* made under these Regulations shall be reviewable in the Superior Court in an action filed within *[60 days]* thereof, in accordance with M.G.L. Ch 249. § 4. An appeal of an action by a board, commission or department that has current regulatory authority for a project and/or activity shall be conducted under the applicable appeal provisions of said board, commission and/or department of the Town of *[____]*. Such an appeal shall result in revocation of the written approval as described under Section 4 of these Regulations, until such time as the appeal process of the applicable board, commission and/or department has been resolved.

K) Project Completion

At completion of the project the permittee shall submit as-built record drawings of all structural stormwater controls and treatment best management practices required for the site as required in Section 7. The as-built drawing shall show deviations from the approved plans, if any, and be certified by a Registered Professional Engineer.

L) Stormwater Management Plan Contents

1. The application for a stormwater management permit shall include the submittal of a Stormwater Management Plan to the *[Stormwater Authority]*. This Stormwater Management Plan shall contain sufficient information for the *[Stormwater Authority]* to evaluate the environmental impact, effectiveness, and acceptability of the measures proposed by the applicant for reducing adverse impacts from stormwater runoff. This plan shall be in accordance with the criteria established in these regulations and must be submitted with the stamp and signature of a Professional Engineer (PE) licensed in the Commonwealth of Massachusetts.

2. The Stormwater Management Plan shall fully describe the project in drawings, narrative, and calculations. It shall include:

    a) 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;
    b) A locus map;
    c) The existing zoning, and land use at the site;
    d) The proposed land use;
    e) The location(s) of existing and proposed easements;
    f) The location of existing and proposed utilities;
    g) The site's existing & proposed topography with contours at 2 foot intervals,
    h) The existing site hydrology;
    i) A description & delineation of existing stormwater conveyances, impoundments, and wetlands on or adjacent to the site or into which stormwater flows;
    j) A delineation of 100-year flood plains, if applicable;
    k) Estimated seasonal high groundwater elevation in areas to be used for stormwater retention, detention, or infiltration;
    l) The existing and proposed vegetation and ground surfaces with runoff coefficients for each;

m) A drainage area map showing pre and post construction watershed boundaries, drainage area and stormwater flow paths, including municipal drainage system flows;

n) A description and drawings of all components of the proposed stormwater management system including:

i. Locations, cross sections, and profiles of all brooks, streams, drainage swales and their method of stabilization;
ii. All measures for the detention, retention or infiltration of water;
iii. All measures for the protection of water quality;
iv. The structural details for all components of the proposed drainage systems and stormwater management facilities;
v. Notes on drawings specifying materials to be used, construction specifications, and expected hydrology with supporting calculations;
vi. Proposed improvements including location of buildings or other structures, impervious surfaces, and drainage facilities, if applicable;
vii. Any other information requested by the *[Stormwater Authority]*.

o) Hydrologic and hydraulic design calculations for the pre-development and post-development conditions for the design storms specified in this Regulation. Such calculations shall include:

i. Description of the design storm frequency, intensity and duration;
ii. Time of concentration;
iii. Soil Runoff Curve Number (RCN) based on land use and soil hydrologic group;
iv. Peak runoff rates and total runoff volumes for each watershed area;
v. Information on construction measures used to maintain the infiltration capacity of the soil where any kind of infiltration is proposed;
vi. Infiltration rates, where applicable;
vii. Culvert capacities;
viii. Flow velocities;
ix. Data on the increase in rate and volume of runoff for the specified design storms, and
x. Documentation of sources for all computation methods and field test results.

p) Post-Development downstream analysis if deemed necessary by the *[Stormwater Authority];*

q) Soils Information from test pits performed at the location of proposed stormwater management facilities, including but not limited to soil descriptions, depth to seasonal high groundwater, depth to bedrock, and percolation rates. Soils information will be based on site test pits logged by a Massachusetts Registered Soil Evaluator, or a Massachusetts Registered Professional Engineer;

r) Landscaping plan describing the woody and herbaceous vegetative stabilization and management techniques to be used within and adjacent to the stormwater practice.

M) Operation and Maintenance Plan Contents

An Operation and Maintenance plan (O&M Plan) is required at the time of application for all projects. The maintenance plan shall be designed to ensure compliance with the Permit, this Bylaw and that the Massachusetts Surface Water Quality Standards, 314, CMR 4.00 are met in all seasons and throughout the life of the system. The Operation and Maintenance Plan shall remain on file with the *[Stormwater Authority]* and shall be an ongoing requirement. The O&M Plan shall include:

1. The name(s) of the owner(s) for all components of the system;

2. A map showing the location of the systems and facilities including catch basins, manholes/access lids, main, and stormwater devices;

3. Maintenance agreements that specify:

    a) The names and addresses of the person(s) responsible for operation and maintenance;
    b) The person(s) responsible for financing maintenance and emergency repairs;
    c) An Inspection and Maintenance Schedule for all stormwater management facilities including routine and non-routine maintenance tasks to be performed;
    d) A list of easements with the purpose and location of each;
    e) The signature(s) of the owner(s).

4. Stormwater Management Easement(s)

    a) Stormwater management easements shall be provided by the property owner(s) as necessary for:

        i. Access for facility inspections and maintenance;
        ii. Preservation of stormwater runoff conveyance, infiltration, and detention areas and facilities, including flood routes for the 100-year storm event;
        iii. Direct maintenance access by heavy equipment to structures requiring regular maintenance.

    b) The purpose of each easement shall be specified in the maintenance agreement signed by the property owner.

    c) Stormwater management easements are required for all areas used for off-site stormwater control, unless a waiver is granted by the [*Stormwater Authority*].

    d) Easements shall be recorded with the Plymouth County Registry of Deeds prior to issuance of a Certificate of Completion by the *[Stormwater Authority].*

5. Changes to Operation and Maintenance Plans

    a) The owner(s) of the stormwater management system must notify the *[Stormwater Authority]* of changes in ownership or assignment of financial responsibility.

    b) The maintenance schedule in the Maintenance Agreement may be amended to achieve the purposes of this Regulation by mutual agreement of the *[Stormwater Authority]* and the Responsible Parties. Amendments must be in writing and signed by all Responsible Parties. Responsible Parties shall include owner(s), persons with financial responsibility, and persons with operational responsibility.

## 7.0 POST-DEVELOPMENT STORMWATER MANAGEMENT CRITERIA

A) At a minimum all projects shall comply with the performance standards of the most recent version of Massachusetts Department of Environmental Protection (DEP) Stormwater Management Policy, as well as the following:

B) General Criteria

The following general performance criteria shall be applicable to all stormwater management plans, unless otherwise provided for in this Regulation:

1. No Untreated Discharges

   All stormwater runoff generated from land development and land use conversion activities shall not discharge untreated stormwater runoff directly to a wetland, local water body, municipal drainage system, or abutting property, without adequate treatment.

2. Channel Protection

   Protection of channels from bank and bed erosion and degradation shall be provided by

   *[attenuating the 24-hour extended detention storage of runoff of the post-development 1-year, 24-hour return frequency storm event] (default option – optimal) OR*

   *[controlling the peak discharge rate from the 2-yr storm event to the pre-development rate as required by the MA DEP Stormwater Management Policy] (alternative option – minimum)*

3. Overbank Flooding Protection

   Downstream overbank flood and property protection shall be provided by

   *[attenuating the post-development peak discharge rate to the pre-development rate for the 10-year, 24-hour return frequency storm event as required by the MA DEP Stormwater Management Policy]. (default option - optimal)*

4. Extreme Flooding Protection

   Extreme flooding and public safety protection shall be provided by

   *[attenuating the peak discharge rate from the 100-yr, 24-hour return frequency storm event to the pre-development rates] (default option - optimal) OR*

   *[controlling and safely conveying the 100-year, 24 hour return frequency storm event such that flooding is not exacerbated] (alternative option - minimum) OR*

   *[evaluating the 100-year, 24-hour return frequency storm event to demonstrate no increased flooding impacts off-site, as required by the MA DEP Stormwater Management Policy] (another alternative option - minimum)*

5. Recharge

   a) Annual groundwater recharge rates shall be maintained, by promoting infiltration through the use of structural and non-structural methods. At a minimum, annual recharge from the post development site shall mimic the annual recharge from pre-development site conditions.

   b) The stormwater runoff volume to be recharged to groundwater should be determined using the methods prescribed in the latest version of *[the Massachusetts DEP Stormwater Management Manual or an equivalent qualifying local manual].* The recharge requirements shall apply to all activities within the jurisdiction of this Regulation except as noted, and unless specifically waived by *[Stormwater Authority]*. The recharge criterion is not required for any portion of a site designated as a stormwater hotspot (see Section 7.10 of this Regulation). In addition, the *[Stormwater Authority*] may relax or eliminate the recharge requirement at its discretion, if the site is situated on unsuitable soils or is in a redevelopment area with documentation of prior contaminated soils.

6. Structural Practices for Water Quality

   a) Presumed Compliance with Massachusetts Water Quality Standards *(default option - minimum)*

      All structural stormwater management facilities shall be selected and designed using the appropriate criteria from the most recent version of the Massachusetts DEP Stormwater Management Manual.

      For other structural stormwater controls not included in the Massachusetts Stormwater Management Manual, or for which pollutant removal rates have not been provided, the effectiveness and pollutant removal of the structural control must be documented through prior studies, literature reviews, or other means and receive approval from the [*Stormwater Authority*] before being included in the design of a stormwater management system.

      Structural best management practices (BMPs) must be designed to remove [80%] of the average annual post development total suspended solids (TSS) and [40%] for total phosphorus [TP], and [30%] for total nitrogen (TN). It is presumed that a BMP complies with this performance goal if it is:

      i) Sized to capture the prescribed water quality volume;
      ii) Designed according to the specific performance criteria outlined in the *[Massachusetts Stormwater Management Manual or an approved local equivalent];*
      iii) Constructed properly; and
      iv) Maintained regularly.

   b) Pollutant Loading Calculation Assessment *(additional option - optimal)*

      i) For subdivisions of *[30]* lots or more, any commercial project with a building *[10,000]* square feet or more, or *[any project in an area designated by the Stormwater Authority as a sensitive/critical area],* a pollutant loading calculation shall be conducted to document compliance with water quality standards by calculating pre-development loads, calculating uncontrolled post-development loads and then

applying a prescribed pollutant removal efficiency to selected practices to arrive at a net pollutant load delivery. The post-developed load must be equal to or less than the pre-developed load.

ii) The methodology for this calculation shall be in accordance with *[reference approved local method/approach]*.

