

**KENT COUNTY  
DRAIN COMMISSIONER  
SITE DEVELOPMENT RULES**

**Procedures and Design Standards for Stormwater Management**



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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
GASB	Governmental Accounting Standards Board
GIS	Geographic Information System/Services
GVMC	Grand Valley Metropolitan Council
HSG	Hydrologic Soil Group
LGROW	Lower Grand River Organization of Watersheds
LID	Low Impact Development
MDEQ	Michigan Department of Environmental Quality
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
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

County	County of Kent, State of Michigan
County Road Commission	The Kent County Road Commission
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 Proprietor to design the site plan for a plat or any other land development, including stormwater management and drainage
Drain Commissioner	The Drain Commissioner of the County of Kent, State of Michigan
Health Department	The Kent County Health Department
Proprietor	Any person, landowner, firm, association, partnership, corporation, or combination of any of them that holds an ownership interest in land, and who submits a site plan for drainage review (may also be referred to as the Developer)
Register of Deeds	The Kent County Register of Deeds
Review Engineer	The engineer appointed by the Drain Commissioner to review the stormwater management and drainage elements of a plat or any other land development

## I. LETTER OF INTENT

Kent County Drain Commissioner  
Pursuant to Section 105 of Act 288  
Public Acts of Michigan (PA) of 1967, as amended  
and  
Section 402 of the Federal Clean Water Act, as amended  
Nonpoint Source Discharge Elimination System (NPDES)  
for Municipal Separate Storm Sewer Systems (MS4)

IT IS HEREBY ORDERED that the *Kent County Site Development Rules*, promulgated pursuant to The Land Division Act, formerly the Subdivision Control Act (Section 105 of Act 288, PA 1967, as amended by Act 591, PA 1996), are hereby adopted and shall be followed in the processing of all subdivision plats, and all other private, commercial and public land developments (e.g., condominiums, planned unit developments, manufactured housing communities, and other residential, commercial, industrial, or institutional developments), which impact established county or intercounty drains under the jurisdiction of the Kent County Drain Commissioner pursuant to the Michigan Drain Code (Act 40, PA 1956, as amended), or for which the Kent County Drain Commissioner provides support to other state or county agencies, and site plan review support for stormwater management to local units of government via resolution or ordinance.

Updates or revisions to these rules may be published from time-to-time as deemed necessary by the Kent County Drain Commissioner. Revisions to the standards affecting the MS4 permit requirements must be reviewed and approved by the Michigan Department of Environmental Quality (DEQ) prior to publication.

A resolution to authorize the fee schedule set forth herein, pursuant to the authority granted in the Land Division Act, was adopted by the Kent County Board of Commissioners.

IT IS HEREBY FURTHER ORDERED that the effective date of the following rules shall be the 1<sup>st</sup> day of January, 2020.

Ken Yonker  
Kent County Drain Commissioner



## II. PURPOSE

This manual was produced to update and unify site plan review procedures within Kent County. It is the purpose of these site development rules to establish a uniform set of minimum standards for the management of stormwater to be applied county-wide and meet the following objectives:

1. Ensure stormwater drainage systems and BMPs are adequate to address stormwater management needs within a proposed development, and protect the drainage, property, and water rights of landowners outside of the proposed development.
2. Reduce flood damage due to development.
3. Minimize the degradation of existing watercourses.
4. Prevent an increase in nonpoint source pollution.
5. Maintain site hydrology to avoid detrimental changes in the balance between stormwater runoff, groundwater recharge, and evapotranspiration.

### A. Compliance with State Land Division Statute

The Land Division Act, formerly known as the Subdivision Control Act (Act 288, PA 1967, as amended by Act 591, PA 1996), requires the county drain commissioner to publish rules governing the internal drainage of proposed subdivisions and outlets for drainage. The rules in this manual are intended to assist land developers by providing uniform procedures to be followed in the processing of preliminary and final plats, construction drawings, and establishment of county drains and their branches within and without of these subdivisions.

### B. Compliance with State and Federal Stormwater Mandates

The National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit requires the drain commissioner to adopt an ordinance or other regulatory mechanism to address post-construction stormwater runoff from private, commercial, and public development and redevelopment projects, including preventing or minimizing water quality impacts. County drains located within an urbanized area defined by the United States Environmental Protection Agency (US EPA) are considered MS4s. The County 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 treatment 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 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).

## C. Preferred Stormwater Management Strategies

The Drain Commissioner’s preferred strategies for the management of stormwater within Kent County are as follows:

### **Regional Stormwater Management (optional)**

The management of stormwater on a regional basis is encouraged where practical, particularly where site constraints preclude effective onsite treatment of stormwater. A regional stormwater management approach 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.<sup>1</sup> Specific requirements are provided in Part 2 section “Regional Stormwater Management Facility.”

### **Alternative Approach for Channel Protection**

An alternative approach using extended detention is allowed by the Drain Commissioner 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 and payment-in-lieu programs are allowed in the MS4 permit but have not been adopted by the Drain Commissioner.

### **Low Impact Development**

Where regional stormwater management is not available to developers, Onsite Low Impact Development (LID) is the preferred stormwater management strategy to meet the multiple objectives identified above. LID uses the basic principle modeled after nature to manage rainfall where it lands. The outcome of LID is mimicking existing site hydrology by using design techniques to infiltrate, filter, store, evaporate and detain runoff close to its source. Many of these techniques incorporate the use of vegetation and are collectively referred to as Green Infrastructure.

A LID approach offers additional benefits in terms of increased property value and potential cost savings.<sup>2</sup> Developers can often reduce the size of storage facilities and stormwater infrastructure by incorporating LID principles into a site design up front.

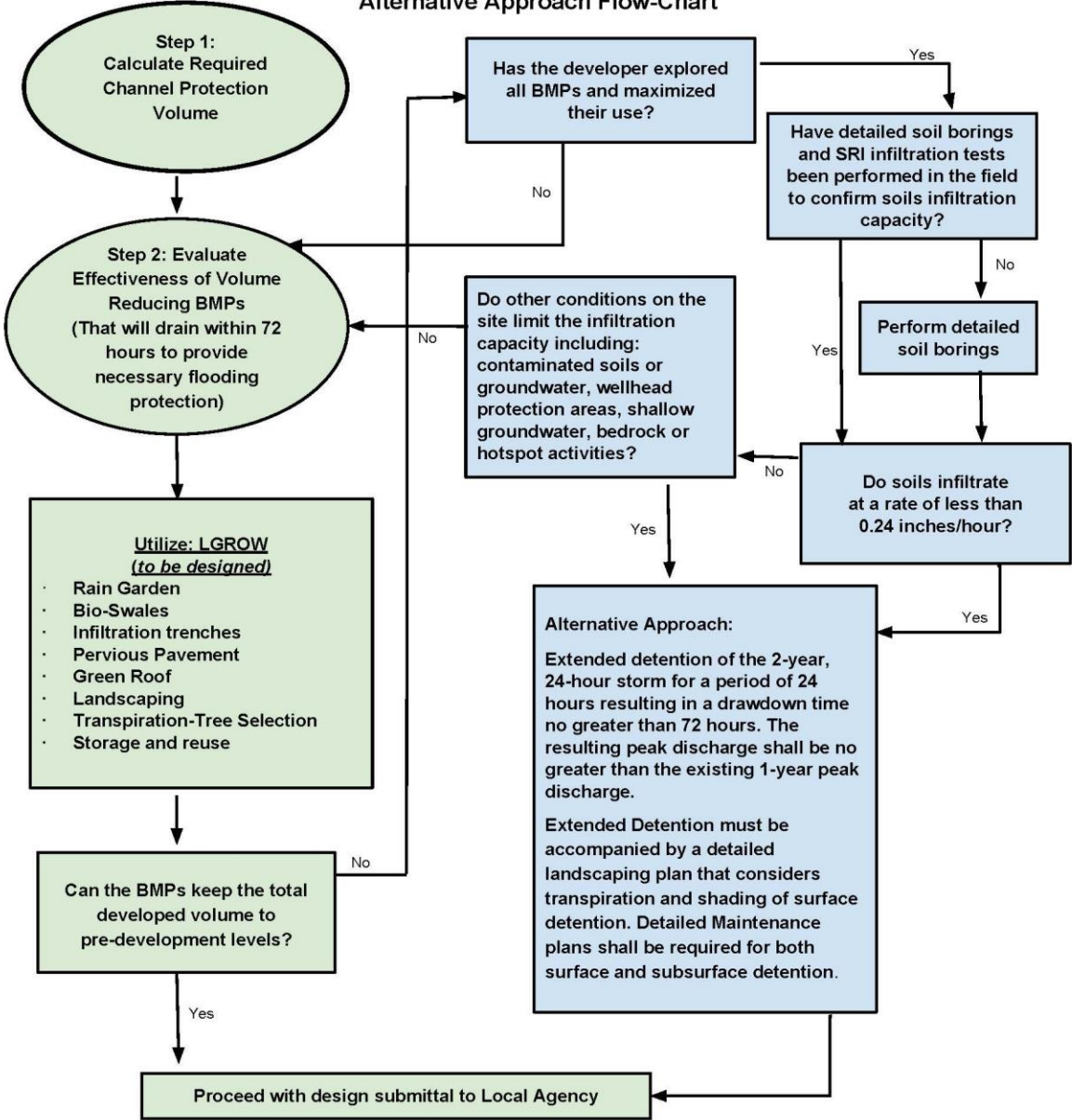
The *Low Impact Development Manual for Michigan* (SEMCOG, 2008) was used to develop this manual. The standards in this manual incorporate LID principals into the design process and include design criteria for LID and small site BMPs.

