WAYNE COUNTY STORM WATER MANAGEMENT PROGRAM
PROGRAM CLARIFICATIONS, ERRATA, AND REVISIONS
July 2015

SUMMARY AND HISTORY

Administrative Rules

Amendment to the Wayne County Storm Water Administrative Rules, adopted by Wayne County Commission Resolution No. 2015-70-011

Storm Water Standards Manual

Chapter 4: Obtaining Storm Water Construction Approval (11 July 2008; 8 June 2011)

Chapter 6: General Design Standards (July 2015)

Chapter 7: Additional Requirements
  • Section 7.4: Easements (8 June 2009)
  • Section 7.12: Closed Conduits (11 July 2008)

Chapter 8: Specific Design Standards and Guidance for Best Management Practices
  • Best Management Practices (11 July 2008)
  • Section 8.1.1 Open Detention Basins (11 July 2008; July 2015)
  • Section 8.1.2 Retention Basins (July 2015)
  • Section 8.1.3 Underground Detention Systems (11 July 2008; 8 June 2009; October 2009; July 2015)
  • Section 8.1.4 Outlets for Forebays and Open Detention Basins (11 July 2008)
  • Section 8.2.1 Forebays (July 2015)
  • Section 8.2.2 Bioretention (July 2015)
  • Section 8.2.3 Manufactured Treatment Systems (11 July 2008; 8 June 2009)
  • Section 8.3.2 Vegetated Swales (11 July 2008)

Chapter 11: Sample Calculations (July 2015)


Appendices
  • Appendix A: Engineer’s Certificate of Construction (11 July 2008)
  • Appendix E-4: Wayne County Parks Division, Permit Guidelines for Site Restoration (8 June 2009; 9 October 2009; July 2015)

Other Guidance Available from Wayne County Website
  • Other information not included in the Standards Manual which may be helpful in implementing the Wayne County Storm Water Management Program is available at http://waynecounty.com/doe/1174.htm
  • Information about the overall Wayne County construction permit process, including the Construction Permit Application Kit, is available at http://waynecounty.com/dps/construction_permits.htm
NOTE: In September 2009, the Department of Environment and Department Public Services were merged into a reorganized Department of Public Services. The names of and services provided by Divisions of the former Department of Environment and Department Public Services remain unchanged. Thus, references to the “Department of Environment” throughout all documents related to the Wayne County Storm Water Management Program are now to “Department of Public Services”. With the exception of Chapter 12 (Contacts), the Storm Water Management Standards Manual will not be updated to reflect the reorganization until the next release of the Storm Water Management Standards Manual.

### WAYNE COUNTY STORM WATER ADMINISTRATIVE RULES

<table>
<thead>
<tr>
<th>Rule</th>
<th>Description of Change</th>
<th>Type of Change</th>
<th>Date(s) of Change</th>
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</thead>
<tbody>
<tr>
<td>Chapter 2, Rule 202</td>
<td>Revision to definitions:</td>
<td>Revision</td>
<td>July 2015 by Commission Resolution 2015-70-011</td>
</tr>
<tr>
<td></td>
<td>• Buffer strip</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Free board</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>New definition:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Top of Bank or Top of Embankment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter 6, Rule 603D</td>
<td>Revisions to requirements for buffer strips</td>
<td>Revision</td>
<td>July 2015 by Commission Resolution 2015-70-011</td>
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### WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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</thead>
<tbody>
<tr>
<td>Preface: Document Updates and Internet Access</td>
<td>All</td>
<td>Update Wayne County website addresses</td>
<td>Update</td>
<td>July 2015</td>
</tr>
<tr>
<td>Chapter 3: Administration and Regulations</td>
<td>3-5</td>
<td>Update website address for information about communities in which soil erosion and sedimentation control permits are issued by Wayne County: <a href="http://waynecounty.com/doe/soilerosion.htm">http://waynecounty.com/doe/soilerosion.htm</a></td>
<td>Update</td>
<td>July 2015</td>
</tr>
</tbody>
</table>
### Wayne County Storm Water Management Program
Clarifications, Revisions, Updates, and Errata

**July 2015**

#### WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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<tbody>
<tr>
<td><strong>Chapter 4: Obtaining Storm Water Construction Approval</strong></td>
<td>In June 2009, Wayne County Department of Public Services (DPS) published additional documents:</td>
<td><strong>Clarification</strong></td>
<td><strong>8 June 2009 Website address update:</strong> July 2015</td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td>Section 4.7</td>
<td>Clarify that Wayne County may require clean out of storm water systems prior to approval of final inspection and release of permits and remaining financial assurance.</td>
<td><strong>Clarification</strong></td>
<td><strong>11 July 2008</strong></td>
</tr>
</tbody>
</table>

**Chapter 6: General Design Standards**

| 6-6 | Section 6.3.3 | Revised requirements for buffer strips | **Revision** | **July 2015** |

**Chapter 7: Additional Requirements**

| 7-1 | Section 7.1.2, Closed Conduits (3rd paragraph, 1st bullet) | Clarify the definition of “outlet” in the hydraulic grade line (HGL) calculation (see Rule 711(B)(4)): | **Clarification** | **11 July 2008; 8 June 2009** |
| 7-3 | Section 7.4, Easements | Revise the text of Item 1 to read as follows: “1. An open County Drain or watercourse with a maximum bank to bank width that is 30 feet or greater must have an easement to the extreme width of the drain, plus 30 feet. The easement must be centered on the centerline of the drain or watercourse.” | **Revision** | **8 June 2009** |
| 7-3 | Section 7.6, County Park Property | Add reference to Appendix E-4 (Wayne County Parks Division, Permit Guidelines for Site Restoration). | **Clarification** | **8 June 2009** |
| 7-4 | Section 7.8, Temporary Measures During | Update website address for information about Wayne County’s Soil Erosion and Sedimentation Control Program: | **Errata** | **8 June 2009;** |
## Wayne County Storm Water Management Program
### Clarifications, Revisions, Updates, and Errata
#### July 2015

| WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0) |
|---|---|---|---|
| **Page** | **Paragraph** | **Description of Change** | **Type of Change** | **Date(s) of Change** |
| Construction (last sentence in last paragraph) | http://waynecounty.com/doe/soilerosion.htm | Clarify requirements that storm water management components that include plantings that are specific to the functioning of a storm water management component but are not on the plant lists in the Wayne County Storm Water Standards is allowable if shown on landscaping plans submitted/stamped by a registered landscape architect (RLA) and certification form stamped by the RLA (see revised Appendix A). | Clarification | July 2015 |

### Chapter 8: Best Management Practices

<table>
<thead>
<tr>
<th><strong>Section 8.1.1: Open Detention Basins</strong></th>
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<tbody>
<tr>
<td>8-3</td>
</tr>
<tr>
<td>8-8</td>
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<tr>
<td>8-16C</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Section 8.1.2: Retention Basins</strong></th>
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<tbody>
<tr>
<td>8-17</td>
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<thead>
<tr>
<th><strong>Section 8.1.3: Underground Detention Systems</strong></th>
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<tr>
<td>8-19</td>
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### WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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<tbody>
<tr>
<td>8-19</td>
<td>Preferred Design Elements and Materials (second paragraph)</td>
<td>Revise requirements for spacing of pipes for underground detention systems consisting of pipes</td>
<td>Revision</td>
<td>July 2013</td>
</tr>
<tr>
<td>8-19</td>
<td>Preferred Design Elements and Materials</td>
<td>Revise requirements for access to underground detention systems</td>
<td>Revision</td>
<td>9 October 09</td>
</tr>
<tr>
<td>8-20A</td>
<td>Preferred Design Elements and Materials</td>
<td>Revise list of approved storm water collection chamber (SCC) detention systems</td>
<td>Revision</td>
<td>July 2013</td>
</tr>
<tr>
<td>8-19</td>
<td>Preferred Design Elements and Materials; Installation</td>
<td>Revise specifications to allow use of storm water collection chambers (SCC) for underground detention systems</td>
<td>Revision</td>
<td>9 October 09</td>
</tr>
<tr>
<td>8-20A</td>
<td>Preferred Design Elements and Materials; Installation</td>
<td>Revise specifications for use of smooth-lined corrugated plastic pipe (CPE) to allow CPE with maximum size of 60-inches for all uses and to impose additional requirements for backfill cover for applications under pavement.</td>
<td>Revision</td>
<td>9 October 09</td>
</tr>
<tr>
<td>8-20A</td>
<td>Installation</td>
<td>Revise installation specifications to require underground detention system to be entirely enveloped with Geotextile fabric if soil conditions warrant.</td>
<td>Revision</td>
<td>8 June 2009</td>
</tr>
</tbody>
</table>
| 8-19   | Preferred Design Elements and Materials (entire section is revised)       | • Require access risers to be installed in underground detention systems made of pipes to allow for inspection and maintenance.  
• Provide new guidance for use of pumped outlets.  
• Revise materials specifications to allow for use of corrugated metal pipe (CMP), polymer coated corrugated steel pipe (PCCSP), and smooth-lined corrugated plastic pipe (CPE).  | Revision       | 11 July 2008       |
### WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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<tbody>
<tr>
<td>8-20A</td>
<td>Installation (entire section is revised)</td>
<td>• Specify materials testing requirements, including revised contact number for Testing Lab.</td>
<td>Revision</td>
<td>11 July 2008</td>
</tr>
</tbody>
</table>
| 8-20B | Installation (entire section is revised) | • Revise installation specifications to require:  
  o backfill materials, backfill compaction, and minimum cover over pipe  
  o installation must be observed by Wayne County  
  o documentation of installation must be provided to Wayne County  
  • Revise contact number for scheduling inspection | Revision | 11 July 2008 |
| 8-21  | Example A: Flow Restrictor without Overflow  
8-22  | Example B: Flow Restrictor with Overflow | Revise figures that illustrate example outlet structures | Revision | 11 July 2008 |

**Section 8.1.4: Outlets for Forebays and Open Detention Basins**

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<tr>
<th>Page</th>
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<tbody>
<tr>
<td>8-25A</td>
<td>Example Forebay and Open Detention Basin Detail</td>
<td>Revise example outlet detail</td>
<td>Clarification</td>
<td>11 July 2008</td>
</tr>
<tr>
<td>8-23</td>
<td>Preferred Design Elements and Materials (1st bullet point)</td>
<td>New guidance for use of pumped outlets</td>
<td>Clarification</td>
<td>11 July 2008</td>
</tr>
</tbody>
</table>
| 8-24  | Preferred Design Elements and Materials (last bullet point) | • Revise guidance for anti-seep collars  
  • New specifications for testing during riser fabrication  
  • New guidance and specifications for installation | Clarification | 11 July 2008 |
| 8-25A | Example Forebay and Open Detention Basin Detail | Revise example outlet detail | Clarification | 11 July 2008 |
### WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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<tbody>
<tr>
<td><strong>Section 8.2.1: Forebays</strong></td>
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</tbody>
</table>
| 8-26 | Design Standards | • Revise specifications for buffer strips around retention basins  
• Add reference to figure in Section 8.1.1, Attachment C | Revision | July 2015 |
| **Section 8.2.2: Bioretention** | | | | |
| 8-29 thru 8-32 | Design Standards and Preferred Design Elements | Revisions to many Design Standards and Preferred Design Elements | Revision | July 2015 |
| 8-32 thru 8-33 | Materials | Revisions to material specifications for underdrain gravel blanket | Revision | July 2015 |
| 8-34D | | New detail “Typical Bioretention Overflow Structure” | Clarification | July 2015 |
| **Section 8.2.3: Manufactured Treatment Systems** | | | | |
| 8-23 to 8-36D | All | • Include information about manufactured treatment systems approved for use  
• New Table 8.2.3-1: Peak Flow Rates for Various Models of Manufactured Treatment Systems Approved by Wayne County under This Section | Revision | 8 June 2009 |
| 8-35 | Description (2nd paragraph) | Add online reference to revised Manufactured Treatment Systems: Certification Procedure (March 2009)  
Revised reference (July 2015):  
| 8-35 | Design Standards (all) | Revise definitions of pollutant removal efficiency and required documentation | Revision | 11 July 2008 |
| 8-36 8-36A | Preferred Design Elements and Materials (all) | • Revise design flows  
• Make bypass structure optional  
• Revise loading specification  
• Impose new backfill cover requirement  
• Revise Materials specifications and testing requirements | Revision | 11 July 2008 |
### WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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<tr>
<td>8-36A</td>
<td>Installation (all)</td>
<td>• Revise installation specifications to require:</td>
<td>Revision</td>
<td>11 July 2008</td>
</tr>
<tr>
<td>8-36B</td>
<td></td>
<td>o backfill materials, backfill compaction, and minimum cover over pipe</td>
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<td></td>
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<td>o installation must be observed by Wayne County</td>
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<td></td>
<td>o documentation of installation must be provided to Wayne County</td>
<td></td>
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<tr>
<td>8-39</td>
<td>Design Criteria (7th bullet)</td>
<td>Revise minimum slope to be 0.15%</td>
<td>Revision</td>
<td>11 July 2008</td>
</tr>
<tr>
<td>11-8</td>
<td>Section 11.2: Typical Storm Water Management System with Underground Detention</td>
<td>Include new Section 11.2 to provide sample calculations for design of an underground detention system at an example development site</td>
<td>Clarification</td>
<td>July 2015</td>
</tr>
<tr>
<td>11-13</td>
<td>Section 11.3: Typical Storm Water Management System with Bioretention</td>
<td>Include new Section 11.3 to provide sample calculations for design of a bioretention system at an example development site</td>
<td>Clarification</td>
<td>July 2015</td>
</tr>
<tr>
<td>All</td>
<td>Update references and websites for various agencies that may require permits and approvals for development projects in Wayne County</td>
<td>Update</td>
<td>July 2015</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Section 12.2</td>
<td>Update references for Wayne County contacts to reflect September 2009 merger of the Department of Environment and Department Public Services into a reorganized Department of Public Services.</td>
<td>Update</td>
<td>9 October 09</td>
</tr>
<tr>
<td></td>
<td>Section 12.2</td>
<td>Update website addresses for Wayne County departments to reflect new County website launched March 2009.</td>
<td>Update</td>
<td>8 June 2009</td>
</tr>
<tr>
<td>All</td>
<td>Revise contact information for agencies that may require other permits and approvals</td>
<td>Clarification</td>
<td>11 July 2008</td>
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## WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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<td></td>
<td><strong>Appendix A: Engineer's Certificate of Construction</strong></td>
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</table>
|     |           | • Revise example certificate  
• Specify contents of attachment required for systems that include vegetation specific to the functioning of a storm water management component that is not included on plant lists included in the Wayne County Storm Water Standards | Revision | 11 July 2008 |
|     |           | **Appendix B: Model Community Resolutions Accepting Long Term Maintenance of Storm Water Management Systems** | | |
|     | Appendix B-1 (2nd paragraph) | Correct citation to the Wayne County Storm Water Management Ordinance (Chapter 9 instead of Chapter 7) | Errata | July 2015 |
|     | Appendix B-2 (2nd paragraph) | Correct the citation to the Wayne County Administrative Rules | Errata | 11 July 2008 |
|     | Appendix B-1 (3rd paragraph) | | | |
|     | **Appendix E-4: Wayne County Parks Division, Permit Guidelines For Site Restoration** | Revised site restoration specifications for construction activities on property owned by Wayne County Parks | Revision | July 2015 |
|     | Appendix E-4 | | | |
|     | Table 1 | Various corrections | Errata | 9 October 09 |
|     | Appendix E-4 | New appendix describing site restoration specifications for construction activities on property owned by Wayne County Parks | Revision | 8 June 09 |
BOUND COPIES OF THE WAYNE STORM WATER MANAGEMENT PROGRAM DOCUMENTS AND UPDATES TO THEM CAN BE OBTAINED FOR A FEE AT WAYNE COUNTY'S PERMIT OFFICE

PERMIT OFFICE
DIVISION OF ENGINEERING
WAYNE COUNTY DEPARTMENT OF PUBLIC SERVICES
33809 MICHIGAN AVENUE
WAYNE, MI 48184-1738
(734) 595-6504

INSTRUCTIONS FOR ACCESSING WAYNE COUNTY STORM WATER MANAGEMENT PROGRAM DOCUMENTS AND UPDATES FROM THE INTERNET

USING YOUR INTERNET BROWSER, ACCESS THE “STORM WATER MANAGEMENT” PAGE OF THE WAYNE COUNTY WEBSITE AT HTTP://WWW.WAYNECOUNTY.COM/1122.HTM

1. THE MIDDLE SECTION OF THIS “STORM WATER MANAGEMENT” PAGE HAS LINKS TO INFORMATION ABOUT WAYNE COUNTY’S STORM WATER MANAGEMENT PROGRAM AS FOLLOWS:

- **Wayne County Storm Water Management Ordinance and Administrative Rules Summary**
  Click on this title to obtain a summary of the Wayne County Storm Water Management Ordinance program and to access the *Storm Water Management Ordinance* and *Administrative Rules* documents. The direct link to this page is [http://waynecounty.com/doe/1170.htm](http://waynecounty.com/doe/1170.htm)

- **Standards Manual**
  Click on this title to access the Standards Manual. Each chapter and appendix of the Standards Manual is presented as a separate file. This format facilitates future revisions to the manual. Note that each page of the manual is dated. A comprehensive listing of pages revised since the February 2007 issuance of Version 3.0 of the manual is shown as the first item on this page and is entitled “Program Clarifications, Errata & Revisions”. The direct link to this page is [http://waynecounty.com/doe/1172.htm](http://waynecounty.com/doe/1172.htm)

- **Supplemental Information**
  Click on this title to access other guidance materials related to the Wayne County Storm Water Management Program but not included in the Standards Manual. The current version of the “Program Clarifications, Errata & Revisions” document is also available from this page. Please check this page periodically for new materials. The direct link to this page is [http://waynecounty.com/doe/1174.htm](http://waynecounty.com/doe/1174.htm)
• **Local Storm Water and Watershed Management Practices Constructed/Implemented in Southeast Michigan**
  Click on this title to access project summaries, photos, location and contact information, weblinks, and other information for a variety of storm water and watershed management practices in the categories:
  - Bioretention / Low Impact Development / Native Landscaping
  - Manufactured Treatment Systems and Underground Detention
  - Detention Ponds/Constructed Wetlands
  - Streambank Stabilization
  - Woody Debris Management
  - Green Buildings

  The direct link to this page is [http://waynecounty.com/doe/1190.htm](http://waynecounty.com/doe/1190.htm)

All documents are presented in .pdf format; Adobe Acrobat Reader™ software is required to view or print these documents. Adobe Acrobat Reader™ software is available free of charge at [http://get.adobe.com/reader/](http://get.adobe.com/reader/)

2. Applicants for construction approvals for storm water management systems should also visit the Wayne County Permit Office pages of the Wayne County website at

This page presents additional information relevant to obtaining approvals for construction of storm water management systems, including:

• **Construction Permit Application Kit**
  - Frequently Asked Questions
  - Permit Application Form
  - Commercial Plan Checklist
  - Residential Plan Checklist
  - Plan Review Cost Schedule

• **Rules, Specification And Procedures For Construction Permits**
  - The latest rules, specifications, procedures and requirements applicable to all construction permit work in Wayne County

• **Standard Plans For Permit Construction**
  - Approved construction standards, typical drawings, details and notes for use in preparing construction plans
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- **6.3.3 Additional Requirements**

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- **7.1.2 Closed Conduits**
- **7.1.3 County Road Culverts and Bridges**
- **7.2 Downstream Improvements**
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- **7.5 County Drains**
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- **7.8 Temporary Measures During Construction**
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  - **8.1.1 Open Detention Basins**
  - **8.1.2 Retention Basins**
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  - **8.2.1 Forebays**
  - **8.2.2 Bioretention Areas**
  - **8.2.3 Manufactured Treatment Systems**
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  - **8.4.2 Live Fascines**
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CHAPTER 6: GENERAL DESIGN STANDARDS

Designing storm water management systems to meet the performance standards in the Wayne County Storm Water Management Standards is the responsibility of the applicant or its designee. Wayne County maintains the right to require applicants to modify storm water management system designs to ensure that the performance standards are satisfied. Applicants must evaluate the project’s impact over the long-term and on a watershed scale. Taking these factors into account, the following sections describe general design standards for storm water management systems.

Additional design standards for storm water management systems may be found in Chapters 7 and 8.

6.1 Determination of Peak Flow Rate

6.1.1 Rational Method
The Rational Method for calculating storm water runoff is generally acceptable for calculating peak flow rate at a particular location within a storm water management system. Alternative methods may be required when the County determines that another method is necessary to satisfy the requirements of the Standards (see Section 6.1.2).

To calculate peak flow rate using the Rational Method, an applicant must use the following Rational Method Formula:

\[ Q = C \times I \times A \]

where:
- \( Q \) = peak flow rate (cfs)
- \( C \) = runoff coefficient
- \( I \) = rainfall intensity (in/hr)
- \( A \) = drainage area (acres)

The peak flow rate for each component of a storm water management system must be calculated using a composite runoff coefficient, the entire tributary drainage area, and a design rainfall intensity adjusted based on time of concentration. Values for the various terms used in the Rational Method Formula in determining peak flow at a particular location must be determined as follows:

- Drainage area (A) means the entire upstream land area that drains to that location, including any off-site drainage area. (In general, drainage from off-site should not be passed through on-site storm water management facilities. However, there are situations where this is unavoidable.)

- Peak flow rate (Q) must be calculated with the assumption that off-site drainage areas are developed consistent with any applicable master land use plan, storm water standards and storm water master plan enacted by the local community in which the storm water management system is located, and the Wayne County Storm Water Management Standards.

- The composite runoff coefficient (C) must be based on the percentage of surface types in the drainage area upstream of that location. Surface types to be used are shown in the following table.
### MINIMUM ACCEPTABLE RUNOFF COEFFICIENTS

<table>
<thead>
<tr>
<th>Type of Surface</th>
<th>Runoff Coefficient (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Surfaces</td>
<td>1.00</td>
</tr>
<tr>
<td>Roofs</td>
<td>0.95</td>
</tr>
<tr>
<td>Asphalt or concrete pavements</td>
<td>0.95</td>
</tr>
<tr>
<td>Gravel, brick, or macadam surfaces</td>
<td>0.85</td>
</tr>
<tr>
<td>Semi-pervious: lawns, parks, playgrounds</td>
<td></td>
</tr>
</tbody>
</table>

**Type of Land Use | Time of Conc. (tₒ) (min)**

- Multiple Units: 15
- Commercial/Industrial: 15
- Single family residential: 20
- Unimproved land:  
  
\[ tₒ = \frac{L}{(60 \times V)} \text{ and } V = 0.48 \times S^{\frac{1}{2}} \]

where

- \( tₒ \): initial time of concentration (minutes)
- \( L \): length of overland sheet flow (feet)
- \( S \): slope of overland sheet flow (%)
- \( V \): velocity of overland sheet flow (ft/sec)

For all other downstream locations in the storm water management system, the time of concentration (t) is the sum of (1) the initial time of concentration and (2) the travel time from the upstream end to the location being analyzed.

### DESIGN RAINFALL INTENSITIES

<table>
<thead>
<tr>
<th>Design Storm</th>
<th>Intensity (in/hr) for ( t &lt; 60 \text{ min.} )</th>
<th>Intensity (in/hr) for ( t &gt; 60 \text{ min.} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-year</td>
<td>( 151.8/(t+19.9) )</td>
<td>( 162.3/(t+25.4) )</td>
</tr>
<tr>
<td>50-year</td>
<td>( 212.5/(t+23.3) )</td>
<td>( 230.3/(t+30.3) )</td>
</tr>
<tr>
<td>100-year</td>
<td>( 233.7/(t+23.5) )</td>
<td>( 294.0/(t+45.0) )</td>
</tr>
</tbody>
</table>

\( t \): time of concentration: the time duration (minutes) required for runoff from the most remote area of the watershed to reach the point of study.

Data from U.S. Weather Service Station Records for Detroit, 1896 - 1942

- The time of concentration for a particular design storm varies with slope, surface cover, and the length of the surface flow path. Other variables, including anticipated rainfall intensity and infiltration capacity of the soil and surface cover, also affect the time of concentration.
- For the most upstream end of the storm water management system, the time of concentration is referred to as the initial time of concentration and is determined in accordance with the following table.

### INITIAL TIME OF CONCENTRATION

<table>
<thead>
<tr>
<th>Type of Land Use</th>
<th>Time of Conc. (tₒ) (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Units</td>
<td>15</td>
</tr>
<tr>
<td>Commercial/Industrial</td>
<td>15</td>
</tr>
<tr>
<td>Single family residential</td>
<td>20</td>
</tr>
<tr>
<td>Unimproved land</td>
<td></td>
</tr>
</tbody>
</table>
  
\[ tₒ = \frac{L}{(60 \times V)} \text{ and } V = 0.48 \times S^{\frac{1}{2}} \]

- Corps of Engineers HEC-RAS or HEC-HMS;
- Soil Conservation Service UD-21, TR-20 or TR-55; and

### 6.1.2 Alternative Methods

The Rational Method Formula may not be an adequate design tool for calculating storm water runoff from large drainage systems. Alternative runoff hydrograph prediction methods are widely available and may be required by the Permit Office for sizing the drainage systems on large sites and/or smaller sites that present unique flood control or water resources protection issues. Acceptable alternative methods are:

- Corps of Engineers HEC-RAS or HEC-HMS;
- Soil Conservation Service UD-21, TR-20 or TR-55; and

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6-2  
Revised July 2015
• U.S. EPA’s Storm Water Management Model (SWMM).
These methods must be based on the SCS Type II, 24-hour rainfall distribution and assume a conservative wet weather antecedent conditions.

6.2 General Design Standards for Flood Control

Storm water management systems designed to satisfy the flood control performance standards described in Section 5.1 must include a detention system and/or retention basin that is designed and constructed in accordance with this Section.

6.2.1 Detention Systems

Generally, two types of detention systems are most often designed in Wayne County: open detention basins and underground detention systems.

Open detention basins are man-made surface waters designed to temporarily detain storm water runoff to control peak flow rates and provide for pollutant removal through settling and plant uptake. There are two types of open detention basins traditionally used in Wayne County:
• Traditional detention basins, which detain storm water runoff for an extended period of time in a permanent pool and remove sediment and other pollutants via settling. The permanent pool in a traditional detention basin must be a minimum of 4 feet deep.
• Constructed wetlands, where over 50% of the surface area typically is covered by wetland vegetation. Permanent wetland pool depths vary between 0.5 and 3.0 feet depending on vegetation type.

Underground detention systems consist of one or more underground pipes or structures designed to provide the required storage volumes (both the bank full flood and flood control volumes) for a development project. Just as with any above ground means of storm water detention, underground detention systems must have a restricted outlet that limits outflow for the bank full flood and for the maximum allowable release rate from the development site.

Additional design standards for open detention basins and underground detention systems is presented in Chapter 8.

Flood Control Storage Volume
Detention systems that are designed to meet the flood control performance standards described in Section 5.1 must provide enough flood control storage volume so as not to exceed the maximum allowable runoff rate for the site. Equations used to determine the required storage volume are shown in the box below.

<table>
<thead>
<tr>
<th>Detention Systems: Flood Control Storage Volume Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drainage Areas Greater Than Five Acres</strong></td>
</tr>
<tr>
<td>Detention of the 100-year storm is required to control flooding events. Volume required should be based on the following relationships:</td>
</tr>
<tr>
<td>$Q_a = 0.15 \text{ cfs/acre} \times A$</td>
</tr>
<tr>
<td>$Q_o = \frac{Q_s}{A \times C}$</td>
</tr>
<tr>
<td>$T_{100} = -45 + \sqrt{\frac{19845}{Q_o}}$</td>
</tr>
<tr>
<td>$V_{s100} = \frac{17649 \times T_{100}}{(T_{100} + 45)} - 40 \times Q_o \times T_{100}$</td>
</tr>
<tr>
<td>$V_{t100} = V_{s100} \times A \times C$</td>
</tr>
</tbody>
</table>

**Drainage Areas Five Acres or Less**
Detention of the 10-year storm is required for flood control purposes. Volume required should be based on the following relationships:

| $Q_a = 0.15 \text{ cfs/acre} \times A$ |
| $Q_o = \frac{Q_s}{A \times C}$ |
| $T_{10} = -19.9 + \sqrt{\frac{4530}{Q_o}}$ |
| $V_{s10} = \frac{9108 \times T_{10}}{(T_{10} + 19.9)} - 40 \times Q_o \times T_{10}$ |
| $V_{t10} = V_{s10} \times A \times C$ |

where:

$Q_a = \text{Maximum allowable outflow rate from the detention system (cfs)}$

$Q_o = \text{Maximum allowable outflow rate per acre imperviousness (cfs/acre imperviousness)}$
6.2.2 Retention Basins
Retention basins are man-made surface waters designed to store storm water runoff and provide gravity settling of pollutants. Retention basins infiltrate storm water into the soil rather than discharging it to a surface water or closed conduit.

Flood Control Storage Volume
Retention basins that are designed to meet the flood control performance standards described in Section 5.1 must provide enough flood control storage volume to retain the volume of storm water equal to the runoff from two consecutive 100-year storm events. The equation used to determine the required storage volume is shown in the box below.

