PROCEDURES AND DESIGN STANDARDS MANUAL FOR STORMWATER MANAGEMENT
(Rev. March 1st, 2024)

MACOMB COUNTY PUBLIC WORKS COMMISSIONER




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iv Acronyms

BMPs – Best Management Practices

CN – Curve Number

CP – Channel Protection (design criteria)

CTC – Certified True Copy

DOT – Department of Transportation

DA – Drainage Area

EGLE – Michigan Department of Environment, Great Lakes & Energy (formerly MDEQ)

FEMA – Federal Emergency Management Agency

FHWA – Federal Highway Administration

GPS – Global Positioning System

HEC 14 – Hydrologic Engineering Center's Hydraulic Design of Energy Dissipators for Culverts and Channels

HEC-RAS – Hydrologic Engineering Center's River Analysis System

HY8Energy – Windows 95/NT4 Energy Dissipator Design Software

I_a – Initial abstraction

LTU – License to Use

MCPWO – Macomb County Public Works Office

MDEQ – Michigan Department of Environmental Quality (former name of Michigan Department of Environment, Great Lakes & Energy; ELGE)

MTD – Manufactured Treatment Device

MS4 – Municipal Separate Storm Sewer System

NEH - National Engineering Handbook, USDA-NRCS

NPDES – National Pollutant Discharge Elimination System

NRCS – Natural Resources Conservation Service (formerly Soil Conservation Service)

OSDS – On-Site Sewage Disposal System

OHWM – Ordinary High Water Mark

Q_{bkf} – Bankfull Discharge A.K.A Channel forming Discharge AKA Effective Discharge Channel Forming Flow

Q_{peak} – Peak Flow of design storm event

RECPs – Rolled Erosion Control Products

SAD – Special Assessment District

SESC – Soil Erosion and Sediment Control

SCS – Soil Conservation Service

t_c – Time of Concentration

TR-55 –Technical Release 55, *Urban Hydrology for Small Watersheds*, (USDA-SCS, 1986)

TSS – Total Suspended Solids

USDA-– United States Department of Agriculture

USGS – United States Geological Survey

W:D – Width to Depth Ratio

WSE – Water Surface Elevation

WQ – Water Quality (design criteria)

WQV – Water Quality Volume

PART I - BACKGROUND & JURISDICTION

The Macomb County Public Works Office (MCPWO) has previously operated under its 1967 Rules and Regulations for Internal and External Drainage for Subdivisions, as required by Public Act 288 of 1967. Due to new regulations affecting the MCPWO, specifically Phase II National Pollutant Discharge Elimination System (NPDES) Stormwater Regulations, and more available information for better stormwater conveyance, the MCPWO has updated its design standards. The most recent revision of 'Procedures and Design Standards for Stormwater Management' will supersede all previously adopted rules and regulations.

The updated MCPWO's Procedures and Design Standards for Stormwater Management draws its authority from the following State and/or Federal laws:

- The Land Division Act Public Act No. 288 of 1967, as amended; M.C.L. §§ 560.101 – 560.293
- The Michigan Drain Code Public Act No. 40 of 1956, as amended M.C.L. §§ 280.1 – 280.630
- The Mobile Home Commission Act Public Act No. 96 of 1987, as amended; M.C.L. §§ 125.2301 – 125.2350
- The Condominium Act Public Act No. 59 of 1978, as amended; M.C.L. §§ 559.101 – 559.276
- Part 91, Soil Erosion and Sedimentation Control, Natural Resources and Environmental Protection Act, Act 451 of the Public Acts of 1994
- Part 17 of the Michigan Administrative Code Being Sections R 323.1701 to R 323.1714.
- Code of Federal Regulations Title 40, Chapter 1, Subchapter D, Part 122 (NPDES MS4 Program Requirements).
- Part 31 Water Resource Protection, Natural Resources and Environmental Protection Act, Act 451 of the Public Acts of 1994
- Part 41 Sewerage Systems, Natural Resources and Environmental Protection Act, Act 451 of the Public Acts of 1994

As previously mentioned, the County's *Procedures and Design Standards for Stormwater Management* were updated to address stormwater management and stormwater impacts on county drains and county assets as necessary to comply with the requirements of the Phase II National Pollutant Discharge Elimination System (NPDES) Stormwater Regulations. The County and the Public Works Office have a joint NPDES stormwater discharge permit which is managed by the Macomb County Public Works Office. MCPWO is working with local communities, school districts and other stakeholders to implement several watershed management plans. As a result, the new requirements were developed to meet many sets of goals and objectives. This stormwater management approach includes design criteria for water quality, channel protection, flood protection, and long-term maintenance to ensure the long-term effectiveness of stormwater management facilities.

This stormwater management approach includes design criteria for water quality, channel protection, flood protection, and long-term maintenance.

The types of development covered by the *Procedures and Design Standards for Stormwater Management* include, but are not limited to, plats, subdivision condominiums, manufactured (mobile) home parks and any other project requiring the Macomb County Public Works Commissioner approval. Public Acts and local ordinances give the Macomb County Public Works Commissioner the authority to review these projects to ensure compliance with MCPWO standards. The "Land Division Act" (PA 288 of 1967) requires final preliminary plat approval and final plat approval by the Macomb County Public Works Commissioner. Subdivision condominiums, land divisions, and other developments may require the Macomb County Public Works Commissioner approval if the local municipality requires it.

The MCPWO will review these types of developments to help minimize any possibility of adverse effects to the development, adjacent property, and the environment due to stormwater runoff.

The MCPWO exercises authority over the design of stormwater management practices that convey, store, and treat stormwater runoff from a construction project or earth change that discharges to a County drain or other county stormwater asset. The MCPWO's *Procedures and Design Standards for Stormwater Management* regulate the design of such management facilities with the following objectives:

- Protect public health, safety, and welfare.
- Promote uniform drainage procedures for development of all lands within Macomb County.
- Provide a comprehensive framework for managing stormwater that effectively achieves multiple objectives – water quality, channel protection and flood control.
- Incorporate design standards that control both water quantity and quality.
- Encourage innovative stormwater management practices that meet the criteria contained within these rules.
- Provide guidelines on the selection of effective structural and non-structural stormwater management practices for development sites.
- Improve the quality of stormwater management practices in Macomb County including: performance, longevity, safety, ease of maintenance, community acceptance, and environmental benefits.
- Emphasize maintenance of the facilities.
- Strengthen the protection of natural features.
- Encourage more effective soil erosion and sedimentation control measures.

I.1 - MCPWO Stormwater Standards Applicability

This manual sets design and construction standards to be used by the MCPWO stormwater division in review of proposed construction projects within its jurisdiction. These standards are the minimum requirements of the MCPWO stormwater division and should not be construed as all-inclusive. The design engineer must also consider other requirements for entities at the federal, state, and local levels when developing stormwater management facilities. Exceptions will be considered and require approval by MCPWO.

Standards concerning stormwater drainage systems are the primary focus of this manual and may consist of open ditches, swales, closed conduits or a combination of methods to convey stormwater. Drainage facilities shall be constructed in accordance with these minimum specifications for Macomb County. Other standards may apply such as the Michigan Department of Transportation (MDOT), Macomb County Department of Roads (MCDR), or local governments, which may be more stringent and shall be adhered to when applicable.

The MCPWO recognizes that it is difficult to develop one set of uniform standards that can accommodate all variables and unique site circumstances. Waivers or variances from specific provisions of these standards may be requested, and alternatives consistent with the overall intent of stormwater quantity and quality management may be proposed, subject to the approval of the MCPWO.

These standards apply to projects involving new development, redevelopment, and any other project types that meet any of the conditions specified in Table I-1.

Table I-1 - Projects subject to MCPWO requirements

Project Condition	Description
Disturbed Area / Earth Change Area	Projects that disturb and/or make an earth change to one (1) or more acres
Project involving a large common plan of development or sale	Projects disturbing less than one (1) acre but are also part of a larger common plan of development or sale that would disturb one acre or more in total (e.g., staged developments, or multiple small disturbances in quick secession can trigger MCPWO standards).
Projects impacting or discharging to County Assets	County Assets may include but are not limited to county drains, property/buildings owned by Macomb County, and/or storm sewer systems owned/managed by the Macomb County Department of Roads.
When Macomb County manages the first MS4 district encountered by the site discharge	Macomb County is subject to the MS4 requirements set by the State of Michigan. The County is responsible to manage the runoff volume, rate, water quality, and reporting requirements set by the MS4 program. As such, when Macomb County represents the first MS4 district encountered by the site discharge MCPWO standards apply to the project to ensure compliance with the MS4 program.

I.1.A - Past and Future MCPWO Standards Revisions

The MCPWO stormwater standards should be considered a living document that will be revised periodically to reflect changes to engineering standards, federal & state law, and to support both environmental quality, economic development, and overall quality of life in Macomb County. In some cases, development projects are studied and designed over several years, within that timeframe stormwater regulations may be revised. In these cases, MCPWO reserves the right to choose which set of standards or combination of standards are required to receive a permit. Table I-2 provides information regarding previous versions of the MCPWO standards.

Table I-2 - Previous Versions of the MCPWO Design Standards

Document Title	Published Date	Brief Description of Select Features
Procedures and Design Standards for Stormwater Management	May 28, 2021 & October 1, 2020	• NOAA Atlas 14 Rainfall • Standard MCPWO Drain Cross-section • Water Quality Control Volume and Water Quality Control Rate • CPVC 1.2"rainfall runoff infiltration requirements • CPRC 1.9" rainfall runoff 48-hour release • Variable 100-yr release rate
Procedures and Design Standards for Stormwater Management	July 30, 2008	• Bulletin 71 Rainfall Depths • CN based Channel Protection Volume • Overbank Flood Protection; 100-year max release of 0.2 cfs/acre • 100-year basin volume was the greater of either 2IN of runoff/acre, or the Oakland County calculation method. • 2-year rain event to be release over 24 hours.

I.1.B - Conflicts Between Review Agency Design Standards

If a conflict between regulatory agency requirements is discovered, it is recommended that the designer takes the following actions:

- Contact both agencies to resolve the conflict
- Default to the stricter of the two standards
- If the conflict involves calculation methods; show multiple versions of calculations using both standards

I.2 - When is a MCPWO Permit or Stormwater Approval Required?

Table I-3 - MCPWO permit requirement likelihood by storm water discharge location

Storm water Discharge Location [1]	**Likelihood of requiring MCPWO Stormwater Division Permit/Approval?[1]**	**Likelihood of requiring MCPWO SESC Division Permit?[1,2]**
Local municipality requires/requests MCPWO Stormwater Review	Highly Likely	Highly Likely
Constructing A New Tap Or Outfall To A County Drain Or County Road Sewer/Ditch	Highly Likely	Highly Likely
Directly Discharging to an Existing Drain Tap Or Outfall	Highly Likely	Highly Likely
Directly Discharging to an Existing or Proposed Macomb County Road Sewer	Highly Likely	Highly Likely
Directly Discharge to a Regional Detention/Retention Basin	Highly Likely	Highly Likely
Directly Discharge to a wetland or floodplain that connects to a County Drain Or County Road Sewer/Ditch	Possibly	Highly Likely
Directly Discharge to Lake St. Clair	Un-likely	Highly Likely
Directly Discharge to Waterways Under The Jurisdiction Of EGLE	Un-likely	Highly Likely
Situation not listed or have questions?	Contact MCPWO to schedule a Pre-Application meeting	

1 = The details of each project may impact whether a permit is required please contact MCPWO for confirmation.

2 = MCPWO manages SESC permits for many communities within the County, however, some municipalities operate their own SESC program. Contact MCPWO and the local municipality for more information.

I.2.A - Typical Permit Application Review Process

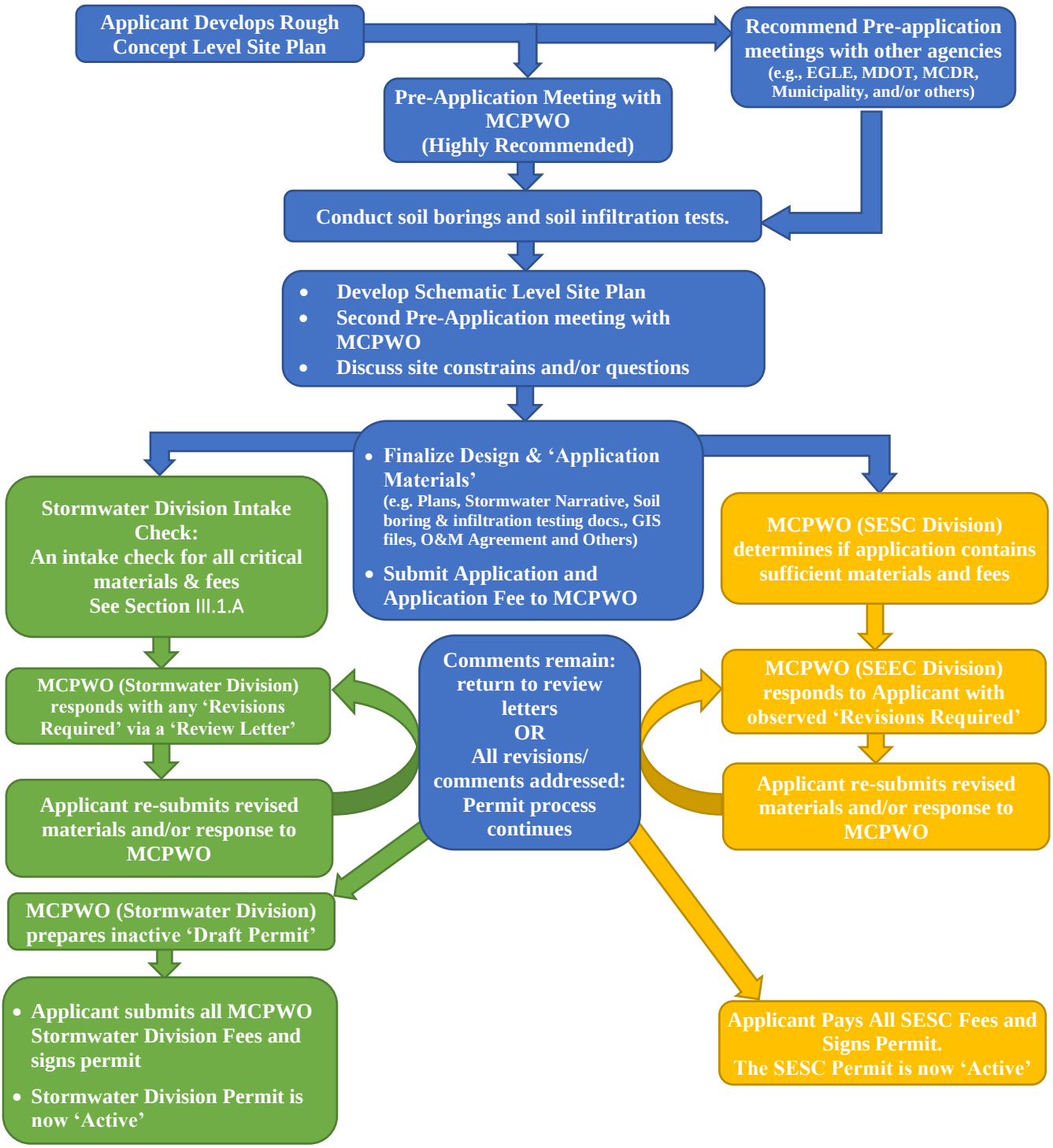


Figure I-1 - Typical Permit Application Review Process

I.2.B - Application/Review/Permit/Contract Status Terminology

Table I-4 - Typical MCPWO Application & Permit/Stormwater Review Status Terminology

Document: Status[1]	Description
'Pre-Application'	• Applicant has not yet submitted a permit application to MCPWO to communicate project intent. • Applicant prepares rough concept level design. • Highly recommend the Applicant contact MCPWO and submit a 'Pre-Application Meeting Request'.
'Application: Withdrawn'	MCPWO or the applicant has withdrawn application from any further review process. A new Application and Review Fee must be submitted to restart the Application process.
'Application: Fees Required'	MCPWO requires that review fees are paid before the Application Review can begin.
'Application: Under Review'	MCPWO is determining if the application contains sufficient materials to begin detailed review or MCPWO is currently performing a detailed review
'Application: Review Letter - Revisions Required'	MCPWO has reviewed submitted application materials and requires that revisions and/or questions are adequately addressed.
'Draft Permit' or 'Draft Drain Contract' or 'Stormwater Review: Approved' or 'Letter of No-Objection Issued'	• Draft Permit or Drain Contract – Documents have been reviewed by MCPWO and requires no further revisions unless the design/plan changes. The Draft Permit or Drain Contract has been prepared by MCPWO but will remain inactive until final payment, signature, and/or other items from applicant are received by MCPWO. • Stormwater Review: Approved – MCPWO has completed its review of the project and has approved the submitted materials. • A 'Letter of No-Objection' is issued when MCPWO has reviewed the project application and finds that 'based on MCPWO's understanding of the information provided' a MCPWO Drain Permit or review is not required.
'Active Permit or Drain Contract'	The MCPWO permit application process is complete. If active permits have also been obtained from all other applicable reviewing agencies the project may perform the permitted work.
'Expired Permit'	Based on the conditions of the prepared or active permit; the permit is expired and, per MCPWO decision, the applicant must request an extension or submit a new application.
'Permit or Drain Contract Violation'	The project is considered in violation of its permit and must comply with directions provided in the violation notice.
'Closed Permit or Drain Contract'	Permitted work has been performed and has been accepted by MCPWO. Typically, no additional work may be performed under this permit.

[1] = MCPWO is not limited to the provided list of typical document: status combinations

I.2.C – Project Components Reviewed by MCPWO

Table I-5 - List of Typical Project Components Reviewed & Not Reviewed by MCPWO

Project Components Typically Reviewed by MCPWO Stormwater Division (A non-comprehensive list)	
Project Components	Description
Water Quality Control (WQC) of stormwater	• Review system of BMPs used and aspects of their design that may impact infiltration performance, TSS capture performance, and/or potential contaminate release.
Volume of stormwater (CPVC)	• Size/volume of detention basin. • Volume of stormwater infiltrated.
Flow rate of stormwater (CPRC/V_{ED})	• Rate of release of the Extended Detention Volume. • Reliability of the outlet control system to resist clogging and tempering.
Design reliability to achieve MS4 & Detention Flood Control (DFC) goals	• Ability of the system to continue infiltrate, discharge, and remove sediment for decades. This may impact BMP design, Outlet control structure design, & material selection.
Hydrologic and Hydraulic aspects of crossings and/or structures proposed on county assets	• Hydraulic calculations of drain crossings. • Hydrologic flow estimates of drain crossings. • Review of select hydrologic and hydraulic computer programs.
Natural Channel Design and/or stream stability	• Channel dimensions, erodibility/stability, and flooding potential. • Instream habitat structures (e.g. Rock vanes, J-Hooks, Cross-Vanes, Riffles)
Drain Easement documentation	• Drain easements are reviewed for size, usability, and documentation status.
Ability of the local drain to accept flow	• MCPWO may inspect and/or review historic drain information to determine the ability of the drain to accept flow.

Project Components <u>NOT</u> Typically Reviewed by MCPWO Stormwater Division (A non-comprehensive list)	
Project Components	Description
On-Site storm sewer collection and conveyance network	• The on-site storm sewer collection system (including pipe flow capacity upstream of the detention system). MCPWO will work with local municipalities to resolve issues regarding the interaction of a detention system and/or drain on the on-site storm sewer network.
Detention/Retention facility aspects not affecting MS4 goals	• Aspects that do not generally affect MS4 goal such as side slopes, safety shelves, basin planting plans, forebay configuration, fences, and others.
Site grading	• Generally, MCPWO does not review site grading unless associated with floodplains, channel cross-sections, and/or basin freeboard
Structural design aspects of the project	• MCPWO does not typically review structural components of the project such as rebar design, concrete mixtures, footing designs, bridge abutments and/or superstructures, structure buoyancy, and/or other similar topics.
Geotechnical stability of structures	• Geotechnical information submitted to MCPWO is primarily evaluated to assess the site's ability to infiltrate water only. A structural analysis (foundation and pavement design recommendations) is insufficient for drainage design.
Electrical/Data service and/or sensor/remote operation	• The design, setup, installation, and integration of electrical, sensor, or data systems is not typically reviewed by MCPWO. MCPWO will review the proposed start, stop, and trigging levels needed for automatic operations of installations such as pump stations.
Wetland determinations, threatened and endangered species, SHPO requirements	• MCPWO does not typically independently verify the location, size, and type of wetlands associated with a project. Nor does the office typically independently verify the potential presence of threatened and endangered species, or SHPO qualifying sites.
MCPWO reserves the right to review and comment on all aspects of the project. If required, MCPWO may also contact and relay aspects of our review to other reviewing agencies and await an agency response.	

PART II - GOALS TO REDUCE IMPACTS OF DEVELOPMENT ON WATER RESOURCES

Every development site is part of a drainage system or watershed. In Macomb County, each drainage system is comprised of a network of streams, drains, storm sewers, and ditches that comprise one of several subwatersheds. Most of the water that runs off the land in Macomb County ends up in the Clinton River and Lake St. Clair. A map in Appendix C (Figure Appendix C-1) illustrates the subwatersheds located within Macomb County.

II.1 - Altered Watershed Hydrology

The health of any river system is largely based on how the land in the watershed is managed. Management at the subwatershed and catchment scale is the most effective in achieving measurable protection and restoration (CWP, 1998). Current research indicates that, as directly connected impervious surface area increases (with storm sewers), there is a detrimental impact on water quality, channel erosion, and stream ecology. An impervious surface is any area that no longer allows rainfall to soak into the ground. Impervious areas include, but are not limited to, roads, sidewalks, patios, rooftops, and driveways. When a site is developed, it loses its natural storage potential for rainfall. Consequently, rain that previously infiltrated into the ground, evaporated or transpired, or was temporarily stored in depressions and tree canopies, now rapidly runs off of the site. This increased runoff causes a number of changes in watershed hydrology (Figure II-1). These changes in hydrology include:

i. Increased volume of runoff, which raises the magnitude and frequency of severe flood events.
ii. Greater frequency of "bankfull" floods - those that fill the stream channel to the top of its banks, but do not spill over into the floodplain. Increased bankfull-flooding subjects the stream channel to continual disturbance and scour.
iii. Higher velocities due to the combined effect of greater discharge, reduced time of concentration, and smoother hydraulic surfaces.
iv. Increased stream flow fluctuations as runoff is concentrated into peaks that are sharper, faster, and higher, followed by equally abrupt returns to pre-storm level discharges. Increased flow fluctuations disrupt habitats and reduce the diversity of aquatic species regardless of water quality.
v. Reduced infiltration into the underlying water table, which in turn lowers the level of water supply aquifers and surface water bodies dependent on groundwater to maintain base flows during dry periods.

II.2 - Changes in Stream Morphology

Increased runoff and flow fluctuations change the dimensions of streams by widening and downcutting the stream channel. Other consequences include:

1. Accelerated streambank erosion occurs as channels are severely disturbed by undercutting, tree-fall, and slumping.
2. Sediment loads may increase due to construction site runoff and streambank erosion. Excessive sediment loads settle out and form shifting bars that often accelerate the erosion process by deflecting runoff into sensitive streambank areas. Sediment deposition may also adversely affect hydraulic capacity and increase maintenance requirements.
3. Modification of aquatic habitats begins as the pools and riffles that characterize natural streams are eliminated as the gradient of the stream adjusts to accommodate frequent floods. The voids between stones on the streambed are filled with sediment, destroying the habitat of fish and aquatic insects.

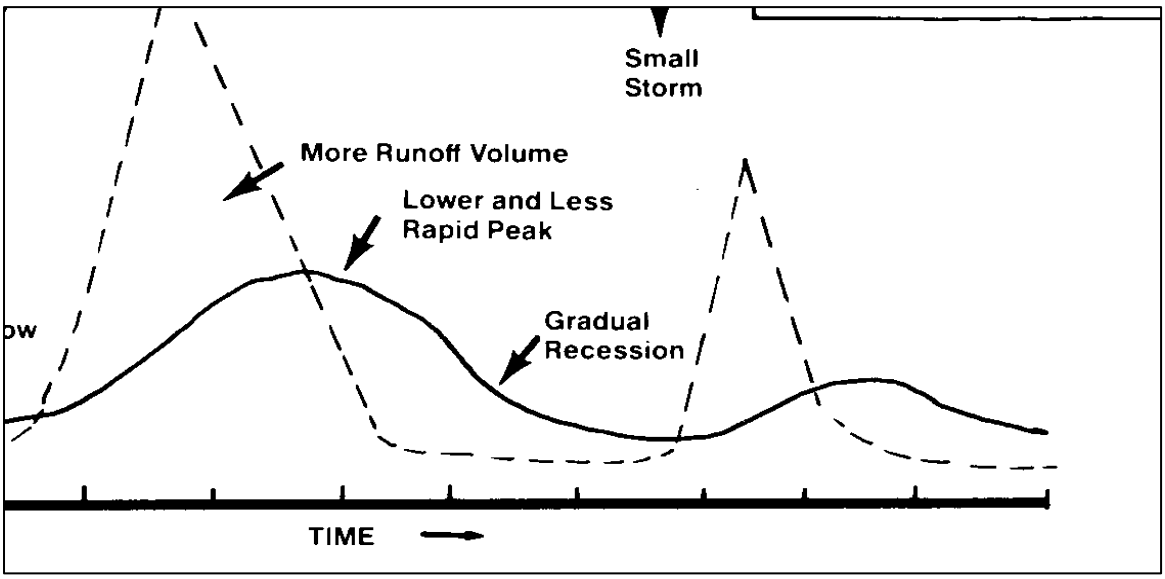


Figure II-1 - Stream Hydrology Changes as Runoff Rates Increase (Schueler, 1987)

II.3 - Changes in Water Quality

Stormwater runoff collects various pollutants and contaminants as it moves across urbanized surfaces, ultimately affecting the quality of water in nearby streams, rivers, lakes, and other water bodies. Here's how urban stormwater runoff can impact water quality:

1. Surface Contaminants: As stormwater flows over paved surfaces, it picks up pollutants like oil, grease, heavy metals (such as lead, zinc, and copper), fertilizers, pesticides, and litter. These substances are commonly found in urban areas and are washed into storm drains or directly enter nearby water bodies. They can have detrimental effects on water quality, leading to increased toxicity and harming aquatic life.

2. Sedimentation: Urban areas are often characterized by extensive construction and land development. During rainstorms, stormwater runoff erodes soil and sediment from construction sites, bare land, and eroded areas. Excessive sedimentation in water bodies can decrease water clarity, disrupt aquatic habitats, and suffocate aquatic organisms by clogging their gills.

3. Nutrient Load: Stormwater runoff can carry high levels of nutrients, such as nitrogen and phosphorus, from various sources like lawn fertilizers, pet waste, and sewage leaks. These nutrients can cause eutrophication, an excessive growth of algae and aquatic plants, when they enter water bodies. Eutrophication depletes oxygen levels in the water, leading to the death of fish and other organisms that depend on oxygen.

4. Thermal Pollution: Urban surfaces, such as asphalt and concrete, absorb and retain heat, elevating the temperature of stormwater runoff. When heated stormwater is discharged into water bodies, it can increase the water temperature, which negatively impacts aquatic ecosystems. Higher temperatures can reduce dissolved oxygen levels, alter species composition, and disrupt the reproductive cycles of aquatic organisms.

5. Bacterial and Chemical Contamination: Urban stormwater runoff can carry harmful bacteria, viruses, and chemicals from various sources, including pet waste, faulty sewage systems, industrial areas, and agricultural operations. This contamination poses risks to both human health and aquatic life. Bacteria like E. coli can cause waterborne diseases, while chemicals can have toxic effects on aquatic organisms and disrupt ecological balance.

To mitigate the adverse effects of urban stormwater runoff on water quality, various stormwater management practices must be employed. These include the use of green stormwater infrastructure (such as rain gardens and permeable pavements) to promote natural infiltration and filtration, construction of detention ponds and wetlands to capture and treat runoff, implementation of best management practices to minimize pollution sources, and public education on responsible stormwater management practices. These measures aim to reduce pollutants and improve overall water quality.

PART III - GENERAL REQUIREMENTS FOR MCPWO PERMIT/APPROVAL APPLICATIONS

The following section outlines the general requirements that shall be met when performing any work on a county drain or its appurtenances. Once the MCPWO Engineering Division has approved the engineering plans, a permit must be applied for with the MCPWO, Soil Erosion and Sedimentation Control (SESC) Division.

III.1 – Permit/Approval Requirements

A permit shall be required from the MCPWO prior to performing any work on a county drain or its appurtenances. The purpose of the permit process is to protect the drainage district(s) from activities that could be a detriment to the county drain and add cost to that district in the future. A drain permit issued by the MCPWO will not relieve the applicant and/or his/her 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.

The types of work requiring a permit from the MCPWO include, but are not limited to, the following (also see Table I-3):

- Connecting/tapping to any part of a county drain, whether it is an open ditch, enclosed drain, manhole or drainage structure. A tap can be a direct connection or a pipe outlet and can also include altering the flow of an existing tap.
- Connecting/tapping to any part of a Macomb County Department of Roads drainage network, whether it is an open ditch, enclosed drain, manhole or drainage structure. A tap can be a direct connection or a pipe outlet and can also include altering the flow of an existing tap.
- Crossing over or under any part of an open ditch or enclosed pipe. Examples of crossings include but are not limited to utility lines, driveways, culverts, sidewalks, and bridges.
- Performing work within a County Drain Easement.

Approval by both the MCPWO Stormwater Division and SESC Division may be required prior to permit issuance and commencing work. Depending on the extent of work proposed, a contract with the MCPWO may be required. Plan submittals should conform to the engineering plan requirements listed in Appendix P, Section Part IV, as appropriate. A soil erosion permit under the guidelines of the Macomb County SESC Ordinance and the Michigan Soil Erosion and Sedimentation Control Act, P.A. 451, Part 91 Public Acts of 1994, as amended, must be obtained from the MCPWO, or other appropriate agency, prior to any construction.

Approval by the MCPWO is required prior to permit issuance and commencing work. Plan submittals should conform to the engineering plan requirements listed in Appendix P, & Part IV, as appropriate.

III.1.A – Permit/Approval Application Submittal: Required Documents

The MCPWO will review permit/approval applications to assure that the project meets MCPWO standard and that the receiving County asset is not adversely impacted by the project. **The permit/approval application must include the following information (if applicable):**

1. **Construction Plans (Required for Application Acceptance at Intake Check):** The proprietor will submit to the project portal (see Section **III.1.B**) a complete set of the engineering construction plans, drawn to a scale no smaller than 1" = 40', and on 24" x 36" sheets. The plans shall be sealed and signed by a professional engineer, drawn to standard engineering scales, and include MCPWO standard detail sheets. The submittal shall include all required information listed in Section **Part IV** - Engineering Plan Set Submittal & Approval Procedures and may also require items shown in **Appendix P**.
2. **Stormwater Narrative (Required for Application Acceptance at Intake Check):** A site stormwater narrative that includes a summary of the proposed stormwater management system is required for each site plan submittal (see **Appendix K**- Stormwater Narrative: Template and Details). This narrative must also include (at a minimum):
    - All storage volume calculations, assumptions, drainage area illustrations, collection system hydraulic calculations, downstream boundary condition,
    - Landuse Summary Table – As part of Macomb County's MS4 permit; the applicant must complete and submit the landuse summary table provided in **Table Appendix K-1**,
    - Geotechnical Reports – these shall include soil borings and infiltration testing results used to establish the infiltration capabilities for the site. (see requirements provided in Part **VI.2.B.2 – Soil Infiltration Testing**),
    - Operations & maintenance summary, and
    - Other information necessary to show how the development will meet Macomb County's design and long-term performance standards.
3. **Soil Erosion and Sedimentation Control Plan (Required for Application Acceptance at Intake Check):** A soil erosion and sedimentation control plan must be provided as part of the overall plan set plan set, the MCPWO SESC Division will conduct a SESC permit review process that is predominatly independent from the MCPWO Stormwater Division. Before construction can begine a SESC permit will likely be required under the guidelines of the Macomb County SESC Ordinance and the Michigan Soil Erosion and Sedimentation Control Act, P.A. 451, Part 91 Public Acts of 1994, as amended, will be obtained from the MCPWO, or other appropriate agency, prior to any construction.
4. **Easement Dedication** – The applicant must submit to MCPWO any required materials needed to dedicate the proper easements for review and recordation. MCPWO (not the applicant) will finalize the recordation of the easments. The easement must be dedicated to the County drain drainage district (see Section **III.5**). If an easement does not exist or a new easement is required proper easements must be secured before commencing work. Prior to construction or work within a County Drain, a dedicated and recorded easement must be in place.

5. A Stormwater Facility Operation and Maintenance (O&M) Agreement shall be submitted by the landowner to ensure stormwater measures continue to function as designed. See Appendix M - Agreement for Maintenance of Stormwater Management Practices for example agreement. The O&M plan should include a plan for all proposed stormwater components (collection system, water quality treatment, infiltration, extended detention, and flood control). This should also include the Recorded Memorandum of Stormwater Management O&M Agreement when available.
6. Draft Master Deed – If applicable, a draft master deed including the following language must be submitted. "NOTE: THE CHANGING OF GRADE, PLACEMENT OF FILL OR PERMANENT STRUCTURES (I.E. POOLS, FENCES, SHEDS, ETC.) IN THE 'DRAIN NAME' DRAINAGE EASEMENT IS PROHIBITED."
7. GIS Data - As part of Macomb County's MS4 permit with the State and EGLE, projects that modify or discharge to a portion of the County system must be recorded in GIS format. The applicant must supply GIS data that depicts the type, location, shape, and size of stormwater features. Contact MCPWO of GIS submission details.
8. Other Agencies Permit, Approvals, or Statements – MCPWO may require additional documentation from other agencies that may or may not have an interest in the project.

III.1.B – Permit/Approval Application Submittal Method

The Macomb County Public Works Online Project Portal is now the perfered method used to submit permit application documents and recive updates throughout the plan review submittals. A password protected account is provided, where you can complete all required information as fore mentioned. Using the Online Portal the applicant can download/upload all plan sets, pay review and permit fees, stay up to date on the current status of your review and approval process. Contractor Information should be uploaded/updated in the project portal system once a this information is known.

Subject to normal website maintenance practices and occassional downtimes, the portal is available via the MCPWO website 24 hours a day 365 days a year for your convenience.

III.1.C – Post Permit Requirements

1. Permits and Right-of-way - A permit application must be completed and accompanied by any necessary fee and release of rights-of-way in recordable form, executed by all owners of interest.
2. SESC Notification - A notice of 72 hours must be given to the MCPWO, Soil Erosion and Sedimentation Control Division prior to any construction affecting the drain.
3. Stormwater Division Notification – A notice of 24 hours must be given to MCPWO Construction Division prior to any construction affecting.
4. Work in accordance with permit - work must be completed in accordance with the plans and specifications submitted by the proprietor and permitted by this office.
5. Work to follow MCPWO Standards - Work performed on the County drain or its appurtenances must be performed in accordance with the MCPWO's Storm Drain Notes and Details Sheet.