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<sup>1</sup> 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.

<sup>2</sup> United States Environmental Protection Agency (December 2007). *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*, EPA 841-F-07-006.

Lower Grand River Organization of Watersheds MS4 Stormwater Ordinance Committee  
 Alternative Approach Flow-Chart



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

### **III. AUTHORITY**

#### **A. Land Division Act**

All plats recorded with the Register of Deeds must conform to the Michigan Land Division Act, formerly known as the Subdivision Control Act (Act 288, PA 1967, as amended by Act 591, PA 1996). Under this Act, the drain commissioner is responsible for ensuring that the stormwater drainage system of a subdivision is adequate to address stormwater management needs within the proposed subdivision and to protect downstream landowners. The drain commissioner has the authority, through the subdivision review process, to require that county drains, both inside and outside of a plat, be established or improved to the standards established by the drain commissioner when necessary for the proper drainage of a proposed subdivision.

#### **B. Mobile Home Commission Act**

The standards set forth herein will be applied in review for plans for mobile home parks prepared under the Michigan Mobile Home Commission Act (Act 96, PA 1987.) The drain commissioner has jurisdiction to review and approve outlet drainage, and internal drainage only if the streets or drains are dedicated to the public.

#### **C. Condominium Act**

The standards set forth herein will be applied in review of site condominium and regular condominium plans prepared under the Michigan Condominium Act (Act 59, PA 1978, as amended.) A notice of proposed action is required to be provided to the drain commissioner.

#### **D. Drain Code**

The Michigan Drain Code (Act 40, PA 1956, as amended) provides the drain commissioner with jurisdiction over all drains established within a county. As such, the drain commissioner has an obligation to maintain the integrity of any given drain from all activities including development, which may directly impact the drain. All developments that discharge directly to an established county or intercounty drain shall conform to the requirements herein.

#### **E. Review Authority Granted by Local Municipalities**

All developments where review authority is granted to the Drain Commissioner by the local municipality (i.e. township, city, village) shall conform to the requirements herein. The Drain Commissioner's review of private drainage systems will focus on the discharge of stormwater offsite, but will also include review of the internal drainage and the accommodation of surface water from upstream areas.

#### **F. Provisions for Requirements in Addition to Minimum Standards**

These rules provide minimum standards to be complied with by Proprietors and in no way limit the authority of the municipality 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. Proposed site plans shall complement any local stormwater master plans that may exist and/or comply with any ordinance in effect in the municipalities where the site development is located.

The Drain Commissioner 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 Drain Commissioner.

## IV. APPLICABILITY

### A. Review Required

These standards apply to private and public development and redevelopment projects in Kent County. These standards also apply to projects being completed by the Kent County Drain Commissioner, including road projects.

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

1. Plats.
2. Mobile Home communities.
3. At the request of the municipality, site condominiums with public streets and private developments requiring site plan review at the local level (may be less than 1 acre).
4. All new development and redevelopment projects, including private, commercial and public projects that disturb at least one acre or more, and projects less than one acre that are part of a larger common plan of development or sale that would disturb one acre or more, and discharge directly or indirectly into a regulated county MS4 (a county drain located within an urbanized area defined by the EPA under the NPDES program). For the purpose of these rules, all county drains located within an urbanized area are considered an MS4 even if they are Waters of the State. Except for the development types listed above, review authority must be granted to the Drain Commissioner by the local municipality.

### B. Exemptions

The following development activities are exempt from these standards:

1. Construction of individual single and two-family residential structures.
2. Additions or modifications to existing single and two-family residential structures.

### C. Redevelopment

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

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

## V. SEVERABILITY CLAUSE

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

## VI. FEES

The fees for reviewing a plat or site development under these rules are set forth in the Schedule of Fees, which is **Appendix I** to this document.

## I. SUBMISSION AND APPROVAL

These procedures have been developed in the context of the plat requirements specified in the Land Division Act, which lays out a submittal and approval process. A preliminary plat and final plat are required by statute. A pre-application review meeting may be requested by the Proprietor as stated in the statute for the purpose of an informal review of the concept plan for the preliminary plat. A site evaluation may also be requested.

For other categories of developments, including site condominiums, submittal of a preliminary site plan is recommended, but not required. Construction drawings are required for all developments.

Plats, site condominiums and other developments where the stormwater system is to be established as a county drain, must also follow the additional procedures outlined for drains under the jurisdiction of the Drain Commissioner.

### A. Submission

The following submittals are required for Drain Commissioner review and approval:

#### Site Plan Review

1. The checklists included in **Appendix A** and calculations prepared by a professional engineer licensed in the State of Michigan.
2. Applicable fee (refer to Part 1 section "Fees").
3. Other required documentation per these standards.
  - a. Drain Forms found in **Appendix C**.
  - b. Application and Permit found in **Appendix G**.

#### Final Plat

1. Evidence of preliminary plat approval. The preliminary plat must be approved by the municipal governing body in which the proposed development is located. Evidence of this approval shall be submitted to the Drain Commissioner's office with the final plat.
2. Final plat. The Land Division Act requires that one (1) true copy of the final plat be delivered to the Drain Commissioner for review. Final plats must be prepared in accordance with the requirements of the Land Division Act. Final plat mylars of the number and type are directed by the Michigan Department of Commerce.
3. Construction Records. Acceptable construction record drawings and post-construction certification from the Design Engineer must be submitted along with the final plat. A Proprietor who desires to expedite the formal platting procedure shall enter into an agreement with the Drain Commissioner and post surety for faithful performance of the agreement (refer to Part 2 section "Surety").

### B. Changes and Resubmission

#### Preliminary Plat

Approval of the preliminary plat by the local governing body is required under the Land Division Act. Further, the approval of federal and state agencies may also be required. Approval of the preliminary plat is not intended to be final approval. If the Proprietor and/or the Drain Commissioner find it advantageous to make changes before the final plat is presented to the Drain Commissioner for signature, such changes can be made, provided that the same procedures outlined above are repeated with each change in the layout.

If the Proprietor finds it advantageous to make changes in the preliminary plat or site plan, they shall be incorporated in the plan and a new preliminary plat or site plan shall be resubmitted for approval. Resubmission is required even though the original layout may have already been approved.

### **Construction Drawings**

If the Proprietor finds it advantageous or necessary to make design changes, or if the information given to the Drain Commissioner does not represent the conditions as they exist on the ground, and revisions are required as a result, such revisions shall be made by the Proprietor and the drawings resubmitted to the Drain Commissioner for approval.

## **C. Approval**

Payment of all fees is prerequisite to approval (refer to Part 1 section "Fees").

### **Preliminary Plat**

The Drain Commissioner within thirty (30) days after receipt of the preliminary plat will approve it, approve it subject to conditions, or reject it. If the preliminary plat is approved, the Drain Commissioner will note its approval on the copy to be returned to the Proprietor, or by letter if the Proprietor does not need the preliminary plat to be returned. If the preliminary plat is approved subject to conditions or rejected, the reasons for rejection and requirements for approval shall be given in writing to the Proprietor and each of the other officers and agencies to which the Proprietor was required to submit the preliminary plat.

### **Construction Drawings**

The Land Division Act gives no time limit in which final construction plans must be reviewed. The Drain Commissioner will approve or reject construction drawings in writing within thirty (30) days of receipt of a complete submittal.

