TECHNICAL MEMORANDUM

TO: **Boylston Stormwater and LID Bylaw Working Group**

FROM: Woodard & Curran, Inc.

DATE: March 13, 2006

RE: Stormwater and LID Bylaw– Research Findings

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1. INTRODUCTION

As the first step in creating a comprehensive stormwater management bylaw for the Town of Boylston, Woodard & Curran (W&C) researched stormwater and low impact development (LID) related bylaws, ordinances, and regulations currently in use in other communities in Massachusetts and applicable regional and national examples. LID is an innovative approach to stormwater management in which stormwater management practices seek to mimic the natural hydrologic regime. These examples will be used in developing language for Boylston's Bylaw. This Technical Memorandum presents a summary of our research findings.

W&C compiled a library of model bylaws/ordinances, actual stormwater bylaws/ordinances, regulations, and guidance manuals developed at various local, regional, and state levels. Ms. Andrea Cooper, Massachusetts Smart Growth Coordinator, provided an extensive library of LID information; power point presentations, websites, guidance documents, etc. In the interest of time and limited resources, W&C chose to review in detail examples most applicable to the Town of Boylston. In particular, examples were selected that addressed stormwater management in a rural environment and legal considerations in the Commonwealth of Massachusetts.

The scope of the analysis included criteria for erosion & sediment controls during construction, post-construction stormwater controls in new development and redevelopment, and prohibition of illicit discharges. The components researched for Boylston's Bylaw include; administrative/procedural format, water quantity criteria, water quality criteria, recharge criteria, site development criteria, approved practices, redevelopment, and other elements such as stormwater credits and fees.

The following documents were reviewed:

Guidance Material

- Center for Watershed Protection. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. 1998.
- Massachusetts Attorney General. *Adoption of Local Stormwater Bylaws*.
- Massachusetts Stormwater Management Policy. March 1997.
- Prince George's County, Maryland Department of Environmental Resources. *Low Impact Development (LID) Integrated Management Practices Guidebook*. January 2002.

- City of Salem, MA. *Urban Stormwater Management Guidebook*. December 31, 2005.

Bylaws/Ordinances/Regulations

- Executive Office of Environmental affairs (EOEA). Massachusetts Smart Growth Toolkit. Model Low Impact Development (LID) Bylaw.
- Massachusetts Attorney General. Stormwater Management and Land Disturbance Bylaw.
- Massachusetts Attorney General. Bylaw Governing Post-construction Stormwater Managemenr of New Developments and Redevelopments.
- Massachusetts Attorney General. Bylaw Governing Discharges to the Municipal Storm Drain System.
- City of Salem, MA. Stormwater & Low Impact Development Ordinance. December 31, 2005.
- City of Salem, MA. Stormwater & Low Impact Development Regulations. December 31, 2005.

2. ADMINISTRATIVE / PROCEDURAL CONSIDERATIONS

2.1 DOCUMENT TYPE

In the Town of Boylston, stormwater will be regulated through a *bylaw* and *regulations*, defined as:

- *Bylaw* – Town Law that must be adopted at Town Meeting. A bylaw may include detailed specific criteria or may have a general description that gives authority to implementing regulations and reference to a design manual.
- *Regulations* – Typically presents detailed specific criteria of required stormwater management elements. May also give authority by a reference to a technical design manual.

Once Boylston's Bylaw and Regulations are adopted, the following manuals can provide additional guidance to residents, developers, and designers.

- *Design Manual* – A detailed design manual with performance criteria, technical specifications and design requirements.
- *Guidance Manual* – May be similar to a design manual, but provides guidance and is not necessarily regulated.

