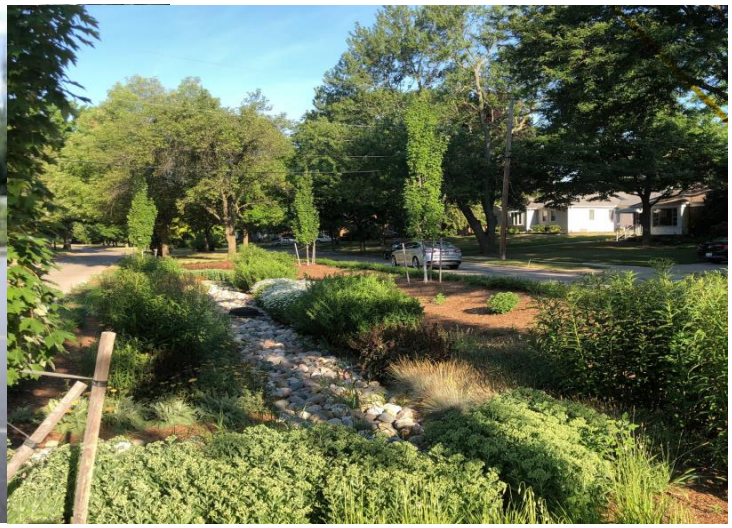

WRC
WATER RESOURCES COMMISSIONER
Jim Nash

OAKLAND COUNTY
WATER RESOURCES COMMISSIONER

Stormwater Engineering Design Standards

Requirements, Rules, and Design Criteria for Stormwater Management

11/22/2021

Table of Contents

Section I - Oakland County Stormwater Standards

Part A: Standards

The Environmental Protection Agency (EPA) through the Michigan Department of Environment, Great Lakes, and Energy (EGLE) requires the County of Oakland and other regulated entities to comply with the National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Separate Storm Sewer System (MS4) permit requirements. The purpose of these standards is to address Post-Construction Stormwater Runoff Controls required under this permit.

These standards are a result of ongoing regional collaboration between Oakland, Wayne, Macomb and Livingston Counties with the following overall objectives:

1. Provide a comprehensive framework for managing stormwater that addresses surface water quality, channel and infrastructure protection, localized flood control and long-term operations and maintenance.
2. Incorporate design standards that control both the quantity and quality of stormwater runoff.
3. Require volume reducing Low Impact Development (LID) design measures, or Best Management Practices (BMPs), such as infiltration, preservation of natural areas, enhanced vegetation and reduced imperviousness to control runoff volume to the Maximum Extent Practicable (MEP).
4. Strengthen the protection of natural features.
5. Protect public health, safety and welfare.
6. Promote economic development using straightforward and uniform drainage standards for site development throughout Oakland County, as well as across Southeast Michigan.
7. Provide guidelines and additional resources for the selection of effective structural and vegetative stormwater BMPs for development sites.
8. Enhance the sustainability of stormwater management practices in Oakland County including performance, longevity, safety, maintenance, community acceptance, and environmental benefits.
9. Establish a framework to increase the likelihood of long-term operation and maintenance of the stormwater management practices.
10. Use the most currently published, relevant rainfall statistics.
11. Promote a consistent design process by using a set of simple equations to determine runoff rates, detention volumes, water quality treatment and infiltration requirements.

WRC's Stormwater Rules address water quality, volume, and flood control. Section I includes an overview of the rules, including key equations used to demonstrate compliance with the standards.

Part B: Authority

The Oakland County Water Resources Commissioner's (WRC) office will apply these standards within its legal authority and jurisdiction as outlined in the following regulations:

1. The Subdivision Control Act, Act 288 of the Public Acts of Michigan of 1967, as amended.
2. The Michigan Drain Code, Public Act 40 of 1956, as amended.
3. The Mobile Home Commission Act, Act 96 of the Public Acts of Michigan of 1987, as amended.
4. Part 31, MS4 General Permit, Water Resources Protection, Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Oakland County's MS4 permit covers regulated county stormwater systems under the jurisdiction of the OCWRC office (direct discharges to County Drains), the Oakland County Parks and Recreation Commission and the County of Oakland. The Road Commission for Oakland County should be contacted for applicable standards within their stormwater jurisdiction.
5. EGLE Wastewater Discharge Permit, Rule 323.2161a, Post-Construction Requirements.

To promote consistent regional site development stormwater practices, communities and other entities responsible for the management of stormwater systems and MS4 permit compliance are encouraged to adopt these standards. Additionally, communities that operate combined sewer systems and are party to CSO permit compliance are also encouraged to adopt these standards. Local municipalities may elect more restrictive standards and when conflicting standards arise, the more stringent requirements shall govern. These standards establish minimum requirements for the design, construction and maintenance of stormwater systems for subdivisions, site condominiums, commercial, industrial and other development and redevelopment projects.

All construction activity within the WRC's stormwater permitting authority will be reviewed by the WRC's Permitting Department to determine if the activity is regulated. The WRC's office will use the following applicability criteria to assist in making this determination and to clarify which stormwater standards apply to the proposed construction activity.

These rules were developed in close coordination with Wayne, Macomb, and Livingston Counties, as well as the City of Detroit. This provides a generally consistent set of standards across Metro Detroit.

Part C: Applicability

These standards shall apply to development and redevelopment projects with construction activity greater than or equal to 1 acre, or part of a common plan of development resulting in a development or redevelopment activity greater than or equal to 1 acre in size, including without limitation, clearing, grading, excavating, construction and paving, that results in an earth change or disturbance in the existing cover or topography of land, including any external demolition, modification, or alteration of a site or the footprint of a building.

Common exemptions to these stormwater standards include the following:

1. Resurfacing of an asphalt, concrete, or similar surface (i.e., 'mill and fill') that does not expose the aggregate or subgrade or result in replacement of the onsite drainage system.
2. The practices of clearing, plowing, and tilling soil and harvesting for the purpose of crop production.
3. The project does not meet the development or redevelopment criteria in this standard.
4. The development or redevelopment project construction activity is less than 1.0 acre.
5. The development or redevelopment project is for one single family detached dwelling that is not part of a common plan of development.
6. The development or redevelopment project is for emergency maintenance and work performed to protect public health and safety.
7. The development or redevelopment project discharges solely to a RCOC stormwater system or right-of-way. Contact the RCOC permit staff at the Road Commission for Oakland County Official Website (rcocweb.org) for RCOC-specific stormwater requirements.
8. Other exemptions listed herein or approved by the OCWRC office.

These rules apply to development within WRC's stormwater jurisdiction & MS4 permit jurisdiction.

At the community's discretion, they can also adopt these rules to meet their stormwater & MS4 permit needs.

To protect all water resources under WRC stormwater jurisdiction, WRC requires applicable standards to be implemented for development and redevelopment projects located both inside and outside the Regulated MS4 Area. Similarly, to protect all water resources under WRC stormwater jurisdiction, WRC requires applicable standards to be implemented for development and redevelopment projects regardless of whether they discharge stormwater to a MS4 or not.

The WRC office continues to collaborate with the George W. Kuhn Combined Sewer District communities in adopting Post-Construction stormwater standards to meet its Combined Sewer System NPDES permit requirements. Many of these communities have both separate and combined systems and the goal is to adopt similar Post-Construction standards that meet local and regional needs for both types of systems. Currently, the standards outlined herein are encouraged to be used in the GWK combined district; collaboration continues with a goal of adoption of these standards in both MS4 and combined sewer communities.

These standards supersede all previous versions and revisions, and updates will be available on the WRC's website (www.oakgov.com/water) including registration information to receive revisions and updates to these standards as they become available. These standards are intended to be a living document and updated as necessary to reflect ongoing changes in climate and regulatory conditions. Before submitting a site plan for stormwater permitting, please refer to the WRC website above for the most recent version of the standards.

Part D: Channel Protection Volume Control

Channel Protection Volume Control (CPVC) is necessary to protect natural watercourses from increased erosion and sedimentation as a result of increased imperviousness and runoff volume as development occurs. CPVC also promotes groundwater recharge, stabilizes flow rates and baseflow in our natural watercourses, and addresses water quality control criteria (Total Suspended Solids).

CPVC shall be implemented to the Maximum Extent Practicable (MEP). The required Channel Protection Volume (V_{CP-R}) is the post-development site runoff volume from a 1.3-inch rainfall event.

The following CPVC implementation process is summarized in Appendix A (Channel Protection Flowchart).

The Channel Protection Volume Control (CPVC) volume is intended to control runoff volume under post-development conditions for a 1.3-inch rainfall event

1. Implement land use practices that limit the increase in runoff volume, such as LID practices including (but not limited to) a design emphasis on naturalized areas (i.e., meadow or wooded areas vs. turf grass), reduced impervious coverage, etc.

2. Calculate the required Channel Protection Volume using the following equation:

Eq. I-1	$V_{CP-R} = 4{,}719\ x\ C\ x\ A$
C =	Post-development runoff coefficient
A =	Contributing area in acres
V_{CP-R} =	Required CPVC volume in cubic feet

3. Provide adequate infiltration and/or storage/reuse BMPs, to the MEP, to provide the calculated CPVC volume. This may include (but is not limited to) bioretention, rain gardens, bio-swales, pervious pavement, cisterns, green roofs, and infiltration trenches. For water reuse BMPs (i.e., cisterns), water demand (such as gray water or irrigation water) must be established and documented to show adequate drawdown times.

   a. When the measured in-situ infiltration rate is above 0.5 in/hr., supplemental measures, such as subsoil amendments and/or a perforated underdrain system, are not required.

   b. When the measured in-situ infiltration rate is between 0.24 in/hr. and 0.5 in/hr., soils are marginally suitable for infiltration BMPs, and supplemental measures are required. Supplemental measures may include subsoil amendment, or an underdrain located at the top of the storage bed layer to maximize infiltration.

c. When the measured in-situ infiltration rate is less than 0.24 in/hr., infiltration is deemed impractical, and the use of this BMP is therefore waived. When infiltration is waived, other volume-reducing LID practices must be implemented to the MEP.

d. Infiltration BMPs shall completely dewater in less than 72 hours, consisting of 24-hour dewatering for the surface volume, and 48-hour dewatering of the void space (soil storage) volume. Water storage/reuse BMPs shall also be designed to fully dewater within 72 hours.

4. Pretreatment is required for all BMPs to remove fine sediment, trash, and debris to preserve the longevity and function of the BMPs.

a. Common methods of BMP pretreatment include mechanical separators, sediment forebays, vegetated filter strips, vegetated swales, constructed filters, and curb cuts with sediment traps.

5. To incentivize and encourage stormwater infiltration on all sites, the *provided* Channel Protection Volume, (V_{CP-P}) can be subtracted from the required 100-year detention volume, V_{100D} (see equations in Part G below). Upon subtracting the provided Channel Protection Volume from the required 100-year detention volume, the resulting volume cannot be less than the Extended Detention Volume (V_{ED}, see Part E below).

Channel Protection Volume Control (infiltration) is required when the measured in-situ infiltration rate is ≥ 0.24 inches/hour and groundwater is at least 2 feet below the bottom layer of the proposed BMP

For underground infiltration BMPs that are not easily accessible for inspection and maintenance, such as underground detention system infiltration, this Channel Protection Volume is generally not credited and will be evaluated on a case-by-case basis by the OCWRC's office.

Infiltration BMPs are prohibited in areas containing contaminated soils/groundwater, wellhead protection areas, high seasonal groundwater (less than 2 feet from the bottom of the stone storage layer of the infiltration BMP to the seasonally high groundwater table) and in areas with hotspot activities and setback restrictions (foundations, property lines, drinking wells, septic fields, pavement, etc.) as defined in the standards. When any of the above adverse conditions are demonstrated, other volume-reducing LID practices must be implemented to the MEP.

Part E: Channel Protection Rate Control: Extended Detention

Channel Protection Rate Control (CPRC) is necessary to protect natural watercourses from increased erosion and sedimentation as a result of increased imperviousness and runoff rates as development occurs. Channel protection rate control is based on a 2-year / 24-hour storm event. The CPRC shall be implemented to the MEP as outlined below.

1. Extended Detention is required for the site's post-development runoff volume from a 1.9-inch rainfall event. This Extended Detention Volume (V_{ED}) shall be dewatered in not less than 48 hours.
2. Calculate the required Extended Detention Volume using the following equation:

Eq. I-2	$V_{ED} = 6{,}897\ x\ C\ x\ A$
C =	Post-development runoff coefficient
A =	Contributing area in acres
V_{ED} =	Required Extended Detention Volume in cubic feet

3. The Extended Detention requirement effectively maintains the 2-year pre-settlement peak flow rates, to the MEP, for new developments and reduces the existing 2-year peak flow rates for redevelopments.

Part F: Water Quality Control

Water Quality Control (WQC) focuses on limiting the concentration of Total Suspended Solids (TSS) in post-development runoff to either of the following water quality standards: 80 mg/L, or 80% TSS reduction. WQC shall be implemented to the MEP as outlined below.

WQC can be achieved one of several ways:

1. Infiltration (i.e., runoff volume-reducing) or water reuse BMPs that achieve the required Channel Protection Volume (V_{CP-R}, see Part D) meet the TSS requirements for only areas tributary to an infiltration BMP. If any areas on a site plan bypass infiltration BMPs, those areas must receive alternative TSS treatment (see below for other options).

2. Mechanical separators designed for the required TSS removal at a peak flow rate (Q_{WQ}) generated by a 1-year peak flow as calculated below:

Eq. I-3	$Q_{WQ} = C\ x\ I_1 x\ A$
Q_{WQ} =	Peak flow rate for mechanical separator design in cfs
C =	Post-development runoff coefficient
I_1 =	Rainfall intensity in inches/hour
A =	Contributing area in acres

Eq. I-4	$I_1 = \frac{30.20}{(T_C\ +\ 9.17)^{0.81}}$
I_1 =	Rainfall intensity in in/hr
T_C =	Time of Concentration (minutes)

3. Sediment forebay(s), when combined with downstream Extended Detention. Forebays shall be designed with a volume equal to 15% of the Water Quality Volume (0.15 x V_{WQ}) and capture heavy sediment at inlet pipe locations. Access shall be provided to accommodate sediment removal equipment. The required sediment forebay volume, V_F, is calculated below:

Eq. I-5	$V_F = 0.15V_{WQ} =\ 545\ x\ C\ x\ A$
C =	Post-development runoff coefficient
A =	Contributing area in acres
V_{WQ} =	Required Water Quality Volume in cubic feet

4. The following treatment methods are effective at meeting the OCWRC water quality requirements:
   a. Bioretention BMPs (infiltration), discharging to a conventional detention basin* (wet or dry)
   b. Mechanical separator(s), discharging to a conventional detention basin* (wet or dry)
   c. Sediment forebay(s), discharging to a conventional detention basin* (wet or dry)

   * *Conventional detention basins include hydraulic controls for both V_{ED} and V_{100D}*

Part G: Detention & Flood Control

Detention and flood control is a critical component in stormwater design as it helps to prevent excess peak flows and reduces the likelihood of flooding downstream of a development site. The regional collaboration has resulted in the following Detention and Flood Control standards.

Detention and Flood Control shall be implemented to manage the ***100-year peak runoff rate*** for developed sites as outlined below. The allowable 100-year post-development peak flow rate (Q_{100P}) shall be approved by the WRC office on a case-by-case basis and will be calculated one of two ways:

1. Using the Variable Release Rate (see equations below)
2. County-determined peak flow rate based on a documented County Drain flow capacity or other known downstream capacity limitations (flow rate provided in cfs/acre)

WRC (or any local review authority) reserves the right to set a specific discharge rate that is below the Variable Release Rate where outlet capacity is restricted

Prior to commencing with site plan design, please contact the WRC Permitting Department to confirm which of the above methods are more restrictive and will apply to your site. The chosen method to determine the 100-year post-development peak flow rate can have a significant impact on required detention pond volume.

The Variable Release Rate and corresponding post-development peak flow rate are calculated as follows:

Eq. I-6	$Q_{VRR} = 1.1055 - 0.206\ln(A)$
Q_{VRR} =	Allowable release rate in cfs/acre
A =	Contributing area in acres
	The variable release rate (cfs/acre) is capped at 1.0 cfs/acre for developments 2 acres or less. For all developments equal to or greater than 100 acres, the variable release rate is 0.15 cfs/acre.

Eq. I-7	$Q_{100P} = Q_{VRR}\ x\ A$
Q_{100P} =	Allowable 100-year post-development peak flow rate in cfs
A =	Contributing area in acres

If downstream capacity is insufficient for the proposed development, the developer can make improvements that may include construction of additional off-site conveyance capacity, improvements to the existing drain, acquisition of easements from downstream property owners, etc. The developer is responsible for securing all necessary easement(s) from downstream property owners and is responsible for all improvement costs.

All stormwater discharges from the proposed development site shall outlet within the watershed where the flows originated, unless approval is obtained from the WRC's office. Offsite runoff shall bypass the proposed site's stormwater system. If this cannot be achieved, detailed hydrologic and hydraulic calculations shall be provided to the WRC office to demonstrate that no adverse impacts will occur downstream from the 10-year and 100-year storm events.

When calculating the required detention volume, all on-site contributing drainage areas shall be used in the calculation. Volume stored within the forebay and extended detention area may be applied towards the required detention volume. Please refer to Appendix C for typical detention basin profiles and stormwater design calculations.

The required 100-year detention volume (V_{100D}) is calculated as follows:

1. Calculate the total 100-year runoff volume (V_{100R}) under post-development conditions:

Eq. I-8	$V_{100R} = 18{,}985\ x\ C\ x\ A$
C =	Post-development runoff coefficient
A =	Contributing area in acres
V_{100R} =	Post-development 100-year runoff volume in cubic feet

2. Calculate the 100-year peak inflow rate, Q_{100IN}, into the detention basin; this is the post-development peak instantaneous flow prior to (upstream of) the detention basin:

Eq. I-9	$Q_{100IN} = C\ x\ I_{100}\ x\ A$
Q_{100IN} =	100-year post-development peak inflow rate in cfs
C =	Post-development runoff coefficient
I_{100} =	100-year peak rainfall intensity in inches/hour
A =	Contributing area in acres

3. Calculate the Storage Curve Factor for the 100-year detention volume (R):

Eq. I-10	$R = \left[0.206 - 0.15 \ln\left(\frac{Q_{100P}}{Q_{100IN}}\right)\right]$
R =	Storage Curve Factor (dimensionless)
Q_{100P} =	100-year post-development peak flow rate in cfs
Q_{100IN} =	100-year post-development peak inflow rate in cfs

4. Finally, calculate the 100-year detention basin size, identifying any credits to the detention basin volume to reflect the provided Channel Protection Volume (V_{CP-P}))

Eq. I-11	$V_{100D} = (V_{100R}\ x\ R) - V_{CP-P}$
V_{100D} =	Required 100-yr detention volume in cubic feet
V_{100R} =	100-year runoff volume in cubic feet
R =	Storage Curve Factor (dimensionless)
V_{CP-P} =	**Provided** CVPC volume in cubic feet
	KEY RULE: $V_{100D} \geq V_{ED}$

Check to verify the adjusted 100-year detention basin volume is equal to or greater than the Extended Detention Volume (V_{ED}). Under no circumstances shall the adjusted detention basin volume be less than V_{ED}.

Part H: Operations and Maintenance

Long-term Operations and Maintenance (O&M) Plans are required for County Stormwater Systems and Non-County Stormwater Systems and are summarized below. To facilitate routine inspections, all O&M requirements and documents listed below shall be incorporated into the plan set on dedicated O&M-specific plan sheets. When O&M responsibilities or requirements are modified or updated, the respective O&M Plan sheet(s) shall be updated accordingly.

County Stormwater Systems

The following MS4 Permit O&M requirements apply to all regulated County Stormwater Systems owned, operated and maintained by the WRC's office, the Oakland County Parks and Recreation Commission and the County of Oakland, hereafter referred to as County Departments:

1. Prior to the start of any development or redevelopment activity meeting the criteria defined in Part C: Applicability, the County Department shall obtain a Drain Permit from the WRC's Permitting Department. Coordination with the WRC's Permitting Department is recommended at the conceptual stage of development projects to ensure that permit requirements are clearly identified early in the planning process.

2. To ensure consistent perpetual O&M of the site's stormwater system and to enhance water quality protection, prior to Drain Permit issuance, the WRC's Permitting Department shall review and approve the County Department's site-specific Stormwater Management O&M Plan with the following requirements:

   a. Purpose of the plan.

   b. Drainage area description and details.

   c. Description of the stormwater system and its individual components.

   d. Specific short-term, intermediate and long-term maintenance tasks.

   e. Inspection and maintenance tasks, frequencies and responsibilities.

   f. Employee and contractor training requirements and responsibilities.

   g. Approved construction drawings including stormwater calculations, details, elevations and a location map, etc.

   h. Approved O&M Plan sheet(s) to facilitate routine O&M inspections.

   i. County Departments shall submit an Annual Stormwater System O&M Summary, for their stormwater systems, to the WRC's Environmental Department for County MS4 permit

Maintaining stormwater systems is critical for ensuring they meet ongoing water quality and flood control needs. Individual County Departments are responsible for completing all (perpetual) O&M tasks and for maintaining detailed O&M tracking records for their stormwater systems.

reporting. Individual County Departments are responsible for completing all O&M tasks and for maintaining detailed O&M tracking records for their stormwater systems.

Non-County Stormwater Systems

The following MS4 Permit O&M requirements apply to all regulated Non-County Stormwater Systems owned, operated and maintained by others, which directly connect to a County Stormwater System:

1. Prior to the start of any development activity meeting the site applicability criteria defined in Part C: Applicability, a Drain Permit shall be obtained from the WRC's Permitting Department. Coordination with the WRC's Permitting Department is recommended at the conceptual stage of development projects to ensure that permit requirements are clearly identified early in the planning process.
2. To ensure consistent perpetual O&M of the site's stormwater system and to enhance water quality protection, prior to Drain Permit issuance, the WRC's Permitting Department shall review and approve the site-specific Stormwater Management O&M Agreement between the community and property owner. A fully executed Stormwater Management O&M Agreement is required prior to issuance of the Drain Permit. This agreement shall consist of the following requirements which will be incorporated into the O&M Plan sheet(s):
    a. Legal Description: A legal description and reduced copy map to identify the land parcel(s) affected by this Agreement. This map shall be prepared for each site and must include a reference to a Subdivision Plat, parcel survey, or Condominium Master Deed, and a map to illustrate the affected parcel(s).

    The community is responsible for enforcement of the O&M requirements as outlined in the Stormwater Management O&M Agreement and their MS4 permit.

    b. Stormwater System Description and Map: A location map of the entire stormwater system. This map must be prepared for each site and the scale of the map shall show necessary detail.
    c. Stormwater O&M Plan Sheet(s): The site-specific Stormwater O&M Plan shall include the following requirements:
        - Description of the stormwater system, drainage area, and its individual components.
        - Specific short-term, intermediate and long-term maintenance tasks.
        - Inspection and maintenance tasks, frequencies and responsibilities (matrix/table).
        - Employee and contractor O&M training requirements, certifications, and responsibilities.
        - BMP Details
        - Property owners are responsible for completing all O&M tasks and maintaining O&M records for their stormwater systems. Upon request, property owners shall submit an Annual Stormwater System O&M Summary to OCWRC's Permitting Department for

tracking only. The community is responsible for enforcement of the O&M requirements as outlined in the Stormwater Management O&M Agreement and their MS4 permit.

d. Memorandum of Stormwater Management Operations and Maintenance Agreement: This O&M Memorandum acknowledges a perpetual requirement of stormwater system operations and maintenance, which is recorded with the Register of Deeds to put any future property owners, or interest holders, on notice of the Stormwater System and the Stormwater O&M Plan. This O&M Memorandum references the required Stormwater Management O&M Agreement, which resides with the local community to ensure consistency and periodic updates as necessary. A copy of the recorded document shall be submitted to OCWRC prior to closure of the Drain Permit.

Appendix G-Stormwater Management O & M Agreement is an approved "example" agreement. However, the WRC office recognizes that community-specific O & M agreements, ordinances and programs may also be proposed and submitted to the WRC for approval. When developing alternative O & M programs for consideration, the community should reference EGLE'S Post-Construction Stormwater Runoff Controls Program Compliance Assistance Document (available on EGLE's website) and their MS$ permit.

Part I: Stormwater Tracking & Mapping

Collecting data on site runoff characteristics is critical for WRC and the local review jurisdiction (if applicable) to meet ongoing EGLE permit requirements. This will be accomplished with a ***Land Use Summary Table***, which must be included on the O&M Plan Sheet of each submitted site plan (see table below). Additionally, GIS-based site data (in the form of a shapefile) will be required as a condition of site plan approval. GIS data will be limited to key stormwater components that will require future inspection and maintenance.

Land Use Summary

must be included on the O&M Plan Sheet for all site plans

	Characteristic	Existing Conditions	Proposed Conditions
Land Use Data	**Total Development Area (ac)**		
	Impervious Area (ac)		
	Total Pervious Area (ac)		
	Pervious Area Breakdown by Cover Type		
Pervious Area			
	Meadow/fallow/natural areas (non-cultivated)	x.xx acres	x.xx acres
	Predominant NRCS Soil Type (A, B, C, or D)		
	Improved areas (turf grass, landscape, row crops)	x.xx acres	x.xx acres
	Predominant NRCS Soil Type (A, B, C, or D)		
	Wooded Areas	x.xx acres	x.xx acres
	Predominant NRCS Soil Type (A, B, C, or D)		
	CPVC Volume ***Calculated*** (cubic feet)		
	CPVC Volume ***Provided*** (cubic feet)		
	CPRC Volume Provided (cubic feet)		

The Professional Engineer who signs and seals this site plan certifies that the values in this table reflect the WRC stormwater calculations required for this development and that geotechnical investigations were performed that provide conclusive documentation that demonstrates whether infiltration (i.e., CPVC Volume Control) is practicable.