### **Final Plat**

Final plat review will be completed by the Drain Commissioner's office within ten (10) days of submission by the Proprietor. If the plat is not acceptable, written notice of rejection and the reasons therefore will be given to the Proprietor and the clerk of the related municipality. Upon approval, the Drain Commissioner will sign the plat, and the plat will be executed.



## D. Expiration of Approval

### Preliminary and Construction Drawings

If the Proprietor does not present the final plat to the Drain Commissioner for approval within a period of two (2) years after receiving approval of the tentative layout, it will be necessary to resubmit the layout for review. The preliminary and construction drawings are no longer valid and a new submittal is required. If an extension beyond this period is needed, the Proprietor shall submit a written request along with resubmittal fees to the Drain Commissioner for an extension (refer to Part 1 section “Fees”). The Drain Commissioner may grant a two-year extension of the approval and may require updated or additional information, if needed. Should modifications be made to the drawings, a new review may be required subject to the appropriate fees.

## E. Staged Development

Should the Proprietor 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 Proprietor intends to follow. Each subsequent plat or site plan shall follow the same procedure until the entire area controlled by the Proprietor is developed.

Final acceptance by the Drain Commissioner 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 Drain Commissioner are proposed.

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

One (1) paper copy and one (1) electronic copy shall be submitted to the Drain Commissioner with a letter of certification by the Design Engineer for all developments reviewed under these rules. Construction record drawings must be submitted prior to release of any review deposit.

At a minimum, construction record drawings shall contain the information listed on the checklists (**Appendix A**). The Drain Commissioner shall have thirty (30) days to review construction record drawings.

## 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 Management Facilities

Stormwater management facilities within a development planned to have multiple lot owners 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.

#### Offsite Stormwater

Surface water flows from offsite land shall be routed around the development's onsite stormwater system whenever possible. An onsite detention basin shall not be used to pass this flow through the site. If water from offsite is directed through an onsite detention basin, the basin must either be designed as a regional stormwater management facility, or detain the existing offsite water to the same flood control standard as the site.

#### Stormwater Discharge

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 or the existing discharge rate from the site.
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 any increase to the existing design discharge from the site development, it is the Proprietor's responsibility to:
  - a. Stabilize or upsize the existing conveyance system, or establish a county drain to provide the needed design level of flood protection.
  - b. Obtain flooding easements for measurable increases in water levels determined to cause an adverse impact.
  - c. Provide additional onsite stormwater controls.
5. Discharge to groundwater shall not cause groundwater mounding sufficient to adversely impact structures or adjacent property.
6. Post-development discharge shall not cause downstream impairments by the contribution of pollutants.
7. Post-development discharge shall not cause downstream impairments to coldwater streams due to thermal properties of the discharge.

It is the Proprietor's obligation to meet this standard. Should a stormwater system, as built, fail to comply with the rules herein, it is the Proprietor'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 Drain Commissioner's review and approval.

### B. Regional Stormwater Management Facility

Regional stormwater management facilities are designed to serve multiple developments or parcels with more than one property owner at the time of development or redevelopment.

The Drain Commissioner may pursue projects within a drainage district through the petition process to construct facilities to serve a particular drainage area, or may approve facilities proposed to be constructed by individual Developers. Private facilities must have a written agreement between responsible parties with recorded easements to ensure operation and maintenance of the facility in perpetuity. Agreements must specify maximum allowable runoff coefficients for each parcel contributing to the facility.

The regional facility should be constructed first, prior to any development or redevelopment. Written approval is required from the Drain Commissioner if construction is to be delayed. Financial surety and temporary onsite measures must be provided until the facility is constructed.

## C. Restrictive Covenants

For plats, a copy of restrictive covenants related to drainage shall be provided to the Drain Commissioner for approval. A sample restrictive covenants with the necessary language is included in **Appendix F**. Covenants shall be recorded at the Register of Deeds with the recording of the plat. A restriction note shall be placed on the Final Plat Mylar that reads:

*This Plat is subject to restrictions as required by Act 288 of 1967, as amended, on certain Lots with respect to the requirements of the Kent County Drain Commissioner which are recorded in Instrument number \_\_\_\_\_, of records of this county.*

For condominiums, a copy of the master deed language related to drainage shall be provided to the Drain Commissioner for approval, only if a county drain is being established. A copy of the Master Deed shall be recorded with the Register of Deeds prior to release of surety.

### Block Grading Plan

A block grading plan shall be incorporated in the restrictive covenants of the plat or master deed to ensure proper drainage of individual lots. In addition, the Proprietor shall provide a copy of the block grading plan to the Drain Commissioner and the municipality for their permanent files. The block grading plan shall include the Lowest Allowable Floor Elevation and Lowest Allowable Opening Elevation for each lot, and include the “basement type” for each lot (e.g. walkout, daylight, or standard basement) as indicated by the topography of each site and according to the approved design plans.

### Minimum Floor and Opening Elevations

Minimum building floor and opening elevations shall be established to eliminate the potential of structural damage and flooding of building interiors.

A certification by the Design Engineer that the minimum floor and opening elevations do not pose a risk of flooding for up to the 100-year storm shall be provided for each development or phase of development prior to approval. Documentation to support allowable minimum floor and opening elevations shall be submitted with construction drawings.

#### Criteria for determining the Lowest Allowable Floor Elevation

1. Proximity to detention/retention facilities due to groundwater mounding (which may not be apparent until after construction).
2. Groundwater elevations from monitor wells, test pits and/or soil borings including any soil mottling noted in the soil profile.
3. Regional and cyclical groundwater levels available online.
4. Hydrogeologic studies and groundwater modeling.

#### Criteria for determining the Lowest Allowable Opening Elevation

1. Proximity to open drain or natural watercourse, pond or wetland and the 100-year flood elevation.
2. Proximity to detention/retention basin and design high water level.
3. Proximity to drainage swales and/or flood routes designed to convey the 100-year storm event runoff including overflows from detention/retention basins.
4. Proximity to an enclosed storm sewer system with open ends or catch basins that could surcharge during the 100-year storm event.
5. Type of building foundation (e.g. walkout, daylight, or standard basement) as dictated by the topography of each site.

The lowest allowable floor elevations shall be set at 2-foot or more above the highest known ground water elevation. The lowest allowable floor and/or opening elevations shall be set 1-foot or more above the 100-year floodplain, floodway or design high water level of the stormwater system.

Minimum floor and opening elevations shall be incorporated in the restrictive covenants of the plat or master deed, including bench mark references. It is the responsibility of the Proprietor to provide a sufficient number of bench marks (NAVD 88 datum) to use as a reference for establishment of minimum floor and opening elevations for all lots.

A waiver from the set elevations may be granted by the Drain Commissioner following receipt of a certification from a professional engineer licensed in the State of Michigan demonstrating that the proposed elevation does not pose a risk of flooding. An agreement is required to be recorded against the original Restrictive Covenants.

#### **Footing Drains and Sump Pumps**

Where footing drains and sump pumps are required or utilized, a stormwater lateral shall be provided for each parcel at the time of construction when storm sewer is available. Provide direction in the restrictive covenants of the plat or condominium master deed for footing drain and sump pump outlets by identifying the connection within an exhibit.

#### **Easements for Side Yard and Surface Drainage**

Private easements for enclosed yard drains and surface drainage are for the benefit of upland lots within the development or upland sites that currently drain across the proposed plat or site. Language shall be included within the restrictive covenants of the plat or condominium master deed that clearly notifies property owners of the location and purpose of private easements for side yard and surface drainage, as well as restrictions on use or modification of these areas. A separate, recordable easement form is not required.

**Soil Erosion and Sedimentation Control Permits**

It is the responsibility of the Proprietor to contact the Kent County Road Commission to determine which lots if any need Soil Erosion and Sedimentation Control Permits.

**Responsibility for Maintenance of Open Water Bodies**

If applicable, 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. Maintenance Plan and Agreement**

For private developments, a legally binding maintenance agreement between the Proprietor and the municipality shall be required before approval is granted within the urbanized area. The maintenance agreement shall include a maintenance plan and schedule, and requires tracking of compliance.

Contact the municipality for necessary forms, documents and compliance process. Verify with the municipality that a maintenance agreement will be required for site developments located outside of an urbanized area.

A copy of the recorded maintenance agreement should be presented to the Drain Commissioner prior to construction drawing approval.

The Drain Commissioner may require a county drain to be established under section 433 of the Michigan State Drain Code.

### III. DRAINS UNDER JURISDICTION OF THE DRAIN COMMISSIONER

#### A. Responsibility for Stormwater System Ownership and Maintenance

##### Plats

Plats may be established as county drains under the jurisdiction of the Drain Commissioner or placed under the jurisdiction of another municipality.

