# Stormwater Standards Manual

## Procedures & Design Criteria for Stormwater Management

City of Grand Rapids
Kent County, Michigan

**City of Grand Rapids**
**Kent County, Michigan**

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## List of Abbreviations

### Acronyms

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| BMP | Best Management Practice |
| CN | Curve Number |
| DEQ | Michigan Department of Environmental Quality (Michigan Department of Environment, Great Lakes and Energy as of April 7, 2019) |
| DNR | Michigan Department of Natural Resources |
| EPA | United States Environmental Protection Agency |
| GIS | Geographic Information System |
| GVMC | Grand Valley Metropolitan Council |
| HSG | Hydrologic Soil Group |
| LGROW | Lower Grand River Organization of Watersheds |
| LID | Low Impact Development |
| LUDS | Land Use Development Services |
| MCL | Michigan Compiled Laws |
| MDOT | Michigan Department of Transportation |
| MS4 | Municipal Separate Storm Sewer System |
| NAVD 88 | North American Vertical Datum of 1988 |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resource Conservation Service |
| O&M | Operation and Maintenance |
| PA | Public Acts of Michigan |
| SEMCOG | Southeast Michigan Council of Governments |
| SESC | Soil Erosion and Sedimentation Control |
| TMDL | Total Maximum Daily Load |
| TR-55 | Technical Release 55 |
| TSS | Total Suspended Solids |
| USDA | United States Department of Agriculture |
| USGS | United States Geological Survey |

## List of Units

| | |
|---|---|
| ft ( ′ ) | feet |
| in ( ″ ) | inches |
| ac | acre |
| cfs | cubic feet per second |
| cft | cubic feet |
| hr | hour |
| H:V | horizontal to vertical |
| in/hr | inches per hour |
| mg/L | milligrams per liter |
| min | minute |

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## Definitions

| | |
|---|---|
| City | The municipal corporation that is the City of Grand Rapids, Michigan, and includes all authorized agents of the City of Grand Rapids when acting within the scope of their authority |
| City Manager | The City Manager of the City of Grand Rapids and any persons designated to act on behalf of the City Manager in the administration or enforcement of this Chapter |
| City Stormwater Drainage System (CSDS) | Includes all wetlands, surface water bodies, and all public storm drainage structures used in connection with the collection, control, transportation, treatment, or discharge of stormwater runoff and exempted discharges within the City of Grand Rapids. The CSDS does not include sewers or other facilities connected to the Grand Rapids Sanitary Sewage Disposal System, nor does the CSDS include private stormwater drainage facilities, which receive or convey stormwater runoff exclusively from privately owned property |
| Design Engineer | The civil engineer who is a professional engineer licensed under Article 20 of the Occupational Code (Act 299, PA 1980) retained by the Land Owner to design the site plan for a plat or any other land development, including stormwater management and drainage |
| Land Owner | Any person who owns real property, or who holds a recorded easement on the property, or who is engaged in construction in a public right-of-way in accordance with sections 13, 14, 15, and 16 of Act No. 368 of the Public Acts of 1925, as amended, (MCL 247.183, 247.184, 247.185, and 247.186) as defined in the Administrative Rules, Part 17 of the Natural Resources and Environmental Protection Act, 1994, PA 451, as amended (Act 451) |
| Redevelopment | Redevelopment. Any change to the land or its use that involves:<br>(a) A paved parking or driveway surface of one thousand (1,000) square feet or more that is being removed down to the sub-base and replaced.<br>(b) A change in the drainage system serving the property.<br>(c) A substantial improvement of the property. |
| Register of Deeds | The Kent County Register of Deeds |
| Sewershed | The area where stormwater is conveyed by the CSDS to a common outfall or point of discharge (refer to Figure 1, page 5) |

# I. PURPOSE

The City maintains a storm sewer infrastructure that serves a majority of its jurisdictional area. As the City continues to grow and redevelop, stormwater drainage systems will be necessary to provide for public safety, convenience, and the protection of property. The future of the City's surface water and groundwater resources also depends to a great extent on the management of storm water runoff. The City takes an active role in protecting these resources through effective stormwater management planning and practices.

It is the purpose of this design criteria manual to establish a uniform set of minimum stormwater standards to meet the following objectives in accordance with the Stormwater Ordinance (Chapter 32 of Title II of the Code of the City of Grand Rapids provides stormwater standards and Chapter 67 of Title V of the Code of the City of Grand Rapids provides applicability.):

1. Reduce artificially induced flood damage.
2. Minimize increased storm water runoff rates and volumes from identified new land development.
3. Minimize the deterioration of existing watercourses, culverts and bridges, and other structures.
4. Encourage water recharge into the ground where geologically favorable conditions exist.
5. Prevent an increase in non-point source pollution.
6. Maintain the integrity of stream channels for their biological functions, as well as for drainage and other purposes.
7. Minimize the impact of development upon stream bank and streambed stability.
8. Reduce erosion from development or construction projects.
9. Preserve and protect water supply facilities and water resources by means of controlling increased flood discharges, stream erosion, and runoff pollution.
10. Reduce storm water runoff rates and volumes, soil erosion, and non-point source pollution, wherever practicable, from lands that were developed without storm water management controls meeting the purposes of these standards.
11. Reduce the adverse impact of changing land use on water bodies.

The intent of this manual is to provide guidance on meeting the City of Grand Rapids Stormwater Standards which are not fully duplicated within this manual. Stormwater Standards are included by reference only. Please refer to Chapter 32 of Title II of the Code of the City of Grand Rapids for the complete Stormwater Standards and Chapter 67 of Title V of the Code of the City of Grand Rapids for applicability.

## A. Compliance with State and Federal Stormwater Mandates

The National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit requires the City to adopt an ordinance or other regulatory mechanism to address post-construction stormwater runoff from new development and redevelopment projects, including preventing or minimizing water quality impacts. The City is required to obtain a permit under Section 402 of the Federal Clean Water Act, as amended, and under Water Resources Protection (Part 31, Act 451, PA 1994) of the Michigan Natural Resource and Environmental Protection Act (NREPA), as amended. The Post-Construction Storm Water Runoff Program of the MS4 permit requires among other things:

1. A water quality performance standard to ensure specified reductions in total suspended solids.
2. A channel protection performance standard to address resource impairments resulting from increases in bankfull flow rates and volumes.
3. A review procedure for the evaluation of infiltration BMPs to meet water quality and channel protection standards in areas of soil or groundwater contamination.

4. Measures to address associated pollutants in identified "hot spots," which include past, current, or future land uses with the potential for significant pollutant loading that could result in the contamination of surface water or groundwater, including public water supplies.
5. A long-term operation and maintenance (O&M) plan and agreement allowing for the inspection of the BMP, including a mechanism for tracking the transfer of O&M responsibility and compliance.

The minimum standards in this manual adhere to the Post-Construction Storm Water Runoff Program requirements for new and redevelopments set forth in the *State of Michigan National Pollutant Discharge Elimination System Permit Application for Discharge of Storm Water to Surface Waters of the State from a Municipal Separate Storm Sewer System* (DEQ, 2013, Rev 10/2014).

## B. Preferred Stormwater Management Strategies

It is the position of the City to promote the following stormwater management strategies:

### Low Impact Development

Onsite Low Impact Development (LID) is the preferred stormwater management strategy to meet the multiple objectives identified above. The *Low Impact Development Manual for Michigan* (SEMCOG, 2008) was used to develop this manual. Further documentation of the impacts of development on land and water resources and the importance of stormwater management can be found in Chapter 2 of the *Low Impact Development Manual for Michigan* (SEMCOG, 2008). In addition, Structural Best Management Practices specifications developed specifically for the City of Grand Rapids are presented in the City of Grand Rapids Green Infrastructure Standards (Green Book) presented separately.

A LID approach provides multiple benefits in terms of preservation of natural areas and greenspace, maintaining site hydrology, while improving water quality, and doing so in a manner that often leads to increased property value and offers a potential cost savings.[1] Land Owners can often reduce the size of storage facilities and stormwater infrastructure by incorporating LID principles into a site design up front. This manual provides rules for the stormwater “credits” allowed through the use of specific LID best management practices (BMPs).

### Alternative Approach for Channel Protection

An alternative approach using extended detention is preferred by the City over payment-in-lieu programs when the full channel protection volume cannot be retained onsite. These standards provide specific criteria for determining the conditions under which the alternative approach will be approved for use. A flow chart outlining this process is shown on the following page.

Off-site mitigation for channel protection is allowed where physical constraints of individual sites may preclude effective onsite treatment of stormwater. Off-site mitigation allows for the use of superior performing BMPs that require more space, and provides more flexibility for BMPs to be sited strategically to address a known water quality issue.[2] Specific requirements are provided in Part 2 section “Off-site Mitigation and Payment-in-lieu.”

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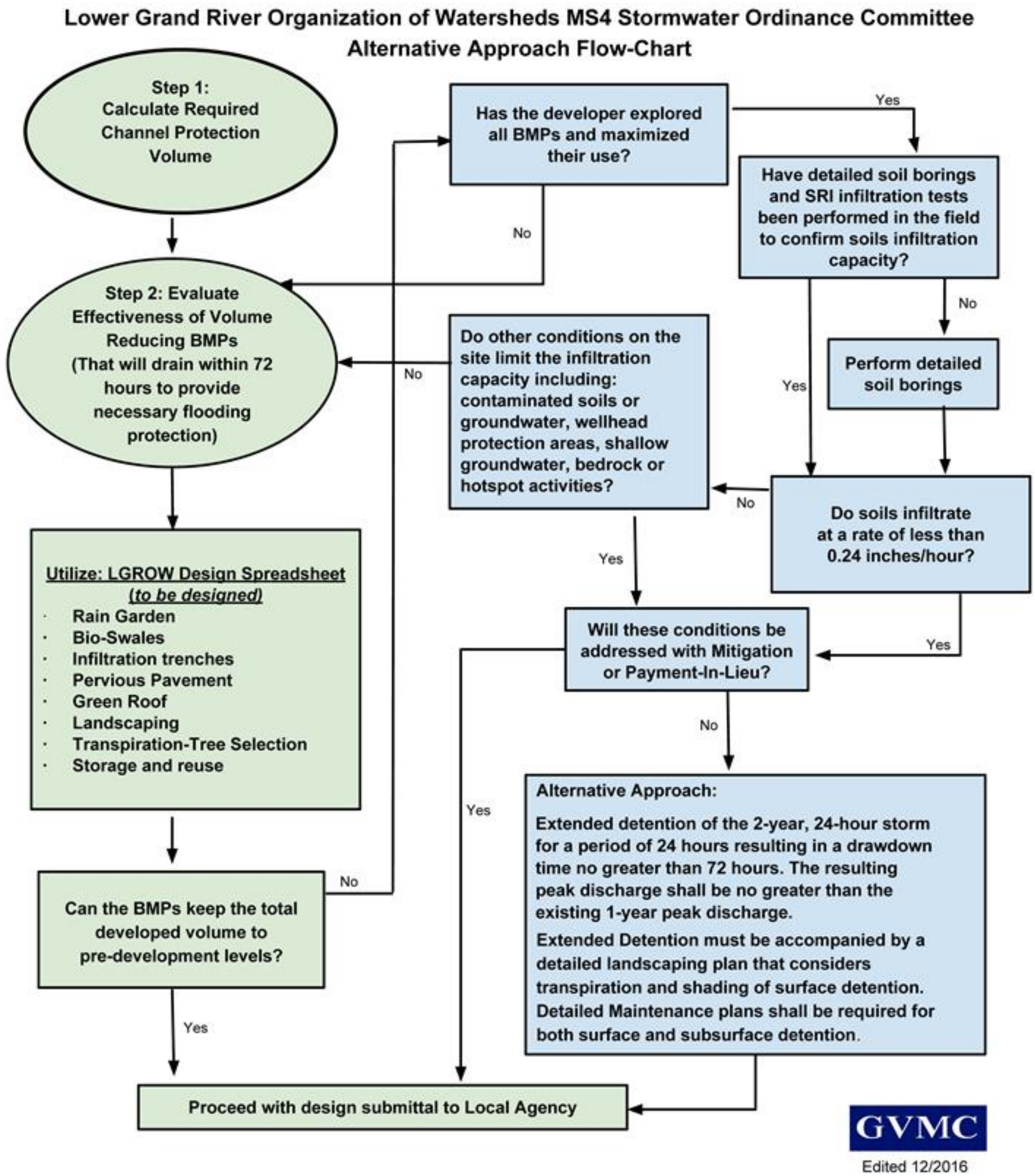
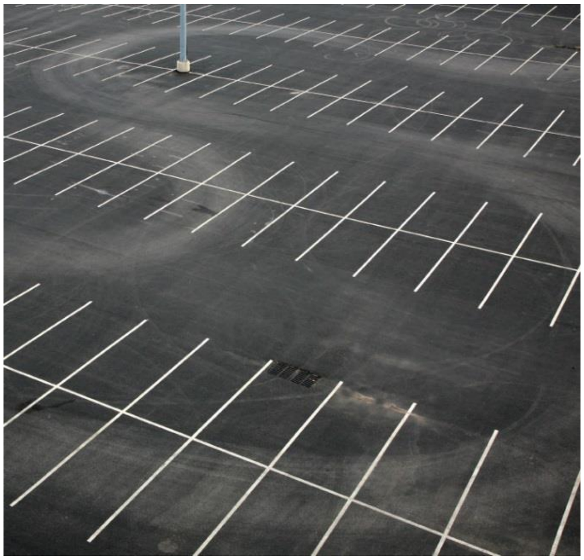
[1] United States Environmental Protection Agency (December 2007). *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*, EPA 841-F-07-006.

[2] Maupin, Miranda, and Wagner, Theresa (2003). *Regional Facility vs. On-site Development Regulations: Increasing Flexibility and Effectiveness in Development Regulation Implementation*, City of Seattle, Seattle, Washington.


Lower Grand River Organization of Watersheds MS4 Stormwater Ordinance Committee
Alternative Approach Flow-Chart
Step 1: Calculate Required Channel Protection Volume
Step 2: Evaluate Effectiveness of Volume Reducing BMPs (That will drain within 72 hours to provide necessary flooding protection)
Utilize: LGROW Design Spreadsheet (to be designed)
Rain Garden
Bio-Swales
Infiltration trenches
Pervious Pavement
Green Roof
Landscaping
Transpiration-Tree Selection
Storage and reuse
Can the BMPs keep the total developed volume to pre-development levels?
Yes
No
Has the developer explored all BMPs and maximized their use?
Yes
No
Have detailed soil borings and SRI infiltration tests been performed in the field to confirm soils infiltration capacity?
No
Yes
Perform detailed soil borings
Do other conditions on the site limit the infiltration capacity including: contaminated soils or groundwater, wellhead protection areas, shallow groundwater, bedrock or hotspot activities?
No
Yes
Do soils infiltrate at a rate of less than 0.24 inches/hour?
No
Yes
Will these conditions be addressed with Mitigation or Payment-In-Lieu?
Yes
No
Alternative Approach:
Extended detention of the 2-year, 24-hour storm for a period of 24 hours resulting in a drawdown time no greater than 72 hours. The resulting peak discharge shall be no greater than the existing 1-year peak discharge.
Extended Detention must be accompanied by a detailed landscaping plan that considers transpiration and shading of surface detention.
Detailed Maintenance plans shall be required for both surface and subsurface detention.
Proceed with design submittal to Local Agency
GVMC
Edited 12/2016

