City of Providence
STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

RESOLUTION OF THE CITY COUNCIL

No. 110

Approved March 6, 2017

RESOLVED, That His Honor, the Mayor, is hereby authorized to execute a Consent Agreement with the Department of Environmental Management ("RIDEM") to address the City's failure to comply with the series of directives from RIDEM regarding the City's Rhode Island Pollutant Elimination System General Permit, entitled "Storm Water Discharge from Small Municipal Separate Storm Sewer Systems" ("MS4"). RIDEM is prepared to issue a Notice of Violation ("NOV") which would compel the City to pay $175,000 in penalties for these MS4 failures. However, as an alternative, the City has negotiated the attached Consent Agreement, which avoids the NOV and allows the City to expend the funds which would otherwise be charged as penalties towards other Supplementary Environmental Projects which would partially address the MS4 concerns and complete environmental remediation projects in several City wards.

IN CITY COUNCIL
MAR 02 2017
READ AND PASSED
PRES.
CLERK

I HEREBY APPROVE.
Mayor
Date: 3/6/17

IN CITY COUNCIL
OCT 06 2016
FIRST READING
REFERRED TO COMMITTEE ON
PUBLIC WORKS
CLERK

THE COMMITTEE ON
Public Works
Recommends
CLERK
10-26-16 - continued

THE COMMITTEE ON
PUBLIC WORKS
Approves Passage of
The Within Resolution
Clerk
1-30-17 - APPROVED

IN CITY COUNCIL
FEB 16 2017
And Referred Back
To The Committee on
Public Works
ACTING CLERK

THE COMMITTEE ON
PUBLIC WORKS
Approves Passage of
The Within Resolution
Clerk
3-22-17 - approved

Council President Aponte and Councilman Igliozzi, By Request

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

OFFICE OF COMPLIANCE AND INSPECTION

In Re: City of Providence

File Nos.: OCI-WP-16-40 X-ref
RIPDES RIR040005

CONSENT AGREEMENT

A. *INTENT & PURPOSE*

This Agreement is entered by and between the Rhode Island Department of Environmental Management's Office of Compliance & Inspection ("RIDEM") and the City of Providence ("Providence"). This Agreement is entered in accordance with Section 42-17.1-2 et seq. of the Rhode Island General Laws ("R.I. Gen. Laws") for the purpose of resolving the alleged violations set forth in a Notice of Violation ("NOV") issued to Providence by the RIDEM on ______________.

B. *STIPULATED FACTS*

(1) WHEREAS, on 19 December 2003, the RIDEM issued Rhode Island Pollutant Elimination System ("RIPDES") General Permit Number RIR040000 entitled "Storm Water Discharge from Small Municipal Separate Storm Sewer Systems and from Industrial Activity at Eligible Facilities Operated by Regulated Small MS4s" (the "General Permit").

(2) WHEREAS, the General Permit authorizes the discharge of stormwater from small municipal separate storm sewer systems ("MS4s") that are operated by municipalities.

(3) WHEREAS, on 18 March 2004, Providence obtained coverage under the General Permit through the submission of a Notice of Intent ("NOI") and Stormwater Management Program Plan ("SWMPP") to the RIDEM.

(4) WHEREAS, for the purposes of this Agreement, the separate storm sewer system covered under the General Permit means the system as defined in Rule 31(b)(19) of the RIDEM's *Regulations for the Rhode Island Pollutant Discharge Elimination System*, except for the system that serves those roadways that are private roads and are listed and attached hereto and incorporated as Attachment A or state roads as defined by RI Gen. Laws Chapter 24-8, as amended. Attachment A may be amended by mutual agreement of the parties in writing.

(5) WHEREAS, the parties agree that stormwater controls implemented by Providence to address the Total Maximum Daily Load ("TMDL") entitled "Total Maximum Daily Load For Dissolved Oxygen and Phosphorus, Mashapaug Pond, Rhode Island-September 2007" (the "Mashapaug Pond TMDL") will fulfill Providence's responsibilities[1] to address bacteria for the Mashapaug Pond portion of the TMDL entitled "Rhode Island Statewide Total Maximum Daily Load, September 2011" (the "Statewide Bacteria TMDL").

(6) WHEREAS, the RIDEM received a copy of a report entitled "Roger Williams Park Ponds, Water Quality Management Plan", dated June 2013, that was prepared by the Horsley Witten Group et al (the "RWPP Plan"). The executive summary is attached hereto and incorporated herein as Attachment B.

(7) WHEREAS, on ____________ the RIDEM issued a NOV to Providence alleging certain violations of Rhode Island's Water Pollution Act, the RIDEM's *Water Quality Regulations* and the RIDEM's *Regulations for the Rhode Island Pollutant Discharge Elimination System*. The violations pertained to the failure to comply with the General Permit.

(8) WHEREAS, in lieu of proceeding with an administrative adjudicatory hearing on the NOV and to affect a timely and amicable resolution of the NOV, the RIDEM and Providence hereby agree that it is in the best interest of the parties and in the public interest to resolve the issues raised in the NOV.

(9) WHEREAS, the RIDEM finds that this Agreement is a reasonable and fair settlement and adequately protects the public interest in accordance with Rhode Island's Water Pollution Act and the RIDEM's *Water Quality Regulations* and the RIDEM's *Regulations for the Rhode Island Pollutant Discharge Elimination System*.

(10) WHEREAS, on __________2017, the City Council for Providence reviewed the terms and conditions of this Agreement and determined the same to be fair and reasonable, in the best interest of Providence, and contains appropriate and meaningful actions to improve water quality in the community, and duly authorized the Mayor to execute this Agreement on behalf of Providence and perform and undertake any and all necessary actions to further implement and comply with the terms and conditions contained herein.

[1] This terminology reflects the RIDEM's position that meeting the Mashapaug Pond TMDL will encompass any bacteria requirement incorporated in the Statewide Bacteria TMDL. As of the date of this Consent Agreement, the RIDEM has not provided notice of the applicability of the Statewide Bacteria TMDL. The parties acknowledge that RIDEM could provide such notice at any point in time, triggering compliance requirements for Providence. While the Statewide Bacteria TMDL is not presently in effect, the parties have negotiated in good faith to achieve the results which would otherwise be mandated if Providence had received official notice of that TMDL.

C. AGREEMENT

(1) JURISDICTION – The RIDEM has jurisdiction over the subject matter of this Agreement and has personal jurisdiction over Providence. Providence has the legal authority and has been duly authorized to enter into this Agreement.

(2) FORCE and EFFECT – This Agreement shall have the full force and effect of a final compliance order issued after a full hearing on the merits pursuant to the Administrative Procedures Act, R.I. Gen. Laws Section 42-35-1 et seq. and R.I. Gen. Laws Section 42-17.7-1 et seq. from which no timely appeal was taken, and which is enforceable in Superior Court in accordance with R.I. Gen. Laws Section 42-17.1-2(21)(vi).

(3) APPLICATION – The provisions of this Agreement shall apply to and be binding upon the RIDEM, Providence and its agents, servants, employees, successors, and assigns and all persons, firms and corporations acting under, through and for Providence in the performance of work relating to or impacting the requirements of this Agreement.

(4) CONDITIONS –

(a) Providence shall complete the following actions to comply with the Order section of the NOV:

(i) Implement the requirements of the General Permit as follows.

1. **By 1 March 2017,** submit to the RIDEM a downspout disconnection program that is consistent with the recommendations in the RWPP Plan that provides public awareness and outreach, a manual with options for the commercial or residential property owners, and annual demonstration pilot projects (the "Downspout Disconnection Program");

2. **By 1 March 2017**, submit to the RIDEM a paper based street sweeping tracking system that is sufficient to document the date, location, and miles of sweeping of all roads (the "Street Sweeping Tracking System");

3. **Upon approval of the Street Sweeping Tracking System by the RIDEM and annually thereafter**, implement the Street Sweeping Tracking System;

4. **By 10 March 2017 and annually thereafter**, submit the MS4 Annual Report to the RIDEM. The MS4 Annual Report shall be developed in a manner that fulfills the General Permit and include all the information within the document entitled "Compliance Reporting Requirements", which is attached hereto and incorporated herein as Attachment C;

5. **By 31 March 2017**, submit to the RIDEM an Illicit Discharge Detection and Elimination ("IDDE") Plan for screening and monitoring of MS4 outfalls and interconnections, investigation of sub-catchment areas, and removal of illicit discharges that is consistent with this Agreement and a document entitled "EPA New England Bacterial Source Tracking Protocol Draft January 2012", which is attached hereto and incorporated herein as Attachment D. Providence shall amend its SWMPP to incorporate the revised IDDE Plan within 6 months of the RIDEM's approval. The IDDE Plan must include, but is not limited to, the requirements, guidelines, procedures, and deadlines in the document entitled "IDDE Plan Requirements", which is attached hereto and incorporated herein as Attachment E;

6. **By 31 March 2017**, establish and maintain an inventory of municipally-owned structural controls (both baseline existing conditions and as they are constructed) and establish procedures to ensure adequate maintenance practices are followed;

7. **Within 3 Months of the RIDEM's approval of the IDDE Plan,** initiate the investigation of high priority outfalls and portions of the MS4 identified in a document entitled "IDDE Investigation Priorities List, City of Providence, March 2016", which is attached hereto and incorporated herein as Attachment F. Investigations shall be completed in accordance with the timeframes in the approved IDDE Plan;

8. **By 30 June 2017**, submit an amended SWMPP to the RIDEM (the "Amended SWMPP") that includes procedures for review of all new land development projects and all redevelopment projects to address the following:
   a. Applicability thresholds and permit application requirements;
   b. Incorporation of strategies to reduce runoff volume through low impact development and green infrastructure;
   c. Ensuring adequate long-term operations and management;
   d. Coordination of State and local land development permits; and
   e. Performance criteria for impaired waterbodies to ensure that new development projects result in no net increase of total phosphorous or bacteria and redevelopment projects reduce total phosphorous and bacteria to the maximum extent practicable;

9. **By 30 June 2017**, submit to the RIDEM electronically in an ArcGIS compatible format, using RI State Plane Coordinate system - feet, NAD1983, a GIS map of Providence's combined, sanitary and storm sewer systems, identifying the extent of the regulated area and the MS4, and including description of how the map was developed;

10. **By 30 June 2017**, develop a Geo-spatial database system to record and report IDDE complaints, investigations, and remedial measures taken;

11. **By 30 June 2017**, complete dry weather surveys during the January-April timeframe of the outfalls that are attached hereto and incorporated herein as Attachment G. Providence must document visual and olfactory observations and include in these inspections sampling for the parameters listed in Attachment E, Part B and as required by the General Permit;

12. **Within 6 months of the RIDEM's approval of the Amended SWMPP**, adopt ordinances that are consistent with the Amended SWMPP to address post-construction runoff from new development and redevelopment projects and submit to the RIDEM the ordinances and a letter from the City Solicitor certifying that the ordinances were duly adopted and provides the authority for Providence to carry out the requirements of the General Permit (the "Ordinances"). At a minimum, the Ordinances must address applicability, exemptions, performance standards, application requirements, and penalties for failure to properly operate and maintain best management practices;

13. **By 10 March 2018 and annually thereafter**, provide to the RIDEM a report of the results of the IDDE investigations, the revised ranking of priorities, and the revised implementation schedule with the MS4 Annual Report in accordance with Attachment C;

14. **By 30 June 2018**, implement the Ordinances;

15. **By 30 June 2019, and annually thereafter**, inspect all catch basins and manholes for sediment accumulation and clean as necessary. Increased inspections and maintenance should be considered. After at least 2 consecutive years of operational data has been collected, Providence may submit a request for approval for a lesser frequency of inspection based on evidence indicating the system does not require annual cleaning;

16. **By 31 December 2019**, establish and maintain an inventory of privately-owned structural controls (as they are constructed) and establish procedures to ensure adequate maintenance practices are followed;

17. **By 31 December 2019**, develop and implement a Geo-spatial database system to record and report MS4 maintenance (street sweeping, inspection and cleaning of structures, and asset

management), and implement a means to record the same data electronically through a GPS contracted system;

18. **By 30 June 2020**, submit to the RIDEM electronically in an ArcGIS compatible format, using RI State Plane Coordinate system - feet, NAD1983, a GIS map of Providence's combined, sanitary and storm sewer systems. The map shall include, but not be limited to, locations of all outfalls, receiving waters, catch basins, manholes, pipes, culverts, swales, and ditches that contribute drainage to Providence's outfalls. Providence shall field verify flow direction and connectivity by, at a minimum, visual observation of the invert elevation of pipes connected to each catch basin, and determine the connectivity of each catch basin with the ultimate discharge/outfall. Providence will use good faith efforts to identify the location of all interconnections between existing public and private drainage systems and with other MS4s (for example, the Rhode Island Department of Transportation and the City of Cranston); and

19. **By 30 June 2020**, inspect all city-owned catch basins and manholes for illicit connections and non-stormwater discharges and document the results of these inspections;

(ii) Implement the recommendations in the RWPP Plan in accordance with the requirements below:

1. Complete the following projects identified and described in the RWPP Plan: RWP-3B; RWP-6; RWP-17/18; RWP-26; and RWP-28. As of the date of entry of this Agreement, Providence has completed said projects and shall receive load reduction credits as determined in accordance with a document entitled "Methodologies for Calculating Pollutant Load Reductions Achieved for Structural Stormwater Controls and Enhanced Non-Structural BMPs and Methodologies for Calculating Runoff Volume Reduction and Peak Flow Attenuation Factors for the Impervious Cover Standard", which is attached hereto and incorporated herein as Attachment L;

2. For the Lower Watershed, complete the non-structural and structural controls by the end of the fiscal year set forth in a document entitled "Proposed Projects in Roger Williams Park", which is attached hereto and incorporated herein as Attachment H;

3. **By 31 December 2017**, for the Upper Watershed, complete a feasibility and impact study of modifications to the weir box located within the discharge channel/pipe system from Mashapaug Pond;

4. **By 31 December 2018,** for the Lower Watershed, implement pavement management, parking requirements, modified shoreline access, and park maintenance practices, such as geese management, leaf litter pick-up, eliminating the use of phosphorus fertilizers, and maintenance of structural stormwater controls;

5. For the Providence Portion of the Lower and Upper Watersheds that contribute flow to the MS4 (including portions interconnected to stormwater drainage systems owned by others) implement the programmatic non-structural controls as follows:

    a. **By 31 December 2017 and annually thereafter,** complete street sweeping at least twice annually;

    b. **By 30 June 2017** and annually thereafter conduct a pollution prevention program targeted at businesses and residents that informs the community on how to become involved in the stormwater program. At a minimum, the program must:

        i. Establish partnerships with governmental, non-governmental entities, and private land owners to develop programmatic and outreach strategies;

        ii. Host an annual convening with partners and stakeholders; and

        iii. Ensure that education and outreach materials are available online and accessible via Providence's website;

    c. **Upon approval of the Downspout Disconnection Program by the RIDEM and annually thereafter,** conduct the Downspout Disconnection Program. If the approval is issued prior to 31 December 2017, Providence shall conduct the program beginning on 31 December 2017;

(iii) **By 31 December 2020**, submit to the RIDEM a TMDL Implementation Plan ("IP") and a Scope of Work ("SOW") for the waterbody segments listed in the table below. Such SOW shall meet the requirement for a scope of work set forth in the TMDLs for each listed waterbody segment;

Waterbody Name and Location	Pollutant	Applicable TMDL
Mashapaug Pond [1]	Phosphorus	Mashapaug Pond TMDL
Roger Williams Park Ponds	Phosphorus	Phosphorus to Address 9 Eutrophic Ponds in Rhode

		Island - September 2007
Roger Williams Park Ponds	Bacteria	Statewide Bacteria TMDL

(iv) **By 31 December 2022**, submit to the RIDEM a TMDL IP and an SOW for the waterbody segments listed in the table below. Such SOW shall meet the requirement for a scope of work set forth in the TMDLs for each listed waterbody segment;

Waterbody Name and Location	**Pollutant/s**	**Applicable TMDL**
Woonasquatucket River	Copper, Lead, Zinc, Bacteria	Woonasquatucket River Fecal Coliform Bacteria and Dissolved Metals - April 2007
West River	Bacteria	Statewide Bacteria TMDL

(v) The TMDL IPs required in Paragraphs C(4)(a)(iii)-(iv) shall meet the requirements of the document entitled, "TMDL Implementation Plan Requirements", which is attached hereto and incorporated herein as Attachment I, and include the following requirements.

1. All recommendations and requirements in the TMDLs consistent with the assumptions and recommendations of those TMDLs that apply to Providence;

2. For each waterbody segment, Providence shall select a combination of structural stormwater controls and enhanced non-structural Best Management Practices ("BMPs") that collectively achieve the most stringent level of control for pollutant load reduction requirements in the heavy metals and phosphorous TMDLs as listed in a document entitled "Providence Percent Reduction TMDL Loads", which is attached hereto and incorporated herein as Attachment J, to the maximum extent practicable, unless the RIDEM approves an alternative level of control;

3. For each waterbody segment with a bacteria TMDL, Providence shall select a combination of structural stormwater controls and enhanced non-structural BMPs that collectively achieve the "Impervious Cover Standard," which is attached hereto and incorporated herein as Attachments K, to the maximum extent practicable, unless the RIDEM approves an alternative level of control;

4. An assessment of the pollutant load reductions achieved and an assessment of compliance with the requirements in Attachment J and Attachment K. Providence shall use the procedures specified in Attachment L to calculate the pollutant removal, runoff volume reduction, and peak flow attenuation achieved by structural stormwater controls and enhanced non-structural BMPs, unless the RIDEM approves an alternative methodology;

5. Implementation of all planned enhanced non-Structural BMPs within 3 months of approval by the RIDEM, except those that require council approval which would be implemented within 6 months, for enhanced non-structural BMPs that are not implemented on a seasonal basis, or no later than the next implementation season following the approval for enhanced non-structural BMPs that are implemented on a seasonal basis. Implementation of all enhanced non-structural BMPs shall continue annually thereafter or as specified in the approved TMDL IP;

6. A schedule for implementation of the proposed structural stormwater controls, including interim design milestones and proposed construction start and completion dates. In developing the schedule, Providence shall target completion of higher priority projects within 4 years of the RIDEM's approval and all projects within 8 years of the RIDEM's approval of the TMDL IP. Providence shall provide an explanation of its schedule, including the prioritization of projects and the rationale for the schedule. In developing the schedule, Providence will consider constructing the controls as part of other planned infrastructure improvement projects, and comply with the objective of providing for consistent progress over time in completing construction of the controls; and

7. TMDL Implementation Plan amendments. If, in the course of design or construction work and associated efforts, Providence concludes that a particular structural control proposed in a TMDL IP is infeasible, Providence shall explain the reasons for its conclusion and, to the maximum extent practicable, propose alternate structural controls and/or enhanced non-structural BMPs to replace the infeasible structural control. If, in the course of design or construction work and associated efforts, Providence concludes that the level of control that a particular structural control will provide is substantially less than was estimated in the current TMDL IP, Providence shall explain the reasons for its conclusion and, to the maximum extent practicable, propose additional structural controls and/or enhanced non-structural BMPs to compensate for the decrease. In either case, Providence shall submit the documentation of its conclusions and its proposals for alternate or additional controls in proposed TMDL IP amendment/s. For alternate or additional controls, the proposed TMDL IP

amendment/s shall include the information specified in Parts 9, 12, and 13 of Attachment I. The proposed TMDL IP amendment/s shall be submitted as soon as possible, but no later than the due date of the next annual MS4 Annual Report following Providence's conclusion that a particular proposed TMDL IP structural control is infeasible or will provide substantially less control than was estimated in the TMDL IP;

(vi) Providence shall propose an amendment to its SWMPP to incorporate RIDEM-approved TMDL IPs (including Operation and Maintenance ("O&M") Plans) within 30 days following RIDEM's approval of each TMDL IP. The SWMPP may be amended by incorporating the TMDL IPs by reference. A list of the TMDL IPs incorporated by reference shall be provided in the MS4 Annual Report. Providence shall implement the TMDL IPs, including the O&M Plans, in accordance with the schedules included in the approved TMDL IPs, as approved by the RIDEM, which schedules may be modified pursuant to Paragraph D (10) below; and

(vii) For new construction or re-construction by Providence, where the newly constructed or re-constructed infrastructure will discharge any pollutants of concern to an Impaired Water Body Segment directly or indirectly, Providence shall implement structural stormwater controls and may implement enhanced non-structural BMPs that will, to the maximum extent practicable, support the achievement of the pollutant load reduction and other requirements of Paragraph C(4)(a)(v). Providence will also consider the implementation of structural stormwater controls in connection with pavement management and other infrastructure development projects that are not new construction or re-construction, including, but not limited to, preservation projects such as mill & overlay, level & overlay, thin overlay, in-place recycling, and reclamation projects, and repair of existing drainage system components at the same line and grade, and, if practical, implement them as part of such projects.

(b) The schedules, reports and other documents that Providence is required to submit to the RIDEM in accordance with Paragraph C(4)(a) above are subject to the RIDEM's review and approval. Upon review, the RIDEM shall provide written notification to Providence either granting formal approval or stating the deficiencies therein. Within a reasonable period of time to be proposed by the RIDEM, but within no fewer than 14 business days of receiving a notification of deficiencies, Providence shall submit to the RIDEM revised schedules, reports, documents or additional information necessary to correct the deficiencies.

(c) Upon the RIDEM's approval of the schedules, reports and other documents, Providence shall complete all work required in accordance with the approved schedule.

(d) Penalty - In lieu of a penalty for non-compliance, and in consideration that the NOV issued in this matter was not prosecuted or that any determination of liability was reached on the merits, and in further consideration that the parties agree an amicable resolution is in the best interest of the public and will more effectively preserve and enhance the environmental quality of Providence's water bodies, a series of supplemental environmental projects shall be initiated and carried out by Providence, as set forth in Attachment O, which is attached hereto and incorporated herein. For each supplemental environmental project ("SEP"), Providence shall be given a credit for the SEP (the "SEP Credit").

(i) **By 1 July 2017,** Providence shall complete SEP #1 entitled Education Signage. Providence estimates this SEP is $10,000. Providence shall receive a credit of $10,000 for this SEP;

(ii) **By 1 February 2018,** Providence shall complete SEP #2 entitled Irving Avenue Seekonk River Revitalization. Providence estimates this SEP is $68,000 to $150,000. Providence shall receive a credit of $150,000 for this SEP; and

(iii) **By 1 July 2018,** Providence shall complete SEP #3 entitled Restoration of Riverside Park. Providence estimates this SEP is $55,000. Providence shall receive a credit of $55,000 for this SEP.

(e) If Providence fails to timely complete a SEP, the RIDEM shall notify Providence that it intends to rescind the SEP Credit. Within 14 days of Providence's receipt of written notification by the RIDEM that the RIDEM intends to rescind the SEP Credit, Providence shall either complete the SEP or demonstrate that good cause exists for the delay in completing the SEP. If Providence fails to complete the SEP or does not demonstrate good cause for the delay within said 14 days, Providence shall, within 10 days of Providence's receipt of a written notification from the RIDEM, submit to the RIDEM a check in the amount of the SEP Credit after which Providence shall be under no further obligation to complete the SEP.

(f) Penalties that Providence agrees to pay in this Agreement are penalties payable to and for the benefit of the State of Rhode Island and are not compensation for actual pecuniary loss.

(g) In the event that Providence fails to remit to the RIDEM a payment on or before its due date, that payment will be considered late and Providence will be in default. If the payment is not received within 30 days of its due date, interest shall begin to accrue on the entire unpaid balance at the rate of 12 percent per annum. Interest will accrue at this rate beginning with the day after the due date specified in this Agreement until such date all past due installment payments and interest owed are remitted. Interest shall be calculated using the following generally established accounting principle:

Interest due = (number of days late/365) x (0.12) x (amount of unpaid balance)

(h) All penalty payments shall be in the form of a check payable to the R.I. General Treasurer-Water and Air Protection Account. All payments shall be delivered to:

Chief, RIDEM Office of Compliance and Inspection
235 Promenade Street
Providence, RI 02908-5767

D. COMPLIANCE

(1) EFFECT OF COMPLIANCE – Compliance with and fulfillment of this Agreement shall be deemed to resolve all issues raised in the NOV.

(2) RELEASE FROM REQUIREMENTS OF THE AGREEMENT – Upon the RIDEM's determination that Providence has satisfactorily complied with the requirements of this Agreement expressed as "annually thereafter", Providence is released from its responsibility to continue to comply with said provisions under this Agreement.

(3) FAILURE TO COMPLY – In the event that Providence fails to comply with items specified in Paragraphs C(4)(a), (b) or (c) of the Agreement, Providence shall pay a stipulated penalty of $500 per month for each and every month during which the noncompliance continues, except that the RIDEM may, for good cause shown, defer or reduce such penalty. The payment of a penalty in accordance with this section shall not preclude the RIDEM from seeking any other appropriate remedy (e.g., injunctive relief in Superior Court).

(4) COMPLIANCE WITH OTHER APPLICABLE LAWS – Compliance with the terms of this Agreement does not relieve Providence of any obligation to comply with any other applicable laws or regulations administered by, through or for the RIDEM or any other governmental entity.

(5) ADDITIONAL ENFORCEMENT ACTIONS – Upon a determination by the Director that there is a threat to the public health or the environment, or upon discovery of any new information, the RIDEM reserves the right to take additional enforcement actions as provided by statute or regulation, including, but not limited to, the issuance of "Immediate Compliance Orders" as authorized by R.I. Gen. Laws Section 42-17.1-2(21). This Agreement shall not restrict any right to hearing or other right available by statute or regulation that Providence may have regarding any new enforcement action commenced by the RIDEM after the execution of this Agreement.

(6) FUTURE ACTIVITIES AND UNKNOWN CONDITIONS – This Agreement shall not operate to shield Providence from liability arising from future activities, as of the date of execution of this Agreement.

(7) SCOPE OF THE AGREEMENT – The scope of the Agreement is only violations alleged in the NOV.

(8) NOTICE AND COMMUNICATION – Communications regarding this Agreement shall be directed to:

David E. Chopy, Chief
RIDEM Office of Compliance and Inspection
235 Promenade Street
Providence, RI 02908-5767
(401) 222-1360 ext. 7400

Mary E. Kay, Executive Legal Counsel
RIDEM Office of Legal Services
235 Promenade Street
Providence, RI 02908-5767
(401) 222-6607 ext. 2304

Leah Bamberger, Director of Sustainability
City of Providence
25 Dorrance Street
Providence, RI 02903
(401) 421-7740

Jeffrey Dana, City Solicitor
City of Providence
25 Dorrance Street
Providence, RI 02903
(401) 680-5333

All communications regarding compliance with this Agreement shall be forwarded to the above-referenced addressees by certified mail.

(9) DEFERRAL – The Director may, for good cause shown, defer any of the compliance dates prescribed herein. Good cause for deferral of any compliance date shall be forwarded to the RIDEM in writing at least 15 days prior to the prescribed deadline.

(10) AMENDMENT – The Agreement may be amended by mutual agreement of the parties in writing.

(11) EFFECTIVE DATE – This Agreement shall be deemed entered as of the date of execution by all parties.

IN WITNESS WHEREOF, the undersigned consent to this Agreement in substance and in form.

For the City of Providence

By: ______________________________

Honorable Jorge O. Elorza, Mayor

Dated: ______________________________

For the State of Rhode Island Department of Environmental Management

By: ______________________________

David E. Chopy, Chief

Office of Compliance and Inspection

Dated: ______________________________

Approved as to form and correctness:

____

Jeffrey Dana, City Solicitor

City of Providence Draft Consent Agreement with RIDEM for Non-Compliance with Stormwater Permit
October 26, 2016

History: How did we get here?
Past efforts to improve water quality in Providence focused on Public-owned Treatment Works (POTWs) and discharges of raw sewage from Combined Sewer Outfalls (CSOs). Significant resources have been invested in upgrading the Narragansett Bay Commission (NBC) Field's Point Facility. NBC has also completed the 1st and 2nd phase of CSO elimination. In the years since, there have been very few discharges from the remaining CSOs or the Fields Point wet weather facility. A majority of the flows are captured in the tunnel and pumped back for full treatment.

Water quality studies completed by the DEM indicate that the Providence River, Woonasquatucket River, West River, Mashapaug Pond, and Roger Williams Park Pondsare still being impacted by polluted discharges from the City's storm drains.

In 1990, the Environmental Protection Agency (EPA) issued rules for large municipal separate storm sewer systems (MS4s). Providence was exempted from the Rules at that time because portions of the city are served by the combined sewer system and the city did not meet the threshold of population served. In 2003, EPA issued rules for small MS4s. In 2004, DEM issued the RIPDES Small MS4 General Permit.

Why the time is now?
Providence has made efforts to comply with its stormwater permit, but significant deficiencies remain and require additional resources to achieve compliance. These permit requirements should have been met many years ago and at this time the DEM is compelled to pursue formal enforcement actions to attain compliance.

Importance of compliance with permit

- Stormwater runoff is a significant source of pollution to the Providence River,Woonasquatucket River, West River, Mashapaug Pond, and Roger Williams Park Ponds.
- Providence's stormwater system is contributing to the pollution. This reduces the City's opportunities for recreational uses such as boating, community events such as water-fire, public access such as bike paths, parks, etc.
- More intense rains and the lack of maintenance of the drainage system is making pollution worse and results in street flooding and private property damage.
- Proper and functioning drainage is important to protect the City's investments in other key infrastructure such as roadway pavements and sidewalks.

Key components of Consent Agreement

1. Identifying and mapping the regulated stormwater system by June 30, 2017
2. Amending the post-construction stormwater ordinance draft by June 30, 2017; adopt within 6 months of DEM approval
3. Identifying and removing illegal sources of pollution to the stormwater system; submit plan by March 31, 2017
4. Inspecting, cleaning, and maintaining the storm drain system by June 30, 2019
5. Constructing stormwater controls in priority watersheds such as Mashapaug Pond, Roger Williams Park Ponds (RWPP), Woonasquatucket River, and West River.
6. Phased approach to developing and implementing watershed plans provides opportunity to collaborate with DOT. Plans due between 2017 and 2022. DOT will also be developing watershed plans in the priority watersheds.
7. Allows Providence to avoid payment of a cash penalty to DEM and invest those resources in Providence to improve water quality:
   - Stormwater Education Signage
   - Irving Avenue Seekonk River Revitalization
   - Completion of Bucklin Ave Green Infrastructure Project
   - Restoration of Riverside Park

Recommendation

The proposed agreement is the result of significant efforts by Providence and DEM and represents a fair compromise to address Providence's noncompliance and to reduce stormwater impacts. The DEM urges the City Council to authorize the Mayor to execute this proposed agreement. Should the Council choose not to, the DEM will proceed with the standard approach of issuing the notice of violation, which Providence may then appeal. Filing an appeal will still allow the city to negotiate a settlement, but with little opportunity for additional compromise, this may result in costly and protracted litigation.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

OFFICE OF COMPLIANCE & INSPECTION

IN RE: City of Providence

FILE NO.: OCI-WP 16-40
X-ref RIPDES NO.: RIR040005

NOTICE OF VIOLATION

A. Introduction

Pursuant to Sections 42-17.1-2(21) and 42-17.6-3 of the Rhode Island General Laws, as amended, ("R.I. Gen. Laws") you are hereby notified that the Director of the Department of Environmental Management (the "Director" of "DEM") has reasonable grounds to believe that the above-named party ("Providence") has violated certain statutes and/or administrative regulations under the DEM's jurisdiction.

B. Administrative History

The DEM issued informal notices to Providence on 9 February 2009 and 24 November 2010 for the failure to comply with its storm water permit. The notices identified the actions required to correct the violations. In June 2012, the DEM met with Providence to discuss the actions required to correct the violations. To date, Providence has failed to comply with its storm water permit.

C. Facts

(1) On 19 December 2003, the DEM issued Rhode Island Pollutant Elimination System General Permit Number RIR040031 entitled "Storm Water Discharge from Small Municipal Separate Storm Sewer Systems and from Industrial Activity at Eligible Facilities Operated by Regulated Small MS4s" (the "General Permit").

(2) The General Permit authorizes the discharge of storm water from a small municipal separate storm sewer system ("MS4") that is operated by a municipality.

(3) Part I.C.2 of the General Permit required the MS4 operators to submit a completed Notice of Intent (the "NOI") and Storm Water Management Program Plan (the "SWMPP") to the DEM within 90 days of the effective date of the General Permit to obtain coverage under the General Permit.

(4) On 18 March 2004, Providence submitted to the DEM a NOI and SWMPP.

contributing to phosphorus impairments in Mashapaug Pond and Roger Williams Park Pond. Providence was required to submit an amended SWMPP to the DEM within 180 days to address the MP TMDL Notification and the RWPP TMDL Notification.

(10) On 13 March 2008, the DEM received an amended SWMPP from Providence in response to the WR TMDL Notification.

(11) On or about 14 May 2008, as a result of Providence's failure to respond to the MP TMDL Notification or the RWPP TMDL Notification, coverage under the General Permit for the storm water discharges to Mashapaug Pond and Roger Williams Park Pond ceased.

(12) On 5 December 2008, the DEM advised Providence in a letter that the amended SWMPP submitted in response to the WR TMDL Notification was not satisfactory and coverage under the General Permit for the storm water discharges to the Woonosquatucket River ceased.

(13) In 2010, the DEM reviewed the status of compliance for Providence. The review revealed that Providence failed to:

- (a) Implement an illicit discharge detection program as evidenced by:
  - (i) Implementation of a catch basin and manhole inspection program for illicit connections and non-stormwater discharges; and
  - (ii) Completion of 2 dry weather surveys of the storm water collection system and submission of the results to the DEM;
- (b) Implement a construction site storm water runoff program as evidenced by:
  - (i) Development and implemention of procedures for tracking erosion and sediment control permits including status of reviews and inspections;
- (c) Implement a post construction storm water management program for new development and redevelopment projects as evidenced by:
  - (i) Development and implemention of procedures for tracking post-construction reviews and inspections;
- (d) Implement a pollution prevention and good housekeeping program as evidenced by submission of procedures for identification, listing, and description of all structural controls in the SWMPP and the AR;
- (e) Inspect 100% of catch basins annually and clean as necessary;
- (f) Submit an amended SWMPP to satisfactorily address the WR TMDL Notification; and
- (g) Submit an amended SWMPP in response to the MP Pond TMDL Notification and the RWPP TMDL Notification.

(14) As of the date of the NOV, Providence has failed to:

(c) **Rule 11(B)** – requiring the discharge of pollutants into the waters of the State that comply with the terms and conditions of a permit issued by DEM.

(d) **Rule 13(A)** – prohibiting the discharge of any pollutant into or conducting any activity which will likely cause or contribute pollution to the waters of the State.

(e) **Rule 16(A)** – mandating compliance with all terms, conditions, management practices and operation and maintenance requirements set forth in a permit.

(4) **DEM's *Regulations for the Rhode Island Pollutant Discharge Elimination System* ("RIPDES")**

(a) **Rule 14.02(a)** – requiring the permittee to comply with all conditions of the permit.

(b) **Rule 14.05** – requiring the permittee to take all reasonable steps to minimize or prevent a discharge in violation of the permit.

(c) **Rule 14.06** – requiring the permittee to maintain in good working order and operate as efficiently as possible all treatment works to achieve compliance with the permit.

(d) **Rule 14.17(d)** – requiring the permittee to report monitoring results at the intervals specified in the permit.

E. Order

Based upon the violations alleged above and pursuant to R.I. Gen. Laws Section 42-17.1-2(21), you are hereby ORDERED to:

(1) **Within 180 days of receipt of the NOV**, identify, locate and list all municipally owned and/or maintained and privately owned structural controls that drain to the MS4 (both baseline existing conditions and as they are constructed) and implement procedures to ensure adequate maintenance practices are followed.

(2) **By June 15, 2017**, submit to the DEM:

(8) **By December 31, 2017**, submit an amended SWMPP to the DEM to address the WR TMDL Notification, the MP TMDL Notification and the RWPP TMDL Notification.

F. Penalty

(1) Pursuant to R.I. Gen. Laws Section 42-17.6-2, the following administrative penalty, as more specifically described in the attached penalty summary and worksheets, is hereby ASSESSED, jointly and severally, against each named respondent:

$175,000

(2) The proposed administrative penalty is calculated pursuant to the DEM's *Rules and Regulations for Assessment of Administrative Penalties*, as amended, and must be paid to the DEM within 30 days of your receipt of the NOV. Payment shall be in the form of a check made payable to the "General Treasury - Water & Air Protection Program Account" and shall be forwarded to the DEM Office of Compliance and Inspection, 235 Promenade Street, Suite 220, Providence, Rhode Island 02908-5767.

(3) Penalties assessed against Providence in the NOV are penalties payable to and for the benefit of the State of Rhode Island and are not compensation for actual pecuniary loss.

(4) If any violation alleged herein shall continue, then each day during which the violation occurs or continues shall constitute a separate offense and the penalties and/or costs for that violation shall continue to accrue in the manner set forth in the attached penalty summary and worksheets. The accrual of additional penalties and costs shall be suspended if the DEM determines that reasonable efforts have been made to comply promptly with the NOV.

G. Right to Administrative Hearing

(1) Pursuant to R.I. Gen. Laws Chapters 42-17.1, 42-17.6, 42-17.7 and 42-35, Providence is entitled to request a hearing before the DEM's Administrative Adjudication Division regarding the allegations, orders and/or penalties set forth in Sections B through F above. All requests for hearing MUST:

(a) Be in writing. See R.I. Gen. Laws Sections 42-17.1-2(21)(i) and 42-17.6-4(b);

(b) Be **RECEIVED** by the DEM's Administrative Adjudication Division, at the following address, within 20 days of your receipt of the NOV. See R.I. Gen. Laws Sections 42-17.1-2(21)(i) and 42-17.7-9:

Administrative Clerk

Please be advised that any such inquiries do not postpone, eliminate, or otherwise extend the need for a timely submittal of a written request for a hearing, as described in Section G above.

FOR THE DIRECTOR

By: ______________________________
David E. Chopy, Chief
DEM Office of Compliance and Inspection

Date: ______________________________

CERTIFICATION

I hereby certify that on the ________ day of ______________________________ the within Notice of Violation was forwarded to:

Honorable Jorge O. Elorza, Mayor
City of Providence
25 Dorrance Street
Providence, RI 02903

by Certified Mail.

____

PENALTY MATRIX WORKSHEET

CITATION: Failure to Comply with Storm Water Permit and Water Quality Regulations
VIOLATION NO.: D (1) through (3)

TYPE		
__X__ TYPE I DIRECTLY related to protecting health, safety, welfare or environment.	____TYPE II INDIRECTLY related to protecting health, safety, welfare or environment.	____TYPE III INCIDENTAL to protecting health, safety, welfare or environment.

DEVIATION FROM THE STANDARD

THE DEGREE TO WHICH A PARTICULAR VIOLATION IS OUT OF COMPLIANCE WITH THE REQUIREMENT VIOLATED.

FACTORS CONSIDERED:

Taken from Section 10 (a) (2) of the DEM's *Rules and Regulations for Assessment of Administrative Penalties*

(A) **The extent to which the act or failure to act was out of compliance:** Providence failed to comply with numerous requirements of its MS4 storm water permit and failed to comply with the requirements of several TMDL notifications. Compliance with the conditions of a permit and a TMDL notification are primary objectives of the Water Pollution Act, the DEM's Water Quality Regulations, and the DEM's RIPDES Regulations and are of major importance to the regulatory program.

(B) **Environmental conditions:** Providence operates a small municipal separate storm sewer system (MS4) and discharges storm water from the MS4 to numerous waters of the State, including the Woonosquatucket River, Mashapaug Pond and Roger Williams Park Pond. These waters are designated as Class SB or B water bodies of the State. Class SB or B water bodies are designated for fish and wildlife habitat, primary and secondary contact recreational activities and fish and wildlife habitat. These water bodies are not meeting the water quality standards assigned to the class for pathogens or phosphorus or dissolved metals and are listed as impaired.

(C) **Amount of the pollutant:** Unknown. Varies with rainfall.

(D) **Toxicity or nature of the pollutant:** Storm water contains a multitude of pollutants, including bacteria, metals, phosphorus, nitrogen and petroleum.

(E) **Duration of the violation:** About 11 years. Providence was required to meet numerous conditions of the permit, the first of which was due about March 18, 2005. The DEM only assessed a penalty from January 1, 2010 to present.

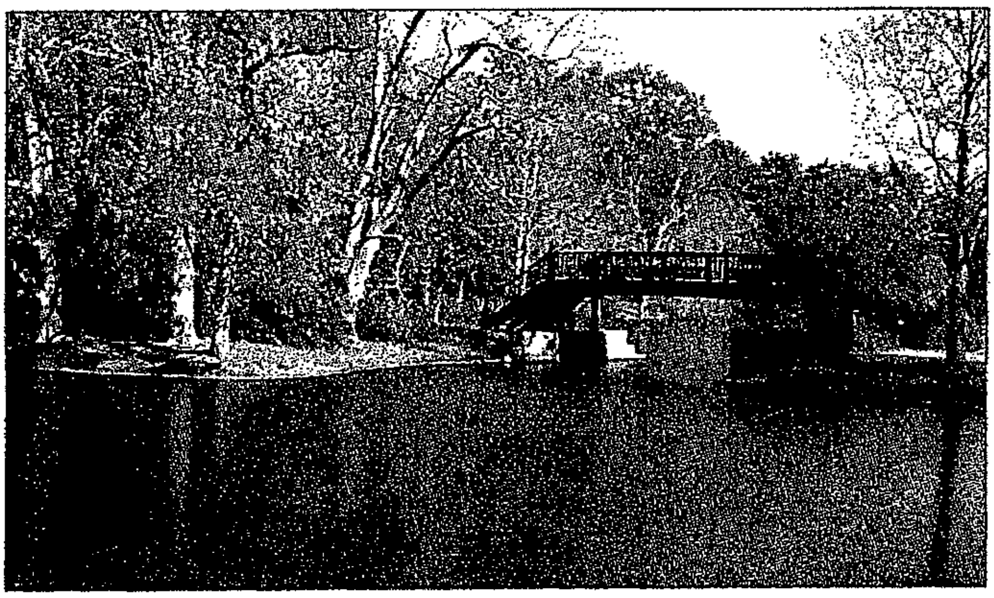
(F) **Areal extent of the violation:** Considered, but not utilized for this calculation.

(continued)

List of Private Roadways

As of the execution of this Agreement, Providence has not provided to the RIDEM a list of private roadways.

Restoring the Ponds in Roger Williams Park: Plan Summary



June 2013

Horsley Witten Group

Land & Coastal Services

Loon Environmental

Narragansett Bay Estuary Program

Providence Parks & Recreation

Geese Management

Animal & Plant Health Inspection Services, U.S. Department of Agriculture—Tim Cozine

Eastern Rhode Island Conservation District—Jessica Blackledge

Water Quality Sampling/Pond Characterization

U.S. Environmental Protection Agency, Atlantic Ecology Division

- Charlie Strobel
- Donald Cobb

University of Rhode Island Watershed Watch

- Linda Green
- Elizabeth Herron
- Bryan Cordeiro

Fish Tissue Analysis

U.S. Environmental Protection Agency, Atlantic Ecology Division—James Lake

Fish & Wildlife, Rhode Island Department of Environmental Management—Alan Libby

Technical Review & Advisory Services

Elizabeth Scott, Office of Water Resources, Rhode Island Department of Environmental Management
Scott Ribas, Office of Water Resources, Rhode Island Department of Environmental Management

Bernie Boudreau, Serve RI
Judy Colauca, Save the Lakes
Holly Ewald, Urban Pond Procession
Wenley Ferguson, Save the Bay
David Gregg, Rhode Island Natural History Survey
Alison Hamel, Rhode Island Department of Transportation
Jimmy Johnson, Rhode Island Bass Federation
Karen Marcotte, Save the Lakes
Bob Nero, Pawtuxet River Watershed Association
Margherita Pryor, U.S. Environmental Protection Agency, Region 1
Richard Ribb, Narragansett Bay Esturary Program
Amelia Rose, Environmental Justice League of RI
Kate Venturini, University of Rhode Island Outreach Center
Vanessa Venturini, University of Rhode Island Outreach Center

Project Team

Project Investigation and Plan Report

Horsley Witten Group

- Rich Claytor, P.E.
- Brian Kuchar, P.E., L.A.
- Michelle West, P.E.

Loon Environmental—Marie Evans Esten

Project Coordination, Project Management, & Public Outreach

U.S. Environmental Protection Agency, Region 1—Mark Spinale

Narragansett Bay Estuary Program

- Tom Ardito
- Leslie Lambert

Land & Coastal Services—Laura Ernst

Providence Parks & Recreation—Robert McMahon

Storm Water Retrofit, Design, Construction & Construction Management

Horsley Witten Group—Brian Kuchar

Gardner + Gerrish, LLC—Tim Gerrish, L.A.

Providence Parks & Recreation

- Joel Boodon, L.A.
- Ed Sanchez, L.A.
- Joe Salem

Yardworks, Inc.

SUMCO, Inc.

Project Signage & Graphics

Narragansett Bay Estuary Program—Leslie Lambert

Bryan Jones Design—Bryan Jones

Providence Park & Recreation—Joel Boodon

Table of Contents

1.0 Introduction

Since the first plan for Roger Williams Park was developed in 1878 by landscape architect Horace Cleveland, the Park ponds have been essential visual and recreational elements in the Park's design. Over the years, the ponds have provided boating opportunities, a place to fish, a home for wildlife, and a visual refuge for urban dwellers looking for relief from crowded city streets.

The Park ponds, however, suffer from algae, aquatic weeds, and road sand sedimentation. In 1982 Park officials dredged three of the ponds in the Park, but it didn't solve the water quality problems, as phosphorous-laden storm water and road sand continued to flow into the ponds.

The ponds were first listed in the Rhode Island Department of Environmental Management's (RIDEM) impaired water bodies list in 1992. The algae and aquatic weed problems in the ponds have gotten worse in the last 10 years. In 2007 RIDEM released a report, Total Maximum Daily Load Report (TMDL), analyzing nine ponds in Rhode Island with the most challenging phosphorous problems. The Roger Williams Park pond system was highlighted by RIDEM for its deteriorating water quality.

In 2010 in cooperation of the Narragansett Bay Estuary Program (NBEP), the Parks Department applied for and received an EPA Region 1 matching grant to examine the pond's pollution problems, to suggest remedies, and to provide a plan for restoring the ponds' water quality.

With the assistance of a Technical Steering Committee, the firm of Horsley Witten Group (HW) was selected to develop a Water Quality Management Plan for the Park ponds. The Committee has helped guide the work of HW which began in July 2011.

Roger Williams Park Ponds Restoration Project Technical Steering Committee

- *Providence Parks & Recreation*
- *Narragansett Bay Estuary Program*
- *U.S. EPA, Region 1*
- *US EPA Atlantic Ecology Division*
- *RI Coastal Resources Management Council*
- *RI Department of Health*
- *RI Department of Environmental Management*
- *RI Department of Transportation*
- *Save the Bay*
- *Save the Lakes*
- *US Fish & Wildlife Service*
- *USDA Natural Resources Conservation Service*
- *University of Rhode Island Watershed Watch*
- *RI Bass Federation*
- *Environmental Justice League of Rhode Island*
- *Serve Rhode Island*
- *Pawtuxet River Authority*
- *RI Natural History Survey*
- *Urban Ponds Procession*

The Steering Committee established the following goals for the project:

Roger Williams Park Ponds Project Goals

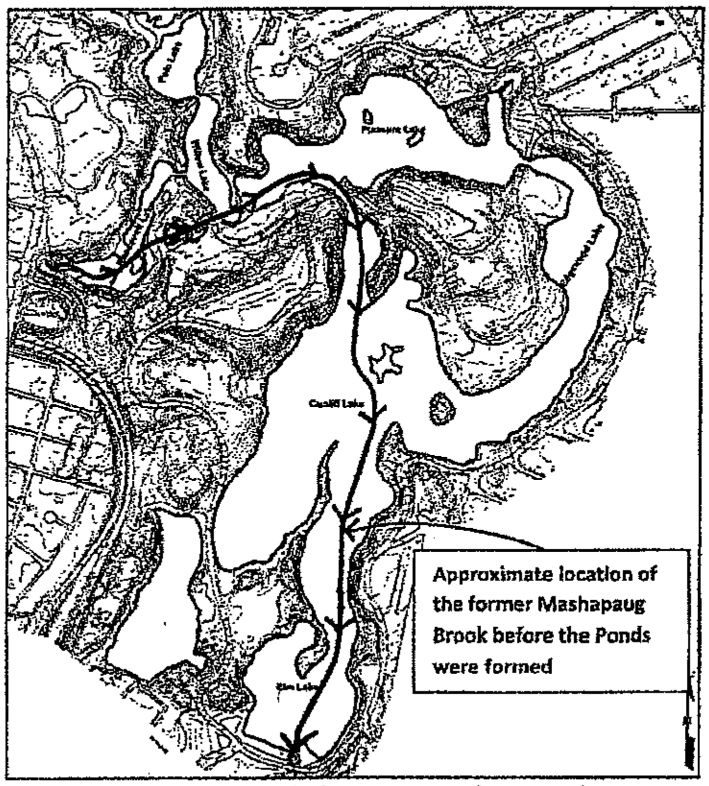
- **Improve water quality, habitat, and biodiversity within the ponds**
- **Improve the overall environmental quality and user experience of the Park**
- **Identify health risks associated with fish consumption; increase public awareness as warranted**
- **Foster watershed awareness and environmental stewardship among Park users and surrounding residents through a public outreach campaign**

Water quality restoration is central to the project's success. HWG undertook extensive investigations, completed a water quality model, and determined that a significant reduction in phosphorus pollution entering the ponds is necessary to achieve water quality improvement. The City and Technical Steering Committee established the following targets for phosphorus pollution reduction in the Ponds, to improve water quality, pond habitat, and Park aesthetics:

Water Quality Restoration—Phosphorus Reduction Targets

- **Reduce phosphorous in the ponds by 20% in five years**
- **Reduce phosphorous loadings in the ponds by 40% in ten years**
- **Over the long term, 20-25 years, reduce phosphorus up to 70%, a reduction which RI Department of Environmental Management suggests would allow the Park ponds to achieve a water quality that would significantly reduce seasonal algae and aquatic weed growth**

2.0 The Roger Williams Park Pond System

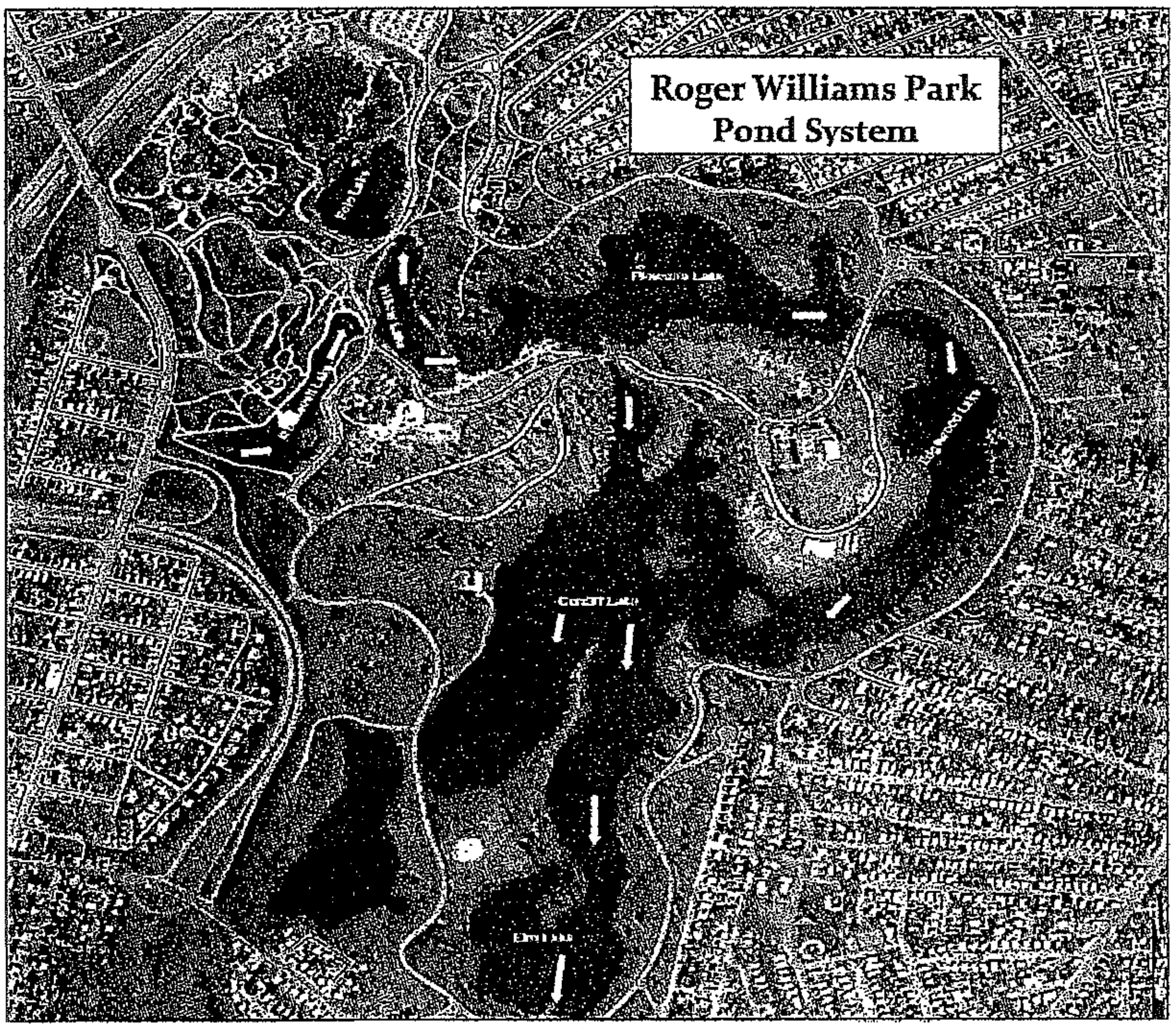


With the exception of Deep Spring Lake, the Park ponds are man-made, and consist of a series of interconnected ponds. As the Park was developed in the latter years of the 19th century, Mashapaug Brook that ran from Mashapaug Pond was used as the primary water source to create the Park ponds. This former location of the Brook in the area that now is the Park is shown in the accompanying graphic.

The Brook was dammed near present day Park Avenue at the southern end of what is now Elm Pond. In conjunction with considerable dredging done in the 19th century, several of the ponds were literally carved out of the landscape. Bridges were built to allow the ponds to flow continuously from one to the other. The general pattern of flow through the Park ponds is from the southern end of Roosevelt Lake, where a 48 inch diameter pipe from Mashapaug Pond is located, to the dam at the southern end of Elm Pond. As the water leaves the Park, it flows into Bellefont Brook, to the Pawtuxet River, and to Narragansett Bay.

Inflow pipe into Roosevelt Pond from Mashapaug Pond

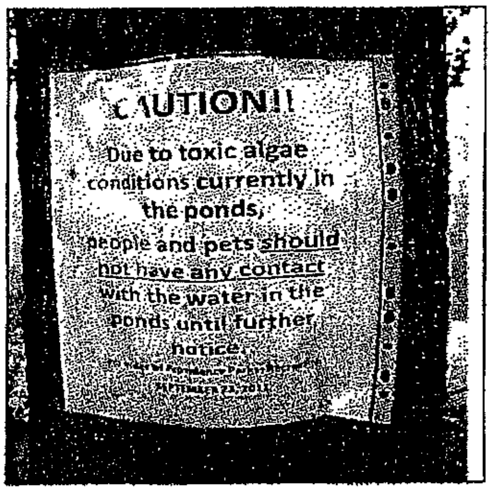
Outflow waterfall at Elm Pond leading to Bellefont Brook



Roger Williams Park Ponds Characteristics

Pond	*Average Depth (feet)*	*Area (Acres)*	*Direction of Flow*
Roosevelt	1.3	3.8	West to East then North to South
Willow	2.0	3.4	South to North and North to South
Polo	2.3	3.6	South to North
Pleasure	2.6	18.6	West to East
Edgewood	3.0	19.3	North to South
Cunliff	4.3	32.3	North to South
Elm	4.3	21.7	North to South

3.0 The Park Ponds are in Trouble Today



For six months each year the Park ponds are free of algae and weeds and reasonably normal in color and clarity. But those six months are from November to April when the ponds are not actively used, and there are fewer Park visitors.

Beginning in May every year, the shallow ponds begin to heat up and turn a pea soup green color culminating with floating algae and acres of weeds in July-October, this is known as eutrophic or hypereutrophic conditions.

Scientists typically look at a few key parameters to help assess water quality conditions, including Chlorophyll a, total phosphorus concentration, and Secchi dish depth (a measure of water clarity). As seen below, water quality data reflects the extent of water quality degradation in the ponds.

Summary of Water Quality Data for Roger Williams Park Ponds (URI Watershed Watch 1993-2012)

Water Quality Parameter	Typical Threshold for Eutrophic Conditions	Average Value in Ponds by Year												
		Pleasure Lake						Roosevelt Lake			Cunliff Lake		Elm Lake	
		1993	1994	2001	2002	2005	2012	1993	1994	2012	2003	2012	2005	2012
Chlorophyll a (ppm)	7.2 to 30	22	28	20	46	57	55	17	26	31	54	55	56	58
Total P (ppm)	25 to 65	85	105	76	64	140	100	65	69	76	120	87	97	82
Secchi Depth (ft)	6.5 to 2.5	5.2	4.6	3.0	2.0	1.6	2.6	5.2	5.2	1.6	2.3	2.6	2.0	3.0

Red Font = value exceeds outside range of Eutrophic Threshold

Why should we care about the poor water quality in the Park ponds?

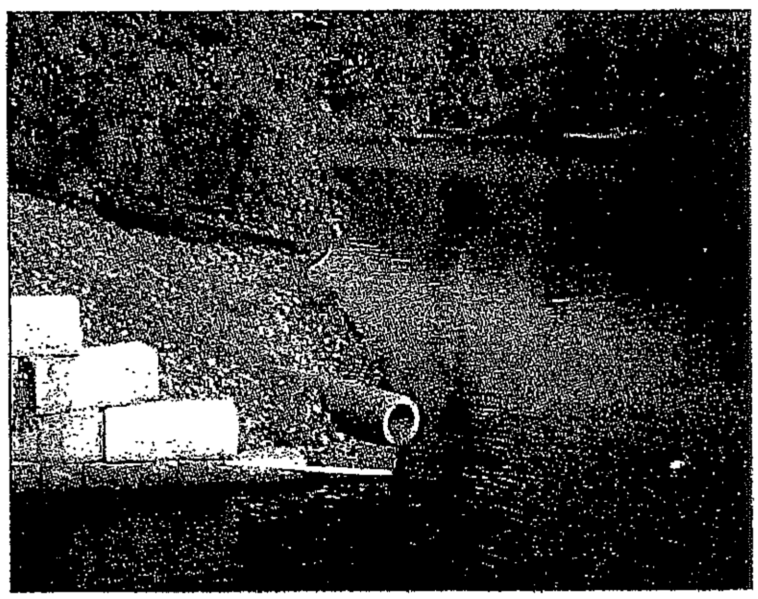
The degraded water quality condition of the ponds is troublesome for many reasons:

- The **boating experience** on the ponds is diminished
- **Biodiversity**, particularly fish species, in the ponds is reduced
- **Shoreline activities, such as picnicking and gatherings,** are unpleasant
- The overall **perception of the park as an enjoyable family place** to visit is negative
- Finally, Roger Williams Park is the primary recreational area for thousands of Providence families who do not have access to the state's beaches, and the restoration of the Park's water resources is a matter of **environmental justice.**

What is causing the water quality problems in the Park ponds?