*See Appendix A of these Model Stormwater Regulations for an example methodology for calculating pollutant load and assessing compliance.*

7. Water Quality Volume

The prescribed water quality volume required in the sizing of a structural stormwater practice shall be

*[calculated as 1.2 x total watershed area x runoff coefficient (Rv), where Rv = 0.05 + 0.009 (I%) and I% = percent of impervious area*] *(default option – optimal) OR*

*[0.50 inches x the total impervious area of the drainage area and 1.0 inches x the total impervious area of the drainage area in critical areas, as specified in the Massachusetts DEP Stormwater Policy*] *(alternative option – minimum)*

8. Hydrologic Basis for Design of Structural Practices

For facility sizing criteria, the basis for hydrologic and hydraulic evaluation of development sites are as follows:

a) Impervious cover is measured from the site plan and includes any material or structure on or above the ground that prevents water from infiltrating through the underlying soil. Impervious surface is defined to include, without limitation: paved parking lots, sidewalks, roof tops, driveways, patios, and paved, gravel and compacted dirt surfaced roads.

b) Off-site areas shall be assessed based on their “pre-developed condition” for computing the water quality volume (i.e, treatment of only on-site areas is required). However, if an offsite area drains to a proposed BMP, flow from that area must be accounted for in the sizing of a specific practice.

c) Off-site areas draining to a proposed facility should be modeled as "present condition" for peak-flow attenuation requirements.

d) The length of sheet flow used in time of concentration calculations is limited to no more than 50 feet for predevelopment conditions and 50 feet for post development conditions.

e) Detention time for the one-year storm is defined as the center of mass of the inflow hydrograph and the center of mass of the outflow hydrograph.

f) The models TR-55 and TR-20 (or approved equivalent) will be used for determining peak discharge rates.

g) The standard for characterizing pre-development land use for on-site areas shall be woods.

h) For purposes of computing runoff, all pervious lands in the site shall be assumed prior to development to be in good condition regardless of conditions existing at the time of

computation.

i) If an off-site area drains to a facility, off-site areas should be modeled, assuming an "ultimate buildout condition" upstream.

j) Determination of flooding and channel erosion impacts to receiving streams due to land development projects shall be measured at each point of discharge from the development project and such determination shall include any runoff from the balance of the watershed which also contributes to that point of discharge.

k) The specified design storms shall be defined as a 24-hour storm using the rainfall distribution recommended by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) or the Northeast Regional Climate Center "Atlas of Precipitation Extremes for the Northeastern United State and Southeastern Canada."

l) Proposed residential, commercial, or industrial subdivisions shall apply these stormwater management criteria to the land development as a whole. Individual lots in new subdivisions shall not be considered separate land development projects, but rather the entire subdivision shall be considered a single land development project. Hydrologic parameters shall reflect the ultimate land development and shall be used in all engineering calculations.

9. Sensitive Areas

Stormwater discharges to critical areas with sensitive resources (i.e., shellfish beds, swimming beaches, aquifer recharge areas, water supply reservoirs) may be subject to additional criteria, or may need to utilize or restrict certain stormwater management practices at the discretion of the *[Stormwater Authority].* The *[Stormwater Authority]* may designate sensitive areas and specific criteria for these areas after conducting a public hearing in accordance with the provisions of Section 4.0 of the Town of *[_____]* Stormwater Bylaw.

10. Hotspots

Stormwater discharges from land uses or activities with higher potential pollutant loadings, known as "hotspots", as defined in the most recent version of the *[MA DEP Stormwater Management Manual or an equivalent qualifying local manual]* –require the use of specific stormwater management BMPs as specified in the most recent version of the *[MA DEP Stormwater Management Manual or an equivalent qualifying local manual]*. The use of infiltration practices without pretreatment is prohibited.

11. *[Stormwater Credits*

*The use of Better Site Design and nonstructural stormwater management measures is encouraged to minimize reliance on structural stormwater management measures. The use of one or more site design measures by the applicant may allow for a reduction in the water quality treatment volume required and the stream channel protection volume required. The applicant may, if approved by the [Stormwater Authority], take credit for the use of stormwater better site design practices to reduce some of the requirements specified in the criteria section of these regulations. The site design practices that qualify for these credits and procedures for applying and calculating the credits are identified in Appendix B of this Model Regulation. ]*

## 8.0 WAIVERS

A) The *[Stormwater Authority]* may waive strict compliance with any requirement of the Town of *[_____]* Stormwater Bylaw or the rules and regulations promulgated hereunder, where:

1. such action is allowed by federal, state and local statutes and/or regulations,
2. is in the public interest, and
3. is not inconsistent with the purpose and intent of the Town of *[_____]* Stormwater Bylaw.

B) Any applicant may submit a written request to be granted such a waiver. Such a request shall be accompanied by an explanation or documentation supporting the waiver request and demonstrating that strict application of the Bylaw does not further the purposes or objectives of this bylaw.

C) All waiver requests shall be acted on within *[30 calendar days]* and written finding will be provided by the *[Stormwater Authority]*.

D) If in the *[Stormwater Authority's]* opinion, additional time or information is required for review of a waiver request, the *[Stormwater Authority]* may request an extension of the review period. In the event the applicant objects to an extension, or fails to provide requested information, the waiver request may be denied, "without prejudice" by the *[Stormwater Authority]*.

## 9.0 SURETY

The [*Stormwater Authority*] may require the permittee to post before the start of land disturbance or construction activity, a surety bond, irrevocable letter of credit, cash, or other acceptable security. The form of the bond shall be approved by town counsel, 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 bond as each phase is completed in compliance with the permit but the bond may not be fully released until the *[Stormwater Authority]* has received the final inspection report as required by Section 11 of these Regulations and issued a Certificate of Completion.

## 10.0 CONSTRUCTION INSPECTIONS

A) Notice of Construction Commencement. The applicant must notify the *[Stormwater Authority]* in advance before the commencement of construction. In addition, the applicant must notify the *[Stormwater Authority]* in advance of construction of critical components of the SWM facility.

B) At the discretion of the *[Stormwater Authority],* periodic inspections of the stormwater management system construction shall be conducted by the Town Officer or a professional engineer or their designee who has been approved by the *[Stormwater Authority].* All inspections shall be documented and written reports prepared that contain the following information:

1. The date and location of the inspection;

2. Whether construction is in compliance with the approved stormwater management plan;

3. Variations from the approved construction specifications; and

4. Any other variations or violations of the conditions of the approved stormwater management plan.

C) The *[Stormwater Authority]* or its designee shall inspect the project site at the following stages, at a minimum:

1. Initial Site Inspection: prior to approval of any plan;

2. Erosion Control Inspection: to ensure erosion control practices are in accord with the filed plan;

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

4. Final Inspection

   a) After the stormwater management system has been constructed and before the surety has been released, all applicants are required to submit actual “as built” plans for any stormwater management facilities or practices after final construction is completed and must be certified by a Professional Engineer.

   b) The *[Stormwater Authority]* shall inspect the system to confirm its "as-built" features. This inspector shall also evaluate the effectiveness of the system in an actual storm. If the inspector finds the system to be adequate he shall so report to the *[Stormwater Authority]* which will issue a Certificate of Completion. As built plans shall be full size plans which reflect the “as built” conditions, including all final grades, developed by a Professional Engineer. All changes to project design should be recorded in red ink on plans to define changes made. All work deleted, corrections in elevations, and changes in materials, should be shown on the as built drawings.

D) Inadequacy of System

1. If the system is found to be inadequate by virtue of physical evidence of operational failure, even though it was built as called for in the Stormwater Management Plan, it shall be corrected by the applicant before the Certificate of Completion is released. If the applicant fails to act the *[Stormwater Authority]* may use the surety bond to complete the work.

2. If the *[Stormwater Authority]* determines that there is a failure to comply with the plan, the property owner shall be notified in writing of the nature of the violation and the required corrective actions. A Stop Work Order shall be issued until any violations are corrected and all work previously completed has received approval by the *[Stormwater Authority]*.

## 11.0 CERTIFICATE OF COMPLETION

A) Upon completion, the applicant is responsible for certifying that the completed project is in accordance with the approved plans and specifications and shall provide regular inspections sufficient to adequately document compliance.

B) The *[Stormwater Authority]* will issue a letter certifying completion upon receipt and approval of the final inspection and reports and/or upon otherwise determining that all work of the permit has been satisfactorily completed in conformance with this Regulation.

## 12.0 PERPETUAL INSPECTION AND MAINTENANCE

A) Maintenance Responsibility

1. Stormwater management facilities and practices included in a stormwater management plan with an inspection and maintenance agreement in accordance with Section 6.M of these Regulations must undergo ongoing inspections to document maintenance and repair needs and ensure compliance with the requirements of the agreement, the plan and this Regulation.

2. The owner of the property on which work has been done pursuant to this Regulation for private stormwater management facilities, or any other person or agent in control of such property, shall maintain in good condition and promptly repair and restore all grade surfaces, walls, drains, dams and structures, vegetation, erosion and sedimentation controls, and other protective devices. Such repairs or restoration and maintenance shall be in accordance with approved plans.

B) Maintenance Inspections

1. All stormwater management facilities must undergo inspections to document maintenance and repair needs and ensure compliance with the requirements of this bylaw and accomplishment of its purposes as specified in the Operation and Maintenance Plan and Maintenance Agreement described under Section 6.M of these regulations.

2. At a minimum, inspections shall occur during the first year of operation and at least once every [three] years thereafter. In addition, a maintenance agreement as specified under Section 6.M of these regulations between the owner and the *[Stormwater Authority]* shall be executed for privately-owned stormwater management systems that specifies the Responsible Party for conducting long term inspections.

3. Inspection reports shall be submitted to and maintained by the *[Stormwater Authority]* for all stormwater management systems. Inspection reports for stormwater management systems shall include:

   a) The date of inspection;
   b) Name of inspector;
   c) The condition of:

      i. Pretreatment devices
      ii. Vegetation or filter media
      iii. Fences or other safety devices
      iv. Spillways, valves, or other control structures
      v. Embankments, slopes, and safety benches
      vi. Reservoir or treatment areas
      vii. Inlet and outlet channels and structures
      viii. Underground drainage
      ix. Sediment and debris accumulation in storage and forebay areas (including catch basins)
      x. Any nonstructural practices
      xi. Any other item that could affect the proper function of the stormwater management system

   d) Description of the need for maintenance;

C) Right-of-Entry for Inspection

The terms of the inspection and maintenance agreement as specified in Section 6.M of these regulations shall provide for the [*Stormwater Authority*] or its designee to enter the property at reasonable times and in a reasonable manner for the purpose of inspection. The *[Stormwater Authority]*, its agents, officers, and employees shall have authority to enter upon privately owned land for the purpose of performing their duties under this Regulation and may make or cause to be made such examinations, surveys, or sampling as the *[Stormwater Authority]* deems necessary, subject to the constitutions and laws of the United States and the Commonwealth.

D) Records of Maintenance and Repair Activities

Parties responsible for the operation and maintenance of a stormwater management facility shall provide records of all maintenance and repairs to the *[Stormwater Authority],* upon request. Parties responsible for the operation and maintenance of a stormwater management facility shall make records of the installation and of all maintenance and repairs, and shall retain the records for at least [5] years. These records shall be made available to the *[Stormwater Authority]* during inspection of the facility and at other reasonable times upon request.

E) Failure to Maintain

1. If a responsible person fails or refuses to meet the requirements of the inspection and maintenance agreement, the *[Stormwater Authority]*, after *[thirty (30)]* days written notice (except, that in the event the violation constitutes an immediate danger to public health or public safety, 24 hours notice shall be sufficient), may correct a violation of the design standards or maintenance requirements by performing the necessary work to place the facility or practice in proper working condition. The *[Stormwater Authority]* may assess the owner(s) of the facility for the cost of repair work which shall be a lien on the property.