## Stormwater Management
## Preferred Approach Incorporates Low Impact Development (LID)



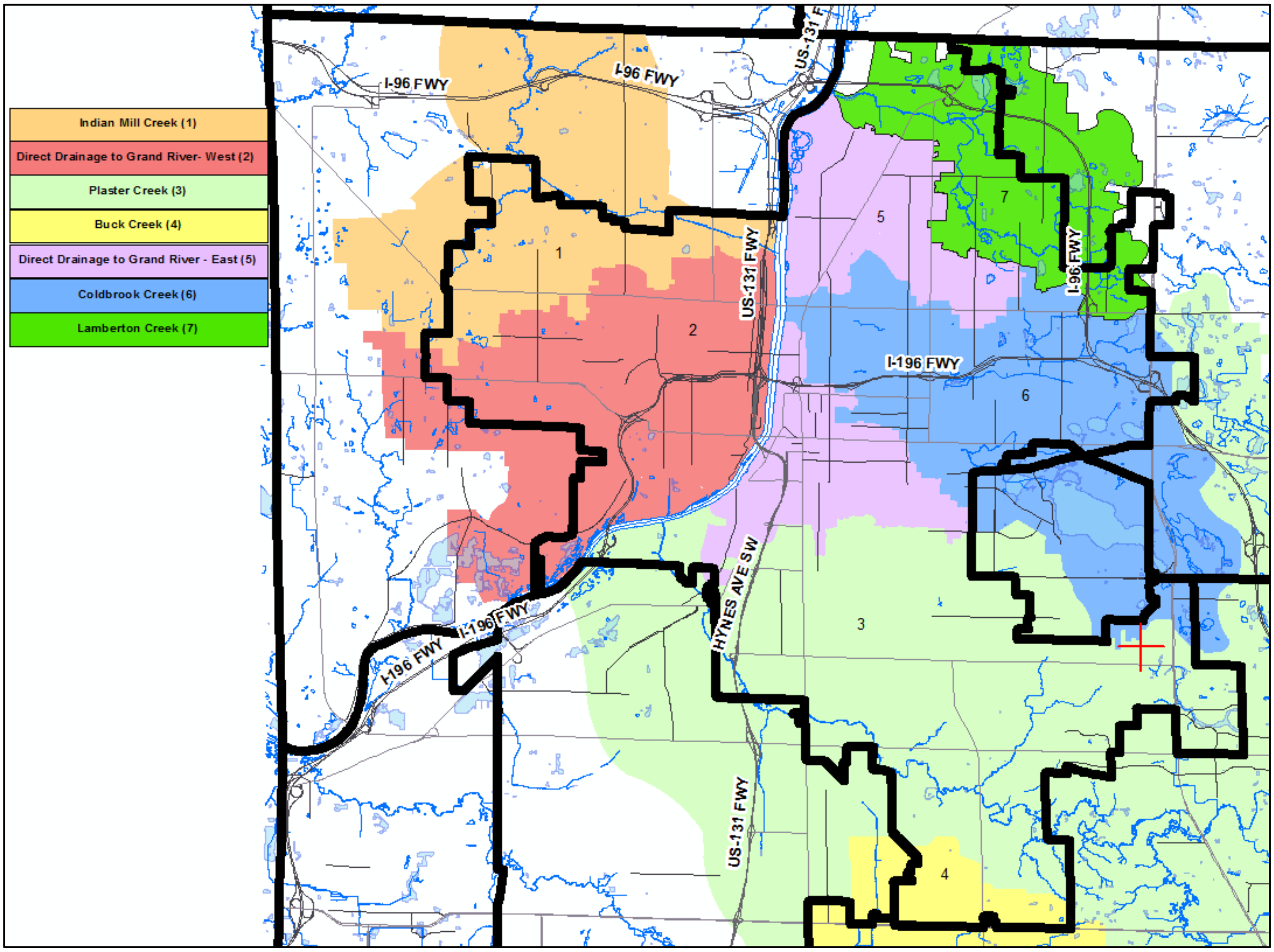
Traditional Parking Lot Design

Preferred: LID Parking Lot Design


Traditional “Big Box” Site Layout


Preferred: Equivalent LID Site Layout

**Figure 1 – Sewershed Map**



# II. AUTHORITY

## A. State Law and Code of City Ordinances

Under state law (MCL 117.3(k)), the City Commission has the power to enact, amend and repeal all ordinances that may be necessary or proper for carrying out the powers conferred and the duties imposed upon the City by the charter and by the laws of the State.

The Code of City Ordinances, Chapter 32 of Title II and Chapter 67 of Title V, establish the site plan review procedure under the Land Division Act (MCL 560.101 et seq.); Condominium Act (MCL 559.101 et seq.) and local regulation of condominiums (MCL 559.241); the Mobile Home Commission Act (MCL 125.2301 et seq.); and the Michigan Zoning Enabling Act (MCL 125.3101 et seq.). Chapter 32 of Title II (Stormwater Ordinance) provides for the regulation and control of stormwater runoff and establishes procedures for obtaining a stormwater permit as part of the site plan approval process. These published Stormwater Standards are incorporated by reference into the Stormwater Ordinance.

## B. Provisions for Requirements in Addition to Minimum Standards

This manual provides minimum standards to be complied with by Land Owners and in no way limit the authority of the City in which the development is situated to adopt or publish and enforce higher standards as a condition of approval of the final plat or site plan.

The City reserves the right to determine site-specific requirements other than those herein, based upon review of the plans. Any deviations from these standards shall be subject to approval by the City.

# III. APPLICABILITY

## A. Review Required

These standards apply to private and public development and redevelopment projects. The standards also apply to projects being completed by the City, including road projects.

The following types of developments shall be subject to review under these standards:

The Land Owner of any proposed development or redevelopment of property in the City, with the exception of single- and two-family residential, that involves the drainage of surface runoff from impervious areas such as roofs, pavements, parking areas, and walks with a total surface area of one thousand (1,000) square feet or more shall apply for and obtain a stormwater discharge permit prior to the start of any construction, earth change, or other work on the project site.

## B. Redevelopment

Redevelopment and additions requiring site plan review shall comply with the current standards for the redeveloped or newly constructed portion of the site.

The City reserves the right to require that the entire site be brought up to the current standards.

# IV. SEVERABILITY CLAUSE

If any part of these standards is found to be invalid, such invalidity shall not affect the remaining portions of the standards which can be given effect without the invalid portion, and to this end the standards are declared to be severable.

# V. ADOPTION AND REVISION

The City of Grand Rapids has adopted Stormwater Standards and Fees by resolution on _____, 20__. Revisions to the standards or fees will be subject to review and approval by the City Commission. Revisions to the standards affecting MS4 permit requirements must be reviewed and approved by DEQ. Revisions to this standards manual will be approved by the City of Grand Rapids Stormwater Oversight Commission.

# VI. FEES

The amount charged for each of the fees established in this Chapter shall be as set forth by resolution of the City Commission. Fees can be found at www.grcity.us/devcenter and apply for the City's Fiscal Year of July 1 to June 30.

# I. SUBMISSION AND APPROVAL

The submittal requirements for a stormwater permit are listed in Section 2.225 of Chapter 32 of the City Code. Other LUDS permit requirements are listed in the LUDS permit checklists in Appendix 1.

## A. Staged Development

Should the Land Owner plan to develop a given area but wish to begin with only a portion of the total area, the original preliminary plat or site plan shall include the proposed general layout for the entire area. The first phase of the development shall be clearly superimposed upon the overall plat or site plan in order to illustrate clearly the method of development that the Land Owner intends to follow. Each subsequent plat or site plan shall follow the same procedure until the entire area controlled by the Land Owner is developed.

Final acceptance by the City of only one portion or phase of a development does not ensure final acceptance of any subsequent phases or the overall general plat or site plan for the entire area; nor does it mandate that the overall general plat or site plan be followed as originally proposed, if deviations or modifications acceptable to the City are proposed.

## B. Submission of Construction Record Drawings (“As-builts”)

Submission requirements are outlined in Appendix 1, and can be accessed online through the City’s website.

# II. STORMWATER DRAINAGE REQUIREMENTS

## A. Drainage Plan

### Drainage Patterns

Proposed drainage for the development shall conform to existing watershed boundaries, natural drainage patterns within the site, or any established county drainage districts.

### Staged Development

Each phase shall be self-sufficient from the standpoint of drainage.

### Location of Stormwater Runoff Facilities

Stormwater runoff facilities for private drainage systems with multiple land ownership shall be located on dedicated outlots, within road rights-of-way, or have separate easements granted to the entity responsible for operation and maintenance of the stormwater management system.

### Limiting Pollutants in Stormwater Discharge

The City Manager is authorized to require dischargers to implement pollution prevention measures, Best Management Practices, or other methods necessary to prevent or reduce the discharge of pollutants into the CSDS.

### Limiting Stormwater Discharge Rates and Volumes

The City Manager is authorized to establish minimum design standards for stormwater discharge release rates and require dischargers to implement on-site retention, detention or other methods necessary to control the rate and volume of surface water runoff discharged into the CSDS when:

1. A parcel of property is being developed or redeveloped in a manner that increases the impervious surface area of the property; or

2. The discharge exceeds the City-calculated pre-development discharge characteristics for the subject property and the City Manager determines that the discharge contributes to an identified drainage, flooding or soil erosion problem.

The rate, volume, concentration, or constitution of stormwater discharged from a site shall not create adverse impacts to downstream property owners and watercourses.

1. Post-development discharge shall not exceed the capacity of the existing infrastructure.
2. Post-development discharge shall not cause adverse impact to offsite property due to concentrated runoff or ponded water of greater height, area, and duration.
3. Discharge shall not cause downstream erosion or sedimentation.
4. For a downstream drainage system that is inadequate to handle the proposed design discharge from the site development, it is the Land Owner’s responsibility to provide additional onsite stormwater controls.

It is the Land Owner’s obligation to meet this standard. Should a stormwater system, as built, fail to comply with the standards herein, it is the Land Owner’s responsibility to have constructed at their expense, any necessary additional and/or alternative stormwater management facilities. Such additional facilities will be subject to the City’s review and approval.

## B. Off-site Mitigation and Payment-in-lieu

### Off-site Mitigation

Off-site mitigation refers to stormwater management practices implemented at another location than the proposed development or redevelopment, but within the same jurisdiction and sewershed to meet channel protection standards required by the MS4 permit. The City also requires that the off-site mitigation is protective of the same watercourse or waterbody to which the site discharges, and is located downstream of the proposed development or redevelopment if possible. Further details to be provided when system established upon permit approval.

### Payment-in-lieu

Payment-in-lieu refers to the Land Owner paying a fee to the City, which is then applied towards a public stormwater management project that fulfills the stormwater requirements for the site. The stormwater management project may be either a new BMP, or a retrofit to an existing BMP. The City will only consider payment-in-lieu if the City has a planned or constructed improvement project meeting the requirements for off-site mitigation. The cost of payment-in-lieu will be determined on a case by case basis, and will represent the actual cost of implementing public water quality enhancements. Further details to be provided when system established upon permit approval.

### Criteria

The determination to approve off-site mitigation or payment-in-lieu will be based on multiple criteria and not solely on the difficulty or cost of implementing BMPs on site. Conditions under which the option to move off site would become available may include:

1. Limited size of the lot outside of the building footprint to create the necessary infiltration capacity even with amended soils.
2. Soil instability as documented by a thorough geotechnical analysis.
3. A site use that is inconsistent with capture and reuse of stormwater.
4. Too much shade or other physical conditions that preclude adequate use of plants.
5. The potential water quality impact from the original project site and the benefits realized at the off-site location.

The City may approve off-site mitigation or payment-in-lieu if the Land Owner demonstrates that site constraints preclude sufficient treatment and restoration of hydrology onsite, and the following minimum requirements are met:

1. Offset ratio. The offset ratio for the amount of storm water not managed onsite in relation to the amount of stormwater required to be mitigated at another site, or for which in-lieu payments will be made is as follows:
   a. First Tier: Manage a minimum of 0.4 inches of storm water runoff onsite, and provide a 1 to 1.5 offset ratio for the remaining amount of storm water managed offsite.
   b. Second Tier: If it completely infeasible to manage the minimum onsite, provide a 1 to 2 offset ratio for the amount of storm water managed offsite.
2. Schedule. Offsite mitigation shall be completed within 24 months after the start of the original site construction.
3. Assurances. Offset and in-lieu projects shall be preserved and maintained in perpetuity through the procedures and tracking system administered by the City.

## C. Restrictive Covenants

For plats and site condominiums, a copy of restrictive covenants or master deed language related to drainage shall be provided to the City along with construction drawings for approval. Covenants and deeds shall be recorded prior to release of posted surety.

**Responsibility for Maintenance of Open Water Bodies**
The restrictive covenant shall state:

*Lot owners are responsible for the management and maintenance of open water bodies for aesthetics, aquatic habitat, recreation and water quality, including liability and costs.*

## D. Soil Erosion and Sedimentation Control Permits

Soil erosion and sedimentation control permits shall be acquired as outlined in Chapter 32 of Title II and Chapter 67 of Title V of the Code of the City of Grand Rapids.

## E. Maintenance Plan and Agreement

A legally binding maintenance agreement between the Land Owner and the City shall be required before approval is granted. The maintenance agreement shall include a maintenance plan and schedule, and requires tracking of compliance. Contact the City for necessary forms, documents and compliance process. A copy of the recorded maintenance agreement must be presented to the City prior to construction drawing approval.

# I. SUMMARY

The following stormwater management requirements comply with the City's Stormwater Ordinance and NPDES MS4 permit and shall apply to all new and redevelopments in the City of Grand Rapids:

1. Protection. The design process shall begin by identifying environmentally sensitive areas located on the site and laying out the site to maximize protection of the sensitive areas.
2. Source Controls. Non-structural BMPs shall be used for protection of environmental sensitive areas on the site, and to reduce the amount of stormwater runoff.
3. Runoff Controls. Stormwater runoff shall be managed onsite using structural BMPs to protect both water resources and real property. Minimum stormwater standards are summarized in **Table 1**. Higher standards may be required for sites that discharge to areas with known issues.
4. Offsite Mitigation. Offsite mitigation facilities are best management practices implemented at another location that the proposed development or redevelopment but within the same jurisdiction and sewershed, downstream of the proposed development or redevelopment. Further details to be provided when system established upon permit approval.
5. Payment-in-Lieu. Payment-in-Lieu refers to the Land Owner paying a fee to the City of Grand Rapids and is applied towards a public stormwater management project. The stormwater management project may be either a new BMP or a retrofit to an existing BMP. The City will only consider payment-in-lieu if the City has a planned or constructed water quality improvement project. The cost of payment-in-lieu would be considered on a case by case basis and will represent the actual cost of implementing public water quality enhancements. Further details to be provided when system established upon permit approval.
6. Watershed Policy Statements. Specific stormwater management policies have been established for identified watersheds and are required to be met in addition to these minimum standards (Appendix 2).
7. Adequate Outlet. The design maximum release rate, volume or concentration of stormwater discharged from a site shall not exceed the capacity of the downstream stormwater infrastructure or cause impairment to the offsite receiving area.
8. BMP Design. BMPs must be designed to meet the minimum criteria provided. BMPs selected to meet the water quality treatment standard must also be shown to reduce TSS in stormwater runoff by at least 80% or to a concentration of no greater than 80 mg/L (refer to **Table 3**).
9. Groundwater. The highest known groundwater elevation and extent of mounding from infiltration BMPs shall be determined to ensure no adverse impacts internal and external to the development.
10. Soils. Test pits or Soil borings and field permeability testing are required for most structural BMPs to determine soil classification, depth to groundwater, infiltration rates, and the presence of other site constraints.
11. Restrictive Covenants. Plats and site condominium developments must incorporate specific requirements for lot grading, minimum floor and opening elevations, footing drains, private easements for side yard drainage, and individual soil erosion and sedimentation control (SESC) permits.
12. Operation and Maintenance. Stormwater BMPs must be designed to allow for operation and maintenance, demonstrated in the review submittals. A maintenance agreement between the Developer and the City shall be required for private stormwater management systems.