The answer to that question is both simple and complex. To understand what is happening to the ponds, we should remember that the ponds are man-made and shallow. They are not natural, geologically-formed deep lakes such as those that exist in other parts of Rhode Island. And because the Park ponds are shallow, they heat up quickly during the warm weather months of the summer.

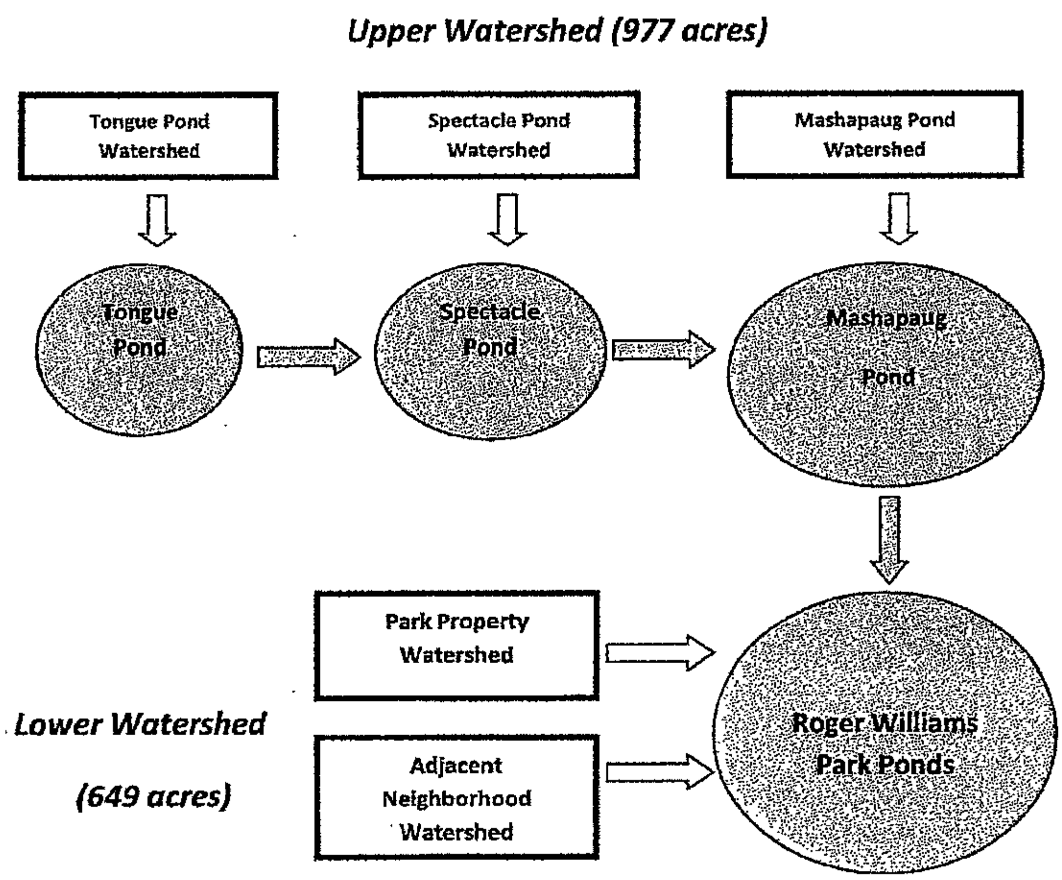
When initially constructed in the 1880's and 1890's, the ponds did not exhibit today's water quality problems. The Park at that time was at the southern end of Providence largely surrounded by vacant land. As the city's population grew, the areas around the park were developed into dense residential neighborhoods. Hundreds of acres of vacant land became houses, businesses, streets, sidewalks, driveways, and parking lots.



City engineers provided these nearby neighborhoods with storm drainage systems with storm water outfalls, many of which drained into the Park ponds. Even the Park's principal source of flow—the Mashapaug Brook—was channeled into a large storm pipe before it entered Roosevelt Pond. Throughout the 20th century, engineers also drained Park roads and parking lots into a storm drainage system which today flows into the Park ponds through many outfall pipes.

Not only did the areas around the Park develop, but the area around Mashapaug Pond (and its feeder ponds: Spectacle Pond and Tongue Pond) also was built up. Mashapaug Pond was relatively pristine when its outflow, Mashapaug Brook, was used to form the Park ponds. Indeed, as late as the early 20th century, Mashapaug Pond was a source of block ice for hundreds of Providence homes.

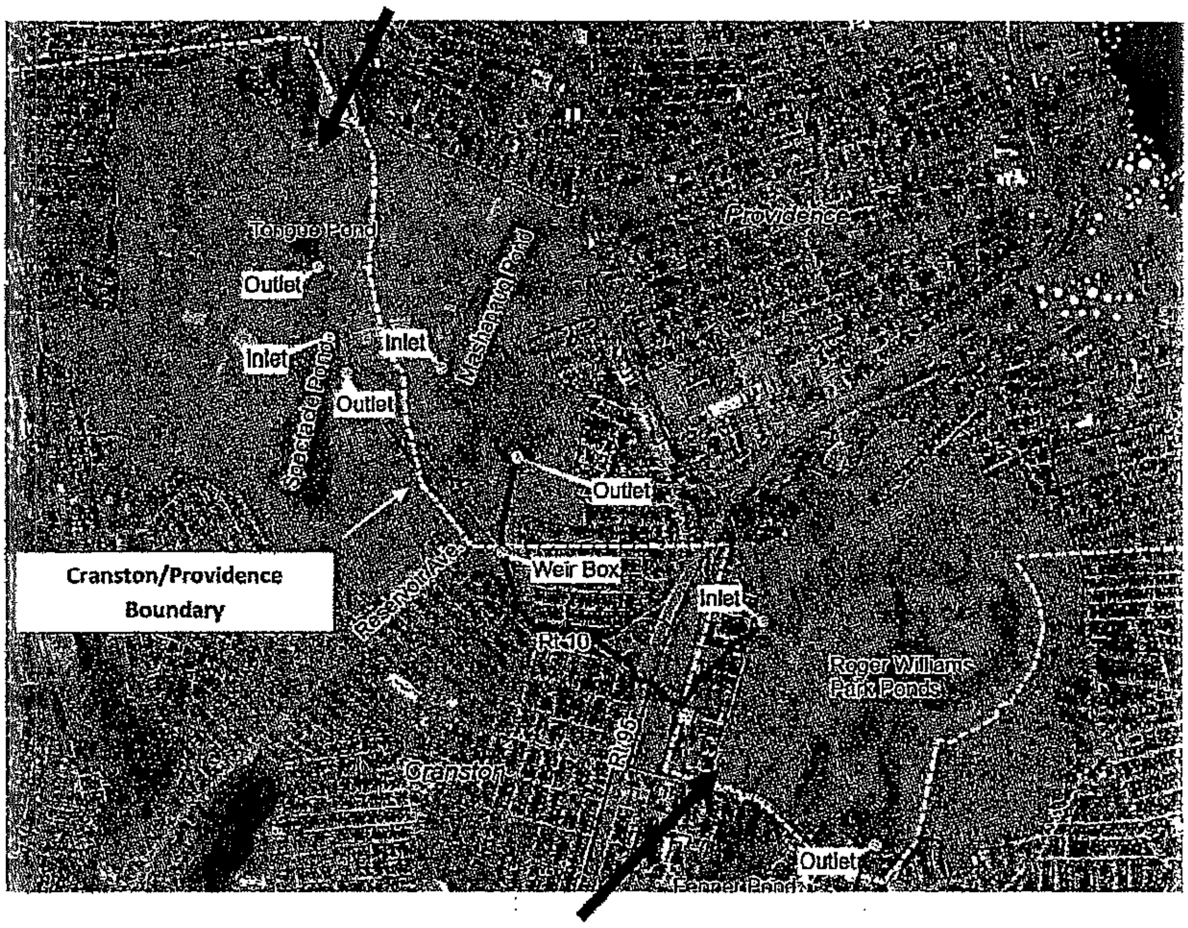
The **accompanying aerial photograph** shows the Park's two main watershed areas—these are the sources of storm water flowing into the Park ponds. The extent of development in the two watersheds is dramatic. The graphic below illustrates the relationship of the Park ponds to its watersheds.



Once dependent solely on the clean water of Mashapaug Brook, the Park ponds have become convenient receptacles for storm water from hundreds of acres of two nearby watersheds. Every time it rains, this polluted storm water drains into the Park ponds. Anything on the impervious surfaces that drains into the Park ponds—dirt, bird waste, pet waste, car chemicals, fertilizer, trash—is carried by the storm water into the Park ponds.

Roger Williams Park Ponds Watersheds

Upper Watershed (977 acres)

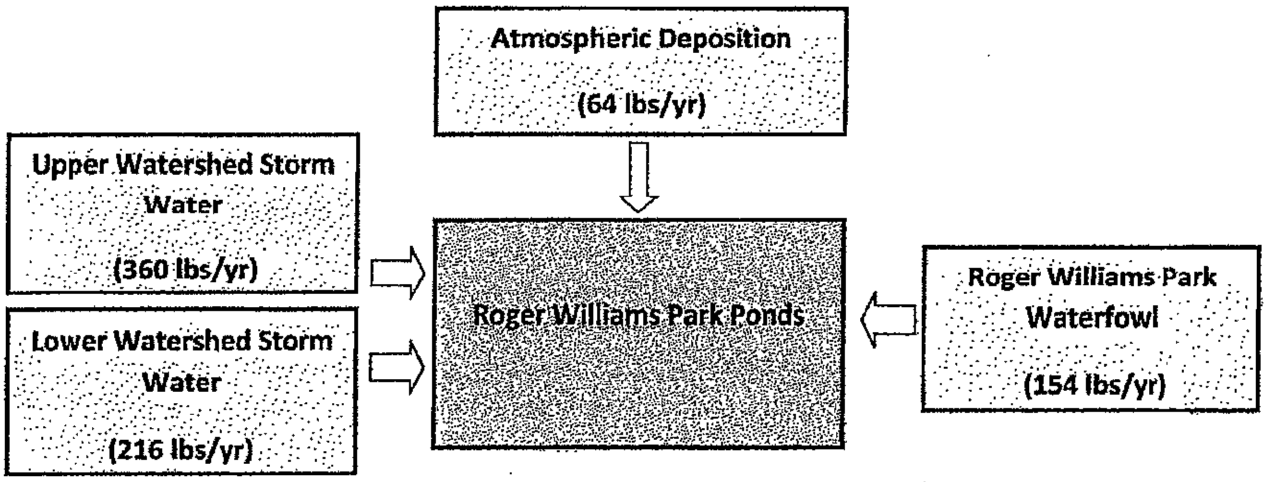


Lower Watershed (649 acres)

Phosphorous is a major concern in the storm water flowing into the Park ponds.

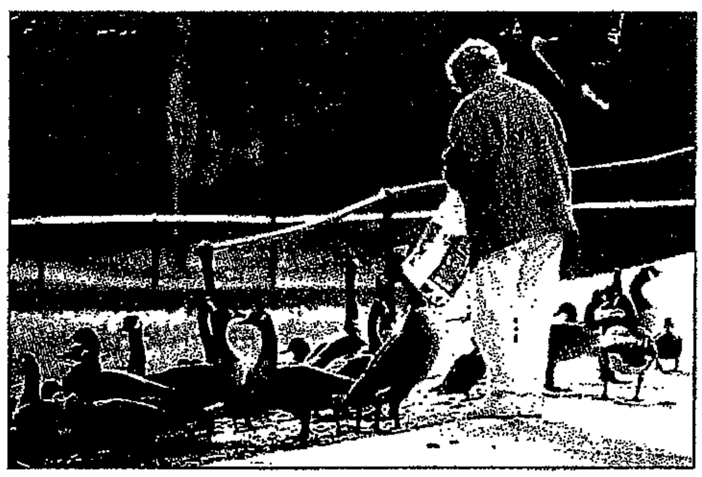
A modest increase in phosphorous in a shallow pond can, under the right conditions, set off a chain of undesirable biological events that can accelerate algal blooms, undesirable plant growth, depletion of dissolved oxygen, and the death of oxygen dependent fish. This process is called eutrophication. This process may take centuries to occur in undeveloped areas, but in the Park ponds eutrophication is accelerated by the storm water entering the ponds after every rain event. **The shallow warm Park ponds provide a perfect situation for phosphorus to stimulate algal blooms and plant growth.** See graphic below for the sources of phosphorous in the Park ponds.

Estimated Annual Amounts and Sources of Phosphorous in the Roger Williams Park Ponds



Source: Horsley Witten Group, 2012

Impervious surfaces are the major source of phosphorous in the ponds. But there is a second significant source of phosphorous: the number of resident Canada geese in the Park. For decades Canada geese stopped along their migration journey in the Park ponds. Once the ponds began to freeze, the geese would continue their journey south. Because of relatively recent climate changes, however, the Park ponds no longer consistently freeze in the December-March months. Gradually, large numbers of geese simply began to winter over in Roger Williams Park. As the resident geese population increased, park visitors unfortunately began to feed them throughout the year.



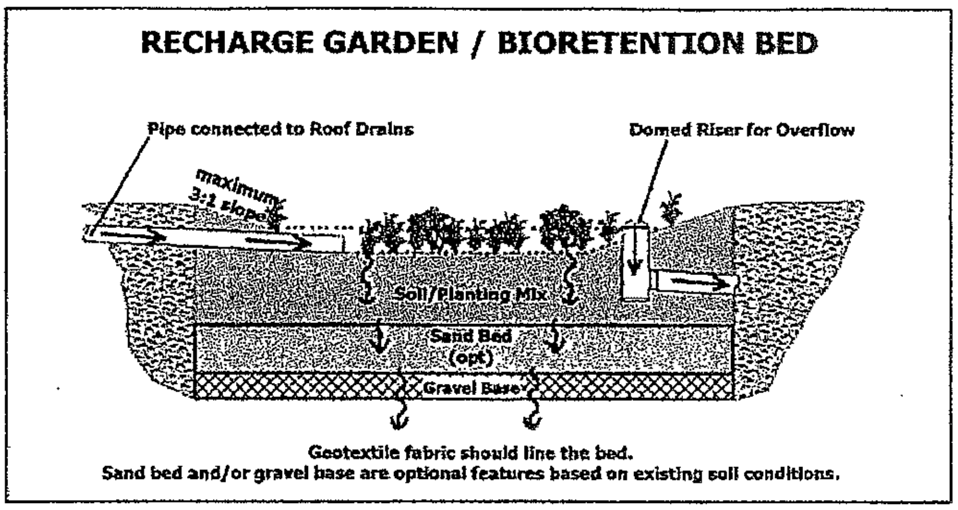
While well-intentioned, public feeding of the geese in the Park is misguided and as recently as July 2012 there were over 600 resident geese living in the Park. Unknown to most of the Park visitors, the gaggles of geese in the Park have been an environmental and public health disaster because of the sheer volume of fecal matter produced by the geese on park lawns and in the park ponds. Park officials began a comprehensive geese management strategy in 2012, including signs instructing the public not to feed the geese.

4.0 What Can Be Done: Best Management Practices

The Horsley Witten Group (HWG) developed scores of potential remedies to reduce phosphorous loadings entering the ponds. Outlined below are some of the **principal categories of best management practices that** potentially may improve the water quality of the Roger Williams Park ponds:

4.1 Structural Storm Water System Changes

- **Storm Water System Retrofits**— HW study examined about 30 places in the Park where the existing storm water pipes could be diverted and re-engineered to enable storm water to flow into bio-retention vegetated areas and swales before entering the groundwater into the ponds. **This technique essentially allows the storm water to be intercepted and to be treated before it enters the pond system.** The graphic below illustrates a typical storm water treatment design. Park officials and the Technical Steering Committee selected several sites to begin implementing storm water retrofit projects. Projects were selected based on phosphorous removal, cost, ease of implementation, and other factors like public education benefits. These sites are shown in Exhibit 4-1.



- **Pavement Reduction**—A basic method for reducing storm water pollution in the ponds is to **reduce the area of impervious surfaces**—primarily parking lots and roadways—in the Park to reduce the amount of storm water flow. The Park has many wide roads that could be narrowed, but this type of structural change needs to consider parking and traffic issues very carefully. Thus, Park staff will examine where pavement can be reduced at a reasonable cost without affecting normal Park use. For example, **the current storm water retrofit project along Roosevelt Pond involves the removal of almost 40,000 sq. ft of road area.**

Exhibit 4-1: 2012-13 Storm Water Retrofit Projects in Roger Williams Park

Site 3B: Carousel Parking Lot

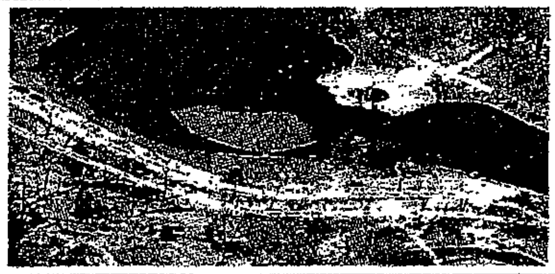
Construct bioretention garden to intercept and treat flow from ½ of the Carousel parking lot.

Status: Completed in 2012

Site 6: Roosevelt Pond

Remove 40,000 sf of road paving; install walkway and rain gardens and shoreline planting.

Status: Completed June 2013



Site 17/18: Polo Lake (DEM Priority site)

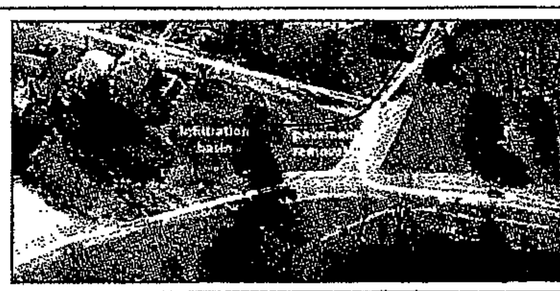
Modify existing inlet structures and divert storm flows to bioretention area.

Status: Completed June 2013

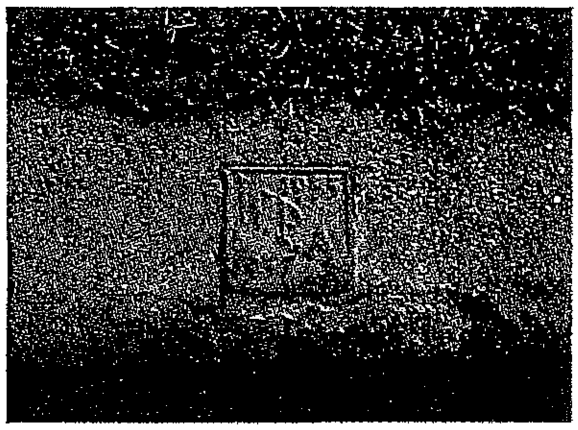
Site 28: Elm Lake at Edgwood Blvd. and FC Greene Memorial Blvd. (DEM priority site)

Remove pavement and create a bioretention area and infiltration basin.

Status: Completed April 2013

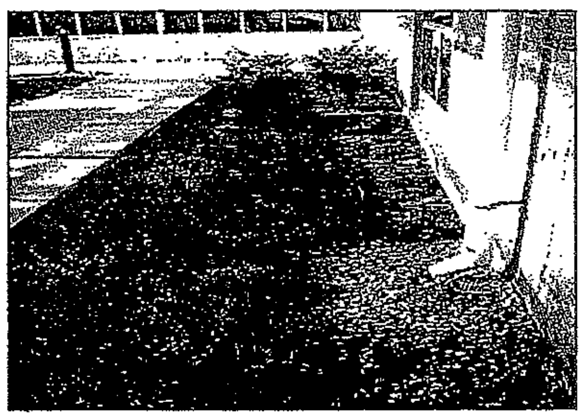


- **Curb Removal**—Roger Williams Park, unlike the large state parks in Rhode Island, has miles of curbing along the roads. This curbing is a legacy of work done by the Works Progress Administration in the 1930's and was a well intentioned effort to channel storm water into catch basins to flow into the ponds.



  There are many opportunities in the Park to selectively remove curbing and to allow storm water to flow into existing grass areas and to be absorbed into groundwater.

- **Disconnecting Building Downspouts**—Many of the Park buildings have downspouts which disconnect directly into the street drainage system. The roof areas in the Park total over 100,000 sq. ft. and they send storm water into the ponds. These downspouts can be disconnected relatively easily from the underground pipes and the downspouts can be altered to divert the storm water into adjacent planting areas. This has been successfully done in a demonstration at the Botanical Center already as seen in the accompanying photo at right.



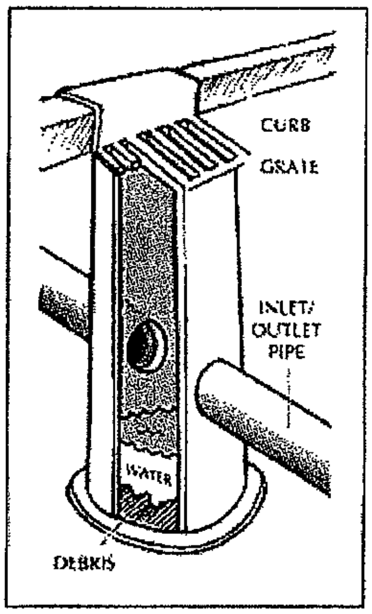
  This practice also offers significant potential in the upper and lower watersheds where **neighborhoods, according to HWG, have generally 50-60% of houses with downspouts directly connected to underground storm water pipes that lead to water bodies.**

__4.2 Non Structural Practices__

While some of the above structural practices will involve considerable capital costs, there are scores of nonstructural practices, much less costly, that can be implemented in the Park and in the nearby watersheds to reduce storm water loadings flowing into the Park ponds.

- **Operations and Maintenance Practices**—Daily operations in Roger Williams Park and the abutting watersheds can be altered and adjusted to reduce storm water pollution. Here are the most significant practices that should be considered:

  --Catch Basin Cleaning: Catch basins in the street "catch" storm water flowing on the street and then discharge the storm water flows from the catch basin through a pipe into a nearby water body. As seen in the accompanying sketch, catch basins are designed to settle out solids before the storm water flows into the discharge pipe. Catch basins can potentially be a significant method for reducing storm water pollution flowing into the Park ponds, if the catch basins are periodically cleaned of the settled solids.



  If the catch basin solids are not regularly cleaned, they eventually fill up the catch basin and storms will flush the solids into the discharge pipe into the nearby water body. Roger Williams Park has approximately 45 catch basins and there are several hundred in the upper and lower watersheds outside of the park. The Parks Department does not have its own vacuum truck to clean out catch basins—it depends on an already burdened Providence Department of Public Works (DPW) to periodically clean Park catch basins as well as the catch basins in the upper and lower watersheds. This catch basin cleaning does not consistently occur because the City insufficient resources to clean approximately 20,000 catch basins throughout the City.

  Park officials are examining how to become self-sufficient for catch basin cleaning.

  --Street Sweeping: One way to reduce the amount of solids and trash on Park and watershed streets from flowing into the storm water drainage system is to sweep the streets more frequently. The Parks Department does not own a street sweeper and depends on Providence DPW to sweep the 10 miles of roads in Roger Williams Park twice a year. Park officials need to determine how to supplement the DPW services with private vendors to ensure a minimum of two street sweeping/year in the Park

--**Mowing Operations:** When the Park was designed in the late 19th century, Park design emphasized grass lawns coming right to the edge of the water. Several thousand feet of shoreline in the Park have shorelines with mowed grass. This design and practice presents an aesthetically pleasing appearance, but it is not a wise water quality management practice: it allows geese to easily go between the ponds and the shoreline making the Park an attractive place to stay; it provides no natural vegetative buffer to absorb pond nutrients. Park officials need to commit to "natural" shoreline and not mow to the water's edge.

Willow Pond shoreline

--**Maintenance Operations "Hot Spots":** HWG identified several areas in Park maintenance areas where better housekeeping by Park staff will minimize pollution from entering the ponds after rain events. The Grounds Maintenance yard and the Mounted Command facility on Noonan Island need to develop best management practices to avoid waste flowing into the ponds.

- **Geese Management**—As pointed out in Section 2, the resident Canada geese contribute to the phosphorous loads that are harming the Park ponds. In 2012 the first steps to manage comprehensively the resident geese were undertaken: addling all of the geese eggs in the Park nests; removing several hundred geese under contract with the US Department of Agriculture; installing "geese education signs" in key geese feeding areas of the Park; and public education of park visitors by summer high school interns. This comprehensive effort needs to continue for several years to keep the resident geese population in check.

- **Shoreline Buffer Planting**—To accelerate natural vegetation along the shorelines, it will be useful to pro-actively plant native plant species along many of the Park shorelines. This will have many water quality management benefits as discussed above under **"Mowing Operations"**.

- **Steep Slope Stabilization**—Most of the sediment that is in the Park ponds is the result of sand washed into the ponds from the upper and lower watershed storm drainage systems, a some pond sediment is from erosion of sloped lawn areas that have lost their grass cover for one reason or another. These steep slopes with bare soil should be re-seeded systematically with appropriate erosion control matting in September of each year.

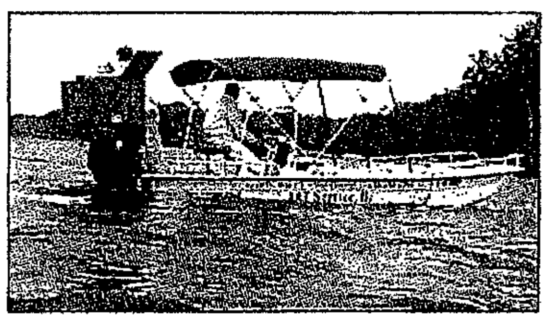
- **Making a Difference: The Public**—Clean water in Roger Williams Park is not just a municipal or public sector responsibility, and it will not occur if total responsibility is left with government actions. Park users, and particularly upper and lower watershed residents, need to do their part to improve the ponds' water quality. HWG indicates that upwards of **60-65% of the phosphorous loads coming into the Park ponds problems come from outside the Park.** Watershed residents and businesses will need to be continually engaged to learn what they do on their properties affects the storm water flowing into the Park. Park officials also need to ramp up efforts to inform and inspire Park visitors to create a constituency for clean ponds.

Lake identification signs will be installed to promote awareness by Park visitors

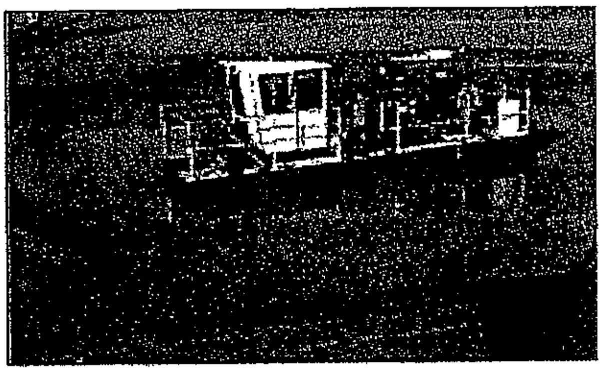
4.3 In-Pond Options

While the land-based options and public outreach will significantly reduce pollution loads entering the pond, many of the actions will be expensive and will make a major difference in the ponds only in the long term. The in-pond management options discussed below should be considered in the mix of actions to be implemented.

- **Chemical Treatment of Aquatic Weeds and Algae**—Park officials have been chemically treating aquatic weeds and algae, under RI DEM permit procedures, for approximately 20 years. Aquatic herbicides are used to treat rooted aquatic weeds and copper sulfate is used to treat algal blooms. The doses for these applications are governed by time of year and water temperature, are relatively inexpensive–about $5,000-7,000 per year, and provide temporary relief for algae and aquatic plants during the Park's busy time of year.



- **Dredging of Pond Sediment**—In the early 1980's Park officials dredged Roosevelt Pond, Willow Pond, and Polo Pond to address water quality problems that existed in the ponds at that time. While well-intentioned, dredging was a very expensive short-term solution. Because nothing was done to control the sediment and phosphorous coming in from the upper watershed into Roosevelt Pond, all three ponds have long since lost the pond depth that was achieved in 1982. In addition, Pleasure Pond has also lost considerable pond depth.



  The lesson from this early 1980's dredging effort is that water quality improvements have to be sequenced properly or the benefit of these actions will be limited. Dredging will be needed again in at least 3 or 4 of the Park ponds, but land based efforts and upper watershed efforts need to be done first.

- **Chemical Treatment of Exiting Sediment in the Ponds**—One of the issues unresolved by the HW study is the extent to which existing sediment in the ponds releases phosphorous into the water column under certain depth and dissolved oxygen conditions. This phenomenon is called "internal recycling" and it may be a significant contributor to phosphorous in the Park's deeper ponds, i.e., Cunliff, Elm and Edgewood. When existing phosphorous loads coming into those ponds from the lower watershed are substantially reduced, water quality testing will need to determine if internal recycling is an issue. At that point Park officials may consider treating the sediment with aluminum sulfate or sodium sulfate. This is a relatively expensive treatment—about $1,500/acre, however, and will require careful dosing to not harm existing fish in the ponds.

<u>4.4 Mashapaug Pond Flow into the Park: Options</u>

The HW study recognized that the goal of reducing phosphorous in the Park ponds from the upper watershed that flows into the Park ponds from Mashapaug Pond will be daunting to achieve. Two cities are involved; three water bodies; scores of dense residential neighborhoods with no common identity or track record of working together; one industrial park; and hundreds of stand-alone businesses.

While all of the above discussed structural, non-structural, and public outreach efforts need to be started and pushed forward, the pace of implementation in the upper watershed will likely be far more challenging than the efforts in the lower watershed.

In the meantime, phosphorous loads from Mashapaug Pond—the major source of pollution for Roger Williams Park—will continue to limit the efforts in the lower watershed to reduce storm water pollution in the Park ponds. What can be done in the interim, before scores of pollution reduction actions are implemented in the upper watershed? The HW study suggests three important small scale solutions that will need more study, but which appear to be promising.

- **Chemical Dosing Station**—The 48" pipe that carries the Mashapaug Brook and the storm water flows from the upper watershed is essentially a point source of pollution for the Park ponds. The HWG study suggests chemical treatment of the water coming from this point source should be considered as an interim measure until long-term solutions in the upper watershed to reduce pollution are implemented. Their suggestion: a dosing station that would treat the phosphorous and suspended solids.

  One or more aluminum compounds would be fed into the storm pipe during storm events, either at the discharge point in Roosevelt Pond or upstream of the Park and would bind up the phosphorous and suspended solids precipitating a floc that would fall out of the flow. HW recognizes the need for extensive study to examine the permitting for such a dosing station, operational requirements, maintenance requirements, treatment protocol, and disposal of the precipitated floc.

- **Mashapaug Brook Weir Box Re-engineering**—When Route 10 was constructed, some of the storm flows from Mashapaug Pond were altered to go through a weir box (just east of RT 10 and south of the Calart Building) into a 72" pipe that bypasses the Park ponds. Currently all of the low flows and smaller storm flows are directed towards the Park ponds through the 48" pipe into Roosevelt Pond. The HW study indicates that if the weir box is modified to divert more of the storm events into the 72" pipe that bypasses the Park ponds that this may reduce the phosphorous loads that come into Roosevelt pond after storms. **However, smaller storms with relative clean flow might then bypass entry into RWP ponds.** A detailed engineering study to examine the feasibility of any weir box modification is needed.

- **Chemical Treatment of Sediment in Mashapaug Pond**—RI Department of Environmental Management indicates in its 2007 report on Mashapaug Pond that "internal recycling" of

phosphorous in Mashapaug Pond maybe a a major contributor to the phosphorous loads originating from Mashapaug Pond and flowing into the Park ponds during the summer months. The conditions in Mashapaug Pond in the summer months—relatively deep pond, high water temperatures, and low dissolved oxygen levels—allow the release of phosphorous into the water column. Thus, treating portions of Mashapaug Pond sediment during summer months with an aluminum or sodium sulfate compound may be able to inactivate phosphorous and bind it to the pond sediment impinging the ability of the phosphorus to be released. A detailed study of this treatment is needed since it may require several acres of Mashapaug Pond to be treated.

5.0 What Can Be Done: Recommendations & Actions

The Horsley Witten Group study outlines an impressive array of best management practices for reducing storm water pollution in the Park ponds. Some key findings and principles should guide Park officials in deciding how to proceed during the next eight to ten years.

A Long-Term Commitment to Managing the Water Quality in the Park Ponds Is Needed. A year-by-year set of cos- effective solutions for the next several years will be required that take advantage of available scarce resources. There are no quick and easy solutions. Park officials need to plug away each year targeting a sequence of activities to reduce storm water pollution entering the ponds.

Engineering Solutions Alone Will Not Clean Up the Park Ponds—Public Attitudes Need to be Changed. HWG looked at 35 structural storm water retrofit projects to address the storm water pollution from existing storm water outfalls in the Park (not including the pipe from Mashapaug Pond) and the total cost was estimated at around $1.8-2.0 million. The Park can't simply buy its way out of the pollution problem in the ponds--first because these infrastructure projects are expensive, and secondly they will not address all of the phosphorous loads flowing into the ponds. Many of the sources of phosphorous coming into the Park ponds are the result of human behavior, such as feeding geese and residential fertilizer used in watershed areas near the Park. A consistent public outreach program is needed to change public behavior and attitudes about the Park ponds.

Water Quality Management Improvements Start at Home in the Parks Department. There are a number of **operational and maintenance tasks** that Park staff need to focus on to help reduce pond pollution, including:

- o systematic catch basin cleaning
- o educating park visitors about geese feeding and littering
- o allowing and providing shoreline buffer vegetation
- o allowing leaves to remain in wooded hillside areas
- o diligently addressing slope erosion issues as they develop each year.

We Will Need Additional Study to Determine Long Term Solutions for Some of the Pond Water Quality Issues. We not only need to provide an annual water quality sampling program in the ponds to monitor the effectiveness of our on-going efforts, we also need to look at the following un-resolved and/or on-going storm water issues:

- **Is it possible to treat the storm water coming into Roosevelt Pond from the Mashapaug Pond** watershed to reduce phosphorous? What are the costs?
- To what extent is the existing sediment that is in the Park ponds releasing phosphorous into the ponds and under what conditions? **Is it cost-effective to selectively treat the sediment in some of the ponds?**
- What would it **cost to dredge selective Park ponds** and what will be the pollution reduction from such an effort?
- **Can some storm flows (and the resulting phosphorous loads) from Mashapaug Pond be diverted away from the 48" pipe entering Roosevelt Pond Would such a diversion have a positive impact or RWP pond water quality?**
- Is it feasible for the City to develop an overall **Regional Storm Water Management District** to fund city wide storm water flow and pollution reduction?

The following Roger Williams Park Pond restoration actions are recommended to be implemented during the 2013 – 2020 period. Depending on the number of actions implemented and the ability to reduce phosphorous from the Mashapaug Pond inflow into Roosevelt Pond, these actions will reduce the phosphorous loads into the Park ponds by 20 to 50% and significantly improve the water quality of the Park ponds. Recommendations are sorted by:

– Roger Williams Park: RWP recommendations

–Lower Watershed outside of Roger Williams Park: LWN recommendations

–Upper Watershed: UW recommendations

Roger Williams Park

#	RECOMMENDATION	2013	2014	2015	2016	2017	2018	2019	2020	COMMENTS
RWP-1	On-going water quality sampling	$5K	$5K	$5K	$5K	$5K	$5K	$5K	$5k	
RWP-2	Public Outreach	$5K	$10K	$5K	$5K	$5K	$10K	$10K	$10K	Cash supplemented by in-kind
RWP-3	Geese Management	$10K	$10K	$5K	←		IN-KIND	→		
RWP-4	Park Landscape									
	-New Master Plan	$15K	$10K							
	-Revised Mowing Operations									
	-Shoreline Buffer Planting		$20K	$20K	$30K					Cash supplemented by in-kind
	-Parkwide Planting			$20K	$20K	$20K	$20K	$20K		Cash supplemented by in-kind
	-Erosion Control Actions		$10K	$10K	$5K	$5K				
RWP-5	RWP Conservancy									
	- Stratgegic Planning	$10K								
	-Organizational Development		$10K							
	-Advocacy and Fundraising									
RWP-6	Chemical Treatment: Weeds & Algae	$10K	$10K	$10K	$10K	$5K	$5K	$5K		
RWP-7	Operations & Maintenance									
	-Purchase Catch Basin Vaccuum Truck		$20K	$20K	$20K	$20K	$20K			5-yr lease purchase
	-Systematic catch basin cleaning									In-kind/park staff
	-Enhanced street sweeping program		$2.5K	$2.5K	$2.5K	$2.5K	$2.5K	$2.5K	$2.5K	Contract services/4 times/yr
RWP-8	Curb and pavement removals		$20K	$20K	$20K	$20K				Majority of work: In-kind
RWP-9	Downspout Disconnections	$10K	$10K							
RWP-10	Storm Water Infrastructure Retro-fits			$75K	$75K	$75K				
RWP-11	Dredging: Roosevelt, Willow, Pleasure									Cost to be determined
RWP-12	Selective In-Pond Sediment Treatment									Cost to be determined

Lower Watershed and Upper Watershed

#	RECOMMENDATION	2013	201 4	201 5	201 6	201 7	201 8	201 9	202 0	COMMENTS
LWN-1	Public Outreach	$5K	$10K	$5K	$5K	$5K	$10K	$10K	$10K	Cash supplemented by in-kind
LWN-2	Operations & Maintenance									
	-Purchase Catch Basin Vaccuum Truck									SEE RWP-7
	-Systematic catch basin cleaning									In-kind/park staff
	-Enhanced street sweeping program		$2.5K	$2.5K	$2.5K	$2.5K	$2.5K	$2.5K	$2.5K	Contracted services
LWN-3	Downspout Disconnection Program		$3K	$3K	$3K	$3K	$3K	$3K		
LWN-4	Environmental & Storm Water Regulatory Enforcement									In-kind/park staff
Upper Watershed										
UW-1	Cranston-Providence Working Group									Cranston-Providence officials
UW-2	Watershed Strategy Plan		$10K							Matching $ with Cranston $
UW-3	Watershed Downspout Disconnection Program									
UW-4	Watershed Public Education Program		$3K	$3K	$3K	$3K	$3K	$3K	$3K	Matching $ with Cranston $
UW-5	Industrial Park Working Group									Mashapaug Pond Businesses
UW-6	Design Services for Prototype Projects for Industrial Park Parking Lots and for Downspout Disconnections		$15K	$15K	$15K					
UW-7	Additional Studies: Weir Box, Mash. Pond Sediment Treatment		$20K	$20K	$20K					

RWP-1 RECOMMENDATION: *Provide On-going Water Quality Sampling*

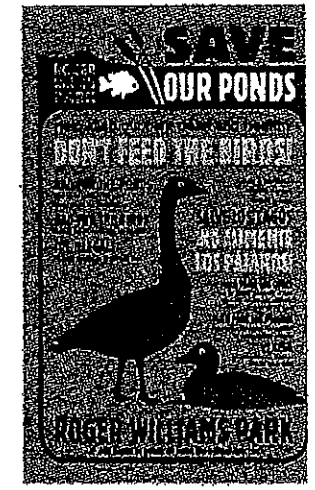
PURPOSE:	o To measure effectiveness of on-going water quality improvement actions o To provide additional data on storm outfall pipe flows o To provide data necessary for additional studies
DESCRIPTION:	This activity should partner with Watershed Watch of URI and the EPA Region 1 laboratory to develop an annual sampling program that will allow Park officials to evaluate water quality changes and to make decisions on future strategies.
TIME FRAME:	2013 - 2020
ESTIMATED COSTS:	$5,000 per year
FUNDING:	Rental fees from Park paddleboat concession

RWP-2 RECOMMENDATION: *Provide a Public Outreach Program in the Park*

PURPOSE:	o To raise awareness of Park users about the ponds as an important aesthetic, recreational, and ecological resource o To instill respectful behavior from Park users towards the Ponds and the Park environment
DESCRIPTION:	Park signage; social media; web site info on water quality; annual Parks Pond Festival.
TIME FRAME:	2013 - 2020
ESTIMATED COSTS:	$5,000-10,000 per year + in-kind
FUNDING	Rental fees from Park permits

RWP-3 RECOMMENDATION: *Continue Geese Management Program*

PURPOSE: o To restrict number of permanent resident Canada geese in the Park to less than 75 geese



DESCRIPTION: Continue comprehensive program begun in 2012 to include geese egg addling program, signage, park ranger enforcement of no feeding of geese. Coordinate w/recommendation RWP-4 (shoreline buffer planting).

TIME FRAME: 2013 - 2020

ESTIMATED COSTS: $5,000-10,000 per year for 2013 - 2015;

FUNDING: Rental fees from Park permits

RWP-4 RECOMMENDATION: *Implement Park Landscape Changes*

PURPOSE:
- o To revise Park mowing operations to conserve shoreline natural vegetation;
- o To install annual plantings to enhance shoreline buffer areas, to prevent turf erosion, and to enhance the park aesthetics

DESCRIPTION: Develop a new Parkwide Landscape Plan to guide landscape operations and plantings for the next eight years. Utilize native plantings and trees for landscape plantings. Provide staff training

TIME FRAME: 2013 - 2020

ESTIMATED COSTS: Master Plan: $25,000;
Planting: $160,000; Erosion Control:
$30,000

FUNDING: Charles H. Smith Trust Fund

RWP-5 RECOMMENDATION: *Develop a Roger Williams Park Conservancy*

PURPOSE:
- o To develop and cultivate a non profit organization to promote and raise funds for the Park
- o To develop a constituency to support the Park
- o To network with in-Park and regional organizations to assist improvements in the Park

DESCRIPTION: Park officials should seek consultant services to develop and organize the Conservancy, including the development of a strategic mission and plan for the organization. Starting in 2015, the RWP Conservancy will hopefully be a partner orgainization providing advocacy and fundraising services.

TIME FRAME: Stragegic planning and organizational development in 2013-14;

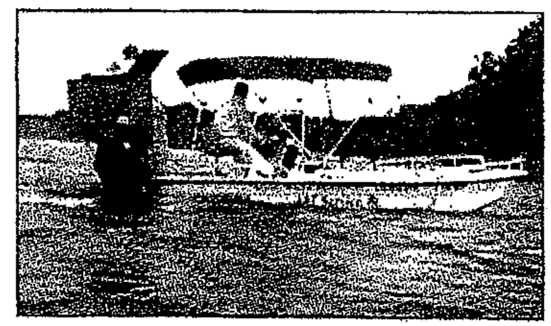
ESTIMATED COSTS: $20,000 for 2013-14;

FUNDING: Grant funding supplemented by park permit fees

RWP-6 RECOMMENDATION: *Chemically Treat Algae and Aquatic Weeds*

PURPOSE:
- o To diminish and control annual algae and aquatic weed growth that occurs every summer in the ponds

DESCRIPTION: Coordinate with RWP-1.



TIME FRAME: 2013 - 2020

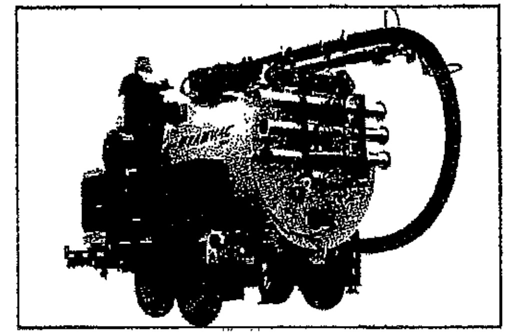
ESTIMATED COSTS: $10,000/per year

FUNDING: Rental fees from Park paddleboat concessions

RWP-7 RECOMMENDATION: Upgrade Operations and Maintenance

PURPOSE: o *To prevent solids and debris from catch basins and roads from being washed into the Park* storm drains and into the Ponds after rain events

DESCRIPTION: Parks officials would lease purchase a trailer vacuum catch basin cleaner with a 6 cy capacity and do its own catch basin cleaning without relying on DPW.
Parks would also supplement DPW street sweeping with additional contracted services .



TIME FRAME: 2013 - 2020

ESTIMATED COSTS: $22,500/year for 2014-2018; $2.5K/year 2019-2020

FUNDING: Lease purchase program for CB cleaner; park permit fees.

RWP-8 RECOMMENDATION: *Remove Selected Curbs and Pavement*

PURPOSE: o To reduce amount of storm water and related pollutants from entering the Park ponds from park roads

DESCRIPTION: Curb removal in the Park will be more cost effective than pavement removal in the Park, so this recommendation will focus on removing curb in areas of the park where storm water could flow on to existing vegetated areas. Turf areas receiving flow will need a turf reinforcement product

TIME FRAME: 2014 - 2017.

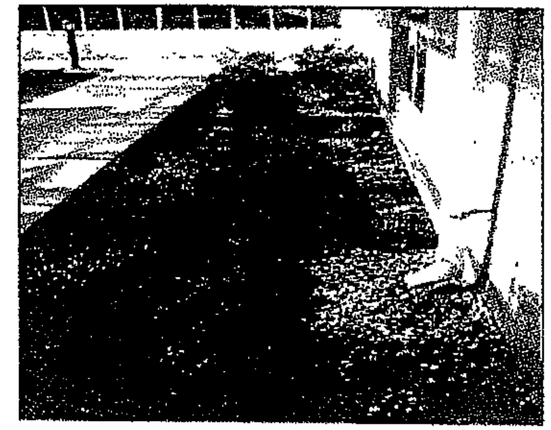
ESTIMATED COSTS: $20,000/year from 2014 - 2017

FUNDING: Charles H. Smith Trust Fund

RWP-9 RECOMMENDATION: *Disconnect Building Downspouts*

PURPOSE: o To reduce amount of storm water and related pollutants from Park building roofs from entering the Park storm water system

DESCRIPTION: Develop alternative places for downspout rain water to go without going into the Park storm system. This initiative would target the main Park buildings.



TIME FRAME: 2013 - 2014.

ESTIMATED COSTS: $10,000/year for 2013-2014

FUNDING: Charles H. Smith Trust Fund

RWP-10 RECOMMENDATION: *Install Additional Storm Water Retro-fits*

PURPOSE: o To intercept storm water and related pollutants from existing storm drainage system and re-direct it to swales, rain gardens, and bio-retention areas for treatment

DESCRIPTION: The Park will complete 4 sites in 2013 that were begun <u>in 2012. Approximately 3 more high priority DEM sites will be done in 2015-2017.</u>

TIME FRAME: 2015 - 2017

ESTIMATED COSTS: $75,000/year for 3 years supplemented with in-kind.

FUNDING: Charles H. Smith Trust Fund

RWP-11 RECOMMENDATION: *Conduct Dredging in Selected Park Ponds*

PURPOSE:	o To restore pond depth in selected ponds to enhance recreational boating, to improve pond aesthetics, and to diminish aquatic weed growth.
DESCRIPTION:	A detailed study and permit application would be completed in 2018 if it appears that efforts to reduce road sand from getting into the inflow pipe in Roosevelt Pond have been successful. The ponds to be dredged will be dependent on costs. Roosevelt Pond would be the highest priority.
TIME FRAME:	2018-2020
ESTIMATED COSTS:	To be determined
FUNDING:	To be determined

RWP-12 RECOMMENDATION: *Treat Sediment in Selected Pond Areas*

PURPOSE:	o To prevent release of phosphorous in summer months when dissolved oxygen levels are low
DESCRIPTION:	This action will be targeted to Elm Pond, Cunliff Pond, and Edgewood Pond after phosphorous loads entering these ponds have been substantially reduced.
TIME FRAME:	2018-2020
ESTIMATED COSTS:	$1,500 - $2,000 acre
FUNDING:	To be determined

LWN-1 **RECOMMENDATION:** ***Provide Public Outreach to Nearby Residents about the Park Ponds***

PURPOSE:
- To raise awareness of Park neighbors about the ponds as an important resource
- To let Park neighbors know how they as homeowners can prevent pollution in the Park

DESCRIPTION: Fliers; door-to-door educational effort with student interns; invitation to Park events. Coordinate with RWP-2

TIME FRAME: 2013 - 2020

ESTIMATED COSTS: $5,000-10,000/year

FUNDING: Summer jobs program; park permits fees; in-kind

LWN-2 **RECOMMENDATION:** ***Provide Catch Basin Cleaning/Street Sweeping in Neighborhood Watershed***

PURPOSE:
- To prevent solids and debris from catch basins and roads from being washed into the Park storm drains into the Ponds after rain events from neighborhood streets adjacent to the Park

DESCRIPTION: Parks would supplement DPW street sweeping in selected adjacent neighborhood streets to ensure 2/year service. Parks would do catch basin cleaning in selected streets adjacent to the Park.

TIME FRAME: 2014 - 2020

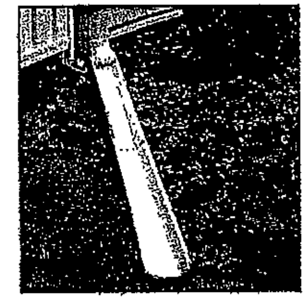
ESTIMATED COSTS: $2,500/year for street sweeping; catch basin cleaning would be done in-kind by park staff

FUNDING: Park permits fees; in-kind

LWN-3 **RECOMMENDATION:** ***Develop and Provide Homeowner Downspout Disconnection Program in Neighborhood Watershed***

PURPOSE: o To reduce amount of storm water and related pollutants from homeowner building roofs from entering the Park storm water system

DESCRIPTION: Park officials will develop a manual with a menu of downspout disconnect options for homeowners with varying types of yard configurations. Annual demonstrations will be held on local streets. Park officials will supply downspout diversion devices as needed.



TIME FRAME: 2014 - 2020

ESTIMATED COSTS: $3,000/year

FUNDING: Park permits fees; in-kind

LWN-4 **RECOMMENDATION:** ***Advocate Enforcement of Environmental and Site Design Regulations for Neighborhood Commercial Development***

PURPOSE:
- o To ensure that businesses comply with environmental regulations for property conditions
- o To ensure that businesses in the commercial area comply with site design regulations for storm water when businesses seek re-design permits.

DESCRIPTION: Park officials will develop a data base of business property owners and develop a relationship with DPW environmental officials and with the city Planning Department.

TIME FRAME: 2013 - 2020

ESTIMATED COSTS: in-kind/park staff

FUNDING: in-kind

UW-1 RECOMMENDATION: *Develop a Joint Cranston-Providence Working Working Group on Storm Water Management in the Upper Watershed*

PURPOSE:

o To develop and sustain a working relationship and coordinated effort to reduce storm water runoff pollution in the Mashapaug Pond Watershed

DESCRIPTION: This working group will include Cranston DPW officials, Providence DPW officials, Providence Park officials, and the Environmental Justice League of RI. Efforts will focus on drainage system analysis, public education efforts, and municipal actions related to catch basin cleaning and street sweeping.

TIME FRAME: 2013 – 2020

ESTIMATED COSTS: in-kind/park staff

FUNDING: in-kind

UW-2 RECOMMENDATION: *Develop Storm Water Strategy for the Watershed*

PURPOSE:

o To develop a priority schedule for te next 8 years for reducing storm water pollution in the Watersheds

DESCRIPTION: A $20,000 engineering study would be completed to analyze the drainage system, to estimate phosphorous loadings by sub-watershed, to recommend priority actions, and to estimate costs.

TIME FRAME: 2014

ESTIMATED COSTS: $20,000

FUNDING: $10,000-Cranston; $10,000-Providene (source to be determined)

UW-3

RECOMMENDATION: *Implement Downspout Disconnection Program in the Watersheds*

PURPOSE:

- To reduce amount of storm water and related pollutants from homeowner building roofs from entering Tongue, Spectacle, and Mashapaug ponds

DESCRIPTION: The Working Group will develop a manual with a menu of downspout disconnect options with varying types of yard configurations. Annual demonstrations will be held on local streets.

TIME FRAME: 2014 - 2020

ESTIMATED COSTS: in-kind

FUNDING: in-kind

UW-4

RECOMMENDATION: *Implement a Public Outreach Program for the Watershed Property Owners*

PURPOSE:

- To raise awareness of residents about the ponds as an important resource
- To let residents know how they as homeowners can prevent pollution in the ponds

DESCRIPTION: Fliers; door-to-door educational effort with student interns; other activities to be determined. Coordinate with UW-1

TIME FRAME: 2014 - 2020

ESTIMATED COSTS: Annual costs: $3,000-Cranston; $3,000-Providence, supplemented by in-kind

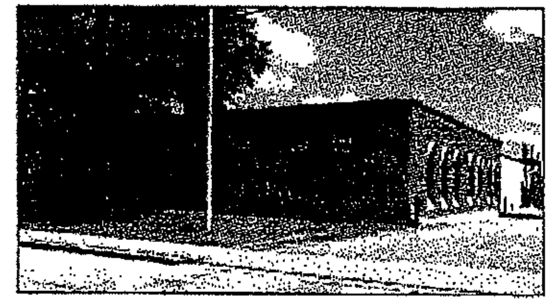
FUNDING: To be determined

UW-5 **RECOMMENDATION:** ***Help to Form a Huntington Industrial Park Association***

PURPOSE:

- To raise awareness of business about Mashapaug Pond as an important resource
- To let businesses know how they as property owners can prevent pollution in Mashapaug Pond

DESCRIPTION: Park officials have begun working with the City Department of Planning and the Environmental Justice League of RI to re-activate an association. Park officials will focus on the storm water issue and cleanup of Mashapaug Pond.



TIME FRAME: 2013 - 2020

ESTIMATED COSTS: in-kind, Park staff

FUNDING: in-kind

UW-6 **RECOMMENDATION:** ***Develop Prototypical Designs for Managing Storm Water on the Properties in the Huntington Industrial Park***

- To provide engineering guidance, cost estimates, and typical design solutions to Industrial Park property owners to stimulate action by individual property owners

DESCRIPTION: Park officials will hire an engineering firm to develop prototypical design solutions for a variety of existing properties in the Industrial Park.

TIME FRAME: 2014 - 2016

ESTIMATED COSTS: $15,000/year for 3 years

FUNDING: To be determined

UW-7 RECOMMENDATION: *Implement Studies on Weir Box Re-engineering, Sediment Treatment, and a Potential Chemical Dosing Station*

PURPOSE:

- **To determine the feasibility, advisability, and cost of Horsley Witten suggestions for major reductions in phosphorous entering Roger Williams Park ponds from Mashapaug Pond**

DESCRIPTION: **Park officials will hire an engineering firm to perform these starting with the Weir Box Re-engineering study.**

TIME FRAME: **2014 - 2016**

ESTIMATED COSTS: **$20,000/year for 3 years**

FUNDING: **To be determined**

4.0 Proposed Implementation Plan

4.1 Introduction

This chapter presents an implementation plan for allocating funds and efforts for the RWP Pond complex water quality improvement for both the Upper and Lower Watersheds. Although the recommendations presented are all viable options for improving water quality over the next decades, some will be easier to implement than others. Therefore, some of the recommended practices are identified as a first step in the quality management process. The long-term improvement of the water quality in the RWP pond complex will require a commitment beyond the next 10 years to not only change current stormwater treatment practices and watershed management, but also to alter the Parks general appearance and maintenance practices to reduce the impacts to the Ponds. This plan identifies both structural and non-structural practices, including programmatic improvements to be implemented within both the Upper and Lower Watersheds.

4.2 Lower Watershed

The measures and recommendations provided for the Lower Watershed take into consideration the Park's historical importance to the City of Providence and its current use by local residents and tourists alike. These recommendations have been developed to be implemented without significant changes to overall park character. Options identified during the watershed assessment and presented within this section include the following:

- Structural BMPs;
- Non-structural BMPs;
- In-pond treatment;
- Public education;
- Water quality monitoring; and
- Additional studies.

4.2.1 Structural BMPs

Table 4.1 provides six individual retrofit opportunities identified during the assessment process and selected by the Steering Committee for short-term implementation. These sites were selected from a list of 30 practices and were chosen using the results of the BMP ranking system provided in (**Section 3.0**) and through assessment of other priorities by the Steering Committee. The retrofits are located throughout the Park (**Figure 4.1**) and include the following structural control practices:

- Stormwater diversion structures;
- Vegetated wet swales;
- Vegetated dry swales;
- Infiltration basins; and
- Bioretention.

Non-structural practices are also incorporated into the overall concepts, and include buffer restoration, removal of geese habitat/feeding areas, and pavement reduction.

Table 4.1. Recommended Stormwater BMP Retrofit Locations

Site ID*	Location	Description
RWP-3B	Carousel Parking Lot	Construct bioretention in existing degraded pervious area at entrance for half of parking lot runoff; overflow into existing closed drainage system
RWP-17/18	F.C. Greene Memorial Blvd	Create paved flume/inlet structure direct road runoff to wet swale; modify box culvert to create diversion structure to divert runoff to bioretention
RWP-24	F.C. Greene Memorial Blvd between Cunliff and Deep Spring Lakes	Increase buffer vegetation and reduce road width/impervious surface; remove curb and add vegetated swale in buffer to capture water before it outfalls through the existing spillway
RWP-28	Intersection of Edgewood, Beachmont and F.C. Greene Memorial Blvd	Remove pavement and add a sand filter; install paved flumes and forbays prior to the main sand filter cell; design overflow structure to connect into existing pipe with outfall into the lake
RWP-6	Roosevelt Lake across from monument	Pavement removal, raingardens, and buffer restoration
RWP-12	Ornamental Bridge at Casino	Diversion structure into a terraced bioretention under the bridge

*Site ID corresponds to locations on watershed maps and to candidate project field form ID's

As part of this WQMP, the Project Team worked together to design and permit all of the practices listed in Table 4.1. All of the sites, excluding Site 3B, required DEM review and approval of both the BMP design and the proposed disturbance within the perimeter wetland buffer. During the watershed assessment, Site RWP-6 was initially targeted as a suitable site for a Wet Vegetated Treatment System (WVTS). After discussions with the Parks and Recreation Department and their landscape architect, Gardner+Gerrish, it was determined that the portion of F.C Greene Memorial Boulevard which runs through this site would be removed, thereby eliminating most of the stormwater runoff from impervious cover. Due to this change in park design and reduction in impervious cover, it was determined the WVTS would not be necessary for the treatment of stormwater runoff and simple rain gardens and buffer restoration would be a better option for this location. Tim Gardner, RLA (Gardner+Gerrish) developed the plans for permitting of this site.

Upon review and approval from the DEM, and in coordination with the City of Providence and the Parks and Recreation Department, construction drawings and specifications were developed and put out to public bid for the following sites:

- Site RWP 17/18 – Diversion structure and wet swale
- Site RWP 24 – Bioswale
- Site 28 – Sand Filter

Through additional funding secured by Rhode Island Natural History Survey (RINHS), it was determined the following two additional sites would be selected for installation.