2.2 COMPONENTS OF A BYLAW

The format for a Stormwater Bylaw may consist of some or all of the following elements, based on W&C review of sample/model bylaws and ordinances:

1. ***General Provisions***, including:
    1. **Background/Findings** – This section briefly establishes the environmental, economic, social, and legal justification for the adoption of a stormwater management bylaw;
    2. **Purpose and Intent** – This section describes the purpose of the bylaw and lists a general set of objectives to reduce the impact of stormwater on receiving waters;
    3. **Authority** – This section describes the authority under which the bylaw is adopted and defines the regulating agency or municipal department responsible for implementing the bylaw;

4. **Applicability** – This section describes the thresholds and exemptions for the stormwater management bylaw (such as, size of the site development that will trigger the bylaw);
5. **Administration** – Describes the specific requirements under which the bylaw will be administered, implemented, and enforced;
6. **Compatibility** – Brief statement describing that the bylaw will not interfere with other bylaws, rules or regulations, statures, or other provision of law;
7. **Severability** – This is a disclaimer that allows that if any provision, paragraph, sentence, or clause of the bylaw is rendered invalid for any reason, all other provisions shall continue in full force and effect; and
8. **Development of a Stormwater Design Manual** – This furnishes additional policy, criteria and information, including specifications and standards, for the proper implementation of the requirements of the bylaw. Creating this Manual is preferable to fully describing design requirements in the bylaw as it allows changes over time without requiring the formal process needed to change bylaw language.

2. ***Definitions*** – Defines key words found throughout the bylaw that establish the official legal meaning of such words.
3. ***Permit Procedures*** **–** Describes the stormwater management program permit procedures and application requirements.
4. ***Waivers*** – This section describes the process and conditions by which an applicant may request to waive the stormwater management plan requirements.
5. ***General Performance Criteria*** – Describes the performance criteria that must be addressed for stormwater management, including water quantity, water quality, and/or recharge requirements.
6. ***Requirements for Stormwater Management Plan Review and Approval*** – This section describes the required content of the stormwater management plan, which is required with all permit applications.
7. ***Construction Inspection*** – This section describes the inspection provisions and provides site entry rights for the municipality for the proposed development to ensure proper construction of the facility under the approved stormwater management plan.
8. ***Operation and Maintenance Plan*** – This section contains information on the operation and maintenance submittal and compliance requirements of the proposed stormwater controls. This section also contains provisions for the site entry and inspection of stormwater facilities.
9. ***Surety*** – This section describes the monetary legal arrangements prior to issuance of a permit to insure that the stormwater practices are installed by the permit holder, as required by the approved stormwater management plan.
10. ***Certificate of Completion*** – This section describes the requirements for issuance of a Certificate of Completion upon receipt and approval of the final reports, computations, and/or as-built plans to establish that all the work of the permit has been satisfactorily completed in conformance with the bylaw.

11. ***Enforcement and Penalties*** – This section defines the legal enforcement provisions of the bylaw and documents how the municipality may pursue civil and criminal penalties for any violation of the bylaw.

2.3 LOCAL GOVERNING AUTHORITY

Stormwater Management is regulated in Massachusetts by both the U.S. Environmental Protection Agency (EPA) through the Clean Water Act and the Massachusetts Department of Environmental Protection (DEP) through the Wetlands Protection Act. Locally, stormwater can be regulated by a variety of municipal entities, such as:

- Planning Board;
- Engineering Department;
- Board of Health;
- Conservation Commission;
- Department of Public Works; and/or
- Other municipal departments.

Many existing stormwater bylaws and ordinances give the governing authority to the Conservation Commission (such as Dedham, MA and Fitchburg, MA).

2.4 APPLICABILITY

We found a number of thresholds and exemptions in the stormwater bylaws and ordinances reviewed. Thresholds are generally defined as activities that trigger the bylaw. Exemptions describe circumstances whereby the ordinance does not apply. The Stormwater and LID Bylaw Working Group should carefully choose thresholds and exemptions that are appropriate for Boylston. The selection of a threshold usually involves a balance between resource protection and permit burden and must be carefully evaluated by a municipality considering available staff resources, cost, and natural resource sensitivity. The following are examples of thresholds and exemptions used in the example ordinances reviewed.

Example Thresholds:

- All activities that result in disturbance of one or more acres of land that drains to the municipal separate storm sewer system. (AG)
- 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 a parcel of land, or any activity that will alter the drainage characteristics of a parcel of land, unless exempt pursuant to Section 3B 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 LID Permit.