Retention Basins: Flood Control Storage Volume Requirements
Retention basins are required to retain the volume of storm water equal to the runoff from two consecutive 100-year storm events. Volume required should be based on the following relationship:

\[ V_r = 2 \times 16500 \times A \times C \]

where:
- \( V_r \) = Flood control storage volume of retention basin (ft³)
- \( A \) = Drainage area (acres)
- \( C \) = Runoff coefficient

6.2.3 Adequate Outlet
Storm water management systems must have an adequate storm water outlet. At a minimum, the capacity of the outlet must not exceed the discharge's reasonable share of the maximum capacity of the downstream closed conduit or watercourse, as determined by the County.

If the County determines that a proposed detention system does not have an adequate outlet, the applicant may be required to design and construct improvements to the downstream County Drain, watercourse, or closed conduit. The County will determine the extent to which downstream improvements are required.

6.2.4 Flood Plain Restrictions
Storm water management systems may not be constructed within a 100-year floodplain unless the storm water management system satisfies the requirements listed below. Construction within a 100-year floodplain must be approved by MDEQ as well as the County.

- The storm water management system must not diminish the net storage capacity of the floodplain. Compensatory storage is required for any reduction in floodplain storage capacity.

- The storm water management system must not negatively alter the conveyance of the watercourse.

- During a design storm event, the storage capacity of the storm water management system must remain available for detention of storm water runoff from the development site.

- The storm water management system must minimize disruption to the riparian habitat of the floodplain by developing and implementing a plan for minimizing disturbance that is acceptable to the County.

6.2.5 Additional Requirements
To the fullest extent possible, storm water management systems must follow the natural drainage patterns within the development site and within the watershed in which it is located.

Storm water management systems that include surface water components cannot be located within pre-existing surface waters.
### 6.3 General Design Standards for Water Resources Protection

#### 6.3.1 Pretreatment Systems

Storm water management systems must include a pretreatment system at each inlet to each detention system and/or retention basin. The pretreatment system must either:

1. Be designed and constructed such that the storm water management system achieves the pollutant removal rate (80% or more of the annual average total suspended solids load) specified by the water resources protection performance standard (see Section 5.2); and/or
2. Be designed and constructed to capture the first flush and release it gradually to the detention system and/or retention basin over a period of twenty-four (24) hours.

If an applicant designs a system to capture and release the first flush (as described above in option 2), the storage volume required to capture the first flush for the area tributary to the pretreatment system must be calculated based on the following relationship.

\[
V_{t\,ff} = \frac{1815 \times A \times C}{1815 \times A \times C}
\]

where:
- \(V_{t\,ff}\) = first flush storage volume (ft³)
- \(A\) = drainage area tributary to inlet (acres)
- \(C\) = runoff coefficient

Additionally, for option 2, the pretreatment system must have a flow restrictor designed to gradually release the first flush storage volume over a period of twenty-four (24) hours. The 24-hour average allowable release rate must be determined in accordance with the following relationship:

\[
Q_{avg\,ff} = \frac{V_{t\,ff}}{86400}
\]

where:
- \(Q_{avg\,ff}\) = 24-hour average allowable outflow rate (cfs)
- \(V_{t\,ff}\) = first flush storage volume (ft³)

If one or more forebays are used as pretreatment system(s), the volume of the forebays above any permanent pool may be used to satisfy a portion of the flood control storage volume (described in Section 6.2.1) and the bank full flood storage volume (described in Section 6.3.2). If a permanent pool is provided, the volume of the permanent pool may not be used to satisfy these other storage volume requirements.

#### 6.3.2 Bank Full Flood Requirements

Soil erosion from stream banks and channels is of special concern in Wayne County. As development activity increases impervious surface area, the frequency and duration of bank full flow conditions increases. As a result, streams naturally attempt to become wider and deeper to convey the increased flows. This process can lead to channel and bank erosion and the destruction of aquatic habitat.

To address this concern, each storm water management system (except for retention basins), must capture runoff from the bank full flood and release it gradually over a period of forty (40) hours. The storage volume necessary to capture and treat runoff from the bank full flood must be calculated based on the following relationship:

\[
V_{t\,bf} = \frac{5160 \times A \times C}{5160 \times A \times C}
\]

where:
- \(V_{t\,bf}\) = bank full flood storage volume (ft³)
- \(A\) = drainage area (acres)
- \(C\) = runoff coefficient

Additionally, the pretreatment system must have a flow restrictor designed to gradually release the bank full flood storage volume over a period of forty (40) hours. The 40-hour average allowable release rate must be determined in accordance with the following relationship:

\[
Q_{avg\,bf} = \frac{V_{t\,bf}}{144000}
\]

where:
- \(Q_{avg\,bf}\) = 40-hour average allowable outflow rate (cfs)
- \(V_{t\,bf}\) = bank full flood storage volume (ft³)
For detention systems that are intended to meet both the flood control and water resources protection performance standard, the lower portion of the flood control storage volume can also be used to capture the bank full flood. With this approach, the total volume required is equal to the flood control storage volume, not the sum of the flood control and bank full storage volumes. The volume of the permanent pool within an open detention system does not satisfy any of the flood control or bank full storage volume requirements.

6.3.3 Additional Requirements
To protect water resources, Wayne County has adopted the following additional requirements to minimize pollutants in storm water runoff from development projects.

**Buffer Strip**
A buffer strip is a zone that is used for filtering direct storm water runoff into a storm water management system and for providing maintenance access to a storm water management system. A buffer strip must be established and/or preserved along the edge of any surface water in the development site (except for bioretention areas and vegetated swales).

- The minimum width of a buffer strip is 25 feet, except in the following circumstances:
  - The minimum width of a buffer strip is 15 feet if:
    - The buffer strip is around a retention basin, an open detention basin, or a forebay associated with an open detention basin or retention basin, and the drainage area to the retention basin, open detention basin, or forebay has a of 5 acres or less; or
    - The buffer strip is around a retention basin, an open detention basin, or a forebay associated with an open detention basin or retention basin, and (1) the retention basin, open detention basin, or forebay has a drainage area greater than 5 acres; and (2) no storm water from areas outside of or within the buffer strip enters the basin or forebay via direct sheet flow.
  - The minimum width of a buffer strip around bioretention areas is 2 feet.
  - The width of buffer strips is measured as follows:
    - The width of buffer strips along watercourses and around or along surface waters other than open detention basins, retention basins, forebays, and bioretention areas is measured from the top of bank of the watercourse and surface water.
    - The width of buffer strips around open detention basins, retention basins, and forebays is measured from the minimum freeboard elevation of the surface water.
    - The width of the buffer strip around or along bioretention areas is measured from the maximum water surface elevation of the ponding area associated with the bioretention area.

- Additional requirements for buffer strips associated with open detention basins and retention basins are described in Section 8.1.
- Additional requirements for buffer strips associated with forebays are described in Section 8.2.1.
- Additional requirements for buffer strips associated with bioretention areas are described in Section 8.2.2.
- The ground slope of a buffer strip should not be steeper than 1:6.
- Construction activities, paving, and chemical application, except for construction activities needed to create or establish the buffer strip, are prohibited in the buffer strip.

**Landscape Plan**
Because vegetation is an important part of many components of storm water management systems, a landscaping plan must be submitted to the County.

- The plan must depict landscaping elements that function as part of the storm water management system, including the buffer strip.
- The landscape plan must include (at a minimum) specifications for the soils and plant materials that the applicant proposes to include in the landscape; and a description of the methods and planting techniques that the
applicant proposes to utilize during landscape installation.

- The installation and maintenance of the landscaping described in the landscape plan is included as regulated construction activity for which the County may require financial assurance.

Guidance and requirements for landscaping plans are described in Chapter 8.

**Other**
Healthy streams have natural temperatures that are cooler than that of stormwater runoff. Applicants should consider incorporating landscaping or other features to minimize the temperature of storm water runoff, and the adverse effect that high water temperatures may have on the receiving water quality. For example:

- Provide trees or other means to shade open detention basins and certain other storm water management components.
- Provide an outlet structure for open detention basins which draws water from the (cooler) bottom of the basin.
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CHAPTER 7: ADDITIONAL REQUIREMENTS

This chapter presents additional requirements that may apply to storm water management systems in Wayne County.

7.1 Storm Water Conveyances

Storm water management systems may use watercourses or structures such as closed conduits, culverts, or bridges as a means of conveying stormwater runoff. Watercourses and closed conduits must be designed to standards described in this section. Storm water runoff conveyed within or under County Roads must also meet the additional requirements described in Section 7.3.

7.1.1 Watercourses

Natural watercourses should be preserved whenever possible. The Permit Office will not approve modifications to natural watercourses (e.g., installing a concrete channel or enclosure) unless the modification is necessary to address a demonstrated public safety, health or welfare issue. When such modifications are deemed necessary, the appropriate governmental agencies must be contacted for review and approval.

The flow capacity of each reach of a watercourse that is part of a storm water management system must be equal to or greater than the peak flow rate for a 10-year storm. The flow capacity of a watercourse must be calculated in accordance with the “Manning Formula” as follows:

\[
Q = \frac{1.486 \times A \times R^{2/3} \times S^{1/2}}{n}
\]

where:
- \( Q \) = flow capacity (cfs)
- \( A \) = cross sectional flow area (ft²)
- \( n \) = Manning’s coefficient of roughness
- \( P \) = wetted perimeter (feet)
- \( R \) = hydraulic radius = \( A/P \) in feet
- \( S \) = hydraulic gradient (ft/ft)

In general, a minimum “\( n \)” of 0.035 will be used for the roughness coefficient unless special treatment is given to the bottom and side slopes, such as sodding, riprap or paving.

7.1.2 Closed Conduits

The flow capacity of each reach of a closed conduit that is part of a storm water management system must be equal to or greater than the peak flow rate for a 10-year storm. The Manning Formula (shown above) must be used to determine the flow capacity of a closed conduit.

The invert elevation of each closed conduit entering a forebay with a permanent pool must be equal to or greater than the permanent pool elevation.

The hydraulic grade lines (HGLs) of closed conduits must meet both of the following requirements:

- The hydraulic grade line must be calculated based on 10-year storm flows, starting with the crown elevation at the outlet. This gradient must not be higher than 2.5 feet below the rim elevation at any upstream manhole location. However, exceptions may be granted in special circumstances such as for managing storm water in and around truck docks.
  - For systems with forebays: The HGL starts at the crown of the pipe entering the forebay.
  - For systems with underground detention systems: The HGL starts at the crown of the pipe entering the manufactured treatment structure.
- The rim elevation at any manhole location along the closed conduit upstream of a detention system must be at least one (1) foot above the design water level of the detention system.
The minimum and maximum allowable closed conduit velocities are 2.5 and 8.0 feet per second, respectively. The maximum allowable velocity within the conduit may only be exceeded where special provisions have been made to dissipate energy.

The maximum distance between manholes, catch basins, and inlets may not exceed 300 feet plus 100 additional feet for every 1 foot of diameter for closed conduits over 36 inches in diameter.

Manholes or junction chambers must be constructed at all closed conduit junctions and angle points and at all changes in conduit size and/or slope.

The inlets and outlets for all closed conduits require an end treatment and soil stabilization measures, and some closed conduits may also require a grate to prevent entry into the conduit by children and animals. The specific requirements, which depend on the size of the conduit and the location/configuration of the inlet or outlet, are provided in Section 8.3.1.

7.1.3 County Road Culverts and Bridges
Under separate requirements administered by the Wayne County Permit Office, special provisions apply to culverts and bridges that convey a watercourse under a County Road, whether the culvert or bridge will be newly constructed or will be constructed to replace an existing culvert or bridge. If the watercourse is a County Drain, see Sections 7.4 and 7.5 for additional requirements that may apply.

The hydraulic capacities of culverts and bridges must be calculated using a method approved by the County. All bridges and culverts also must be designed with adequate soil erosion protection.

Bridges that convey a watercourse under a County Road must be designed to pass the peak flow rate for a 100-year storm with no harmful increase in backwater elevations. The 100-year storm elevation upstream of a bridge also must be at least one (1) foot below the lowest elevation of either the bridge deck or the approach pavements to the structure.

Culverts that convey a watercourse under a County Road must be designed to convey at least the peak flow rate for a 10-year storm, as determined using the methods described in Section 6.1.1. Culverts that will be inundated by storms larger than the design storm established by the Michigan Department of Transportation or the Michigan Department of Environmental Quality must be designed with soil erosion protection that is adequate for the inundated condition.

7.2 Downstream Improvements
If the County determines that a proposed storm water management system does not include an adequate storm water outlet, the Applicant may be required to design and construct improvements to the downstream drain, watercourse or closed conduit. The County determines the extent to which downstream improvements may be required to provide an adequate storm water outlet.

7.3 County Roads
The County may establish additional or alternative requirements for storm water management systems in County Roads. Three such requirements are described below. Contact the Wayne County Permit Office for more information on these and other requirements.

1. The minimum diameter of closed conduits in County road rights-of-way is 12 inches.

2. As a general policy, Wayne County does not permit the discharge of storm water runoff from improved property abutting a County Road into the County Road storm drainage system. Exceptions to this policy can be made on the basis of economic hardship if (1) there are no other cost-feasible storm outlets available and (2) there is adjudged sufficient capacity in the Road storm drainage system. When exceptions are granted, the permitted storm discharge into the County Road storm drainage system is restricted to a discharge rate equal to the lesser of the following criteria based on a 10-year storm:
   - 0.103 cfs per station (100 feet) of County Road frontage available to the site;
   - 0.15 cfs per acre of area proposed to drain into the County Road drainage system.

3. Required design standards and construction specifications for storm water management systems in the County Road right-of-way must conform to Wayne County’s most current standards. Information regarding these standards can be obtained from the Permit Office.

7.4 Easements
Pursuant to the Drain Code, Wayne County generally requires the following minimum easement widths for established County Drains and other watercourses.
1. An open County Drain or watercourse with a maximum bank to bank width that is 30 feet or greater must have an easement to the extreme width of the drain, plus 30 feet. The easement must be centered on the centerline of the drain or watercourse.

2. An open County Drain or watercourse with a maximum bank to bank width that is less than 30 feet must have an easement equal to the extreme width of the drain, plus 24 feet. The easement must be centered on centerline of the drain or watercourse.

3. Enclosed County Drains with an internal diameter of 8 feet or less must have an easement of 20 feet centered on the centerline of the enclosure.

4. Enclosed County Drains with an internal diameter that exceeds 8 feet must have an easement of 25 feet centered on the centerline of the enclosure.

The easement widths described above govern generally. The County may require an alternative width if the County determines that additional easement is required for proper construction, or because of special circumstances. Note that Wayne County does not allow any buffer strips required under the Storm Water Management Standards to overlap with County Drain easements. Exceptions to the easement requirements described above are within the County's sole discretion.

7.5 County Drains
Applicants who propose projects that would modify an established County Drain or an established drainage district may be subject to additional requirements. The Wayne County Drains Office is located within the Wayne County Department of Environment.

7.6 County Park Property
The County may establish additional or alternative requirements for storm water management systems in County park property or which outlet within County park property. For example, special provisions apply to inlets/outlets on County park property as described in Section 8.3.1 and Appendix E-1. Specific requirements for restoration of County Park property disturbed by construction are presented in Appendix E-4.

7.7 Wetlands
The natural drainage pattern of the land within a development site must not be altered in any way that may cause adverse affects to existing wetland areas. Untreated storm water will not be permitted to outlet directly into a natural or mitigation wetland area. The level of treatment required to discharge storm water runoff to a natural or mitigation wetland area is determined by MDEQ. However, at a minimum, storm water discharged into a natural or mitigation wetland must pass through a pretreatment system. The pretreatment system must be designed in accordance with the requirements described in Section 6.3.1.

In addition to Wayne County approval of the storm water management system for a development project, the design of any wetland created for mitigation must also be approved by MDEQ.

7.8 Temporary Measures during Construction
As described in Chapter 3, projects that involve earth change activities may need to implement temporary storm water management measures to comply with additional federal NPDES requirements that apply to construction activity that disturbs one or more acres of land. More information about the NPDES requirements is available from MDEQ's Water Bureau; see Chapter 12 for contact information.

Projects that involve earth change activities also may need to implement temporary storm water management measures under the state Soil Erosion and Sedimentation Control (SESC) program and Wayne County's Soil Erosion and Sedimentation Control Ordinance, Chapter 94 of the Code of Ordinances of Wayne County (2001). More information about these programs and the types of projects that require a permit under these programs is available in Chapter 3.

Projects within Wayne County that must obtain a SESC permit from WCDOE must comply with the measures described in this section. An overview of the permit process is shown in Figure 7-1. WCDOE will not issue a SESC permit for a project that requires a storm water construction approval from the Permit Office until storm water construction approval has been obtained. Additional information about Wayne County's SESC program, and a downloadable copy of the permit application package, is available from the County's website (http://waynecounty.wc/mygovt/doe/depts/lrmd/Programs/secs/permit_info.aspx).

7.8.1 General Earth Change Requirements
In conformance with the state SESC program and the SESC Ordinance, Wayne County generally requires the following temporary measures during construction:
The proposed work shall be carried out in accordance with approved earth change plans and in compliance with all requirements of the permit and state laws and regulations.

Earth changes must be conducted in a manner that effectively reduces accelerated soil erosion and resulting sedimentation.

Persons engaged in earth change activities must, in conformance with state law, implement and maintain acceptable soil erosion and sedimentation control measures that effectively reduce accelerated soil erosion.

Earth changes must be scheduled and completed in a manner that will limit the exposed area of any disturbed land for the shortest possible period of time, as determined by WCDOE.

Sediment caused by accelerated soil erosion must be removed from runoff water before it leaves the site of the earth change.

Temporary or permanent facilities designed and constructed for the conveyance of water around, through or from the earth change area must be designed to limit the water flow to a non-erosive velocity.

Temporary soil erosion control measures must be maintained until permanent soil erosion measures are installed and approved. Permanent soil erosion control measures must be maintained for a minimum of one year after the project passes WCDOE’s “completion inspection.”

Permanent soil erosion control measures for all slopes, channels, ditches, or any other disturbed land area must be completed within five calendar days after final grading or earth moving activity has been completed.

Soil tracked, spilled, dumped or deposited onto public streets, highways, sidewalks, or other public thoroughfares must be removed promptly.

Permittees shall notify the WCDOE as to when the “project completion” inspection can be made.

7.8.2 General Plan Requirements
Under state law and the SESC Ordinance, three sets of earth change plans must be submitted before regulated earth changes may commence. The plans must be sealed by a Professional Engineer or Landscape Architect registered in the State of Michigan.

Each set of earth change plans must include drawings of the earth change at a scale not more than 100 feet to the inch, including a legal description; a site location map which includes the proximity of any proposed earth change to lakes, streams or wetlands; existing structures; existing contour intervals which clearly show the character of the land; proposed contour intervals which clearly show the future character of the land; and a description of the existing vegetation on the site.

Each set of earth change plans must also include details for the proposed earth changes, including:

- Location of the physical limits of each proposed earth change including the location of temporary soil stockpile areas. If soil is to be removed from the site, the location of the offsite disposal area must be identified.

- A description and location of all existing and proposed on-site drainage facilities, including detailed storm sewer plans, drainage arrows for surface drainage, and the ultimate drainage outlet for the site.

- Time and sequence of each proposed earth change with approximate dates for major grading activities, including site stripping, rough grading and cut and fill; construction of detention basin, roads and underground utilities, digging basements and backfilling lots; final grading, landscaping paving. This sequence must include a description of temporary erosion control measures to prevent sediment from leaving the project site during each of the proposed earth change activities. A description and location of all proposed temporary and permanent soil erosion control measures.

- Approved standard details of all temporary and permanent soil erosion control measures.

7.8.3 Wayne County Plan Requirements
Wayne County imposes additional requirements for earth change plans. In addition to the general plan requirements discussed above, the following design and maintenance features must be shown on the plan and included in the construction sequence:
A perforated riser pipe with stone filter must be installed on all open detention basins and sediment basins on projects five acres or more in size.

A temporary crushed rock tracking pad must be installed at the construction entrance and exit. This tracking pad must be maintained with fresh stone periodically. Construction traffic must be limited to designated entrance and exit.

Street scraping and cleaning (sweeping) must be conducted on a regular schedule. At a minimum, one sweeping must occur each week, and one scraping must occur at the end of each workday.

Paved storm sewer inlets must be protected by a single sheet of filter fabric conforming to Geotex III P as manufactured by Synthetic Industries, Inc. or equivalent woven monofilament filter fabric (ASTM flow rate = 110 gallons per minute/per square foot).

Catch-all type inlet filters are required at all low points in the paved roads of multi-family housing projects.

Rear yard (beehive-type) storm sewer inlets must be protected by a woven geotextile filter fence 24 inches in height securely fixed with lath and staples to hardwood stakes spaced no more than four feet on center. The silt fence must be trenched in a minimum of six inches into the ground.

All catch basins and inlets in areas that are determined to be susceptible to flooding must have catch-all type inlet filters.

All exposed earth must be stabilized with seed and mulch or sod within five days of final grade. Sediment basins must be stabilized with seed and straw mulch blankets. Straw blankets must be staked into the ground five days after the construction of the sediment basin.

An undisturbed, vegetative buffer strip of at least 25 feet must be retained around rivers, creeks, streams, wetlands, drains, and other sensitive areas.

Straw mulch blankets must be used on 3:1 slopes or greater. (Three foot horizontal, one foot vertical)

Ditches, swales, and other areas that will channel concentrated runoff must be stabilized within five days of construction. Temporary rock check dams must be installed to slow water to non-erosive velocities in areas of concentrated flow.

Road rights-of-way must be stabilized with seed and mulch within five days of completing utility work in the right of way.

Areas of earth change that are disturbed beyond the fall seeding deadline (November 1) may require dormant seeding and straw mulch securely anchored to the ground.

Single family lots, during construction, must have a silt fence barrier and a temporary crushed rock tracking pad installed as per the approved plan.

A single family residence, prior to receiving a Certificate of Occupancy, must have a silt fence barrier, or 15 feet of mulch blanket installed back of the curb across the entire front of the lot. The silt fence must be trenched in a minimum of six inches into the ground.

Rip rap must be immediately installed after construction of outlets and culverts.

### 7.8.4 Performance Deposit

WCDOE does not issue SESC permits for an earth change unless the permittee first posts with Wayne County a bond, certified check, or irrevocable bank letter of credit in the amount equal to that which would be required for the surety bond. If a bond is used, it must be executed by the permittee and a corporate surety with authority to do business in this state as a surety. The bond must be in the amount of the established total cost of the earth change work authorized by the permit, but in no case may the bond amount be for less than $1,500.00 per acre of earth change.

Each bond must provide assurance for the maintenance of the finished project for a period of one year after the "project completion" inspection is made. Deposits or bonds shall be submitted to the WCDOE with the permit application. Upon permit issuance, the bond will be posted with the County Clerk by the WCDOE.

No performance deposit is required for a permit classified as a single-family residence.
7.8.5 **Inspections and Enforcement**

Once an application for a permit is received by WCDOE and before a permit is issued, an initial site investigation is made in the field. After permit issuance, earth change inspections are made periodically to assure compliance with the permit, state law, and the SESC Ordinance. When all grading is complete and all permanent erosion control measures are installed, a project completion inspection is made prior to permit expiration. Finally, one year after the completion inspection, a final inspection is made to ensure that permanent erosion control measures are still functioning effectively.

NOTE: No earth change work (grading, excavation, fill, topsoil, stripping, etc.) within 500 feet of a lake, stream, or drain or that disturbs more than one acre of land may begin until a permit is issued under state law. Such earthwork which begins without a permit is violation of the law and subject to legal proceedings.

7.8.6 **Extension of Permit**

If the permittee is unable to complete the work within the 30 month permit period, he must present in writing to the WCDOE, a request for an extension of the permit. Requests for extension shall be made at least ten (10) days before permit expiration. If, in the opinion of the WCDOE, such an extension is warranted, additional time may be granted for the completion of the work. An additional permit and inspection fee is required to extend the permit.

7.8.7 **Modifications of Approved Plans**

All proposed modifications of the approved earth change plans must be submitted to and approved by the WCDOE. All necessary specifications and related reports shall be submitted with any proposal to modify the approved earth change plan. No earthwork in connection with any proposed modifications is permitted without the approval of the WCDOE.
FIGURE 7-1

PROCEDURE FOR OBTAINING A
SOIL EROSION AND SEDIMENTATION CONTROL PERMIT
PROCEDURE FOR OBTAINING A
SOIL EROSION AND SEDIMENTATION CONTROL PERMIT

THE APPLICANT
- fills out an Application Letter/Form
- provides 3 sets of plans for review
- submits the required Plan Review Fee, Permit Inspection Fee, and Performance Deposit

WAYNE COUNTY
assigns a project number and reviews the plans

THE APPLICANT
revises the plans per Wayne County comments and resubmits plans for approval

Plans Not Approved

Plants Approved

WAYNE COUNTY
contacts the applicant and schedules a Preconstruction Meeting

THE APPLICANT
- attends a Preconstruction Meeting
- signs Enforcement Agreement that communicates understanding of the approved plan
- receives 3 sets of approved plans and the Permit

WAYNE COUNTY
authorizes the construction and places the site on the Inspection Schedule

THE APPLICANT
provides Wayne County with 48 hours advance notice of the pending start of construction

THE PERMIT HOLDER/PROPERTY HOLDER
constructs the project in accordance with the Wayne County Standards and Specifications and in accordance with the permit and approved plans.

WAYNE COUNTY
performs regular inspections of the site and forwards inspection reports to the Permit Holder

THE PERMIT HOLDER
completes all required work as specified within the permit and requests a Final Inspection

WAYNE COUNTY
will perform a Final Inspection of the permitted work

Work is Not in Compliance

Work is in Compliance

WAYNE COUNTY
Finalizes the permit and issues the Performance Deposit Release

WAYNE COUNTY
Prepares a status report of all uncompleted work items

PERMIT HOLDER
- Brings the project back into compliance with the Permit as Directed by Wayne County
- Notifies Wayne County of Project completion.
8.1.1 Open Detention Basins

Open detention basins are man-made surface waters designed to temporarily detain storm water runoff to control peak flow rates and provide for pollutant removal through settling and plant uptake. There are two types of open detention basins traditionally used in Wayne County:

- Traditional detention basins, which detain storm water runoff for an extended period of time in a permanent pool and remove sediment and other pollutants via settling.
- Constructed wetlands, where over 50% of the surface area typically is covered by wetland vegetation. Permanent wetland pool depths may vary between 0.5 and 3.0 feet, depending on vegetation type.

**Design Standards**

Open detention basins must be sized to detain the required storage volumes (both the bank full and flood control volumes). Design standards specific to open detention basins include the following:

- A forebay or other pretreatment system is required at each inlet to the detention basin. Pretreatment systems trap sediment before entering the detention basin, reduce the incoming runoff velocities, and spread runoff evenly over the detention basin to create sheet flow conditions. Section 8.2 of this manual provides detailed information and design criteria for pretreatment systems.
- All closed conduits entering or exiting an open detention system should have an end treatment and adequate soil erosion protection, as described in Section 8.3.1. Some enclosures should also be covered with a grate to prevent children and animals from entering the enclosure.
- Open detention basins must have a restricted outlet that limits outflow for the bank full flood and for the maximum allowable release rate from the development site.
- Flow restrictors, overflow structures, and emergency spillways are required for all open detention basins. Section 8.1.4 provides design criteria for outlet structures associated with forebays and open detention basins. Flow restrictors must be placed near or within the embankment of the detention basin to provide ready maintenance access.
- Open detention basins must include a minimum four (4) foot deep permanent pool that allows for removal of urban pollutants through settling and biological uptake. The volume of the permanent pool does not satisfy any portion of the required flood control storage volume.
- The design water level of an open detention basin must not exceed five (5) feet above the permanent pool water level.
- A minimum of one (1) foot of freeboard is required above the design water level of an open detention basin.
- Providing a safe design is a primary consideration for all storm water management systems. Side slopes for open detention basins must not be steeper than 1:6. Further safety measures (e.g., aquatic benches or safety shelves, vegetative and barrier plantings) may be warranted depending on the type of development.
- Although use of terraced side slopes generally is discouraged when other alternatives exist, terraced side slopes may be approved for open detention basins in certain, limited circumstances at the discretion of Wayne County. The overall slope of a terraced side of an open detention basin should not be steeper than 1:3. An example detail for terraced side slopes is provided in Appendix E-3.
- Open detention basins may not be located within pre-existing surface waters.
- Plant vegetation is required for all types of open detention basins to control erosion and enhance sediment entrainment. A landscaping plan is required for open detention basins, due to the importance of the vegetation to the function of the entire system. Use of a registered landscape architect with experience in storm water management system design and native landscaping is encouraged.
- In constructed wetlands, a diversity of depth zones throughout the basin should be used to meet the unique growing requirements of divergent wetland plants. Use of a qualified professional with specific expertise in hydrology and wetland plant ecology is recommended for design and construction of these systems.
- A buffer strip must be provided around all surface waters such as open detention basins. Except as noted below, the buffer strip must be at least 25 feet wide measured from the minimum freeboard elevation of the surface water or basin. Of the minimum 25 ft width, a minimum of 15 feet of the buffer strip should be exterior to the pond perimeter defined by the top of bank. The slope of the buffer strip should be 1:6 or flatter. These provisions ensure that there is sufficient room along the top of the basin to provide access to the basin for maintenance. The right side of the figure "Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins" provided in Attachment C to this section illustrates a typical buffer strip associated with an open detention basin.
- In the following situations, the minimum width of the buffer strip around open detention basins is 15 feet measured from the minimum freeboard elevation of the basin:
  - When an open detention basin has a drainage area 5 acres or less; or
  - When an open detention basin has a drainage area greater than 5 acres and no storm water from areas outside of or within the buffer strip enters the basin via direct sheet flow (See the right side of the figure "Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins" provided in Attachment C to this section).