- Site RWP-6 - Roosevelt Lake pavement reduction, rain gardens and buffer restoration
- Site RWP-12 - Terraced bioretention facility

Construction drawings and specifications were developed in coordination with RINHS, NBEP and the Parks and Recreation Department.

Local contractors were selected based upon bid price and qualifications. Sites RWP-6, 17/18, 24 and 28 were selected for final construction. Due to bid prices and limited funding, it was determined that Site RWP-12 would not be constructed as part of this funding round, but will be considered for construction at a future date. Construction began at Site RWP-28 and RWP-6 in November 2012. A comparison of the bid price and planning and design level cost estimates is provided in Table 4.2.

Table 4.2. Planning Level and Bid Costs Comparison

Site ID*	Location	Planning Level Cost	Design Level Cost	Bid Price
RWP-3B	Carousel Parking Lot	Demonstration	Demonstration	Demonstration
RWP-17/18	F.C. Greene Memorial Blvd	$32,500	$77,000	
RWP-24	F.C. Greene Memorial Blvd between Cunliff and Deep Spring Lakes	$49,000	$91,000	
RWP-28	Intersection of Edgewood, Beachmont and F.C. Greene Memorial Blvd	$140,000	$113,000	
RWP-6	Roosevelt Lake across from monument	NA	NA	$297,000
RWP-12	Ornamental Bridge at Casino	$89,000	$121,000	$112,000
*Site ID corresponds to locations on watershed maps and to candidate project field form ID's				

The 28 remaining stormwater retrofit sites identified in Chapter 3 should also be considered as part of the short-term and mid-term recommendations. As funds become available, or if general site improvements are undertaken in the general vicinity of the remaining sites, the opportunity to construct additional stormwater retrofits may be possible within 10 years. It may not be possible to construct all of remaining sites within the next 10 years; therefore these sites should also be included as part of any long-term plans developed for the Park. Detailed descriptions and planning level cost estimates for the remaining retrofit sites are provided in **Appendix F and G.**

4.2.2 Non-Structural BMPs

Site Specific

A number of site specific non-structural opportunities were identified to prevent pollution, enhance park appearance, reduce geese habitat, and provide public education and outreach opportunities. **Table 4.4** provides five individual nonstructural opportunities identified during the assessment process for short-term implementation. The five sites were selected from a list of fourteen practices which included:

- Buffer restoration;
- Slope stabilization; and
- Curb removal.

Unlike the stormwater retrofits, these practices were not ranked, but were selected based on visibility and public education outreach potential, practice type, and urgency of implementation. The practices chosen for short-term implementation include buffer restoration and slope stabilization and were selected from the BMP ranking list provided in **(Section 3.0)**. The retrofits are located throughout the Park **(Figure 4.2)** and include structural control practices including stormwater diversion structures, vegetated swales, and bioretention. Non-structural practices are also included as part of the overall concepts and include buffer restoration, removal of geese habitat/feeding areas, and pavement reduction.

Table 4.3. Recommended Short-Term Non-structural Locations

Site ID*	Location	Description	Practice
RWP-1G	Shoreline near Boathouse	Re-vegetate buffer area with low-growing grasses and shrubs	Buffer Restoration
RWP-2	Road by Carousel	Plant native material; augment soils and convert low area at yard drain to rain garden; shoreline buffer plantings	Buffer Restoration
RWP-16	Hillside near Polo Lake	Plant with native, low-growing grasses and shrubs to stabilize and provide vegetated buffer to Polo Lake	Slope Stabilization
RWP-22	Hillside erosion near Pleasure Lake	Re-vegetate erosion near stairs; re-plant area of recent storm damage/tree removal; remove area of Japanese knotweed	Slope Stabilization
RWP-23	F.C. Greene Memorial Blvd by Temple of Music	Curb removal only and create areas of no-mow meadows	Curb Removal

*Site ID corresponds to locations on watershed maps and to candidate project field form ID's

The nine remaining non-structural sites identified in Chapter 3 should also be considered as part of the short-term and mid-term recommendations. As funds become available, or if general site improvements are undertaken in the general vicinity of the remaining sites, the opportunity to provide additional improvements may be possible within the next 10 years. However, it may not be possible to construct all of remaining sites within this timeframe;

therefore these sites should also be included in any the long-term plans developed for the Park. Detailed descriptions and planning level cost estimates for the remaining sites are provided in **Appendix H and I.**

Programmatic

The first priority in the implementation of the non structural programmatic practices should be the development of a comprehensive O&M Plan for the existing and recently installed stormwater management practices as described in **Section 3.2.3.** The development of an O&M Plan is critical to not only the long-term proper operation and function of the recently installed stormwater retrofit BMPs, but also to address the neglected existing stormwater conveyance system within the Park. This includes the cleaning of all clogged catch basins and the implementation of an enhanced street sweeping program. During the assessment, numerous catch basins were identified as clogged that have significant impacts on how stormwater runoff is managed within the Park. Specifically, in the section of F.C. Greene Boulevard in the Park's eastern area along Edgewood and Elm Lakes, there are a significant amount of clogged catch basins. Many of the same catch basins along F.C. Greene Boulevard that were identified in the watershed assessment were also identified as clogged in the "Roadway Improvement Project – Roger Williams Avenue – Phase II" plan set dated 1995. In some instances, stormwater runoff travels long distances via overland flow due to clogged basins, thereby inundating the ultimate downstream receiving structures. It should be noted the recommended stormwater retrofits referenced in **Section 4.2.1** have assumed that the existing catch basins will be cleaned and functioning properly and have been sized accordingly. Turf management including fertilization and mowing frequency, and park staff training should also be addressed in the O&M Plan.

As mentioned earlier, the improvement of the water quality in the RWP Ponds will require a long-term commitment to not only changing current stormwater treatment practices and watershed management, but also to altering the Park's general appearance and maintenance practices to reduce the impacts to the Ponds. In order to address these issues and move forward with the implementation of both the short-term and long-term recommendations of this WQMP, it is recommended that a comprehensive park master planning process begin within the next one to five years. At a minimum a comprehensive park master plan is needed to address the current park usage, roads, sidewalks and other paved surfaces (both vehicular and pedestrian) for removal or pavement reduction, parking requirements, modified shoreline access, and park maintenance practices. A master plan for the Park will be instrumental in serving as a guide for the appropriate implementation of stormwater quality control practices and should address not only water quality, but park usage and the implication of any significant changes of the its historical character.

The Park was originally designed in 1878 for a specific use and purpose in the context of that time. Over the years changes have been made to address changing needs, such as the widening of roadways by the WPA in the 1930s to accommodate vehicular traffic, and it seems appropriate that a master plan be developed to more closely reflect modern usage and environmental concerns. The identification of "low mow "areas to create grassy meadows or the reduction of formal shoreline access are examples of changes that could be undertaken to improve water quality and change current usage detrimental to the overall RWP Ponds appearance and health. The development of an all encompassing master plan would serve as a guiding document to lead the Park and water quality management into the 21st Century.

Geese Management/Population Control

A Geese Control Plan has been developed by USDA APHIS and measures have already been taken within the Park to reduce the overall Canada Geese population. This will be an on-going effort within the Park and should be considered as an integral part of the WQMP.

Leaf Litter Pick Up

The Parks and Recreation Department should continue their current leaf litter pick up program. Spring and fall leaf litter should be scheduled for the road and lawn areas. A leaf litter pick up program should also be discussed with both Cranston and Providence. Information pertaining to the importance of leaf litter pick up should be included in any proposed neighborhood public outreach programs.

Phosphorus Ban

If not already doing so, the Parks and Recreation Department should eliminate the use of phosphorus fertilizers in lawn areas. A phosphorus ban should be considered for the Park's surrounding cities of both Cranston and Providence and eventually statewide. At a minimum, awareness regarding the negative impact of phosphorus use should be included in any public outreach program.

4.2.3 In-Pond Treatment

Completion of any major in-pond treatments, such as dredging, within the next 10 years will require a strong commitment from the City and aggressive action. Additional studies, permitting, and design plans will need to be completed prior to implementation of any in-pond management actions as described in **Section 3.2.6**. The recommended priorities for the next one to five years are based upon the recommendations found in **Section 3.2.6**.

1. **Continue the control of nuisance rooted aquatic plants**
   Obtain annual written reports on the locations and types of plants treated and the locations of invasive species. As part of the plant control the Parks and Recreation Department should begin to complete annual quantitative evaluations of plant community conditions and changes.

2. **Continue the control of nuisance algal blooms.**
   Complete a study of phytoplankton species and numbers within the RWP Ponds and continue to collect data at the same frequency as basic water quality data.

3. **Begin monitoring of RWP Ponds for Secchi depth, dissolved oxygen and nutrients several times a year.**
   See **Section 4.2.5**.

4. **Evaluate the fishery and consider carp control.**
   Verify carp population by completing a fisheries survey.

5. **Treatment of the inflow from the Upper Watershed at the Roosevelt Pond inlet to reduce total phosphorus load by approximately half and reduce the total suspended solids load substantially.**
   The alum dosing station is viewed as a potential priority project that will provide interim relief while other watershed management options are proceeding, and as protection on investments made in other in-pond management approaches. Therefore preparation of an engineering feasibility/design study to determine the best method for treating the inflow from Mashapaug Pond should occur within the next three years. See **Section 4.2.5.**

6. **Dredge Roosevelt, Polo, Willow and Pleasure Ponds to remove soft sediment accumulation and rooted aquatic plants.**
   Complete a study to determine soft sediment depth within the targeted ponds, and perhaps all the Ponds, to confirm which have substantial soft sediment accumulation. Sample and test areas targeted for dredging for toxics and metals required to determine dredging disposal options.

7. **Inactivate sediment available phosphorus in Edgewood, Cunliff and Elm Lakes.**
   Complete a more comprehensive evaluation of loosely sorbed, iron-bound and total phosphorus in the RWP Pond sediments.

4.2.4 Public Education

As identified in **Section 3.2.7,** public education and outreach is an important element of any water quality management plan. Educating the public on the water quality issues and identifying ways for the Park visitors and surrounding neighborhoods to assist in water quality improvement should be the first step. The following short-term recommendations have been developed, based upon **Section 3.2.7,** to lay the foundation for a long-term public education and outreach program for all of the Park users

General Items

The first step should include some general organization and the development of a central watershed volunteer group. Members should include representatives from all user groups and could be used to assist with the creation and implementation of a long-term education and outreach program. A strong volunteer organization is critical to the long-term success of any public outreach program, therefore, the following general recommendations are provided:

1. The Friends of Roger Williams Park Ponds organization should be strengthened and expanded. The creation of the Facebook page and the current project website located on the NBEP website are a strong first step, but the development of a stand-alone park website, or one linked to the City of Providence website, should be considered. It could

provide a central location for the dissemination of all park and pond related information. The following links are examples of both stand-alone and linked park websites:

http://www.centralparknyc.org/

http://www.cityofboston.gov/freedomtrail/bostoncommon.asp

http://www.riparks.com/colt.htm

http://www.ballardpark.org/

A website could also serve as an effective tool to generate more interest in the Park and encourage volunteerism, which could include park clean ups, water sampling and/or monitoring, fish surveys, and other park related efforts.

2. The Parks and Recreation Department, in collaboration with NBEP, should continue the public meetings and consider expanding to include guest speakers to discuss issues related to the Park.

Residential Audience

The Park is surrounded by a diverse spectrum of residential neighborhoods. These neighborhoods have a direct impact on the Ponds through usage from the residents as well as the direct contribution of stormwater runoff to the RWP Ponds. Outreach within these neighborhoods is vital to not only change detrimental park usage patterns, but to encourage stormwater runoff reduction through onsite management at the residential level. The following short-term recommendations are provided to target this group:

1. Conduct a public stormwater retrofit installation demonstration within the Park. This program could benefit the Parks and Recreation Department maintenance crew and local landscape contractors, as well as surrounding residents alike. The design and construction of a raingarden could be explained and demonstrated as well as a discussion on suitable residential applications to disconnect pavement and roof runoff from the storm drainage system. The retrofit demonstration project advertisement should include targeted mailings, local newspaper ad, cable access television stations, radio, and other media outlets in advance of project implementation. Publish a follow-up article in the *Providence Journal* or story on the local news stations. Site RWP-2 (raingarden near the Carousel) would be a good candidate for educational signage.

2. The creation or distribution of an existing informational pamphlet providing an overview of BMPs (e.g., rain gardens and/or rain barrels) that can be installed on individual properties to reduce stormwater runoff. In addition, residents in the surrounding neighborhoods should be targeted for information on catch basin stenciling, proper pet

waste management, and pond-friendly lawn care. This information could also be linked to the Park website proposed under the general recommendations.

3. Install educational signage at select stormwater retrofit sites along the perimeter of the Park and abutting the residential neighborhoods. Sites 28 and 29 would be good candidates for this type of signage.

Frequent Park Users

The Park has a diverse group of frequent users including fisherman, boaters, kayakers, bicyclists, sports enthusiast, and the geese feeders. Due to this group's diversity and transient nature of their visits, public education to this group has proven to be the most difficult. Education targeted to this group will need to be incorporated into the use areas and address the need to alter current behaviors that might be detrimental to the pond water quality or the public health. The following short-term recommendations are provided to target this group:

1. Warning signs should continue to be posted to alert fisherman and boaters on the health risks related to fish consumption and the contact with pond water. This group of park users could also be a valuable resource for a fish inventory through the use of an interactive website.

2. The distribution of up-to-date water quality information through a park website or Facebook page.

3. Educational signage should be installed to explain the link between stormwater runoff, pond water quality, the constructed BMPs, and the health of the fish population. Site RWP 24 or the boat ramp would be a good candidate for educational signage to target this group.

4. The geese feeders are probably the most difficult group to reach, as they comprise all of the Park users and often see the geese as a park attraction. As a first step, educational signage should be installed at the proposed BMP locations identified as geese feeding areas to explain water quality and the importance of reduction of geese habitat. Sites RWP-6, RWP-17/18, and RWP-24 would be good candidates for this type of educational signage.

Casual Park Visitors

The Park is a significant tourist attraction for both in-state residents as well as visitors from around New England and abroad. The high number of visitors to the Park presents a unique opportunity to reach a wide spectrum of park users that can have a significant, yet unknowingly, impact on the water quality of the Ponds. The following recommendations are provided to target this group:

1. Install educational signs highlighting both the structural and non-structural BMPs installed within the most frequently visited areas of the Park (Roosevelt, Willow, and

Polo Lakes). These signs should not only highlight the improved water quality treatment, but also focus on the reduction of geese habitat/feeding areas, the value of a vegetated shoreline, and identification of plants used. The signs should promote awareness of the BMP benefits to the Ponds and their importance to all visitors. Sites RWP-1G and RWP-2 would be good candidates for this type of educational signage.

2. Create an informational pamphlet providing an overview of the water quality issues and to raise awareness. This pamphlet could be distributed to visitors at the Carousel, Boathouse, and Zoo.

3. Linkage of websites between different entities within the Park, such as Roger Williams Park Zoo, local and state agencies such as, RIDEM, City of Providence and the City of Cranston, or informational websites where links to basic homeowner stormwater education guidance material is posted.

Park Staff and Other facilities

This group includes park maintenance and the other facilities that would benefit from educational opportunities related to site maintenance both within the Park and at their individual facilities.

1. Public stormwater retrofit installation demonstration as identified under general recommendations.
2. A maintenance seminar to focus on good stormwater maintenance practices as well as "green" landscape practices.

4.2.5 Water Quality Monitoring

A few programs in Rhode Island are already in place to measure certain relevant water quality indicators. These include:

- The Narragansett Bay Commission (NBC) Environmental Monitoring and Data Analysis;
- The University of Rhode Island (URI) Watershed Watch Program; and
- The EPA/AED.

The NBC is a publicly owned facility treating wastewater from domestic, commercial, and industrial sources in the metropolitan Providence and Blackstone Valley areas. It tracks and publishes the levels of nutrients, totals suspended solids, biochemical oxygen demand, fecal coliform, and other water quality parameters throughout its service areas. Although the NBC monitoring program does not currently include the RWP Ponds, it is a good example of a monitoring program to both measure effectiveness of control measures and provide education and outreach for the general public.

The URI Watershed Watch (URIWW) Program is involved in long-term ecological monitoring of Rhode Island's fresh and salt water resources and provides training, equipment, supplies, and analytical services to local governments, watershed, and other organizations to assess water quality. The URIWW program makes the monitoring data publicly available, improving water quality awareness of local governments as well as the general public.

In addition the EPA/AED (2011) completed a sampling round of the Ponds in 2011. Results of that sampling are to be provided under separate report from EPA.

Several suggested monitoring recommendations have been referenced in previous sections (See **Chapter 2** and **Section 3.2.6.**) as necessary to document changes in water quality over time. Listed below is a summary of these suggestions and additional recommendations for implementation within the next one to three years:

1. EPA/AED should repeat the 2011 monitoring of water quality parameters at least one additional time including, but not limited to Secchi depth, surface dissolved oxygen, surface conductivity, bottom dissolved oxygen, bottom conductivity, and water chemistry parameters.
2. Secchi depth and dissolved oxygen could be monitoring regularly by URIWW in years two and three several times during the spring, summer, and fall (refer to **Section 3.2.6** for specifics).
3. Fish species and population survey should be conducted to establish where bottom dwelling fish are abundant and potentially contributing to sediment resuspension.
4. Citizen volunteer or URIWW monitoring of constructed stormwater structural control practices should occur once annually for physical and aesthetic parameters, including but not limited to evidence of erosion, depth of sediment, and success of plant species growth and development.
5. Citizen volunteer or URIWW monitoring of non-structural vegetative planting success should occur once annually beginning in year two.
6. Monitor geese population (see separate report prepared by Tim Cozine).

Results of all monitoring should be published and posted to the project website and distributed to the public.

4.3 Upper Watershed

In the Upper Watershed (see **Section 3.3**), the assessment of different watershed management strategies was limited to the most obvious stormwater retrofit locations, including an on-site demonstration (Site UW-2), general recommendations for pollution prevention in three neighborhoods and properties with large on-site impervious cover/LUHPPLs. In addition, the field team conducted an initial assessment of the weir box located within the discharge channel/pipe system from Mashapaug Pond. The following implementation recommendations are suggested:

- The cities of Cranston and Providence should investigate funding opportunities for implementation of one or more pilot stormwater retrofit projects. Any of the five project locations identified in the Upper Watershed would serve as a good demonstration project.

Site UW-3, in particular, includes drainage from both municipalities and might be an ideal site for cooperative implementation. Short term implementation would include securing funds to design and construct one or more facilities. Current implementation cost for retrofits within an urban watershed range from approximately $30,000 to as high as $130,000 per acre of impervious cover treated depending on land use, soil type, and site specific factors (HW, 2011). For planning purposes, a cost of $50,000 per impervious acre treated would be a reasonable number for any of the proposed projects identified for the Upper Watershed.

- Since all the low flows and smaller storms are diverted in the weir box to flow towards the RWP Ponds, discharging through the 48-inch pipe into Roosevelt Lake, further investigation is warranted to evaluate the feasibility, costs, and environmental benefits/impacts of modifying this existing diversion. It would be relatively inexpensive to modify the weir box to divert some of the current flows into the 72-inch pipe that bypasses the RWP Ponds. An orifice plate could be constructed at the outlet of the 36-inch pipe discharging to the Park ponds with a small office to allow base flow to continue to flow that way and forcing runoff from storm events to flow into the 72-inch pipe. If there are capacity concerns for the 72-inch pipe, the diversion could be sized only to shunt small frequent storms (say in the range of the one-inch precipitation event) in that direction and allow an overflow back into the 36-inch pipe. For planning purposes, a construction cost of $25,000 to $40,000 would be a reasonable estimate for the implementation of a weir box flow modification. The short-term recommendation would be to conduct further investigation to answer the question of "does this make sense?" and whether or not there would be significant permitting and/or other concerns with a modification of this structure. DEM, RIDOT, the City of Providence, and NBEP, among others may have serious concerns regarding this topic. Completion of a detailed feasibility assessment might cost in the range of $15,000 to $20,000.
- Pollution prevention in the Upper Watershed would require a significant and long-term program of public education, outreach, and engagement to be effective. Conversely, though unlikely in the near-term, the cities of Cranston and Providence could enact one or more ordinances to mandate pollution prevention. As a short-term recommendation, the cities should convene a working group to initiate a pollution prevention program targeted at the businesses and residents of the Upper Watershed. The working group should establish goals for implementation and identify metrics to measure success. A planning level cost for such a program would likely in the range of $10,000 to $20,000.

4.4 Additional Studies

The following additional studies the following will need to be performed to further advance some of the recommendations indentified in implementation plan.

- RWP Ponds dredging study;
- Mashapaug Pond weir box modifications study; and
- Mashapaug in-pond treatment study

In order to better assess the in-pond options both a dredging study and in-pond treatment study will need to be completed prior to any actions being taken. A study will determine soft sediment depth within the targeted ponds, and perhaps all the Ponds, and confirm which of the Ponds have substantial soft sediment accumulation. The City should sample and test areas targeted for dredging for toxics and metals required to determine dredging disposal options. Additional sediment sampling will be needed to better characterize the sediments in all ponds.

In the Upper Watershed, additional studies will be needed to assess the viability of the proposed weir box modifications as well as Mashapaug Pond in-pond treatment options including an outflow alum dosing station. Therefore preparation of an engineering feasibility/design study to determine the best method for treating the inflow from Mashapaug Pond should occur within the next three years. The study should investigate the construction of an alum dosing station as well as monitoring the outflow volume and total phosphorus concentration over time to provide a better estimate of actual inputs to revise dosing amounts.

4.5 Estimated Pollutant Load Reductions

The recommendations provided in this WQMP serve as a guideline for improving the water quality of the RWP pond complex. Although this plan provides recommended improvement for both the upper and lower contributing watersheds, it does not provide detailed solutions for all of the potential pollutant problems and their contributing sources, this is particularly true for Mashapaug Pond. The following goals for the Ponds were developed based upon the required 73% phosphorus load reduction identified in the TMDL and by definition would allow the Ponds to meet water quality standards, and consequently would significantly reduce or eliminate the current seasonal algae problems within the Ponds. In short, the goals are to:

- Reduce phosphorous loadings to the Ponds by 20% in five years;
- Reduce phosphorous loadings to the Ponds by 42% in ten years; and
- Over the long term, continue to work towards the reduction of phosphorus loadings by up to 73%.

The estimated phosphorus load reduction summary provided in **Table 4.5** below outlines an aggressive strategy based upon these goals. The load reductions provided assume that all recommendations outline in the WQMP are implemented, including the short-, mid- and long-term management measures. In addition, other more-global management measures, such as improvements in regional air quality and regional or state-wide bans on phosphorus fertilizers, are offered as means to achieve the water quality goals of the TMDL. To meet the reductions identified in **Table 4.5**, the following additional assumptions are provided:

- 20% reduction of the internal pond recycling;
- Implementation of a wide array of structural and non structural BMPs within the Upper Watershed to improve the water quality of the contributing Mashpaug Pond and Spectacle Pond;

- Implementation of a weir box modification or major constructed wetland in Mashapaug Pond to improve the water quality of incoming water between Mashpaug Pond and Roosevelt Lake;
- Implementation of a statewide phosphorus ban or at a minimum a ban within both the Upper and Lower Watersheds;
- Implementation of an aggressive leaf litter pickup and catchbasin cleaning program within both the Upper and Lower Watersheds.
- Additional reductions for atmospheric deposition reductions based upon the continuing trends of improved air quality and the addition of more stringent future environmental regulations.

In order to achieve the identified goals the following short-, mid- and long-term recommendations are provided:

Short-Term (1-5 Years)

- Lower Watershed
    - Structural BMPs: 6 BMPs installed (#s 3B, 6, 12, 17/18, 24 and 28)
    - Non-Structural BMPs:
        - 7.5% reduction due to partial phosphorus ban and leaf litter pickup.
        - Waterfowl: Geese population reduced to 50 birds.
- Upper Watershed
    - Non-Structural BMPs: 7.5% reduction due to partial phosphorus ban and leaf litter pickup.

Mid-Term (5-10 Years)

- Lower Watershed Non-Structural:
    - 10% reduction due to phosphorus ban, leaf litter pickup and catch basin cleaning.
    - Waterfowl: Geese population reduced to 50 birds.
    - Structural BMPs: All 30 BMPs in RWP installed.
- Upper Watershed
    - Structural BMPs: 50% reduction due to weir box modification or major constructed wetland in Mashapaug Pond.
    - Non-Structural BMPs: 15% reduction due to phosphorus ban, leaf litter pickup and catch basin cleaning.
- Internal Pond Recycling: 20% load reduced due to lower incoming loads (from waterfowl and Upper Watershed).

Long-Term (10-25 Years)

- Lower Watershed
    - Non-Structural BMPs: 20% reduction due to phosphorus ban, leaf litter pickup and regular catch basin cleaning and regular street sweeping Structural BMPs: All 30 BMPs in RWP installed + additional BMPs beyond RWP, resulting in 50% load reduction.

- Waterfowl: Geese population reduced to 50 birds.
- Upper Watershed
  - Structural BMPs: 60% reduction due to weir box modification or major constructed wetland in Mashapaug Pond, plus additional BMPs
  - Non-Structural BMPs: 20% reduction due to phosphorus ban, leaf litter pickup, regular catch basin cleaning, and regular street sweeping.
- Atmospheric deposition: 5% load reduced due to cleaner air quality nationally.
- Internal Pond Recycling: 35% load reduced due to lower incoming loads (from waterfowl and Upper Watershed) and 35% of load reduced due to dredging.

Table 4.4. Estimated Phosphorous Load Reduction Summary

Source Area	Current Loading to Ponds		Phosphorus Reduction Over Time by Management Activity						
				Short Term (5 Yrs)		Mid Term (10 Yrs)		Long term (25 Yrs)	
	Load #	%		Load #	% of Total	Load #	% of Total	Load #	% of Total
Atmospheric Deposition	64	6.9	Air quality improvement	0	0	0	0	3.2	0.3
Pond Internal Recycling	128	13.9	Lower incoming load	0	0	25.6	2.8	44.8	4.9
			Dredging	0	0	0	0	44.8	4.9
Waterfowl	154	16.7	Removal/Habitat Alteration	132	14.3	132	14.3	132	14.3
Upper Watershed Stormwater	360	39.0	Non-Structural	27	2.9	54	5.9	72	7.8
			BMPs (includes weir box or other structure)	0	0	126	13.7	216	23.4
Lower Watershed Stormwater	216	23.5	Non-Structural	16.2	1.8	21.6	2.3	43.2	4.7
			BMPs	9.2	1.0	27.5	3.0	108	11.7
Totals	922	100		184.4	20.0	386.7	41.9	664.0	72.0

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Providence
Cranston
Legend
Roger Williams Pond Watershed (Revised October 2011)
Town Boundaries
Non-Structural BMP Retrofit
RIDEM Priority Outfall
Pond Inlet/Outlet (Providence GIS)
N
Feet
350
Horsley Witten Group
Lower Watershed
Recommended Non-Structural
BMP Retrofit Locations
Roger Williams Park
Rhode Island
Date: 1/17/2012
Figure 4.2


Providence
Cranston
Legend
Roger Williams Pond Watershed (Revised October 2011)
Drainage Area to Structural BMP
Town Boundaries
RIDEM Priority Outfall
Pond Inlet/Outlet (Providence GIS)
Catchbasin (Providence/Cranston GIS)
N
Feet
350
Horsley Witten Group
Lower Watershed
Recommended Structural
BMP Retrofit Locations
Roger Williams Park
Rhode Island
Date: 3/28/2013
Figure 4.1

Compliance Reporting Requirements

Providence shall submit to the RIDEM a compliance report for the previous calendar year. Each compliance report shall include, at a minimum, the following items:

1. An identification of all plans, reports, and other submissions required by the Consent Agreement that were completed and submitted;
2. A description of all proposed changes to the remedial measures included in documents as approved by the RIDEM under the terms of the Consent Agreement;
3. An identification of all noncompliance with the requirements of the Consent Agreement. If any noncompliance is reported, the notification shall include the following information:
    a. A description of the noncompliance;
    b. A description of all factors that explain or mitigate the noncompliance;
    c. A description of all actions taken or proposed by Providence to comply with all lapsed requirements; and
    d. The date by which Providence will perform the required actions;
4. The status of all requirements listed in Paragraph C(4)(a)(ii) of the Consent Agreement, including:
    a. For each structural control for which construction was completed since the previous report, a construction report that includes the following information: (i) certification that the structural stormwater control was constructed, and is operating, in accordance with manufacturer or design specifications; (ii) the date construction of the structural stormwater control was completed; and (iii) a description of any differences between the final structural stormwater control as-built and as designed; and
    b. For the non-structural practices , track participation in the pollution prevention and public education programs, and report this information, along with a narrative of Providence's and its partner's outreach and education efforts;
5. The status of Providence's actions to address Impaired Water Body Segments as required under Paragraphs C(4)(a)(iii), (iv) and (v) of the Consent Agreement, that includes a summary of actions proposed in the TMDL Implementation Plan ("IP"); construction status of all structural stormwater controls proposed in the TMDL IP; construction completion date of all structural stormwater controls; and implementation status of all enhanced non-structural BMPs proposed in the TMDL IP, as follows:
    a. A report that identifies each proposed structural control in an approved TMDL IP and the status of implementation of the structural control. For each structural control for which construction was completed since the previous report, a construction report that includes the following information: (i) certification that the structural stormwater control was constructed, and is operating, in accordance with manufacturer or design specifications; (ii) the date construction of the structural stormwater control was completed; and (iii) a description of any

differences between the final structural stormwater control as-built and as designed;

b. The report shall also state the estimate of the level of pollutant removal (and runoff volume reduction and peak flow attenuation if the Impervious Cover Standard is applicable) that was anticipated to be achieved by the proposed structural control at the TMDL IP stage and updated estimates at the construction completed stage. If the estimate at the construction completed stage is different from the estimate in the approved TMDL IP, Providence shall identify the change in estimate and provide a summary of the reasons for the change in estimate. Where Paragraph C(4)(a)(v)7 of the Consent Agreement is applicable, proposed TMDL IP amendment(s) shall be submitted in accordance with the time frames in Paragraph C(4)(a)(v)7 and shall be referenced in the report;

6. A summary of Operations and Maintenance ("O&M") activities performed by Providence for structural stormwater controls (including yearly inspections, but not including minor routine housekeeping, such as mowing or trash removal in median), excluding catch basin inspections and cleaning. The O&M summary shall include the activity, identification of the structural control by type and location, and date. Providence may submit an electronic or paper copy of an O&M report or a report from Providence's maintenance management system;

7. The amount of the MS4 mapping completed, the percent mapped to date, and a current map of the combined, sanitary and storm sewer systems submitted to the RIDEM electronically in an ArcGIS compatible format, using RI State Plane Coordinate system - feet, NAD1983. The map shall include, but not be limited to, locations of all outfalls, receiving waters, catch basins, manholes, pipes, culverts, swales, and ditches that contribute drainage to Providence's outfalls, as well as flow direction and connectivity, and the location of all interconnections between existing public and private drainage systems and with other MS4s;

8. A spreadsheet that includes the location of all stormwater outfall pipes that are owned by Providence (the "Outfall Pipes") along with the names and locations of all receiving waters, with latitudes and longitudes and receiving waters for each pipe; document all procedures used to identify the Outfall Pipes; and submit all the information to the RIDEM. This information shall be submitted using the Excel spreadsheet for reporting such information provided by RIDEM;

9. The total number of Outfall Pipes and interconnections screened in dry weather and in wet weather, and the results of all screening and sampling completed. The results shall include the date of visit, number of outfalls, catch basins, manholes, and interconnections screened, identifier, location (latitude and longitude), receiving water, water body segment name and identification, weather conditions at time of sampling, precipitation in previous 48 hours, the results of field observations, field screening parameter results, and results of all analyses. The report shall include all information and data for the current reporting period and the entire cumulative reporting period to date. The results of the dry and wet weather surveys shall be submitted electronically using the Excel spreadsheet for reporting such information provided by the RIDEM;

10. An update of catch basin and manhole inspections for illicit connections and non-stormwater discharges, including a tabular summary that identifies the structures inspected, date of inspection, findings and corrective actions taken and/or required, and confirms that all of Providence's structures have been inspected at least once. This information shall be submitted to the RIDEM in electronic format;

11. The results of the work to determine whether there are any interconnections between the MS4 and other MS4s through which the MS4 indirectly discharges to the other MS4s' outfall and the results of screening at any such MS4 interconnections;

12. A description of all (i) citizen complaints of illicit discharges, (ii) reports of illicit discharges from the RIDEM, or (iii) internal referrals for IDDE evaluation based upon catch basin inspections or during other construction or maintenance work, and if an IDDE investigation was not initiated, the reasons Providence did not initiate such an investigation;

13. A description of all IDDE illicit discharge investigations Providence conducted, including a description of what information prompted the investigation (e.g., IDDE screening, catch basin inspection, citizen complaint, etc.), on what date that information was received by Providence, the date on which Providence's IDDE investigation was initiated and completed, and the outcome of the IDDE investigation. Should Providence choose to exclude an outfall or parts of a system from investigation, the report shall document and explain the reasoning behind this decision;

14. A list of all IDDE illicit discharge investigations that were not completed within 180 days of initiation of the investigation, a schedule for completing each such IDDE illicit discharge investigation, and an explanation as to why the schedule will ensure that the illicit discharge investigation is completed as expeditiously as possible. For each IDDE illicit discharge investigation schedule listed in the previous report, specify whether Providence complied with its schedule for completion, and if not, the reasons for the delay;

15. An updated list of all the illicit discharges verified through the end of the calendar year, including the following information:

    a. The date the illicit discharge was verified;

    b. The dates the RIDEM was notified of the presence of the illicit discharge;

    c. The date(s) the owner of the illicit discharge was notified;

    d. A list of those illicit discharges verified, but not removed within 120 days of verification, with an explanation for each;

    e. The schedule for the removal of each illicit discharge that was not removed within 120 days of verification and an explanation as to why the schedule will ensure that the illicit discharge is eliminated as expeditiously as possible;

    f. For each schedule for the removal of an illicit discharge listed in the previous report, specify whether Providence complied with its schedule for removal, and if not, the reasons for the delay;

    g. The actions taken to eliminate the illicit discharge and the dates on which the actions were taken;

h. The date the illicit discharge was eliminated; and

i. Dates and results of IDDE dry and wet weather sampling to confirm removal of the illicit discharge;

16. An amended IDDE Plan that includes a revised ranking and prioritization of screening and investigations of infrastructure and a revised implementation schedule;

17. An updated list of Providence's inventory of municipally-owned and privately-owned structural controls that drain to the MS4 (both baseline existing conditions and as they are constructed), and documentation of the date and type of maintenance activities performed that confirms adequate maintenance practices are being followed. This information shall be submitted electronically to the RIDEM;

18. An update of the street sweeping status. The update shall include the total curb-miles in that frequency category, the curb-miles swept (and number of times swept). The update shall also report on streets required to be swept twice annually in the Providence portion of the Lower and Upper Watersheds, as identified in the RWPP Plan, that contribute flow to the MS4 (including portions interconnected to stormwater drainage systems owned by others); and

19. An update of catch basin and manhole inspection and cleaning status, including identification of the catch basins and manholes that were cleaned and/or inspected. This information shall include the number of catch basins and manholes that were inspected, as well as the number that were cleaned, and be broken down by general geographical location. Providence must document the results of the inspections in a tabular summary containing the unique identifier for each catch basin connected to the MS4, the latest inspection date, the latest cleaning date, time between cleanings, available depth from invert to bottom of sump, depth from invert to sediment, depth of accumulation, rate of sediment accumulation (average inches per day), and calculated target frequency of cleaning to maintain sediment accumulation at or below 50% capacity. This information shall be submitted to the RIDEM in electronic format.

EPA New England Bacterial Source Tracking Protocol
Draft – January 2012

Purpose

This document provides a common framework for EPA New England ("EPA-NE") staff to develop and implement bacterial source tracking sample events, and provides a recommended approach to watershed association, municipal, and State personnel. Adopted from Boston Water and Sewer Commission ("BWSC") (2004), Pitt (2004), and based upon fieldwork conducted and data collected by EPA-NE, the protocol relies primarily on visual observations and the use of field test kits and portable instrumentation during dry and wet weather to complete a screening-level investigation of stormwater outfall discharges or flows within the drainage system. When necessary, the addition of more conclusive chemical markers may be included. The protocol is applicable to most typical Municipal Separate Storm Sewer Systems ("MS4s") and smaller tributary streams. The smaller the upstream catchment area and/or more concentrated the flow, the greater the likelihood of identifying an upstream wastewater source.

Introduction

The protocol is structured into several phases of work that progress through investigation planning and design, laboratory coordination, sample collection, and data evaluation. The protocol involves the concurrent collection and analyses of water samples for surfactants, ammonia, total chlorine, and bacteria. When more precise confirmation regarding the presence or absence of human sanitary sewage is necessary, and laboratory capacity is available, the additional concurrent collection of samples for select Pharmaceutical and Personal Care Product ("PPCP") analysis is advised. When presented with a medium to large watershed or numerous stormwater outfalls, the recommended protocol is the screening of all outfalls using the surfactant, ammonia, total chlorine, and bacterial analyses, in addition to a thorough visual assessment. The resulting data and information should then be used to prioritize and sample a subset of outfalls for all parameters, including PPCP compounds and additional analyses as appropriate. Ideally, screening-level analyses can be conducted by state, municipal, or local watershed association personnel, and a prioritized sub-set of outfalls can be sampled through a commercial laboratory or by EPA-NE using more advanced confirmatory techniques.

Step I – Reconnaissance and Investigation Design

Each sample event should be designed to answer a specific problem statement and work to identify the source of contamination. Any relevant data or reports from State, municipal, or local watershed associations should be reviewed when selecting sample locations. Aerial photography, mapping services, or satellite imagery resources are available free to the public through the internet, and offer an ideal way to pre-select locations for either field verification or sampling.

Sample locations should be selected to segregate outfall sub-catchment areas or surface waters into meaningful sections. A common investigative approach would be the identification of a specific reach of a surface water body that is known to be impaired for bacteria. Within this specific reach, stormwater outfalls and smaller tributary streams would be identified by desktop reconnaissance, municipal outfall mapping, and field investigation when necessary. Priority outfalls or areas to field verify the presence of outfalls should be selected based on a number of factors, including but not limited to the following: those areas with direct discharges to critical or impaired waters (e.g. water supplies, swimming beaches); areas served by common/twin-invert manholes or underdrains; areas with inadequate levels of sanitary sewer service, Sanitary Sewer Overflows ("SSOs") or the subject of numerous/chronic sanitary sewer customer complaints; formerly combined sewer areas that have been separated; culverted streams, and; outfalls in densely populated areas with older infrastructure. Pitt (2004) provides additional detailed guidance.

When investigating an area for the first time, the examination of outfalls in dry-weather is recommended to identify those with dry-weather flow, odor, and the presence of white or gray filamentous bacterial growth that is common (but not exclusively present) in outfalls contaminated with sanitary. For those outfalls with dry-weather flow and no obvious signs of contamination, one should never assume the discharge is uncontaminated. Sampling by EPA-NE staff has identified a number of outfalls with clear, odorless discharges that upon sampling and analyses were quite contaminated. Local physical and chemical conditions, in addition to the numerous causes of illicit discharges, create outfall discharges that can be quite variable in appearance. Outfalls with no dry-weather flow should be documented, and examined for staining or the presence of any obvious signs of past wastewater discharges downstream of the outfall.

As discussed in BWSC (2004), the protocol may be used to sample discreet portions of an MS4 sub-catchment area by collecting samples from selected junction manholes within the stormwater system. This protocol expands on the BWSC process and recommends the concurrent collection of bacteria, surfactant, ammonia, and chlorine samples at each location to better identify and prioritize contributing sources of illicit discharges, and the collection of PPCP compounds when more conclusive source identification is necessary.

Finally, as discussed further in Step IV, application of this sampling protocol in wet-weather is recommended for most outfalls, as wet-weather sampling data may indicate a number of illicit discharge situations that may not be identified in dry weather.

Step II – Laboratory Coordination

All sampling should be conducted in accordance with a Quality Assurance Project Plan ("QAPP"). A model QAPP is included as Attachment 1. While the QAPP details sample collection, preservation, and quality control requirements, detailed coordination with the appropriate laboratory staff will be necessary. Often sample events will need to be scheduled well in advance. In addition, the sampling team must be aware of the strict holding time requirements for bacterial samples – typically samples analysis must begin within 6 hours of sample collection. For sample analyses conducted by a commercial laboratory, appropriate coordination must occur to determine each facilities respective procedures and requirements.

The recommendations in this protocol are based on the use of a currently unpublished EPA-NE modification to *EPA Method 1694 – Pharmaceuticals and Personal Care Products in Water, Soil, Sediment, and Biosolids by HPLC/MS/MS.* Several commercial laboratories may offer Method 1694 capability. EPA-NE recommends those entities wishing to utilize a contract laboratory for PPCP analyses ensure that the laboratory will provide quantitative analyses for acetaminophen, caffeine, cotinine, carbamazepine, and 1,7-dimethylexanthine, at Reporting Limits similar to those used by EPA-NE (See Attachment 2). Currently, the EPA-NE laboratory has limited capacity for PPCP sampling, and any proposed EPA-NE PPCP sample events must be coordinated well in advance with the appropriate staff.

Step III – Sample Collection

Once a targeted set of outfalls has been selected, concurrent sampling and analyses for surfactants, ammonia, and total chlorine (which can all be done through the use of field kits), in addition to bacteria (via laboratory analysis) should be conducted. When numerous outfalls with dry-weather flow exist, sample locations should be prioritized according to the criteria mentioned above. In addition, field screening using only the field kits may occur during the field reconnaissance. However, it must be emphasized that the concurrent sampling and analyses of bacteria, surfactant, ammonia, and total chlorine parameters is the most efficient and cost-effective screening method.

When first observed, the physical attributes of each outfall or sampling location should be noted for construction materials, size, flow volume, odor, and all other characteristics listed on the data collection form (Attachment 3). In addition, GPS coordinates should be collected and a photograph of the sample location taken. Whenever possible, the sampling of storm drain outfalls should be conducted as close to the outfall opening as possible. Bacterial samples should be collected first, with care to not disturb sediment materials or collect surface debris/scum as best possible. A separate bottle is used to collect a single water sample from which aliquots will be analyzed for surfactants, ammonia, and total chlorine. A sample for PPCP analysis is recommended to be collected last, as the larger volume required and larger bottle size may cause some sediment disturbance in smaller outfalls or streams. If necessary, a second smaller, sterile and pre-cleaned sampling bottle may be used to collect the surface water which can then be poured into the larger PPCP bottle. Last, a properly calibrated temperature/specific conductance/salinity meter should be used to record all three parameters directly from the stream or outfall. When flow volume or depth is insufficient to immerse the meter probe, a clean sample bottle may be utilized to collect a sufficient volume of water to immerse the probe. In such instances, meter readings should be taken immediately.

As soon as reasonably possible, sample aliquots from the field kit bottle should be analyzed. When concurrent analyses are not possible, ammonia and chlorine samples should be processed first, followed by surfactant analysis, according to each respective Standard Operating Procedure as appropriate based on the particular brand and type of field test kit being used. All waste from the field test kits should be retained and disposed of according to manufacture instructions. Where waste disposal issues would otherwise limit the use of field kits, EPA-NE recommends that, at a minimum, ammonia test strips with a Reporting Limit below 0.5 mg/L be utilized. Such test strips typically are inexpensive and have no liquid reagents associated with their use. Results should be recorded, samples placed in a cooler on ice, and staff should proceed to the next sample location.

Upon completion of sampling and return to the laboratory, all samples will be turned over to the appropriate sample custodian(s) and accompanied by an appropriate Chain-of-Custody ("COC") form.

Step IV – Data Evaluation

Bacterial results should be compared to the applicable water quality standards. Surfactant and ammonia concentrations should be compared to the thresholds listed in Table 1. Evaluation of the data should include a review for potential positive results due to sources other than human wastewater, and for false negative results due to chemical action or interferences. In the EPA-NE region, field sampling has indicated that the biological breakdown of organic material in historically filled tidal wetlands may cause elevated ammonia readings, as can the discharge from many landfills. In addition, salinity levels greater than 1 part per thousand may cause elevated surfactant readings, the presence of oil may likewise indicate elevated levels, and fine suspended particulate matter may cause inconclusive surfactant readings (for example, the indicator ampule may turn green instead of a shade of blue). Finally, elevated chlorine from leaking drinking water infrastructure or contained in the illicit wastewater discharge may inhibit bacterial growth and cause very low bacterial concentrations. Any detection of total chlorine above the instrument Reporting Limit should be noted.

Table 1 – Freshwater Water Quality Criteria, Threshold Levels, and Example Instrumentation [1]

Analyte/ Indicator	Threshold Levels/ Single Sample[3]	Instrumentation
E. coli [2]	235 cfu/100ml	Laboratory via approved method
Enterococci [2]	61 cfu/100ml	Laboratory via approved method
Surfactants (as MBAS)	≥ 0.25 mg/l	MBAS Test Kit (e.g. CHEMetrics K-9400)
Ammonia (NH_3)	≥ 0 .5 mg/l	Ammonia Test Strips (e.g. Hach brand)
Chlorine	> Reporting Limit	Field Meter (e.g. Hach Pocket Colorimeter II)
Temperature	See Respective State Regulations	Temperature/Conductivity/Salinity Meter (e.g. YSI Model 30)

[1] The mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. EPA

[2] 314 CMR 4.00 MA - Surface Water Quality Standards - Class B Waters.

[3] Levels that may be indicative of potential wastewater or washwater contamination

Once dry-weather data has been examined and compared to the appropriate threshold values, outfalls or more discreet reaches of surface water can be selected for sampling or further investigation. Wet-weather sampling is also recommended for all outfalls, in particular for those that did not have flow in dry weather or those with dry-weather flow that passed screening thresholds. Wet-weather sampling will identify a number of situations that would otherwise pass unnoticed in dry weather. These wet-weather situations include, but are not limited to the following: elevated groundwater that can now cause an exchange of wastewater between cracked or broken sanitary sewers, failed septic systems, underdrains, and storm drains; increased sewer volume that can exfiltrate through cracks in the sanitary piping; increased sewer volume that can enter the storm drain system in common manholes or directly-piped connections to storm drains; areas subject to capacity-related SSO discharges, and; illicit connections that are not carried through the storm drain system in dry-weather.

Step V – Costs

Use of field test kits and field instruments for a majority of the analytical parameters allows for a significantly reduced analytical cost. Estimated instrument costs and pro-rated costs per 100 samples are included in Table 2. The cost per 100 samples metric allows averaged costs to account for reagent refills that are typically less expensive as they do not include the instrument cost, and to average out the initial capital cost for an instrument such as a temperature/ conductivity/salinity meter. For such capital costs as the meters, the cost over time will continue to decrease.

Table 2 – Estimated Field Screening Analytical Costs [1]

Analyte/ Indicator	Instrument or Meter [2]	Instrument or Meter Cost/No. of Samples	Cost per Sample (Based on 100 Samples) [3]
Surfactants (as MBAS)	Chemetrics K-9400	$77.35/20 samples ($58.08/20 sample refill)	$3.09
Ammonia (NH_3)	Hach brand 0 – 6 mg/l	$18.59/25 samples	$0.74
Total Chlorine	Hach Pocket Colorimeter II	$389/100 samples ($21.89 per 100 sample refill)	$3.89
Temperature/ Conductivity/ Salinity	YSI	$490 (meter and cable probe)	$4.90

1 Estimated costs as of February 2011
2 The mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. EPA
3 One-time meter costs and/or refill kits will reduce sample costs over time

From Table 2, the field analytical cost is approximately $13 per outfall. Typical bacterial analyses costs can vary depending on the analyte, method, and total number of samples to be performed by the laboratory. These bacterial analyses costs can range from $20 to $60. Therefore, the analytical cost for a single outfall, based on the cost per 100 samples, ranges from $33 to $73. As indicated above, these costs will decrease slightly over time due to one-time capitals costs for the chlorine and temperature/conductivity/salinity meters.

Step VI – Follow-Up

Once all laboratory data has been reviewed and determined final in accordance with appropriate quality assurance controls, results should be reviewed with appropriate stakeholders to determine next steps. Those outfalls or surface water segments that fail to meet the appropriate water quality standard, and meet or exceed the surfactant and ammonia threshold values, in the absence of potential interferences mentioned in Step IV, indicate a high likelihood for the presence of illicit connections upstream in the drainage system or surface water. Whereas illicit discharges are quite variable in nature, the exceedance of the applicable water quality standard and only the ammonia or surfactant threshold value may well indicate the presence of an illicit connection. When available, the concurrent collection and analyses of PPCP data can greatly assist in confirming the presence of human wastewater. However, such data will not be available in all instances, and the collective data set and information regarding the physical characteristics of each sub-catchment or surface water reach should be used to prioritize outfalls for further investigation. As warranted, data may be released to the appropriate stakeholders, and should be accompanied by an explanation of preliminary findings. Release of EPA data should be fully discussed with the case team or other appropriate EPA staff.

References Cited

Boston Water & Sewer Commission, 2004, *A systematic Methodology for the Identification and Remediation of Illegal Connections.* 2003 Stormwater Management Report, chap. 2.1.

Pitt, R. 2004 *Methods for Detection of Inappropriate Discharge to Storm Drain Systems. Internal Project Files.* Tuscaloosa, AL, *in* The Center for Watershed Protection and Pitt, R., *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments*: Cooperative Agreement X82907801-0, U.S. Environmental Protection Agency, variously paged. Available at: http://www.cwp.org.

Instrumentation Cited (Manufacturer URLs)

MBAS Test Kit - CHEMetrics K-9400: http://www.chemetrics.com/Products/Deterg.htm

Portable Colorimeter – Hach Pocket Colorimeter II: http://www.hach.com/

Ammonia (Nitrogen) Test Strips: http://www.hach.com/

Portable Temperature/Conductivity/Salinity Meter: YSI Model 30:
http://www.ysi.com/productsdetail.php?30-28

Disclaimer: The mention of trade names or commercial products in this protocol does not constitute endorsement or recommendation for use by the U.S. EPA.

Attachment 1

Stormwater Monitoring Quality Assurance Project Plan
2012-2017

RFA #

Sampling Plan Acceptance

EPA OES Enforcement and Project Manager/Coordinator **Signature:**	**Date:**
EPA OEME Project Managers/Coordinator **Signature:**	**Date:**
EPA OEME QA Officer **Signature:**	**Date:**
EPA Chemistry Team Lead **Signature:**	**Date:**

1.0 Background

U.S. EPA Administrative Order 5360.1 requires that "all projects involving environmental monitoring performed by or for the U.S. EPA shall not be undertaken without an adequate Quality Assurance Project Plan (QAPP)." The purpose of this document is to describe the process used to develop, select, manage, and finalize stormwater monitoring projects. In describing this process, quality assurance goals and methods will be established, thus ensuring that the overall program and each monitoring project will meet or exceed EPA requirements for quality assurance.

The objective of these projects will be to collect data that is usable by EPA OES enforcement staff for enforcement actions and information requests. The primary focus of this project will be on urban water stormwater outfalls in the New England Region watersheds.

2.0 Sampling overview

Monitoring will be conducted on pre-scheduled days with the Laboratory. Samples will be retrieved from surface water, in stream or outfalls at suspected hotspots or areas that need further delineation. Sample sites will be located using GPS, with an accuracy goal of ±1 meter and PDOP less than 6. Less accurate GPS reading or coordinates from maps will be accepted when site or other conditions do not allow ±1 meter accuracy.

The primary focus of this sampling will be used to identify illegal discharges.
Results from the sampling will be used by EPA enforcement staff for enforcement purposes. For this project, sampling will be conducted according to EPA's Ambient Water Sampling SOP (Table 3). Volunteers and watershed association staff may assist in sampling. All procedures will be followed that are specified in Table 3. Parameter to be sampled will be predetermined by enforcement (OES) and OEME staff, based on data needs.

A. Locations

Site locations will be determined from field or desktop reconnaissance by project staff. Sample analyses will be predetermined based on conditions known about the sampling location prior to sampling. These may include data from previous sampling or from data collected from Mass DEP or local watershed associations. Any of the parameters listed in table 2 may be analyzed.

B. Analytical Methods and Reporting limits

Sample analyses will be conducted by EPA Laboratories.

This effort will test and compare the most appropriate analytical methods including, but not limited to; laboratory analysis, test kits and field analysis to determine the most effective and cost-efficient outfall and in-stream sampling approach.
Multiple and repeated testing will occur at each location to compare different method for identifying sewage contamination.

PPCPs, E.coli and enterococcus will be analyzed by EPA's Laboratory. Surfactants, ammonia, total chlorine will be analyzed with field test kits. Potential additional laboratory analyses include nitrogen (nitrate/nitrite), TSS, BOD, surfactants, ammonia and TPH. The Laboratory used

Attachment 1

for each sampling event will be determined prior to sampling by the OEME Project Manager based on required analyses Laboratory availability and contract funds available.

Where available, a known concentration sample will be used to evaluate the performance of each test method. The known concentration sample will be processed in the field and Laboratory as a routine sample. The analyst or field technician will not know the concentration of the sample prior to analyzing and reporting the sample result. Sampling for PPCP testing will be done using extreme care not to contaminate the sample. No caffeine products should be consumed prior to sampling.

Table 1: Parameter specifications

Parameter (lab – equipment)	Preservation	Holding time
PH	None	Immediate
Temperature	None	Immediate
Sp Cond	None	Immediate
DO	None	Immediate
Total Phosphorus (EPA)	H_2SO_4 (pH <2) + Ice	28 days
TSS (EPA)	Ice	7 days
TSS (Alpha)	Ice	7 days
BOD (Alpha)	Ice	48 hours
Surfactants (Alpha)	Ice	48 hours
Surfactants (field kit – Chemetrics)	None	Immediate
Ammonia (alpha)	H_2SO_4 (pH <2) + Ice	28 days
Ammonia (test strips)	None	Immediate
TPH Petroleum ID (alpha)	Ice	7 Days to extraction 40 days after extraction
E. Coli (EPA)	Ice	6 hrs to lab
Enterococcus (EPA)	Ice	6 hrs to lab
PPCP	Ice (acidified in Lab)	7 day to extraction 40 days after extraction
Chlorine (Field kit – Hach)	None	Immediate

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Table 2: Analytical References and Quality Control Goals

		Water Quality Criteria or Guidelines	Quality Assurance Goals		
Parameter (lab-equipment)	Reporting Limits	(MA or EPA)	Precision	Accuracy	Completeness
PH	4 to 10 units	6.5 - 8.3	0.02 unit	± 0.3 units	90%
Temperature	0 to +40°C	28.3°C	0.1 °C	± 0.15°C	90%
Sp Cond	0 to 100 mS/cm	NA	5 uS/cm	±10% cal std (µS/cm)	90%
DO	0.5mg/l to Sat	≥5 mg/l , ≥60% saturation	0.02mg/l	± .5 mg/l	90%
Total Phosphorus (EPA)	5.0 ug/l	NA	Field dup 30% RPD	MS 70-130%	90%
TSS (EPA)	5mg/L	NA	Field dup 30% RPD	See SOP	
TSS (Alpha)	5 mg/L	NA	Field dup 30% RPD	See SOP	90%
BOD (Alpha)	2 mg/L	NA	Field dup 30% RPD	See SOP	90%
Surfactants (field kit – Chemetrics)	0.25 mg/L[1]	0.25 mg/L	Field dup 30% RPD	TBD	90%
Ammonia (test strips)	0.25 mg/L[1]	1.0 mg/L	Field dup 30% RPD	TBD	90%
TPH Petroleum ID (alpha)	Variable	NA	Field dup 30% RPD	See SOP	
E. Coli (EPA)	4 col./ 100 ml	<=126 col./100 ml* <= 235 col./100 ml	±100 col/100ml or 30% RPD	N/A	90%
Enterococcus (EPA)	1 col/100ml	<=33 col./100 ml* <= 61 col./100 ml	±100 col/100ml or 30% RPD	See SOP	90%
PPCP	TBD	NA	Field dup 50% RPD	TBD	90%
Chlorine (Field kit – Hach)	0.02 mg/l	NA	Field dup 30% RPD	TBD	90%

Note
*Geometric mean Criteria
TBD = To be determined, Field methods and some colorimeter methods do not have accuracy criteria determined.
[1] Needs field verification to confirm

Attachment 1

Table 3: Field and Laboratory References

Parameter	Analytical Method Reference	SOP reference
	Field References- 5/2005	
pH		
Conductivity		
Temperature		
dissolved oxygen	n/a	ECASOP-YSISondes9
Ambient water samples	n/a	ECASop-Ambient Water Sampling2
Chain of custody of samples	n/a	EIASOP-CHAINOFCUST
Sample login, tracking, disposition	n/a	EIASOP-ADMLOG14
	Lab References- 5/2005	
Total Phosphorus (EPA)	EPA 365.3	EIASOP-INGTP8
TSS (EPA)	EPA 160.2	EIASOP-INGTSS-TDS-VRES5
TSS (Alpha)	EPA 160.2,SM2540D	SOP/07-29
BOD (Alpha)	EPA 405.1,SM5210B	SOP/07-13
Surfactants (field kit – Chemetrics)	Chemetrics	Draft
Ammonia (test strips)	Hach	Draft
TPH Petroleum ID (alpha)	8015B (M)	0-017
E. Coli (EPA)	SM9230	ECASOP-TC/EC Colilert2
Enterococcus (EPA)	SM9230	ECASOP-Enterolert1
PPCP	EPA 1694	TBD
Chlorine (Field kit – Hach)	Hach	TBD

*Specific conductance is the only parameter identified as non critical

Bottle list:

Table 4: Bottle Sampling List

Parameter (lab - equipment)	Bottle	Preservation
	Primary analyses	
E. Coli (EPA)	(2) 120ml or 250ml sterile	Ice
Enterococcus (EPA)		Ice
PPCP	1 Liter Amber	Ice (acidified in Lab)
	Optional analyses	
Chlorine (Alpha)	500 ml	Ice
Total Phosphorus (EPA)	125 ml	H_2SO_4 (pH <2) + Ice
TSS (EPA)	1 liter	Ice
TSS (Alpha)	1 liter	Ice
BOD (Alpha)	1 Liter	Ice
TPH Petroleum ID (alpha)	2 -1 Liter Amber Glass tephlon lined	Ice
E. Coli (Alpha)	120 ml sterile	Ice
Enterococcus (Alpha)	120 ml sterile	Ice

C. Quality Control

Calibration:	EPA will calibrate its sondes according to the EPA sonde calibration SOP.
Field duplicate:	One duplicate sample will be collected per sampling event or approximately for every ten samples.
Trip Blank:	OEME Chemist will run appropriate QA samples for PPCP's. One blank sample will be collected for approximately every ten bacteria samples. Reported data that is less than 5 times the trip (field) blank concentration will be flagged.
QC Criteria:	Are specified in table 2, data not meeting this criteria will be reviewed by the Project Manager. Data that does not meet laboratory QA/QC criteria will be flagged by the laboratory.