  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 LID Permit. (Smart Growth Toolkit)

- This Ordinance shall be applicable to the following activities (Salem):
    1. All new development and redevelopment projects, including, but not limited to, any activities requiring a Site Plan application, Subdivision application, land use conversion application;
    2. Any activity that will result in an increased amount of stormwater runoff or pollutants flowing from a parcel of land;
    3. Any land alterations, including, but not limited to, any excavation, paving, curb cutting permit, street opening permit, or any activity that will alter the drainage characteristics of a parcel of land which includes grade changes of 2 feet or greater, unless exempt pursuant to Section 5.B of this Ordinance;
    4. Any increase in impervious area on a parcel of land that is currently greater than or equal to 15% impervious cover, or that will have a total of 15% impervious cover or greater due to the proposed project; and/or
    5. An alteration, redevelopment, or conversion of land use to a hotspot, as defined in Section 4.0 of this Ordinance, shall require a Stormwater & LID Permit.

Example Exemptions:

- 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 [*5,000*] square feet."
- Normal maintenance and improvement of land in agricultural use as defined by the Wetlands Protection Act regulations 310 CMR 10.4. **(required)**
- Maintenance of existing landscaping, gardens or lawn areas associated with a single family dwelling;
- Repair or replacement of an existing roof of a single-family dwelling;
- The construction of any fence that will not alter existing terrain or drainage patterns;
- Construction of utilities (gas, water, electric, telephone, etc.) other than drainage, which will not alter terrain, ground cover, or drainage patterns;
- Emergency repairs to any Stormwater Management facility or practice that poses a threat to public health or safety, or as deemed necessary by the [*LID Authority*];
- Any work or projects for which all necessary approvals and permits have been issued before the effective date of this Bylaw;
- Redevelopment projects are presumed to meet the specified LID requirements described in the LID Bylaw 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, LID 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 LID practice implementation is used for redevelopment projects, the combination of impervious area reduction and the area controlled by a LID practice shall equal or exceed [*40%*].

Other Example Provisions:

- Certain projects may meet the requirements for a Minor Impact Permit (MIP). The requirements for MIPs are specifically defined as part of the Stormwater & LID Regulations promulgated as result of this Ordinance. The Stormwater Authority or his/her authorized agent(s) shall have the authority to issue a MIP if the proposed project meets the requirements set forth in the Stormwater & LID Regulations (Salem).

3. WATER QUALTIY & QUANTITY CRITERIA

Since the Massachusetts Stormwater Management Policy is currently under review and will soon be reissued with improvements, W&C recommend referring to the most current version of this Policy and the accompanying Policy and Technical *Handbooks* to define water quality and water quantity criteria, such as design storms and recharge requirements.

Pollutants typically found in stormwater runoff can be regulated. For example, the following language was used in the City of Salem Stormwater & LID Regulations:

Structural best management practices (BMPs) must be designed to remove 80% of the average annual post-development total suspended solids (TSS) and 40% of total phosphorus (TP), and 30% of 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 design and performance criteria outlined in the Salem's Urban Stormwater Management Guidebook and the Massachusetts Stormwater Management Handbooks;
iii) Constructed properly, as approved by the Strormwater Authority; and
iv) Maintained in accordance with the O&M Plan approved by the Stormwater Authority.

Two basics methods are used to ensure that proposed stormwater management systems comply with state and federal water quality standards. These are the "presumptive compliance" and the "loading calculation" methods.

- The presumptive approach (shown above) – requires compliance with a set of prescribed performance standards, and limits the number of acceptable stormwater treatment practices that are capable of meeting the performance standards.
- The loading calculation approach – requires applicants 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. Further information and a method of performing this calculation are provided in Appendix A.

There are several disadvantages to the onsite load calculation approach, as described by the Center for Watershed Protections' Stormwater Manager's Resource Center. *First, designers can select to use math modeling to their advantage to reduce costs and come into compliance. Second, technical data to support the program option are limited to just a few parameters, such as phosphorous, nitrogen, and sediment. Third, the removal rates for the stormwater practices seldom account for factors where pollutant load removal is compromised, and tend to be optimistic. Lastly, this program option is very intensive in terms of local review and compliance, and requires more staffing to implement.* (SMRC)

4. SITE DESIGN CRITERIA

W&C reviewed two manuals for alternative site design criteria:

- Center for Watershed Protection. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. 1998.
- Prince George's County, Maryland Department of Environmental Resources. *Low Impact Development (LID) Integrated Management Practices Guidebook*. January 2002.