**Table 1 – Minimum Required Stormwater Standards**

| Standard/Where Required | Criteria |
|---|---|
| **Water Quality**<br>"first flush"<br>All sites. | Treat the runoff generated from 1 inch of rain over the project site (i.e. the 90% annual non-exceedance storm) through BMPs designed to reduce post-development TSS loadings by 80%, or achieve a discharge concentration not to exceed 80 mg/L.<br><br>Treatment may be provided through settling (permanent pool or detention), filtration or infiltration, absorption, or chemical/mechanical treatment. |
| **Channel Protection**<br>Surface water discharges. | Retain onsite the increase between the pre-development and post-development runoff volume and rate for all storms up to and including the 2-year, 24-hour rainfall event; OR<br><br>Where site conditions preclude infiltration, an alternative approach may be allowed after all other onsite retention options are maximized: Extended Detention of the 2-year, 24-hour storm for a period of 24 hours resulting in a drawdown time no greater than 72 hours. The resulting peak discharge shall be no greater than the existing 1-year peak discharge.<br><br>Pre-development is defined as the last land use prior to the planned new development or redevelopment. |
| **Flood Control**<br>All sites; unless exception is allowed. | Collection and Conveyance: Design storm sewers open channels and swales for the 10-year storm.<br><br>Detention and Retention: Store runoff from the 25-year storm with a maximum release rate of 0.13 cfs/acre (minimum rate of 0.26 cfs for sites less than 2 acres), unless the site is in a sensitive sewershed listed in Appendix 2.<br><br>Sites in sewersheds sensitive to flooding per Appendix 2, shall store runoff for the 100-year storm.<br><br>Sites in sewersheds sensitive to downstream soil erosion per Appendix 2 shall have its discharge limited to a rate of 0.05 cfs/acre up to the two (2) year rain event.<br><br>If the post-development runoff volume is equal to or less than the existing runoff volume, the maximum release rate may be increased to the pre-development 25-year or 100-year peak runoff rate, as applicable per sewershed.<br><br>Overflow Routes for Extreme Flood Event: Identify overflow routes and the extent of high water levels for the 100-year flood event to ensure no adverse impacts offsite or internal to the site. Where overland flow routes do not exist, storm sewers shall be upsized to a 100-year design, and detention/retention basins shall be increased in size to store a total of 2 times the flood control volume. |
| **Pretreatment**<br>Refer to **Table 3**. | Forebay volume equal to 15% of water quality volume (required for detention/retention basins); Vegetated Filter Strip; Vegetated Swale; Water Quality Device. |
| **Hotspot**<br>Industrial and commercial land uses in **Table 2**; Part 201 and Part 213 sites. | Isolate transfer and storage areas to minimize need for treatment.<br><br>Pretreatment BMP with impermeable barrier above groundwater and provisions for the capture of oil, grease, and sediments. Minimum spill containment volume: 400 gallons. |

**Table 1 – Minimum Required Stormwater Standards**

| Standard/Where Required | Criteria |
|---|---|
| **Coldwater Streams** | Incorporate strategies to promote groundwater recharge and/or reduce temperature of surface discharge water. |

# II. STANDARDS

## A. Water Quality

### Where Required

Treatment of the water quality volume is required for all sites to capture and treat the "first flush" of stormwater runoff that typically carries with it the highest concentration of pollutants.[3]

### Standard

Capture and treatment of the runoff from the 90% annual nonexceedance storm is required for the project site. This storm is approximately equivalent to 1 inch of rain (1.00 inch for Michigan Climatic Zone 8 per DEQ memo "90 Percent Annual Nonexceedance Storms" dated March 24, 2006).

Treatment of the runoff volume from the 90% annual nonexceedance storm with properly designed BMPs to reduce TSS loading by 80%, or achieve TSS discharge concentrations not to exceed 80 mg/L, is required by the MS4 permit.

*Note:* TSS is a surrogate for other pollutants normally found in stormwater runoff. Control of TSS to meet this requirement is expected to achieve control of other pollutants to an acceptable level that protects water quality.

Natural areas of the site left undisturbed and BMPs that provide water quality treatment need not be included in the calculations. This effectively results in the directly connected impervious areas and disturbed pervious areas of the site being used to calculate the water quality volume.

### Treatment BMPs

Selected BMPs must meet the 80% TSS reduction target either alone or in combination. Pollutant (TSS) removal efficiencies for BMPs are provided in **Table 3**. Water quality volume can be provided through one of the following methods:

1. Settling (Permanent Pool or Detention)
2. Filtration
3. Infiltration
4. Absorption
5. Chemical/Mechanical Treatment

<u>Permanent Pool.</u> The volume of a permanent pool incorporated into a stormwater BMP and sized at 2.5 times the water quality volume.[4] This is the volume below the ordinary static water level (also known as dead storage).

<u>Detention.</u> The storage volume provided by detention of stormwater. Extended detention is defined as holding the stormwater runoff volume and releasing it gradually over a period of 24 hours with a drawdown time no greater than 72 hours.

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[3] Stenstrom, Michael K. and Kayhanian, Masoud (2005). *First Flush Phenomenon Characterization*. California Department of Transportation, Sacramento, California.

[4] Barrett, Michael (2005). *BMP Performance Comparisons: Examples from the International Stormwater BMP Database*, Center for Research in Water Resources, PRC#119, University of Texas, 2005 Water Environment Federation.

Filtration. The volume of stormwater runoff routed through a BMP that provides filtration (i.e. an underdrained BMP). In the case of a vegetated filter strip or vegetated swale, the filtering area must meet minimum standards for slope, length, drainage area and vegetative cover.

Infiltration. The volume of stormwater runoff infiltrated into the ground through a stormwater BMP.

Absorption and Chemical/Mechanical Treatment. The volume of stormwater runoff routed through a water quality device.

## B. Channel Protection

### Where Required

Channel protection is required for surface water discharges. More restrictive requirements may be required based on sewershed per Appendix 2.

### Standard

The post-development runoff rate and volume shall not exceed the pre-development rate and volume for all storms up to and including the 2-year, 24-hour storm. Onsite retention of the volume increase is required.

Retention can be provided through infiltration, or interception and evapotranspiration or reuse.

Pre-development is defined as the last land use prior to the planned new development or redevelopment.

### Alternative Approach

Where site constraints limit infiltration, and field permeability testing has confirmed the limits of the infiltration rate, an alternative approach may be allowed after all other onsite design and retention options are maximized. A flowchart detailing the alternative approach method is displayed in Part 1 section I.B. The Application and Checklists found in Appendix 1 must be submitted for approval before the alternative approach can be used. Site constraints that limit the use of infiltration may include:

1. Poorly draining soils (<0.24 inches per hour; typically hydrologic soil groups C and D).
2. Bedrock.
3. High groundwater, or the potential of mounded groundwater to impair other uses.
4. Wellhead protection areas.
5. Stormwater hot spots.
6. Part 201 and Part 213 sites, and areas of soil or groundwater contamination.

Conditions can be addressed with off-site mitigation, payment-in-lieu, the alternative approach, or a combination of these options as the City sees fit, only if the use of all other BMP’s has been maximized.

The alternative approach shall consist of extended detention of the 2-year, 24-hour storm for a period of 24 hours resulting in a drawdown time no greater than 72 hours. The resulting peak discharge shall be no greater than the existing 1-year peak discharge.

*Note:* A developed peak discharge no greater than the existing 1-year peak discharge will meet the MS4 permit requirement of not exceeding the pre-development discharge rate for all storms up to and including the 2-year storm.

If the allowable opening size from an extended detention basin becomes too small for practical design (less than 4 inches), an underdrained bioretention BMP (e.g. bioretention/rain garden, planter box, water quality swale) may be used to protect the orifice. *Note:* Various studies have shown that underdrained biofiltration BMPs provide a significant percentage of volume reduction (23% to 73% for 25th and 75th percentiles),[5] and a large percentage of rate reduction (80% or more).[6]

# C. Flood Control

### Where Required

Flood control is required for all sites.

### Standard

Detention or retention of the 25-year storm with a maximum release rate of 0.13 cfs per acre is required with the exception of those sewersheds listed as sensitive to flooding or soil erosion per Appendix 2.

*Note:* The design storms were selected to balance flood risk management with economics based on federal studies comparing the cost of flood damage to storm return interval.[7] The release rate of 0.13 cfs per acre is selected to be generally protective of floodplains in downstream watercourses and is based on result found in previous hydrologic studies on West Michigan streams.[8] Where volume control is not provided, an extremely low release rate is required to prevent an increase in peak flow rates in downstream watercourses or storm sewers. The increased volume and prolonged duration of runoff from multiple detention basins can have a cumulative effect to increase peak flow rate and duration in downstream reaches.

An alternate peak discharge may be allowed when the volume of runoff discharged from the developed site is equal to or less than the volume of runoff from the existing site for the design storm, the maximum allowable release rate may be increased to the pre-development peak discharge rate for the design storm. However, if detention is already in use on a redevelopment site, the existing controlled release rate is the pre-development release rate.

*Note:* This approach is effective in maintaining peak flow rates and floodplain levels in downstream watercourses, since it better mimics the predevelopment hydrology of a site and eliminates the large volume increases associated with increased flooding.

### Overflow Routes for Extreme Flood Events

Overflow routes and the extent of high water levels for the 100-year flood shall be identified for the site and for downstream areas between the site and the nearest acceptable floodway or outlet. Provisions shall be made to ensure no adverse impacts offsite or internal to the site. Where acceptable overflow routes do not exist, storm sewers shall be upsized for a 100-year design and detention/retention basins shall be increased in size to store a total of 2 times the flood control volume.

*Note:* The intent of the extreme flood criteria is to prevent flood damage from large but infrequent storm events by identifying and/or designing overland flow paths that are clear of structures and have grades below the lowest openings of structures. Overflow routes may include floodplains along open channels, overbank areas along vegetated swales, curb jumps in drives and parking lots, and other flow paths flood waters will take to reach an outlet, whether overland or underground.

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[5] Geosyntec Consultants and Wright Water Engineers, Inc. (May 2012). *International Stormwater Best Management Practices (BMP) Database, Addendum 1 to Volume Reduction Technical Summary (January 2011), Expanded Analysis of Volume Reduction in Bioretention BMPs.*

[6] University of New Hampshire Stormwater Center (2007). *2007Annual Report*.

[7] Johnson, William K. (January 1985). *Significance of Location in Computing Flood Damage*. ASCE Journal of Water Resource Planning and Management.

[8] Camp, Dresser and McKee, Inc. (1991). *Buck and Plaster Creek Stormwater Management Masterplan*, prepared for the Kent County Drain Commissioner.

## D. Pretreatment

### Where Required

Pretreatment is required prior to discharging stormwater runoff to the following structural BMPs to preserve the longevity and function of the BMP:

1. Detention and retention basins
2. Infiltration practices
3. Bioretention/rain gardens
4. Constructed filters
5. Stormwater reuse
6. Water quality swales
7. Treatment BMPs

### Treatment BMPs

Pretreatment provides for the removal of fine sediment, trash, and debris. Methods of pretreatment include:

1. Forebays (including spill containment cells and level spreaders)
2. Vegetated filter strips (including buffers and green roofs)
3. Vegetated swales (including natural flow paths)
4. Water quality devices

### Standard

<u>Sediment Forebay</u>

A minimum pretreatment volume equivalent to 15% of the water quality volume is required for sediment forebays using gravity.

*Note:* This is a conservative approximation of results given by the Hazen Equation for sediment basin sizing using a 50% settling efficiency for a 50-micron particle (silt) with a 1-year peak inflow, consistent with recommendations in the *Low Impact Development Manual for Michigan* (SEMCOG 2008).

<u>Vegetated Filter Strip</u>

Provide a 10-foot minimum sheet-flow length at a maximum slope of 2% with an impervious approach length no greater than 3.5 times the filter strip length, up to a maximum approach length of 75 feet.

Provide a 15-foot minimum sheet flow length for slopes between 2% and 6% with an impervious approach length no greater than 3 times the filter strip length, up to a maximum approach length of 75 feet.

<u>Vegetated Swale</u>

Provide a 20-foot minimum length at a maximum slope of 2% with a 1-foot high check dam at the downstream end, and a maximum upstream drainage area of 0.13 acre per 2-foot of bottom width.

*Note:* Minimum lengths for vegetated filter strips and vegetated swales are selected to provide a workable length for small sites and right-of-way constraints, while providing an area for sediment to drop out of suspension. Vegetated filter strip sizing for pretreatment from *Design of Stormwater Filtering Systems* (Center for Watershed Protection, 1996). Vegetated swale upstream area ratio assumes a 1-year peak inflow (rainfall intensity of 2.16 inches per hour for a time-of-concentration of 15 minutes) from an impervious area, with a settling efficiency of 50% for a 50-micron particle (silt).

<u>Water Quality Device</u>

Configured to trap floatables and sediment. Follow manufacturer's guidelines. The City does not maintain an approved/recommended list of proprietary devices. Each device's specifications will be reviewed for compliance during each review.

## D. Hot Spots

### Where Required

Sites considered to be stormwater hot spots are identified in **Table 2**. Industrial and commercial land use activities on these sites involve the production, transfer, and/or storage of hazardous materials in quantities that pose a high risk to surface and groundwater quality (those exceeding 55 gallons aggregate for liquids and 440 pounds aggregate for dry weights), as defined in Part 5 Rules: Spillage of Oil and Polluting Materials, under Water Resources Protection (Part 31, Act 451, PA 1994). Sites of soil or groundwater contamination under Part 201 Environmental Remediation and Part 213 Leaking Underground Storage Tanks (Act 451, PA 1994) are also included in **Table 2**.

### Standard

Pretreatment volume with a minimum of 400 gallons required for spill containment.

*Note:* The minimum volume provides a reasonable capture size (e.g. a standard liquid propane truck has a hauling capacity of 1,000 gallons) that can be accommodated with a 6-foot diameter water quality device.

Pretreatment BMPs must have an impermeable barrier between the treated material and the groundwater and have provisions for the capture of oil, grease, and sediments.

### Treatment BMPs

Infiltration BMPs will be reviewed to meet performance standards in areas of soil or groundwater contamination to ensure a site design that does not exacerbate existing conditions. Specific stormwater management strategies for areas of existing contamination and hotspots include the following:

1. Isolate transfer and storage areas from permeable surfaces and reduce exposure to stormwater.
2. Identify opportunities for use of infiltration BMPs in other areas of the site.
3. Where storage and transfer areas exposed to stormwater cannot be avoided:
    a. Infiltration of runoff from parking lots and road surfaces is discouraged in favor of a surface water discharge.
    b. Pervious pavements that infiltrate into the groundwater are not permitted because they do not allow for any pretreatment or spill containment.
    c. Perforated pipes for infiltration are not permitted due to the difficulty in isolating an accidental spill.

**Table 2 – Stormwater Hot Spots**

| 2012 North American Industry Classification System (NAICS) | |
|---|---|
| 31 – 33 | Manufacturing |
| 44 – 45 | Retail Trade (441 Motor Vehicle and Parts Dealers, 444 Building Material and Garden Equipment and Supplies Dealers, 447 Gasoline Stations, 454 Non-store Retailers (e.g. fuel dealers)) |
| 48 – 49 | Transportation and Warehousing |
| 71 | Arts, Entertainment, and Recreation (79393 Marinas) |
| 81 | Other Services (8111 Automotive Repair and Maintenance, 8113 Commercial and Industrial Machinery and Equipment Repair and Maintenance, 8123 Dry Cleaning and Laundry Services, 8129 Other Personal Services (e.g. photofinishing laboratory)) |
| | Salvage Yards and Recycling Facilities |
| | Sites classified under Part 201 Environmental Remediation and Part 213 Leaking Underground Storage Tanks (Act 451, PA 1994) of the Michigan compiled laws |
| | Areas with the potential for contaminating public water supply intakes |
| | Other land uses and activities where petroleum products, chemicals or other polluting materials have a high probability of polluting surface or groundwater due to quantity of use, storage or waste products generated, as determined by the City. |
| Many of these sites will also be regulated under the EPA NPDES Industrial Stormwater Program. A detailed list of NAICS industries can be found at: http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012 | |

## E. Coldwater Streams

### Where Required

Coldwater streams require an adequate and stable base flow to maintain their designation and support a cold-water fishery. Designated trout stream maps are available on the Michigan Department of Natural Resources (MDNR) website. Appendix 2 lists the Coldwater Streams located in the City.

### Treatment BMPs

Development practices that increase surface water temperature or eliminate groundwater recharge should be avoided. The following strategies apply to developments located within a watershed of a designated trout stream that also propose a surface water discharge to the coldwater stream. Strategies must be identified on the site plan and/or submittal package.

1. Protect riparian buffers.
2. Stormwater disconnection.
3. Incorporate heat-reducing BMPs such as green roofs and re-forestation.
4. Implement structural BMPs that control volume through infiltration.
5. If detention ponds are used, detention times must be limited to a maximum of 12 hours.
6. Wet ponds should draw water from near the pond bottom to maintain a cooler discharge water temperature.

## F. Watershed Policy Statements

Specific stormwater policies have been adopted by the City for the areas listed in Appendix 2. These include regional management zones for water quality and/or channel protection, sewersheds, and coldwater streams. If the site is located within one of the identified areas, the stormwater management plan for the site must also comply with the policy statements.

# III. DESIGN PROCESS

The stormwater site design process is summarized in the steps below. This process is intended to minimize negative impacts from development sites that could be avoided through proper planning.