##### Other Developments

The storm sewer system of the site condominiums and other multi-lot developments may be established as county drains under the jurisdiction of the Drain Commissioner.

##### Roadside Ditches

In general, the Drain Commissioner will not accept responsibility for roadside ditches. The County Road Commission maintains these if located within the right-of-way of a public road. When required by the County Road Commission, roadside ditches may be established as county drain.

##### Maintenance by Drain Commissioner

The Drain Commissioner shall be responsible for maintenance of all established county drains, including stormwater BMPs dedicated as part of the county drain system. The costs for maintenance shall be assessed to the drainage district under the provisions of the Michigan Drain Code. A maintenance plan must be prepared by the Proprietor and delivered to the Drain Commissioner with the dedication agreement documents.

The Drain Commissioner will not accept ownership and maintenance of any decentralized stormwater BMPs (e.g. rain barrels for individual houses, green roofs, and pervious pavement) as part of the county drain system. All portions of a county drain system must have dedicated easements.

##### Maintenance Agreement

A maintenance agreement is required for retention facilities to be monitored for either 3-years or until the last homesite has been constructed and lawn established. The basin shall be inspected every two weeks or within 24 hours after a significant storm event during the growing season. Any accumulation of sediment on the bottom of the basin shall be cleaned out and disk the soil in the bottom if necessary. A performance bond shall be submitted that covers to cleanings of the basin to ensure the work will be completed.

#### B. Easements

##### Existing Easements

The liber and page (or document number) reference of all recorded easements shall be shown on final plats and construction drawings. Drainage easements obtained prior to 1956 were not required by statute to be recorded. Therefore, it may be necessary to check the permanent record of the Drain Commissioner's office to see if a drain easement is in existence on the subject property. Existing county drain easements (or release of rights-of-way) shall be indicated on the plans and designated with the name of the drain.

##### Proposed Easements

An easement, not land ownership, is the approved method of providing access to, and protection of, public storm drainage facilities. Transfer of land ownership to an established drainage district is not allowed unless permitted in writing by the Drain Commissioner or other applicable authorities.

Within a Plat or Multi-Lot Site Development

All established county drains located within the plat or multi-lot site development, shall have granted easements. Private (exclusive) easements for drainage shall be granted to the appropriate drainage district and must be shown on the final plat or site plan. Related easement language shall be depicted on final plats and/or Exhibit B condominium drawings as follows:

*Easement for [Drainage] [Flooding] [Name of BMP] to the \_\_\_\_\_ Drain Drainage District.*

Separate, recordable easements must be provided in a form acceptable to the Drain Commissioner. Easement forms are included in **Appendix D and E**. Recordable drainage easements shall be submitted to the Drain Commissioner prior to construction drawing approval for private developments and recorded prior to release of surety or final plat approval and the sale of any lots which are to be encumbered by easements. If lots are sold prior to the Proprietor releasing an easement to the drainage district, the Proprietor shall obtain all necessary easements on said lots for completion of the project. Any lots sold on land contract must have the signature of both land contract vendor and vendee on the easement.

Outside the Plat or Site Development

Private (exclusive) easements shall be required downstream of a plat or site development when the discharge is to a watercourse or an open or enclosed drainage way that requires improvements and maintenance to continue to serve as a viable outlet for the plat or site development. Easement forms are included in **Appendix D and E**. Recordable drain easements shall be submitted to the Drain Commissioner prior to construction drawing approval and recorded prior to release of surety. Easements will not be required through public rights-of-way (e.g. county roads).

Offsite Drainage and Flooding Easements

When concentrated stormwater is proposed to be discharged over, onto, or across private property (other than that owned by the Proprietor), and no watercourse or drainage way exists or is proposed to be constructed, the proprietor must attempt at acquiring an easement for discharge. By general rule of natural flow, natural surface waters created by rain or snow must be allowed to flow unrestricted on to lower land over the natural water courses. Therefore, what has naturally drained on the offsite property can continue, however the pre-development flow rate vs the post-development flow rates match each other as closely as possible.

**Easement Width**

Easements shall be situated in such a way as to allow maximum maintenance access (for example, by offsetting them from the drain centerline if required). Minimum easement widths for new stormwater systems shall conform to the following:

Open Channels and Watercourses. Open channels shall have a minimum of 15 feet on each side of the top of bank and a total minimum width of 50 feet.

Open Swales. Open swales shall have a total minimum width of 20 feet.

Enclosed Drains. Easement widths for pipes shall conform to the following table:

Depth to Invert (feet)	Easement Width (feet)
0-7	30
7.1-12	30
12.1-17	40
>17	50

Detention and Retention (Infiltration) Basins. A minimum of 15 feet of open space outside the high water level and around the perimeter of a public detention/retention basin, and an easement over the temporary spoil disposal area must be granted to access and maintain the facility. Ingress and egress easements shall also be provided. For basins located adjacent to county drains, a minimum of 15 feet open, flat space between the basin and the county drain must be granted as a drainage easement for access and maintenance of both.

Other Stormwater BMPs. A minimum of 10 feet around the perimeter of stormwater BMPs (e.g. bioswale/rain garden, infiltration trench) must be granted to access and maintain the BMP.

Generally, the above widths shall govern; however, if the Review Engineer determines that additional easement width is required for proper construction, or because of special circumstances, such facts shall be made known to the Proprietor upon review by the Review Engineer. Exceptions to the above requirements may be made only at the discretion of the Drain Commissioner.

### **C. Surety**

The Proprietor shall post a performance surety prior to construction drawing approval.

The performance surety shall consist of a cash deposit, a certified check or an irrevocable letter of credit drawn on a bank licensed in the State of Michigan in an amount equal to 115% of the uncompleted portion of the project, or \$10,000, whichever is greater.

Valid existing contracts for construction of the stormwater management system and soil erosion control measures executed between the Proprietor and Proprietor's contractor shall be the basis for establishing the portion of the contract to be covered by surety.

In the event the Proprietor has not contracted for the construction of the stormwater management system (Proprietor is the contractor), the Design Engineer shall estimate the cost of said construction. The estimate of cost, as reviewed and approved by the Drain Commissioner, shall be the basis for the amount of surety.

#### **Rebate**

A rebate to the Proprietor may be made as the work progresses with approval by the Drain Commissioner. The amount of the rebate will be equal to the cost of the completed work minus a 10% retainage. In no case shall the surety amount be reduced to less than \$10,000.

#### **Release of Surety**

Upon final inspection, completion of all punch list items, receipt of acceptable construction record drawings and post-construction certification from the Design Engineer, the Drain Commissioner will release the surety.

If the Proprietor does not complete the approved drainage improvements as agreed, the Drain Commissioner will draw on the surety and proceed to fulfill the Proprietor's obligation at such time and in such manner as the Drain Commissioner may determine appropriate.



## D. Dedication Agreements

Developments proposed to have public drains must submit a completed Dedication Agreement. Two methods for establishing and dedicating drainage facilities are provided for by the Michigan Drain Code. Rules developed by the Drain Commissioner for each method are similar.

### Section 433 Agreement

Section 433 of the Michigan Drain Code addresses enlargement of existing drainage districts and creation of new districts where none previously existed. A formal agreement is required between the Proprietor and the Drain Commissioner or intercounty drainage board on behalf of the affected drainage district. Owners of lands not owned by the Proprietor, who will be included in the drainage district, must also sign the agreement. The property of any adjoining landowner who refuses to sign cannot be included in the drainage district for assessment purposes. However, the Proprietor must accommodate surface and subsurface runoff from adjoining properties.