Notes:

- *The Professional Engineer Certification Statement (see above) must be included with the Land Use Summary Table.*
- *Areas to be shown to the nearest 0.01 acre*
- *'Predominant' soil type shall the soil type with the largest percentage coverage over the designated land use (e.g., 70% Soil Type B and 30% Soil Type C shall be listed in the table as "Soil Type B")*
- *USDA soil types cannot be used to determine site suitability for infiltration and meeting the CPVC volume standard; direct infiltration testing will be required to determine site suitability for infiltration*

- *If CPVC requirement is waived, enter ZERO for the 'CPVC Volume Provided'*
- *When more than one soil type exists in one area, assign the predominant soil type for that area*
- *Use NRCS/USDA Online Soil Survey Map to determine soil type (A, B, C, or D):*

  https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

In addition to the Land Use Summary table, the applicant must include the following stormwater system information in the submittal:

1. Project name
2. Project location
3. City / Township / Village name
4. Applicant name and contact information
5. Engineer and owner names, including contact information
6. Description of work and other relevant information
7. ***Stormwater Design Narrative*** (separate document), consisting of the following minimum components:
   a. Summary of the proposed stormwater management system
   b. Geotechnical investigations (e.g., soil borings, infiltration tests, and/or an Environmental Site Assessment)
      i. *NOTE: the stormwater review cannot be approved without the submittal of in-situ soil characteristics and/or evidence of existing soil contamination; this information is necessary to determine whether the Channel Protection Volume Control standard will be required.*
   c. All stormwater calculations, including a list of all assumptions, site characteristics, and other information to support the calculations.
   d. If mechanical separators are to be used, attach the NJDEP certification letter including all NJDEP unit sizing and TSS removal efficiencies.
   e. Figures/schematics of the stormwater management system, including clear references to existing wetlands, floodplains, woodlands or other protected natural features.
   f. Outlet hydraulic calculations, including (if requested by the WRC) calculations and certifications for the hydraulic capacity of the receiving system.
   g. Operations & Maintenance (O&M) Plan for all proposed stormwater components (collection system, water quality treatment, infiltration, extended detention, and flood control) shall be included on the O&M Plan sheet(s).
8. Construction plans developed in accordance with WRC requirements
9. Executed Stormwater Management O&M Agreement
10. Recorded Memorandum of Stormwater Management O&M Agreement

A stormwater report (narrative) is a required component of each site plan submittal; a concise and well-organized report will help to expedite the site plan review process

A final component of the site plan review process is the submittal of a GIS shapefile containing, at a minimum, the layers listed below, which consist of points and polygons that reflect the key components of the stormwater system. This information will be provided only after the technical review is completed. The GIS shapefile must reflect the final approved design and include the following layers (use the layer naming conventions listed below for ease of storing and tracking the GIS data):

1. Development Site – Area (ac), GIS area **polygon** (DSA-1, DSA-X)
    a. This area should reflect the entire area for which the stormwater system is designed
2. Site Discharge Point(s), GIS **points** (D-1, D-2, etc.)
    a. These points should reflect the location of each site discharge point; this is typically the point of connection to a County Drain, city storm sewer, or other drainage feature downstream of the detention basin discharge structure
3. Dry Detention Basins, GIS area (ac) **polygons** (DBASIN-1, etc.)
    a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer
4. Wet Detention Basins, GIS area (ac) **polygons** (WBASIN-1, etc.)
    a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer
5. Retention Basins (no outlet), GIS area (ac) **polygons** (RBASIN-1, etc.)
    a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer
6. Sediment Forebays, GIS area (ac) **polygons** (Forebay-1, etc.)
    a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer
7. Mechanical Separators, GIS **points** (MS-1, etc.)
    a. The points can be placed at a maintenance access point for each structure. If multiple mechanical separator units are proposed, create a point for each unit.
8. Bioretention/Bioswales – GIS area (ac), GIS **polygons** (BR-1, etc.)
    a. The polygon should reflect the bioretention/bioswale footprint including any maintenance or safety buffers
9. Porous Pavement – GIS area (ac), GIS **polygons** (PP-1, etc.)
10. Cisterns/Rain Barrels, GIS **points** (RB-1, etc.)

Section II – Submittal and Review Procedures

Part A: General Requirements

Introduction

The general standards set forth are applied by this office for the review of the following:

1. Subdivisions being established under Act 288 of the Public Acts of 1967.
2. Mobile home plans prepared under P.A. 96 of 1987.
3. Applications for permits to discharge to a County Drain under P.A. 40 of 1956, as amended.
4. Review of stormwater system plans in other classes of developments or re-developments, when requested by local governments.
5. Review of developments being established as Chapter 18 County Drains.

Pre-Application Meeting

The pre-application meeting is a recommended step (not required) for the design and construction of a site that is covered under these standards. There are no fees required for the pre-application meeting.

The purpose of the pre-application meeting is to discuss the WRC standard requirements, existing site characteristics, identify existing in-situ soil conditions (which will determine whether infiltration will be required), Best Management Practices (BMPs) proposed for use on the site, long-term maintenance needs, and the capacity of the stormwater outlet. At this meeting, WRC staff will also confirm whether the development/redevelopment is within a drainage system that has a restricted outlet. This will determine the methodology that shall be used for determining the allowable peak discharge rate. This meeting may allow for a faster, more cost-effective site design by identifying the stormwater management issues early in the design process.

The Property Owner/Applicant will provide the following general information about the proposed development site for review during the meeting with WRC staff:

1. General Site Description / Site Plan
2. Topography
3. Land cover
4. Known environmental concerns (e.g. contaminated soils, “Due Care” Plan)
5. Location of and characteristics of environmental features, including wetlands, undrained areas, woodland areas, etc.
6. Soil types - (Soil survey with USDA NRCS soil group classifications, well/septic records and, if available, soil borings)
7. Potential locations for infiltration BMPs
8. Site environmental history (i.e., Phase 1 ESA)

Electronic Submission of Application and Plans

All Application submittals involving a County owned or operated Drain/Watermain/Sanitary Sewer/Soil Erosion must be made electronically to the WRC Office via our interactive EnerGov Permit Portal. Please refer to **Appendix J**-EnerGov Citizen Self-Service Portal User Guide.

1. You will first need to log into the WRC EnerGov site and register as a user to be able to submit an Application for review and approval.
2. Applications must be submitted by System and/or Property owners or their designated representatives.
3. Once an application has been submitted, the Applicant may invite others giving them permission to interact with the Application submittal process or simply to view the Permit Status.
4. Construction and site plans must be in PDF format with layers flattened, optimized and compressed.
5. JPG format is acceptable for documents or letters.
6. Maximum file size for each file should not exceed 50MB.
7. Below is the URL for our Live EnerGov CSS Portal Site
    - Full URL: https://oaklandcountymi-energovpub.tylerhost.net/apps/selfservice#/home
    - Friendly Link (share in emails): WRC Permitting & Soil Erosion Application Portal

Conceptual Plan Review Requirements

An application for review must be submitted for conceptual plan reviews. WRC will perform a cursory review of the plans and will advise the applicant if an application fee is required. Conceptual plan submittal and review is not a required step for the design and construction of a site. However, if a developer chooses to pursue a conceptual plan review, it may allow for a faster, more cost-effective process by identifying potential stormwater management issues early in the design phase of the project, particularly for sites that have unique characteristics and/or hydraulically restricted outlets. If conceptual plans are submitted, they shall include the following required information and will be submitted prior to the preliminary plat or plan:

1. A brief drainage narrative describing the proposed stormwater management system.
    a. On-site drainage infrastructure.
    b. Off-site drainage patterns of adjacent properties.
    c. Evidence of off-site outlet adequacy by means of certification. See Engineer's Certificate of Outlet in Appendix H.

2. Calculations determining the detention or retention volume requirements for the development.
3. Proposed topography for the detention or retention basin(s) in one-foot intervals.
4. Known environmental concerns and "Due Care" plans.
5. Calculations verifying that the soils provide the percolation rate required for the selected BMPs.
6. Schematic layout for the proposed drainage collection system.
7. Evidence of in-situ soil permeability, prevailing groundwater levels, and the location of proposed BMPs.
8. Soil types and areas of each soil based on USDA Soil Conservation Service classification system. (Please note that this is *not* a substitute for geotechnical investigations to demonstrate in-situ soil permeability).
9. Existing natural features, including wetlands and woodland areas.
10. Limits of disturbance (including consideration of topographical requirements for excavation).
11. Existing FEMA flood zones (Zone A or AE), if applicable.
12. If the development is proposed in an area where flooding problems exist or are anticipated at the site, on adjacent properties or downstream, include a plan for how these issues will be addressed.

After the above items, the WRC will determine if the submittal is sufficient for conceptual approval. The submittal must be complete, correct, and feasible in order to be conceptually approved. If it is determined that the information submitted is insufficient the WRC will advise the applicant of the deficiencies.

Application for Review

An application for review must accompany all plans submitted to WRC for review. The application shall be submitted by the Owner/Developer or the Design Engineer on behalf of the Owner/Developer. Application for review shall be made prior to the start of any work requiring a permit from WRC.

For project sites that will be developed in phases, an application is required for the initial work and new applications will be required for additional work not indicated on the original application.

WRC will perform a cursory review of the plans and will advise the applicant if an application fee is required. The total review, permit, and inspection fees will be determined upon completion of the review.

The review period begins upon the receipt of a completed application, plans and application fees.

Part B: Subdivisions- Sites to be platted under Act 288

Preliminary Plat

General Requirements

A preliminary or tentative plan showing the layout of the area intended to be platted shall be submitted by the Proprietor. This plan shall be prepared under the direction of and sealed by a registered professional engineer. The plan shall be drawn to a standard engineering scale no smaller than 1" = 100' and the sheet(s) of paper must not be larger than 24” x 36”. This preliminary plan is what the Subdivision Control Act of 1967 refers to in Section 111 as a "preliminary plat".

Section 114, Sub-section (3) of the Subdivision Control Act of 1967 requires that the Water Resources Commissioner approve or reject preliminary plats within 30 days of their receipt.

Three copies of the preliminary plat, prepared in accordance with the following requirements, shall be submitted with a letter of transmittal requesting that the preliminary plan be reviewed and, if found satisfactory, approved. The names of the Proprietor and engineering or surveying firm with mailing addresses, telephone, e-mail, and fax numbers for each shall be included with the transmittal.

The preliminary plat shall include:

1. The location of the proposed subdivision with reference to the section and part of section in which the parcel is situated, the name of the township, city or village, a proposed legal description of the site, the number of acres proposed to be platted and a location map with north arrow.
2. The proposed street and alley layout and approximate lot and plat dimensions.
3. All on-site and off-site pertinent factors, the existence and description of which might be of value in determining the overall requirements for the subdivision, such as:
   a. Adjoining roads, subdivisions, and parcels.
   b. Railroads.
   c. High-tension tower lines, underground transmission lines and gas pipelines.
   d. Cemeteries and parks.
   e. Rivers, natural water courses, county drains, lagoons, slips, waterways, streams, lakes, bays, canals, wetlands, wetland boundaries and floodplains.
   f. Existing utilities; storm drains, sanitary sewers, water main, telephone, cable, or fiber optic lines.
   g. Existing and proposed easements for all drainage facilities, including BMP’s and buffer strips.
4. Contour information in two-foot intervals with North American Vertical Datum of 1988 (NAVD 88), or most current national datum, shall be shown on the same plan, otherwise it shall be submitted on a separate sheet.
5. A drainage map, using a United States Geological Survey (USGS) topographic map, or equivalent, that shows the existing drainage area and flow patterns and indicates the proposed drainage pattern.

Inasmuch as improper utility easement location can result in a change in plat layout, the Proprietor is advised to consult with the respective utility companies before presentation of the preliminary plan for approval.

In the case where the Proprietor wishes to subdivide a given area but wishes to begin with only a portion of the total area, the original plan shall include the proposed general layout for the entire area. The part that is proposed to be subdivided first shall be clearly superimposed upon the overall plan in order to clearly illustrate the method of development which the Proprietor intends to follow. Each subsequent plat shall follow the same procedure until the entire area controlled by the Proprietor is subdivided. The final acceptance of a subdivision that is a partial development of a larger general layout does not automatically insure the final acceptance of the overall layout. The intent is to permit some flexibility in the overall layout if future conditions make it desirable or necessary to make any changes.

If the proposed preliminary plan as submitted meets with all the requirements, one approved copy of the preliminary plan will be returned. Approval of the preliminary plan is recommended before proceeding with the preparation of final construction plans. If the proposed plan is not approved as originally submitted, the Commissioner notifies the Proprietor in writing setting forth the reasons for withholding approval and requests that the necessary changes be made, and the revised layout resubmitted.

In accordance with Section 560.120 of Act 288, the preliminary plat approval is valid for two years. If construction plans have not been submitted within that time, a new preliminary plat must be submitted and approved. The two-year period may be extended if applied for by the proprietor and approved by the Water Resources Commissioner in writing.

Drainage Requirements

The preliminary plat must include the general drainage scheme for the proposed subdivision, or the plan will be rejected. The general drainage scheme shall indicate how storm drainage will be provided and where it will outlet. Preliminary calculations for detention and contributing off-site flow must be included on the plan. Additionally, the preliminary plat shall indicate locations of proposed BMP's, soil types and percolation rate(s).

Drainage proposed for subdivisions shall conform to established County Drain districts, existing natural drainage patterns and community master plans. The design shall consider the effect that the drainage proposed in the subdivision has upon the entire drainage basin.

The preliminary plat shall indicate in general, on a USGS topographic map, any drainage originating outside of the subdivision limits which has previously flowed onto or across the subdivision, as well as any natural watercourses and County Drains that traverse or abut the subdivision.

The preliminary plat shall indicate in general any proposed onsite and/or offsite facilities, proposed or existing, required to conduct the drainage to an adequate outlet.

The Water Resources Commissioner's office is not responsible for roadside ditches. Road drainage ditches are under the jurisdiction of the Road Commission for Oakland County (RCOC) or other authority. Any drainage plan that proposes to outlet storm water to a road ditch must be approved by the RCOC or authority that has jurisdiction.

The Water Resources Commissioner shall require that the developer provide assurance of adequate maintenance and inspection of the installation of both the external and internal storm drainage facilities.

Easement Requirements

The following minimum easement widths are required for all storm drainage facilities within the boundaries of the subdivision:

1. Open drains and watercourses:

   The extreme width of the drain or watercourse plus 15 feet from top of bank on both sides of the channel.

2. Enclosed drains:

   A minimum of twenty (20) feet centered on the centerline of the pipe. However, larger pipe size, certain soil conditions, or depth of pipe may require larger easements.

3. Rear yard drains:

   For pipe sizes less than 12 inches in diameter, a minimum of twelve (12) feet centered on the centerline of the pipe.

4. Pump stations, detention/retention basins and other storm drainage facilities shall have sufficient easement area to allow for operation and maintenance of the entire facility, including freeboard area, the banks, and any berms at the top of the banks.

5. BMPs and buffer strips shall have adequate easements to maintain and/or replace the device.

Easement widths for legally established County Drains shall be determined by the WRC. In general, these will conform to the above referenced requirements. Additional easements may be required by the Water Resources Commissioner's office should soil, construction conditions or other circumstances so warrant.

Easement information shall be shown on the preliminary plan, final construction plans and final mylar plat.

The wording relative to easement information shown on the final plat shall be as specifically required by the Water Resources Commissioner's office. All County Drain easements shall be labeled as follows: "Permanent private easement for the NAME County Drain". In Addition, restrictive deed covenants for the development shall include county drain language as described in the appendix.

The Oakland County Water Resources Commissioner's office reserves the right to modify easement requirements at its discretion.

Subdivision Construction Plans

The Proprietor will submit final construction plans that have been prepared under the direction of, and sealed by, a Professional Engineer licensed in the State of Michigan with a completed application form. The Water Resources Commissioner's Office will review the plans for adequacy of storm water management design to ensure that the proposed storm water drainage system has the capacity to handle all contributing flow without diminution of the existing off-site natural drainage patterns.

One set of complete, electronic final construction plans shall be submitted. The plans must be drawn to a scale not smaller than 1" = 50' on sheets no larger than 24" x 36" and designed in accordance with the design criteria presented herein.

Required Information

The plans should include, at minimum, the following:

1. A cover sheet which includes a site legal description and location map with north arrow and the number of acres proposed to be platted. For phased developments, clearly indicate the phase limits and the number of acres in each phase.
2. Subdivision layout of lots, roads, and all existing and proposed easements.
3. Plans, profiles and details of all road and storm sewers. The storm sewer details will include type and class and size of the pipe, length of run, percent of slope, invert elevations, rim elevations, and profile of the hydraulic gradient.
4. A description of the drainage course that will be utilized as the stormwater outlet and evidence that it is adequate for the proposed discharge. It is noted that controlling flow to a rate that is equal to or below the pre-development rate may not be considered to be evidence of adequacy. The Engineer's Certificate of Outlet, must be provided, including the signature and seal of the professional engineer responsible for determining adequacy.
5. Plans and details of the soil erosion and sedimentation control measures. Indicate which measures are temporary or permanent and the party responsible for maintaining the control measures.
6. Plans, cross-section views and details of the detention or retention basins and the outlet. If an existing basin on or off-site will be used, then as-built information must be provided.
7. Topographic map or maps at two-foot contour intervals with North American Vertical Datum of 1988 (NAVD 88), or most current national datum, showing existing topography and proposed grades of the entire area to be subdivided, as well as offsite topography for at least 150' of the adjoining property to the extent that off-site contributing flow can be determined. All off-site contributing flow must be accommodated. This map or maps shall also show all existing watercourses, lakes, and swamps.
8. Calculations, design data and criteria used for sizing all infiltration facilities, drainage structures, open channels and retention/detention facilities including curve numbers or weighted runoff coefficient calculations.

9. Storm drain calculations indicating the number of acres, calculated to the nearest tenth of an acre, contributing to each specific inlet/outlet, the calculated hydraulic gradient elevation, maximum flow in ft^3/sec and the flow velocities for enclosed systems. The calculations shall also include detention/ retention and runoff coefficient calculations as well as design calculations for all drainage swales and overflow structures. Overflow structures must be sized to pass all contributing off-site flow.
10. Specifications governing construction, i.e. material specifications, pipe bedding, construction notes, compaction requirements, etc.
11. Maximum flow in cubic feet per second for both the 10-year and 100-year recurrence interval storm events.
12. Flow velocities for the 10-year recurrence interval storm event.
13. Locations of all drain fields and of all expansion areas. Drain fields shall not be located within drainage easements.
14. Plans and details of proposed infiltration facilities with soil test pits or other testing methods detailed elsewhere in these rules, to verify that the facilities will function per the proposed design.
15. Plans and details of proposed retention/detention facilities. Soil borings may be required at the sites of these facilities.
16. A drainage area map, overlaid onto a copy of the site grading plan, which clearly shows the sub-areas tributary to each drainage structure, BMP and/or retention/detention facility, including acreage curve number (CN) and runoff coefficient (C factor) for each sub-area.
17. Plans, profiles, and details of all stormwater management system including but not limited to the following:
    - Porous Pavement
    - Dry Wells
    - Structural Infiltration Basins
    - Subsurface Infiltration Beds
    - Infiltration Trenches
    - Vegetated Filter Strips
    - Bioretention Systems/Bioswales (Rain Gardens)
    - Green Roofs
    - Water Reuse
    - Retention/Detention Facilities
18. Engineer's certificate attesting to the infiltration rate of the soils being used for BMPs.
19. Details of all drainage structures including but not limited to the following:
    - Manholes
    - Catch basins

- Inlets
- Outlet structures
- Overflow structures
- Check dams

20. A Stormwater Management Operation and Maintenance Agreement, plan, and a proposed schedule for the perpetual maintenance of the complete storm drainage system. Indicate who will be the primary party responsible (i.e. municipality or homeowners' association) for the maintenance. If a Homeowners Association will be the primary party responsible for maintenance of the stormwater system, an appropriate governmental unit shall be named as having underlining authority in perpetuity for overseeing the maintenance of the system, including the responsibility to perform maintenance in the event the Homeowners Association fails to do so. The responsibility for maintenance of the stormwater system shall be included in the subdivision deed restrictions and recorded with the plat. An example of a Stormwater Management Operation and Maintenance Agreement may be found in Appendix G. A copy of the subdivision deed restrictions and executed Agreement must be submitted to the Water Resources Commissioner prior to construction plan approval.

    - Reference Part I for requirements for the GIS data layers for key stormwater management features.

Review Time

The Proprietor shall prepare and submit a preliminary plat and final construction plans to WRC prior to submitting a final (Mylar) plat for approval. WRC shall tentatively approve or reject the preliminary plat within 30 days. A preliminary plat must be submitted and approved prior to submitting the final construction plans. Approval of the preliminary plat and final construction plans is required prior to the Water Resources Commissioner signing the final (Mylar) plat. The construction plan approval is valid for one (1) year. The one-year period may be extended if applied for by the proprietor and approved by the Water Resources Commissioner in writing.

Changes to the Plans

Approval of the final construction plans is intended to be final approval, and the actual signing of the mylar plat is only a formality, as long as there are no changes in the final construction plans from what was approved. If either the Proprietor or the Water Resources Commissioner find it advantageous to make changes before the mylar plat is presented to the Water Resources Commissioner for signature, such changes can be made, provided that the same procedures outlined above are repeated with each change in the layout. The Proprietor is reminded that approval of the proposed subdivision by the local governing body is also required under the Plat Act. Such changes shall be incorporated in the layout and revised construction plans shall be resubmitted even though the original layout may have already been approved by the Water Resources Commissioner. If the Proprietor does not present his mylar plat to the Water Resources Commissioner for approval within a period of one year after receiving approval of the final construction plans, it may be necessary that he resubmit the construction plans for review in the light of new information which may have become available during the interim.

Final Plat

The Proprietor shall submit the final mylar plat to the Water Resources Commissioner for certification. The plat will be reviewed for accurate drainage easements and equivalence with the approved construction plans. If the Commissioner approves the plat, he will affix his signature to it and the plat will be executed. If the Water Resources Commissioner rejects the plat, written notice of such rejection and the reasons therefore are given to the Proprietor within ten days.

Prior to the Proprietor submitting the final mylar plat for certification, the following is required:

1. Approval of the preliminary plat.
2. Approval of the final construction plans.
3. Assurance of adequate maintenance and inspection of the installation of both the external and internal storm drainage facilities.
4. A soil erosion and sedimentation control permit under Part 91 of Act 451 of the Public Acts of 1994 as amended.
5. Payment by the Proprietor of the plat review fee, according to the latest schedule posted on the Oakland County Water Resources Commissioner's website: www.oakgov.com/water.
6. A minimum, non-refundable application fee is required upon submittal of the preliminary plat and the construction plans.
7. Easements:
   a. Easement provisions shall conform to the widths indicated in "Preliminary Plat Easement Requirements" of this Section.
   b. All drainage easements, including freeboard, BMPs and buffer strips, shall be so designated on the plans as well as on the mylar plat.
   c. All existing easements are to be shown and identified on the mylar plat including the Liber and Page.
   d. Existing County Drain easements shall be indicated on the plans as well as the mylar plat and shall be designated as "XX feet wide easement for the "Name" (County) Drain as recorded in Liber___ , Page___".
   e. In cases where storm water is discharged to a drain or watercourse on adjoining private property, an improvement to the drain and an agreement with the property owner may be necessary. An off-site drainage easement will be required if:
      - The watercourse is not depicted as a blue line on a USGS map.
      - It is not indicated on the MIRIS map.
      - The watercourse is not considered wetlands by the governing municipality.

Part C: Mobile Home Developments

Public Act 96 of 1987, The Mobile Home Commission Act, requires a developer of a Mobile Home Park to submit a preliminary plan to the Water Resources Commissioner.

Preliminary Plan

The preliminary plan shall include the location, layout, general design, and a general description of the project. The following information shall be submitted for review:

1. Calculations, design data and criteria used for sizing all infiltration facilities, drainage structures, channels and retention/detention facilities including curve numbers or weighted runoff coefficient calculations.
2. Plans and details of proposed infiltration facilities with soil test pits or other testing methods detailed elsewhere in these rules, to verify that the facilities will function per the proposed design.
3. Plans and details of proposed retention/detention facilities. Soil borings may be required at the sites of these facilities.

Outlet Drainage

The Water Resources Commissioner must review and may approve the outlet drainage for the Mobile Home Park. The design requirements covered in these standards will be used for this review. All pertinent design calculations must be submitted. The interior drainage within the park will not be reviewed unless the park storm drain system is to be established as a County Drain under Chapter 18 of the Drain Code.

The Water Resources Commissioner may approve or reject preliminary plans within 60 days of their receipt; otherwise the plan is considered approved.

Mobile home park construction plans are reviewed by the Mobile Home Commission.

Part D: Drains under the Jurisdiction of the Water Resources Commissioner

Permits

The review application and application fee must be submitted before a site plan is reviewed. Permit fees and inspection deposits are determined on a site-specific basis after the review is completed. A permit shall be required from WRC prior to performing any work to a County Drain or its appurtenances. The following are examples of work:

a. Connecting to any part of an open ditch, enclosed drain or manhole or drainage structure. A tap can be a direct connection or a pipe outlet.

b. Crossing any part of an open ditch or enclosed pipe. Examples of crossings are utility lines, driveways, culverts, and bridges. A minimum clearance of five (5) feet for an open ditch drain and eighteen (18) inches for an enclosed drain must be maintained between the drain and any proposed utility or other underground crossings of the drain.

c. Relocating any part of a County Drain.

d. Enclosing any portion of an existing open ditch County drain.

e. Performing work within a County Drain easement.

f. When the installation of a fence, driveway, patio, pool, or other structure that does not have a foundation, encroaches into the County Drain easement.

g. Any development that will outlet stormwater directly to a County Drain will be reviewed by the Water Resources Commissioner for adequate stormwater management and outlet drainage. All other involvements will have a drainage review performed relevant to the work proposed.

h. The Proprietor shall submit one (1) set of electronic construction plans with a transmittal requesting plan review. The plans must be prepared in accordance with the design standards presented herein and sealed by a Professional Engineer licensed in the State of Michigan. All pertinent design calculations must be submitted with the final construction plans. Preliminary plans may be submitted but are not required.