D. Chain of Custody

Chain of custody procedures will follow the OEME/Investigations Office SOP (Table 3)

3.0 Data Review

EPA Microbiology data will be reviewed by the Biology QAO. Alpha generated microbiology samples will be reviewed by the OEME Project Manager. All field data and draft data reports will be reviewed by the OEME Project manager. Laboratory generated data (from Alpha and EPA) will be reviewed by the Chemistry Team Leader.

4.0 Data reports

Data reports will be reviewed by the Project Coordinator and the OEME Project Manager before a final report is release to the Enforcement Coordinator. Draft reports may be released without a complete review.

Attachment 1

5.0 Attachments

1) Standard Operating Procedure Enterococcus (SM9230B), Multiple Tube Technique. SOP/07-01 *Alpha Analytical, Inc. May 28, 2005*

2) Standard Operating Procedure E. Coli (SM9213D). SOP/07-41 *Alpha Analytical, Inc. May 28, 2005*

3) Standard Operating Procedure MBAS, Ionic Surfactants. Draft SOP *EPA Laboratory. January 28, 2010*

4) Standard Operating Procedure Nitrogen Ammonia. Draft SOP *EPA Laboratory. February 10, 2011*

5) Standard Operating Procedure Total Chlorine. Draft SOP *EPA Laboratory. February 12, 2010*

6) Standard Operating Procedure TSS/ TVSS (SM2540 D, EPA 160.2). SOP/07-29 *Alpha Analytical, Inc. September 29, 2007*

7) Standard Operating Procedure BOD-5day, SBOD-5day, and cBOD-5day (SM 5210B, and EPA 405.1). SOP/07-13 *Alpha Analytical, Inc. September 29, 2007*

8) Standard Operating Procedure TPH 8015D – Modified 0-017 (EPA 8015D Modified) *Alpha Analytical, Inc. March 04, 2008*

9) Standard Operating Procedure determination of Trace Elements in Water and Wastes by Inductively Coupled Plasma- Mass Spectrometry (200.8). SOP/06-11 Alpha Analytical, Inc. July 13, 200

10) Standard Operating Procedure Inductively Coupled Plasma – Mass Spectrometry (6020). SOP/06-10 Alpha Analytical, Inc. October 25, 2007

Attachment 2

EPA United States Environmental Protection Agency

Target Compounds, Uses, and Reporting Limits

Target Compound	Major Use	RL (ng/L)	Daily Dose (ng)
Caffeine	Natural Stimulant	5.0	200,000,000
1,7-DMX	Metabolite of caffeine	2.5	N/A
Acetaminophen	Pain Reliever	2.5	650,000,000
Carbamazepine	Anti- depressant / bi-polar Anti-convulsant (epilepsy)	0.5	100,000,000
Primidone	Anti- epilepsy drug (AED)	5.0	100,000,000
Atenolol	Beta Blocker High Blood Pressure	2.5	50,000,000
Cotinine	Metabolite of Nicotine	0.5	3,500-7,200 (ng/mL)
Urobilin	By-product of hemoglobin breakdown (mammals)	5.0	1,300,000 ng/g in feces
Azithromycin	Antibiotic	1.6	200,000,000

Attachment 3

STORMWATER MONITORING

Field Collection Requirements (To be recorded at each site)

Sample-
Site Name ______________________

Time collected______________________

Date collected______________________

Inspection-
****Take picture at site****
Outfall diameter________('na' if open stream)

Flow estimate________('na' if open stream)

Odor______________________

Color______________________

Turbidity______________________

Floatables______________________

Other observations______________

____

YSI Meter (calibrate in lab)-
Salinity______________________

Temp______________________

Conductivity (give both #'s)

____

Location information-
Short description of where sample was collected at site________________

____

____

GPS______________________________

____

Field Kits listed in the order they should be conducted in, include any applicable notes-

NH3 strip______________________

Cl2 kit______________________
Hach meter – (3 min wait)

Surfactant______________________
Chemetrics K-9400 Blue box/detergent test kit

Additional Notes:

(Note any changes in weather conditions)______________________

____

____

____

____

Attachment 3

STORMWATER MONITORING (PAGE 2)

Field Equipment List

Waste Containers (2 total – clearly labeled):

1 liter amber plastic for surfactants/detergents kit waste
1 liter amber plastic for Cl2 kit waste

Sample Bottles (3 total for each sample location)-
120ml sterile – E.coli/entero
1 Liter amber glass: PPCP, *EPA* (Peter Philbrook)
120ml-250ml plastic – Field Kit Bottle – to be used on site for kits listed above

***Fill out chain of custody

In Carboy Container
☐Log book
☐COC forms
☐Extra sample bottles
☐Colored tape
☐Sharpies
☐Write-On-Rain Pens
☐Paper towels
☐GPS
☐Sampling plan & GPS locations
☐Regular length Powder Free Gloves
☐Squirt bottle of DI Water
☐Coolers with Ice
☐Waders/Boots
☐YSI multi parameter Meter

Illicit Discharge Detection and Elimination (IDDE) Plan Requirements

An IDDE Plan shall address how Providence will screen and monitor the MS4 outfalls and interconnections, inspect the MS4 for illicit connections and non-stormwater discharges, respond to complaints, investigate areas of the MS4, and remove the sources of illicit connections and non-stormwater discharges.

The IDDE Plan shall include, but not be limited to, the following requirements, guidelines, procedures, and deadlines.

A. General Requirements:

1. A process for applying the ranking system for setting priorities for IDDE investigations, screening, and follow-up actions in each catchment of each outfall or discharge point in accordance with guidance provided herein.
2. Standard Operating Procedures ("SOPs") that incorporate an IDDE inspection into Providence's catch basin cleaning, inspection, and repair. During these activities, Providence shall investigate the drainage system for signs of illicit connections and non-stormwater discharges, track and report evidence of illicit discharges, and coordinate appropriate follow up within Providence. Appropriate follow-up actions may include: outfall, manhole or catch basin water sampling and testing, coordination of the removal of illicit discharges, inspection of adjacent properties, and reporting.
3. SOPs to complete the required dry weather surveys of MS4 outfalls during the correct time period to satisfy the General Permit requirements. Providence must document visual and olfactory observations and include in these inspections sampling for the parameters listed in the General Permit and in Part B below.
4. SOPs for tracking IDDE investigations, schedules, priority ranking, and follow-up actions in a database.
5. Providence staff roles and responsibilities for follow-up steps once a potential illicit discharge issue is identified.
6. The date of verification of an illicit discharge shall be the date that Providence has identified a point of entry from a specific location or address that contributes wastewater or other illicit flow to the MS4.
7. Use of the IDDE screening thresholds in Part B below as guidelines for determining the necessity for further investigation, unless otherwise approved by the RIDEM.
8. Use of techniques consistent with Attachment D to the Consent Agreement.
9. A ranked list of structures identified as needing investigation or screening and a schedule to commence the work. This list and schedule shall be updated annually.

B. Screening and Investigation Parameters:
Providence must use the following IDDE screening thresholds as guidelines for determining the necessity for further investigation, unless otherwise approved by the RIDEM. Providence must measure the flow of dry and wet weather discharges when feasible. At a minimum, Providence must analyze dry and wet weather samples for the following parameters:

Bacteria:

Fecal coliform: in excess of 400 most probable number per 100 milliliters;

Coliphage: equal to or greater than 50 plaque forming units per 100 milliliters;

Class AA, A, B, B1, B(a), or B1(a) waters- Enterococcus: greater than 61 colony forming units per 100 milliliters ("cfu/100 ml");

Class SA, SA(b), SB, SB1, SB(a), or SB1(a) waters- Enterococcus: greater than 104 cfu/100 ml;

Surfactants: equal to or greater than 0.25 milligrams per liter ("mg/l") via field kits, or 0.1 mg/l via laboratory analysis;

Ammonia: equal to or greater than 0.5 mg/l;

Chlorine: greater than non-detect (0.02 mg/l method detection limit);

pH: less than or equal to 5 standard units or greater than 9.0 standard units;

Conductivity: greater than or equal to 2,000 micro Siemens per centimeter;

If Providence determines other parameters (different from the ones provided above) to be the most appropriate to identify the source, Providence must provide a narrative justification that explains why the parameter(s) was chosen. This narrative must be included in the report required in Attachment C.

C. Ranking and Prioritization of Stormwater Infrastructure for IDDE Investigations and Re-Screening:
Providence must rank stormwater infrastructure, including outfalls and interconnections, with the purpose of prioritizing screening of infrastructure, and investigating potential illicit discharges as follows:

1. High Priority: Providence must classify as high priority any stormwater infrastructure with known or suspected discharges based upon any of the following information:

   a. Stormwater infrastructure with screening results that indicate sewer input or industrial discharges based on olfactory or visual evidence, including but not limited to olfactory or visual evidence or observations encountered during the dry weather surveys of outfalls and inspections of catch basins, and/or sampling results that exceed thresholds in Part B above, as follows:

i. Bacteria **and** any of the other listed thresholds (with the exception of pH and conductivity) are exceeded; or
ii. Bacteria threshold is exceeded and pharmaceuticals have been detected in elevated concentrations or visual evidence of sewer or excessive odor have been observed; or
iii. Surfactants or ammonia thresholds are exceeded and chlorine has been detected; or
iv. Conductivity and pH thresholds are exceeded.

b. Citizen complaint of illicit discharge as appropriate;
c. Notification by the RIDEM, the EPA, or an interconnected MS4 of presence of suspect illicit discharge as evidenced by criteria listed in Part C.1.a above;
d. Evidence of potential illicit discharges discovered as a result of other activities including but not limited to: mapping, construction, maintenance, and cleaning and repair of catch basins and manholes.

Upon classification as high priority, Providence must initiate an IDDE investigation in accordance with the deadlines in Part E below.

2. Priorities for additional outfall and system screening: Providence must classify as priority any outfalls or interconnections with previously identified dry weather flows where the results of the analysis cannot conclusively determine that the dry weather flow consisted only of stormwater, or where one or more of the System Vulnerability Factors listed in Table 1 below exist within the catchment area. Where either of these conditions exist, Providence must conduct screening as follows:

a. Re-visit outfalls and interconnections during dry weather conditions and sample at a minimum for the parameters listed in Part B above when a flow is observed; and
b. Where flow is not observed during the dry weather re-visiting, Providence must inspect and sample the outfall and interconnections during wet weather conditions, for the parameters listed in Part B above.

Table 1: System Vulnerability Factors
• History of Sanitary Sewer Overflows (SSOs), including, but not limited to, those resulting from wet weather, high water table, or fat/oil/grease blockages • Sewer pump/lift stations, siphons, or known sanitary sewer restrictions where power/equipment failures or blockages could readily result in SSOs • Inadequate sanitary sewer level of service resulting in regular surcharging, customer back-ups, or frequent customer complaints • Common or twin-invert manholes serving storm and sanitary sewer alignments

- Common trench construction serving both storm and sanitary sewer alignments
- Crossings of storm and sanitary sewer alignments
- Sanitary sewer alignments known or suspected to have been constructed with an underdrain system
- Sanitary sewer infrastructure defects such as leaking service laterals, cracked, broken, or offset sanitary infrastructure, directly piped connections between storm drain and sanitary sewer infrastructure, or other vulnerability factors identified through Inflow/Infiltration Analyses, Sanitary Sewer Evaluation Surveys, or other infrastructure investigations
- Areas formerly served by combined sewer systems
- Any sanitary sewer and storm drain infrastructure greater than 40 years old in medium and densely developed areas
- Widespread code-required septic system upgrades required at property transfers (indicative of inadequate soils, water table separation, or other physical constraints of the area rather than poor owner maintenance)
- History of multiple RIDEM actions addressing widespread septic system failures (indicative of inadequate soils, water table separation, or other physical constraints of the area rather than poor owner maintenance)

D. Investigation Scheduling Considerations: Providence must consider the following information when developing schedules for prioritizing the investigations of high priority infrastructure and screening of priority outfalls, catch basins, manholes, and interconnections. Providence may consider the schedules in Paragraph C(4)(a)(i) of the Consent Agreement when developing schedules for follow-up actions.

a. Water bodies that receive a discharge from the MS4 and are drinking water supplies, shell fishing areas, beaches or waters used for contact recreation.

b. Water quality limited waterbodies that receive a discharge from the MS4 or waters with approved TMDLs applicable to Providence, where illicit discharges have the potential to contain the pollutant identified as the cause of the water quality impairment.

c. Density of generating sites - Generating sites are those places, including institutional, municipal, commercial, or industrial sites, with a potential to generate pollutants that could contribute to illicit discharges. Examples of these sites include, but are not limited to, car dealers; car washes; gas stations; garden centers; and industrial manufacturing areas.

d. Age of surrounding development and infrastructure – Industrial areas greater than 40 years old and areas where the sanitary sewer system is more than 40 years old will probably have a high illicit discharge potential. Developments 20 years or younger will probably have a low illicit discharge potential.

e. Sewer conversion – Catchments that were once serviced by septic systems, but have been converted to sewer connections may have a high illicit discharge potential.

f. Historic combined sewer systems – Catchments that were once serviced by a combined sewer system, but have been separated may have a high illicit discharge potential.

g. Density of aging septic systems – Septic systems 30 years or older in residential land use areas are prone to have failures and may have a high illicit discharge potential.

h. Catchments with documented SSOs.

i. Culverted streams – any river or stream that is culverted for distances greater than a simple roadway crossing may have a high illicit discharge potential.

E. Deadlines:

1. Providence must initiate and assess an IDDE investigation within 90 days of identifying or being made aware of the presence of a potential illicit discharge into or from the MS4 based upon receiving any of the information listed above in Parts C.1.a through C.1.d above as criteria for high priority.
2. Investigations must be completed within 180 days of initiation by identifying a point of entry from a specific location or address that contributes wastewater or other illicit flow to the MS4 or documenting that an illicit discharge does not exist, unless not feasible. If an IDDE investigation is not completed within 180 days of initiation of the investigation, Providence must establish a schedule for completing the IDDE investigation as expeditiously as possible.
3. Identify and notify all parties responsible for any illicit discharge and the RIDEM within 30 calendar days of the date of verification of the source, and require immediate cessation of improper disposal practices in accordance with its legal authorities.
4. Illicit discharges to the MS4 shall be eliminated within 120 days of the date of verification. Where elimination of an illicit discharge within 120 days of its verification as an illicit discharge is not possible, take all reasonable and prudent measures to minimize the discharge of pollutants to and from its MS4 and establish an expeditious schedule for its elimination.
5. Complete dry weather and wet weather monitoring for the parameters identified in Part B above within 120 days of removal of the source after a verified illicit discharge to the MS4 has been eliminated to confirm that all illicit discharges have been eliminated.

IDDE Investigation Priorities List

When developing the IDDE Plan, Providence must prioritize illicit discharge detection and elimination within catchments associated with the outfalls that were identified in EPA-approved TMDLs. Illicit discharge detection and elimination should begin with high priority outfalls.

In addition to the outfalls identified by Providence based on complaints, past inspections, and dry weather survey information, Providence must investigate and identify the sources of illicit discharges to the MS4 associated with the following outfalls:

1) Outfall SD-6 (i.e. the outfall to Mashapaug Pond at Lakeview Drive, Providence).
2) Outfalls and interconnections between its MS4 and the RIDOT MS4 in the Olneyville area of Providence, and Kinsley Avenue and Promenade Street.

Name of Town: Providence

General Information		Dry Weather Visit #1	Location in Decimal Degrees		Receiving Water Body Information		Outfall Information				
Inspector	Outfall ID	Date	Longitude	Latitude	Type	Name	Material	Shape	Diameter	Type	NOTES
CH/SD	Mash01	10/3/07	-71.434764	41.790014	LAKE/POND	Mashapaug Pond	Steel	CIRCULAR	20	Single	
CH/SD	Mash02	10/4/07	-71.434759	41.789965	LAKE/POND	Mashapaug Pond	Brick	CIRCULAR	20	Single	
CH/SD	Mash04	10/5/07	-71.435133	41.794020	LAKE/POND	Mashapaug Pond	RCP	CIRCULAR	12	Single	NEED WADERS
CH/SD	Mash05	10/6/07	-71.432840	41.797758	LAKE/POND	Mashapaug Pond	Concrete	CIRCULAR	36	Single	Contact Bob Bain (865-7114) or Jim Gilmore (865-7113) @ Bank of America for access
CH/SD	Mash06	10/7/07	-71.432907	41.799259	LAKE/POND	Mashapaug Pond	Steel	CIRCULAR	16	Single	Contact Bob Bain (865-7114) or Jim Gilmore (865-7113) @ Bank of America for access
CH/SD	Mash07	10/8/07	-71.431174	41.799954	LAKE/POND	Mashapaug Pond	Concrete	CIRCULAR	36	Single	Contact Bob Bain (865-7114) or Jim Gilmore (865-7113) @ Bank of America for access
CH/SD	Mosh02	9/27/07	-71.410110	41.845212	RIVER/STREAM	Moshassuck River	CMP	CIRCULAR	12	Single	Access from Branch Ave on I-95NB, NEED WADERS
CH/SD	Mosh03	9/27/07	-71.410733	41.842434	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	24	Single	
CH/SD	Mosh04	10/2/07	-71.411774	41.835955	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	36	Single	NEED LADDER TO ACCESS
CH/SD	Mosh05	10/11/07	-71.411222	41.830318	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	12	Single	
CH/SD	Mosh06	10/10/07	-71.411201	41.830333	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	12	Single	
CH/SD	Mosh07	10/10/07	-71.411202	41.829916	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	12	Single	
CH/SD	Mosh08	10/10/07	-71.411161	41.829761	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	12	Single	
CH/SD	Mosh09	10/11/07	-71.411058	41.829252	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	12	Single	
CH/SD	Mosh10	8/22/07	-71.410955	41.828989	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	14	Single	
CH/SD	Mosh11	8/22/07	-71.410852	41.828664	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	12	Single	
CH/SD	Mosh12	8/22/07	-71.410873	41.828541	RIVER/STREAM	Moshassuck River	Clay	CIRCULAR	36	Single	
CH/SD	Mosh13	8/22/07	-71.411018	41.828479	RIVER/STREAM	Moshassuck River	RCP	CIRCULAR	20	Single	
CH/SD	Mosh14	10/11/07	-71.410915	41.828309	RIVER/STREAM	Moshassuck River	DIP	CIRCULAR	12	Single/CN	Submerged, Approximate location by plans
CH/SD	Mosh15	10/11/07	-71.410771	41.827985	RIVER/STREAM	Moshassuck River	DIP	CIRCULAR	12	Single/CN	Submerged, Approximate location by plans
CH/SD	Mosh16	10/11/07	-71.410564	41.827560	RIVER/STREAM	Moshassuck River	DIP	CIRCULAR	12	Single/CN	Submerged, Approximate location by plans
CH/SD	Narr10	8/23/07	-71.402696	41.814658	BAY	Narragansett Bay	RCP	CIRCULAR	72	Single	CRANSTON?
CH/SD	Narr11	8/23/07	-71.387842	41.796804	BAY	Narragansett Bay	Granite	CIRCULAR	15	Single	
CH/SD	Narr12	8/23/07	-71.383933	41.793576	BAY	Narragansett Bay	Steel	CIRCULAR	18	Single	
CH/SD	Narr13	8/23/07	-71.384557	41.785474	BAY	Narragansett Bay	RCP	CIRCULAR	36	Single	
CH/SD	Narr14	8/23/07	-71.396770	41.817123	BAY	Narragansett Bay	Concrete	CIRCULAR	36	Triple	NBC???
CH/SD	Narr15	8/23/07	-71.394667	41.817590	BAY	Narragansett Bay	CMP	CIRCULAR	12	Single	
CH/SD	Narr16	8/23/07	-71.393290	41.817568	BAY	Narragansett Bay	CMP	CIRCULAR	12	Single	
CH/SD	Narr17	8/23/07	-71.392877	41.817609	BAY	Narragansett Bay	CMP	CIRCULAR	12	Single	
CH/SD	Narr18	8/23/07	-71.392106	41.817691	BAY	Narragansett Bay	Concrete	TRAPEZIOD	48	Single	RIDOT?
CH/SD	Prov01	8/22/07	-71.410221	41.827230	RIVER/STREAM	Providence River	RCP	CIRCULAR	40	Double	
CH/SD	Prov02	8/24/07	-71.405897	41.823120	RIVER/STREAM	Providence River	Concrete	CIRCULAR	30	Single	
CH/SD	Prov03	8/24/07	-71.407737	41.824185	RIVER/STREAM	Providence River	Concrete	CIRCULAR	18	Single	
CH/SD	Prov04	8/24/07	-71.407979	41.824627	RIVER/STREAM	Providence River	Concrete	CIRCULAR	12	Single	
CH/SD	Prov05	8/24/07	-71.408201	41.825063	RIVER/STREAM	Providence River	Steel	CIRCULAR	16	Single	
CH/SD	Prov06	8/24/07	-71.408330	41.825295	RIVER/STREAM	Providence River	Iron	CIRCULAR	30	Single	
CH/SD	Prov07	8/24/07	-71.408340	41.825290	RIVER/STREAM	Providence River	Iron	CIRCULAR	8	Single	
CH/SD	Prov08	8/24/07	-71.408930	41.825856	RIVER/STREAM	Providence River	Clay	CIRCULAR	12	Single	
CH/SD	Prov09	8/24/07	-71.409078	41.826006	RIVER/STREAM	Providence River	Iron	CIRCULAR	12	Single	
CH/SD	Prov10	8/24/07	-71.409635	41.826508	RIVER/STREAM	Providence River	Concrete	CIRCULAR	48	Double	
CH/SD	Prov11	9/27/07	-71.410254	41.826385	RIVER/STREAM	Providence River	Granite	CIRCULAR	48	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD
CH/SD	Prov12	9/27/07	-71.410141	41.826280	RIVER/STREAM	Providence River	Steel	CIRCULAR	12	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD
CH/SD	Prov13	9/27/07	-71.409157	41.825608	RIVER/STREAM	Providence River	Steel	CIRCULAR	16	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD.

Name of Town: Providence

General Information		Dry Weather Visit #1	Location in Decimal Degrees		Receiving Water Body Information		Outfall Information				
Inspector	Outfall ID	Date	Longitude	Latitude	Type	Name	Material	Shape	Diameter	Type	NOTES
CH/SD	Prov14	9/27/07	-71.408992	41.825393	RIVER/STREAM	Providence River	Steel	CIRCULAR	12-35	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD
CH/SD	Prov15	9/27/07	-71.408627	41.825139	RIVER/STREAM	Providence River	Steel	CIRCULAR	12	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD
CH/SD	Prov16	9/27/07	-71.408653	41.824774	RIVER/STREAM	Providence River	Steel	CIRCULAR	12	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD
CH/SD	Prov17	9/27/07	-71.408400	41.824513	RIVER/STREAM	Providence River	Steel	CIRCULAR	30	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD
CH/SD	Prov18	9/27/07	-71.408392	41.824435	RIVER/STREAM	Providence River	Steel	CIRCULAR	12	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD
CH/SD	Prov19	9/27/07	-71.408383	41.824259	RIVER/STREAM	Providence River	Steel	CIRCULAR	12	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD, 50' N of Crawford St Bridge
CH/SD	Prov20	9/27/07	-71.408140	41.824043	RIVER/STREAM	Providence River	Steel	CIRCULAR	15	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD. Centered under N span of Crawford St. Bridge.
CH/SD	Prov21	9/27/07	-71.408079	41.823919	RIVER/STREAM	Providence River	Steel	CIRCULAR	15	Single	Approximate location, outfall under Memorial BLVD. Point taken above Memorial BLVD
CH/SD	Prov22	9/27/07	-71.407436	41.822883	RIVER/STREAM	Providence River	Concrete	CIRCULAR	18	Single	
CH/SD	Prov23	9/27/07	-71.406674	41.821735	RIVER/STREAM	Providence River	Concrete	CIRCULAR	25	Single	
CH/SD	Prov24	9/27/07	-71.407121	41.823436	RIVER/STREAM	Providence River	DIP	CIRCULAR	12	Single	
CH/SD	PVP33	10/16/07	-71.441881	41.834971	RIVER/STREAM	Pleasant Valley Parkway	Iron	CIRCULAR	10	Single	
CH/SD	PVP34	10/16/07	-71.441764	41.834997	RIVER/STREAM	Pleasant Valley Parkway	Pvc	CIRCULAR	12	Single	
CH/SD	PVP35	10/16/07	-71.439548	41.835331	RIVER/STREAM	Pleasant Valley Parkway	Clay	CIRCULAR	12	Single	
CH/SD	PVP36	10/16/07	-71.439446	41.835357	RIVER/STREAM	Pleasant Valley Parkway	Iron	CIRCULAR	10	Single	
CH/SD	PVP37	10/16/07	-71.439296	41.835395	RIVER/STREAM	Pleasant Valley Parkway	Iron	CIRCULAR	6	Single	
CH/SD	PVP38	10/16/07	-71.438895	41.835439	RIVER/STREAM	Pleasant Valley Parkway	Iron	CIRCULAR	8	Single	
CH/SD	RWP-A	9/25/07	-71.397216	41.777292	LAKE/POND	Pleasure Lake	Concrete	CIRCULAR	24	Single	
CH/SD	RWP-B	9/25/07	-71.407070	41.786630	LAKE/POND	Pleasure Lake	Concrete	CIRCULAR	24	Single	
CH/SD	RWP-C	9/25/07	-71.407320	41.786430	LAKE/POND	Pleasure Lake	Concrete	CIRCULAR	24	Single	
CH/SD	RWP-D	9/25/07	-71.407400	41.784500	LAKE/POND	Pleasure Lake	Concrete	CIRCULAR	24	Single	
CH/SD	RWP-E	9/25/07	-71.412050	41.784470	LAKE/POND	Pleasure Lake	Concrete	CIRCULAR	18	Single	
CH/SD	RWP-F	9/25/07	-71.412050	41.784470	LAKE/POND	Pleasure Lake	PVC	CIRCULAR	12	Single	
CH/SD	RWP-G	9/25/07	-71.406400	41.785180	LAKE/POND	Edgewood Lake	Concrete	CIRCULAR	18	Single	
CH/SD	RWP-H	9/25/07	-71.407950	41.779230	LAKE/POND	Edgewood Lake	CMP	ELIPTICAL	35	Single	
CH/SD	RWP-I	9/25/07	-71.408200	41.779180	LAKE/POND	Edgewood Lake	CMP	CIRCULAR	24	Single	
CH/SD	RWP-J	9/25/07	-71.406950	41.780650	LAKE/POND	Edgewood Lake	Concrete	CIRCULAR	8	Single	
CH/SD	RWP-K	9/25/07	-71.405800	41.782200	LAKE/POND	Edgewood Lake	Concrete	CIRCULAR	8	Single	
CH/SD	RWP-L	9/25/07	-71.410754	41.783737	LAKE/POND	Cunliff's Pond	Concrete	CIRCULAR	10	Single	
CH/SD	RWP-M	9/25/07	-71.416250	41.784270	LAKE/POND	Roosevelt Lake	PVC	CIRCULAR	6	Single	
CH/SD	RWP-N	9/25/07	-71.416180	41.783530	LAKE/POND	Roosevelt Lake	Concrete	CIRCULAR	6	Single	
CH/SD	RWP-O	9/25/07	-71.416720	41.782450	LAKE/POND	Roosevelt Lake	PVC	CIRCULAR	6	Single	
CH/SD	RWP-P	9/25/07	-71.417770	41.782650	LAKE/POND	Roosevelt Lake	Concrete	CIRCULAR	18	Single	
CH/SD	RWP-R	9/25/07	-71.414920	41.784380	LAKE/POND	Willow Lake	PVC	CIRCULAR	6	Single	
CH/SD	RWP-S	9/25/07	-71.415170	41.784570	LAKE/POND	Willow Lake	RCP	CIRCULAR	48	Single	
CH/SD	RWP-T	9/25/07	-71.415250	41.784670	LAKE/POND	Willow Lake	RCP	CIRCULAR	12	Single	
CH/SD	RWP-U	9/25/07	-71.414820	41.787880	LAKE/POND	Polo Lake	Concrete	ELIPTICAL	24	Single	
CH/SD	RWP-V	9/25/07	-71.414530	41.787150	LAKE/POND	Polo Lake	Concrete	BOX	47	Single	
CH/SD	RWP-W	9/25/07	-71.415550	41.786180	LAKE/POND	Polo Lake	Concrete	CIRCULAR	12	Single	
CH/SD	RWP-Z	9/25/07	-71.412962	41.773139	RIVER/STREAM	RWP Release	Concrete	ELIPTICAL	35	Single	
CH/SD	Seek07	12/19/06	-71.379120	41.831054	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek08	12/19/06	-71.378805	41.831566	RIVER/STREAM	Seekonk River	Cobble	BOX	35	Single	

Name of Town: Providence

General Information		Dry Weather Visit #1	Location in Decimal Degrees		Receiving Water Body Information		Outfall Information				
Inspector	Outfall ID	Date	Longitude	Latitude	Type	Name	Material	Shape	Diameter	Type	NOTES
CH/SD	Seek09	12/19/06	-71.378433	41.832053	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek10	12/19/06	-71.378067	41.832519	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek11	12/19/06	-71.377855	41.833044	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek12	12/19/06	-71.377854	41.833570	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek13	12/19/06	-71.378037	41.834116	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek14	12/19/06	-71.378360	41.834601	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek15	12/19/06	-71.378718	41.834908	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek16	12/19/06	-71.379749	41.836709	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek17	12/19/06	-71.379815	41.837130	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek18	12/19/06	-71.379748	41.837552	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Seek19	12/19/06	-71.379675	41.837893	RIVER/STREAM	Seekonk River	Cobble	BOX	36	Single	
CH/SD	Woon40	8/22/07	-71.418244	41.827968	RIVER/STREAM	Woonasquatucket River	Steel	CIRCULAR	12	Single	Point under Providence Place Mall. No satellites.
CH/SD	Woon41	8/22/07	-71.427232	41.823564	RIVER/STREAM	Woonasquatucket River	RCP	CIRCULAR	72	Single	Point under Providence Place Mall. No satellites.
CH/SD	Woon42	8/22/07	-71.415896	41.827354	RIVER/STREAM	Woonasquatucket River	Steel	CIRCULAR	12	Single	Point under Providence Place Mall. No satellites.
CH/SD	Woon43	8/22/07	-71.414842	41.827290	RIVER/STREAM	Woonasquatucket River	Steel	CIRCULAR	25	Single	
CH/SD	Woon44	8/22/07	-71.414844	41.827305	RIVER/STREAM	Woonasquatucket River	RCP	CIRCULAR	18	Single	
CH/SD	Woon45	8/22/07	-71.415187	41.827012	RIVER/STREAM	Woonasquatucket River	Concrete	CIRCULAR	12	Single	
CH/SD	Woon46	8/22/07	-71.414222	41.826575	RIVER/STREAM	Woonasquatucket River	DIP	CIRCULAR	12	Single	Submerged completely. Approximate point by plans, could not find
CH/SD	Woon47	8/22/07	-71.413876	41.826525	RIVER/STREAM	Woonasquatucket River	DIP	CIRCULAR	12	Single	Submerged completely. Approximate point by plans, could not find
CH/SD	Woon48	8/22/07	-71.410662	41.826941	RIVER/STREAM	Woonasquatucket River	DIP	CIRCULAR	24	Single	

Proposed Projects in Roger Williams Park

SITE I.D.	LOCATION	DESCRIPTION	Status / Schedule	Budget	Reference	Anticipated TL Reduction % Red Per YR P	N
RWP-3B	Carousel Parking Lot	Construct bioretention at entrance of parking lot for half of the parking lot runoff; overflow into existing closed drainage system	Complete	$ 18,000.00	V.II - T 4.1	Unk	Unk
RWP-17/18	F.C. Greene Memorial Blvd.	Create paved flume/inlet structure direct road runoff to wet swale modify box culvert to crewt diversion structure; runoff to bioretention swale	Complete	$ 149,000.00	V.II - T 4.1	0.01	0.04
RWP-24	F.C. Greene Mem. Blvd. Between Cunliff and Deep Spring Lakes	Increase buffer vegetation and reduce road width/impervious surface; remove curb, add vegetated swale in buffer to catch water before it outfalls through existing spillway	Complete	$ 162,000.00	V.II - T 4.1	0.02	0.06
RWP-28	Intersection of Edgewood, Beachmont and F.C. Greene Memorial Blvd.	Remove pavement and add sand filter; install paved flumes and forebays prior to main sand filter cell, design overflow structure to connect to existing pipe outfall into the lake	Complete	$ 112,000.00	V.II - T 4.1	1.08	1.57
RWP-6	Roosevelt Lake Across from Monument	Pavement removal; raingardens and buffer restoration	Complete	$ 300,000.00	V.II - T 4.1	0.03	0.05
RWP- 1G	Shoreline Near Boathouse	Re-vegetate buffer area with low-growing grasses & shrubs	Complete	$ 9,000.00	V.II - T 4.3	Unk	Unk
RWP-26	Ballfield Erosion	Fine grading, stabilization, erosion control and seeding; swale	Complete	$ 9,500.00	V.II - Ap H & I	Unk	Unk
RWP-10	Casino Hillside Erosion	Buffer Planting & Re-Seeding	Complete	$ 3,300.00	V.II - Ap H & I	Unk	Unk
RWP-4	F.C. Greene Mem. Blvd -East of Japanese Garden	Buffer Planting & Re-Seeding	Partially Complete FY2018	$ 5,000.00	V.II - Ap H & I	Unk	Unk
RWP-23	F.C. Greene Memorial Blvd. by Temple of Music	Curb Removal only and areas of no-mow meadows	Curbing Complete Plantings Pending	$ 19,500.00	V.II - T 4.3	Unk	Unk
RWP-12	Ornamental Bridge North of Casino	Diversion structure into a terraced bioretention under the bridge	FY2017	$ 159,000.00	V.II - T 4.1	0.06	0.26
RWP-19A	Outfall at Polo Lake-Museum	Terraced Bioswale	FY2018	$ 103,000.00	V.II - Ap F & G	0.04	0.2
RWP-2	Road by Carousel	Plant native material;augment soils and convert low area at yard drain to rain garden; shoreline buffer planting	FY2018	$ 18,600.00	V.II - T 4.3	Unk	Unk
RWP-8	Island @ Elmwood Entrance	Fine grading, stabilization, erosion control and seeding; raingarden	FY2018	$ 21,000.00	V.II - Ap H & I	Unk	Unk
RWP-9A	Hillside Erosion South of Casino	Fine grading, stabilization, erosion control and seeding; pathway removal	FY2018	$ 17,000.00	V.II - Ap H & I	Unk	Unk
RWP-22	Path intersection by Willow & Pleasure Lakes	Fine grading, stabilization, erosion control and seeding; knotweed removal	FY2018	$ 15,000.00	V.II - Ap H & I	Unk	Unk
RWP-1A	Pine Hill Ave	Bioretention Area	FY2018	$ 14,000.00	V.II - Ap F & G	0.01	0.01
RWP-1B	Pine Hill & Maple	Bioretention Area	FY2018	$ 16,000.00	V.II - Ap F & G	0.01	0.01
RWP-1E	Maple Ave	Dryswale	FY2018	$ 21,500.00	V.II - Ap F & G	0.01	0.04
RWP-26A	F.C. Greene Mem. Blvd Ballfield	WVTS	FY2018	$ 6,500.00	V.II - Ap F & G	0.02	0.03
RWP-26B	F.C. Greene Mem. Blvd Ballfield	WVTS	FY2018	$ 9,500.00	V.II - Ap F & G	0.03	0.04
RWP-37A	History Museum Lot	Dry Swale	FY2018	$ 7,000.00	V.II - Ap F & G	0	0
RWP-37B	History Museum Memorial Blvd.	Terraced Bioswale	FY2018	$ 60,000.00	V.II - Ap F & G	0.02	0.09
RWP-37C	History Museum	Bioretention Area	FY2018	$ 50,000.00	V.II - Ap F & G	0.04	0.06

	Babcock Street						
RWP-16	Hillside Near Polo Lake	Plant with native, low growing grasses and shrubs to stabilize and provide vegetated buffer to Polo Lake	FY2019	$ 19,000.00	V.II - T 4.3	Unk	Unk
RWP-25	Temple of Music Access Rd	Bank clearing; fine grading; stabilization; erosion control; planting & re-seeding	FY2019	$ 87,000.00	V.II - Ap H & I	Unk	Unk
RWP-11	Hillside Erosion East of Casino	Fine grading, stabilization, erosion control and seeding; Buffer Planting	FY2019	$ 12,000.00	V.II - Ap H & I	Unk	Unk
RWP-21	Hillside Erosion Near Pleasure Lake	Fine grading, stabilization, erosion control and seeding; planting	FY2019	$ 25,000.00	V.II - Ap H & I	Unk	Unk
RWP-3C	Carousel Parking Lot	Bioretention Area	FY2019	$ 23,500.00	V.II - Ap F & G	0.01	0.03
RWP-9C/9D	Casino Parking Lot	Bioretention Area	FY2019	$ 22,500.00	V.II - Ap F & G	0.01	0.03
RWP-9E	Casino Entrance	Bioretention Area	FY2019	$ 9,000.00	V.II - Ap F & G	0.001	0.02
RWP-19B	Outfall at Polo Lake-Tennis	Dry Swale	FY2019	$ 92,000.00	V.II - Ap F & G	0.05	0.25
RWP-34	Botanical Center/Stables	Bioretention Area	FY2019	$ 130,000.00	V.II - Ap F & G	0.16	0.3
RWP-22	Path Intersection by Willow & Pleasure Lakes	Re-vegetate erosion near stairs; replant area of recent storm damage / tree removal; remove area of Jananese knotweed	FY2020	$ 15,500.00	V.II - T 4.3	Unk	Unk
RWP-16	Hillside South of Polo Lake	Fine grading, stabilization, erosion control and seeding; buffer planting	FY2020	$ 19,000.00	V.II - Ap H & I	Unk	Unk
RWP-1F	Cladrastris Ave Intersection	Bioretention Area	FY2020	$ 8,500.00	V.II - Ap F & G	0	0
RWP-7A	Rt 10 Off-Ramp	Infiltration Basin / Dry Swale	FY2020	$ 14,000.00	V.II - Ap F & G	0.1	0.13
RWP-7B	Outfall at Roosevelt Lake	From Route 10 - WVTS	FY2020	$ 11,000.00	V.II - Ap F & G	0.06	0.05
RWP-19C	Miller Ave	Bioretention Area	FY2020	$ 115,000.00	V.II - Ap F & G	0.08	0.22
RWP-29	Oakland Cemetary and Wentworth Ave.	Terraced/Shallow Bioretention	FY2020	$ 85,000.00	V.II - Ap F & G	0.48	0.93
RWP-30A	Marion Ave & F.C. Greene	Terraced Bioswale	FY2020	$ 203,000.00	V.II - Ap F & G	0.16	0.44
RWP-1C	Cladrastris Ave - Boathouse	Dryswale	FY2021	$ 18,500.00	V.II - Ap F & G	0.01	0.04
RWP-20	Willow Lake - Near Bridge	Buffer Planting & Re-Seeding	FY2021	$ 3,300.00	V.II - Ap H & I		
RWP-14	North of Roosevelt Lake	Shallow Bioretention	FY2021	$ 17,700.00	V.II - Ap F & G	0.011	0.04
RWP-15	Polo Lake Near Rotary	Terraced Bioswale	FY2021	$ 67,500.00	V.II - Ap F & G	0.02	0.11
RWP-30B	Marion Ave & F.C. Greene	WVTS	FY2021	$ 215,000.00	V.II - Ap F & G	0.91	0.82

Note: Estimates are 'Planning Based' and do not reflect actual project costs - construction costs will vary
We are evaluating the report to detremine scope revisions and are working with consultants to formalize pricing
Duplicates have been removed from list
Anticipated TL Reduction of P-N from RWPP Report Page E-7; Table E.5

Projected Reduction	
P	N
3.44 %	5.87 %
LBS / Yr	LBS / Yr
36.91 #	623.15 #

TMDL Implementation Plan Requirements

In addition to the requirements listed in Paragraph C(4)(a)(v) of the Consent Agreement, each TMDL IP must include the following information:

1. For Impaired Water Body Segments with approved TMDLs, identification of the applicable TMDL(s), the pollutant(s) of concern, the required pollutant load reductions for Providence, as required by Paragraph C(4)(a)(v) of the Consent Agreement, and all other recommendations and requirements of the TMDL(s) applicable to Providence.

2. For non-bacteria pollutants of concern, a combination of structural stormwater controls and enhanced non-structural BMPs that collectively satisfy the pollutant load reduction requirements in such TMDLs as listed in Attachment J of the Consent Agreement. The total required pollutant load reduction (in mass per year) shall be expressed as the required pollutant load reduction percentage multiplied by the pollutant loading rate (as mass per acre per year) multiplied by the area of Providence's impervious cover in the Impaired Sub-Watershed that discharges directly or indirectly to the Impaired Water Body Segment. Providence may implement a mixture of types and sizes of controls across catchment areas to the MS4 Discharge Point(s) in an Impaired Sub-Watershed to meet the required pollutant load reduction.

3. For bacteria, a combination of structural stormwater controls and enhanced non-structural BMPs that collectively satisfy the requirements of Attachment K of the Consent Agreement, to the maximum extent practicable, unless the TMDL has specifically determined that such controls are not required. The TMDL IP shall include, but not be limited to the following:

   a. The total area of the Impaired Sub-Watershed for the Impaired Water Body Segment;
   b. The total area of all impervious cover in the Impaired Sub-Watershed (the Rhode Island GIS impervious cover layer is an acceptable source for this information), incorporating updated mapping of catchment delineations produced during mapping of the MS4;
   c. The percentage of the total area in the Impaired Sub-Watershed that is impervious cover. If the overall Impaired Sub-Watershed impervious cover percentage is 10% or below and there are no additional RIDEM-approved TMDL recommendations or requirements for Providence in the Impaired Sub-Watershed, no further information needs to be submitted with the IP for the purposes of this part;
   d. The percentage reduction in all impervious cover that is required to reach 10% impervious cover in the entire Impaired Sub-Watershed;
   e. The total area of impervious cover in the Impaired Sub-Watershed that drains to the MS4 (excluding impervious cover from interconnected MS4s) to the Impaired Water Body Segment;
   f. A map showing the total area of impervious cover in the Impaired Sub-Watershed owned or operated by Providence that discharges directly or indirectly to the Impaired Water Body Segment;

g. The product of Parts 3.d and 3.e of this Attachment, which represents the Equivalent Area of the City impervious cover required to be eliminated under Part 1 of Attachment K of the Consent Agreement.

4. Providence shall use the procedures specified in the document that is attached hereto and incorporated herein as Attachment L of the Consent Agreement to calculate the pollutant removal, runoff volume reduction, and peak flow attenuation achieved by structural stormwater controls and enhanced non-structural BMPs, unless the RIDEM approves an alternative methodology. Providence may include the pollutant removal, runoff volume reduction, and peak flow attenuation achieved by:

   a. Structural stormwater controls installed by Providence prior to the effective date of the Agreement provided that Providence demonstrates that the structural control is performing in accordance with manufacturer design or specifications, including verification of the physical capacity of the structural control;
   b. Enhanced non-structural BMPs to the extent that such BMPs go beyond the scope of the required 6 minimum control measures specified in the General Permit (for example, for additional sweeping, pollutant load reduction credit for the difference in pollutant removal between sweeping once per year and the actual proposed sweeping schedule); and
   c. Structural stormwater controls that are recommended or required by the RIDEM-approved TMDLs or by the Agreement that are installed by Providence after the effective date of the Consent Agreement.

5. For each waterbody segment, Providence shall select a combination of structural stormwater controls and enhanced non-structural BMPs that collectively achieve the most stringent level of control for pollutant load reduction required by Parts 2 and 3 above to the maximum extent practicable, unless the RIDEM approves an alternative level of control.

6. A map or maps showing the extent of all pervious and impervious areas contributing flow to the MS4 discharge points to the Impaired Water Body Segment. The map(s) must include the MS4, including the locations of Providence roads and facilities, catch basins, interconnections with other MS4s, and the MS4 discharge points, and flow directions sufficient to identify which areas contribute to each MS4 discharge point. The outfall points associated with each catch basin shall be provided. If any the MS4 discharge points discharge to another MS4, the entire path through the other MS4 does not need to be mapped, but the eventual discharge location must be identified. If any non-Providence areas contribute flow to the MS4, the inflow point must be indicated and the approximate size of the area contributing inflow must be noted, but the entire non-Providence area does not need to be mapped in detail. The map(s) must show all existing and proposed structural controls in detail sufficient to determine areas contributing flow to each structure. If the IP is submitted electronically, the map(s) may be submitted as a PDF or other image file, or as a GIS file in a format acceptable to the RIDEM. The same map(s) may be used to meet the requirements of this part and Part 3.f. in this Attachment.

7. A description of how Providence has worked, or will work, cooperatively with the operators of all stormwater systems that are interconnected with the MS4 and from which, or into which, stormwater discharges to the Impaired Water Body Segment.

8. A list of all direct or indirect discharges from the MS4 and the Providence-owned or operated areas to the Impaired Water Body Segment. For each such discharge, the list shall identify the following information:

   a. Discharge location;
   b. Size and material of pipe/outfall;
   c. All existing discharge data (flow data and water quality monitoring data);
   d. If the discharge is a connection to another system, the owner/operator of the receiving system; and
   e. All non-Providence stormwater systems, which contribute flow to the outfall through interconnections, and an estimate of the acreage of non-Providence contributing area.

9. A description of all existing and proposed structural stormwater controls and proposed enhanced non-structural BMPs that will be used to meet requirements in Parts 1 through 3 of this Attachment and Paragraph C(4)(a)(v) of the Consent Agreement. The description must include the following information for each control:

   a. Type of control;
   b. For existing structural controls, a photo and documentation that the structural control is performing in accordance with manufacturer design or specifications, including verification of the physical capacity of the structural control;
   c. For proposed structural controls, a preliminary design plan of the structural control;
   d. For all structural controls, the structural dimensions and physical storage capacity of the control to hold runoff volume, and for infiltration controls, the soil type and associated hydrologic soil group present at the control;
   e. For all structural controls, the area contributing drainage to the control;
   f. For all structural and non-structural controls, the area of the Providence's impervious cover treated by the control;
   g. For all structural controls, the treatment depth provided by the control (e.g. for controls treating only impervious cover, the physical storage capacity divided by the area treated; for controls treating both pervious and impervious cover, the calculations according to Attachment L of the Consent Agreement;
   h. For all controls, effective pollutant removal that will be achieved by the control (expressed as a percentage removal);
   i. For all structural controls where the Impervious Cover Standard is applicable,
      i. The Runoff Volume Reduction Factor (for controls that provide infiltration) and the basis for the calculation,
      ii. The Peak Flow Attenuation Factor (for controls that provide peak flow reduction);
   j. For proposed controls, siting and permitting requirements for the control;

k. For proposed controls, identification of all known obstacles to implementation of the control (and any plans to overcome such obstacles); and
l. For proposed controls, preliminary engineering requirements for the control.

10. A listing of all areas of impervious cover being treated to meet requirements in Parts 1 through 3 of this Attachment and Paragraph C(4)(a)(v) of the Consent Agreement. The listed areas should be non-overlapping. The listing must include the following information for each area:

    a. Short identification of area;
    b. Total size of area;
    c. Total amount of Providence's impervious cover, pervious cover and types of pervious cover (in the area);
    d. All controls providing pollutant removal for the area;
    e. Effective pollutant removal by the controls;
    f. Where non-bacteria TMDLs are applicable, total pollutant removal by the controls (in mass per year); and
    g. Where the IC method is applicable:
        i. All controls providing runoff volume reduction
        ii. The resulting runoff volume reduction factor
        iii. The total runoff volume reduction
        iv. All controls providing peak flow attenuation
        v. The resulting peak flow attenuation factor
        vi. The resulting equivalent pervious cover factor
        vii. The resulting equivalent area credit for the area.

    Also include a detailed description of the process and rationale for the selection of the areas being treated and the controls selected for each area.

11. Cost estimates for all proposed structural stormwater controls and enhanced non-structural BMPs, including construction, inspections and maintenance, and on-going operating costs.

12. Evaluation of pollutant removal achieved for the Impaired Sub-Watershed for Impaired Water Body Segments with an RIDEM-approved non-bacteria TMDL. Include the following information for each pollutant of concern:

    a. The required pollutant reduction (according to Part 2 of this Attachment expressed as mass per year);
    b. Total pollutant reduction achieved by all existing and proposed structural controls and enhanced non-structural BMPs in the Impaired Sub-Watershed (according to Parts 9 and 10 of this Attachment, as a sum of mass per year over all areas listed according to Part 10 of this Attachment); and
    c. An assessment of whether the required pollutant load reduction will be met.

13. For Impaired Sub-Watersheds subject to the Impervious Cover Standard, an evaluation of the Equivalent Area credits achieved for the Impaired Sub-Watershed and other information related to benefits achieved, including:

    a. The Equivalent Area of Providence's impervious cover required to be treated, as calculated under Part 1 of Attachment K of the Consent Agreement;
    b. The total Equivalent Area credits achieved for the Impaired Sub-Watershed by Providence controls;
    c. An assessment of whether the required Equivalent Area credits will be met;
    d. The total pollutant (as phosphorus) reduction achieved by Providence controls across the Impaired Sub-Watershed; and
    e. The yearly groundwater recharge volume (calculated as runoff reduction) across all existing and proposed structural controls that provide infiltration.

14. If the total pollutant load reduction and Equivalent Area credits that will be achieved by the proposed and existing structural stormwater controls and proposed enhanced non-structural BMPs do not meet the pollutant load reduction requirements under Paragraph C(4)(a)(v) of the Consent Agreement and Part 2 of this Attachment, and the treatment level requirement of the Impervious Cover Standard under Part 3 of this Attachment and Attachment K of the Consent Agreement, then Providence shall explain why achieving those requirements that are not achieved is not feasible and why the proposed and existing structural controls and proposed enhanced non-structural BMPs will achieve the maximum pollutant reduction and maximum level of treatment to meet the Impervious Cover Standard that are feasible. Where the RIDEM-approved TMDLs specify that groundwater recharge is to be achieved to the maximum extent feasible, Providence shall also explain why the proposed and existing structural controls will achieve the groundwater recharge to the maximum extent feasible. Providence's explanations must include a list of all locations considered for structural stormwater controls, including locations on the Providence roadways, associated rights of way, and easements and on public and privately-owned property adjacent to the Providence property, and a narrative description of the physical, technical, legal, and cost constraints that affect the suitability of those locations and other possible locations in the Impaired Sub-Watershed for structural stormwater controls. Providence may include in its narrative description a discussion of road closure/access issues, highway design guidelines including safety, issues relating to soils and slopes, issues relating to resource areas (e.g. wetlands, rare species, areas of historic significance), and issues relating to utilities. Providence shall evaluate non-Providence property for location of potential structural controls where there is a good opportunity for achieving beneficial treatment of the Providence impervious cover.

15. For Impaired Water Body Segments with RIDEM-approved TMDLs, a description of how the IP addresses all other recommendations or requirements of the TMDLs specific to Providence. The IP shall also address any additional requirements for TMDL implementation plans specified in the TMDLs that are not otherwise addressed pursuant to this Attachment. Where the TMDL identifies priority outfalls (or requires the MS4 operator to identify priority outfalls) and requires the MS4 operator to design and

construct structural controls to reduce the pollutant of concern and stormwater volumes to the maximum extent feasible, the IP shall include a discussion of the priority outfalls identified, an evaluation of the feasibility of distribution of Providence infiltration controls (or controls that provide equivalent water quality treatment where infiltration controls are not feasible), throughout the drainage area of the outfalls (including upland areas), and how the Providence controls selected reduce the pollutant(s) of concern and stormwater volumes discharged by Providence impervious cover to priority outfalls to the maximum extent feasible.

Providence Percent Reduction TMDL Loads

Pollutant Reduction Percentages For Non-Bacterial TMDLs				
TMDL Name (Date)	**WBID**	**Waterbody Name**	**Pollutant**	**Pollutant Reduction Percentage**
Woonasquatucket River Fecal Coliform Bacteria and Dissolved Metals Total Maximum Daily Loads (April 2007)	RI0002007R-10D	Woonasquatucket River	Zinc	35 % Reduction
Woonasquatucket River Fecal Coliform Bacteria and Dissolved Metals Total Maximum Daily Loads (April 2007)	RI0002007R-10D	Woonasquatucket River	Copper	35 % Reduction
Woonasquatucket River Fecal Coliform Bacteria and Dissolved Metals Total Maximum Daily Loads (April 2007)	RI0002007R-10D	Woonasquatucket River	Lead	43 % Reduction
Total Maximum Daily Load For Dissolved Oxygen and Phosphorus Mashapaug Pond, Rhode Island	RI006017L-06	Mashapaug Pond	Phosphorus	65 % Reduction
Total Maximum Daily Loads for Phosphorus To Address 9 Eutrophic Ponds in Rhode Island - September 2007	RI0006017L-05	Roger Williams Park Pond	Phosphorus	78 % Reduction

Impervious Cover ("IC") Standard

It is desirable for a sub-watershed to be similar, in terms of water quality effects, to a watershed with 10% or less impervious cover overall. Accordingly, under the IC Standard, the amount of impervious cover that would need to be eliminated (or treated to act as if it were eliminated) from the sub-watershed to reach the 10% target is calculated, and Providence's proportional share of that amount is also determined. The IC Standard requires Providence to provide treatment of impervious cover that is equivalent to completely eliminating its proportional share of the target reduction. The required treatment that Providence must achieve is referred to as the Equivalent Area Requirement, because Providence may treat a greater amount of impervious cover acreage to a lesser degree, such that the overall reduction (in terms of pollutant removal reduction, runoff volume reduction and peak flow attenuation) is equivalent.

1. Required Treatment Level (Equivalent Area Requirement) - Based on the total size of the Impaired Sub-Watershed and the amount of all (MS4 and non-MS4) impervious cover in the Impaired Sub-Watershed, Providence shall calculate the area of impervious cover that would need to be eliminated from the entire (MS4 and non-MS4) Impaired Sub-Watershed to reach 10% impervious cover for the Impaired Sub-Watershed as a whole, and then express that area to be eliminated as a percentage of existing impervious cover in the sub-watershed. Providence shall calculate the Equivalent Area for the MS4 impervious cover by multiplying that calculated percentage reduction for the overall sub-watershed by the total area of the MS4 impervious cover in the Impaired Sub-Watershed that discharges directly or indirectly to the Impaired Water Body Segment.

   Providence shall implement treatment at least equal to completely eliminating the acreage of impervious cover equal to the Equivalent Area. The required level of treatment can be achieved by treating an amount of impervious cover acreage that is greater than the calculated Equivalent Area to a lesser degree than complete elimination. Providence may implement a mixture of types and sizes of structural controls across catchment areas to the MS4 Discharge Point(s) in an Impaired Sub-Watershed to meet the Impervious Cover Standard, using credits for each control as described below, but Providence must at least evaluate the feasibility of distributing infiltration structural controls across the Impaired Sub-Watershed in areas where the MS4 discharges go directly or indirectly to the Impaired Water Body Segment.

2. Under 10% IC - If the total (MS4 and non-MS4) impervious cover for an Impaired Sub-Watershed is less than 10%, Providence need not implement any new structural stormwater controls in the Impaired Sub-Watershed, unless (a) the RIDEM has specifically determined in an EPA-approved TMDL that Providence should implement structural stormwater controls, in which case Providence shall implement, at the locations indicated by the RIDEM, structural stormwater controls that are consistent with the assumptions and recommendations of the TMDL and the performance standards and criteria in a document entitled RHODE ISLAND STORMWATER DESIGN AND INSTALLATIONS MANUAL AMENDED MARCH 2015 for water quality and groundwater recharge or (b) new structural controls are needed to achieve the requirements of Paragraph C(4)(a)(v) 2 and 3 of the Consent Agreement.

3. Treatment Credits - To achieve treatment equal to the Equivalent Area Requirement, Providence shall implement structural controls or enhanced non-structural BMPs within the Impaired Sub-Watershed that achieve equivalent area credits that total the elimination of the Equivalent Area calculated in Part 1 of this Attachment. For each area treated by structural controls or enhanced non-structural BMPs, the equivalent area credit is equal to the area of impervious cover treated by the control multiplied by the equivalent pervious cover factor. The equivalent pervious cover factor is a fraction ranging from 0 to 1 representing how similar the discharge from the treated impervious cover is to a similar area of the same size with no impervious cover. For example, a factor of 1 indicates that the discharge from the treated impervious cover is equal to the discharge from an area of the same size with no impervious cover, while a factor of 0.5 indicates that the treated discharge is similar to a discharge from an area of the same size that has 50% impervious cover. The area treated for enhanced non-structural BMPs shall be only the area of impervious cover subject to the enhanced non-structural BMP (*e.g.*, the actual street area subject to increased street sweeping) that discharges to the impaired water body.

   The equivalent pervious cover factor shall be calculated as the average of the pollutant removal factor and the flow factor; the flow factor is the average of the runoff volume reduction factor and the peak flow attenuation factor. In other words, the equivalent pervious cover factor = ¼ [(2* pollutant removal factor) + runoff volume reduction factor + peak flow attenuation factor].

   The pollutant removal factor, runoff volume reduction factor, and peak flow attenuation factor for a particular control are each equal to the percentage of impervious cover that would need to be completely eliminated from the control's treated area to reach the same pollutant removal, runoff volume reduction, or peak flow attenuation, respectively, as the control. For instance, if a two-acre area of impervious cover has a peak flow after installation of a control that is similar to a two-acre area that is 25% pervious and 75% impervious, the control would have a 25% peak flow attenuation factor.

   The pollutant removal factor shall be calculated as described in Part 4 below, or another method approved by the EPA. The runoff volume reduction factor shall be calculated as described in Part 5 below, or another method approved by the EPA. The peak flow attenuation factor shall be calculated as described in Part 6 below, or another method approved by the EPA.

4. Pollutant Removal Factor - Unless another method is approved by the EPA, the pollutant removal factor shall be calculated using average annual ("yearly") phosphorous removal by the control (expressed as a percentage) as a surrogate for all pollutants. No removal of phosphorous is considered to be equivalent to no reduction of impervious cover, and a 90% removal of phosphorous is equivalent to all impervious cover eliminated. It is assumed that pollutants vary linearly with percentage of impervious cover. Therefore the pollutant removal factor is the percentage of yearly phosphorous removal divided by 0.9 (except that the pollutant removal factor shall not exceed 1). If the Impaired Water Body Segment is only impaired for nitrogen, Providence may use the yearly nitrogen removal by the control (expressed as a percentage, using a method approved by the EPA) as an option to the yearly phosphorous removal by the control (expressed as a percentage) in calculating the pollutant removal factor.

For each control, the yearly phosphorous removal percentage shall be calculated according to the methods in Attachment L of the Consent Agreement.