## A. Identify Sensitive Areas

Identify existing environmentally sensitive areas on the site plan that may require special consideration or pose a challenge for stormwater management. For the purpose of these standards, sensitive areas include:

1. Waterbodies (lakes and ponds)
2. Rivers and streams
3. Floodplains (and flood prone areas)
4. Riparian areas
5. Wetlands
6. Woodlands
7. Natural drainageways
8. Soils and topography (erodible, steep)
9. Susceptible groundwater supplies
10. Threatened and endangered species habitat

Sensitive areas are determined on a site-specific basis through survey, delineation, aerial photographs, or maps. Sensitive areas must be shown on the site map or drawings. The total acreage of protected areas must also be indicated. The Land Owner must demonstrate a good faith effort to maximize protection of sensitive areas.

## B. Select Source Controls

Source controls reduce the volume of runoff generated onsite, encourage infiltration and evapotranspiration, and prevent pollutants from entering the drainage system. Non-structural BMPs are used for this purpose. Maximize the use of non-structural BMPs as the most effective option for controlling stormwater to meet sensitive area protection requirements and reduce the size of site runoff controls.

## C. Size Runoff Controls

After source controls have been maximized, site runoff controls are typically needed to manage the additional post-development stormwater runoff. Determine the standards applicable to the site to properly size runoff controls. Minimum standards are given in **Table 1**. Identify any additional standards required in Watershed Policy Statements.

## D. Confirm an Adequate Outlet

Once all onsite source and runoff controls have been implemented, excess runoff can be discharged offsite. The design criteria specified in this manual is generally protective of the receiving waterbody. However, the adequate outlet must always be identified downstream of the development to receive the design rate, volume, and concentration of the post-development site runoff. Discharge from the site, including discharge from emergency overflow spillways and pipes, must not cause adverse impact to downstream property or infrastructure (refer to Part 2 section “Limiting Stormwater Discharge Rates and Volumes”).

## E. Select Best Management Practices (BMPs)

Select appropriate stormwater BMPs to meet minimum required pollutant reduction, volume, and peak rate requirements. A list of common BMPs and their treatment ability is given in **Table 3**. The BMPs selected must be designed in accordance with the calculation methods and design criteria provided in *City of Grand Rapids Green Book*. BMPs proposed for use, but not included in this manual or the *Green Book* will be evaluated on an individual basis.

**Table 3 – Stormwater BMP Matrix**

| Stormwater BMP | Treatment | | | |
|---|---|---|---|---|
| | Requires Pretreatment | TSS Removal Efficiency | Provides Pretreatment | Provides Spill Containment |
| **Non-Structural BMPs** | | | | |
| Minimal Disturbance Area | | | | |
| Protect Natural Flow Pathways | | | X | |
| Protect Sensitive Areas | | | | |
| Native Revegetation | | | X | |
| Stormwater Disconnect | | | | |
| **Structural BMPs – Conveyance and Storage** | | | | |
| Storm Sewer | | (22) | | X |
| Culvert or Bridge | | | | |
| Open Channel | | | | |
| Detention Basin (dry) | X | (49) | | |
| Detention Basin (wet) | X | (80) | | |
| Detention Basin (extended/wetland) | X | (72) | | |
| Retention Basins | X | (89) | | |
| Sediment Forebay | | (50) | X | |
| Spill Containment Cell | | (50) | X | X |
| **Structural BMPs – LID and Small Site** | | | | |
| Infiltration Practices | X | (89) | | |
| Bioretention/Rain Garden* | X | (86) | | |
| Bioswale* | | (86) | X | |
| Constructed Filter | X | (86) | X | |
| Planter Box* | | (59) | | |
| Pervious Pavement* | | (84) | | |
| Pervious Pavement* (roof discharge to stone) | | (50) | | |
| Capture Reuse | X | (*) | | X |
| Vegetated Roof | | (*) | X | |
| Water Quality Device | | (*) | X | X |
| Water Quality Swale | | (86) | X | X |
| Vegetated Swale | | (81/50) | X | |
| Vegetated Filter Strip | | (81/50) | X | |
| Level Spreader | | | X | |

Blank  No. BMP does not provide treatment.
X  Yes.
( )  BMP may be used to meet water quality treatment criteria. Median TSS Removal Efficiency in percent.
Source: Fraley-McNeal, L. (September 2007). *National Pollutant Removal Performance Database, Version 3*, Center for Watershed Protection. Bioretention/Rain Garden, Bioswale and Water Quality Swale same as Constructed Filter.
Pervious Pavement average TSS Removal. Source: Rowe, Amy A., Borst, Michael, and O'Connor, Thomas P. (2007). *Pervious Pavement System Evaluation*, EPA, Office of Research and Development.
Storm Sewer average TSS removal for standard catch basin. Source: Pitt, R. and Field, R. (1998). *An Evaluation of Storm Drainage Inlet Devices for Stormwater Quality Treatment,* WEFTEC'98 Water Environment Federation 71st Annual Conference & Exposition, Proceedings Volume 6, Facility Operations I&II.
Sediment Forebay, Spill Containment Cell, and Vegetated Swale/Vegetated Filter Strip sized for pretreatment: 50% settling efficiency used.
( / )  BMP sized for water quality treatment / BMP sized for pretreatment only.
(*)  Submit independent third-party testing results of pollutant removal efficiency for review.
*  TSS removal efficiency assumes underdrained BMP, use value for Infiltration Practices if BMP has no underdrain.
Notes:  Design criteria in this manual is provided to meet or exceed the median TSS removal efficiency.

# F. Tree Protection, Mitigation, and Installation

1. Removal of Trees. Trees in Table 5.11.06 C or Table 5.11.08 B of the City Code with a caliper of 3 inches or greater are considered part of the current Stormwater Runoff Facility. If these trees are removed, they must be replaced with accredited trees whose stormwater uptake will equal that lost within five years. Additional storage will be required if equivalent tree replacement is not included in the new Stormwater Runoff Facility. Volume of stormwater uptake shall be determined using the U.S. Forestry iTree program.
2. Installation of Trees. Installation of accredited trees above the replacement of trees noted above shall equate to a reduction in required stormwater storage volume. The reduction in storage shall be based on the tree's uptake within five years as determined by iTree.
3. Trees in Water Protection Zones. Trees in Table 5.11.06 C or Table 5.11.08 B of the City Code removed from the 75-foot water protection zone described in Sec. 5.11.09 Water Protection shall be replaced with the equivalent of 1.5 gallons of uptake after five years for every one gallon of uptake lost by the removal as determined by iTree.
4. All trees installed per this section shall be considered part of the new Stormwater Runoff Facility and subject to the maintenance agreement.

# I. SOILS INVESTIGATION

## A. Qualifications

Soils investigation by a qualified geotechnical consultant is required for retention and detention basins, infiltration practices, bioretention/rain gardens, constructed filters, planter boxes, and pervious pavement to determine the site soil infiltration characteristics and groundwater level. The geotechnical consultant shall be a professional engineer, soil scientist, or professional geologist.

## B. Background Evaluation

An initial feasibility investigation shall be conducted to screen proposed BMP sites. The investigation involves review of the following resources:

1. County Soil Survey prepared by the NRCS and USDA Hydrologic Soil Group (HSG) classifications.
2. Existing soil borings, wells, or geotechnical report on the site.
3. Onsite septic percolation testing.
4. Cyclical groundwater levels http://waterdata.usgs.gov/mi/nwis/gw

## C. Test Pit/Soil Boring Requirements

A test pit (excavated trench) or soil boring shall be used for geotechnical investigation. Test pits may typically be selected for shallower investigations in locations where groundwater is sufficiently low.

The number of test pits will vary depending on site conditions and the proposed development. The minimum number of test pits or soil borings shall be determined from **Table 4**.

Additional tests should be conducted if local conditions indicate a large variability in soil type, groundwater table, or site conditions.

**Table 4 – Minimum Number of Soil Tests Required**

| Type of BMP | Soil Boring/Test Pit[1] | Depth of Test Pit/ Soil Boring[2] | Field Permeability Test |
|---|---|---|---|
| Retention basin<br>Infiltration bed<br>Rain garden<br>Pervious pavement | 1 soil boring per 5,000 square feet of bottom area; 2 minimum | 10 feet below proposed bottom | 1 test per soil boring |
| Infiltration trench<br>Bioswale | 1 soil boring per 100 linear feet of BMP; 1 minimum, 2 minimum for BMP>200 linear feet | 10 feet below proposed bottom | 1 test per soil boring |
| Dry well<br>Planter box | 1 soil boring minimum | 5 feet below proposed bottom | 1 test per soil boring, minimum of 18" below grade |
| Detention basin | 1 soil boring per 10,000 square feet of bottom area; 1 minimum | 5 feet below proposed bottom | Not Applicable |
| Leaching basin | 1 soil boring/leaching basin | 10 feet below proposed bottom | None |

[1]If the drainage area contributing to the BMP is 5,000 square feet or less, soil borings are sufficient. If the drainage area is greater than 5,000 square feet, test pits are required.

[2]If utilities are present, depth shall be determined by top of utilities.

Excavate a test pit or soil boring in the location of the proposed BMP. The following conditions shall be noted and described, referenced from a top-of-ground elevation:

1. Depth to groundwater recorded during initial digging or drilling, and again upon completion of the excavation.
2. Depth to bedrock or hardpan.
3. Depth and thickness of each soil horizon including the presence of mottling.
4. USDA soil texture classification for all soil horizons.
5. Bottom Elevation of BMP.

Test pit reports and soil boring logs shall include the date(s) data was collected and the location referenced to a site plan.

## D. Highest Known Groundwater Elevation

The highest known groundwater elevation shall be determined by adjusting the measured groundwater elevation using indicators such as soil mottling and regional water level data. It should also take into consideration local conditions that may be temporarily altering water levels at the time of measurement. Such conditions could include, but not be limited to: dewatering, irrigation well or large quantity withdrawals in the area, or areas of groundwater infiltration (such as a nearby retention basin).

## E. Field Permeability Testing

Field permeability testing is required. Laboratory tests are not allowed. Field permeability testing must be conducted before the alternative approach for channel protection will be considered. Acceptable field tests include:

1. Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer test below or ASTM D3385.
2. Percolation test listed below (similar to wastewater systems).

The minimum number of field permeability tests shall be determined from **Table 4**. The City reserves the right to request additional field permeability testing be performed on questionable sites.

Tests shall be conducted in the location of the proposed BMP at the proposed bottom elevation. An alternate testing depth may be approved by the City Manager if material is identical and groundwater is not an issue.

Tests shall not be conducted in the rain or within 24 hours of significant rainfall events (>0.25 inch) or when the ground is frozen.

Field permeability testing reports shall include the date(s) data was collected and the location referenced to a site plan.

### Methodology for Double-ring Infiltrometer Field Test

A double-ring infiltrometer consists of two concentric metal rings. These rings are driven into the ground and filled with water. The outer ring prevents divergent flow. The drop in water level or volume within the inner ring is used to calculate an infiltration rate. The diameter of the inner ring should be approximately 50-70% of the diameter of the outer ring, with a minimum inner ring size of 4 inches.

Equipment for double-ring infiltrometer test:

1. Two concentric rings six inches high or greater.
2. Water Supply.
3. Stopwatch or Timer.
4. Ruler or measuring tape.
5. Flat board for driving the cylinders uniformly into the soil.
6. Log sheets for recording data.

Procedure for double-ring infiltrometer test:

1. Prepare a level testing area.
2. Place the outer ring and use a flat board to drive the ring into the soil a minimum of 2 inches.
3. Place the inner ring in the center of the outer ring and use a flat board to drive the ring into the soil a minimum of 2 inches. The bottom of both rings should be at the same elevation.
4. The test area should be presoaked immediately prior to testing. Fill both rings with water to the rim at 30 minute intervals for 1 hour. The maximum water depth in the rings should be 4 inches. The drop in water level during the last 30 minutes of the presoaking period should be applied to the following standard to determine the interval between readings:
   a. If the water level drop is 2 inches or more, use 10 minute intervals.
   b. If the water level drop is less than 2 inches, use 30-minute intervals.
5. Obtain a measurement of the drop in water level in the center ring at appropriate intervals. After each reading, refill both rings to the rim. Measure the water level in the center ring from a fixed reference point and continue at the interval determined until a minimum of 8 readings are made or until a stabilized rate of drop is obtained. A stabilized rate of drop is a difference of ¼ inch or less between the highest and lowest readings of four consecutive readings.
6. The water level drop that occurs in the center ring during the final period of the average stabilized rate represents the infiltration rate for the test location.

### Methodology for Percolation Test

Equipment for percolation test:

1. Post hole digger or auger.
2. Water supply.
3. Stopwatch or timer.
4. Ruler or measuring tape.
5. Log sheets for recording data.
6. Tool for soil scarification.
7. Coarse sand or fine gravel.
8. A fixed reference point during measurement.

Procedure for percolation test:

The percolation test methods are based on the criteria for onsite sewage investigation of soils. A 24-hour presoak is generally not required since infiltration systems will not be continuously saturated.

1. Prepare a level testing area.
2. Prepare a hole with a uniform diameter of 6 to 10 inches and a depth of 8 to 12 inches. Scarify the bottom and sides of the hole to remove any smeared soil surfaces and to provide a natural soil interface for percolation. Remove loose material from the hole.

3. Place 2 inches of coarse sand or gravel in the bottom of the hole to protect the soil from scouring or clogging.
4. Presoak the hole immediately prior to testing. Place water in the hole to a minimum depth of 6 inches over the bottom and readjust every 30 minutes for 1 hour.
5. Apply the following standard to the drop in water level during the last 30 minutes of the final presoaking period.
    a. If water remains in the hole, the interval for readings during the percolation test is 30 minutes.
    b. If no water remains in the hole, the interval for readings during the percolation test is reduced to 10 minutes.
6. After the final presoaking period, adjust the water in the hole to a minimum depth of 6 inches and readjust when necessary. Record the water level depth and hole diameter.
7. Make water level measurements from a fixed reference point and continue measurements at the predetermined interval until a minimum of 8 readings are completed or until a stabilized rate of drop in water level is obtained. A stabilized rate of drop is a difference of ¼ inch or less between the highest and lowest readings of 4 consecutive readings.
8. The water level drop that occurs in the center ring during the final period of the average stabilized rate represents the infiltration rate for the test location.
9. The average measured rate must be adjusted to account for the discharge of water from both the sides and bottom of the hole and to develop a representative infiltration rate. Adjust the final percolation rate according to the following formula:

    Infiltration Rate = (Percolation Rate)/(Reduction Factor)

    Where the reduction factor is given by:

$$Rf = \frac{2d1 - \Delta d}{DIA}$$

$d1 = Initial\ Water\ Depth\ in.$

$$\Delta d = \frac{Average}{Final} Water\ Level\ Drop\ (in.)$$

$$DIA = Diameter\ of\ Percolation\ Hole\ (in.)$$

The percolation rate is simply divided by the reduction factor as calculated above to yield the representative infiltration rate. In most cases, the reduction factor varies from 2 to 4 depending on the percolation hole dimensions and water level drop. (Wider shallower tests have lower reduction factors because proportionately less water exfiltrates through the sides.)

*Note:* The area reduction factor accounts for the exfiltration occurring through the sides of the percolation hole. It assumes the rate is affected by the depth of water in the hole and that the percolating surface of the hole is uniform soil. If these assumptions are not true, then other adjustments may be necessary.

## F. Design Infiltration Rates

A conservative value for the infiltration rate is used to calculate the storage volume of infiltration BMPs due to the uncertainty the soil will infiltrate at the design rate during the time the basin is filling.

The infiltration rate determined from field permeability testing shall be divided by a factor of 2 to calculate the design infiltration rate, up to a maximum design infiltration by soil texture class provided in **Table 5**. The design infiltration rate shall be used to calculate the storage volume and minimum infiltration area of the BMP necessary to drain the allotted drawdown time.

Soil testing, following the requirements as outlined in Part 4, Section E of this document, will be conducted to assess the soils before the alternative approach can be considered.

**Table 5** provides design values of the infiltration rate and effective water capacity (void ratio) for soils based on their textural classification. The soil textural classes shown in **Table 5** correspond to the soil textures of the USDA Soil Textural Triangle shown in **Figure 2**.