6. Completion Notification - The MCPWO shall be notified in writing within ten (10) days of the completion of a project.
7. Final Inspection - A final inspection will be performed, and a letter of permit closure may be issued.
8. As-Built Info - The applicant must submit GPS locations (sub-meter accuracy) of all constructed manholes, taps and crossings, in addition GIS data that depicts the type, location, shape, and size of stormwater features as well as other information presented in Section III.1.A.
9. Permit Expiration - A stormwater permit shall expire when work has not commenced within one (1) year of the date of issuance or has significantly exceeded the originally anticipated construction completion date. The MCPWO may extend the permit upon the request of the applicant in writing.
10. Permit Rescindment - The MCPWO may rescind or revoke a permit if there is a violation of the conditions of the permit, if new information is found, or if there is a misrepresentation or failure to disclose relevant facts in the application.
11. Application Withdrawal - MCPWO or the application has withdrawn application from any further review process. A new Application and Review Fee must be submitted to restart the Application process. MCPWO may withdraw an application after 90-days if no new materials are received and/or the applicant in non-responsive to communication.

III.2 – Drain Activities Not Requiring a Permit or Approval

The following activities do not require a permit from the MCPWO. There may be exceptions so always contact the MCPWO to verify whether a permit is required prior to performing any work on a county drain or its appurtenances.

1. MCPWO Contracts - Work being performed under a MCPWO Contract.
2. Tree Trimming - The trimming of trees and brush in the County drain. However, a permit may be required if there is any tree removal or earthwork associated with the trimming.
3. Aerial Utility Lines – Utility lines that cross county drains above ground.

III.3 - Drain Contract Requirements

A drain project agreement and separate contract shall be required from the MCPWO prior to performing any extensive work on a County drain or its appurtenances. A drain contract issued by the MCPWO will not relieve the applicant and/or his/her 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. **The types of work requiring a contract from the MCPWO include, but are not limited to:**

- Relocating any portion of a county drain.
- Enclosing any portion of an existing open county drain.
- Performing work within a county drain easement.

The following list of items must be accomplished and/or received prior to the execution of a drain contract:

1. **A petition, along with the appropriate filing fee**, from the proprietor to make improvements to a county drain.
2. **A County drain board** will determine if a drain improvement is necessary with the type of improvement being selected by MCPWO.
3. **Engineering construction plans** must be approved by MCPWO.
4. **Company Representative signing contract:** The company name, address and phone number of the proprietor's selected contractor and the name and title of a representative for said company who will sign the contract. The MCPWO must approve the selected contractor as qualified and in good standing.
5. **The bid prices** from the selected contractor for all drain construction items. Bid prices shall be from the items and quantities as listed on the approved engineering plans for the County drain. Items and prices must be based on the Standard Specifications of the MCPWO.
6. **Contractor insurance and bonds** as required by the contract.
7. **A Soil Erosion and Sedimentation Control plan** developed under the guidelines of the Michigan Soil Erosion and Sedimentation Control Act, P.A. 451, Part 91 Public Acts of 1994, as amended, must be approved by the MCPWO, or other appropriate agency, prior to any construction. Upon execution of the contract and prior to commencing work, the contractor must schedule a preconstruction meeting at the MCPWO.

III.4 - Plot Plan Requirements

If a county drain is located on the property, the following information must be included on the plot plan when applying for a permit:

1. Show and label the County drain and its associated easement. Liber & Page number for this information should be included if available.
2. Include a drain cross-section and profile, drawn to scale. If an open County drain, field verify the drain elevations.
3. Add the following note: "NOTE: THE CHANGING OF GRADE, PLACEMENT OF FILL OR PERMANENT STRUCTURES (I.E. POOLS, FENCES, SHEDS, ETC.) IN THE 'DRAIN NAME' DRAINAGE EASEMENT IS PROHIBITED."
4. Show any water bodies and wetlands including natural and artificial watercourses, regulated wetlands, and wetland boundaries, floodplains, lakes and lagoons.

III.5 - Easement Requirements

1. Retention/detention basins or other stormwater management facilities easements: Retention/detention basins or other stormwater management facilities easements will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment, deposition of spoils, and other activities identified in the development's stormwater system maintenance plan.
2. Easement widths will be determined by the Public Works Commissioner and be situated in such a way as to allow for maintenance access. In general, easement widths will conform to the information provided in Table III-1.

Table III-1 - Country Drain Easement Width Requirements by Type

Drain Type	Easement Requirements
a) Open County Drains	The easement width will vary by the width of the bankfull channel, the Shelfway width, the terrace slope angle, and the Maintenance Access Width (see for definitions). **(Round up to the nearest 5 ft multiple)**
b) Enclosed County Drains	The easement required by the MCPWO will vary based on pipe size, depth, and soil types. The following equation should be used as a guideline for estimating the easement required by the MCPWO. **(Round up to the nearest 5 ft multiple)** • Enclosed Drain Easement Width = Pipe diameter + 2xDepth to pipe bottom + 2 feet
• MCPWO reserves the right to require additional easement width of both open and enclosed county drains.	

III.5.A - Easements to be Platted

1. If a County drain easement is to be platted, the easement on final plat shall read as follows:

   "'XX' feet wide easement to the 'DRAIN NAME' Drainage District for drainage"

2. The location and purpose of drainage easements should be clearly described in subdivision deed restrictions or condominium master deeds. Language will be included within the subdivision deed restrictions or condominium master deed that clearly notifies property owners of the presence of stormwater management facilities and accompanying easements, as well as restrictions on use or modification of these areas. A copy of the draft Master Deed and easement restrictions must be submitted during the project permit/review process.

III.5.B - Drain Easement: New or Existing Dedication

Prior to construction or work within a County Drain, a dedicated easement must be in place. If an easement does not exist or a new easement is required, the proprietor must secure the proper easements before commencing work. The easement must be dedicated to the County drain drainage district. The following requirements must be submitted to dedicate a County drain easement:

1. Metes & bounds and Legal Description: descriptions of both the property and the proposed easement, along with a sketch on 8 ½ x 11-inch paper.
2. Authorized Persons, Deeds, & Consent Resolutions: The name(s) of the person(s) authorized to sign the easement document. A property deed will be required for proof of ownership. A Consent Resolution is needed if the applicant organization is an LLC or Inc.
3. Payment of the recording fee. The fee shall be made payable to the Macomb County Register of Deeds and submitted when the executed easement is returned to the MCPWO. MCPWO will submit easement documentation prepared by the applicant in order to record the easement.

III.5.C - Drain Easement Encroachment

In general, encroachments are not to be allowed in County drain easements unless a hardship is demonstrated. All encroachment requests will be reviewed on a case by case basis. A LTU must be executed if an encroachment is approved. If an encroachment is discovered in a County drain that was not approved by the MCPWO, it must be removed at the expense of the owner.

License-to-Use (LTU): If a utility or other permanent feature is to be located within the right-of-way of any County drain or drainage easement, it shall be approved by the MCPWO. If approved, a License-to-Use (LTU) Agreement must be executed by MCPWO prior to construction. Approved utilities & features will be located such that it will not increase the expense of maintaining the drainage facility.

III.5.D – Drain Easement: Relinquishment / Abandonment / Amendment / Adding Lands

In order to relinquish a County drain easement, the MCPWO must approve the request. Once approved by MCPWO, the following procedure must be completed:

1. **The property owner must submit a letter** requesting the relinquishment and the associated deposit to cover administrative and legal publication costs.
2. **Submit an exhibit showing the parcel**, the easement to be relinquished across the parcel, and the legal description of both the parcel and the easement. The exhibit shall also include the Liber and Page(s) of the easement, if available. A Legal Description of the property is also needed.

   Note: Relinquishing platted drain easements will also require circuit court action.

In order to process a Drain Easement Relinquishment/Abandonment/Amendment/Adding Lands please Submit the Following Items to the MCPWO Property Specialist:

- **Ownership Information:** Legal Owner of Property, Including Name and Address. A copy of the property deed is required for ownership verification.
- **If LLC or Corporation:** Consent Resolution or Similar to Verify Signers Authority IE: Manager, President, ETC.
- **Exhibit of the Site** with Legal Description
- **Exhibit of Existing Easement** with Legal Description
- **Exhibit of the Proposed** Amended/Abandoned /Relinquished Easement with the Legal Description
- **Metes and Bounds** are Required in Sketch and Legal Description
- **Liber and Page** information shall be included on the Exhibit, if available
- **Engineer's Certificate** – An Engineer's Certificate (see **Appendix I**) along with supporting hydraulic & hydrologic information must be provided for review to MCPWO in a 'Letter of Determination'.
- **Letter of Determination** – The letter of determination must include relevant hydraulic & hydrologic information needed to prove that a proposed project will not result in a detriment to the drains or surrounding properties both upstream or downstream of the project.

PART IV - ENGINEERING PLAN SET SUBMITTAL & APPROVAL PROCEDURES

All site developments or projects subject to MCPWO standards require engineering construction plan review and permitting from the MCPWO. These rules provide minimum standards to be complied with by proprietors, and in no way limit the authority of the local municipality in which the development is situated to adopt and enforce higher standards as a condition of approval of the site plan. The following section outlines the requirements that shall be met when submitting plans for unplatted developments. The review of the engineering construction plans may not be as extensive as plat reviews but involves similar requirements. Upon the request of a municipality, the MCPWO may review and offer comments on a site development or construction project.

IV.1 – Plan Set Requirements - Overall

The MCPWO will review the submitted plan set to assure that adequate stormwater drainage will be provided and that the proposed stormwater management system adequately provides for water quantity and quality management to ensure protection of property owners, lands, and watercourses both within the proposed development and downstream. **Approval of construction plans by the MCPWO is valid for one (1) calendar year.** If an extension beyond this period is needed, the proprietor will submit a written request to the Public Works Commissioner for an extension. The Public Works Commissioner may grant one-year extensions of the approval, and may require updated or additional information, if needed. Should modifications be made to the plans, a new set of plans must be submitted for review and approval. **A cover letter shall be included with the plans which states the changes made to the plans.**

Construction shall be based on the MCPWO permitted plan set. If additional changes to the plan set are needed after a permit has been drafted or activated, the applicant must submit the revised plan set for additional review and approval before construction begins.

If applicable, all construction plans sets shall include the items provided in section IV.2 – "- Plan Set Requirements - Drainage Information" as well as the following items:

a) **Signed and Sealed** - The plan set shall be sealed and signed by a professional engineer.

b) **Contact Information** - The names of the proprietor and engineering firm, with mailing and e-mailing addresses, and telephone numbers for each shall be included with the transmittal. Plans will be prepared under the direction of, and sealed and signed by, a professional

engineer registered in the State of Michigan and will be in accordance with these *Procedures and Design Standards for Stormwater Management.*

c) **Plan scale** – Plans shall be drawn to a scale no smaller than 1" = 40', and on 24" x 36" sheets.

d) **Dimensioning** - The proposed project layout with all dimensions, including the proposed drainage system for the project. Show all utility crossings and taps.

e) **Topography** - Topographic maps, at two-foot contour intervals or less on NAVD 88 datum, showing existing and proposed grades, as well as off-site topography over at least 100 feet of the adjoining property. Plans must list the date the site topographic survey was performed. Where existing conditions, at the time of plan submittal, differ from conditions at the time of survey, the MCPWO may require an updated topographic survey.

f) **Water & Wetlands** - Maps will also show all existing watercourses, lakes and wetlands, and the extent of all off-site drainage areas contributing flow to the development.

g) **Open drains and watercourses cross-sections** - shall be shown with a typical ditch cross-section and matching contours. Proposed cross-sections shall be shown with existing and proposed elevations and labeled with appropriate stations.

h) **Easements, Drains, & Drainage Structures** - Plans, profiles, names, easements, and details of all open drains, drainage swales, and drainage structures.

i) **Drainage Areas** - A drainage area map, overlaid onto a copy of the site grading plan, which clearly shows the areas tributary to each inlet and/or storage basin. Any off-site drainage area boundaries tributary to a specific inlet and/or storage basin must be clearly mapped. Show design data and criteria used for designing detention/retention basins and sizing all drainage structures and channels including weighted runoff coefficient calculations(also see Section **IV.2**).

j) **Storm System Overview** - A single sheet showing all proposed storm drainage facilities with drainage easements shall be submitted. This sheet shall be overlaid on the overall road and utility plan and drawn to a scale no smaller than 1" = 100' (also see Section **IV.2**).

k) **Storm sewer calculations -** Storm sewer 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 cubic feet per second (cfs), and the flow velocities for enclosed systems. Show design data and criteria used for designing detention/retention basins and sizing all drainage structures and channels including weighted runoff coefficient calculations. Refer to **Part V**. for calculation requirements (also see Section **IV.2**).

l) **Storm sewer information** - Plan views, profiles and details of all roads and storm sewers. The storm sewer plans will include type, size, and class of pipe, length of run, percent of slope, invert elevations, rim elevations, locations of utility crossings, cover depth, backfill type, depth and compaction, and profile of the hydraulic gradient, as specified in these *Procedures and Design Standards for Stormwater Management* (also see Section **IV.2**).

m) **Retention/detention facilities** - Plans and details of proposed detention/retention facilities. Soil borings are required at the sites of these facilities. Show design data and criteria used

for designing detention/retention basins and sizing all drainage structures and channels including weighted runoff coefficient calculations (also see Section IV.2).

n) **SESC measures** - Plans and details of the proposed soil erosion and sedimentation control (SESC) measures, both temporary (during construction) and permanent, as required by, P.A. 451, Part 91 Public Acts of 1994, as amended and the Macomb County SESC ordinance.

o) **Construction specifications** – Construction specifications for the stormwater management facilities shall be shown. Show design data and criteria used for designing detention/retention basins and sizing all drainage structures and channels including weighted runoff coefficient calculations.

p) **Drain fields / Septic Systems** - Locations of all septic/drain fields as approved by the Macomb County Health Department and of all reserve areas. Septic/drain fields and reserve areas shall not be located within County drain drainage easements.

q) **Road crossing signage** - Approved 'Ours to Protect' and 'Report a Polluter' signage shall be required for the development at road crossings for open county drains (see **Appendix D** for sign information).

r) **Reference Sections** - The submittal may require pieces of information listed throughout this manual.

IV.2 - Plan Set Requirements - Drainage Information

Development projects are required to provide access and capacity for any existing drainage tributary to the site. The increased volume of water discharged due to development of the site must not create adverse impacts to downstream property owners and watercourses. These adverse impacts may include, but are not limited to, flooding, excessive soil saturation, crop damage, erosion, and/or degradation in water quality or habitat. Proposed drainage for the development will conform to any established county drainage districts.

The increased volume of water discharged due to development of the site must not create adverse impacts to downstream property owners and watercourses.

The proposed drainage plan will, in every way feasible, respect and conform to the natural drainage patterns within the site and the watershed in which it is located or conform to drainage patterns approved by the MCPWO.

All plan sets will include the following required stormwater management information:

1. Calculations Shown - All calculations used to design components of stormwater management systems.
2. Show Overall System - The overall stormwater management system for the proposed development, indicating how stormwater management will be provided and where the drainage will outlet.
3. Stormwater Facilities & Easements - The location of any on-site and/or off-site stormwater management facilities and appropriate easements (typical 10' minimum) that will be dedicated to the entity responsible for future maintenance. Easement information will be consistent with Section III.5. Provided liber and page number for easement if known.
4. Downstream Receiving Outlet Feature & Capacity - A description of the off-site outlet and evidence of its adequacy. Estimation of the water surface elevation within receiving waterway/storm sewer system for various design events should be considered. Additional/adequate off-site easement may be required.
5. Site Drainage Boundaries - A map, at the USGS scale, showing the drainage area boundaries of the proposed development and its relationship with existing drainage patterns.
6. Natural Watercourse or Drain Drainage Area – Show and label any natural watercourses and/or county drains (including: natural and artificial watercourses, regulated wetlands, and wetland boundaries, floodplains, lakes and lagoons) passing through or alongside the proposed development along with area of upstream watershed and current zoning.
7. Natural Watercourse or Drain Hydrology Calculations – For any natural watercourses and/or county drains passing through or alongside the proposed development provide calculations of runoff from upstream areas for storm events including but not limited to the 100-year (24-hour) and 10-year (24-hour) design storms. Calculations shall consider future developed conditions according to the current land use plan for the area.
8. Natural Watercourse or County Drain Cross-sections and Profiles - Provide cross-sections and profiles, drawn to scale, of the existing drain with existing and proposed elevations. Drain elevations should be field verified.
9. Special Conditions and Floodplains - If development is proposed in an area where special drainage problems exist or are anticipated at the site, on adjacent properties, or downstream, more stringent design requirements than those contained in these Procedures and Design Standards for Stormwater Management may be required. If any part of the site lies within a floodplain, then it shall satisfy local, state, and federal requirements for the appropriate project type within a floodplain.
10. Add the following note to the plan set and Master Deed: "NOTE: THE CHANGING OF GRADE, PLACEMENT OF FILL OR PERMANENT STRUCTURES (I.E. POOLS, FENCES, SHEDS, ETC.) IN THE 'DRAIN NAME' DRAINAGE EASEMENT IS PROHIBITED."

PART V - DESIGN CRITERIA AND ENGINEERING STANDARDS FOR COUNTY DRAINS

The following section outlines the design criteria that shall be used on projects that require MCPWO review and/or permit. The requirements reflect the MCPWO's need to protect public health, convenience, and welfare per the Michigan Drain Code, as well as meet its NPDES Phase 2 permit requirements.

V.1 - Determination of Culvert or Pipe Size

All culvert & pipe design calculations must be submitted to the MCPWO for review. **Calculations must be signed and sealed by a Professional Engineer and must include:**

The Rational Method can be used to determine the peak flow contributing to a culvert.

1. **Delineation on a topographic map** of the area contributing to the culvert or pipe.
2. **Hydrologic calculations** to determine the amount of flow from surface runoff.
3. **Hydraulic calculations** used to determine the size of the culvert or pipe.
4. **Calculations for height of cover, gauge size, and expected loads**. The designer should consider if pipe/structure buoyancy calculations are necessary.
5. **Backwater calculations** - When an existing culvert or pipe is proposed to be modified, backwater calculations and/ or downstream calculations shall be considered. Backwater calculations and/ or downstream calculations must be submitted upon MCPWO request see **Table V-8** for guidance.
    a. This office will use the "Rational Method", the SCS (NRCS) Method, or other prior approved method, to determine the flow contributing to the culvert or pipe. Culverts or pipes shall be sized to pass a design flow event specified by MCPWO (typically the 10-year or 100-year storm event) or the governing design storm of the watercourse, which may be higher.
    b. The flow velocity within the culvert or pipe when flowing full shall be neither siltative nor erosive. Therefore, flow velocity shall not exceed 5 fps when outletting to an open drain, and shall not exceed 10 fps within an enclosed pipe. In addition, flow velocities must be greater then 2.5 fps.
    c. For culverts, the FHWA's HY8 Culvert Analysis will be used to check the culvert design (See references in **Appendix B**). Other methods may be acceptable if pre-approved with MCPWO before permit application submittal.

V.1.A - Hydrology Calculation Methods

The Rational Method is more ideal for smaller drainage areas; assumes a uniform rainfall intensity, and is ideally used for areas less than 100 acres. Although MCPWO staff may approve the use of the Rational Method for drainage areas larger than 100 acres, in no case can the Rational Method be used to calculate peak flows for a drainage area larger than 200 acres. Additional pre-approved hydrology calculation methods include (note: modifications may be necessary to override the default regional rainfall depths to match current local rainfall statistics):

- Curve Number Method (a/k/a SCS/NRCS Curve Number Method);
- WinTR-55,
- WinTR-20,
- HEC-HMS
- EPA-SWMM
- NO LONGER ACCEPTED: "Computing Flood Discharges for Small Ungaged Watersheds – manual and spreadsheet" by Sorrell, R. C., 2003 - Will no longer be accepted since the spreadsheet does not accept NOAA Atlas 14 rainfall data.

If these programs are used, estimated return internal event flows, pipe capacities, hydraulic grade lines, and other design properties shall be provided on the plan set to facilitate understanding of the intended design without consulting the hydrology/hydraulic model.

Proprietary hydrology/hydraulics software programs must be pre-approved with MCPWO before each project submittal. These programs may include Info-SWMM, XPSWMM, PCSWMM, HydroCAD, & others. MCPWO does not necessarily have a license for these programs and therefore reviewing inputs, reviewing outputs, and long-term record keeping becomes an issue.

V.1.B - Rational Method Calculations

The MCPWO will use the "Rational Method", the SCS (NRCS) Method, or other prior approved method, to determine the flow contributing to the culvert or pipe. Culverts or pipes shall be sized to pass a design flow event specified by MCPWO (typically the 10-year or 100-year storm event) or the governing design storm of the watercourse, which may be higher.The "Rational Method" is defined in :

Table V-1 – (Q_{peak}) Rational Method

$Qpeak = \bar{C}_{10yr} * I * A$	
Q_{peak} =	Peak runoff (cfs)
$\bar{C}_{10yr}$ =	Area weighted runoff coefficient during a 10-year rainfall event (see Table V-3)
I =	Average rainfall intensity (inches/ hour) for a storm with a duration equal to the time of concentration
A =	Drainage area (acres) (including all tributary on-site area, off-site area, developed areas, and undeveloped areas)

V.1.B.1 - *Runoff Coefficients*

The runoff coefficient is based upon the potential for runoff of the contributing acreage. The runoff coefficient and supporting calculations must be included with the plan submittal. The runoff coefficient is calculated using **Table V-2** and **Table V-3**:

Table V-2 - (C) Area Weighted Runoff Coeifficent

$$\bar{C}_{10yr} = \frac{\sum_{sub=1}^{n}(A_{sub} * \bar{C}_{10yrsub})}{\sum_{sub=1}^{n} A_{sub}}$$

$\bar{C}_{10yr}$ =	Area weighted runoff coefficient during a 10-year rainfall event
C_{sub} =	Runoff coefficient for each sub-area (see **Table V-3**)
n =	Total number of sub-areas
A_{sub} =	Drainage area for each sub-area (acres)

Note: When filling out the land use summary table (**Table Appendix K-1**). The site will need to be grouped into impervious areas and pervious areas.

Table V-3 – Minimum Acceptable 10-Year Event Runoff Coefficients for use in Rational Method

	Surface Type	Runoff Coefficient (10-year event)			
Water areas	Dry/Wet Detention/Retention Basin	1.00			
	Water surfaces	1.00			
Impervious Surfaces	Roofs	0.95			
	Asphalt or concrete pavements	0.95			
	Gravel, brick, or macadam surfaces	0.85			
Pervious Surfaces	Pervious Surface Type	Hydrologic Soil Group (HSG)			
		A	B	C	D
	Lawns & open space (good condition)	0.1	0.2	0.35	0.45
	Forested (good condition)	0.1	0.15	0.30	0.40
	Meadow/No-Mow-Zone (good condition)	0.1	0.15	0.30	0.40
	Bioretention	Provide Supporting Info			
	Porous Pavement / Green Roof	Provide Supporting Info			

- Source: Runoff coefficients are selected to reproduce a similar runoff volume as predicted by the NRCS CN Method for a 10-year, 24-hour, rainfall event and assuming Antecedent Moisture Condition II with initial abstract (Ia) = 0.2S. CNs for "Open Spaces, Good Condition" for Lawns and Open, and a CN of 98 for Brick, and Pavement surfaces.
- **Soils with dual HSG classifications (i.e. A/D, B/D, C/D) shall be considered as 50% drained conditions and 50% undrained condition. The designer may elect to assume a larger percentage of D soils.**
- C-factors often vary between different municipalities and review agencies. The designer should select the largest required C-factors amongst all potential review agencies.
- A modifier should be added onto the pervious surface values provided based on slope. For slopes <4% add 0; slopes between 4% to 8% add 0.05; slopes >8% add 0.1
- Gravel surfaces are still considered impervious for the land use summary table (**Table Appendix K-1**), however, due to their potential to infiltrate some water, gravel surfaces are not allowed in stormwater hotspots.
- All fill material placed on site will be considered HSG D unless certified otherwise by a soils engineer.

V.1.C - Time of Concentration

Unless additional calculations are provided, an initial time of concentration of 20 minutes may be used for developments that contain ≤ %40 impervious area (e.g. single-family residential subdivisions) or a minimum of 15 minutes for developments that contain > %40 impervious area (e.g. medium density residential, commercial, institutions, and industrial sites).

It is important to realize that rational method calculations are highly impacted by changes in time of concentration. In general, expanses of vegetated lawn or open field have much longer times of concentration than paved areas. There are scenarios in which a smaller impervious area (with a short Tc) can generate peak runoff rates larger than the full site area while using a longer Tc. The designer should consider this possibility during the design process.

The design engineer may also use a calculated time of concentration, if desired. The methodology and computations used to determine time of concentration must be submitted for review. The time of concentration for unimproved, pre-development lands will be checked using the following formulas or from TR-55:

Table V-4 – (T_C) Time of Concentration formula for unimproved, pre-developed lands

$Tc = Length / (V * 60)$	
Tc =	Time of concentration (minutes)
Length =	Distance from most distant point in the watershed (ft)
V =	Velocity (ft/sec) (see **Table V-5**)
60	Converts seconds to minutes
MCPWO may require a shorter time of concentration based on special site conditions.	

The velocity of the flood flow is determined from an empirical formula depending on the channel type as shown in **Table V-5**:

Table V-5 – (V) Velocity Equations for various flood flow types

Small tributary	$V = 2.1 \times S^{0.5}$
Waterway	$V = 1.2 \times S^{0.5}$
Sheet Flow	$V = 0.48 \times S^{0.5}$
S =	slope (%)

When more than one type of flow exists, the individual flows should be summed up to find the total time of concentration. The maximum allowable length for sheet flow is 300 feet. Any change or breaks in slope should be considered a new segment and velocity for that segment computed.

V.1.D - Rainfall Intensity Calculation

The average rainfall intensity (I) shall be determined from the following equations. For drainage areas with a Tc > 60 minutes, consult the NOAA Atlas 14 Point Precipitation Frequency Estimates for the location of the project (link below and see Table Appendix H-1):

Table V-6 - (I) Design rainfall intensity

	$I = \frac{30 * y^{0.22}}{(Tc + 9.17)^{0.81}}$
I =	Design rainfall intensity (inches/hour)
y =	Design storm return period (years)
Tc =	Time of concentration (minutes)

NOAA Atlas 14 Hyperlink: PF Map: Contiguous US (noaa.gov)

V.2 - Design Criteria for Enclosed Drains

An enclosed storm drain system must be designed to accommodate the stormwater runoff from a 10-year, 24-hr storm from the entire contributing watershed. If located within a regulated 100-yr floodplain, then the enclosed storm drain system must be designed to accommodate the stormwater runoff from a 100-yr, 24-hr storm from the entire contributing watershed. The "Manning" formula shown in Table V-7 will be used to check the pipe size:

Table V-7 - Manning Pipe Flow Capacity Formula

	$Q = \frac{1.486}{n} * A_X * R^{2/3} * S^{1/2}$
Q =	Flow capacity (ft^3/s)
n =	Manning coefficient of roughness
A_X =	Cross-sectional area of flow through pipe (ft^2)
R =	Hydraulic radius of pipe, A/P_W (ft)
P_W =	Wetted perimeter of pipe (ft)
S =	Hydraulic Grade Slope (ft/ft) Calculations should consider potential backwater conditions and adjust starting hydraulic grade elevation accordingly (see guidelines in Table V-8)

The following applies to the design of an enclosed drainage feature including storm sewer and culverts:

1. **Provide all calculations** in a format similar to the Storm Drain Design Chart in **Appendix O**. When using a stormwater software program (e.g., HEC-RAS, SWMM, HY-8) the computer files must also be submitted.
2. **Starting Hydraulic Grade / Downstream Hydraulic Grade:** the downstream hydraulic grade for a closed conduit should follow the guidelines presented in **Table V-8**.
3. **Calculate and show in profile, the hydraulic grade line** (either 10-year or 100-year) for the entire system. The hydraulic gradient for the design event should be designed to be within the pipe, but in adverse conditions should be no higher than one (1) foot below the rim elevation of any drainage structure (see **Table V-8**) unless pre-approved by MCPWO.
4. **Pipe surcharging** – Where site conditions allow, closed conduits should be designed to flow without surcharging the upstream end of the conduit, however, surcharging may be allowed for situations with problematic site conditions.
5. **Minimum pipe size:** The minimum pipe size for storm drains accepting surface runoff 12-inches in diameter (concrete). Rear yard pipes are allowed a minimum size of 8" Sch 40 PVC, but must be used in conjunction with a drainage swale that directs runoff to a minimum 12-inch diameter pipe (concrete).
6. **Premium pipe joints** must be used to prevent infiltration.
7. **Max/Min Flow Velocities** - Storm drains shall be designed to have a minimum velocity flowing full of 2.5 ft/sec and a maximum velocity of 10 ft/sec. The velocity at a pipe outfall into an enclosed or open drainage network should be less than 5.0 ft/sec to prevent scouring at the outlet. If higher velocities at a pipe outfall cannot be avoided, additional scour protection measures will be required.
8. **The Manning's 'n' value** for concrete pipes is 0.013 and 0.024 for corrugated metal pipe.
9. **Energy dissipaters** shall be installed at all outlets according to the Macomb County Public Works Commissioner's storm drain notes and details sheet. Energy dissipaters shall be designed in accordance with FHWA standards (HEC14 or HY8Energy) and shall be submitted to the MCPWO.
10. **Riprap** may consist of fragmented limestone or other suitable rock underlain with geotextile fabric. **Broken concrete is not allowed.** Riprap sizing shall be based on acceptable calculations methods based on estimated flow velocities or shear stress.

Table V-8 - Starting Hydraulic Grade Line Scenario Guideline

Scenario Number	Contributing Drainage Feature	Receiving Drainage Feature	Hydraulic Grade Line Guideline
1.	Enclosed Conduit	Enclosed Conduit when the conduit is more than 1,000 feet from a downstream waterway	Top of crown of pipe of the receiving conduit
2.	Enclosed Conduit	Enclosed Conduit within 1,000 feet from a downstream waterway	Designer's Discretion: Top of crown of pipe of the receiving conduit OR FEMA estimated or designer calculated design event elevation for nearby watercourse OR Calculated water elevation corresponding with the receiving system (nearby watercourse) event specified in **Table V-9**
3.	Outlet Control Structure	Any receiving drainage feature	The designer should consider if the downstream hydraulic grade line could reduce the head pressure acting on the outlet control structure. Backwater effects may reduce the release rate through orifices potentially reducing Q100allowable and causing water elevations to rise higher than intended.
4.	Enclosed Conduit	Detention Basin/ Retention Basin/ Underground Storage/ Forebay	MCPWO recommends the greater of: Local Municipal Engineering Rule OR *For Open Basins and underground basins:* An elevation corresponding to **3/4 of the depth** of the effective 100-year detention volume storage area. OR *The V_{ED} Elevation*
5.	Enclosed Conduit	Bioretention/Bioswale	Top of ponded water elevation within the Bioretention/Bioswale
6.	Enclosed Conduit OR Culvert	Open Drain/Ditch/ Waterway/swale	Designer's Discretion of: FEMA estimated or designer calculated design event elevation within the receiving drainage feature OR Calculated water elevation corresponding with the receiving system event specified in **Table V-9**
7.	Open Drain/Ditch/ Waterway/swale	Long reach of the same Open Drain/Ditch/ Waterway/swale without a nearby confluence to another drainage feature	FEMA estimated or designer calculated design event elevation. Designer should investigate the receiving waterway downstream of the design to account for any constructions (e.g. culverts, bridges, changes in channel capacity) that may control the starting hydraulic grade for the design.
8.	Open Drain/Ditch/ Waterway/ swale	Nearby confluence with another Open Drain/Ditch/ Waterway/swale/ Impoundment OR Enclosed Conduit	Designer's Discretion of: FEMA estimated or designer calculated design event elevation within the receiving drainage feature OR Calculated water elevation corresponding with the receiving system event specified in **Table V-9**

- The starting hydraulic grade line guidelines provided here should be considered relative to the circumstances of each drainage system. Other scenarios or factors exist beyond those presented here. Contact the MCPWO if you have questions regarding choosing an appropriate starting hydraulic grade line.
- MCPWO reserves the right to require the use of a particular starting hydraulic grade line on any project

Table V-9 - Frequencies for Coincidental Occurrence

Area Ratio Receiving To Contributing	Frequencies for Coincidental Occurrence					
	10-Year Storm Design Event		50-Year Storm Design Event		100-Year Storm Design Event	
	Receiving System	Contributing System	Receiving System	Contributing System	Receiving System	Contributing System
10,000 to 1	1-yr	10-yr	2-yr	50-yr	10-yr	100-yr
1,000 to 1	2-yr	10-yr	5-yr	50-yr	10-yr	100-yr
100 to 1	5-yr	10-yr	10-yr	50-yr	25-yr	100-yr
10 to 1	10-yr	10-yr	25-yr	50-yr	50-yr	100-yr
1 to 1	10-yr	10-yr	50-yr	50-yr	100-yr	100-yr

For the case of a tributary stream or a storm sewer, its relative independence may be qualitatively evaluated by a comparison of its drainage area with that of the receiving stream. A short duration storm which causes peak discharges on a small watershed may not be critical for a larger watershed. Also, it may safely be assumed that if the same storm causes peak discharges on both watershed, the peaks will be out of phase. To aid in the evaluation of joint probabilities, refer to the information provided in this table.

MCPWO may require alternative assumptions based on the site conditions within the contributing watershed and/or the receiving watershed.