5. Runoff Volume Reduction Factor - Unless another method is approved by the EPA, the runoff volume reduction factor is based on the percentage yearly reduction of runoff volume as a result of the control. No reduction in runoff volume is considered to be equivalent to no reduction of impervious cover, and a reduction of 90% of runoff volume is equivalent to all impervious cover eliminated. It is also assumed that runoff volume varies linearly with impervious cover percentage. The runoff volume reduction factor is therefore the percentage yearly reduction of runoff volume divided by 0.9 (except that the runoff volume reduction factor shall not exceed 1).

   For each control, the percentage yearly reduction of runoff volume shall be calculated according to the methods in Attachment L of the Consent Agreement.

6. Peak flow attenuation factor -
   The peak flow attenuation factor is based on the highest twelve-hour runoff flow rate in an average year for conditions ranging from 0 to 100% impervious cover. This will be calculated assuming that peak flow varies linearly with the size of the area contributing flow, and varies linearly with the percentage of impervious cover in the contributing area.

   The highest twelve-hour runoff flow rate for each control will be calculated using the methods in Attachment L of the Consent Agreement.

   The peak flow attenuation factor will be calculated based on the reduction in peak flow rate achieved by the structural control from the completely impervious model. No reduction from the completely impervious model shall have a peak flow attenuation factor of 0, while a control that reduces peak flow down to the level of the completely pervious model shall have a peak flow attenuation factor of 100%; for partial attenuation of peak flow, the peak flow attenuation factor will be based on linear interpolation between the peak flow rates for the completely pervious and completely impervious models.

Methodologies for Calculating Pollutant Load Reductions Achieved for Structural Stormwater Controls and Enhanced Non-Structural BMPs and Methodologies for Calculating Runoff Volume Reduction and Peak Flow Attenuation Factors for the Impervious Cover Standard

A. Pollutant Load Reductions and Yearly Pollutant Removal Percentages Calculation

For non-bacteria TMDLs with a pollutant load reduction percentage that applies to Providence, the pollutant load reduction Providence is required to meet in accordance with Attachment J of the Consent Agreement and Part 2 of Attachment I of the Consent Agreement for a given Impaired Water Body Segment is the required pollutant load reduction percentage multiplied by the pollutant loading rate (as mass per acre per year) multiplied by the area of the MS4 impervious cover in the Impaired Sub-Watershed that discharges directly or indirectly to the Impaired Water Body Segment. To determine the extent of the contribution of an individual structural control or enhanced non-structural BMP to meeting this requirement, it is necessary to calculate the pollutant load reduction achieved by the control. Pollutant loading rates and/or average annual ("yearly") pollutant removal rates (expressed as a percentage) for individual controls are required to be determined for input to these calculations.

Yearly pollutant removal rates (expressed as a percentage) for individual controls are also required to be determined as one of the inputs to calculations under Attachment K of the Consent Agreement related to meeting the requirements of Paragraph C(4)(a)(v)4 of the Consent Agreement.

1. Pollutant Loading Rates

For those calculations which require yearly phosphorus pollutant loading rates from the MS4 areas as inputs, Providence shall use either (a) the roadway impervious cover and developed land pervious cover phosphorus yearly load export rates in a document entitled "Methods to Calculate Phosphorus Load Reductions for Structural Stormwater Best Management Practices in the Watershed", which is attached hereto and incorporated herein as Attachment M of the Consent Agreement or (b) other yearly phosphorus loading rates proposed by Providence, subject to review and approval by the RIDEM, based on credible stormwater runoff phosphorus quality information that is representative of road/ highway impervious cover, and, if applicable, associated pervious cover, for New England, *e.g.*, United States Geological Survey ("USGS") studies in Rhode Island.

For those calculations which require yearly zinc, other metals, nitrogen, or total suspended solids ("TSS") loading rates as inputs, Providence shall use either (a) yearly loading rates for the specific pollutant provided by the RIDEM, where available, or (b) other yearly loading rates for the specific pollutant proposed by Providence, subject to review and approval by the RIDEM, based on credible stormwater runoff quality information that is representative of road/highway impervious cover and, if applicable, associated pervious cover, for New England, *e.g.*, USGS studies in Rhode Island.

2. Yearly Pollutant Removal Percentages for Individual Controls

a. Structural Controls

Providence shall use the calculation methods and BMP Performance Curves and BMP Performance Tables in Attachment M of the Consent Agreement to determine yearly phosphorus removal percentages for calculating the pollutant load reduction achieved by individual structural controls for the types of structural controls specifically addressed by these performance curves and tables and for other types of structural controls that are analogous, where phosphorus is the pollutant of concern.

These methods and tables shall also be used to determine the yearly phosphorus removal percentages for individual controls when calculating the Pollutant Removal Factor described in Attachment K of the Consent Agreement.

Providence shall also use methods in Attachment M of the Consent Agreement and BMP Performance Curves and BMP Performance Tables similar to those in Attachment M of the Consent Agreement that have been developed by the EPA, where available, to determine yearly zinc, TSS, or nitrogen pollutant removal percentages to be used in calculating zinc, TSS, or nitrogen load reduction achieved by individual structural controls for the types of structural controls specifically addressed by these performance curves and tables and for other types of structural controls that are analogous, where zinc, TSS, or nitrogen, respectively, is the pollutant of concern. The percentages in the BMP Performance Curves and BMP Performance Tables developed for zinc shall also be used for other metal(s), where those metal(s) are the pollutant(s) of concern.

Providence may develop similar types of curves and tables, subject to review and approval by the RIDEM, for particular types of controls that are not analogous to the types of controls for which BMP Performance Curves and BMP Performance Tables have been developed by the EPA.

b. Enhanced Non-Structural BMPs

Providence shall use the methods in a document entitled "Phosphorus Reduction Credits for Selected Enhanced Non-Structural BMPs in the Watershed", which is attached hereto and incorporated herein as Attachment N of the Consent Agreement to calculate phosphorus load reduction credits for individual enhanced non-structural BMPs implemented by Providence that fall within the categories described in Attachment N of the Consent Agreement. Providence shall also use the Phosphorus Reduction Factors in these methods for individual controls when calculating the Pollutant Removal Factor described in Attachment K of the Consent Agreement.

Where pertinent and appropriate, Providence shall use methods similar to those in Attachment N of the Consent Agreement developed by the EPA, where available, to calculate nitrogen or TSS load reduction credits for individual enhanced non-structural control practices implemented by Providence that fall within the categories described in Attachment N of the Consent Agreement.

Where pertinent and appropriate, Providence may develop methods to calculate credits for enhanced non-structural control practices for other pollutants of concern or for types of enhanced non-structural controls not addressed in Attachment N of the Consent Agreement for its use in assessing pollutant loading reduction credits, subject to review and approval by the RIDEM.

B. <u>Runoff Volume Reduction Calculation</u>

For calculation of the Runoff Volume Reduction Factor described in Attachment K of the Consent Agreement for an individual control related to meeting the requirements of Paragraph C(4)(a)(v)4 of the Consent Agreement a determination of the yearly stormwater runoff volume reduction (expressed as a percentage) for the individual control (for those controls that provide infiltration) is required as an input.

Providence shall use the methods and BMP Performance Curves and BMP Performance Tables in Attachment M of the Consent Agreement to determine the yearly stormwater runoff volume reduction percentages for individual controls that provide infiltration when calculating the Runoff Volume Reduction Factor described in Attachment K of the Consent Agreement for the types of structural controls that provide infiltration specifically addressed by these performance curves and tables and for other types of structural controls that are analogous.

Providence may develop similar types of curves and tables, subject to review and approval by the RIDEM, for particular types of controls that provide infiltration that are not analogous to the types of controls for which BMP Performance Curves and BMP Performance Tables have been developed by the EPA.

C. <u>Peak Flow Attenuation Calculation</u>

For calculation of the Peak Flow Attenuation Factor described in Attachment K of the Consent Agreement for an individual control related to meeting the requirements of Paragraph C(4)(a)(v)4 of the Consent Agreement, a determination of the attenuation in peak flow provided by the individual control is required (for the types of controls that reduce peak flow rate) as an input.

Providence shall develop, for the RIDEM review and approval, curves and tables that indicate peak flow (as the maximum twelve-hour flow in an average year) for a model one-acre impervious watershed after treatment by different types and depths of structural controls. Providence shall also provide peak flows for the model one-acre watershed at 100% and 0% impervious cover without any treatment. Providence shall use SWMM or similar modeling, or an alternative as approved by the RIDEM, to develop these curves and tables, for use in calculating the attenuation in peak flow provided by the individual control.

ATTACHMENT 3 TO APPENDIX F

Methods to Calculate Phosphorus Load Reductions for Structural Stormwater Best Management Practices in the Watershed

List of Tables:

List of Figures:

Methods to Calculate Phosphorus Load Reductions for Structural Stormwater Best Management Practices in the Watershed

This attachment provides methods to determine design storage volume capacities and to calculate phosphorus load reductions for the following structural Best Management Practices (structural BMPs) for a Watershed:

1) Infiltration Trench;
2) Infiltration Basin or other surface infiltration practice;
3) Bio-filtration Practice;
4) Gravel Wetland System;
5) Porous Pavement;
6) Wet Pond or wet detention basin;
7) Dry Pond or detention basin; and
8) Water Quality Swale.

Additionally, this attachment provides methods to design and quantify associated phosphorus load reduction credits for the following four types of semi-structural/non-structural BMPs

9) Impervious Area Disconnection through Storage (e.g., rain barrels, cisterns, etc);
10) Impervious Area Disconnection;
11) Conversions of Impervious Area to Permeable Pervious Area; and
12) Soil Amendments to Enhance Permeability of Pervious Areas.

Methods and examples are provided in this Attachment to calculate phosphorus load reductions for structural BMPs for the four following purposes:

1) To determine the design volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area is 100% impervious;
2) To determine the phosphorus load reduction for a structural BMP with a known design volume when the contributing drainage area is 100% impervious;
3) To determine the design volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces; and
4) To determine the phosphorus load reduction for a structural BMP with a known design volume when the contributing drainage area has impervious and pervious surfaces.

Examples are also provided for estimating phosphorus load reductions associated with the four semi-structural/non-structural BMPs.

Also, this attachment provides the methodology for calculating the annual stormwater phosphorus load that will be delivered to BMPs for treatment (BMP Load) and to be used for quantifying phosphorus load reduction credits. The methods and annual phosphorus export load rates presented in this attachment are for the purpose of counting load reductions for various BMPs treating storm water runoff from varying site conditions (i.e., impervious or pervious surfaces) and different land uses (e.g. commercial and industrial). The estimates of annual phosphorus load and load reductions by BMPs are to demonstrate compliance with the permittee's Phosphorus Reduction Requirement under the permit.

Structural BMP performance credits: For each structural BMP type identified above (BMPs 1-8), long-term cumulative performance information is provided to calculate phosphorus load reductions or to determine needed design storage volumes to achieve a specified reduction target (e.g., 65% phosphorus load reduction). The performance information is expressed as cumulative phosphorus load removed (% removed) depending on the physical storage capacity of the structural BMP (expressed as inches of runoff from impervious area) and is provided at the end of this Attachment (see Tables 3-1 through 3-18 and performance curves Figures 3-1 through 3-17). Multiple tables and performance curves are provided for the infiltration practices to represent cumulative phosphorus load reduction performance for six infiltration rates (IR), 0.17, 0.27, 0.53, 1.02, 2.41, and 8.27 inches/hour. These infiltration rates represent the saturated hydraulic conductivity of the soils. The permittee may use the performance curves provided in this attachment to interpolate phosphorus load removal reductions for field measured infiltration rates that are different than the infiltration rates used to develop the performance curves. Otherwise, the permittee shall use the performance curve for the IR that is nearest, but less than, the field measured rate.

Semi-Structural/Non-structural BMP performance credits: For each semi-structural/non-structural BMP type identified above (BMPs 9-12), long-term cumulative performance information is provided to calculate phosphorus load reductions or to determine needed design specifications to achieve a desired reduction target (e.g., 50% phosphorus load reduction). The performance information is expressed as cumulative runoff volume reduction (% removed) depending on the design specifics and actual field conditions. Cumulative percent runoff volume reduction is being used to estimate the cumulative phosphorus load reduction credit for these BMPs. To represent a wide range of potential conditions for implementing these types of BMPs, numerous performance tables and curves have been developed to reflect a wide range of potential conditions and designs such as varying storage volumes (expressed in terms of varying ratios of storage volume to impervious area (0.1 to 2.0 inches)); varying ratios of impervious source area to receiving pervious area based on hydrologic soil groups (HSGs) A, B, C and D (8:1, 6:1, 4:1, 2: 1 and 1:1); and varying discharge time periods for temporary storage (1, 2 or 3 days). The default credits are provided at the end of this Attachment (see Tables 3-19 through 3-26 and performance curves Figures 3-18 through 3-38).

EPA will consider phosphorus load reductions calculated using the methods provided below to be valid for the purpose of complying with the terms of this permit for BMPs that have not been explicitly modeled if the desired BMP has functionality that is similar to one of the simulated BMP types. Please note that only the surface infiltration and the infiltration trench BMP types were simulated to direct storm water runoff into the ground (i.e., infiltration). All of the other simulated BMPs represent practices that have either under-drains or impermeable liners and therefore, are not hydraulically connected to the sub-surface soils (i.e., no infiltration). Following are some simple guidelines for selecting the BMP type and/or determining whether the results of any of the BMP types provided are appropriate for another BMP of interest.

Infiltration Trench is a practice that provides temporary storage of runoff using the void spaces within the soil/sand/gravel mixture that is used to backfill the trench for subsequent infiltration into the surrounding sub-soils. Performance results for the infiltration trench can be used for all subsurface infiltration practices including systems that include pipes and/or chambers that provide temporary storage. Also, the results for this BMP type can be used for bio-retention systems that rely on infiltration when the majority of the temporary storage capacity is provided in the void spaces of the soil filter media and porous pavements that allow infiltration to occur.

Surface Infiltration represents a practice that provides temporary surface storage of runoff (e.g., ponding) for subsequent infiltration into the ground. Appropriate practices for use of the surface infiltration performance estimates include infiltration basins, infiltration swales, rain gardens and bio-retention systems that rely on infiltration and provide the majority of storage capacity through surface-ponding. Design specifications for various surface infiltration systems are provided in the most recent version of *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

Bio-filtration is a practice that provides temporary storage of runoff for filtering through an engineered soil media. The storage capacity is typically made of void spaces in the filter media and temporary ponding at the surface of the practice. Once the runoff has passed through the filter media it is collected by an under-drain pipe for discharge. Depending on the design of the filter media manufactured or packaged bio-filter systems such as tree box filters may be suitable for using the bio-filtration performance results. Design specifications for bio-filtration systems are provided in the most recent version of *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

Gravel Wetland performance results should be used for practices that have been designed in accordance or share similar features with the design specifications for gravel wetland systems provided in the most recent version of *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

Porous Pavement performance results represent systems with an impermeable under-liner and an under-drain. *If porous pavement systems do not have an impermeable under-liner so that filtered runoff can infiltrate into sub-soils then the performance results for an infiltration trench may be used for these systems.* Design specifications for porous pavement systems are provided in the most recent version of *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

Extended Dry Detention Pond performance results should only be used for practices that have been designed in accordance with the design specifications for extended dry detention ponds provided in the most recent version of *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf)

Water Quality Wet Swale performance results should only be used for practices that have been designed in accordance with the design specifications for a water quality wet swale provided in the most recent version of *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf)

Impervious Area Disconnection using Storage (e.g., rain barrels, cistern, etc) performance results are for collecting runoff volumes from impervious areas such as roof tops, providing temporary storage of runoff volume using rain barrels, cisterns or other storage containers, and discharging stored volume to adjacent permeable pervious surfaces over an extended period of time.

Impervious Area Disconnection performance results are for diverting runoff volumes from impervious areas such as roadways, parking lots and roof tops, and discharging it to adjacent vegetated permeable surfaces that are of sufficient size with adequate soils to receive the runoff without causing negative impacts to adjacent down-gradient properties. Careful consideration must be given to the ratio of impervious area to the pervious area that will receive the discharge. Also, devices such as level spreaders to disperse the discharge and provide sheet flow should be employed whenever needed to increase recharge and avoid flow concentration and short circuiting through the pervious area. Soil testing is needed to classify the permeability of the receiving pervious area in terms of HSG.

Conversion of Impervious Area to Permeable Pervious Area phosphorus load reduction credits are for replacing existing impervious surfaces (such as traditional pavements and buildings with roof tops) with permeable surfaces. To be eligible for credit, it is essential that the area previously covered with impervious surface be restored to provide natural or enhanced hydrologic functioning so that the surface is permeable. Sub-soils beneath pavements are typically highly compacted and will require reworking to loosen the soil and the possible addition of soil amendments to restore permeability. Soil testing is needed to classify the permeability (in terms of HSG) of the restored pervious area.

Soil Amendments to Increase Permeability of Pervious Areas performance results are for the practice of improving the permeability of pervious areas through incorporation of soil amendments, tilling and establishing dense vegetation. This practice may be used to compliment other practices such as impervious area disconnection to improve overall performance and increase reduction credits earned. Soil testing is needed to classify the permeability (in terms of HSG) of the restored pervious area.

Alternative Methods:

A permittee may propose alternative long-term cumulative performance information or alternative methods to calculate phosphorus load reductions for the structural BMPs identified above or for other structural BMPs not identified in this Attachment.

EPA will consider alternative long-term cumulative performance information and alternative methods to calculate phosphorus load reductions for structural BMPs provided that the permittee provides EPA with adequate supporting documentation. At a minimum, the supporting documentation shall include:

1) Results of continuous BMP model simulations representing the structural BMP, using a verified BMP model and representative long-term (i.e., 10 years) climatic data including hourly rainfall data;
2) Supporting calculations and model documentation that justify use of the model, model input parameters, and the resulting cumulative phosphorus load reduction estimate;
3) If pollutant removal performance data are available for the specific BMP, model calibration results should be provided; and

4) Identification of references and sources of information that support the use of the alternative information and method.

If EPA determines that the long-term cumulative phosphorus load reductions developed based on alternative information are not adequately supported, EPA will notify the permittee in writing, and the permittee may receive no phosphorus reduction credit other than a reduction credit calculated by the permittee using the default phosphorus reduction factors provided in this attachment for the identified practices. The permittee is required to submit to EPA valid phosphorus load reductions for structural BMPs in the watershed in accordance with the submission schedule requirements specified in the permit and Appendix F.

Method to Calculate Annual Phosphorus Load Delivered to BMPs (BMP Load)

The **BMP Load** is the annual phosphorus load from the drainage area to each proposed or existing BMP used by permittee to claim credit against its stormwater phosphorus load reduction requirement (i.e., Phosphorus Reduction Requirement). The BMP Load is the starting point from which the permittee calculates the reduction in phosphorus load achieved by each existing and proposed BMP.

Examples are provided to illustrate use of the methods. Table 3-1 below provides annual phosphorus load export rates (PLERs) by land use category for impervious and pervious areas. The permittee shall select the land use category that most closely represents the actual use of the watershed. For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value. If the HSG is not known, assume HSG C/D conditions for the phosphorus load export rate. For watersheds with institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial/industrial land use category for the purpose of calculating phosphorus loads. Table 3-2 provides a crosswalk table of land use codes between land use groups in Table 3-1 and the codes used by MassGIS.

BMP Load: To estimate the annual phosphorus load reduction that a storm water BMP can achieve, it is first necessary to estimate the amount of annual phosphorus load that the BMP will receive or treat (BMP Load).
For a given BMP:

1) Determine the total drainage area to the BMP;

2) Distribute the total drainage area into impervious and pervious subareas by land use category as defined by Tables 3-1 and 3-2;

3) Calculate the phosphorus load for each land use-based impervious and pervious subarea by multiplying the subarea by the appropriate phosphorus load export rate provided in Table 3-1; and

4) Determine the total annual phosphorus load to the BMP by summing the calculated impervious and pervious subarea phosphorus loads.

Example 3-1 to determine phosphorus load to a proposed BMP: A permittee is proposing a surface stormwater infiltration system that will treat runoff from an industrial site with an area of 12.87 acres (5.21 hectares) and is made up of 10.13 acres of impervious cover (e.g., roadways, parking areas and rooftops), 1.85 acres of landscaped pervious area and 0.89 acres of wooded area both with HSG C soils. The drainage area information for the proposed BMP is:

BMP Subarea ID	Land Use Category	Cover Type	Area (acres)	P export rate (lb/acre/yr)*
1	Industrial	impervious	10.13	1.78
2	Landscaped (HSG C)	pervious	1.85	0.21
3	Forest (HSG C)	pervious	0.89	0.12

*From Table 3-1

The phosphorus load to the proposed BMP (BMP Load) is calculated as:

BMP Load $= (IA_{Ind} \times PLER_{Ind}) + (PA_{Ind} \times PLER_{Ind}) + (PA_{FOREST} \times PLER_{For})$
$= (10.13 \times 1.78) + (1.85 \times 0.21) + (0.89 \times 0.12)$
$=$ **18.53 lbs P/year**

Table 3- 1: Average annual distinct phosphorus load (P Load) export rates for use in estimating phosphorus load reduction credits the MA MS4 Permit

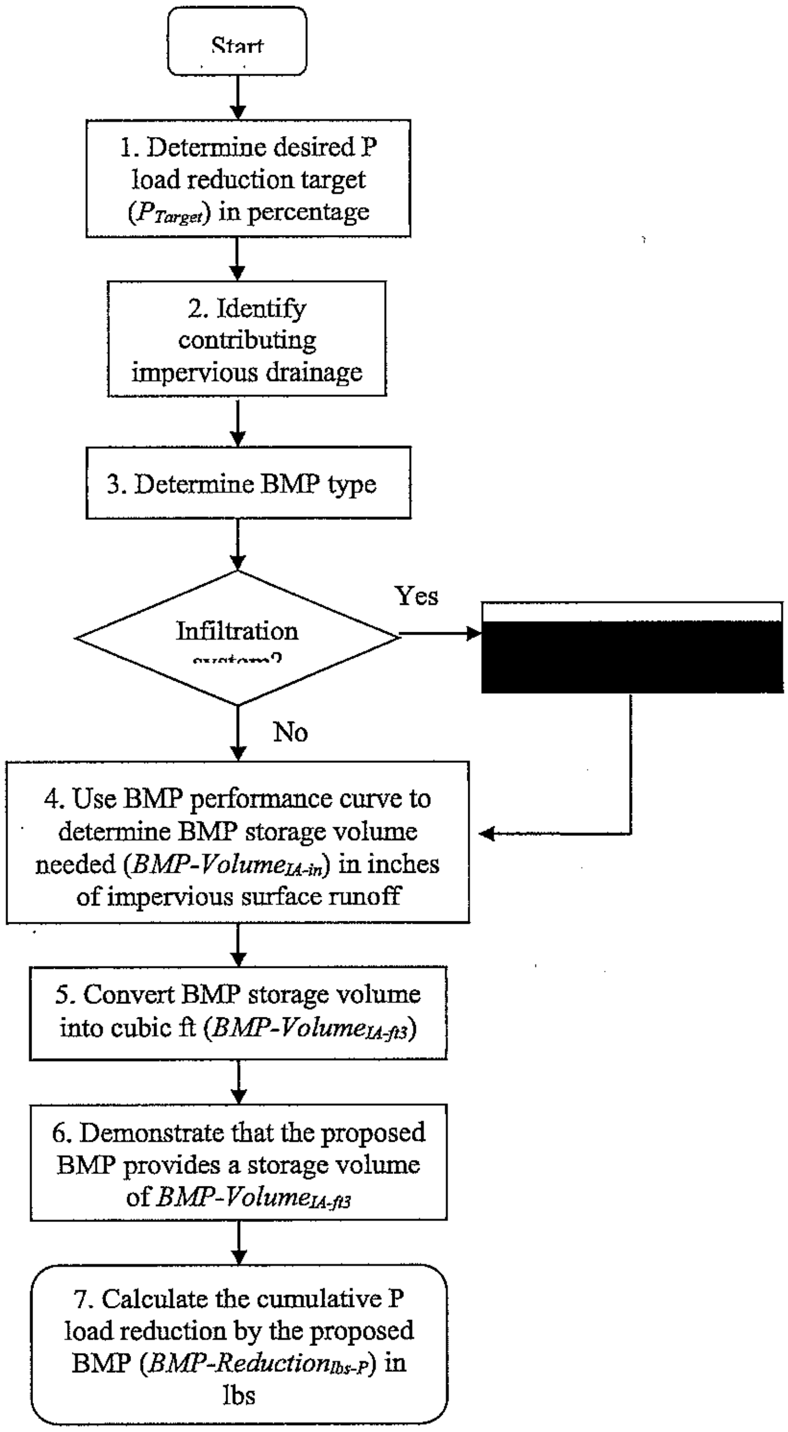
Phosphorus Source Category by Land Use	Land Surface Cover	P Load Export Rate, lbs/acre/year	P Load Export Rate, kg/ha/yr
Commercial (Com) and Industrial (Ind)	Directly connected impervious	1.78	2.0
	Pervious	See* DevPERV	See* DevPERV
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	2.6
	Pervious	See* DevPERV	See* DevPERV
Medium -Density Residential (MDR)	Directly connected impervious	1.96	2.2
	Pervious	See* DevPERV	See* DevPERV
Low Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	1.7
	Pervious	See* DevPERV	See* DevPERV
Highway (HWY)	Directly connected impervious	1.34	1.5
	Pervious	See* DevPERV	See* DevPERV
Forest (For)	Directly connected impervious	1.52	1.7
	Pervious	0.13	0.13
Open Land (Open)	Directly connected impervious	1.52	1.7
	Pervious	See* DevPERV	See* DevPERV
Agriculture (Ag)	Directly connected impervious	1.52	1.7
	Pervious	0.45	0.5
*Developed Land Pervious (DevPERV)- Hydrologic Soil Group A	Pervious	0.03	0.03
*Developed Land Pervious (DevPERV)- Hydrologic Soil Group B	Pervious	0.12	0.13
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group C	Pervious	0.21	0.24
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group C/D	Pervious	0.29	0.33
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group D	Pervious	0.37	0.41

Table 3- 2: MassGIS land-use categories with associated land-use groups for phosphorus load calculations

Mass GIS Land Use LU_CODE	Description	Land Use group for calculating P Load - 2013/14 MA MS4
1	Crop Land	Agriculture
2	Pasture (active)	Agriculture
3	Forest	Forest
4	Wetland	Forest
5	Mining	Industrial
6	Open Land includes inactive pasture	open land
7	Participation Recreation	open land
8	spectator recreation	open land
9	Water Based Recreation	open land
10	Multi-Family Residential	High Density Residential
11	High Density Residential	High Density Residential
12	Medium Density Residential	Medium Density Residential
13	Low Density Residential	Low Density Residential
14	Saltwater Wetland	Water
15	Commercial	Commercial
16	Industrial	Industrial
17	Urban Open	open land
18	Transportation	Highway
19	Waste Disposal	Industrial
20	Water	Water
23	cranberry bog	Agriculture
24	Powerline	open land
25	Saltwater Sandy Beach	open land
26	Golf Course	Agriculture
29	Marina	Commercial
31	Urban Public	Commercial
34	Cemetery	open land
35	Orchard	Forest
36	Nursery	Agriculture
37	Forested Wetland	Forest
38	Very Low Density residential	Low Density Residential
39	Junkyards	Industrial
40	Brush land/Successional	Forest

(1) Method to determine the design volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area is 100% impervious:

Flow Chart 1 illustrates the steps to determine the design volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area is 100% impervious.



Flow Chart 1: Method to determine BMP design volume to achieve a known phosphorous load reduction when contributing drainage area is 100% impervious.

1) Determine the desired cumulative phosphorus load reduction target (P_{target}) in percentage for the structural BMP;

2) Determine the contributing impervious drainage area (IA) in acres to the structural BMP;

3) Determine the structural BMP type (e.g., infiltration trench, gravel wetland). For infiltration systems, determine the appropriate infiltration rate for the location of the BMP in the Watershed;

4) Using the cumulative phosphorus removal performance curve for the selected structural BMP (Figures 3-1 through 3-18), determine the storage volume for the BMP ($BMP\text{-}Volume_{IA\text{-}in}$), in inches of runoff, needed to treat runoff from the contributing IA to achieve the reduction target;

5) Calculate the corresponding BMP storage volume in cubic feet ($BMP\text{-}Volume_{IA\text{-}ft^3}$) using $BMP\text{-}Volume_{IA\text{-}in}$ determined from step 4 and equation 3-1:

$BMP\text{-}Volume_{IA\text{-}ft^3}$ = IA (acre) x $BMP\text{-}Volume_{IA\text{-}in}$ x 3630 ft³/ac-in **(Equation 3-1)**

6) Provide supporting calculations using the dimensions and specifications of the proposed structural BMP showing that the necessary storage volume, $BMP\text{-}Volume_{IA\text{-}ft^3}$, determined from step 5 will be provided to achieve the P_{Target}; and

7) Calculate the cumulative phosphorus load reduction in pounds of phosphorus ($BMP\text{-}Reduction_{lbs\text{-}P}$) for the structural BMP using the BMP Load (as calculated from the procedure in Attachment 1 to Appendix F) and P_{target} by using equation 3-2:

$BMP\text{-}Reduction_{lbs\text{-}P}$ = BMP Load x (P_{target} /100) **(Equation 3-2)**

Example 3-2 to determine design volume of a structural BMP with a 100% impervious drainage area to achieve a known phosphorus load reduction target:

A permittee is considering a surface infiltration practice to capture and treat runoff from 2.57 acres (1.04 ha) of commercial impervious area that will achieve a 70% reduction in annual phosphorus load. The infiltration practice would be located adjacent to the impervious area. The permittee has measured an infiltration rate (IR) of 0.39 inches per hour (in/hr) in the vicinity of the proposed infiltration practice. Determine the:

A) Design storage volume needed for an surface infiltration practice to achieve a 70% reduction in annual phosphorus load from the contributing drainage area ($BMP\text{-}Volume_{IA\text{-}ft^3}$); and

B) Cumulative phosphorus reduction in pounds that would be accomplished by the BMP ($BMP\text{-}Reduction_{lbs\text{-}P}$)

Solution:

1) Contributing impervious drainages area (IA) = 2.57 acres

BMP type is a surface infiltration practice (i.e., basin) with an infiltration rate (IR) of 0.39 in/hr

Solution continued:

3) Phosphorus load reduction target (P_{target}) = 70%

4) The performance curve for the infiltration basin (i.e., surface infiltration practice), Figure 3-8, IR = 0.27 in/hr is used to determine the design storage volume of the BMP (BMP-Volume $_{IA-in}$) needed to treat runoff from the contributing IA and achieve a P_{target} = 70%. The curve for an infiltration rate of 0.27 in/hr is chosen because 0.27 in/hr is the nearest simulated IR that is less than the field measured IR of 0.39 in/hr. From Figure 3-8, the BMP-Volume $_{IA-in}$ for a P_{target} = 70% is 0.36 in.

5) The BMP-Volume $_{IA-in}$ is converted to cubic feet (BMP-Volume $_{IA-ft^3}$) using Equation 3-1:

BMP-Volume $_{IA-ft^3}$ = IA (acre) x BMP-Volume $_{IA-in}$ x 3,630 ft^3/acre-in
BMP-Volume $_{IA-ft^3}$ = 2.57 acre x 0.36 in x 3,630 ft^3/acre-in
= **3,359 ft^3**

6) A narrow trapezoidal infiltration basin with the following characteristics is proposed to achieve the P_{Target} of 70%:

Length (ft)	Design Depth (ft)	Side Slopes	Bottom area (ft^2)	Pond surface area (ft^2)	Design Storage Volume (ft^3)
355	1.25	3:1	1,387	4,059	3,404

The volume of the proposed infiltration practice, 3,404 ft^3, exceeds the BMP-Volume $_{IA-ft^3}$ needed, 3,359 ft^3 and is sufficient to achieve the P Target of 70%.

7) The cumulative phosphorus load reduction in pounds of phosphorus for the infiltration practice (BMP-Reduction $_{lbs-P}$) is calculated using Equation 3-2. The BMP Load is first determined using the method described above.

BMP Load = IA x impervious cover phosphorus export loading rate for commercial use (see Table 3-1)
= 2.57 acres x 1.78 lbs/acre/yr
= 4.58 lbs/yr

BMP-Reduction $_{lbs-P}$ = BMP Load x (P_{target} /100)
BMP-Reduction $_{lbs-P}$ = 4.58 lbs/yr x (70/100)
= **3.21 lbs/yr**

Alternate Solution: Alternatively, the permittee could determine the design storage volume needed for an IR = 0.39 in/hr by performing interpolation of the results from the surface infiltration performance curves for IR = 0.27 in/hr and IR = 0.52 in/hr as follows (replacing steps 3 and 4 on the previous page):

Alternate solution continued:

Using the performance curves for the infiltration basin (i.e., surface infiltration practice), Figures 3-8, IR = 0.27 in/hr and 3-9, IR = 0.52 in/hr, interpolate between the curves to determine the design storage volume of the BMP (BMP-Volume $_{IA\text{-}in}$) needed to treat runoff from the contributing IA and achieve a P $_{target}$ = 70%.

First calculate the interpolation adjustment factor (IAF) to interpolate between the infiltration basin performance curves for infiltration rates of 0.27 and 0.52 in/hr:

$$IAF = (0.39 - 0.27)/ (0.52 - 0.27) = 0.48$$

From the two performance curves, develop the following table to estimate the general magnitude of the needed storage volume for an infiltration swale with an IR = 0.39 in/hr and a P $_{target}$ of 70%.

Table Example 3-1-1: Interpolation Table for determining design storage volume of infiltration basin with IR = 0.39 in/hr and a phosphorus load reduction target of 70%

BMP Storage Volume	% Phosphorus Load Reduction IR = 0.27 in/hr ($PR_{IR=0.27}$)	% Phosphorus Load Reduction IR = 0.52 in/hr ($PR_{IR=0.52}$)	Interpolated % Phosphorus Load Reduction IR = 0.39 in/hr ($PR_{IR=0.39}$) **$PR_{IR=0.39}$= IAF($PR_{IR=0.52}$ – $PR_{IR=0.27}$) + $PR_{IR=0.27}$**
0.3	64%	67%	65%
0.4	74%	77%	75%
0.5	79%	82%	80%

As indicated from Table Example 3-1, the BMP-Volume $_{IA\text{-}in}$ for $PR_{IR=0.39}$ of 70% is between 0.3 and 0.4 inches and can be determined by interpolation:

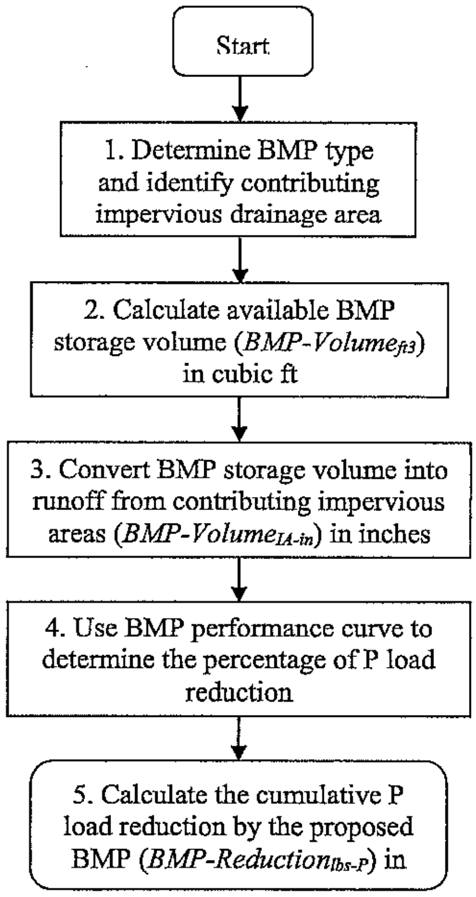
$$\text{BMP-Volume}_{IA\text{-}in} = (70\% - 65\%)/ (75\% - 65\%) \times (0.4 \text{ in} - 0.3 \text{ in}) + 0.3 \text{ in}$$
$$= 0.35 \text{ inches}$$

5 alternative) Convert the resulting BMP-Volume $_{IA\text{-}in}$ to cubic feet (BMP-Volume $_{IA\text{-}ft^3}$) using equation 3-1:

$$\text{BMP-Volume}_{IA\text{-}ft^3} = 2.57 \text{ acre} \times 0.35 \text{ in} \times 3{,}630 \text{ ft}^3/\text{acre-in}$$
$$= \mathbf{3{,}265 \text{ ft}^3}$$

(2) <u>Method to determine the phosphorus load reduction for a structural BMP with a known design volume when the contributing drainage area is 100% impervious:</u>

Flow Chart 2 illustrates the steps to determine the phosphorus load reduction for a structural BMP with a known design volume when the contributing drainage area is 100% impervious.



Flow Chart 2: Method to determine the phosphorus load reduction for a BMP with a known design volume when contributing drainage area is 100% impervious.

1) Identify the structural BMP type and contributing impervious drainage area (IA);

2) Document the available storage volume (ft^3) of the structural BMP (BMP-Volume $_{ft^3}$) using the BMP dimensions and design specifications (e.g., maximum storage depth, filter media porosity);

3) Convert BMP-Volume $_{ft^3}$ into inches of runoff from the contributing impervious area (BMP-Volume $_{IA\text{-}in}$) using equation 3-3:

   BMP-Volume $_{IA\text{-}in}$ = BMP-Volume $_{ft^3}$/ IA (acre) x 12 in/ft x 1 acre/43560 ft^2 **(Equation 3-3)**

4) Determine the % phosphorus load reduction for the structural BMP (BMP Reduction $_{\%\text{-}P}$) using the appropriate BMP performance curve (Figures 3-1 through 3-18) and the BMP-Volume $_{IA\text{-}in}$ calculated in step 3; and

5) Calculate the cumulative phosphorus load reduction in pounds of phosphorus for the structural BMP (BMP Reduction $_{lbs\text{-}P}$) using the BMP Load as calculated from the

procedure described above and the percent phosphorus load reduction determined in step 4 by using equation 3-4:

$$\text{BMP Reduction}_{lbs\text{-}P} = \text{BMP Load} \times (\text{BMP Reduction}_{\%\text{-}P}/100) \quad \textbf{(Equation 3-4)}$$

Example 3-2: Determine the phosphorus load reduction for a structural BMP with a known storage volume capacity when the contributing drainage area is 100% impervious:

A permittee is considering a bio-filtration system to treat runoff from 1.49 acres of high density residential (HDR) impervious area. Site constraints would limit the bio-filtration system to have a surface area of 1200 ft^2 and the system would have to be located next to the impervious drainage area to be treated. The design parameters for the bio-filtration system are presented in Table Example 3-2-1.

Table Example 3-2-1: Design parameters for bio-filtration system for Example 3-2

Components of representation	Parameters	Value
Ponding	Maximum depth	0.5 ft
	Surface area	1200 ft^2
	Vegetative parameter[a]	85-95%
Soil mix	Depth	2.5 ft
	Porosity	0.40
	Hydraulic conductivity	4 inches/hour
Gravel layer	Depth	0.67 ft
	Porosity	0.40
	Hydraulic conductivity	14 inches/hour
Orifice #1	Diameter	0.5 ft

[a] Refers to the percentage of surface covered with vegetation

Determine the:

A) Percent phosphorus load reduction (BMP Reduction $_{\%\text{-}P}$) for the specified bio-filtration system and contributing impervious drainage area; and

B) Cumulative phosphorus reduction in pounds that would be accomplished by the bio-filtration system (BMP-Reduction $_{lbs\text{-}P}$)

Solution:

1) The BMP is a bio-filtration system that will treat runoff from 1.49 acres of impervious area (IA = 1.49 acre);

2) The available storage volume capacity (ft^3) of the bio-filtraton system (BMP-Volume $_{BMP\text{-}ft^3}$) is determined using the surface area of the system, depth of ponding, and the porosity of the filter media:

BMP-Volume $_{BMP\text{-}ft^3}$ = (surface area x pond maximum depth) + ((soil mix depth + gravel layer depth)/12 in/ft) x surface area x gravel layer porosity)

= (1,200 ft^2 x 0.5 ft) + ((38/12) x 1,200 ft^2 x 0.4)

= 2,120 ft^3

Solution continued:

3) The available storage volume capacity of the bio-filtration system in inches of runoff from the contributing impervious area (BMP-Volume $_{IA\text{-}in}$) is calculated using equation 3-3:

   BMP-Volume $_{IA\text{-}in}$ = (BMP-Volume $_{ft^3}$/ IA (acre) x 12 in/ft x 1 acre/43560 ft^2
   BMP-Volume $_{IA\text{-}in}$ = (2120 ft^3/1.49 acre) x 12 in/ft x 1 acre/43560 ft^2
   = 0.39 in

4) Using the bio-filtration performance curve shown in Figure 3-13, a **51%** phosphorus load reduction (BMP Reduction %-P) is determined for a bio-filtration system sized for 0.39 in of runoff from 1.49 acres of impervious area; and

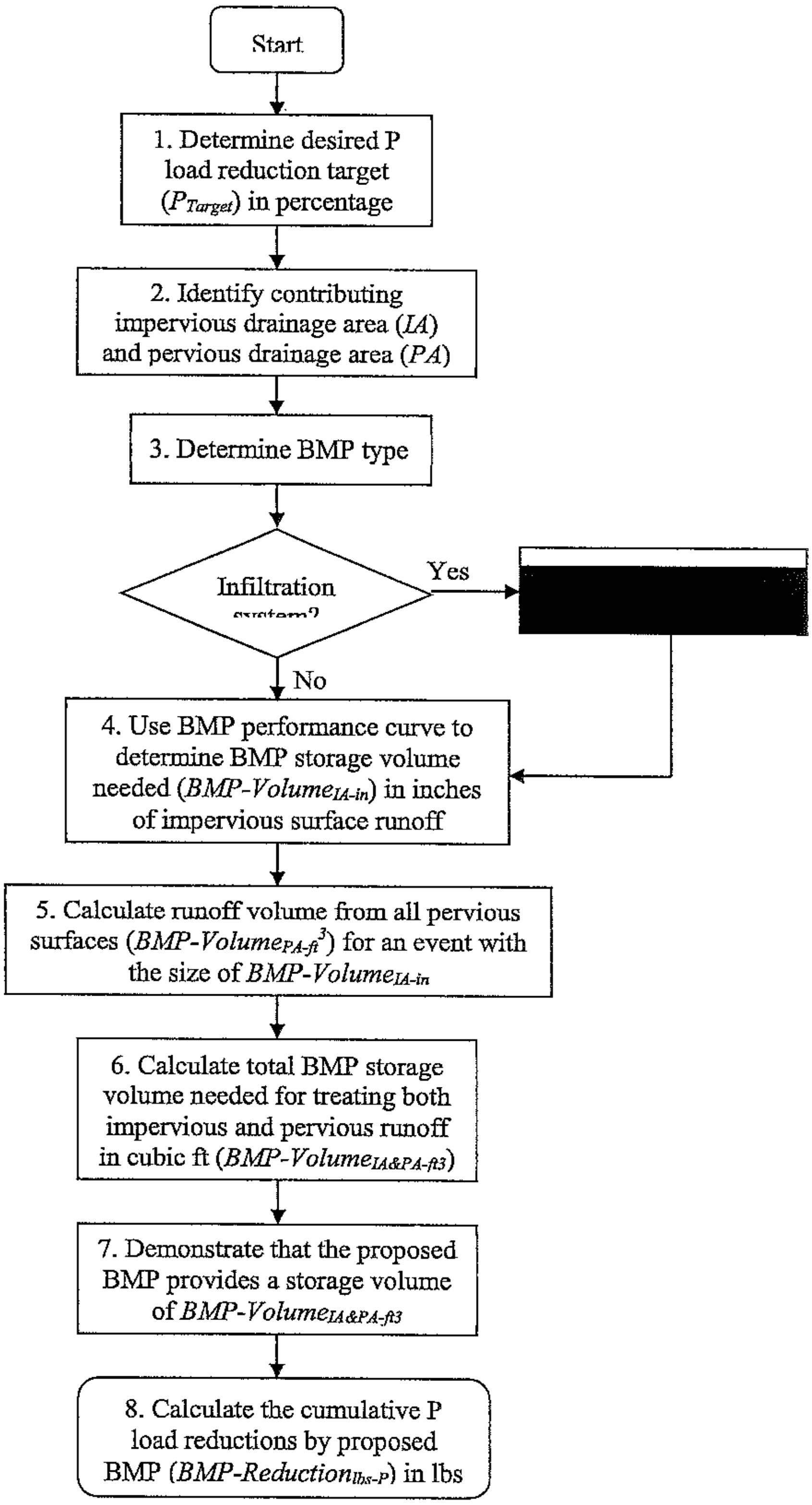
5) Calculate the cumulative phosphorus load reduction in pounds of phosphorus for the bio-filtration system (BMP Reduction $_{lbs\text{-}P}$) using the BMP Load as calculated from the procedure described above and the BMP Reduction $_{\%\text{-}P}$ determined in step 4 by using equation 3-4. First, the BMP Load is determined as specified above:

   BMP Load = IA x impervious cover phosphorus export loading rate for HDR (see Table 3-1) = 1.49 acres x 2.32 lbs/acre/yr
   = 3.46 lbs/yr

   BMP Reduction $_{lbs\text{-}P}$ = BMP Load x (BMP Reduction $_{\%\text{-}P}$/100)
   BMP Reduction $_{lbs\text{-}P}$ = 3.46 lbs/yr x (51/100)
   = 1.76 lbs/yr

(3) Method to determine the design storage volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces:

Flow Chart 3 illustrates the steps to determine the design storage volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces.


Start
1. Determine desired P load reduction target (P_{Target}) in percentage
2. Identify contributing impervious drainage area (*IA*) and pervious drainage area (*PA*)
3. Determine BMP type
Infiltration
Yes
[redacted]
No
4. Use BMP performance curve to determine BMP storage volume needed ($BMP\text{-}Volume_{IA\text{-}in}$) in inches of impervious surface runoff
5. Calculate runoff volume from all pervious surfaces ($BMP\text{-}Volume_{PA\text{-}ft^3}$) for an event with the size of $BMP\text{-}Volume_{IA\text{-}in}$
6. Calculate total BMP storage volume needed for treating both impervious and pervious runoff in cubic ft ($BMP\text{-}Volume_{IA\&PA\text{-}ft3}$)
7. Demonstrate that the proposed BMP provides a storage volume of $BMP\text{-}Volume_{IA\&PA\text{-}ft3}$
8. Calculate the cumulative P load reductions by proposed BMP ($BMP\text{-}Reduction_{lbs\text{-}P}$) in lbs

Flow Chart 3: Method to determine the design storage volume of a BMP to reach a known P load reduction when both impervious and pervious drainage areas are present.

1) Determine the desired cumulative phosphorus load reduction target (P_{target}) in percentage for the structural BMP;
2) Characterize the contributing drainage area to the structural BMP by identifying the following information for the impervious and pervious surfaces:
   Impervious area (IA) - Area (acre) and land use (e.g., commercial)

   Pervious area (PA) – Area (acre) and runoff depths based on hydrologic soil group (HSG) and rainfall depth. Table 3-3 provides values of runoff depth from pervious areas for various rainfall depths and HSGs. Soils are assigned to an HSG on the basis of their permeability. HSG A is the most permeable, and HSG D is the least permeable. HSG categories for pervious areas in the drainage area shall be estimated by consulting local soil surveys prepared by the National Resource Conservation Service (NRCS) or by a storm water professional evaluating soil testing results from the drainage area. If the HSG condition is not known, a HSG D soil condition should be assumed.

Table 3- 3: Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups (HSGs)

Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups					
	Runoff Depth, inches				
Rainfall Depth, Inches	Pervious HSG A	Pervious HSG B	Pervious HSG C	Pervious HSG C/D	Pervious HSG D
0.10	0.00	0.00	0.00	0.00	0.00
0.20	0.00	0.00	0.01	0.02	0.02
0.40	0.00	0.00	0.03	0.05	0.06
0.50	0.00	0.01	0.05	0.07	0.09
0.60	0.01	0.02	0.06	0.09	0.11
0.80	0.02	0.03	0.09	0.13	0.16
1.00	0.03	0.04	0.12	0.17	0.21
1.20	0.04	0.05	0.14	0.27	0.39
1.50	0.08	0.11	0.39	0.55	0.72
2.00	0.14	0.22	0.69	0.89	1.08

Notes: Runoff depths derived from combination of volumetric runoff coefficients from Table 5 of *Small Storm Hydrology and Why it is Important for the Design of Stormwater Control Practices*, (Pitt, 1999), and using the Stormwater Management Model (SWMM) in continuous model mode for hourly precipitation data for Boston, MA, 1998-2002.

3) Determine the structural BMP type (e.g., infiltration trench, gravel wetland). For infiltration systems, determine the appropriate infiltration rate for the location of the BMP in the Watershed;
4) Using the cumulative phosphorus removal performance curve for the selected structural BMP, determine the storage volume capacity of the BMP in inches needed to treat runoff from the contributing impervious area ($BMP\text{-}Volume_{IA\text{-}in}$);

5) Using Equation 3-5 below and the pervious area runoff depth information from Table 3-3-1, determine the total volume of runoff from the contributing pervious drainage area in cubic feet (BMP Volume $_{PA-ft^3}$) for a rainfall size equal to the sum of BMP Volume $_{IA-in}$, determined in step 4. The runoff volume for each distinct pervious area must be determined;

   BMP-Volume $_{PA\ ft^3} = \sum$ (PA x (runoff depth) x 3,630 ft³/acre-in) $_{(PA1,\ldots PAn)}$
   (Equation 3-5)

6) Using equation 3-6 below, calculate the BMP storage volume in cubic feet (BMP-Volume $_{IA\&PA-ft^3}$) needed to treat the runoff depth from the contributing impervious (IA) and pervious areas (PA);

   BMP-Volume $_{IA\&PA-ft^3}$ = BMP Volume $_{PA-ft^3}$ + (BMP Volume $_{IA-in}$ x IA (acre) x 3,630 ft³/acre-in) **(Equation 3-6)**

7) Provide supporting calculations using the dimensions and specifications of the proposed structural BMP showing that the necessary storage volume determined in step 6, BMP-Volume $_{IA\&PA-ft^3}$, will be provided to achieve the P $_{Target}$; and

8) Calculate the cumulative phosphorus load reduction in pounds of phosphorus (BMP-Reduction $_{lbs-P}$) for the structural BMP using the BMP Load (as calculated from the procedure in Attachment 1 to Appendix F) and the P $_{target}$ by using equation 3-2:

   BMP-Reduction $_{lbs-P}$ = BMP Load x (P $_{target}$ /100) **(Equation 3-2)**

Example 3-3: Determine the design storage volume of a structural BMP to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces

A permittee is considering a gravel wetland system to treat runoff from a high-density residential (HDR) site. The site is 7.50 acres of which 4.00 acres are impervious surfaces and 3.50 acres are pervious surfaces. The pervious area is made up of 2.5 acres of lawns in good condition surrounding cluster housing units and 1.00 acre of stable unmanaged woodland. Soils information indicates that all of the woodland and 0.50 acres of the lawn is hydrologic soil group (HSG) B and the other 2.00 acres of lawn are HSG C. The permittee wants to size the gravel wetland system to achieve a cumulative phosphorus load reduction (P $_{Target}$) of 55% from the entire 7.50 acres.

Determine the:

A) Design storage volume needed for a gravel wetland system to achieve a 55% reduction in annual phosphorus load from the contributing drainage area (BMP-Volume $_{IA\&PA-ft^3}$); and
B) Cumulative phosphorus reduction in pounds that would be accomplished by the BMP (BMP-Reduction $_{lbs-P}$)

Example 3-3 continued:
<u>Solution:</u>

1) The BMP type is gravel wetland system.

2) The phosphorus load reduction target (P_{Target}) = 55%.

3) Using the cumulative phosphorus removal performance curve for the gravel wetland system shown in Figure 3-14, the storage volume capacity in inches needed to treat runoff from the contributing impervious area (BMP Volume $_{IA-in}$) is 0.71 in;

Using equation 3-5 and the pervious runoff depth information from Table 3-3, the volume of runoff from the contributing pervious drainage area in cubic feet (BMP Volume $_{PA-ft^3}$) for a rainfall size equal to 0.71 in is summarized in Table Example 3-3-A. As indicated from Table 3-3, the runoff depth for a rainfall size equal to 0.71 inches is between 0.6 and 0.8 inches and can be determined by interpolation (example shown for runoff depth of HSG C):

Runoff depth (HSG C) = (0.71 – 0.6)/(0.8 – 0.6) x (0.09 in – 0.06 in) + 0.06 in
= 0.07 inches

Table Example 3-3-A: Runoff contributions from pervious areas for HDR site

ID	Type	Pervious Area (acre)	HSG	Runoff (in)	Runoff = (runoff) x PA (acre-in)	Runoff = Runoff (acre-in) x 3630 ft^3/acre-in (ft^3)
PA1	Grass	2.00	C	0.07	0.14	508
PA2	Grass	0.50	B	0.01	0.0	0.0
PA3	Woods	1.00	B	0.01	0.0	0.0
Total	-----	**3.50**	-----	-----	**0.14**	**508**

4) Using equation 3-6, determine the BMP storage volume in cubic feet (BMP-Volume $_{IA\&PA-ft^3}$) needed to treat 0.71 inches of runoff from the contributing impervious area (IA) and the runoff of 0.14 acre-in from the contributing pervious areas, determined in step 5 is:

BMP Volume$_{IA\&PA-ft^3}$ = BMP Volume $_{PA\ ac-in}$ + (BMP Volume $_{IA-in}$ x IA (acre)) x 3,630 ft^3/acre-in)
BMP Volume$_{IA\&PA-ft^3}$ = (508 ft^3+ (0.71 in x 4.00 acre)) x 3,630 ft^3/acre-in
= 10,817 ft^3

5) Table Example 3-3-B provides design details for of a potential gravel wetland system

Solution continued:

Table Example 3-3-B: Design details for gravel wetland system

Gravel Wetland System Components	Design Detail	Depth (ft)	Surface Area (ft^2)	Volume (ft^3)
Sediment Forebay	**10% of Treatment Volume**			
Pond area	----	1.33	896	1,192
Wetland Cell #1	**45% of Treatment Volume**			
Pond area	—	2.00	1,914	3,828
Gravel layer	porosity = 0.4	2.00	1,914	1,531
Wetland Cell #2	**45% of Treatment Volume**			
Pond area	—	2.00	1,914	3,828
Gravel layer	porosity = 0.4	2.00	1,914	1,531

The total design storage volume for the proposed gravel wetland system identified in Table Example 3-3-C is 11,910 ft^3. This volume is greater than 11,834 ft^3 ((BMP-Volume $_{IA\&PA\text{-}ft^3}$), calculated in step 6) and is therefore sufficient to achieve a P $_{Target}$ of 55%.

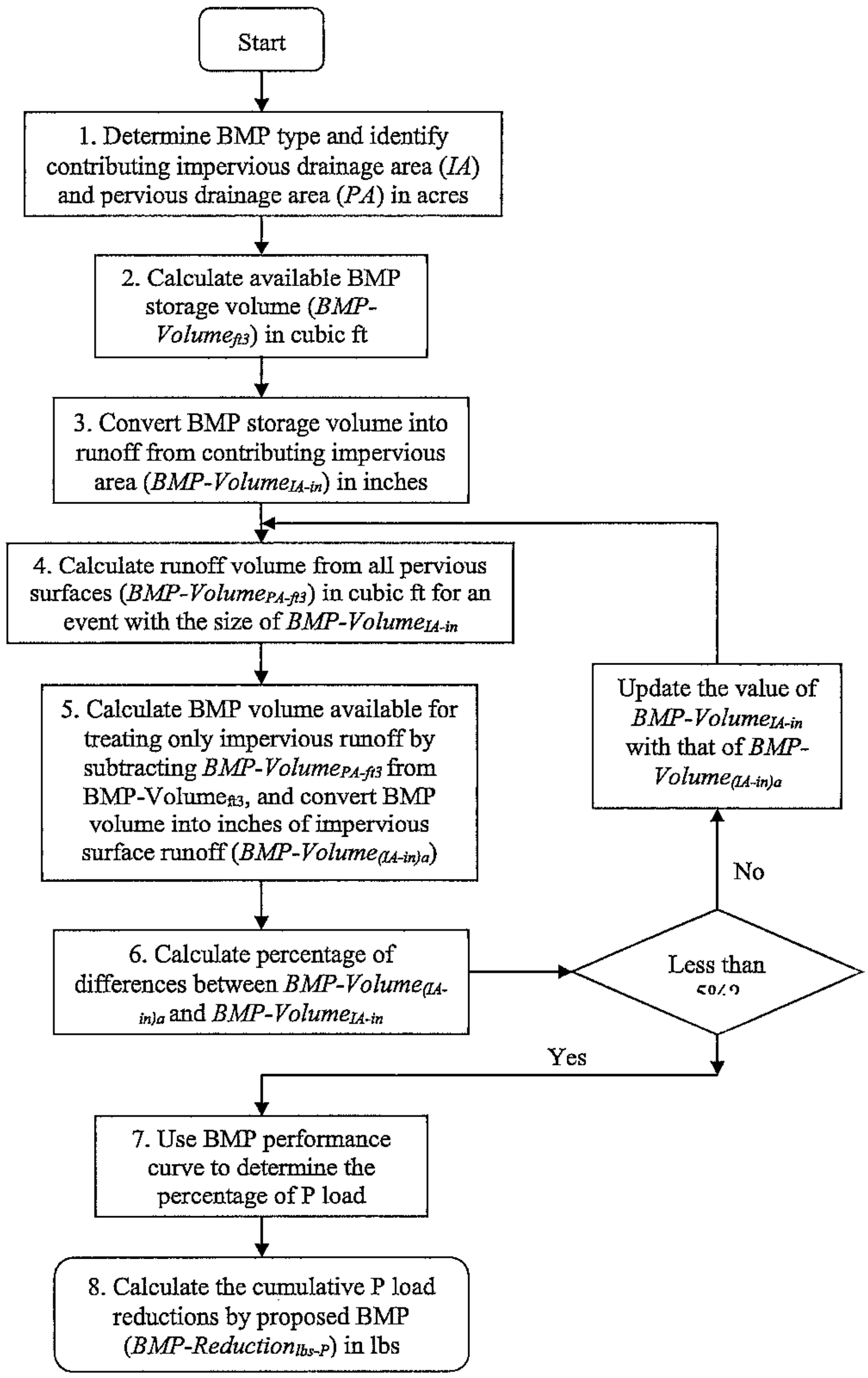
6) The cumulative phosphorus load reduction in pounds of phosphorus (BMP-Reduction $_{lbs\text{-}P}$) for the proposed gravel wetland system is calculated by using equation 3-2 with the BMP Load and the P $_{target}$ = 55%.