**Preferred Design Elements**

- Open detention basins should be designed to maximize sheet flow across the open water portion of the facility.
- The shape and configuration of open detention basins will vary considerably based on detention type and storage requirements, local topography, land availability, hydraulic considerations, and other site-specific constraints. Generally, a rectangular configuration is preferable, with an approximate length to width ratio of 3:1. Inlet and outlet pipes should be placed at opposite ends.
• If a terraced side slope is approved by Wayne County for use in a detention basin, the materials proposed for use in its construction should be approved by the local community.
• Baffles may be used to increase the flow path and maintain the topography.
• If aerating devices are used as part of a storm water management system, they should be designed to minimize disturbance of bottom sediments. For example, open detention basins may need to have a deeper permanent pool if an aerating device is used. Bubbler systems are the preferred type of aerating device as they have been found to be more efficient at providing aeration. The manufacturer’s recommendations should be followed in regards to design and maintenance.
• The locations of any mechanical structures/devices necessary for pond operation should be identified on the plans. The location should include a description of whether the structure/device is above ground or below ground.
• When discharge is within a watershed where thermal impacts are a primary concern, deep wet ponds with bottom draw may be required.

Vegetation Specifications
• A landscaping plan is required for open detention basins due to the importance of the vegetation to the function of the entire system. Vegetation should be specified for each zone within the detention basin as follows:
  • Pond zone (permanent water depths from 0 to 3 ft deep): Vegetation in the pond zone is entirely or partially submerged and should consist of a combination of native plant plugs and bare-root stock.
  • Edge zone (permanent water elevation to bank full elevation): Vegetation in the edge zone must withstand periods of inundation and drought. This vegetation also stabilizes the side slopes of the facility.
  • Upland zone (bank full elevation to 100-year flood elevation and beyond): Vegetation in the upland zone may have little or no inundation by storm water, and must withstand periods of drought. This vegetation also stabilizes the side slopes of the system. Note that the buffer strip lies within the upland zone.

The landscaping plan for open detention basins should identify the following items:
• Existing site conditions and vegetation (e.g., trees 6-in caliper and larger) that may be affected by the project;
• Plan view of the open detention basin, including one foot grading contours;
• Elevations in the open detention basin, including detention basin bottom elevation, permanent water elevation, bank full storm elevation, 100-year storm elevation, and freeboard elevation;
• Area in square feet of each of the three planting zones (pond zone, edge zone, and upland zone);
• Seed mixes and wetland plugs/bare root stock in each of the three planting zones;
• Plant spacing and applicable depths, based on industry standards; and
• If the construction plans include any mechanical structures/equipment necessary for pond operation, use of evergreen trees (or other trees/shrubs recommended for the appropriate pond zone) around the mechanical structure should be considered if visual screening of the equipment is appropriate for the location.

All plant material and planting applications should meet all guidelines set by the American Standard of Nursery Stock. All plant stock should be grown by suppliers or nurseries certified by the Michigan Native Plant Producers Association (see “References and Additional Resources” on page 8-6).

The type of vegetation used for open detention basins is dependant on site-specific conditions, such as soil types, amount of sunlight, and other factors. Vegetation for open detention basins should be composed of a mixture of species that will provide temporary cover (e.g., quick growing species such as annual rye grass (lilium multiflorum)) and species which will provide the permanent cover (e.g., seed oats).
Use of native plants and “no mow zones” is encouraged. Native plants are adapted to the local climate and conditions, and have numerous short-term and long-term advantages.

Vegetation for open detention basins should be specified in the following categories:

- **Seed mixes** – Many species can be successfully established from seed mixes, including grasses, sedges and rushes; and forbs (herbaceous plants, other than grasses, that commonly grow in fields or meadows). Forbs are used for re-vegetation, wild flower gardens, prairie and detention basin planting and roadside plantings.

- **Bare-root stock** – Plants received with very little, if any, soil around the roots. Bare-root stock generally is wrapped in Hessian cloth or plastic to prevent the roots from drying out.

- **Plugs** – Plants raised as individual plants, each in a small container about the size of an ice cube. The cube of greenhouse soil (“plug”) can be pried from the tray, containing an individual plant up to 6 inches tall. Using a digging stick, the plants are plugged into the soil.

Additional specifications for designing the planting areas in each zone of an open detention basin are appended to the end of this section as Attachment A. The specifications recommend native plant species for each zone of open detention systems built in Wayne County.

Local community requirements for vegetation should also be consulted.

**Construction**

Proper construction techniques, particularly installation of vegetation, are important to the successful functioning of open detention basins, especially for constructed wetland-type open detention basins in order to establish a dense and diverse emergent wetland plant community. General guidelines for vegetation installation include:

- If emergent plant stock is proposed in the pond zone, the supplied plug material must have sufficient vegetative growth extending out of the water once planted.
- Seed must be planted above the permanent water elevation.
- All seeded areas should be properly stabilized with a much blanket pegged in place.
- Depending on the type of vegetation, barriers may be required for one year to protect the plantings (e.g., snow fence or netting to deter wildlife, prevent mowing).
- Additional guidance on seed and sod specifications and installation is provided in Section 8.5.1 of this manual.

For constructed wetland-type open detention basins, preparation of the wetland bed prior to planting is crucial to success. Good results can be achieved through the five-step process shown in Attachment B to this section.

**Maintenance**

Maintenance activities for open detention basins are listed below. These activities must be identified in the maintenance plan that the applicant must submit with an application for storm water construction approval. Additionally, provision for maintenance access should be shown on the plan; it is recommended that the maintenance access to the storm water management system be a minimum of 15-feet wide. The landscape plan should be designed to prevent obstruction of the access by trees and shrubs.

- Inspect and clean the storm sewer system and catch basins upstream from the detention basin (every five years or as needed).
- Inspect for sediment accumulation at the inlet pipes and remove sediment which may be
impeding flow (semiannually and after rain events).

- Inspect inlets, outlets, and appurtenances (e.g., grates) annually for structural integrity.
- Check the outlets regularly for clogging and clean when necessary, especially after large storm events.
- Inspect the stone around riser-type outlet structures semiannually and after rain events. If stone has accumulated sediment, vegetation and/or debris to an extent that water is not flowing through the stone and out of the pond as originally designed, then the stone should be replaced.
- Check for floatables and debris and remove as necessary.
- Remove dead vegetation that obstructs flow (early spring).
- Check banks and bottom for erosion, and regrade or reshape as necessary (annually).
- Remove sediment when accumulation reaches 6 – 12 inches or if resuspension is observed.
- Recess banks near inlet/outlet and stabilize eroded banks as necessary.
- Inspect detention basin and buffer strip zone for invasive species such as purple loosestrife, phragmites, buckthorn (common & glossy), honeysuckle and autumn olive that out-compete native vegetation (annually - July).
- Have a professional selectively remove invasive species (annually, July-August). Purple loosestrife flower heads can be clipped off to reduce seed production until plant removal may be achieved. If woody debris is cut, the cut should be four inches above the ground surface and the stumps should be treated with herbicide immediately after cutting, and monitor for sucker growth. Use of chemicals within the pond (e.g., for control of algae or invasive species) requires a permit from the MDEQ.
- Plantings must be monitored for two years after establishment. Replacement will be necessary as determined by the agency having jurisdiction over the system.
- During the first two growing seasons, all areas planted with native prairie seed mix should be mowed three times at a height of 6-8 inches in order to control weeds. Beginning in the third year, a burning or mowing regimen should be instituted, either burning or mowing once in spring, or once in the fall.
- Except as described herein, ensure that no mowing, chemical application, or construction has occurred in the buffer strip (annually). If it has, take corrective action to ensure these activities do not occur in the future.
- Except as described herein, ensure that chemicals are not applied to any aspect of the open detention basin, including the bottom, side slopes or buffer strip.
- If the outlet is pumped, then only a licensed electrician or company that provided the pump system should conduct maintenance.

References and Additional Resources

- Washtenaw County Water Resources Commissioner, Rules and Guidelines – Procedures and Design Criteria for Stormwater
Management Systems, August 6, 2014 (and previous version May 15, 2000).
Available from link on webpage http://www.ewashtenaw.org/government/drain

- Wild Ones Organization, http://www.wildones.org
ATTACHMENT A: SPECIFICATIONS FOR PLANTING ZONES FOR OPEN DETENTION BASINS

All material in this appendix is adapted from “General Landscaping Requirement, Storm Water Detention Basins”, Zoning of the Code of Laws and Ordinances, Charter Township of Canton, July 11, 2006 and used courtesy of Canton Township, Municipal Services Division.
A combination of native plant plugs and bare-root stock should be planted in the pond zone (0 to 3 feet deep). The tables below identify native plants recommended for the pond zone of an open detention basin. Alternate species or genus from those recommended in the following tables may be specified if they meet the criteria for successful establishment in each pond zone.

Additional factors for design of vegetation within the pond zone of an open detention basin include:

- Plants should be selected based on whether they will be submerged, emergent, or wetland edge.
- A minimum of four plant species is recommended for the pond zone, planted in equal numbers of species, scattered in groupings of similar species throughout the entire zone.
- Initial plantings should cover a minimum of 25% of the outer 15 foot perimeter of the pond zone.
- For constructed wetlands, rooted wetland species, such as cattails, bulrush and sedges, are placed throughout the majority of the wetland area.
  - A mixture of wetland plants should be used in the shallow pool that extends laterally across the basin.
  - A diversity of depth zones should be used throughout the system to meet the unique growing requirements of divergent wetland plants.
- Planting of purple loosestrife is not permitted as this invasive plant forms dense colonies which out-compete the native environment.

Alternately, the pond zone may be seeded with a suitable mix if it is demonstrated that the pond hydrology will be controlled for the establishment of the proposed mix.
**Native Plants for Pond Zone (minimum 4 species)**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Spacing (inches on center)</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Spacing (inches on center)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acorus calamus</em></td>
<td>Sweet flag</td>
<td>24</td>
<td><em>Polygonum amphibium</em></td>
<td>Water knotweed</td>
<td>36</td>
</tr>
<tr>
<td><em>Carex lacustris</em></td>
<td>Common lake sedge</td>
<td>24</td>
<td><em>Pontederia cordata</em></td>
<td>Pickerel weed</td>
<td>24</td>
</tr>
<tr>
<td><em>Cephalanthus occidentalis</em></td>
<td>Buttonbush</td>
<td>5 feet</td>
<td><em>Potamogeton natans</em></td>
<td>Common pondweed</td>
<td>36</td>
</tr>
<tr>
<td><em>Decodon verticillatus</em></td>
<td>Swamp Loosestrife</td>
<td>24</td>
<td><em>Potamogeton pectinatus</em></td>
<td>Sago pondweed</td>
<td>36</td>
</tr>
<tr>
<td><em>Elodea canadensis</em></td>
<td>Common waterweed</td>
<td>36</td>
<td><em>Sagittaria latifolia</em></td>
<td>Common arrowhead</td>
<td>24</td>
</tr>
<tr>
<td><em>Hibiscus laevis</em></td>
<td>Halberd-leaved rose mallow</td>
<td>24</td>
<td><em>Scirpus acutus</em></td>
<td>Hard-stemmed bulrush</td>
<td>18</td>
</tr>
<tr>
<td><em>Hibiscus palustris</em></td>
<td>Swamp rose mallow</td>
<td>24</td>
<td><em>Scirpus atrovirens</em></td>
<td>Dark green rush</td>
<td>18</td>
</tr>
<tr>
<td><em>Iris virginica shrevei</em></td>
<td>Blue flag iris</td>
<td>18</td>
<td><em>Scirpus cyperinus</em></td>
<td>Wool grass</td>
<td>24</td>
</tr>
<tr>
<td><em>Justicia americana</em></td>
<td>Water willow</td>
<td>5 feet</td>
<td><em>Scirpus fluviatilis</em></td>
<td>River bulrush</td>
<td>18</td>
</tr>
<tr>
<td><em>Nelumbo lutea</em></td>
<td>Lotus</td>
<td>48</td>
<td><em>Scirpus validus creber</em></td>
<td>Great bulrush</td>
<td>18</td>
</tr>
<tr>
<td><em>Nuphar advena</em></td>
<td>Yellow pond lily</td>
<td>36</td>
<td><em>Sparganium americanum</em></td>
<td>American bur reed</td>
<td>18</td>
</tr>
<tr>
<td><em>Nymphaea tuberosa</em></td>
<td>White water lily</td>
<td>36</td>
<td><em>Sparganium eurycarpum</em></td>
<td>Common bur reed</td>
<td>18</td>
</tr>
<tr>
<td><em>Peltandra virginica</em></td>
<td>Arrow arum</td>
<td>18</td>
<td><em>Vallisneria Americana</em></td>
<td>Tape grass</td>
<td>36</td>
</tr>
</tbody>
</table>

Note: Plant species selected should cover 25% of the pond zone and should also cover the range of water depths within the pond zone (0 ft to 3 ft). (For example, 4 plant species may not all be placed at an 18-inch water depth covering 25% of the pond zone.)
OPEN DETENTION BASINS: EDGE ZONE VEGETATION

A variety of trees, shrubs, wildflowers, and grasses may be planted in the edge zone along the banks of detention basins. A native wetland edge or native sedge meadow seed mix is recommended.

**Edge Zone: Native Seed Mixes**

**Grasses/Sedges/Rushes (Minimum 5 species)**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carex <code>lurida</code></td>
<td>Bottlebrush sedge</td>
<td>Juncus effuses</td>
<td>Common rush</td>
</tr>
<tr>
<td>Carex vulpinoidea</td>
<td>Brown fox sedge</td>
<td>Leersia oryzoides</td>
<td>Rice cut grass</td>
</tr>
<tr>
<td>Echinochloa crusgalli</td>
<td>Barnyard grass</td>
<td>Scirpus acutus</td>
<td>Hard-stemmed bulrush</td>
</tr>
<tr>
<td>Elymus Canadensis</td>
<td>Canada wild rye</td>
<td>Scirpus atrovirens</td>
<td>Dark green rush</td>
</tr>
<tr>
<td>Glyceria striata</td>
<td>Fowl manna grass</td>
<td>Scirpus pungens</td>
<td>Chairmaker’s rush</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scirpus validus creber</td>
<td>Great bulrush (softstem)</td>
</tr>
</tbody>
</table>

**Native Forbs (Minimum 9 species)**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acorus calamus</td>
<td>Sweet flag</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actinomeris alternifolia</td>
<td>Wingstem</td>
<td>Mimulus ringens</td>
<td>Monkey flower</td>
</tr>
<tr>
<td>Alisma subcordatum</td>
<td>Common water plantain</td>
<td>Peltandra virginica</td>
<td>Arrow arrum</td>
</tr>
<tr>
<td>Asclepias incarnate</td>
<td>Swamp milkweed</td>
<td>Polygonum pensylvanicum</td>
<td>Pinkweed</td>
</tr>
<tr>
<td>Aster simplex</td>
<td>Panicled aster</td>
<td>Pontederia cordata</td>
<td>Pickerel weed</td>
</tr>
<tr>
<td>Bidens spp.</td>
<td>Bidens, various</td>
<td>Rosa palustris</td>
<td>Swamp rose</td>
</tr>
<tr>
<td>Cassia hebecarpa</td>
<td>Wild senna</td>
<td>Rudbeckia laciniata</td>
<td>Wild golden glow</td>
</tr>
<tr>
<td>Eupatorium perfoliatum</td>
<td>Common boneset</td>
<td>Sagittaria latifolia</td>
<td>Common arrowhead</td>
</tr>
<tr>
<td>Helianthus annuus</td>
<td>Sneezeweed</td>
<td>Spiraea alba</td>
<td>Meadowsweet</td>
</tr>
<tr>
<td>Iris virginica shrevei</td>
<td>Blue flag iris</td>
<td>Verbena hastata</td>
<td>Blue vervain</td>
</tr>
<tr>
<td>Ludwigia alternifolia</td>
<td>Seedbox</td>
<td>Vernonias fasciculata</td>
<td>Common ironweed</td>
</tr>
</tbody>
</table>

Note: A quick growing species such as annual rye grass (*lillium multiflorum*) and species which will provide the permanent cover (e.g., seed oats) should also be included in all Edge Zone seed mixes.

**Edge Zone: Native Shrubs**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alnus rugosa</td>
<td>Speckled alder</td>
<td>Ilex verticillata</td>
<td>Winterberry (MI Holly)</td>
</tr>
<tr>
<td>Aronia melanocarpa</td>
<td>Black chokeberry</td>
<td>Potentilla fruticosa</td>
<td>Shrubby cinquefoil</td>
</tr>
<tr>
<td>Betula pumila</td>
<td>Bog birch</td>
<td>Sambucus Canadensis</td>
<td>Elderberry</td>
</tr>
<tr>
<td>Cephalanthus occidentalis</td>
<td>Buttonbush (plant in min. 6” water)</td>
<td>Spiraea alba</td>
<td>Meadowsweet</td>
</tr>
<tr>
<td>Cornus amomum</td>
<td>Silky dogwood</td>
<td>Viburnum lentago</td>
<td>Nannyberry</td>
</tr>
<tr>
<td>Cornus stolonifera</td>
<td>Red-oiser dogwood</td>
<td>Viburnum trilobum</td>
<td>American highbush cranberry</td>
</tr>
</tbody>
</table>
Edge Zone: Native Trees

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer saccharinum</td>
<td>Silver maple</td>
<td>Quercus bicolor</td>
<td>Swamp white oak</td>
</tr>
<tr>
<td>Betula nigra</td>
<td>River birch</td>
<td>Liquidambar styraciflua</td>
<td>Sweetgum</td>
</tr>
<tr>
<td>Carpinus caroliniana</td>
<td>American hornbeam</td>
<td>Liriodendron tulipifera</td>
<td>Tuliptree</td>
</tr>
<tr>
<td>Nyssa sylvatica</td>
<td>Black gum</td>
<td>Quercus palustris</td>
<td>Pin oak</td>
</tr>
<tr>
<td>Platanus occidentalis</td>
<td>Sycamore</td>
<td>Salix nigra</td>
<td>Black willow</td>
</tr>
</tbody>
</table>

OPEN DETENTION BASINS: UPLAND ZONE VEGETATION

A variety of trees, shrubs, wildflowers, and grasses may be planted in the edge zone in the upland zone of open detention basins. Depending on the location and function of a detention basin within a development, vegetation within the Upland Zone may vary. Native plants recommended for the upland zone of an open detention basin are shown in the following tables.

For detention basins located at development entrances, adjacent to primary or secondary roads, adjacent to or directly behind proposed homes or are located within more formally landscaped areas in the proposed development: It is recommended that the seed mix for the Upland Zone extend from the upper boundary of the Edge Zone to the top of bank or slope. The area beyond the top of bank or slope of the basin should be sodded with an approved sod material. Section 8.5.1 provides additional specifications for sod installed as part of storm water management systems.

For detention basins adjacent to natural areas (forested areas, creeks/streams, wetlands), in remote areas, within interior areas of the development, adjacent to or directly behind proposed homes and terraced basins: seed mix appropriate for the areas extending beyond the 100-year flood elevation and top of bank or slope and functioning as a buffer for the pond should be a mesic-to-dry prairie mix, consisting of a broad-spectrum of prairie grasses and wildflowers with species that vary in height profile and also offer a variety of cover and food options for wildlife. The natural area seeded with prairie mix should be a minimum of fifteen (15) feet wide.

Upland Zone: Seed Mixes
Grasses/Sedges/Rushes (Minimum 5 species)

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calamagrostis canadensis</td>
<td>Blue joint grass</td>
<td>Glyceria striata</td>
<td>Fowl manna grass</td>
</tr>
<tr>
<td>Carex comosa</td>
<td>Bristly sedge</td>
<td>Juncus effusus</td>
<td>Common rush</td>
</tr>
<tr>
<td>Carex hystericina</td>
<td>Porcupine sedge</td>
<td>Leersia oryzoides</td>
<td>Rice cut grass</td>
</tr>
<tr>
<td>Carex stricta</td>
<td>Common tussock</td>
<td>Panicum virgatum</td>
<td>Switch grass</td>
</tr>
<tr>
<td>Carex vulpinoidea</td>
<td>Brown fox sedge</td>
<td>Scirpus atrovirens</td>
<td>Dark green rush</td>
</tr>
<tr>
<td>Echinochloa crusgalli</td>
<td>Barnyard grass</td>
<td>Scirpus validus creber</td>
<td>Great bulrush</td>
</tr>
<tr>
<td>Elymus canadensis</td>
<td>Canada wild rye</td>
<td>Spartina pectinata</td>
<td>Prairie cord grass</td>
</tr>
</tbody>
</table>
## Upland Zone: Native Forbs (Minimum 9 species)

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Agalinis tenuifolia</em></td>
<td>Slender false foxglove</td>
<td><em>Juncus effusus</em></td>
<td>Common rush</td>
</tr>
<tr>
<td><em>Alisma subcordatum</em></td>
<td>Common water plantain</td>
<td><em>Liatris spicata</em></td>
<td>Marsh blazing star</td>
</tr>
<tr>
<td><em>Angelica atropurpurea</em></td>
<td>Great angelica</td>
<td><em>Lobelia cardinialis</em></td>
<td>Cardinal flower</td>
</tr>
<tr>
<td><em>Asclepias incarnata</em></td>
<td>Swamp milkweed</td>
<td><em>Lobelia siphilitica</em></td>
<td>Great blue lobelia</td>
</tr>
<tr>
<td><em>Aster novae-angliae</em></td>
<td>New England aster</td>
<td><em>Ludwigia alternifolia</em></td>
<td>Seedbox</td>
</tr>
<tr>
<td><em>Aster puniceus</em></td>
<td>Bristly aster</td>
<td><em>Peltandra virginica</em></td>
<td>Arrow arrum</td>
</tr>
<tr>
<td><em>Aster simplex</em></td>
<td>Panicled aster</td>
<td><em>Physostegia virginiana</em></td>
<td>Obedient plant</td>
</tr>
<tr>
<td><em>Aster umbellatus</em></td>
<td>Flat-top aster</td>
<td><em>Pycnanthemum virginianum</em></td>
<td>Common mountain mint</td>
</tr>
<tr>
<td><em>Bidens cernua</em></td>
<td>Nodding Burr marigold</td>
<td><em>Sagittaria latifolia</em></td>
<td>Common arrowhead</td>
</tr>
<tr>
<td><em>Cassia hebecarpa</em></td>
<td>Wild senna</td>
<td><em>Silphium perfoliatum</em></td>
<td>Cup plant</td>
</tr>
<tr>
<td><em>Coreopsis tripteris</em></td>
<td>Tall coreopsis</td>
<td><em>Solidago rugosa</em></td>
<td>Rough goldenrod</td>
</tr>
<tr>
<td><em>Eupatorium maculatum</em></td>
<td>Spotted joe-pye weed</td>
<td><em>Sparganium eurycarpum</em></td>
<td>Common bur reed</td>
</tr>
<tr>
<td><em>Eupatorium perfoliatum</em></td>
<td>Common boneset</td>
<td><em>Spiraea alba</em></td>
<td>Meadowsweet</td>
</tr>
<tr>
<td><em>Gentiana andrewsi</em></td>
<td>Bottle gentian</td>
<td><em>Verbena hastata</em></td>
<td>Blue vervain</td>
</tr>
<tr>
<td><em>Helenium autumnale</em></td>
<td>Sneezeweed</td>
<td><em>Vernonia fasciculata</em></td>
<td>Common ironweed</td>
</tr>
<tr>
<td><em>Iris virginica shrevei</em></td>
<td>Blue flag iris</td>
<td><em>Zizia aurea</em></td>
<td>Golden alexanders</td>
</tr>
</tbody>
</table>

### Notes:
- An quick growing species such as annual rye grass (*lillium multiflorum*) and species which will provide the permanent cover (e.g., seed oats) should also be included in all Upland Zone seed mixes.
- These native plants are appropriate for the Upland Zone; from the bank full elevation to the 100-year flood elevation and beyond. This seed selection consists of sedge meadow, wet-to-mesic prairie, and dry-to-mesic prairie plant species.

## Upland Zone: Native Shrubs

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ceanothus americanus</em></td>
<td>New Jersey tea (dry-mesic)</td>
<td><em>Lindera benzoin</em></td>
<td>Spicebush (mesic)</td>
</tr>
<tr>
<td><em>Cornus foemina</em></td>
<td>Gray dogwood</td>
<td><em>Physocarpus opulifolius</em></td>
<td>Ninebark (dry or mesic)</td>
</tr>
<tr>
<td><em>(C. racemosa)</em></td>
<td>(dry to wet-mesic)</td>
<td><em>Rhus aromatica</em></td>
<td>Fragrant sumac (dry)</td>
</tr>
<tr>
<td><em>Corylus americana</em></td>
<td>American filbert (dry or mesic)</td>
<td><em>Sambucus canadensis</em></td>
<td>Elderberry (wet-mesic)</td>
</tr>
<tr>
<td><em>Hamamelis virginiana</em></td>
<td>Witch-hazel (dry-mesic)</td>
<td><em>Viburnum dentatum</em></td>
<td>Arrowwood (dry-mesic)</td>
</tr>
</tbody>
</table>
### Upland Zone: Native Trees

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acer rubrum</em></td>
<td>Red maple (mesic)</td>
<td><em>Cercis Canadensis</em></td>
<td>Redbud (mesic)</td>
</tr>
<tr>
<td><em>Acer saccharum</em></td>
<td>Sugar maple (mesic)</td>
<td><em>Crataegus crusgalli</em></td>
<td>Cockspur hawthorn</td>
</tr>
<tr>
<td><em>Amelanchier arborea</em></td>
<td>Serviceberry (Juneberry)(dry or mesic)</td>
<td><em>Gymnocladis dioicus</em></td>
<td>Kentucky coffeetree (mesic)</td>
</tr>
<tr>
<td><em>Betula alleghaniensis</em></td>
<td>Yellow birch (mesic)</td>
<td><em>Ostrya virginiana</em></td>
<td>Hip-hornbeam Ironwood (dry-mesic)</td>
</tr>
<tr>
<td><em>Carya cordiformis</em></td>
<td>Bitternut hickory (mesic)</td>
<td><em>Quercus alba</em></td>
<td>White oak (mesic)</td>
</tr>
<tr>
<td><em>Carya glabra</em></td>
<td>Pignut hickory (dry)</td>
<td><em>Quercus imbricaria</em></td>
<td>Shingle oak (mesic)</td>
</tr>
<tr>
<td><em>Carya lacinosa</em></td>
<td>Shellbark hickory (mesic)</td>
<td><em>Quercus macrocarpa</em></td>
<td>Bur oak (dry or mesic)</td>
</tr>
<tr>
<td><em>Carya ovata</em></td>
<td>Shagbark hickory (dry-mesic)</td>
<td><em>Quercus muehlenbergii</em></td>
<td>Chinkapin oak (dry or mesic)</td>
</tr>
<tr>
<td><em>Celtis occidentalis</em></td>
<td>Hackberry (mesic)</td>
<td><em>Quercus prinoides</em></td>
<td>Dwarf chinkapin oak (dry)</td>
</tr>
<tr>
<td><em>Celtis tenuifolia</em></td>
<td>Dwarf hackberry (dry-mesic)</td>
<td><em>Quercus rubra</em></td>
<td>Red Oak (mesic)</td>
</tr>
<tr>
<td><strong>Tilia americana</strong></td>
<td></td>
<td></td>
<td>American basswood (mesic)</td>
</tr>
</tbody>
</table>

Note: These plants range from dry to mesic according to the moisture conditions in the Upland Zone. Small sizes of native trees and shrubs may be proposed to increase plant diversity. The total tree caliper inches must equal the calculated caliper inches of required trees.
**Natural Basin: Dry Upland Zone: Permanent Grasses (Minimum 5 species)**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andropogon gerardii</td>
<td>Big bluestem grass</td>
<td>Koeleria cristata</td>
<td>June grass</td>
</tr>
<tr>
<td>Andropogon scoparius</td>
<td>Little bluestem grass</td>
<td>Panicum virgatum</td>
<td>Switch grass</td>
</tr>
<tr>
<td>Bouteloua curtipendula</td>
<td>Side-oats gramma</td>
<td>Sorghastrum nutans</td>
<td>Indian grass</td>
</tr>
<tr>
<td>Elymus canadensis</td>
<td>Canada wild rye</td>
<td>Sporobolus heterolepis</td>
<td>Prairie dropseed</td>
</tr>
</tbody>
</table>

**Natural Basin: Dry Upland Zone: Native Forbs (Minimum 9 species)**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amorpha canescens</td>
<td>Lead plant</td>
<td>Lupinus perennis</td>
<td>Wild lupine</td>
</tr>
<tr>
<td>Anemone cylindrica</td>
<td>Thimbleweed</td>
<td>Monarda fistulosa</td>
<td>Wild bergamot</td>
</tr>
<tr>
<td>Aquilegia canadensis</td>
<td>Wild columbine</td>
<td>Parthenium integrifolium</td>
<td>Wild quinine</td>
</tr>
<tr>
<td>Asclepias tuberosa</td>
<td>Butterfly weed</td>
<td>Petalostemon purpureum</td>
<td>Purple prairie clover</td>
</tr>
<tr>
<td>Aster ericoides</td>
<td>Heath aster</td>
<td>Physostegia virginiana arenaria</td>
<td>Prairie obedient plant</td>
</tr>
<tr>
<td>Aster laevis</td>
<td>Smooth blue aster</td>
<td>Pyrenanthemum virginianum</td>
<td>Common mountain mint</td>
</tr>
<tr>
<td>Aster novae-angliae</td>
<td>New England aster</td>
<td>Ratibida pinnata</td>
<td>Yellow coneflower</td>
</tr>
<tr>
<td>Baptista leucantha</td>
<td>White wild indigo</td>
<td>Rudbeckia hirta</td>
<td>Black-eyed susan</td>
</tr>
<tr>
<td>Cassia fasciculata</td>
<td>Partridge pea</td>
<td>Rudbeckia subtomentosa</td>
<td>Sweet black-eyed susan</td>
</tr>
<tr>
<td>Coreopsis lanceolata</td>
<td>Sand coreopsis</td>
<td>Silphium laciniatum</td>
<td>Compass plant</td>
</tr>
<tr>
<td>Coreopsis tripteris</td>
<td>Tall coreopsis</td>
<td>Solidago junccea</td>
<td>Early goldenrod</td>
</tr>
<tr>
<td>Echinacea purpurea</td>
<td>Broad-leaved purple coneflower</td>
<td>Solidago nemoralis</td>
<td>Old-field goldenrod</td>
</tr>
<tr>
<td>Eryngium yuccifolium</td>
<td>Rattlesnake master</td>
<td>Solidago rigida</td>
<td>Stiff goldenrod</td>
</tr>
<tr>
<td>Helianthus mollis</td>
<td>Downy sunflower</td>
<td>Tradescantia ohiensis</td>
<td>Common spiderwort</td>
</tr>
<tr>
<td>Heliopsis helianthoides</td>
<td>False sunflower</td>
<td>Vernonia altissima tenuiortichia</td>
<td>Hairy tall ironweed</td>
</tr>
<tr>
<td>Lespedeza capitata</td>
<td>Round-headed bush clover</td>
<td>Veronicastrum virginicum</td>
<td>Culver's root</td>
</tr>
<tr>
<td>Liatris aspera</td>
<td>Rough blazing star</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: These native plants are appropriate for areas surrounding basins categorized as natural basins and recommended within areas that have elevations higher than the 100-year flood elevation. This seed selection consists of dry-to-mesic prairie, basic prairie, and low-profile prairie plant species.
ATTACHMENT B: WETLANDS CONSTRUCTION TECHNIQUES

• **Step 1 - Prepare the Final Pondscaping and Grading Plans for the Wetland:** At this stage the engineer, landscape architect, and wetland expert work jointly to prepare a pondscaping and grading plan for the wetland. It is also an appropriate time to order the wetland plant stock from aquatic nurseries, since up to six to nine months lead time may be needed to fill orders.