These two site design methods are generally described below. These manuals will be used for reference throughout this project.

4.1 LOW IMPACT DEVELOPMENT

Low Impact Development (LID) began in Prince George's County, Maryland in the mid-1980s with the introduction of bioretention technology. LID was pioneered to help Prince George's County address the growing economic and environmental limitations of conventional stormwater management practices.

LID is "an innovative approach to stormwater management in which an attempt is made to duplicate the hydrologic regime of an undeveloped watershed." This approach is implemented by engineering a site so that the post-development hydrologic functions remain close to pre-development conditions by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. LID techniques can be applies to almost all components of the urban environment, including not only open space, but also rooftops, streetscapes, parking lots, sidewalks, and medians. LID is a versatile approach that can be applied equally well to new development, urban retrofits, and redevelopment / revitalization projects.

4.2 BETTER SITE DESIGN

The following summary of better site design was provided by the Center for Watershed Protection (CWP) at http://www.cwp.org/better_site_design.htm.

Better site design is a fundamentally different approach to residential and commercial development. It seeks to accomplish three goals at every development site: to reduce the amount of impervious cover, to increase natural lands set aside for conservation, and to use pervious areas for more effective stormwater treatment. To meet these goals, designers must scrutinize every aspect of a site plan— its streets, parking spaces, setbacks, lot sizes, driveways, and sidewalks— to see if any of these elements can be reduced in scale. At the same time, creative grading and drainage techniques reduce stormwater runoff and encourage more infiltration.

Why is it so difficult to implement better site design in so many communities? The primary reason is the outdated development rules that collectively govern the development process: a bewildering mix of subdivision codes, zoning regulations, parking and street standards, and drainage regulations that often work at cross-purposes with better site design. Few developers are willing to take risks to bend these rules with site plans that may take years to approve or that may never be approved at all. In 1997, a national Site Planning Roundtable was convened to address ways to encourage better site design techniques in more communities. The participants represented the diverse mix of organizations that affect the development process and provided the technical and real-world experience to make better site design happen. After two years of discussion, the roundtable endorsed 22 better site design techniques that offer specific guidance that can help achieve one of the basic better site design goals. These techniques are grouped into three areas:

1. *Residential Streets and Parking Lots*
2. *Lot Development*
3. *Conservation of Natural Areas*

The techniques are not intended to be strict guidelines, and their actual application should be based on local conditions.

5. REDEVELOPMENT PROJECTS

Redevelopment projects must be addressed differently than new development projects. Per the Massachusetts Stormwater Management Policy Handbook, "redevelopment of previously developed sites must meet the Stormwater Management Standards to the maximum extent practicable. However, if it is not practicable to meet all the Standards, new (retrofitted or expanded) stormwater management systems must be designed to improve existing conditions." First, the Town must define exactly what qualifies as redevelopment. According to the Massachusetts Stormwater Management Policy Handbook, redevelopment projects include:

- Maintenance and improvements of existing roadways, including widening less than a single lane, adding shoulders, and correcting substandard intersections and drainage, and repaving; and
- Development, rehabilitation, expansion, and phased projects on previously developed sites, provided the redevelopment results in no net increase in impervious area.

Next, the Town must decide the level of stormwater management standards to which redevelopment projects will be held. Providing cost effective stormwater treatment at redevelopment sites is often a difficult task, and these projects may be given reduced criteria to meet to allow for site constraints. For example, the State of Maryland currently requires that proposed redevelopment project designs include either at least a 20% reduction in existing site impervious area, management of at least 20% of the water quality volume, or some combination of both.

LID infiltration techniques may not be appropriate for these projects where there are contaminated soils. There must be special consideration for stormwater management at "hotspots," or areas where land use or activities generate highly contaminated runoff, with concentrations in excess of those typically sound in stormwater. Hotspots can include 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. These types of land uses are common in a dense urban environment such as Salem.