Original Source: USACE Norfolk District, 1974
(Adapted from MDOT Drainage Manual Table 7-7)

V.3 - Design Criteria for Open Drains

The following considerations must be made during the design of an open County drain:

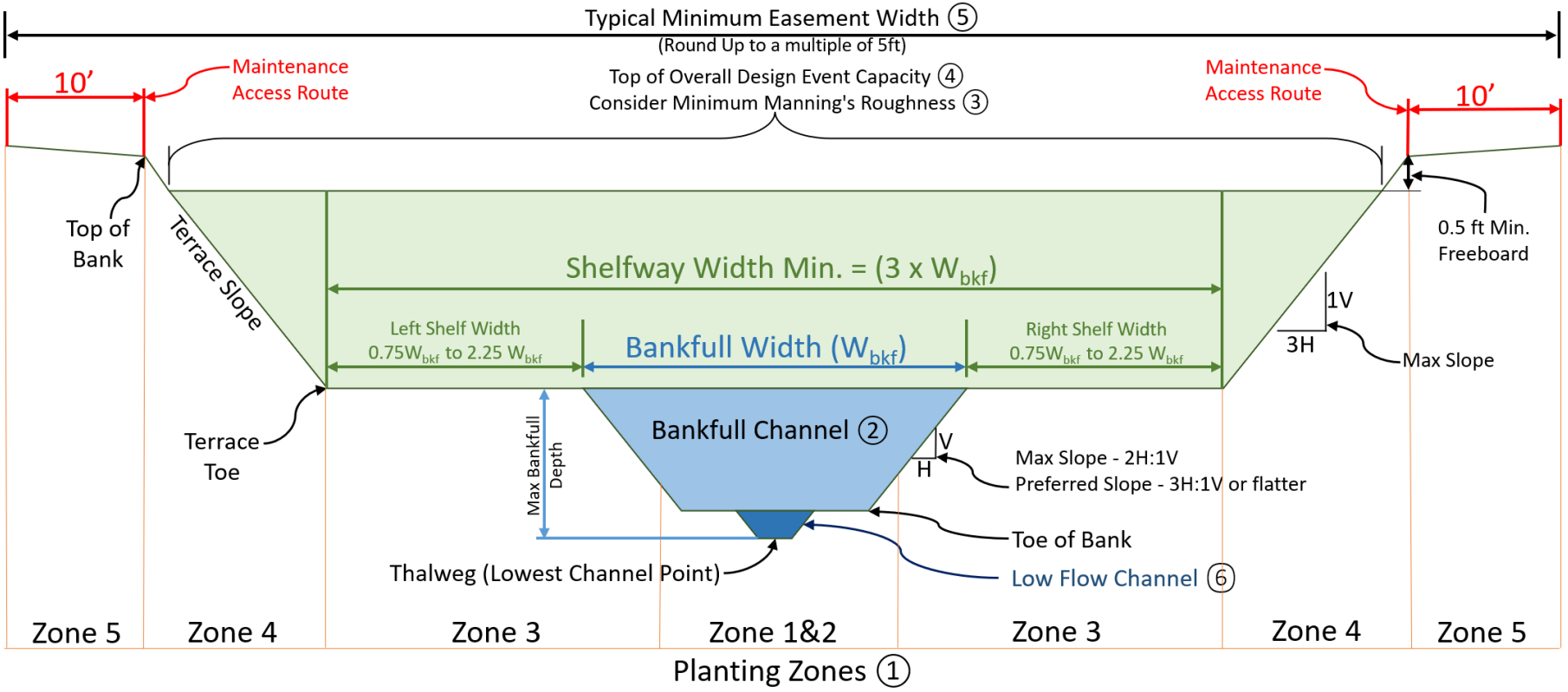
1. **Minimize water quality impacts** from construction and nonpoint source pollution need to be minimized to the maximum extent practicable.
2. **When a County asset is the proposed outlet** for a site's storm drainage system, the standards regarding stormwater detention (Section **V.3** and others) shall apply.
3. **Permanent structures and detention basins** may not be constructed within the permanent County drain easement. Unless approved by MCPWO.
4. **Limited downstream hydraulic conditions** may affect receiving flow capacity of a drainage system. In this situation, the discharge from the site shall be limited to conform to the governing downstream conditions or an increase in the downstream capacity may be required.
5. **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. In cases where the drain outlet has already reached capacity, the burden is on the proprietor to design and construct, at his expense, any necessary improvements to the capacity of the Drain or downstream outlet.

V.3.A - Standard Open County Drain Design

The standard cross-section for an open County drain is a multi-stage design (Figure V-1). The cross-section shall have multiple stages consisting of an active bankfull channel within a larger shelf width. The construction of a low-flow channel may also be required. Table I-2 describes the primary features of the standard drain cross-section.

Table V-10 – Primary Multi-Stage Channel Features

Low Flow Channel
• The low flow (or thalweg) channel will increase channel velocity and depth during periods of low discharge to improve sediment conveyance and thereby improve channel stability.
Bankfull Channel
• In stable/natural alluvial stream channels with a hydraulically-connected floodplain, the point where the flow just begins to overtop the banks of a stable channel into its shelf width. • Bankfull discharge typically correlates with a return interval flow event ranging between 1.2 year to 1.8 years (generally assumed to be a 1.5-year return interval event). • For streams with developed/impacted watersheds or for streams that have been mechanically dredged, bankfull discharge elevation may be completely contained within channel banks. • The shelfway elevation should be designed to correspond with bankfull flow estimates or based on bankfull indicators observed on-site.
Shelfway
• The area contained within terrace side slopes or setback levees which includes the bankfull channel and area adjacent to the channel that will carry moving water during times of flooding. This may or may not conform to the NFIP floodway. The shelfway width will be the greater of 4X the design bankfull width (W_{bkf}), or will match the existing shelfway width of the surrounding existing channel.



Notes:

- Cross-section is shown Looking Downstream. Cross-sections shall be represented looking downstream unless special circumstances apply.
- If the permit applicant owns only one side of the drain, one maintenance access route must be provided. The route must be provided regardless of whether an existing maintenance access route exists on the other side of the drain.
- If the permit applicant owns both sides of the drain, maintenance access routes are required on both side of the drain.
- The range of shelf widths are provided to allow for steam sinuosity. Generally, streams should be centered in their shelfway while allowing for an intentional stream sinuosity.

References:

① VIII.2 - Native Plantings
② V.3.A.1 - Bankfull Discharge
③ V.3.B – Standard Drain Manning's Roughness Coefficient
④ V.3 - Design Criteria for Open Drains
⑤ III.5 - Easement Requirements
⑥ V.3.A.2 -Standard Drain Cross-section

Figure V-1 - Standard Multi-Stage Channel Riffle Cross-Section

V.3.A.1 - *Bankfull Discharge*

The bankfull discharge Q_{bkf}, (aka, channel-forming discharge) is a general term that is considered to be a single discharge equivalent in its effect to the range of discharges that govern the shape and size of a stable, natural channel.

The following method should be used to determine Q_{bkf}:

Recurrence Interval:
The actual recurrence interval that corresponds to the channel-forming discharge in a stream based on statistical analysis. Studies have shown determined that the bankfull discharge (determined in the field at USGS gauging stations) corresponded to the 1.2-year to 1.8-year (average 1.5-year) recurrence interval on a flood frequency curve developed from long-term data at a gauge station. The recurrence interval of bankfull discharge can vary depending on the local conditions; however, it is less than the 2-year flood.

The recurrence interval of bankfull discharge can vary depending on the local conditions; however, it is typically about a 1.5-year event.

Determining bankfull within a stream:
Appropriate analog approaches (field verified measurements of bankfull dimensions from stable 'reference' reaches) should be used for bankfull channel design and the results should be checked with empirical equations, hydraulic geometry relationships, return width interval hydrology estimates and/or permissible velocity and shear stress methods. USDA-NRCS National Engineering Handbook, NEH-654 (referenced in Appendix B) discusses the principles of channel design and provides guidance on various design methods. The threshold design method should only be used for very laterally confined or below in-line ponds or other sediment-free channel reaches.

If another method is proposed, it is recommended that the designer obtain approval from MCPWO prior to proceeding with the design.

V.3.A.2 -*Standard Drain Cross-section*

Figure V-1 depicts the standard drain cross-section intended to be used over riffle stream facets. Cross-sections over other stream facets such as runs, pools, and glides should follow a similar format while adjusting within the bankfull channel according to natural channel design as appropriate.

The following list applies to the design of open County drains:

1. **Hydrology** for the overall channel capacity may be determined from USGS gauge station data, EGLE Discharge Request, TR-55, the Rational Method or with appropriate models such as HEC-HMS or EPA SWMM (Other methods may be used with prior approval from MCPWO). Hydraulics for the drain must be determined using Manning's equation or with MCPWO pre-approved models such as HEC-RAS or EPA SWMM (**Appendix H**). Verify the appropriate design event with MCPWO staff prior to commencing design.
2. **Size the overall drain** to convey the design discharge specified by MCPWO (typically 10-year / 24-hour storm event or 100-year / 24-hour storm event) with a minimum 0.5 ft of freeboard. MCPWO staff reserve the right to require a 100-year design storm; this may include larger drainage areas, areas adjacent to critical facilities, and/or other scenarios.
3. **Manning's n roughness coefficient** for a MCPWO drain cross-section within the bankfull channel and shelfway will be the minimum value specified in section **V.3.B**.
4. **Vegetation and channel roughness -** The drain shall be designed to carry an overall design storm capacity as determined by MCPWO with minimum 0.5 ft of freeboard. Design roughness coefficients of the channel shall be based on the fully-vegetated condition. **The minimum Manning's roughness coefficient used to design the overall drain capacity, including the bankfull channel and shelfway, is specified in section V.3.B** (also see **Figure V-1 & Section V.3.B).**
5. **The bankfull channel** shall be designed to provide long-term vertical stability such that the channel gradient and dimensions are maintained and the bed will not undergo excessive erosion or deposition. Design of the bankfull channel shall conform to permissible shear stress design methods and channel stability checks, at a minimum. Sediment entrainment (or competence), defined as the ability to move the largest sized sediment (typically during a bankfull event), shall be determined for gravel bed channels (average bed material >2mm). If critical shear stress is too low, then the slope should be adjusted and/or the W:D ratio may be adjusted (see **Figure V-1).**
6. **A low flow channel** must be constructed within the bankfull channel if the drainage area exceeds 2 square miles and sediment transport capacity has not been determined (see **Figure V-1).** The use of a properly designed low flow channel can increase the sediment transport capacity by 18-20% (Rosgen, 2008).
7. **Bankfull near crossings** – The bankfull channel width may widen to accommodate a reasonable transition into or out of a culvert/bridge/structure as determined by MCPWO. Additional capacity may be required at the bankfull elevation to provide floodplain drainage at bridges or culverts.
8. **Sediment Transport -** Adequate sediment transport capacity, defined as the ability to convey the incoming sediment load (tons/yr), should be verified for construction of channel reaches longer than 15 times the bankfull channel width using HEC-6, FLOWSED/POWERSED, or various other sediment transport equations.
9. **Provide or maintain floodplain form** – provide a minimum shelf way of four times the width of the bankfull channel (see **Figure V-1**)or match the existing surround shelf with (whichever is greater). If constructing the required floodplain width is not possible due to site constraints, the maximum width practicable shall be provided. This may require steeper side slopes along one or both sides of the flood conveyance channel with appropriate fencing.

V.3.B – Standard Drain Manning's Roughness Coefficient

Flow capcity of a Drain is partially dependant on the releative roughness or resistance to flow created by the surface lining the cross-section. MCPWO will use Manning's Roughness Coeffient (n) to represent the relative roughness of drain vegetation and soils under full leaf-out vegetation conditions.

MCPWO requires a minimum Manning's roughness coefficient of 0.05 be applied to the proposed bankfull channel, shelfway, and terrace slopes when determining the overall drain capacity. As seen in Table V-11, a value of 0.05 represents a dredged channel with a clean bottom and uncut weeds/brush along the sides. Higher roughness coeffients shall be used if a higher value better represents existing and/or proposed conditions. The existing channel may be represented with a Manning's roughness coefficient less than 0.05 if needed to represent true site conditions.

V.3.C - Open Drain Construction

Construction means and methods will vary with each county drain construction project. When constructing any portion of a new or existing county drain, the following requirements and considerations will apply:

1. Minimize vegetation disturbance: The methods of construction should minimize the area and duration of land and vegetation disturbance, where possible. All disturbed/earth change areas within the County easement shall be promptly stabilized.
2. The riffle/pool topography of the bankfull channel bed should be retained or enhanced and not graded flat and uniform. Figure V-1 is a conceptual drawing of the standard (riffle) cross section. A trapezoidal cross-section may be assumed for design purposes, but constructed cross-sections should be more parabolic-shaped.
3. Cross-sections within pool facets should have dimensions similar to Figure V-1 but with asymmetrical cross sections.
4. The proposed channel gradient must consider the elevation of road culverts and other permanent grade controls.
5. Landscaping shall follow the appropriate requirements of Part VIII.

6. **Back slope of the bankfull channel** shall not be steeper than 3:1 (H:V) when vegetated.

   The banks of the bankfull channel shall be predominantly deformable (unarmored) vegetated banks. Armoring banks of the bankfull channel with riprap and other structural revetments should be minimized. Bank armoring should generally be used only to protect infrastructure or where required due to a narrow shelf width which may occur due to existing infrastructure (**Figure V-2**). If eroded or disturbed during construction, banks should be stabilized with vegetative approaches combined with rolled erosion control products as a first consideration. See **Appendix I** for guidelines on rolled erosion control products (Washington, 2003) and referenced in **Appendix B** for more detailed streambank protection guidelines.

7. **Riprap** – When riprap is used, it shall be sized to resist the velocity, shear force, ice forces, scour potential, potential for debris impact, and wave impact forces that are present at the installation location. Riprap shall be angular limestone. Rip rap must be installed using either geotextile filter fabric or a stone bedding filter layer.

Figure V-2 - Concept of Deformable (Vegetated) Bank Treatment

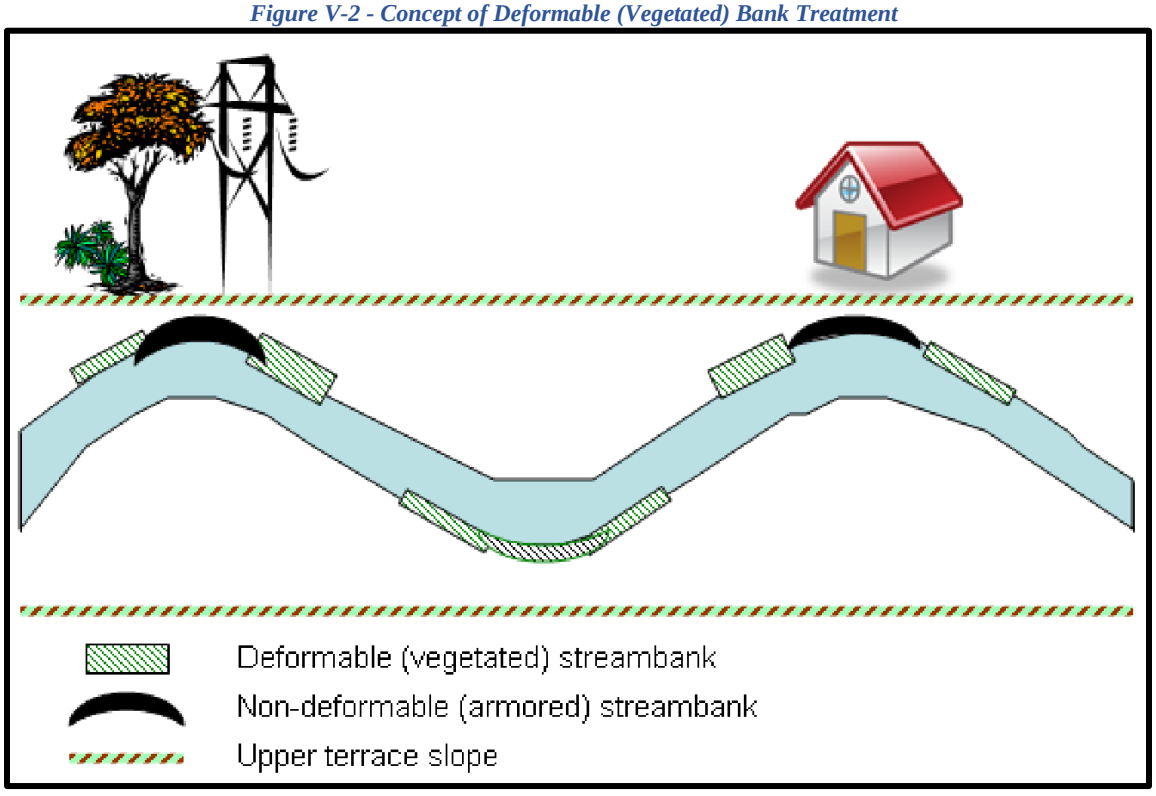


Table V-11 - Manning's n for Channels (adapted from Chow, 1959)-Coefficients for Channels and Floodplains

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Brush			
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in summer	0.040	0.060	0.080
3. medium to dense brush, in summer	0.070	0.100	0.160
c. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160
4. Excavated or Dredged Channels			
Earth winding and sluggish			
1. grass, some weeds	0.025	0.030	0.033
2. dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
3. earth bottom and rubble sides	0.028	0.030	0.035
4. stony bottom and weedy banks	0.025	0.035	0.040
5. cobble bottom and clean sides	0.030	0.040	0.050
Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.050	0.080	0.120
2. clean bottom, brush on sides	0.040	0.050	0.080
3. same as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140

PART VI - MANAGING STORMWATER RUNOFF

VI.1 - Stormwater Management Approach

Thoughtful site planning reduces the negative impacts associated with development. Communities, regulatory agencies, and designers must evaluate the impact of each individual development project over the long-term and on a subwatershed scale. Stormwater Best Management Practices (BMPs) should be used that function together as a system to insure that the volume, rate, timing, and pollutant load of runoff remains similar to that which occurred under natural, pre-development conditions. This can be achieved through a coordinated network of structural and nonstructural methods designed to provide both source and site control.

VI.1.A - Runoff Source Controls

Source controls reduce the volume of runoff generated on-site, and eliminate initial opportunities for pollutants to enter the drainage system. They are the best option for controlling stormwater and include the following key actions:

a. Preserve existing natural features that perform stormwater management functions, such as natural depressions, wetlands, forests/trees, and vegetation along streambanks.

b. Reduce the area of impervious surfaces through site planning. Minimize enclosed storm sewer systems and directly connected imperviousness by conveying stormwater through vegetated swales, or other MBP methods where possible.

c. Careful design, installation, and maintenance of erosion control mechanisms throughout the construction period is imperative. Effective erosion control measures include minimizing the area and length of time that a site is disturbed by construction phasing, installing, and maintaining effective erosion control measures, and promptly stabilizing disturbed/earth change areas.

VI.1.B - Runoff Site Controls

Site controls are used after the implementation of source controls to convey, pre-treat, and treat (i.e., detain, retain or infiltrate) the stormwater runoff generated by development. The engineering and design techniques available to achieve these objectives is dictated by site configuration, soil type, and the receiving waterway, but some universal guidelines for controlling stormwater quality and quantity can be stated. The following four categories of site controls are listed in order of consideration.

a. Infiltration - The most effective stormwater quality controls are infiltration practices, which reduce both the peak runoff rate and volume. Infiltration devices are most applicable to small drainage areas and sites with suitable soils and no potential for groundwater contamination.

b. Conveyance - Excess runoff must be discharged into conveyance systems once other methods of reducing and treating stormwater on-site have been implemented and carried off-site to a suitable outlet. For this purpose, vegetated swales are generally preferred to curb and gutter systems and enclosed storm drains. Enhanced swale designs can increase the time of concentration, reduce volumetric requirements, and provide water quality benefits.

c. Basins - The next most effective stormwater site controls are detention basins which reduce peak runoff rates.

d. Filtering Systems and Manufactured Treatment Devices (MTDs) – Filtering practices and MTDs are allowed, but adequate source controls that have been integrated into the design are preferred. MCPWO can provide a list or pre-approved MTD devices upon request. Devices that have not been pre-approved must submit laboratory testing data/results from review by MCPWO as part of the permit process.

The preferred hierarchy of structural site controls provides a comprehensive framework for evaluating the place and function of individual practices within a stormwater management system. The most important practices are source controls that preserve and protect the natural environment. The use of source control measures is preferred and will minimize required detention pond sizing on site.

Stormwater Best Management Practices (BMPs) should be designed to function together as a system to ensure that the volume, rate, timing, and pollutant load of runoff remains similar to that which occurred under natural, pre-development conditions.

VI.2 - Stormwater Management - Unified Sizing Criteria

The MCPWO's criteria address a range of rainfall events that are anticipated at developed sites. These criteria apply to all new and re-development projects that disturb and/or create and earth change of one acre or more, including projects less than one acre that are part of a larger common plan of development or sale that would disturb one acre or more. Certain stormwater management requirements may be modified by the MCPWO based on the receiving waters, the site's location within the watershed, and other site-factors. The MCPWO's stormwater management program is divided into four management zones based on their relative rainfall frequency, as shown in **Table VI-1**.

Table VI-1 - Summary of Unified Sizing Criteria

Management Zone	Description
Water Quality Control (WQC) (See Section VI.2.A.1)	• Limit post-development runoff Total Suspended Solids (TSS) concentrations to either of the following water quality standards: a site-specific maximum concentration of 80 mg/l, or 80% TSS reduction. • Treat the runoff generated from the site for a 1.0" rain event which is the equivalent of the 90% non-exceedance storm. For volume based WQC practices (see section **VI.2.A.1**). For flow based WQC practices (MTDs) see section **VI.2.A.2**
Channel Protection Volume Control (CPVC) AKA (V_{VC}) (See Section (VI.2.B)	The Channel Protection Volume Control (CPVC) Volume (V_{VC}) reduces the negative impacts of impaired hydrology, increased erosion, deposition, and altered sediment load of streams primarily by encouraging infiltration. The (V_{VC}) is the post-development site runoff volume from a 1.20-inch rainfall (see **Table VI-8**). • Evaluate site soil infiltration (see section **VI.2.B.2**) • Implement source control practices promotion of naturalized area; reduced imperviousness • Reduce pavement, increase and/or maintain natural areas, provide infiltration and/or storage and/or water reuse BMPs
Channel Protection Rate Control (CPRC) AKA (V_{ED}) [A.K.A. Extended Detention] (See Section VI.2.E)	The Channel Protection Rate Control (CPRC) is required for the site's post-development and is based on the runoff volume from a 1.9-inch rainfall. This CPRC Volume (V_{ED}) shall be dewatered over a minimum period of 48 hours. • Determine (V_{ED}) using **Table VI-9**. • Design a detention/outlet control system that releases the (V_{ED}) in minimum of 48-hours.
Detention & Flood Control (DFC) A.K.A. (V_{100DET}) (See Section VI.2.F)	The DFC is intended to manage the runoff from a 100-year storm event. The entire detention practice, including the DFC must drain within a maximum of 72 hours (see Section **VI.2.F**). • The (V_{ED}) is the minimum allowable volume for a detention system. Some BMPs, may qualify for a credited toward the V_{100DET}; up to a maximum of the V_{VC}

VI.2.A Water Quality Control (WQC)

Water Quality Control (WQC), also commonly referred to as the First Flush volume, is required to limit post-development runoff Total Suspended Solids (TSS) concentrations to either of the following water quality standards: maximum TSS concentration of 80 mg/l, or 80% TSS reduction. Table VI-5 shows the accepted TSS removal efficiencies of multiple BMPs. Water Quality Control requirements can be partially achieved through the following methods.

1. Channel Protection Volume Control (CPVC) and Table VI-2 Treatment of the WQC volume is automatically achieved if a CPVC requirements are calculated and met for the specific area draining to individual BMPs or a BMP treatment train. No portion of the disturbed/earth change site can drain without treatment unless specifically discussed and approved with MCPWO.
2. Manufactured Treatment Devices (MTD): MTDs shall be sized to provide treatment of the 1-year recurrence interval water quality peak flow rate (Q_{WQ}) (see Table VI-3). Not all MTDs will be accepted, the designer must submit documentation of MTD TSS removal efficiency testing.
3. Tributary areas that have achieved CPVC upstream, in most cases, will also meet WQC.
4. Wet or dry detention basin with forebay (provided that the permanent pool meets the minimum depth and volume requirements listed in Sections VI.3 & VI.2.A.5.) Please note that both wet and dry basins must incorporate forebays to receive TSS removal credit as shown in Table VI-4.
5. Other (Swales, Filter Strips, etc.).

VI.2.A.1 - *Water Quality Volume (V_{WQ})*

The Water Quality Control Volume (V_{WQ}) is intended to treat the first flush runoff volume from a site, based on post-development site conditions of a 1.0-inch rainfall. The V_{WQ} is calculated using Table VI-2:

Table VI-2 - (V_{WQ}) Water Quality Volume

$V_{WQ} = 3{,}630 * P * \bar{C}_{10yr} * A$	
$\bar{C}_{10yr}$ =	Area weighted runoff coefficient during a 10-year event
A =	Total contributing drainage area (acres)
V_{WQ} =	Required volume (ft^3)
P =	Precipitation depth (1.0 inch)

VI.2.A.2 *Water Quality Peak Flows (Q_{WQ})*

Detention basins, media filtration, infiltration, and most vegetative practices (bioretention, wet swales, dry swales, filter strips) are water volume based. However, certain water quality treatment practices use a flow rate as the design variable (a rate-based design). The water

quality flow (Q_{WC}) is the peak flow rate associated with the water quality design storm, which is associated with a 1-year recurrence interval peak flow rate. This flow rate can be calculated using **Table VI-3**, with intensity generally limited to a maximum of 2.0 inches/hour, which is associated with most drainage areas small enough to be tributary to a water quality BMP. This flow rate can be used for the design of the following:

- **Manufactured Treatment Devices (MTDs)** such as swirl concentrators, media filtration units, or multi-chamber treatment trains.
- **Grass-lined drainage channels** (not wet or dry water quality swales which should be designed based on water quality volume).
- **Flow diversion structures** for off-line stormwater treatment practices.
    - Additional products can be added to a pre-approved MTD list if laboratory testing of sediment removal efficiency is provided. MCPWO will evaluate the quality and reliability of the provided information.

Table VI-3 - (Q_{WQ}) Water Quality Peak Flow Rate for Manufactured Treatment Devices

$Q_{WQ} = \bar{C}_{10yr} * I_{MTD} * A$	
Q_{WQ} =	1-year recurrence interval water quality peak flow rate
$\bar{C}_{10yr}$=	Post-construction site runoff coefficient
I_{MTD} =	I_{MTD} = 2 in/hr
A =	Total contributing drainage area (acres)
Tc =	Contributing area's time of concentration (minutes)

VI.2.A.3 – *Sediment Forebays*

The primary purpose of a sediment forebay is to capture and settle out sediment and other particulate matter from stormwater runoff or other water sources before it enters a downstream water body. By allowing sediment to settle out within the forebay, the water that continues downstream is cleaner and less likely to cause environmental harm. Forebays are traditionally separated from the rest of the basin by an earthen berm. A forebay control structure is required to release water from the forebay into the main body of the basin. An overflow weir must be provided to allow high flow events to access the rest of the basin. Erosion control measures must be taken to prevent flows from scouring the forebay berm.

Forebays shall be sized to be 15% of the Water Quality Volume (0.15 x V_{WQ}) when no infiltration is intended downstream of the forebay. When infiltration is intended downstream; the volume of the forebay shall be equal to or greater than the Water Quality Volume. Please note that in order to receive TSS removal credit (see **Table VI-4**), both wet and dry basins must utilize a sediment forebay.

VI.2.A.4 *Media Filtering Systems*

Filtering systems include sand filters, compost or peat/sand filters, and manufactured filtering devices. Filtering systems should be designed off-line to treat the water quality discharge for sites less than 5 acres and to bypass larger flows from treatment. Pre-treatment of filtering systems must be provided. Stormwater filtering systems are recommended to treat the runoff from stormwater "hotspot" sites. Design guidance is provided in Claytor and Schueler, 1996; DWSD, 2020; and SEMCOG, 2008 (Appendix B).

VI.2.A.5 – *BMPs & Treatment Train Total Suspended Solids (TSS) Removal*

Table VI-5 provides the pollutant removal capabilities of typical stormwater best management practices (BMPs) based on research studies documented in the American Society of Civil Engineers (ASCE) International Stormwater BMP Database. The TSS removal efficiencies for individual BMPs are used to demonstrate a TSS reduction of 80% or more in the water quality volume.

If there is insufficient evidence or documentation that a BMP will perform as intended, then the MCPWO will not allow the listed TSS removal rates. A BMP that does not achieve the required 80% TSS removal rate may be used as part of a treatment train to meet Water Quality Control criterion. MCPWO encourages the use of the SEMCOG Low Impact Development Manual for Michigan as a practical design guidance document that will likely achieve the MCPWO listed TSS removal rates.

The designer can determine the TSS removal rate of a single BMP or an in-series BMP treatment train by using the procedure shown in Table VI-4.

Table VI-4 - Treatment Train TSS Removal Efficiency

$e_{TSS} = 1 - (1 - e_1)(1 - e_2) \ldots (1 - e_n)$	
e_{TSS} =	Treatment train removal efficiency
e_n =	Removal efficiency of the nth BMP (Table VI-5)

Table VI-5 - Typical Sediment Removal Rates of Stormwater Best Management Practices (BMPs)

BMP Type	TSS Removal Rate (%)
Wet Detention Basin (with forebay)[1, 2, 3, 4]	60% [3,4]
Dry Detention Basin (with forebay)[2, 3, 4]	40% [3,4]
Pervious Pavement System [5]	60%
Constructed Stormwater Wetland [6, 3]	50%[3]
Vegetated Swale [7]	30%
Lateral Vegetated Filter Strip [8]	40%
Sand and Media Filter [9]	80%
Bioretention/Bioswale [10]	70%
Catch Basin Sump and Hooded Outlet [11]	20%
Manufactured Treatment Devices (MTDs)[12,13] / Isolator Rows [12,13,14]	*12, 13, 14
Underground Storage (without isolator rows and/or pre-treatment)[2]	0%

* =TSS Removal Rate depends on independent testing.

[1] The permanent Pool in a wet detention basin must have a volume greater than or equal to 25% of the DFC volume of the basin. The permanent pool must be at least four feet deep and have a similar shape/configuration to the rest of the basin.

[2] Wet detention basins, dry detention basins, and underground storage systems must provide extended detention and be sized to meet MCPWO criteria.

[3] To receive TSS removal rate credit, inlets and the outlet must be on opposite sides of the basin to allow for sediment particles to settle.

[4] To receive TSS removal rate credit, a properly designed sediment forebay must be included as part of the system. The forebay alone does not provide any additional TSS removal rate credit. (For forebay sizing see Section VI.2.A)

[5] Pervious pavement systems must be a full depth design including stone reservoir to receive TSS removal rate credit.

[6] Stormwater wetland must include vegetation and variable bottom topography and sized for at least the 1-inch storm event .

[7] Stormwater must travel along length of swale to receive credit.

[8] Stormwater must travel/traverse as sheet flow across lateral vegetated filter strips to receive TSS removal rate credit.

[9] Sand or Media Filter must be full depth for the 1-inch storm event with stormwater passing through filter to receive TSS removal rate credit.

[10] Bioretention/Bioswale must have a defied inlet and outlet, include appropriate plants, and have amended soils (i.e. a prescribed bioretention soil mixture). It must be adequately sized to capture the 1-inch storm event from the contributing drainage area.

[11] Catch basin sump must be at least two feet deep and the outlet must be sized to cover entire outlet pipe.

[12] Professionally certified results of independent testing will determine the TSS removal rate of specific MTDs & isolator rows.

[13] MTD TSS removal rates are typically based on an in-flow rate basis. Therefore, it is difficult to determine what size/model of MTD is needed to completely treat inflows where partial TSS removal occurs as part of a treatment train. In order to downsize an MTD, the manufacturer must provide physical laboratory testing results of TSS removal rates while the MTD operates at various flow rates.

[14] The MTD must be able to internally or externally bypass the design event flow of the system.

VI.2.B Channel Protection Volume Control (CPVC)

As a result of increased imperviousness and runoff rates associated with development, the stability, flooding potential, and ecological health of natural watercourses are negatively impacted by increased erosion, increased sedimentation, and overall alteration of the magnitude, frequency, and intensities of flows. These issues can be improved by incorporating a combination of stormwater best management practices that reducing the total site runoff volume, primarily via infiltration.

To address these issues, and to satisfy the Macomb County's Municipal MS4 state permit requirement, we will require projects to incorporate Channel Protection Volume Control (CPVC or V_{VC}). The Channel Protection Volume Control is the targeted volume of water the development must manage by reducing the overall volume stormwater runoff, primarily via infiltration, which promotes groundwater recharge and stabilizing flow rates and baseflow in our natural watercourses. The MCPWO may waive or reduce the CPVC requirements for certain developments that pose no or minimal threat to channel stability such as those directly discharging to continuous enclosed drains that outlet to Lake St. Clair.

The Channel Protection Volume Control Volume (CPVC or V_{VC}) is the post-development site runoff volume from a 1.20-inch rainfall. Table VI-6 provides a summary of the CPVC implementation process.

Table VI-6 - Summary of CPVC Design Process

Item	Reference Section
Consider if the site is eligible for infiltration and is not "a stormwater hotspot"	VI.2.B.1
Preliminary Review of Soil Infiltration	VI.2.B.2
Determine Channel Protection Volume Control (CPVC)	VI.2.B
Consider likely locations and design depths of infiltration BMPs	VI.2.B.3 VI.2.B.4
Conduct infiltration testing at locations and appropriate depths relative to the bottom of proposed infiltration BMPs	VI.2.B.2
Consider a pre-application meeting with MCPWO to discuss questions regarding testing and design alternatives.	I.2
If testing supports infiltration; finalize BMP design to provide the full CPVC	VI.2.B.2 VI.2.B.3 VI.2.B.4
If infiltration tests show low infiltration rate and/or capacity provide the CPVC to the MEP	VI.2.B.3
Summarize the CPVC design process or MEP process in stormwater narrative. Submit geotechnical and/or infiltration testing reports to MCPWO for review.	III.1.A

VI.2.B.1 - *Infiltration Site Constraints Stormwater Hotspots*

Infiltration BMPs are prohibited in areas containing contaminated soils/groundwater, wellhead protection areas, high groundwater (less than 2 feet from bottom of infiltration bed 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. Design in these areas shall include the use of non-infiltrating runoff volume reducing BMPs to the MEP. An Environmental Site Assessment is required to demonstrate the presence of contaminated soils.

Sites under MCPWO review that are determined to be stormwater "hotspots" may require a greater level of stormwater treatment. Stormwater filtration systems combined with pre-treatment practices may be required, at the MCPWO's discretion, to treat heavy metals, nutrients, dissolved pollutants, and total petroleum hydrocarbons.
A stormwater hotspot is a land use or activity that generates higher than average concentrations of pollutants and may include, but is not limited to, the following:

1. Vehicle salvage yards and recycling facilities
2. Vehicle fueling stations
3. Vehicle service and maintenance facilities
4. Vehicle and equipment cleaning facilities
5. Fleet storage areas
6. Industrial sites (based on SIC codes)
7. Marinas with service and maintenance
8. Outdoor liquid container storage
9. Outdoor loading/unloading facilities
10. Public works storage areas
11. Facilities that generate or store hazardous materials
12. Commercial nursery
13. Auto dealer lots
14. DOT storage areas
15. On-site sewage disposal systems (OSDS)
16. Other land uses and activities as determined by the MCPWO

General site infiltration should also be limited for stormwater hotspot sites.