• **Step 2 - Grade the Wetland to Interim Elevations:** Once the basic excavation of the storm water wetland has been completed, it is time to create the major topographic features within the wetland, such as wedges, benches, and deep water channels. A skid loader or other excavator can be used to form the internal complexity within the wetland. These topographic features can only be added while working in the “dry.” Spot surveys should be made to ensure that the interim elevations are 3 to 6 inches below the final elevations for the wetland.

• **Step 3 - Add Topsoil/Wetland Mulch Amendments:** Since most storm water wetlands are excavated to deep subsoils, they often lack the nutrients and organic matter needed to support vigorous growth of wetland plants. It is therefore essential to add 3 to 6 inches of topsoil or wetland mulch to all depth zones in the wetland from 1 foot below the normal pool to 6 inches above. Topsoil can be stockpiled during construction of the wetland or can be scavenged from elsewhere at the development site. Wetland mulch is preferable to topsoil if it is available.

• The importance of soil amendments in excavated wetlands cannot be overstressed; poor survival and future wetland coverage are likely if these soils are not added (Bowers, 1992). Fertilizers and other soil amendments are not needed if topsoil or wetland mulch are used.

• **Step 4 - Grade the Wetland to Final Elevations:** After topsoil or wetland mulch has been added to the storm water wetland, the wetland can be graded to its final elevations. This is normally done by “roughing up” the interim elevations with a skid loader or other equipment to achieve the desired micro topography across the wetland. All wetland features above the normal pool should be temporarily stabilized by hydroseeding or seeding over straw.

• **Step 5 - Measure and Stake Planting Depths:** The storm water wetland is surveyed and staked at the onset of the planting season. Depths in the wetland should be measured to the nearest inch to confirm the original planting depths of the planting zone. At this time, it may be necessary to modify the pondscape plan to reflect altered depths or the availability of wetland plant stock. Surveyed planting zones should be marked on the as-built or design plan, and also located in the field using stakes or flags.

For constructed wetlands, plant plugs or container-grown wetland plant stock should be planted. The transplanting window extends from early April to mid-June. Planting after these dates is quite chancy, as emergent wetland plants need a full growing season to build the root reserves needed to get through the winter. If at all possible, plants should be ordered at least six months in advance to ensure the availability of desired species.
It is not necessary to plant more than half the wetland surface area. If the appropriate planting depths are achieved, the entire wetland should be colonized within three years. The wetland area should be subdivided into separate planting zones of more or less constant depth. One plant species should be planted within each flagged planting zone based on its approximate depth requirements. Individual plants should be planted 18 inches on center within each single species “clump.”

Post-nursery care of wetland plants is very important during the interval between delivery of the plants and subsequent planting, as they are prone to desiccation. Stock should be frequently watered and shaded while on-site.

After the second growing season, reinforcement plantings may be needed to expand the spatial coverage of the wetland.
ATTACHMENT C:

DETAIL FOR REQUIRED BUFFER STRIPS FOR FOREBAYS, OPEN DETENTION BASINS, AND RETENTION BASINS WITH DRAINAGE AREA GREATER THAN 5 ACRES
REQUIRED BUFFER STRIP FOR FOREBAYS, OPEN DETENTION BASINS, AND RETENTION BASINS
(DRAINAGE AREA GREATER THAN 5 ACRES)
NOT TO SCALE
8.1.2 Retention Basins

Description
Retention basins are man-made surface waters designed to provide gravity settling of pollutants and to promote infiltration into the soil rather than discharging the storm water runoff to a surface water or closed conduit. The soils beneath a proposed retention basin must be sufficiently permeable to allow the infiltration of storm water.

Design Standards
Design standards for retention basins include the following:

- A registered Professional Engineer must certify that the soils beneath a proposed retention basin are sufficiently permeable to allow the infiltration of storm water and storm water runoff. Calculations showing the percolation rate of soils below the proposed retention basin must be provided.
- A forebay or other pretreatment system is required at each inlet to the retention basin. Pretreatment systems trap sediment before entering the retention basin, reduce the incoming runoff velocities, and spread runoff evenly over the retention basin to create sheet flow conditions. Section 8.2 of this manual provides detailed information and design criteria for pretreatment systems.
- All closed conduits entering retention basins should have an end treatment and adequate soil erosion protection, as described in Section 8.3.1. Some enclosures should also be covered with a grate to prevent children and animals from entering the enclosure.
- Retention basins must be designed to retain the volume of storm water equal to the runoff from two consecutive 100-year storm events as described in Section 6.2.2. The design storage volume in a retention basin must be provided above the existing ground water elevation.
- A minimum of one (1) foot of freeboard is required above the design water level of a retention basin.
- Providing a safe design is a primary consideration for all storm water management basins. Side slopes for retention basins may not be steeper than 1:6. Further safety measures (e.g., safety shelves, vegetative and barrier plantings) may be warranted depending on the type of development.
- Although use of terraced side slopes generally is discouraged when other alternatives exist, terraced side slopes may be approved for retention basins in certain, limited circumstances at the discretion of Wayne County. The overall slope of a terraced side of a retention basin should not be steeper than 1:3. An example detail for terraced side slopes is provided in Appendix E-3.
- An emergency spillway is required for all retention basins. The applicant must demonstrate that there exists a defined drainage path downstream from the emergency spillway to allow discharge when flows exceed the design water level. Design criteria for emergency spillways are the same as those for open detention basins as described in Section 8.1.4.
- Retention basins may not be located within pre-existing surface waters.
- A buffer strip must be provided around all surface waters such as retention basins. Except as noted below, the buffer strip must be at least 25 feet wide measured from the minimum freeboard elevation of the basin or surface water. Of the minimum 25 ft width, a minimum of 15 feet of the buffer strip should be exterior to the pond perimeter defined by the top of bank. The slope of the buffer strip should be 1:6 or flatter. These provisions ensure that there is sufficient room along the top of the basin to provide access to the basin for maintenance. The buffer strip requirements illustrated in the figure “Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins” in Attachment C of Section 8.1.1 for open detention basins are applicable to retention basins.
- In the following situations, the minimum width of the buffer strip around retention basins is 15 feet measured from the minimum freeboard elevation of the basin:
When a retention basin has a drainage area 5 acres or less; or
- When a retention basin has a drainage area greater than 5 acres and no storm water from areas outside of or within the buffer strip enters the basin via direct sheet flow (see the right side of the figure “Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins” in Attachment C of Section 8.1.1).

- Plant vegetation, such as along the side slopes of retention basins, is necessary to control erosion and enhance sediment entrapment. A landscaping plan is required for retention basins, due to the importance of the vegetation to the function of the entire system. Use of a professional landscape architect with experience in storm water management system design and native landscaping is encouraged.

**Preferred Design Elements**

- Calculations showing the percolation rate of soils should be based on soil borings. Wayne County generally requires soil borings to be taken as follows:
  - Minimum four soil borings per retention basin.
  - Borings should be taken every 200 feet within the perimeter of the basin.
  - Borings should be at least 10 feet deep, measured from the bottom elevation of the proposed basin.
- Soil samples collected from borings should be collected every five vertical feet. Soil analysis should include:
  - Sieve analysis
  - Hydrometer reading
  - Soil classification
  - Standard penetration numbers
  - The shape and configuration of retention basins may vary, depending on storage requirements, local topography, land availability, hydraulic considerations, and other site-specific constraints.
- Retention basins should be designed to maximize sheet flow across the open water portion of the facility.
- If aerating devices are used as part of a storm water management system, they should be designed to minimize disturbance of bottom sediments. For example, retention basins may need to have a deeper permanent pool if an aerating device is used. Bubbler systems are the preferred type of aerating device as they have been found to be more efficient at providing aeration. The manufacturer’s recommendations should be followed in regards to design and maintenance.
- If a terraced side slope is approved for use in a retention basin, the materials proposed for use in its construction should be approved by the local community.

**Vegetation Specifications**
The type of vegetation used is dependant on site-specific conditions, such as soil types, amount of sunlight, and other factors. Vegetation specifications for retention basins are the same as those for open detention basins (see Section 8.1.1).

**Maintenance**

Required maintenance activities for retention basins are the same as those for open detention basins (see Section 8.1.1). These activities must be identified in the submitted maintenance plan. Additionally, provision for maintenance access should be shown on the plan; it is recommended that the maintenance access be a minimum of 15 feet wide.

**References**

See references in Section 8.1.1
8.1.3 Underground Detention Systems

Description
Underground detention systems consist of one or more underground pipes or structures designed to provide the required storage volumes (both the bankfull flood and flood control volumes) for a development project. Just as with any above ground means of storm water detention, underground detention systems must have a restricted outlet that limits outflow for the bankfull flood and for the maximum allowable release rate from the development site.

Underground detention systems are the least preferred method of detention and generally are allowable only when an open detention system is not feasible for a given site.

Preferred Design Elements and Materials
Before entering an underground detention system, storm water runoff must pass through a pretreatment system as described in Section 6.3.1. All construction components and materials used from the pre-treatment structure through the underground detention system out to the point of discharge must be tested, inspected and approved by Wayne County. The pretreatment system includes the last structure in the collection system leading into the treatment system.

For underground detention systems consisting of pipes, spacing of the pipes should conform to the manufacturer’s recommendation except that a minimum clearance of 12 inches is required between pipes to provide for adequate backfill and support (as described in “Installation,” below).

Underground detention systems must confine storm water runoff to the interior of the detention system, and may discharge storm water only through a restricted outlet. Examples of two types of restricted outlets are shown on the following pages. Example A, a restricted outlet with no overflow, is appropriate for underground detention systems that discharge to a storm water management system within a Wayne County road right-of-way or other County-owned property, or to any other storm water management system with restrictions on the allowed inflow. Example B, a restricted outlet with overflow, is appropriate for underground detention systems that discharge to surface waters or other storm water management systems. Note that the designs for a restricted outlet for underground detention systems shown in Examples A and B illustrate acceptable designs; other designs also may be acceptable.

If a manufactured treatment system is installed upstream of the underground detention system, the underground detention system should be designed, to the extent possible, such that the flood control design water elevation within the underground detention system is equal to or below the controlling water surface elevation in the manufactured treatment system. This design consideration is necessary to maximize the performance of this type of pretreatment system and to minimize the resuspension of collected sediment.

Wayne County prefers gravity outlets to pumped outlets from underground detention systems. If an underground detention system is designed to include a pumped outlet:

- Pumps should be located downstream of the flow restrictor within the outlet
- Two pumps should be provided in any pumped outlet system:
  - If the system is designed to use one pump, with one pump as a backup, each pump should be sized to operate such that the maximum pumping capacity does not exceed the allowable release rate (Qa)
  - If the system is designed to use two pumps alternately or at the same time, the maximum pumping capacity of the system should not exceed the allowable release rate (Qa) at any time.
A manhole structure should be provided downstream of the pump station.

Access
All underground detention systems should have a means to inspect and maintain the entire system. For underground detention systems made of pipes, access risers (minimum of 24-inch diameter) and clean outs (size as recommended by manufacturer) are required. For storm water collection chamber (SCC) underground detention systems, inspection ports (sized as recommended by manufacturer) are required.

It is the responsibility of the system manufacturer to detail the access to the system. For systems made of corrugated metal pipe and polymer-coated corrugated steel pipe, the gauge of the material used for the risers should follow the same requirements as listed for the detention system pipe materials.

Materials
Wayne County is authorized to restrict the types of materials that may be used to construct underground detention systems. Generally, underground detention systems should be constructed from pre-cast or cast-in-place concrete, corrugated metal pipe (CMP), polymer-coated corrugated steel pipe (PCCSP), reinforced concrete pipe (RCP), smooth-lined corrugated plastic pipe (CPE), or storm water collection chambers (SCC). Unless otherwise indicated in this section, materials used for underground detention systems should meet the requirements of the current MDOT Standard Specification for Construction.

Storm water detention systems made of pre-cast or cast-in-place reinforced concrete structures should conform to current Wayne County Specifications for Structural Concrete with the wall thickness not less than the minimum thickness necessary to sustain HS20 loading requirements, as determined by a registered Professional Engineer. Pipe openings should be sized to accept pipes of the specified size(s) and material(s) and should be sealed with hydraulic cement conforming to ASTM C595.

Underground detention systems made of reinforced concrete pipe should conform to ASTM C76.

Circular CMP should conform to AASHTO M36 (ASTM A760) and should be made from aluminum coated sheet conforming to AASHTO M274. The use of the continuous welded seam process in the fabricating of pipe is not permitted. Unless otherwise approved by the Wayne County Permit Engineer, CMP is limited to a maximum diameter of 60-inches. See Table 8.2.3-1 for additional information.

Polymer coated corrugated steel pipe (PCCSP) should conform to AASHTO M245 (ASTM A762) using AASHTO M246 (ASTM A742) Grade 250/250 polymer on zinc coated steel meeting AASHTO M218. The use of the continuous welded seam process in the fabricating of pipe is not permitted. Unless otherwise approved by the Wayne County Permit Engineer, PCCSP is limited to a maximum diameter of 60-inches. See Table 8.1.3-1 for additional information.

Smooth-lined corrugated plastic pipe should conform to AASHTO M294, Type S and should be limited to a maximum size of 60-inches. In areas where the CPE pipe will be under the influence of pavement, the cover should be a minimum of 24-inches measured from the top of pipe to the top of a concrete (rigid) pavement or 24-inches from the top of pipe to the bottom of asphalt (flexible) pavement.

Underground detention systems consisting of SCC should conform to ASTM F 2418. The structural design of the SCC, its structural backfill and requirements for its installation should ensure that the load factors specified in the AASHTO LRFD Bridge Design Specifications, Section 12.12 are met. It is required that the factors for both long-duration dead loads and short-duration live loads, based on the AASHTO Design Truck for HS-20 live loads and deep burial earth loads with consideration for impact and the presence of multiple vehicles. To date, the Stormtech™ SC-740, SC-310, MC-3500, and MC-4500 have been approved by Wayne County as meeting these criteria.

Testing
The manufacturer of underground detention system elements must contact the Wayne County Testing Office (734-595-6504 x 2015) at least 72 hours prior to testing.
to fabrication to schedule inspection during fabrication. Wayne County inspects the material fabrication process to ensure that the manufacturer’s testing of the product occurs at the applicable AASHTO or ASTM standards. Testing of pipe materials should occur at the following frequencies:

- **RCP** should be tested at a frequency of one test per 200 pieces per size per day.
- **CMP and PCCSP** should be tested at a frequency of one test per 2,500 lineal feet per heat number.
- **CPE** should be tested at a frequency of one test per 1,000 straight length of pipe per diameter per lot number.

Testing of SCC and end caps should occur at a frequency of one test per 200 pieces (chambers or end caps) or per shift, whichever is less.

**Installation**

Wayne County is authorized to restrict the methods used to construct underground detention systems. At a minimum, unless otherwise directed by the County, installation of underground detention systems constructed of pipes should conform to the current MDOT specification(s) for installation of the specific pipe material used. Based on soil conditions, Wayne County may require the entire underground detention system to be enveloped with geotextile fabric conforming to MDOT Section 910.

For underground detention systems consisting of pipes and SCC, a stable foundation is necessary to ensure that the proper line and grade is maintained. Unstable foundations may be undercut and replaced with MDOT Class I granular bedding material placed in 6 inch lifts and compacted to 95% of its maximum unit weight. Other methods of stabilization can be used if approved by the Wayne County Permit Engineer.

For underground detention systems consisting of CPE, CMP, and PCCSP, embedment materials should be worked under the haunches by hand for pipes 30-inches and larger.

When installing underground pipe as part of an underground detention system, backfill should be as follows:

- **RCP**: backfill should conform to Wayne County Trench “A” backfill and Trench “B” backfill specifications.
- **CPE, CMP, or PCCSP**: the dimensions of the trench backfill are the same as Trench “A” and “B”; however, 2G, 34G, 6A or 21AA stone or gravel should be used as backfill to a minimum of 6-in above the pipe. In the event that a different backfill is used above the 2G, 34G, 6A or 21AA stone or gravel, a geotextile separation fabric shall be used between the two different materials. A minimum cover from the bottom of the pavement to the top of the pipe should be 12 inches except for CPE pipe under the influence of pavement, in which case the cover shall be a minimum of 24-inches measured from the top of pipe to the top of a concrete (rigid) pavement or 24-inches from the top of pipe to the bottom of asphalt (flexible) pavement.
- **CMP and PCCSP**: the minimum cover (including the 21AA or 22A backfill from the top of pipe) from the top of the pipe to the bottom of the pavement is 12-inches, plus the pavement thickness.

For underground detention systems consisting of SCC, foundations and embedment stone should be clean, angular stone meeting the requirements of MDOT 4AA, 6A, 6A or the requirements of Wayne County Specifications for 3-in x 1-in maintenance aggregate (no crush concrete) with a maximum percentage of 5% passing the #200 sieve.

Backfill for all types of underground detention system should be installed as follows:

- All backfill materials should be placed in a balanced manner making sure that no more than a 2 lift differential is present from one side of the pipe/SCC/structure to the other. Balanced lifts should be advanced across the width of the system, evenly along the length of the system throughout the backfilling process.
- All backfill materials should be placed in lifts of maximum 10-inches.
For each backfill lift, all materials should be compacted to a minimum of 95% (90% minimum required for 6A and 21AA) of the backfill material’s maximum unit weight at moisture content not greater than optimum. The maximum unit weight of the backfill materials should be determined by the AASHTO T 180 or Michigan Cone Method. The frequency of the compaction testing should be one test per lift of backfill per 200 lineal feet or less of trench.

A Wayne County Permit Engineer must observe the installation of all underground detention systems. Contact the Wayne County Permit Office (734-595-6504 x 2009) at least 72 hours prior to installation to schedule inspection during installation. Wayne County will not accept any underground detention systems installed when a County Permit Engineer is not present; permits and financial assurances will not be released at the conclusion of construction for such systems.

Documentation of the following items relative to the installation of underground detention systems is required to be submitted to the Wayne County Permit Engineer before permits and financial assurances are released:

- All backfill materials are from Wayne County tested stock.
- All backfill materials were placed in lifts of maximum 10-inches.
- For each backfill lift, all materials were compacted to a minimum of 95% of the backfill material’s maximum unit weight at moisture content not greater than optimum. If 6A and 21AA backfill was used, materials were compacted to 90% of the backfill material’s maximum unit weight at moisture content not greater than optimum.
- The maximum unit weight of the backfill material was determined by the AASHTO T 180 or Michigan Cone Method.
- The compaction was tested a minimum of one test per lift of backfill per 200 lineal feet or less of trench.

**Maintenance**

Underground detention systems should be inspected every 6 months to verify proper operation, and to identify and perform any necessary maintenance. As a general rule, the detention system requires cleaning if its volume is reduced by more than 10 percent due to the accumulation of silt and sediment.
Table 8.1.3-1

WALL THICKNESS REQUIREMENTS FOR CORRUGATED METAL PIPE AND POLYMER COATED CORRUGATED STEEL PIPE (DIAMETER-GAUGE)

<table>
<thead>
<tr>
<th>DIAMETER (INCHES)</th>
<th>SIZE OF CORRUGATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 2/3-in x ½-in</td>
</tr>
<tr>
<td>UP TO 30</td>
<td>0.079-in - 14 ga.</td>
</tr>
<tr>
<td>36 - 54</td>
<td>0.079-in - 14 ga.</td>
</tr>
<tr>
<td>60</td>
<td>0.109-in - 12 ga.</td>
</tr>
</tbody>
</table>

- All welds for aluminized pipe should be coated with a paint containing zinc dust as described in the Materials Section of ASTM A 780 and should be applied to a dry film thickness of at least 0.005 inch. Any repair to damaged aluminized coatings should be in accordance with ASTM A 760 Section 11.
- All welds for polymer pre-coated pipe (PCCSP) should first be coated with a zinc dust paint as described above followed by a polymer coating similar and compatible to the original polymer coating or a protective coating meeting ASTM A 849. Repairs to damaged PCCSP should be in accordance with ASTM A 762.
- Welding on site is not permitted unless approved by the Wayne County Permit Engineer.
- Elliptical CMP or PCCSP is not permitted.
- CMP and PCCSP connections should be per the manufacturer’s recommendations.
- Larger size CMP or PCCSP will be as approved by the Wayne County Permit Engineer.
Page intentionally left blank to facilitate double-sided printing
* Oil/Water separator is required for outflow pipe less than 12" dia.

Wayne County Frame and cover type "A".

Rim elevation =

Flood control design
Water elevation =

Bankfull flood elevation =

Invert =

Flow

SECTION "A-A"

1. This type of flow restrictor structure to be used only with underground detention systems.
2. Overflow is not allowed to a Wayne County road storm system or enclosed drain.
3. The precast reinforced flow restrictor structure shall be manufactured per ASTM C-478 specifications and meeting HS20 loading requirements.
4. The structure geometric and reinforcement details shall be per Wayne County standard details "H" series.

Example A: Flow restrictor without overflow
Not to scale

Flow restrictor wall
Front view

Number and size of holes as per design. Minimum 1" dia. Equally spaced, minimum 6" O/C.
* Oil/water separator is required for outflow pipe less than 12" dia.

Wayne County frame and cover type "A".

**SECTION "A-A"**

1. This type of flow restrictor structure to be used only with underground detention systems.
2. Overflow is not allowed to a Wayne County road storm system or enclosed drain.
3. The precast reinforced flow restrictor structure shall be manufactured per ASTM C-478 specifications and meeting H520 loading requirements.
4. The structure geometric and reinforcement details shall be per Wayne County standard details "FR" series.

**EXAMPLE B: FLOW RESTRICTOR WITH OVERFLOW**

Not to scale
8.1.4 Outlets for Forebays and Open Detention Basins

Description
Forebay outlets convey flow from a forebay into detention systems and retention basins. Forebay outlets must include a flow restrictor, which conveys restricted flow, and a weir, which conveys unrestricted flow.

Outlets from open detention basins convey flow from the detention basin into a surface water or off-site closed conduit. Required outlets from open detention basins include a flow restrictor to convey restricted flow, an overflow structure to discharge when the water level exceeds the design water level, and an emergency spillway to convey unrestricted flow. An example of a storm water management system with forebay and open detention basin outlets is shown in the detail at the end of this section.

Design Standards for Forebay Outlets
Outlets for forebays must be designed as follows:

- Flow restrictors in forebays must be placed near or within the embankment of the forebay to provide ready maintenance access and must be constructed of materials that minimize future maintenance requirements.
- Flow restrictors must be designed to gradually release the first flush storage volume over a period of twenty-four (24) hours, as described in Section 6.3.1.
- Forebays must include a weir to allow discharge from the forebay into the detention system or retention basin when the forebay water level exceeds the top of the forebay storage volume. The weir must be designed to convey the peak flow rate tributary to the forebay for the 10-year design storm.

Design Standards for Open Detention Basin Outlets
Outlets for open detention basins must be designed as follows:

- A flow restrictor is required in each detention basin. Depending on which performance standard(s) the system is being designed to meet, the flow restrictor may be designed to meet the flood control outflow requirements, the bank full flood outflow requirements, or both.
  - For flood control, the flow restrictor must be designed such that the maximum outflow rate at the design water level does not exceed the maximum allowable outflow rate for flood control as determined by the equations described in Section 6.2.1.
  - For water resources protection, the flow restrictor must be designed to gradually release the bank full flood storage volume over a period of forty (40) hours as described in Section 6.3.2.
- Flow restrictors in open detention basins must be placed near or within the embankment of the basin to provide ready maintenance access. Flow restrictors must be constructed of materials that minimize future maintenance requirements.
- An overflow structure must be provided to allow discharge when the basin water level exceeds the design water level. The overflow structure and its outlet pipe must be designed to convey the peak flow rate tributary to the basin for the 10-year design storm.
- An emergency spillway with a defined downstream drainage path must be provided to allow discharge from the basin when flows exceed the capacity of the overflow structure. The emergency spillway elevation must be 6 inches below the top of freeboard elevation. The spillway must be armored to prevent erosion of the berm.

Preferred Design Elements and Materials
- Wayne County prefers gravity outlets versus pumped outlets from open detention basins. If an open detention basin is designed to include a pumped outlet:
  - Pumps should be located downstream of the flow restrictor within the outlet
  - Two pumps should be provided in any pumped outlet system:
    - If the system is designed to use one pump, with one pump as a backup, each pump should be sized to operate such that the maximum pumping capacity does not exceed the allowable release rate (Qa)
    - If the system is designed to use two pumps alternately or at the same time, the maximum pumping capacity of the system should not exceed the allowable release rate (Qa) at any time.
  - A manhole structure should be provided downstream of the pump station.
• Risers and overflow structures should be constructed of 12-gage corrugated metal pipe (CMP) conforming to ASTM A760 and should be made from aluminum coated sheet conforming to AASHTO M274. The use of the continuous welded seam process in the fabricating of pipe is not permitted. Risers and overflow structures should have a minimum diameter of 36-inches.
• Riser holes should be 1 inch minimum diameter but no larger in size than the surrounding stone. The holes should be spaced a minimum of 4 inches apart, on center, both vertically and horizontally. The holes should be pre-drilled prior to galvanizing.
• Risers and overflow structures should have a 2-foot deep sump and a concrete base of 6-inch minimum thickness. The concrete base should be constructed of either pre-cast concrete meeting ASTM C478, or cast-in-place concrete with a 28-day strength requirement of 3,500 psi.
• Risers and overflow structures should be securely attached to the base. They may be embedded in concrete or affixed by an approved fastening method.
• The top of risers and overflow structures should be equipped with a steel grate. Openings should be a minimum of 3 inches square and a maximum of 4 inches square.
• Stone filter backfill around risers should consist of 3-inch diameter washed stone, with an outer blanket of MDOT 6A stone. The side slope of the stone blanket is typically 1:4.
• The berm on which an emergency spillway rests should be made of approved embankment material placed and compacted as roadway embankment per the current MDOT Standard Specifications for Construction.
• The concrete base for the risers and overflow structures should be constructed on a suitable subgrade material compacted to 95% of its maximum unit weight. Unsuitable subgrade materials will be removed at the direction of the Permit Engineer, backfilled with MDOT Class 2 granular material in no more than 10-in lifts, and compacted to 95% of its maximum unit weight.
• Onsite welding of the CMP riser is not permitted unless approved by the Wayne County Permit Engineer.