*Note: Each Town should investigate whether the [Stormwater Authority] would be authorized to impose a lien on property through its regulations and/or has the ability to automatically establish a lien. The authority to establish a lien is sometimes by specific statute.*

2. After notification is provided to the person responsible for carrying out the maintenance plan of any deficiencies discovered from an inspection of a stormwater management system, the person responsible for carrying out the maintenance plan shall have 30 days or other time frame mutually agreed to between the *[Stormwater Authority]* and the person responsible for carrying out the maintenance plan to correct the deficiencies. The *[Stormwater Authority]* shall then conduct a subsequent inspection to ensure completion of repairs.

## 13.0 ENFORCEMENT

A) The *[Stormwater Authority]* or an authorized agent of the *[Stormwater Authority]* shall enforce this Bylaw, regulations, orders, violation notices, and enforcement orders, and may pursue all civil, criminal and non-criminal remedies for such violations.

B) Notices and Orders

1. The *[Stormwater Authority]* or an authorized agent of the *[Stormwater Authority]* may issue a written notice of violation or enforcement order to enforce the provisions of this Bylaw or the regulations thereunder, which may include requirements to:

a) Cease and desist from construction or land disturbing activity until there is compliance with the Bylaw and the stormwater management permit;

b) Repair, maintain; or replace the stormwater management system or portions thereof in accordance with the operation and maintenance plan;

c) Perform monitoring, analyses, and reporting;

d) Fix adverse impact resulting directly or indirectly from malfunction of the stormwater management system.

2. If the enforcing person determines that abatement or remediation of adverse impacts is required, the order may set forth a deadline by which such abatement or remediation must be completed. Said order may further advise that, should the violator or property owner fail to abate or perform remediation within the specified deadline, the Town of *[_____]* may, at its option, undertake such work, and the property owner shall reimburse the Town of *[_____]* for expenses incurred.

3. Within thirty (30) days after completing all measures necessary to abate the violation or to perform remediation, the violator and the property owner shall be notified of the costs incurred by the Town of *[_____]* 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 thirty (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 thirty (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, the costs shall become a special assessment against the property owner and shall constitute a lien on the owner's property for the amount of said costs. Interest shall begin to accrue on any unpaid costs at the statutory rate provided in G.L. Ch. 59, § 57, after the thirty-first day at which the costs first become due.

C) Any person who violates any provision of the Town of *[_____] Stormwater* Bylaw, or regulation, order or permit issued thereunder, may be ordered to correct the violation and/or shall be punished by a fine of not more than *[$_____]*. Each day or part thereof that such violation occurs or continues shall constitute a separate offense.

D) Non-Criminal Disposition. As an alternative to criminal prosecution or civil action, the Town of *[_____]* may elect to utilize the non-criminal disposition procedure set forth in G.L. Ch. 40, §21D and *[the citation town enabling vote/bylaw (if applicable)]* of the Town of *[_____]* in which case *[title or other authorized agent]* of the Town of *[_____]* shall be the enforcing person. The penalty for the 1st violation shall be *[$_____].* The penalty for the 2nd violation shall be *[$_____].* The penalty for the 3rd and subsequent violations shall be *[$ _____].* Each day or part thereof that such violation occurs or continues shall constitute a separate offense.

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

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

## 14.0 SEVERABILITY

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

# Appendix A: Method of Pollutant Load Calculation for Compliance with Water Quality Standards

*This appendix is included with the Model Stormwater Bylaw and Regulations to provide additional guidance to municipalities considering the adoption of the loading calculation approach as a requirement for large or complex projects, or projects located in sensitive areas. Prior to adoption of the sample approach presented here, each municipality should review the methodology in detail and generate the appropriate regulatory language to effectively implement this requirement.*

For certain magnitude projects, a loading calculation analysis may be required by applicants to document compliance with water quality standards by calculating pre-development pollutant loads, calculating uncontrolled post-development pollutant loads and then applying a prescribed pollutant removal efficiency to selected practices to arrive at a net pollutant load delivery. The post-developed load must be equal to or less than the pre-developed load.

**Pollutant Loading Calculation Approach for Compliance**

Because of the potential for some projects to exceed pre-developed loads, even with Best Management Practices (BMPs) that are designed to meet performance standards, the *[Stormwater Authority]* may require applicants to prepare pollutant loading calculations that are intended to keep pollutant levels to the pre-developed condition baseline. The *[Stormwater Authority]* may require the maintenance of a "no net increase" in pollutant load; new development cannot exceed the pre-developed load based on pre-developed land cover conditions that are present at the time an applicant files for a Stormwater Management Permit. Loading from redevelopment projects may be required to be reduced 10% from existing levels. The *[Stormwater Authority]* may require a pollutant loading assessment for targeted pollutants to a receiving water body, based on pollutants of concern (i.e., phosphorus for freshwater systems, nitrogen for saltwater systems, and/or sediment).

The following computational exercise may be used to ensure that above provisions are met:

1. Loadings are computed for the pre-developed condition based on pre-development pollutant loading values;

2. The load from the proposed development is computed based on the proposed level of impervious cover and the appropriate loading factor for that land use. The *[Stormwater Authority]* shall require that the net difference between these two loads be reduced (or captured) by effective stormwater treatment practices.

This appendix presents data and a methodology for using the Simple Method (Schueler, 1987) to estimate pollutant load from a site or drainage area.

The Simple Method estimates stormwater runoff pollutant loads for urban areas. The technique requires a modest amount of information, including the subwatershed drainage area and impervious cover, stormwater runoff pollutant concentrations, and annual precipitation. With the Simple Method, an applicant can either break up land use into specific areas, such as residential, commercial, industrial, and roadway and calculate annual pollutant loads for each type of land, or

utilize more generalized pollutant values for "urban runoff." It is also important to note that these values may vary depending on other variables such as the age of development.

The Simple Method estimates pollutant loads for chemical constituents as a product of annual runoff volume and pollutant concentration, as:

$$\mathbf{L = 0.226 * R * C * A}$$

Where: L = Annual pollutant load (lbs)
R = Annual runoff (inches)
C = Pollutant concentration (mg/l)
A = Area (acres)
0.226 = Unit conversion factor

For bacteria, the equation is slightly different, to account for the differences in units. The modified equation for bacteria is:

$$\mathbf{L = 103 * R * C * A}$$

Where: L = Annual load (billion colonies)
R = Annual runoff (inches)
C = Bacteria concentration (1,000/ ml)
A = Area (acres)
103 = Unit conversion factor

Stormwater pollutant concentrations can be estimated from local or regional data, or from national data sources. Table A.1 presents typical concentration data for pollutants in urban stormwater.

**Table A.1 National Median Concentrations for Chemical Pollutants in Stormwater Runoff**

| Constituent | Units | Urban Runoff |
|---|---|---|
| TSS | mg/l | 54.51 |
| TP | mg/l | 0.261 |
| TN | mg/l | 2.001 |
| Cu | ug/l | 11.11 |
| Pb | ug/l | 50.71 |
| Zn | ug/l | 1291 |
| F Coli | 1,000 col/ ml | 1.52 |

Sources:
1: Pooled NURP/USGS (Smullen and Cave, 1998)
2: Schueler (1999)

In addition, some source areas appear to be particularly important for some pollutants. Table A.2 summarizes these data for several key source areas. It is important to note that, because the Simple Method computes runoff based on an impervious area fraction, it cannot be easily used to isolate pervious sources, such as lawns. In addition, a composite runoff concentration can be developed based on the fraction of lawn, driveway, and roof on a residential site, for example.

| **Table A.2 Pollutant Concentration from Different Source Areas/Land Uses** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Constituent** | **TSS[1]** | **TP[2]** | **TN[3]** | **F Coli[1]** | **Cu[1]** | **Pb[1]** | **Zn[1]** |
| Units | mg/l | mg/l | mg/l | 1,000 col/ ml | ug/l | ug/l | ug/l |
| Residential Roof | 19 | 0.11 | 1.5 | 0.26 | 20 | 21 | 312 |
| Commercial Roof | 9 | 0.14 | 2.1 | 1.1 | 7 | 17 | 256 |
| Industrial Roof | 17 | - | - | 5.8 | 62 | 43 | 1,390 |
| Commercial/Res Parking | 27 | 0.15 | 1.9 | 1.8 | 51 | 28 | 139 |
| Industrial Parking | 228 | - | - | 2.7 | 34 | 85 | 224 |
| Residential Street | 172 | 0.55 | 1.4 | 37 | 25 | 51 | 173 |
| Commercial Street | 468 | - | - | 12 | 73 | 170 | 450 |
| Rural Highway | 51 | - | 22 | - | 22 | 80 | 80 |
| Urban Highway | 142 | 0.32 | 3.0 | - | 54 | 400 | 329 |
| Lawns | 80 | 2.1 | 9.1 | 24 | 17 | 17 | 50 |
| Landscaping | 37 | - | - | 94 | 94 | 29 | 263 |
| Driveway | 173 | 0.56 | 2.1 | 17 | 17 | - | 107 |
| Heavy Industrial | 124 | - | - | - | 148 | 290 | 1600 |
| Residential (general)[4] | 100 | 0.40 | 2.2 | - | - | 18 | 37 |
| Commercial (general)[4] | 75 | 0.20 | 2.0 | - | - | 370 | 250 |
| Industrial (general)[4] | 120 | 0.40 | 2.5 | - | - | - | - |
| Sources:<br>1: Claytor and Schueler (1996)<br>2: Average of Steuer et al. (1997), Bannerman (1993) and Waschbusch (2000)<br>3: Steuer et al. (1997)<br>4: Caraco (2001), default values averaged from several individual assessments | | | | | | | |

Pre-developed loads are usually estimated from specific loading rates based on pre-developed land cover. The following lists typical unit loading rates for key pollutant parameters from forest and rural land uses (Caraco, 2001).