Open detention basins and underground detention basins also represent a potential to introduce hotspot contaminates into the groundwater. With this in mind, **underground detention systems constructed on hotspots shall be fully enclosed.** Open detention systems constructed on hotspots with measured soil infiltration rates equal to or faster than 0.24 inches per hour will require the installation of an impermeable liner. **When soil infiltration rates are less than 0.24 inches per hour, an impermeable liner is not required if a professional engineer specializing in geotechnical engineering certifies that existing soils do not present a potential for introducing contaminates to the groundwater.**

EGLE industrial stormwater permit warning: Please Note - Stormwater hotspots may also require an EGLE industrial permit. These permits are intended to regulate various industrial activities to ensure they comply with environmental laws and protect air, water, and land resources. The specific activities that require an EGLE industrial permit may vary depending on the type of industry and the potential environmental impact. MCPWO may require the applicant to provide confirmation from EGLE that an industrial permit has been received or in not required.

VI.2.B.2 – *Soil Infiltration Testing*

MCPWO accepts the results of 3 different infiltration testing procedures. A qualified professional must exercise judgment in the selection of the infiltration test method. The three infiltration testing methods used to determine a design infiltration rate are:

- Open pit falling head.
- Encased falling head.
- Double-ring infiltrometer.

Factors of Safety

To account for the unpredictable and uncertain nature of infiltration testing; **field 'measured infiltration rates' shall be divided by a minimum of 2. The result shall be referred to as the 'design infiltration rate'**. MCPWO will accept a maximum design infiltration of 4 inches per hour even if measured infiltration rates report higher values.
See "**Appendix Q– Infiltration Testing Methodology**" for testing procedure details.

Minimum Number of Required Tests

The number of required infiltration tests may vary by type of development proposal or by design approach. The following list describes how many tests are required for a typical project.

- **When infiltration testing is required by MCPWO, a minimum of two infiltration tests** are required for a site. The ultimate number of tests will depend on the anticipated soil conditions across the site and the size of the site. For larger sites with variable soils, contact MCPWO to review the infiltration testing plan.
- **Infiltration tests shall be located** within 25 ft or less of a BMP footprint in order to be considered representative of the BMP area. Each individual BMP needs to have documented infiltration rates.
- **BMPs with unusually long, large, or unusual site characteristics** may require additional infiltration testing.
- **MCPWO may require additional testing for any reason.**

General Testing Criteria

- Testing must be conducted or overseen by a qualified professional. This professional must be a Professional Engineer (PE) licensed in the State of Michigan.

- The depth of the test must correspond to the facility depth. If a confining layer, or soil with a greater percentage of fines, is observed during the subsurface investigation to be within 2 feet of the bottom of the planned infiltration system, the testing should be conducted within that confining layer.
- Based on EGLE requirements and conformance with any required Depth to Groundwater Investigation Requirements, the boring log must be continued to a depth adequate to show separation between the bottom of the infiltration facility and the seasonal high groundwater level. The boring depth will vary, based on facility depth.
- Tests must be performed in the immediate vicinity of the proposed facility. Exceptions can be made to the test location provided the qualified professional can support that the strata are consistent from the proposed facility to the test location. **The test must be conducted in the twenty-four months prior to the MCPWO plan review submission.**
- Infiltration testing **should not** be conducted in engineered or undocumented fill.

Infiltration Test Report Requirements

The Infiltration Test Report must be attached to the project's Stormwater Narrative as part of the plan review submission. The following must be included in the Infiltration Testing Report:

- **Statement of project understanding** (proposed stormwater system).
- Name, contact information, professional license information and qualifications of the person conducting the infiltration test.
- **Summary of subsurface conditions** encountered, including soil textures and the depth that they were found.
- **Summary of pre-saturation timing**.
- **Summary of infiltration testing including location and number of tests and testing method used.** Discussion of how the tests were performed (i.e. pipe type or diameter or test pit dimensions).
- **Infiltration testing results in inches per hour** for each interval as well as the average for the entire testing period
- **Recommended design infiltration rate.**
- **Groundwater observation**s within exploration and an estimate of the depth to seasonal high groundwater.
- **Site plan showing location of infiltration tests.**
- **Boring or test pit logs.** Boring or test pit logs will be required when an applicant's proposal relies on the presence of specific subsurface strata that allows infiltration. The logs must include an associated soil classification consistent with ASTM D2488-00, Standard Practice for Classification for Description and Identification of Soils (Visual-Manual Procedure). The logs must also include any additional pertinent subsurface information, such as soil moisture conditions, depth and description of undocumented or engineered fill, soil color and mottling conditions, soil stiffness or density, and approximate depth of contact between soil types.
- **A summary of the Infiltration Test Data Tables** (see **Table VI-7** for example)

Table VI-7. Example Infiltration Test Date Table

(An infiltration testing report must be submitted as part of the plan review application package)

Location: Lot 105, Point Heights Subdivision			**Date:** 6/28/2008		**Test Hole Number:** 3
Depth to bottom of hole: 57 inches			**Dimension of hole:** 0.5 feet diameter		**Test Method:** Encased Falling Head
Tester's Name: C.J. Tester **Tester's Company:** Tester Company **Tester's Contact Number:** 555-1212					
Depth (feet):			**Soil Texture:**		
0-0.5			Black Top Soil		
0.5-1.0			Brown SM		
1.0-2.2			Brown ML		
2.2-5.1			Brown CL		
Presaturation Start Time: Presaturation End Time:					
Time:	**Time interval (minutes):**	**Measurement, (feet):**	**Drop in water level, (feet):**	**Infiltration rate, (inches per hour):**	**Remarks:**
9:00	0	3.75	-		Filled with 6"
9:20	20	3.83	0.08		
9:40	20	3.91	0.08	2.88	
10:00	20	3.98	0.07	2.52	
10:20	20	4.04	0.06	2.16	
10:40	20	4.11	0.07	2.52	
11:00	20	4.17	0.06	2.16	
11:20	20	4.225	0.055	1.98	
					Adjusted to 6" level for Trial #2

VI.2.B.3 *Applying Measured Infiltration Test Results*

1. The CPVC is commonly achieved by providing adequate infiltration and/or storage/reuse BMPs. This may include (but is not limited to) bioretention, rain gardens, bio-swales, pervious pavement, cisterns, green roofs, infiltration trenches, and/or infiltrating underground detention systems. Non-structural BMPs, such as impervious area reduction, natural vegetation (as opposed to turf grass), and disconnected impervious surfaces (roofs and pavement areas that drain onto vegetated surfaces) are good design alternatives to reduce runoff volume, with thereby reduces the required size of any structural BMP.
2. Geotechnical investigations to demonstrate whether infiltration can be achieved on a given site is a required component of a site permit/review submittal. As part of the stormwater narrative, the applicant must submit a written explanation of the project site's ability or inability to meet the full CPVC goals (see Section III.1.A) along with a detailed discussion of the CPVC features used. Any site plan submittal that does not include a geotechnical investigation is considered incomplete and will be returned without a full technical review.

3. **Site suitability for infiltration BMPs** is ultimately determined by geotechnical investigations & infiltration testing. Soil and groundwater characteristics must be verified using geotechnical investigations (see Section **VI.2.B.2– Soil Infiltration Testing**). USDA/NRCS soil maps (Web Soil Survey) should be evaluated as an initial site planning tool to predict the location of the best drain soils on site, however, USDA/NRCS soil maps will not be adequate to establish soil infiltration capacity.

    a. **When in-situ measured infiltration rates are at or below 0.24 in/hr.**, infiltration may not be a practical alternative for volume control, and the CPVC requirement should then be implemented to the MEP as determined by MCPWO. Alternatively, the project design may provide other improvements (structural and non-structural BMPs) to the site and/or downstream waterways that improve and support the hydrologic, hydraulic, and/or water quality goals discussed as part of the Macomb County MS4 permit.

    b. **When in-situ measured infiltration rates are 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 aggregate storage bed layer to maximize infiltration.

    c. **When the in-situ measured infiltration rate is at or above 0.5 in/hr.,** supplemental measures are not required. Unless extraordinary site conditions exist; projects with measured soil infiltration rates equal to or above 0.5 in/hr will be required to infiltrate the full CPVC volume.

    d. **If full infiltration of the CPVC requirement is not practical,** the volume shall always be provided to the Maximum Extent Practicable (MEP). Other beneficial LID practices must be implemented to the MEP. If the project intends to claim that the full calculated CPVC cannot be addressed, then the stormwater narrative must explain the associated site constraints, that limit CPVC to the MEP. The narrative should also describe considered design alternatives, why these alternatives are not practicable and describe how the proposed design supports the goals of Macomb County's MS4 permit.

    e. **Measured Infiltration Rate Vs Design Infiltration Rate:** The above listed items refer to the measured infiltration rate obtained during infiltration testing. The design infiltration rate shall have an applied factor of safety as described in Section **VI.2.B.2**.

    f. **BMP Drain Time:** Infiltration BMPs shall completely dewater in less than 72 hours. The combined storage volume of the surface water and the effective soil layer void space must be drained in 48-hours. Soil layers shall be considered to have 20% effective void space. Stone layers shall be considered to have 30% void space.

    g. **Maximum Allowable Design Infiltration Rate:** A maximum design infiltration rate of 4 inches per hour can be used in stormwater system and/or BMP design.

4. **The value of Channel Protection Volume Control Volume provided by BMPs ($V_{VC\ provided}$) may be credited** towards the $V_{100DET,}$ however, the final detention volume must be the greater of V_{100DET} or the $V_{ED.}$.
5. **Pretreatment is required if any infiltration BMP / Facility that provides DFC volume:** To preserve the longevity and function of infiltration BMPs; pretreatment is required to removing fine sediment, trash, and debris. Common methods of BMP pretreatment include mechanical separators, forebays, vegetated filter strips, vegetated swales, constructed filters, curb cuts with sediment traps and bioretention (when not used for DFC volume credit).

VI.2.B.4 - *Calculating the Channel Protection Volume Control Volume (V_{VC})*

The Channel Protection Volume Control Volume is the post-development site runoff volume from a 1.20-inch rainfall and shall be calculated using **Table VI-8**:

Table VI-8- (V_{VC}) Calculated Channel Protection Volume Control Volume

$V_{VC} = 3{,}630 * P * \bar{C}_{10yr} * A$	
V_{VC} =	Calculated Channel Protection Volume Control (FT^3)
P =	Precipitation depth (1.2 inches)
$\bar{C}_{10yr}$=	Area weighted post-development runoff coefficient for a 10-year rain event.
A =	Total contributing drainage area (acres)

VI.2.C - Infiltration BMPs / Facilities

Infiltration facilities such as infiltration basins, infiltration trenches, dry wells, and permeable pavements may be considered where site conditions allow. Infiltration facilities temporarily store and infiltrate the water quality volume within 72 hours and bypass larger flows. Design guidance for infiltration facilities and other stormwater BMPs is provided in the Detroit Water and Sewerage Department (DWSD) Stormwater Management Design Manual and the Southeast Michigan Council of Government (SEMCOG) Low Impact Development (LID) Manual for Michigan (SEMCOG LID Manual) (DWSD, 2020 and SEMCOG, 2008 as referenced in **Appendix B**). The following requirements apply:

1. **Initial USDA-NRCS soil classifications (from Web Soil Survey)** can be used as an initial planning tool to assess the feasibility of infiltration practices and to eliminate unsuitable areas, although geotechnical investigations must be performed before final design. The MCPWO minimum measured infiltration rate recommended to facilitate the proper functioning of infiltration practices is 0.24 in/hr. The measured infiltration rate must be verified by field infiltration testing. See section **VI.2.B.2** for testing and reporting requirements.
2. **Maximum Allowable Design Infiltration Rate:** A maximum design infiltration rate of 4 inches per hour can be used in stormwater system and/or BMP design.

3. **Structural infiltration devices** such as basins and, to a lesser degree, trenches may suffer high failure rates due to clogging. Therefore, an aggressive maintenance program and upstream pre-treatment measures (such as sumps, swirl concentrators, sedimentation basins and grass filter strips) shall be incorporated into any stormwater management system that employs infiltration devices (except dry wells receiving rooftop runoff). In general, pre-treatment is more important for a structural infiltration device that has a tributary impervious area that exceeds 10 times the footprint of the infiltration device (e.g., a 1,000 square foot bioretention cell treating a drainage area 10,000 square feet or larger should have an upstream pre-treatment measure (an oversized sump structure at the bioretention inlet is a common practice).
4. **The seasonal high water table** The bottom of infiltration facilities shall be a minimum of 2 feet above the bottom of an infiltration BMP where stormwater would infiltrate into native sub-soil.
5. **Stormwater "hotspot" sites:** Infiltration practices shall not be used at stormwater "hotspot" sites (see section **VI.2.B.1**), including areas with documented subsurface contamination.

   If the proposed use of the site does would not qualify as a stormwater hotspot but existing/previous land use may be considered a stormwater hotspot; then an Environmental Site Assessment is required to demonstrate if on-site infiltration would be potentially hazardous.
6. **Heavy equipment** shall not be allowed in contact with the bottom of infiltration practices during construction and must be noted thus on the grading plan.

VI.2.C.1 *Bioretention Unit Design Guidelines*

Bioretention areas are landscaped depressions that accept sheetflow from a grass filter strip and remove pollutants with mechanisms similar to a forested area. Design guidance is provided in USEPA, 2004 (**Appendix B**). Additional MCPWO bioretention requirements are provided in the following list:

- **Surface ponding depth** shall not exceed 24 inches
- **Setbacks from a bioretention unit** shall be as follows:
  - Adjacent property line: 10 feet
  - Building foundation: 10 feet
  - Private well: 50 feet
  - Public well: 200 feet from Type I or Type IIa wells, 75 feet from Type IIb or Type III wells (Safe Drinking Water Act, Act 399, PA 1976)
  - Septic system drain field: 50 feet
- **Clean outs:** All underground pipes shall have clean-outs accessible from the surface.

- Amended soil media shall be considered to have a soil texture class of sandy loam and a minimum as-built saturated hydraulic conductivity / infiltration rate of 0.5 inches per hour.
    - The maximum design infiltration rate of the amended soil shall be 0.5 inches per hour.
    - The soil media mix shall be called out on the construction plans as: Compost: minimum 20%; Sand: 20-80%; Topsoil: maximum 30% (with less than 5% clay content)
    - The minimum allowable soil thickness is 18 inches
    - An effective porosity of 20% within the soil media shall be used for storage volume design calculations.
- Aggregate layers shall use a porosity of 30% for storage volume design calculations.
- BMP drain time: see Section VI.2.B.3
- Inflows: Flows may not be introduced to a bioretention unit via stormsewer pipes or underdrain pipes that directly connect into the aggregate layer or soil layer. Inflows should be introduced to the unit through non erosive pipe connections to the top of the planted soil layer, sheet flows, and/or curb cuts.

Figure VI-1. Vegetated Bioretention (Source: Macomb County)

VI.2.C.2 – *Vegetated Swales Design Guidance*

Swales are broad, shallow channels that primarily remove pollutants through sedimentation. Swales provide some control of runoff quantity and timing through infiltration and an increase in time of concentration. If the use of swales has been approved by MCPWO and the local municipality to meet WQ Criteria or for stormwater BMPs, the swales should be vegetated predominantly with sod-forming grasses for cool humid regions such as:

- Bentgrasses (*Agrostis spp*.)
- Blue-Grasses (*Poa spp*.)
- Fescues (*Festuca rubra and F. ovina*)
- Perennial Ryegrass (*Lolium perenee).*

Wet Swales – Seed mixes for wet swales should also contain at least four (4) forb, grass, and/or sedge plant species (no trees or shrubs) from Table Appendix L-1 to Table Appendix L-4.

Dry Swales – Seed mixes for dry swales should also contain at least four (4) forb, grass, and/or sedge plant species (no trees or shrubs) from Table Appendix L-3 to Table Appendix L-4.

The design of traditional swales can be enhanced to provide pollutant removal. The design of water quality swales is a flow rate-based design that uses Manning's equation to determine the velocity and depth based on channel slope and dimensions. The design of wet and dry swales is based on conveying a 10-year flow with negligible erosion.

Swales shall be designed to safely convey the 2-yr storm at non-erosive conditions and have adequate capacity for the 10-yr, 24-hr storm with at least 0.5ft of freeboard.

Figure VI-2. Native Plantings (Source: Macomb County)

VI.2.D - Upland Areas Used for Stormwater Management

Upland meadows or areas of re-forestation may be established as part of the site stormwater plan. The planting materials for upland areas should coincide with Zone 5 (Table Appendix L-5 to Table Appendix L-6 in Appendix L). For upland areas where a 'no mow' mix of grasses is desired, a mixture of four to six fine fescue species should be used. Several proprietary mixes are available.

VI.2.E - Channel Protection Rate Control (CPRC) / 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. The CPRC shall be implemented as outlined below.

1. **Channel Protection Rate Control** is required for the site's post-development and is based on the runoff volume from a 1.9-inch rainfall. This CPRC Volume will be provided via Extended Detention of the CPRC volume. The Extended Detention Volume (V_{ED}) shall be dewatered over a minimum period of 48 hours . The entire detention practice, including the Detention Flood Control volume (DFC) [see Section **VI.2.F**], must drain within a maximum of 72 hours.
2. **To calculate the required V_{ED}**, which is the post-development runoff volume from a 1.9-inch rainfall event use **Table VI-9**:

Table VI-9 - (V_{ED}) Required Extended Detention Volume

$V_{ED} = 3{,}630 * P * \bar{C}_{10yr} * A$	
V_{ED} =	Required CPRC volume (ft^3)
$\bar{C}_{10yr}$ =	Area weighted composite runoff coefficient for the contributing area
A =	Total contributing drainage area (acres)
P =	Precipitation depth (1.9 inches)

3. **Per Macomb County's agreement with EGLE via the MS4 permit; the CPRC requirement effectively maintains** the 2-year pre-development peak flow rates, to the MEP, for new developments and reduces the existing 2-year peak flow rates for redevelopments.

VI.2.F - Detention & Flood Control (DFC)

Safe conveyance of the 100-year, 24-hr storm must be provided from the site or through the detention basin with 1 foot of freeboard. No permanent structures shall be allowed within the limits of the established 100-year floodplain for tributaries with a drainage area of two square miles or greater. **No fill shall be allowed within the floodplain without an appropriate compensatory cut.**

The stormwater conveyance systems under the jurisdiction of the MCPWO shall have the minimum capacity of the 10-year storm, with overflow capacity of the 100-year storm. Review of proposed projects by other local, county, state, or federal agencies may have additional capacity requirements such as at road crossings. The MCPWO may waive or reduce the Detention and Flood Control (DFC) requirements for certain developments that pose no or minimal threat to overbank flooding such as those directly discharging drains that outlet to Lake St. Clair.

VI.2.F.1 - *DFC: Release Rate*

The allowable 100-year post-development peak flow rate (Q_{100ALL}) shall be approved by the MCPWO on a case-by-case basis and typically will not be allowed to exceed **the smallest of the of the applicable scenarios presented in Table VI-10. Please note:** The MCPWO detention basin sizing method and calculations assume that water from the basin will be released at a rate near to and less than the allowable maximum. Releasing water significantly slower than the allowable maximum may result in an undersized detention basin.

Table VI-10 – (Q_{100ALL}) Allowable 100-Year Post-Development Peak Flow Rate

Item	Scenario Description	Allowable 100-year post-development peak flow rate (Q_{100ALL})
The Q_{100ALL} shall be the lesser of the following scenarios if applicable to the project:		
1	**Site-specific restricted flow rates**	Due to downstream capacity limitations, or flooding. Please note enclosed drain systems are more likely to be unable to accept discharges greater than 0.15 cfs/acre. Contact MCPWO by e-mail to confirm if any known downstream capacity limitations exist.
2	**Projects draining to a system managed by the Macomb County Department of Roads**	These projects will be restricted to a 4" outlet maximum. In these cases, the 4" connection may control the maximum Allowable 100-Year Post-Development Peak Flow Rate (Q_{100ALL}). Flow velocities from the 4" outlet may not cause erosion at the outlet.
3	**Local municipality or other reviewing agencies release rate**	In some cases, another review agency may require a smaller release rate then the MCPWO. In these cases, the smallest allowable release rate shall be use as Q_{100ALL} for the remainder of the detention basin calculation method.
5	**Release rate is based on the size of the development**	Calculate the Variable Release Rate (VRR) based on the development sizes provided below:
6	**Special Circumstance: The provided 100-year post-development peak flow rate ($Q_{100\text{-}provided}$) from the project is significantly slower than Q_{100ALL}**	It is anticipated that projects will attempt to release water from a detention facility at a rate near the Q_{100ALL} but without exceeding the Q_{100ALL}. However, should the project release at a significantly slower rate, either by choice or by physical limitation, Q_{100ALL} shall be restricted to the provided 100-year post-development peak flow rate.
Development size is considered to be sum of all on-site and off-site contributing drainage areas (unless otherwise specified by MCPWO).		

Development Size	Release Rate
2 acres or less	1.0 cfs/acre
Greater than 2 acres but less than 100 acres	Use **Table VI-11**
Greater than 100 acres	0.15 cfs/acre

Table VI-11 - (QV_{RR}) Variable Release Rate (if applicable based on Table VI-10)

$$Q_{VRR} = 1.1055 - 0.206\text{Ln}(A)$$

Q_{VRR} =	Variable 100-Year Release Rate (cfs/acre)
A =	Contributing site area (acres)

VI.2.F.2 - *Downstream Receiving Capacity*

In no event shall the maximum design rate or design volume of discharge exceed the maximum capacity of the downstream land, channel, pipe or watercourse to accommodate the flow. It is the proprietor's obligation to meet this standard. Should a stormwater system, as-built, fail to comply, it is the proprietor's responsibility to design and construct, or have constructed at his/her expense, any necessary additional and/or alternative stormwater management facilities. Such additional facilities will be subject to the MCPWO's review and approval.

If downstream capacity is insufficient for the proposed development, the developer may be required to 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 easements and/or permits, from downstream property owners and is responsible for all improvement costs.

If no adequate watercourse exists to effectively receive a concentrated flow of water from the proposed development, the discharge shall be reduced to sheet flow at pre-settlement rates prior to exiting the site. Further, if the proposed stormwater management system cannot achieve pre-settlement conditions with respect to both rate and volume of stormwater runoff, it is the responsibility of the developer to secure necessary easements from downstream property owners and must still comply with the design standards provided herein.

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

A flood impact analysis may be required at the MCPWO's discretion to verify that there will be no adverse impacts on peak flow or total discharge volume during the 10-yr 24-hr storm, 100-yr 24-hr storm, or other flow events upstream or downstream of the property. The analysis shall be as determined by HEC-RAS, EPA SWMM, or other acceptable methods. The MCPWO may require more restrictive DFC Criteria based on the flood impact analysis or where existing buildings or infrastructure are located within the 100-yr floodplain. When another authorized agency requires a model, then a copy of the approved model must be provided to the MCPWO for their records.

VI.2.F.3 - *Detention Volume Calculation*

When calculating the required detention volume, all contributing drainage areas, including the area of the detention basin itself, shall be used in the calculation. Off-site drainage areas may should be made to bypass the detention basin if possible. Volume stored within the forebay and detention area may be applied towards the required detention volume. Please refer to **Appendix H** for typical detention basin profiles and stormwater design calculations. The required detention volume can be calculated using the following series of equations presented in **Table VI-12**, **Table VI-13**, and The runoff volume from a 100-year storm using the following equation:

Table VI-12 – (V_{100RUN}) Volume of 100-Year Rainfall Runoff Calculation

$V_{100RUN} = 3{,}630 * 5.2 * (\bar{C}_{10yr} * 1.3) * A$	
V_{100RUN} =	Volume of 100-Year Rainfall Runoff (ft^3)
3,630 =	Conversion factor (43,560ft^2/12 in/ft)
5.2 =	NOAA Atlas 14, 100-year 24-hour event rainfall depth (**Table Appendix H-1**)(Inches)
$\bar{C}_{10yr}$ =	Area weighted average runoff coefficient for the contributing site area for a 10-year rain event (unitless)
A =	Total contributing drainage area (acres)
1.3 =	Multiplier representing the increased runoff associated with the 100-year storm event. If ($\bar{C}_{10yr}$*1.3) > 1 then set ($\bar{C}_{10yr}$*1.3) equal to 1. (unitless)
A =	Total contributing drainage area (acres)

The storage curve factor ('R') originates from a modified curve based on information originally presented in the TR55 manual (**Figure 6-1** of 210-VI-TR-55, Second Ed., June 1986). This curve graphs the relationship between a {basin storage volume/total runoff volume} value against a {basin outlet rate/runoff inflow rate} value. The storage curve factor ('R') factor can be calculated using the following equation (also see **Figure Appendix H-1**):

Table VI-13 - (R) Detention Storage Curve Factor - from Modified TR-55 Modeling

$R = 0.206 - 0.15\text{Ln}(Q_{100ALL}/Q_{100IN})$	
R =	Detention Storage Curve Factor
Q_{100ALL} =	Allowable 100-year post-development peak flow rate (cfs) [See **Table VI-10**]
Q_{100IN} =	100-year post-development inflow rate (cfs) $Q_{100IN} = (\bar{C}_{10yr} x 1.3)(I_{100yr})(A)$ I_{100yr} is calculated using **Table V-6**
1.3 =	Multiplier representing the increased runoff associated with the 100-year storm event. If ($\bar{C}_{10yr}$*1.3) > 1 then set ($\bar{C}_{10yr}$*1.3) equal to 1. (unitless)

Table VI-14 shows how to calculate the required detention volume which is the product of the storage curve factor and the 100-year runoff volume minus the Channel Protection Volume-Credit (VVC-Credit). See section **VI.2.B** for information regarding the Channel Protection Volume-Credit (VVC-Credit).

Table VI-14 - (V_{100DET}) Required 100-Year Detention Basin Volume

$V_{100DET} = (V_{100RUN} * R) - V_{VC-Credit}$	
V_{100DET} =	Required 100-Year Detention Basin Volume **(The constructed storage system volume must be the greater of V_{ED} or V_{100DET})**
V_{100RUN} =	Volume of 100-Year Rainfall Runoff (ft^3)[See **Table VI-12**]
R =	Detention Storage Curve Factor
$V_{VC-Credit}$ =	Volume of the Channel Protection Volume Control Credit (see section **VI.2.B**)
	The Channel Protection Volume-Credit cannot exceed the Channel Protection Volume-Required (Maximum $V_{VC-Credit} \leq V_{VC}$).

VI.2.F.1 *($V_{VC-Credit}$) Channel Protection Volume Credit*

MCPWO allows the use of Channel Protection Volume credit ($V_{VC-Credit}$) to reduce the required 100-Year Detention Basin Volume (V_{100DET}). Unless extraordinary conditions exist, the final 100-Year Detention Basin Volume (V_{100DET}) must be equal to or larger than the Extended Detention Volume (V_{ED}). The $V_{VC-Credit}$ is equal to the Channel Protection Volume Provided ($V_{VC-Provided}$) by implementing various BMPS that reduce the overall volume of stormwater runoff, primarily via infiltration and promote groundwater recharge, stabilizing flow rates, and more natural baseflows in our drains and watercourses. **BMPs with the potential to infiltrate water or release water over a 48 hour period are eligible for $V_{VC-Credit}$. The Channel Protection Volume-Credit cannot exceed the Calculated Channel Protection Volume ($V_{VC-Credit} \leq V_{VC}$). The constructed storage system volume must be the greater of V_{ED} or V_{100DET}**

$V_{VC-Credit}$ eligible BMPs include but are not be limited to:

- Bioretention systems (see Section **VI.2.C.1**)
- Porous Pavement
- Water Reuse Systems
- Cisterns
- Infiltration Trenches
- MCPWO will discuss on a site by site basis other methods & practices that may be $V_{VC-Credit}$ eligible.

Specifics of the BMP design and the native soil infiltration capacity will impact the accepted credit volume. Contact the MCPWO before submitting a permit application for questions regarding maximizing of Channel Protection Volume credits.

VI.3 - Open Detention, Retention, and Underground Detention Design

Detention basins store stormwater runoff temporarily before discharging into a waterway. Conventional dry detention basins are typically designed strictly for flood control and may not provide adequate water quality treatment.

VI.3.A – Dry & Wet Detention Basin General Guidelines

Stormwater management planning should be addressed before the design stage:

a. Wet detention basins are generally preferable to dry detention basins, since they allow more particulates to settle out, and remove some soluble pollutants.

b. No Conveyance Pipe Storage: Pipes used for conveyance may not be used as storage volume.

c. The developer has an obligation to contact local municipalities to determine how the proposed development will impact the subwatershed and whether the proposed stormwater management approach is consistent with the watershed management plan and/or community master plan.

d. Forbays are required to receive TSS removal credit from the basin

f. **Water Quality** Control (WQC) design criteria should be incorperated into the design to minimize cloggging of the system either by TSS pre-treatment and/or anti-clogging stratigies at the outlet control structure.

g. **The discharge shall outlet** within the drainage basin where flows originate and may not be diverted to another drainage basin, unless by approval of the MCPWO. A Certification Form for Adding Lands to a Drainage District (see **Appendix J**) must be submitted to the MCPWO.

h. **Conduct a site evaluation**. Identify unique or sensitive natural areas. Locate any springs near the proposed basin site and re-locate the basin if necessary to prevent instability of the detention berms and structures.

i. **Collect soil samples** from the site if a wet pond is proposed. Determine soil permeability and the ability to inhibit seepage and maintain a permanent pool. Determine the soil's ability to support loads and maintain its shape.

j. **Try to integrate the basin into the site** as a natural site amenity.

k. **Flooding potential** must be minimized upstream and downstream of the proposed site by the designer.

l. **All utility lines and sanitary sewers should be located outside of the basin** footprint. Verify that no local private wells will be affected by the proposed basin.

m. **Basin Location:** Determine if the selected basin location will accommodate all of the required storage volumes.

n. **Vegetate all open channels** discharging to the basin to minimize erosion.

o. **Verify local requirements concerning basin safety and long-term maintenance.**

p. **If the basin is used to control sediment during development**, then the design pool depth and design grade shall be restored prior to installing permanent landscaping and stabilization measures. **As-Built plans shall be submitted for all detention systems.**

q. **Sediment pretreatment**, (e.g A forebay, manufactored treatment device, or BMPs) is required for all detention and retention basins to facilitate cost effective sediment removal.

r. **The shape and configuration of retention basins** may vary, depending on storage requirements, local topography, land availability, hydraulic considerations, and other site-specific constraints.

s. **Restricted conveyance systems** designed to create backflow into stormwater storage facilities are not permitted. A storm sewer line shall not be used as both an inlet and outlet line to a stormwater storage facility.

A site stormwater narrative is required with plan submittals and must summarize proposed stormwater management system (see section III.1.A).

VI.3.A.1 *Dry Detention Basin Specific Guidelines*

1. **A forebay must be included to qualify** to receive the TSS removal rate listed in **Table VI-5**. The majority of the site runoff volume and drainage area must outlet to the forebay in order to receive the TSS removal rate.
2. **Have a staged outlet structure** to provide extended detention of the Channel Protection Rate Control (CPRC) volume outlined in Section **VI.2.E**.
3. **Dry detention basins must be planted to prevent erosion as suspension of solids.**

VI.3.A.2 *Wet/Permanent Pool Detention Basins Specific Guidelines*

1. **A forebay must be included to qualify** to receive the TSS removal rate listed in **Table VI-5**. The majority of the site runoff volume and drainage area must outlet to the forebay in order to receive the TSS removal rate.
2. **Permanent pool depth** must be a minimum of 4 feet
3. **Permanent pool volume** must be at least 25% of the 100-year flood control volume (V_{100DET}).

VI.3.A.3 *Pumped Outlet Systems*

1. **Pumped outlet systems are discouraged** due to their increase expense, increased risk, and increased maintenance needs. Pumped outlet system should only be used if a gravity drained outlet is impractical.
2. **Pumped outlet systems shall utilize a traditional outlet control structure** upstream of the outlet pump. The flow capacity of the pump itself may not act as the outflow rate control for the system.

VI.3.B - Retention Basins

A “no-outlet” retention basin is only permissible when there is no other available positive outlet for the stormwater runoff from the property. Macomb County discourages the use of retention basins and will permit their use only in cases where the applicant has clearly demonstrated that constructing a functional outlet (gravity or pumped) is infeasible and where adequate soil infiltration rates have been demonstrated via geotechnical investigations.

The proposed storage volume of the retention basin is calculated on the basis of total contributing acreage, including the basin area and all off-site areas that flow onto the property. Sufficient storage and dewatering capacity must be provided for two consecutive (back-to-back) 24hr, 100-year storm events over a period of 48 hours.

The retention storage is calculated as volume provided in the basin above the existing groundwater elevation.

- An overflow facility 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 are required for the off-site overflow route.
- Pre-treatment (TSS controls) must be installed upstream of every proposed inlet to the retention basin. This reduces sediment loading to the retention basin and helps to ensure the long-term functionality of the retention basin.
- One (1) foot of freeboard must be provided above the proposed storage elevation.
- The maximum storage depth of a retention basin is five (5) feet

Retention basins will not be permitted unless the following minimum site characteristics are demonstrated via geotechnical investigations:

- Minimum design infiltration capacity of existing soils (below the proposed bottom elevation of the retention basin) is a design infiltration rate of 1.0 in/hr (this ensures a maximum drawdown time of 72 hours for a maximum storage depth of six feet)
- Prevailing groundwater level is at least four feet below the proposed bottom elevation of the retention basin

PART VII - DRAIN CONSTRUCTION

VII.1 - Connections to County Drains (Taps)

All taps to a county drain must conform to the MCPWO standards and requirements. It is desired that all connections be tapped into a manhole or catch basin. If this is not possible and connection must be made in the main line sewer, a blind tap may be permitted. The following tap requirements include, but are not limited to, the following:

VII.1.A - Blind Taps

All taps to county drains must be connected with reinforced concrete pipe, unless an alternative pipe material is approved by the MCPWO.

a. **All taps must have a concrete collar** per detail 1-F or 1-F2. (Refer to **Appendix G**)

b. **No tap is allowed at a pipe joint.**

c. **No jackhammer or sledge hammer** shall be used for the tap until a diameter has been established with a star drill or concrete saw per detail 1-F2. (Refer to **Appendix G**)

d. **All connections must be properly sealed** to prevent leakage and/or infiltration into the storm system.

e. **Global Positioning System (GPS) locations** (sub-meter accuracy) of all constructed taps to the County drain must be submitted in an acceptable electronic format.