Testing
The CMP riser must be inspected during fabrication. CMP manufacturers must contact the Wayne County Testing Office (734-595-6504 x 2015) at least 72 hours prior to fabrication to schedule inspection during fabrication. Wayne County inspects the material fabrication process to ensure that the manufacturer’s testing of the product occurs at the applicable AASHTO or ASTM standards.

Installation
Wayne County is authorized to restrict the methods used to construct outlets from forebays and open detention systems. Specifications for construction of these types of outlets include:
• Any field modifications to risers, overflow structures, or other outlet pipes should be performed in accordance with ASTM A780.
• The berm on which an emergency spillway rests should be made of approved embankment material placed and compacted as roadway embankment per the current MDOT Standard Specifications for Construction.
• The concrete base for the risers and overflow structures should be constructed on a suitable subgrade material compacted to 95% of its maximum unit weight. Unsuitable subgrade materials will be removed at the direction of the Permit Engineer, backfilled with MDOT Class 2 granular material in no more than 10-in lifts, and compacted to 95% of its maximum unit weight.
• Onsite welding of the CMP riser is not permitted unless approved by the Wayne County Permit Engineer.

A Wayne County Permit Engineer must observe the installation of outlets for forebays and open detention systems. Contact the Wayne County Permit Office (734-595-6504 x 2009) at least 72 hours prior to installation to schedule inspection during installation. Wayne County will not accept any forebay or detention system outlet installed when a County Permit Engineer is not present; permits and financial assurances will not be released at the conclusion of construction for such systems.

Documentation of the following items relative to the installation of outlets for forebays or open detention systems is required to
be submitted to the Wayne County Permit Engineer before permits and financial assurances are released:

- MDOT 6A stone, 3-inch washed stone, and Class 2 granular material were from Wayne County tested stock.
- Berm materials were compacted to the requirements of roadway embankment per the current edition of the MDOT Standard Specification for Construction.
- Test reports indicating the 28-day compressive strength of the cast-in-place concrete utilizing 6-in x 12-in cylinders. Concrete failing to meet the 28-day compressive strength of 3,500 psi must be removed and replaced with concrete meeting the 28-day strength requirement.
- All pre-case manhole bases were provided from Wayne County tested stock.
- In the event any unsuitable soils were removed to create a suitable subgrade for the base(s), test results for the compacted backfill must be provided.

**Maintenance**

Inlets and outlets should be checked regularly for clogging and the system should be cleaned as necessary. Sediment should be removed if accumulation reaches 6 inches or if re-suspension is observed. Pipe inspections should be made to verify that the pipe is not crumbling or broken.
EXAMPLE: FOREBAY AND OPEN DETENTION BASIN DETAIL
8.2.1 Forebays

**Description**
Forebays are man-made surface waters used as pretreatment systems. Forebays are designed to temporarily store the first flush of runoff from a storm event and provide for pollutant removal through settling. A forebay or other pretreatment system is required at each inlet to a detention system or retention basin.

**Design Standards**
Forebays must capture the first flush and release it gradually to the detention system and/or retention basin over a period of twenty-four (24) hours. Section 6.3.1 provides detailed information regarding how to calculate the storage volume required to capture the first flush for the area tributary to each forebay, and how to calculate the average allowable release rate form the forebay.

Design standards specific to forebays include the following:

- The volume of the forebay above any permanent pool may be used to satisfy a portion of the flood control storage volume (described in Section 6.2.1) and the bank full flood storage volume (described in Section 6.3.2). If a permanent pool is provided, the volume of the permanent pool may not be used to satisfy these other storage volume requirements.
- All closed conduits entering or exiting a forebay should have an end treatment and adequate soil erosion protection, as described in Section 8.3.1. Some enclosures should also be covered with a grate to prevent children and animals from entering the enclosure.
- A buffer strip must be provided around all surface waters such as forebays. Except as noted below, the buffer strip must be at least 25 feet wide measured from the minimum freeboard elevation of the surface water or forebay. Of the minimum 25 ft width, a minimum of 15 feet of the buffer strip should be exterior to the forebay perimeter defined by the top of bank. The slope of the buffer strip should be 1:6 or flatter. These provisions ensure that there is sufficient room to provide access to the forebay for maintenance.

The buffer strip requirements illustrated in the figure “Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins” in Attachment C of Section 8.1.1 for open detention basins are applicable to forebays.

- In the following situations, the minimum width of the buffer strip around a forebay is 15 feet measured from the minimum freeboard elevation of the forebay:
  - When the forebay has a drainage area 5 acres or less; or
  - When the forebay has a drainage area greater than 5 acres and no storm water from areas outside or within the buffer strip enters the forebay via direct sheet flow.

- Plant vegetation, such as along the side slopes of retention basins, is necessary to control erosion and enhance sediment entrapment. A landscaping plan is required for retention basins, due to the importance of the vegetation to the function of the entire system. Use of a professional landscape architect with experience in storm water management system design and native landscaping is encouraged.

- Forebays may not be located within pre-existing surface waters.
- Design standards for outlet structures associated with forebays are described in Section 8.1.4.

Wayne County generally requires forebays to have side slopes no steeper than 1:6. However, earthen berms used as a weir between the forebay and an open detention basin have no minimum side slope requirement.

**Vegetation Specifications**
The type of vegetation used is dependant on site-specific conditions, such as soil types, amount of sunlight, and other factors. Vegetation specifications for forebays are the same as those for open detention basins (see Section 8.1.1).

**Maintenance**
Maintenance activities for forebays are the same as those for open detention basins (see Section 8.1.1). These activities must be identified in the submitted maintenance plan.
8.2.2 Bioretention Areas

Bioretention areas are designed to use soil and plant material to mimic natural processes and store, filter and infiltrate storm water into the ground. Bioretention areas may be used anywhere to achieve a degree of stormwater treatment; the location depends in part on the type of facility employed. Common applications include:

- Pretreatment system for detention systems and retention basins.
- Within parking lots: bioretention areas are recessed and the pavement is graded to these areas, where storm water is captured and treated (see figure above). Traditional parking lots typically have curbed, elevated islands of vegetation.

- On new residential subdivision lots or commercial lots, near the source of the runoff generated from impervious surfaces.
- Areas upland from inlets or outfalls that receive sheet flow from graded areas.
- Areas of the site that are planned to be excavated or cut.
- In stormwater management retrofit and redevelopment situations, the addition of bioretention facilities will provide some improvement in the amount of runoff and in water quality.

Schematic showing example Bioretention Area (Photo bottom left and Figure above from Wisconsin Department of Natural Resources, Post Construction Stormwater Management presentations)

Benefits of Use
Potential benefits for the incorporation of bioretention facilities as part of storm water management systems include:

- Assist with compliance with Wayne County Storm Water Standards
- Reduces impervious surfaces and increases the amount of disconnected impervious areas, which reduces the amount of storm water runoff that must be managed.
- Potential reductions in the need for and size of traditional storm sewers and storm water management systems.
- The above ground pooled water and some of the below ground storage volume can be counted toward meeting the water resources protection requirements described in Chapters 5 and 6.
Greater lot yields.
May count as both part of the required stormwater management system and toward local landscape and/or green space requirements.
Increases natural habitats within a development.
Construction and maintenance of bioretention facilities can be less costly than detention ponds.

Components of a Typical Bioretention Area (Figure from Bioretention Manual, Prince George’s County, Maryland)

Features of Bioretention Areas
Bioretention areas typically have the following features:

- **Grass buffer strips** reduce runoff velocity and filter particulate matter.
- **Sand bed** provides aeration and drainage of the planting soil and assists in the flushing of pollutants from soil materials.
- **Ponding area** provides storage of excess runoff and facilitates the settling of particulates and evaporation of excess water.
- **Organic layer** performs the function of decomposition of organic material by providing a medium for biological growth (such as microorganisms) to degrade petroleum-based pollutants. It also filters pollutants and prevents soil erosion.
- **Planting soil** provides the area for storm water storage and nutrient uptake by plants. The planting soils contain clays, which adsorb pollutants such as hydrocarbons, heavy metals and nutrients.
- **Vegetation** functions in the removal of water through evapotranspiration and pollutant removal through nutrient cycling.

Design Standards
Bioretention areas must be designed as follows:

- The drainage area to each bioretention area should be smaller than 5 acres and preferably less than 1 acre. Note that there can be multiple bioretention areas within a given development site.
- Sheet flow to bioretention areas should travel a maximum distance of 150 feet.
- A vegetated buffer strip with a minimum width of 2 feet must be provided around each bioretention area. The width of the buffer strip around bioretention areas is measured from the maximum water surface elevation of the ponding area associated with the bioretention area.
- The depth of the ponding area in a bioretention area cannot exceed 6 inches (see Typical Bioretention Cross-Section at end of this section). A maximum of 3 inches to 4 inches is preferred for areas that receive high hydraulic loading or have soils with low infiltration rates. This should be done in combination with a smaller drainage area.
- Soil borings and field infiltration/laboratory tests must be performed to determine characteristics of the in-situ soils at the proposed bioretention areas.
- Bioretention areas must include an underdrain and overflow structure (see Typical Bioretention Overflow Structure detail at end of this section), unless the applicant demonstrates that the infiltration rate of soil within the bioretention area is sufficient to prevent excess ponding. Underdrains must satisfy the following requirements:
  - Underdrains must have a hydraulic capacity greater than the infiltration rate of the soil in the bioretention area.
  - The underdrain must be perforated along its entire length. The location of the perforations (invert of pipe or elsewhere) depends upon the design of the facility. Typically, the perforations are placed closest to the invert of the pipe to achieve maximum potential for draining the facility. The perforations can be placed near the top of the pipe if an anaerobic zone is intended. Water below the perforated portion of the underdrain will have a tendency to
accumulate during periods of saturation. Otherwise, water will have a tendency to infiltrate into the surrounding in-situ soils.

- Underdrains cannot be perforated within 5 feet of where the underdrain system connects to a storm sewer structure.
- Underdrains must include an adequate outlet into a detention system, retention basin, storm sewer or watercourse to achieve positive flow.
- A 6-inch gravel bed is required to protect underdrain pipes and to reduce clogging. A gravel blanket around the underdrain helps keep it free of possible soil transport.
- The underdrain system must include a cleanout well to provide access for cleaning the system.

- The bottom of bioretention areas should be 3 feet or more above the seasonal high ground water table.
- A maximum of 20% void spaces in the planting soils and underdrain gravel blankets can be considered storage volume within the bioretention area.
- Bioretention areas may not be located within pre-existing surface waters.

Grading and Landscape Plans

Applicants that propose to include one or more bioretention areas as components of a storm water management system must submit a grading plan for the development project. The grading plan must clearly identify bioretention areas in relation to the topography and physical location. In addition, the grading plan must clearly identify routes for construction traffic that direct traffic around the bioretention areas. Allowing construction traffic to traverse a bioretention area may compact the soils or other subsurface media.

Applicants that propose to include one or more bioretention areas as components of a storm water management system also must submit a landscape plan for the development project. At a minimum, the landscape plan must specify soils and plant materials that the applicant proposes to include in a landscape, and describe the methods and planting techniques that the applicant proposes to utilize. Landscaping is included as regulated construction activity for which financial assurance must be provided.

Preferred Design Elements

- Distributed placement of bioretention areas across a development site results in smaller, more manageable subwatersheds within the development site.
- On new residential subdivision lots or commercial lots, bioretention areas should be located near the source of the runoff generated from impervious surfaces. Facilities should be located near the perimeters and edges to maintain typical use of the property.
- Bioretention areas should not be located within 10 feet of building foundations unless the building design incorporates adequate waterproofing measures. Bioretention areas should not be located near wellheads or septic systems.
- Bioretention areas should not be located within 10 feet of public road rights of way.
- To minimize excess ponding, excess runoff should be diverted away from the bioretention by grading the elevation of maximum surface ponding equivalent to the elevation at which runoff is discharging into the bioretention area.
- A safe overland flow path for the excess runoff is recommended.
- Bioretention areas should be designed as off-line systems whenever possible. This is to prevent erosive flow of water within the facility.
- Sloped areas exceeding 20% should not be used for bioretention unless “weep-garden” designs are employed.
- Bioretention areas should not be built where wooded areas would need to be cleared, to make room for the facility.
- Bioretention areas should be located away from traveled areas such as public pathways to avoid compaction.
- In parking lot applications, bumper blocks or gapped curbing should be used to prevent entry of vehicles into the bioretention area.
- A raised underdrain has the effect of providing a storage area below the invert of the underdrain discharge pipe. The storage area is equal to the void space of the material used.
Filters
Filter material should be used between the gravel blanket around the underdrain and the planting soil above.

- A pea gravel diaphragm to filter water and soil before passing through to the underdrain gravel blanket is recommended. It should have a minimum thickness of 3-4 inches and a maximum thickness of 8 inches. Where situations permit, a greater depth may be appropriate, although the depth generally should not exceed 12 inches.
- A permeable filter fabric should be placed between the underdrain gravel blanket and the pea gravel diaphragm where the underdrain is located. The filter fabric should extend 2 ft to either side.
- Filter fabric may be placed along the "walls" of the bioretention area to help direct the water flow downward and to reduce lateral flows. For example, to prevent lateral flow under roads and parking lot pavement, filter fabric can be placed along the sidewalls of a bioretention area that is installed in the median strip or parking lot landscape island. The fabric should extend from the subgrade over the stone.

Rain Garden at Lathrup Village Offices (Photo courtesy of Lillian Dean, Southeastern Oakland County Water Authority)

Planting Soil
- The planting soil should have sufficient depth to provide adequate moisture capacity and to create space for root systems. There is a preferred mixture for planting soil used in bioretention facilities (see “Material Specifications” below).
- Planting soil should be 4 inches deeper than the bottom of the largest root ball.

Plants
- Select plant materials that can tolerate extreme hydrologic changes, pollutant loading, and highly variable soil mixture conditions. Use of native plants is highly recommended. The material specification section below presents plant species recommended for bioretention areas.
- The minimum recommended caliper size for trees planted within a bioretention facility is 1 inch.
- Plant material and planting applications should meet guidelines set by the American Standard of Nursery Stock. Plant stock should be grown by suppliers or nurseries certified by the Michigan Native Plant Producers Association (see “References” for this section).

Material Specifications
- **Planting Soil**: Planting soil should have a sandy loam, loamy sand, or loam texture per USDA textural triangle. Maximum clay content is <5%. The soil mixture should have pH between 5.5 and 6.5 with an organic content of 1.5 – 3.0 %. The soil mixture should have an infiltration rate greater than 0.5 in/hour. The soil should be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches. No other materials or substances should be mixed or dumped within the bioretention area that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations. The planting soil should be free of Bermuda Grass, Quack Grass, Johnson Grass, Mugwort, Nutsedge, Poison Ivy, Canadian Thistle, Tearthub, or other noxious weeds.
- **Sand**: Sand should be clean and free of deleterious materials. For planting soil, MDOT Class II clean sand is recommended.
- **Mulch**: Mulch should consist of raw hardwood, MDOT Quality Product List (QPL). Grass clippings are unsuitable for mulch, primarily due to the excessive quantities of nitrogen built up in the materials.
- **Geotextile fabric**: Geotextile fabric should maintain a flow rate of 125 GPM per square foot. MDOT specifications are recommended (Table 910-1).

- **Underdrain gravel blanket**: The gravel blanket should be double washed, 1-1/2 inches in size. MDOT 4AA, 6A, or 6AA porous material is recommended.

- **Pea Gravel**: Pea gravel should be washed, river-run, round diameter, ¼ - ½ inches in size.

- **Underdrain piping**: A variety of materials can be used for underdrain piping, including heavy-duty PVC pipe and corrugated metal pipe. Other pipe materials may be used.

- **Vegetation**: The following is a partial listing of plants native to southeast Michigan that may be suitable for bioretention areas. The plants listed here are excellent for moist organic gardens that are “dry” within 48 hours of a rain. Check sun/shade conditions before planning and planting.

  **Wildflowers, sedges, and grasses**
  - Beardtongue (*Penstemon digitalis*)
  - Bergamot (Bee-Balm) (*Monarda fistulosa*)
  - Black-Eyed Susan (*Rudbeckia hirta*)
  - Blue Flag Iris (*Iris Virginica*)
  - Blue Vervain (*Verbena hostata*)
  - Boneset (*Eupatorium perfoliatum*)
  - Canada Anemone (*Anemone canadensis*)
  - Columbine (*Aquilegia canadensis*)
  - Culver’s Root (*Veronicastrum virginicum*)
  - Indian Grass (*Sorghastrum nutans*)
  - Joe-Pye Weed (*Eupatorium Maculatum*)
  - Marsh Blazing Star (*Liatris spicata*)
  - Missouri Ironweed (*Vernonia missurica*)
  - New England Aster (*Aster novae-angliae*)
  - Old-Field Cinquefoil (*Potentilla simplex*)
  - Porcupine Sedge (*Carex hystericina*)
  - Sneezeweed (*Helenium autumnale*)
  - Spiderwort (*Tradescantia Ohiensis*)
  - Swamp Goldenrod (*Solidago patula*)
  - Swamp Milkweed (*Asclepias incarnata*)
  - Tall or Green-Headed Coneflower (*Rudbeckia trilobum*)
  - Tall Tickseed (*Coreopsis verticillata*)
  - White Turtlehead (*Chelone glabra*)
  - White Vervain (*Verbena urticiforia*)
  - Wild Strawberry (*Fragaria virginiana*)

- **Shrubs**
  - American Cranberrybush Viburnum (*Viburnum trilobum*)
  - Black Chokeberry (*Aronia prunifolia*)
  - Common Buttonbush (*Cephalanthus occidentalis*)
  - Meadowsweet (*Spiraea alba*)
  - Ninebark (*Physocarpus opulifolius*)
  - Redosier Dogwood (*Cornus stolonifera*)
  - Shrubby Cinquefoil (*Potentilla fruticosa*)
  - Shrubby St. John’s-Wort (*Hypericum prolificum*)
  - Spicebush (*Lindera benzoin*)
  - Steeplebush (*Spiraea tomentosa*)

**Construction**

Proper construction techniques (including proper grading), adequate landscaping, suitable soil mixtures, and approved materials are critical to the success of bioretention areas.

- The grading plan for the entire development project must clearly identify the bioretention areas. Grading of or construction traffic over those areas should be avoided.

- The area surrounding the bioretention areas should be stabilized prior to construction of the bioretention areas to minimize compaction and contamination of the bioretention site.

- Placement of the gravel over the underdrain must be done with care. Avoid dropping the gravel high levels from a backhoe or front-end loader bucket. Spill directly over underdrain and spread manually.

- Placement of the planting soil in the bioretention area should be in lifts of 12 to 18 inches and lightly compacted. Minimal compaction effort can be applied to the soil by tamping with a bucket from a dozer or backhoe. Do not use heavy equipment within the bioretention facility. Heavy equipment can be used around the perimeter of the basin to supply soils and sand. Grade bioretention materials with light equipment such as a compact loader or a dozer/loader with marsh tracks.

- Compaction will significantly contribute to design failure. Compaction can be alleviated at the base of the bioretention facility by using a primary tilling operation such as a chisel plow, ripper, or subsoiler. These tilling operations are
to re-fracture the soil profile through the 12-inch compaction zone. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment.

- Rototill 2 to 3 inches of sand into the base of the bioretention facility before back filling the facility and placement of underdrain. Pump any ponded water before preparing (rototilling) base.
- In order to speed up the natural compaction process, presoaking the placed soil may be performed. Significant settlement can occur after the first presoak, and additional settlement may occur subsequent to the initial wetting. If time and construction scheduling permits, it is preferable to allow natural settlement to occur with the help of rain events to presoak the soil medium.

**Construction of Rain Garden at Lathrup Village Offices**  
(Photo courtesy of Lillian Dean, Southeastern Oakland County Water Authority)

**Maintenance**

Proper maintenance will not only increase the expected life span of the facility, but will also improve aesthetics. Annual maintenance of plant material, soil layer and the mulch layer is required for the overall success of bioretention systems.

- Mulch should be re-applied once every six months, to maximize nitrogen uptake by the facility and to help control growth of unwanted plants. The mulch layer should be removed and replaced every 2 years.
- Mulch should be uniformly applied approximately 2 to 3 inches in depth. Piling mulch around the base of the tree is not recommended as the tree may become infested with pests and diseases. Mulch applied any deeper than three inches reduces proper oxygen and carbon dioxide cycling between the soil and the atmosphere, and keeps roots from making good contact with the soil.
- Soils begin filtering pollutants immediately but can lose their ability to function in this capacity over time. Evaluation of soil fertility is important in maintaining an effective bioretention system. It is recommended that soils be tested annually and replaced when soil fertility is lost. Depending on environmental factors, this usually occurs within 5-10 years of construction.
- As with any garden, bioretention requires weeding to control growth of unwanted plants that can be invasive, consuming the intended planting, and destroying the aesthetic appeal. Weeding should be accomplished routinely and at least monthly.
- Water in the facility should infiltrate the system within 4-6 hours or less. Clogging or blockage of either the surface layer or fines obstructing the filter fabric used between the gravel bed/underdrain and the surrounding planting soil usually causes pooling water. Including a clean out pipe in the underdrain system will provide access for cleaning the system. Removing the mulch layer and raking the surface may correct the surface blockage problem. For blocked filter fabric, use lengths of small reinforcing bar (e.g., 2-3 ft of #4 rebar) to puncture the fabric with holes every 1-foot on center. If the soils themselves are causing the problem, punch holes in the soil or optionally, install a “sand window” at least 1 foot wide running vertically to the underdrain system elevation.
- If plants wilt during the heat of the day, but recover in the evening, watering is not necessary. The plants are simply conserving moisture. If they do not recover, watering is indicated. Another good rule of thumb is to stick a pencil or screwdriver about four inches into the soil. If the soil is moist at that depth, watering is not needed. If the soil is dry, and the shrubs or trees were planted within the last three years, watering is necessary.
- If any of the plants do not perform well, become diseased or die, they should be replaced.
- For trimming and harvesting, the current practice is to leave ornamental grasses and
perennial seed heads standing to provide winter interest, wildlife forage, and homes for beneficial insects. Plants should not be cut back until spring when new growth commences, and even then it is only done for neatness; it does not impact growth. Plants may be pinched, pruned, sheared or deadheaded during the growing season to encourage more flowering, a bushier plant, or a fresh set of leaves. Diseased or damaged plant parts should be pruned as they occur. If a plant is pest-infested, perform cleanup in fall to deny the pest a home. Trees and shrubs may be pruned for shape or to maximize fruit production.

- The properly designed bioretention area should thrive and allow planting materials to expand and propagate, eventually becoming overcrowded. If this occurs, perennial plants should be divided in spring or fall.
- By design, bioretention facilities are located in areas where nutrients (especially nitrogen) are significantly elevated above natural levels. Fertilization in such areas usually is unnecessary, because it is unlikely that soil fertility will be the limiting factor in plant growth. If soil fertility is in doubt, a simple soil test can resolve the question. If fertilization should become necessary, an organic fertilizer will provide nutrients as needed without disrupting soil life.
- Runoff flowing into bioretention facilities may carry trash and debris with it, particularly in commercial settings. Trash and debris should be removed regularly both to ensure that inlets do not become blocked and to keep the area from becoming unsightly.

References and Additional Resources
- American Hort. www.americanhort.org
- City of Wayne (MI), “City Hall Storm Water Quality Improvements Project Fact Sheet” and project summary, Clean Michigan Initiative Nonpoint Source Grant “City Hall Storm Water Quality Improvements”. Contact: Ramzi El-Gharib, City Engineer. Additional project information provided by Michelle West; Ayres, Lewis, Norris & May, Inc.
  Project summaries, photos, location and contact information, web links, and other information for a variety of storm water and watershed management practices in six categories including Bioretention / Low Impact Development / Native Landscaping
- Low Impact Development Center www.lowimpactdevelopment.org
Resources For Native Plant Material

  http://www.MNPPA.org
  http://www.macd.org/
- Wild Ones Organization.
  http://www.wildones.org/
Typical Bioretention Cross-Section
N.T.S.

Cover "C" Per
Wayne County S-15
Or Equal

TYPICAL BIORETENTION OVERFLOW STRUCTURE
NOT TO SCALE

* UNDERDRAIN PIPE SHOULD NOT BE PERFORATED WITHIN 5 FT OF THE OVERFLOW STRUCTURE
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8.2.3 Manufactured Treatment Systems

Description
Manufactured treatment systems are manmade devices or structures that are used to remove sediment and other particulate matter from storm water runoff. Manufactured treatment systems may be used at the inlets to underground detention systems, open detention basins, or retention basins. By removing settleable materials, pretreatment systems reduce the amount of material that accumulates in detention/retention systems, and the frequency at which accumulated materials must be removed. Manufactured treatment systems are particularly applicable in small development sites for meeting the water resources protection performance standard of the Wayne County Storm Water Management Standards.

Wayne County periodically evaluates various types of manufactured treatment systems for conformance with the design standards, preferred design elements, and materials specifications presented in this section. Please refer to the “Guideline for Wayne County Review of Manufactured Treatment Systems” document available from the Wayne County website for more information about the review process (see the “Supplemental Information” webpage at http://waynecounty.wc/mygovt/doe/depts/wqd/supplement_info.aspx). Please contact the Wayne County Permit Office (734-595-6504) for more information about which types of manufactured treatment systems have been reviewed by Wayne County under this procedure.

Design Standards

- Manufactured treatment systems must include a chamber or other device to accumulate and store settleable solids in a manner and a location that will prevent re-suspension of previously captured particulates.
- The system should be capable of removing 80% of the net annual Total Suspended Solids (TSS) load based on a 75-micron (and smaller) particle size for a gradation mix of “50-125” microns.
  - Annual TSS removal efficiency estimates or models must be based on documented removal efficiency performance from certified full-scale independent studies (for example, laboratory tests) over a range of storm sizes.
  - The tested full-scale model should be tested for efficiency under various flow rates at equal increments. The flow rate increments should start at a minimum of 10% of presumed capacity up to at least 25% above the presumed capacity. There should be a minimum of 3 tests at each incremental flow rate. The influent concentration should be a maximum of 300 mg/L.
  - Supporting engineering calculations and other relevant documentation for upscaling and downscaling the full-scale tests of select size units to other size units should be provided.
  - Generally, annual TSS removal efficiency models should be corroborated by field tests performed by an independent third party using influent and effluent composite samples from a minimum of ten storms at one location.
  - Procedures for submitting a manufactured treatment system to Wayne County for review for compliance with these criteria are documented in “Guideline for Wayne County Review of Manufactured Treatment Systems”; check the website for the most current version of this document (http://waynecounty.wc/mygovt/doe/depts/wqd/supplement_info.aspx).
  - A water-lock feature must be incorporated into the design of the storm water treatment system to prevent the introduction of trapped oil and floatable contaminants to the downstream piping during routine maintenance and to ensure that no oil escapes the system during subsequent storm events.
  - Peak flow rates for various models of manufactured treatment systems that have been approved by the County under this section are shown in Table 8.2.3-1.
  - The installed manufactured treatment system (manufactured unit and surrounding soil structure) must sustain an HS20 loading as determined by a Professional Engineer licensed in the State of Michigan.
  - The minimum cover of backfill material should be recommended by the manufacturer and approved by the Permit Engineer.

Preferred Design Elements and Materials
Due to the potential for manufactured treatment systems to malfunction and/or create maintenance problems, Wayne County recommends that manufactured treatment systems incorporate the following design elements:

- Manufactured treatment systems should be designed to treat up to the peak flow rate for the design storm event (i.e., 10-year storm).
• Manufactured treatment systems should be designed so that they do not re-suspend trapped sediments or re-entrain floating contaminants at flow rates up to or exceeding those for the design storm event.
• The system pump-out volume should be less than ½ of the total system volume.
• The system should not create backwater in the upstream piping network for flows up to and including the design storm event.
• Direct access should be provided to the sediment and floatable contaminant storage chambers to facilitate maintenance. The storage chambers should have no appurtenances or restrictions within them which would prohibit removal of accumulated sediment and debris during maintenance.