BMP-Reduction $_{lbs\text{-}P}$ = BMP Load x (P $_{target}$ /100) **(Equation 3-2)**

Using Table 3-1, the BMP Load is calculated:
BMP Load = (IA x PLER $_{HDR}$) + (PA lawn $_{HSG\,B}$ x PLER $_{HSG\,B}$) + (PA lawn $_{HSG\,C}$ x PLER $_{HSG\,C}$) +(PA forest x PA PLER $_{For}$)
= (4.00 acre x 2.32 lbs/acre/yr) + (0.50 acres x 0.12 lbs/acre/yr) + (1.00 acre x 0.21 lbs/acre/yr) + (1.00 acres x 0.13)
= 9.68 lbs/yr
BMP-Reduction $_{lbs\text{-}P}$ = BMP Load x (P $_{target}$ /100)
BMP-Reduction $_{lbs\text{-}P}$ = 9.68 lbs/yr x 55/100
= **5.32 lbs/yr**

(4) Method to determine the phosphorus load reduction for a structural BMP with a known storage volume when the contributing drainage area has impervious and pervious surfaces:

Flow Chart 4 illustrates the steps to determine the phosphorus load reduction for a structural BMP with a known storage volume when the contributing drainage area has impervious and pervious surfaces.


Start
1. Determine BMP type and identify contributing impervious drainage area (*IA*) and pervious drainage area (*PA*) in acres
2. Calculate available BMP storage volume (*BMP-Volume*$_{ft3}$) in cubic ft
3. Convert BMP storage volume into runoff from contributing impervious area (*BMP-Volume*$_{IA\text{-}in}$) in inches
4. Calculate runoff volume from all pervious surfaces (*BMP-Volume*$_{PA\text{-}ft3}$) in cubic ft for an event with the size of *BMP-Volume*$_{IA\text{-}in}$
5. Calculate BMP volume available for treating only impervious runoff by subtracting *BMP-Volume*$_{PA\text{-}ft3}$ from BMP-Volume$_{ft3}$, and convert BMP volume into inches of impervious surface runoff (*BMP-Volume*$_{(IA\text{-}in)a}$)
6. Calculate percentage of differences between *BMP-Volume*$_{(IA\text{-}in)a}$ and *BMP-Volume*$_{IA\text{-}in}$
Less than
No
Update the value of *BMP-Volume*$_{IA\text{-}in}$ with that of *BMP-Volume*$_{(IA\text{-}in)a}$
Yes
7. Use BMP performance curve to determine the percentage of P load
8. Calculate the cumulative P load reductions by proposed BMP (*BMP-Reduction*$_{lbs\text{-}P}$) in lbs

Flow Chart 4: Method to determine the phosphorus load reduction for a BMP with known storage volume when both pervious and impervious drainage areas are present.

1) Identify the type of structural BMP and characterize the contributing drainage area to the structural BMP by identifying the following information for the impervious and pervious surfaces:

   Impervious area (IA) – Area (acre) and land use (e.g., commercial)

   Pervious area (PA) – Area (acre) and runoff depth based on hydrologic soil group (HSG) and size of rainfall event. Table 3-3 provides values of runoff depth for various rainfall depths and HSGs. Soils are assigned to an HSG based on their permeability. HSG categories for pervious areas in the Watershed shall be estimated by consulting local soil surveys prepared by the National Resource Conservation Service (NRCS) or by a storm water professional evaluating soil testing results from the Watershed. If the HSG condition is not known, a HSG C/D soil condition should be assumed.

2) Determine the available storage volume (ft^3) of the structural BMP (BMP-Volume $_{ft^3}$) using the BMP dimensions and design specifications (e.g., maximum storage depth, filter media porosity);

3) To estimate the phosphorus load reduction of a BMP with a known storage volume capacity, it is first necessary to determine the portion of available BMP storage capacity (BMP-Volume $_{ft^3}$) that would treat the runoff volume generated from the contributing impervious area (IA) for a rainfall event with a depth of *i* inches (in). This will require knowing the corresponding amount of runoff volume that would be generated from the contributing pervious area (PA) for the same rainfall event (depth of *i* inches). Using equation 3-6a below, solve for the BMP capacity that would be available to treat runoff from the contributing imperious area for the unknown rainfall depth of *i* inches (see equation 3-6b):

$$\text{BMP-Volume}_{ft^3} = \text{BMP-Volume}_{(IA\text{-}ft^3)i} + \text{BMP-Volume}_{(PA\text{-}ft^3)i} \quad \textbf{(Equation 3-6a)}$$

   Where:

   BMP-Volume $_{ft^3}$ = the available storage volume of the BMP;

   BMP-Volume $_{(IA\text{-}ft^3)i}$ = the available storage volume of the BMP that would fully treat runoff generated from the contributing impervious area for a rainfall event of size *i* inches; and

   BMP-Volume $_{(PA\text{-}ft^3)i}$ = the available storage volume of the BMP that would fully treat runoff generated from the contributing pervious area for a rainfall event of size *i* inches

   Solving for BMP-Volume $_{(IA\text{-}ft^3)i}$:

BMP-Volume $_{(IA\text{-}ft^3)i}$ = BMP-Volume $_{ft^3}$ - BMP-Volume $_{(PA\text{-}ft^3)i}$ **(Equation 3-6b)**

To determine BMP-Volume $_{(IA\text{-}ft^3)i}$, requires performing an iterative process of refining estimates of the rainfall depth used to calculate runoff volumes until the rainfall depth used results in the sum of runoff volumes from the contributing IA and PA equaling the available BMP storage capacity (BMP-Volume $_{ft^3}$). For the purpose of estimating BMP performance, it will be considered adequate when the IA runoff depth (in) is within 5% IA runoff depth used in the previous iteration.

For the first iteration (1), convert the BMP-Volume $_{ft^3}$ determined in step 2 into inches of runoff from the contributing impervious area (BMP Volume $_{(IA\text{-}in)1}$) using equation 3-7a.

BMP-Volume $_{(IA\text{-}in)1}$ = (BMP-Volume$_{ft^3}$/ IA (acre)) x (12 in/ft /43,560 ft^2/acre) **(Equation 3-7a);**

For iterations 2 through n (2…n), convert the BMP Volume $_{(IA\text{-}ft^3)2...n}$, determined in step 5a below, into inches of runoff from the contributing impervious area (BMP Volume $_{(IA\text{-}in)2...n}$) using equation 3-7b.

BMP-Volume $_{(IA\text{-}in)2...n}$ = (BMP-Volume $_{(IA\text{-}ft^3)2...n}$ / IA (acre)) x (12 in/ft /43,560 ft^2/acre) **(Equation 3-7b);**

4) For 1 to n iterations, use the pervious runoff depth information from Table 3-3 and equation 3-8 to determine the total volume of runoff (ft^3) from the contributing PA (BMP Volume $_{PA\text{-}ft^3}$) for a rainfall size equal to the sum of BMP-Volume $_{(IA\text{-}in)1}$, determined in step 3. The runoff volume for each distinct pervious area must be determined.

   BMP Volume $_{(PA\text{-}ft^3)1...n}$ = ∑ ((PA x (runoff depth) $_{(PA1, PA2..PAn)}$ x (3,630 ft^3/acre-in) **(Equation 3-8)**

5) For iteration 1, estimate the portion of BMP Volume that is available to treat runoff from only the IA by subtracting BMP-Volume $_{PA\text{-}ft^3}$, determined in step 4, from BMP-Volume $_{ft^3}$, determined in step 2, and convert to inches of runoff from IA (see equations 3-9a and 3-9b):

   BMP-Volume $_{(IA\text{-}ft^3)2}$ = ((BMP-Volume$_{ft^3}$- BMP Volume $_{(PA\text{-}ft^3)1}$) **(Equation 3-9a)**

   BMP-Volume $_{(IA\text{-}in)2}$ = (BMP-Volume $_{(IA\text{-}ft^3)2}$/IA (acre)) x (12 in/ft x 1 acre/43,560 ft^2) **(Equation 3-9b)**

   If additional iterations (i.e., 2 through n) are needed, estimate the portion of BMP volume that is available to treat runoff from only the IA (BMP-Volume $_{(IA\text{-}in)3..n+1}$) by subtracting BMP Volume $_{(PA\text{-}ft^3)2..n}$, determined in step 4, from BMP Volume $_{(IA\text{-}ft^3)3..n+1}$, determined in step 5, and by converting to inches of runoff from IA using equation 3-9b):

6) For iteration a (an iteration between 1 and n+1), compare BMP Volume $_{(IA\text{-}in)a}$ to BMP Volume $_{(IA\text{-}in)a-1}$ determined from the previous iteration (a-1). If the difference in these values is greater than 5% of BMP Volume $_{(IA\text{-}in)a}$ then repeat steps 4 and 5, using BMP Volume $_{(IA\text{-}in)a}$ as the new starting value for the next iteration (a+1). If the difference is less than or equal to 5 % of BMP Volume $_{(IA\text{-}in)a}$ then the permittee may proceed to step 7;
7) Determine the % phosphorus load reduction for the structural BMP (BMP Reduction $_{\%\text{-}P}$) using the appropriate BMP performance curve and the BMP-Volume $_{(IA\text{-}in)n}$ calculated in the final iteration of step 5; and
8) Calculate the cumulative phosphorus load reduction in pounds of phosphorus for the structural BMP (BMP Reduction $_{lbs\text{-}P}$) using the BMP Load as calculated from the procedure in Attachment 1 to Appendix F and the percent phosphorus load reduction (BMP Reduction $_{\%\text{-}P}$) determined in step 7 by using equation 3-4:

BMP Reduction $_{lbs\text{-}P}$ = BMP Load x (BMP Reduction $_{\%\text{-}P}$/100) **(Equation 3-4)**

Example 3-4: Determine the phosphorus load reduction for a structural BMP with a known design volume when the contributing drainage area has impervious and pervious surfaces

A permittee is considering an infiltration basin to capture and treat runoff from a portion of the medium density residential area (MDR). The contributing drainage area is 16.55 acres and has 11.75 acres of impervious area and 4.8 acres of pervious area (PA) made up mostly of lawns and landscaped areas that is 80% HSG D and 20% HSG C. An infiltration basin with the following specifications can be placed at the down-gradient end of the contributing drainage area where soil testing results indicates an infiltration rate (IR) of 0.28 in/hr:

Table Example 3-4-A: Infiltration basin characteristics

Structure	Bottom area (acre)	Top surface area (acre)	Maximum pond depth (ft)	Design storage volume (ft^3)	Infiltration Rate (in/hr)
Infiltration basin	0.65	0.69	1.65	48,155	0.28

Determine the:

A) Percent phosphorus load reduction (BMP Reduction $_{\%\text{-}P}$) for the specified infiltration basin and the contributing impervious and pervious drainage area; and
B) Cumulative phosphorus reduction in pounds that would be accomplished by the BMP (BMP-Reduction $_{lbs\text{-}P}$)

Example continued:

Solution:

1) A surface infiltration basin is being considered. Information for the contributing impervious (IA) and pervious (PA) areas are summarized in Tables Example 3-4-A and Example 3-4-B, respectively.

Table Example 3-4-B: Impervious area characteristics

ID	Land use	Area (acre)
IA1	MDR	11.75

Table Example 3-4-C: Pervious area characteristics

ID	Area (acre)	Hydrologic Soil Group (HSG)
PA1	3.84	D
PA2	0.96	C

2) The available storage volume (ft^3) of the infiltration basin (BMP-Volume $_{ft^3}$) is determined from the design details and basin dimensions; BMP-Volume $_{ft^3}$ = 48,155 ft^3.

3) To determine what the BMP design storage volume is in terms of runoff depth (in) from IA, an iterative process is undertaken:

Solution Iteration 1

For the first iteration (1), the BMP-Volume$_{ft^3}$ is converted into inches of runoff from the contributing impervious area (BMP Volume $_{(IA-in)1}$) using equation 3-5a.

BMP Volume $_{(IA-in)1}$ = (48,155 ft^2/ 11.75 acre) x (12 in/ft /43,560 ft^2/acre)
= 1.13 in

4-1) The total volume of runoff (ft^3) from the contributing PA (BMP Volume $_{PA-ft^3}$) for a rainfall size equal to the sum of BMP Volume $_{(IA-in)1}$ determined in step 3 is determined for each distinct pervious area identified in Table Example 3-4-B using the information from Table 3-3 and equation 3-5. Interpolation was used to determine runoff depths.

BMP Volume $_{(PA-ft^3)1}$ = ((3.84 acre x (0.33 in) + (0.96 acre x (0.13 in)) x 3,630 ft^3/acre-in
= 5052 ft^3

5-1) For iteration 1, the portion of BMP Volume that is available to treat runoff from only the IA is estimated by subtracting the BMP Volume $_{(PA-ft^3)1}$, determined in step 4-1, from BMP Volume$_{ft^3}$, determined in step 2, and converted to inches of runoff from IA:

BMP Volume $_{(IA-ft^3)2}$ = 48,155 ft^3 – 5052 ft^3
= 43,103 ft^3

BMP Volume $_{(IA-in)2}$ = (43,103 ft^3/11.75 acre) x (12 in/ft x 1 acre/43,560 ft^2)
= 1.01 in

Solution continued:

6-1) The % difference between BMP Volume $_{(IA\text{-}in)\,2}$, 1.01 in, and BMP Volume $_{(IA\text{-}in)1}$, 1.13 in is determined and found to be significantly greater than 5%:

% Difference = ((1.13 in – 1.01 in)/1.01 in) x 100
= 12%

Therefore, steps 4 through 6 are repeated starting with BMP Volume $_{(IA\text{-}in)\,2}$ = 1.01 in.

Solution Iteration 2

4-2) BMP-Volume $_{(PA\text{-}ft^3)2}$ = ((3.84 acre x 0.21 in) + (0.96 acre x 0.12 in)) x 3,630 ft^3/acre-in
= 3,358 ft^3

5-2) BMP-Volume $_{(IA\text{-}ft^3)\,3}$ = 48,155 ft^3 – 3,358 ft^3
= 44,797 ft^3

BMP-Volume $_{(IA\text{-}in)\,3}$ = (44,797 ft^3/11.75 acre) x (12 in/ft x 1 acre/43,560 ft^2)
= 1.05 in

6-2) % Difference = ((1.05 in – 1.01 in)/1.05 in) x 100
= 4%

The difference of 4% is acceptable.

7) The % phosphorus load reduction for the infiltration basin (BMP Reduction $_{\%\text{-}P}$) is determined by using the infiltration basin performance curve for an infiltration rate of 0.27 in/hr and the treatment volume (BMP-Volume $_{Net\ IA\text{-}in}$ = 1.05 in) calculated in step 5-2 and is **BMP Reduction $_{\%\text{-}P}$ = 93%.**

The performance curve for IR = 0.27 is used rather than interpolating between the performance curves for IR = 0.27 in/hr and 0.52 in/hr to estimate performance for IR = 0.28 in/hr. An evaluation of the performance curves for IR = 0.27 in/hr and IR = 0.52 in/hr for a design storage volume of 1.05 in indicate a small difference in estimated performance (BMP Reduction $_{\%\text{-}P}$ = 93% for IR = 0.27 in/hr and BMP Reduction $_{\%\text{-}P}$ = 95% for IR = 0.52 in/hr).

8) The cumulative phosphorus load reduction in pounds of phosphorus (BMP-Reduction $_{lbs\text{-}P}$) for the proposed infiltration basin is calculated by using equation 3-2 with the BMP Load and the P $_{target}$ of 93%.

BMP-Reduction $_{lbs\text{-}P}$ = BMP Load x (P $_{target}$ /100) **(Equation 3-2)**

Using Table 3-1, the BMP load is calculated:

BMP Load = (IA x impervious cover phosphorus export loading rate for industrial)
+ (PA $_{HSG\ D}$ x pervious cover phosphorus export loading rate for HSG D)
+ (PA $_{HSG\ C}$ x pervious cover phosphorus export loading rate for HSG C)

Solution continued:

= (11.75 acre x 1.96 lbs/acre/yr) + (3.84 acre x 0.37 lbs/acre/yr)
+ (0.96 acre x 0.21 lbs/acre/yr)
= 24.65 lbs/yr

BMP-Reduction $_{lbs-P}$ = 24.22 lbs/yr x 93/100 = **22.93 lbs/yr**

Example 3-5: Determine the phosphorus load reduction for disconnecting impervious area using storage with delayed release.

A commercial operation has an opportunity to divert runoff from 0.75 acres of impervious roof top to a 5000 gallon (668.4 ft^3) storage tank for temporary storage and subsequent release to a0.09 acres of pervious area (PA) with HSG C soils.
Determine the:

A) Percent phosphorus load reduction rates (BMP Reduction $_{\%-P}$) for the specified impervious area (IA) disconnection and storage system assuming release times of 1, 2 and 3 days for the stored volumes to discharge to the pervious area; and
B) Cumulative phosphorus reductions in pounds that would be accomplished by the system (BMP-Reduction $_{lbs-P}$) for the three storage release times, 1, 2 and 3 days.

Solution:

1. Determine the storage volume in units of inches of runoff depth from contributing impervious area:
   Storage Volume $_{IA-in}$ = (668.4 ft^3/(0.75 acre x 43.560 ft^2/acre)) x 12 inch/ft
   = 0.25 inches

2. Determine the ratio of the contributing impervious area to the receiving pervious area:
   IA:PA = 0.75 acres/0.09 acres
   = 8.3
3. Using Table 3-21 for a IA:PA ratio of 8:1, determine the phosphorus load reduction rates for a storage volume of 0.25 inches that discharges to HSG C with release rates of 1, 2 and 3 days: Using interpolation the reduction rates are shown in Table 3-5-A:

Table Example 3-5-A: Reduction Rates

Percent Phosphorus load reduction for IA disconnection with storage HSG C			
Storage Volume $_{IA-in}$	Storage release rate, days		
	1	2	3
0.25	39%	42%	43%

4. The cumulative phosphorus load reduction in pounds of phosphorus for the IA disconnection with storage (BMP-Reduction $_{lbs-P}$) is calculated using Equation 3-2. The BMP Load is first determined using the method described above.

Solution continued:

BMP Load = IA x phosphorus export loading rate for commercial IA (see Table 3-1)
= 0.75 acres x 1.78 lbs/acre/yr
= 1.34 lbs/yr

BMP Reduction $_{lbs\text{-}P}$ = BMP Load x (BMP Reduction $_{\%\text{-}P}$/100)

BMP Reduction $_{lbs\text{-}P}$ = 1.34 lbs/yr x (39/100)
= **0.53 lbs/yr**

Table Example 3-5-B presents the BMP Reduction $_{lbs\text{-}P}$ for each of the release rates:

Table Example 3-5-B: Reduction Load

Phosphorus load reduction for IA disconnection with storage HSG C, lbs			
Storage Volume $_{IA\text{-}in}$	Storage release rate, days		
	1	2	3
0.25	0.53	0.56	0.58

Example 3-6: Determine the phosphorus load reduction for disconnecting impervious area with and without soil augmentation in the receiving pervious area.

The same commercial property as in example 3-5 wants to evaluate disconnecting drainage from the 0.75 acre impervious roof top and discharging it directly to 0.09 acres of pervious area (PA) with HSG C. Also, the property has the opportunity to purchase a small adjoining area (0.06 acres) to increase the size of the receiving PA from 0.09 to 0.15 acres and to allow the property owner to avoid having to install a drainage structure to capture overflow runoff from the PA. The property owner has been informed that the existing PA soil can be tilled and augmented with soil amendments to support denser vegetative growth and improve hydrologic function to approximate HSG B.

Determine the:

A) Percent phosphorus load reduction rates (BMP Reduction $_{\%\text{-}P}$) for the specified impervious area (IA) disconnection to both the 0.09 and 0.15 acre receiving PAs with and without soil augmentation; and
B) Cumulative phosphorus reductions in pounds that would be accomplished by the IA disconnection for the various scenarios (BMP-Reduction $_{lbs\text{-}P}$).

Solution:

1. Determine the ratio of the contributing impervious area to the receiving pervious area:
   IA:PA = 0.75 acres/0.09 acres
   = 8.3
   IA:PA = 0.75 acres/0.15 acres
   = 5.0

Solution Continued:

2. Using Table 3-26 and Figure 3-40 for a IA:PA ratios of 8:1 and 5:1, respectively, determine the phosphorus load reduction rates for IA disconnections to HSG C and HSG B:

Table Example 3-6-A: Reduction Rates

Percent Phosphorus load reduction rates for IA disconnection		
Receiving PA	**IA:PA**	
	8:1	5:1
HSG C	7%	14%
HSG B (soil augmentation)	14%	22%

3. The cumulative phosphorus load reduction in pounds of phosphorus for the IA disconnection with storage (BMP-Reduction $_{lbs\text{-}P}$) is calculated using Equation 3-2. The BMP Load was calculated in example 3-5 and 1.34 lbs/yr.

BMP Reduction $_{lbs\text{-}P}$ = BMP Load x (BMP Reduction $_{\%\text{-}P}$/100)
For PA of 0.09 acres HSG C the BMP Reduction $_{lbs\text{-}P}$ is calculated as follows:
BMP Reduction $_{lbs\text{-}P(0.09ac\text{-}HSG\ C)}$ = 1.34 lbs/yr x (7/100)
= **0.09 lbs/yr**
Table Example 3-6-B presents the BMP Reduction $_{lbs\text{-}P}$ for each of the scenarios:

Table Example 3-6-B: Reduction

Pounds Phosphorus load reduction for IA disconnection, lbs/yr		
Receiving PA	**Area of Receiving PA, acres**	
	0.09	**0.15**
HSG C	0.09	0.19
HSG B (soil augmentation)	0.19	0.29

Example 3-7: Determine the phosphorus load reduction for converting impervious area to permeable/pervious area.

A municipality is planning upcoming road reconstruction work in medium density residential (MDR) neighborhoods and has identified an opportunity to convert impervious surfaces to permeable/pervious surfaces by narrowing the road width of 3.7 miles (mi) of roadway from 32 feet (ft) to 28 ft and eliminating 3.2 miles of 4 ft wide paved sidewalk (currently there are sidewalks on both sides of the roadways targeted for restoration). The newly created permeable/pervious area will be tilled and treated with soil amendments to support vegetated growth in order to restore hydrologic function to at least HSG B.

Determine the:

A) Percent phosphorus load reduction rate (BMP Reduction $_{\%\text{-}P}$) for the conversion of impervious area (IA) to permeable/pervious area (PA); and
B) Cumulative phosphorus reduction in pounds that would be accomplished by the project (BMP-Reduction $_{lbs\text{-}P}$).

Solution:

1. Determine the area of IA to be converted to PA:

   New PA = (((3.7 mi x 4 ft) + (3.2 mi x 4 ft)) x 5280 ft/mi)/43,560 ft^2/acre
   = 3.35 acres

2. Using Table 3-27, the phosphorus load reduction rate for converting IA to HSG B is 94.1%
3. The BMP Load is first determined using the method described above.

   BMP Load = IA x phosphorus export loading rate for MDR IA (see Table 3-1)
   = 3.35 acres x 1.96 lbs/acre/yr
   = 6.57 lbs/yr

4. The cumulative phosphorus load reduction in pounds of phosphorus for the IA conversion (BMP-Reduction $_{lbs\text{-}P}$) is calculated using Equation 3-2.

   BMP Reduction $_{lbs\text{-}P}$ = BMP Load x (BMP Reduction $_{\%\text{-}P}$/100)
   BMP Reduction $_{lbs\text{-}P}$ = 6.57 lbs/yr x (94.1/100)
   = 6.18 lbs/yr

5. The net phosphorus load reduction is equal to the reduction BMP Reduction $_{lbs\text{-}P}$ for the IA conversion less the new phosphorus load from the PA being restored:

   Net BMP Reduction $_{lbs\text{-}P}$ = 6.18 lbs/yr – (3.35 acres x 0.12 lbs/acre/yr (Table 3-1))
   = 5.78 lbs/yr

Table 3- 4: Infiltration Trench (IR = 0.17 in/hr) BMP Performance Table

Infiltration Trench (IR = 0.17 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	14.7%	27.6%	48.6%	64.1%	74.9%	82.0%	91.6%	95.4%
Cumulative Phosphorus Load Reduction	18%	33%	57%	73%	83%	90%	97%	99%

Figure 3- 1: BMP Performance Curve: Infiltration Trench (infiltration rate = 0.17 in/hr)

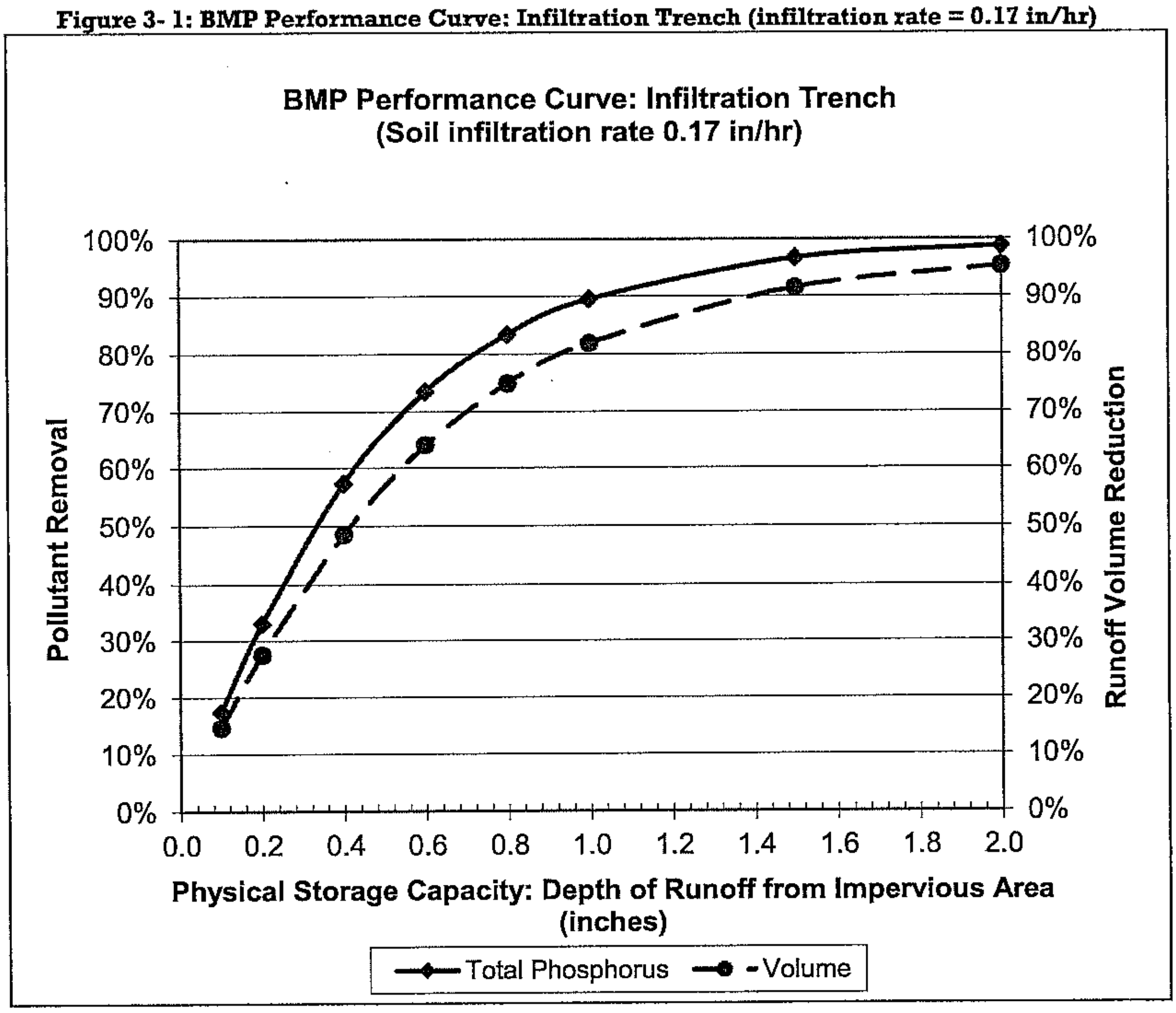


Table 3- 5: Infiltration Trench (IR = 0.27 in/hr) BMP Performance Table

Infiltration Trench (IR = 0.27 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	17.8%	32.5%	55.0%	70.0%	79.3%	85.2%	93.3%	96.3%
Cumulative Phosphorus Load Reduction	20%	37%	63%	78%	86%	92%	97%	99%

Figure 3- 2: BMP Performance Curve: Infiltration Trench (infiltration rate = 0.27 in/hr)

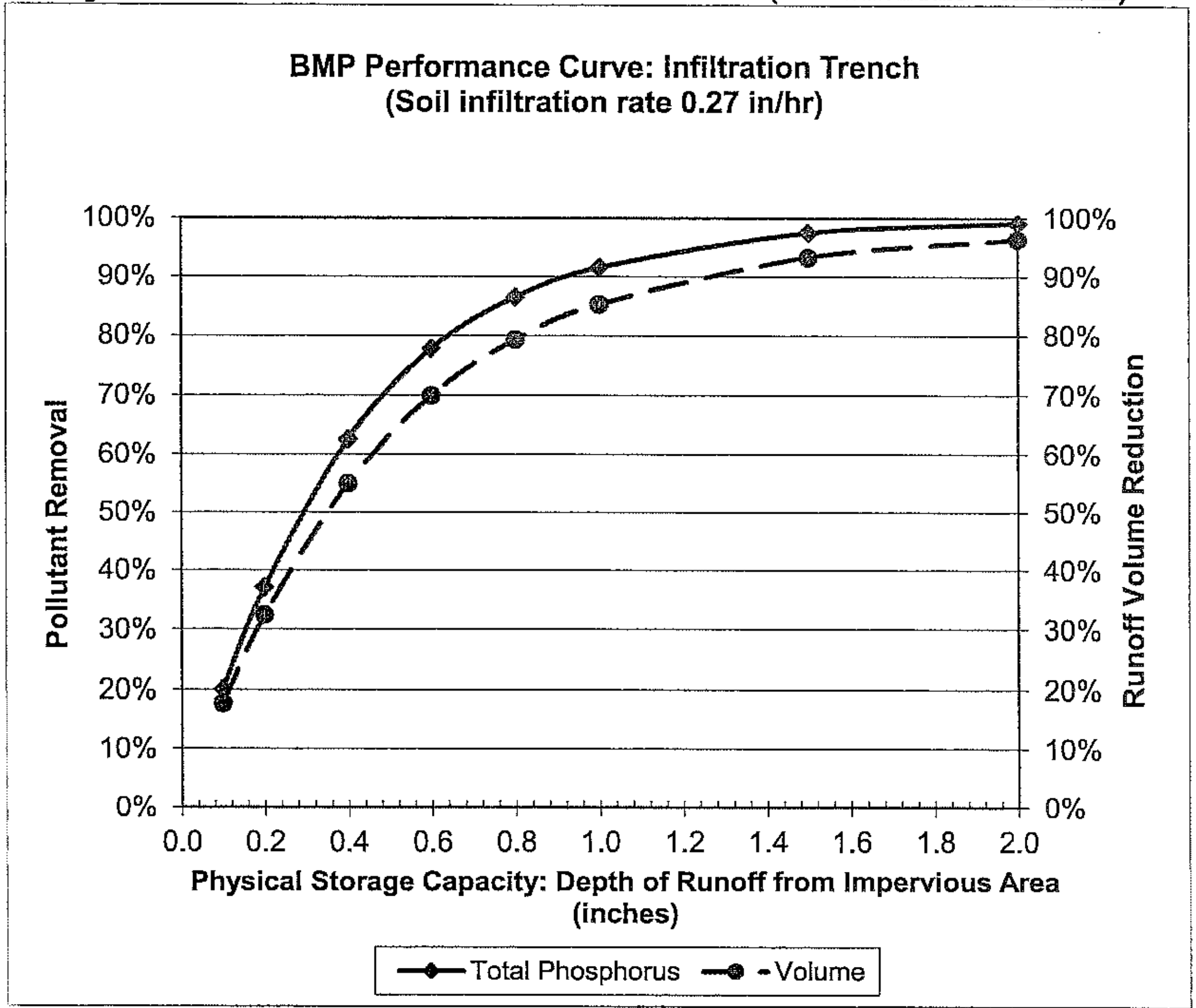


Table 3- 6: Infiltration Trench (IR = 0.52 in/hr) BMP Performance Table

Infiltration Trench (IR = 0.52 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	22.0%	38.5%	61.8%	75.7%	83.7%	88.8%	95.0%	97.2%
Cumulative Phosphorus Load Reduction	23%	42%	68%	82%	89%	94%	98%	99%

Figure 3- 3: BMP Performance Curve: Infiltration Trench (infiltration rate = 0.52 in/hr)

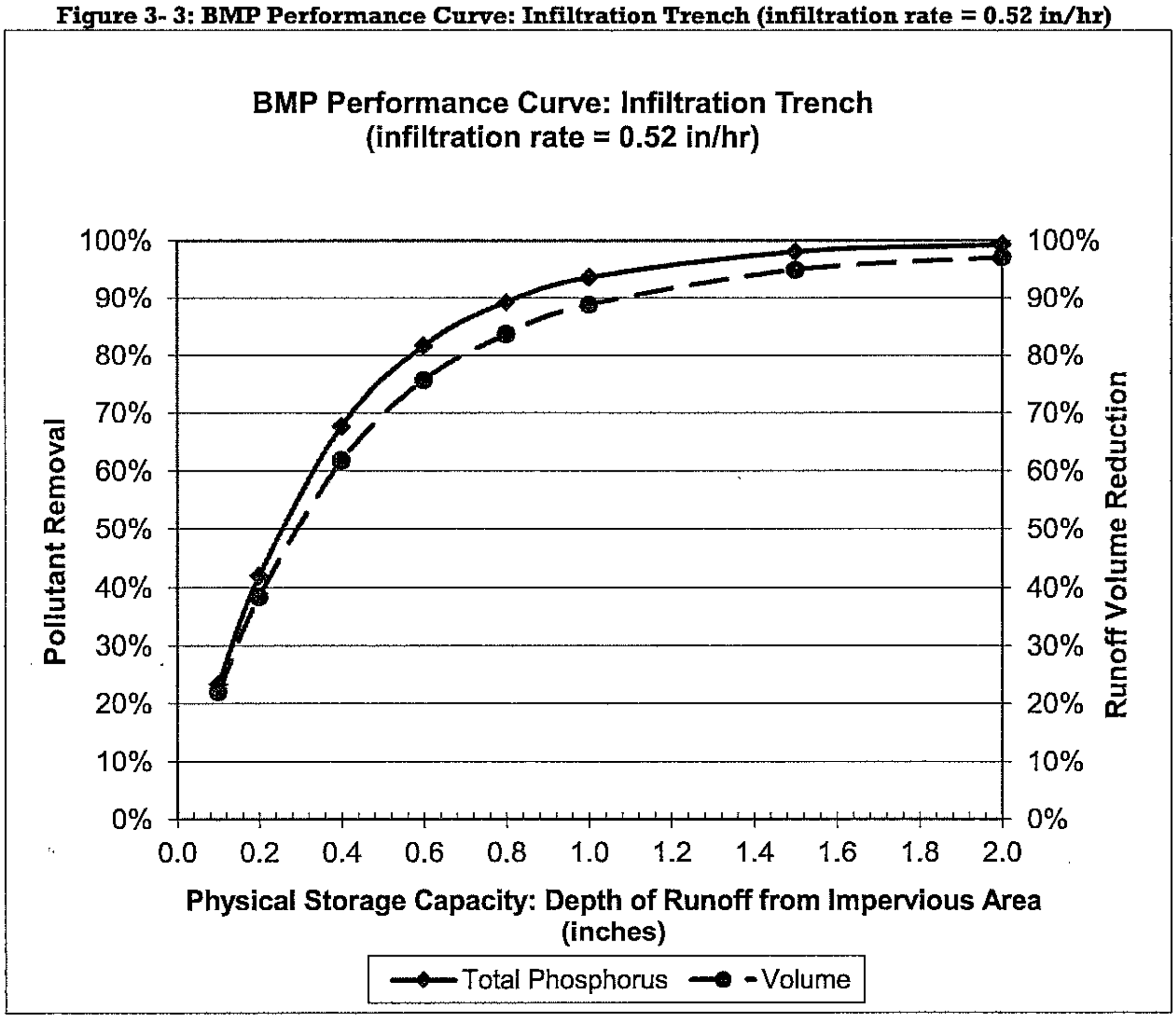


Table 3- 7: Infiltration Trench (IR = 1.02 in/hr) BMP Performance Table

Infiltration Trench (IR = 1.02 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	26.3%	44.6%	68.2%	81.0%	88.0%	92.1%	96.5%	98.3%
Cumulative Phosphorus Load Reduction	27%	47%	73%	86%	92%	96%	99%	100%

Figure 3- 4: BMP Performance Curve: Infiltration Trench (infiltration rate = 1.02 in/hr)

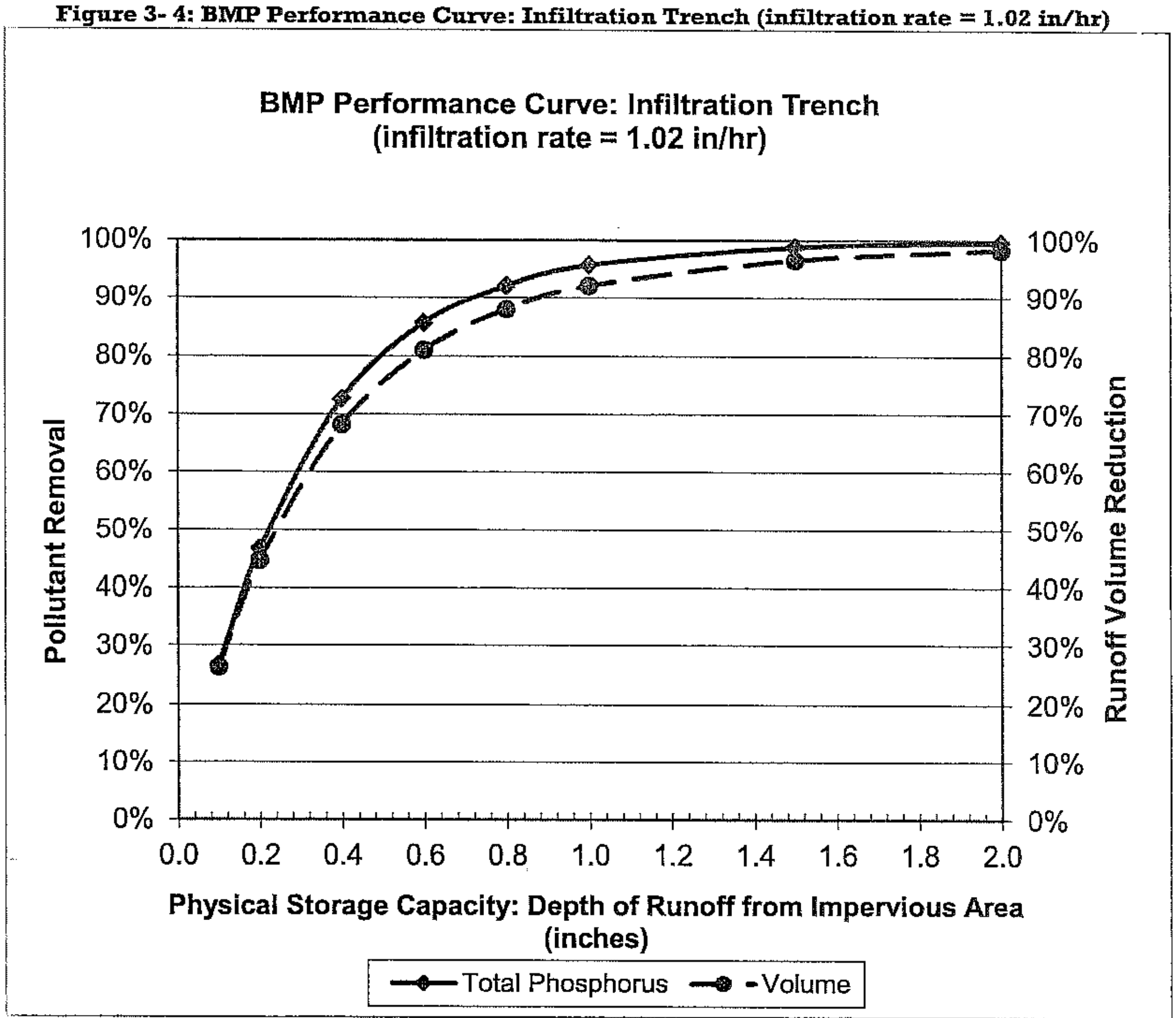


Table 3- 8: Infiltration Trench (IR = 2.41 in/hr) BMP Performance Table

Infiltration Trench (IR = 2.41 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	34.0%	54.7%	78.3%	88.4%	93.4%	96.0%	98.8%	99.8%
Cumulative Phosphorus Load Reduction	33%	55%	81%	91%	96%	98%	100%	100%

Figure 3- 5: BMP Performance Curve: Infiltration Trench (infiltration rate = 2.41 in/hr)

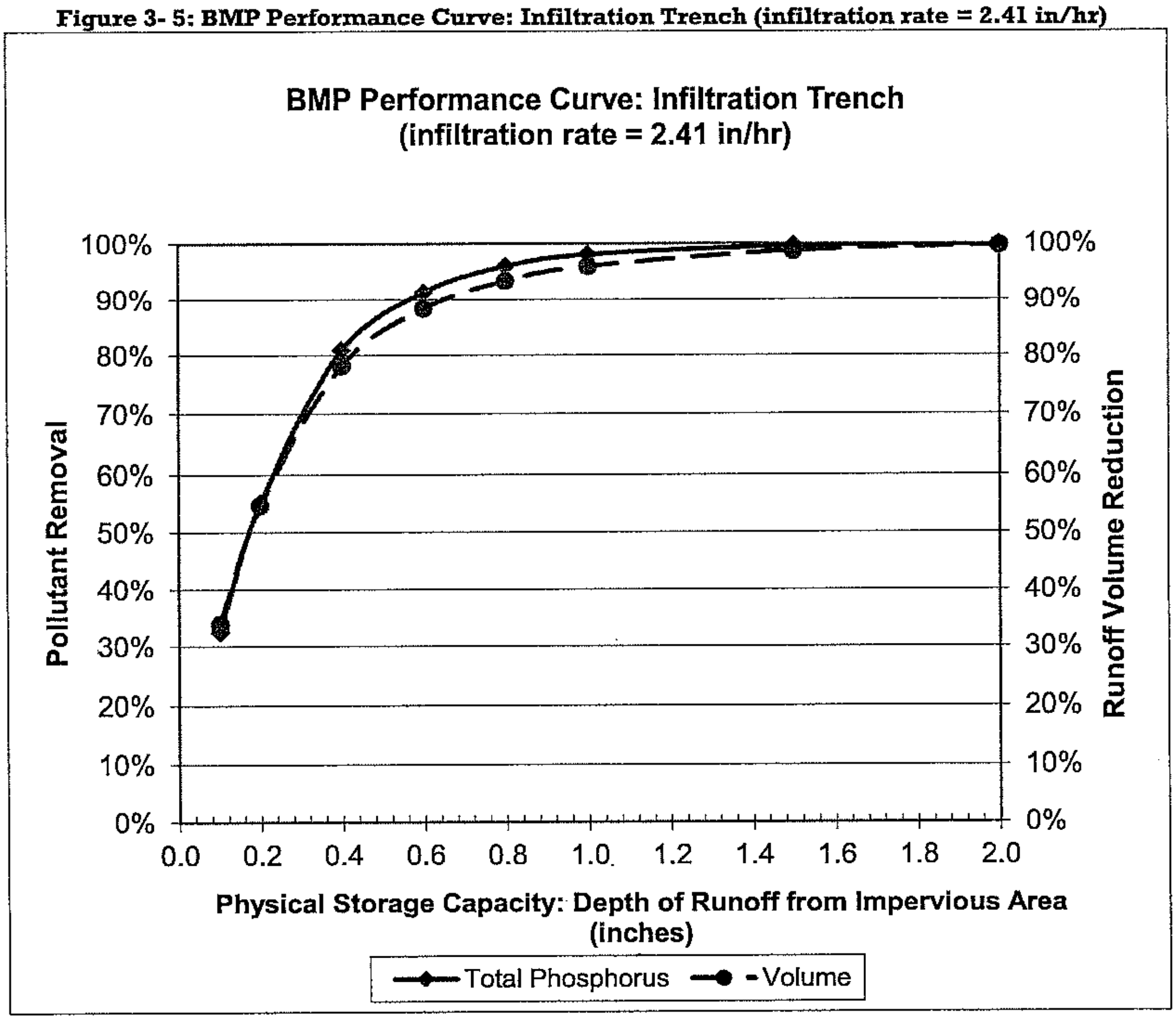


Table 3- 9: Infiltration Trench (8.27 in/hr) BMP Performance Table

Infiltration Trench (8.27 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	53.6%	76.1%	92.6%	97.2%	98.9%	99.5%	100.0%	100.0%
Cumulative Phosphorus Load Reduction	50%	75%	94%	98%	99%	100%	100%	100%

Figure 3- 6: BMP Performance Curve: Infiltration Trench (infiltration rate = 8.27 in/hr)

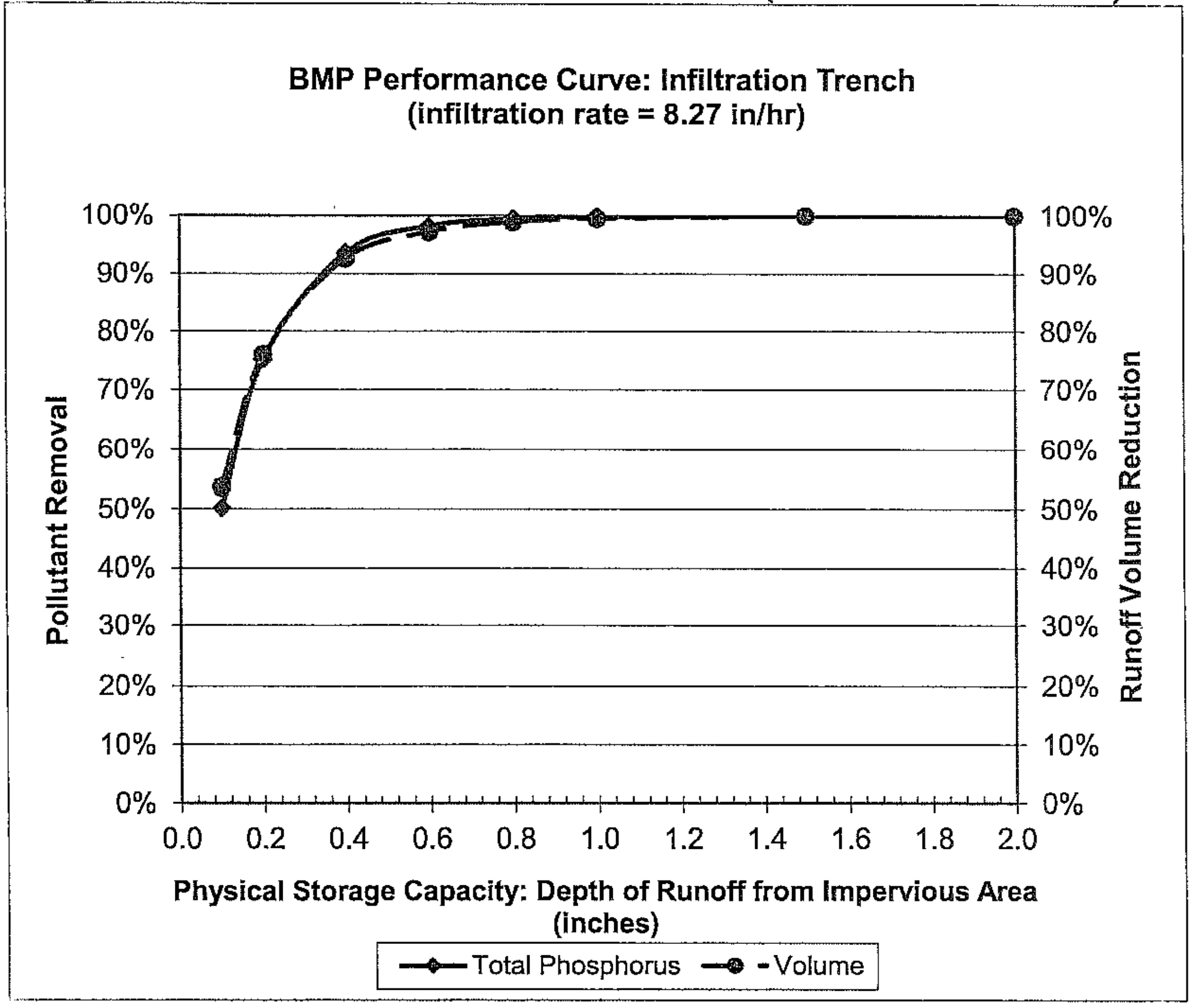


Table 3- 10: Infiltration Basin (0.17 in/hr) BMP Performance Table

Infiltration Basin (0.17 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	13.0%	24.6%	44.2%	59.5%	70.6%	78.1%	89.2%	93.9%
Cumulative Phosphorus Load Reduction	35%	52%	72%	82%	88%	92%	97%	99%

Figure 3- 7: BMP Performance Curve: Infiltration Basin (infiltration rate = 0.17 in/hr)

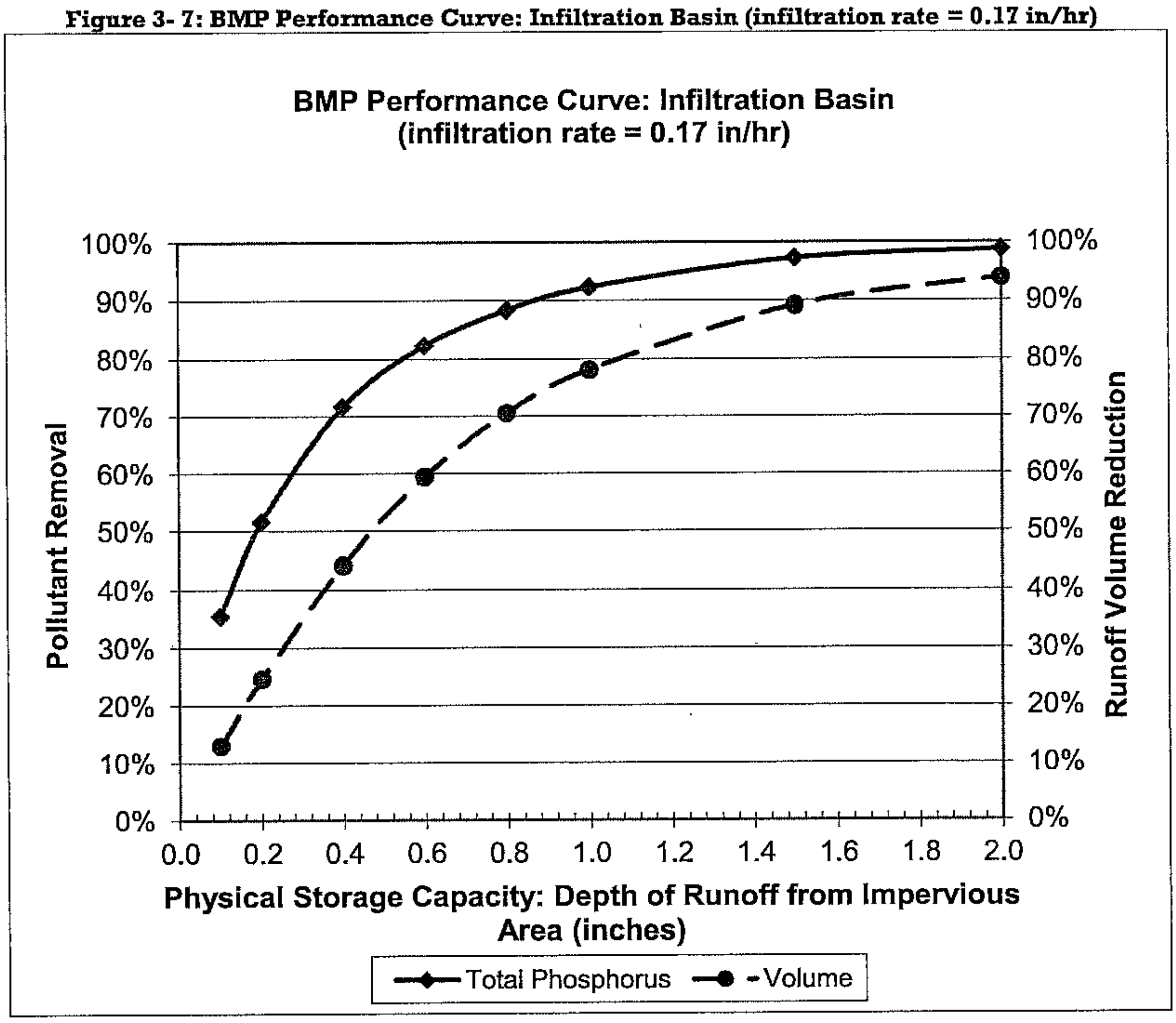


Table 3- 11: Infiltration Basin (0.27 in/hr) BMP Performance Table

Infiltration Basin (0.27 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	16.3%	29.8%	51.0%	66.0%	76.0%	82.4%	91.5%	95.2%
Cumulative Phosphorus Load Reduction	37%	54%	74 %	85%	90%	93%	98%	99%

Figure 3- 8: BMP Performance Curve: Infiltration Basin (infiltration rate = 0.27 in/hr)

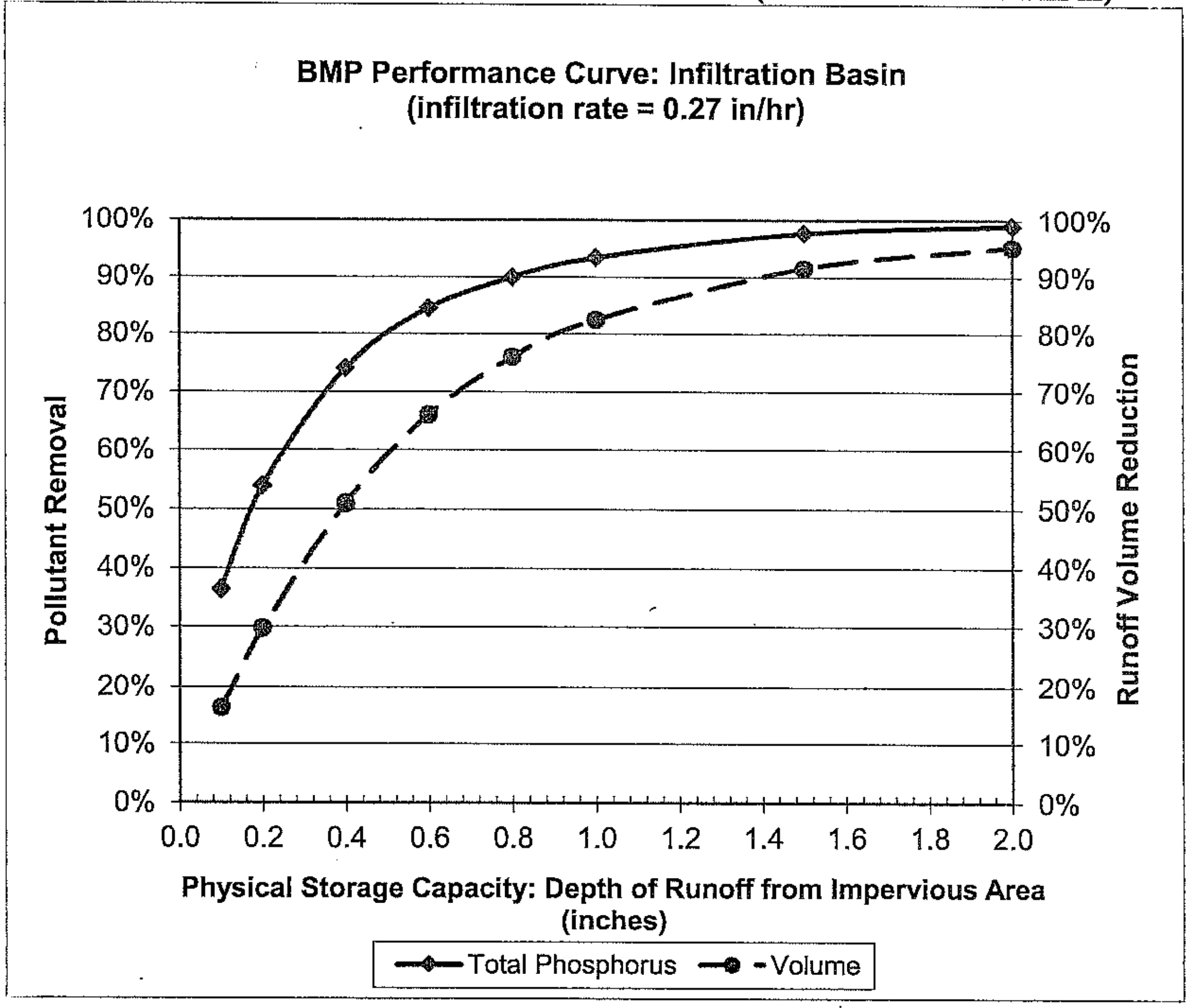


Table 3- 12: Infiltration Basin (0.52 in/hr) BMP Performance Table

Infiltration Basin (0.52 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	20.2%	35.6%	58.0%	72.6%	81.3%	86.9%	94.2%	96.7%
Cumulative Phosphorus Load Reduction	38%	56%	77%	87%	92%	95%	98%	99%

Figure 3- 9: BMP Performance Curve: Infiltration Basin (infiltration rate = 0.52 in/hr)