General Permit Information Requirements

All plans shall include the following information:

a. The location of the proposed development by means of a location map at sufficient scale.

b. Legal description for the parcel to be developed.

c. The number of acres to be developed.

d. Contours, at two-foot intervals or less, with U.S.G.S. datum.

e. The proposed drainage system for the development.

f. The proposed street, alley and lot layouts and approximate dimensions.

g. Soil survey information with USDA NRCS soil group Classification.

h. Known environmental concerns and/or "Due Care" plan.

i. Engineer's certificate attesting to the infiltration rate of the soils. test pits or other testing methods detailed elsewhere in these rules, will be required at the location of all infiltration facilities, including but not limited to:

- Bioretention Systems/Bioswales (Rain Gardens)
- Porous Pavement
- Dry Wells
- Structural Infiltration Beds
- Subsurface Infiltration Beds
- Infiltration Trenches
- Vegetated Filter Strips

j. Soil tests may be required at various other locations including the sites of proposed retention/detention facilities, and as needed in areas where high ground water tables exist.

k. Certain County Drains have limited hydraulic capacity. These drains are listed in Appendix C. The allowable discharge to these drains will be dictated by the Water Resources Commissioner and may be more stringent than these design requirements.

l. The proprietor will prepare a maintenance plan for the long-term maintenance of the stormwater system. The proprietor shall enter into a Stormwater Management Operations and Maintenance Agreement with the local city, village, or township for the continued maintenance of the stormwater system. An example of a Stormwater Management Operations and Maintenance Agreement can be found in the Appendix G. The Agreement must describe the mechanism to be established for long-term maintenance of the stormwater management system, and the responsible government agency for maintenance oversight if maintenance is to be performed by a private entity. An executed copy of the Agreement shall be submitted to the WRC prior to approval of the permit.

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

Permit Requirements

a. The review application and application fee, appropriate permit fee and inspection deposit must be submitted before the permit is issued. Permit fees are determined on a site-specific basis.

b. A notice of 48 hours must be given to the Water Resources Commissioner's Inspection Department prior to any construction affecting the drain. In the event that our Inspection Department is not notified as stipulated herein the entire inspection deposit will be forfeited.

c. Flow shall be maintained in the drain at all times during construction.

d. All work shall be completed in accordance with the plans and specifications approved by the Water Resources Commissioner.

e. A cash deposit in an amount satisfactory to the Water Resources Commissioner to cover WRC inspection services shall be deposited to insure satisfactory completion of the project in accordance with the approved plans. The permittee shall contact the Water Resources Commissioner to perform an inspection of the permitted activity. Failure to contact the WRC for inspection of the work will result in forfeiture of all deposit money.

f. The contractor performing the work must have current cash and surety bonds with the WRC.

g. Work performed on the County Drain or its appurtenances must be performed in accordance with the Water Resources Commissioner's Storm Drain Notes and Details Sheet.

h. A drain permit issued by the Water Resources Commissioner's Office will not relieve the applicant and/or his contractor of the responsibility of obtaining permits, approvals or clearances as may be required from federal, state or local authorities, the public utilities and private property owners.

i. An as-built plan of the drain involvement must be submitted.

j. The Water Resources Commissioner shall be notified in writing within ten days of the completion of a project so that a final inspection of the permitted work can be performed.

k. All permit requirements must be completed prior to the Water Resources Commissioner refunding any remaining inspection deposit money.

l. A permit shall expire when work has not commenced within one year of the date of issuance. The Water Resources Commissioner may extend the permit for a period of time upon the request of the Owner/Developer in writing.

m. The Water Resources Commissioner may revoke a permit if there is a violation of the conditions of the permit or if there is a misrepresentation or failure to disclose relevant facts in the application.

n. A drain permit is separate from a Soil Erosion Control Permit.

Drainage Districts and Easements

County Drain Drainage District limits must be followed when designing the site. Drainage Districts do not necessarily conform to existing topography. If drainage originating outside of a certain district is discharged within the district, a revision to the drainage district boundaries will be required. Contact the Water Resources Commissioner's office regarding this process.

Drains constructed prior to 1956 may not have a recorded easement. However, the easement exists in the permanent records at the Water Resources Commissioner's office. At that time easements for drainage purposes were not required to be recorded with the County Clerk; it was legally sufficient to have them on file at the drain office. Therefore, it may be necessary to record a new County Drain easement, depending upon the work that is proposed, and the County Drain involved. If a new easement is required, contact the Water Resources Commissioner's Office regarding this process.

Part H: Operations and Maintenance

Long-term Operations and Maintenance (O&M) Plans are required for County and Non-County Stormwater Systems directly connected to a County Stormwater System as summarized below. To facilitate routine inspections, all O&M requirements and documents listed below shall be incorporated into the plan set on dedicated O&M-specific plan sheets. When O&M responsibilities or requirements are modified or updated, the respective O&M Plan sheet(s) shall be updated accordingly.

County and Non-County Stormwater Systems

The following MS4 Permit O&M requirements apply to all regulated County Stormwater Systems owned, operated, and maintained by WRC's office, the Oakland County Parks and Recreation Commission and the County of Oakland, hereafter referred to as County Departments and all regulated Non-County Stormwater Systems owned, operated, and maintained by others, which directly connect to a County Stormwater System:

A WRC approved O & M Plan Sheet, fully executed Stormwater Management O&M Agreement and recorded Memorandum of Stormwater Management O & M Agreement, are required prior to issuance of the Drain Permit.

1. Prior to the start of any development activity meeting the site applicability criteria defined in Part C: Applicability, a Drain Permit shall be obtained from WRC's Permitting Department. Coordination with WRC's Permitting Department is recommended at the conceptual stage of development projects to ensure that permit requirements are clearly identified early in the planning process.

2. To ensure consistent perpetual O&M of the site's stormwater system and to enhance water quality protection, prior to Drain Permit issuance, WRC's Permitting Department shall review and approve the site-specific Stormwater Management O&M Agreement between the community and property owner. A fully executed Stormwater Management O&M Agreement is required prior to issuance of the Drain Permit. This agreement shall consist of the following requirements which will be incorporated into the O&M Plan sheet(s):

    a. Legal Description: A legal description and reduced copy map to identify the land parcel(s) affected by this Agreement. This map shall be prepared for each site and must include a reference to a Subdivision Plat, parcel survey, or Condominium Master Deed, and a map to illustrate the affected parcel(s).

    b. Stormwater System Description and Map: A description of the stormwater system and its individual components and a location map of the entire stormwater system. This map must be prepared for each site and the scale of the map shall show necessary detail.

    c. Stormwater O&M Plan Sheet(s): The site-specific Stormwater O&M Plan shall include the following requirements:

        - Property information and property owner.
        - Brief description of the stormwater system, drainage area, and its individual components.

- Description of maintenance responsibility and manner of ensuring maintenance responsibility, such as employee and contractor O&M training requirements, certifications, and responsibilities.
- O&M Matrix (see table below)
    - Specific short-term, intermediate, and long-term maintenance tasks.
    - Inspection and maintenance tasks, frequencies, and responsibilities.
- BMP detail sheets and/or manufacturer specifications
- Approved construction drawings including stormwater calculations, details, elevations, a location map, and engineer's certification of construction.
- Land use summary table (see Part I of this section for table of submittal requirements).
- The O&M plan must be approved and signed by a certified person. The following certifications are approved by WRC: Professional Engineer (PE), National Green Infrastructure Certification Program (NGICP) by WEF, Construction Storm Water Operator (CSWO) certification by EGLE, or Certified Stormwater Manager (CSM) by American Public Works Association (APWA).

Example Operations and Maintenance Matrix

Maintenance Activities	Frequency	Stormwater Management Practices								
		Forebay	Inlet Structure	Bioretention Practices (bioswales, rain gardens)	Pavement Areas	Permeable Pavement	Subsurface Detention	Surface Detention	Catch Basins	Outlet Structure
Inspect for Trash, litter and/or debris accumulation	12 times per year									
Inspect For Floatable, Dead Vegetation, and Debris	12 times per year									
Overgrown vegetation that interferes with access, line of sight or safety	2-12 times a year									
Inspect all components during wet weather and compare to as-builts	2 times per year									
Inspect for sediment accumulation	2 times per year									
Vacuum/street sweeping	2 times per year									
Erosion stabilization/control	1 time per year									
Remove and replace dead vegetation	1 time per year									
Remove floatables, dead vegetation and debris	1 time per year									
Sweeping of paved and pervious pavement surfaces	As Needed									
Replacement of mulch layer and top 6 inches of bioretention soil	1 time every 2-3 years									
Fertilization for first year of vegetation	1 time initially									
Remove accumulated solids by vactoring	2-4 times per year or as recommended by vendor									

Repair and Replacement	Frequency									
Replace fill material for permeable pavement	As Needed									
Structural repairs	As Needed									
Structural replacement	As Needed									
Wildlife management	As Needed									
Replace stone filter material around outlet structure	Every 3 to 5 years									

Note(s):

Mechanical separators follow the manufacturer's guidelines for operation and maintenance.

d. Annual Stormwater System O&M Summary: Property owners and Individual County Departments are responsible for completing all O&M tasks and maintaining O&M records for their stormwater systems. Property Owners and County Departments shall submit an Annual Stormwater System O&M Summary to WRC's Permitting Department for tracking only. The community is responsible for enforcement of the O&M requirements as outlined in the Stormwater Management O&M Agreement and their MS4 permit. The summary shall include the following:

    - Property information and property owner.
    - Description of the stormwater system, drainage area and its individual components.
    - Description of maintenance responsibility.
    - O&M matrix filled out for each stormwater management practice with inspection date, inspector, field notes, and signed certification of qualified inspector.
    - Maintenance or repairs needed for each stormwater management practice.
    - Maintenance or repairs completed to date for each stormwater management practice.

e. Memorandum of Stormwater Management Operations and Maintenance Agreement: This O&M Memorandum acknowledges a perpetual requirement of stormwater system operations and maintenance, which must be recorded with the Register of Deeds to put any future property owners, or interest holders, on notice of the Stormwater System and the Stormwater O&M Plan. This O&M Memorandum references the required Stormwater Management O&M Agreement, which resides with the local community to ensure consistency and periodic updates as necessary. A copy of the recorded document shall be submitted to WRC prior to closure of the Drain Permit.

Appendix G - Stormwater Management O&M Agreement is an approved **"**example" agreement, however, WRC's office recognizes that community-specific O&M agreements, ordinances and programs may also be proposed and submitted to OCWRC for approval. When developing alternative O&M programs for consideration, the community should reference EGLE's Post-Construction Stormwater Runoff Controls Program Compliance Assistance Document (available on EGLE's website) and their MS4 permit.

Part I: Stormwater Tracking & Mapping

Collecting data on site runoff characteristics is critical for WRC and the local review jurisdiction (if applicable) to meet ongoing EGLE MS4 permit requirements. This will be accomplished with a ***Land Use Summary Table***, which must be included on the O&M Plan Sheet of each submitted site plan (see table below). Additionally, GIS-based site data (in the form of a shapefile) will be required as a condition of site plan approval. GIS data will be limited to key stormwater components that will require future inspection and maintenance.

Land Use Summary

must be included on the O&M Plan Sheet for all site plans

	Characteristic	Existing Conditions	Proposed Conditions
Land Use Data	**Total Development Area (ac)**		
	Impervious Area (ac)		
	Total Pervious Area (ac)		
	Pervious Area Breakdown by Cover Type		
Pervious Area			
	Meadow/fallow/natural areas (non-cultivated)	x.xx acres	x.xx acres
	Predominant NRCS Soil Type (A, B, C, or D)		
	Improved areas (turf grass, landscape, row crops)	x.xx acres	x.xx acres
	Predominant NRCS Soil Type (A, B, C, or D)		
	Wooded Areas	x.xx acres	x.xx acres
	Predominant NRCS Soil Type (A, B, C, or D)		
	CPVC Volume ***Calculated*** (cubic feet)		
	CPVC Volume ***Provided*** (cubic feet)		
	CPRC Volume Provided (cubic feet)		

The Professional Engineer who signs and seals this site plan certifies that the values in this table reflect the OCWRC stormwater calculations required for this development and that geotechnical investigations were performed that provide conclusive documentation that demonstrates whether infiltration (i.e., CPVC Volume Control) is practicable.

Notes:

- *The Professional Engineer Certification Statement (see above) must be included with the Land Use Summary Table.*
- *Areas to be shown to the nearest 0.01 acre*
- *'Predominant' soil type shall the soil type with the largest percentage coverage over the designated land use (e.g., 70% Soil Type B and 30% Soil Type C shall be listed in the table as "Soil Type B")*
- *USDA soil types cannot be used to determine site suitability for infiltration and meeting the CPVC volume standard; direct infiltration testing will be required to determine site suitability for infiltration*
- *If CPVC requirement is waived, enter ZERO for the 'CPVC Volume Provided'*
- *When more than one soil type exists in one area, assign the predominant soil type for that area*
- *Use NRCS/USDA Online Soil Survey Map to determine soil type (A, B, C, or D):*

Submitting GIS data is a new, but important, requirement; it allows for the development of a database for WRC and municipalities to track the location of stormwater BMPs for future inspection and enforcement activities

https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

In addition to the Land Use Summary table, the applicant must include the following stormwater system information in the submittal:

A final component of the site plan review process is the submittal of a GIS shapefile containing, at a minimum, the layers listed below, which consist of points and polygons that reflect the key components of the stormwater system. This information will be provided only after the technical review is completed. The GIS shapefile must reflect the final approved design and include the following layers (use the layer naming conventions listed below for ease of storing and tracking the GIS data):

1. Development Site – Area (ac), GIS area **polygon** (DSA-1, DSA-X)
    a. This area should reflect the entire area for which the stormwater system is designed
2. Site Discharge Point(s), GIS **points** (D-1, D-2, etc.)
    a. These points should reflect the location of each site discharge point; this is typically the point of connection to a County Drain, city storm sewer, or other drainage feature downstream of the detention basin discharge structure
3. Dry Detention Basins, GIS area (ac) **polygons** (DBASIN-1, etc.)

   a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer

4. Wet Detention Basins, GIS area (ac) **polygons** (WBASIN-1, etc.)
   a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer
5. Retention Basins (no outlet), GIS area (ac) **polygons** (RBASIN-1, etc.)
   a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer
6. Sediment Forebays, GIS area (ac) **polygons** (Forebay-1, etc.)
   a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer
7. Mechanical Separators, GIS **points** (MS-1, etc.)
   a. The points can be placed at a maintenance access point for each structure. If multiple mechanical separator units are proposed, create a point for each unit.
8. Bioretention/Bioswales– GIS area (ac), GIS **polygons** (BR-1, etc.)
   a. The polygon should reflect the bioretention footprint including any maintenance or safety buffers
9. Porous Pavement – GIS area (ac), GIS **polygons** (PP-1, etc.)
10. Cisterns/Rain Barrels, GIS **points** (RB-1, etc.)

Part F: Chapter 18 Drains

Chapter 18 Drains are new developments within Oakland County where the local municipality has passed an ordinance that requires all residential and certain commercial drainage systems to be established as County Drains in accordance with the provisions of Section 433, Chapter 18 of the Public Acts of 1956, as amended, the Michigan Drain Code. At present, Oakland and West Bloomfield Townships each have such an ordinance. Please refer to Section IV, “Establishing a Chapter 18 Drain” for additional information.

Section III General Design Criteria

Part A: Determination of Surface Runoff

Rational Method

The Rational Method assumes uniform rainfall intensity and is best suited for small or individual sites and can be used for sizing swales, open channels, enclosed drains, BMP volumes, manufactured stormwater treatment systems and culverts. For site design purposes, the Modified Rational Method will be used, which takes into consideration both land use and soil types. The Modified Rational Method will be used to determine flows for the 1-year, 10-year and 100-year storm events. The 1-year storm will be used to size manufactured stormwater treatment systems, flows into individual BMP's, and the Water Quality Volume (V_{WQ}). The Modified Rational Method is defined as follows:

Eq. III-1	$Q = C \times I \times A$
Q =	Peak Runoff (ft^3/s)
C =	Composite Runoff Coefficient for the Drainage Area
I =	Average Rainfall Intensity (in/hr).
A =	Drainage area (Acre)

Coefficient of Runoff

A representative coefficient of runoff, (C), will be used based upon the imperviousness of the contributing acreage. The range of this coefficient may vary from 0.15 to 1.00. The runoff coefficient calculation must be included with on the drainage breakup sheet with the submittal. Certain calculations require a composite runoff coefficient value. A composite runoff coefficient is calculated as follows:

C Values		
Green Space	HSG A	0.15
	HSG B	0.20
	HSG C	0.25
	HSG D	0.30
Impervious Areas		0.95
Water		1.00

*HSG = Hydrological Soil Group

Eq. III-2	$C = \frac{\sum_{i=1}^{n}(A_i \times C_i)}{\sum_{i=1}^{n} A_i}$
C =	Composite Runoff Coefficient for the Drainage Area
n =	Total number of sub-areas
C_i =	Runoff coefficient for each sub-area
A_i =	Drainage area for each sub-area (Acre)

Modified Rational Method

The Modified Rational Method will be used to calculate many of the required volumes. The value 3630 is a constant to convert the (inch)(acre) to ft^3 [1-inch = 1/12 ft; 1-acre = 43,560 ft^3]. The modified rational method is used to calculate the water quality volume (V_{WQ}), the Channel Protection Volume (V_{CP-R}), the Forebay Volume (V_F), the Extended Detention Volume (V_{ED}), and the 100-Year Storm Volume (V_{100R}).

Eq. III-3	$V = 3{,}630\ x\ P\ x\ C\ x\ A$
V =	Required volume in cubic feet
P =	Precipitation depth in inches
C =	Post-development composite runoff coefficient
A =	Contributing area in acres

Rainfall Depths

Rainfall depths used within the Modified Rational Method to calculate the required volumes are:

	Rainfall Depths (inch)	
90th percentile storm (1-inch) for Water Quality	P_{wq}=	1.00
1.30-inch for Channel Protection Volume Control	P_{cpvc}=	1.30
1.90-inch for Channel Protection Rate Control-Extended Detention	P_{cprc}=	1.90
15 percent of the Water Quality Volume for the Forebay	P_{fb}=	0.15
10-year 24-hour storm for Conveyance	P_{10} =	3.41
100-year 24-hour storm for Flood Control	P_{100}=	5.40

Time of Concentration

The time of concentration (T_c) is the time required for water to travel from the hydraulically most remote point of the drainage sub-area to a design point. The T_c is used in the Rational Method to estimate peak flow for sizing storm sewer systems, or for applying unit hydrographs and NRCS curve number methods to generate and route runoff hydrographs for sizing storm sewer systems and stormwater controls.

When determining the time of concentration for a pipe network, an initial time of concentration of 20 minutes for the farthest upstream inlet will be used for residential developments and 15 minutes for commercial or industrial developments. For sites less than 5 acres, an initial time of concentration of 10 minutes will be used.

When determining the time of concentration for a pipe network, an initial time of concentration of 20 minutes for the farthest upstream inlet will be used for residential developments and 15 minutes for commercial or industrial developments. For sites less than 5 acres, an initial time of concentration of 10 minutes will be used. The time of concentration is calculated using travel time for the 10-year discharge through the system where Manning's equation is used to compute velocity.

Eq. III-4	$T_t = \frac{\mathrm{L}}{3{,}600v}$
Tt =	Travel time in hours
L =	Flow length in feet
v =	Average velocity in feet/second as determined by Manning's equation for pipe flow

Eq. III-5	$v = \mathrm{K} \times \mathrm{S}^{1/2}$
v =	Average velocity in feet/second
S =	Slope of flow path in percent
K =	Coefficient *K* = 0.48 for Sheet Flow *K* = 1.20 for Swales or Shallow Drainage Course *K* = 2.10 for Ditches and Watercourses

Eq. III-6	$T_c = \frac{\mathrm{L}}{60V}$

T_C =	Time of concentration in minutes
L =	Flow length in feet
V =	Flow velocity in feet/second

For overland flow, the velocity is calculated for each of the flow characteristic types present along the longest flow path across the drainage area.

Rainfall Intensity

The rainfall intensity used for stormwater design is based on NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 8 Version 2: Midwestern States, including Michigan, based on the average of the Pontiac WWTP, Troy-Rockwell, Eastpointe, Washington, Howell WWTP, Detroit Metro AP, and Wayne-Canton stations. This regional rainfall data average was then converted into an IDF curve equation used for all storm return periods for ease of use.

Eq. III-7	$I = \frac{30.20p^{0.22}}{(T_c + 9.17)^{0.81}}$
I =	Average rainfall intensity in inches/hour
p =	Design storm return period in years
T_C =	Time of concentration in minutes

Regional* 24-Hour Average Rainfall Amounts

Storm Event	Rainfall Amount (inch)
1 Year	2.07
2 Year	2.38
5 Year	2.87
10 Year	3.32
100 Year	5.23
* Region includes Livingston, Macomb, Oakland and Wayne counties	

Part B: Stormwater Conveyance

Stormwater conveyance systems may consist of open ditch drains, swales, closed conduits or a combination of methods to convey stormwater. Design and construction of stormwater conveyance will follow WRC's specifications, as a minimum. Other more stringent standards such as: Michigan Department of Transportation, Road Commission for Oakland County, or local community, shall also be followed.

For work involving County Drains, please refer to WRC construction specifications, available from WRC's website, for approved construction materials.

Drainage Structures

The flows to specific catch basin or inlet covers shall conform to the following:

1. Combination curb and gutter inlet (MDOT Cover K, or equivalent): A maximum of 3.1 ft^3/sec at 0% grade (sump condition), and then decreasing as grade increases.
2. Gutter inlet (MDOT Cover D, or equivalent): A maximum of 3.2 ft^3/sec as 0% grade (sump condition), and then decreasing as grade increases.
3. Rear yard or ditch inlet (MDOT Beehive Cover E, or equivalent): In general, a maximum of 2.5 ft^3/sec at 0% grade (sump condition), and then decreasing as grade increases. However, a smaller or larger maximum inflow may be allowed as is warranted by surrounding finished grading.

Drainage inlets or manholes shall be located as follows:

1. To assure complete positive drainage of all areas of the site.
2. At all low points of streets and rear yards. Runoff shall not flow across a street Intersection.
3. Maximum of 600 feet of drainage from any developed point on the site to a structure or BMP.
4. Manholes shall not be spaced more than 400 feet apart for pipes less than 48" in diameter. Longer pipe runs may be allowed for larger sized pipe, but in all cases maintenance access must be determined to be adequate.
5. Any change in pipe direction requires a manhole or catch basin.
6. All materials will be of such quality as to guarantee a maintenance-free expectancy of at least 50 years and will meet all applicable A.S.T.M standards.

Outlet velocities greater than 5 ft/sec will require energy dissipation measures.

Stormwater Outlets

1. The velocity at a pipe outfall should be no greater than 10 ft/sec to prevent scouring. Outlet velocities greater than 5 ft/sec will require energy dissipation measures.

2. Riprap shall be installed at all outlets according to the Oakland County Water Resources Commissioner's Storm Drain Notes and Details Sheet.
   a. Riprap may consist of minimum 8" diameter to 15" diameter fragmented limestone or other suitable rock set on a stone bedding underlain with geotextile fabric. Larger diameter outlets may require larger riprap as velocity and flow conditions dictate.
   b. Cobblestone, broken concrete, or grouted riprap are not acceptable.
3. A bar screen is required for all pipe outlets and inlets 18" diameter and larger.
4. Outlets to open channels shall be installed at the bottom of the open channel with headwalls or flared end sections.

Enclosed Storm Drains

An enclosed storm drain system must be designed to accommodate the storm water runoff from a 10-year storm event from the site and any offsite contributing runoff. The Manning Equation (Eq. 8) will be used to check the pipe size.

Eq. III-8	$Q_{10} = \frac{1.486}{n} \; x \; A_{pipe} \; x \; R^{2/3} \; x \; s^{1/2}$
Q_{10} =	10-year flow rate cubic feet/second
n =	Manning coefficient of roughness (See Table Below)
A_{pipe} =	Cross-sectional area of pipe
R =	Hydraulic radius of pipe (A_{pipe}/P) in feet
P =	Wetted perimeter in feet
s =	Pipe slope (ft/ft)

n value based on pipe material	
n value	Pipe Material
0.013	smooth concrete pipe
0.013	approved flexible pipe (plastic)
0.025	unlined corrugated metal pipe

*Refer to WRC specification "Materials- Storm Drain" for approved pipe materials for County Drains

1. The hydraulic grade line is calculated for the entire system with an assumed downstream elevation of 0.80 x diameter of the outlet pipe or the permanent pool elevation, whichever is greater.
2. The enclosed storm drain should be designed to flow full, i.e. with a hydraulic grade line at or near the top of pipe. The pipe will be allowed to surcharge in certain circumstances, but the peak hydraulic grade line must be a minimum of one (1) foot below grade.

3. The minimum pipe size for storm drains accepting surface runoff is 12" diameter.
   a. Rear yard pipes or sump pump collector pipes may be smaller, but must be used in conjunction with a drainage swale that directs runoff to a minimum 12" diameter pipe structure.
4. Pipe joints shall have premium rubber gaskets designed to prevent excessive infiltration.
5. Storm drains shall be designed flowing full to have a minimum velocity of 2.5 ft/sec and a maximum velocity of 10 ft/sec.
6. The minimum depth of pipe shall be 42 inches from grade to the springline (i.e. horizontal midpoint) of the pipe.
7. In areas where local ordinance requires sump pump leads to be connected into an enclosed system, these taps shall be made directly into storm sewer structures or into cleanouts.