Forest:

TSS: 100 lbs/acre/year
TP: 0.2 lbs/acre/year
TN: 2.0 lbs/acre/year
FC bacteria: 12 billion col/acre/year

Rural:

TSS: 300 lbs/acre/year
TP: 0.75 lbs/acre/year
TN: 5.0 lbs/acre/year
FC bacteria: 39 billion col/acre/year

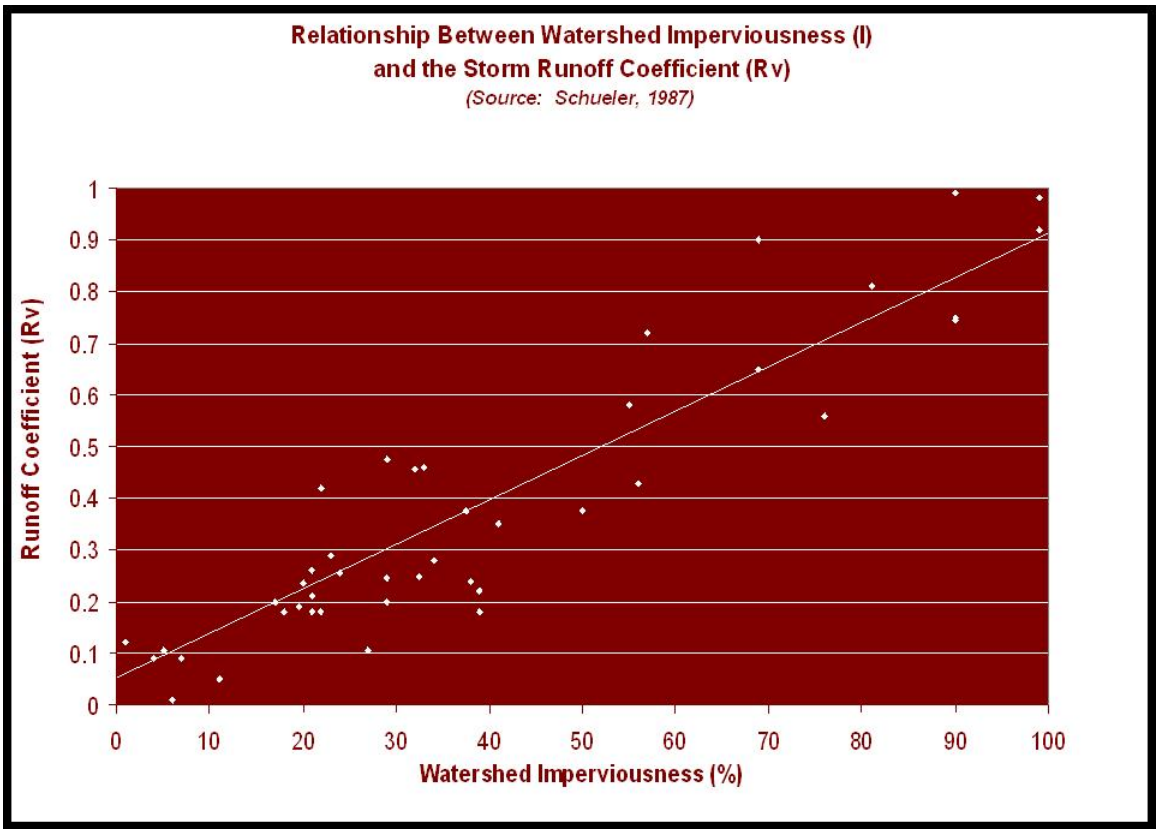


**Figure A.1: Relationship between Watershed Imperviousness and the Stormwater Runoff Coefficient**

The Simple Method calculates annual runoff as a product of annual runoff volume, and a runoff coefficient (Rv). Runoff volume is calculated as:

$$\mathbf{R = P * P_j * Rv}$$

Where: R = Annual runoff (inches)
P = Annual rainfall (inches)
$P_j$ = Fraction of annual rainfall events that produce runoff (usually 0.9)
Rv = Runoff coefficient

In the Simple Method, the runoff coefficient is calculated based on impervious cover in the drainage area. This relationship is shown in Figure A.1. Although there is some scatter in the data, watershed imperviousness does appear to be a reasonable predictor of Rv. The following equation represents the best fit line the dataset (N=47, R2=0.71).

$$\mathbf{Rv=0.05+0.9I_a}$$

Where: $I_a$ = Impervious fraction

The Simple Method uses different impervious cover values for separate land uses within a subwatershed. Representative impervious cover data, are presented in Table A.3 (Cappiella and Brown, 2001). In addition, Towns may have detailed impervious cover information if they

maintain a detailed land use/land cover GIS database, or applicants can measure impervious cover directly from site plans.

| **Table A.3 Land Use and Impervious Cover Estimates** | |
|---|---|
| **Land Use Category** | **Mean Impervious Cover** |
| Agriculture | **2** |
| Open Urban Land* | **9** |
| 2 Acre Lot Residential | **11** |
| 1 Acre Lot Residential | **14** |
| 1/2 Acre Lot Residential | **21** |
| 1/4Acre Lot Residential | **28** |
| 1/8 Acre Lot Residential | **33** |
| Townhome Residential | **41** |
| Multifamily Residential | **44** |
| Institutional** | **31-38%** |
| Light Industrial | **50-56%** |
| Commercial | **70-74%** |

* Open urban land includes developed park land, recreation areas, golf courses, and cemeteries.

** Institutional is defined as places of worship, schools, hospitals, government offices, and police and fire stations

Source: Cappiella and Brown, 2001

The Simple Method should provide reasonable estimates of changes in pollutant export resulting from urban development activities. However, several caveats should be kept in mind when applying this method.

The Simple Method is most appropriate for assessing and comparing the relative stormflow pollutant load changes of different land use and stormwater management scenarios. The Simple Method provides estimates of storm pollutant export that are probably close to the "true" but unknown value for a development site, catchment, or subwatershed. However, it is very important not to overemphasize the precision of the results obtained. For example, it would be inappropriate to use the Simple Method to evaluate relatively similar development scenarios (e.g., 34.3% versus 36.9% Impervious cover). The Simple Method provides a general planning estimate of likely storm pollutant export from areas at the scale of a development site, catchment or subwatershed. More sophisticated modeling may be needed to analyze larger and more complex drainage areas.

In addition, the Simple Method only estimates pollutant loads generated during storm events. It does not consider pollutants associated with baseflow volume. Typically, baseflow is negligible or non-existent at the scale of a single development site, and can be safely neglected. However, catchments and subwatersheds do generate baseflow volume. Pollutant loads in baseflow are generally low and can seldom be distinguished from natural background levels (NVPDC, 1980). Consequently, baseflow pollutant loads normally constitute only a small fraction of the total pollutant load delivered from an urban area. Nevertheless, it is important to remember that the load estimates refer only to storm event derived loads and should not be confused with the total pollutant load from an area. This is particularly important when the development density of an area is low. For example, in a large low density residential subwatershed (Imp. Cover < 5%), as

much as 75% of the annual runoff volume may occur as baseflow. In such a case, the annual baseflow nutrient load may be equivalent to the annual stormflow nutrient load.

The removal efficiencies of various BMPs are also needed to determine final annual pollutant loads. Table A.4 provides estimates of the average pollutant removal efficiency of the five BMP categories.

**Table A.4 Suggested Pollutant Removal Rate for Stormwater BMPs (%)**

| Constituent | TSS | TP | TN | Metals[1] | Bacteria |
|---|---|---|---|---|---|
| **Wet Ponds** | 80 | 50 (51) | 35 (33) | 60 (62) | 70 |
| **Stormwater Wetlands** | 80[2] (76) | 50 (49) | 30 | 40 (42) | 80 (78) |
| **Filtering Practices** | 85 (86) | 60 (59) | 40 (38) | 70 (69) | 35 (37) |
| **Infiltration Practices[4]** | 90[3] (95) | 70 | 50 (51) | 90[3] (99) | 90[4] |
| **Water Quality Swales** | 85 (84) | 40 (39) | 50[5] (84) | 70 | 0 (-25)[6] |

1. Average of zinc and copper. Only zinc for infiltration
2. Many wetland practices in the database were poorly designed, and we consequently adjusted sediment removal upward.
3. It is assumed that no practice is greater than 90% efficient.
4. Data inferred from sediment removal.
5. Actual data is based on only two highly performing practices.
6. Assume 0 rather than a negative removal.

Note: Data in parentheses represent median pollutant removal data reported in the *National Pollutant Removal Database - Revised Edition* (Winer, 2000).
(Source: CWP, 2001)

These data were adjusted for convenience and to reflect biases in the data. These efficiencies represent ideal pollutant removal rates that cannot be achieved at all sites. Of particular importance is how to account for practices applied in series (e.g., two ponds applied in sequence). If the volume within the practices adds up to the total water quality volume, they are assumed to act as a single practice with that volume. Otherwise, total pollutant removal should be determined by the following equation:

$$\mathbf{R = L\ [(E_1) + (1- E_1)E_2 + (1-((E_1)+(1- E_1)E_2)E_3 + \ldots]}$$

Where: R = Pollutant Removal (lbs)
L = Annual Load from Simple Method (lbs.)
$E_i$ = Efficiency of the ith practice in a series

Another adjustment can be made to these removals to account for loss of effectiveness and irreducible concentrations. Evidence suggests that, at low concentrations, BMPs can no longer remove pollutants. Table A.5 depicts typical outflow concentrations for various BMPs. Another simplified way to account for this phenomenon is to reduce the efficiency of a second or third practice in a series. For example, the estimated removal efficiency could be cut in half to reflect inability to remove fine particles.

| **Table A.5 Typical BMP Effluent Concentrations** | | | | | |
|---|---|---|---|---|---|
| **Constituent** | **TSS** (mg/l) | **TP** (mg/l) | **TN** (mg/l) | **Cu** (ug/l) | **Zn** (ug/l) |
| **Wet Ponds** | 17 | 0.11 | 1.3 | 5.0 | 30 |
| **Wetlands** | 22 | 0.20 | 1.7 | 7.0 | 31 |
| **Filtering Practices** | 11 | 0.10 | 1.12 | 10 | 21 |
| **Infiltration Practices** | 17[1] | 0.05[1] | 3.8[1] | 4.8[1] | 39[1] |
| **Open Channel Practices** | 14 | 0.19 | 1.12 | 10 | 53 |
| 1. Data based on fewer than five data points<br>(Source: Winer, 2000) | | | | | |

**Summary of The Simple Method Calculation Procedure**

1. Calculate Pre-Development Pollutant Load
   - Use the equation L = 0.226 * R * C * A (or L = 103 * R * C * A for bacteria) to determine pre-development pollutant loading, where R = P * $P_j$ * Rv, C is determined by values in tables A.1 or A.2, and A is the area of the site. Rv is the predeveloped volumetric runoff coefficient, usually in the range of 0.1 for woods to 0.2 for meadow.
2. Calculate "Uncontrolled" Post-Development Pollutant Load
   - Use the equation L = 0.226 * R * C * A (or L = 103 * R * C * A for bacteria) to determine post-development pollutant loading without BMPs, where R = P * $P_j$ * Rv, C is determined by values in tables A.1 or A.2, and A is the area of the site. Rv is determined by Rv=0.05+0.9Ia, where values from $I_a$ may be determined by Table A.3.
3. Determine Efficiency Removal Rates of proposed BMPs
   - Use Table A.4 to obtain pollutant removal rates for the proposed BMPs. If more than one BMP is to be used in series, calculate the total effective removal rate using R = L [($E_1$) + (1- $E_1$)$E_2$ + (1-(($E_1$)+(1- $E_1$)$E_2$)$E_3$ + …]
4. Determine "Controlled" Post-Development Pollutant Load
   - Multiply the uncontrolled post-development pollutant load by the total pollutant removal rate, to obtain the amount of pollutant removed.
   - Subtract the total amount of pollutant removed from the uncontrolled post-development load, to obtain the "controlled" post-development pollutant load.
5. Compare Controlled Development Load versus Pre-Development Load
   - If the post-development controlled load is less than or equal to the pre-development load, then the proposed design complies with the prescribed loading calculation criteria. If not, the designer must revise the project design to reduce the pollutant loadings, or revise the design to include an alternate system of BMPs.

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# Appendix B: Example System of Stormwater Management Credits and Incentives

## B.1 Stormwater Credits

The current stormwater management criteria in Massachusetts provides a strong general incentive to reduce impervious cover at the site level. The storage required to meet all of the sizing criteria (water quality, recharge, 2-year, 10-year, and 100-year control) are directly related to impervious cover. Any reductions in impervious cover result in smaller required storage volumes and, consequently, smaller land consumption areas and lower construction costs. In an effort to apply a more holistic approach to stormwater management, five specific non-structural practices called *stormwater credits*, or incentives for better environmental site design, are provided for designers that will significantly reduce the size and cost of structural practices.