VII.1.B - Manhole Taps

a. **All taps shall be made so that a 1 foot (minimum) wall area exists** between the proposed tap and any existing pipe inside the manhole.

b. **Class B concrete collar and bedding** shall be a minimum of 12 inches and shall be placed on undisturbed soil and extend to the first joint of the proposed tap per detail 1-F. (Refer to **Appendix G**)

c. **Taps to manholes** must be pointed in the inside.

d. **All taps shall be cut flush** with the inside wall of the manhole.

e. **All debris in manhole**, as a result of the tap construction, shall be removed after construction is complete.

f. **GPS locations** (sub-meter accuracy) of all constructed taps to the County drain must be submitted in an acceptable electronic format.

VII.1.C - Open Drain Taps

a. **Tap invert and orientation:** All taps shall be constructed at the drain invert and perpendicular to the County drain per detail 1-G. (Refer to **Appendix G**)

b. **Pipe Location:** Pipe shall not extend beyond the intersection of top of pipe and drain bank. (i.e. Pipe shall not be exposed.)

c. **Construction requirements and end section treatments** are as stated on the Macomb County Public Works Commissioner's Storm Drain Notes and Details Sheet.

A 5-foot minimum vertical clearance is required between the invert of an open County drain and any underground utility.

d. **Flared end sections** shall be included for all drain taps

e. **No bar screen will be allowed** on the end section.

f. **Taps shall be bedded in sand cement** dry mix Grade C (2500 PSI-5.0 sack) for the last 2 ½ pipe plus end section (Refer to **Appendix G**).

g. **Riprap** shall be placed around the open end section is accordance with MCPWO standard details (Refer to **Appendix G**).

h. **A manhole is required inside the drain easement line**. No sump allowed (Refer to **Appendix G**)

i. **Minimum pipe slope** shall be used for all Taps as defined in section **V.2**.

j. **GPS locations** (sub-meter accuracy) of all constructed taps to the County drain must be submitted in an acceptable electronic format.

VII.1.D - Sump Pump Leads to Pipes

a. **Blind taps for sump pump leads** will only be allowed to connect to a County drain pipe section when a manhole, catch basin or inlet does not exist for the area to which the lead will service per detail 1-H (Refer to **Appendix G**). Blind taps for sump leads will not be allowed in new developments. Sump pump leads must exit the structure above grade before being buried and continuing on towards its connection with a downstream stormwater feature.

b. **GPS locations** (sub-meter accuracy) of all constructed taps to the County drain must be submitted in an acceptable electronic format.

VII.2 - Crossing a County Drain

1. **Utility Invert Minimum clearance –** A minimum clearance of five (5) feet must be maintained between the invert of an open County drain and any proposed underground utility or other underground crossing. Additional depth may be required.

2. Outer Diameter Minimum clearance - A minimum clearance of eighteen (18) inches for an enclosed County drain shall be maintained between the outside diameter of the drain and proposed underground utilities or other underground crossing. Additional clearance may be required.
3. GPS locations - (sub-meter accuracy) of all constructed crossings to the County drain must be submitted in an acceptable electronic format.

VII.2.A - County Drain Drainage Structures

Where applicable, all catch basin or manhole covers should include embossment, as appropriate to drainage outlet, of **'Dump No Waste, Drains to [INSERT RIVER/LAKE NAME HERE]'** Refer to MCPWO Standard Detail Sheets for additional details.

VII.2.B - Pipe Requirements

Contractor must supply MCPWO with copies of pipe certification slips matching pipe required for contract prior to installing. Refer to MCPWO Standard Detail Sheets for additional details.

Reinforced Concrete Pipe (RCP)

a. All RCP shall be premium joint (rubber gasket) unless otherwise indicated on the set of drawings approved by MCPWO.
b. All joints in RCP having a diameter of 36 inches and larger shall be pointed up on the inside with mortar after backfilling and/or grouting has been completed.
c. Class of the RCP shall be that indicated on the set of drawings approved by MCPWO.

Alternative Pipe Materials – All taps shall be reinforced concrete pipe to 1st manhole. All other alternative materials require approval.

VII.2.C - Trench Width Requirements

1. The maximum width of trench at top of pipe shall be the outside diameter of the pipe, plus 24 inches.
2. If the maximum trench width is exceeded, the Contractor, at his own expense, shall construct a concrete cradle or other type of approved bedding to provide support for the additional load.
3. When sand bedding is used, the maximum trench widths shall be used to permit compaction of the bedding around the pipe.
4. If stone bedding is used, a minimum of 6 inches clearance shall be provided on each side of the pipe.
5. Safe trench responsibility: In any case, the Contractor, at his own expense, shall be responsible for maintaining a safe trench at all times.

VII.2.D - Bedding and Cradles for RCP

VII.2.D.1 - *Bedding: (See Detail 1-B in Appendix G)*

Pipe bedding is defined as that material placed from a minimum of 6 inches below the pipe to the ¼ point of the pipe. If shall consist of sand, pea stone or of Portland Cement in combination with pea stone and sand as shown in Table VII-1.

Table VII-1 - Pipe Bedding Requirements by Size and Special Condition

Pipe Size	Bedding Requirement
Under 48 Inches	Sand or Pea Stone
48 Inches and Larger	Pea Stone
Special Items	**Bedding Requirement**
In Road R.O.W.	See Details 1-Z.1 thru 1-Z.5 in Appendix G
Horizontal Elliptical, Radius, Precast Bends, MH "T", Increaser/Reducers	Concrete Cradle (See Detail 1-B in Appendix G)

VII.2.D.2 - *Concrete Cradle: (See Detail 1-B in Appendix G)*

Concrete Cradle is defined as that material placed from a minimum of 6 inches below the pipe to the centerline of the pipe when required. It shall consist of sand, pea stone and Portland Cement dry mix. Grade C (2500 Psi – 5 sack)

VII.2.E - Laying of Pipe and Connections

Pipe shall be laid from the lower end of sewer upstream, with the bell end up grade. The use of brick, lumps of clay, wood, etc., to level the pipe will not be permitted. Pipe shall be rammed "home" and if joints do not remain tightly closed or construction is in saturated sand, a cable and winch, or other approved means, shall be used to maintain a tight joint.

All pipe shall be laid to line and grade as called for on the plans using a laser beam and target. Each pipe as laid shall be excavated to provide equal clearance on both sides of the pipe. After the pipe is set, care shall be taken in backfilling so as not to disturb its line or grade. As work progresses, the interior of the pipe shall be thoroughly cleaned.

VII.2.F - Backfilling: (See Detail 1-B in Appendix G)

Backfilling is defined as the placement of approved material, by an acceptable method, in the excavation from the top of the bedding or top of cradle, to the proposed ground surface grade.

1. **All backfill material** shall be free from refuse, vegetable or organic matter, boulders, rocks or stones, or other material which is unsuitable.
3. **All excavation shall be backfilled** to a point 1 foot above the top of the pipe immediately after installation.
4. **Backfill density testing, when required,** shall be at the expense of the developer.

Note: For backfill within the ROAD ROW see Details 1-Z.1 thru 1-Z.5 in **Appendix G**.

VII.3 - Manholes, Catch Basins, and Inlets

1. In-Line Manholes: (See Details 1-C & 1-D in Appendix G)

   Diameters shall be as follows:

Table VII-2 - Pipe Size and Manhole/Structure Sizing

Pipe Size	Junction Sizing / Configuration
12-inch to 24-inch pipe	4-foot diameter manhole
30-inch to 42-inch pipe	5-foot diameter manhole
48-inch and Larger	Precast "T" and Riser Section (Minimum Riser Diameter of 4 feet)

2. Junction Manholes or Manholes at turns: (See Detail 1-DD in Appendix G)

   Shall be 8 feet diameter maximum and have a minimum of 1 foot of wall area between incoming pipes inside the manhole. Structures will be required for Junction Manholes and Manholes at turns requiring a diameter greater than 8 feet.

3. Materials for Manholes, Catch Basins, and Inlets

   a. Water for concrete and mortar shall be clean and fresh, free from oil, acids, and organic matter.

   b. Mortar for laying brick and/or block, for pointing of joints, and for plastering outside of structures shall be composed of 1 part Portland Cement and 2-1/2 parts masonry sand.

VII.3.A - Backfill Around Structures

All backfill placed within 3 feet of manholes, catch basins, inlets and other underground structures shall be of approved sand, placed in 1-foot layers and compacted.

VII.3.B - Disposal of Excavated Material

Excavated material not suitable for backfill or in excess of the quantity required for backfilling shall be disposed of by the Contractor at his own expense.

VII.3.C - Maintenance of Existing Drainage

If it is necessary in the performance of the work to interrupt existing drainage, temporary drainage facilities shall be provided until the existing drainage facilities are restored. Flows in County drains must be maintained at all times during construction.

VII.3.D - Method of Measurement

Sewers shall be measured in place as the actual horizontal length, in lineal feet, from the center-of-manhole to center-of-manhole. When structures such as junction chambers, pump stations, etc., are constructed on sewer lines, measurement shall be to inside-face of such structure.

PART VIII - OPERATION & MAINTENANCE STANDARDS

The stability and effectiveness of many stormwater BMPs is dependent on well-established vegetation and proper maintenance. Proper landscaping practices, appropriate selection of the types and species of vegetation, and adequate short-term maintenance are necessary to establish vegetation and prevent invasive plant species. Once BMPs are stabilized and functioning, periodic maintenance will be necessary to insure proper functioning condition. **If a BMP does not require periodic sediment removal and maintenance, then it is not working to treat water quality.**

VIII.1 - Landscaping Requirements

1. A landscaping plan is required for open County drains and stormwater systems that are designed to meet stormwater management requirements. Incorporating regionally native plants into the design is required because these plants are better adapted to local climate and soil conditions and tend to need less long-term maintenance. The County may consider waivers from specific landscaping requirements.

Disturbed areas/earth change areas must be stabilized within 5 days of final grading per Part 91, P.A. 451. Vegetative stabilization of all disturbed/earth change areas with slopes between 4:1 and 1:1 (H:V) should be completed with appropriate erosion control blankets rather than seed and mulch. Disturbed/earth change areas on flatter slopes may be stabilized with appropriate mulching or blankets. Areas exposed to channelized flow may require the use of erosion control blankets, turf reinforcement mats, stone revetment, or other measures to provide stabilization. Guidelines on the application of Rolled Erosion Control Products for permanent erosion control are provided in **Appendix I**.

1. **Landscaping Plans** should be developed to achieve a diverse mix of vegetation in riparian areas. A minimum of 6 species should be selected from each applicable planting zone list (**Table Appendix L-1** to **Table Appendix L-6**).
2. **Seed for plant species** listed in **Appendix L** shall be applied at a minimum rate of 10 lb/ac in addition to the cover crop mix. A recommended minimum seeding rate for over-seeding partially vegetated areas or to supplement existing vegetation is 50% of the standard seeding rate (5 lb/ac).
3. **A minimum 4" of compost** or relatively weed seed-free topsoil, and necessary soil amendments (as determined by soil testing) shall be tilled into compacted subsoils to a minimum depth of 8-10" where vegetation is to be established on excavated subsoils. It is the designer's responsibility to consider specific site conditions and standard horticultural practices in the development of the Landscaping Plan.

Figure VIII-1. Riparian Buffer (Source: Macomb County)

VIII.2 - Native Plantings

VIII.2.A - Open County Drains

1. Riparian planting materials will generally coincide with Zone 3 up to Zone 5 depending on the channel topography (Figure VIII-2).
2. Vegetative buffers shall be retained or established for a minimum width of 25 feet from each side of the waters edge along open County drains. Buffers also generally coincide with Zone 3 up to Zone 5 depending on the channel topography (Figure VIII-2)
3. Trees and woody shrubs should be retained to the extent practicable during open County drain construction. The priority is to maintain trees and/or shrubs on the east side of north-south flowing channels and on the south side of east-west flowing channels (or large trees on the north side). Tree and shrub coverage shall be retained or established along the channel easement such that 50-70% shade canopy of the bankfull channel is provided. Trees shall be bare-root and a minimum 1-1.5" caliper.
4. A designed cross-sectional Manning's Roughness Coefficient shall be part of the basis for the allowable type, height, size, and density of vegetation allowed within a County Drain to meet hydraulic capacity goals. The minimum roughness coefficient for MCPWO drain is specified in section V.3.B. Excessive growth of invasive woody vines and shrubs, beyond the intent of the

drain design, shall be removed by cutting and spraying the stump by a licensed applicator in accordance with applicable regulations (Appendix L, Table Appendix L-7).

5. Herbaceous understory plantings shall be established at appropriate planting and/or seeding rates.
6. The establishment and maintenance of vegetation along open County drains may vary based on the bankfull channel width and applicable watershed management goals and objectives. The following general guidelines apply:
   a. Zone 1 – Submergent Vegetation – Located underwater and below the ordinary highwater mark
   b. Zone 2 – Emergent Vegetation - Located within a zone near the typical water's edge/ordinary high-water mark.
   c. Zone 3 – A diverse mix of herbaceous plants (primarily sedges) and marginal grasses shall be established along with occasional flood tolerant trees and shrubs.
   d. Zone 4 – Establish and maintain canopy woody vegetation for 50-70% bankfull channel canopy. Healthy, mature floodplain trees should be protected. Woody shrubs may be trimmed to the ground, if necessary, and then allowed to re-grow every 3 to 7 years along open channels. Some thinning of the canopy may be required to allow shrubs or herbaceous vegetation to become established when stabilizing streambanks using vegetative practices.
   e. Zone 5 – A low growing, "No Mow" fine fescue mix or a low growing native grass only mix should be established along the upper easement. No trees or woody shrubs.

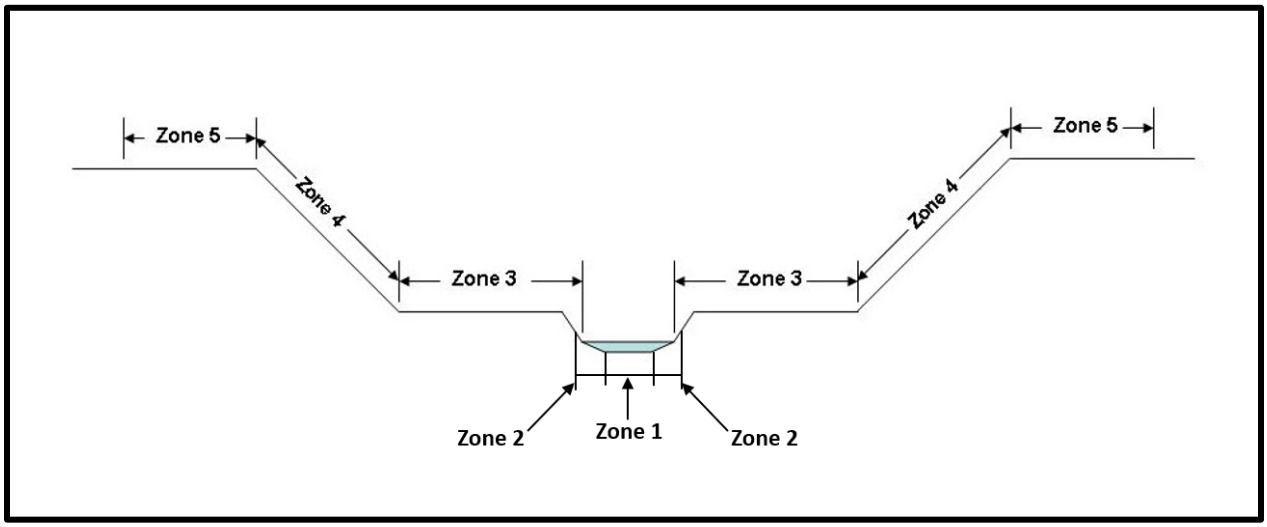


Figure VIII-2 - Planting Zones for Open County Drains

VIII.2.B - Prohibited Plant Species

Exotic, invasive plant species shall not be introduced within open county drains or BMPs. Invasive species can quickly take over a disturbed reach of stream and reduce adequate conveyance. For a re-vegetation project to control erosion, benefit water quality, and allow proper conveyance, invasive species must be restricted and controlled. Common species that should be prohibited and should be removed from riparian areas are outlined in Table Appendix L-7. Long-range management plans (see Section Appendix M) shall be provided by the proprietor for the ongoing removal of these plant species for BMPs used for stormwater management.

VIII.3 - Vegetation Maintenance for Stormwater Management BMPs

The long-term maintenance plan for the development's storm water management practices and system (Appendix M) used for stormwater management shall include provisions for establishing and maintaining vegetation. The first few years after planting are critical. The following periodic maintenance is required to establish plants through this phase:

1. Watering during the first year will be important, no supplemental watering will be required once native plantings are established. Extensive lawn irrigation may promote disease and lodging (breaking of stalks).
2. Access to newly seeded areas shall be limited with fencing, signage, or other appropriate methods.
3. Appropriate signage is required to insure preservation, reduce feeding of waterfowl, or to address safety issues.

4. **Maintenance Education:** The persons responsible for site maintenance shall be consulted and riparian residents should be educated regarding appropriate mowing and maintenance practices. Edging, temporary fencing, or other methods may be required to prevent mowing during the initial period of plant establishment. Permanent boundary markers and signage shall be installed to delineate the easement and identify "No Mow" or "Grow Zones" (See **Appendix D**). Areas in Zones 4 and 5 may be maintained annually by mowing or electrical trimming to a minimum height of 6-8" in late fall or early spring to remove dead plant materials. More frequent trimming and mowing of riparian areas is not recommended.
5. **Natural vegetation should be allowed to grow** along open drains and natural streams to control erosion and provide some shading.
6. **Periodically and following storm events**, stabilized areas should be inspected for erosion and any rills or gullies repaired.
7. **Following the first two growing seasons**, determine if reinforcement plantings are needed.
8. **The emergency overflow spillway**, side slopes, and detention pond embankments may be trimmed once in the late fall or early spring to a minimum height of 6-8 inches. Litter and debris shall be removed from the inlet and outlet structures and the general basin area at this time.
9. **Excessive algae and ecologically invasive aquatic plant** growth shall be removed to prevent decomposition, nutrient cycling, and associated nuisances.

Figure VIII-3 - Controlled Burn Maintenance (Source: Macomb County)

VIII.4 - Inspections

Prior to the approval of the final construction plans, the proprietor shall have made arrangements acceptable to the MCPWO for inspection during construction, including submittal of inspection reports, and for final verification of the construction by a Michigan registered professional engineer. These arrangements will include an inspection schedule that defines the specific junctures during construction when on-site inspection and written verification by a professional engineer will occur.

VIII.5 - Maintenance Requirements

A satisfactory agreement that assures long-term maintenance of all drainage improvements used for stormwater management shall be in place before the project completion or the submittal of the final plat. This office will not accept the responsibility for the maintenance of any storm water management practice unless it is being constructed as part of a Chapter 18 County Drain. A long-term maintenance plan for the storm water practices and management system shall be submitted to the Public Works Commissioner as part of the Agreement for Maintenance of Storm Water Management Practices. An example agreement and plan are provided in Appendix M.

A long-term maintenance plan for the storm water practices and management system shall be submitted to the Public Works Commissioner as part of the *Agreement for Maintenance of Storm Water Management Practices.*

The maintenance plan must include the following general elements:

1. The plan must show the locations and the physical limits of all the storm water management practices and identify the party responsible for maintaining each system component.
2. The plan must provide for periodic monitoring of the system to determine whether the system is functioning properly. The plan must identify the personnel training and inspection and preventative maintenance activities that are necessary to ensure that the system continues to function properly. Components of the training, inspections and preventative maintenance shall include:
    a. The owner shall retain the services of a qualified individual such as a registered Professional Engineer (PE), Certified Professional in Storm Water Quality (CPSWQ), NICET Certified Engineering Technologist in Stormwater and Wastewater System Inspection, or EGLE Certified Storm Water Operator (NPDES – construction sites) to provide inspection and maintenance services.
    b. An inspection and maintenance schedule must be included and a log kept of all inspections, maintenance activities and repairs. The log must provide:

i. Date of activity

ii. Name of person performing activity

iii. Description of activity and additional maintenance and/or repair that is needed

3. Vegetation establishment & maintenance: The plan must include provisions for establishing and maintaining vegetation including the vegetation that is integral to the proper functioning of the practices.
4. Maintenance Schedule: The plan must set forth a schedule for implementing the activities necessary to ensure the proper functioning of the system.
5. Remedial action responsibility: The plan must commit the entity responsible for maintenance to performing remedial actions necessary to repair, modify, or reconstruct the system in the event that the system does not function properly as designed.

PART IX - FREQUENTLY ASKED QUESTIONS/DEVELOPMENT SCENARIOS

SCENARIO 1: Partial Site Redevelopment over 1-acre disturbed

An existing commercial site, built in the 1970s with no stormwater management facilities, has a proposed 50,000 square foot building addition, with no changes to the parking lot area. Do we just address stormwater management for the addition, or do we need to look at the overall site? If just the addition, how is the 100-year release rate determined: using the overall site acreage or just the area of new disturbance?

Answer: The stormwater rules will apply, as the disturbed area exceeds 1.0 acre, although the rules will apply only to the disturbed area/earth change associated with the new building addition.

In some cases, it is sometimes difficult to segregate the drainage from the older (unmodified areas) from the newer impervious areas. The applicant needs to do what they can to keep the two drainage systems separate before the site discharge point. For instance, if a parking lot is replaced on a commercial property, that drainage needs to be treated and stored in a detention basin; the drainage from the existing adjacent building does not need to be treated and stored, so you would need to keep that drainage system separated and route it around the new system and tie in downstream of the detention basin. If that isn't possible, it may be necessary to incorporate that runoff into the proposed stormwater management system; that may require unique design considerations.

SCENARIO 2: Partial Site Redevelopment with mill and fill parking lot

An existing school site, built in the 1980s ago with no stormwater management facilities, has a planned 30,000 square foot building addition; the parking lots will be milled and capped (i.e., "mill and fill") with no pavement expansion. The total disturbed/earth change area is proposed to be 40,000 square feet (building expansion plus grading/landscaping areas).

The stormwater rules will not apply in this situation, as the disturbed area is less than 1.0 acre. Mill and fill is not considered new impervious area (it is considered pavement maintenance). If the parking lot replacement includes the removal of the existing surface to the aggregate or subgrade layer, it is considered new impervious area.

SCENARIO 3: Partial Site Redevelopment with parking lot reconstruction

An existing site, built in the 1980s with no stormwater management facilities, has a planned 30,000 square foot building addition. The existing 90,000 square foot parking lot will be repaved with removal of the existing asphalt and placement of new asphalt (the existing aggregate base will remain and will not be regraded).

The rules will not apply to the new addition and new pavement areas, as the disturbed area is less than 1.0 acre under the condition that the parking lot aggregate is exposed but not disturbed. The parking lot repaving is not considered disturbed area if when the existing pavement is removed the existing gravel and/or subgrade layer and/or subbase layer is only exposed and not regraded.

SCENARIO 4: Milled and Resurfaced Parking Lot over 1-acre

Existing office park, built in early 2000s with a stormwater detention pond. The parking lot (200,000 square feet) will be milled and resurfaced.

No stormwater management necessary. This is considered pavement maintenance only.

SCENARIO 5: Removed and Replaced Parking Lot over 1-acre

Existing office park, built in early 2000s with a stormwater detention pond. The parking lot (200,000 square feet) will be removed and replaced with a new parking lot (no increase in hard surface).

The stormwater rules will apply to this site, as the disturbed/earth change area exceeds the 1.0-acre threshold. The existing stormwater management system may need to be retrofitted to meet current requirements, including Channel Protection Volume Control (i.e., infiltration) and water quality control (i.e., TSS control). The existing detention pond and outlet structure may need to be retrofitted to meet the current flood control requirements.

SCENARIO 6: New building & new parking lot are greater than 1-acre

New apartment complex; the building is 15,000 square feet and the proposed parking lot is 25,000 square feet. The overall construction (disturbed/earth change area) is 50,000 square feet.

Stormwater rules apply to this site, as the area of disturbance exceeds 1.0 acre. While the new impervious area is less than 1.0 acre, the disturbed/earth change area triggers stormwater rules.

SCENARIO 7: Reconfigured Hardscape over 1-acre that reduces total impervious area

10-acre shopping center redevelopment, including 400,000 square feet (9.2 acres) of impervious area (the existing development had no stormwater detention). The proposed plan includes a building remodel and the parking lot will be reconfigured and rebuilt with a reduction in impervious surface. The existing parking lot was 320,000 square feet (7.3 acres) and the new parking lot will be 240,000 square feet (5.5 acres).

The stormwater rules will apply to this site, as the disturbed area exceeds the 1.0-acre threshold. Even if the impervious area is reduced, the rules will still apply. The stormwater management system must be designed to manage the area of disturbance, which includes the new parking lot footprint (5.5 acres) plus the pervious areas surrounding the parking lot. The stormwater controls (detention pond and water quality controls) do not need to accommodate the existing building footprint, although the stormwater conveyance system must be designed to accommodate roof drainage and safely convey it to the proposed outlet.

SCENARIO 8: Reconfiguration of a site over 1-acre with minimal impervious area

Existing commercial site, built in the 1970s with no stormwater management facilities. The existing sports complex is being reconstructed with a new track (closely matching the configuration of the old track), and replacement of the grass field with synthetic turf.

Depends on the area of land disturbance. Any land disturbance of 1.0 acre or larger automatically triggers the stormwater rules, as this is an EGLE/EPA requirement.

Appendix A - Definition of Terms

100-year Floodplain: The floodplain area subject to a one percent chance of flooding in any given year.

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

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

1-year Storm: A rainfall depth or peak flow rate that is exceeded, on average, about once per 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.

Afforestation: Supplements existing trees with a net increase in canopy cover.

Appurtenances: A legal term for what belongs to and goes with something else, the accessories or things usually conjoined with the substantive matter in question.

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 Channel: The lower stage, meander channel that corresponds to the capacity of the channel-forming (dominant) or effective discharge.

Bankfull Flow or Discharge: In stable alluvial streams with a fully connected floodplain, the point where the flow (of a stable channel) just begins to overtop the banks into its floodplain. Visual bankfull flow indicators can be identified in the field to help determine Bankfull flow and level. In undisturbed watersheds, a bankfull flow is expected to occur on average every 1 to 2 years and controls the shape and form of natural channels. For streams in developed areas where hydrology has been impacted or the channel cross-section has been artificially altered, bankfull indicators may exist below top-of-bank.

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. BMPs include but are not limited to the following:

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 Unit: 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.

Borings: Cylindrical samples of soil profile used to determine infiltration capacity of soil types and ground water.

Buffer Strip: A zone where plantings capable of filtering stormwater are established or preserved and where construction, paving and chemical applications are prohibited.

Catch Basin: A collection structure below ground designed to collect and convey water into the storm sewer system.

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 Public Works Commissioner.

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.

Daylighting: Removing an existing storm sewer and restoring an open channel.

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 rainstorms or snow melt events.

2. **Wet Detention Basin:** A basin that contains a permanent pool of water that may remove sediment, nutrients, and to other pollutants from stormwater runoff.

3. **Underground Detention System:** One or more underground pipes and/or other structures that are utilized as a detention system.

4. **Regional Detention Basin:** A wet or dry detention basin that receives water from multiple sites as an alternative to storage on-site.

5. **Extended Detention Basin:** A wet, dry, underground, or regional 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

6. **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.

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)

Development: Any activity that involves constructing buildings or otherwise altering land for new uses. This includes any human-made change in the natural cover or topography of the land (see definition of Disturbed Area/Earth Change area)

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

Disturbed Area/Earth Change area: A human-made change in the natural cover or topography of the land, including cut and fill activities which may result in or contribute to soil erosion or sedimentation of the waters of Macomb County and the State. Earth change does not include gardening, plowing and tilling of soil for the purpose of crop production.

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

Drainage Facility / Drainage Feature: Any facility used to transport or store stormwater.

Easement (also known as "Right-of-Way"): An interest in land owned by another that entitles its holder to a specific limited use and enjoyment. A legal right granted by a property owner to another entity giving that entity limited use of the property involved for a specific purpose. The Public Works Commissioner secures temporary and permanent easements adjacent to county drains for the purpose of construction and maintenance access.

Effective Discharge: The term effective discharge is the streamflow that does most of the work in transporting sediment over the long term. It is determined by combining a flow duration curve and a sediment discharge rating curve.

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.

Emergent Zone: The emergent zone of a wet pond is generally 0 to 18 inches deep. A wide variety of native wetland plant species are adapted to the emergent zone.

Encroachment: Altering property so as to restrict or burden the interest holder's use of the property.

Erosion: The wearing away of the land surface by wind, water, ice and gravity dislodging soil particles. Evidence of erosion includes gullies, rills, sediment, plumes, etc.

Fill: Added earth which changes the contour of the land.

Filter Fabric: Textile or relatively small mesh or pore size that is used to 1) allow water to pass through while keeping sediment out (permeable), or 2) prevent both runoff and sediment from passing through (impermeable).

First Flush: The delivery of a highly concentrated pollutant loading during the early stages of a storm due to the washing effect of runoff on pollutants that have accumulated on the land.

Floodplain: For a given flood event that area of land adjoining a continuous watercourse that has been covered temporarily by water.

Floodplain Zone: The floodplain zone is normally dry but may flood during snowmelt and after large storms. Floodplain zones are generally flat terraces and are common along rivers and streams.

Shelf Way: The width of the area located between terrace toes on either side of the channel subject to frequent overflow.

Shelf Width: The level area of land adjacent to a one side stream channel that is subject to frequent overflow. The shelf width can differ between the left and right side of the channel.

Flow Path: The travel distance that stormwater runoff traverses to reach a design point. The design point may be a stormwater detention pond, wetland, pipe, manhole, culvert, drain, or other drainage features.

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.

Fluvial: Relating to a stream or river; produced by stream action.

Freeboard: The space from the top of an embankment to the highest water elevation expected for the largest design storm to be stored. The space is required as a safety margin in a pond or 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]

Geomorphology: The branch of geology that studies the nature and origin of landforms. The natural forces that shape landforms include water, ice, wind, gravity and time. Fluvial geomorphology is the study of the formation of landforms by the action of flowing water.

Geotextile: A woven fabric capable of passing water but able to hold back soil.

Global Positioning System (GPS): A system capable of providing worldwide navigation and positioning by pinpointing locations.

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.

Hotspot: A land use or activity that generates higher than average concentrations of pollutants.

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 maximum rate at which the soil can absorb falling rain or melting snow. Usually expressed in inches/hour or centimeters/second. Also referred to as Saturated Soil Conductivity (K_{sat}). There is an important distinction between 'measured infiltration rate' and 'design infiltration rate'. 'Measured infiltration rate' is the supposed saturated infiltration rate of soils as determined by geotechnical infiltration testing (see Section **VI.2.B** & **Appendix Q**). 'Design infiltration rate' is the resulting value after applying a factor of safety adjustment to the measured infiltration rate (see Section **VI.2.B.2**)

Infiltration Capacity: The maximum rate at which the soil can absorb falling rain or melting snow. Usually expressed in inches/hour or centimeters/second. Capacity should also consider if a infiltration volume restriction is realistic, for example soil layer seams or fill material may pose volume limitation as their extent is unknown.

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.

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.

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.

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.

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.

Invert: The interior surface of the bottom of any pipe. This may also refer to the interior surface of drainage structures and culverts.

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.

License: Permission or authority to do a particular act or series of acts on land of another without possessing any estate or interest in the land.

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 (MTD): 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.

Maximum Extent Practicable (MEP): MEP is the standard promulgated in EPA's rule that MS4s are required to meet. The definition of MEP is "To reduce and/or eliminate to the extent achievable using control measures that are technologically available, economically practicable, and achievable in light of best industry practice."

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.

Meander Length: The distance equal to one wavelength along a curving stream channel (**Table Appendix A-1**).

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)..

Off-site Detention: Detention provided at a regional detention facility as opposed to storage on-site.

On-Site Detention: Where stormwater is detained on a site verses a regional location.

One-Hundred Year Flood: A flood that has one percent (1%) chance occurring in any given year.

Ordinary High Water Mark: The line between upland and bottomland which persist 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 design structure, typically including internal weir walls and/or orifices that gradually release stormwater from a detention facility at various required rates for various flow events.

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.

Permeable: Ability to absorb water.

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)

Petition: A legal request to the Drain Commissioner to perform a maintenance improvement or construction project.

Plat: A legal procedure whereby a larger piece of property is divided into smaller sections and is accompanied by a full description of the original property the dimension of each lot to be subdivided and all relevant deed restrictions and easements as described in the Land Division Act.

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.

Pollutant: Any substance that is regulated under the Clean Water Act, 42 U.S.C. 1251 et seq. or under Part 31 of the Michigan Natural Resources an Environmental Protection Act, MCC 324.3101 et seq. or is of such character and in such quantities that when it reaches a body of water, soil or air, it contributes to the degradation or impairment of its usefulness or renders it offensive.

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

Prescriptive Easement: An easement created by use of another's property for a certain number of years.

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.

Project Engineer: A professional engineer licensed in Michigan that performs the engineering design for the development.

Proprietor: Any person, firm, association, partnership, corporation or any combination thereof that owns property proposed for development.

Public Works Commissioner: A statutory officer elected on a partisan basis every four years. S/he is responsible for the administration of the Drain Code of 1956, as amended. The duties of the Public Works Commissioner include the construction and maintenance of County drains, determining drainage districts, apportioning costs of drains among property owners, and receiving bids and awarding contracts for drain construction. The Public Works Commissioner also approves drainage in subdivisions.

Radius of Curvature: Describes the magnitude of a bend present for a meander of a stream (a symmetrical meander is equation is provided in **Table Appendix A-1**). The Radius of Curvature can be measured for an existing stream meander as shown in **Figure Appendix A-1**.

Table Appendix A-1 - Theoretical Radius of Curvature in a Symmetrical Stream Meander

Eq. A.1	$Rc = L_m K^{-1.5} / 13(K-1)^{1/2}$
Rc =	Radius of curvature
L_m =	meander wavelength
K =	sinuosity
To calculate the radius of curvature for an existing stream meander bend see **Figure Appendix A-1**.	