#### Submittals

1. Agreement. The Proprietor and all parties having legal interest in the plat or development, as well as adjoining landowners, whose properties will be included in the enlarged or new drainage district, shall enter into a formal agreement dedicating drainage facilities therein for public use. The agreement form will be completed by the Proprietor in coordination with the Drain Commissioner and stipulate conditions of transfer and responsibilities of parties. Section 433 Agreement forms are included in **Appendix C**. The Drain Commissioner will determine which agreement form will be necessary. The 433 Agreement shall be signed by an authorized representative of the Proprietor and Drain Commissioner and be submitted for recording at the Register of Deeds prior to final plat approval and the sale of any lots in a plat or units in a site condominium. If property is sold on a land contract, both land contract vendor and vendee must sign the agreement. If more than one individual, corporation, partnership, or limited liability company has interest in the property, duly authorized representatives of each shall sign the 433 Agreement. Proprietor shall obtain on the 433 Agreement the signatures of all landowners or unit owners to whom lots are sold, if any.
2. Legal Descriptions.
  - a. Route and Course. The Design Engineer shall provide centerline descriptions for each drain or branch to be dedicated.
  - b. Drainage District. The Design Engineer shall provide a description of the contributing drainage district benefiting from such improvements. One (1) electronic file in .pdf format, and one (1) paper copy of a 24-inch by 36-inch drainage district map showing the drainage district boundary line, route & course of the drain, roads, lot and parcel lines with numbering, townships and sections, and other pertinent information shall be required. The Drain Commissioner may also require that adjoining drainage district boundaries changed by the dedication be described in their entirety for amending documents pertaining to those drains.
3. Certification. The Design Engineer shall include a sealed and dated statement attesting that (a) lands to be added to a drainage district naturally drain into the area served by the existing drain or that the existing drain is the only reasonably available outlet and attesting to the adequacy of existing receiving drains, or (b) that the outlet for the existing drain is the only reasonably available outlet and attesting to the adequacy of the outlet.
4. Specifications for construction.
5. The 433 Agreement is recorded with the Register of Deeds.

### Maintenance Fee

The Michigan Drain Code requires that any person dedicating a drain for public use shall provide funding for initial maintenance operations. Contribution is calculated by taking the lesser amount of \$2,500 or 5% of the cost of constructing the drain and its appurtenances. These funds shall be submitted to the Drain Commissioner prior to final plat approval and/or execution of the 433 Agreement. The funds are deposited in the account set up for the subject drain and are not refundable.

The \$2,500 fee is based on a stormwater system consisting solely of gravity components. Systems with non-gravity components are subject to fees above and beyond \$2,500.

### **Section 425 Application and Petition**

Section 425 of the Michigan Drain Code addresses the addition of branch drains to serve lands entirely within an existing drainage district and the enclosure or tiling of an existing drain. A Section 425 Agreement is required when a Proprietor wishes to relocate, improve and/or enclose a county drain on their own property at their expense. The Proprietor must petition the Drain Commissioner or intercounty drainage board for permission to construct or improve the additional drainage for public use.

### Submittals

1. The Drain Commissioner's legal counsel will draft the agreement with the Proprietor responsible for all costs.
2. Legal Descriptions. The Design Engineer or surveyor shall provide the centerline (route & course) descriptions for the branch drain or extension.
3. Certification. The Design Engineer shall include a sealed and dated statement attesting to the adequacy of existing receiving drains.
4. Specifications for construction.

## E. Construction

### Documentation of Value

Governmental accounting standards (GASB Statement 34) require the County to report the value of their drain infrastructure. The Proprietor shall submit documentation relative to the contract covering the work to be performed including the cost of construction with an itemized breakdown.

### Preconstruction Meeting

The Drain Commissioner may request a preconstruction meeting be held with all involved parties.

### Inspections

The Proprietor shall submit an inspection fee (refer to Part 1 section “Fees”).

#### By Proprietor

Upon request of the Drain Commissioner, the Proprietor shall retain a qualified inspector, supervised by the Design Engineer, to perform construction inspection of storm drains and appurtenances that will be the responsibility of the Drain Commissioner to operate and maintain to assure construction according to Drain Commissioner approved plans.

#### By Drain Commissioner

The Drain Commissioner may employ an inspector on behalf of the drainage district should it appear that the installation fails to meet minimum requirements. Spot inspections by the Review Engineer are to verify the proper construction of the drainage system. Inspection by the Drain Commissioner or the Review Engineer shall not relieve the Design Engineer or the municipal engineer of their obligations.

#### Final Inspection

The Drain Commissioner will complete a final inspection jointly with the County Road Commission. The Drain Commissioner will issue a letter to the Proprietor upon final acceptance.

### Proprietor Responsibility for Improvement

The Proprietor should take whatever precautions he deems necessary in direct relation with his contractor in order to assure the work performed by the contractor meets the approval of the Commissioner. The Proprietor shall be held totally responsible for the fulfillment of his obligations to the Commissioner.

### Cleaning

The Proprietor shall be responsible for cleaning and removing sediment from all sewers, manholes, catch basins, or other structures affected by the development both on-site and off-site before final release.

### Stabilization of Site

All unpaved areas shall have an established ground cover before final release. Sodding or seeding and mulch shall be done in accordance with current MDOT standard construction specifications.

### Floodway Certification

Prior to final plat approval, all floodways shall be established and certified by a registered engineer along with a floodway certified elevation plan.

**Post-Construction Certification**

A post-construction letter of certification from the Design Engineer that certifies construction of the county or intercounty drains in accordance with the approved construction drawings shall be submitted to the Drain Commissioner.

**Construction Record Drawings (“As-builts”)**

Construction record drawings shall be submitted by the Proprietor to the Drain Commissioner in accordance with the submission requirements (refer to Part 2 section “Submission of Construction Record Drawings”).

## F. Permits for County Drains

Refer to Part 1 section “Fees” for Drain Use Permit fees, and **Appendix G** for County Drain Use Permits.

### **Utilities**

If any utilities are to be located within the drainage easement of the proposed development, the Design Engineer shall present plans detailing such utilities to the Drain Commissioner for approval as to location. Utility plans shall be presented at the same time as construction drawings so that all details of construction and location may be checked and properly oriented with each other.

### **Encroachments**

Permission is required to place an encroachment within an existing drain easement.

### **Crossings and Maintenance**

A permit is required for maintenance to a county drain including installation of crossings and shall be presented at the same time as construction drawings.

### **Tapping**

A permit shall be obtained from the Drain Commissioner prior to tapping any open or enclosed county drain and shall be presented at the same time as construction drawings.

### Footing Drains

Whenever building footing drains are required or utilized, footing drain leads shall be provided from a drainage structure (to the greatest extent practical) to service each lot. The Proprietor shall also provide a marker or monument indicating the location of the footing drain lateral access point.

### Floor Drains

Floor drains shall be connected to the sanitary sewer system and not the storm sewer system.

## I. SUMMARY

The following stormwater management requirements comply with the county NPDES MS4 permit and shall apply to all new and redevelopments in Kent County:

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. Stormwater standards are summarized in **Table 1**. Higher standards may be required for sites that discharge to areas with known issues.
4. Offsite Stormwater Management Options. Regional stormwater management facilities are encouraged, particularly where site constraints preclude effective onsite treatment of stormwater. Off-site mitigation may be approved to meet channel protection performance standards at a higher mitigation ratio.
5. 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 K**).
6. 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.
7. 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 total suspended solids (TSS) in stormwater runoff by at least 80% or to a concentration of no greater than 80 mg/L (refer to **Table 3**).
8. 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.
9. Soils. Test pits 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.
10. 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.
11. Easements. Easements are required for drainage systems accepted by the Drain Commissioner as a county drain.
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 local municipality is required for private stormwater management systems in urbanized areas that discharge to an MS4. A maintenance agreement between the Developer and the Drain Commissioner is required for stormwater systems established as county drains when a private entity or organization wishes to conduct the maintenance. A maintenance plan and compliance tracking is required as part of the maintenance agreement.

**Table 1 – Minimum Required Stormwater Standards**

Standard/Where Required	Criteria
<b>Water Quality</b> “first flush” All sites.	<p>Treat the runoff generated from 1 inch of rain over the project site (i.e. the 90% annual nonexceedance storm) through BMPs designed to reduce post-development TSS loadings by 80%, or a achieve a discharge concentration not to exceed 80 mg/L.</p> <p>Treatment may be provided through settling (permanent pool or detention), filtration or infiltration, absorption, or chemical/mechanical treatment.</p>
<b>Channel Protection</b> Surface water discharges.	<p>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</p> <p>Where site conditions preclude infiltration, an alternative approach may be allowed after all other onsite retention options are exhausted: 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.</p> <p>Pre-development is defined as the last land use prior to the planned new development or redevelopment.</p>
<b>Flood Control</b> All sites; unless exception is allowed.	<p>Collection and Conveyance: Design storm sewers and swales for the 10-year storm, and open channels for the 25-year storm.</p> <p>Detention: Store runoff from the 25-year storm with a maximum release rate of 0.13 cfs per acre.</p> <p>Retention: Store runoff from the 100-year storm with an emergency overflow OR store runoff from back-to-back 100-year storms with no emergency overflow. When sizing the basin, infiltration cannot be accounted for to reduce the required volume.</p> <p>Overflow Routes for Extreme Flood: Identify overflow routes and the extent of high water levels for the 100-year flood to ensure no adverse impacts offsite or internal to the site. Where overland flow routes do not exist or where adverse impacts may occur, detention/ retention basins shall be increased in size to mitigate adverse impacts. Overflow route shall be sized to convey the 10-year peak inflow rate.</p>
<b>Pretreatment</b> Refer to <a href="#">Table 3</a> .	Forebay volume equal to 15% of water quality volume (required for detention/retention basins); Vegetated Filter Strip; Vegetated Swale; Water Quality Device.
<b>Hotspot</b> Industrial and commercial land uses in <a href="#">Table 2</a> ; Part 201 and Part 213 sites.	<p>Isolate transfer and storage areas to minimize need for treatment.</p> <p>Pretreatment BMP with impermeable barrier above groundwater and provisions for the capture of oil, grease, and sediments. Minimum spill containment volume: 400 gallons.</p>

**Table 1 – Minimum Required Stormwater Standards**

Standard/Where Required	Criteria
<b>Coldwater Streams</b>	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.<sup>3</sup>

#### 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

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

<sup>3</sup> Stenstrom, Michael K. and Kayhanian, Masoud (2005). *First Flush Phenomenon Characterization*. California Department of Transportation, Sacramento, California.