Open Watercourses

1. Appropriate permits from agencies such as the Michigan Department of Environment, Great Lakes, and Energy (EGLE) must be obtained and submitted to the WRC's office.
2. The SCS method, Rational Method, or other prior approved method will be used to determine the amount of flow contributing to the watercourse. All watercourses must be sized to accommodate the runoff from a 10-year storm event. WRC's office will use the Manning Equation (EQ. 8). to check the capacity of the watercourse. The appropriate values for "*n*" are as follows:

n Value Based on Open Channel Conditions	
n value	Channel Condition
0.025-0.030	Maintained grass channel, rear yard swales
0.030-0.035	Natural channels, some grass and weeds, little or no brush
0.035-0.050	Dense growth of weeds, depth of flow greater than weed height
0.035-0.050	Some weeds, light brush on banks

3. Open channel flow velocities shall be neither siltative nor erosive. In general, the minimum acceptable non-siltative velocity will be 2.5 ft/sec.
4. Erosion protection shall be placed at bends, drain inlets and outlets, and other locations as required in all open ditches.
5. Side slopes of channels shall be no steeper than 1 foot vertical to 3 feet horizontal, unless fencing is provided. Ditches with steep grades shall be protected by sod, vegetation or other means to prevent scour.
6. All bridges shall be designed to provide a 2-foot minimum 100-year flood stage freeboard to the underside of the bridge. The bridge footings shall be deep enough to be below the frost line and to

allow a 5-foot channel deepening. Bridge footings and columns may not be located within the open channel.

7. Areas within open drain rights-of-way, which have been cleaned, re-shaped or in any manner disturbed shall be seeded and mulched, sodded or re-vegetated with other plant materials.

Determination of Culvert Size

All culvert design calculations must be submitted to this office for review. Culverts serving an upstream watershed equal to or greater than two square miles will also require an EGLE permit (Part 31 of Water Resources Protection Act, Public Act 451 of 1994, as amended). Calculations must be sealed by a Professional Engineer and must include:

1. Delineation on a topographic map of the area contributing to the culvert.
2. Hydrologic calculations to determine the flow.
3. Hydraulic calculations used to determine the size of the culvert.
4. Calculations for depth of cover and expected loads.
5. When an existing culvert is proposed to be modified, backwater calculations and/or downstream calculations may also be required for review.
6. This office will use the Rational Method, SCS Method, or other prior approved method to determine the flow contributing to the culvert. Culverts are sized to pass a minimum 10-year storm event or the governing design storm of the watercourse, whichever is greater.
7. The velocity within the culvert shall be neither siltative nor erosive.
8. The Manning Equation or inlet headwater control or outlet tailwater control nomographs will be used to check the culvert design.

Part C: Channel Protection Volume Control

Both onsite water quantity and quality must be managed to control flooding, reduce downstream erosion and protect water quality. Channel Protection Volume Control shall be implemented to the Maximum Extent Practicable (MEP), and in general, should follow the guidelines recommended by SEMCOG Low Impact Development Manual for Michigan: A Reference Guide for Implementers and Reviewers and The City of Detroit: Stormwater Management Design Manual. Several non-structural and structural Best Management Practices (BMPs) are referenced within this Section.

Non-Structural BMPs

The use of Non-Structural BMPs is an important part of a project's stormwater management system. The following Non-Structural BMPs are self-crediting; use of these BMPs automatically provides a reduction in impervious area and/or stormwater runoff resulting in a lessor runoff coefficient, larger time of concentration, and lower peak flows. A corresponding reduction in the stormwater management requirements set forth by these rules occurs. Additionally, the use of these BMPs may be affected by other regulations/guidance (Master Plans, zoning, subdivision, etc.). These BMPs are strongly encouraged:

- Protect Natural/Special Value Features
- Protect/Conserve/Enhance Riparian Areas
- Protect/Utilize Natural Flow Pathways
- Preserve Open Space (e.g. clustering)
- Reduce Street Width/Area
- Reduce Parking Width/Area
- Minimize Disturbed Area (Cluster Developments)
- Protection of Existing Trees (part of minimizing disturbance)
- Re-Vegetate and Re-Forest Disturbed Areas
- Rooftop Runoff (downspout) Disconnection
- Disconnection of Impervious Areas (Non-Roof)

Structural BMP General Requirements

All runoff generated by a proposed development should be conveyed into a stormwater BMP facility for infiltration, evapotranspiration, and/or water quality treatment, to the MEP.

The following criteria will apply to the design of all stormwater BMPs:

1. Preform initial NRCS soil classification (from soil survey) and infiltration testing to determine the feasibility of infiltration practices and eliminate unsuitable areas.
2. In multi-ownership developments, locate BMPs facilities on common-owned property within an easement. BMPs facilities shall not be located on private lots, condominium units, or located within a County Drain, sewer, or water easements.

3. Infiltration/reuse BMPs are engineered to dewater surface water in 24-hours and completely within 72-hours from the end of a storm event. Dewatering is defined as having no excess stormwater from an event present in the BMP including both surface ponding and subsurface storage.

Infiltration BMPs should completely dewater in 72 hours including 24 hours for surface ponding and 48 hours for subsurface storage.

4. BMPs incorporating pumps are discouraged. In rare cases where pumping is justified, additional design provisions are required, including but not limited to backup power and gravity-based overflow routing.
5. A recommended horizontal distance of 4 ft and a minimum horizontal distance of 2 feet between the seasonal high-water table and bottom of infiltration facilities is required.
6. In areas where the infiltration rate varies across the development, the developer shall maximize the use of infiltration BMPs within areas of having the most favorable ($K_{sat} \geq 0.50$ inches/hour) soils.
7. Pre-treatment of all stormwater is required before entering a BMP facility to prevent premature failure of the system. Pre-treatment can be accomplished by the following:
    a. Vegetative Filter Strips
    b. Vegetative Swales
    c. System inlets with sumps
    d. Centralized infiltration BMPs (i.e. infiltration basins) pre-treatment consists of a forebay or manufactured treatment system
    e. Other methods of pre-treatment will be considered by this office on a case-by-case basis
8. The use of decentralized stormwater BMPs are preferred unless the developer can demonstrate that decentralized stormwater infiltration and/or Total Suspended Solids (TSS) removal is not practical.
9. A minimum of one infiltration test per proposed infiltration BMP location is required.
10. For large, centralized infiltration BMPs, exceeding 10,890 square feet (1/4 acre), multiple infiltration tests are required at a minimum of four tests per acre, rounded up. For example, a BMP with an area of 0.4 acre would require 2 infiltration tests.
11. The use of heavy equipment within infiltration areas should be avoided during construction to prevent compaction of soils. Locations of infiltration BMPs should be identified and sectioned off during construction to limit access.
12. Prior to installation of an infiltration BMP, the in-situ soils should be prepared by adding additional soil amendments (such as sand or compost) and/or through mechanical loosening of soil. Examples of mechanical loosening include rototilling or scarifying the soil with a long-toothed backhoe bucket. These techniques will improve infiltration underneath the infiltration BMP.
13. Generally, infiltration BMPs should be avoided in the following areas:
    a. In areas with compacted fill soils.
    b. In areas with high pollutant loads, including sites that receive constant sediment, trash, other debris, and places where chemicals are stored or handled.

c. In areas where it will be difficult to access the BMP, on a regular basis, for maintenance or cleaning.

d. In areas where materials, especially landscaping supplies, are stockpiled.

e. In areas there are routinely wet.

The required Channel Protection Volume Control (V_{CP-R}) is based on the 1.30-inch rain depth over the site using Eq. 9. The simplified form is:

Eq. III-9	$V_{CP-R} = 4{,}719\ x\ C\ x\ A$
V_{CP-R} =	Required CPVC volume in cubic feet
C =	Post-development composite runoff coefficient
A =	Contributing area in acres

Technical Infeasibility

For projects where technical infeasibility exists, the design engineer must document and quantify that stormwater strategies, such as infiltration, evapotranspiration, water harvesting and water reuse, have been used to the maximum extent possible and that implementation of these methods are infeasible due to site constraints and not economic considerations. The burden of proof of Technical Infeasibility lies with the design engineer. Documentation of technical infeasibility should include, but may not be limited to, engineering calculations, geological reports, hydrological analyses and site maps. A determination that the performance design goals cannot be achieved on the site should include analyses that rule out the use of an adequate combination of infiltration, evapotranspiration, and water use measures. Adequate documentation must be submitted to WRC for review and final determination. Examples of site conditions that may prevent the application of stormwater BMP's to the METF includes*:

The use of infiltration BMPs to the MEP is based on site constraints and not economic considerations.

1) The conditions on the site preclude the use of infiltration practices due to the presence of shallow bedrock, contaminated soils, high ground water or other factors, such as underground facilities, utilities or location of the development within a wellhead protection area.

2) The design of the site precludes the use of soil amendments, plantings of vegetation or other designs that can be used to infiltrate and evapotranspirate stormwater runoff.

3) Water harvesting and reuse are not practical or possible due to the volume of water used for irrigation, toilet flushing, industrial make-up water, wash-waters, etc. is insignificant to warrant the application of water harvesting and use systems.

4) Modifications to an existing building to manage stormwater are not feasible due to structural or plumbing constraints or other factors.

5) Sites where the site area is too small to accommodate adequate infiltration practices for the impervious area to be served.

6) Soils that cannot be sufficiently modified to provide reasonable infiltration rates.

7) Situations where site use is inconsistent with the capture and use of stormwater or other physical conditions on site that preclude the use of plants for evapotranspiration or bioinfiltration.

8) Retention and/or use of stormwater onsite or discharge of stormwater onsite by infiltration having an adverse effect on the site, gradient of surface or subsurface water, receiving watershed, or water body ecological processes.

9) Federal, state of local requirements or permit conditions that prohibit water collection or make it technically infeasible to apply LID practices.

* Adapted from EPA Section 438 Technical Guidance December 2009.

Infiltration Testing

The infiltration testing must provide information related to the conditions at the bottom of the infiltration BMP. General infiltration test guidelines are as follows:

1. Any test used to determine infiltration rates for BMPs, shall be performed at the location and extend to the bottom elevation of the proposed infiltration BMP.
2. Infiltration tests must not be conducted in the rain, within 24 hours of significant rainfall events (>0.5 inches), when the ground is frozen, or when the temperature is below freezing.
3. Infiltration tests should be conducted in the field.
4. All infiltration rates used for the design of BMPs must be certified by a Professional Engineer licensed in the State of Michigan and submitted to the WRC's office.
5. Following all testing, the surface must be restored.
6. Additional infiltration tests may be necessary due to subsurface variability, water table depth or topography. The WRC's office will determine if more tests will be required.

Infiltration tests may include, but not limited to, the following methods:

1. Test Pits used in conjunction with any of the infiltration tests listed below
    a. Double-ring Infiltrometer test – estimate for vertical movement of water through the bottom of the test area
        i. ASTM 2003 Volume 4.08, Soil and Rock (I): Designation D 3385-03, Standard Test Method for Infiltration Rate of Soils in Field Using a Double-Ring Infiltrometer
        ii. ASTM 2002 Volume 4.09, Soil and Rock (II): Designation D 5093-90, Standard Method of Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring
    b. Percolation tests – estimate for vertical movement of water through the bottom and sides of the test area

c. Encased falling head permeability test – estimate for vertical movement of water through the bottom of the test area

d. Guelph permeameter

e. Constant head permeameter (Amoozemeter)

2. When using test pits, a minimum of 2 infiltration tests are required per test pit.

3. Soil Borings

a. The use of soil borings to determine infiltration rates is discouraged. If soil borings are used in lieu of test pits, a safety factor of 2 is applied to the final K_{sat} value. This is due to the limited sample and the inability to test in-situ soil characteristics when preforming a soil boring.

Note: Other tests selected by the design engineer that can accurately represent the in-situ infiltration rate may be used at the discretion of this office.

The following infiltration (K_{sat}) values shall be used to determine the appropriate design methods for infiltration BMPs:

K_{sat} Values	
Ksat ≥ 0.50 in/hr	No supplemental measures are required for Infiltration BMPs to provide the infiltration volume
0.50 in/hr≥ Ksat ≥ 0.24 in/hr	Install supplemental measures, which may include subsoil amendment, or an underdrain placed at the top of the storage bed layer to ensure dewatering in the event underlying soils fail to provide adequate drawdown or dewatering time. If underdrains are selected, design shall allow stormwater to percolate through the soils first, with the underdrain serving as a secondary outlet, by placing the underdrain in the upper level of the BMP, with pipe perforations located along the underdrain invert.
Ksat ≤ 0.24 in/hr	***Soils are not suitable for infiltration. Alternative volume reducing LID practices must be used to the MEP to reduce stormwater volume.***

BMP Volume Calculations

The most practical way to reduce stormwater runoff is to incorporate infiltration based structural BMPs. Infiltration based BMPs include bioretention basin/rain garden, vegetated bioswales, porous pavement, infiltration basins, subsurface infiltration beds, dry wells, and infiltration trenches. These BMPs share the common feature of storing stormwater on the surface or in a subsurface matrix and allowing the water infiltrate over a period of 24 to 48 hours depending on the BMP. For BMPs that incorporate vegetation, stormwater runoff is also reduced through evapotranspiration. Other structural BMPs, such as vegetated roofs and water harvesting / reuse systems can also provide volume reduction and be used to meet the Channel Protection Volume Requirement (V_{CP-R}) The basic calculations for the V_{CP-R} achieved for BMPs are as follows:

Bioretention Basin/Rain Garden

The Infiltration Area is the average area of a Bioretention Basin or Rain Garden is defined as:

Eq. III-10	$A_t = \frac{A_1 + A_2}{2}$
A_t =	Average infiltration area in square feet
A_1 =	Area of bioretention at ponding depth in square feet
A_2 =	Bottom bioretention surface area in square feet

Volume Calculations

The storage volume of a Bioretention Basin or Rain Garden is defined as the sum of surface storage, subsurface void space within the engineered soil media and/or stone layer, and the infiltration volume occurring during a six-hour period. The infiltration volume is calculated using the in-situ infiltration rate of the underlying soils.

Eq. III-11	$V_{ss} = A_t \; x \; H$
V_{ss} =	Surface storage volume in cubic feet
A_t =	Average infiltration area in square feet
H =	Maximum BMP ponding depth in feet

Eq. III-12	$V_{subsurface} = (h_{soil} \; x \; e_{soil} + h_{stone} \; x \; e_{stone}) \; x \; SA$
$V_{subsurface}$ =	Storage volume in the soil and/or stone layer in cubic feet
h_{soil} =	Engineered soil depth in feet
h_{stone} =	Stone depth in feet (if stone is present)
SA =	Bottom surface area in square feet
e_{soil} =	Void ratio of engineered soil (unitless)
e_{stone} =	Void ratio of stone (unitless) (if stone is present)

Eq. III-13	$V_i = \frac{K_{sat} \; x \; S_f \; x \; 6 \; x \; A_t}{12in}$
V_i =	Infiltration volume in cubic feet during a six hour period
K_{sat} =	Infiltration rate in inches/hour
S_f =	K_{sat} safety factor
A_t =	Average infiltration area in square feet

Eq. III-14	$V_{tbr} = V_{ss} + V_{subsurface} + V_i$
V_{tbr} =	Total bioretention volume in cubic feet
V_{ss} =	Surface storage volume in cubic feet
$V_{subsurface}$ =	Storage volume in the soil and/or stone layer in cubic feet
V_i =	Infiltration volume in cubic feet

Bioswale

Bioswales are linear bioretention basins that convey stormwater in addition to providing infiltration. If check dams are utilized within the bioswale, the volume behind each check dam can be estimated from the following:

The infiltration volume for Bioswales can be calculated using the Bioretention/Rain Garden equations. (EQ 10 through 14)

Eq. III-15	$V_t = 0.5\ x\ L_{swale}\ x\ H_{swale}\ x\ \frac{W_t + W_b}{2}$
V_t =	Storage volume in cubic feet
L_{swale} =	Length of swale in feet
H_{swale} =	Depth of swale check dam in feet
W_t =	Top width of swale check dam in feet
W_b =	Bottom width of swale check dam in feet

Infiltration Basin/Trench

Infiltration area and volume calculations are the same as for Bioretention BMPs.

Porous Pavement

The infiltration area and volume calculations are the same as bioretention BMPs. However, the reservoir layer is the layer of open-graded stone beneath the pavement layer and there is no surface storage. Use Eq. 16 to calculate the volume in the stone using H as the thickness of the open-graded stone below the pavement. For the infiltration volume (V_i see above Eq. 15).

Eq. III-15	$V_t = 0.5\ x\ L_{swale}\ x\ H_{swale}\ x\ \frac{W_t + W_b}{2}$
V_t =	Storage volume in cubic feet
L_{swale} =	Length of swale in feet
H_{swale} =	Depth of swale check dam in feet
W_t =	Top width of swale check dam in feet
W_b =	Bottom width of swale check dam in feet

Eq. III-16	$V_{tpp} = V_{stone} + V_i$
V_{tpp} =	Total pervious pavement volume in cubic feet
V_{stone} =	Stone storage volume in cubic feet
V_i =	Infiltration volume in cubic feet

Vegetated Roofs

Vegetated roofs, also known as green roofs or living roofs, are very effective as reducing rooftop runoff from small to medium sized storm events. Vegetated roofs reduce volume by intercepting rainfall in a layer of growing media and/or in a retention layer. The water is then evapotranspirated back into the atmosphere. Volume reduction credit for a vegetated roofing system will be evaluated on a case-by-case basis since most vegetated roofing systems are proprietary.

Water Reuse

Water reuse consists of storage vessels, such as cisterns, which store a specified volume of stormwater runoff and release (reuse) the runoff volume for onsite irrigation or internal uses such as industrial water or sanitary systems. The total aggregate storage volume credit shall be equal to the total storage volume of all storage vessels identified in the site plan that also include a documented reuse plan. The reuse plan demonstrates how the stored water will be used in between rain events such that the storage vessels are ready to receive stormwater runoff from the next rainfall event.

The consideration of other volume reducing BMP's will be evaluated by OCWRC on a case-by-case basis.

Part D: Water Quality Control

All detention and retention basins shall have a sediment forebay, manufactured treatment system, or BMPs upstream to treat the water quality volume entering the flood control basin. Water quality devices must be installed to treat all incoming flow into the basin. If there is no stormwater detention requirement, water quality treatment is still required to reduce Total Suspended Solids (TSS) concentrations to a maximum of 80 mg/L, or a 80% TSS removal before discharging from a site.

Water quality treatment is automatically achieved if Channel Protection Volume Control requirements are met.

The Water Quality Volume can be calculated as follows

Eq. III-17	$V_{wq} = 3{,}630 \times C \times A$
V_{wq} =	Water Quality volume in cubic feet
C =	Composite runoff coefficient
A =	Contributing area in acres

The Water Quality Rate is used to design Manufactured Stormwater Treatment Systems and can be calculated using the following equation:

Eq. III-18	$Q_{wq} = C \times A \times \frac{30.20}{(Tc + 9.17)^{0.81}}$
Q_{wq} =	Water Quality rate in cubic feet per second
C =	Composite runoff coefficient
A =	Contributing area in acres
Tc =	Time of concentration in minutes

Manufactured Stormwater Treatment Systems

Manufactured stormwater treatment systems (MSTS) are used to remove sediment and other particulate matter from stormwater runoff. However, they are not to be used for soil erosion control during construction. The following are requirements for manufactured treatment systems:

1. MSTS must be installed upstream of the stormwater detention system. If the site is not required to provide stormwater detention, a manufactured treatment system must be installed upstream of the connection to the receiving system.
2. The MSTS shall be designed off-line to allow continuance of flow in the event the manufactured treatment system becomes obstructed.
3. Calculations for sizing mechanical treatment devices shall be based on the following:
   a. The 1-year peak flow rain event (2.07" rainfall) using the Modified Rational Method as shown in Eq. III-3.
   b. Site specific time of concentration (T_c) and associated rainfall intensity (I)
   c. The area shall include all post-developed, disturbed areas contributing to the MSTS.
   d. Tributary areas to volume reducing BMPs, located within the overall contributing drainage area to the manufactured treatment system, may be subtracted from the manufactured treatment system's contributing drainage area for design purposes.
4. The MSTS shall conform to the standards set forth and certified by the New Jersey Department of Environmental Protection (NJDEP) for manufactured treatment systems, as defined at http://www.njstormwater.org/treatment.html, including offline use, manhole diameter size, and custom or multiple units.
5. The NJDEP certified treatment flow rate (cfs) for a manufacturer and model shall be higher than the calculated peak discharge for a particular site and documentation of how the MSTS meets the WRC water quality control standards shall be submitted.
6. Please refer to WRC construction specifications for approved manufacturers of manufactured treatment systems installed on County Drains.

When using manufactured treatment systems, Extended Detention is still required for rate control.

Forebay Design

The purpose of the forebay is to capture and collect silt, trash and debris into one area, and prevent sediment buildup in the main flood control basin., The forebay shall be a separate basin, which can be formed within the flood control basin by constructing a separation with an earthen berm, concrete retaining wall or other divider.

The required forebay volume (V_F) is the based on the 0.15-inch rainfall using the Modified Rational Method (Eq. III-3). Please note that the design criteria below is for the permanent forebay and not for a sediment forebay used for soil erosion control during construction.

The volume of the forebay may be credited towards the total stormwater detention volume for the site.

Eq. III-19	$V_F = 545\ x\ C\ x\ A$
V_F =	Forebay volume in cubic feet
C =	Composite runoff coefficient
A =	Contributing area in acres

When calculating the volume of an irregularly shaped basin or forebay the WRC's office will use Eq. III-20 for calculating the volume of a frustum of a circular cone. The procedure consists of determining the volumes of successive layers of frustums, and then summing these volumes to obtain the total volume of the basin.

Eq. III-20	$V = \frac{H_1}{3}(A_1 + A_2 + (A_1\ x\ A_2)^{\frac{1}{2}}$
V =	Forebay volume in cubic feet
H_1 =	Difference in depth between two successive depth contours feet
A_1 =	Area of the basin within the outer depth contour being considered in square feet
A_2 =	Area of the basin within the inner depth contour being considered in square feet

1. The forebay shall be designed to dewater using the same number of orifices required for the extended detention volume.
2. A permanent standpipe with gravel filter is required for the forebay outlet control structure.
3. The forebay should have a sump at a minimum of 2 feet below the outlet to capture sediment and prevent resuspension of sediment. The bottom of the basin should slope toward the sump area to capture the sediment.
4. The forebay should also have a fixed sediment depth marker to measure the amount of sediment that has accumulated. The sediment should be removed when half of the sediment storage capacity has filled in.
5. The forebay is designed with the same general considerations given to Detention Basins. See Part G: Detention & Flood Control Facilities

Part E: Channel Protection Rate Control: Extended Detention

A portion of the flood control storage volume is designated the Extended Detention Volume (V_{ED}). The V_{ED} is intended to control approximately a 2-year rate (1.90" rainfall) to the MEP to protect channels from erosive release rates. Extended Detention also meets the Water Quality requirement. The V_{ED} is designed to release over a period of 48-hours to the MEP. The V_{ED} is calculated as follows:

Eq. III-21	$V_{ED} = 6{,}897\ x\ C\ x\ A$
V_{ED} =	Extended detention volume in cubic feet
C =	Composite runoff coefficient
A =	Contributing area in acres
Eq. III-22	$H_{ED} = \frac{V_{ED}}{4{,}666 \times \sqrt{h_{ED}}}$
H_{ED} =	Number of 1" holes needed to control the extended detention release rate
h_{ED} =	Total head on the orifices in feet

Note: This formula is used for 1" circular holes only.

Part F: Detention & Flood Control Facilities

On-site detention of stormwater runoff is required for sites as outlined in Section I. Cases where the outlet or community allows for the undetained stormwater discharge will be evaluated on a case-by-case basis. However, Water Quality and Channel Protection Volume and Extended Detention Rate Control requirements will still apply.

General Detention System Design Requirements

The required 100-year detention volume (V_{100D}) is calculated based on the following:

1. The peak 100-year inflow (Q_{100IN}) from a particular site based on:
   a. The 100-year rain event using the Modified Rational Method (Eq. III-3).
   b. Site specific time of concentration (T_c).
   c. The area shall include all post-developed, on site, areas contributing to the detention system.

Eq. III-23	$Q_{100IN} = C\ x\ I_{100}\ x\ A$
Q_{100IN} =	100-year post-development peak inflow rate in cubic feet per second
C =	Composite runoff coefficient
I_{100} =	100-year rainfall intensity
A =	Contributing area in acres

Eq. III-24	$I_{100} = \frac{83.3}{(T_c + 9.17)^{0.81}}$
I_{100} =	100-year rainfall intensity
T_C =	Site-specific time of concentration for the development in minutes

The peak allowable 100-year discharge (Q_{100P}) is the lesser of:

1. The restricted rate for the drain (ft^3/Acre)
2. The prorated share of the drain's capacity (ft^3/Acre)
3. The Variable Release Rate (Q_{VRR}) (ft^3/Acre)

Eq. III-25	$Q_{VRR} = 1.1055 - 0.206\ x \ln(A)$
Q_{VRR} =	Allowable release rate in cfs/acre (Max 1.0 ft^3/acre)
A =	Contributing area in acres

Note: The discharge rates are in ft^3/acre, for Q_{100P} multiply by A.

The modified TR-55 storage curve is used to calculate the storage curve factor (R).

Eq. III-26	$R = 0.206 - 0.15\ x \ln\left(\frac{Q_{100P}}{Q_{100IN}}\right)$
R =	Storage curve factor
Q_{100P} =	100-year post-development peak discharge flow rate in cfs
Q_{100IN} =	100-year post-development peak inflow rate in cfs

The total volume from the 100-year storm is based on Eq. 27:

Eq. III-27	$V_{100R} = 18{,}985\ x\ C\ x\ A$
V_{100R} =	Post-development 100-year runoff volume in cubic feet
C =	Composite runoff coefficient
A =	Contributing area in acres

Note: $\frac{5.23in}{12in} 1\ ft\ x\ 43{,}560\ \frac{sf}{acre} = 18{,}985\ (rounded)$

The required 100-year detention volume V_{100D} is:

Eq. III-28	$V_{100D} = V_{100R}\ x\ R - V_{cp-p}$
V_{100D} =	100-year detention volume in cubic feet
V_{100R} =	100-year runoff volume in cubic feet based on Eq. III-27
R =	Storage curve factor

Note: The Volume of Extended Detention (V_{ED}) and Forebay Volume (V_F) are counted toward the V_{100D} requirement.