Non-structural practices are increasingly recognized as a critical feature of effective stormwater management, particularly with respect to site design. In most cases, non-structural practices will need to be combined with structural practices to meet stormwater requirements. The key benefit of non-structural practices is that they can reduce the generation of stormwater from the site. In addition, they can provide partial removal of many pollutants and contribute to groundwater recharge. The five proposed non-structural stormwater credits are:

Credit 1. Disconnection of Rooftop Runoff
Credit 2. Disconnection of Non-Rooftop Runoff
Credit 3. Stream Buffers
Credit 4. Grass Channels
Credit 5. Environmentally Sensitive Development

This section describes each of the credits for the five groups of non-structural practices and specifies minimum criteria to be eligible for the credit. Towns may need to update or revise some of the local subdivision regulations and/or zoning bylaws to ensure that the credit will be applicable to their jurisdiction. In addition, the Massachusetts Department of Environmental Protection (DEP) will need to validate the volume reductions in order to ensure compliance with the Massachusetts Wetlands Protection Act.

The application of these credits does not relieve the design engineer or reviewer from the standard of engineering practice associated with safe conveyance of stormwater runoff and good drainage design.

Several of the stormwater credits apply towards meeting the Massachusetts Stormwater Policy's recharge requirement. The Massachusetts Stormwater Policy currently only recognizes a volume based approach to meeting this criterion. Recently however, it has been demonstrated that disconnecting impervious area to drain over pervious areas can result in significant recharge to groundwater. Therefore, some jurisdictions (most notably the States of Vermont and Maryland) have developed recharge criterion that credit recharge based on an "area method," as opposed to strictly a volume method. To better understand this approach both the "volume method" and "area method" are described as follows.

The intent of the recharge criteria (which is often denoted as $Re_v$) is to maintain pre-developed groundwater recharge rates at development sites to preserve existing water table elevations, thereby helping to support baseflow to streams and wetlands, as well as to help augment drinking water supplies.

The objective of the criteria is to mimic the average annual recharge rate for the prevailing hydrologic soil group(s) (HSG) present at a development site. Therefore, the recharge volume can be determined as a function of annual predevelopment recharge for a given soil group, average annual rainfall volume, and amount of impervious cover at a site. Being a function of site impervious cover, the criterion provides an incentive to engineers and developers to reduce site imperviousness.

The recharge can be satisfied by one of two methods or a combination of both. The first is designated as the "**Percent Volume Method**," and is based on infiltrating the recharge volume using one or more of the approved structural practices (such as infiltration trench, infiltration basins, or drywells). The second method is designated as the "**Percent Area Method**," and is based on draining runoff from some or all of a site impervious area through one or more of the approved nonstructural practices.

Based on this approach, the **Percent Volume Method** is as follows:

$Re_v = (F)(A)(I)/12$

Where:
- $Re_v$ = Recharge volume (acre-feet)
- F = Recharge factor (in inches, see below)
- A = Site area (in acres)
- I = Site imperviousness (expressed as a decimal)

| Hydrologic Soil Group | Recharge Factor (F) |
|---|---|
| A | 0.40 |
| B | 0.25 |
| C | 0.10 |
| D | waived |

An example calculation of this method is provided below.

> *Example*: A 50-acre site is to be developed as a residential subdivision near Burlington, MA. The impervious area for the development will be 20 acres (i.e., 40% imperviousness). Half of the impervious area overlays HSG "B" soils and half of the impervious area overlays HSG "C" soils. The recharge requirement would be calculated as follows:
>
> Compute a weighted F = [(0.25 in)(10 ac) + (0.10 in)(10 ac)]/20 ac = 0.175 inches
> $Re_v$ = (0.175 in) (50 ac) (0.4)/(12 in/ft) = 0.29 ac-ft

Under the **Percent Area Approach**, the recharge requirement can be met by draining a calculated recharge area through one or more of several nonstructural approaches (this is where stormwater credits are most applicable). The calculation is as follows:

$Re_a = (F)(A)(I)$

Where: $Re_a$ = Recharge area requiring treatment (acres)
F = Recharge factor based on HSG (same values as above, but dimensionless)
A = Site area in acres
I = Site imperviousness (expressed as a decimal)

The required recharge area ($Re_a$) is equivalent to the recharge volume and can be achieved by a non-structural practice (e.g., filtration of sheet flow from disconnected impervious surfaces). In addition, a combination of both of the methods can be used to meet the recharge requirement at a site.

If an applicant elects to utilize both the Percent Volume and Percent Area Methods to meet the recharge requirement, the following applies:

1. Calculate both the $Re_v$ and $Re_a$ for the site.
2. The site impervious area draining to an approved nonstructural practice is subtracted from the $Re_a$ calculation from step 1, above;
3. The remaining $Re_a$ is divided by the original $Re_a$ to calculate a pro-rated percentage that needs to be met by the Percent Volume Method;
4. The pro-rated percent is multiplied by the original $Re_v$ to calculate a new $Re_v$ that must be met by an approved structural practice(s)

With this basic understanding of how the recharge requirement can be met on a project, it is now appropriate to review the suite of stormwater credits that can meet both recharge, water quality and, in a few cases, some of the water quantity controls as well.

## B.2 Credit No. 1: Disconnection of Rooftop Runoff Credit

A credit is given when rooftop runoff is "disconnected" and then directed over to a pervious area where it can either infiltrate into the soil or flow over it with sufficient time and velocity to allow for filtering. The credit is typically obtained by grading the site to promote overland flow through vegetated channels or by providing bioretention[1] areas either on-lot or in common areas.

If a rooftop is adequately disconnected, the disconnected impervious area can be deducted from total impervious cover, therefore reducing water quality volume requirements. In addition, disconnected rooftops can be used to meet the recharge requirement as a non-structural practice under the **Percent Area Method**.

*Restrictions on the Credit*

The rooftop disconnection credit is subject to the following restrictions:

- Disconnection must be designed to adequately address the issue of basement seepage;
- The contributing length of rooftop to a discharge location shall be 75 feet or less;
- The rooftop contributing area to any one discharge location cannot exceed 1,000 $ft^{2;}$
- The length of the "disconnection" shall be equal to or greater than the contributing rooftop length;
- Disconnections will only be credited for residential lot sizes greater than 6,000 sq. ft;
- The entire vegetative "disconnection" shall be on a slope less than or equal to 5.0%;
- Where provided, downspouts must be at least 10 feet away from the nearest impervious surface to discourage re-connection to the drainage network;
- Where a gutter/downspout system is not used, the rooftop runoff must drain as either sheetflow from the structure or drain to a subsurface drain field that is not directly connected to the drainage network;
- Disconnections are encouraged on relatively permeable soils (HSGs A and B); therefore, no soil evaluation is required;
- In less permeable soils (HSGs C and D), the water table depth and permeability shall be evaluated by a professional engineer to determine if a spreading device is needed to provide sheetflow over grass surfaces. In some cases, dry wells (see Figure B.1), french drains or other temporary underground storage devices may be needed to compensate for a poor infiltration capability;
- For those rooftops draining directly to a stream buffer, one can only use either the rooftop disconnection credit or the stream buffer credit (Credit 3), not both; and
- To take credit for rooftop disconnection for a designated hotspot land use, the rooftop runoff must not co-mingle with runoff from any paved surfaces.

[1] Bioretention systems (also referred to as "rain gardens" or "biofilters") are so-called low impact development stormwater management systems that manage and treat stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The method combines physical filtering and adsorption with bio-geochemical processes to remove pollutants. The system consists of an inflow component, a pretreatment element, an overflow structure, a shallow ponding area (less than 9" deep), a surface organic layer of mulch, a planting soil bed, plant materials, and an underdrain system to convey treated runoff to a downstream facility.

An example of this credit is provided below.

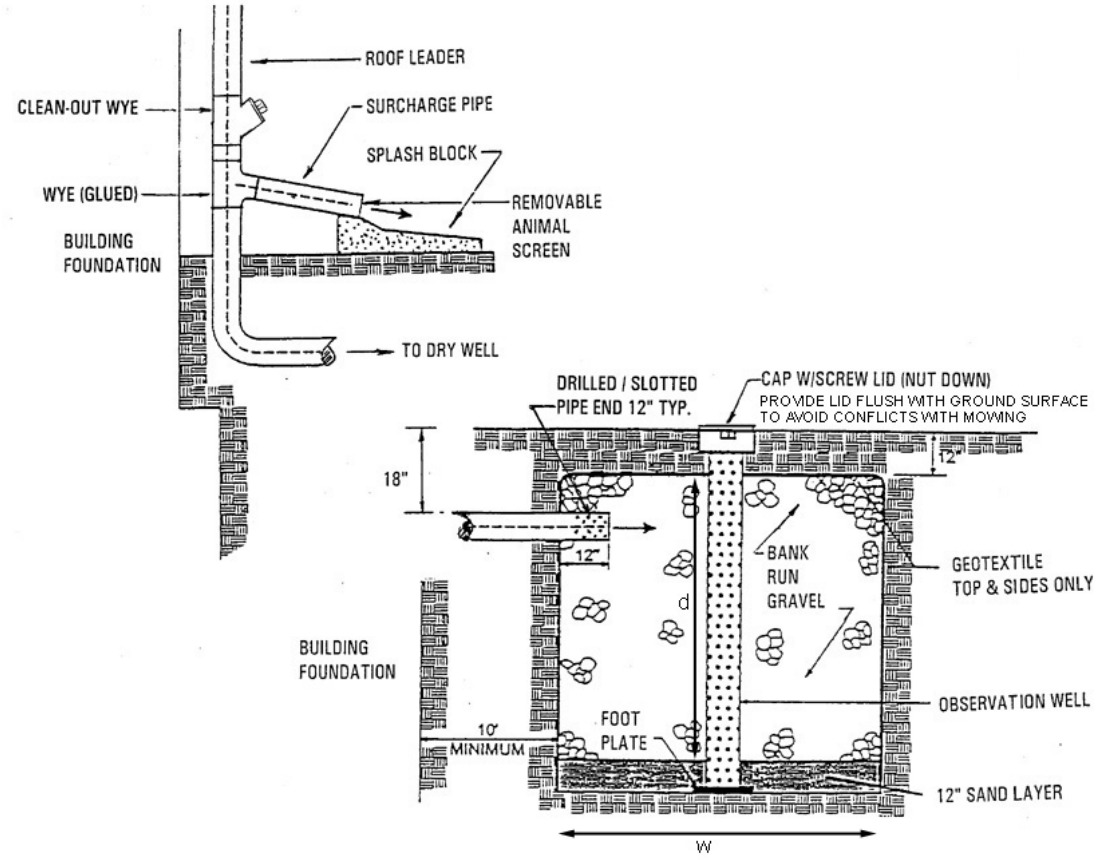



**Figure B.1 Schematic of Dry Well (Source: adapted after Howard County, MD)**

## Rooftop Disconnection Credit Example Application

Given the following base data:
Site Data: 108 Single Family Residential Lots (~ ½ acre lots)
Site Area = 45.1 ac
Original Impervious Area = 12.0 ac;
Site Soils Types: 78% "C", 22% "D"
Composite Recharge Factor, F = 0.08
Original $Re_v$ = 0.08 acre-feet; $Re_a$ = 0.96 acres
Original water quality requirement = 1.0"/impervious acre = 1.0"(12.0 ac)/12 = 1.0 acre-foot
(site is located in a critical area)