6. FEES

In many of the sample bylaws/ordinances reviewed by W&C, municipalities were authorized to collect a variety of potential fees from the applicant. These fees should be calculated for each project based on a fee schedule described in the bylaw/ordinance or regulations.

According to the Attorney General's guidance, towns should be aware that application of their fee provisions could result in municipal revenues brushing up against or exceeding the limits imposed on local government by state statutes. Likewise, a lawful fee is one that only covers the Board's reasonably anticipated costs of providing the services for which the fee is assessed. The town should discuss with Town Council whether the fee provisions, collectively, and as applied, amount to a tax not specifically authorized by the Legislature and are therefore unlawful. Here are some examples of fees that should be considered by Boylston in their Bylaw.

6.1 PERMIT AND APPLICATION FEES

It is a standard procedure to charge the applicant a non-refundable permit and application fee at the time of application to cover expenses connected with the review of the Stormwater Management Permit. According to the Attorney General's office, a "lawful fee is one that only covers the Board's reasonably anticipated costs of providing the services for which the fee is assessed."

For example town, county, state, and federal projects are exempt from fees in Dedham. All other projects pay the larger fee of $30.00 or $0.0030 per square foot of the parcel.

6.2 ENGINEERING AND CONSULTANT REVIEW FEES

Consultant fees should be determined at the time of project review based on a specific scope of work. Consultant fees may be outlined in Rules and Regulations promulgated under the bylaw/ordinance (that is, define hourly rates, projects, and activities subject to technical review). In some Towns, an "Engineering Consultant Fee Acknowledgement" form must be completed and submitted with any application.

The Attorney General's office offers guidance on administering and collecting review fees. The following guidance is from Massachusetts General Laws Chapter 44, Section 53:

- Conservation Commissions, Zoning Boards, Planning Boards, and Boards of Health are authorized to impose a fee to pay for its anticipated expenses in retaining a consultant, to draw upon the funds collected for the stated purpose, and to return unused portions to the applicant.
- Any fees collected by the town from an applicant to cover consultant review must be deposited with the Town Treasurer and made part of the town's general fund. Such funds would only be available for the purpose for which they were assessed (paying the consultant) once an appropriation is made by Town Meeting.

7. ENFORCEMENT

It is critical that Boylston's new provisions for stormwater management include adequate enforcement mechanisms.

7.1 ENTRY ONTO PRIVATE PROPERTY

At times, it will be necessary for Town staff or their consultants to enter upon private property for the investigation of an apparent or suspected violation of the bylaw. However, municipal officials do not have the authority under a local bylaw to conduct warrantless searches of private property without permission of the owner. Therefore, the new stormwater bylaw and other legal language will certainly contain provisions for performing site inspection as necessary throughout construction and in the case of suspected violations. Inspection will be contingent upon the owner's written permission. In the case that the owner refuses to grant entry, the Town will need to obtain a warrant.

7.2 CRIMINAL PENALTY & FINES

Boylston's stormwater bylaw will include a Criminal Penalty. Example language from the Attorney General's *Stormwater Management and Land Disturbance Bylaw* is as follows:

Any person who violates any provision of this by-law, regulation, order or permit issued there under, 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 offence.

The Town will need to review the entirety of the General Bylaws to be sure there is no conflicting or superseding language that would invalidate such a penalty.

7.3 NON-CRIMINAL DISPOSITION

General Laws, Chapter 40, Section 21D also allows municipalities to use non-criminal disposition as a method to enforce town bylaws. Such provisions require the Town to designate an enforcing person and provide for a specific penalty for violations.

8. LOW IMPACT DEVELOPMENT CREDITS

The Massachusetts Smart Growth Toolkit Model LID Bylaw has provisions for a system of Stormwater Credits. This system encourages the use of Better Site Design and nonstructural stormwater management measures to minimize reliance on structural stormwater management measures. Refer to Appendix A of the Model LID Bylaw, available at http://www.mass.gov/envir/smart_growth_toolkit/bylaws/LID-Bylaw.pdf.