General Detention Basin Requirements

1. Detention volume on a basin is defined as the volume of detention provided above the invert of the outflow pipe and calculated using Eq. III-28. Other calculation methods may be used subject to pre-approval, on a case-by-case basis.
2. Any volume provided below the invert of the outflow pipe is considered as a permanent pool of water and is not included as storage volume.
3. An irregular basin shape is preferred with flow entering the basin being evenly distributed to minimize stagnant zones. The distance between the inlet and the outlet should be maximized to obtain the greatest flow distance during periods of low flow.
4. Basin side slopes may not exceed 1 foot vertical to 6 feet horizontal for a wet basin or basins with a permanent water feature, and 1 foot vertical to 4 feet horizontal for a dry basin unless fencing is provided. Additional fencing will be required as needed, depending upon basin depth, depth of permanent pool, etc. Requirements regarding fencing will be evaluated on a case-by-case basis.
5. One foot of freeboard shall be provided above the 100-year stormwater elevation. A vertical distance of 0.50’ shall be provided between the 100-year storage elevation and the emergency overflow spillway.
6. A primary overflow structure (standpipe or overflow manhole) shall be provided with its rim set at the 100-year storm elevation.
7. All basins must be permanently stabilized to prevent erosion.
8. Adequate, unrestricted maintenance access from a public or private right of-way to the detention system must be provided. The access must be on a slope of 6:1 or less, designed to withstand H25 loading, and will provide direct access to the detention or retention facility, forebay, control structure, and outlet.
9. Detention basins constructed by building up on existing grade must have compacted berms with a clay core keyed into native soils.
10. For dry basins, the use of swales or berms, on the bottom of the basin, is required to provide positive flow to the outlet.
11. In-line detention basins are strongly discouraged and are prohibited on watercourses having an upstream watershed greater than 2 square miles or on a County Drain. In-line basins are also prohibited if the waterway to be impounded traverses any area outside of the proposed development.
12. It is recommended that a permanent buffer strip of natural vegetation extending at least 15 feet in width beyond the freeboard elevation be maintained or restored around the perimeter of all stormwater storage facilities. No lawn care chemicals should be applied within the buffer area. This requirement should be cited in the Subdivision Restrictions, Maintenance Agreement and/or Master Deed documents.
13. Basin designs must include a landscaping plan that incorporates plant species native to the local region and indicates how aquatic and terrestrial areas will be vegetated, stabilized and maintained. It is

recommended that native wetland plants shall be used in the retention/detention facility design, either along the aquatic bench, fringe wetlands, safety shelf and side slopes, or within the shallow areas of the pools.

Detention System Outlet and Overflow Structure Design

All detention systems must have a method of dewatering to the proposed bottom of storage. The use of an outlet control structure with internal weir or orifices appropriately sized to restrict the discharge rate to Q_{100P} and Q_{ED} is required. When checking the outlet rate the standard orifice equation (Eq. III-29) will be used:

Eq. III-29	$Q_p = C_O \; x \; A_O \; x \; \sqrt{2 \; x \; g \; x \; h}$
Q_P =	Allowable outflow in cubic feet per second
C_O =	Orifice coefficient (0.62 if standard opening)
A_O =	Orifice area in square feet
g =	Gravity constant (32.2 ft/s^2)
h =	Total head on orifice in feet

For outlet control sizing, the minimum orifice size is 3" without clogging protection. If a 3" diameter orifice permits discharge in excess of the allowable outflow, then a different restricted outlet design will be required, such as a weir or standpipe with stone filter. The minimum orifice size for standpipe design is 1" diameter.

The following equations will be used to check weir design:

Eq. III-30	$Q_{weir} = 3.33 \; x \; L_{weir} \; x \; h_{weir}{}^{3/2}$
Q_{weir} =	Discharge over the weir in cubic feet per second
L_{weir} =	Length of weir crest in feet
H_{weir} =	Head above the weir crest in feet

Eq. III-31	$Q_{weir} = 2.5 \; x \; h_{weir}{}^{5/2}$
Q_{weir} =	Discharge over the weir in cubic feet per second
H_{weir} =	Head above the weir notch bottom in feet

Eq. III-32	$Q_{weir} = 3.33\ x\ L_{weir}\ x\ h_{weir}^{3/2}$
Q_{weir} =	Discharge over the weir in cubic feet per second
L_{weir} =	Length of weir crest in feet
H_{weir} =	Head above the weir crest in feet

Eq. III-33	$Q_{weir} = 3.367\ x\ L_{weir}\ x\ h_{weir}^{3/2}$
Q_{weir} =	Discharge over the weir in cubic feet per second
L_{weir} =	Length of weir crest in feet
H_{weir} =	Head above the weir crest in feet

Michael R. Lindeburg, P.E., Civil Engineering Reference Manual, Professional Publications, Inc., CA, 1999

1. The outlet pipe or drainage path must be designed to carry the flow from all on-site and off-site contributing drainage areas.
2. A cut-off collar or anti-seep diaphragm may be required to be installed around the outlet pipe within the bank of the basin, depending on the depth of storage in the basin.
3. All detention basins must have an overflow structure located at the design 100-year (V_{100D}) storage elevation. This structure will route the stormwater past the restrictor in emergency situations. The overflow must have the capacity to pass the 10-year on-site flow plus the off-site tributary flow. The overflow structure shall have a bar screen or trash hood.
4. All detention basins must also have an emergency overflow structure or spillway. The emergency overflow invert shall be set at the 100-year elevation plus 0.5 ft and be sized to convey the 100-year peak detention pond inflow rate plus the offsite tributary flow.
5. Calculations supporting the primary and secondary emergency overflow hydraulic capacities shall be submitted for review. An adequate flow path for detention system overflow (including easements, if necessary) shall be detailed in the site plan.
6. Use of a pumped outlet is discouraged. However, if no feasible gravity outlet is available, stormwater pump stations with emergency backup generators may be used.
7. For storm drain systems being established as Chapter 18 Drains, the restrictive orifice outlet must be grouted inside a minimum 12” diameter pipe located downstream of the Extended Detention standpipe. The restrictor must be sized for the on-site flow that is tributary to the basin. The basin overflow structure shall be sized to pass the on-site flow and the off-site tributary flow. Please see Section IV Chapter 18 Drains, for additional design requirements.

Underground Detention Facilities

1. Underground detention facilities may be allowed on sites where traditional stormwater management measures are not feasible. Each site will be evaluated on an individual basis.
2. Complete details, calculations and specifications must be submitted for the facility. The underground facility must comply with all standards imposed on traditional facilities; including, but not limited to, a restricted outlet, overflow structure, overflow route, and a perpetual maintenance plan.
3. Due to the difficulty of removing silt and sediment from the aggregate, the void space of the aggregate bedding and backfill around the underground detention facilities will not be considered as detention volume.
4. Underground detention facilities are prohibited in developments where the storm water detention facilities are under the jurisdiction of this office.

Utilizing Wetlands, Waterbodies and Natural Low Areas as an Ultimate Outlet

1. Prior to approval of any proposed plan to use existing wetlands or waterbodies for detention purposes, permits from the appropriate state and local agencies must be obtained. Proof of such permits must be submitted.
2. Calculations must be submitted that indicate the stage rise of the wetland or waterbody due to the developed runoff. Each site is entitled to their pro-rata share of the capacity of the wetlands.
3. A freeboard elevation must be established at one foot above the calculated stage rise.
4. The stage rise should be calculated from the ordinary high-water elevation.
5. There shall no direct discharge of stormwater to wetlands. The discharge must be routed through an upstream forebay or mechanical treatment device, followed by a level spreader or rip rap, on the wetland fringe, prior to discharging to the wetlands.
6. A natural buffer strip is required around the perimeter. A drainage easement that encompasses the entire area on site, including freeboard and buffer strip, will be required. In addition, off site easements may be necessary due to the increase in impoundment height.
7. The character of the wetlands must not be altered by the addition of the storm water. A control structure must be constructed at the outflow of the wetland area to release stormwater at a restricted rate as determined by these rules. The wetland must return to its normal water level within 48 hours.
8. Stormwater runoff directed to natural low areas will be considered the same as retention. The area must have the capacity to hold two consecutive 100-yr storm events and have a designated overflow route. Each site adjacent to the wetlands is entitled to their pro-rata share of the capacity of the depression for the land area tributary to it. A drainage easement that includes the entire area, including off-site properties, encompassing the freeboard elevation will be required.

Retention Basin Design

A “no-outlet” retention basin is only permissible subject to certain conditions that include, but are not limited to, the following:

1. There is no other available positive outlet for the stormwater runoff from the property. Every effort should be made to provide a means to de-water the basin, including a pump outlet and possible downstream improvements.
2. The Volume of the Retention Basin is calculated as follows:

Eq. III-34	$V_{RB} = (18{,}985\ x\ C\ x\ A\ x\ 2) - V_C$
V_{RB} =	Total retention basin volume in cubic feet
C =	Composite runoff coefficient
A =	Contributing area in acres
V_c =	Volume of 100% BMP Credit in cubic feet

3. The permeability of the soils shall follow all requirements set forth for large BMPs with the exception of the following:
   a. The Basin shall be able to dewater a 100-year storm (V_{100R}) within 72 hours based on the infiltration rates.
   b. When calculating the volume of storage, no credit will be given for infiltration volume within the basin. However, infiltration volume from upstream BMPs may be credited towards the total retention volume required.
4. An infiltration trench is not considered an acceptable substitution for permeable soils.
5. The general requirements for retention basins shall follow the requirements for detention basins.
6. An overflow route from the retention basin must be provided. Elevations of surrounding buildings, development or other features that would be impacted by a basin overflow must be indicated. The overflow route may not endanger any existing structures or features. Downstream drainage easements may be required for the overflow route.
7. The proprietor must submit a soil boring log taken within the basin bottom area to a depth of 25 feet below existing ground or 20 feet below proposed basin bottom elevation.
8. WRC reserves the right to require additional storage up to that required by two consecutive 100-year storm events based on the results of soils data or the overflow assessment.

Part G: Maintenance Requirements

An executed Stormwater Management Operations and Maintenance Agreement for the proposed stormwater system shall be submitted prior to this office granting final approval of the development. The WRC will not accept the responsibility for the maintenance of any stormwater system unless it is being constructed as part of a County Drain.

The maintenance plan must include the following:

1. The locations of all the stormwater system components, structures and BMPs
2. Specific maintenance requirements for the stormwater components including the required inspection cycle, personnel, training, inspection activities, and preventative maintenance required to ensure that the stormwater system functions properly.
3. The owner shall retain the services of a qualified individual, which may include a Licensed Professional Engineer, Certified Professional in Storm Water Quality (CPSWQ), NICET Certified Engineering Technologist in Stormwater and Wastewater System Inspection, or EGLE Certified Stormwater Operator (NPDES construction sites) to provide inspection and maintenance services.
4. A log of all inspections, maintenance activities and repairs are required. The log must provide, the date of activity, name of person performing activity and the description of activity performed.
5. Provisions for establishing and maintaining vegetation that is integral to the proper functioning of the stormwater system.
6. Identify the entity responsible for the maintenance and/or repair of the stormwater system, including modifying or reconstructing the system, if the system does not function as designed.
7. A schedule for implementing the activities necessary for proper functioning of the system.
8. A maintenance agreement must allow the local government the right to access, inspect, and maintain the stormwater system. The maintenance agreement shall allow the local community to complete the following:
    a. Inspect the structural or vegetative BMPs;
    b. Perform necessary maintenance or corrective actions neglected by the BMP owner
    c. Track the transfer of the operation and maintenance responsibility of the BMP in the event ownership of the property changes.
9. A copy of the Stormwater Management Operations and Maintenance Agreement or Memorandum of Stormwater Management Operations and Maintenance Agreement shall be recorded at the Register of Deeds.
10. A copy of the executed agreement of memorandum must be submitted prior to WRC's approval of the plans.
11. An example of the Agreement is included in the Appendix.

Part H: Drains Under the Jurisdiction of the Water Resources Commissioner

When a County Drain is the proposed outlet for a site's storm drainage system, the standards outlined herein regarding stormwater storage volume and allowable outflow must be followed. There may be cases where the existing outlet has limitations due to downstream conditions. In this situation, the discharge from the site will be restricted to conform to the governing downstream conditions. The allowable outflow from the proposed site will be limited to the pro-rata share of the capacity of the drain. The site's pro-rata equitable share of the outlet capacity should be calculated and shown on the construction plans.

There may also be cases where the outlet has already reached capacity. The burden is on the developer/proprietor to design and construct, at his expense, any necessary improvements to the downstream outlet. Such designs will be reviewed by the WRC office for adequacy.

Locations, easements and drainage service area boundaries for County Drains are available from the WRC Office. Permanent structures may not be constructed within the easement of a County Drain. This includes stormwater storage facilities or BMPs. All basins and BMPs must be located entirely outside of the County Drain permanent easement.

Easements

1. Prior to 1956, County Drain easements were not required by statute to be recorded with the County Clerk; it was legally sufficient to have them on file at the drain commissioner's office. Therefore, it is necessary to check the permanent records of the Water Resources Commissioner's Office to see if a drain easement is in existence on the subject property.
2. It may be necessary to record a new easement for that part of the County Drain that traverses the site. The existing easement may be abandoned in consideration for the granting of the new easement.
3. For open ditch drains, the easement must be at minimum, wide enough to include the extreme width of the open ditch drain plus 15' on each side measured from the top of bank. In addition, a vegetated buffer strip may be required. For enclosed drains, the easement must be a minimum of twenty (20) feet centered on the centerline of the pipe. However, larger pipe size, certain soil conditions, or depth of pipe may require larger easement widths.
4. The proposed easement must be submitted to this office for review. Upon completion of the project, the owner's engineer is required to provide the WRC Right-of-Way Department with an existing or "as-built" metes and bounds centerline description of the entire length of the drain through the referenced property. Upon submittal of the description, along with proof of property ownership, WRC Right-of-Way Department will prepare the necessary documents for execution by the owner(s).

5. This office must also be provided with one set of digital As-Built engineering drawings, cleaned of all background debris, showing plan, profile and the new easement of the drain.
6. Proposed County Drain easements shall be indicated on the plans as well as the mylar plat and shall be designated as 'permanent private easement for the "Name" (County) Drain'. In addition, the following note must be added to the mylar plat:
    a. The use of the word "private" does not limit in any way the scope of the easement granted to the "Name" (County) Drain Drainage District"

Drainage Service Areas (Districts)

1. A Drainage Service Area and Special Assessment District are each a legally established boundary for the area served by a County Drain. Drainage Service Areas do not always match the topographical area tributary to a County Drain. Drainage Service Areas shall not be violated when designing a drainage system.
2. Alterations to a Drainage Service Area and/or a Special Assessment District may be made by following the procedure established in the Drain Code. Approval must be granted by the Water Resources Commissioner or the Drainage Board.

Connections to County Drains

1. Taps to pipe and manholes shall be cored (sawed) wherever possible. If the tap cannot be cored, the proposed opening shall be star-drilled or cut with a concrete saw to establish a diameter prior to using a hammer to make the tap opening.
2. All taps shall be located to provide a minimum of one foot of manhole wall between tap openings.
3. Taps to manholes shall be pointed on the inside of the structure.
4. Taps shall be cut flush with the inside wall of the manhole and not protrude into the structure.
5. Depending on the location of the tap, manhole steps may need to be relocated at the applicant's expense.
6. No taps are allowed at a pipe joint.
7. Taps to open channel drains shall have a flared end section installed on a 42" minimum depth concrete footing. Taps 18" and larger to open channels shall have bar screens.
8. Riprap shall be installed at all outlets according to the Oakland County Water Resources Commissioner's Storm Drain Notes and Details Sheet. Riprap may consist of 8" to 15" diameter fragmented limestone or other suitable rock on a stone bedding underlain with geotextile fabric. Cobblestone, broken concrete or grouted riprap are not acceptable. Larger diameter outlets may require larger riprap as velocity and flow conditions dictate.
9. In areas where local ordinance requires sump pump leads to be connected into an enclosed system, these taps shall be made directly into storm sewer structures or into cleanouts.

10. Sump pump lines and connections shall not fall under the long-term operation and maintenance of the Water Resources Commissioner's Office and will not become part of an established County Drain. Maintenance of such lines will be the responsibility of the property owners and shall be so specified in subdivision restrictive covenants or condominium master deed agreements.

Crossing County Drains

1. A minimum clearance of 5 feet is required between open swale/ditch inverts and underground utilities unless special provisions are employed. Special provisions include encasement of utility lines in concrete or installation of the utility inside a steel casing when crossing under the open channel.
2. All bridges shall be designed to provide a 2-foot minimum flood stage freeboard to the underside of the bridge. The bridge footings shall be deep enough to be below the frost line and to allow a 5-foot channel deepening. Bridge footings and columns may not be located within the open channel.
3. A minimum clearance of 18 inches from the outside wall of an enclosed County Drain to any proposed utility or other underground crossing of the drain shall be provided.

Soil Erosion and Sediment Control

Soil erosion and sediment control devices shall be installed as required by the Water Resources Commissioner's "Erosion Control Manual" within municipalities where the Soil Erosion and Sedimentation Control Program is administered by WRC. The following points should be kept in mind when designing an erosion control plan for a site:

1. Areas within open drain rights-of-way, which have been cleaned, re-shaped or in any manner disturbed shall be seeded and mulched or otherwise vegetated.
2. The smallest practical area of raw land should be exposed at one time during development.
3. When raw land is exposed during development, the exposure should be kept to the shortest practical period of time.
4. Temporary vegetation and/or mulching should be used to protect critical areas exposed during development.
5. The permanent final vegetation and structures should be installed as soon as practicable in the development.
6. The development plan should be fitted to the topography and soil type so as to create the least erosion potential.
7. Wherever feasible, natural vegetation should be retained and protected.

   Proposed BMP locations should be protected at all times during construction to prevent sedimentation and compaction of soils that could lead to underperformance or failure of BMPs. This includes but is not limited to stabilizing surfaces adjacent to BMPs and installing temporarily erosion and sedimentation control structures at outlets to BMPs.

Part I: Assets Under Local Jurisdictions

For discharges into a non-county asset, some communities may have more restrictive standards than presented herein and those standards would supersede these standards. For all non-county assets, it is recommended that designers still consider the following when designing their stormwater management systems to local jurisdiction codes:

- Verify adequate outlet to community watercourses or pipes.
- Consider all potential hydraulic restrictions at outlet and assume full tailwater conditions when calculating release rates from basins and hydraulic grade line through the pipe network.
- Provide vertical separation (recommend two feet) between site stormwater design and receiving pipe or open watercourse.
- Verify the drainage area that will trigger a stormwater review (some communities might have a threshold lower than 1 acre).
- Determine whether the development is within a stormwater master planning area that could impact site specific standards for water quality and peak flow control.

Section IV – Chapter 18 Drains

The purpose of this standard is to guide the Owner/Developers of new developments within Oakland County communities which require drainage systems to be established as County Drains in accordance with the provisions of Section 433, Chapter 18 of the Public Acts of 1956, as amended, the Michigan Drain Code.

Plan requirements shall follow those identified in Section III for Subdivision Construction Plans with the following additions:

1. A plan and recommended schedule for the perpetual maintenance of the complete storm drainage system. Note that a Stormwater Management Operation and Maintenance Agreement is not required for Chapter 18 County Drains.
2. An access road shall be provided for all forebay and detention/retention facilities. The access road shall be designed to support heavy equipment (H25 loading).

Design of the Chapter 18 Drain shall follow the criteria set forth in Section III, WRC Specification Materials-Storm Drain, and WRC Drain Standard Detail Sheet, with the following additional requirements:

Pipe:

- 12” Minimum Pipe Size
- 10-Year Storm Design
- Hydraulic Grade Line in Pipe
- Velocity Less than 10 f.p.s.

Sump Pump:

- Serving More than One (1) Dwelling Unit 8” Minimum Size
- Minimum Size for House Leads is 4”
- All Connections to Storm Drains are Pre-manufactured
- Refer to WRC Drain Standard Detail Sheet

In areas where local ordinance requires sump pump leads to be connected into an enclosed system, these taps shall be made directly into storm sewer structures or into cleanouts.

Sump pump line connections shall not fall under the long-term operation and maintenance of the Water Resources Commissioner's Office and will not become a part of an established County Drain. Maintenance of such lines will be the responsibility of the property owners, and shall be so specified in the subdivision restrictions or condominium master deed agreements.

Stormwater Basins:

Please refer to the equations in Section III-General Detention System Design Requirements

Outflow from Basin

Outflow will be restricted per Section III. Downstream effects of storm water discharge will be the major consideration in sizing the outlet.

Outlets

Riprap shall be installed at all outlets according to the WRC Storm Drain Notes and Details Sheet. Riprap may consist of minimum 8" diameter to 15" diameter fragmented limestone or other suitable rock underlain with geotextile fabric. Cobblestone, broken concrete or grouted riprap is not acceptable. Larger diameter outlets may require larger riprap as velocity and flow conditions dictate.

A bar screen is required for all pipe outlets and inlets 18" diameter and larger.

Stormwater Treatment

1. Sediment forebays or manufactured stormwater treatment systems with external by-pass, and/or L.I.D. practices may be considered for stormwater treatment, but subject to OCWRC approval
2. The manufactured stormwater treatment system shall conform to the standards set forth and certified by the New Jersey Department of Environmental Protection (NJDEP) as listed at http://www.njstormwater.org/treatment.html, including offline use, manhole diameter size, and custom or multiple units.
3. The NJDEP Certified Treatment Flow rate (cfs) for a manufacturer and model shall be higher than the calculated peak discharge (qp) for a particular site.
4. Only the manufactured stormwater treatment systems specified in WRC specification Materials-Storm Drain are approved for County Drains.

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NOTE: All drainage systems will be evaluated on a case-by-case basis. Local conditions/ requirements/situations may cause exceptions to the above requirements, the published Design Criteria for Subdivisions, Standard Details or other rules which may apply.

Part B: Easement Requirements

The Developer and/or Land Owner shall provide to this office permanent easements for the proposed County Drain drainage facilities. Easement requirements vary with the type of site being developed. If the site is a platted subdivision, the easements must be shown on the final digital plat and the standard WRC easement language must be included in the Deed Restrictions. If the site is a condominium development, the easements must be shown on the "Exhibit B" drawings and the standard WRC easement language must be included in the Master Deed. A copy of the proposed Deed Restrictions/Master Deed must be submitted to this office for review. A recorded copy must be on file at this office prior to the final construction plan approval.

Easement requirements are as follows:

1. The minimum acceptable easement for a storm drain shall be 20 foot wide. Extreme depth and/or large pipe may require a wider easement.
2. The minimum acceptable easement for 8" diameter sump pump lines shall be 12 foot wide.
3. The minimum acceptable easement for a detention/retention basin shall be 12 feet from the high water elevation or at the one (1) foot freeboard elevation, but may not be less than 12 feet.
4. Language for Subdivision Plats (Must be on Final Digital):
5. Use of the word "private" does not limit in any way the scope of the easement granted to the Name (County) Drainage District.

WRC reserves the right to modify the easement requirements at its discretion.

Typical Easement for Subdivision

The following language shall be included in the deed restrictions for the subdivision:

. . . subject to a perpetual and permanent easement in favor of the Oakland County Water Resources Commissioner, the _____ Drainage District, a Michigan statutory public corporation as represented by the Oakland County Water Resources Commissioner (referred to as "grantee") and grantee's successors, assigns and transferees, in, over, under and through the property described on Exhibit A (or plat, liber, page) hereto, which easement may not be amended or revoked except with the written approval of grantee, and which contains the following terms and conditions and grants the following rights:

1. The easement shall be for the purposes of developing, establishing, constructing, repairing, maintaining, deepening, cleaning, widening and performing any associated construction activities and grading in connection with any type of drainage facilities or storm drain in any size form, shape or capacity;
2. The grantee shall have the right to sell, assign, transfer or convey this easement to any other governmental unit;

3. No owner in the subdivision shall build or convey to others any permission to build any permanent structures on the said easement;
4. No owner in the subdivision shall build or place on the area covered by the easement any type of structure, fixture or object, or engage in any activity or take any action, or convey any property interest or right, that would in any way either actually or threaten to impair, obstruct, or adversely affect the rights of grantee under the said easement;
5. The grantee and its agents, contractors and designated representative shall have right of entry on, and to gain access to, the easement property;
6. It is understood that under Michigan law, the Drainage District is comprised of all of the owners of the subdivision and that any and all expenses, claims or damages in any way arising from or incident to the construction, operation and maintenance of the drain and easement will be assessed against the Drainage District.

The rights granted to the Oakland County Water Resources Commissioner, the _____ _____ Drainage District, and their successors and assigns, under Section _____of these restrictions may not, however, be amended without the express written consent of the grantee hereunder. Any purported amendment or modification of the rights granted thereunder shall be void and without legal effect unless agreed to in writing by the grantee, its successors or assigns.

Typical Easement for Condominium

The following language shall be included in the deed restrictions for the condominium complex:

> . . . subject to a perpetual and permanent easement in favor of the Oakland County Water Resources Commissioner, the _____ Drainage District, a Michigan statutory public corporation, as represented by the Oakland County Water Resources Commissioner (referred to as "grantee"), and grantee's successors, assigns and transferees, in, over, under and through the property described on Exhibit A hereto, which easement may not be amended or revoked except with the written approval of grantee, and which contains the following terms and conditions and grants the following rights:
>
> 1. The easement shall be for the purposes of developing, establishing, constructing, repairing, maintaining, deepening, cleaning, widening and performing any associated construction activities and grading in connection with any type of drainage facilities, storm drains or related appurtenances, in any size form, shape or capacity;
> 2. The grantee shall have the right to sell, assign, transfer or convey this easement to any other governmental unit;
> 3. No owner in the condominium complex shall build or convey to others any permission to build any permanent structures on the said easement;
> 4. No owner in the condominium complex shall build or place on the area covered by the easement any type of structure, fixture or object, or engage in any activity or take any action, or convey any property interest or right, that would in any way either actually or threaten to impair, obstruct, or adversely affect the rights of grantee under the said easement;

5. The grantee and its agents, contractors and designated representatives shall have right of entry on, and to gain access to, the easement property;
6. It is understood that under Michigan law, the Drainage District is comprised of all of the owners of the condominium complex and that any and all expenses, claims or damages in any way arising from or incident to the construction, operation and maintenance of the drain and easement will be assessed against the Drainage District.