<sup>4</sup> 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.



**Detention.** 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.

**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 proprietary water quality device.

## B. Channel Protection

### Where Required

Channel protection is required for surface water discharges.

### 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. Design Engineer certification 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 Drain Commissioner 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 25<sup>th</sup> and 75<sup>th</sup> percentiles),<sup>5</sup> and a large percentage of rate reduction (80% or more).<sup>6</sup>

## C. Flood Control

### Where Required

Flood control is required for all sites.

### Standard

Detention of the 25-year storm with a maximum release rate of 0.13 cfs per acre is required, or retention of the 100-year storm, or back to back 100-year storms with no positive outlet. For basins that will be taken over as County Drains, when sizing the basin, infiltration cannot be accounted for to reduce the required volume. For all other basins, the reviewing engineer shall clarify how infiltration can be used for flood control volume.

Detention of the 25-year storm is required generally. If there are known existing flooding problem areas that will be impacted by the proposed development, detention of the 100-year storm is required.

*Note:* The 25-year storm is selected to balance flood risk management with economics based on federal studies comparing the cost of flood damage to storm return interval.<sup>7</sup> 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.<sup>8</sup> When 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 (or may be required) under certain conditions, including, but not limited to:

1. Sites located in a watershed with a non-mandated detention zone, or a regional stormwater management facility as dictated by the Watershed Policy Statement (**Appendix K**).
2. Direct discharges to waterbodies or watercourses where the Developer demonstrates that the receiving waters possess capacity to convey the post development discharge safely and with no negative downstream impacts due to increased flow rates, water levels or velocities. In addition, the peak flow of the receiving waters cannot be increased by the proposed development (i.e. there is a sufficient difference in the timing of the two hydrographs).
3. When the site is located adjacent to or within a floodplain, excavation of new floodplain in lieu of standard stormwater detention may be required. The excavated volume shall be equal to the standard detention basin storage volume. Only the volume above the 2-year and below the 100-year floodplain elevation can be counted to meet the volume requirement.

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<sup>5</sup> 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*.

<sup>6</sup> University of New Hampshire Stormwater Center (2007). *2007 Annual Report*.

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

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

### Overflow Routes for Extreme Flood

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, a dual 100-year capacity storm sewer shall be constructed and detention/retention basins shall be increased in size to store a total of 2 times the flood control volume. Overflow routes from detention/retention basins shall be designed to convey the 10-year storm peak inflow rate. An overland floodway shall be constructed to serve all trapped yard basins and low areas in the road to prevent flooding from a severe storm and shall be designed to convey the 100-year storm for all contributing drainage.

*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. The critical floodway elevation shall be at least 1 foot below the minimum building opening.

### National Flood Insurance Program

Projects located within the 100-year floodplain of a river or stream come under the jurisdiction of the Flood Hazard Regulatory Authority as found in Part 31, Water Resources Protection of the Natural Resource and Environmental Protection Act, Act 451 of the Public Acts of 1994. A permit needs to be filed with the Department of Environmental Quality (DEQ) for projects that involve construction, filling, and grading within a floodplain area.

The objectives of Part 31 are: a) to ensure that the flood carrying capabilities of the rivers and streams is maintained such that the floodways are not obstructed and that flood elevations are not increased or flow diverted, and b) to ensure that the floodway portion of floodplains are not inhabited.

Many communities in Kent County also participate in the National Flood Insurance Program (NFIP). The program makes flood insurance available in those communities agreeing to regulate future floodplain construction. Associated with the program are community floodplain mapping, building standards, federal lending restriction, and flood insurance rates supportive of local floodplain regulation. In order for a community to participate in the NFIP local regulations must be in force to:

1. Require that new construction and substantial improvements in flood prone areas be designed and anchored to prevent flotation, collapse, or lateral movement, be constructed with materials and utility equipment resistant to flood damage, and be constructed by methods and practices to minimize flood damages.
2. Require, where flood elevation data are available, that:
  - a. All new construction and substantial improvements of residential structures located in flood hazard areas have the lowest floor (including basement) elevated to or above the 100-year flood level.
  - b. All new construction and substantial improvements of nonresidential structures in flood hazard areas have the lowest floor (including basement) elevated or dry floodproofed to or above the 100-year flood level. A registered professional engineer or architect must certify floodproofing.
3. Require anchoring of mobile homes in flood prone areas.
4. Maintain a record of all lowest floor elevations to which new buildings have been constructed or existing buildings have been floodproofed when the structures are located in a flood hazard area.

Floodplains are mapped for most communities that participate in the FIPF. Floodplain maps are available for inspection in city, village, and township offices, or may be obtained from the DEQ. The DEQ may also be able to provide estimates of flood elevations in many streams, and in communities where maps do not exist.

In Kent County, the following communities participate in the NFIP and may have a floodplain map:

Cities of: East Grand Rapids, Grand Rapids, Grandville, Kentwood, Lowell, Walker, and Wyoming.

Village of Sparta

Townships of: Ada, Algoma, Alpine (no map), Caledonia, Cannon, Cascade, Plainfield, and Sparta.

### **Floodplain Mitigation**

Natural floodway filling or alteration shall not be allowed without review and approval by the Kent County Drain Commission and compliance with the Floodplain Regulatory Authority found in Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA) on watercourses with contributing drainage area of 2 square miles or greater. If a floodway has not been mapped, the applicant's consultant shall provide the floodway delineation to the Kent County Drain Commission for approval. Natural floodway fringe filling or alteration shall not be allowed without review and approval by the Kent County Drain Commission and compliance with the Floodplain Regulatory Authority found in Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA) on watercourses with contributing area of 2 square miles or greater. If a floodplain has not been mapped, the applicant's consultant shall provide the floodplain delineation including the floodway to the Kent County Drain Commission for approval.

To provide for streambank stability a buffer zone is to be established and called out on a recorded plat, an approved block grading plan, a site plan, or an improvement plan. This zone shall consist of existing natural tree and vegetation slope protection within a minimum of 25 feet from the ordinary high water mark. This buffer zone shall be maintained as is, that is, no earth change or disturbance is to take place.

Replacement of lost floodplain shall meet the following criteria.

1. Replacement of the loss of floodplain storage volume at a 1 to 1 ratio unless watershed conditions warrant a higher ratio. This applies to floodplain associated with rainfall events up to a 100-year frequency. The grading plan shall provide for an equivalent volume of storage for floodplains associated with more frequent events such as 10 and 25 year frequencies.
2. Storm water detention does not apply toward the replacement volume.
3. Floodplain storage volume shall be computed above the seasonal high ground water level only.
4. The inflow and outflow rates to the area shall be consistent with predevelopment rates.
5. Up to 50 percent of the floodplain mitigation storage volume may be used for snow storage.
6. The proximity of the floodplain mitigation area shall provide for an equivalent hydrologic impact to the receiving stream and adjacent parcels.

## **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

### 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

#### Sediment Forebay

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).

#### Vegetated Filter Strip

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.

#### Vegetated Swale

Provide a 20-foot minimum length at a maximum slope of 4% 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 2.20 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).

#### Water Quality Device

Configured to trap floatables and sediment. Follow manufacturer's guidelines.

## E. 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 Drain Commissioner.
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: <a href="http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012">http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012</a>	

## F. 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](#).

### 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.

## G. Watershed Policy Statements

Specific stormwater policies have been adopted by the Drain Commissioner for the watersheds identified in **Appendix K**.