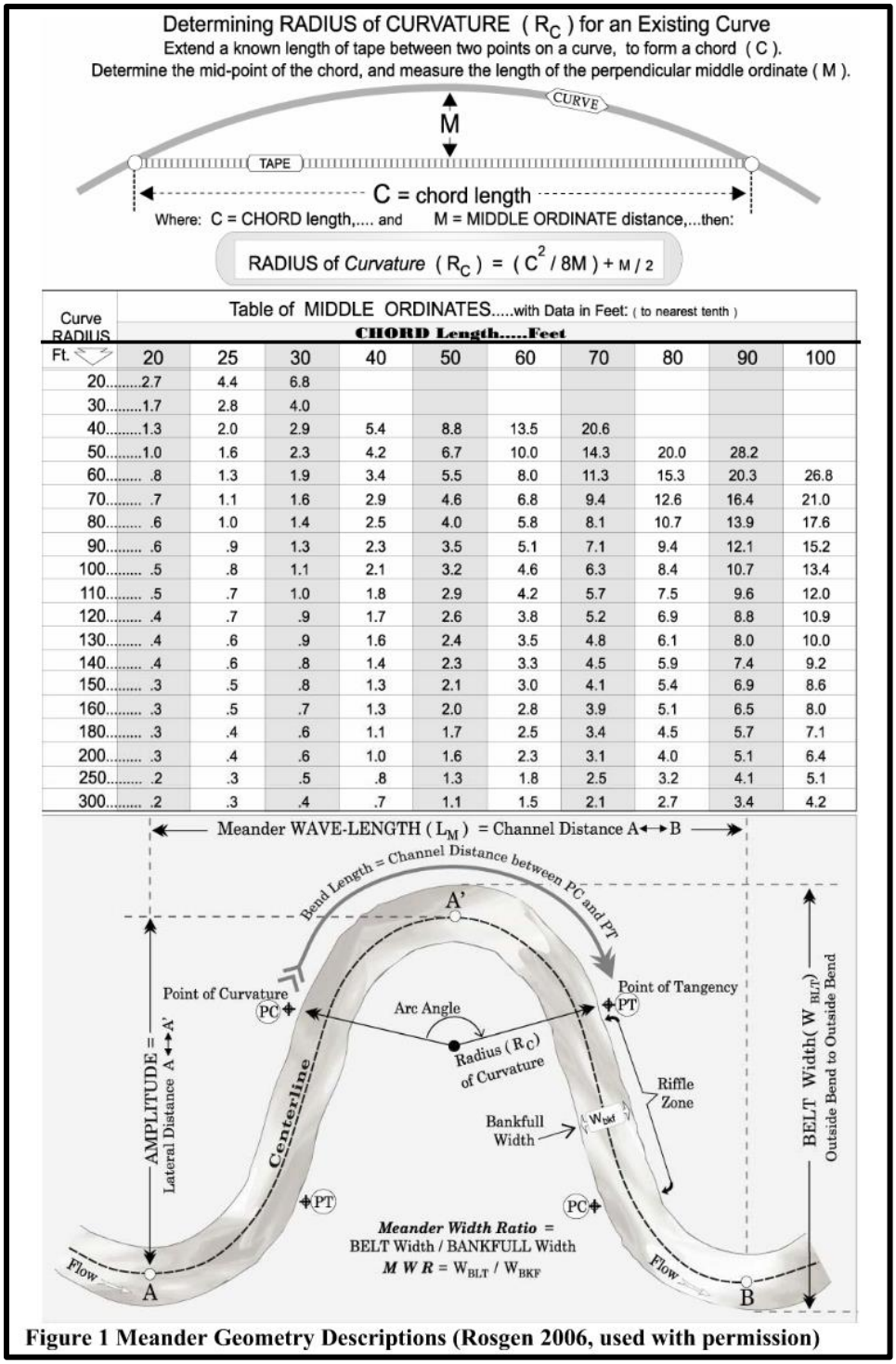


Table of MIDDLE ORDINATES.....with Data in Feet: (to nearest tenth)

Curve RADIUS Ft. \ CHORD Length.....Feet	20	25	30	40	50	60	70	80	90	100
20	2.7	4.4	6.8							
30	1.7	2.8	4.0							
40	1.3	2.0	2.9	5.4	8.8	13.5	20.6			
50	1.0	1.6	2.3	4.2	6.7	10.0	14.3	20.0	28.2	
60	.8	1.3	1.9	3.4	5.5	8.0	11.3	15.3	20.3	26.8
70	.7	1.1	1.6	2.9	4.6	6.8	9.4	12.6	16.4	21.0
80	.6	1.0	1.4	2.5	4.0	5.8	8.1	10.7	13.9	17.6
90	.6	.9	1.3	2.3	3.5	5.1	7.1	9.4	12.1	15.2
100	.5	.8	1.1	2.1	3.2	4.6	6.3	8.4	10.7	13.4
110	.5	.7	1.0	1.8	2.9	4.2	5.7	7.5	9.6	12.0
120	.4	.7	.9	1.7	2.6	3.8	5.2	6.9	8.8	10.9
130	.4	.6	.9	1.6	2.4	3.5	4.8	6.1	8.0	10.0
140	.4	.6	.8	1.4	2.3	3.3	4.5	5.9	7.4	9.2
150	.3	.5	.8	1.3	2.1	3.0	4.1	5.4	6.9	8.6
160	.3	.5	.7	1.3	2.0	2.8	3.9	5.1	6.5	8.0
180	.3	.4	.6	1.1	1.7	2.5	3.4	4.5	5.7	7.1
200	.3	.4	.6	1.0	1.6	2.3	3.1	4.0	5.1	6.4
250	.2	.3	.5	.8	1.3	1.8	2.5	3.2	4.1	5.1
300	.2	.3	.4	.7	1.1	1.5	2.1	2.7	3.4	4.2

Figure 1 Meander Geometry Descriptions (Rosgen 2006, used with permission)

Figure Appendix A-1 - Meander Geometry Descriptions (Rosgen 2006, used with permission)

Rational Formula: A simple technique for estimating peak discharge rates for very small developments based on the rainfall intensity, watershed time of concentration and runoff coefficient.

Reforestation: Involves planting trees to compensate for tree clearing during site construction.

Regime: Equilibrium or erosion and deposition in a channel over time such that the channel maintains its characteristics

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

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: The holding of runoff in a basin without release except by means of evaporation, infiltration or emergency bypass.

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 (Recurrence) Interval: A discharge based on statistical return intervals. Leopold determined that the bankfull discharge (measured in the field at USGS gauging stations) corresponded to the 1.2 to 1.8-yr (an average of a 1.5-yr) return interval on a flood frequency curve developed from long-term data at a gauge station. The actual return interval that corresponds to the channel-forming discharge in a stream can vary depending on the local hydrology and geology.

Riffle: Shallow, steeper, section of stream with fast currents at low flow.

Right-of-Way: A legal right of passage over another person's land.

Rip-Rap: A combination of large stone, cobbles and boulders used to line channels, stabilize banks, reduce runoff velocities or filter out sediment.

Riparian: Of, pertaining to, or situated or dwelling on the margin of a river or other waterbody.

Riser: 1. 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. **2.** A pipe rising from underground tile to allow surface water to enter the tile in a low area.

Runoff: The excess portion of precipitation that does not infiltrate into the ground but "runs off" and reaches a stream, water body or storm sewer.

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.

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.

Seasonal High Water Ground Level: The highest level of groundwater that occurs frequently enough for the water to stain the soils.

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

Sheet Flow: Runoff which flows over the ground surface as a thin even layer, not concentrated in a channel or pipe.

Shelfway – The area of land within the MCPWO standard multi-stage drain cross-section that is situated between the left and right terrace toe. This land is intended to be relatively flat and subject to flooding during events that generate a bankfull discharge or greater. The minimum width of the shelfway is based on a multiple of channels bankfull width.

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

Sinuosity: The ratio of stream length to valley length or the ratio of valley slope to stream gradient

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 Natural Resource Conservation Service into four runoff potential groups. The groups range from A soils, which are very permeable and produce little runoff, to D soils which are not very permeable 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 Asset: Any structure, feature, or appurtenance that is designed to collect, detain, retain, treat, or convey stormwater runoff, including without limitation, buffer strips, swales, gutters, catch basins, stormsewer, closed conduits, detention systems, pretreatment systems, wetlands, pavement, unpaved surfaces, structures, watercourses, surface waters, ditches, or county drains.

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 EGLE 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.

Stream Order: The Strahler method for classifying streams as part of a drainage network. The smallest unbranched mapped tributary is classified as first order; the stream receiving the tributary is classified as second order and so on. Streams that have no branches or tributaries are first order. Streams that receive only first order streams are second order. Streams that receive only first and second order streams are third order. The mainstem always has the highest order.

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. These assets are divided into two general classifications: (1) those which are considered waters of the state (including lakes, watercourses, wetlands and impoundments), and (2) those which are part of a stormwater system (including detention basins, forebays, bioretention areas and retention areas).

Submergent Zone: The submergent zone is found in areas of 3-6 feet of water in wet ponds. Submergent vegetation makes up this zone because emergent vegetation generally does not grow deeper than 3 feet. Submergent species are important for wildlife habitat and pollutant removal, especially nitrates and phosphorus.

Swale: A natural depression or wide shallow ditch used to temporarily convey, store, or filter runoff.

Tailwater: The depth of water at the downstream end of a culvert or crossing. May also be considered 'downstream hydraulic grade line' or 'backwater'.

Tap: A storm drain connection to a County drain.

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 MCPWO for review and final determination. Examples of site conditions that may prevent the application of stormwater BMPs 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).

Tributary Area: The entire land, including adjacent property that produces runoff to a given point in the stormwater conveyance system or a storage basin.

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.

Water Quality: The biological, chemical and physical conditions of a waterbody, often measured by its ability to support life.

Watercourse: A natural or artificial channel or pipe 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.

Wet Meadow Zone: The wet meadow zone is a constantly moist area that can become inundated. The transition area between open water and the shoreline is prone to erosion. Therefore, it is an important area for plant establishment.

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.

Upland Zone: The upland zone is seldom or never inundated. A wide variety of native plant species are well adapted to the upland zone and their selection will depend on the site conditions.

Appendix B - References

Annable, W., 2001, On the Design of Natural Channels: Decisions, Direction and Design, published in Natural Channel Systems conference proceedings, Niagara Fall, Canada.

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Huff, F.A. and J. R. Angel, 1992, Bulletin 71 – Rainfall Frequency Atlas of the Midwest (MCC Research Report 92-03).

Rosgen, D., 2006, River Assessment and Monitoring course – reference figures, Lubrecht Forest, MT.

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Stormwater Management Practices Design

Caraco, D. and Claytor, R. A., 1997, Stormwater BMP Design Supplement for Cold Climates, http://www.cwp.org/cold-climates.htm.

Center for Watershed protection (CWP), 1998, Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds.

DWSD, 2020, Stormwater Management Design Manual, https://detroitmi.gov/document/stormwater-management-design-manual

Michigan Department of Environmental Quality, 1999, Stormwater Management Guidebook, http://www.michigan.gov/deq/0,1607,7-135-3313_3684_3725-9441--,00.html.

OCDC, Engineering Design Standards for Storm Water Facilities: Requirements, Rules and Design Criteria for Stormwater Management, 2006, http://www.oakgov.com/drain/assets/docs/Standards/engineering_design_standards_for_storm_water_fac_04_%20071.pdf

Pitt, R.and J. Voorhees, 2002, The Design and Use of Detention Facilities for Stormwater Management Using DETPOND, http://unix.eng.ua.edu/~rpitt/SLAMMDETPOND/WinDetpond/WinDETPOND%20user%20guide%20and%20documentation.pdf

SEMCOG, 2008, Low Impact Development Manual for Michigan, https://semcog.org/desktopmodules/SEMCOG.Publications/GetFile.ashx?filename=LowImpactDevelopmentManualforMichiganSeptember2008.pdf

Winogradoff, D. A., 2002, The Bioretention Manual, Prince George's County, MD, http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/Bioretention/bioretention.asp.

Open Channel and Culvert Design

Federal Highway Administration, HY8Energy Culvert Analysis automates the design methods described in FHWA publications: (HDS-5) Hydraulic Design of Highway Culverts, (HEC-14) Hydraulic Design of Energy Dissipators for Culverts and Channels, and (HEC-19) Hydrology. http://www.fhwa.dot.gov/engineering/hydraulics/software/softwaredetail.cfm#hy8energy and http://www.fhwa.dot.gov/engineering/hydraulics/pubs/06086/.

Huff, F.A. and J. R. Angel, 1992, Bulletin 71 – Rainfall Frequency Atlas of the Midwest (MCC Research Report 92-03).

USDA - NRCS, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html.

USDA - NRCS, 2006, National Engineering Handbook 654: NRCS Stream Restoration Design Handbook, http://policy.nrcs.usda.gov/index.aspx.

BMP Monitoring

BMP monitoring should follow: USEPA and ASCE, 2002, Urban Stormwater BMP Performance Monitoring. http://www.bmpdatabase.org/docs/Urban%20Stormwater%20BMP%20Performance%20Monitoring.pdf

Soil Erosion and Sediment Control Measures

- http://macdc.net/Resources/SoilErosionManual/
- Washington State, 2003, Integrated Streambank Protection Guidelines, http://wdfw.wa.gov/hab/ahg/ispgdoc.htm.
- Michigan Department of Management and Budget, SESC Guidebook, http://www.michigan.gov/dmb/0,1607,7-150-9152_32245---,00.html.

Additional Resources

Additional resources on stormwater management practices can be found online at:

- www.lid-stormwater.net/intro/background.htm
- www.lowimpactdevelopment.org/brochures.htm
- http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm

Appendix C - Map

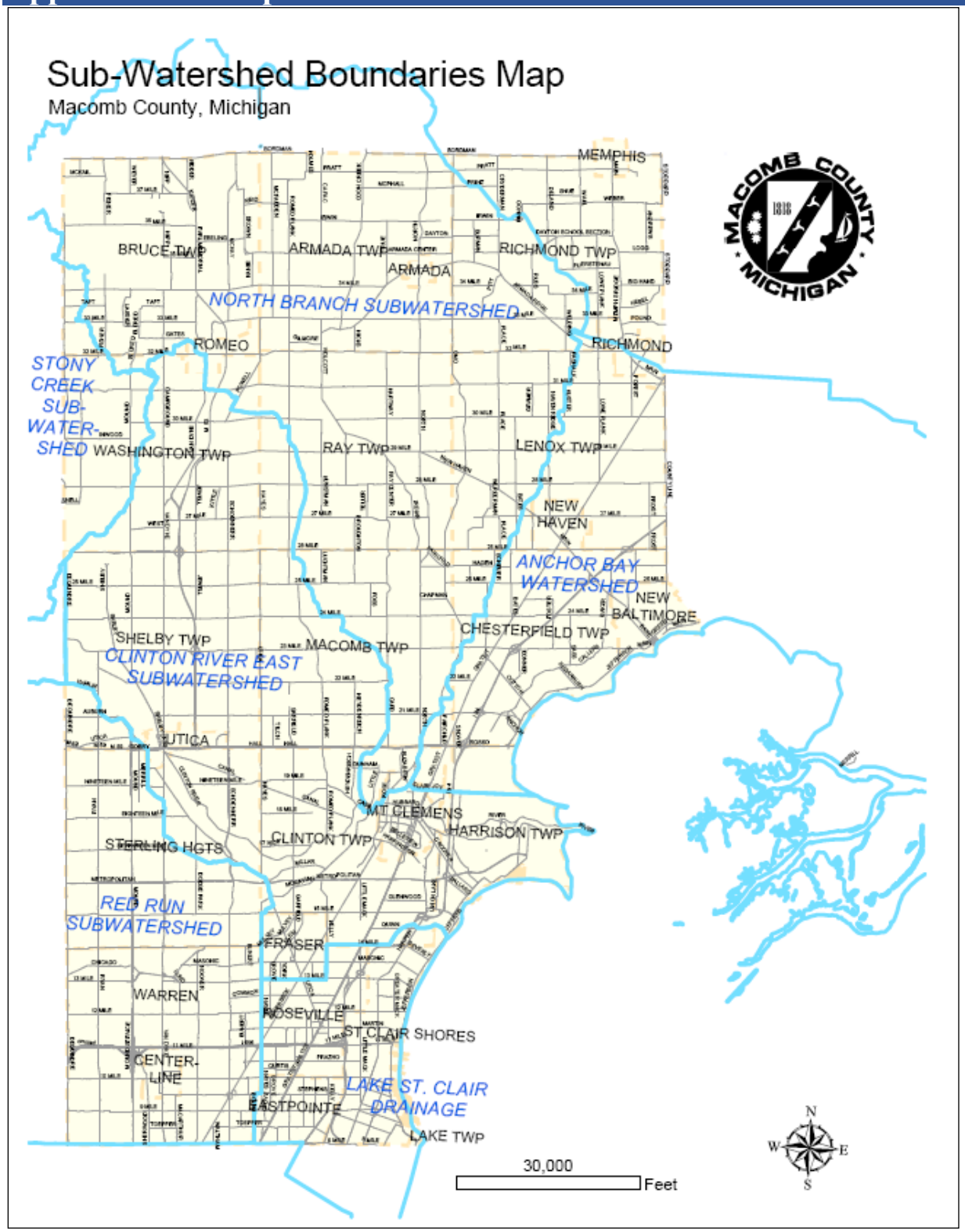


Figure Appendix C-1 - Subwatersheds of Macomb County

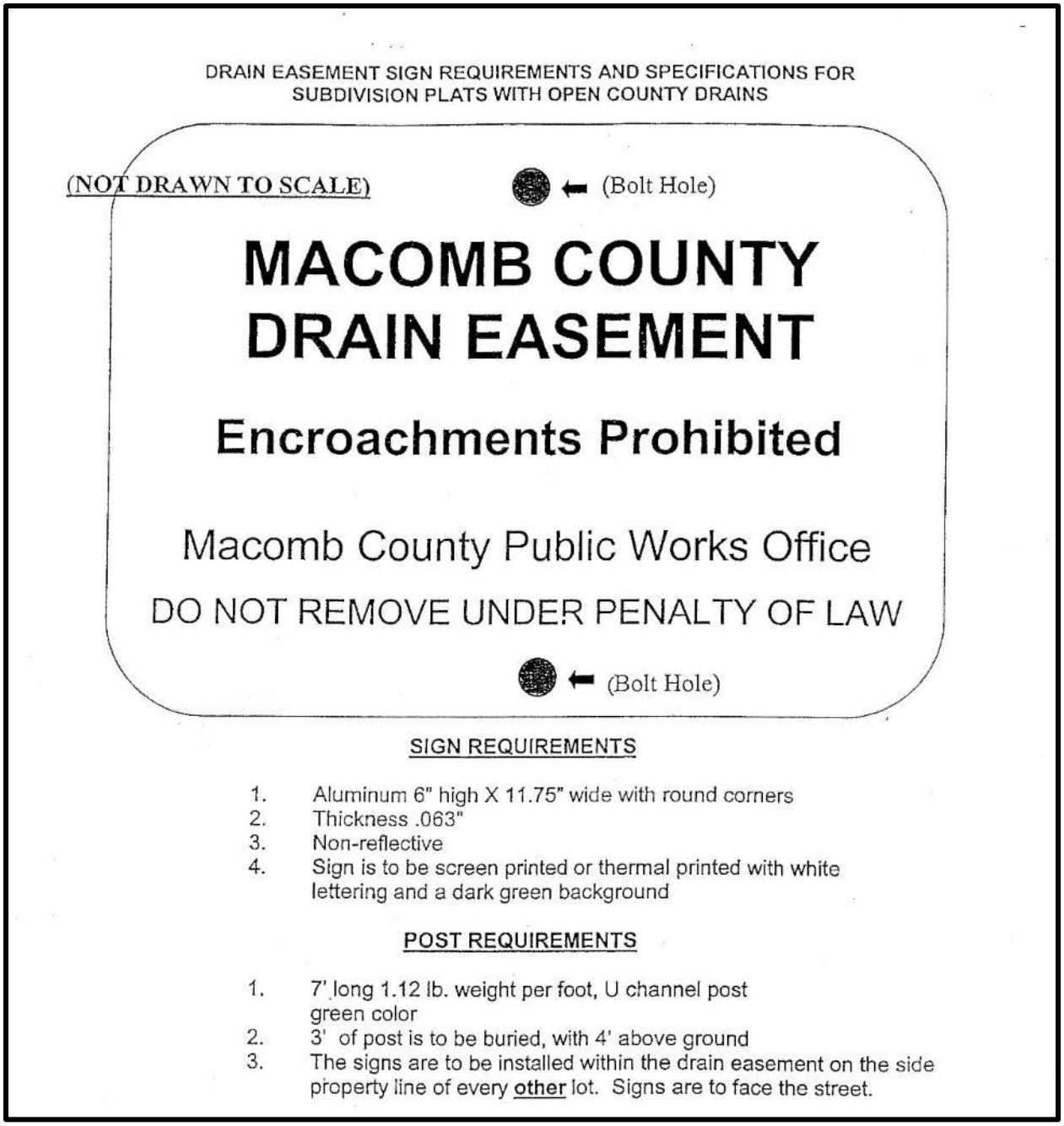
Appendix D - Signage

'Ours to Protect' Signs

'Ours to Protect' signs educate and bring awareness to residents and visitors of the watershed they are located within and what County drain they are crossing. The 'Ours to Protect' sign shall have the County drain name on the sign. Verify with the MCPWO the correct drain name, watershed and spelling before installation. Contact the Macomb County Department of Roads (MCDR) for the sign specifications and requirements for installation within a County road easement. Please consult with the MCDR and your municipality for all installation, permits, maintenance and any other additional requirements.

'Grow Zone' Sign

'Grow Zone' signs shall be based on the Wayne County sign, shown below, but personalized to include Macomb County's Drain Name, if applicable . 'Grow Zone' signs mark the boundaries of designated grow zone areas near lakes, rivers or streams. They feature trees, grasses and a flowing stream, the words: "Grow Zone" and the following caption: "To Improve Wildlife Habitat & Water Quality". 'Grow Zone' signs shall be made of durable metal construction and shall measure no smaller than 8" x 12" and no larger than 12" x 18". Please consult with your municipality for all installation, permits, maintenance and any other additional requirements.



DRAIN EASEMENT SIGN REQUIREMENTS AND SPECIFICATIONS FOR
SUBDIVISION PLATS WITH OPEN COUNTY DRAINS

(NOT DRAWN TO SCALE) ← (Bolt Hole)

MACOMB COUNTY
DRAIN EASEMENT

Encroachments Prohibited

Macomb County Public Works Office

DO NOT REMOVE UNDER PENALTY OF LAW

← (Bolt Hole)

SIGN REQUIREMENTS

1. Aluminum 6" high X 11.75" wide with round corners
2. Thickness .063"
3. Non-reflective
4. Sign is to be screen printed or thermal printed with white lettering and a dark green background

POST REQUIREMENTS

1. 7' long 1.12 lb. weight per foot, U channel post green color
2. 3' of post is to be buried, with 4' above ground
3. The signs are to be installed within the drain easement on the side property line of every **other** lot. Signs are to face the street.

Figure Appendix D-1 - Macomb County Drain Easement Sign

Appendix E - Final Plat Checklist

MCPWO Final Plat Check List

For Internal Use Only

Subdivision Name: _____

MCPWO Log No. _____ CVT: _____

MCPWO Final Preliminary Plat Approval Date: _____

Final plat lot numbers match approved final preliminary plans? _____ If no, why:

_____

The storm easements on the final plat/certified true copy were checked against the approved final preliminary plat, MCPWO Log No. _____. Initial if easements on the final plat and/or Certified True Copy are approved: CTC _____ CTC & FP _____ FP _____

County Drain Onsite?	Yes	No	If Yes, select type:	Open Enclosed
Drain Improvement Required?	Yes	No	If Yes, Developer Agreement No. _____	
Off-site Easement Required?	Yes	No	If Yes, Executed easement on file?	Yes No
Is County Drain Easement labeled properly?	Yes	No		
Detention Required?	Yes	No		
Deed Restrictions on File?	Yes	No		
SAD Established?	Yes	No		
100-year Floodplain Shown?	Yes	No	N/A	

Signage:

Note whether required and if installed.

Type	Required?		Installed?	
Easement Signs:	Yes	No	Yes	No
'Ours to Protect Signs':	Yes	No	Yes	No

Permits:

MCPWO permit required? Yes No If Yes, Permit No. _____

Disposition of Plat: _____

Reviewed by: _____

Appendix F - Macomb County Public Works Commissioner's Certificate

County Drain Commissioner's Certificate

Approved on _____, as complying with Section 192 of Act 288, P.A. of 1967, and the applicable rules and regulations published by my office in the County of Macomb.

_____
Candice S. Miller
Macomb County Public Works Commissioner

Certificate signing date: _____

Appendix G - Standard Details

NOTE: Standard Details are provided on the Macomb County Public Works website, however, please contact the Macomb County Public Works Office to obtain ensure you are utilizing the most recent standard details before incorporating into project design.

Appendix H - Design Reference

NOTE: Design References provided herein are listed as examples only. Please contact the Macomb County Public Works Office to ensure you are utilizing applicable design references and practices before incorporating into project design. Early coordination with the Macomb Public Works Office is a crucial component of any site design.

A. Determination of Surface Runoff

It is the designer's responsibility to determine the most appropriate methods to calculate stormwater runoff volumes and flood peaks based on the best available data. Preferable approaches include statistical analysis of measure gauge station data, EGLE's modified TR-55 Method, or the Rational Method, and computer models (PC-SWMM, HEC-1, HEC-RAS). Other models and methods should be submitted to the MCPWO for approval before finalizing designs. The methods and calculations shall be submitted to the MCPWO with the Project Plans.

Stormwater conveyance systems incorporating pumps shall not be permitted in developments with multiple owners, such as subdivisions and site condominiums unless the applicant is able to demonstrate that there is no feasible alternative.

1. Gauged Locations – Statistical Analysis

A statistical analysis of a gauging station record provides the most accurate hydrograph and discharge-probability relationship for a watercourse. Such information may be available from the Michigan Department of Environmental Quality or the U.S. Geological Survey (USGS). The available USGS gauge station data is online at: http://waterdata.usgs.gov/mi/nwis.

Peak flow information may be calculated at a gauged site may be extrapolate upstream or downstream, or to an adjacent watershed with similar drainage characteristics. The assumption that flows are a function of drainage area may not be appropriate if basin characteristics change from the gauged site. Flow duration and flood frequency curves can also be extrapolated by dividing the flows by an index flood discharge such as bankfull discharge or the mean annual flood (recurrence interval of 2.33 years). DetailsSheet (2) (macombgov.org) Such transfer methods may also be useful to calibrate models. Caution should be taken when extrapolating data.

2. TR-55

For watersheds up to 20 square miles, the suggested method for determining surface runoff is TR-55. The conveyance computations should be based on the NOAA Atlas 14 rainfall depths (see Table Appendix H-1), using an MSE3 rainfall distribution, for a 10-year/24-hr storm. The method will require the following information:

- Drainage area
- Rainfall data
- Land use
- Soil type
- Time of concentration

Note: "Computing Flood Discharges for Small Ungaged Watersheds – manual and spreadsheet" by Sorrell, R. C., 2003. Will no longer be accepted as the method has not yet integrated NOAA Atlas 14 rainfall data.

B. Mean Frequency Distributions for Storm Periods of 5 Minutes to 60 Days and Recurrence Intervals of 1 to 100 Years in Macomb County (from NOAA Atlas 14)

NOAA Atlas 14, Volume 8, Version 2
Location name: Utica, Michigan, USA*
Latitude: 42.6704°, Longitude: -83.0145°
Elevation: 640.02 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

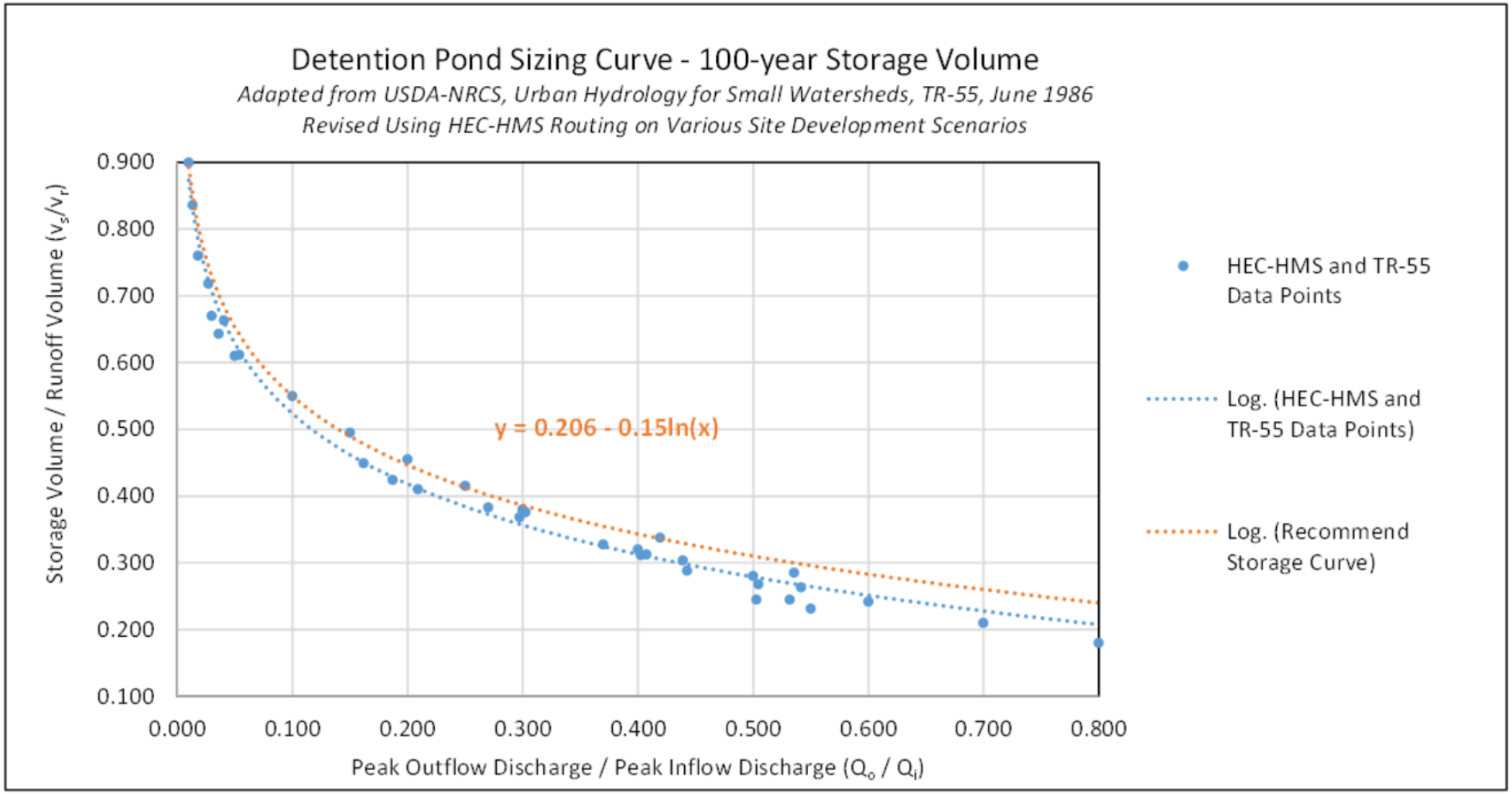
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.296 (0.230-0.383)	0.353 (0.274-0.457)	0.448 (0.347-0.580)	0.528 (0.407-0.685)	0.639 (0.478-0.845)	0.726 (0.533-0.966)	0.815 (0.580-1.10)	0.905 (0.622-1.24)	1.03 (0.682-1.42)	1.12 (0.727-1.57)
10-min	0.434 (0.337-0.561)	0.518 (0.402-0.669)	0.656 (0.508-0.850)	0.773 (0.595-1.00)	0.936 (0.700-1.24)	1.06 (0.780-1.42)	1.19 (0.849-1.61)	1.33 (0.910-1.81)	1.50 (0.998-2.09)	1.64 (1.07-2.29)
15-min	0.529 (0.411-0.684)	0.631 (0.490-0.816)	0.800 (0.620-1.04)	0.943 (0.726-1.22)	1.14 (0.854-1.51)	1.30 (0.951-1.73)	1.46 (1.04-1.96)	1.62 (1.11-2.21)	1.83 (1.22-2.54)	2.00 (1.30-2.80)
30-min	0.728 (0.566-0.941)	0.873 (0.678-1.13)	1.11 (0.860-1.44)	1.31 (1.01-1.70)	1.59 (1.19-2.10)	1.81 (1.32-2.40)	2.02 (1.44-2.73)	2.25 (1.54-3.07)	2.54 (1.69-3.53)	2.77 (1.80-3.87)
60-min	0.933 (0.725-1.21)	1.12 (0.868-1.45)	1.43 (1.11-1.85)	1.69 (1.30-2.19)	2.06 (1.55-2.73)	2.36 (1.73-3.14)	2.66 (1.89-3.59)	2.97 (2.04-4.06)	3.39 (2.25-4.71)	3.72 (2.41-5.19)
2-hr	1.14 (0.894-1.45)	1.36 (1.07-1.74)	1.75 (1.37-2.23)	2.07 (1.61-2.66)	2.54 (1.92-3.33)	2.91 (2.16-3.84)	3.29 (2.37-4.40)	3.69 (2.56-5.01)	4.24 (2.84-5.83)	4.66 (3.05-6.46)
3-hr	1.27 (1.00-1.61)	1.51 (1.20-1.92)	1.93 (1.52-2.45)	2.29 (1.80-2.92)	2.82 (2.15-3.69)	3.25 (2.42-4.26)	3.69 (2.67-4.91)	4.16 (2.90-5.62)	4.80 (3.24-6.59)	5.31 (3.49-7.33)
6-hr	1.51 (1.21-1.89)	1.77 (1.42-2.22)	2.23 (1.78-2.80)	2.64 (2.09-3.32)	3.24 (2.51-4.21)	3.74 (2.83-4.88)	4.27 (3.14-5.65)	4.84 (3.42-6.50)	5.64 (3.84-7.69)	6.28 (4.17-8.59)
12-hr	1.78 (1.44-2.20)	2.04 (1.65-2.53)	2.51 (2.02-3.11)	2.94 (2.35-3.65)	3.58 (2.82-4.61)	4.13 (3.16-5.34)	4.71 (3.50-6.18)	5.35 (3.82-7.13)	6.25 (4.30-8.46)	6.98 (4.67-9.48)
24-hr	2.05 (1.68-2.51)	2.33 (1.91-2.85)	2.84 (2.31-3.48)	3.30 (2.67-4.05)	3.99 (3.17-5.07)	4.57 (3.54-5.84)	5.20 (3.90-6.74)	5.87 (4.23-7.75)	6.83 (4.75-9.17)	7.61 (5.14-10.2)
2-day	2.34 (1.93-2.82)	2.67 (2.21-3.23)	3.26 (2.69-3.95)	3.79 (3.11-4.59)	4.55 (3.64-5.70)	5.19 (4.05-6.53)	5.85 (4.42-7.49)	6.56 (4.77-8.55)	7.55 (5.29-10.0)	8.34 (5.68-11.1)
3-day	2.55 (2.13-3.06)	2.91 (2.42-3.49)	3.53 (2.93-4.24)	4.08 (3.37-4.91)	4.88 (3.92-6.05)	5.53 (4.35-6.92)	6.22 (4.72-7.90)	6.95 (5.07-8.99)	7.96 (5.60-10.5)	8.77 (6.00-11.6)
4-day	2.74 (2.30-3.27)	3.11 (2.60-3.71)	3.75 (3.13-4.48)	4.31 (3.58-5.16)	5.13 (4.14-6.33)	5.79 (4.57-7.21)	6.49 (4.96-8.22)	7.24 (5.31-9.33)	8.27 (5.84-10.9)	9.09 (6.24-12.0)
7-day	3.23 (2.73-3.81)	3.63 (3.07-4.28)	4.31 (3.63-5.09)	4.90 (4.11-5.81)	5.76 (4.70-7.03)	6.46 (5.14-7.95)	7.19 (5.54-9.01)	7.97 (5.89-10.2)	9.04 (6.43-11.8)	9.88 (6.84-13.0)
10-day	3.68 (3.13-4.30)	4.10 (3.48-4.80)	4.82 (4.08-5.66)	5.44 (4.59-6.41)	6.35 (5.20-7.69)	7.08 (5.67-8.66)	7.84 (6.07-9.76)	8.65 (6.42-11.0)	9.75 (6.97-12.6)	10.6 (7.38-13.9)
20-day	4.98 (4.29-5.76)	5.50 (4.74-6.36)	6.37 (5.47-7.38)	7.11 (6.07-8.27)	8.16 (6.75-9.73)	9.00 (7.27-10.8)	9.85 (7.69-12.1)	10.7 (8.05-13.5)	12.0 (8.61-15.3)	12.9 (9.04-16.7)
30-day	6.12 (5.31-7.02)	6.75 (5.85-7.74)	7.78 (6.73-8.95)	8.65 (7.43-9.98)	9.84 (8.18-11.6)	10.8 (8.74-12.8)	11.7 (9.17-14.2)	12.6 (9.50-15.7)	13.9 (10.0-17.7)	14.8 (10.4-19.1)
45-day	7.61 (6.65-8.65)	8.41 (7.35-9.58)	9.70 (8.45-11.1)	10.7 (9.30-12.3)	12.1 (10.1-14.1)	13.2 (10.7-15.5)	14.1 (11.2-17.1)	15.1 (11.4-18.7)	16.4 (11.9-20.7)	17.3 (12.2-22.2)
60-day	8.91 (7.83-10.1)	9.89 (8.69-11.2)	11.4 (10.0-13.0)	12.6 (11.0-14.4)	14.2 (11.9-16.4)	15.3 (12.5-17.9)	16.4 (12.9-19.6)	17.3 (13.1-21.2)	18.5 (13.5-23.3)	19.4 (13.8-24.8)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