The rights granted to the Oakland County Water Resources Commissioner, the _____ _____ Drainage District, and their successors and assigns, under Section _____ _____of this master deed may not, however, be amended without the express written consent of the grantee hereunder. Any purported amendment or modification of the rights granted thereunder shall be void and without legal effect unless agreed to in writing by the grantee, its successors or assigns.

Part C: Request to Establish a County Drain

The Developer must first submit to this office one set of electronic construction plans and one digital copy, sealed by a Licensed Professional Engineer, for the proposed development along with a letter requesting that the development's drainage facilities be established as a County Drain. WRC's Engineering Design Standards for Storm Water Facilities and Standard Details for (County) Drains must be followed when designing the drain.

Submission of the following information is required:

a. Request to establish the _____ County Drain.
b. Engineer's certification of the adequacy of the drainage outlet.
c. Title work for the property being served by the Drain.
d. Names, titles, addresses or parties to execute the Drain Agreement.
e. Unified/Single property description with acreage, sidwell number(s) and a survey closure document.
f. Construction cost estimate for all drainage facilities.
g. All applicable fees and deposits.
h. Signed Deed Restrictions with County Drain language.
i. Maps and legal description of any right of ways or off site easements that may be necessary for drainage facilities.

Plan Submittal

Plan submittal must be in accordance with the regulations of the municipality where the development is located. It is the responsibility of the Developer to contact the municipality and confirm whether plans should be submitted directly to WRC or to the municipality first.

This office will review the construction plans and a determination will be made as to the adequacy of the design with respect to the Oakland County Water Resources Commissioner's requirements and to applicable laws and standards. If the local municipality has more stringent standards, then the municipality standards shall govern. Revisions to the plans or additional information may be requested at this time.

Final construction plan approval will not be granted until the Agreement is executed and all required documents and fees have been received. This office will issue a letter of construction approval with conditions. If the conditions as set forth in our construction plan approval letter are met, this office will then provide construction inspection of the drainage facilities. Construction of the storm drain system may not begin until the construction plans have been approved. After the construction plans have been approved, this office will process the final subdivision plat as set forth in the Subdivision Control Act of 1967, as amended.

In the case where the Chapter 18 Drain development will be a platted subdivision, the procedures for a preliminary and final plat must also be followed.

Agreement to Establish a County Drain

Upon approval of the construction plans by this office, the Developer and/or Land Owner of Record must enter into an agreement to establish the new County Drain or Branch Drain of an existing legally established County Drain. A district enlargement may also be necessary for the Branch Drain. The Developer and/or Land Owner must provide this office with a copy of the Title Policy or other proof of land ownership. A metes and bounds property description, with closure and Sidwell numbers, an estimate of the proposed construction cost of the drainage facilities, and the names, titles, addresses and companies of the people who will execute the Agreement shall also be submitted.

Once this office has received all of the above information, we will prepare an Agreement for signature by the involved parties. After the Agreement has been signed by all parties and notarized, the Water Resources Commissioner will have the Agreement recorded with the Oakland County Clerk's Office. The Agreement must be executed prior to construction plan final approval.

Engineer's Certification Outlet

Prior to approval of the construction plans, the Developer's Engineer must certify that the outlet for the proposed drain is adequate and will not cause detriment or diminution of the drainage services it now provides. An example of the Engineer's Certificate may be found in the Appendix.

Fee Schedule

Administrative Costs	1% but not less than $1,050.00	$	_____
Maintenance Fund	5% but not to exceed $2,500.00	$	_____
Inspection Deposit	To be calculated	$	_____
Contingency Deposit	10% of Drain construction estimate	$	_____

Note: Fees are based on percentage of storm drain system construction cost. All fees are in cash. Make checks payable to the Oakland County Water Resources Commissioner. Please indicate the name of the project or Drain on the check

Part D: Inspections

This office will provide full time construction inspection of the storm drain system. Drainage facilities constructed without appropriate inspection by this office or its designated representative may not be accepted by this office as a County Drain.

The Developer and/or Land Owner are responsible for the liabilities, operation and maintenance of the storm drainage system until it is accepted for service by the Water Resource Commissioner's Office.

This office or its designated representative will perform daily inspection of the storm drainage facility construction. This is to ensure that the storm drainage system is constructed according to the plans and specifications approved by this office.

This office will issue a series of construction inspection approvals at several milestones of the project, which will indicate that the contractors have successfully completed various phases of the construction.

WRC's Inspection Department must be notified **3 WORKING DAYS** prior to commencing construction and for all acceptance inspections.

Full time inspection is required for all aspects of storm drain construction.

The system must be constructed in accordance to the Oakland County Water Resources Commissioner's specifications.

All field changes must be **PRE-APPROVED** by the Oakland County Water Resources Commissioner prior to installation.

First Inspection

The purpose of the Construction Inspection approval is to release the underground contractor from responsibility of damage to the underground drainage system by others during future construction on this project site:

Requirements of the First Inspection:

a. All pipes and structures are to be free of dirt and debris.
b. Structures must be complete, plastered or pointed, channels, benches and castings in place.
c. All inlets and outlets must be completed with riprap in place.
d. All storm water detention/retention facilities and forebays must be constructed and stabilized.
e. All erosion control measures in place as well as a stated policy to maintain the soil erosion controls.
f. The storm drainage system must be completed and fully functional.

Second Inspection

The Second Inspection will be performed after the pavement has been completed. The purpose of the Second Inspection is to relieve the Pavement Contractor from responsibility for future damage to the storm drainage system.

Third Inspection

The purpose of the Third Inspection is to accept the drainage system for conditional maintenance and operation by the Oakland County Water Resources Commissioner and to relieve the Developer and/or Land Owner from the responsibility for maintenance of the storm drainage system.

The Developer and/or Land Owner are still responsible for the systems integrity until the completion of the final accounting and acceptance by the Oakland County Water Resources Commissioner.

All easements for the operation and maintenance of the County Drain including "Exhibit B" drawings, offsite drainage easements and recorded Deed Restrictions or a Master Deed with the appropriate drain easement language, along with As-Built plans for the Drain, must be submitted to this office and approved prior to this office scheduling the Third Inspection.

The Third Inspection will consist of a thorough and complete inspection of the entire storm drain system. A punch list of any outstanding construction items will be prepared and forwarded to the Developer and/or Developer's representative for resolution. Once these punch list items have been addressed and corrected, then a Third Inspection approval may be issued.

The Third Inspection can be scheduled after the following requirements have been met:

a. All disturbed areas have been re-vegetated and that the right of ways and all easements, detention basins, forebays and swales are sodded or vegetated with an approved plant material. All easement area vegetation must be established.
b. That the local governing body has no objections to the finalization of the project.
c. That there are no outstanding soil erosion issues and no history of poor soil erosion practices by the Developer and/or Land Owner.
d. All required documents and fees have been submitted and approved.

Final Acceptance

One year after conditional acceptance of the Drain for operation and maintenance, the Developer is allowed to request, in writing, that a final accounting be made by this office. The project will be reviewed by this office and our Inspection Unit will perform a final walk through inspection of the Drain if the following requirements have been met:

a. All conditions of the Agreement are satisfied.
b. The drain is functional and serviceable.
c. There are no outstanding liens or judgements against the storm drainage system.
d. A Developer's Declaration and Developer's affidavit are on file in this office.

If all the requirements have been met, a final accounting will be performed and a letter of final acceptance will be issued along with any remaining refundable deposits.

Please note that if the Developer fails to complete the requirements of the Agreement, the project will be declared abandoned, and the storm drainage system will not be maintained by the Oakland County Water Resources Commissioner's Office and all deposit moneys will be forfeited.

Part E: As-Built Drawings Requirements

Immediately following the completion of construction, the Developer and/or Land Owner shall furnish this office with a set of As-Built Drawings corrected to indicate as-built conditions. Upon approval of these drawings, the Developer and/or Land Owner shall submit one (1) set of reproducible drawings and one digital copy of the as-built construction drawings.

The following information shall be required on the as-built drawing and digital copy of the construction plan of the drain:

1. A Cover Sheet, which includes:
   a. Drain Name
   b. Location map with north arrow
   c. Drainage District (Property) legal description
   d. Storm sewer pipe manufacturer (type, class & joint)
   e. Manhole manufacturer
   f. Casting type and manufacturer
   g. Fitting type, class and manufacturer
2. A General Site/Utility Plan with boundary designation
3. A Grading Plan, which includes:
   a. Storm sewer as-built rim elevations
   b. As-built contours of all detention or retention basins and BMPs
   c. The location and permanent easement of all basin access drives
4. Plan and Profile views of all storm sewer 12” diameter and larger, which includes:
   a. As-built pipe length and slope
   b. As-built rim and invert elevations
   c. Show the sump pump lead locations on the plan view
   d. Road culverts with as-built information
   e. Top of pipe or invert elevation of the utility for all utility crossings. There should be a minimum of 18” clearance between the storm sewer and the utility.
   f. Note any special bedding, undercutting or piling extent and depth
   g. The term AB should follow all verifications.
5. A Drainage Area Map Sheet
6. Hydraulic calculations for storm sewer pipe and design calculations for all detention or retention basins, basin overflow structures and drainage swales. The as-built volume of all basins must be calculated.

The as-built plans must be submitted and approved prior to the third inspection being scheduled.

Appendices

Appendix A: Terms and Definitions

100-Year Storm: A rainfall depth that has a 1% chance of being exceeded in a given year.

10-year Storm: A rainfall depth that has a 10% chance of being exceeded in a given year.

1-year Storm: A rainfall depth that has a 100% chance of being exceeded in a given year.

90th Percentile Storm: A rainfall depth in which 90 percent of the rainfall events that produce runoff will be less than or equal to this depth.

Aquatic Bench or Safety Shelf: A bench, usually 4-feet to 5-feet wide, that is constructed around the inside perimeter of a permanent pool with depths that range from 0 inches to 12 inches. Typically vegetated with emergent plants, the bench augments pollutant removal, provides habitat, conceals trash, changes in water level, and enhances safety.

Bankfull Flow: A condition where flow completely fills the stream channel to the top of the bank. In undisturbed watersheds, this occurs on average every 1 to 2 years and controls the shape and form of natural channels.

Best Management Practice (BMP): Structural and non-structural practices and techniques that mitigate the adverse impacts caused by land development on water quality and/or water quantity.

1. **Buffer Strip:** A zone that is used for filtering direct stormwater and stormwater runoff into a stormwater management system and for providing maintenance access to a stormwater management system.
2. **Cistern:** Containers that store large quantities of stormwater above or below ground. They can be used on residential, commercial, and industrial sites.
3. **Dry well:** Small infiltration pits or trenches filled with aggregate that receive clean runoff primarily from rooftops.
4. **Green infrastructure (GI):** Management of wet weather flows using BMPs that use or mimic natural processes and result in improved water quality, evapotranspiration, or infiltration. This is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits, and reduces and treats stormwater at its source while delivering environmental, social, and economic benefits.
5. **Green Roof:** Conventional rooftops that include a thin covering of vegetation allowing the roof to function more like a vegetated surface. The layer thickness varies between 2-6 inches and consists of vegetation, waterproofing, insulation, fabrics, growth media, and other synthetic components.
6. **Pervious Pavement:** An infiltration technique that combines stormwater infiltration, storage, and structural pavement that consists of a permeable surface underlain by a storage reservoir.
7. **Planter Box:** A device containing trees and plants near streets and buildings constructed to prevent stormwater from directly draining into drainage systems.

8. **Pretreatment System:** A structure, feature, or appurtenance, or combination thereof, that is used as a component of a stormwater management system to remove incoming pollutants from stormwater.

9. **Riparian Buffer:** An area next to a stream, river, or lake that preserves water quality by filtering sediments and pollutants from stormwater before it enters the water body. It also protects banks from erosion, provides natural storage for flood waters, preserves open space, and provides habitat for wildlife. Development is often restricted or prohibited in this area. The buffers should be vegetated with herbaceous and woody native plants, or left in their natural state.

10. **Vegetated Filter Strip:** Uniformly graded vegetated surface located between pollutant source areas and downstream receiving waters.

11. **Vegetated Swale:** A conveyance, open to the atmosphere, consisting of a broad, shallow channel lined with vegetation to slow and filter stormwater runoff and promote infiltration. (Note: this swale has no in-soil storage)

12. **Bioretention:** A water quality practice that utilizes landscaping plantings and soil media to treat stormwater runoff by collecting it in shallow depressions before being absorbed by the soil and vegetation. There are three main types of bioretention.

    a. **Rain Garden:** A small, simple bioretention system associated with single family homes or small commercial development. This system has no regulated infiltration rate and as such only qualifies for the water quality requirement. However, as such this system does not require infiltration testing to construct or maintain.

    b. **Bioretention Basin:** A large bioretention system associated with commercial and industrial development. This system has water quality, volume reduction capabilities, and requires infiltration testing.

    c. **Bioretention swale:** A linear bioretention system associated with stormwater conveyance and Check Dams to slow, filter, and infiltrate the stormwater. This system has both water quality and volume reduction capabilities and requires infiltration testing.

CFS: Cubic feet per second.

Check Dam: A crushed rock or earthen structure used in vegetated swales to reduce water velocities, promote sediment deposition, and enhance infiltration.

Closed Conduit: An enclosed conveyance system designed to carry stormwater runoff such that the surface of the water is not exposed to the atmosphere, including without limitation, storm sewers, culverts, enclosed County drains, and pipes.

Construction Activity: A human-made activity, including without limitation, clearing, grading, excavating, construction and paving, that results in an earth change or disturbance in the existing cover or topography of land, including any modification or alteration of a site or the “footprint” of a building that results in an earth change or disturbance in the existing cover or topography of land.

Conveyance: Any structure or other means of safely conveying stormwater or stormwater runoff within a stormwater management system, including without limitation, a watercourse, closed conduit, culvert, or bridge.

County Drain: Drains established pursuant to the Michigan Drain Code of 1956, MCL 280.1 et seq., as amended, that are under the jurisdiction of the WRC.

Culvert: A structure, including supports, built to carry a feature over a surface water or watercourse, with a clear span of less than 20 feet measured along the center of the feature being carried.

Design Storm: The rainfall event used as the basis of design for stormwater drainage facilities.

Design Water Level: The water surface elevation in a detention system at which the storage volume in the system (above the permanent pool water level, if any) equals the required flood control storage volume.

Detention System: A component of a stormwater management system, either aboveground or belowground, that detains stormwater and stormwater runoff. Detention systems can be classified as follows:

1. **Dry Detention Basin:** A basin that remains dry except for short periods following rain storms or snow melt events.
2. **Extended Dry Detention Basin:** A dry detention basin that has been designed to increase the length of time that stormwater will be detained beyond the normal dewatering time of 24-48 hours.
3. **Wet Detention Basin:** A basin that contains a permanent pool of water that will effectively remove nutrients in addition to other pollutants.
4. **Extended Wet Detention Basin:** A wet detention basin that has been designed to increase the length of time that stormwater will be detained beyond the normal dewatering time of 24-48 hours.
5. **Regional Detention Basin:** A wet or dry detention basin that receives water from multiple sites as an alternative to storage on-site.
6. **Underground Detention System:** One or more underground pipes and/or other structures that are utilized as a detention system.
7. **Constructed Wetland:** An open detention basin that uses a variety of water depths and wetland plants to provide pollutant removal and provide temporary storage of stormwater runoff to prevent downstream flooding and the attenuation of runoff peaks.

Discharge: The flow rate of water passing through the outlet at a given time, usually expressed as cubic feet per second (CFS).

Disturbed Area: An area where human activity has removed or altered the natural vegetative soil cover and the soil is susceptible to erosion.

Drainage Area: The entire upstream land area from which stormwater runoff drains to a particular location, including any off-site drainage area.

Detention time: The time required for the gradual reduction in water level in a BMP due to the combined effect of infiltration, evaporation and discharge from the peak or storage to full dewatering to the lowest outlet elevation. (i.e. in a bioretention area this would include dewatering of the soil media)

Easement: A legal right, granted by a property owner to another entity, allowing that entity to make limited use of the property involved for a specific purpose. Easements are recorded on the title to the land and transfer with the sale of land.

Emergency Spillway: A channel constructed in the embankment of an open detention or retention basin that is used to control flows in excess of the overflow structure capacity to prevent erosion of the berm.

Floodplain: For a given flood event, that area of land adjoining a continuous watercourse that has been covered temporarily by water. This design standard, the term floodplain includes all physical floodplains weather or not they have been officially mapped by FEMA.

Flow Path: The distance that a parcel of water travels through a stormwater detention pond or wetland. It is defined as the distance between the inlet and outlet, divided by the average width. [defines the time of concentration calculation] – or just move it to the Tc definition.

Flow Restrictor: A structure, feature, or device in a detention system or pretreatment system that is used to restrict the discharge from the system for specified design storm(s).

Forebay: A small, separate storage area near the inlet to a detention basin, used to trap and settle incoming sediments before they can be delivered to the basin.

Freeboard: The vertical distance from the design water level to the top of the embankment of an open detention basin or retention basin.

French Drain: A subgrade drain consisting of a trench filled with aggregate to permit movement through the trench and into the soil. The trench may also contain perforated pipe to enhance the efficiency of the system. [reference in Underdrain definition]

Ground Water Table: The uppermost extent of naturally existing water beneath the earth's surface between saturated soil particles and rock that supplies wells and springs. At least two feet of separation is required between the normal ground water elevation and the bottom of the bioretention filter media.

Impervious Surface: A surface that prevents the infiltration of water into the ground such as all roofs, streets, sidewalks, driveways, parking lots, highly compacted soils, and gravel.

Infiltration Rate: The rate of infiltration (inches/hour) of in-situ soils at the base (subgrade) of a designed BMP, as determined by on-site soil evaluation certified by a Professional Engineer. Also referred to as Saturated Soil Conductivity (K_{sat}) or In-Situ Infiltration Rate.

Inlets: A stormwater collection structure designed to collect and convey surface water into the stormwater management system via a grated cover.

1. **Standard Inlet:** A stormwater collection structure designed to collect and convey surface water from a paved area into the stormwater management system. An Inlet is normally 2 feet in diameter, is

designed so that stormwater is collected via a grated cover and falls directly into the storm drain. (GIS Feature Class HydroDrainInlet, Subtype 1 Standard Inlet)

2. **Catch Basin:** A stormwater collection structure designed to collect and convey surface water from a paved area into the stormwater management system. A catch basin is normally 4 feet in diameter, is designed so that stormwater is collected via a grate cover and sediment falls to the bottom of the catch basin sump not directly into the storm drain. (GIS Feature Class HydroDrainInlet, Subtype 2 CatchBasin)
3. **Rear Yard Catch Basin:** A stormwater collection structure designed to collect and convey surface water from an unpaved area into the stormwater management system. A rear yard catch basin is normally 4 feet in diameter, is designed so that stormwater is collected via a grate cover and sediment falls to the bottom of the catch basin sump not directly into the storm drain. (GIS Feature Class HydroDrainInlet, Subtype 3 RearYardCatchBasin)
4. **Yard Inlet:** A stormwater collection structure designed to collect and convey surface water from an unpaved area into the stormwater management system. A yard inlet consists of a 2 ft. diameter manhole, is designed so that stormwater is collected via a grated cover and falls directly into the storm drain then into a water quality BMP. (GIS Feature Class HydroDrainInlet, Subtype 4 YardInlet)
5. **Leaching Basin:** A stormwater collection structure designed to collect and convey surface water into the soil subgrade. A leaching basin consists of a square or round structure with perforated sides and no base cookie, is designed so that stormwater is collected via a grated cover or delivered through a connecting storm drain and is filtered through stone and infiltrated the soil. (GIS Feature Class HydroDrainInlet, Subtype 5 LeachingBasin)

Level-Spreader: A device used to spread stormwater runoff uniformly over the ground surface as sheet flow to prevent concentrated, erosive flow from occurring, and to enhance infiltration.
Manhole: A stormwater structure designed to allow access into a closed conduit or other underground component of a stormwater management system. A manhole has a minimum diameter of 4 feet, is designed with a concrete flow channel at the bottom of the manhole and is fitted with a solid cover.
Manufactured Treatment Device: A pre-fabricated stormwater treatment structure utilizing settling, filtration, absorptive/adsorptive materials, vortex separation, vegetative components, and/or other appropriate technology to remove pollutants from stormwater runoff. The TSS removal rate for manufactured treatment devices must meet the NJDEP certification of the pollutant removal rates.

Municipal Separate Storm Sewer System (MS4): A system of conveyances that include, but are not limited to, catch basins, curbs, gutters, ditches, man-made channels, pipes, tunnels, and/or storm drains, and similar means of collecting or conveying runoff that do not connect with a wastewater collection system or treatment plant and instead discharge into Waters of the State.

Native Plants: Plant species that occurs naturally in the Southeast Michigan ecosystem, and habitat without direct or indirect human actions.

Natural Resources Conservation Service (NRCS): A federal agency of the United States Department of Agriculture (USDA) that works with farmers, ranchers, forest landowners, local and state governments, and other federal agencies to maintain healthy and productive working landscapes, and to protect our natural resources through conservation.

Natural Wetland: Michigan's wetland statute, Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, defines a wetland as "land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation or aquatic life, and is commonly referred to as a bog, swamp, or marsh." The definition applies to public and private lands regardless of zoning or ownership. Many wetland areas have only a high ground water table and standing water may not be visible. Types of wetlands include deciduous swamps, wet meadows, emergent marshes, conifer swamps, wet prairies, shrub-scrub swamps, fens, and bogs.

Non-point Source Pollution: Stormwater conveyed pollution that is not identifiable to one particular source, and is occurring at locations scattered throughout the drainage basin. Typical sources include erosion, agricultural activities, and runoff from urban lands.

Non-structural BMPs: Stormwater runoff treatment techniques that use natural measures to reduce pollution levels that do not involve the construction or installation of devices (e.g. management actions). [site BMPs]

Ordinary High Water Mark: The line between upland and bottomland which persists through successive changes in water level, below which the presence of water is so common or recurrent that the character of the soil and vegetation is markedly different from the upland.

Outlet Control Structure: A horizontal pipe or series of pipes or vertical riser pipe designed to gradually release stormwater from a pond over a 24 to 48-hour interval.

Overflow Structure: A structure designed to allow unrestricted discharge from a component of a stormwater management system when the water level exceeds the design water level. [cross reference with emergency overflow]

Peak Discharge or Flow Rate: The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.

Permanent Pool: A pool in a wet detention system that provides additional removal of pollutants through settling and biological uptake.

Pervious or Porous Pavement: Traditionally impervious surfaces designed to allow stormwater to be stored in a layer of open graded stone and then infiltrate into the ground. (Pervious Concrete, Pervious Asphalt, Pervious Pavers)

Plunge Pool: A small permanent pool located at either the inlet to, or outfall from a BMP. The primary purpose of the pool is to dissipate the velocity of stormwater runoff, but it can also provide some pre-treatment.

Ponding Area: In bioretention areas, the area where excess stormwater runoff is temporarily stored prior to infiltration into the ground.

Professional Engineer (PE): Only an engineer licensed in the State of Michigan may prepare, sign and seal, and submit engineering plans and drawings for approval. PEs must continuously demonstrate their competency and maintain and improve their skills by fulfilling the State of Michigan continuing education requirements.

Regulated Wetland: Any wetland protected by federal, state, and or local government regulation.

Rational Method Formula: A technique for estimating peak flow rates at a particular location within a stormwater management system, based on the rainfall intensity, watershed time of concentration, and a runoff coefficient. Q = ciA

Release Rate: The rate of discharge in volume per unit time from a detention facility [reference PEAK flow and differentiate between pre-vs post and prescribed rate]

Retention Basin: The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass. Retention is discouraged under all circumstances unless there is no practical way to provide an outlet. Pre-treatment in the form of infiltration BMPs, sediment forebays, and mechanical separators is required for sediment removal.

Return Interval: A statistical term for the average time of expected interval that an event of some kind will equal or exceed given conditions (e.g., a stormwater flow that occurs every 2 years).

Riprap: A combination of large stone, cobbles, and boulders used to line watercourses, stabilize banks, reduce runoff velocities, or filter out sediment.

Riser: A vertical pipe extending from the bottom of a basin that is used to control the discharge rate from the basin for a specified design storm. When this is used for soil erosion control during construction it is considered temporary.

Runoff: The excess portion of precipitation that does not infiltrate into the ground, but "runs off" into streams, water bodies, and/or storm sewers.

Runoff Coefficient: The ratio of the amount of water that is NOT absorbed by the surface to the total amount of water that falls during a rainstorm [define and differentiate from percent impervious] – cross reference with rational method. State when it is used and when CN is used.

Saturated Soil Conductivity (K_{sat}): The rate of infiltration (inches/hour) of in-situ soils at the base (subgrade) of a designed BMP, as determined by on-site soil evaluation certified by a Professional Engineer. Also referred to as Infiltration Rate or In-Situ Infiltration Rate.

Sediment: Soil material that is transported from its site of origin by water. May be in the form of bed load, suspended or dissolved.

Sheet Flow: Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel. Maximum allowable sheet flow length is 100 feet.

Short Circuiting: The passage of runoff through a BMP in less than the theoretical or design detention time.

Soil Erosion: The increased loss of the land surface that occurs as a result of the wearing away of land by the action of wind, water, gravity, or a combination of wind, water, gravity or human activities.

Soil Group, Hydrologic: A classification of soils by the NRCS into four runoff potential groups. The groups range from "A Soils" which are very permeable and produce little runoff, to "D Soils" which are relatively impermeable and produce much more runoff.

Spillway: A depression in the embankment of a pond or basin, used to pass peak discharges in excess of the design storm.

Stabilization: The establishment of vegetation or the proper placement, grading, or covering of soil to ensure its resistance to soil erosion, sliding, or other earth movement.

Stormwater: Water resulting from precipitation, including without limitation rain, snow, snowmelt. Also referred to as "runoff".

Stormwater Management Plan: Ordinances, orders, rules, regulations, and other mechanisms that provide for the management of stormwater to prevent flooding and to ensure the restoration and/or protection of surface waters.