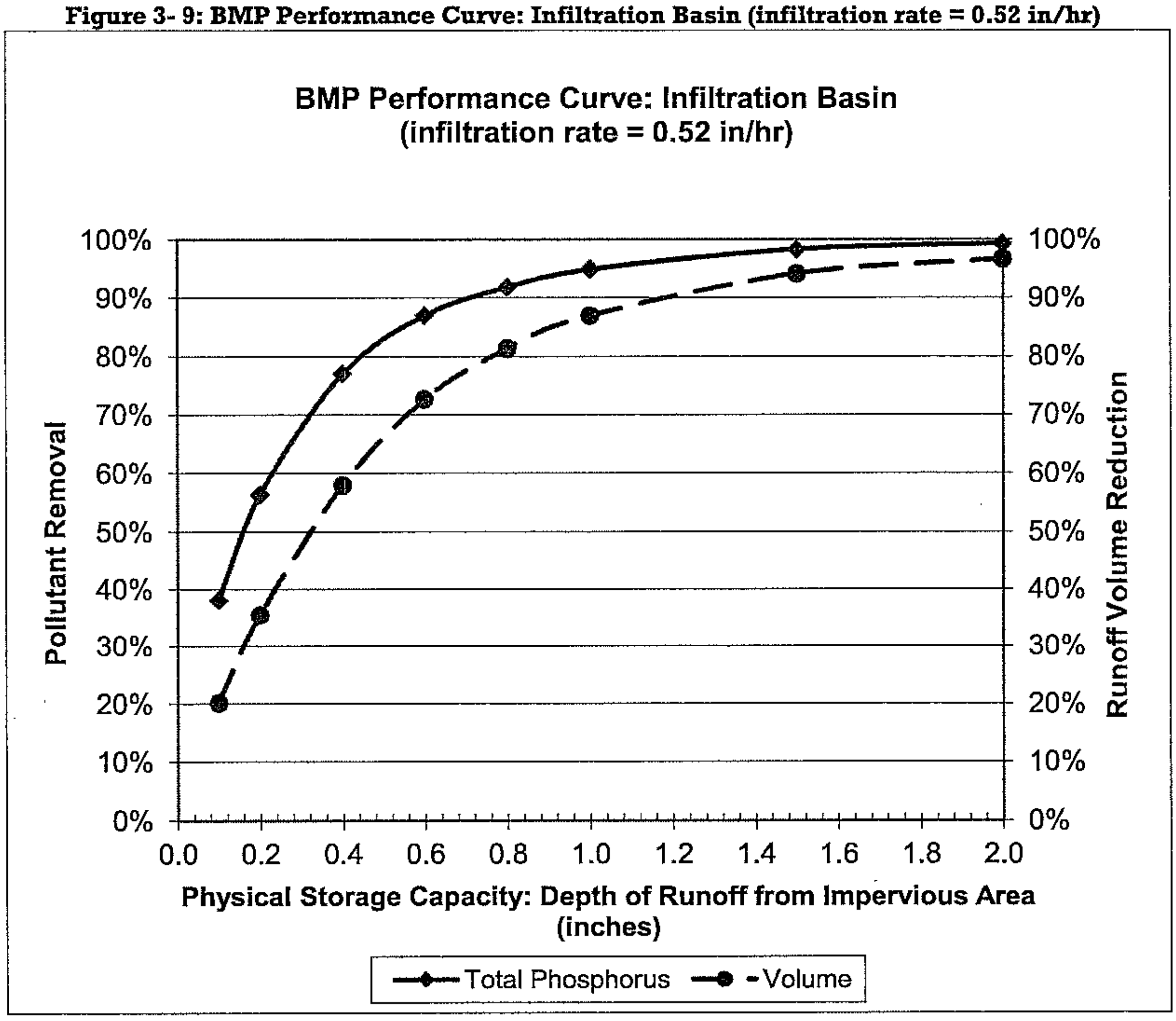


Table 3- 13: Infiltration Basin (1.02 in/hr) BMP Performance Table

Infiltration Basin (1.02 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	24.5%	42.0%	65.6%	79.4%	86.8%	91.3%	96.2%	98.1%
Cumulative Phosphorus Load Reduction	41%	60%	81%	90%	94%	97%	99%	100%

Figure 3- 10: BMP Performance Curve: Infiltration Basin (Soil infiltration rate = 1.02 in/hr)

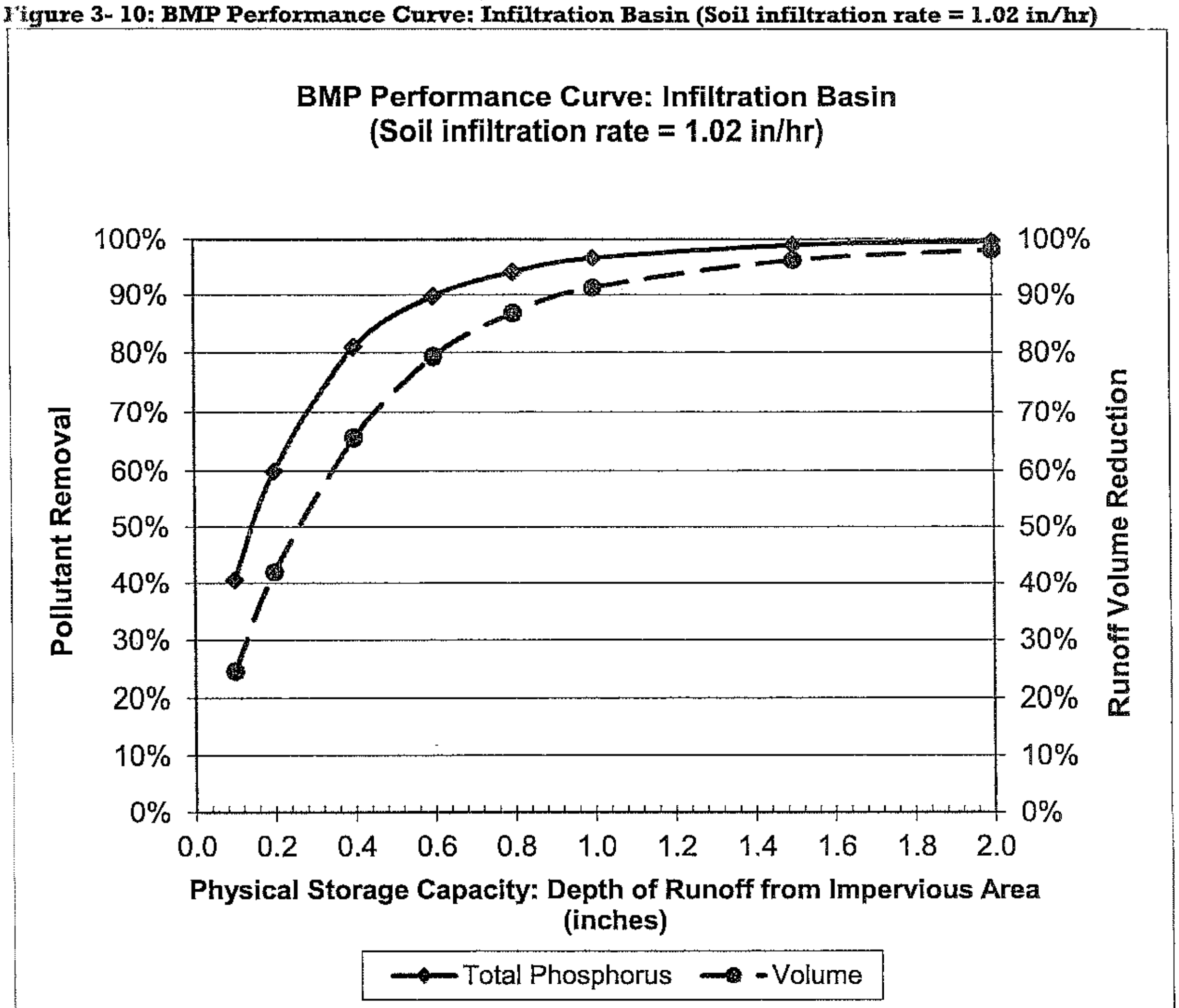


Table 3- 14: Infiltration Basin (2.41 in/hr) BMP Performance Table

Infiltration Basin (2.41 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	32.8%	53.8%	77.8%	88.4%	93.4%	96.0%	98.8%	99.8%
Cumulative Phosphorus Load Reduction	46%	67%	87%	94%	97%	98%	100%	100%

Figure 3- 11: BMP Performance Curve: Infiltration Basin (infiltration rate = 2.41 in/hr)

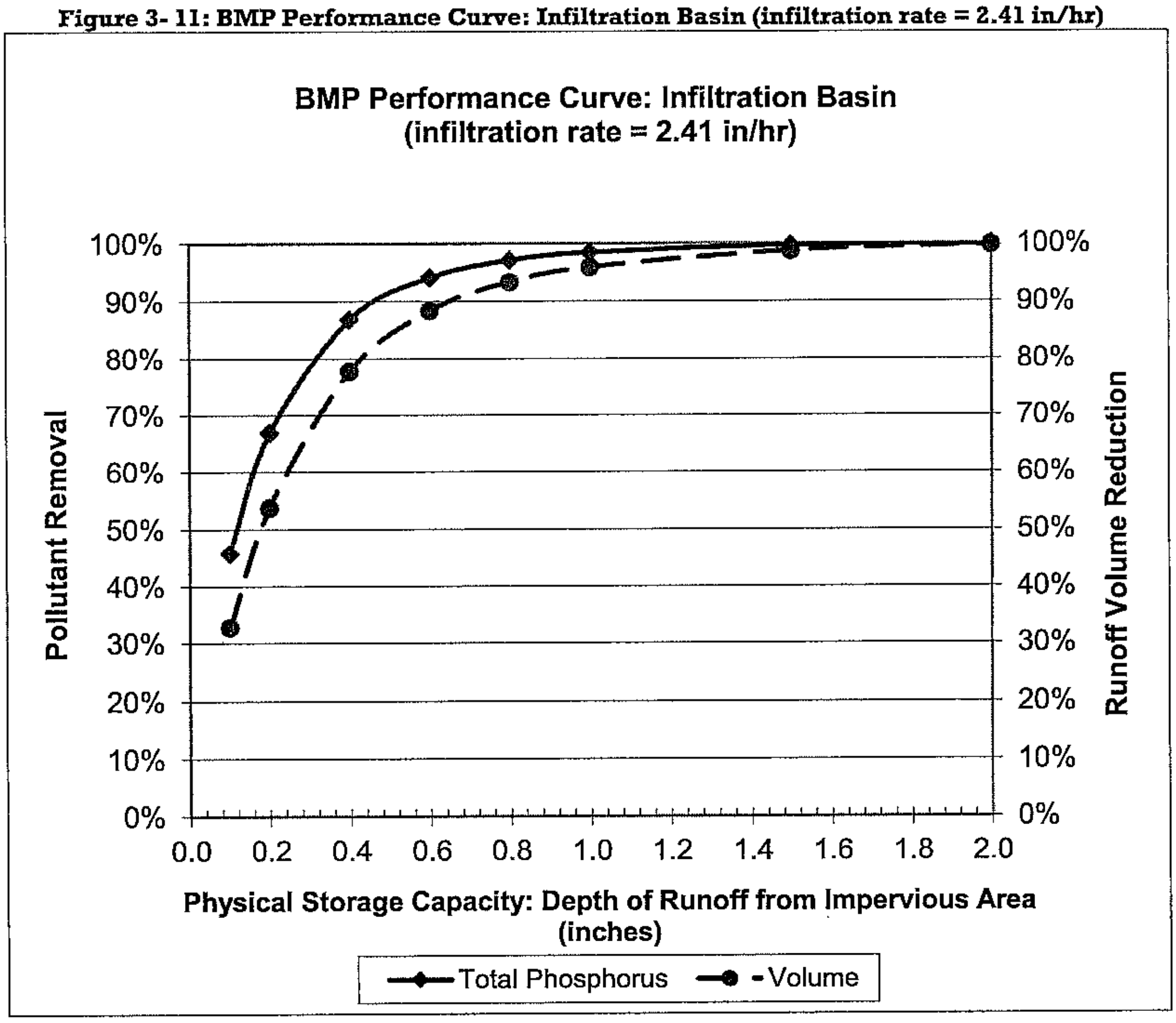


Table 3- 15: Infiltration Basin (8.27 in/hr) BMP Performance Table

Infiltration Basin (8.27 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	54.6%	77.2%	93.4%	97.5%	99.0%	99.6%	100.0%	100.0%
Cumulative Phosphorus Load Reduction	59%	81%	96%	99%	100%	100%	100%	100%

Figure 3- 12: BMP Performance Curve: Infiltration Basin (infiltration rate = 8.27 in/hr)

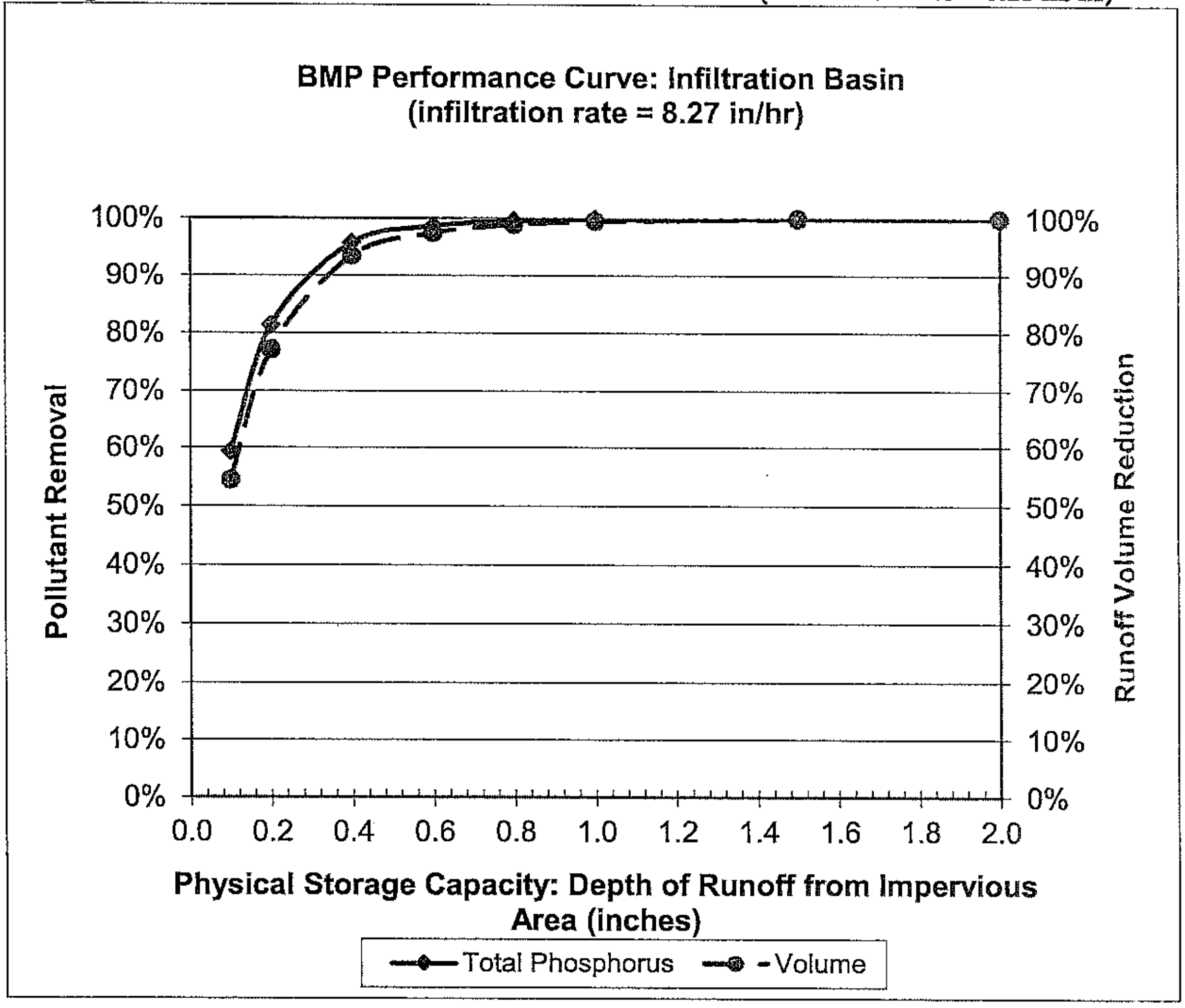


Table 3- 16: Biofiltration BMP Performance Table

Biofiltration BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	19%	34%	53%	64%	71%	76%	84%	89%

Figure 3- 13: BMP Performance Curve: Biofiltration

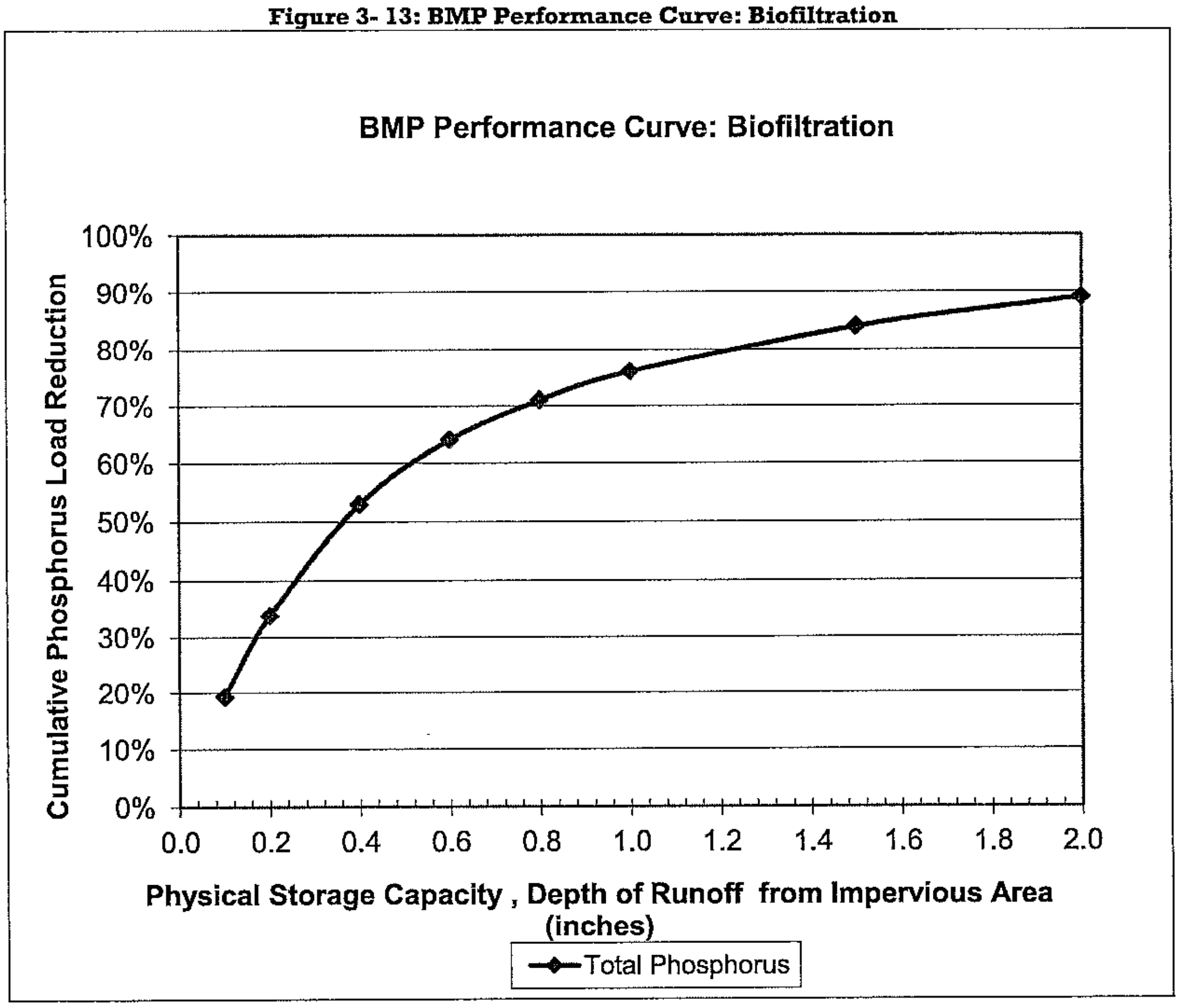


Table 3- 17: Gravel Wetland BMP Performance Table

Gravel Wetland BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	19%	26%	41%	51%	57%	61%	65%	66%

Figure 3- 14: BMP Performance Curve: Gravel Wetland

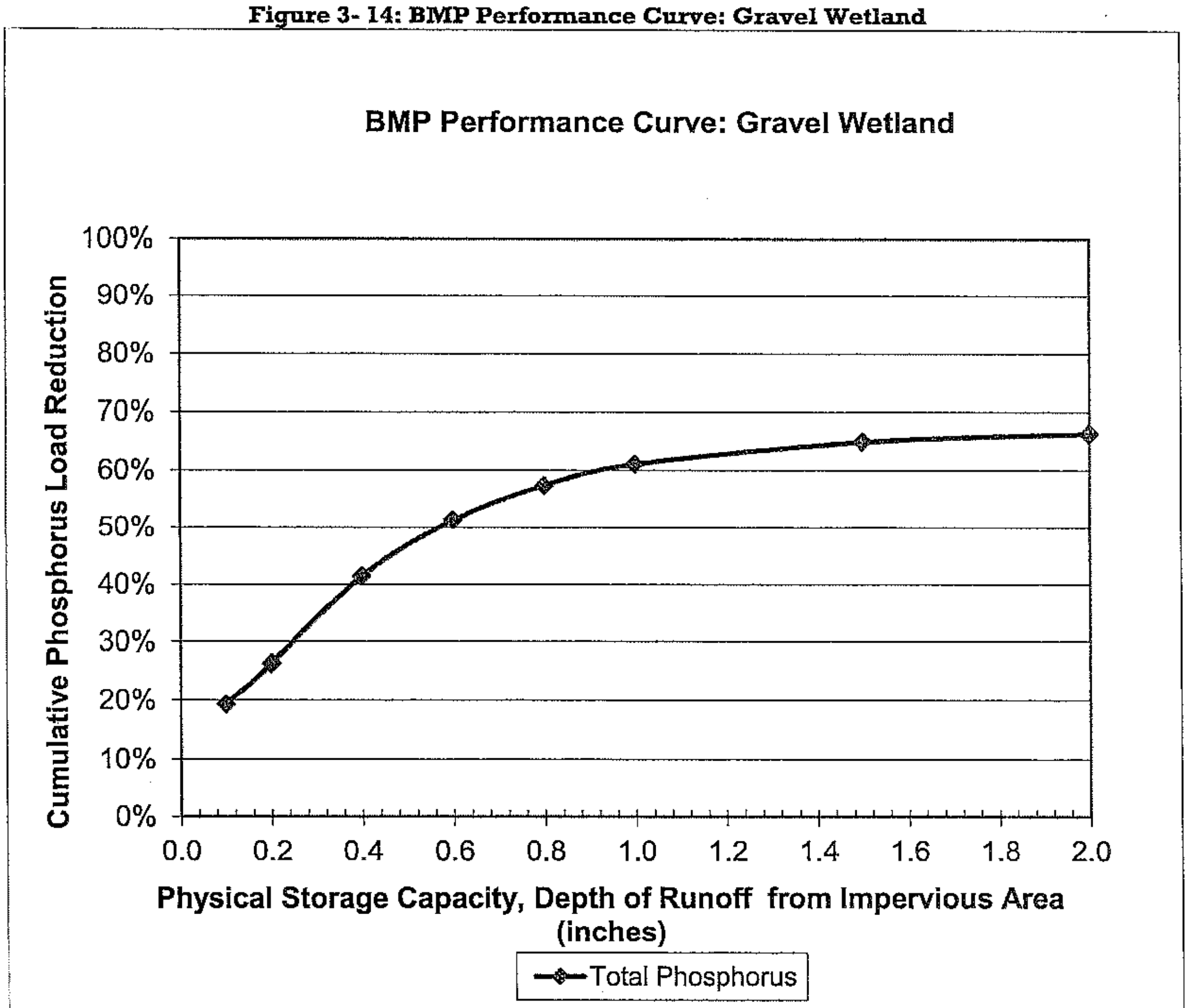


Table 3- 18: Porous Pavement BMP Performance Table

Porous Pavement BMP Performance Table: Long-Term Phosphorus Load Reduction				
BMP Capacity: Depth of Filter Course Area (inches)	12.0	18.0	24.0	32.0
Cumulative Phosphorus Load Reduction	62%	70%	75%	78%

Figure 3- 15: BMP Performance Curve: Porous Pavement

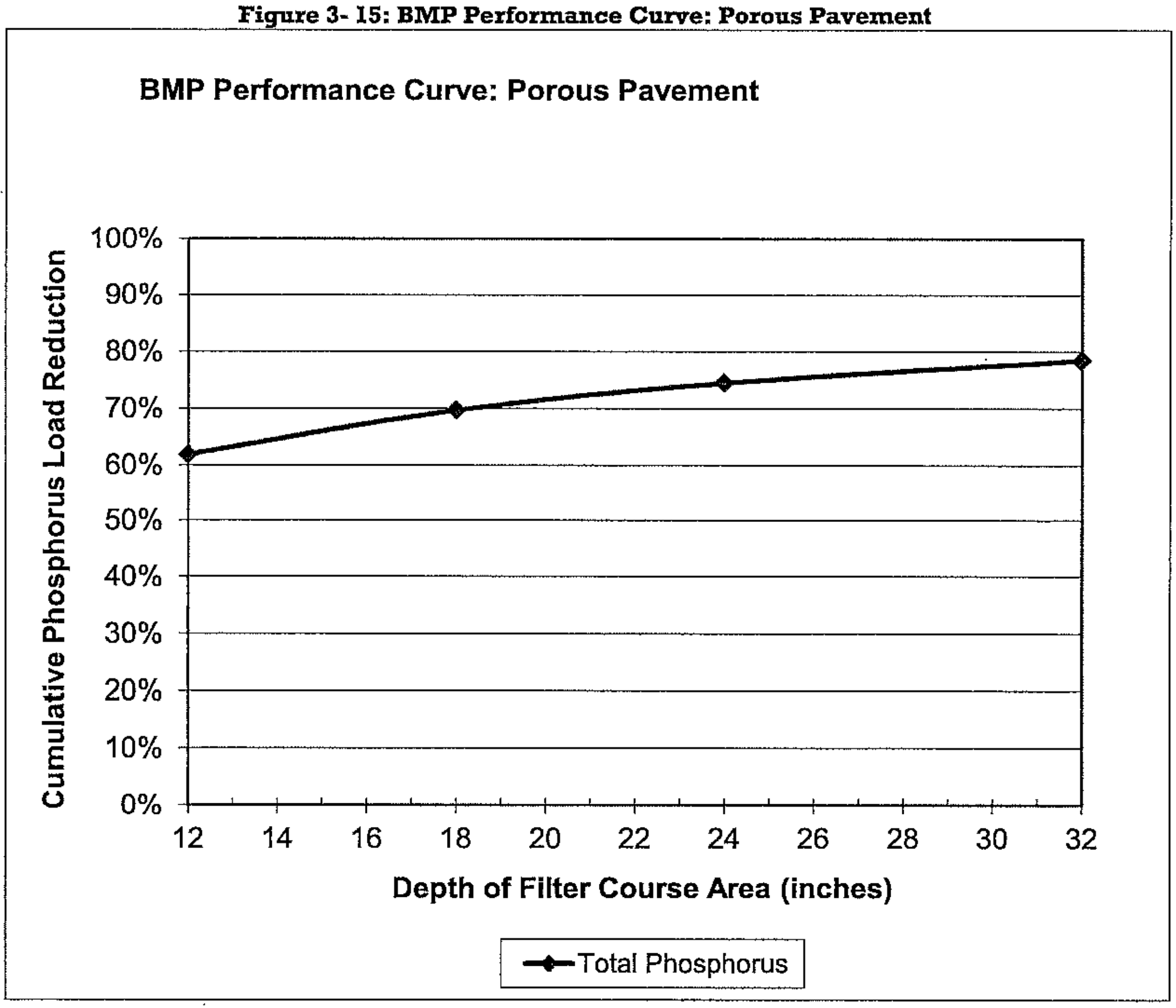


Table 3- 19: Wet Pond BMP Performance Table

Wet Pond BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	14%	25%	37%	44%	48%	53%	58%	63%

Table 3- 20: Dry Pond BMP Performance Table

Dry Pond BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	3%	6%	8%	9%	11%	12%	13%	14%

Figure 3- 16: BMP Performance Curve: Dry Pond

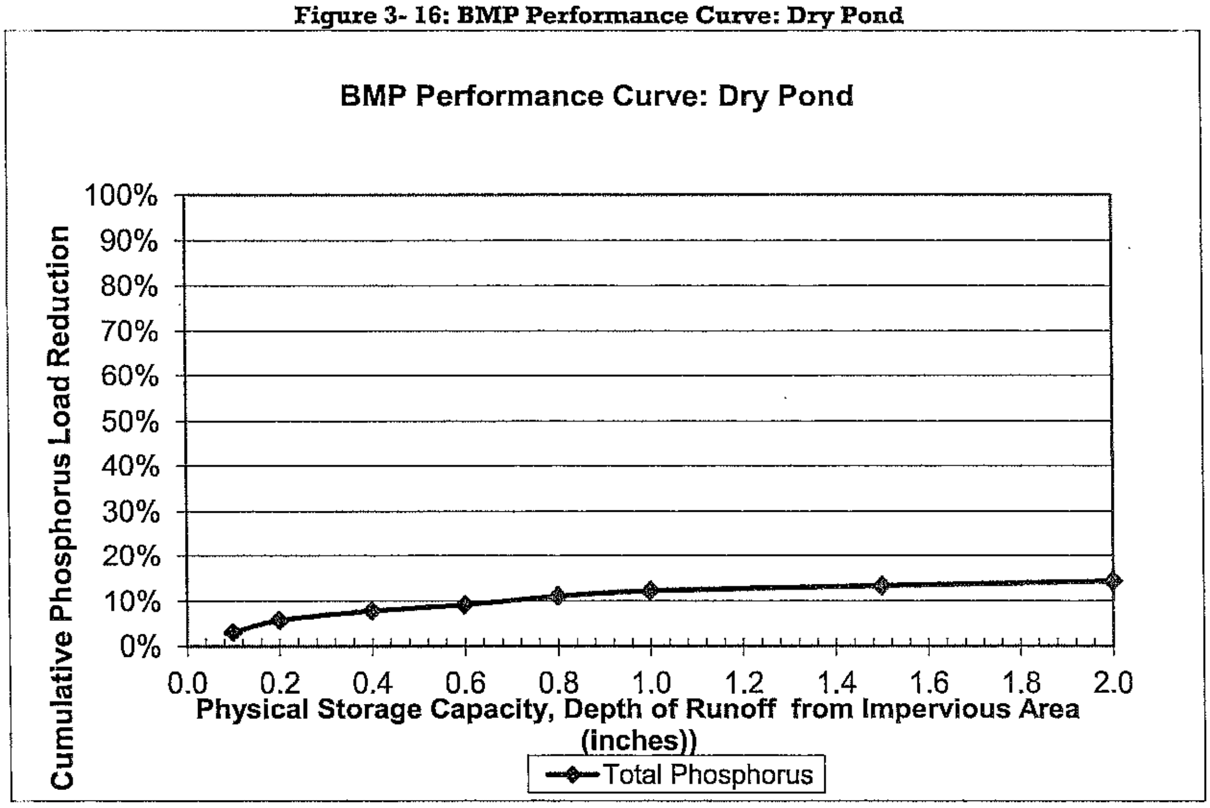


Table 3- 21: Grass Swale BMP Performance Table

Grass Swale BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	2%	5%	9%	13%	17%	21%	29%	36%

Figure 3- 17: BMP Performance Curve: Grass Swale

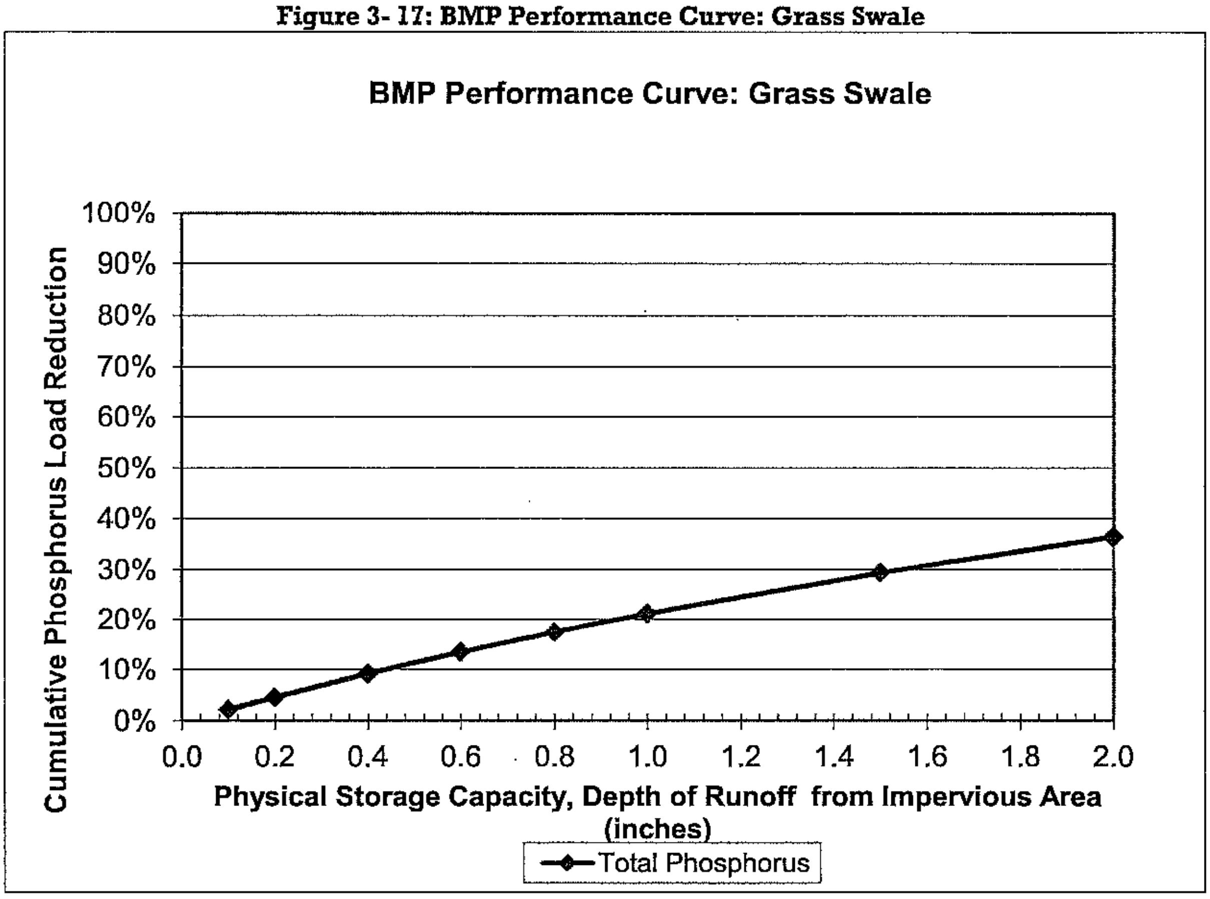


Table 3- 22: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1

Impervious Area Disconnection through Storage : Impervious Area to Pervious Area Ratio = 8:1												
Storage volume to impervious area ratio	Total Runoff Volume (TP) Reduction Percentages											
	HSG A			HSG B			HSG C			HSG D		
	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	22%	22%	21%
0.2 in	40%	38%	37%	40%	38%	37%	37%	38%	37%	24%	26%	27%
0.3 in	52%	50%	49%	52%	50%	49%	40%	46%	49%	24%	26%	27%
0.4 in	61%	59%	58%	59%	59%	58%	40%	48%	54%	24%	26%	27%
0.5 in	67%	66%	64%	62%	66%	64%	40%	48%	56%	24%	26%	27%
0.6 in	70%	71%	70%	62%	70%	70%	40%	48%	56%	24%	26%	27%
0.8 in	71%	78%	77%	62%	73%	77%	40%	48%	56%	24%	26%	27%
1.0 in	71%	80%	80%	62%	73%	79%	40%	48%	56%	24%	26%	27%
1.5 in	71%	81%	87%	62%	73%	81%	40%	48%	56%	24%	26%	27%
2.0 in	71%	81%	88%	62%	73%	81%	40%	48%	56%	24%	26%	27%

Figure 3- 18: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG A Soils

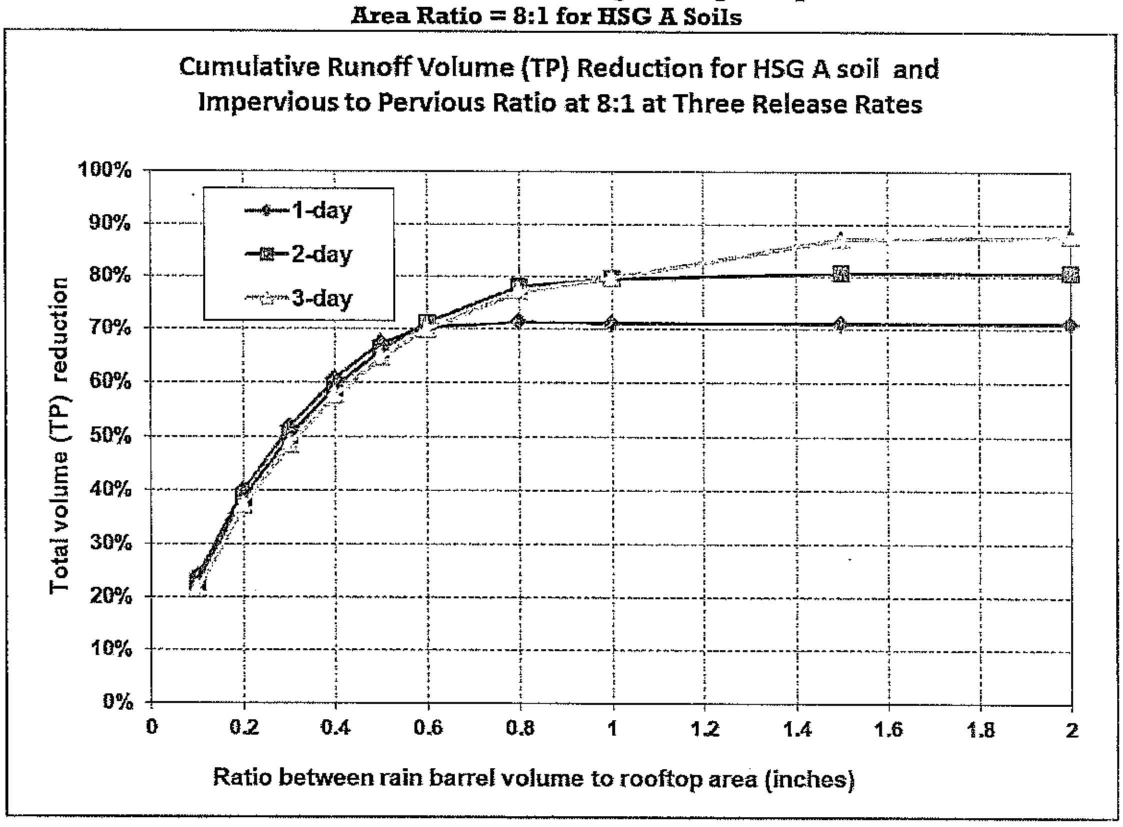


Figure 3- 19: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG B Soils

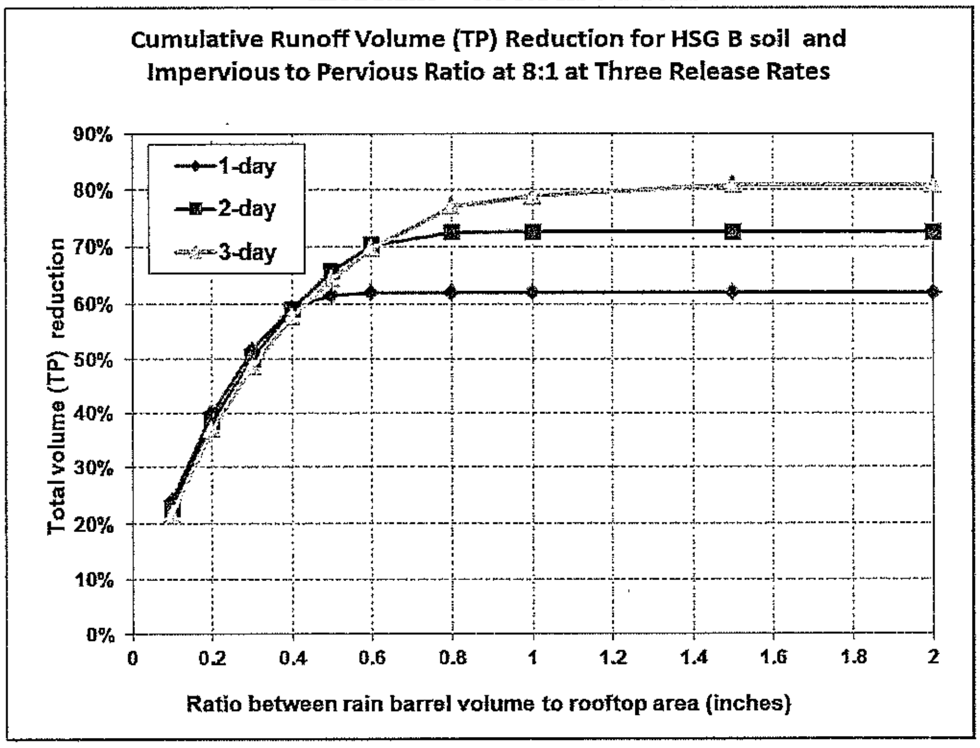


Figure 3- 20: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG C Soils

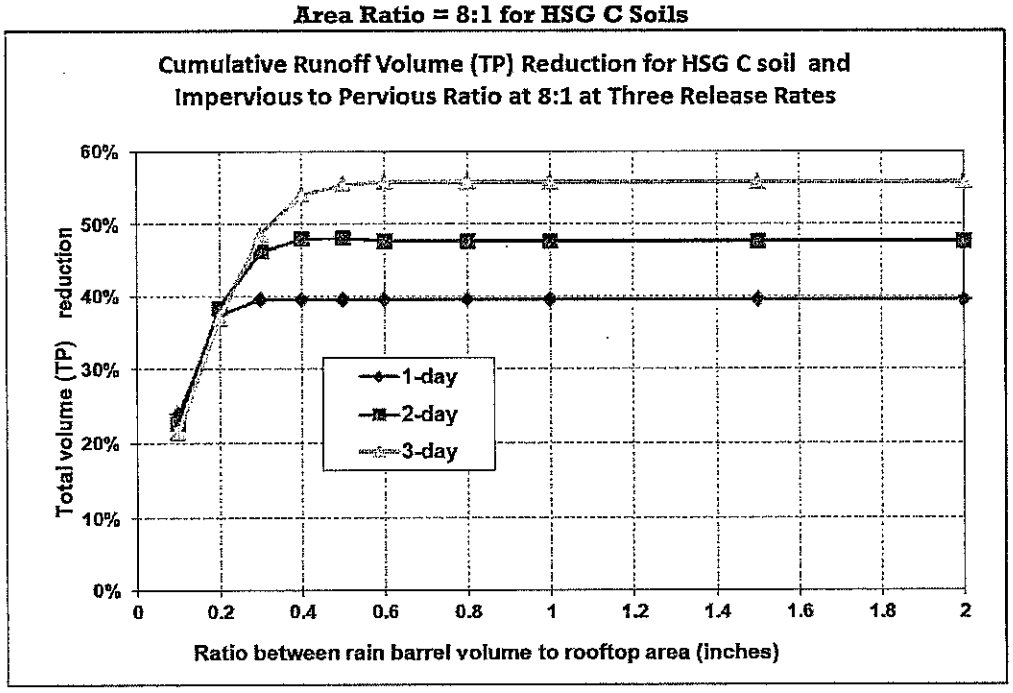


Figure 3- 21: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG D Soils

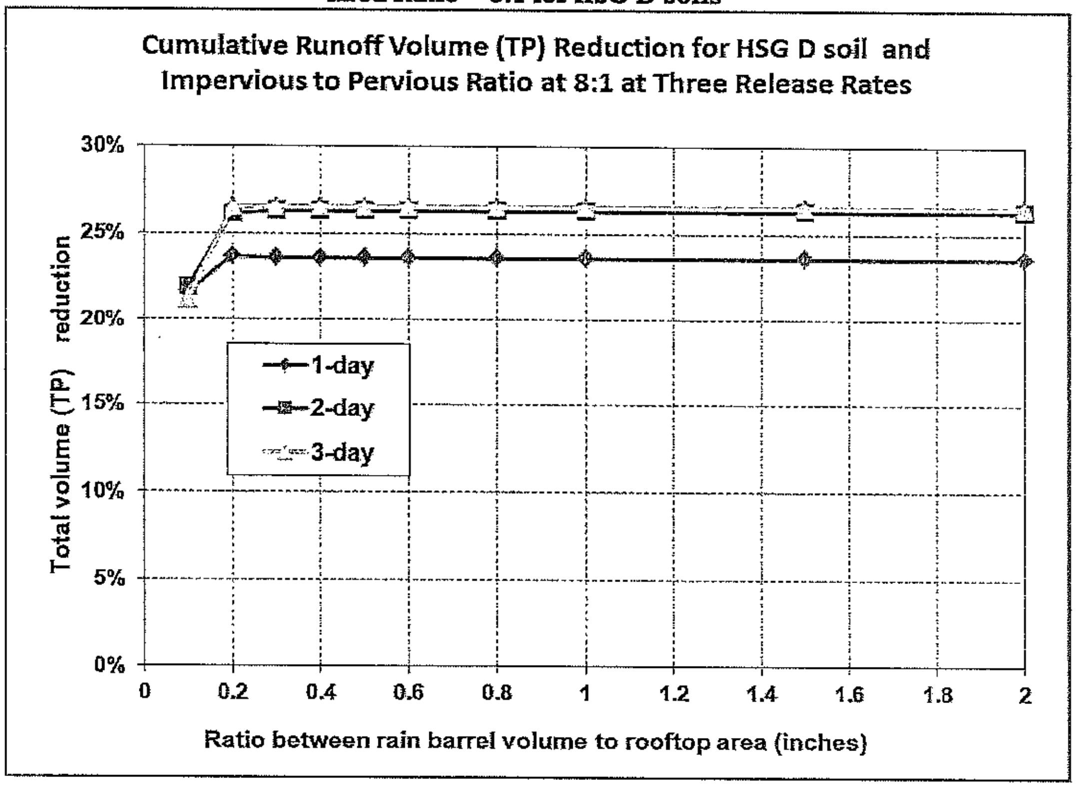


Table 3- 23: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1												
Rain barrel volume to impervious area ratio	Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages											
	HSG A			HSG B			HSG C			HSG D		
	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	23%	23%	22%
0.2 in	40%	38%	37%	40%	38%	37%	40%	38%	37%	28%	30%	33%
0.3 in	52%	50%	49%	52%	50%	49%	47%	50%	49%	29%	31%	34%
0.4 in	61%	59%	58%	61%	59%	58%	48%	55%	58%	29%	31%	34%
0.5 in	67%	66%	64%	67%	66%	64%	48%	57%	63%	29%	31%	34%
0.6 in	73%	71%	70%	70%	71%	70%	48%	57%	65%	29%	31%	34%
0.8 in	78%	78%	77%	71%	78%	77%	48%	57%	66%	29%	31%	34%
1.0 in	79%	81%	80%	71%	79%	80%	48%	57%	66%	29%	31%	34%
1.5 in	79%	87%	88%	71%	80%	87%	48%	57%	66%	29%	31%	34%
2.0 in	79%	87%	91%	71%	80%	87%	48%	57%	66%	29%	31%	34%

Figure 3- 22: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG A Soils

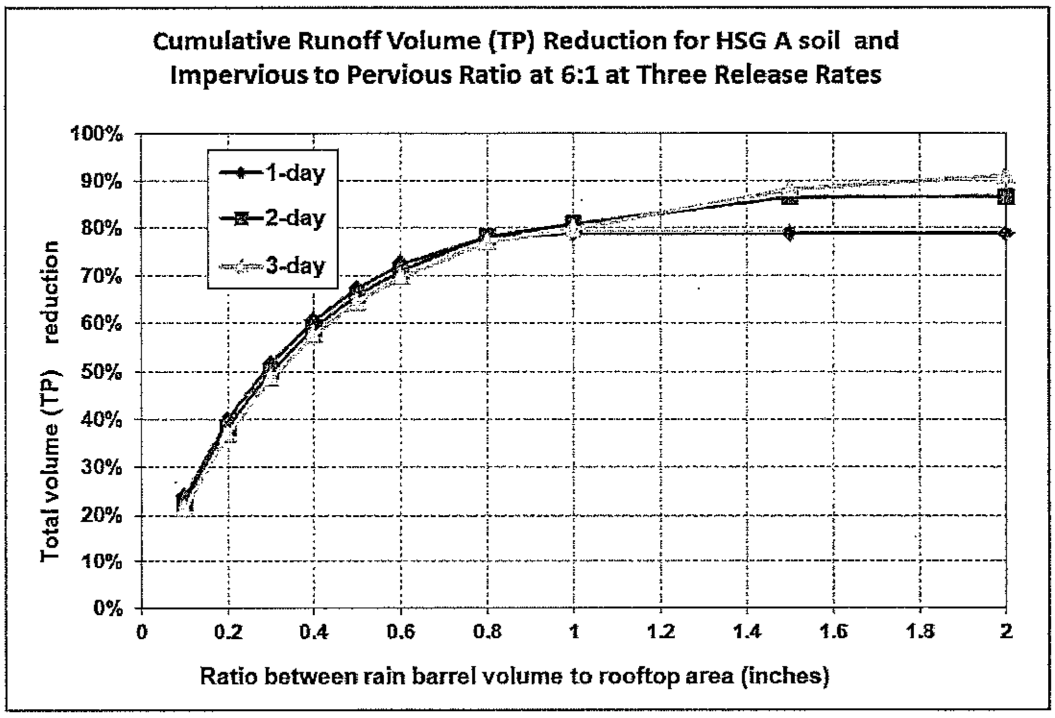


Figure 3- 23: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG B Soils

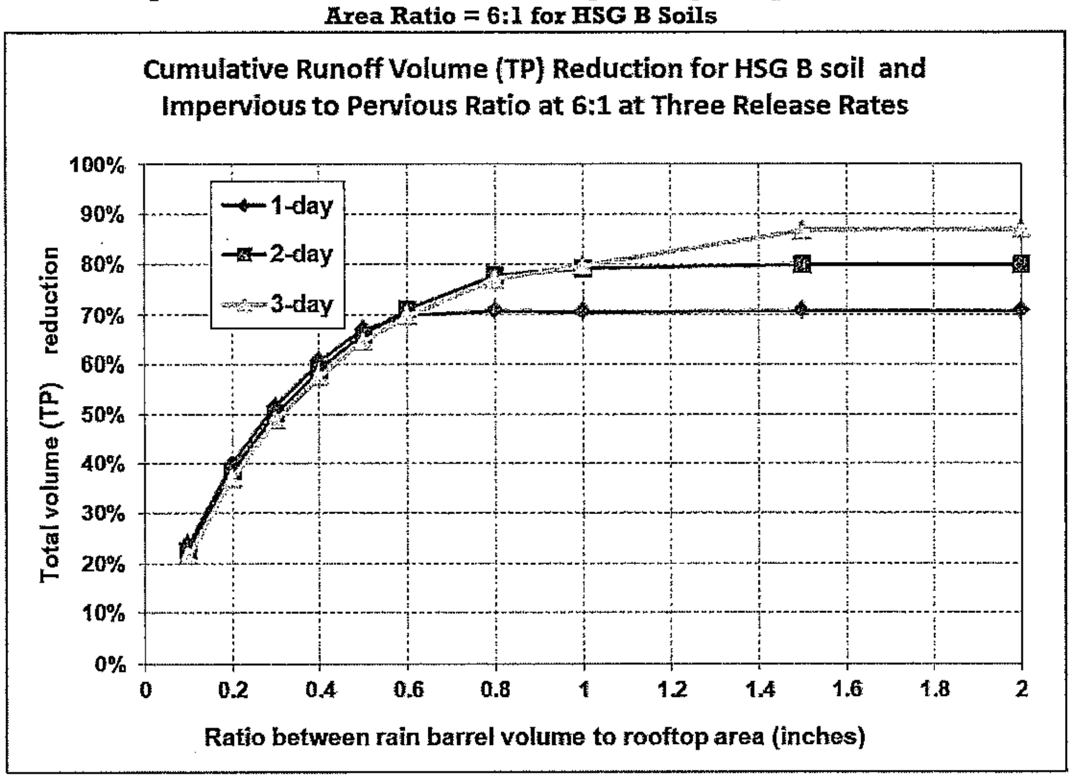


Figure 3- 24: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG C Soils

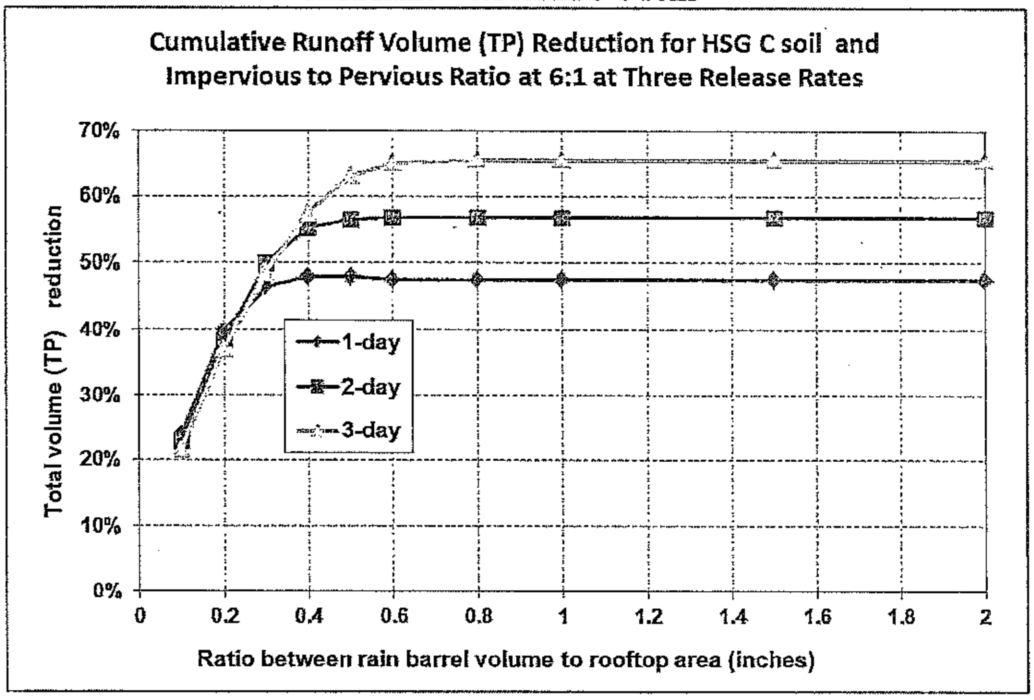


Figure 3- 25: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG D Soils

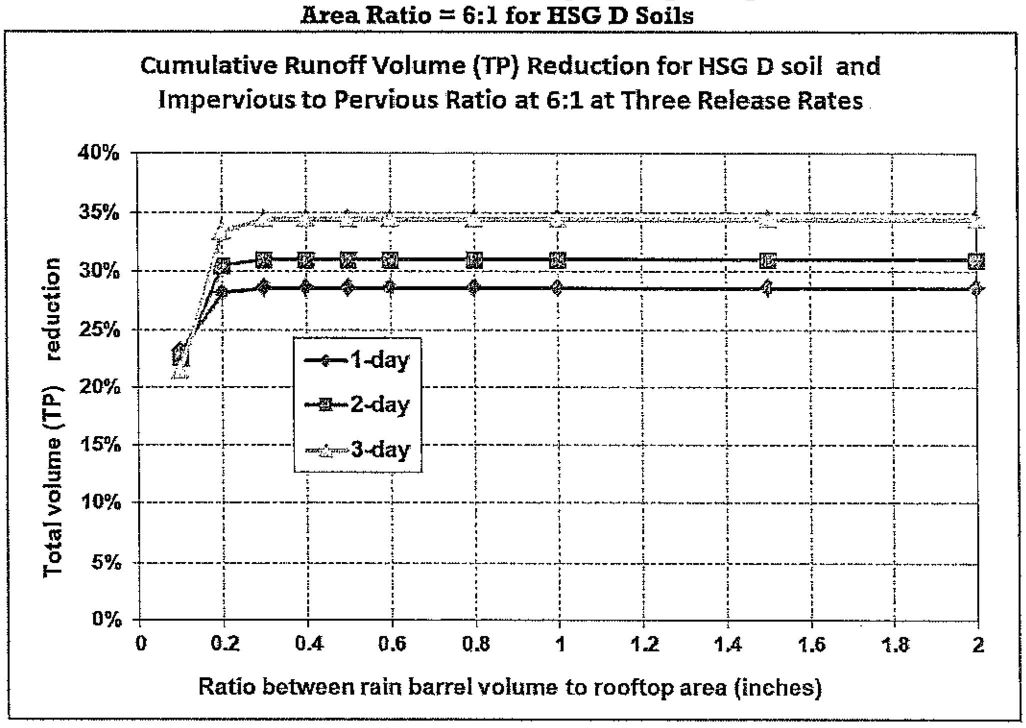


Table 3- 24: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1												
Storage volume to impervious area ratio	Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages											
	HSG A			HSG B			HSG C			HSG D		
	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	24%	23%	22%
0.2 in	40%	38%	37%	40%	38%	37%	40%	38%	37%	37%	37%	37%
0.3 in	52%	50%	49%	52%	50%	49%	52%	50%	49%	39%	42%	45%
0.4 in	61%	59%	58%	61%	59%	58%	58%	59%	58%	39%	42%	47%
0.5 in	67%	66%	64%	67%	66%	64%	60%	65%	64%	40%	42%	47%
0.6 in	73%	71%	70%	73%	71%	70%	61%	68%	70%	40%	42%	47%
0.8 in	79%	78%	77%	79%	78%	77%	61%	69%	75%	40%	42%	47%
1.0 in	82%	81%	80%	80%	81%	80%	61%	69%	76%	40%	42%	47%
1.5 in	87%	89%	88%	80%	87%	88%	61%	69%	76%	40%	42%	47%
2.0 in	87%	91%	91%	80%	88%	91%	61%	69%	76%	40%	42%	47%