*Note*: Infiltration is the process by which water on the ground surface enters the soil. Infiltration rate is a measure of the rate at which soil is able to absorb rainfall or irrigation in inches per hour. The rate decreases as the soil becomes saturated. The design infiltration rate assumes saturated conditions and closely approximates the hydraulic conductivity (typically given in feet per day) of the near-surface soil.

*Note*: The effective water capacity of a soil is the fraction of the void spaces available for water storage measured in inches per inch.

**Table 5 – Design Infiltration Rates by USDA Soil Texture Class**

| Soil Texture Class | Effective Water Capacity[1] (inches per inch) | Design Infiltration Rate[2] (inches per hour) | HSG |
|---|---|---|---|
| Gravel | 0.40 | 3.60 | A |
| Sand | 0.35 | 3.60 | A |
| Loamy Sand | 0.31 | 1.63 | A |
| Sandy Loam | 0.25 | 0.50 | A |
| (Medium) Loam | 0.19 | 0.24 | B |
| Silty Loam / (Silt) | 0.17 | 0.13 | B |
| Sandy Clay Loam | 0.14 | 0.11 | C |
| Clay Loam | 0.14 | 0.03 | D |
| Silty Clay Loam | 0.11 | 0.04 | D |
| Sandy Clay | 0.09 | 0.04 | D |
| Silty Clay | 0.09 | 0.07 | D |
| Clay | 0.08 | 0.07 | D |

[1]Source: Maryland Department of Environment (2000). *Maryland Stormwater Design Manual*, Appendix D.13, Table D.13.1 (Rawls, Brakensiek and Saxton, 1982).

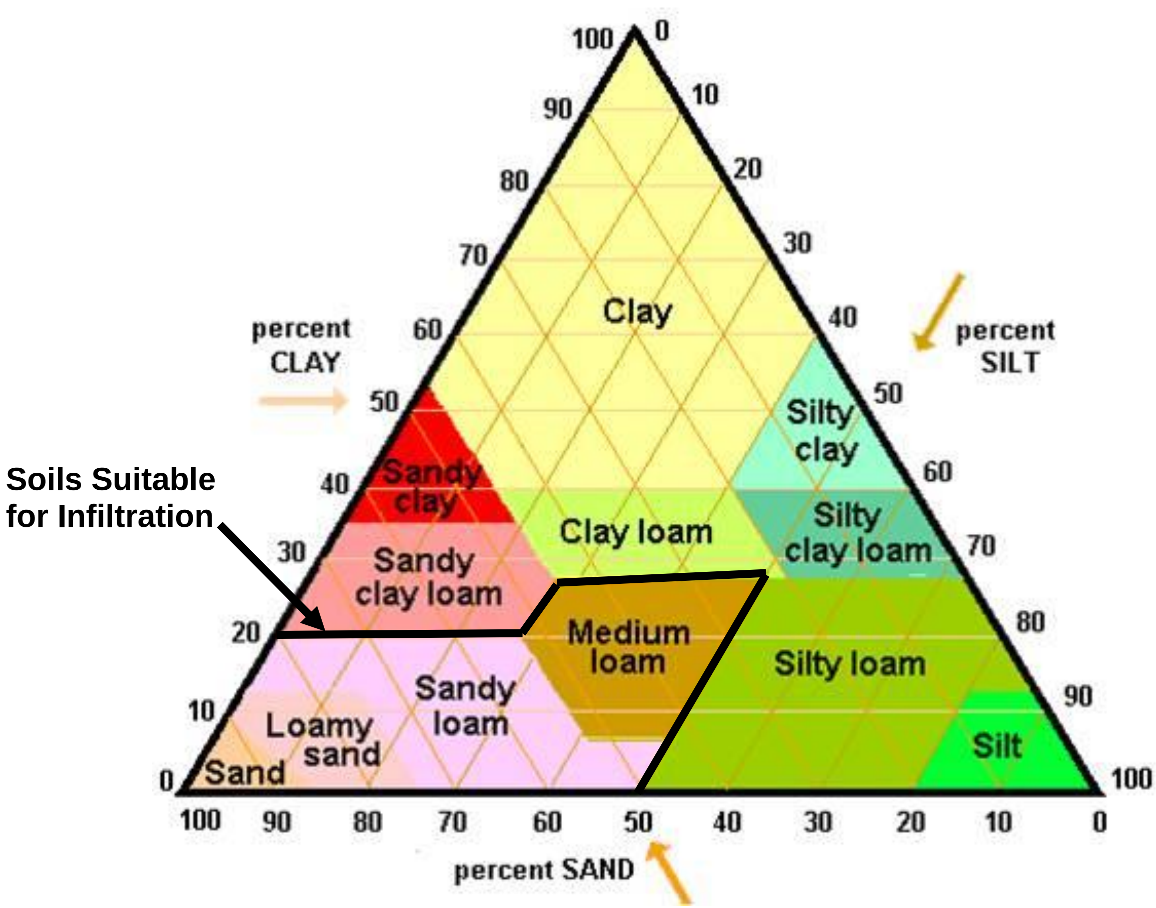
[2]Source: Wisconsin Department of Natural Resources (2004). *Site Evaluation for Stormwater Infiltration (1002)*, Table 2 (Rawls, 1998). *Note*: Values are reduced by approximately a factor of 2 from those given in Table D.13.1.

## G. Minimum Allowable Infiltration Rate

Soil textures with design infiltration rates less than 0.24 inches per hour are deemed not suitable for infiltration BMPs.

Soils with design infiltration rates as low as 0.24 inches per hour may be used for LID and Small Site BMPs if suitable supplemental measures are included in the design. Supplemental measures may include subsoil amendment, or underdrain placed at the top of the storage bed layer.

**Figure 2 – USDA Soil Textural Triangle**



# II. CALCULATION METHODOLOGY

The Rational Method and the NRCS Runoff Curve Number Method are typically used to calculate stormwater runoff, peak discharges and runoff volumes for design of stormwater conveyance and storage systems. The NRCS method is presently the only acceptable method to calculate the channel protection volume. The Small Storm Hydrology Method is used to calculate runoff volumes from the smaller rainfall amounts used for water quality treatment.

## A. Calculating Runoff

### 1. Rational Method

The Rational Method may be used to calculate stormwater runoff volumes and peak discharges to size conveyance and storage systems for contributing drainage areas of 40 acres or less. The peak runoff rate is given by the equation:

$$Q = CIA \tag{4.1}$$

where:

$Q$ = peak runoff rate (cubic feet per second).

$C$ = weighted runoff coefficient of the drainage area.

$I$ = average rainfall intensity for a storm with a duration equal to the time of-concentration of the drainage area (inches per hour). Use rainfall amounts from **Table 11** and divide by the duration in hours to obtain the average rainfall intensity (I).

$A$ = drainage area (acres).

Runoff coefficients sizing conveyance systems shall be selected from **Table 6**.

**Table 6 – Rational Method Runoff Coefficients (2 to 500-year rainfall frequencies)**

| Character of Surface | Return Period (years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
| Asphaltic | 0.75 | 0.85 | 0.95 | 0.97 | 1.00 | 1.00 | 1.00 |
| Concrete/roof | 0.75 | 0.85 | 0.95 | 0.97 | 1.00 | 1.00 | 1.00 |
| | | | | | | | |
| Grass areas (lawns, parks, etc.) | | | | | | | |
| *Poor condition* (grass cover less than 50% of the area) | | | | | | | |
| Flat, 0 to 2% | 0.32 | 0.34 | 0.37 | 0.40 | 0.44 | 0.47 | 0.58 |
| Average, 2% to 7% | 0.37 | 0.40 | 0.43 | 0.46 | 0.49 | 0.53 | 0.61 |
| Steep, over 7% | 0.40 | 0.43 | 0.45 | 0.49 | 0.52 | 0.55 | 0.62 |
| | | | | | | | |
| *Fair condition* (grass cover 50% to 75% of the area) | | | | | | | |
| Flat, 0 to 2% | 0.25 | 0.28 | 0.30 | 0.34 | 0.37 | 0.41 | 0.53 |
| Average, 2% to 7% | 0.33 | 0.36 | 0.38 | 0.42 | 0.45 | 0.49 | 0.58 |
| Steep, over 7% | 0.37 | 0.40 | 0.42 | 0.46 | 0.49 | 0.53 | 0.60 |
| | | | | | | | |
| *Good condition* (grass cover larger than 75% of the area) | | | | | | | |
| Flat, 0 to 2% | 0.21 | 0.23 | 0.25 | 0.29 | 0.32 | 0.36 | 0.49 |
| Average, 2% to 7% | 0.29 | 0.32 | 0.35 | 0.39 | 0.42 | 0.46 | 0.56 |
| Steep, over 7% | 0.34 | 0.37 | 0.40 | 0.44 | 0.47 | 0.51 | 0.58 |
| | | | | | | | |
| Source: C.T. Haan, B.J. Barfield, J.C. Hayes (1994). *Design Hydrology & Sedimentology for Small Catchments*. | | | | | | | |

Runoff coefficient for sizing detention/retention basins, which are designed for higher rainfall frequencies, shall be selected from **Table 11**.

Time-of-concentration for the Rational Method is the sum of overland flow and channel flow. A minimum of 15 minutes shall be used.

Overland flow time may be calculated using the following formula:

$$t_o = \left(\frac{2Ln}{3\sqrt{s}}\right)^{0.4673} \quad (4.2)$$

where:

$t_o$ = time of overland flow (minutes)

$L$ = length (feet); the distance from the extremity of the subcatchment area in a direction parallel to the slope until a defined channel is reached. Overland flow will become channel flow within 1,200 feet in almost all cases*

$n$ = surface retardants coefficient (from **Table 7**)

*s* = slope (feet per foot); the difference in elevation between the extremity of the subcatchment area and the point in question divided by the horizontal distance

**Table 7 – Surface Retardants Coefficients**

| Type of Surface | Coefficient (n value) |
|---|---|
| Smooth impervious surface | 0.02 |
| Smooth bare packed soil | 0.10 |
| Poor grass, cultivated row crops, or moderately rough bare surface | 0.20 |
| Pasture or average grass | 0.40 |
| Deciduous timberland | 0.60 |
| Conifer timberland, deciduous timberland with deep forest litter, or dense grass | 0.80 |
| *Source: Formula, coefficients and empirical observations from W.S. Kerby, J.M. Asce. Servis, Van Doren & Hazard Engineers, Topeka, Kansas. "Time of Concentration for Overland Flow" as included in ENGINEER'S NOTEBOOK. | |

Channel flow shall be calculated using Manning's equation (English Units):

$$V = \frac{An}{1.49 R^{\frac{2}{3}} S^{\frac{1}{2}}} \tag{4.3}$$

where:

*V* = velocity (feet per second)
*A* = wetted area (square feet)
*n* = Manning's roughness coefficient (from **Table 8**)
*R* = hydraulic radius (feet)
*S* = slope (feet per foot)

**Table 8 – Manning's Roughness Coefficients**

| Conduit | Coefficients |
|---|---|
| **Closed Conduits** | |
| Asbestos-Cement Pipe | 0.011 to 0.015 |
| Brick | 0.013 to 0.017 |
| Cast Iron Pipe (Cement-lined and seal-coated) | 0.011 to 0.015 |
| Concrete (Monolithic) | |
| Smooth forms | 0.012 to 0.014 |
| Rough forms | 0.015 to 0.017 |
| Concrete Pipe | 0.011 to 0.015 |
| Corrugated-Metal Pipe (1/2-inch corrugated) | 0.022 to 0.026 |
| Paved invert | 0.018 to 0.022 |
| Spun asphalt-lined | 0.011 to 0.015 |
| Plastic Pipe (Smooth) | 0.011 to 0.015 |
| Vitrified Clay Pipes | 0.011 to 0.015 |
| Liner channels | 0.013 to 0.017 |
| **Open Channels** | |
| Lined Channels | |
| Asphalt | 0.013 to 0.017 |
| Brick | 0.012 to 0.018 |
| Concrete | 0.011 to 0.020 |
| Rubble or riprap | 0.020 to 0.035 |
| Vegetal | 0.030 to 0.040 |
| Excavated or Dredged | |
| Earth, straight and uniform | 0.020 to 0.030 |
| Earth, winding, fairly uniform | 0.025 to 0.040 |
| Rock | 0.030 to 0.045 |
| Unmaintained | 0.050 to 0.140 |
| Natural Channels (streams, top width at flood state <100 feet) | |
| Fairly regular section | 0.030 to 0.070 |
| Irregular section with pools | 0.040 to 0.100 |
| Source: American Society of Civil Engineers and the Water Pollution Control Federation (1969). *Design and Construction of Sanitary and Storm Sewers*. | |

The time-of-concentration is then:

$$Tc = t_o + \frac{L_c}{60V} \qquad (4.4)$$

where:

$Tc$ = time-of-concentration (minutes)
$t_o$ = time of overland flow (minutes)
$L_c$ = length of channelized flow (feet)
$V$ = velocity of channelized flow (feet per second)
*60* = factor to convert seconds to minutes

## 2. Runoff Curve Number Method

The Runoff Curve Number Method developed by the NRCS may be used to calculate stormwater runoff volumes and peak discharges to size conveyance and storage systems. This method must be used when it is necessary to calculate runoff volumes for channel protection. The formulas are as follows:

$$Qv = \frac{(P - 0.2S)^2}{(P + 0.8S)} \quad (4.5)$$

where:

$Q_v$ = surface runoff (inches). *Note*: Qv=0 if P ≤ 0.2S

$P$ = rainfall (inches)

$S$ = potential maximum retention after runoff begins (inches)

and where:

$$S = \frac{1000}{CN} - 10 \quad (4.6)$$

Surface runoff (Qv) is calculated separately for each land use and soil type combination. Total runoff volume can then be calculated by the formula:

$$Vt = (\sum_i Q_{vi} A_i) \times 3630 \quad (4.7)$$

where:

*Vt* = total runoff volume of the design storm (cubic feet)

*Qv* = surface runoff for the $i^{th}$ land use (inches)

*A* = contributing area associated with the $i^{th}$ land use (acres)

*3630* = factor to convert acre-inches to cubic feet

Curve Number (CN) values are taken from NRCS TR-55, and provided in **Table 9**.

The "Water" cover type shall be used for detention/retention basins with a permanent pool or surface water temporarily ponded during the rain event. The "Meadow" or "Open spaces" cover type may be used for vegetative BMPs, including those that temporarily pond surface water, to receive credit for channel protection.

<u>Peak Discharge</u>

The LGROW Design Spreadsheet, or NRCS computer software such as WinTR-55 may be used to calculate peak stormwater runoff rates. A Michigan Unit Hydrograph is used in the LGROW Design Spreadsheet and can be input into WinTR-55.

*Note:* Using the standard NRCS unit hydrograph will overestimate peak runoff rates by 30 to 50 percent or more.

**Table 9 – Curve Numbers (CNs) from TR-55**

| Land Use Description | | Curve Number[1] | | | |
|---|---|---|---|---|---|
| | | Hydrologic Soil Group | | | |
| Cover Type | Hydrologic Condition[2] | A | B | C | D |
| Cultivated land | Good | 64 | 75 | 82 | 85 |
| Pasture or range land | Poor | 68 | 79 | 86 | 89 |
| | Fair | 49 | 69 | 79 | 84 |
| | Good | 39 | 61 | 74 | 80 |
| Meadow | | 30 | 58 | 71 | 78 |
| Orchard or tree farm[3] | Poor | 57 | 73 | 82 | 86 |
| | Fair | 43 | 65 | 76 | 82 |
| | Good | 32 | 58 | 72 | 79 |
| Woods | Poor | 45 | 66 | 77 | 83 |
| | Fair | 36 | 60 | 73 | 79 |
| | Good | 30[4] | 55 | 70 | 77 |
| Open spaces (grass cover)[5] | Poor | 68 | 79 | 86 | 89 |
| | Fair | 49 | 69 | 79 | 84 |
| | Good | 39 | 61 | 74 | 80 |
| Paved parking lot, roof, driveway | | 98 | 98 | 98 | 98 |
| Gravel[6] | | 88 | 93 | 94 | 95 |
| Bare Soil | | 77 | 86 | 91 | 94 |
| Water[7] | | 100 | 100 | 100 | 100 |

Source: U.S. Department of Agriculture Soil Conservation Service (1986). *Urban Hydrology for Small Watersheds*, *Technical Release No. 55*.