Rooftop Credit (see Figure B.2)
42 houses disconnected
Average house area = 2,500 $ft^2$
Net impervious area reduction = (42)(2,500 $ft^2$) / (43,560 $ft^2$/ac) = 2.41 acres
New impervious area = 12.0 – 2.41 = 9.59 acres;

**Required recharge ($Re_a$) is 0.96 acres and 2.41 acres were disconnected thereby meeting 100% of the recharge requirement.**

New water quality volume = 1.0" (9.59)/12 = 0.80 acre-feet; or a 0.20 acre-foot reduction

**Percent Reductions Using Rooftop Disconnection Credit:**

- $Re_v$ = 100%
- Water quality = (1.0 – 0.8) / 1.0 = 20.0%

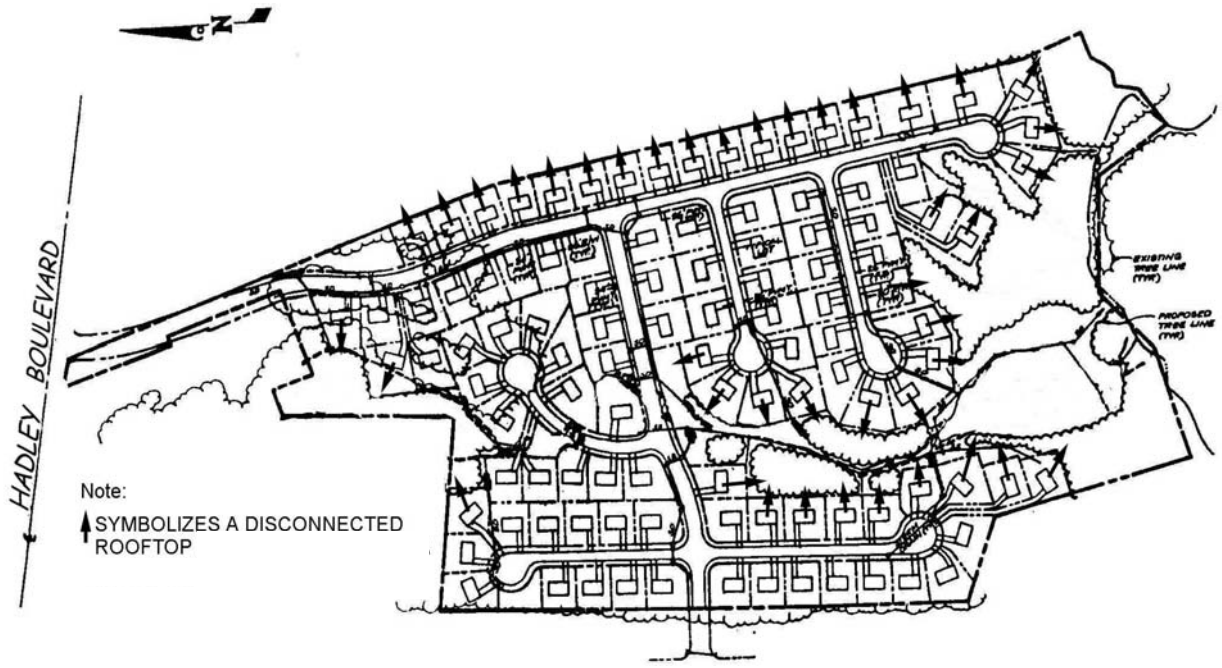



**Figure B.2 Schematic of Rooftop Disconnection Credit**

## B.3 Credit No 2: Disconnection of Non-Rooftop Runoff Credit

Credit is given for practices that disconnect surface impervious cover runoff by directing it to pervious areas where it is either infiltrated into the soil or filtered (by overland flow). This credit can be obtained by grading the site to promote overland vegetative filtering.

These "disconnected" areas can be subtracted from the site impervious area when computing the water quality treatment volume. In addition, disconnected surface impervious cover can be used to meet the recharge requirement as a non-structural practice under the **Percent Area Method**.

*Restrictions on the Credit*

The credit is subject to the following restrictions:

- The maximum contributing impervious flow path length shall be 75 feet;
- Runoff cannot come from a designated hotspot land use;
- The length of the "disconnection" must be equal to or greater than the contributing length;
- The entire vegetative "disconnection" shall be on a slope less than or equal to 5.0%;
- The surface impervious area to any one discharge location cannot exceed 1,000 $ft^2$;
- Disconnections are encouraged on relatively permeable soils (HSGs A and B); therefore, no soil evaluation is required;
- In less permeable soils (HSGs C and D), the water table depth and permeability shall be evaluated by a professional engineer to determine if a spreading device such as a french drain, gravel trench or other temporary storage device is needed to compensate for poor infiltration capability; and
- For those areas draining directly to a buffer, only the non-rooftop disconnection credit or the stream buffer credit can be used, not both;

See Section B.8 for an example application of this credit draining to a filter strip.

## B.4 Credit No. 3: Stream Buffer Credit

This credit is given when stormwater runoff is effectively treated by a stream buffer. Effective treatment constitutes capturing runoff from pervious and impervious areas adjacent to a stream buffer and treating runoff through the overland flow in a natural vegetative or forested buffer. The use of a filter strip is also recommended to treat overland flow in the green space of a development site (see Figure B.3). The credits include:

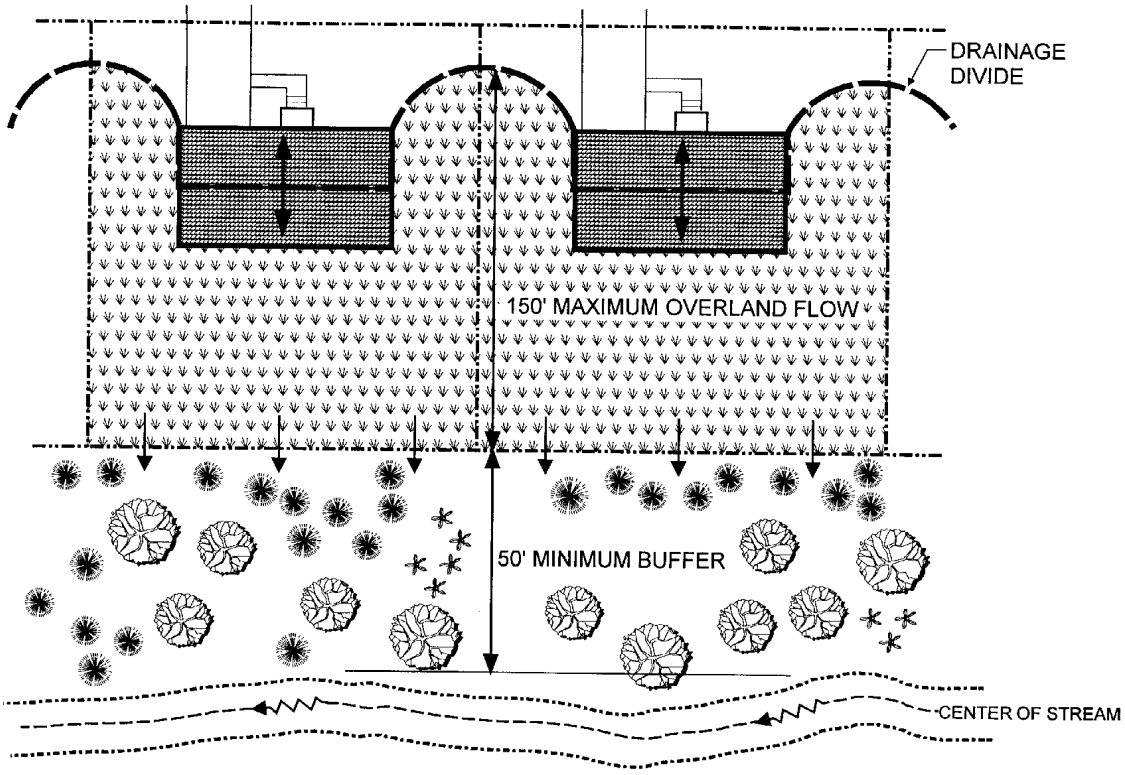
- The impervious area draining by sheet flow to a stream buffer is subtracted from the site's initial impervious area in the water quality calculation.
- The impervious area draining to stream buffer contributes to the recharge requirement, ($Re_v$), under the **Percent Area Method**.

*Restrictions on the Credit*

The credit is subject to the following conditions:

- The minimum stream buffer width (i.e., perpendicular to the stream flow path) shall be 50 feet as measured from the bank elevation of a stream or the boundary of a wetland;
- The maximum contributing path shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces;
- The average contributing overland slope to and across the stream buffer shall be less than or equal to 5.0%;
- Runoff shall enter the stream buffer as sheet flow. A level spreading device shall be utilized where local site conditions prevent sheet flow from being maintained;
- The credit is not applicable if rooftop or non-rooftop disconnection is already provided (i.e., no double counting); and
- Stream buffers shall remain ungraded and uncompacted, and the over-story and under-story vegetation shall be maintained in a natural condition;

See Section B.8 for an example application of this credit.



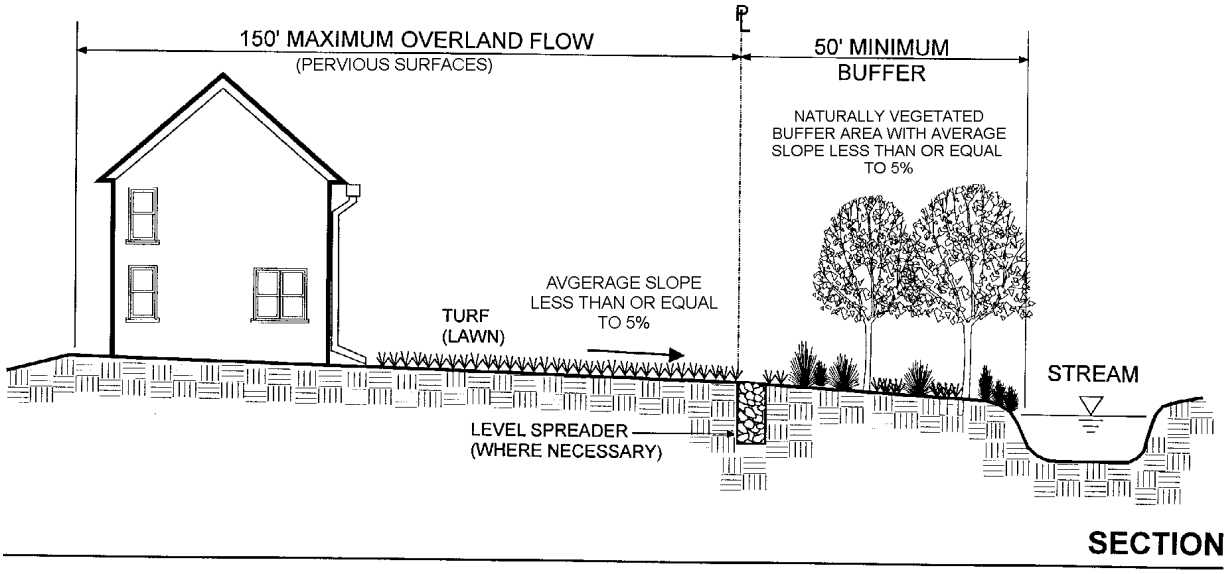




**Figure B.3 Example of Stream Buffer Credit Option**

## B.5 Credit No. 4: Grass Channel Credit

Credit may be given when open grass channels are used to reduce the volume of runoff and pollutants during smaller storms (i.e., 1.0 inches and less).