APPENDIX A: METHODS FOR COMPLIANCE WITH WATER QUALITY STANDARDS

Method of Pollutant Load Calculation for Compliance with Water Quality Standards

Versions of this example were used in the South Shore Model Stormwater & LID Bylaw and the Salem Stormwater & LID Ordinance.

For certain projects defined in Section 7.C.4 of these Regulations, a loading calculation analysis is 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 set forth in the Stormwater & LID Regulations 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 summary of the Simple Method provided here was based on the New York State Department of Environmental Conservation stormwater manual, entitled “*Reducing the Impacts of Stormwater Runoff from New Development*”, with only minor modifications.

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:

L = 0.226 * R * C * A

Where: L = Annual pollutant load (lbs)
R = Annual runoff (inches)
C = Pollutant concentration (mg/l) (see Table A-1 or Table A-2)
A = Area of the site (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:

L = 103 * R * C * A

Where: L = Annual load (billion colonies)
R = Annual runoff (inches)
C = Bacteria concentration (1,000 col / ml) (see Table A-1 or Table A-2)
A = Area of the site(acres)
103 = Unit conversion factor

Pollutant Concentrations

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	mg/l	0.011
Pb	mg/l	0.051
Zn	mg/l	1.291
Fecal Coliform	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	mg/l	mg/l	mg/l
Residential Roof	19	0.11	1.5	0.26	0.020	0.021	0.312
Commercial Roof	9	0.14	2.1	1.1	0.007	0.017	0.256
Industrial Roof	17	-	-	5.8	0.062	0.043	1.390
Commercial/Res Parking	27	0.15	1.9	1.8	0.051	0.028	0.139
Industrial Parking	228	-	-	2.7	0.034	0.085	0.224
Residential Street	172	0.55	1.4	37	0.025	0.051	0.173
Commercial Street	468	-	-	12	0.073	0.170	0.450
Rural Highway	51	-	22	-	0.022	0.080	0.080
Urban Highway	142	0.32	3.0	-	0.054	0.400	0.329
Lawns	80	2.1	9.1	24	0.017	0.017	0.050
Landscaping	37	-	-	94	0.094	0.029	0.263
Driveway	173	0.56	2.1	17	0.017	-	0.107
Heavy Industrial	124	-	-	-	0.148	0.290	1.600
Residential (general)[4]	100	0.40	2.2	-	-	0.018	0.037
Commercial (general)[4]	75	0.20	2.0	-	-	0.370	0.250
Industrial (general)[4]	120	0.40	2.5	-	-	-	-

Sources:
1: Claytor and Schueler (1996)
2: Average of Steuer et al. (1997), Bannerman (1993) and Waschbusch (2000)
3: Steuer et al. (1997)
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