These policy recommendations have resulted from hydrologic and hydraulic analysis and/or monitoring performed during engineering studies. The policy statements identify specific stormwater management standards and the areas where these standards must be used to meet resource protection goals.

If the site is located within one of the identified watersheds, 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 rules, 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. Sand dunes
8. Natural drainageways
9. Soils and topography (erodible, steep)
10. Susceptible groundwater supplies
11. 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 Developer 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 of 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 [Appendix K](#) 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 Developer must always demonstrate an adequate outlet exists 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 properties or infrastructure (refer to Part 2 section “Stormwater Discharge”).

#### 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 **Appendix B** of this manual. BMPs proposed for use, but not included in this manual 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
<b>Non-Structural BMPs</b>				
Minimal Disturbance Area				
Protect Natural Flow Pathways			X	
Protect Sensitive Areas				
Native Revegetation			X	
Stormwater Disconnection				
<b>Structural BMPs – Conveyance and Storage</b>				
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)		
<b>Structural BMPs – LID and Small Site</b>				
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
Sediment Forebay		(50)	X	
Spill Containment Cell		(50)	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). <i>National Pollutant Removal Performance Database, Version 3</i> , 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). <i>Pervious Pavement System Evaluation</i> , EPA, Office of Research and Development. Storm Sewer average TSS removal for standard catch basin. Source: Pitt, R. and Field, R. (1998). <i>An Evaluation of Storm Drainage Inlet Devices for Stormwater Quality Treatment</i> , 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.				

**Table 3 – Stormwater BMP Matrix**

Stormwater BMP	Treatment			
	Requires Pretreatment	TSS Removal Efficiency	Provides Pretreatment	Provides Spill Containment
(*)	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.				

## 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 Requirements

A test pit shall be used for geotechnical investigation.

A test pit is an excavated trench with a depth necessary to encounter saturated conditions or to the bottom of the proposed BMP. Infiltration system that are significantly deeper than the existing topography will result in reduced infiltration rates.

The number of test pits will vary depending on site conditions and the proposed development. In general, test pits shall be evenly distributed at the rate of 6 to 8 pits per acre of BMP area. The minimum number of test pits shall be determined from **Table 4**. Additional tests may be requested based on local conditions and initial findings (e.g. large variability in soil type, high groundwater table).

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

Type of BMP	Test Pit	Depth of Test Pit	Field Permeability Test
Retention basin Infiltration bed Rain garden Pervious pavement	1 test pit per 5,000 square feet of bottom area; 2 minimum	10 feet below proposed bottom	1 test per test pit
Infiltration trench Bioswale	1 test pit per 100 linear feet of BMP; 2 minimum	10 feet below proposed bottom	1 test per test pit
Dry well Leaching basin Planter box	1 test pit minimum	5 feet below proposed bottom	1 test per test pit
Detention basin	1 test pit per 10,000 square feet of bottom area; 1 minimum	5 feet below proposed bottom	Not Applicable

Excavate a test pit 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. Soil texture, structure and color for each horizon.
6. Observance of pores or roots (size, depth).

Test pit reports 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 test 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 Infiltrometers (ASTM D3385).
2. Percolation tests (similar to wastewater systems).

The minimum number of field permeability tests shall be determined from **Table 4**. The Drain Commissioner 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 allowed 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 (>0.5 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  $\frac{1}{4}$  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.

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

*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 rate 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 in the allotted drawdown time. For basins that will be taken over as county drains, when sizing the basin, infiltration cannot be accounted for to reduce the required volume. For all other basins, the reviewing engineer shall clarify how infiltration can be used for flood control volume.

The least permeable soil horizon within 4 feet below the proposed BMP bottom elevation shall be used to select the design infiltration rate.

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 1**.

*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 <sup>1</sup> (inches per inch)	Design Infiltration Rate <sup>2</sup> (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

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

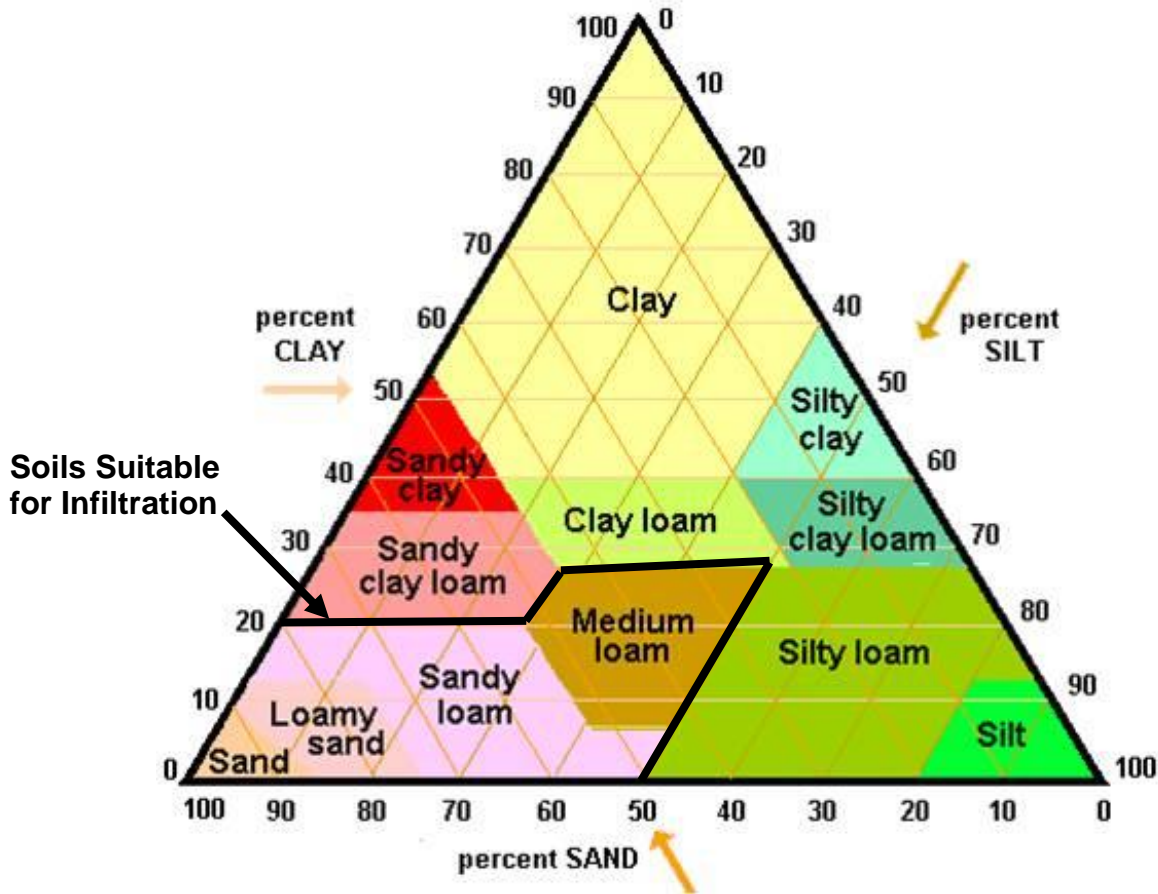
<sup>2</sup>Source: Wisconsin Department of Natural Resources (2004). *Site Evaluation for Stormwater Infiltration (1002)*, Table 2 (Rawls, 1998). *Note:* Values are reduced by approximately a factor of 2 from those given in Table D.13.1.

## 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 1 – 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:

$$Q = CIA \quad (4.1)$$

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 10** 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.)							
<i>Poor condition</i> (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
<i>Fair condition</i> (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
<i>Good condition</i> (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). <i>Design Hydrology &amp; Sedimentology for Small Catchments</i> .							

Runoff coefficient for sizing detention/retention basins, which are designed for higher rainfall frequencies, shall be selected from **Table 6**.

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:

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

where:

- $V$  = velocity (feet per second)
- $A$  = wetted area (square feet)
- $n$  = Manning's roughness coefficient (from [Table 12](#))
- $R$  = hydraulic radius (feet)
- $S$  = slope (feet per foot)

The time-of-concentration is then:

$$Tc = t_o + \frac{L_c}{60V} \tag{4.4}$$

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:

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

where:

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

$P$  = rainfall (inches)

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

and where:

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

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

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

where:

$V_t$  = total runoff volume of the design storm (cubic feet)

$Q_v$  = surface runoff for the  $i^{\text{th}}$  land use (inches)

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

3630 = factor to convert acre-inches to cubic feet

Curve Number (CN) values are taken from Technical Release No. 55 (TR-55), and provided in **Table 8**.