**Materials Specifications**

Manufactured treatment systems may be constructed from pre-cast or cast-in-place concrete or other materials approved by Wayne County and should meet the following specifications:

- For treatment systems made of cast-in-place or pre-cast concrete:
  - Concrete for pre-cast manufactured treatment systems should conform to ASTM C 857 and C 858.
  - Cement should be Type II Portland cement conforming to ASTM C 150.
  - Treatment systems constructed from pre-cast concrete should be manufactured in accordance with ASTM C 478.
    - Sections should be cured by an approved method and should not be shipped until (1) at least 5 days have passed since fabrication and/or repair, and (2) the concrete has attained a compressive strength of 4,000 psi.
  - Manufactured treatment systems constructed from cast-in-place concrete or reinforced concrete should conform to current Wayne County specifications for structural concrete.
  - Sections should have tongue and groove or ship-lap joints with a butyl mastic sealant conforming to ASTM C 990.
  - Wall thicknesses should not be less than 6 inches or as otherwise shown on the dimensional drawings
  - Openings should be sized to accept pipes of the specified size(s) and material(s), and should be sealed with hydraulic cement conforming to ASTM C 595M.
  - Internal aluminum plate components should be aluminum alloy 5052-H32 in accordance with ASTM B 209.
  - A bitumen sealant in conformance with ASTM C 990 should be utilized in affixing the aluminum swirl chamber to the concrete vault.
- For manufactured treatment systems (including smooth bubble and weir plates) fabricated from high density polyethylene (HDPE):
  - Virgin HDPE material should be used, conforming with the minimum requirements of cell classification 424420C (4-in – 10-in diameter) and 435440C (12-in – 60-in diameter) per ASTM C 3350.
  - The virgin HDPE material should be evaluated using the notched constant ligament-stress (NCLS) test as specified in Section 9.5 and 5.1 of AASHTO M294 and ASTM F2306.
  - Weir and battle plates shall be welded at all interfaces between the plate and water quality unit.
- For manufactured treatment systems fabricated from corrugated polyethylene pipe (CPE):
  - The system and all required fittings should conform to AASHTO M294 Type S.
  - Fittings and couplings must be noncorrugated, solid sleeve fabricated from polyethylene with a gasket on both sides of the joint.
  - Split collar couplers are not allowed.
  - Weir and battle plates shall be welded at all interfaces between the plate and water quality unit.

**Testing**

The manufacturer of these systems must contact the Wayne County Testing Office (734-595-6504 x 2015) at least 72 hours prior to fabrication to schedule inspection during fabrication. Wayne County inspects the material fabrication process to ensure that the manufacturer’s testing of the product occurs at the applicable AASHTO or ASTM standards.

**Installation**

Manufactured treatment systems must be constructed to serve the capacity shown on the drawings and as specified in the approved permit plans. The system must be installed at elevations and locations shown on the approved plans, or as otherwise directed by the County.

A Wayne County Permit Engineer must observe the installation of all manufactured treatment systems. Contact the Wayne County Permit Office (734-595-6504 x 2009) at least 72 hours days prior to installation to schedule inspection during
installation. Wayne County will not accept any manufactured treatment systems installed when a County Permit Engineer is not present; permits and financial assurances will not be released at the conclusion of construction for such systems.

The following procedures should be followed for installation of manufactured treatment systems:

- For concrete manufactured treatment systems, installation should conform to ASTM specification C 891 “Standard Practice for Installation of Underground Precast Utility Structures.” Cast-in-place installation should follow Wayne County specifications for structural concrete. Installation procedures recommended by the manufacturer, if any, should also be consulted.
- For manufactured treatment systems made of materials other than concrete, installation procedures recommended by the manufacturer should be followed. These procedures should be included in the application package submitted to Wayne County for approval of the entire storm water management system for the development project.
- The base unit of the manufactured treatment system should be placed on a subbase consisting of MDOT Class II granular material of a minimum thickness of six inches, or greater after compaction by the “Controlled Density Method” to 95% of the Maximum Unit Weight. The granular subbase should be checked for level prior to setting and the pre-cast base section of the trap should be checked for level at all four corners after it is set. If the slope from any corner to any other corner exceeds 0.5%, the base section should be removed and the granular subbase material re-leveled.
- For pre-cast concrete systems, prior to setting subsequent sections, a bitumen sealant that conforms to ASTM C 990 should be placed along the construction joint in the section that is already in place. Pre-cast sections should be set in a manner that will result in a watertight joint.
- For manufactured treatment systems made of materials other than concrete, prior to setting subsequent sections, a sealant that conforms to the specification recommended by the manufacturer should be placed along the construction joint in the section that is already in place. Sections should be set in a manner that will result in a watertight joint.
- For pre-cast concrete systems, holes made in the concrete sections for handling or other purposes should be plugged with a nonshrink grout or by using grout in combination with concrete plugs.
- For manufactured treatment systems made of materials other than concrete, holes made in the unit for handling or other purposes should be plugged with materials meeting the specification recommended by the manufacturer for such materials.
- For pre-cast concrete systems, where holes must be cut in the pre-cast sections to accommodate pipes, cutting should be completed before the sections are set in place, to prevent any subsequent jarring which may loosen the mortar joints. For manufactured treatment systems made of materials other than concrete, field cutting of the system to accommodate pipes is not allowed.
- Backfill around the manufactured treatment system should consist of:
  - MDOT Class II granular material for systems made of cast-in-place and pre-cast concrete
  - MDOT 6A, 2G, or 34G material for systems made of HDPE or CPE
- All backfill materials should be placed in a balanced manner and such that there is no more than a 2 lift differential from one side to the other. Balanced lifts should be advanced across the width of the system, evenly along the length of the system throughout the backfilling process.
- All backfill materials should be placed in lifts of maximum 10-inches in depth.
- For each backfill lift, all materials should be compacted to a minimum of 95% (90% minimum required for backfill consisting of MDOT 6A material) of the backfill material’s maximum unit weight at a moisture content not greater than the optimum. The maximum unit weight of the backfill material should be determined by the AASHTO T 180 or Michigan Cone Method. The frequency of the compaction testing should be one or more tests per lift of backfill around the trench of the structure.

Documentation of the following items relative to the installation of manufactured treatment systems is required to be submitted to the Wayne County Permit Engineer before permits and financial assurances before are released:

- All backfill materials are from Wayne County tested stock.
- All backfill materials were placed in lifts of maximum 10-inches.
- For each backfill lift, all materials were compacted to a minimum of 95% of the backfill material’s maximum unit weight at moisture content not greater than optimum. If MDOT 6A backfill material was used, materials were compacted to 90% of the backfill material’s maximum unit weight at moisture content not greater than optimum.
• The maximum unit weight of the backfill material was determined by the AASHTO T 180 or Michigan Cone Method.
• The compaction was tested a minimum of one test per lift of backfill around the trench of the structure.

**Maintenance**
Manufactured treatment systems should be maintained in accordance with the manufacturer’s recommended schedule.
# Table 8.2.3-1

PEAK FLOW RATES OF VARIOUS MODELS OF MANUFACTURED TREATMENT SYSTEMS
APPROVED BY WAYNE COUNTY UNDER THIS SECTION

Kennedy Solutions, Inc (KSI) Storm Water Treatment Systems

<table>
<thead>
<tr>
<th>KSI Model</th>
<th>Chamber Size/Diameter (inches)</th>
<th>Peak Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series 350</td>
<td>36</td>
<td>1.8</td>
</tr>
<tr>
<td>Series 500</td>
<td>48</td>
<td>2.3</td>
</tr>
<tr>
<td>Series 750</td>
<td>48</td>
<td>3.3</td>
</tr>
<tr>
<td>Series 1000</td>
<td>48</td>
<td>4.1</td>
</tr>
<tr>
<td>Series 1250</td>
<td>48</td>
<td>5.0</td>
</tr>
<tr>
<td>Series 1500</td>
<td>60</td>
<td>6.2</td>
</tr>
<tr>
<td>Series 1750</td>
<td>60</td>
<td>7.4</td>
</tr>
<tr>
<td>Series 2000</td>
<td>60</td>
<td>8.3</td>
</tr>
<tr>
<td>Series 2500</td>
<td>60</td>
<td>9.8</td>
</tr>
<tr>
<td>Series 3000</td>
<td>60</td>
<td>11.3</td>
</tr>
<tr>
<td>Series 3500</td>
<td>60</td>
<td>13.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stormceptor STC™ Model</th>
<th>Peak Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>0.48</td>
</tr>
<tr>
<td>900</td>
<td>0.99</td>
</tr>
<tr>
<td>1200</td>
<td>1.27</td>
</tr>
<tr>
<td>1800</td>
<td>2.22</td>
</tr>
<tr>
<td>2400</td>
<td>3.48</td>
</tr>
<tr>
<td>3600</td>
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<td>7200</td>
<td>13.98</td>
</tr>
<tr>
<td>11000</td>
<td>22.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vortechs™ Model</th>
<th>Peak Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>1.2</td>
</tr>
<tr>
<td>2000</td>
<td>2.1</td>
</tr>
<tr>
<td>3000</td>
<td>3.4</td>
</tr>
<tr>
<td>4000</td>
<td>4.5</td>
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<td>5000</td>
<td>6.4</td>
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<td>7000</td>
<td>8.3</td>
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<td>9000</td>
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<tr>
<td>11000</td>
<td>13.1</td>
</tr>
<tr>
<td>16000</td>
<td>18.8</td>
</tr>
</tbody>
</table>
8.3.2 Vegetated Swales

Description
Vegetated swales are broad, shallow channels lined with vegetation that slow and filter storm water runoff and promote infiltration. Vegetated swales can serve as storm water management conveyance and may also be used to achieve a degree of stormwater treatment. Common applications include:

- Storm water conveyance within a development site. Vegetated swales can replace curbs, gutters, and storm sewer systems along roads or and/or parking areas where local community standards and site conditions permit.
- Storm water management retrofit and redevelopment situations. The addition of grassed swales will provide some improvement in the amount of runoff and in water quality.

Vegetated swales are best suited for relatively small drainage areas such as areas of sheet drainage up to 2 acres (e.g. along roadways, around parking lots, and as buffers between properties). They may count both as part of the required storm water management system and toward local landscape and/or green space requirements.

Design Criteria

- A maximum 150-foot distance of sheet drainage to the swale is recommended, with varying grades up to a maximum of 3%.
- If a storm sewer discharges into a swale, energy dissipation should be used at the point of inlet.
- The flow capacity of vegetated swales used as conveyance in storm water management systems must equal or exceed the peak flow rate for the 10-year storm.
- To reduce the possibility of erosion, swales should be designed with peak flows that do not exceed 5 cfs.
- Flow velocities in vegetated swales should range between a minimum of 2 ft/sec and a maximum of 5 ft/sec.
- Check dams may be used to reduce velocities, promote infiltration, increase storage and enhance water quality. Earthen check dams are not recommended because of their potential to erode. Toe protection is recommended for all check dams.
- The minimum acceptable longitudinal slope of a vegetated swale is 0.15% unless other techniques such as infiltration devices are employed.
- The maximum longitudinal slope of a vegetated swale should not exceed 3%, unless check dams are used.
- Swale length should be a minimum of 200 feet wherever possible, to increase the contact time of storm water.
- A parabolic or trapezoidal shape is recommended, with side slopes no steeper than 3:1. Soil conditions, vegetative cover and maintenance ability should be considered when designing the side slopes.
- A minimum freeboard of 6 inches below the top of bank is recommended.
- The maximum recommended water depth for temporary pooling of water is 6 inches. A maximum of 3 inches to 4 inches is preferred for areas that receive high hydraulic loading or have soils with low infiltration rates. This should be done in combination with a smaller drainage area.
- Clearance between the swale invert and underground utilities should be addressed as part of the design process. A minimum clearance of 5 feet between swale invert and underground utilities is recommended unless special provisions are employed.
- There may be additional design criteria for vegetated swales adjacent to roads, particularly those under the jurisdiction of another agency (e.g., MDOT).
- Grading plans for the development project should clearly identify the location of vegetative swales in relation to the topography and physical location. The grading plans should clearly identify the routing of construction traffic such that it does not traverse the swale locations.
- Swales should follow the natural, pre-development drainage path when possible.
Vegetation Specifications
Applicants that propose to use vegetated swales as part of a storm water management system must submit a landscaping plan with the application for storm water construction approval. The landscaping plan is required because vegetation is essential to the proper functioning of the swale. Landscaping is part of the regulated construction activity for which financial assurance must be provided.

Vegetation should be uniform and should consist of fine, turf-forming water-resistant grasses. Deep-rooted native wetland and upland grasses are preferred for infiltration and reduced maintenance.

In areas with high groundwater and/or little slope, the southeast Michigan native plants suitable for bioretention areas (see Section 8.2.2) should be considered. The plants listed in Section 8.2.2 are excellent for moist organic areas that are “dry” within 48 hours of a rain.

Plant material and planting applications should meet guidelines set by the American Standard of Nursery Stock (see “References” on page 8-5). Plant stock should be grown by suppliers or nurseries certified by the Michigan Native Plant Producers Association.

Maintenance
Maintenance of vegetated swales should be focused on keeping a dense, healthy vegetated cover and keeping up the hydraulic and removal efficiency of the channel. Maintenance activities related to the vegetated cover include mowing (with grass never cut shorter than the design flow depth), weed control, and re-planting/seeding of bare areas. “River friendly” lawn and garden practices (see References below) should be followed in the maintenance of vegetated swales.

Vegetated swales should periodically be cleared of debris and blockages. Periodic sediment cleanout should be done manually to avoid the transport of resuspended sediments in periods of low flow and to prevent a damming effect from sediment buildup.

Damaged areas (e.g., ruts or holes) within a channel should be repaired utilizing a suitable soil that is properly tamped and seeded.

Inlets and outlets should be inspected periodically for blockage, signs of soil erosion, and structural damage. Swales should be inspected for sediment accumulation semiannually and after rain events. Sediment that is impeding flow should be removed. Inlets, outlets, and appurtenances (e.g., grates) should be inspected annually for structural integrity. Outlets should be checked regularly for clogging and should be cleaned when necessary, especially after large storm events.

References
- International Storm Water Best Management Practices Database. www.bmpdatabase.org
- The following documents, published by the (SE MI) Healthy Lawns and Gardens Technical Advisory Committee, are available from Wayne County’s website at http://www.waynecounty.com/doe/watershed/mgmtBioretention.htm
  o “Healthy Law Care Tips”, Spring 2006.
  o “Earth Friendly Fertilizers Recommended for Lake and River Water Quality Protection, Southeast Michigan”, 2006
  o See also their website www.healthylandscapes.com
- United States Environmental Protection Agency, Office of Water. Storm Water Technology Fact Sheet: Vegetated
References: Native Landscaping

  http://www.macd.org/rollovers/nativeplants/nphome.html
- United States Environmental Protection Agency
  www.epa.gov/greenacres/
- Wild Ones Organization. Landscaping with Native Plants.
  www.for-wild.org

Resources For Native Plant Material

- Michigan Native Plant Producers Association, “Plants and Seeds Source Guide” and “List of Member Nurseries”.
  http://www.MNPPA.org
CHAPTER 11: SAMPLE CALCULATIONS

11.1 TYPICAL STORM WATER MANAGEMENT SYSTEM WITH OPEN DETENTION BASIN

The following example is used to illustrate the calculations required to design a typical storm water management system. In this example, a single family residential development project is proposed on a 24-acre parcel of land and discharges to a water course. Determine the developed runoff coefficient, storm sewer, forebay, open detention basin, and outlet sizing requirements necessary for proper design of the storm water management system assuming no off-site area drains onto the parcel. The detention basin is intended to meet the flood control and water resource protection performance standards.

Runoff Volume Determination

In this example, the proposed land use for the site is as follows:

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area (A) (acres)</th>
<th>Runoff Coefficient (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>2</td>
<td>0.95</td>
</tr>
<tr>
<td>Lawn (Soil Group D, 3%)</td>
<td>19</td>
<td>0.45</td>
</tr>
<tr>
<td>Asphalt, concrete</td>
<td>3</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Runoff coefficient information may be found in Chapter 6 of this manual.

Calculate the weighted runoff coefficient:

\[ C = \frac{\sum (A_i \times C_i)}{A} \]

\[ C = \frac{[(2 \times 0.95) + (19 \times 0.45) + (3 \times 0.95)]}{(2+19+3)} = 0.55 \]

C = runoff coefficient
A = drainage area (acres)

Closed Conduit Sizing

This sample closed conduit calculation is for three runs of storm sewer pipe within the storm water management system. The following equations are used:

Rational Method

\[ Q = C \times I \times A \]

Q = peak flow rate (cfs)
C = runoff coefficient
I = rainfall intensity (in/hr)
A = drainage area (acres)

Rainfall Intensity

\[ I = \frac{151.8}{t + 19.9} \]

I = rainfall intensity (in/hr)
t = time of concentration, or the time duration (minutes) required for runoff from the most remote area of the watershed to reach the point of study. An initial time of concentration of 20 minutes should be used for single family residential land use.

Manning Formula

\[ Q = \frac{(1.486 \times A \times R^{2/3} \times S^{1/2})}{n} \]

Q = flow capacity (cfs)
A = cross sectional flow area (ft²)
n = Manning’s roughness coefficient
P = wetted perimeter (feet)
R = hydraulic radius (A/P in feet)
S = hydraulic gradient (ft/ft)

Calculations

Sample calculations for determining conduit sizes are illustrated in the table at the top of the following page. The calculations are based on a Manning’s roughness coefficient of 0.013.
Sample Calculations for Closed Conduit Sizing
For a 10-Year Storm Sewer Design

\[ Q = C \times \frac{151.8}{(t+19.9)} \times A \]

<table>
<thead>
<tr>
<th>Storm Sewer Line</th>
<th>From Structure</th>
<th>To Structure</th>
<th>Incremental Area (Acres)</th>
<th>C Factor</th>
<th>Equivalent Area 100% Acres</th>
<th>Total Area 100% Acres CA</th>
<th>( t ) (Time (min))</th>
<th>( I ) (inch per hour)</th>
<th>( Q = CIA ) (cfs)</th>
<th>Pipe diam. (in)</th>
<th>Slope %</th>
<th>Length of Line (ft)</th>
<th>Manning Vel. in Pipe (ft/sec)</th>
<th>Time of Flow (min)</th>
<th>Manning Capacity of Sewer (cfs)</th>
<th>H.G. Elev. Upper End (ft)</th>
<th>Upper Invert Elev. (ft)</th>
<th>Lower Invert Elev. (ft)</th>
<th>Upper Structure Rim Elev. (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB1</td>
<td>CB2</td>
<td>0.38</td>
<td>0.35</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
<td>20.00</td>
<td>3.80</td>
<td>0.51</td>
<td>12</td>
<td>0.50%</td>
<td>105</td>
<td>3.23</td>
<td>0.54</td>
<td>2.54</td>
<td>24.61</td>
<td>24.75</td>
<td>24.22</td>
<td>27.75</td>
</tr>
<tr>
<td>CB2</td>
<td>R1</td>
<td>0.48</td>
<td>0.40</td>
<td>0.19</td>
<td>0.32</td>
<td>0.32</td>
<td>20.54</td>
<td>3.75</td>
<td>1.22</td>
<td>12</td>
<td>0.80%</td>
<td>78</td>
<td>4.07</td>
<td>0.32</td>
<td>3.20</td>
<td>24.59</td>
<td>24.12</td>
<td>23.50</td>
<td>27.75</td>
</tr>
<tr>
<td>R1</td>
<td>MH1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.32</td>
<td>0.32</td>
<td>20.86</td>
<td>3.72</td>
<td>1.21</td>
<td>4</td>
<td>0.80%</td>
<td>1</td>
<td>2.11</td>
<td>0.01</td>
<td>0.18</td>
<td>24.50</td>
<td>23.50</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Forebay Design**

Since the detention basin has only one inlet pipe, the basin will be designed with a single forebay with a permanent pool at elevation 100.5 feet. In accordance with the Ordinance and Rules, the forebay will be designed to capture the first flush runoff from the site and gradually release it over a period of 24 hours.

**Required Volume**

Determine the forebay volume required to store the first flush of runoff from the site.

\[ V_{ff} = 1,815 \times A \times C \]

\[ V_{ff} = 1,815 \times 24 \text{ acres} \times 0.55 = 23,958 \text{ ft}^3 \]

**Storage Provided**

The forebay storage volume provided should be shown in 1- foot (maximum) increments above the permanent pool water surface elevation (100.5 ft) as indicated in the table below. The incremental and cumulative storage volume provided at each elevation should be determined using the average surface area for that foot of depth.

The total storage volume provided in the forebay should be greater than or equal to the required forebay volume, which is the first flush storage volume. Determine the water surface elevation corresponding to the first flush storage volume by interpolation from the table of storage provided, as follows:

\[ Z_{ff} = \text{first flush storage elevation in forebay (ft)} \]

\[ Z_{ff} = 101.5 + (102.5 – 101.5) \times \frac{(23,958 – 11,542)}{(25,450 – 11,542)} \]

\[ = 102.4 \text{ ft} \]

**Outlet Design**

In this example, the forebay outlet will be designed as shown in the detail included in Section 8.1.4. The vertical riser and riser outlet pipe will be the primary outlet for the forebay. The weir/spillway will be the secondary outlet, which conveys flow into the detention basin when the forebay is full.

The top of the riser will be set at the first flush storage elevation (102.4 ft). The riser outlet pipe will have an upstream invert elevation of 100.5 feet. The crest of the weir/spillway (between the forebay and the detention basin) will be set to match the top of the riser (elevation 102.4 ft).
Riser Outlet Pipe and Flow Restrictor Sizing

To gradually release the first flush storage volume over a period of 24 hours, the desired average release rate is:

\[ Q_{\text{avg ff}} = \frac{V_{\text{ff}}}{86,400} \]

\[ Q_{\text{avg ff}} = \frac{23,958}{86,400} = 0.277 \text{ cfs} \]

The riser outlet pipe and flow restrictor will be sized to convey the desired average release rate given the average head in the forebay. Numerous orifices will be placed in the riser to convey unrestricted flow from the forebay into the riser. The riser outlet pipe (calculations follow) and not these orifices will serve as the restrictor for flow out of the forebay.

It should be noted that a similar riser and flow restrictor design are used for controlling the maximum release rate from the detention basin, but the calculations (shown on pg. 11-7) are performed differently. The forebay outlet pipe flow restrictor is sized using the average head to achieve an average release rate, while the detention basin outlet pipe flow restrictor is sized using the maximum head to achieve a maximum allowable release rate.

Since the forebay has a trapezoidal cross section, 2/3 of the maximum head in the forebay is a reasonable approximation to the average head as follows:

\[ h_{\text{avg}} = 0.667 \times (Z_{\text{ff}} - Z_{\text{out}}) \]

where: \( Z_{\text{out}} \) = upstream crown elevation of riser outlet pipe (ft) assuming the outlet pipe is designed to flow full at 0.277 cfs

The riser outlet pipe and flow restrictor calculations for the forebay are performed based on two key assumptions:

1. The forebay is completely full and the downstream detention basin is completely empty when forebay dewatering begins. This means the forebay will dewater in about 24 hours for a storm whose runoff matches the first flush storage volume, but will dewater faster for smaller storms (due to the smaller volume), and will dewater slower in larger storms (due to the higher downstream head on the riser outlet pipe).

2. During dewatering of the forebay (only), there is free discharge from the forebay riser outlet pipe into the detention basin.

Use the orifice equation to determine the required riser outlet pipe diameter which will yield the desired average release rate and holding time.

\[ d_{\text{out}} = \text{assume 4 inches (0.33 ft) for calculating } h_{\text{avg}} \]

\[ Z_{\text{out}} = 100.5 + 0.33 = 100.83 \text{ ft} \]

\[ h_{\text{avg}} = 0.667 \times (102.4 - 100.83) = 1.05 \text{ ft} \]

\[ A_{\text{out}} = \frac{Q_{\text{avg ff}}}{(0.62 \times \sqrt{2} \times g \times h_{\text{avg}})} \]

\[ A_{\text{out}} = \frac{0.277}{(0.62 \times \sqrt{2} \times 32.2 \times 1.05)} \]

\[ = 0.0543 \text{ ft}^2 \]

\[ d_{\text{out}} = 0.263 \text{ ft (3.16 inches)} \]

Since the riser outlet pipe should be a minimum of 4 inches in diameter, a 3-inch diameter hole will be drilled in the end cap on the vertical run of the outlet tee to act as the flow restrictor. No recalculation of \( h_{\text{avg}} \) is needed since the selected riser outlet pipe diameter equals the assumed diameter used in calculating \( h_{\text{avg}} \).

\[ d_{\text{out}} = 4 \text{ inches (0.333 ft)} \]

\[ A_{\text{out}} = 0.0871 \text{ ft}^2 \]

\[ d_{o} = 3 \text{ inches (0.25 feet)} \]

\[ A_{o} = 0.0491 \text{ ft}^2 \]

The actual average release rate through the flow restrictor and outlet pipe is:

\[ Q_{\text{avg ff}} = 0.62 \times A_{o} \times \sqrt{2} \times g \times h_{\text{avg}} \]

\[ Q_{\text{avg ff}} = 0.62 \times 0.0491 \times \sqrt{2} \times 32.2 \times 1.05 \]

\[ = 0.250 \text{ cfs} \]
Actual holding time is:

$$T_{ff} = \frac{V_{ff}}{(Q_{avg_{ff}} \times 3,600)}$$

$$T_{ff} = \frac{23,958}{(0.250 \times 3,600)} = 26.6 \text{ hrs, or approximately 24 hrs --- O.K.}$$

**Riser Outlet Pipe Slope**

Determine riser outlet pipe slope to be consistent with earlier assumption that it is flowing full at the actual average release rate. Use Manning’s equation with $n = 0.012$ for PVC pipe.

$$\text{Slope (ft/ft)} = \left[\frac{Q_{avg_{ff}} \times n}{(1.486 \times A_{out} \times R^{2/3})}\right]^2$$

$$R = \frac{d_{out}}{4} = \frac{0.333}{4} = 0.083 \text{ ft}$$

$$\text{Slope} = \frac{0.250 \times 0.012}{(1.486 \times 0.0871 \times 0.083^{2/3})} = 0.0148 \text{ ft/ft (1.5 %)}$$

Use 4 inch PVC pipe at 1.5 % slope.

Check velocity at full pipe flow condition against maximum allowable closed conduit velocity.

$$V = \frac{Q_{avg_{ff}}}{A_{out}} = \frac{0.250}{0.0871} = 2.87 \text{ ft/sec}$$

$$2.87 < V_{max} \text{ of 8 ft/sec --- O.K.}$$

**Outlet Weir Design**

The forebay outlet weir must be designed to convey flow from the forebay into the detention basin when the forebay level exceeds the top of the forebay storage volume. The weir must be designed to convey the peak flow rate tributary to the forebay for the 10-year design storm. The calculation assumes there is free discharge from the forebay into the detention basin.

From the storm sewer design calculations using the Rational Method (not included), the peak flow rate entering the forebay is 25 cfs. In this example, the embankment elevation between the forebay and detention basin will be set at 103.0 feet. The crest elevation of the weir within the embankment is set at the first flush storage elevation of 102.4 ft. The required width of the weir is determined using the following weir equation:

$$Q = C \times B \times H^{(3/2)}$$

where:

- $Q$ = Peak flow rate (cfs)
- $C$ = Coefficient (which varies with the type of weir)
- $B$ = Bottom width of the weir (ft)
- $H$ = Maximum allowable head on weir (ft)

For this example, a weir coefficient of 3.4 will be assumed to be representative.

$$B = \frac{25}{[3.4 \times (103 - 102.4)^{(3/2)}]} = 15.8 \text{ ft}$$

Therefore, the width of the weir from the forebay into the detention basin will be specified as 16 ft.

**Open Detention Basin Design**

Since the site is larger than 5 acres, the maximum allowable outflow from this site is 0.15 cfs/acre for the 100-year storm. The open detention basin will be designed with a permanent pool at elevation 100.0 feet, after verifying that this is below the downstream invert of the 30 foot long forebay riser outlet pipe as follows:

$$\text{Downstream Invert} = 100.5 - (0.0148 \times 30) = 100.06 > 100.0 -- \text{O.K.}$$

**Required Volume**

Determine the flood control storage volume required.

- $Q_a$ = maximum allowable outflow rate from the detention system (cfs)
- $Q_a = 0.15 \text{ cfs/acre} \times A$
- $Q_a = 0.15 \text{ cfs} \times 24 \text{ acres} = 3.6 \text{ cfs}$
- $Q_o$ = maximum allowable outflow rate per acre imperviousness (cfs/acre imperviousness)
- $Q_o = Q_a / (A \times C)$
- $Q_o = 3.6 / (24 \times 0.55)$
- $Q_o = 0.27 \text{ cfs/acre imperviousness}$

$$T_{100} = \text{Storage time defined as the instant storage begins until peak storage is attained (minutes)}$$
\[ T_{100} = -45 + \sqrt{19,845 / Q_o} \]

\[ T_{100} = -45 + \sqrt{19,845 / 0.27} = 226.1 \text{ minutes} \]

\[ V_s = \text{Maximum volume of water stored in the detention system per acre imperviousness (ft}^3/\text{acre imperviousness)} \]

\[ V_{s\ 100} = \frac{[(17,649 \times T_{100})/(T_{100} + 45)] - 40 \times Q_o}{x \times T_{100}} \]

\[ V_{s\ 100} = \frac{[(17,649 \times 226.1)/(226.1 + 45)] - 40 \times 0.27 \times 226.1}{x} \]

\[ V_{s\ 100} = 12,278 \text{ ft}^3/\text{acre imperviousness} \]

\[ V_{t\ 100} = \text{maximum volume of water stored in the detention system (ft}^3) \]

\[ V_{t\ 100} = V_{s\ 100} \times A \times C \]

\[ V_{t\ 100} = 12,278 \times 24 \times 0.55 = 162,070 \text{ ft}^3 \]

Determine the bank full flood storage volume \( (V_{t\ bf}) \)

\[ V_{t\ bf} = 5,160 \times A \times C \]

\[ V_{t\ bf} = 5,160 \times 24 \times 0.55 = 68,110 \text{ ft}^3 \]

### Storage Provided

The detention basin storage volume provided should be shown in one foot (maximum) increments above the permanent pool water surface elevation (100.0 ft) as indicated in the table shown at the top of the next column on this page. The incremental and cumulative storage volume provided at each elevation should be determined using the average surface area for that foot of depth. The volumes in this table include all volume in the detention basin, plus the portion of the forebay volume that is above the first flush storage elevation of 102.4 feet.