[1]Antecedent moisture condition II and initial abstract ($I_a$) = 0.2S

[2]Poor Condition: pasture or open space with less than 50% ground cover or heavily grazed with no mulch; woods - forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

Fair Condition: pasture or open space with 50% to 75% grass cover and not heavily grazed; woods are grazed but not burned, and some forest litter covers the soil.

Good Condition: cultivated land (row crops, straight row) with conservation treatment (crop residue cover), also small grain; pasture or open space with 75% or more ground cover and lightly or only occasionally grazed; woods are protected from grazing, and litter and brush adequately cover the soil.

[3]CN's shown were computed for areas with 50% woods and 50% pasture (grass) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown are equivalent to those of pasture.

[6]Surface only; not including right-of-way.

[7]Water added.

Time-of-concentration for the Runoff Curve Number Method shall be calculated using NRCS TR-55 methodology as outlined below. A minimum of 0.1 hour (6 minutes) shall be used.

The flow path is split into three sections – sheet flow, shallow concentrated flow, and open channel flow. The travel time is computed for each flow regime. The time-of-concentration is then the sum of the travel times:

$$Tc = t_1 + t_2 + t_3 \tag{4.8}$$

(1) For sheet flow the travel time ($t_1$) in hours is given as:

$$t_1 = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}} \tag{4.9}$$

where:

*n* = Manning's roughness coefficient from **Table 8**
*L* = flow length (feet)
$P_2$ = 2-year, 24-hourprecipitation depth from **Table 11**
*s* = slope (feet/foot)

(2) Shallow concentrated flow velocities are calculated for paved and unpaved surfaces. The velocities are given as:

$$v = \begin{matrix} 16.1345 s^{0.5} & Unpaved \\ 20.3282 s^{0.5} & Paved \end{matrix} \tag{4.10}$$

where:

*s* = slope (feet/foot)
*v* = velocity in feet per second

The flow length (feet) is then divided by the velocity (feet per second) and a conversion factor of 3600 to obtain travel time ($t_2$) in hours:

$$t_2 = \frac{L}{3600v} \tag{4.11}$$

(3) Open channel flow uses Manning's equation to calculate the velocity based on slope, flow area, and wetted perimeter (refer to Equation 4.3). The flow length (feet) is then divided by the velocity (feet per second) to obtain travel time ($t_3$) in hours (refer to Equation 4.11).

<u>BMP Residence Time</u>

BMP residence time shall be calculated as the storage volume divided by the 10-year peak inflow rate.

### 3. Small Storm Hydrology Method

The Small Storm Hydrology Method is used to calculate the water quality treatment volume. The method was developed to estimate the runoff volume from urban land uses for relatively small storm events ( 1 inch or less) where the Rational and NRCS Methods prove less accurate. Water quality volume is calculated by the formula:

$$Vwq = ARv(1)(3630) \tag{4.12}$$

where:

*Vwq* = minimum required water quality volume (cubic feet)
*A* = area (acres); the developed portion of the site, both impervious and pervious, not receiving treatment with a non-structural BMP
*Rv* = area-weighted volumetric runoff coefficient (from **Table 10**)
*1* = 90% non-exceedance storm rainfall amount (inches)
*3630* = factor to convert acre-inches to cubic feet

The Volumetric Runoff Coefficients (Rv) provided in **Table 10** are similar to the Rational runoff coefficient, but are exclusive to the rainfall amount (1-inch).

**Table 10 – Runoff Coefficients for Small Storm Hydrology Method**

| Rainfall Amount (inches) | Volumetric Runoff Coefficient, Rv | | | | | |
|---|---|---|---|---|---|---|
| | Directly Connected Impervious Area | | | Disturbed Pervious Area | | |
| | Flat Roofs/ Unpaved | Pitched Roofs | Paved | Sandy Soils (HSG A) | Silty Soils (HSG B) | Clayey Soils (HSG C&D) |
| 1.0 | 0.815 | 0.965 | 0.980 | 0.035 | 0.120 | 0.2015 |

Source: Adapted from SEMCOG (2008). *Low Impact Development Manual for Michigan*, Table 9.3. (R. Pitt (2003). *The Source Loading and Management Model (WinSLAMM): Introduction and Basic Uses)*.

## B. Rainfall

The rainfall duration-frequency table provided in **Table 11** shall be used with the Rational Method to determine rainfall intensity for rainfall duration equal to the time-of-concentration. Divide the rainfall amount by the duration in hours to obtain the rainfall intensity.

The 24-hour rainfall amounts provided in **Table 11** shall be used with the Runoff Curve Number Method.

An MSE4 rainfall distribution shall be used when a unit hydrograph approach is used (e.g. WinTR-55 computer program).

**Table 11 – Rainfall Amounts (inches)**

| Duration | 1-Year | 2-Year | 5-Year | 10-Year | 25-Year | 50-Year | 100-Year |
|---|---|---|---|---|---|---|---|
| 24-hr | 2.22 | 2.56 | 3.18 | 3.77 | 4.66 | 5.43 | 6.27 |
| 12-hr | 1.95 | 2.25 | 2.81 | 3.33 | 4.13 | 4.82 | 5.56 |
| 6-hr | 1.69 | 1.96 | 2.45 | 2.91 | 3.60 | 4.19 | 4.82 |
| 3-hr | 1.45 | 1.69 | 2.11 | 2.50 | 3.08 | 3.57 | 4.09 |
| 2-hr | 1.31 | 1.53 | 1.92 | 2.26 | 2.78 | 3.21 | 3.66 |
| 1-hr | 1.05 | 1.24 | 1.55 | 1.83 | 2.24 | 2.58 | 2.94 |
| 30-min | 0.80 | 0.94 | 1.18 | 1.39 | 1.70 | 1.95 | 2.21 |
| 15-min | 0.54 | 0.63 | 0.79 | 0.93 | 1.14 | 1.31 | 1.49 |
| 10-min | 0.44 | 0.52 | 0.65 | 0.76 | 0.93 | 1.07 | 1.22 |
| 5-min | 0.30 | 0.35 | 0.44 | 0.52 | 0.64 | 0.73 | 0.83 |
| Source: NOAA (2013). *Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 8, Version 2.0*. Rainfall amounts from: GRAND RAPIDS INTL AP. Station ID 20-3333. | | | | | | | |

# C. Calculating Storage Volumes and Release Rates

## 1. Water Quality

Treatment of the runoff generated from 1 inch of rain (the 90% annual nonexceedance storm) over the developed portion of the site is required. Water quality volume is calculated using the Small Storm Hydrology Method.

Calculation of TSS removal efficiency for BMPs in a series is described in Part 4 section "TSS Accounting."

## 2. Pretreatment

Pretreatment volume may be included in the total water quality volume, and is calculated as:

$$Vpt = 0.15(Vwq) \tag{4.13}$$

where:
*Vpt* = minimum required pretreatment volume (cubic feet)
*Vwq* = water quality volume (cubic feet)

## 3. Channel Protection

a. Retention

Channel protection consists of retaining onsite the net increase in runoff volume between pre-development and post-development conditions for a 2-year, 24-hour storm using the Runoff Curve Number Method. Channel protection volume is calculated with the following equation:

$$Vcp = Vt_{post} - Vt_{pre} \tag{4.14}$$

where:
*Vcp* = minimum required channel protection volume (cubic feet)
$Vt_{post}$ = total runoff volume of the 2-year, 24-hour storm for post-development conditions
$Vt_{pre}$ = total runoff volume of the 2-year, 24-hour storm for pre-development conditions

Pre-development is defined as the last land use prior to the planned new development or redevelopment.

b. Extended Detention

If retention of the total channel protection volume is not possible due to site constraints, an alternative approach using extended detention may be allowed.

The storage volume of an extended detention basin shall be sized for that part of the 2-year volume difference not met by retention, with a maximum release rate that results in a 24-hour detention time. The peak discharge for a 24-hour detention time may be calculated assuming triangular inflow and outflow hydrographs with a lag between the peaks of 24 hours. If the inflow peak occurs 12 hours into the 24-hour inflow hydrograph, the outflow peak should occur 36 hours into a 72-hour outflow hydrograph as shown in **Figure 3**. The extended detention peak discharge can then be computed with the following equation:

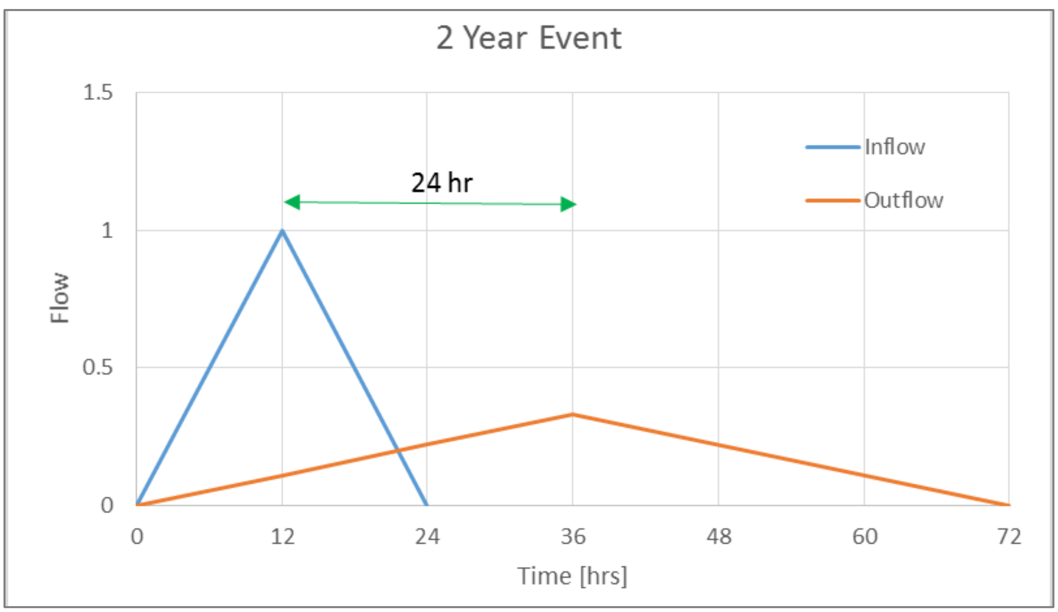
$$Q_{ED} = (Vcp - Vret)/(36*3600) \tag{4.15}$$

where:

| | | |
|---|---|---|
| $Q_{ED}$ | = | peak extended detention release rate (cubic feet per second) |
| *Vcp* | = | total channel protection volume required (cubic feet) |
| *Vret* | = | channel protection volume met by retention (cubic feet) |
| *36*3600* | = | half of the base time of outflow hydrograph (seconds) |

The 2-year peak discharge after extended detention ($Q_{ED}$) must be equal to or less than the existing 1-year peak discharge. (Exceptions may be made for HSG A, where extended detention has been approved due to site constraints, but existing runoff is zero.) If the 1-year peak discharge limit is not met, the total channel protection volume provided must be increased to reduce the required extended detention volume. Simply using a lower extended detention release rate will violate the 72 hour drawdown time requirement.

**Figure 3 – Extended Detention Hydrograph**



## 4. Flood Control

Detention and retention basin storage volumes for flood control can be calculated 1) using the methods and equations provided in this section; 2) using the LGROW Design Spreadsheet, which uses the NRCS Curve Number Method and performs pond routing for detention; or 3) using other acceptable hydrologic and hydraulic computer models with submittal of clear and complete input and output.

### a. Detention

Detention of the proper design rainfall event per **Table 11** for the watershed with a maximum allowable release rate of 0.13 cfs per acre is required with 0.26 cfs minimum for sites less than 2 acres. Per Appendix 2, sites discharging stormwater runoff into a drainage system, which includes sensitive downstream open channels that are susceptible to stream bank erosion shall have its discharge limited to a rate of 0.05 cubic feet per second per acre up to the 2-year, 24-hour rain event.

If the volume of runoff released from the developed site, including total disturbed area, is less than or equal to the volume of runoff from the existing site for the proper design storm, a maximum release rate no greater than the pre-development proper design storm peak runoff rate may be used. However, if detention is already in use on a redevelopment site, the existing controlled release rate is the pre-development release rate.

(1) Rational Method for Detention

If the Rational Method is used, the minimum required storage volume shall be calculated by the "Modified Chicago" Method. Runoff Coefficients for use in detention storage calculations shall be selected from **Table 6** to account for rainfalls exceeding a 10-year frequency.

The calculated storage volume shall be multiplied by 1.25 to obtain the minimum required storage volume.

*Note:* This additional adjustment is necessary, since the Modified Chicago Method tends to underestimate the storage volume when compared to pond routing, particularly for short times-of-concentrations (15 to 30 minutes)[9].

The volume of stormwater runoff stored and infiltrated by upstream retentive BMPs (Vbmp) may be subtracted from the required detention basin storage volume.

(2) Runoff Curve Number Method for Detention

If the Runoff Curve Number Method is used, the minimum required storage volume shall be determined through routing using the LGROW Design Spreadsheet, or may be calculated by the formula:

$$V_{fc} = \frac{(Qp - Qout)}{Qp} Vt - Vbmp \tag{4.16}$$

[9] Stahre, Peter and Urbonas, Ben (1990). Stormwater Detention For Drainage, Water Quality and CSO Management, pp. 268 274.

where:

| | | |
|---|---|---|
| $V_{fc}$ | = | minimum required storage volume for flood control (cubic feet) |
| *Qp* | = | peak runoff rate (cubic feet per second) |
| *Qout* | = | maximum allowable peak discharge (cubic feet per second) |
| *Vt* | = | post-development runoff volume for the 25-year or 100-year, 24-hour storm (cubic feet) |
| *Vbmp* | = | volume (storage + infiltration) provided by upstream retentive BMPs |

*Note*: This formula provides a conservative approximation of the required storage volume. Therefore, the volume of any upstream BMPs can be subtracted from the storage volume versus the total runoff volume.

b. Retention

Retention basins shall be sized for the 25-year, 24-hour rainfall event, unless in sewersheds sensitive to flooding per Appendix 2.

**(1) Rational Method for Retention**

If the Rational Method is used, the minimum required storage volume shall be calculated by the "Modified Chicago" Method.

The calculated storage volume shall be multiplied by 1.25 to obtain the minimum required storage volume.

The discharge or exfiltration rate into the soil from the retention basin shall be calculated as:

$$Qout = Ai/(12 \times 3600) \tag{4.17}$$

where:

| | | |
|---|---|---|
| $Q_{out}$ | = | discharge rate (cubic feet per second) |
| *A* | = | infiltration area (square feet) |
| *i* | = | design infiltration rate (inches per hour) |
| *12* | = | factor to convert inches to feet |
| *3600* | = | factor to convert hours to seconds |

**(2) Runoff Curve Number Method for Retention**

If the Runoff Curve Number Method is used, the minimum required storage volume (Vs) shall be calculated by subtracting the volume infiltrated by the BMP during the infiltration time (Vinf) from the flood control event runoff volume (Vt).

$$Vs = Vt - V_{inf} \tag{4.18}$$

The flood control event runoff volume (Vt) is calculated using Equation 4.7.

The infiltrating volume is calculated as:

$$V_{inf} = i * A * t_{inf}/12 \tag{4.19}$$

where:
$V_{inf}$ = infiltrating volume (cubic feet)
$i$ = design infiltration rate (inches per hour)
$A$ = infiltration area (square feet)
$t_{inf}$ = infiltration time (hours); the period when the BMP is receiving runoff and capable of infiltrating at the design rate
*12* = factor to convert inches to feet

Based on extensive computer modelling, the infiltration time is found to be a function of the drain time through the BMP. An empirical formula was developed to model this function for drain times between 0 and 72 hours. Note: this is equation is not valid for drain times greater than 72 hours.

$$t_{inf} = 2.0 + t_d \left(0.222 - 0.553 * log_{10}\left({}^{t_d}/_{72}\right)\right) \tag{4.20}$$

The drain time through the BMP is calculated as:

$$t_d = 12 * V_S/(A * i) \tag{4.21}$$

where:
$t_d$ = BMP drain time (hours)
$V_S$ = storage volume of the BMP (cubic feet)
$i$ = design infiltration rate (inches per hour)
$A$ = infiltration area (square feet)
*12* = factor to convert inches to feet

The volume of stormwater runoff stored and infiltrated by upstream retentive BMPs (Vbmp) may be subtracted from the flood control event runoff volume reaching the retention basin.