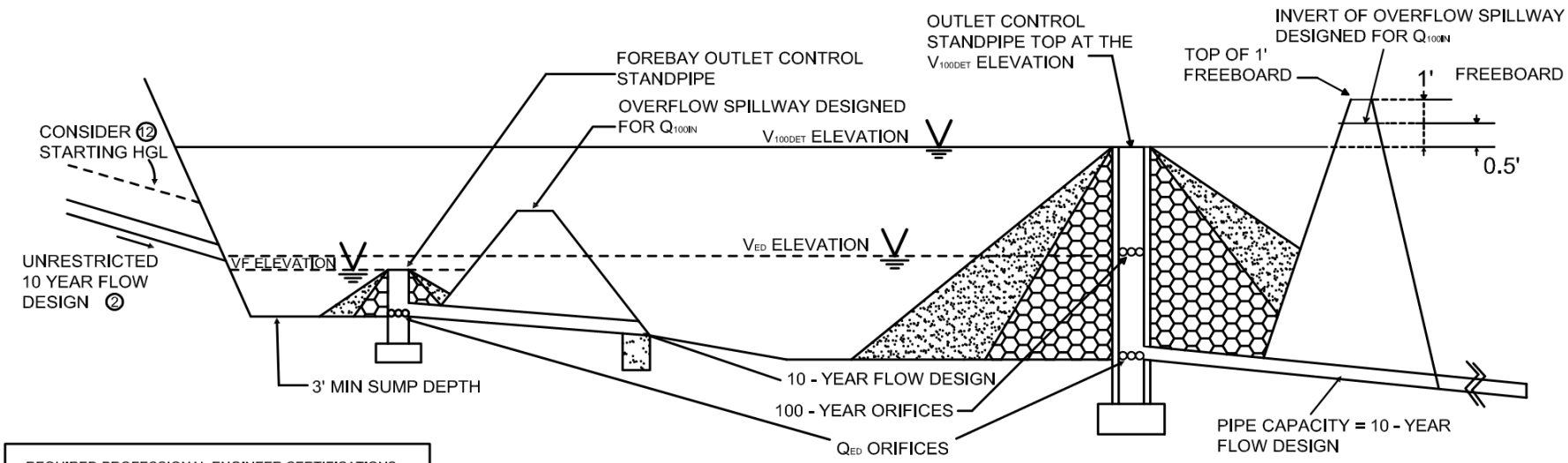
Table Appendix H-1 - Mean Frequency Distributions for Storm Periods of 5 Minutes to 60 Days and Recurrence Intervals of 1 to 100 Years in Macomb County (from NOAA Atlas 14)



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

Figure Appendix H-1 - (R) Factor - Detention Basin Sizing Factor



REQUIRED PROFESSIONAL ENGINEER CERTIFICATIONS

- CHANNEL PROTECTION VOLUME "CREDIT" (V_{CPvC}) ⑧
- INFILTRATION RATES ⑨
- 100 - YEAR ALLOWABLE OUTLET RATE (Q_{100ALL}) ⑥
- MEP FOR ACHIEVED CPVC VOLUME ⑪
- STORMWATER SYSTEMS O&M PLANS ⑩

FOREBAY VOLUME (V_F) ①

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})

$V_F = ((3630)(C_{10YR})(A)(1)) \times 0.15$

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

FOREBAY OUTLET SIZE

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

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

EXTENDED DETENTION VOLUME (V_{ED}) ③

$V_{ED} = (3,630)(C_{10YR})(A)(P)$

P_{ED} = 1.9" RAINFALL

EXTENDED DETENTION OUTLET RATE ④

V_{ED} VOLUME MUST BE RELEASED IN APPROXIMATELY 48 HRS +/- 10%

THE ENTIRE BASIN MUST DEWATER IN LESS THAN 72 HOURS.

100 YEAR POST-CONSTRUCTION INLET RATE (Q_{100IN}) ⑤

$Q_{100IN} = (C_{10YR} \times 1.3) \times A \times I_{100YR}$

IF $C_{10YR} \times 1.3$ IS > 1 THEN USE 1

$I = (30 \times Y^{0.22})/(T_C + 9.17)^{0.81}$

Y = RETURN INTERVAL IN YEARS

T_C = TIME OF CONCENTRATION IN MINUTES ⑬

100 YEAR ALLOWABLE OUTLET RATE (Q_{100ALL}) ⑥

THE ALLOWABLE 100 YEAR OUTLET RATE, IN CFS, IS THE LESSER OF:

- PROJECTS DRAINING TO A SYSTEM MANAGED BY MACOMB COUNTY DEPARTMENT OF ROADS MUST DISCHARGE THROUGH A 4" PIPE
- LOCAL MUNICIPALITY OR OTHER REVIEWING AGENCIES RELEASE RATE
- SITE SPECIFIC RELEASE RATE AS DETERMINED BY MCPWO
- DEVELOPMENT BETWEEN 2-100 ACRES: QVRR = 1.1055 - 0.206Ln(A) (CFS/ACRE) FOR DEVELOPMENTS OUTSIDE OF THIS RANGE, SEE ⑥

100-YEAR DETENTION VOLUME (V_{100DET}) ⑦

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

R = STORAGE CURVE FACTOR

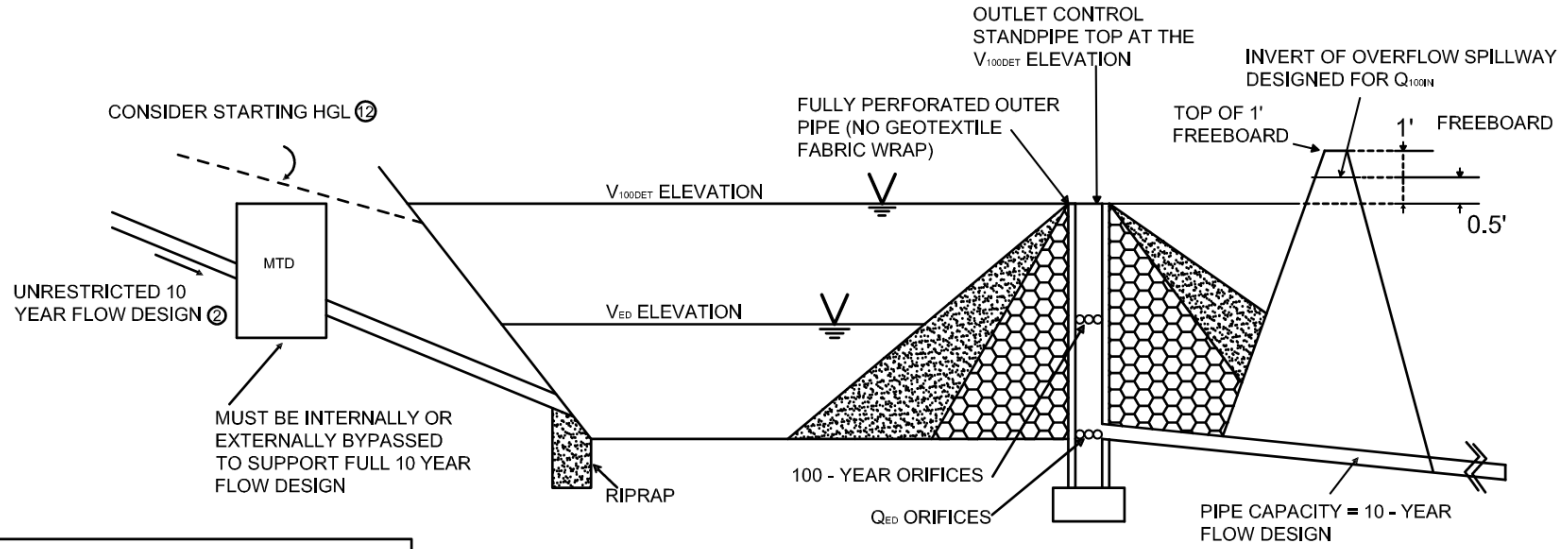
$V_{100IN} = 3,630(5.2) \times (C_{10YR} \times 1.3)(A)$

$V_{100DET} = (V_{100RUN} \times R) - V_{VC\text{-}CREDIT}$ ⑧

DRAWN: WHJ
DATE: 6/21/2023
THIS DRAWING IS FOR REFERENCE ONLY

①Section VI.2.A.2	④Section VI.2.E	⑦Section VI.2.F	⑩Part VIII	⑬Section V.1.C
②Table V-1	⑤Table V-6	⑧Table VI-14	⑪Section VI.2.B	
③Table VI-9	⑥Table VI-10	⑨Section VI.2.B.3	⑫Table V-8	

Figure Appendix H-2 - Typical Detention Basin with Manufactured Treatment Device



REQUIRED PROFESSIONAL ENGINEER CERTIFICATIONS

- CHANNEL PROTECTION VOLUME "CREDIT" ($V_{VC-CREDIT}$) ⑧
- INFILTRATION RATES ⑨
- 100 - YEAR ALLOWABLE OUTLET RATE (Q_{100ALL}) ⑥
- MEP FOR ACHIEVED CPVC VOLUME ⑪
- STORMWATER SYSTEMS O&M PLANS ⑩

MANUFACTURED TREATMENT DEVICE ①

REQUIRED WATER QUALITY TREATMENT IS 80 MG/L TSS, OR 80% TSS REMOVAL FOR FLOWS AT OR BELOW Q_{WQ}

SIZED BASED ON THE WATER QUALITY CONTROL PEAK FLOW RATE (Q_{WQ})

$Q_{WQ} = (C_{10YR})(A)(2)$

REPLACES FOREBAY REQUIREMENT IF ALL SITE IS TREATED

INSTALLED UPSTREAM OF ANY DETENTION OR RETENTION BASIN

CHANNEL PROTECTION RATE ③
CONTROL (CPRC) VOLUME (V_{ED})

$V_{ED} = (3{,}630)(C_{10YR})(A)(P)$

P_{ED} = 1.9" RAINFALL

EXTENDED DETENTION OUTLET RATE ④

V_{ED} VOLUME MUST BE RELEASED IN APPROXIMATELY 48 HRS +/- 10%

THE ENTIRE BASIN MUST DEWATER IN LESS THAN 72 HOURS.

100 YEAR POST-CONSTRUCTION INLET RATE (Q_{100IN}) ⑤

$Q_{100IN} = (C_{10YR} \times 1.3) \times A \times I_{100YR}$

IF $C_{10YR} \times 1.3$ IS > 1 THEN USE 1

$I = (30 \times Y^{0.22})/(TC + 9.17)^{0.81}$

Y = RETURN INTERVAL IN YEARS

T_C = TIME OF CONCENTRATION IN MINUTES ⑬

100 YEAR ALLOWABLE OUTLET RATE (Q_{100ALL}) ⑥

THE ALLOWABLE 100 YEAR OUTLET RATE IS THE LESSER OF:

- PROJECTS DRAINING TO A SYSTEM MANAGED BY THE MACOMB COUNTY DEPARTMENT OF ROADS MUST DISCHARGE THROUGH A 4" PIPE
- LOCAL MUNICIPALITY OR OTHER REVIEWING AGENCIES RELEASE RATE
- SITE SPECIFIC RELEASE RATE AS DETERMINED BY MCPWO
- DEVELOPMENT BETWEEN 2-100 ACRES: $Q_{VRR} = 1.1055 - 0.206\text{Ln}(A)$ (CFS/ACRE) FOR DEVELOPMENTS OUTSIDE OF THIS RANGE, SEE ⑥

DETENTION FLOOD CONTROL 100 YEAR(V_{100DET}) ⑦

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

R = STORAGE CURVE FACTOR

$V_{100RUN} = 3{,}360(5.2) \times (C_{10YR} \times 1.3)(A)$

$V_{100DET} = (V_{100RUN} \times R) - V_{VC-CREDIT}$ ⑧

DRAWN: WHJ
DATE: 6/21/2023
THIS DRAWING IS FOR REFERENCE ONLY

① Section VI.2.A.2
② Table V-1
③ Table VI-9
④ Section VI.2.E
⑤ Table V-6
⑥ Table VI-10
⑦ Section VI.2.F
⑧ Table VI-14
⑨ Section VI.2.B.3
⑩ Part VIII
⑪ Section VI.2.B
⑫ Table V-8
⑬ Section V.1.C

Figure Appendix H-3 – Typical Detention Basin with Forebay

Appendix I - Application Guidelines for Rolled Erosion Control Products

NOTE: Guidelines on rolled erosion control products are provided to promote the use of appropriate materials to stabilize slopes and channel stabilization applications. It is the designer's responsibility to select the appropriate materials based on local soil conditions and other site-specific variables. The County accepts no responsibility for the misapplication of the guidelines contained herein.

Guidelines on rolled erosion control products are provided to promote the use of appropriate materials to stabilize slopes and channel stabilization applications. It is the designer's responsibility to select the appropriate materials based on local soil conditions and other site-specific variables. The County accepts no responsibility for the misapplication of the guidelines contained herein.

The following guidelines are excerpt with permission from the Erosion Control Technology Council (ECTC) Standard Specification for Rolled Erosion Control Products (RECPs). The following guidelines apply to work which consists of constructing temporary and permanent installations to control erosion, enhance vegetation establishment, establishment, and survivability on slopes, channels, and includes installing RECPs.

Rolled Erosion Control Products (RECPs) are defined by ECTC as a temporary degradable or long-term non-degradable material manufactured or fabricated into rolls designed to reduce soil erosion and assist in the growth, establishment and protection of vegetation. RECPs are designated as follows:

a) **Mulch control netting.** - A planar woven natural fiber or extruded geosynthetic mesh used as a temporary degradable rolled erosion control product to anchor loose fiber mulches.

b) **Open weave textile.** - A temporary degradable rolled erosion control product composed of processed natural or polymer yarns woven into a matrix, used to provide erosion control and facilitate vegetation establishment.

c) **Erosion control blanket.** - A temporary degradable rolled erosion control product composed of processed natural or polymer fibers mechanically, structurally or chemically bound together to form a continuous matrix to provide erosion control and facilitate vegetation establishment.

d) **Turf reinforcement mat. -** A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.

e) **Temporary Rolled Erosion Control Products -** For applications where natural vegetation alone will provide sufficient permanent erosion protection, furnish a temporary rolled erosion control product with the necessary longevity and performance properties to effectively control erosion and assist in the establishment of vegetation under the anticipated immediate site conditions. The temporary rolled erosion control product shall conform to one of the following specifications and corresponding properties found in **Table Appendix I-1** to **Table Appendix I-3**.

f) **Permanent Rolled Erosion Control Products -** For applications where natural vegetation alone will not sustain expected flow conditions and/or provide sufficient long-term erosion protection, furnish a permanent rolled erosion control product with the necessary performance properties to effectively control erosion and reinforce vegetation under the expected long-term site conditions. The permanent erosion control product shall conform to one of the specifications and corresponding properties found in **Table Appendix I-4**.

The Erosion Control Technology Council (ECTC) *is a non-profit organization. Its mission is to develop performance standards, uniform testing procedures, and guidance on the application and installation of rolled erosion control products (RECPs). The ECTC promotes the use of erosion control mats and blankets through industry leadership and education in the hope of making a broad contribution to the science of erosion control and environmental preservation. More information about ECTC can be obtained from their website http://www.ectc.org.*

Table Appendix I-1 - ECTC Standard Specification for Temporary Rolled Erosion Control Products

For use where natural vegetation alone will provide permanent erosion protection.

ULTRA SHORT-TERM - Typical 3 month functional longevity						
			Slope Applications*		Channel Applications*	
Type	Product Description	Material Composition	Maximum Gradient	C Factor[2,5]	Max. Shear Stress[3,4,6]	Minimum Tensile Strength[1]
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	5:1 (H:V)	≤ 0.10 @ 5:1	0.25 lbs/ft^2 (12 Pa)	5 lbs/ft (0.073 kN/m)
1.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	4:1 (H:V)	≤ 0.10 @ 4:1	0.5 lbs/ft^2 (24 Pa)	5 lbs/ft (0.073 kN/m)
1.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	≤ 0.15 @ 3:1	1.5 lbs/ft^2 (72 Pa)	50 lbs/ft (0.73 kN/m)
1.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	2:1 (H:V)	≤ 0.20 @ 2:1	1.75 lbs/ft^2 (84 Pa)	75 lbs/ft (1.09 kN/m)

* "C" factor and shear stress for Types 1.A., 2.A. and 3.A mulch control nettings must be obtained with netting used in conjunction with pre-applied mulch material.

[1] Minimum Average Roll Values, Machine direction using ECTC Mod. ASTM D 5035.

[2] "C" Factor calculated as ratio of soil loss from RECP protected slope (tested at specified or greater gradient, h:v) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions using Erosion Control Technology Council (ECTC) Test Method # 2.

[3] Required minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in) soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #3.

[4] The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 - 0.05.

[5] Acceptable large-scale test methods may include ASTM D 6459, Erosion Control Technology Council (ECTC) Test Method # 2, or other independent testing deemed acceptable by the engineer.

[6] Per the engineer's discretion. Recommended acceptable large-scale testing protocol may include ASTM D 6460, Erosion Control Technology Council (ECTC) Test Method #3 or other independent testing deemed acceptable by the engineer.

Table Appendix I-2 - ECTC Standard Specification for Temporary Rolled Erosion Control Products

For use where natural vegetation alone will provide permanent erosion protection.

SHORT-TERM - Typical 12 month functional longevity						
			Slope Applications*		Channel Applications*	
Type	Product Description	Material Composition	Maximum Gradient	C Factor[2,5]	Max. Shear Stress[3,4,6]	Minimum Tensile Strength[1]
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	5:1 (H:V)	≤ 0.10 @ 5:1	0.25 lbs/ft^2 (12 Pa)	5 lbs/ft (0.073 kN/m)
2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	4:1 (H:V)	≤ 0.10 @ 4:1	0.5 lbs/ft^2 (24 Pa)	5 lbs/ft (0.073 kN/m)
2.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	≤ 0.15 @ 3:1	1.5 lbs/ft^2 (72 Pa)	50 lbs/ft (0.73 kN/m)
2.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	2:1 (H:V)	≤ 0.20 @ 2:1	1.75 lbs/ft^2 (84 Pa)	75 lbs/ft (1.09 kN/m)

Table Appendix I-3 - ECTC Standard Specification for Temporary Rolled Erosion Control Products

For use where natural vegetation alone will provide permanent erosion protection.

EXTENDED-TERM - Typical 24 month functional longevity						
			Slope Applications*		Channel Applications*	
Type	Product Description	Material Composition	Maximum Gradient	C Factor[2,5]	Max. Shear Stress[3,4,6]	Minimum Tensile Strength[1]
3.A	Mulch Control Nets	A slow degrading synthetic mesh or woven natural fiber netting.	5:1 (H:V)	≤ 0.10 @ 5:1	0.25 lbs/ft^2 (12 Pa)	25 lbs/ft (0.36 kN/m)
3.B	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5:1 (H:V)	≤ 0.25 @ 1.5:1	2.00 lbs/ft^2 (96 Pa)	100 lbs/ft (1.45 kN/m)
4	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1:1 (H:V)	≤ 0.25 @ 1:1	2.25 lbs/ft^2 (108 Pa)	125 lbs/ft (1.82 kN/m)

Table Appendix I-4 - ECTC Standard Specification for Permanent Rolled Erosion Control Products

For applications where vegetation alone will not sustain expected flow conditions and/or provide sufficient long-term erosion protection.

PERMANENT[1] - All categories of TRMs must have a minimum thickness of 0.25 inches (6.35 mm) per ASTM D 6525 and U.V. stability of 80% per ASTM D 4355 (500 hours exposure).					
			Slope Applications*	Channel Applications*	
Type	Product Description	Material Composition	Maximum Gradient	Maximum Shear Stress[4,5]	Minimum Tensile Strength[2,3]
5.A	Turf Reinforcement Mat	Turf Reinforcement Mat (TRM) – A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.	5:1 (H:V)	6.0 lbs/ft^2 (288 Pa)	125 lbs/ft (1.82 kN/m)
5.B	Turf Reinforcement Mat		5:1 (H:V)	8.0 lbs/ft^2 (384 Pa)	150 lbs/ft (2.19 kN/m)
5.C	Turf Reinforcement Mat		5:1 (H:V)	10.0 lbs/ft^2 (480 Pa)	175 lbs/ft (2.55 kN/m)

[1] For TRMs containing degradable components, all property values must be obtained on the non-degradable portion of the matting alone.

[2] Minimum Average Roll Values, machine direction only for tensile strength determination using ASTM D 6818 (Supercedes Mod. ASTM D 5035 for RECPs)

[3] Field conditions with high loading and/or high survivability requirements may warrant the use of a TRM with a tensile strength of 44 kN/m (3,000 lb/ft) or greater.

[4] Required minimum shear stress TRM (fully vegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in.) soil loss) during a 30-minute flow event in large scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #3.

[5] Acceptable large-scale testing protocol may include ASTM D 6460, Erosion Control Technology Council (ECTC) Test Method #3, or other independent testing deemed acceptable by the engineer.

Installation of Rolled Erosion Control Products (RECPs)

For the proper installation of RECPs follow: "Installation Guide for Rolled Erosion Control Products (RECPs) Including Mulch Control Nettings (MCNs), Open Weave Textiles (OWTs), Erosion Control Blankets (ECBs), and Turf Reinforcement Mats (TRMs)", available on the ECTC website at http://www.ectc.org/specifications.asp#table1.

Appendix J - Certification Form for Adding Lands to a Drainage District

NOTE: Certification information contained herein is provided as general reference only. Please contact the Macomb County Public Works Office to obtain copies of the most recent certification language before incorporating into project design.

SAMPLE CERTIFICATION FORM
FOR ADDING LANDS TO A DRAINAGE DISTRICT
TO BE RETYPED ON ENGINEERING FIRM'S LETTERHEAD
USING THE FOLLOWING LANGUAGE.

Date

Candice S. Miller
Macomb County Public Works Commissioner
115 South Groesbeck, PO Box 806
Mt. Clemens, MI 48046-0806

Attention: _____ (Appropriate Engineer)

RE: ENGINEER'S CERTIFICATION
(Insert name & location of proposed development)
(Insert name of drainage district)
(Insert description of lands to be added to drainage district)

Dear Commissioner Miller:

This is to certify (Insert statement #1 or #2 below, as appropriate) and that there is sufficient capacity in the (insert drain name) for it to serve as an adequate outlet for these lands without detriment or diminution of the drainage services which the outlet presently provides.

_____
Engineer's signature

Registration No:_____

Statement #1 – …the lands to be added naturally drain to the existing drain…..

Statement #2 - …the existing drain is the only reasonable outlet for the lands to be added….

Appendix K - Stormwater Narrative: Template and Details

A site Stormwater Narrative that includes a summary of the proposed stormwater management system is required for each site plan submittal (see section III.1.A). The Stormwater Narrative will summarizes the source & magnitude of stormwater runoff, stormwater management methods, site constraints, applicable geotechnical results, operations & maintenance summary and more. Overall, the Stormwater Narrative provides a basis of design that describes how the stormwater system will function and how the site satisfies both MCPWO stormwater standards and Macomb County MS4 goals. A Stormwater Narrative at a minimum should include the information listed below:

Site Stormwater Narrative Containing Must Contain:

1. Project Name
2. Project Location (City/Township, Section #, Address)
3. Applicant/Owner name and contact information.
4. Engineer/Agent contact information.
5. A Description of work to be performed and any planed future phases.
6. Summary of proposed stormwater management system.
7. All stormwater calculations, including a list of all assumptions, site characteristics, outlet hydraulic calculations, and other information to support the calculations.
8. Total Disturbed Area / Area of Earth Change, & Drainage areas
9. Site Channel Protection Volume – Calculated, Provide, and Credited (cf)
    a. If site constraints limit the ability of the project to provide the full calculated CPVC volume.
    b. If the project is unable to provide the full CPVC explain what prevents the project from doing so. For example, high groundwater, stormwater hotspot, conflict between requirements from various regulatory agencies and/or others.
10. Site Channel Protection Rate Control - Provided (cf)
11. Site Detention and Flood Control Volume – Provided (cf)
12. If mechanical separators are to be used, include supporting documentation for unit sizing and TSS removal efficiencies.
13. Figures/schematics of the stormwater management system, including references to existing wetlands, floodplains, woodlands or other protected natural features.
14. Geotechnical Reports – these shall include soil borings and Infiltration testing results used to establish the infiltration capabilities for the site. See requirements provided in section VI.2.B.2 – Soil Infiltration Testing.
15. Land Use Summary Table (see Table Appendix K-1)
    - Site pre-development & post-development: impervious area (ac) & Runoff Coefficient C
    - Site pre-development & post-development: pervious area (ac) & NRCS soil group / Hydraulic Soil Group & vegetation/cover type

Table Appendix K-1 – Land use Summary Table

Land Use Summary Table			
	Characteristic	Existing Conditions	Proposed Conditions
Development Area	*Total Development Area (ac)*		
	Total Impervious Area (ac)		
	Total Pervious Area (ac)		
	Total Water and/or Detention/Retention Area (ac)		
Pervious Area Land Use Data	*Pervious Area Breakdown by Cover Type*		
	Meadow/fallow/natural areas (non-cultivated)(ac)		
	Predominant NRCS Soil Type (A, B, C, or D)		
	Altered areas (turf grass, landscape, row crops)(ac)		
	Predominant NRCS Soil Type (A, B, C, or D)		
	Wooded Areas		
	Predominant NRCS Soil Type (A, B, C, or D)		
CPVC	*CPVC Volume **Calculated** (cubic feet)*		
	*CPVC Volume **Provided** (cubic feet)*		
	*CPRC Volume **Calculated** (cubic feet)*		
	*CPRC Volume **Provided** (cubic feet)*		
If the site is unable to provide the full calculated CPVC due to site constraints, briefly describe the site constraints below and how the project achieves the CPVC requirement to the maximum extent practicable:			

The Professional Engineer who signs and seals this site plan certifies that the values in this table reflect the 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*
- *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

Appendix L - Plant Lists

Table Appendix L-1 - Species List for Planting Zone 1 (Adapted from Shaw & Smidt, 2003)

Zone 1 Submergent zone	**3-6 feet of water**
Scientific Name	**Common Name**
Forbs and Ferns	
Brasenia schreberi	Water shield
Ceratophyllum demersum	Coontail
Elodea Canadensis	Elodea
Lemna trisulca	Lesser duckweed
Myriophyllum exalbesieus	Water milfoil
Nelumbo lutea	Lotus (Threatened in Michigan)
Nuphar lutea	Yellow water-lily
Nymphaea odorata	White water-lily
Potamogeton illinoensis	Illinois pondweed
Potamogeton natans	Floating-leaved pondweed
Potamogeton pectinatus	Sago pondweed
Ranunculus flabellaris	Yellow water crowfoot
Spirodela polyrrhiza	Giant duckweed
Urticularia vulgaris	Bladderwort
Vallisneria americana	Wild celery
Woffia columbiana	Watermeal

Table Appendix L-2 - Species List for Planting Zone 2

Zone 2 Emergent zone	**0-18 inches of water**
Scientific Name	**Common Name**
Trees and Shrubs	
Cephalanthus occidentalis	Buttonbush
Ilex verticillata	Winterberry
Physocarpus opulifolius	Ninebark
Forbs and Ferns	
Acorus calamus	Sweet flag
Alisma trivale	Water plantain
Caltha palustris	Marsh marigold
Polygonum amphibium	Water smartweed
Pontederia cordata	Pickerelweed
Sagittaria latifolia	Broadleaved arrowhead
Sparganium eurycarpum	Giant burreed
Grasses, Sedges and Rushes	
Carex aquatilis	Water sedge
Carex lacustris	Lake sedge
Carex stricta	Tussock sedge
Juncus balticus	Baltic rush
Juncus effuses	Soft rush
Scirpus acutus	Hardstem bulrush
Scirpus fluviatilis	River bulrush
Scirpus pungens	Three-square bulrush
Scirpus validus	Soft-stem bulrush

Table Appendix L-3 - Species List for Planting Zone 3 (1 of 2)

Zone 3 Wet meadow zone	**Permanent moisture**
Scientific Name	**Common Name**
Trees and Shrubs	
Amorpha fruticosa	Indigo bush
Salix nigra	Black willow
Sambucus pubens	Red-berried elder
Forbs and Ferns	
Anemone canadensis	Canada anemone
Angelica atropurpurea	Angelica
Asclepias incarnate	Marsh milkweed
Aster lanceolatus (simplex)	Panicle aster
Aster novae-angliae	New England aster
Aster puniceus (A. luncidulus)	Swamp aster
Bidens cernua	Beggarsticks
Boltonia asteroids	Boltonia
Chelone glabra	Turtlehead
Eryngium yuccifolium	Rattlesnake master (Threatened in Michigan)
Eupatorium maculatum	Joe-pye-weed
Eupatorium perfoliatum	Bonset
Euthanmia graminifolia	Grass-leaved goldenrod
Gentiana andrewsii	Bottle gentian
Helenium autumnale	Sneezeweed
Impatiens capensis	Jewelweed
Iris versicolor	Blueflag
Liatris spicata	Marsh (Dense) blazingstar
Lilium superbum	Turk's-cap lily
Lobelia cardinalis	Cardinal flower
Lobelia siphilitica	Blue lobelia
Lysimachia thrysiflora	Tufted loosestrife
Onoclea sensibilis	Sensitive fern
Osmunda regalis	Royal fern
Physostegia virginiana	Obedient plant
Potentilla palustris	Marsh cinquefoil
Pycnanthemum virginianum	Mountain mint
Scutterlaria lateriflora	Mad-dog skullcap
Silphium perfoliatum	Cup plant (Threatened in Michigan)
Thalictrum dasycarpum	Tall meadowrue
Verbena hastata	Blue vervain
Vernonia missurica	Ironweed
Veronicastrum virginicum	Culver's root

Table Appendix L-4 - Species List for Planting Zone 3 - Continued (2 of 2)

Zone 3 - Wet meadow zone	**Permanent Moisture Zone**
Scientific Name	**Common Name**
Grasses, Sedges and Rushes	
Andropogon gerardii	Big bluestem
Bromus ciliatus	Fringed brome
Calamagrostis canadensis	Canada blue-joint grass
Carex bebbii	Bebb's sedge
Carex comosa	Bristly (Cosmos) sedge
Carex crinita	Fringed sedge
Carex hystericina	Porcupine sedge
Carex lacustris	Lake Bank sedge
Carex languinosa	Wooly sedge
Carex lasiocarpa	Wooly needle sedge
Carex retrorsa	Retrorse sedge
Carex stipata	Awl-fruited sedge
Carex vulpinoidea	Fox sedge
Eleocharis obtusa	Blunt spikerush
Elymus canadensis	Canada Wild Rye
Elymus riparius	River Bank Wild Rye
Elymus virginicus	Virginia Wild Rye
Equisetum fluviatile	Horsetail
Glyceria grandis	Giant manna grass
Glyceria striata	Fowl manna grass
Juncus balticus	Baltic rush
Juncus effusus	Soft rush
Juncus torreyi	Torrey rush
Leersia oryzoides	Rice-cut grass
Panicum virgatum	Switchgrass
Scirpus atrovirens	Green bulrush
Scirpus cyperinus	Woolgrass
Scirpus fluviatilis(Schoenoplectus f.)	River bulrush
Scirpus americanus (Schoenoplectus pungens)	Three-square bulrush
Scirpus validus(Schoenoplectus tabernaemontani)	Soft-stem bulrush
Spartina pectinata	Prairie cord grass

Table Appendix L-5 - Species List for Planting Zone 4

Zone 4 - Floodplain zone	**Flooded during snowmelt and large storms Zone**
Scientific Name	**Common Name**
Trees and Shrubs	
Acer saccharinum	Silver maple
Alnus incana	Speckled alder
Aronia melanocarpa	Black chokeberry
Betula nigra	River birch
Celtis occidentalis	Hackberry
Cephalanthus occidentalis	Buttonbush
Cornus amomum	Silky dogwood
Cornus sericea	Red-osier dogwood
Physocarpus opulifolius	Ninebark
Populus deltoids	Eastern cottonwood
Quercus bicolor	Swamp white oak
Salix discolor	Pussy willow
Salix exigua	Sandbar willow
Salix nigra	Black willow
Sambucus pubens	Red-berried elder
Spiraea alba	Meadowsweet
Viburnum lentago	Nannyberry
Viburnum trilobum	High bush cranberry
Forbs and Ferns	
Anemone Canadensis	Canada anemone
Aster puniceus (A. luncidulus)	Swamp aster
Boltonia asteroides	False aster
Impatiens capensis	Jewelweed
Lobelia cardinalis	Cardinal flower
Lobelia siphilitica	Blue lobelia
Lysimachia thrysiflora	Tufted loosestrife
Physostegia virginiana	Obedient plant
Potentilla palustris	Marsh cinquefoil
Scutterlaria lateriflora	Mad-dog skullcap
Silphium perfoliatum	Cup plant (Threatened in Michigan)
Symplocarpus foetidus	Skunk cabbage
Vernonia missurica	Ironweed
Grasses, Sedges and Rushes	
Carex comosa	Bristly (Cosmos) Sedge
Elymus virginicus	Virginia wild rye
Elymus canadensis	Canada Wild Rye
Elymus riparius	River Bank Wild Rye
Leersia oryzoides	Rice-cut grass
Panicum virgatum	Switchgrass
Scirpus atrovirens	Green bulrush
Spartina pectinata	Prairie cord grass