Stormwater Management System: Any structure, feature, or appurtenance subject to the Ordinance, or a rule promulgated pursuant to the Ordinance, that is designed to collect, detain, retain, treat, or convey stormwater runoff, including without limitation buffer strips, swales, gutters, catch basins, closed conduits, detention systems, pretreatment systems, wetlands, pavement, unpaved surfaces, structures, watercourses, or surface waters.

Stream: By MDEQ definition: "a river, creek, or surface waterway that may or may not be defined by Act 40, P.A. of 1956; has definite banks, a bed, and visible evidence of continued flow or continued occurrence of water, including the connecting water of the Great Lakes." Even if water flow is intermittent, it is classified as a stream.

Surcharge: A condition in which the water level in a storm drain rises above the crown of the conduit.

Surface Water: A body of water, including without limitation seasonal and intermittent waters, in which the surface of the water is exposed to the atmosphere, including without limitation lakes, open detention basins, forebays, watercourses, bioretention areas, retention basins, wetlands, and impoundments.

Tailwater: The depth of water at the downstream end of a culvert or crossing. [mention potential for tailwater to impact detention pond outlet]

Technical Infeasibility: Each site proposed for development is unique due to soils, land cover, topography, location, etc. Therefore, waivers or variances from certain provisions of these standards may be requested when it can be demonstrated that these standards are technically infeasible. In these situations, alternatives consistent with the overall intent of these standards must be proposed for consideration.

For projects where technical infeasibility exists, the design engineer must document and quantify that stormwater strategies, such as infiltration, evapotranspiration, and harvesting and water use have been used to the maximum extent technically feasible (METF) and that implementation of these methods are infeasible due to site constraints. The burden of proof of Technical Infeasibility lies with the design engineer. Documentation of technical infeasibility should include, but may not be limited to, engineering calculations, geological reports, hydrological analyses and site maps. A determination that the performance design goals cannot be achieved on the site should include analyses that rule out the use of an adequate combination of infiltration, evapotranspiration, and water use measures. Adequate

documentation must be submitted to WRC for review and final determination. Examples of site conditions that may prevent the application of stormwater BMP's to the METF includes:

1. The conditions on the site preclude the use of infiltration practices due to the presence of shallow bedrock, contaminated soils, high ground water or other factors, such as underground facilities, utilities or development location within a wellhead protection area.
2. The design of the site precludes the use of soil amendments, plantings of vegetation or other designs that can be used to infiltrate and evapotranspirate stormwater runoff.
3. Water harvesting and use are not practical or possible due to the volume of water used for irrigation, toilet flushing, industrial make-up water, wash-waters, etc. is insignificant to warrant the application of water harvesting and use systems.
4. Modifications to an existing building to manage stormwater are not feasible due to structural or plumbing constraints or other factors.
5. Sites where the site area is too small to accommodate adequate infiltration practices for the impervious area to be served. (Less than one acre)
6. Soils that cannot be sufficiently modified to provide reasonable infiltration rates.
7. Situation where site use is inconsistent with the capture and use of stormwater or other physical conditions on site that preclude the use of plants for evapotranspiration or bio-infiltration.
8. Retention and/or use of stormwater onsite or discharge of stormwater onsite by infiltration having an adverse effect on the site, gradient of surface or subsurface water, receiving watershed, or water body ecological processes.
9. Federal, state of local requirements or permit conditions that prohibit water collection or make it technically infeasible to apply LID practices.

Adapted from EPA Section 438 Technical Guidance December 2009.

Time of Concentration (T_C): The time duration (typically in minutes) that is required for stormwater runoff from the most remote area of the watershed to reach a given location in a stormwater management system.

Total Suspended Solids: Particles or other solid material suspended in stormwater or stormwater runoff. "Total suspended solids" is commonly expressed in concentration (mg/l).

Underdrain: One or more underground pipes installed beneath bioretention areas, terraced side slopes, or other structures to facilitate conveyance of stormwater runoff from beneath the structure to another part of the stormwater management system.

Upland Zone: The area within an open detention basin or retention basin between the bank full elevation to the 100- year flood elevation and beyond.

Watercourse: A natural or artificial channel for flowing water.

Watershed: The complete area or region of land draining into a single outlet, watercourse, surface water, or closed conduit that is separate from other watersheds by a divide.

Waters of the State (Michigan): Any groundwater, lakes, including the Great Lakes bordering the state, rivers, streams, and all other water courses and bodies of water within the jurisdiction of the state including wetlands.

Weir: A structure that extends across the width of a body of water, channel, watercourse, or closed conduit, and is used to impound, measure, or in some way alter the flow of water through the channel.

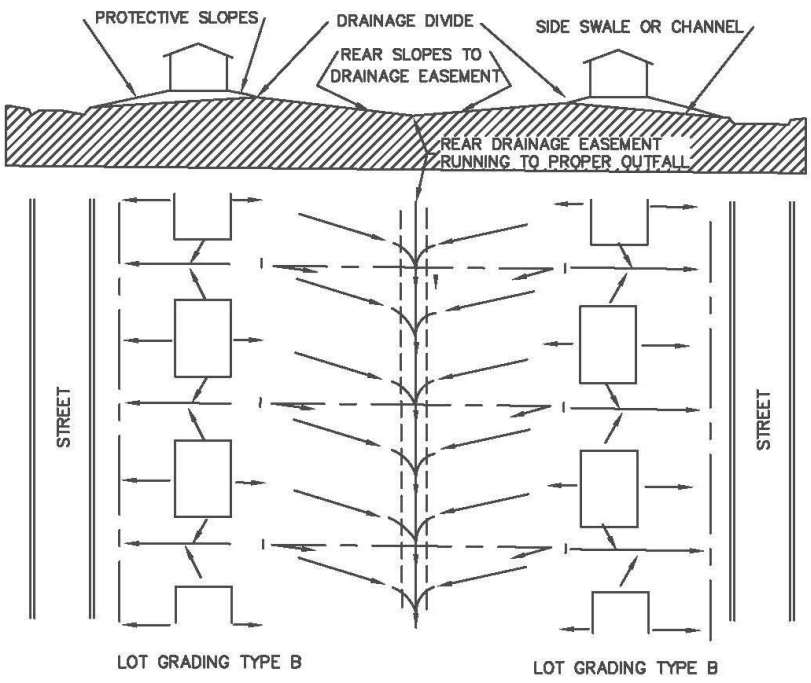
Wetland: An area that is saturated by surface or groundwater with vegetation adapted for life under those soil conditions, such as swamps, bogs, fens, marshes and estuaries.

Wetland Mitigation: A regulatory term that refers to the process of constructing new wetland acreage to compensate for the loss of natural wetlands during the development process. Mitigation seeks to replace structural and functional qualities of the natural wetland type that has been destroyed. Stormwater wetlands typically do not count for credit as mitigation, because their construction does not replicate all the ecosystem functions of a natural wetland.

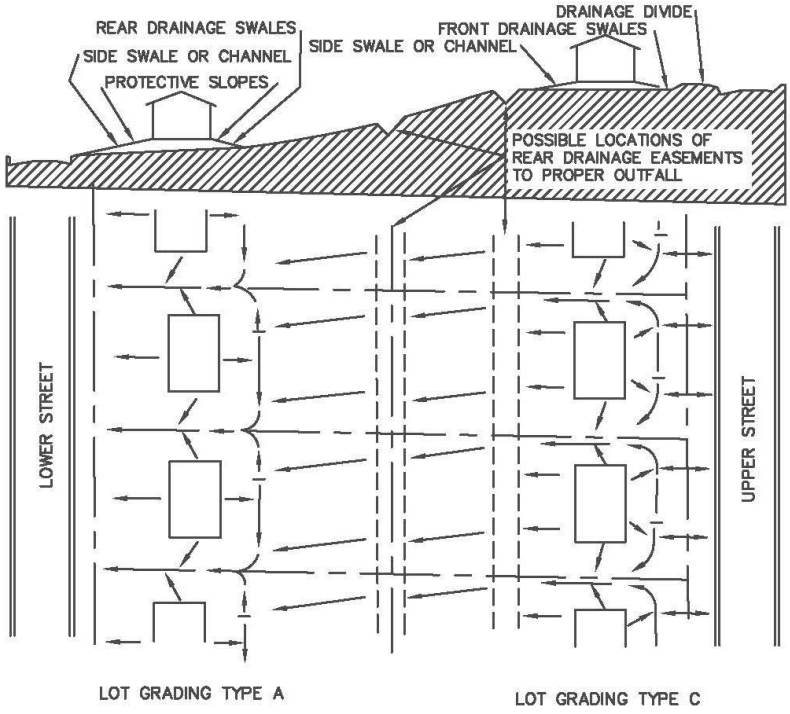
Appendix B: Lot Grading

The Oakland County Water Resources Commissioner will review the grading plan for sites that will be platted under Act 288 and a subdivision or site condominium included in the Chapter 18 Drain program. Positive drainage is required. Final lot grading inspection is under the jurisdiction of the local municipality. The minimum requirements are as follows:

1. The grading of the lot shall be such that surface runoff is directed away from homes and towards swales, ditches or drainage structures. Provision for drainage either by filling and grading or by providing some type of outlet shall be made for all areas within the proposed subdivision.
2. A proposed finished floor grade and proposed lot grading must be shown for each home or structure. A minimum of ½ foot of fall is required away from the home and between lots. Proposed grades may be indicated with spot grades or contours. A distinction between existing and proposed grades should be evident on the plans.
3. Where a walkout or daylight basement is proposed, sufficient grades should be shown at the location of the walkout to indicate positive drainage away from the walkout. Additional spot grades at the house corners and rear yard should be shown.
4. Where finished grades indicate a substantial amount of drainage across adjoining lots, a drainage swale of sufficient cross-section and slope shall be provided on the lot line to intercept this drainage.
5. Sufficient off-site topography must be shown to determine the extent of contributing runoff. Provisions must be made to accommodate the off-site contributing flow.
6. Lots that lie within a flood plain shall satisfy the EGLE and FEMA requirements for subdivisions within a flood plain. In no case will the filling of a lot be permitted if the flood plain is so restricted as to cause possible flooding or back up of the stream.



BLOCK GRADING TYPE 4: VALLEY ALONG REAR LOT LINES



BLOCK GRADING TYPE 3: STEEP CROSS SLOPE

Appendix C: Reference Materials

Site Plan Example 1

The example site is a proposed commercial development. Total development area of the site is 10.32 acres consisting of primarily HSG Type B soils under a mixture of impervious cover, turf grass, meadow and woods. Infiltration tests conducted on the site yielded an observed infiltration rate of 1 inch/hour. A minimum of one infiltration test per BMP location is required, but for this example, a single infiltration rate is applied. A mechanical separator or sediment forebay is not required given the use of infiltration BMPs for water quality treatment. The site has a 1% slope.

Area, A	10.32	acres
Proposed Impervious Acres	4.80	acres
Proposed Pervious Acres	5.52	acres
Infiltration Rate	1	in/hr
Runoff Coefficient, C	0.59	
100-yr peak intensity	6.31	in/hr

Infiltration Feasibility

Test pit infiltration tests were performed at the bottom of each proposed infiltration BMP and resulted in a 1 inch/hour infiltration rate for each BMP. No supplemental measures are required for infiltration BMPs at this site.

K_{sat} Values	
Ksat ≥ 0.50 in/hr	No supplemental measures are required for Infiltration BMPs to provide the infiltration volume
0.50 in/hr≥ Ksat ≥ 0.24 in/hr	Install supplemental measures, which may include subsoil amendment, or an underdrain placed at the top of the storage bed layer to ensure dewatering in the event underlying soils fail to provide adequate drawdown or dewatering time. If underdrains are selected, design shall allow stormwater to percolate through the soils first, with the underdrain serving as a secondary outlet, by placing the underdrain in the upper level of the BMP, with pipe perforations located along the underdrain invert.
Ksat ≤ 0.24 in/hr	***Soils are not suitable for infiltration. Alternative volume reducing LID practices must be used to the MEP to reduce stormwater volume.***

Land Use Summary

must be included on the COVER SHEET for all site plans

Pervious Area Land Use Data

Characteristic	Existing Conditions	Proposed Conditions
Total Development Area (ac)	10.32	10.32
Impervious Area (ac)	0	4.80
Total Pervious Area (ac)	10.32	5.52
Pervious Area Breakdown by Cover Type		
Meadow/fallow/natural areas (non-cultivated)	4.00 acres	0 acres
Predominant NRCS Soil Type (A, B, C, or D)	Type B	Type B
Improved areas (turf grass, landscape, row crops)	2.32 acres	5.05 acres
Predominant NRCS Soil Type (A, B, C, or D)	Type B	Type B
Wooded Areas	4.00 acres	0 acres
Predominant NRCS Soil Type (A, B, C, or D)	Type B	Type B
Proposed Pond Area (acres)		0.47
Required CPVC Volume (cubic feet)		28,733
Provided CPVC Volume (cubic feet)		***29,400***
Required ED Volume (cubic feet)		41,994
Provided ED Volume (cubic feet)		***42,000***

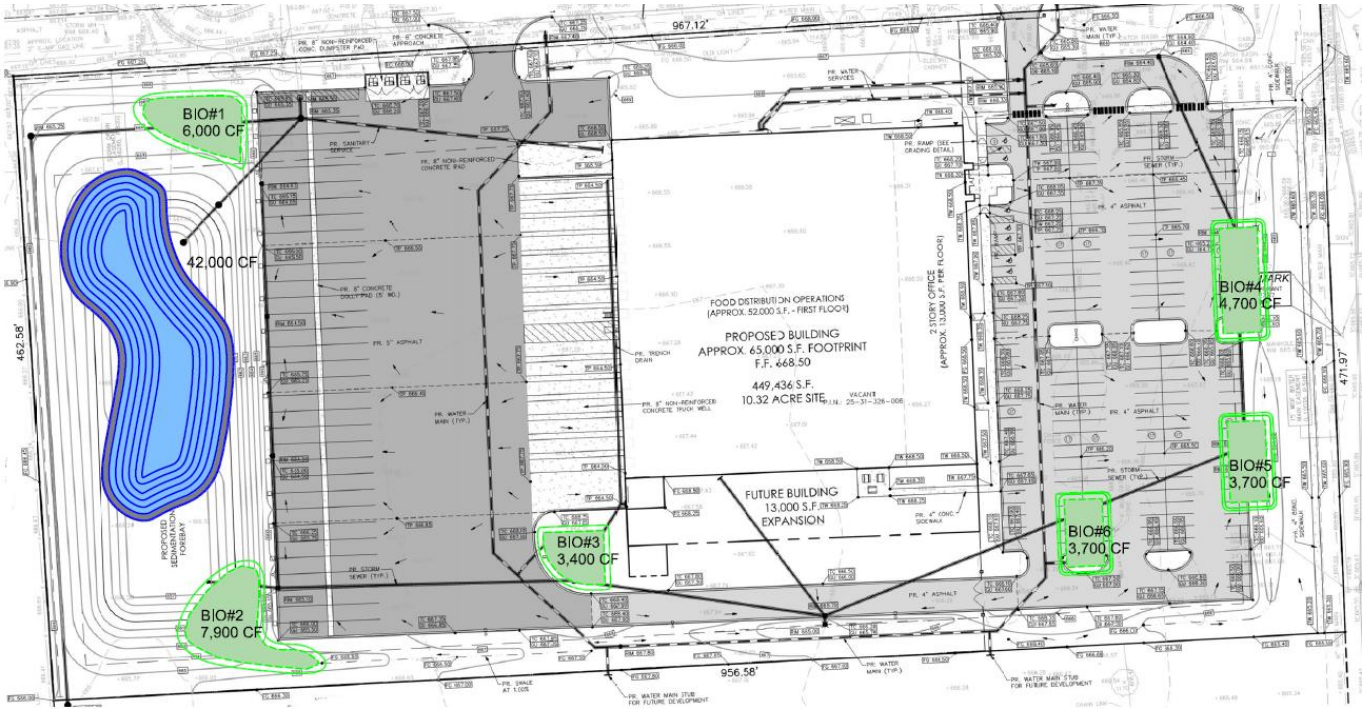


Figure 1 - Example 1 Commercial Site

Calculate the Composite Runoff Coefficient

$$C = \frac{\sum_{i=1}^{N}(A_i x C_i)}{\sum_{i=1}^{N} A_i}$$

$$C = \frac{(4.80x0.95) + (5.05x0.20) + (0.47x1)}{10.32} = 0.59$$

C Values		
Green Space	HSG A	0.15
	HSG B	0.20
	HSG C	0.25
	HSG D	0.30
Impervious Areas		0.95
Water		1.00

Calculate Time of Concentration

Sheet Flow

$$v = K\ x\ S^{0.5}$$

$v = 0.48\ x\ 1^{0.5} = 0.48\frac{ft}{s}$

$T_t = \frac{\text{L}}{3600v}$

$T_t = \frac{120\text{ ft}}{3600\left(0.48\frac{ft}{s}\right)} = 0.0694\ hrs = 4.2\ min$

Waterway Flow

$v = K\ x\ S^{0.5}$

$v = 1.2\ x\ 1.3^{0.5} = 1.37\frac{ft}{s}$

$T_t = \frac{\text{L}}{3600v}$

$T_t = \frac{300\text{ ft}}{3600\left(1.37\frac{ft}{s}\right)} = 0.0609\ hrs = 3.7\ min$

Pipe Flow

$v = 3\frac{ft}{sec}$rom pipe network calculations – not shown)

$T_t = \frac{\text{L}}{3600v}$

$T_t = \frac{1300\text{ ft}}{3600\left(3\frac{ft}{s}\right)} = 0.1204\ hrs = 7.2\ min$

$T_c = 4.2\ min + 3.7\ min + 7.2\ min = 15.1\ min$

Calculate 100-year Peak Intensity

$$I_{100} = \frac{83.3}{(T_c + 9.17)^{0.81}}$$

$T_c = 15.1\ minutes$

$$I_{100} = \frac{83.3}{(15.1 + 9.17)^{0.81}} = 6.29\frac{in}{hr}$$

Calculate Channel Protection Volume

$V_{CPVC} = 4{,}719\ x\ C\ x\ A$

$V_{CPVC} = 4{,}719\ x\ 0.59\ x\ 10.32\ acres = 28{,}733\ cubic\ feet$

Calculate Channel Protection Rate Control: Extended Detention

$V_{ED} = 6{,}897\ x\ C\ x\ A$

$V_{ED} = 6{,}897\ x\ 0.59\ x\ 10.32\ acres = 41{,}994\ cubic\ feet$

Calculate 100-year Peak Inflow

$Q_{100IN} = C\ x\ I_{100}\ x\ A$

$I_{100} = 6.29\frac{in}{hr}$ (Calculated on previous page)

$Q_{100IN} = 0.59\ x\ 6.29\frac{in}{hr}\ x\ 10.32\ acres = 38.30\ cfs$

Determine the Peak Allowable 100-year Discharge

Q_{100P} is the lesser of:

1. The restricted rate for the drain (ft^3/Acre)
2. The prorated share of the drain's capacity (ft^3/Acre)
3. The Variable Release Rate (Q_{VRR}) (ft^3/Acre)

In this example, it is assumed the drain capacity is capable of receiving the runoff from the site and the variable release rate will be utilized.

Calculate the Variable Release Rate

$Q_{VRR} = 1.1055 - 0.206\ x\ \ln(A)$

$Q_{VRR} = 1.1055 - 0.206\ x\ \ln(10.32\ acres) = 0.625\frac{cfs}{acre}$

$Q_{100P} = Q_{VRR}\ x\ A$

$Q_{100P} = 0.625\frac{cfs}{acre}\ x\ 10.32\ acres = 6.45\ cfs$

Calculate Storage Curve Factor

$$R = 0.206 - 0.15\ x \ln\left(\frac{Q_{100P}}{Q_{100IN}}\right)$$

$$R = 0.206 - 0.15\ x \ln\left(\frac{6.45\ cfs}{38.30\ cfs}\right) = 0.473$$

Calculate the 100-year Runoff

$$V_{100R} = 18{,}985\ x\ C\ x\ A$$

$$V_{100R} = 18{,}985\ x\ 0.59\ x\ 10.32\ acres = 115{,}596\ cubic\ feet$$

Calculate the 100-year Storage Volume

$$V_{100D} = V_{100R}\ x\ R$$

$R = 0.474$ (Calculated on Previous Page)

$$V_{100D} = 115{,}596\ x\ 0.473 = 54{,}677 \text{ cubic feet}$$

The site plan must be designed to accommodate the following volumes:

- V_{CPVC}: 28,733 cubic feet
- V_{ED}: 41,994 cubic feet
- V_{100D}: 54,677 cubic feet

  * If the volume control requirement is met, the CPVC volume can be subtracted from (credited against) the 100-year flood control volume.

Outlet Calculations

Note: If the CPRC volume is at or above the flood control volume, a single control (CPRC) is only for the orifice. Volume above the 100-year allowable will be controlled by the outlet pipe (overflow weir). Additionally, for pipe sizing downstream of the detention pond, supporting calculations would need to be provided (not shown here).

Calculate the Extended Detention Release Rate

$$Q_{ED} = \frac{V_{ED}}{172{,}800}$$

$$Q_{ED} = \frac{41{,}994\ cubic\ feet}{172{,}800} = 0.24\ cfs$$

Orifice Calculations

Extended Detention Orifice Design

$$Q_p = C_O\ x\ A_O\ x\ \sqrt{2\ x\ g\ x\ h}$$

$$Q_p = 0.62\ x\ 0.022\ x\ \sqrt{2\ x\ 32.2\ x\ 3.6} = 0.21\ cfs$$

0.62 used for standard orifice opening

h = water level at 50% V_{ED} (based on Extended Detention basin design)

2" orifice opening will need additional protection from clogging.

Orifice sized for extended detention allowable discharge rate (0.21 cfs).

Infiltration BMP Calculations

Average Infiltration Area (Bioretention Cell 1)

$$A_t = \frac{A_1 + A_2}{2}$$

$$A_t = \frac{2{,}650\ sf + 3{,}500\ sf}{2} = 3{,}075\ square\ feet$$

Surface Storage Volume (Bioretention Cell 1)

$$V_{ss} = A_t\ x\ H$$

$$V_{ss} = 3{,}075\ sf\ x\ 1\ ft = 3{,}075\ cubic\ feet$$

Subsurface Storage Volume (Bioretention Cell 1)

$$V_{soil} = h\ x\ SA\ x\ e$$

Void ratio 0.30 (max)

$$V_{soil} = 1.5\ ft\ x\ 3{,}075\ sf\ x\ 0.3 = 1{,}384\ cubic\ feet$$

Infiltration Storage (Bioretention Cell 1)

$$V_i = \frac{K_{sat}\ x\ S_f\ x\ 6\ x\ A_t}{12in}$$

$$V_i = \frac{1\frac{in}{hr}\ x\ 1\ x\ 6\ x\ 3{,}075\ sf}{12in} = 1{,}538\ cubic\ feet$$

Bioretention Total Storage Volume (Bioretention Cell 1)

$$V_{tbr} = V_{ss} + V_{subsurface} + V_i$$

$$V_{tbr} = 3{,}075\ cf + 1{,}384\ cf + 1{,}538\ cf = 5{,}997\ cubic\ feet$$

Rounded to 6,000 cubic feet.

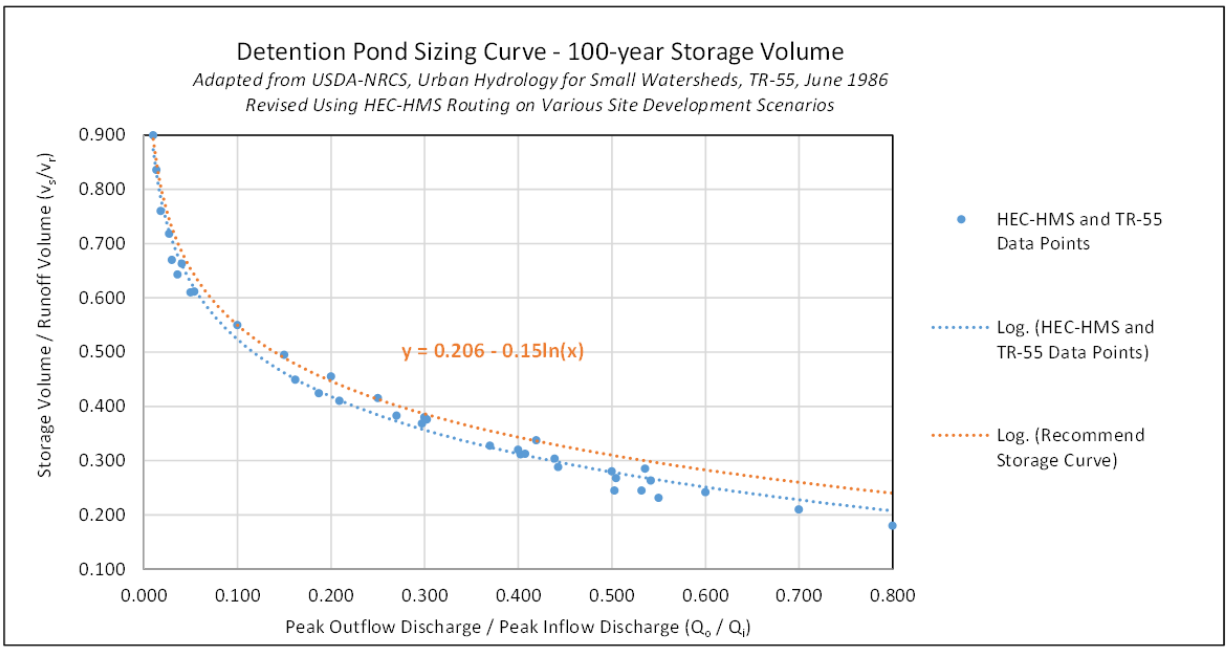
Summary of Bioretention Cell Storage

Location	Bottom Contour Area (SF)	Top Contour Area (SF)	Avg Area (SF)	Surface Storage (CF)	Soil Storage (CF)	Infiltration Storage (CF)	Total Storage (CF) (Rounded)
1	2,650	3,500	3,075	3,075	1,384	1,538	6,000
2	3,300	4,800	4,050	4,050	1,823	2,025	7,900
3	1,400	2,100	1,750	1,750	788	875	3,400
4	1,400	2,400	1,900	1,900	855	950	3,700
5	2,000	2,800	2,400	2,400	1,080	1,200	4,700
6	1,400	2,400	1,900	1,900	855	950	3,700
Total Volume Provided				**15,075**	**6,785**	**7,538**	**29,400**

Total volume provided by infiltration BMPs exceeds the required Channel Protection Volume (28,733 cf).