Use of a grass channel will automatically meet the minimum recharge $Re_v$ requirement (under the **Percent Area Method**) regardless of the geometry or slope. If designed according to the following design criteria, the grass channel will meet the water quality treatment requirements for certain kinds of residential development.

Note: Runoff curve numbers (CNs) for 2-year, 10-year, and 100-year control will not change.

*Grass Channel Design Criteria*

The credit is obtained if a grass channel meets the following criteria.

- Land use is moderate to low density residential (maximum density of 4 du/ac);
- The bottom width shall be 2 foot minimum and 6 foot maximum (if a larger channel is needed, a compound cross section may be used);
- The side slopes shall be 3H:1V or flatter;
- The channel slope shall be less than or equal to 4.0%; and
- The length of the grass channel shall be equal to the roadway length.

### Grass Channel Credit Example Application

Base Data
Site Data: 108 Single Family Residential Lots (~ ½ acre lots)
Site Area = 45.1 ac
Original Impervious Area = 12.0 ac; or I = 12.0/45.1 = 26.6%
Site Soils Types: 78% "C", 22% "D"
Composite F = 0.08
Original $Re_v$ = 0.08 acre-feet; $Re_a$ = 0.96 acres
Original $WQ_v$ = 1.0 acre-feet

Grass Channel Credit (see Figure B.4)
Entire site is open section road, but only 11.2 acres meet the water quality requirement design criteria for the grass channel credit (i.e., 3:1 sideslopes, 2 foot bottom width and slope less than or equal to 4%).

**Required recharge ($Re_a$) is 0.96 acres and the full site is drained by grass channels, thereby meeting 100% of the recharge requirement.**

New water quality Area = (45.1 – 11.2) = 33.9 acres, assume new impervious cover = 0.266(33.9 ac) = 9.0 acres.
New $WQ_v$ = 1.0"(9.0)/12 = 0.75 acre-feet; or a 0.25 acre-foot reduction

**Percent Reductions Using Grass Channel Credit:**

- $Re_v$ = 100%
- $WQ_v$ = (1.0 – 0.75) / 1.0 = 25.0%

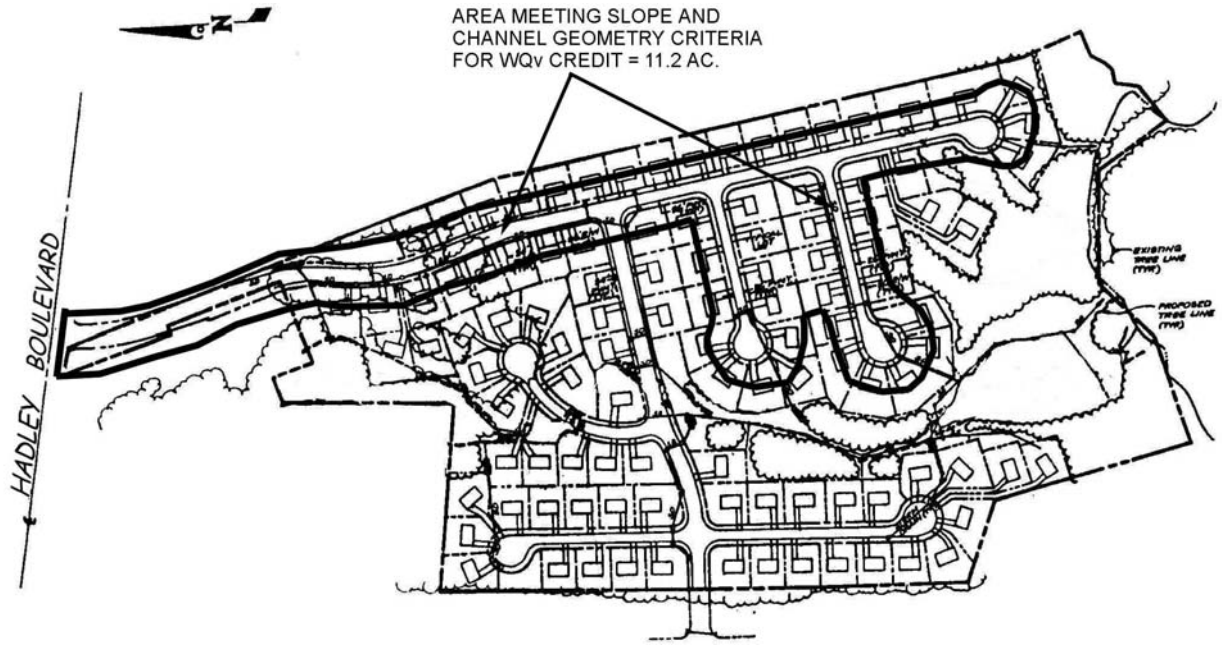



**Figure B.4 Schematic of Grass Channel Credit**

## B.6 Credit No. 5: Environmentally Sensitive Development Credit

This credit is given when a group of environmental site design techniques are applied to lower density or rural residential development. The credit eliminates the need for structural practices to treat both the $Re_v$ and water quality and can reduce required volumes for peak control of the 2-year, 10-year and 100-year storms.

*Minimum Criteria for Credit*

The $Re_v$ and water quality requirements are completely met without the use of structural practices in certain low density (less than 1 dwelling unit per acre) residential developments when the following conditions are met:

- The total impervious cover footprint is less than 15 % of lot area;
- A minimum of 25% of the site is protected in natural conservation areas.
- Rooftop runoff is disconnected in accordance with the criteria outlined under Credit 1 (Section B.2);
- Grass channels are used to convey runoff versus curb and gutter for roads and/or driveways (with no specific constraints on water quality volume, velocity or minimum retention time); and
- Stream buffers are incorporated into the site design on both perennial and intermittent streams (where applicable).

The designer must still address applicable stormwater detention for all roadway and connected impervious surfaces (i.e, 2-year, 10-year, and 100-year control).

## Environmentally Sensitive Rural Development Credit Example Application

Base Data
Site Data: a single family lot that is part of an 8 acre low density subdivision in a critical area
Lot Area = 2.5 ac
Conservation Area = 0.65 ac
Impervious Area = .35 ac = 14%
Site Soils Types: 100% "B"
F = 0.25
Original water quality volume = 1.0" (.35) (43,560/12) = 1,270.5 $ft^3$
Original $Re_v$ = (2.5) (0.08) (.25) (43,560/12) = 182 $ft^3$

Environmentally Sensitive Rural Credit (see Figure B.5)
**Required recharge is considered met by site design.**
**Required water quality volume is considered met by site design.**
2-year, 10-year & 100-year control: No change in CN, $t_c$ may be longer which would reduce storage requirements.

**Percent Reductions Using Environmentally Sensitive Rural Credit:**

- $Re_v$ = 100%
- Water quality requirment = 100%

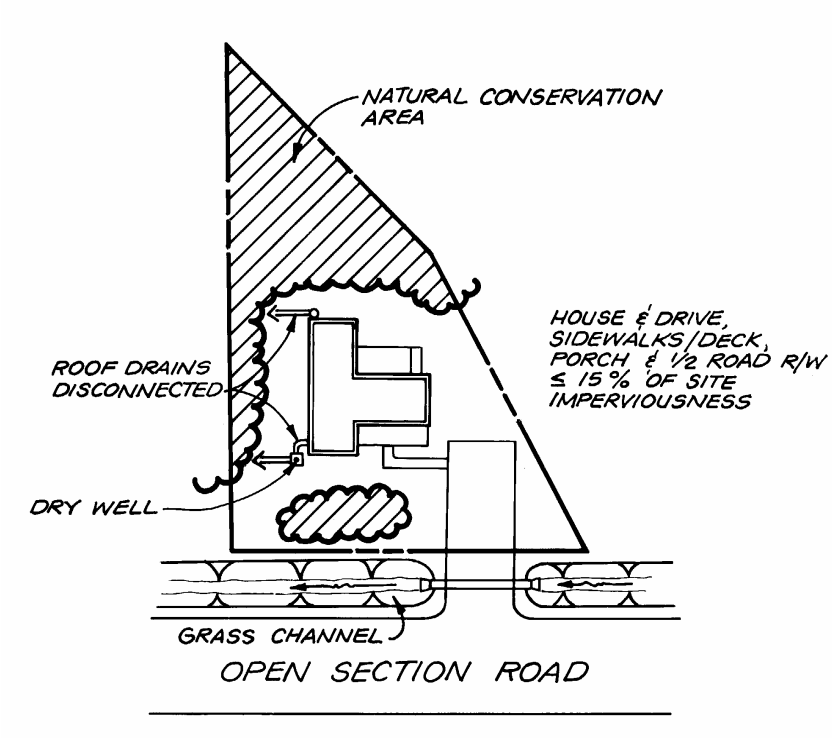



**Figure B.5 Schematic of Environmentally Sensitive Rural Development Credit**

## B.7 Dealing with Multiple Credits

Site designers are encouraged to utilize as many credits as they can on a site. Greater reductions in stormwater storage volumes can be achieved when many credits are combined together (e.g. disconnecting rooftops and utilizing grass channel for drainage design). However, credits cannot be claimed twice for an identical area of the site (e.g. claiming credit for stream buffers and disconnecting rooftops over the same site area, draining to the same location).

## B.8 Other Strategies to Reduce Impervious Cover

Site planning practices that reduce the creation of impervious area in new residential and commercial developments and therefore reduce the water quality requirements for the site should be encouraged whenever feasible[2]. Examples of progressive site design practices that minimize the creation of impervious cover include:

- Narrower residential road sections;
- Shorter road lengths;
- Smaller turnarounds and cul-de-sac radii;
- Permeable spill-over parking areas (these areas should be valued as 50% impervious, unless designed specifically for infiltration);
- Smaller parking demand ratios;
- Smaller parking stalls for a percentage of lots;
- Angled one way parking;
- Cluster subdivisions;
- Smaller front yard setbacks;
- Shared parking and driveways; and
- More creatively designed pedestrian networks.

Where these techniques are employed, it may be possible to reduce stormwater storage volumes. For example, since the water quality treatment volume is directly based on impervious cover, a reduction in impervious cover reduces required storage. For 2-year, 10-year, and 100-year management, the designer can compute curve numbers (CNs) based on the actual measured impervious area at a site using the following equation (adopted from TR-55, 1986):

$$(98)\ I + (CN)\ P = CN$$

where: I = percent impervious area at the site
P = percent pervious area at the site
CN = curve number for the appropriate pervious cover

[2] The reader is referred to the following two references for a more detailed presentation of better site design and low impact development: 1) Center for Watershed Protection. 1998. *Better Site Design A Handbook for Changing Development Rules in Your Community*. Ellicott City, MD; and 2) Prince George's County MD Dept. of Environmental Resources. 1999. *Low Impact Development Design Strategies: An Integrated Design Approach.* Largo, MD.