Figure 3- 26: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG A Soils

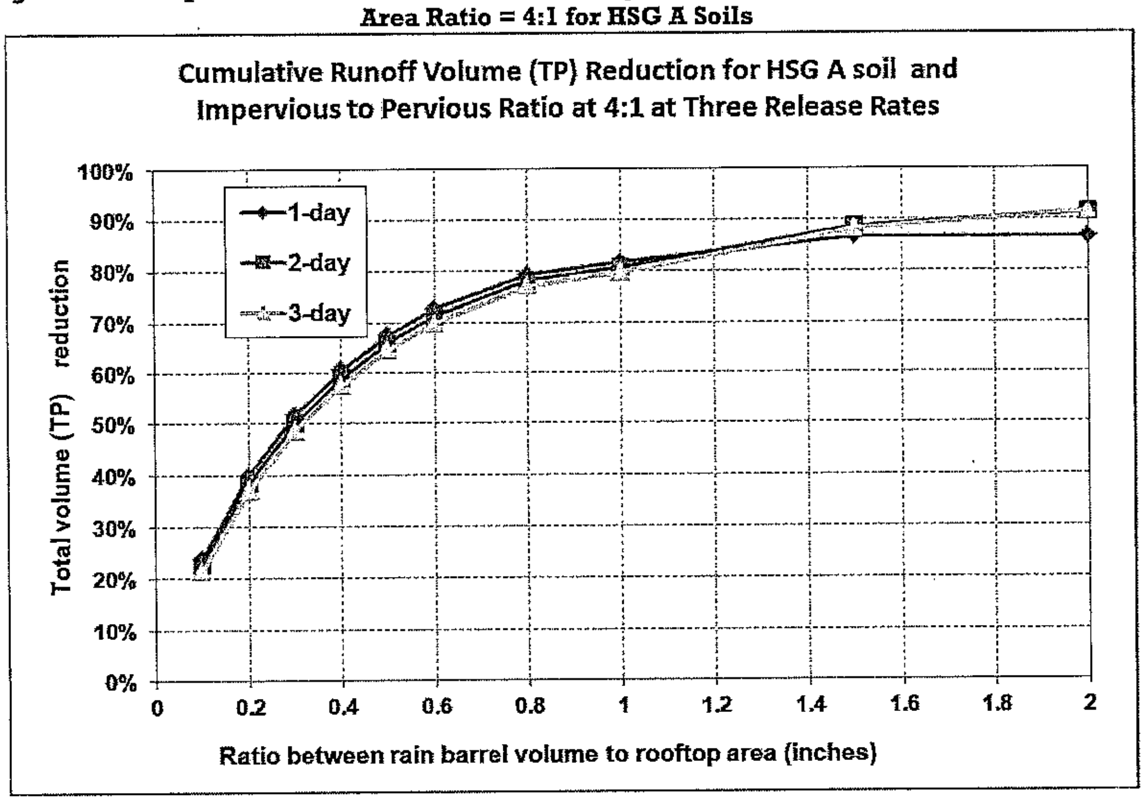


Figure 3- 27: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG B Soils

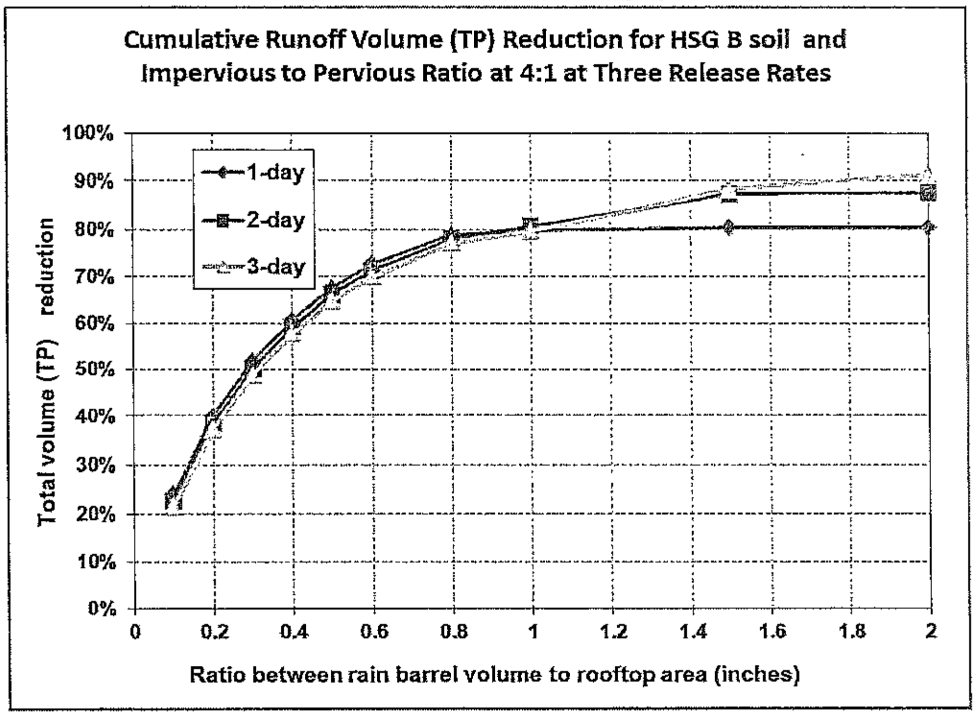


Figure 3- 28: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG C Soils

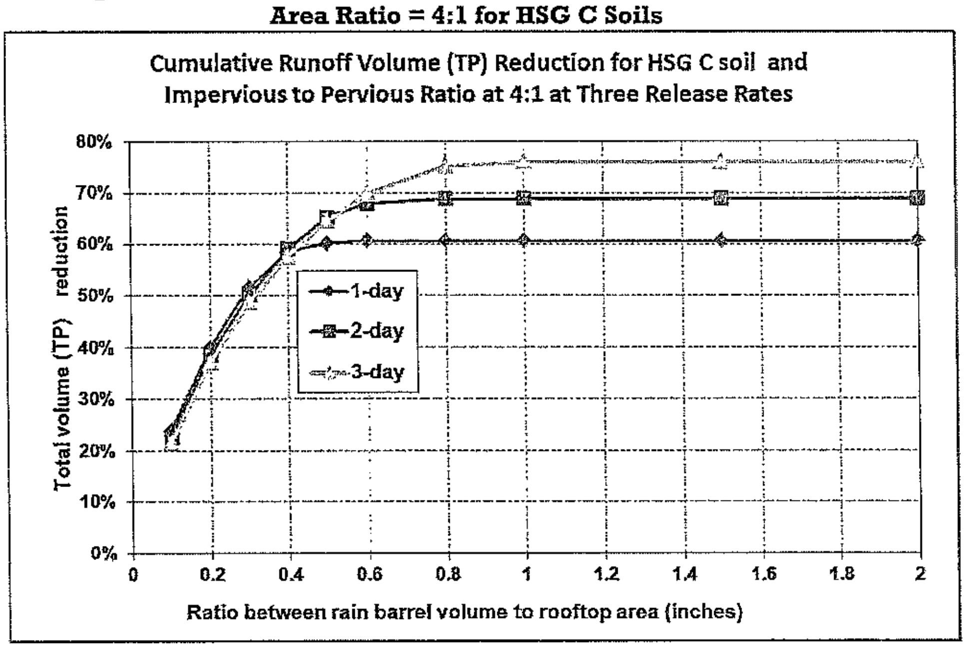


Figure 3- 29: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG D Soils

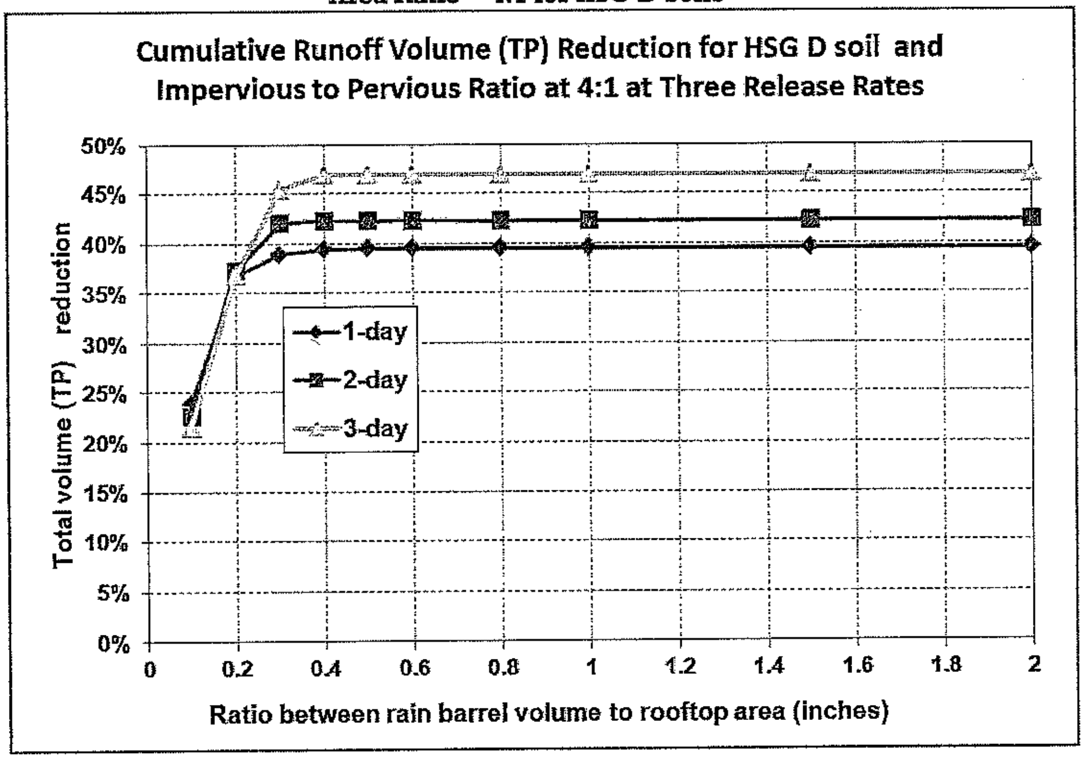


Table 3- 25: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 2:1

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 2:1												
Storage volume to impervious area ratio	Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages											
	HSG A			HSG B			HSG C			HSG D		
	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	24%	23%	22%
0.2 in	40%	38%	37%	40%	38%	37%	40%	38%	37%	40%	38%	37%
0.3 in	52%	50%	49%	52%	50%	49%	52%	50%	49%	51%	50%	49%
0.4 in	61%	59%	58%	61%	59%	58%	61%	59%	58%	57%	58%	57%
0.5 in	67%	66%	64%	67%	66%	64%	67%	66%	64%	59%	62%	63%
0.6 in	73%	71%	70%	73%	71%	70%	72%	71%	70%	59%	62%	67%
0.8 in	79%	78%	77%	79%	78%	77%	77%	78%	77%	59%	62%	67%
1.0 in	82%	81%	80%	82%	81%	80%	78%	81%	80%	59%	62%	67%
1.5 in	89%	89%	88%	89%	89%	88%	78%	84%	88%	59%	62%	67%
2.0 in	92%	92%	91%	91%	92%	91%	78%	84%	89%	59%	62%	67%

Figure 3- 30: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG A Soils

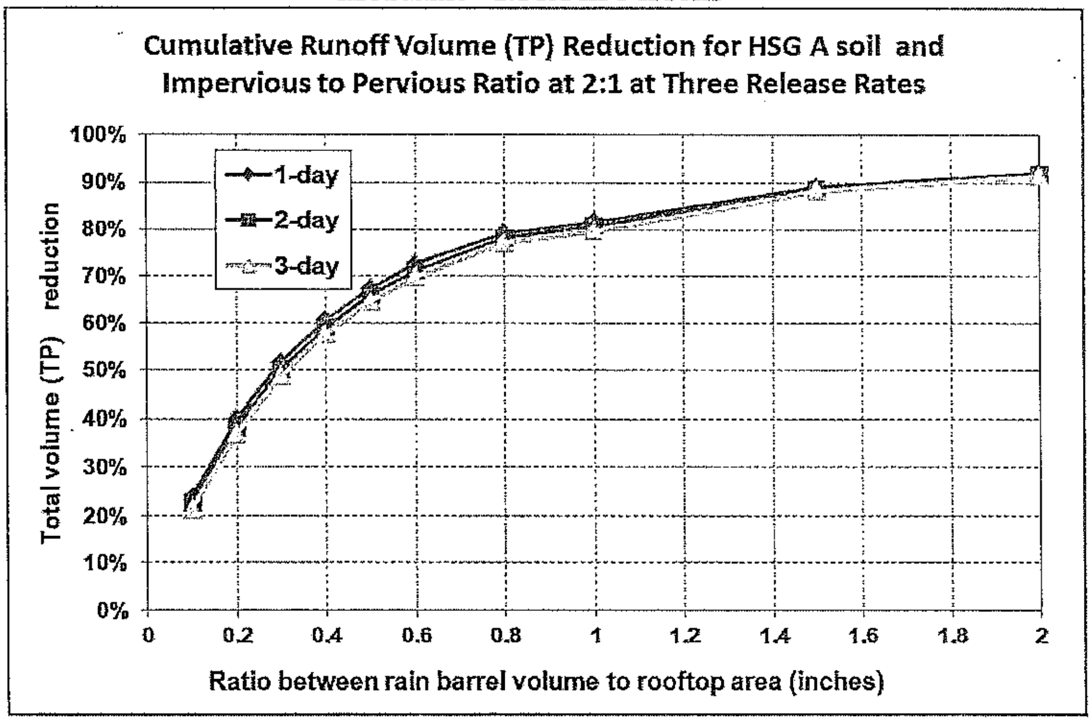


Figure 3- 31: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG B Soils

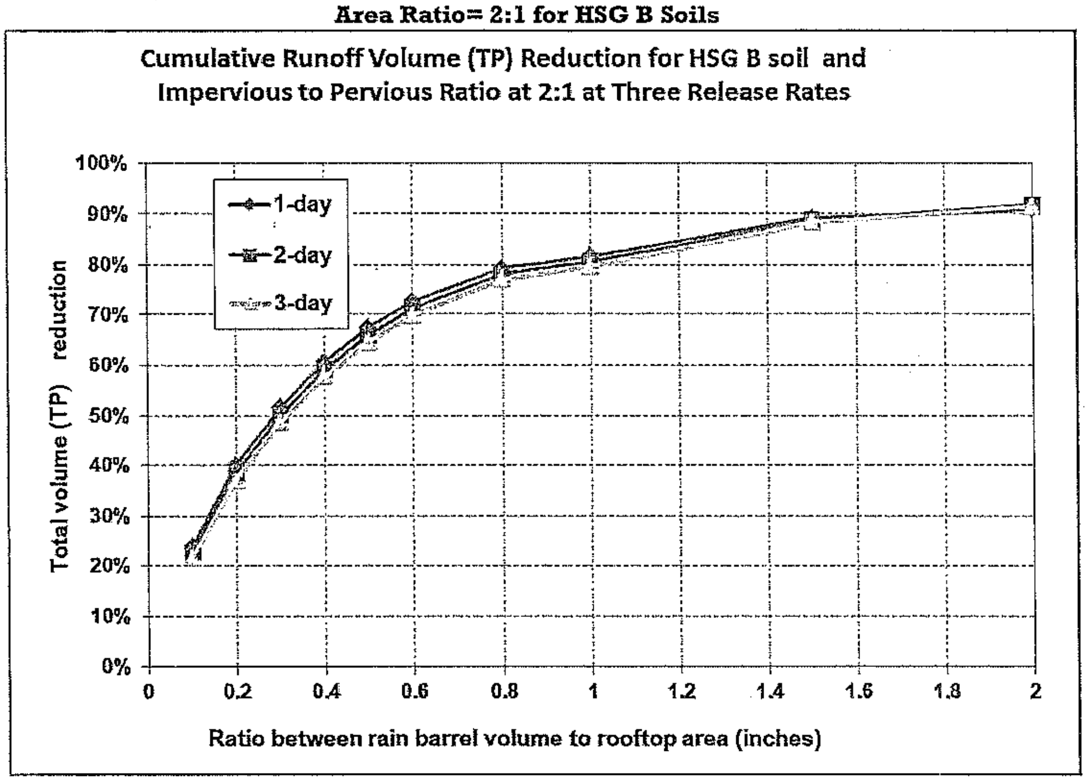


Figure 3- 32: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG C Soils

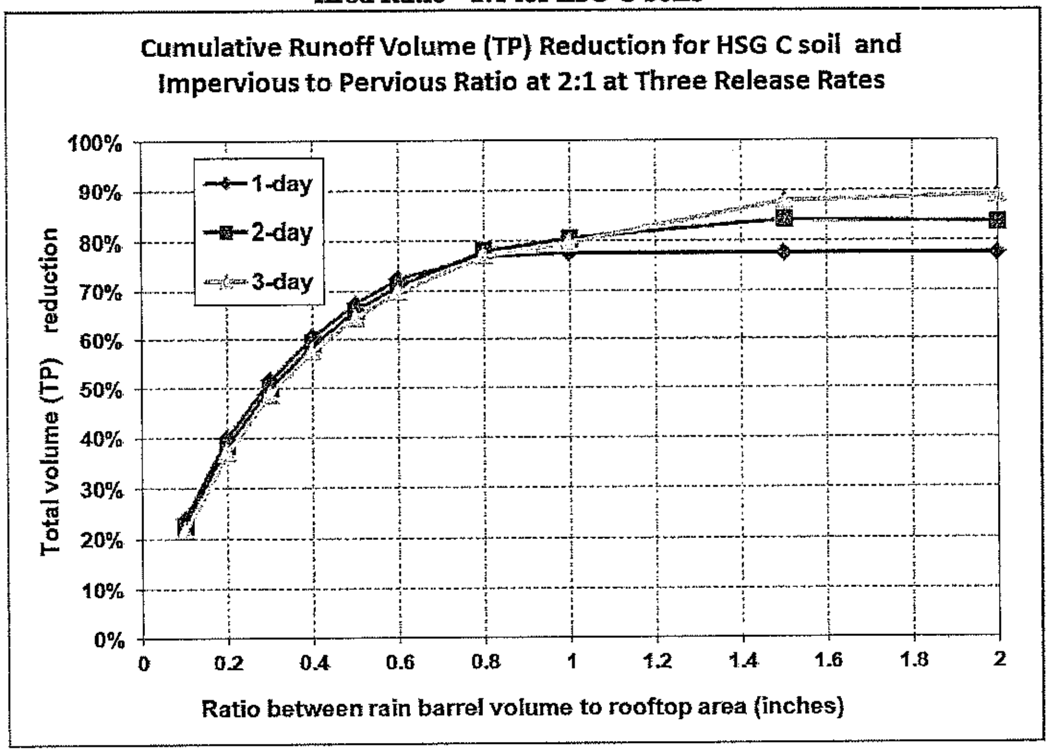


Figure 3- 33: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG D Soils

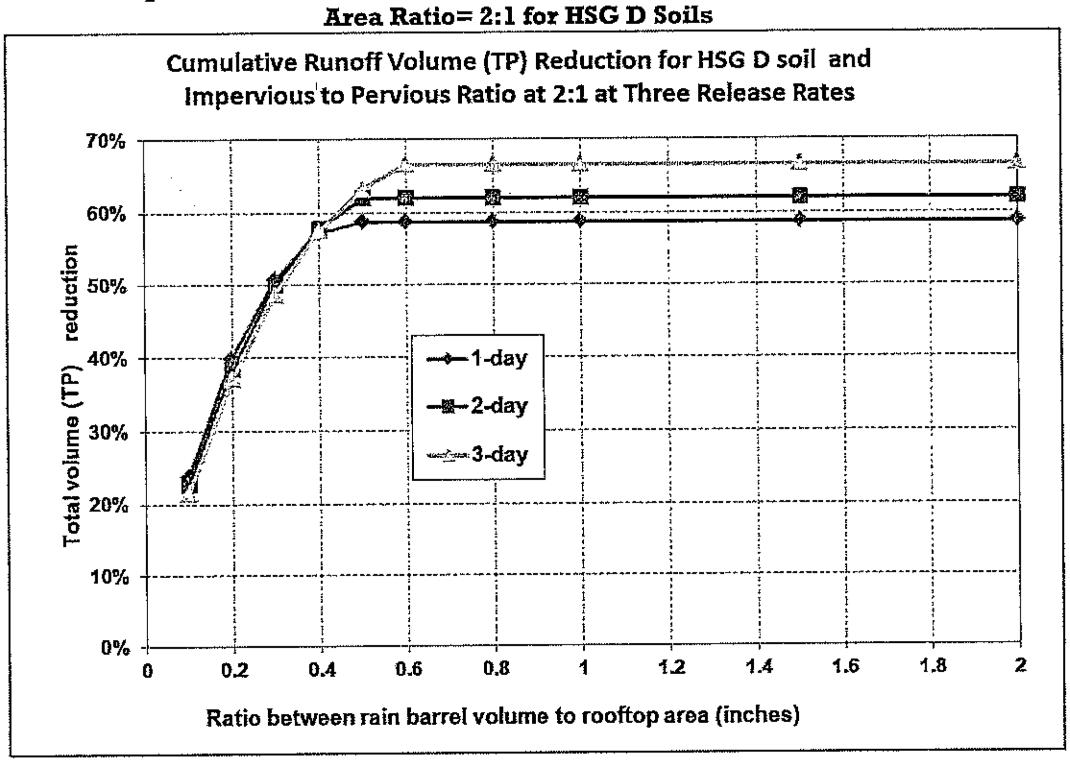


Table 3- 26: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1												
Storage volume to impervious area ratio	Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages											
	HSG A			HSG B			HSG C			HSG D		
	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	24%	23%	22%
0.2 in	40%	38%	37%	40%	38%	37%	40%	38%	37%	40%	38%	37%
0.3 in	52%	50%	49%	52%	50%	49%	52%	50%	49%	52%	50%	49%
0.4 in	61%	59%	58%	61%	59%	58%	61%	59%	58%	61%	59%	58%
0.5 in	67%	66%	64%	67%	66%	64%	67%	66%	64%	67%	66%	64%
0.6 in	73%	71%	70%	73%	71%	70%	73%	71%	70%	72%	71%	70%
0.8 in	79%	78%	77%	79%	78%	77%	79%	78%	77%	78%	78%	77%
1.0 in	82%	81%	80%	82%	81%	80%	82%	81%	80%	79%	80%	80%
1.5 in	89%	89%	88%	89%	89%	88%	89%	89%	88%	80%	82%	86%
2.0 in	92%	92%	91%	92%	92%	91%	91%	92%	91%	80%	82%	86%

Figure 3- 34: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG A Soils

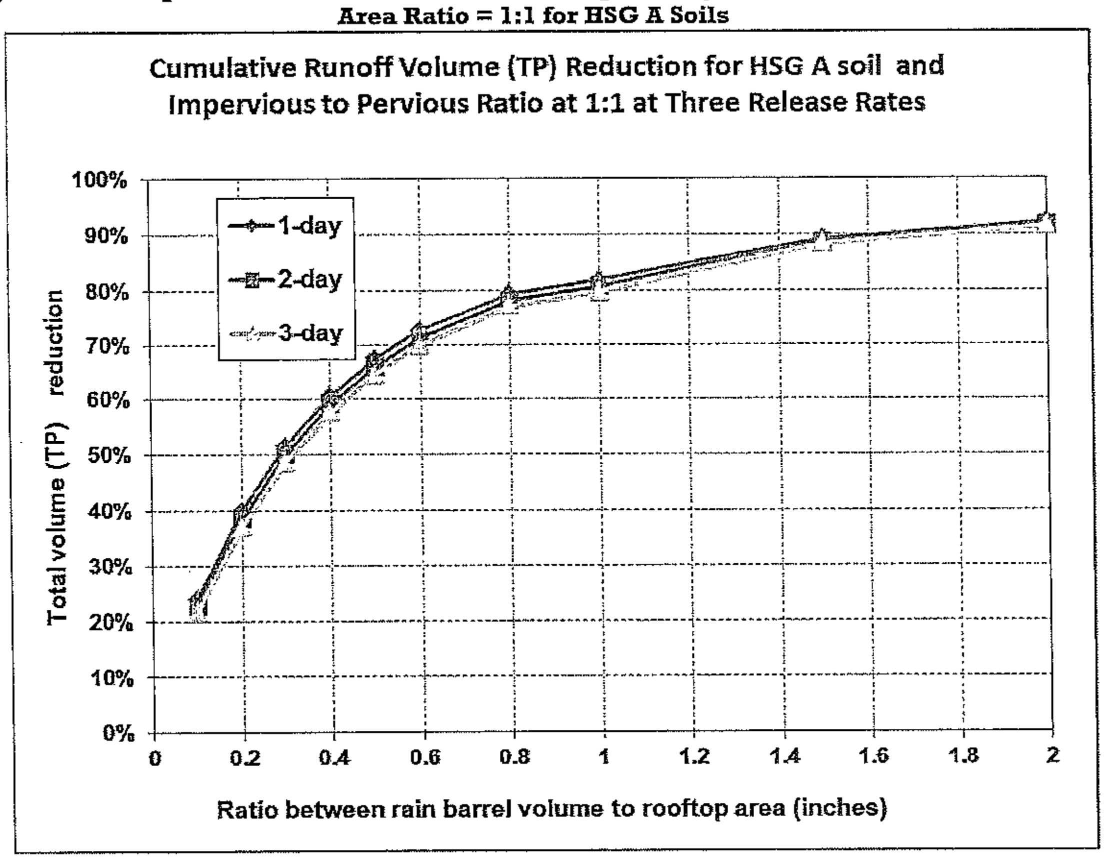


Figure 3- 35: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG B Soils

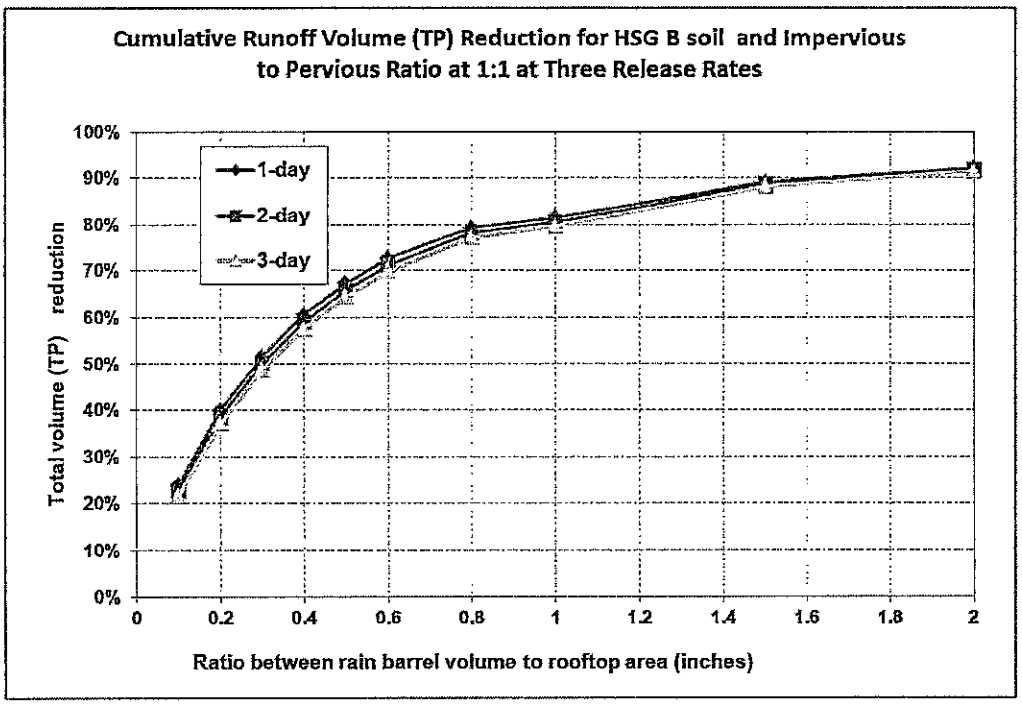


Figure 3- 36: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG C Soils

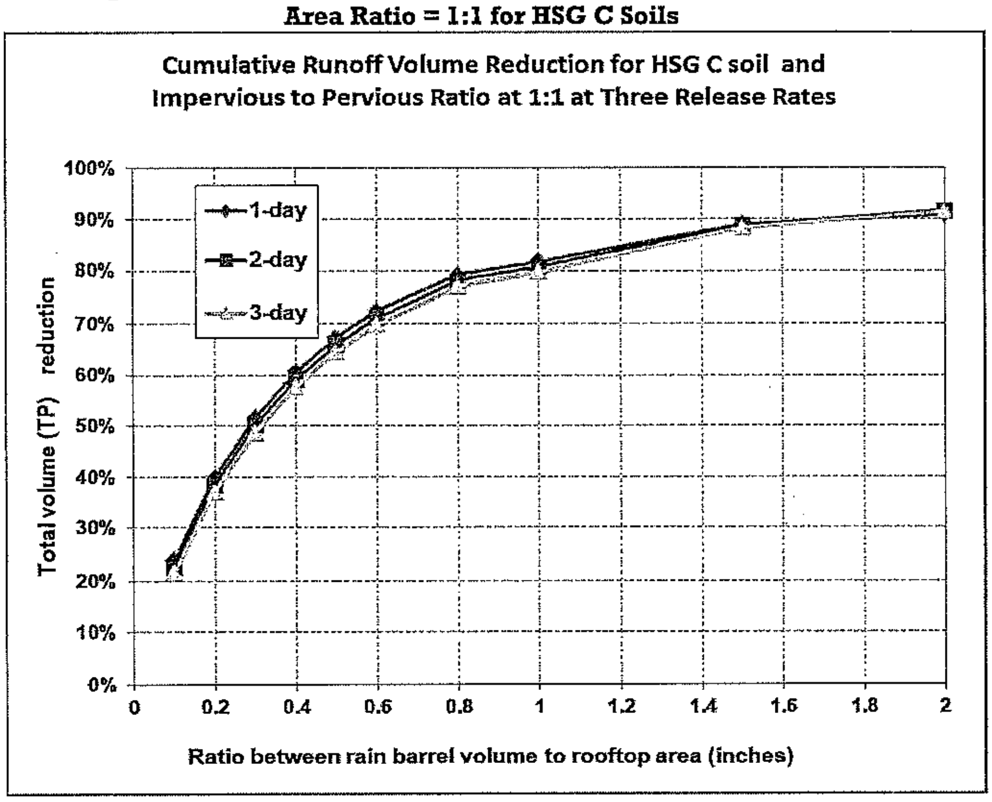


Figure 3- 37: Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG D Soils

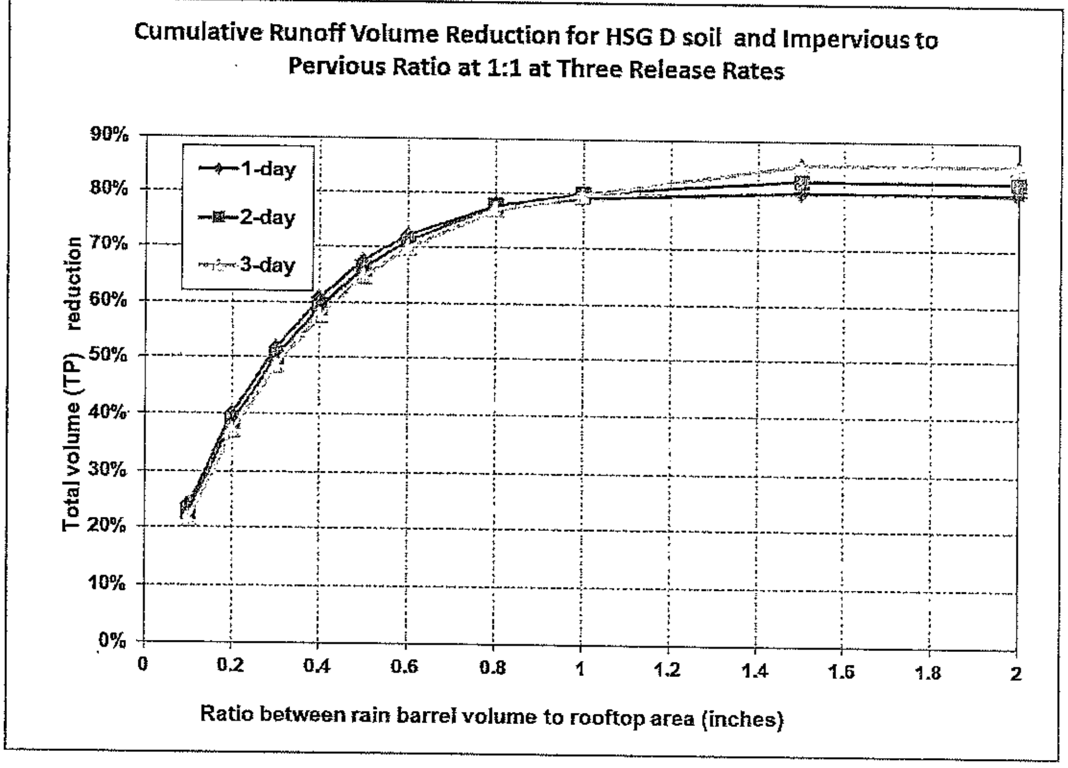


Table 3- 27: Impervious Area Disconnection Performance Table

Impervious area to pervious area ratio	Soil type of Receiving Pervious Area			
	HSG A	HSG B	HSG C	HSG D
8:1	30%	14%	7%	3%
6:1	37%	18%	11%	5%
4:1	48%	27%	17%	9%
2:1	64%	45%	33%	21%
1:1	74%	59%	49%	36%
1:2	82%	67%	60%	49%
1:4	85%	72%	67%	57%

Figure 3- 38: Impervious Area Disconnection Performance Curves

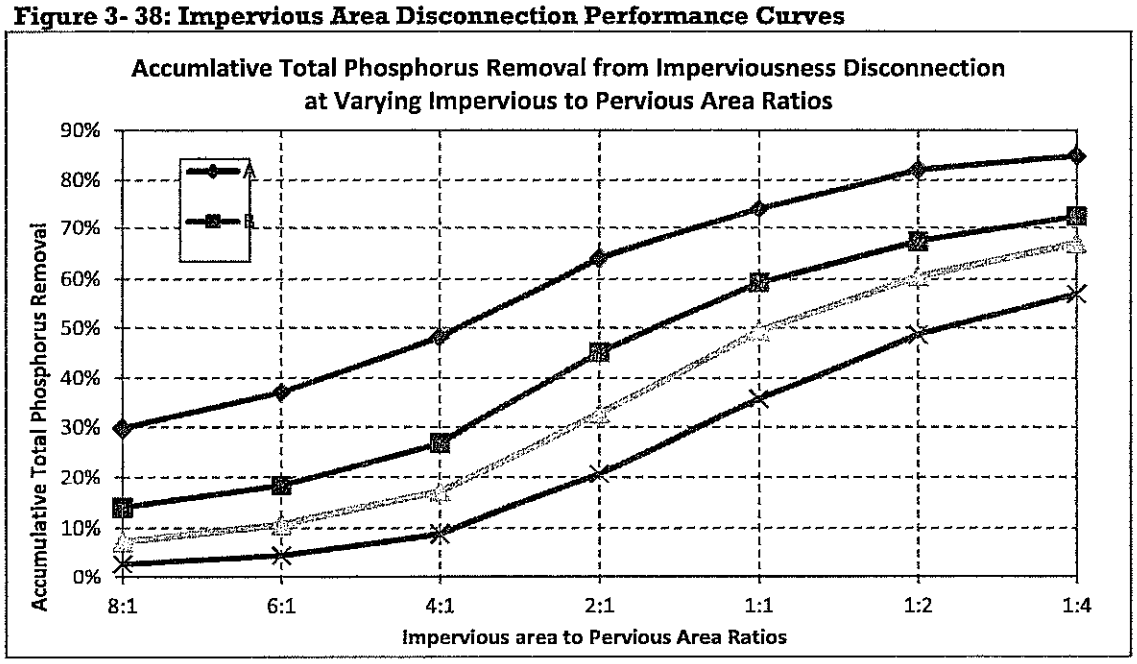


Table 3- 28: Performance Table for Conversion of Impervious Areas to Pervious Area based on Hydrological Soil Groups

Land-Use Group	Cumulative Reduction in Annual Stormwater Phosphorus Load				
	Conversion of impervious area to pervious area-HSG A	Conversion of impervious area to pervious area-HSG B	Conversion of impervious area to pervious area-HSG C	Conversion of impervious area to pervious area-HSG C/D	Conversion of impervious area to pervious area-HSG D
Commercial (Com) and Industrial (Ind)	98.5%	93.5%	88.0%	83.5%	79.5%
Multi-Family (MFR) and High-Density Residential (HDR)	98.8%	95.0%	90.8%	87.3%	84.2%
Medium -Density Residential (MDR)	98.6%	94.1%	89.1%	85.0%	81.4%
Low Density Residential (LDR) - "Rural"	98.2%	92.4%	85.9%	80.6%	75.9%
Highway (HWY)	98.0%	91.3%	84.0%	78.0%	72.7%
Forest (For)	98.2%	92.4%	85.9%	80.6%	75.9%
Open Land (Open)	98.2%	92.4%	85.9%	80.6%	75.9%
Agriculture (Ag)	70.6%	70.6%	70.6%	70.6%	70.6%

Table 3- 29: Performance Table for Conversion of Low Permeable Pervious Area to High Permeable Pervious Area based on Hydrological Soil Group

Land Cover	Cumulative Reduction in Annual SW Phosphorus Load from Pervious Area				
	Conversion of pervious area HSG D to pervious area-HSG A	Conversion of pervious area HSG D to pervious area-HSG B	Conversion of pervious area HSG D to pervious area-HSG C	Conversion of pervious area HSG C to pervious area-HSG A	Conversion of pervious area HSG C to pervious area-HSG B
Developed Pervious Land	92.7%	68.3%	41.5%	83.5%	79.5%

ATTACHMENT 2 TO APPENDIX F

Phosphorus Reduction Credits for Selected Enhanced Non-Structural BMPs in the Watershed

The permittee shall use the following methods to calculate phosphorus load reduction credits for the following enhanced non-structural control practices implemented in the Watershed:

1) Enhanced Sweeping Program;
2) Catch Basin Cleaning;
3) No Application of Fertilizers Containing Phosphorus; and
4) Organic Waste and Leaf Litter Collection program

The methods include the use of default phosphorus reduction factors that EPA has determined are acceptable for calculating phosphorus load reduction credits for these practices.

The methods and annual phosphorus load export rates presented in this attachment are for the purpose of counting load reductions for various BMPs treating storm water runoff from varying site conditions (i.e., impervious or pervious surfaces) and different land uses (e.g. industrial and commercial) within the impaired watershed. Table 2-1 below provides annual phosphorus load export rates by land use category for impervious and pervious areas. The estimates of annual phosphorus load and load reductions resulting from BMP implementation are intended for use by the permittee to measure compliance with its Phosphorus Reduction Requirement under the permit.

Examples are provided to illustrate use of the methods. In calculating phosphorus export rates, the permittee shall select the land use category that most closely represents the actual use for the area in question. For watersheds with institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial land use category for the purpose of calculating phosphorus loads. Table 2-2 provides a crosswalk table of land use codes between land use groups in Table 2-1 and the codes used by Mass GIS. For pervious areas, permittees should use the appropriate value for the hydrologic soil group (HSG) if known, otherwise, assume HSG C/D conditions.

Alternative Methods and/or Phosphorus Reduction Factors: A permittee may propose alternative methods and/or phosphorus reduction factors for calculating phosphorus load reduction credits for these non-structural practices. EPA will consider alternative methods and/or phosphorus reduction factors, provided that the permittee submits adequate supporting documentation to EPA. At a minimum, supporting documentation shall consist of a description of the proposed method, the technical basis of the method, identification of alternative phosphorus reduction factors, supporting calculations, and identification of references and sources of information that support the use of the alternative method and/or factors in the Watershed. If EPA determines that the alternative methods and/or factors are not adequately supported, EPA will notify the permittee and the permittee may receive no phosphorus reduction credit other than a reduction credit calculated by the permittee following the methods in this attachment for the identified practices.

Table 2-1: Proposed average annual distinct P Load export rates for use in estimating P Load reduction credits in the MA MS4 Permit

Phosphorus Source Category by Land Use	Land Surface Cover	P Load Export Rate, lbs/acre/year	P Load Export Rate, kg/ha/yr
Commercial (Com) and Industrial (Ind)	Directly connected impervious	1.78	2.0
	Pervious	See* DevPERV	See* DevPERV
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	2.6
	Pervious	See* DevPERV	See* DevPERV
Medium -Density Residential (MDR)	Directly connected impervious	1.96	2.2
	Pervious	See* DevPERV	See* DevPERV
Low Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	1.7
	Pervious	See* DevPERV	See* DevPERV
Highway (HWY)	Directly connected impervious	1.34	1.5
	Pervious	See* DevPERV	See* DevPERV
Forest (For)	Directly connected impervious	1.52	1.7
	Pervious	0.13	0.13
Open Land (Open)	Directly connected impervious	1.52	1.7
	Pervious	See* DevPERV	See* DevPERV
Agriculture (Ag)	Directly connected impervious	1.52	1.7
	Pervious	0.5	0.5
*Developed Land Pervious (DevPERV) – HSG A	Pervious	0.03	0.03
*Developed Land Pervious (DevPERV) – HSG B	Pervious	0.12	0.13
*Developed Land Pervious (DevPERV) – HSG C	Pervious	0.21	0.24
*Developed Land Pervious (DevPERV) – HSG C/D	Pervious	0.29	0.33
*Developed Land Pervious (DevPERV) – HSG D	Pervious	0.37	0.41

Notes:

- For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value from this table. If the HSG is not known, assume HSG D conditions for the phosphorus load export rate.
- Agriculture includes row crops. Actively managed hay fields and pasture lands. Institutional land uses such as government properties, hospitals and schools are to be included in the commercial and industrial land use grouping for the purpose of calculating phosphorus loading.
- Impervious surfaces within the forest land use category are typically roadways adjacent to forested pervious areas.

Table 2-2: Crosswalk of Mass GIS land use categories to land use groups for P load calculations

Mass GIS Land Use LU CODE	Description	Land Use group for calculating P Load - 2013/14 MA MS4
1	Crop Land	Agriculture
2	Pasture (active)	Agriculture
3	Forest	Forest
4	Wetland	Forest
5	Mining	Industrial
6	Open Land includes inactive pasture	open land
7	Participation Recreation	open land
8	spectator recreation	open land
9	Water Based Recreation	open land
10	Multi-Family Residential	High Density Residential
11	High Density Residential	High Density Residential
12	Medium Density Residential	Medium Density Residential
13	Low Density Residential	Low Density Residential
14	Saltwater Wetland	Water
15	Commercial	Commercial
16	Industrial	Industrial
17	Urban Open	open land
18	Transportation	Highway
19	Waste Disposal	Industrial
20	Water	Water
23	cranberry bog	Agriculture
24	Powerline	open land
25	Saltwater Sandy Beach	open land
26	Golf Course	Agriculture
29	Marina	Commercial
31	Urban Public	Commercial
34	Cemetery	open land
35	Orchard	Forest
36	Nursery	Agriculture
37	Forested Wetland	Forest
38	Very Low Density residential	Low Density Residential
39	Junkyards	Industrial
40	Brush land/Successional	Forest

(1) Enhanced Sweeping Program: The permittee may earn a phosphorus reduction credit for conducting an enhanced sweeping program of impervious surfaces. Table 2-2 below outlines the default phosphorus removal factors for enhanced sweeping programs. The credit shall be calculated by using the following equation:

$$Credit_{sweeping} = IA_{swept} \times PLE_{IC\text{-}land\ use} \times PRF_{sweeping} \times AF \qquad \textbf{(Equation 2-1)}$$

Where:

$Credit_{sweeping}$ = Amount of phosphorus load removed by enhanced sweeping program (lb/year)

IA_{swept} = Area of impervious surface that is swept under the enhanced sweeping program (acres)

$PLE_{IC\text{-}land\ use}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)

$PRF_{sweeping}$ = Phosphorus Reduction Factor for sweeping based on sweeper type and frequency (see Table 2-3).

AF = Annual Frequency of sweeping. For example, if sweeping does not occur in Dec/Jan/Feb, the AF would be 9 mo./12 mo. = 0.75. For year-round sweeping, AF=1.0[1]

As an alternative, the permittee may apply a credible sweeping model of the Watershed and perform continuous simulations reflecting build-up and wash-off of phosphorus using long-term local rainfall data.

Table 2-3: Phosphorus reduction efficiency factors ($PRF_{sweeping}$) for sweeping impervious areas

Frequency[1]	Sweeper Technology	$PRF_{sweeping}$
2/year (spring and fall)[2]	Mechanical Broom	0.01
2/year (spring and fall)[2]	Vacuum Assisted	0.02
2/year (spring and fall)[2]	High-Efficiency Regenerative Air-Vacuum	0.02
Monthly	Mechanical Broom	0.03
Monthly	Vacuum Assisted	0.04
Monthly	High Efficiency Regenerative Air-Vacuum	0.08
Weekly	Mechanical Broom	0.05
Weekly	Vacuum Assisted	0.08
Weekly	High Efficiency Regenerative Air-Vacuum	0.10

[1]For full credit for monthly and weekly frequency, sweeping must be conducted year round. Otherwise, the credit should be adjusted proportionally based on the duration of the sweeping season (using AF factor).

[2] In order to earn credit for semi-annual sweeping the sweeping must occur in the spring following snow-melt and road sand applications to impervious surfaces and in the fall after leaf-fall and prior to the onset to the snow season.

Example 2-1: Calculation of enhanced sweeping program credit ($Credit_{sweeping}$): A permittee proposes to implement an enhanced sweeping program and perform weekly sweeping from March 1 – December 1 (9 months) in their Watershed, using a vacuum assisted sweeper on 20.3 acres of parking lots and roadways in a high-density residential area of the Watershed. For this site the needed information is:

IA_{swept}	= 20.3 acres
$PLE_{IC\text{-}HDR}$	= 2.3 lb/acre/yr (from Table 2-1)
$PRF_{sweeping}$	= 0.08 (from Table 2-2)
AF	= (9 months / 12 months) = 0.75

Substitution into equation 2-1 yields a $Credit_{sweeping}$ of 3.2 pounds of phosphorus removed per year.

$Credit_{sweeping}$ = $IA_{swept} \times PLE_{land\ use} \times PRF_{sweeping} \times AF$
= 20.30 acres x 2.3 lbs/acre/yr x 0.08 x 0.75
= **2.8 lbs/yr**

<u>**(2) Catch Basin Cleaning:**</u> The permittee may earn a phosphorus reduction credit, $Credit_{CB}$, by removing accumulated materials from catch basins (i.e., catch basin cleaning) in the Watershed such that a minimum sump storage capacity of 50% is maintained throughout the year. The credit shall be calculated by using the following equation:

$$Credit_{CB} = IA_{CB} \times PLE_{IC\text{-}land\ use} \times PRF_{CB} \quad \textbf{(Equation 2-2)}$$

Where:

$Credit_{CB}$	=	Amount of phosphorus load removed by catch basin cleaning (lb/year)
IA_{CB}	=	Impervious drainage area to catch basins (acres)
$PLE_{IC\text{-}and\ use}$	=	Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)
PRF_{CB}	=	Phosphorus Reduction Factor for catch basin cleaning (see Table 2-4)

Table 2-4: Phosphorus reduction efficiency factor (PRF_{CB}) for semi-annual catch basin cleaning

Frequency	Practice	PRF_{CB}
Semi-annual	Catch Basin Cleaning	0.02

Example 2-2: Calculation for catch basin cleaning credit (Credit $_{CB}$):
A permittee proposes to clean catch basins in their Watershed (i.e., remove accumulated sediments and contaminants captured in the catch basins) that drain runoff from 15.3 acres of medium-density residential impervious area. For this site the needed information is:

IA_{CB}	= 15.3 acre
$PLE_{IC\text{-}MDR}$	= 2.0 lbs/acre/yr (from Table 2-1)
PRF_{CB}	= 0.02 (from Table 2-4)

Substitution into equation 2-2 yields a Credit $_{CB}$ of 0.6 pounds of phosphorus removed per year:

$$\text{Credit}_{CB} = IA_{CB} \times PLE_{IC\text{-}MDR} \times PRF_{CB}$$
$$= 15.3 \text{ acre} \times 2.0 \text{ lbs/acre/yr} \times 0.02$$
$$\mathbf{= 0.6 \text{ lbs/yr}}$$

(3) No Application of Fertilizers Containing Phosphorus: If within the permittees regulated area there has been historical and regular use of fertilizer containing phosphorus, the permittee may earn a phosphorus reduction credit (Credit $_{fertilizer}$) by effectively ending the use of fertilizers that contain phosphorus to managed and landscaped pervious areas (lawn areas) from which runoff discharges to the TMDL waterbody or its tributaries. The application of any fertilizers containing phosphorus at any time during the reporting year within the permittee's regulated area shall preclude the permittee from earning this credit for the reporting year. The permittee must provide written certification to EPA annually that no fertilizers containing phosphorus have been applied to any area in the Watershed in order to earn the credit. The Credit $_{fertilizer}$ (in lb/year) shall be determined using the following equation:

$$\text{Credit}_{fertilizer} = WPLER * 0.5 * \sum^{LU}(Area_{LU} * Lawn\%_{LU} * FF) \qquad \textbf{(Equation 2-3)}$$

Where:

WPLER[3]	= Weighted Phosphorus Load Export Rate (lb/ac/yr) for the municipality, based on the distribution of hydrologic soil groups in the municipality.
0.5	= Phosphorus reduction factor: based on available data, EPA expects that phosphorus concentrations in runoff from landscaped pervious areas will be reduced by 50% when phosphorus is removed from fertilizers.
$Area_{LU}$	= total area (acres) for each of 10 relevant land uses identified by EPA (see example calculation) within the municipality; default values for each town determined by EPA using Mass GIS data.
$Lawn\%_{LU}$	= lawn area percentage (decimal form) for each of the 10 relevant land uses; default values provided by EPA through analysis of Mass GIS data

[3] Lawn phosphorus export rates were calculated using the same modelling approach as the export rates in Table 2-1, but with more specific grassy area land use data.

FF = Fertilization factor = 0.5 for EPA default values; the percentage of lawn area currently receiving P fertilizer applications (decimal form).

Example 2-3: Calculation for P-free fertilizer credit (Credit $_{fertilizer}$):

A permittee is planning to adopt the upcoming Massachusetts phosphorus fertilizer ban within their regulated area under the MS4. EPA has provided the town with a WPLER of 0.181 lb/acre/yr based on soil types in the area. Through a survey, the town determines that approximately 60% of lawns are fertilized in town. The town determines the total areas for each of the 10 land uses[4] in the regulated area through a spatial analysis and uses default EPA lawn percentages for each land use.

So: WPLER = 0.181 lb/ac/yr FF = 60% = 0.6

These values are shown in the table on the next page. For each land use, the total area and the lawn percentage are multiplied to get the lawn area for each land use; the fertilization factor is multiplied in; these values are added up for each land use in the last column to get the total fertilized lawn area in the permittee's regulate area.

Land use (LU)	$Area_{LU}$ (acre)	Lawn % (as decimal)	FF	$Area_{LU}$ x Lawn % x FF
Low Density Residential	180	0.25	0.6	27.0
Medium Density Residential	259	0.20	0.6	31.1
Participation Recreation	23	0.42	0.6	5.8
Golf Courses	25	0.62	0.6	9.3
Public/Institutional Lands	51	0.19	0.6	5.9
Very Low Density Residential	27	0.16	0.6	2.6
Multi-Family Residential	40	0.19	0.6	4.5
High Density Residential	13	0.05	0.6	0.4
Commercial	34	0.01	0.6	0.2
Industrial	123	0.01	0.6	0.7
				87.5 = total fertilized lawn area (acres)

Then, the credits are determined by Equation 2-3:

$$Credit_{fertilizer} = WPLER * 0.5 * \sum^{LU}(Area_{LU} * Lawn\%_{LU} * FF)$$

Where WPLER has been calculated for the municipality by EPA (0.181 lb/ac/yr) and the sum expression (Σ) is equal to the total fertilized lawn area (calculated above as 87.5 ac). Substitution of these values into Equation 2-3 yields the total fertilizer credits:

Credit $_{fertilizer}$ = 0.181 lb/ac/yr * 0.5 * 87.5 acres
= **7.9 lb/yr**

[4] Not all 10 land uses may be present within the regulated area within each community. Land uses not represented within the regulated area should have 0 acre for the $Area_{LU}$ in the calculation table (next page).

NOTE: For permittees within the Charles River Watershed, EPA has calculated default fertilizer reduction credits using spatial data for the regulated areas within these municipalities and the default lawn percentages shown above. Permittees may choose to use the default EPA credits or may use the EPA-calculated WPLERs, along with site-specific information about land uses and fertilizer use, to calculate $Credit_{fertilizer}$ using the method described above. The calculated WPLERs for the permittees, as well as the calculated default fertilizer credits, are provided in Table 2-5 on the next page.

Table 2-5: Calculated weighted export rates and fertilizer credits for Charles River Watershed small MS4 permittees

Town	WPLER (lb/acre/yr)	$Credit_{fertilizer}$ (lb/yr)	Town	WPLER (lb/acre/yr)	$Credit_{fertilizer}$ (lb/yr)
Arlington	0.261	1.2	**Mendon**	0.119	0.3
Ashland	0.207	1.7	**Milford**	0.205	34.0
Bellingham	0.152	10.8	**Millis**	0.130	16.0
Belmont	0.227	8.0	**Natick**	0.240	37.6
Brookline	0.273	53.9	**Needham**	0.221	44.8
Cambridge	0.261	9.0	**Newton**	0.252	113.1
Dedham	0.290	23.7	**Norfolk**	0.096	15.8
Dover	0.216	16.7	**Sherborn**	0.162	13.3
Foxborough	0.139	0.1	**Somerville**	0.291	8.2
Franklin	0.236	58.8	**Walpole**	0.156	3.7
Holliston	0.164	33.2	**Waltham**	0.255	45.4
Hopedale	0.162	2.0	**Watertown**	0.283	21.1
Hopkinton	0.136	9.5	**Wayland**	0.209	1.4
Lexington	0.206	16.3	**Wellesley**	0.220	56.7
Lincoln	0.238	9.9	**Weston**	0.159	40.9
Medfield	0.148	21.6	**Westwood**	0.248	18.8
Medway	0.159	28.8	**Wrentham**	0.076	6.0

(4) Enhanced Organic Waste and Leaf Litter Collection program: The permittee may earn a phosphorus reduction credit by performing regular gathering, removal and disposal of landscaping wastes, organic debris, and leaf litter from impervious surfaces from which runoff discharges to the TMDL waterbody or its tributaries. In order to earn this credit ($Credit_{leaf\ litter}$), the permittee must gather and remove all landscaping wastes, organic debris, and leaf litter from all impervious roadways and parking lots at least once per week during the period of September 1 to December 1 of each year. The gathering and removal shall occur immediately following any landscaping activities in the Watershed and at additional times when necessary to achieve a weekly cleaning frequency. The permittee must ensure that the disposal of these materials will not contribute pollutants to any surface water discharges. The permittee may use an enhanced sweeping program (e.g., weekly frequency) as part of earning this credit provided that the sweeping is effective at removing leaf litter and organic materials. The $Credit_{leaf\ litter}$ shall be determined by the following equation:

$\text{Credit}_{\text{leaf litter}} = (\text{Watershed Area}) \times (\text{PLE}_{\text{IC-land use}}) \times (0.05)$ **(Equation 2-4)**

<u>Where:</u>

$\text{Credit}_{\text{leaf litter}}$	= Amount of phosphorus load reduction credit for organic waste and leaf litter collection program (lb/year)
Watershed Area	= All impervious area (acre) from which runoff discharges to the TMDL waterbody or its tributaries in the Watershed
$\text{PLE}_{\text{IC-land use}}$	= Phosphorus Load Export Rate for impervious cover and specified land use (lbs/acre/yr) (see Table 2-1)
0.05	= 5% phosphorus reduction factor for organic waste and leaf litter collection program in the Watershed

<u>Example 2-4: Calculation for organic waste and leaf litter collection program credit ($\text{Credit}_{\text{leaf litter}}$):</u> A permittee proposes to implement an organic waste and leaf litter collection program by sweeping the parking lots and access drives at a minimum of once per week using a mechanical broom sweeper for the period of September 1 to December 1 over 12.5 acres of impervious roadways and parking lots in an industrial/commercial area of the Watershed. Also, the permittee will ensure that organic materials are removed from impervious areas immediately following all landscaping activities at the site. For this site the needed information to calculate the $\text{Credit}_{\text{leaf litter}}$ is:

Watershed Area = 12.5; and
$\text{PLE}_{\text{IC-commercial}}$ = 1.8 lbs/acre/yr (from Table 2-1)

Substitution into equation 2-4 yields a $\text{Credit}_{\text{leaf litter}}$ of 1.1 pounds of phosphorus removed per year:

$$\text{Credit}_{\text{leaf litter}} = (12.5 \text{ acre}) \times (1.8 \text{ lbs/acre/yr}) \times (0.05) = 1.1 \text{ lbs/yr}$$

The permittee also may earn a phosphorus reduction credit for enhanced sweeping of roads and parking lot areas (i.e., $\text{Credit}_{\text{sweeping}}$) for the three months of use. Using equation 2-1, $\text{Credit}_{\text{sweeping}}$ is:

$\text{Credit}_{\text{sweeping}} = \text{IA}_{\text{swept}} \times \text{PLE}_{\text{IC-land use}} \times \text{PRF}_{\text{sweeping}} \times \text{AF}$ **(Equation 2-1)**
IA_{swept} = 12.5 acre
$\text{PLE}_{\text{IC-commercial}}$ = 1.8 lbs/acre/yr (from Table 2-1)
$\text{PRF}_{\text{sweeping}}$ = 0.05 (from Table 2-2)
AF = 3 mo./12 mo. = 0.25

Substitution into equation 2-1 yields a $\text{Credit}_{\text{sweeping}}$ of 0.28 pounds of phosphorus removed per year.

$$\text{Credit}_{\text{sweeping}} = \text{IA}_{\text{swept}} \times \text{PLE}_{\text{IC-commercial}} \times \text{PRF}_{\text{sweeping}} \times \text{AF} = 12.5 \text{ acre} \times 1.8 \text{ lbs/acre/yr} \times 0.05 \times 0.25 = \mathbf{0.28 \text{ lbs/yr}}$$

Supplemental Environmental Projects

#1 Educational Signage
Educational signage at current green infrastructure projects would also help to build public understanding of the importance of stormwater management, build momentum for sustainable solutions, and meet your education requirements.

Branding image / signage.

Timeline: 9 months

Estimated Cost: $10,000

#2 Irving Avenue Seekonk River Revitalization
Stormwater runoff from the Irving Avenue hill is currently causing significant erosion of infrastructure on the south side of Irving Avenue and, most significantly, at River Drive, and is damaging the shoreline itself. Stormwater is channeled down Irving by the oversized paved roadway, abetted by high curbs and without strategically placed drain outlets, towards a particularly degraded area along the riverbank opposite York Pond. Much of this stormwater runoff entirely bypasses York Pond, the natural detention/retention feature for the 240+-acre watershed.

Removal of some pavement along Irving Avenue and Gulf Road, the installation of two strategically located drains and removal of an eroded asphalt sidewalk on the south (pond) side of Irving would minimize the generation of stormwater runoff in the first place, and installation of bioretention systems including appropriate planting would filter and infiltrate stormwater runoff downhill as close to the source as possible (before reaching the Seekonk River). Additional strategic improvements in this location, including plantings, special crosswalk treatments, minor intersection geometry adjustments, and way-finding, would increase pedestrian and bicycle safety and beautify this key gateway to the riverfront while continuing to build momentum for change to this important citywide park and public access resource.

Timeline: 18 months

Cost Estimate: $68,000 - $150,000

#3 Restoration of Riverside Park

The Providence Parks Department is working with the Woonasquatucket River Watershed Council to restore the site of a 7,500 sq ft mill building that was recently demolished. The area to be restored is located within Riverside Park on Aleppo Street in Providence and would be used for passive recreation. The park is bounded by Aleppo Street on the north and east, and the Woonasquatucket River and the Woonasquatucket River Greenway on the south and north, and is considered an environmental justice area. The project would respect the history and brownfield nature of the site, and treat stormwater from the site. The proposed restoration activities at the site include:

- Expand existing swale at Riverside Park to compensate for water at a yet to be designed parking area (actually berm two sides rather than swale) - 15' x 100' - $ 6,500.00
- Add additional plants to existing 400ft swale to improve water retention and treatment ((@ 1' O.C. – 1,500 Each - $ 16,500.00)
- Install street trees – 4 total - $ 2,500.00
- Create berm at parking area walk - $ 2,500.00
- Create green/live trellis using existing shade structure to reduce heat and take up stormwater at park: $8,000

Timeline: 2 years

Estimated cost: $55,000