Please note that since the CPVC is met, the Water Quality requirement is also achieved.

Detention Pond Sizing Curve



Original TR-55 Table included Qo/Qi values ranging from 0.10 to 0.80

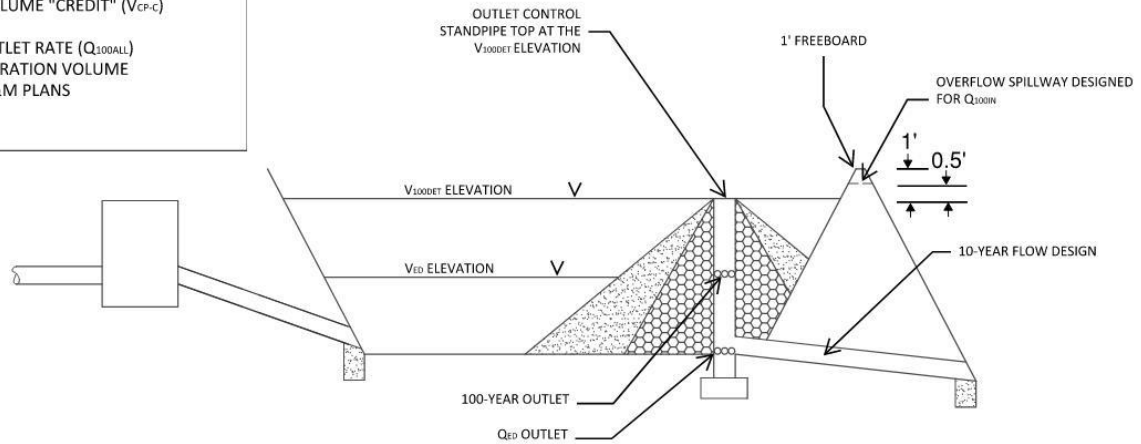
Additional values added using HEC-HMS routing, including Qo/Qi values less than 0.10

Typical Detention Basin/Forebay Cross Sections

TYPICAL DETENTION BASIN WITH MECHANICAL SEPERATOR

REQUIRED PROFESSIONAL ENGINEER CERTIFICATIONS

-CHANNEL PROTECTION VOLUME "CREDIT" (V_{CP-C})
-INFILTRATION RATES
-100-YEAR ALLOWABLE OUTLET RATE (Q_{100ALL})
-MEP FOR ACHIEVED INFILTRATION VOLUME
-STORMWATER SYSTEM O&M PLANS



MECHANICAL SEPARATOR

REQUIRED WATER QUALITY TREATMENT IS 80 MG/L TSS, OR 80% TSS REMOVAL

SIZED BASED ON THE 1-YEAR WATER QUALITY PEAK FLOW RATE (Q_{WQ})

$Q_{WQ}= (C)(I_1)(A)$

REPLACES FOREBAY REQUIREMENT

INSTALLED OFFLINE AND UPSTREAM OF ANY DETENTION OR RETENTION BASIN

NOTES:
-MUST BE NJDEP CERTIFIED
-EXCLUDES UPSTREAM CONTRIBUTING AREA'S WHERE 1-INCH WATER QUALITY CONTROL IS PROVIDED THROUGH OTHER BMP'S

EXTENDED DETENTION VOLUME (V_{ED})

EXTENDED DETENTION CONTROLS THE 2-YEAR BANK FULL RELEASE RATE BY DEWATERING THE V_{ED} OVER 48-HOURS

$V_{ED}= (6,897)(C)(A)$

EXTENDED DETENTION OUTLET RATE

$Q_{ED}=(V_{ED})/(172,800)$

$H_{ED}=(V_{ED})/((4,666)(h)^{(1/2)})$

H_{ED}= NUMBER OF 1-INCH DEWATERING HOLES
h=TOTAL HEAD ON THE ORIFICES

100-YEAR POST-CONSTRUCTION INLET RATE (Q_{100IN})

$Q_{100IN}=(C)(I_{100})(A)$

$I = [(30.2033)(P^{0.2203})]/[(T_C + 9.1747)^{0.8069}]$

100-YEAR ALLOWABLE OUTLET RATE (Q_{100ALL})

THE ALLOWABLE 100-YEAR OUTLET RATE IS THE LESSER OF:

-OCWRC RESTRICTED RATE FOR THE DRAIN (Q_R)
-PRO-RATED SHARE OF THE DRAINS CAPACITY (Q_P)
OR
-THE VARIABLE RELEASE RATE (Q_{VRR})

$Q_{VRR}=1.1055 - 0.206LN(A)$

100-YEAR DETENTION VOLUME (V_{100DET})

$R=0.206-(0.15)(LN(Q_{100ALL}/Q_{100IN}))$

R=STORAGE CURVE FACTOR

$V_{100RUN}=(18,900)(C)(A)$

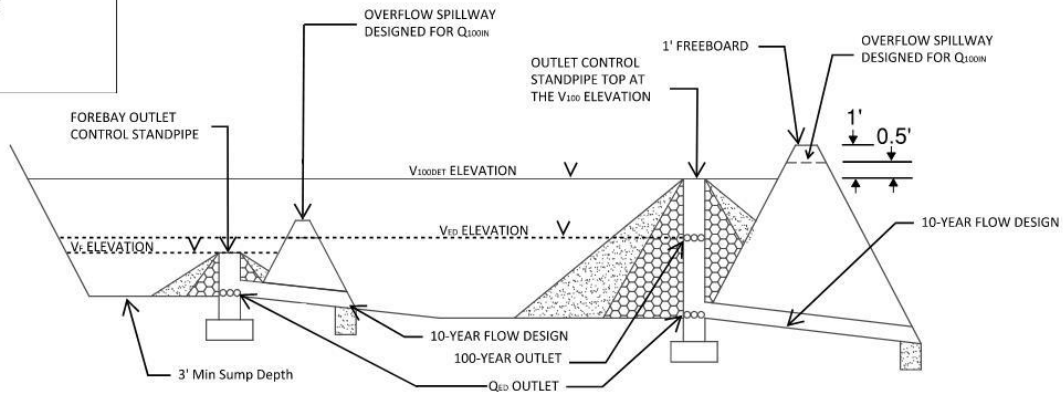
$V_{100DET}=(V_{100RUN})(R)-V_{CP-C}$

REV-11/22/2021

TYPICAL DETENTION BASIN WITH FOREBAY

REQUIRED PROFESSIONAL ENGINEER CERTIFICATIONS

-CHANNEL PROTECTION VOLUME "CREDIT" ($V_{CP\text{-}C}$)
-INFILTRATION RATES
-100-YEAR ALLOWABLE OUTLET RATE (Q_{100ALL})
-MEP FOR ACHIEVED INFILTRATION VOLUME
-STORMWATER SYSTEM O&M PLANS



FOREBAY VOLUME (V_F)

A FOREBAY FOR ALL INLETS SHALL CAPTURE SILT, SAND, TRASH AND DEBRIS FOR REMOVAL. THEY ARE SIZED AT 15% OF THE WATER QUALITY VOLUME (V_{WQ})

$V_F = (545)(C)(A)$

V_F IS A MINIMUM OF V_{WQ} WHEN DOWNSTREAM INFILTRATION IS PROPOSED

FOREBAY OUTLET SIZE

THE FOREBAY OUTLET SIZE IS THE SAME AS THE EXTENDED DETENTION OUTLET SIZE

NOTE: ALTERNATIVE FOREBAY OUTLETS REQUIRE PRE-APPROVAL FROM THE OCWRC

EXTENDED DETENTION VOLUME (V_{ED})

EXTENDED DETENTION CONTROLS THE 2-YEAR BANK FULL RELEASE RATE BY DEWATERING THE V_{ED} OVER 48-HOURS

$V_{ED} = (6,897)(C)(A)$

EXTENDED DETENTION OUTLET RATE

$Q_{ED}=(V_{ED})/(172,800)$

$H_{ED}=(V_{ED})/((4,666)(h)^{(1/2)})$

H_{ED}= NUMBER OF 1-INCH DEWATERING HOLES
h=TOTAL HEAD ON THE ORIFICES

100-YEAR POST-CONSTRUCTION INLET RATE (Q_{100IN})

$Q_{100IN}=(C)(I)(A)$

$I = [(30.2033)(P^{0.2203})]/[(T_C + 9.1747)^{0.8069}]$

100-YEAR ALLOWABLE OUTLET RATE (Q_{100ALL})

THE ALLOWABLE 100-YEAR OUTLET RATE IS THE LESSER OF:

-OCWRC RESTRICTED RATE FOR THE DRAIN (Q_R)
-PRO-RATED SHARE OF THE DRAINS CAPACITY (Q_P)
OR
-THE VARIABLE RELEASE RATE (Q_{VRR})

$Q_{VRR}=1.1055 - 0.206LN(A)$

100-YEAR DETENTION VOLUME (V_{100DET})

$R=0.206-(0.15)(LN(Q_{100ALL}/Q_{100IN}))$

R=STORAGE CURVE FACTOR

$V_{100RUN}=(18,900)(C)(A)$

$V_{100DET}=(V_{100RUN})(R)-V_{CP\text{-}C}$

REV-11/22/2021

List of County Drains with Hydraulically Restricted Outlets

Drain	Capacity (cfs/acre)
John E. Olsen	0.0776
Brown	0.1
Taylor-Ladd	0.1
Dry Run	0.1
Sinking Bridge	0.0776
Holland	0.0776
New Hudson East of Airport	0.068
Vinewood	0.0776
Galloway	0.09
Blackwood	0.03

Appendix D: George W. Kuhn Combined Sewer District Requirements

Appendix E: Standard Variables

TC: Contributing Area Time of Concentration (Minutes)

A: Contributing Area (Acres)

C: Composite Post-Construction Runoff Coefficient for the Drainage Area

H_{ED}: Number of 1-inch Holes Required for Dewatering

Q_{ED}: Extended Detention Outlet Rate (CFS)

Q_{100IN}: 100-year Post-Construction Inlet Rate (CFS)

Q_{100ALL}: 100-year Allowable Outlet Rate (CFS) is the lesser of Q_R, Q_P, Q_{VRR}

Q_R: Restricted Outlet Rate (CFS) – Request from OCWRC office

Q_P: Pro-rated Share of the Drain Capacity (CFS)

Q_{VRR}: Variable Release Rate (CFS)

Q_{WQ}: 1-year Water Quality Design Rate for Mechanical Separators (CFS)

R: Storage Curve Factor

V_F: Forebay Volume (CF)

V_{ED}: Extended Detention Volume Required (CF)

V_{ED-P}: Extended Detention Volume Provided (CF)

V_{100IN}: 100-year Inlet Volume (CF)

V_{100DET}: 100-year Detention Volume (CF), where $V_{100DET} = V_{100RUN} \times R - V_{CP-C}$

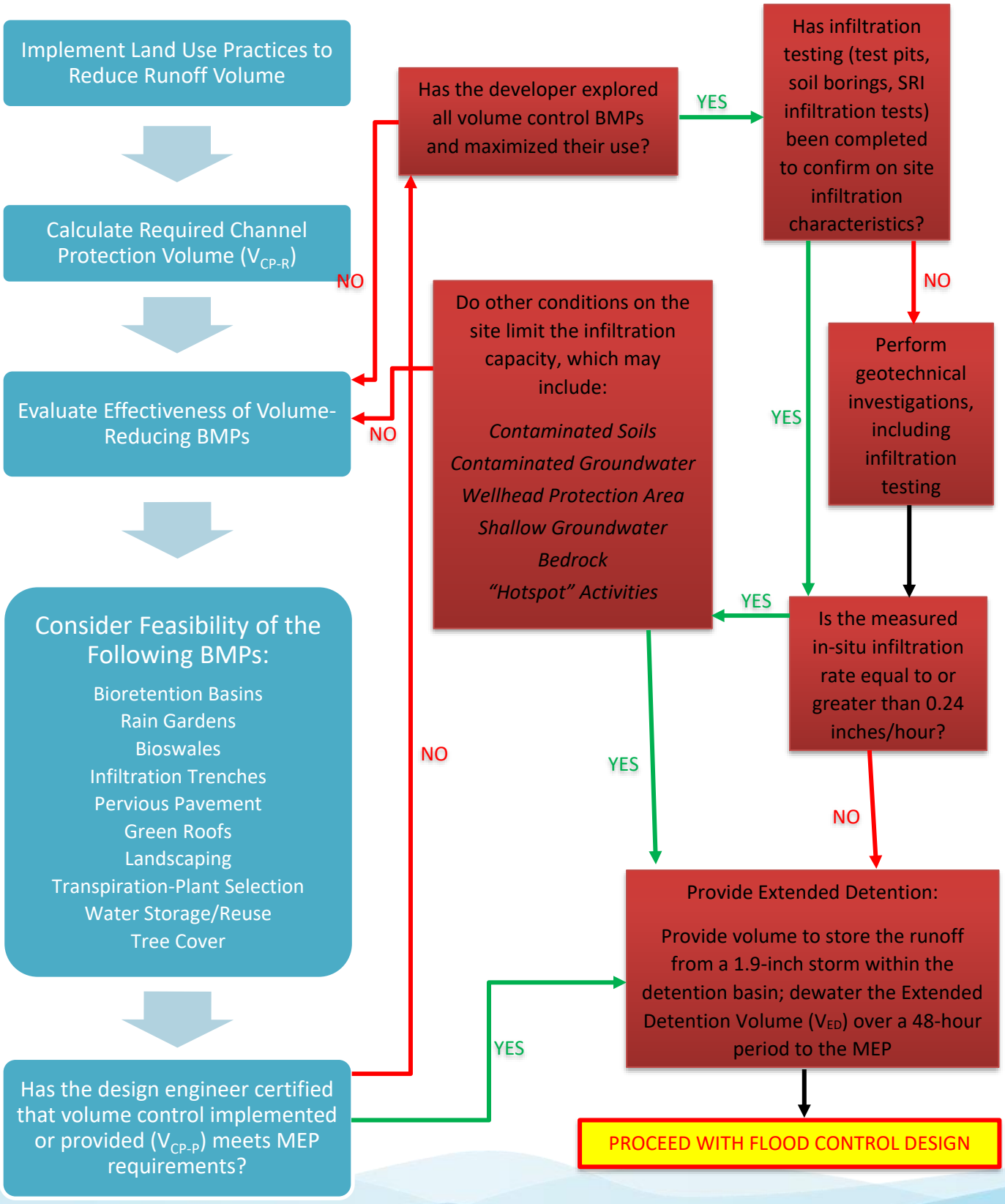
V_{CP-R}: Channel Protection Volume - Required (CF)

V_{CP-P}: Channel Protection Volume - Provided (CF)

V_{CP-C}: Channel Protection Volume - Credit (CF), where $V_{CP-C} = V_{CP-P}$ and $V_{CP-C} \leq V_{CP-R}$

V_{WQ}: Water Quality Volume (CF)

Appendix F: Channel Protection Flow Chart


Implement Land Use Practices to Reduce Runoff Volume
Calculate Required Channel Protection Volume (V_{CP-R})
Evaluate Effectiveness of Volume-Reducing BMPs
Consider Feasibility of the Following BMPs:
Bioretention Basins
Rain Gardens
Bioswales
Infiltration Trenches
Pervious Pavement
Green Roofs
Landscaping
Transpiration-Plant Selection
Water Storage/Reuse
Tree Cover
Has the design engineer certified that volume control implemented or provided (V_{CP-P}) meets MEP requirements?
NO
YES
Has the developer explored all volume control BMPs and maximized their use?
NO
YES
Has infiltration testing (test pits, soil borings, SRI infiltration tests) been completed to confirm on site infiltration characteristics?
NO
YES
Perform geotechnical investigations, including infiltration testing
Do other conditions on the site limit the infiltration capacity, which may include:
Contaminated Soils
Contaminated Groundwater
Wellhead Protection Area
Shallow Groundwater
Bedrock
"Hotspot" Activities
YES
Is the measured in-situ infiltration rate equal to or greater than 0.24 inches/hour?
NO
YES
Provide Extended Detention:
Provide volume to store the runoff from a 1.9-inch storm within the detention basin; dewater the Extended Detention Volume (V_{ED}) over a 48-hour period to the MEP
PROCEED WITH FLOOD CONTROL DESIGN

Appendix G: Maintenance Agreement

Stormwater Management Operations and Maintenance Agreement

This Agreement is made on [DATE], by and between [Community Name], (hereinafter "Community") whose address is [address] and [Owner Name], whose address is [address], (hereinafter "Owner"). Community and Owner agree as follows:

Article I. <u>The Subject Property</u>.

1.1 Owner owns the property located at and commonly known as [address or general description] (hereinafter the "Subject Property"). The legal description of the Subject Property is set forth at ***Exhibit A***.

Article II. <u>The Stormwater System</u>.

2.1 Owner, in accordance with Oakland County Stormwater Standards and State Municipal Separate Storm Sewer System permit requirements, agrees to install and maintain a Stormwater System on the Subject Property in accordance with approved plans and conditions. The Stormwater System is set forth at ***Exhibit B***.

2.2 After construction has been verified and accepted by the Community for the Stormwater System, the Owner shall file with the Community the "as-built" documents showing the design and construction details and shall reference this Agreement.

2.3 The Stormwater System will be governed by the terms and conditions in this Agreement.

Article III. <u>The Stormwater O&M Plan</u>.

3.1 The Owner shall be solely responsible for the installation, maintenance, and repair of the Stormwater System, drainage easements, and associated landscaping identified in Exhibit B in accordance with the Stormwater Management Operations and Maintenance Plan, hereinafter the "Stormwater O&M Plan" set forth at ***Exhibit C*** to this Agreement.

3.2 The Stormwater O&M plan is subject to approval by the Community.

3.3 The Owner agrees that the Stormwater O&M Plan is intended to and will serve the Subject Property in perpetuity.

3.4 The Owner, at its expense, shall secure from any affected owners of land all easements and releases of right-of-way necessary for implementation of the Stormwater O&M Plan and shall record them with the Oakland County Register of Deeds. These easements and releases of rights-of-way shall not be altered, amended, vacated, released, or abandoned without prior written approval of the Community.

3.5 No alterations or changes to the Stormwater O&M Plan shall be permitted unless they are deemed to comply with this Agreement and are approved in writing by the Community.

3.6 The Owner shall retain the services of a qualified inspector as described in Exhibit C – Maintenance Requirement 1) to operate and ensure the maintenance of the Stormwater O&M Plan.

3.7 The Owner shall annually, by December 30th, provide to the Community records (logs, invoices, reports, data, etc.) of inspections, maintenance, and repair of the Stormwater System in compliance with the Stormwater O&M Plan.

3.8 The Community agrees to enforce compliance with the annual inspection, maintenance and repair records as set forth in 3.7 above, such enforcement may require an ordinance.

Article IV. <u>Access and Enforcement</u>.

4.1 The Community or its designee is authorized to access the property as necessary to conduct inspections of the Stormwater System, implication of the Stormwater O&M Plan, or drainage easements to ascertain compliance with the intent of this Agreement.

Upon written notification by the Community or their designee of required maintenance or repairs, the Owner shall complete the specified maintenance or repairs within a reasonable time frame determined by the Community. The Owner shall be liable for the failure to undertake any maintenance or repairs so that the public health, safety and welfare shall not be endangered nor the road improvement damaged.

4.2 If the Owner does not keep the Stormwater System in reasonable order and condition, or complete maintenance activities in accordance with the Stormwater O&M Plan, or the reporting required in 3.7 above, the Community is authorized, but not required, to perform the specified inspections, maintenance or repairs in order to preserve the intended functions of the Stormwater System and prevent the Stormwater System from becoming a threat to public health, safety, general welfare or the environment.

4.3 In the case of an emergency, as determined by the Community, no notice shall be required prior to the Community performing emergency maintenance or repairs. The Community may levy the costs and expenses of such inspections, maintenance or repairs against the Owner.

The Community, at the time of entering upon said Stormwater System for the purpose of maintenance or repair, may file a notice of lien in the office of the Register of Deeds of Oakland County upon the property affected by the lien. If said costs and expenses are not paid by the Owner, the Community may pursue the collection of same through appropriate court actions and in such a case, the Owner shall pay in addition to said costs and expenses all costs of litigation, including attorney fees.

4.4 The Owner hereby conveys to the Community an easement over, on and in the property described in Exhibit A for the purpose of access to the Stormwater System for the inspection, maintenance and repair thereof, should the Owner fail to properly inspect, maintain and repair the Stormwater System.

Article V. Term and Covenants.

5.1 The Owner agrees that this Agreement shall bind all current and future owners of the property. The Owner agrees in the event that the Subject Property is sold, transferred, or leased to provide information to the new owner, operator, or lessee regarding proper inspection, maintenance and repair of the Stormwater System and Stormwater O&M Plan. The information shall accompany the first deed transfer and include Exhibits B and C and this Agreement. The transfer of this information shall also be required with any subsequent sale, transfer or lease of the Subject Property.

5.2 The Owner agrees that the rights, obligations and responsibilities hereunder shall commence upon execution of the Agreement.

Article VI. The Memorandum.

6.1 The Owner shall record with the Oakland County Register of Deeds a Memorandum of Stormwater Management Operations and Maintenance Agreement which serves as notice of this Agreement in a title search, the template for which is set forth at ***Exhibit D*** to this Agreement.

Article VII. Claims and Authority.

The Owner, its agents, representatives, successors and assigns shall defend, indemnify and hold Community harmless from and against any claims, demands, actions, damages, injuries, costs or expenses of any nature whatsoever, hereinafter "Claims", fixed or contingent, known or unknown, arising out of or in any way connected with the design, construction, use, maintenance, repair or operation (or omissions in such regard) of the Stormwater System, appurtenances, connections and attachments thereto which are the subject of this Agreement. This indemnity and hold harmless shall include any costs, expenses and attorney fees incurred by Community in connection with such Claims or the enforcement of this Agreement.

7.1 The parties whose signatures appear below hereby represent and warrant that they have the authority and capacity to sign this agreement and bind the respective parties hereto.

IN WITNESS WHEREOF, the Owner and Community have executed this agreement on the day and year first above written.

Owner

By: _____

Its: _____

STATE OF MICHIGAN)

)ss.

_____ COUNTY)

The foregoing instrument was acknowledged before me on this_____ day of _____, 20 ___, by _____, the _____ of _____.

_____

Notary Public

Community

By: _____

Its: _____

STATE OF MICHIGAN)

)ss.

_____ COUNTY)

The foregoing instrument was acknowledged before me on this_____ day of _____, 20 ___, by _____, the _____ of _____.

_____

Notary Public

Explanation of Exhibits

Exhibit A – Legal Description: Provide a legal description and reduced copy map to identify the land parcel(s) affected by this Agreement. This exhibit must be customized for each site. It must include a reference to a Subdivision Plat, Certified Survey number, or Condominium Plat, and a map to illustrate the affected parcel(s).

Exhibit B – Stormwater System Description and Map: Provide a written description and location map of the Stormwater System. This exhibit must be customized for each site. Map scale must be sufficiently large enough to show necessary detail.

Exhibit C – Stormwater O&M Plan: This exhibit explains the basic function of the stormwater management operation and maintenance plan, schedule, and budget providing the minimum specific maintenance activities and frequencies for each practice. The minimum elements of this exhibit include a description of the drainage area and the installed Stormwater System, a description of the specific maintenance activities which should include the following in addition to specific maintenance actions:

- Employee training and duties,
- Routine service requirements,
- Operating, inspection, and maintenance schedules, and
- Detailed construction drawings showing all critical components and their elevations.

The plan must include maintenance tasks and schedules. Refer to the Low Impact Development Manual for Michigan for maintenance task checklists for permanent BMPs and create a table of applicable maintenance tasks and schedules.

Exhibit D – Template for Memorandum of Stormwater Management Operations and Maintenance Agreement: This exhibit contains a template for said Memorandum to be recorded with the County Register of Deeds to put any future owners, or interest holders, on notice of the Stormwater System and the Stormwater System O&M Plan.

WRC
WATER RESOURCES COMMISSIONER
Jim Nash

Memorandum of Stormwater Management Operations and Maintenance Agreement

The "Owner" _____ and the "Community" _____ have entered into a Stormwater Management Operations and Maintenance Agreement dated _____ for real property located in the State of Michigan, County of Oakland, City of _____ and further described as follows:

[real property description]

Commonly known as: _____

Parcel ID: _____

The Stormwater Management Operations and Maintenance Agreement provides for a stormwater management operation and maintenance plan for a stormwater system located on the real property. It authorizes easements for the local community to take enforcement action if the Agreement is breached. This Agreement runs with the land, binds all current and future owners of the real property and serves the real property in perpetuity.

Owner:

By: _____

Its: _____

STATE OF MICHIGAN)

)ss.

_____ COUNTY)

The foregoing instrument was acknowledged before me on this_____ day of _____, 2017, by _____, the _____ of _____.

_____

Notary Public

Recording Fee: $15.00

Drafted by and Return to:

Appendix H: Engineer's Certificate of Outlet

Date:

Oakland County Water Resources Commissioner

Building 95 West – One Public Works Drive

Waterford, Michigan 48328-1907

Attention: _____

Reference: Proposed _____

Location _____

Gentlemen:

ENGINEER'S CERTIFICATION

This is to certify that existing drain or watercourse (select one) is the only reasonable outlet for the proposed _(name of development)_____, located in the city/township/village (select one) of _____and that the existing drain or watercourse (select one) has sufficient capacity to serve as an adequate outlet for __(name of development)_____without detriment or diminution of the drainage services which the outlet presently provides.

_____

Registration No.: _____