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.

### Peak Discharge

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 8 – Curve Numbers (CNs) from TR-55**

Land Use Description		Curve Number <sup>1</sup>			
Cover Type	Hydrologic Condition <sup>2</sup>	Hydrologic Soil Group			
		A	B	C	D
Cultivated land	Poor	72	81	88	91
	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 <sup>3</sup>	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 <sup>4</sup>	55	70	77
Open spaces (grass cover) <sup>5</sup>	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 <sup>6</sup>		88	93	94	95
Bare Soil		77	86	91	94
Water <sup>7</sup>		100	100	100	100

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

<sup>1</sup>Antecedent moisture condition II and initial abstract ( $I_a$ ) = 0.2S

<sup>2</sup>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 that 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.

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

<sup>4</sup>Actual curve number is less than 30; use CN = 30 for runoff computations.

<sup>5</sup>CN's shown are equivalent to those of pasture.

<sup>6</sup>Surface only; not including right-of-way.

<sup>7</sup>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:

$$Tc = t_1 + t_2 + t_3 \quad (4.8)$$

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

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

where:

- $n$  = Manning's roughness coefficient from **Table 12**
- $L$  = flow length (feet)
- $P_2$  = 2-year, 24-hour precipitation depth from **Table 10**
- $s$  = slope (feet/foot)

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

$$v = \begin{array}{l} 16.1345 s^{0.5} \text{ Unpaved} \\ 20.3282 s^{0.5} \text{ Paved} \end{array} \quad (4.10)$$

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:

$$t_2 = \frac{L}{3600 v} \quad (4.11)$$

(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).

#### BMP Residence Time

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 where the Rational and NRCS Methods prove less accurate. Water quality volume is calculated by the formula:

$$V_{wq} = ARv(1)(3630) \quad (4.12)$$

where:

- $V_{wq}$  = 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 9**)
- $1$  = 90% non-exceedance storm rainfall amount (inches)
- $3630$  = factor to convert acre-inches to cubic feet

The Volumetric Runoff Coefficients ( $Rv$ ) provided in **Table 9** are similar to the Rational runoff coefficient, but are exclusive to the rainfall amount (1-inch).

**Table 9 – 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*).

The area-weighted volumetric runoff coefficient,  $Rv$ , is calculated as:

$$Rv = \frac{A_1Rv_1 + A_2Rv_2 + \dots + A_nRv_n}{A}$$

where:

- $Rv_n$  = runoff coefficient for sub-area  $n$
- $A_n$  = area of sub-area  $n$  (acres)
- $A$  = sum of the areas of all sub-areas (acres)

## B. Rainfall

The rainfall duration-frequency table provided in **Table 10** 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 10** 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 10 – 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). <i>Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 8, Version 2.0.</i> 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 the TSS removal efficiency for BMP's 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:

$$V_{pt} = 0.15(V_{wq}) \quad (4.13)$$

where:

$V_{pt}$  = minimum required pretreatment volume (cubic feet)

$V_{wq}$  = 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:

$$V_{cp} = V_{t_{post}} - V_{t_{pre}} \quad (4.14)$$

where:

$V_{cp}$  = minimum required channel protection volume (cubic feet)

$V_{t_{post}}$  = total runoff volume of the 2-year, 24-hour storm for post-development conditions

$V_{t_{pre}}$  = 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 2**. The extended detention peak discharge can then be computed with the following equation:

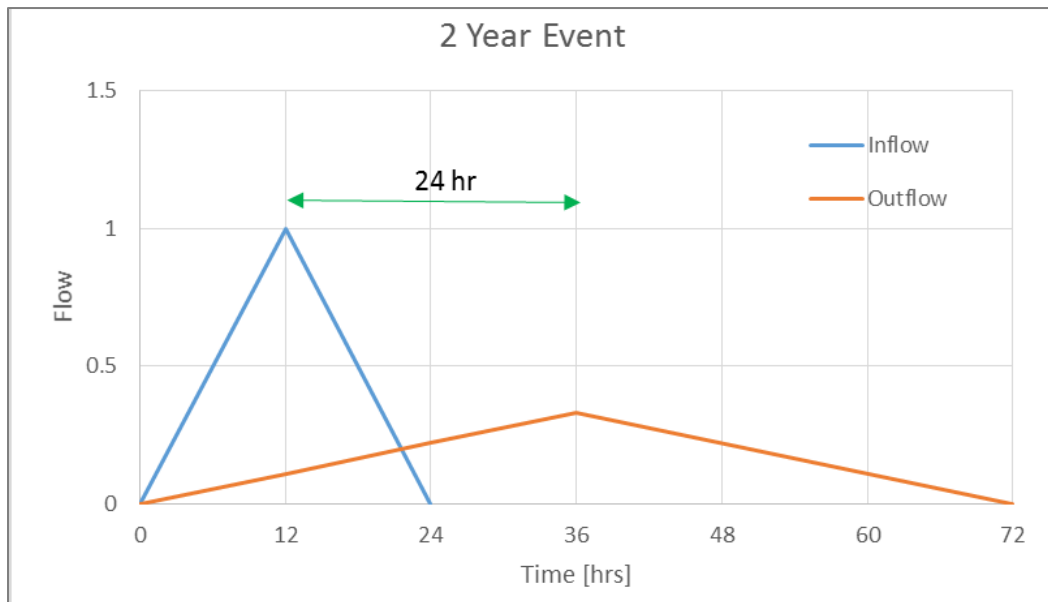
$$Q_{ED} = (V_{cp} - V_{ret}) / (36 * 3600) \tag{4.15}$$

where:

- $Q_{ED}$  = peak extended detention release rate (cubic feet per second)
- $V_{cp}$  = total channel protection volume required (cubic feet)
- $V_{ret}$  = 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 2 – 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 25-year rainfall event with a maximum allowable release rate of 0.13 cfs per acre is required, unless an exception is allowed.

##### (1) Rational Method for Detention

If the Rational Method is used, the minimum required storage volume shall be calculated by the “Modified Chicago” Method. A Microsoft Excel spreadsheet application (Rational Method spreadsheet) is provided with this manual. Runoff Coefficients for use in detention storage calculations shall be selected from **Table 6** to account for rainfalls exceeding a 10-year frequency. Frequency adjustment of factors of 1.1 and 1.25 have been applied for the 25- and 100-year frequencies respectively, with a maximum value of 1.00.

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

*Note:* An additional adjustment factor of 1.25 shall be applied to the calculated storage volume since this method tends to underestimate the storage volume when compared to pond routing, particularly for short times-of-concentrations (15 to 30 minutes)<sup>9</sup>.

The volume of stormwater runoff stored and infiltrated by upstream retentive BMPs ( $V_{bmp}$ ) may be subtracted from the required detention basin storage volume. Contact the reviewing engineer for applicability.

##### (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:

$$V_{fc} = \frac{(Q_p - Q_{out})}{Q_p} V_t - V_{bmp} \quad (4.16)$$

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<sup>9</sup> 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)  
 $Q_p$  = peak runoff rate (cubic feet per second)  
 $Q_{out}$  = maximum allowable peak discharge (cubic feet per second)  
 $V_t$  = post-development runoff volume for the 25-year, 24-hour storm (cubic feet)  
 $V_{bmp}$  = total 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 to store the runoff from a 100-year, 24-hour rainfall event, or back to back 100-year storm events with no positive outlet. For basins that will be taken over as County Drains, when sizing the basin, infiltration cannot be accounted for to reduce the volume. For all other basins, the reviewing engineer shall clarify how infiltration can be used for flood control volume.

**(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:

$$Q_{out} = Ai / (12 \times 3600) \quad (4.17)$$

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 ( $V_s$ ) shall be calculated by subtracting the volume infiltrated by the BMP during the infiltration time ( $V_{inf}$ ) from the flood control event runoff volume ( $V_t$ ).

$$V_s = V_t - V_{inf} \quad (4.18)$$

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

The infiltrating volume is calculated as:

$$V_{inf} = i * A * t_{inf} / 12 \quad (4.19)$$

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 equation is not valid for drain times greater than 72 hours.

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

The drain time through the BMP is calculated as:

$$t_d = 12 * V_s / (A * i) \quad (4.21)$$

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 ( $V_{bmp}$ ) 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  $V_t$ .

## 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 Kent County Drain Commissioner.

### 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:

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

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:

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

where  $\Delta t$  is the time step,  $i+1$  refers to the present time and  $i$  refers to a time  $\Delta t$  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.