Retentive BMPs Sized for Water Quality and Channel Protection

This method shall be used to calculate the required storage volume of retentive BMPs used for water quality or channel protection by substituting the water quality or channel protection volume for Vt.

## D. LGROW Design Spreadsheet

The LGROW Design Spreadsheet is a Microsoft Excel spreadsheet application developed for Design and Review Engineers to show compliance with the stormwater standards. The spreadsheet allows the user to size BMPs in series and in parallel, but is not intended to be used for the complete design of BMPs. A copy of the spreadsheet and tutorial is available from the City.

### Runoff

The spreadsheet uses the Runoff Curve Number Method to compute runoff volumes by subcatchment. A tabular TR-55 approach is used with a Michigan unit hydrograph to compute peak runoff rates. The spreadsheet can be used to calculate the required channel protection volume and the flood control volume for both detention and retention. The Small Storm Hydrology Method is used to calculate the required water quality volume.

The 24-hour rainfall amounts and rainfall distribution specified in Part 4 section "Rainfall" are incorporated into the spreadsheet. Time-of-concentration formulas from NRCS TR-55 are also incorporated into the spreadsheet to calculate peak discharges. Output is graphed as hydrographs and summarized in tabular form for a range of rainfall frequencies.

The spreadsheet allows the user to select non-structural and structural BMPs to meet required runoff rates and volumes.

### TSS Accounting

The spreadsheet can be used to calculate the TSS reduction for a series of BMPs. The TSS removal efficiencies for the BMPs provided in **Table 3** are used to demonstrate a TSS reduction of 80% or more. When BMPs are used in series (i.e. a treatment train) to achieve the 80% reduction, the TSS removal efficiency of the treatment train is calculated as:

$$e_{TSS} = 1 - (1 - e_1)(1 - e_2) \cdots (1 - e_n) \tag{4.22}$$

where $e_{TSS}$ is the removal efficiency of the treatment train, and $e_n$ is the removal efficiency for the $n^{th}$ BMP in the chain of $n$ BMPs. This calculation assumes all water entering the treatment train is passed through to the next downstream BMP. The spreadsheet allows the user to calculate TSS reduction when either all or a portion of the water quality volume is passed downstream.

BMPs used for water quality treatment can be classified as retentive or pass-through. Retentive BMPs (e.g. infiltration practice) retain and treat some or all of the water quality volume. Pass-through BMPs (e.g. catchbasin) treat all of the water entering and send this volume to the next BMP or subcatchment.

TSS accounting is done by tracking TSS through the subcatchments. In order to do this, it is assumed that one unit of TSS is the mass of TSS carried by one cubic foot of the water quality volume. The effective removal efficiency is the BMP removal efficiency multiplied by the portion of the water quality volume treated by the BMP. The TSS removed for each BMP is the effective removal efficiency multiplied by the TSS remaining in the treatment train.

The TSS removal efficiency for the subcatchment and/or site is the sum the TSS removed by all BMPs divided by the total TSS to be treated. The released water volume and the TSS remaining are both passed to the next downstream subcatchment.

### Pond Routing

Detention storage volume for flood control is computed by numerically routing the hydrograph for the developed site through a detention basin (pond). The steps in the process are as follows:

1. The inflow hydrograph is interpolated from a collection of scaled hydrographs computed using TR-20 for various times-of-concentration and the ratio of initial abstract to total rainfall (Ia/P) values. This is similar

to the tabular TR-55 approach. The hydrograph collection was generated using the Michigan specific dimensionless unit hydrograph.

2. Structural BMP volumes are removed from the front of the hydrograph, effectively reducing the required flood control volume. The resulting hydrograph does not start until all retention volume is satisfied.
3. The inflow hydrograph adjusted for structural BMPs is routed through a detention pond model using the Modified Puls Method (see Section 8.4.8 of the MDOT Drainage Manual). The pond is assumed to be prismatic and defined by a bottom area, side slope, and orifice diameter. Pond routing is the calculation of the outflow hydrograph given the inflow hydrograph and pond characteristics. This calculation is based on the continuity equation written in differential form:

$$\frac{dV}{dt} = I - Q$$

where *V* is the volume of water in storage in the pond at time *t*, *I* is the inflow at time t, and *Q* is the outflow at time t. To calculate the outflow hydrograph, a finite difference method approximation of the continuity equation is used. This allows Q to be calculated as a time series:

$$\left(V_{i+1} + Q_{i+1}\frac{\Delta t}{2}\right) = \left(I_{i+1} + I_i - Q_i\right)\frac{\Delta t}{2} + V_i$$

where *Δt* is the time step, *i+1* refers to the present time and *i* refers to a time *Δt* earlier. At time *i+1* everything on the right hand side of the equation is known, allowing the value of the left hand side to be determined. Since V and Q are both functions of the pond depth, *H*, given the pond characteristics a table that relates values of pond depth, *H*, to values of $\left(V + Q\frac{\Delta t}{2}\right)$ can be constructed. This table is then used to find the pond depth at time i+1. Given this pond depth, the storage volume, V, and outflow, Q, can also be computed at time i+1. The calculation can then proceed to the remaining time steps resulting in the outflow hydrograph.

4. The pond model characteristics include bottom area, side slope, and orifice diameter. The spreadsheet computes the required orifice diameter to produce the desired peak discharge at an arbitrary depth of 5 feet. The sides are conservatively assumed to be vertical.
5. The spreadsheet runs a macro that iteratively adjusts the bottom area until the desired peak discharge and storage depth are met.

### Application

The LGROW Design Spreadsheet can assist the Design Engineer in applying the correct land uses and Curve Numbers in calculating channel protection volume, accounting for travel time through BMPs, accounting for total TSS reduction from a series of BMPs, and quickly evaluating a variety of stormwater management options for a range of rainfall frequencies.

Design calculations submitted using the LGROW Design Spreadsheet can help to expedite the review process because reviewing engineers are familiar with the spreadsheet and can more quickly check that requirements are being met. Spreadsheet submittals shall include all printed output in pdf format accompanied by a complete working Excel file matching the printed output.

The spreadsheet is a tool for demonstrating compliance with standards. It is not a tool for designing BMPs. The Design Engineer is responsible for effective BMP design in accordance with best practices, requirements, and guidance provided herein.

Portions of the computational programming in the spreadsheet are not visible to the user. Users are encouraged to validate the spreadsheet output following the computational methods presented in the Documentation tab. The Design Engineer is responsible for their own calculations to demonstrate compliance with these standards.

# Appendix 1

# Application and Checklists

Forms can be found by
clicking here.

# Instructions
# Land Use Development Services

## What is Land Use Development Services?

The Land Use Development Services (LUDS) review and permitting program provides the City's customers with a single point of access for the following development-related services:

- ***Planning Director Review*** – Determines whether a project is compliant with the Zoning Code and any conditions of approval by the Board of Zoning Appeals, Planning Commission, or City Commission.
- ***Stormwater Drainage Review*** – Determines whether a project is compliant with the City's stormwater regulations.
- ***Soil Erosion and Sedimentation Control (SESC) Review*** – Determines whether a project is compliant with the State of Michigan's regulations protecting water resources from development-related erosion.
- ***Temporary Occupancy of the Public Right-of-Way*** – Authorizes temporary use of City streets or sidewalks for construction-related activities.
- ***LUDS Inspections*** – Field inspections verify that a project is constructed according to the plans accepted by City staff.

For developers, the benefits of the LUDS program include a single application, a coordinated review process, and a consolidated review and permit fee.

## When is a LUDS Permit Required?

A LUDS Permit is required for these project types, under most circumstances:

- New multi-family, commercial, industrial, and institutional buildings
- Additions to multi-family, commercial, industrial, and institutional buildings
- Major site work, including parking lots
- New buildings and additions (including single-family residential) located in the flood plain
- New buildings and additions (including single-family residential) located within 500 feet of a water body (lake, river, stream, or drainage ditch) or wetland
- Other projects as required by Chapter 67 of the Grand Rapids City Code

## On-Line Plan Review Status and Comments

Following application submittal, the Land Owner and Site Designer will receive a confirmation notice with a plan review number for the project. Plan review status and comments are available on the City's website, www.grcity.us/devcenter, click on "Plan Review Comments."

## Submittal Requirements

A complete LUDS application consists of the following:

- LUDS Plan Review Application form
- LUDS-Director Review Attachment form (not required for single-family or two-family projects)
- A CD or DVD containing all of the pages normally submitted in a hard copy plan set (PDF format)

An incomplete application may be returned or held until all required materials have been received.

The City's objective is to review complete applications within 5 business days. Following the review, the Land Owner and Site Designer will be notified that a LUDS Permit can be issued or that revisions are required to the application, plans, or design.

## Plan Requirements

The plan type(s) must be included in the title block. Two or more plan types may be combined in a single page where feasible, provided that the individual types are listed in the title block. Checklists of required plan elements are available on the City's website, www.grcity.us/devcenter. These checklists are not exhaustive. Applicants should include any additional information that they deem to be reasonably necessary to adequately evaluate the proposed use or activity and its effects on the City, including additional studies, graphics, or written materials.

- ☑ **Site Plan** (Required)
- ☐ **Landscape Plan**
- ☐ **Lighting (Photometric) Plan**
- ☐ **Building Elevation Plan**
- ☐ **SESC Plan**
- ☐ **Stormwater Drainage (Utility) Plan**

## Who May Apply for a LUDS Permit?

While a Site Designer or other party may submit the LUDS Plan Review Application and the required plans, only a Land Owner (as defined by Chapter 67 of the Grand Rapids City Code) can be issued a LUDS Permit. For the LUDS Permit to be valid, a Land Owner must sign the LUDS Permit document, have the document stamped by the City, pay the review and permit fee, and submit a Supplemental Permit Data form listing the General Contractor, Certified Stormwater Operator (required for all projects 1 acre or larger), and any other relevant contractors working on the project.

# Instructions
# Land Use Development Services

**Please print or type when completing application forms.**

**All items are required unless otherwise noted.**

## Plan Review Application Instructions

I.A. Provide the official name given the project by the developer, the principal address used to reference the project's location, and the permanent parcel number of that address.

I.B. Provide all requested details on the project:
- Project size is the area to be altered subject to the LUDS Permit, not necessarily the total parcel area
- Impervious area is that portion of the total impervious area to be modified or added
- Zone district and zone neighborhood classification are available on the City's website, www.grcity.us/devcenter, click on "Interactive Mapping"

I.C. Describe all major site work and construction, including excavation, structures, paving, landscaping, etc.

I.D. Select a single proposed land use category, then follow the directions below the dashed line:
- For single-family and two-family projects, continue to Item I.E.
- For all other projects, check one of the boxes below the dashed line
  - If the project has already been approved, provide the approval date
  - If the project has not been approved, complete and attach the LUDS-Director Review Attachment form

I.E. If there is no proposed change in land use, check the box and continue to Section II; otherwise, describe the current land use in detail.

II.A. Provide the date of birth, name, and contact information of the Land Owner (Note: The Land Owner must be a person who meets the definition found in Chapter 67 of the Grand Rapids City Code).

II.B. (As Applicable) Provide the name and contact information of the Site Designer.

## Director Review Attachment Instructions

(Not required for single-family or two-family projects.)

I.A. Provide the official name given the project by the developer, the principal address used to reference the project's location, and the permanent parcel number of that address.

I.B. Provide lot frontage, depth, area (in square feet or acres), and shape.

I.C. Check all applicable project categories.

II. Provide a detailed description of the project, including all proposed uses (may be attached as a separate page). NOTE: The project description is a critical element of Director Review. A highly detailed description will expedite the review process; a short description will require follow-up communication by City staff, possibly delaying the review.

III. Check each submitted plan type and provide the applicable sheet number(s). NOTE: Plan checklists are available on the City's website, www.grcity.us/devcenter.

## Temporary Occupancy Attachment Instructions

(Not required if project does not involve temporary use of City streets or sidewalks for construction-related activites.)

NOTE: This form may be submitted on its own if temporary use of City streets or sidewalks is the only service requested.

I.A. Provide the official name given the project by the developer, the principal address used to reference the project's location, and the permanent parcel number of that address.

I.B. Describe the City street or sidewalk to be occupied.

I.C. Explain why the project cannot be completed without temporary use of the City street or sidewalk.

II.A. Provide the start date, finish date, and schedule of daily operations.

II.B. Explain how traffic adjustments will be made in accordance with the Michigan Manual of Uniform Traffic Control Devices.

II.C. Explain how the City street or sidewalk will be restored after use.

III.A. Provide the name and contact information of the Land Owner for the project.

III.B. ***If temporary use of City streets or sidewalks is the only service requested, the applicant need not be the Land Owner, but such applicant's name and contact information must be provided.***

* ***Sign and date the form.***

# LUDS Checklist
# Site Plan

## Purpose of the Site Plan

The Site Plan is required to provide the information needed for City staff to adequately review the proposed use or activity for the site. The type or level of information may vary depending upon the scale, scope, or nature of the project. The information shall be presented in sufficient detail with adequate dimensions to show the size and placement of all proposed structures, driveways, parking lots, roads, and streets. The plan shall include land features such as wetlands, floodplains, creeks, lakes, ponds, and surface drainage facilities. The information shall be provided in sufficient detail to determine the demand on the capacities of public services and facilities.

## General Plan Requirements

- ☐ Title block with sheet number, designer contact information and dates(s) of submission/revision
- ☐ Minimum 24” x 36” sheet size, to scale:
  - For less than 3 acres, not less than 1” = 50’
  - For 3 or more acres, 1”=100’
- ☐ Scale, north arrow, and location map
- ☐ Property boundaries and property dimensions (including width, length, acreage, and frontage)
- ☐ Any existing or proposed streets
- ☐ The location, surface width, and right-of-way width of public rights-of-way, streets, drives, alleys, existing and proposed easements (including type), acceleration and deceleration lanes, pedestrian walkways, and loading areas, including relationship to existing rights-of-way

## Site Plan Specific Requirements

- ☐ A project description
- ☐ The common description and complete legal description of the property
- ☐ Existing zoning of the property and zoning of all abutting properties
- ☐ Net acreage (minus rights-of-way and submerged land) and total acreage of the property
- ☐ Existing lot lines, building lines, structures, parking areas, and other improvements on the site and within 50 feet of the site
- ☐ Computations, with documentation, of average setbacks, where required
- ☐ Topography on the site and within 50 feet of the site at two-foot contour intervals, referenced to a U.S.G.S. benchmark
- ☐
- ☐ Proposed lot lines, lot dimensions, property lines, setback dimensions, structures, and other improvements on the site and within 100 feet of the site
- ☐ Proximity to intersection(s) and major thoroughfares
- ☐ Location of existing drainage courses, floodplains, streams, and wetlands with elevations
- ☐ Natural resources/features to be preserved
- ☐ Location of existing and proposed above or below ground storage facilities, and any containment structures for chemicals or flammable/hazardous materials
- ☐ Location of exterior lighting (site & building lighting)
- ☐ Location and size of all signs
- ☐ Location of trash receptacles and transformer pads and method of screening
- ☐ Extent of any outdoor sales or display area
- ☐ Dimensions, curve radii, and centerlines of existing and proposed access points, roads, and road rights-of-way or access easements
- ☐ Driveways and intersections within 250 feet of the site
- ☐ Cross section details of proposed roads, driveways, parking lots, sidewalks, and non-motorized paths illustrating materials and thickness
- ☐ Dimensions of acceleration, deceleration, and passing lanes
- ☐ Dimensions of parking spaces, islands, circulation aisles, and loading zones
- ☐ Calculations for required number of parking and loading spaces
- ☐ Designation of fire lanes
- ☐ Traffic regulatory signs and pavement markings
- ☐ Location of existing and proposed sidewalks/pathways within the site or right-of-way
- ☐ Location, height, and outside dimensions of all storage areas and facilities
- ☐ Number, location, and density by type of residential units, if applicable
- ☐ Location, size, and purpose of any proposed open spaces or recreational areas

# LUDS Checklist
# Soil Erosion Sedimentation Control Plan

## Purpose of the SESC Plan

The SESC Plan is required to provide the information needed for City staff to review the adequacy of the proposed controls to minimize the erosion of soil and the discharge of soil sediments from the site. The type or level of information may vary depending upon the scale, scope, or nature of the project and the components (Best Management Practices) of the proposed controls. The information shall be presented in sufficient detail to show type, dimensions, sizes, and placement of all proposed control components.