The total storage volume provided in the detention basin should be greater than or equal to the required flood control storage volume. Determine the water surface elevation corresponding to the bank full flood and 100-year flood by interpolation from the table of storage provided as described below.

The portion of the bank full flood to be captured in the detention basin is determined by subtracting the first flush storage volume provided in the forebay.

\[ V_{t\ bf\ -\ adjusted} = 68,110 - 23,958 = 44,152 \text{ ft}^3 \]

\[ Z_{bf} = \text{bank full flood storage elevation (ft)} \]

\[ Z_{bf} = 102.4 + (103.0 - 102.4) \times \frac{44,152 - 38,901}{60,542 - 38,901} \]

\[ = 102.5 \text{ ft} \]

The portion of the flood control storage volume to be captured in the detention basin is also determined by subtracting the first flush storage volume provided in the forebay.

\[ V_{t\ 100\ -\ adjusted} = 162,070 \text{ ft}^3 - 23,958 \text{ ft}^3 \]

\[ = 138,112 \text{ ft}^3 \]

\[ Z_{100} = \text{flood control storage elevation (ft), also referred to as the design water level for the basin} \]

\[ Z_{100} = 104 + (105 - 104) \times \frac{138,112 - 101,209}{147,970 - 101,209} \]

\[ = 104.8 \text{ ft} \]

### Storage Provided in Detention Basin and Forebay in Addition to First Flush Storage Volume

<table>
<thead>
<tr>
<th>Elev. (feet)</th>
<th>Basin Only</th>
<th>Forebay (only above elev. Zff)</th>
<th>Basin Only</th>
<th>Forebay (only above elev. Zff)</th>
<th>Cumul. Volume (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>13,103</td>
<td>---</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>101.0</td>
<td>15,631</td>
<td>---</td>
<td>14,350</td>
<td>0</td>
<td>14,350</td>
</tr>
<tr>
<td>102.0</td>
<td>18,359</td>
<td>---</td>
<td>16,979</td>
<td>0</td>
<td>31,329</td>
</tr>
<tr>
<td>102.4</td>
<td>19,506</td>
<td>14,902</td>
<td>7,572</td>
<td>0</td>
<td>38,901</td>
</tr>
<tr>
<td>103.0</td>
<td>21,287</td>
<td>16,466</td>
<td>12,234</td>
<td>9,407</td>
<td>60,542</td>
</tr>
<tr>
<td>104.0</td>
<td>24,415</td>
<td>19,232</td>
<td>22,835</td>
<td>17,832</td>
<td>101,209</td>
</tr>
<tr>
<td>105.0</td>
<td>27,744</td>
<td>22,198</td>
<td>26,063</td>
<td>20,698</td>
<td>147,970</td>
</tr>
</tbody>
</table>

### Outlet Design

In this example, the detention basin outlet will be designed as shown in the detail in Section 8.1.4.
The vertical riser and riser outlet pipe will be the primary outlet for the detention basin. The overflow structure will be the secondary outlet, which will only receive flow when the flood control storage volume is exceeded. The emergency spillway is provided to convey flow out of the detention basin during extreme storm events or if the outlet pipe is clogged.

The top of the riser and the overflow structure will both be set at the design water level of (104.8 ft). The riser outlet pipe will have an upstream invert elevation of 100.0 feet. The minimum freeboard elevation will be 105.8 ft. The crest of the emergency spillway will be set at elevation 105.3 ft, or 6 inches below the freeboard elevation.

**Bank Full Flood Flow Restrictor Sizing**

To gradually release the bank full flood storage volume over a minimum of 40 hours, a number of holes will be drilled in the riser pipe at the permanent pool water elevation to act as the flow restrictor. The average release rate for the 40 hour period is calculated as follows:

\[
Q_{avg\ bf} = \frac{V_{t\ bf}}{144,000}
\]

\[
Q_{avg\ bf} = \frac{68,110}{144,000} = 0.47 \text{ cfs}
\]

The calculation above is based on the simplifying assumption that the portion of the bank full flood stored in the forebay and the portion stored in the detention basin can be handled as one common volume.

A number of 1-inch diameter holes will be drilled in the riser at elevation 100.0 feet. The number of holes will be selected to convey the average release rate for the bank full flood given the average head in the detention basin. Since the detention basin has a trapezoidal cross section, 2/3 of the maximum head on the orifice is a reasonable approximation for the average head on the orifice as follows:

\[
h_{avg\ us} = 0.667 \times (Z_{bf} - Z_{out})
\]

where \(Z_{out}\) = water surface elevation inside the riser

Use the orifice equation to determine the required number of holes which will yield the desired average release rate and holding time. Since the riser outlet pipe will be sized to convey the maximum allowable 100 year flood release rate, it will have negligible depth at 0.47 cfs and \(Z_{out}\) can be approximated as the upstream invert elevation of the riser outlet pipe.

\[
h_{avg\ us} = 0.667 \times (102.5 - 100.0) = 1.67 \text{ ft}
\]

\[
A_o = \frac{Q_{avg\ bf}}{(0.62 \times \sqrt{2 \times g \times h_{avg}})}
\]

\[
A_o = \frac{0.47}{(0.62 \times \sqrt{2 \times 32.2 \times 1.67})} = 0.0731 \text{ ft}^2
\]

\[
d_o = 1 \text{ inch} (0.00545 \text{ ft}^2)
\]

Required number of 1-inch holes = \(0.0731/0.00545 = 13.4\)

Use fourteen 1-inch diameter holes at elevation 100.0.

The actual average release rate through the orifice for the assumed conditions is:

\[
Q_{avg\ bf} = 0.62 \times A_o \times \sqrt{2 \times g \times h_{avg}}
\]

\[
Q_{avg\ bf} = 0.62 \times 14 \times 0.00545 \times \sqrt{2 \times 32.2 \times 1.67} = 0.491 \text{ cfs}
\]

Actual holding time for the bank full flood for the assumed condition is:

\[
T_{bf} = \frac{V_{t\ bf}}{(Q_{avg\ bf} \times 3,600)}
\]

\[
T_{bf} = \frac{68,110}{(0.491 \times 3,600)} = 38.5 \text{ hrs, or approximately 40 hrs --- O.K.}
\]

**Check of Forebay Design Assumption**

In sizing the forebay outlet pipe and flow restrictor it was assumed that there was free discharge from the forebay riser outlet pipe into the detention basin when dewatering the forebay after a storm that just fills the first flush storage volume. Therefore it is necessary to verify that the bank full flood flow restrictor will pass the actual average release rate without inhibiting free discharge from the forebay riser outlet pipe.
The downstream crown elevation of the forebay riser outlet pipe is 100.39.

Use the orifice equation to determine the detention basin head for this condition.

\[ h = \frac{Q_{avg} \cdot f}{(0.62 \cdot A)^2} / (2 \cdot g) \]

\[ h = \left[ \frac{0.25}{(0.62 \cdot 14 \cdot 0.00545)} \right]^2 / (2 \cdot 32.2) \]

\[ = 0.17 \text{ ft} \]

Based on the bank full flood flow restrictor as designed, the water surface elevation in the detention basin when conveying the average release rate from the first flush volume is 100.17 feet. Therefore, the basin water surface will not inhibit free discharge from the forebay riser outlet pipe into the detention basin.

**Riser Outlet Pipe and Flood Control Flow Restrictor Sizing**

The riser outlet pipe and flow restrictor will be sized to convey the desired maximum allowable release rate (for the 100 year flood) at the design water level in the detention basin (104.8 feet). Numerous orifices will be placed in the riser above the bank full flood elevation to convey unrestricted flow from the detention basin into the riser. These orifices will not serve as a flow restrictor for the maximum release rate. As noted in the forebay outlet pipe flow restrictor calculations (see page 11-3), the calculations below are based on the maximum head on the riser rather than the average head as used for the forebay calculations.

\[ Q_{\max} = Q_a = 3.6 \text{ cfs (from Storage Volume calculations)} \]

\[ h_{\max} = (Z_{100} - Z_{out}) \]

where: \( Z_{out} = \) upstream crown elev. of riser outlet pipe (ft) assuming the outlet pipe is designed to flow full at 3.6 cfs.

Determine the riser outlet pipe diameter to achieve the maximum release rate.

\[ d_{out} = \text{assume 10 inches (0.83 ft) for calculating } h_{\max} \]

\[ Z_{out} = 100.0 + 0.83 = 100.83 \text{ ft} \]

\[ h_{\max} = 104.8 - 100.83 = 3.97 \text{ ft} \]

\[ A_{out} = \frac{Q_{\max}}{(0.62 \cdot \sqrt{2 \cdot g \cdot h_{\max}})} \]

\[ A_{out} = 3.6 / (0.62 \cdot \sqrt{32.2 \cdot 3.97}) \]

\[ = 0.363 \text{ ft}^2 \]

\[ d_{out} = 0.680 \text{ ft (8.16 inches)} \]

An 8-inch diameter outlet pipe without any orifice would achieve the desired maximum release rate. However, since it would require an excessive slope for the riser outlet pipe, a 10-inch diameter outlet pipe will be used instead with a flow restrictor. No recalculation of \( h_{\max} \) is needed since the selected riser outlet pipe diameter equals the assumed diameter used in calculating \( h_{\max} \). An 8-inch diameter hole will be drilled in the end cap on the vertical run of the outlet tee.

\[ d_{out} = 10 \text{ inches (0.833 ft)} \]

\[ A_{out} = 0.545 \text{ ft}^2 \]

\[ d_o = 8 \text{ inches (0.667 ft)} \]

\[ A_o = 0.349 \text{ ft}^2 \]

The actual maximum release rate through the flow restrictor and outlet pipe is:

\[ Q_{\max} = 0.62 \cdot A_o \cdot \sqrt{2 \cdot g \cdot h_{\max}} \]

\[ Q_{\max} = 0.62 \cdot 0.349 \cdot \sqrt{32.2 \cdot 3.97} \]

\[ = 3.46 \text{ cfs.} \]

\( Q_{\max} \) of 3.46 cfs < 3.6 cfs and within 10% of 3.6 cfs -- O.K.

**Riser Outlet Pipe Slope**

The riser outlet pipe slope must be selected consistent with the earlier assumption that it is flowing full at the actual maximum release rate. Use Manning’s formula with \( n = 0.012 \) for PVC pipe.

\[ \text{Slope (ft/ft)} = \left( \frac{Q_{\max} \cdot n}{(1.486 \cdot A_{out} \cdot R^{2/3})} \right)^{1/2} \]

\[ R = d_{out}/4 = 0.833/4 = 0.208 \text{ ft} \]

\[ \text{Slope (ft/ft)} = \left( \frac{3.46 \cdot 0.012}{(1.486 \cdot 0.545 \cdot 0.208^{2/3})} \right)^{1/2} \]
Slope = 0.0213 ft/ft (2.13 %)

Use 10 inch PVC pipe at 2.1 % slope.

Check velocity at full pipe flow condition against minimum and maximum allowable closed conduit velocities:

\[ V = \frac{Q_{\text{max}}}{A_{\text{out}}} = \frac{3.46}{0.545} = 6.35 \text{ ft/sec} \]

6.35 > \( V_{\text{min}} \) of 2.5 ft/sec; 6.35 < \( V_{\text{max}} \) of 8 ft/sec --- O.K.

**Overflow Structure Outlet Pipe Size and Slope**

The overflow structure outlet pipe must be sized to convey the peak flow rate into the storm water management system for the 10-year storm event. The calculation assumes there is free discharge from the overflow structure outlet pipe into the downstream surface water or closed conduit.

From the storm sewer design calculations using the Rational method (not included), the peak flow rate entering the system is 25 cfs. In this example, the designer will select 27-inch reinforced concrete pipe (RCP) and will determine required slope by using Manning’s formula with \( n = 0.013 \) for RCP.

\[
\text{Slope (ft/ft)} = \left( \frac{Q \times n}{1.486 \times A \times R^{2/3}} \right)^{1/2}
\]

\[
A = 3.98 \text{ ft}^2
\]

\[
R = \frac{d}{4} = \frac{2.25}{4} = 0.563 \text{ ft}
\]

\[
\text{Slope (ft/ft)} = \left[ \left( \frac{25 \times 0.013}{1.486 \times 3.98 \times 0.563^{2/3}} \right) \right]^{1/2}
\]

\[
\text{Slope} = 0.00649 \text{ ft/ft (0.65%)}
\]

Use 27 inch RCP at slope of 0.65%.

Check velocity at full pipe flow condition against minimum and maximum allowable closed conduit velocities:

\[ V = \frac{Q}{A} = 25 / 3.98 = 6.28 \text{ ft/sec} \]

6.28 > \( V_{\text{min}} \) of 2.5 ft/sec; 6.28 < \( V_{\text{max}} \) of 8 ft/sec --- O.K.

**11.2 TYPICAL STORM WATER MANAGEMENT SYSTEM WITH UNDERGROUND DETENTION**

The following example is used to illustrate the calculations required to design a typical storm water management system utilizing underground detention to meet the requirements of the Wayne County Storm Water Management Ordinance. In this example, a single family residential development project is proposed on a 2.5-acre parcel of land with 400 feet of road frontage and discharges to a Wayne County road storm system. Determine the developed runoff coefficient, storm sewer, mechanical forebay, underground detention system, and outlet sizing requirements necessary for proper design of the storm water management system assuming no off-site area drains onto the parcel. The detention system is intended to meet the flood control and water resource protection performance standards.

**Runoff Volume Determination**

In this example, the proposed land use for the site is as follows:

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area (acres)</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>0.5</td>
<td>0.95</td>
</tr>
<tr>
<td>Lawn (Soil Group D, 3%)</td>
<td>1.0</td>
<td>0.45</td>
</tr>
<tr>
<td>Asphalt, concrete</td>
<td>1.0</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Runoff coefficient information may be found in Chapter 6 of this manual.

Calculate the weighted runoff coefficient:

\[
C = \frac{\sum (A_i \times C_i)}{A}
\]

\[
C = \frac{[(0.5 \times 0.95)+(1.0 \times 0.45)+(1.0 \times 0.95)]/(0.5+1.0+1.0)}{= 0.75}
\]

\[
C = \text{runoff coefficient; } A = \text{drainage area (acres)}
\]

**Closed Conduit Sizing**

This sample closed conduit calculation is for three runs of storm sewer pipe within the storm water
management system. The following equations are used:

**Rational Method**

\[ Q = C \times I \times A \]

- \( Q \) = peak flow rate (cfs)
- \( C \) = runoff coefficient
- \( I \) = rainfall intensity (in/hr)
- \( A \) = drainage area (acres)

**Rainfall Intensity**

\[ I = \frac{151.8}{t + 19.9} \]

- \( I \) = rainfall intensity (in/hr)
- \( t \) = time of concentration, or the time duration (minutes) required for runoff from the most remote area of the watershed to reach the point of study. An initial time of concentration of 20 minutes should be used for single family residential land use.

**Manning Formula**

\[ Q = \frac{(1.486 \times A \times R^{2/3} \times S^{1/2})}{n} \]

- \( Q \) = flow capacity (cfs)
- \( A \) = cross sectional flow area (ft^2)
- \( n \) = Manning’s roughness coefficient
- \( P \) = wetted perimeter (feet)
- \( R \) = hydraulic radius (A/P in feet)
- \( S \) = hydraulic gradient (ft/ft)

**Calculations**

Sample calculations for determining conduit sizes are illustrated in the table at the top of the following page. The calculations are based on a Manning’s roughness coefficient of 0.013.

**Forebay Design**

Since the underground detention system has a mechanical forebay, first flush calculations are not needed.

---

**Underground Detention System Design**

The maximum allowable outflow from this site is 0.15 cfs/acre or 0.103 cfs per 100 feet of frontage, whichever is less (see section 7.3 of the storm ordinance). The underground detention system will be designed with an average invert elevation at 100.0 feet (\( Z_o \)) after verifying that this is above the downstream invert at the discharge point.

**Required Volume**

Determine the flood control storage volume required.

\[ Q_a = \text{maximum allowable outflow rate from the detention system (cfs)} \]

\[ Q_a = 0.15 \text{ cfs/acre} \times A = 0.15 \text{ cfs} \times 2.5 \text{ acres} = 0.375 \text{ cfs} \]

Or

\[ Q_a = 0.103 \text{ cfs} \times (400' \text{ of Frontage} / 100) = 0.412 \text{ cfs} \]

Therefore, \( Q_a = 0.375 \text{ cfs} \) (The smaller value will be used)

\[ Q_o = \text{maximum allowable outflow rate per acre imperviousness (cfs/acre imperviousness)} \]

\[ Q_o = Q_a / (A \times C) \]

\[ Q_o = 0.375 / (2.5 \times 0.75) = 0.20 \text{ cfs/acre imperviousness} \]

\[ T_{10} = \text{Storage time defined as the instant storage begins until peak storage is attained (minutes)} \]

\[ T_{10} = -19.9 + \sqrt{4,530 / Q_o} \]

\[ T_{10} = -19.9 + \sqrt{4,530 / 0.20} = 130.6 \text{ minutes} \]

\[ V_s = \text{Required volume of water stored in the detention system per acre imperviousness} \]

\( (\text{ft}^3 / \text{acre imperviousness}) \)
### Sample Calculations for Closed Conduit Sizing
For a 10-Year Storm Sewer Design

\[ Q = C \times \frac{151.8}{(t + 19.9)} \times A \]

<table>
<thead>
<tr>
<th>Storm Sewer Line</th>
<th>From Structure</th>
<th>To Structure</th>
<th>Incremental Area (Acres)</th>
<th>C Factor</th>
<th>Equivalent Area 100% Acres CA</th>
<th>Total Area 100% Acres CA</th>
<th>t (min)</th>
<th>I (inch per hour)</th>
<th>Q (cfs)</th>
<th>Pipe diam (in)</th>
<th>Slope %</th>
<th>Time of Flow (min)</th>
<th>Manning Capacity of Sewer (cfs)</th>
<th>H.G. Elev. Upper End (ft)</th>
<th>Upper Invert Elev. (ft)</th>
<th>Lower Invert Elev. (ft)</th>
<th>Upper Structure Rim Elev. (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB1</td>
<td>CB2</td>
<td>0.38</td>
<td>0.35</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
<td>20.00</td>
<td>3.80</td>
<td>0.51</td>
<td>12</td>
<td>0.50%</td>
<td>105</td>
<td>3.23</td>
<td>0.54</td>
<td>2.54</td>
<td>24.61</td>
<td>24.75</td>
</tr>
<tr>
<td>CB2</td>
<td>R1</td>
<td>0.48</td>
<td>0.40</td>
<td>0.19</td>
<td>0.32</td>
<td>0.32</td>
<td>20.54</td>
<td>3.75</td>
<td>1.22</td>
<td>12</td>
<td>0.80%</td>
<td>78</td>
<td>4.07</td>
<td>0.32</td>
<td>3.20</td>
<td>24.59</td>
<td>24.12</td>
</tr>
<tr>
<td>R1</td>
<td>MH1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.32</td>
<td>0.32</td>
<td>20.86</td>
<td>3.72</td>
<td>1.21</td>
<td>4</td>
<td>0.80%</td>
<td>1</td>
<td>2.11</td>
<td>0.01</td>
<td>0.18</td>
<td>24.50</td>
<td>23.50</td>
</tr>
</tbody>
</table>

\[
V_{s,10} = \left( \frac{9,108 \times T_{10}}{T_{10} + 19.9} \right) - 40 \times Q_o \times T_{10}
\]

\[
V_{s,10} = \left[ \frac{9,108 \times 130.6}{130.6 + 19.9} \right] - 40 \times 0.20 \times 130.6
\]

\[
V_{s,10} = 6,859 \text{ ft}^3/\text{acre imperviousness}
\]

\[
V_{t,10} = \text{Required volume of water stored in the detention system (ft}^3\)
\]

\[
V_{t,10} = V_{s,10} \times A \times C
\]

\[
V_{t,10} = 6,859 \times 2.5 \times 0.75 = 12,861 \text{ ft}^3
\]

Determine the water surface elevation corresponding to the bank full flood \(Z_{bf}\) and 10-year flood \(Z_{10}\) by solving the circle segment formula, as follows:

\[
Z_{bf} / Z_{10}
\]

Determine the bank full flood storage volume \(V_{t,bf}\)

\[
V_{t,bf} = 5,160 \times A \times C
\]

\[
V_{t,bf} = 5,160 \times 2.5 \times 0.75 = 9,675 \text{ ft}^3
\]

**Storage Provided**

The underground detention system storage volume should be equal or exceeds the required volume. In this example, 60-inch diameter pipe is selected with a total length of 660 ft consistent of two hearers and five runs.

Pipe size = 60 inch = 5 ft

Cross sectional area = \(D^2 \times \pi / 4\)

\[
= 5^2 \times \pi / 4 = 19.635 \text{ ft}^2
\]

Header Length = 35 ft

Run Length = 118 ft

Total Volume Provided

\[
= (2 \times 35 + 5 \times 118) \times 19.635
\]

\[
= 12,959 \text{ ft}^3 > 12,861 \text{ ft}^3, \text{ O.K.}
\]

Determine the segment area for bank full volume by dividing the required bank full volume over the total length of the provided detention system

\[
A_{bf} = \frac{V_{bf}}{\text{Total length}} = \frac{9,675}{660} = 14.66 \text{ ft}^2
\]

By solving the circle segment formula, the water depth is determined to be 3.50 ft.

\[
Z_{bf} = \text{bank full flood storage elevation (ft)}
\]

\[
Z_{bf} = 100 + 3.50 = 103.50 \text{ ft}
\]

Determine the segment area for flood control volume by dividing the required flood control volume over the total length of the provided detention system

\[
A_{10} = \frac{V_{10}}{\text{Total length}} = \frac{12,861}{660} = 19.49 \text{ ft}^2
\]

By solving the circle segment formula, the water depth is determined to be 4.86 ft.
Outlet Design
In this example, the underground detention system outlet will be designed as shown in the detail in Section 8.1.3. The flow restrictor structure and the outlet pipe will be the primary outlet for the underground detention system.

The flow restrictor structure can be placed at any location (within the site limits) downstream the underground detention system. Assuming the outlet pipe is 4-inch in diameter with a slope of 3.33% and located 15 ft downstream the underground detention system, the inlet invert of the flow restrictor structure shall be at elevation 99.5 ft (Zout).

Bank Full Flood Flow Restrictor Sizing
To gradually release the bank full flood storage volume over a minimum of 40 hours, a number of holes will be drilled in the flow restrictor wear wall at the inlet invert. The average release rate for the 40 hour period is calculated as follows:

$$Q_{avg \ bf} = \frac{V_{t \ bf}}{144,000}$$

$$Q_{avg \ bf} = 9,675 / 144,000 = 0.067 \text{ cfs}$$

A number of 1.25-inch diameter holes will be drilled in the wear wall (at 6-inch minimum spacing) at elevation 99.5 ft. The number of holes will be selected to convey the average release rate for the bank full flood given the average head in the underground detention system. Since the underground detention system has a circular cross section, 1/2 of the maximum head of water depth plus the static head on the orifice is a reasonable approximation for the average head on the orifice as follows:

$$h_{avg \ us} = 0.5 \times (Z_{bf} - Z_o) + (Z_o - Z_{out})$$

$$h_{avg \ us} = 0.5 \times (103.5 - 100.0) + (100 - 99.5) = 2.25 \text{ ft}$$

$$A_o = \frac{Q_{avg \ bf}}{0.62 \times \sqrt{2 \times g \times h_{avg}}}$$

$$A_o = 0.067 \text{ cfs} / (0.62 \times \sqrt{2 \times 32.2 \times 2.25}) = 0.00898 \text{ ft}^2$$

$$d_o = 1.25 \text{ inch (0.00852 ft}^2)$$

Required number of 1.25-inch holes = 0.00898/0.00852 = 1.054

Use one 1.25-inch diameter holes at outlet elevation 99.5.

The actual average release rate through the orifice for the assumed conditions is:

$$Q_{avg \ bf} = 0.62 \times A_o \times \sqrt{2 \times g \times h_{avg}}$$

$$Q_{avg \ bf} = 0.62 \times 1 \times 0.00852 \times \sqrt{2 \times 32.2 \times 2.25} = 0.064 \text{ cfs}$$

Actual holding time for the bank full flood for the assumed condition is:

$$T_{bf} = \frac{V_{t\ bf}}{(Q_{avg\ bf} \times 3,600)}$$

$$T_{bf} = 9.675 / (0.064 \times 3,600) = 41.99 \text{ hrs, or approximately 40 hrs} \quad \text{--- (within 10%) O.K.}$$

Outlet Pipe and Flood Control Flow Restrictor Sizing
The outlet pipe and flow restrictor will be sized to convey the desired maximum allowable release rate at the design water level in the underground detention system (104.86 feet). The calculations below are based on the maximum head in the detention system rather than the average head as used for the bank full calculations.

$$Q_{max} = Q_a = 0.375 \text{ cfs}$$

$$h_{max} = (Z_{t0} - Z_{out})$$
\[ h_{\text{max}} = (104.86 - 99.5) = 5.36 \text{ ft} \]

Since the bank full orifice is contributing to the maximum allowable release rate, the actual flow rate shall be calculated to determine if additional holes are required.

\[ Q_{\text{max (bf)}} = 0.62 \times 1 \times 0.00852 \times \sqrt{2} \times 32.2 \times 5.36 \]
\[ = 0.098 \text{ cfs} < 0.375 \text{ cfs} \]

Since the bank full hole contribution discharge rate is less than the allowable flow rate, additional holes will be required. These additional holes shall be placed at the bank full elevation (103.5 ft).

\[ Q_{\text{max (adjusted)}} = 0.375 - 0.098 = 0.277 \text{ cfs} \]

The maximum depth of water on the additional holes shall be the design water level in the underground detention system (104.86 feet) minus the bank full water level (103.5 ft).

\[ h_{\text{max (adjusted)}} = (Z_{10} - Z_{\text{bf}}) = 104.86 - 103.5 = 1.36 \text{ ft} \]

Use the orifice equation to determine the required number of holes which will yield the desired maximum release rate.

\[ A_o = Q_{\text{max (adjusted)}}/(0.62 \times \sqrt{2} \times g \times h_{\text{max (adjusted)}}) \]
\[ A_o = 0.277 \text{ cfs} / (0.62 \times \sqrt{2} \times 32.2 \times 1.36) \]
\[ = 0.0477 \text{ ft}^2 \]
\[ d_o = 2.0 \text{ inch} (0.02182 \text{ ft}^2) \]

Required number of 2.0-inch holes
\[ = 0.0477/0.02182 \]
\[ = 2.186 \]

Use two 2.0-inch diameter holes at elevation 103.5.

The actual maximum release rate through the orifice is:

\[ Q_{\text{actual}} = Q_{\text{max (bf)}} + 0.62 \times A_o \times \sqrt{2} \times g \times h_{\text{max adj}} \]
\[ Q_{\text{actual}} = 0.098 + 0.62 \times 2 \times 0.02182 \times \sqrt{2} \times 32.2 \times 1.36 \]
\[ = 0.351 \text{ cfs} < 0.375 \text{ cfs} \]

(within 10%) O.K.

**Flow Restrictor Outlet Pipe Slope**

The flow restrictor outlet pipe slope must be selected consistent with the earlier assumption that it is flowing full at the actual maximum release rate. In this example we will use 4-inch diameter outlet pipe and discharging to a Wayne County road storm system. Use Manning’s formula with \( n = 0.012 \) for PVC pipe.

\[ \text{Slope (ft/ft)} = \left[ \frac{(Q_{\text{max}} \times n)}{(1.486 \times A_{\text{out}} \times R^{2/3})} \right]^2 \]
\[ R = d_{\text{out}}/4 = 0.333/4 = 0.08333 \text{ ft} \]
\[ \text{Slope (ft/ft)} = \left[ (0.375 \times 0.012)/(1.486 \times 0.0873 \times 0.0833^{2/3}) \right]^2 \]
\[ \text{Slope} = 0.0331 \text{ ft/ft} (3.31 \%) \]

Use 4 inch PVC pipe at 3.31 % slope.

Check velocity at full pipe flow condition against minimum and maximum allowable closed conduit velocities:

\[ V = Q_{\text{max}} / A_{\text{out}} = 0.375 / 0.0873 = 4.29 \text{ ft/sec} \]

\[ 4.29 > V_{\text{min}} \text{ of 2.5 ft/sec}; \ 4.29 < V_{\text{max}} \text{ of 8 ft/sec} \ --- \text{O.K.} \]
11.3 TYPICAL STORM WATER MANAGEMENT SYSTEM WITH BIORETENTION

The following example is used to illustrate the calculations required to design a typical storm water management system utilizing bioretention to meet the requirements of the Wayne County Storm Water Management Ordinance. In this example, bioretention is designed to treat stormwater discharged from a 0.8 acre site during a 10-year design storm.