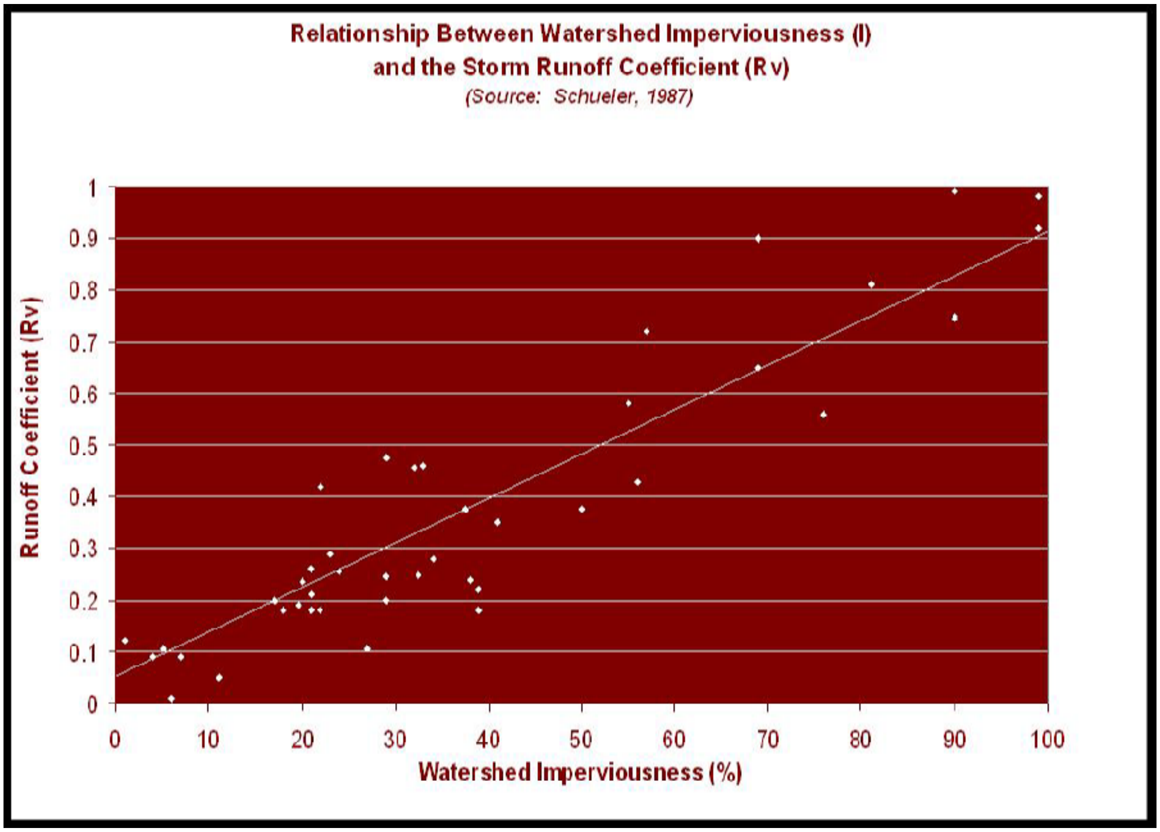

Figure A-1: Relationship between Watershed Imperviousness and the Stormwater Runoff Coefficient

Annual Runoff

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).

$$\mathbf{Rv = 0.05+0.009\ I_a}$$

Where:
- I_a = % Impervious Cover (see Table A-3)

Impervious Cover Data

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, communities may have detailed impervious cover information if they maintain a detailed land use/land cover GIS database. **When possible, applicants should 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
1/4 Acre 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

Limitations of the Simple Method

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.

Stormwater Best Management Practice (BMP) Pollutant Removal

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:

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

Where: $\mathbf{P_R}$ = Pollutant Removal (lbs)
L = Annual Load from Simple Method (lbs.)
E_i = Efficiency of the ith practice in a series (see Table A-4)

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 (Source: Winer, 2000)

Summary of The Simple Method Calculation Procedure

1. Calculate Pre-Development Pollutant Load (L_{pre})

- Use the equation $L_{pre} = 0.226 * R * C * A$ (or $L_{pre} = 103 * R * C * A$ for bacteria) to determine pre-development pollutant loading, where R = P * Pj * 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. For redevelopment, use the runoff coefficient that best describes the site's existing conditions.

2. Calculate "Uncontrolled" Post-Development Pollutant Load (L_{post})

- Use the equation $L_{post} = 0.226 * R * C * A$ (or $L_{post} = 103 * R * C * A$ for bacteria) to determine uncontrolled 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+0.009Ia, where values from I_a may be determined by Table A-3.

3. Determine Efficiency Removal Rates of proposed BMPs (E_i)

- Use Table A-4 to obtain pollutant removal rates for the proposed BMPs.

4. Determine "Controlled" Post-Development Pollutant Load ($L_{control}$)

- Multiply the uncontrolled post-development pollutant load (L_{post}) by the total pollutant removal rate, to obtain the amount of pollutant removed. If more than one BMP is to be used in series, calculate the total effective pollutant removal using $P_R = L_{post}\ [(E_1) + (1- E_1)E_2 + (1-((E_1)+(1-E_1)E_2)E_3 + \ldots]$
- Subtract the total amount of pollutant removed (P_R) from the uncontrolled post-development load (L_{post}), to obtain the "controlled" post-development pollutant load ($L_{control}$).

5. Compare Controlled Development Load versus Pre-Development Load

- If the post-development controlled load ($L_{control}$) is less than or equal to the pre-development load (L_{pre}), 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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