## General Plan Requirements

- ☐ Title block with sheet number, designer contact information and dates(s) of submission/revision
- ☐ Minimum 24" x 36" sheet size, to scale:
  - For less than 3 acres, not less than 1" = 50'
  - For 3 or more acres, 1"=100'
- ☐ Scale, north arrow, and location map
- ☐ Property boundaries and property dimensions (including width, length, acreage, and frontage)
- ☐ Any existing or proposed streets
- ☐ The location, surface width, and right-of-way width of public rights-of-way, streets, drives, alleys, existing and proposed easements (including type), acceleration and deceleration lanes, pedestrian walkways, and loading areas, including relationship to existing rights-of-way

## SESC Plan Specific Requirements

- ☐ Predominant soil type (sand, silt, clay, other)
- ☐ Limits of earth change (must be specifically called out)
- ☐ Topographic map showing surface elevation contours at two foot intervals or less. Spot elevations with a maximum grid of 25 feet may be substituted when a site is less than one-half (1/2) acre
- ☐ The location of any floodplain areas, bodies of water, wetlands, and all known natural resources or natural features to be preserved
- ☐ Location of all construction site entrances and exits and means for preventing the tracking of soil off site
- ☐ Location of any stockpile areas with means for protecting against wind and water erosion
- ☐ Location of any construction staging areas, dumpsters, and waste disposal areas, particularly those areas where flammable or hazardous materials may be stored. Show all proposed spill prevention and containment measures
- ☐ The location and size of all existing and proposed surface and subsurface water drainage facilities, and county and/or local drainage ways
- ☐ Emergency overland flow route from the site
- ☐ The location of all existing and proposed landscaping and vegetation, or make reference to the Landscape Plan
- ☐ The approximate locations of all buildings, structures, and driveways on properties within 100 feet of any lot line of the subject properties
- ☐ Narrative description or legend of all SESC measures and Best Management Practices to be utilized
- ☐ Installation details of all SESC measures
- ☐ Schedule for the implementation, installation, and maintenance of the SESC measures and Best Management Practices

# LUDS Checklist
# Stormwater Drainage (Utility) Plan

CITY OF GRAND RAPIDS

## Purpose of the Drainage Plan

The Drainage Plan is required to provide the information needed for City staff to review the adequacy of the proposed drainage system and to evaluate possible impacts to the City's Stormwater Drainage System. The proposed drainage system must be designed to manage the amount and rate of the stormwater runoff from the site, as well as the quality of the runoff discharged from the site. The type or level of information may vary depending upon the scale, scope, or nature of the project and the components (Best Management Practices) of the proposed drainage system. The information shall be presented in sufficient detail to show dimensions, sizes and placement of all proposed drainage components.

## General Plan Requirements

- ☐ Title block with sheet number, designer contact information and dates(s) of submission/revision
- ☐ Minimum 24" x 36" sheet size, to scale:
  - For less than 3 acres, not less than 1" = 50'
  - For 3 or more acres, 1"=100'
- ☐ Scale, north arrow, and location map
- ☐ Property boundaries and property dimensions (including width, length, acreage, and frontage)
- ☐ Any existing or proposed streets
- ☐ The location, surface width, and right-of-way width of public rights-of-way, streets, drives, alleys, existing and proposed easements (including type), acceleration and deceleration lanes, pedestrian walkways, and loading areas, including relationship to existing rights-of-way

## Drainage Plan Specific Requirements

- ☐ A summary description of the proposed drainage system
- ☐ Topography on the site and within 50 feet of the site at two-foot contour intervals, referenced to a U.S.G.S. benchmark
- ☐ The location of any floodplain areas, bodies of water, wetlands, and all known natural resources or natural features to be preserved
- ☐ Building floor elevations and surface opening elevations
- ☐ The location and size of all surface and subsurface water drainage facilities, and county and/or local drainage ways, existing and proposed, with flow and runoff calculations
  - ☐ Site drainage data (pervious area, impervious area, pavement area)
  - ☐ Hydrology data (design storm, peak discharge rate, peak on-site storage volume)
  - ☐ Surface runoff storage facility data (volume, maximum depth, side slopes)
  - ☐ Runoff treatment data (runoff area being treated, peak treatment rate, treatment unit retained water volume, treatment unit surface area and flow length, and maximum sediment volume)
  - ☐ The location, size, invert elevations, top elevation, and bottom elevation of existing and proposed pipes, catch basins, manhole or other drainage structures
- ☐ Emergency overland flow route from the site
- ☐ The location of all existing and proposed landscaping and vegetation, including number of trees and shrubs by species and caliper, or make reference to the Landscaping Plan
- ☐ The location of dumpsters, waste disposal areas, and loading facilities
- ☐ The approximate locations of all buildings, structures, and driveways on properties within 100 feet of any lot line of the subject properties

## Other Utility Plan Requirements

- ☐ Location of sanitary sewers and septic systems, existing and proposed
- ☐ Location and size of existing and proposed water mains, well sites, water service, storm sewer loads, and fire hydrants
- ☐ Location of above and below ground gas, electric, and telephone lines, existing and proposed
- ☐ Location of transformers and utility boxes

**Engineer's Certification for Use of Alternative Approach for Channel Protection:**

I am the Design Engineer for ________________________________ and certify that I have followed the LGROW Alternative Approach Flowchart, and maximized the use of BMPs to meet the channel protection volume standard through reduction of runoff and onsite retention. The following site constraints preclude meeting the channel protection standard through volume control:

(Check all that apply)

- ☐ Poorly draining soils (< 0.24 inches per hour infiltration capacity; typically HSG C and D).
- ☐ Part 201 and Part 213 sites, and areas of soil or groundwater contamination.
- ☐ High groundwater, or the potential of mounded groundwater to impair other uses.
- ☐ Wellhead protection areas.
- ☐ Bedrock.
- ☐ Other: ____________________________________________________________________________

______________________________________ ____________________

(Printed Name) (Date)

______________________________________ _____________________

(Signature) (PE license no.)

# Appendix 2

# Watershed Policy Statements

## Watershed Policy Statements

### Plaster Creek

The Plaster Creek watershed has open channels susceptible to stream bank erosion. Discharge rates in the Watershed are limited to 0.05 cfs per acre for up to the two-year, 24-hour storm.

The Plaster Creek Watershed does not have adequate downstream floodways. Storage volumes in the watershed shall be for the 100-year, 24-hour storm.

### Coldbrook Creek Watershed

The Coldbrook Creek Watershed does not have adequate downstream floodways. Storage volumes in the watershed shall be for the 100-year, 24-hour storm.

### Indian Mill Creek Watershed

Indian Mill Creek is a cold water creek. As such, the watershed is subject to Coldwater Stream requirements per part III.II.F.

### Buck Creek

Buck Creek is a cold water creek. As such, the watershed is subject to Coldwater Stream requirements per part III.II.F.

# Appendix 3

# BMP Design Criteria for Stormwater Controls

# Table of Contents – Appendix 3

# I. NON-STRUCTURAL BEST MANAGEMENT PRACTICES

Non-structural BMPs consist of protection measures that reduce the volume of stormwater runoff from the site. This differs from the goal of many structural BMPs which is to help mitigate the impact of stormwater runoff.

Design criteria is provided for the following non-structural BMPs:

A. Minimal Disturbance Area
B. Protect Natural Flow Pathways
C. Protect Sensitive Areas
D. Native Revegetation
E. Stormwater Disconnect

Further information and examples are provided in the BMP Fact Sheets in Chapter 6 of the *Low Impact Development Manual for Michigan* (SEMCOG, 2008):

All of the following criteria must be met to receive credit for each non-structural BMP selected for use.

# A. Minimal Disturbance Area

## 1. Summary

| | |
|---|---|
| Description: | Identify and avoid disturbance to existing pervious areas during construction to reduce potential for erosion and increased runoff. |
| Application: | Larger sites with pervious areas; difficult to implement on small, high-density developments. |
| Pretreatment Required: | No. |
| Maintenance Plan: | Yes, for trees receiving a credit. |
| Calculation Credits: | |
| Volume Reduction: | Assign a CN reflecting open space in "good" condition, or woods in "good" condition, or a combination.<br>For small sites, individual trees can receive a credit of 800 square feet per tree, counted as woods in "good" condition.[1] |
| Rate Reduction: | By virtue of lower CN. |
| Water Quality: | Exempt from water quality criteria. |

[1]Source: *Low Impact Development Manual for Michigan* (SEMCOG, 2008).
*Note*: Trees in minimal disturbance areas receive a larger area credit than trees planted under "Native Revegetation" due to the assumption that the existing trees will typically be larger and more mature than planted trees at the time of site plan submittal and during ensuing years.

## 2. Criteria

This BMP applies to those portions of buildable lots located outside of lot building zones, construction traffic areas, and staging areas that can be maintained as "minimal disturbance areas" during construction (i.e. wooded back portions of residential lots, green space required by ordinance).

Minimal disturbance area – Construction disturbance is limited to clearing of brush and minor grading. No clear-cutting, excavation, filling, stockpiling of material, or construction traffic is allowed. Area is vegetated after disturbance (if any).

a. Identify minimal disturbance areas on site plan and construction drawings.

b. Minimal disturbance areas must be protected by having the limits delineated/flagged/fenced in the field. Notes to this effect must be included on construction drawings.

c. Minimal disturbance areas must not be subject to excessive equipment movement. Vehicle traffic and storage of equipment and/or materials is not permitted.

d. Pruning or other required maintenance of vegetation is permitted. Additional planting with site-appropriate plants including turf grass is permitted.

e. Areas receiving credit must be located on the development project.

## B. Protect Natural Flow Pathways

### 1. Summary

| | |
|---|---|
| Description: | Identify and map natural drainage features to maximize protection and benefits of use. |
| Application: | Lower-density developments. |
| Pretreatment Required: | No. This BMP can provide pretreatment. |
| Maintenance Plan: | Yes. |
| Calculation Credits: | |
| Volume Reduction: | Assign a CN reflecting a meadow or open spaces in “good” condition. |
| Rate Reduction: | Due to longer time-of-concentration for natural flow pathway. |
| Water Quality: | Exempt from water quality criteria. |

### 2. Criteria

a. Identify all existing natural flow pathways on site plan.

b. Identify natural flow pathways to be protected on site plan and construction drawings.

c. Protected natural flow pathways on private property must have an easement or deed restriction to prevent future disturbance or neglect.

d. Natural flow pathways to be protected must have the limits delineated/flagged/fenced in the field. Notes to this effect must be included on construction drawings.

e. Identify flow pathways designed as part of the stormwater management system including strategies such as:

(1) Increased length.
(2) Increased roughness.
(3) Decreased slope.

f. Ensure adequacy of flow pathway for post-development flows.

# C. Protect Sensitive Areas

## 1. Summary

| | |
|---|---|
| Description: | Identify, map and prioritize sensitive areas on the site to be preserved and protected in perpetuity. |
| Application: | Plats; Condominiums; More difficult to implement as development density increases. |
| Pretreatment Required: | No. |
| Maintenance Plan: | No. |
| Calculation Credits: | Remove protected sensitive areas from stormwater management calculations, or select an appropriate existing land use if necessary to include the area for sizing of conveyance systems. |
| Volume Reduction: | Exempt from channel protection criteria. |
| Rate Reduction: | Exempt from flood control criteria. |
| Water Quality: | Exempt from water quality criteria. |

## 2. Criteria

This BMP includes protected areas on the development property located on separate out lots or set-asides with language in the master deed or bylaws that requires protection and preservation, and that restricts land uses to those that do not increase runoff.

a. Identify all sensitive areas on site plan.

b. Identify all sensitive areas to be protected on the site plan and construction drawings.

c. Sensitive areas to be protected must have the limits delineated/flagged/fenced in the field during construction and visible permanent boundary markers set to minimize encroachment (as appropriate). Notes and details to this effect must be included on construction drawings.

d. Identify municipal ordinance requirements, if any, and incorporate sensitive area standards for development site. In the absence of a local ordinance, standards for riparian buffers shall consist of:

   (1) Variable width depending on topography, minimum 25-foot width (Zone 1).
   (2) Naturally vegetated.

e. Minimal clearing is allowed for lot access and fire protection.

f. For activities proposed within floodplains the Developer shall demonstrate any activity proposed within a 100-year floodplain will not diminish the flood storage capacity. Compensatory storage will be required at a minimum ratio of one-to-one (1:1) for all lost floodplain storage.

   (1) The compensating cut must be available during a flood event.
   (2) Water must be able to move freely from stream to storage.
   (3) Excavation must be adjacent to the floodplain.
   (4) Flood storage must be between the 2-year flood elevation and the 100-year flood elevation.
   (5) Compensating storage shall NOT be provided through channel widening.

# D. Native Revegetation

## 1. Summary

| | |
|---|---|
| Description: | Restoration of disturbed pervious areas with deeper-rooted native plants in lieu of conventional turf grass to reduce runoff volume. |
| Application: | All development types; Limitations where rapid establishment of dense turf grass is needed to prevent erosion in concentrated flow situations. |
| Pretreatment Required: | No. This BMP can provide pretreatment. |
| Maintenance Plan: | Yes. |
| Calculation Credits: | |
| Volume Reduction: | Assign a CN reflecting a meadow.<br>For small sites, individual trees can receive a credit of 200 square feet per tree, counted as woods in “good” condition.[1] |
| Rate Reduction: | By virtue of lower CN. |
| Water Quality: | Exempt from water quality criteria. |

[1]Source: SEMCOG (2008). *Low Impact Development Manual for Michigan*.
*Note*: Trees in minimal disturbance areas receive a larger area credit than trees planted under “Native Revegetation” due to the assumption that the existing trees will typically be larger and more mature than planted trees at the time of site plan submittal and during ensuing years.

## 2. Criteria

a. Identify native revegetation areas on site plan and construction drawings.

b. Native revegetation areas must be protected by having the limits delineated/flagged/fenced in the field. Notes to this effect must be included on construction drawings.

c. Standards shall consist of:

(1) Variable width depending on topography, minimum 25-foot width (Zone 1).

(2) Native revegetation selected from the *Low Impact Development Manual for Michigan* (SEMCOG, 2008), Appendix C.

d. Areas receiving credit must be located on the development project.

# E. Stormwater Disconnect

## 1. Summary

| | |
|---|---|
| Description: | Minimize runoff volume by disconnecting impervious areas from the stormwater conveyance system. |
| Application: | Rooftops; Driveways; Walkways; Patio areas; Minor roads. |
| Pretreatment Required: | No. |
| Maintenance Plan: | Yes. |
| Calculation Credits: | |
| Volume Reduction: | Weight impervious CN with pervious area CN for open spaces in “good” condition.<br>The following weighted CNs can be assigned to the disconnected impervious area. They assume a pervious area twice the size of the impervious area.<br>A: 59; B: 73; C: 82; D: 86 |
| Rate Reduction: | By virtue of weighted CN. |
| Water Quality: | Exempt from water quality criteria. |

| A | B | C | D |
|---|---|---|---|
| 59 | 73 | 82 | 86 |

## 2. Criteria

a. Stormwater from rooftops and other impervious areas is considered disconnected if it is routed to a stabilized vegetated area, or an onsite depression storage area that meets the following criteria:

(1) Pervious area is not a structural BMP that must be designated to treat the runoff from the impervious surface.

(2) Impervious area must be limited to 1,000 square feet per discharge point.

(3) Roof downspouts and curb cuts must be at least 10 feet away from the nearest connected impervious surface to discourage “re-connections.”

(4) Disconnection in less permeable soils (HSGs C and D) may require the use of dry wells, french drains, or other temporary storage device to compensate for poor infiltration capability if ponding of water for extended period of time becomes problematic.

(5) For disconnects to stabilized vegetated areas:
- (a.) Size of disconnect area shall be twice the size of the contributing impervious area.
- (b.) Length of disconnect area must be at least the length of the flow path of the contributing impervious area (maximum 75 feet).
- (c.) Slope of disconnect area must be no greater than 5%.
- (d.) Disconnect area may be a “minimal disturbance area.”

(6) Disconnection must ensure no basement seepage.

b. Identify disconnect areas on site plan and construction drawings.