Bioretention System Design Criteria

From Section 8.2.2, key design criteria related to calculation of storage volumes in bioretention areas include:

1. Bioretention should be used for drainage areas of less than 5 acres and preferably less than 1 acre. There should be a maximum distance of 150 feet of sheet drainage to each bioretention area.

2. The bottom of bioretention areas should be 3 feet or more above the seasonal high ground water table.

3. A maximum 6 inches of ponding storage is allowed on top of bioretention areas.

4. A maximum of 20% void spaces in the planting soils and underdrain gravel blankets can be considered storage volume within the bioretention area.

5. Soil borings and field infiltration/laboratory tests must be used to determine characteristics of the in-situ soils at proposed bioretention areas. Bioretention areas should include underdrains and overflow structures if the subgrade soils below the bioretention areas are not sufficiently permeable.

6. Proper landscaping and maintenance of bioretention areas is essential and must conform to requirements specified in Section 8.2.2.

### Bioretention System Design

In this example, the proposed land use for the site is as follows:

<table>
<thead>
<tr>
<th>Area (acre)</th>
<th>C</th>
<th>A x C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lawn</td>
<td>0.40</td>
<td>0.25*</td>
</tr>
<tr>
<td>Gravel</td>
<td>0</td>
<td>0.85</td>
</tr>
<tr>
<td>Pavement + Roof</td>
<td>0.40</td>
<td>0.95</td>
</tr>
<tr>
<td>Total</td>
<td>0.80</td>
<td></td>
</tr>
</tbody>
</table>

Cave. = 0.60

*Runoff Coefficient depends on soil type and ground slope (see Storm Water Manual page 6-2)

A (area) = 0.80 Acres
Frontage = 145 Feet

Q_o (allowable) = 0.15 x A
= 0.15 x 0.80 = 0.12 cfs

OR

Q_o (allowable) = 0.103 x Frontage/100 = 0.15 cfs

Use the Smaller Value, Q_o = 0.12 cfs

\[ V_{S,10} = 9108 \times T_{10} / (T_{10} + 19.9) - 40 \times Q_o \times T_{10} \]
= 614.4 ft³/(acre-impervious)

\[ V_{T,10} = V_{S,10} \times A \times C \]
= 3175 ft³ Required Storage Volume

Calculation of the actual storage provided is shown in the table on the next page. These calculations assume the typical bioretention cross section detail presented in Section 8.2.2, and the following key design criteria as described above:

- Maximum 6 inches of ponding storage allowable on top of bioretention areas, and
- Maximum of 20% void spaces in the planting soils and underdrain gravel

The actual storage provided is estimated to be 3234 ft³, which is greater than the required storage volume of 3175 ft³ --- OK.
Provided Volume Within the Bioretention Area
(Based on Typical Bioretention Plan and Cross-Section)

<table>
<thead>
<tr>
<th>Ponding Storage on Top</th>
<th>Elevation (Ft.)</th>
<th>Area (Ft²)</th>
<th>Volume (Ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Maximum 6&quot; Deep)</td>
<td></td>
<td></td>
<td>V = H / 3 [A₁ + A₂ + (A₁ A₂)½]</td>
</tr>
<tr>
<td></td>
<td>699.5</td>
<td>4000</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>699.0</td>
<td>3000</td>
<td>= 0.5 / 3 [3000 + 4000 + (3000 x 4000)½] = 1744</td>
</tr>
</tbody>
</table>

| Storage in Planting Soils and Gravel Layers | Elevation (Ft.) | Area (Ft²) | Volume (Ft³) |
| (Based on 20% Void Space)                   |                |            | 3 / 3 [3000 + 2000 + (3000 x 2000)½] (20%) = 1490 |
|                                            | 699.0          | 3000       | 0            |
|                                            | 696.0          | 2000       |              |

Total Storage Provided = 3234 Ft³
3234 FT³ > 3175 FT³, OK
CHAPTER 12: CONTACTS

For all questions regarding Construction Approvals under Wayne County’s Storm Water Program, please contact:

Permit Office
Division of Engineering
Wayne County Department of Public Services
33809 Michigan Avenue
Wayne, MI 48184-1738
(734) 595-6504

For more information, including the construction permit application kit, see:
http://www.waynecounty.com/dps/construction_permits.htm

There may be other permits and approvals that you may need to acquire before starting your project

12.1 Local Community

Your local community may require review and approval of site plans under a variety of programs:

- Zoning
- Soil Erosion and Sediment Control
- Storm Water Management
- Sanitary Sewer Service

Information about floodplains or flood elevations is maintained by the local community (not Wayne County).

12.2 Wayne County

Work within County Road Rights-of Way or Other County Property (e.g., County Parks)

Subdivision Site Plan Review

Permit Office
Division of Engineering
Wayne County Department of Public Services
33809 Michigan Avenue
Wayne, MI 48184-1738
(734) 595-6504

Erosion and Sedimentation Control Permits

Land Resource Management Division
Wayne County Department of Public Services
3600 Commerce Court
Wayne, MI 48184
(734) 326-3936

For more information, including a permit application kit, visit:
“http://waynecounty.com/doe/soilerosion.htm”

Information on County Drains and Modifications to County Drains and/or County Drainage Districts and to Petition for Drain Improvements or Creation of a Drainage District

Drain Office
Wayne County Department of Public Services
400 Monroe, Suite 400
Detroit, Michigan 48226
(313) 224-8116

Sanitary Sewer Extension Permits

(applications are submitted through local community)

Philip Kurikesu, Permit Engineer
Wayne County Department of Public Services
Land Resource Management Division
3600 Commerce Court, Building E
Wayne, MI 48184-2803
Phone: (734) 326-5591

For more information, including a permit application kit, visit:
“http://waynecounty.com/doe/1029.htm”

Wells and Private Sewage Disposal Systems (Septic Tanks)

Environmental Health Division
Wayne County Department of Public Health
5454 Venoy Road
Wayne, MI 48184
Ph: 734-727-7400

See also for more information:
http://www.waynecounty.com/hhs/wellpermits.htm
http://www.waynecounty.com/hhs/onsitesewage.htm
12.3 State Agencies

12.3.1 Michigan Department of Transportation (MDOT)

Permits for Storm Water Drainage Affecting MDOT Right-of-Way

Taylor Transportation Service Center
Michigan Department of Transportation
6510 Telegraph Rd.
Taylor, MI 48180
Phone: 313-375-2400
Fax: 313-375-0822

Detroit Transportation Service Center
Michigan Department of Transportation
1050 Sixth Street
Detroit, MI 48226
(313) 965-6350
Fax: 313-965-6340

See also for more information:
http://michigan.gov/mdot/0,1607,7-151-9623_26662_26679_27267_48606-182161--,00.html

12.3.2 Michigan Department of Environmental Quality (MDEQ)

Storm Water Permits for Municipal, Industrial or Construction Site Discharges

MDEQ - Water Resources Division
Southeast Michigan District Office
27700 Donald Court
Warren, MI 48092-2793
(586) 753-3700

See also for more information:
“http://michigan.gov/deq/0,4561,7-135-3313_3682_3716--,00.html”

Permits for Projects Involving Wetlands

MDEQ –Water Resources Division
Southeast Michigan District Office
27700 Donald Court
Warren, MI 48092-2793
(586) 753-3700

See also for more information about wetlands regulation:
“http://michigan.gov/deq/0,4561,7-135-3313_3687--,00.html”

For permit application, see:
“http://michigan.gov/deq/0,1607,7-135-3307_29692_24403--,00.html”

Permits for Projects Involving Floodplains and Streambank Work

MDEQ- Land and Water Management Division
Southeast Michigan District Office
27700 Donald Court
Warren, MI 48092-2793
(586) 753-3700

See also for more information, including permit application:
“http://michigan.gov/deq/0,1607,7-135-3307_29692_24403--,00.html”

12.4 Federal Agencies

12.4.1 Federal Emergency Management Agency (FEMA)

Permits for Activities Which May Alter Existing Flood Plains

MDEQ - Water Resources Division
Southeast Michigan District Office
27700 Donald Court
Warren, MI 48092-2793
(586) 753-3700

Flood Insurance Rate Maps (FIRM), Flood Insurance Study (FIS) texts, and Other Flood-Map-Related Products

- Contact your local community
- FEMA Map Service Center, online at https://msc.fema.gov/portal

12.4.2 U.S. Army Corps of Engineers (COE)

Online at: http://www.lre.usace.army.mil/

Permits for Activities in Navigable Waters or Waters of the U.S., Activities which Impact Existing COE Civil Works Projects, or Other COE Jurisdiction

APPENDIX A

Engineer’s Certificate of Construction

Revised: 11 July 2008
Engineer’s Certificate of Construction

Wayne County: Construction permit #: _____________
Review Number: _____________

Project Name: __________________________________________________________________
Project Address/Location: _________________________________________________________
City/Township of: ________________________________________________________________, Wayne County, Michigan.

I hereby certify that the construction and installation of the Storm Water Management System of the project known as _________________________________________________________________ is complete as of the date ________________. All components of the storm water management system have been constructed and installed in accordance with the construction plans approved by the Wayne County Department of Public Services, Permit Office and comply with the Wayne County Storm Water Management Program.

Signed: ___________________________________
Licensed Professional Engineer (Michigan)

NOTE: This certification must be stamped with the seal of a professional engineer licensed in the State of Michigan. The certificate submitted must be the original.

Please Return Certification to:
Department of Public Services - Permit Office
Attn: Division Permit Construction Manager
33809 Michigan Avenue
Wayne, Michigan 48184

Revised: 11 July 2008
Attachment A to
Engineer’s Certificate of Construction

THIS ATTACHMENT MUST BE COMPLETED IF:
1. The storm water management system contains elements where vegetation is critical to the functioning of a storm water management component, including but not limited to: Open Detention Basins, Bioretention Areas, Vegetated Swales, Streambank Stabilization, and Vegetation/Riparian Corridor Management.

2. Plantings incorporated into the system design are not included on plant lists in the Wayne County Storm Water Standards and were instead based on landscaping plans submitted by a Registered Landscape Architect (RLA).

Wayne County: Construction permit #: ______________
Review Number: ______________

Project Name: __________________________________________
Project Address/Location: ______________________________________
City/Township of: __________________________________________, Wayne County, Michigan.

I hereby certify that the plantings incorporated into the design of the Storm Water Management System for the project known as ________________________________________were completely and correctly installed as of the date _______________. The plantings were installed in accordance with the construction plans for the landscaping elements approved by the Wayne County Department of Public Services, Permit Office and comply with the Wayne County Storm Water Management Program.

Signed: ___________________________________
Registered Landscape Architect (Michigan)

NOTE:
This certification must be stamped with the seal of a landscape architect licensed in the State of Michigan. The certificate submitted must be the original.

Please Return Certification to:
Department of Public Services - Permit Office
Attn: Division Permit Construction Manager
33809 Michigan Avenue
Wayne, Michigan 48184

Revised: 11 July 2008
APPENDIX B

Model Community Resolutions
Accepting Long Term Maintenance Of Storm Water Management System

B.1: Model Community Resolution for Single Project

B.2: Model Annual Community Resolution
APPENDIX B-1

MODEL COMMUNITY RESOLUTION ACCEPTING LONG TERM MAINTENANCE OF STORM WATER MANAGEMENT SYSTEM

Resolution No. _______________

At a Regular Meeting of the ____________________________ (Name of Community Governing Board) on ________________ (date), the following resolution was offered:

WHEREAS, chapter 9 of the Wayne County Storm Water Management Ordinance (“Wayne County Ordinance”), requires storm water management systems to be maintained in perpetuity to ensure that the systems function properly as designed;

WHEREAS, Rule 1001 of the Wayne County Storm Water Management Administrative Rules (“Administrative Rules”) requires applicants for storm water construction approval to submit long term maintenance plans as part of an application for storm water construction approval;

WHEREAS, ____________________ ("Developer") has applied to the Wayne County Department of Public Services for a storm water construction approval with respect to a project named ____________________ ("Project") located at ____________________ (City/Village/Township);

WHEREAS, Developer’s application for storm water construction approval has been assigned permit review number ________________ (Insert permit review number).

WHEREAS, Developer submitted a plan to the County and ____________________ ("Community") entitled ________________ (Title, author, and date of Plan) (“Plan”) for long-term maintenance of the storm water management system(s) at the Project pursuant to Rule 801, which Plan has been tentatively approved by the County pending issuance of this resolution and has been accepted by (Community), and

WHEREAS, (Community) has agreed to assume jurisdiction and accept responsibility for long-term maintenance of storm water management system(s) at the Project in perpetuity;

NOW THEREFORE BE IT RESOLVED, that (Community) assumes jurisdiction over and accepts responsibility for long term maintenance of storm water management system(s) at the Project pursuant to the Wayne County Ordinance, the Administrative Rules, the Plan, and the storm water construction approval issued by Wayne County;

BE IT FURTHER RESOLVED, that approval be and is hereby granted, authorizing (Authorized Community Official) to execute, on behalf of (Community), Permit [No. ________________] for long term maintenance of storm water management system issued by Wayne County for the Project.

[Insert Certification Language of Local Community here]

Items in boxes MUST be included in the final resolution
APPENDIX B-2
ANNUAL COMMUNITY RESOLUTION ACCEPTING
LONG TERM MAINTENANCE OF STORM WATER MANAGEMENT SYSTEMS

Resolution No. ________________

At a Regular Meeting of the ____________________________ [Name of Community Governing Board] on ___________________________ [date], the following resolution was offered:

WHEREAS, chapter 9 of the Wayne County Storm Water Management Ordinance (“Wayne County Ordinance”), requires storm water management systems to be maintained in perpetuity to ensure that the systems function properly as designed;

WHEREAS, pursuant to chapter 4 of the Wayne County Ordinance, after reviewing and approving applications for storm water construction approval, Wayne County issues permits for the long-term maintenance of each storm water management systems, which permits are executed by Wayne County and the public entity that assumes jurisdiction over and accepts responsibility for long-term maintenance of the storm water management system;

WHEREAS, [Community] has agreed to assume jurisdiction over and accept responsibility in perpetuity for maintenance of all storm water management system(s) constructed within [Community] during the period referenced below, to ensure that the storm water management systems function properly as designed and constructed; and

WHEREAS, [Community] has designated _________________ [Name of Authorized Community Official], the _____________________________ [Title of Individual] of [Community], as the person responsible for executing long-term maintenance permits on behalf of [Community] for the period referenced below.

NOW THEREFORE BE IT RESOLVED, that [Community] assumes jurisdiction over and accepts responsibility for long-term maintenance of all storm water management systems constructed within [Community] during the period ______________ through ________________ 20__ [period not to exceed one year] pursuant to the Wayne County Ordinance, the Administrative Rules, long-term maintenance plans for storm water management systems constructed within [Community], and the storm water construction approvals issued by Wayne County; and

BE IT FURTHER RESOLVED, that approval be and is hereby granted, authorizing _________________ [Authorized Community Official] to enter into and execute, on behalf of [Community], long-term maintenance permits issued by Wayne County for storm water management systems constructed within [Community] during the period ______________ through ________________ 20__.

[Insert Certification Language of Local Community here]

NOTE: Items in boxes MUST be included in the final resolution.
APPENDIX E-4

Wayne County Parks Division
Permit Guidelines for Site Restoration

Revised July 2015
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WAYNE COUNTY DEPARTMENT OF PUBLIC SERVICES
PARKS DIVISION

PERMIT GUIDELINES FOR SITE RESTORATION
Revised: 1 July 2015

General Guidelines:
1. The Contractor shall be responsible at no expense to the Owner, for any damage to Park property, including but not limited to; athletic fields, boardwalks, bridges, comfort stations, fences, lawns, paved pathways, picnic shelters, planting material, playground structures, signs and site furnishings.
2. The Contractor shall provide and maintain a safe and adequate travel route at all times for Park visitors throughout the duration of the Project. All equipment shall be stored in a manner that is safe to Park visitors and approved by the Wayne County Parks Design Staff.
3. The Contractor shall be responsible for contacting and coordinating with all pertinent utility companies at least 72 hours in advance of any digging to familiarize themselves with all underground utilities, pipes and structures. The Contractor shall assume sole responsibility for any cost incurred due to damage of any utilities.
4. The Contractor shall not willfully proceed with the construction as designed when it is obvious that unknown obstructions and/or grade differences exist. Such conditions shall be immediately brought to the attention of the Wayne County Parks Design Staff. The Contractor shall assume full responsibility for all necessary revisions due to failure to give proper notification.
5. Any discrepancies between dimensioned layout and actual field conditions shall be immediately brought to the attention of the Wayne County Parks Design Staff. The Contractor shall assume full responsibility for all necessary revisions due to failure to give proper notification.
6. The Contractor shall be responsible for any coordination with subcontractors as required to accomplish installation operations.
7. The Contractor shall provide and maintain positive surface drainage.

Lawn Restoration
1. All lawn that is disturbed due to construction activities shall be restored to its original state by the Contractor at no expense to the Owner.
2. Remove diseased or unsatisfactory lawn growth. Do not bury into soil. Remove topsoil containing foreign materials, including oil drippings, stone, gravel, and construction materials.
3. All disturbed areas shall be rough graded to meet the existing adjoining grades and any extraneous materials, i.e. rocks, wood, construction debris or equipment shall be removed and disposed of in a legal manner.
4. After rough grade is met, all disturbed lawn areas shall receive a minimum of 4” of clean, fertile, friable, topsoil of sandy loam character, free of any extraneous material. It will be the Contractor’s responsibility to supplement any salvaged topsoil supply to meet the minimum 4” depth.

5. Following the installation of topsoil, the approval of final grade by the Wayne County Parks Design Staff shall be required prior to reseeding of disturbed areas.

6. Apply a starter fertilizer (15-30-15) at a rate of 5lbs. per 1,000 sf thoroughly and evenly via a mechanical rotary or drop type spreader.

7. Perform seeding operations immediately after preparation of disturbed areas and when soil is dry and winds do not exceed 5 m.p.h. Apply recommended seed via a mechanical rotary or drop type spreader. After seeding, rake or drag surface of soil lightly to incorporate seed into top of soil. Areas that are identified to be seeded prior to construction shall be designated on drawings. The following seed mix is recommended, however alternates can be submitted Wayne County Parks Design Staff for review.

<table>
<thead>
<tr>
<th>Seed</th>
<th>Purity</th>
<th>Germination</th>
<th>Mixture %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky Bluegrass</td>
<td>99%</td>
<td>85%</td>
<td>10%</td>
</tr>
<tr>
<td>Turf-Type Perennial Ryegrass</td>
<td>99%</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>Creeping Red Fescue</td>
<td>98%</td>
<td>85%</td>
<td>20%</td>
</tr>
<tr>
<td>Hard Fescue</td>
<td>97%</td>
<td>85%</td>
<td>20%</td>
</tr>
<tr>
<td>Turf-Type Tall Fescue</td>
<td>98%</td>
<td>85%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Seeding application rate: 7lbs. per 1,000 sf.

8. Immediately following seeding operations, the Contractor shall install straw mulch in a uniform manner with continuous coverage over all seeded areas. Anchor straw by mechanical means or with a liquid tackifier at a rate of 60 gals. per acre.

9. Hydroseeding applications may be utilized for establishing new lawns using a mixture of specified fertilizer, tackifier at a rate of 60 gals. per acre, wood cellulose fiber mulch at a rate of 2,000 lbs. per acre and specified seed mix.

10. Water newly seeded areas. The Contractor shall maintain adequate soil moisture until new grass is established.

Grow Zones Restoration
1. All “Grow Zones” that are disturbed due to construction activities shall be restored to their original state.
2. “Grow Zones” shall be located in the field prior to construction by the Contractor and the Wayne County Parks Design Staff.
3. The Contractor shall consult with the Wayne County Parks Design Staff prior to restoration for the recommended Seed Mix and application method(s).

Tree Inventory Plan
1. Any person wishing to perform land clearing or grubbing activities, remove or transplant trees of any D.B.H. within Park Property of Wayne County shall not do so until they have received approval from the Permits office.
2. Applicant shall submit a Tree Inventory Plan that is performed by a registered land surveyor or certified arborist and includes the following:
   a. Topographic information delineating both existing and proposed contours.
b. Existing and proposed structures, utilities and pavement.
c. Property lines, R.O.W. and easements that are applicable.
d. The location and approximate drip line of all existing deciduous trees 6” D.B.H. or greater and existing evergreen trees 10’ height or greater.
   i. These trees shall be tagged in the field by identifying numbers using non-corrosive metal tags and shown on the plan with their respective number.
e. All existing deciduous trees 6” D.B.H. or greater and existing evergreen trees 10’ height or greater shall also be identified on a list using both their common and botanical names with their corresponding number. Please also indicate size and condition. Those trees that meet the Landmark Tree Requirements below shall also be identified.
f. Identify clearly all existing deciduous trees 6” D.B.H. or greater, existing evergreen trees 10’ height or greater and any Landmark Trees that are proposed to be removed.
g. The location of all replacement trees according to the Tree Replacement Standards below. Applicant shall also furnish a plant list that includes quantities, common and botanical names, size, root type and spacing.
h. A table including the total number of deciduous trees 6” D.B.H. or greater, evergreen trees 10’ height or greater on site, landmark trees, total number of trees proposed to be removed and the total number of replacement trees required.
   i. The location of tree protection fence and associated details per Wayne County Parks Standards shall also be included on the plan.

3. Landmark Trees are any existing tree in good condition that are 24” D.B.H. or greater or is of a type and D.B.H. equal to or greater than those shown on the list below.

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
<th>Landmark D.B.H. (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies species</td>
<td>Fir</td>
<td>18</td>
</tr>
<tr>
<td>Acer species</td>
<td>Maple</td>
<td>18</td>
</tr>
<tr>
<td>Aesculus carnea</td>
<td>Horse Chestnut</td>
<td>18</td>
</tr>
<tr>
<td>Aesculus glabra</td>
<td>Buckeye</td>
<td>18</td>
</tr>
<tr>
<td>Alnus glutinosa</td>
<td>Black Alder</td>
<td>12</td>
</tr>
<tr>
<td>Asimina triloba</td>
<td>Pawpaw</td>
<td>8</td>
</tr>
<tr>
<td>Betula species</td>
<td>Birch</td>
<td>18</td>
</tr>
<tr>
<td>Carpinus species</td>
<td>Hornbeam</td>
<td>8</td>
</tr>
<tr>
<td>Carya species</td>
<td>Hickory</td>
<td>18</td>
</tr>
<tr>
<td>Castanea dentata</td>
<td>American Chestnut</td>
<td>8</td>
</tr>
<tr>
<td>Catalpa species</td>
<td>Catalpa</td>
<td>18</td>
</tr>
<tr>
<td>Cercis canadensis</td>
<td>Redbud</td>
<td>8</td>
</tr>
<tr>
<td>Cladrastis lutea</td>
<td>Yellowwood</td>
<td>12</td>
</tr>
<tr>
<td>Cornus florida</td>
<td>Flowering Dogwood</td>
<td>8</td>
</tr>
<tr>
<td>Crataegus species</td>
<td>Hawthorn</td>
<td>12</td>
</tr>
<tr>
<td>Diospyros virginiana</td>
<td>Persimmon</td>
<td>12</td>
</tr>
<tr>
<td>Fagus grandifolia</td>
<td>American Beech</td>
<td>18</td>
</tr>
<tr>
<td>Ginkgo biloba</td>
<td>Ginkgo</td>
<td>12</td>
</tr>
<tr>
<td>Gymnocladus dioicus</td>
<td>Kentucky Coffeetree</td>
<td>16</td>
</tr>
<tr>
<td>Juglans nigra</td>
<td>Black Walnut</td>
<td>18</td>
</tr>
<tr>
<td>Juniperus species</td>
<td>Cedar</td>
<td>12</td>
</tr>
<tr>
<td>Larix laricina</td>
<td>Larch/Tamarack</td>
<td>12</td>
</tr>
<tr>
<td>Liquidambar styraciflua</td>
<td>Sweetgum</td>
<td>12</td>
</tr>
<tr>
<td>Liriodendron tulipifera</td>
<td>Tuliptree</td>
<td>12</td>
</tr>
<tr>
<td>Botanical Name</td>
<td>Common Name</td>
<td>Landmark D.B.H. (inches)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Malus species</td>
<td>Crabapple</td>
<td>12</td>
</tr>
<tr>
<td>Metasequoia glyptostroboides</td>
<td>Dawn Redwood</td>
<td>16</td>
</tr>
<tr>
<td>Nyssa sylvatica</td>
<td>Blackgum</td>
<td>16</td>
</tr>
<tr>
<td>Ostrya virginiana</td>
<td>Ironwood</td>
<td>8</td>
</tr>
<tr>
<td>Picea species</td>
<td>Spruce</td>
<td>18</td>
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<tr>
<td>Pinus species</td>
<td>Pine</td>
<td>18</td>
</tr>
<tr>
<td>Platanus species</td>
<td>London Plane/Sycamore</td>
<td>18</td>
</tr>
<tr>
<td>Prunus species</td>
<td>Cherry</td>
<td>18</td>
</tr>
<tr>
<td>Pseudotsuga menziesii</td>
<td>Douglas Fir</td>
<td>18</td>
</tr>
<tr>
<td>Quercus species</td>
<td>Oak</td>
<td>16</td>
</tr>
<tr>
<td>Sassafras albidum</td>
<td>Sassafras</td>
<td>14</td>
</tr>
<tr>
<td>Taxodium distichum</td>
<td>Bald Cypress</td>
<td>12</td>
</tr>
<tr>
<td>Tilia americana</td>
<td>Basswood</td>
<td>18</td>
</tr>
<tr>
<td>Tsuga canadensis</td>
<td>Eastern Hemlock</td>
<td>12</td>
</tr>
<tr>
<td>Ulmus americana</td>
<td>American Elm</td>
<td>18</td>
</tr>
</tbody>
</table>

**Tree Replacement**

1. Any person wishing to remove trees that are in good condition shall do so in accordance with the following schedule:

<table>
<thead>
<tr>
<th>Size of Removed Tree</th>
<th>Number of replacement trees to removed tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous Tree 6” D.B.H. or greater</td>
<td>3:1 (minimum 2.5” caliper)</td>
</tr>
<tr>
<td>Evergreen Tree 10’ height or greater</td>
<td>3:1 (minimum 8’ height)</td>
</tr>
<tr>
<td>Landmark Tree (see list)</td>
<td>1:1 (number of caliper inches = D.B.H. inches)</td>
</tr>
</tbody>
</table>

2. All replacement trees shall be of similar species to those being removed. Replacement trees shall be nursery grown and comply with ANSI Z60. Species, proposed size and any substitutions must be approved by the Wayne County Parks Design Staff prior to shipment or installation. Installation shall be per Wayne County Parks Standards. The suggested plant list is indicated below.

**Replacement Plant suggestions:**

**Canopy Trees**

- Acer rubrum – Red Maple
- Acer saccharum – Sugar Maple
- Carya ovata – Shagbark Hickory
- Fagus grandifolia – American Beech
- Liriodendron tulipifera – Tulip Tree
- Nyssa sylvatica – Black Gum
- Ostrya virginiana – Ironwood
- Platanus occidentalis – Sycamore
- Quercus bicolor – Swamp White Oak
- Quercus imbricaria – Shingle Oak
- Quercus macrocarpa – Bur Oak
- Quercus rubra – Red Oak
- Tilia americana - Basswood

**Evergreen Trees**

- Abies concolor – White Fir
- Picea glauca – White Spruce
- Picea pungens – Colorado Spruce
- Pinus Strobus – White Pine
- Taxodium distichum – Bald Cypress
- Tsuga Canadensis – Eastern Hemlock

**Flowering Trees**

- Amelanchier canadensis – Serviceberry
- Cercis canadensis – Eastern Redbud
- Cornus florida – Flowering Dogwood
- Crataegus crus-galli inermis ‘Crusader’
- Malus species – Crab Apple
**Bike Paths**
1. All County Bike Paths within or in close proximity of construction limits shall be adequately barricaded for the duration of construction. Appropriate signage shall be installed where necessary to adequately inform visitors of the construction zone and directions for an alternative route.
2. All Bike Paths removed or damaged as a result of construction shall be replaced with 3.5" depth bituminous pavement. The section of pavement shall include an 8" depth 21AA aggregate base compacted per current MDOT standards, 2" depth 13A leveling course, tack coat and a 1.5" depth 36A wearing course. The bituminous pavement shall be installed per current MDOT installation methods.

**Road Shoulders**
1. All Road shoulders shall be restored with 4" of topsoil and seeded as specified. No gravel will be allowed beyond the asphalt shoulder. Shoulder restoration shall meet all current MDOT standards.

**Park Drives**
1. All Park Drives that are within or in close proximity to construction limits shall be replaced and restored to their original state. Construction applications shall meet all current MDOT standards and project specifics should be taken into consideration prior to commencement of restoration.
2. All construction equipment and materials remaining on site following construction period shall be removed and disposed of off site.

Through the Permits Office, the Wayne County Parks Design Staff shall review all construction permits within or in close proximity to Park property prior to issuance of a permit.

Please contact: Elizabeth Iszler, Chief of Planning and Design: (734) 261-4312