Figures B.6 and B.7 show an example of a retail site designed as a conventional development, and as a site planned using improved site design practices and techniques, respectively. Some of the noteworthy features of the innovative site plan include: preservation of some forested areas, establishment of a stream buffer, reduced parking ratios, compact and pervious overflow parking spaces, and use of vegetated stormwater practices such as filter strips and bioretention areas.

Though not all land use types and developments are amenable to every approach described here, there are more opportunities for flexibility and creativity in site design than many realize. Redevelopment sites also can utilize several of these practices and techniques in the redesign of an area.

The following example (using Figures B.6 and B.7) quantifies the water quality and recharge requirement reductions that can be realized by implementing several of these practices and design techniques.

Base Data (see Figure B.6)
Site Area = 9.3 ac
Original Impervious Area = 6.5 ac; or I = 6.5/9.3 = 69.9%
Site Soils Types: 50% "B", 50% "C," split evenly over the impervious area
Composite F = [0.25 (6.5/2) + 0.10 (6.5/2)]/6.5 = 0.18
Original $Re_v$ = 0.18 (6.5)/12 = 0.10 acre-feet
Original Water Quality Requirement = 1.0"(6.5 ac)/12 = 0.54 acre-feet

Site Planning Strategies (see Figure B.7)
The revised site incorporates the following features:

- 1.8 acres preserved in a conservation easement.
- 0.46 acres of parking lot drain to a buffer with an overland flow path less than 75 feet (Credit No. 3: stream buffer credit).
- 0.28 acres of parking lot/loading area drain to a filter strip with an overland flow path less than 75 feet (Credit No. 2: disconnection of non-rooftop runoff credit).
- The total site impervious area was reduced from 6.3 acres to 5.8 acres by the site design revision; the new site I = 5.8/9.3 = 62.4%.

The new storage requirements for $Re_v$:

- New composite F = [0.25 (5.8 ac/2) + 0.10 (5.8 ac/2)]/5.8 = 0.18
- New $Re_v$ (**Percent Volume Method**) = 0.18 (5.8 ac)/12 = 0.09 acre-feet
- New $Re_a$ (**Percent Area Method**) = FAI = 0.18 (9.3 ac)(.624) = 1.04 acres
- Using the **Percent Area Method** and noting that 0.46 acres drain to the buffer and 0.28 acres drain to a filter strip, then $Re_a$ = 1.04 ac – (0.46 ac + 0.28 ac) = 0.3 acres
- Therefore, the remaining $Re_v$ = (0.3 ac/1.04 ac) (0.09 ac-ft) = 0.02 acre-feet

**0.02 acre-feet must be managed by an approved "structural" practice.**

The new storage requirement for water quality control is:

- New Impervious Area (to take credit for non-rooftop disconnection and buffer credits) = 5.8 ac – (0.28 ac + 0.46 ac) = 5.06 acres;
- New water quality requirement = 1.0”(5.06 ac)/12 = 0.42 acre-feet; or a 0.12 acre-foot reduction

**Percent Reductions Using Site Planning Strategies:**

- $Re_v = (0.10 – 0.02) / 0.10 = 80.0\%$
- $WQ_v = (0.54 – 0.42) / 0.54 = 22.0\%$

Also, with a 0.5-acre net reduction in site imperviousness, the CN for computing the 2-year, 10-year and 100-year control will be lower, thereby reducing the storage requirements for these storms by a modest amount.

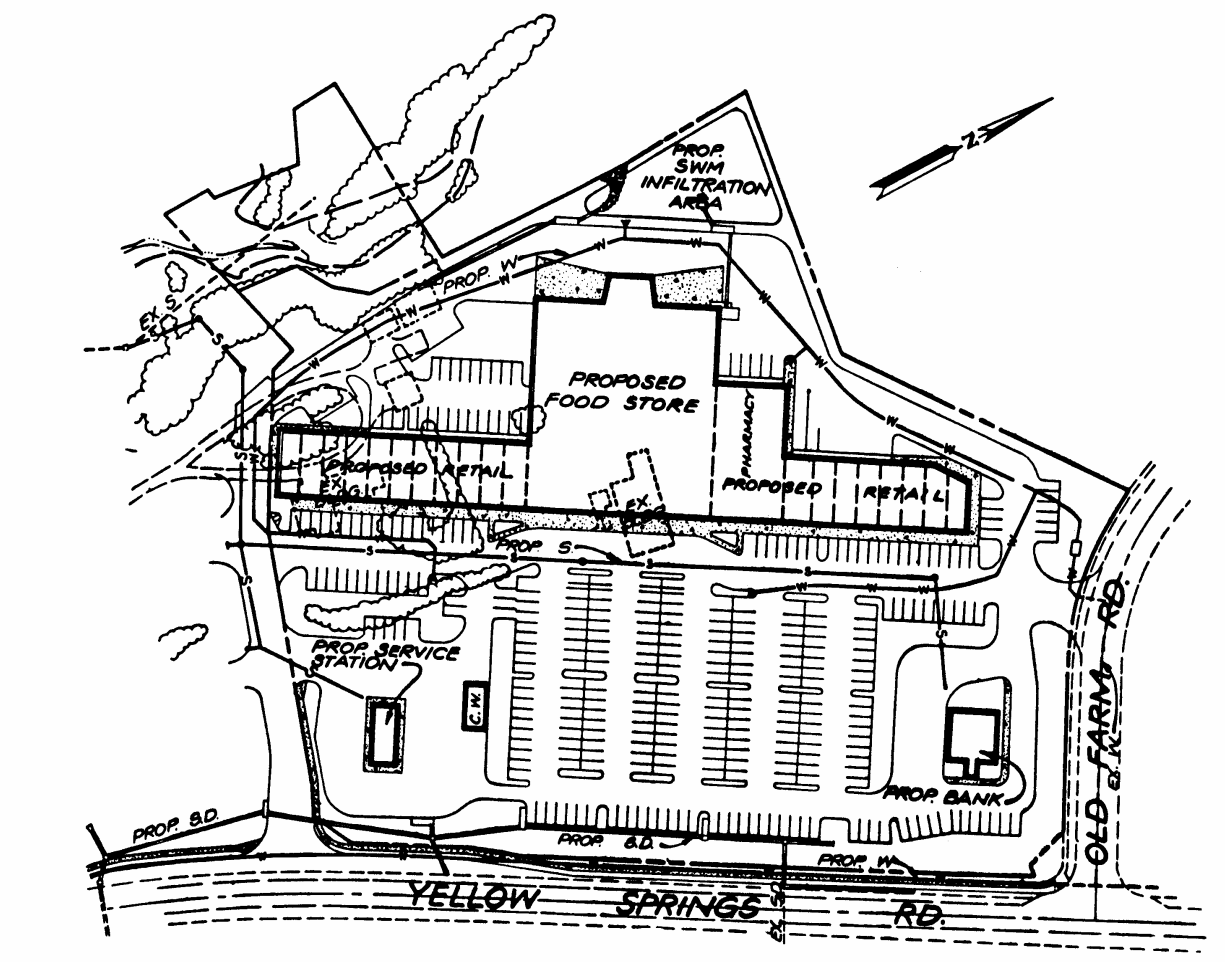



**Figure B.6 Example of Conventional Retail Site Design**

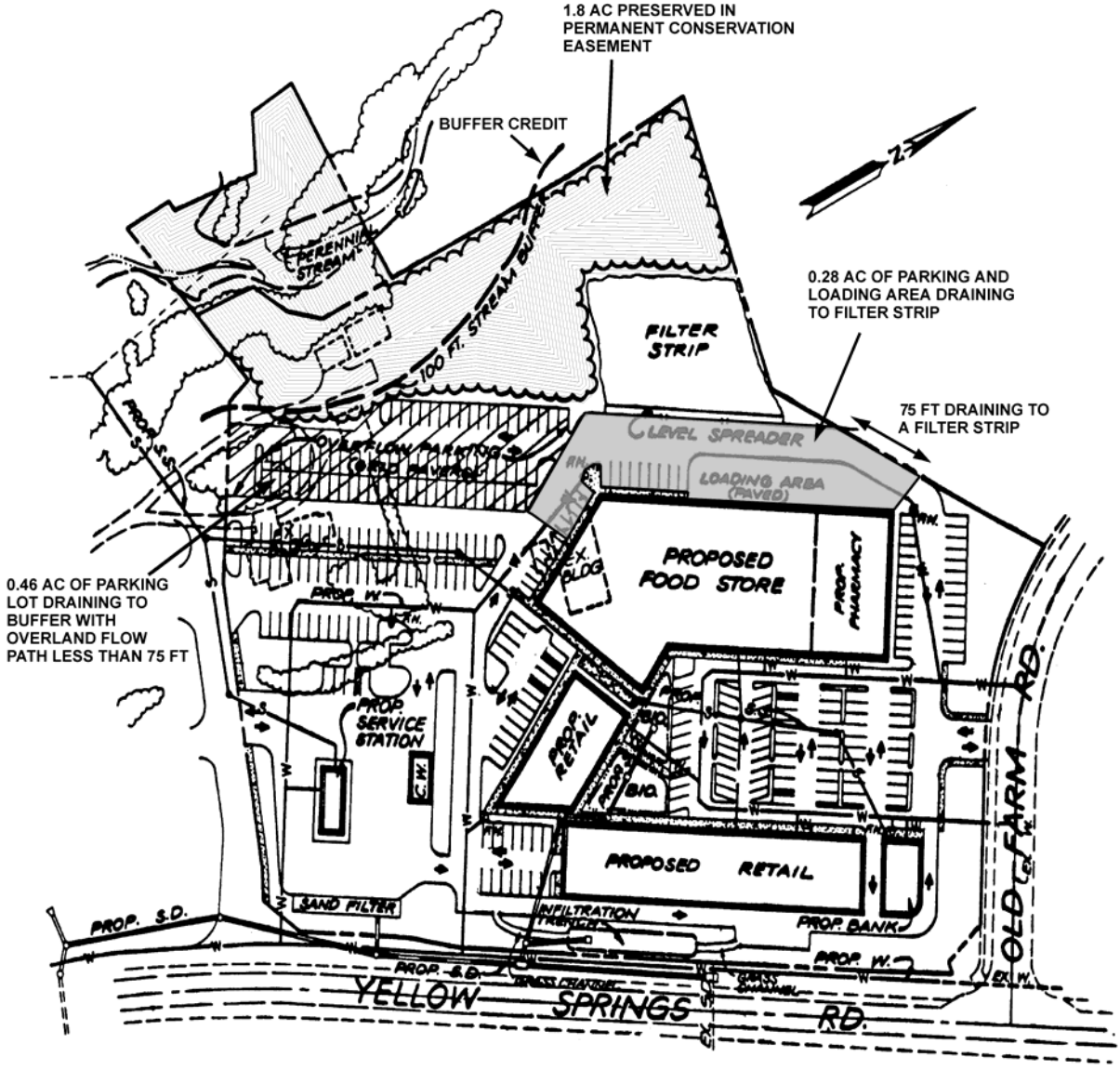



**Figure B.7 Example of Improved Retail Site Design**