Table Appendix L-6 - Species List for Planting Zone 5

Zone 5 Upland zone	**Seldom or never inundated Zone**
Scientific Name	**Common Name**
Trees and Shrubs	
Cornus racemosa	Gray dogwood
Populus tremuloides	Quaking aspen
Quercus bicolor	Swamp white oak
Viburnum lentago	Nannyberry
Viburnum trilobum	American cranberry
Forbs and Ferns	
Agastache scrophulariaefolia	Giant hyssop
Allium stellatum	Prairie wild onion
Arisaema triphyllum	Jack-in-the-pulpit
Artemisia ludoviciana	Prairie sage
Asclepias tuberosa	Butterfly milkweed
Aster laevis	Smooth aster
Aster lanceolatus (simplex)	Panicled aster
Aster macrophyllus	Bigleaf aster
Aster pilosus	Frost aster
Athyrium filix-femina	Lady fern
Boltonia asteroids	False aster
Epilobium angustifolium	Fireweed
Galium boreale	Northern bedstraw
Helianthus grosseserratus	Sawtooth sunflower
Heuchera richardsonii	Prairie alumroot
Monarda fistulosa	Wild bergamot
Onoclea sensibilis	Sensitive fern
Potentilla palustris	Marsh cinquefoil
Pteridium aquilinum	Bracken fern
Pycnanthemum virginianum	Mountain mint
Ratibida pinnata	Yellow coneflower
Rudbeckia subtomentosa	Brown-eyed Susan (Threatened in Michigan)
Smilacina racemosa	False Solomon's seal
Solidago flexicaulis	Zig-zag goldenrod
Solidago riddellii	Riddell's goldenrod
Solidago rigida	Stiff goldenrod
Tradescantia ohiensis	Ohio spiderwort
Veronicastrum virginicum	Culver's root
Zizia aurea	Golden alexanders
Grasses, Sedges and Rushes	
Andropogon gerardii	Big bluestem
Panicum virgatum	Switchgrass
Schizachyrium scoparium	Little bluestem
Sorghastrum nutans	Indian grass

Table Appendix L-7 - Prohibited Invasive Species List

Scientific Name	Common Name	National Wetland Category	Type
Acer ginnala	Amur maple	Upland	Tree
Acer platanoides	Norway maple	Upland	Tree
Agropyron repens	Quake grass	Facultative Upland	Grass
Alliaria petiolata	Garlic mustard	Facultative	Forb
Alnus glutinosa	Black alder	Facultative Wetland	Tree
Arctium minus	Common burdock	Upland	Forb
Berberis thunbergii	Japanese barberry	Facultative Upland (-)	Shrub
Berberis vulgaris	Common barberry	Facultative Upland	Shrub
Bromus inermis	Hungarian brome, smooth brome	Upland	Grass
Celastrus orbiculatus	Oriental bittersweet	Upland	Vine
Centaurea maculosa	Spotted knapweed	Upland	Forb
Cirsium arvense	Canada thistle	Facultative Upland	Forb
Cirsium vulgare	Bull thistle	Facultative Upland (-)	Forb
Convolvulus arvensis	Field-bindweed	Upland	Forb
Coronilla varia	Crown vetch	Upland	Forb
Cotoneaster microphyllus	Cotoneaster	Upland	Shrub
Ctonoeaster pannosus	Cotoneaster	Upland	Shrub
Cotoneatser lacteus	Cotoneaster	Upland	Shrub
Dipsacus laciniatus	Cut-leaved teasel	Upland	Forb
Elaeagnus umbellata	Autumn olive	Facultative Upland	Shrub
Euonymus alata	Burningbush	Upland	Shrub
Euonymus fortunei	Wintercreaper	Upland	Vine
Euphorbia esula	Leafy spurge	Upland	Forb
Hendra helix	English ivy	Upland	Vine
Hesperis matronalis	Dame's rocket	Upland	Forb
Ligustrum obtusifolium	Border privet	Upland	Shrub
Ligustrum vulgare	Common privet	Facultative (-)	Shrub
Lonicera japonica	Japanese honeysuckle	Facultative Upland	Vine
Lonicera maackii	Maack's or amur honeysuckle	Upland	Shrub
Lonicera morrowi	Morrow's honeysuckle	Upland	Shrub
Lonicera tatarica	Smooth tartarian honeysuckle	Facultative Upland	Shrub
Lonicera x bella	Showy bush honeysuckle	Upland	Shrub
Lythrum salicaria	Purple loosestrife	Obligate Wetland	Forb
Melilotus alba	White sweet clover	Facultative Upland	Forb
Melilotus officinalis	Yellow sweet clover	Facultative Upland	Forb
Miscanthus sinensis	Chinese silver grass	Upland	Grass
Myriophyllum spicatum	Eurasian water milfoil	Obligate Wetland	Forb
Pachysandra terminalis	Pachysandra	Upland	Forb
Pastinaca sativa	Wild parsnip	Upland	Forb
Phalaris arundinacea	Reed canary grass	Facultative Wetland (+)	Grass
Phalaris canariensis	Canary grass	Facultative Upland	Grass
Phragmites australis	Reed	Facultative Wetland (+)	Grass
Polygonum cuspidatum	Japanese knotweed	Facultative Upland	Forb
Polygonum sachalinense	Giant knotweed, japanese bamboo	Upland	Forb
Rhamnus cathartica	Common/european buckthorn	Facultative Upland	Tree
Rhamnus frangula	Glossy buckthorn, tallhedge	Facultative (+)	Shrub
Rhamnus utilis	Buckthorn	Upland	Shrub
Rosa multiflora	Multiflora rose	Facultative Upland	Shrub
Rumex crispus	Curly or sour dock	Facultative (+)	Forb
Spiraea japonica	Japanese spiraea	Upland	Shrub
Taxux cuspidata	Japanese yew	Upland	Shrub
Typha angustifolia	Narrow leaf cattail	Obligate Wetland	Forb
Typha x glauca	Hybrid cattail	Obligate Wetland	Forb
Ulmus pumila	Siberian elm	Upland	Tree

Appendix M - Agreement for Maintenance of Stormwater Management Practices

AGREEMENT FOR MAINTENANCE OF STORMWATER MANAGEMENT PRACTICES

[Owners Name], as "Owner(s)" of the property described below, in accordance with _____ (County/Municipal Regulations), agrees to install and maintain stormwater management practice(s) on the subject property in accordance with approved plans and conditions. The Owner further agrees to the terms stated in this document to ensure that the stormwater management practice(s) continues serving the intended function in perpetuity. This Agreement includes the following exhibits:

Exhibit A: Legal description of the real estate for which this Agreement applies ("Property").
Exhibit B: Location map(s) showing a location of the Property and an accurate location of each stormwater management practice affected by this Agreement.
Exhibit C: Long-term Maintenance Plan that prescribes those activities that must be carried out to maintain compliance with this Agreement.

Note: After construction has been verified and accepted by the County/Municipality for the stormwater management practices, an addendum(s) to this agreement shall be recorded by the Owner showing design and construction details and provide copies of the recorded document to the County/Municipality. The addendum may contain several additional exhibits.

Through this Agreement, the Owner(s) hereby subjects the Property to the following covenants, conditions, and restrictions:

1. The Owner(s), at its expense, shall secure from any affected owners of land all easements and releases of rights-of-way necessary for utilization of the stormwater practices identified in Exhibit B and shall record them with the County/Municipality 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 County/Municipality.
2. The Owner(s) shall be solely responsible for the installation, maintenance and repair of the stormwater management practices, drainage easements and associated landscaping identified in Exhibit B in accordance with the Maintenance Plan (Exhibit C).
3. No alterations or changes to the stormwater management practice(s) identified in Exhibit B shall be permitted unless they are deemed to comply with this Agreement and are approved in writing by the County/Municipality.
4. The Owner(s) 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 management practice(s) identified in Exhibit B in accordance with the Maintenance Plan (Exhibit C).

5. The Owner(s) shall annually, by December 30th, provide to the County/Municipality records (logs, invoices, reports, data, etc.) of inspections, maintenance, and repair of the stormwater management practices and drainage easements identified in Exhibit B in accordance with the Maintenance Plan. Inspections are required at least after every major rain event.

6. The County/Municipality or its designee is authorized to access the property as necessary to conduct inspections of the stormwater management practices or drainage easements to ascertain compliance with the intent of this Agreement and the activities prescribed in Exhibit C. Upon written notification by the County/Municipality or their designee of required maintenance or repairs, the Owner(s) shall complete the specified maintenance or repairs within a reasonable time frame determined by the County/Municipality. The Owner(s) shall be liable for the failure to undertake any maintenance or repairs.

7. If the Owner(s) does not keep the stormwater management practice(s) in reasonable order and condition, or complete maintenance activities in accordance with the Plan contained in Exhibit C, or the reporting required in 3 above, or the required maintenance or repairs under 4 above within the specified time frames, the County/Municipality is authorized, but not required, to perform the specified inspections, maintenance or repairs in order to preserve the intended functions of the practice(s) and prevent the practice(s) from becoming a threat to public health, safety, general welfare or the environment. In the case of an emergency, as determined by the County/Municipality, no notice shall be required prior to the County/Municipality performing emergency maintenance or repairs. The County/Municipality may levy the costs and expenses of such inspections, maintenance or repairs plus a ten percent (10%) administrative fee against the Owner(s). The County/Municipality at the time of entering upon said stormwater management practice for the purpose of maintenance or repair may file a notice of lien in the office of the Register of Deeds of the County/Municipality upon the property affected by the lien. If said costs and expenses are not paid by the Owner(s), the County/Municipality may pursue the collection of same through appropriate court actions and in such a case, the Owner(s) shall pay in addition to said costs and expenses all costs of litigation, including attorney fees.

8. The Owner(s) hereby conveys to the County/Municipality an easement over, on and in the property described in Exhibit A for the purpose of access to the stormwater management practice(s) for the inspection, maintenance and repair thereof, should the Owner(s) fail to properly inspect, maintain and repair the practice(s).

9. The Owner(s) agrees that this Agreement shall be recorded and that the land described in Exhibit "A" shall be subject to the covenants and obligations contained herein, and this agreement shall bind all current and future owners of the property.

10. The Owner(s) agrees in the event that the 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 management practice(s). 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 Property.

11. The Owner(s) agree that the rights, obligations and responsibilities hereunder shall commence upon execution of the Agreement.

12. 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.

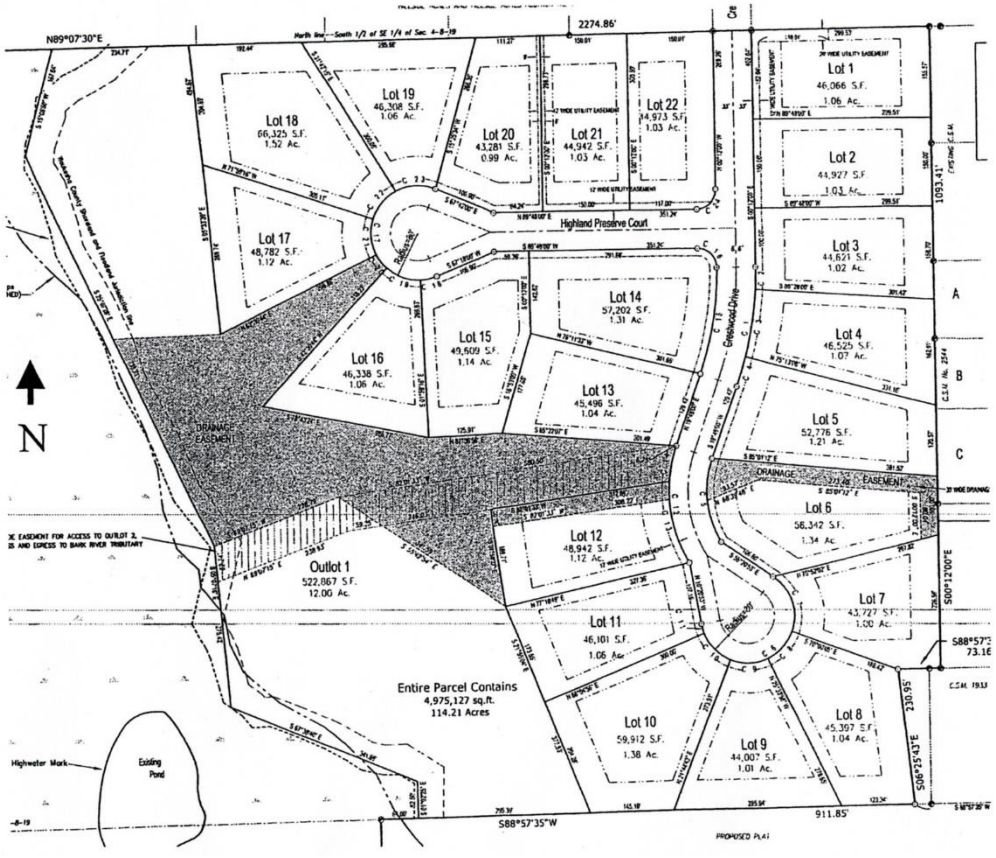
Exhibit A – Legal Description (Sample)

The following description and reduced copy map identifies the land parcel(s) affected by this Agreement.

[*Note: An example legal description is shown below. This exhibit must be customized for each site, including the minimum elements shown. It must include a reference to a Subdivision Plat, Certified Survey number, or Condominium Plat, and a map to illustrate the affected parcel(s).*]

Project Identifier: Clinton Preserve Subdivision Acres: 40
Date of Recording: October 22, 2006
Map Produced by: ABC Engineering, P.O. Box 20, Clinton Twp., MI
Legal Description: **Lots 1 through 22 of Clinton Preserve Subdivision, located in the Southwest Quarter (SW1/4) of Section 16, Township 2N, Range 13E (Clinton Township) Macomb County, Michigan.**
[If no land division is involved, enter legal description as described on the property title here.]

Clinton Preserve Subdivision



Drainage Easement Restrictions: Shaded area on map indicates a drainage easement for stormwater collection, conveyance, and treatment. No buildings or other structures are allowed in these areas. No grading or filling is allowed that may interrupt stormwater flows in any way. See Exhibit C for specific maintenance requirements for stormwater management practices within this area. See subdivision plat for details on location.

Exhibit B – Location Map (Sample)
Stormwater Management Practices Covered by this Agreement

[*An example location map and the minimum elements that must accompany the map are shown below. This exhibit must be customized for each site. Map scale must be sufficiently large enough to show necessary details*.]

The stormwater management practices covered by this agreement are depicted in the reduced copy of a portion of the construction plans, as shown below. The practices include on wet detention basin, two forebays, two grass swales (conveying stormwater to the forebays) and all associated pipes, earthen berms, rock chutes, and other components of these practices. All of the noted stormwater management practices are located within a drainage easement in Outlot 1 of the subdivision plat as noted in Exhibit A.

Subdivision Name: **Clinton Preserve Subdivision**
Stormwater Practices: **Wet Detention Basin #1, forebays (2), grass swales (2)**
Location of practices: **All that part of Outlot 1, bounded and described as follows:** [If no land division is involved, enter a metes and bounds description of the easement area.]
Titleholders of Outlot 1: **Each Owner of Lots 1 through 22 shall have equal (1/22) undividable interest in Outlot 1** [For privately owned stormwater management practices, the titleholder(s) must include all new parcels that drain to the stormwater management practice.]

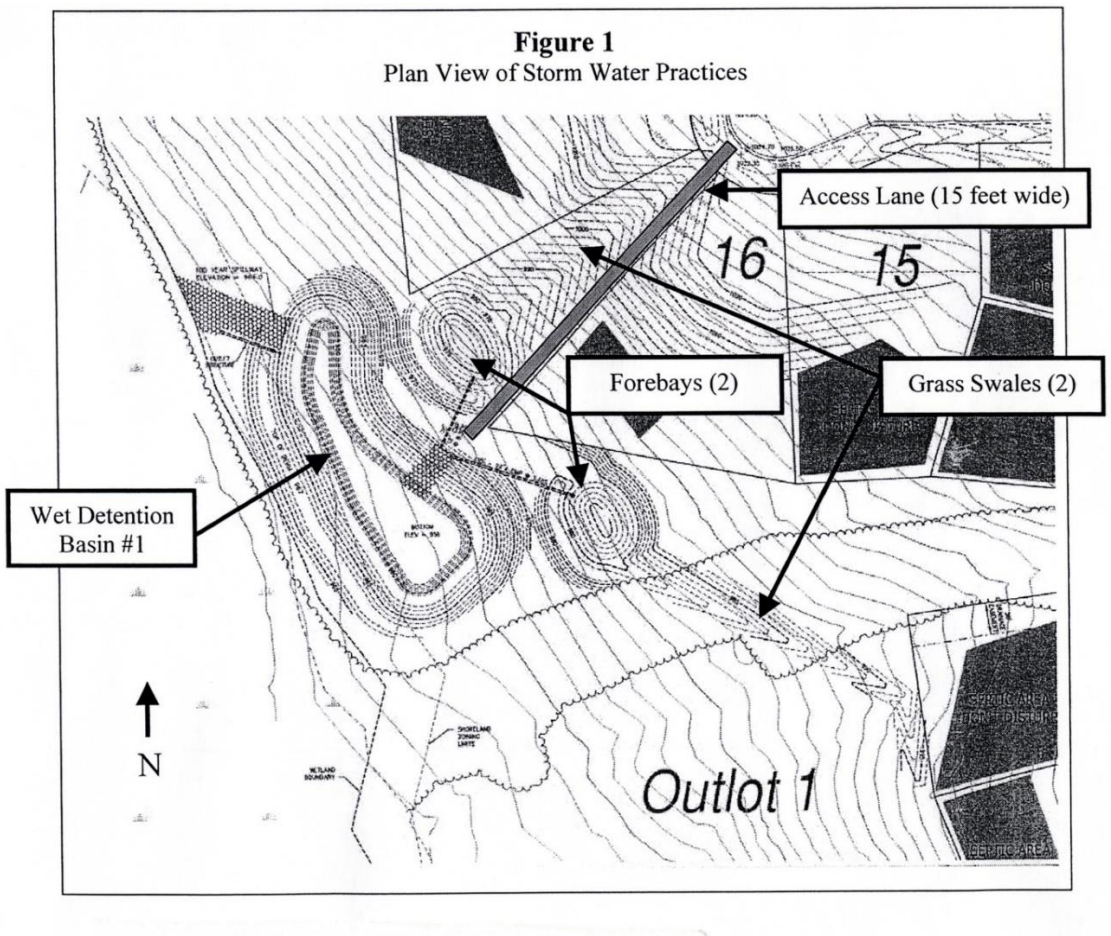


Exhibit C
Stormwater Practice Maintenance Plan

[Example Maintenance Plan language is provided below. The exhibit must be customized for each site. The minimum elements of this exhibit include: a description of the drainage area and the installed stormwater management practices, a description of the specific maintenance activities for each practice which should include in addition to specific actions:

- *employee training and duties,*
- *routine service requirements,*
- *operating, inspection and maintenance schedules, and*
- *Detailed construction drawings showing all critical components and their elevations.]*

This exhibit explains the basic function of each of the stormwater practices listed in Exhibit B and provides the minimum specific maintenance activities and frequencies for each practice. The maintenance activities listed below are aimed to ensure these practices continue serving their intended functions in perpetuity. The list of activities is not all inclusive, but rather indicates the minimum maintenance that is expected to be preformed for these practices. Vehicle access to the stormwater practices is shown in Exhibit B. Any failure of a stormwater practice that is caused by lack of maintenance will subject the Owner(s) to enforcement of the provisions listed in the Agreement by the County/Municipality.

System Description

The wet detention basin "A" shown in Exhibit B is designed to treat the water quality volume, provide extended detention of the bankfull event, and maintain pre-development downstream peak flows. The basin has two forebays located at the low end of two grass swales. In addition to conveyance, the grass swales detain, filter and infiltrate the runoff from smaller storms. Each forebay is 5 feet deep and is connected to the main pool by 18 and 24 inch metal pipes that outlet onto a rock chute. The forebays allow coarse sediments to settle, thus reducing maintenance frequency of the main basin. The main pool will remove a portion of the fine sediment. The locations, dimensions, elevations and details of the practices and structures are provided in the exhibit figures.

The main basin receives runoff from a 67.1 acre drainage area (41.2 acres within the subdivision and 25.9 acres off-site drainage from the east). During high rainfall or snow melt events, the water level will temporarily rise in the basin and slowly drain back down to the elevation of the control structure. The water level is controlled by a 12-inch concrete pipe extending through the berm in the northwest corner of the basin (see exhibit figures). On the face of the 12-inch pipe is a metal plate with a 3-inch drilled orifice. This orifice restricts the outflow rate and controls the water level at elevation 962.5. Washed 2-inch stone is placed in front of the orifice to prevent clogging. During extreme runoff events high flows may enter the grated concrete riser or flow over the rock lined emergency spillway.

Maintenance Requirements

The following activities will be completed to ensure the proper function of the stormwater practices described above:

1. All personnel providing inspection and maintenance services shall be a Professional Engineer, Certified Professional in Storm Water Quality (CPSWQ), NICET Certified Engineering Technologist in Stormwater and Wastewater System Inspection, or an EGLE Certified NPDES (construction site) Stormwater Operator.
2. An inspection and maintenance schedule will be developed and a log will be kept of all inspections, maintenance activities, and repairs. The log will provide the date of the activity, the name of the person providing the service and a description of the activity.
3. The practices will be inspected after each major rain event (such as >2.2 inches over 24 hours) for general condition.
4. All outlet pipes, the trash rack on the outlet riser and the stone in front of the restricted orifice will be inspected at least quarterly to ensure there is no blockage from floating debris or ice and that the water level is as designed. Any blockage will be removed immediately and irregularities in water level corrected. The washed stone around riser structures will be replaced at least every two years.
5. The vegetation in and around the basin, in the swales and buffer strips will be inspected semi-annually to assess growth, survival and percent cover. Plants will be replaced and areas will be seeded as appropriate.
6. The two swales planted with native sedges, grasses, and wildflowers shall be established and preserved to allow the free flow of runoff. No woody plants such as bushes or trees or buildings or structures will be allowed in the swale areas. The swales will not be mowed. They may be maintained by string trimming to a minimum height of 6" before April 1 to remove dead plant materials. Woody plants may be trimmed to the ground every few years. Invasive plant species and pests shall be controlled through IPM practices.
7. No grading or filling will be done that will interrupt flows.
8. Grass, swales, inlets and outlets will be checked after heavy rains and periodically (minimum of quarterly) for signs erosion. Eroding areas will be repaired immediately to prevent premature sediment build-up in the forebays or main basin. Appropriate erosion control blankets will be utilized in repairing grassed areas.
9. No trees or woody plants will be planted or allowed to grow on the berms of the basin. The berms will be inspected annually and any woody plants will be removed.
10. If floating algae or weed growth becomes a nuisance (decay, odors, etc.), it will be removed from the basin and/or forebays and placed in an appropriate upland site away from drainage areas. Wetland vegetation will be established and maintained along the waters edge for esthetic and pollutant removal purposes.
11. The forebays and main basin will be inspected annually for sediment accumulation. Sediment in the forebays or the basin will be removed when it has accumulated to a level of 3 feet below the outlet elevation or when 60 percent of the volume has been filled (typically every 5 to 10 years). All excavated sediment will be placed in an appropriate upland site and stabilized to avoid erosion.
12. No grading or filling of the basin or berm will be done except during sediment removal.
13. A minimum 25-foot buffer of native plants will be maintained around the forebays and basin for aesthetics, stabilization, pollutant removal, and goose deterrent purposes. The buffer strip and the grass filters may be maintained by string trimming to a minimum height of 6" before April 1 to remove dead plant materials, allow for erosion inspection, and prevent blockage of structures.

Appendix N - Drain Improvement Petition

NOTE: Petition information contained herein is provided as general reference only. Please contact the Macomb County Public Works Office to obtain copies of the most recent petition language before incorporating into project design.

Application to Improve a County Drain

Revised January 1, 2021

To: Candice S. Miller
Macomb County
Public Works Commissioner

The undersigned owns property, described on Exhibit A attached, located within the Drainage District for the Drain, an established county drain under the jurisdiction of the Macomb County Public Works Commissioner. The undersigned requests that a portion of the drain be improved in order to facilitate its use of the property, pursuant to provisions of the Michigan Drain Code, Public Act 40 of 1956, Michigan Compiled Laws 280.1 and, if applicable, the Michigan Subdivision Control Act, Public Act 288 of 1967, Michigan Compiled Laws 560.1. The nature and location of the drain improvement requested are generally described as follows:

_____

_____

_____

_____

The undersigned agrees to pay all costs related to the proposed drain improvement, including all costs that would otherwise be assessed against signers of the application for the drain improvement, and other property owners in the drainage district. The undersigned agrees to deposit a non-refundable fee to the MCPWO for administrative and legal expenses related to the processing of this application to improve a county drain, to convey all easements necessary for the drain improvement and maintenance.

The undersigned agrees to protect, defend, indemnify and hold Macomb County, Macomb County Public Works Commissioner, subject Drainage District, constituent units of government and public agencies within the subject Drainage District and officers, agents and employees of the above named entities free and harmless from and against any and all losses, penalties, damages, settlements, costs, charges, professional fees or other expenses or liabilities of every kind and character arising out of or relating to any and all claims, legal fees, liens, demands, court costs, obligations, actions, proceedings or causes of action of every kind and character in connection with or arising directly or indirectly out of this Application and/or its performance. Without limiting the generality of the foregoing, all claims, etc. relating to personal injury, death, damage to property, defects in materials or workmanship, actual or alleged infringement of any patent, trademark, copyright or of any other tangible or intangible personal or property right, or any actual or alleged violation of any applicable statute, ordinance, administrative order, rule, regulation, or court decree, shall be included in the indemnity. The Applicant agrees to investigate, handle, respond to, provide defense for and defend any such claims, etc., at its sole expense and agrees to bear all other costs and related expenses, even if the claims, etc. are groundless, false or fraudulent. In any case in which this indemnification would violate legal prohibition, the foregoing provisions concerning indemnification shall not be construed to indemnify the indemnities for damage arising out of bodily injury to persons or damage to property caused by or resulting from the sole negligence of the indemnities.

By: _____ Date:_____
(Signature)

_____
(Print name & title)

_____
(Company name, if applicable)

_____
Address, City, State, Zip Code Telephone Fax

Name of Applicant's Engineering Firm:_____

_____
Address, City, State & Zip Code Telephone Fax

Exhibit A

Description of Applicant's property located within the Drainage District for the _____ _____ Drain.

City, Township or Village:

Property Sidwell Number:

Property Address, if available:

Commercial Name, if applicable:

Legal Description:

Completed application is to be accompanied by a check in the amount of $2,600.00, payable to the MACOMB COUNTY PUBLIC WORKS.

Do not write below this line. To be completed by Macomb County Public Works Office.

Amount of Deposit Date of Deposit Check Number Project Number

Drain Improvement Petition - One Site.-1-2019

OFFICE OF
MACOMB COUNTY PUBLIC WORKS COMMISSIONER
CANDICE S. MILLER

PETITION FOR MAINTENANCE AND IMPROVEMENT OF A DRAIN

To the Macomb County Public Commissioner:

The signers of this petition request that the _____ Drain be maintained and improved as provided in Chapter 8 of Public Act 40 of 1956, as amended, to alleviate drainage issues in the Drainage District. ALL COSTS ARE TO BE BORNE BY THE DEVELOPER.

The _____ Drain is located in _____, Macomb County, Michigan.

This petition is signed by at least five (5) freeholders with lands liable for assessment in the _____ Drain Drainage District.

Signers acknowledge and understand that this Petition may be circulated and signed in counterparts, and that all such counterparts together constitute a single Petition.

	Signature	Printed Name	Property ID Number
1			
	Address	Date	
2			
	Address	Date	
3			
	Address	Date	
4			
	Address	Date	

	Signature	Printed Name	Property ID Number
5			
	Address	Date	
	Signature	Printed Name	Property ID Number
6			
	Address	Date	
	Signature	Printed Name	Property ID Number
7			
	Address	Date	

Completed petition is to be accompanied by a check in the amount of $3,000.00, payable to the MACOMB COUNTY TREASURER.

AFFIDAVIT OF CIRCULATOR OF PETITION

I Hereby Certify that I did personally circulate this petition and the signatures to same were made in my presence and are the genuine signatures of those whose names are affixed.

Dated:_____, 20____

_____
Print Name:

STATE OF MICHIGAN)
)ss.
COUNTY OF _____)

Telephone No.: _____

On _____, 20____, before me, a Notary Public in and for said County, personally appeared_____to me known to be the person described in and who circulated the foregoing petition.

_____
_____, Notary Public
_____ County, Michigan
Acting in _____ County, Michigan
My Commission Expires: _____

INSTRUCTIONS FOR CIRCULATOR OF PETITION

- Property within the drainage district must be identified by street address, permanent parcel number, or subdivision name and lot number. One of these forms of identification must be provided or the petition will not be accepted.
- The term "Freeholder" includes persons: who own real property free and clear, who own property subject to a mortgage, and who are buying or selling property on a land contract. It also includes parties who own a life estate or who have a lifetime lease on property within the drainage district.
- On property owned by a husband and wife, both may sign the petition and have their signatures counted.
- If property is owned by a corporation, the petition must be signed by its president or secretary.
- If property is being sold on land contract, both the buyer or seller may sign and have their signatures counted.
- On property owned by joint tenants in common, all tenants may sign and have their signatures counted.
- A minimum of five signatures is required.
- **Completed petition is to be accompanied by a check in the amount of $3,120 payable to the MACOMB COUNTY PUBLIC WORKS.**

Appendix O - Storm Drain Design Chart

$$Q = \frac{1.486\ AR^{2/3}S^{1/2}}{n}$$

$$Q = CIA$$

STORM DRAIN DESIGN CHART

DATE: _____

PROJECT NAME: _____

CALCULATIONS BY: _____

From M.H.	To M.H.	Increment Acres (A)	Runoff Coeff. (C)	Equiv. Area (CA)	Total Area (CA)	Time of Conc. T_c (Min.)	Intensity I (In/Hr.)	Flow Q=CIA (c.f.s.)	Full Flow Capacity of Pipe (c.f.s.)	Diam. of Pipe (In.)	Length of Pipe Run (Ft.)	Slope of Pipe (%)	Slope of HG (%)	Full Flow Velocity V (Ft/Sec.)	Pipe Flow Time (Min.)	Upper End Rim Elev.	Upper End HG Elev.	Lower End HG Elev.	Upper End Invert Elev.	Lower End Invert Elev.

Appendix P - Procedures for Submittal & Approval of Subdivision Plats

Subdivision Plat Procedure - Purpose

All plats recorded with the Register of Deeds must conform to the Land Division Act, Act 288 of the Public Acts of 1967, as amended. Under this Act, the Macomb County Public Works Commissioner is responsible for ensuring that the drainage or stormwater management system of a subdivision is adequate for the development, and for protecting landowners and natural resources. The procedures, standards and recommendations set forth in the *Procedures and Design Standards for Stormwater Management* are designed for these purposes.

The Macomb County Public Works Commissioner has the authority, through the subdivision review process, in accordance with the provisions of Act 288, to require that county drains, both inside and outside a plat, be improved to the standards established by the MCPWO when necessary for the proper drainage of a proposed subdivision.

Under these *Procedures and Design Standards for Stormwater Management*, the MCPWO will ensure that all stormwater facilities necessary for a proposed subdivision have an appropriate governmental unit responsible in perpetuity for performing maintenance or for overseeing the performance of maintenance by a private entity, such as a property owner's association.

These standards of the MCPWO apply in the review of the following:

- Applications for permits to discharge to a county drain under P.A. 40 of 1956, as amended.
- Lot splits and subdivision sites to be platted under Public Act 288.
- Review of stormwater system plans in other classes of developments or redevelopments, when agreed upon by local governments and the county.

These rules provide minimum standards to be complied with by proprietors, and in no way limit the authority of the local municipality in which the development is situated to adopt and enforce higher standards as a condition of approval of the final plat.

Tentative Preliminary Plat Submittal and Review

Submittal Requirements & Procedures

The submittal of a tentative preliminary plat is encouraged but not required. The submittal will aid the site engineer and proprietor in understanding any requirements that may be required by the MCPWO. However, if a tentative preliminary plat is submitted for MCPWO review, certain plat requirements must be met. These requirements have been developed in the context of tentative preliminary plat submittal under the Michigan Land Division Act.

1. A tentative preliminary plat showing the layout of the area intended to be subdivided or developed will be submitted to the MCPWO by the proprietor. This plat will be prepared under the direction of, and sealed and signed by, a registered professional engineer or a registered land surveyor. The tentative preliminary plat shall be drawn to a standard engineering scale on 24" x 36" sheets.
2. Two copies of the tentative preliminary plat, prepared in accordance with the rules set forth in this section, will be submitted together with a letter of transmittal requesting that the tentative preliminary plat be reviewed. The names of the proprietor and engineering or surveying firm, with mailing and emailing addresses, fax, and telephone numbers for each, will be included with the transmittal.
3. Should the proprietor plan to subdivide or develop a given area but wishes to begin with only a portion of the total area, the original tentative preliminary plat will include the proposed general layout for the entire area. The first phase of the subdivision will be clearly superimposed upon the overall plan in order to illustrate clearly the method of development that the proprietor intends to follow. Each subsequent plat or phase will follow the same procedure until the entire area controlled by the proprietor is subdivided.

Should the proprietor plan to subdivide or develop a given area but wishes to begin with only a portion of the total area, the original tentative preliminary plat will include the proposed general layout for the entire area.

4. Review and comments by the MCPWO of only one portion or phase of the subdivision does not ensure final acceptance of any subsequent phases or the overall general plat for the entire area, nor does it mandate that the overall general plat be followed as originally proposed if deviations or modifications acceptable to the MCPWO are proposed.

General Information Requirements

The development shall accept existing drainage originating outside of the development limits that flows onto or across the development. All tentative preliminary plats will include the following information:

1. The location of the proposed development by means of a small location map.
2. Date of plat design and any revision dates.
3. North arrow.
4. The township, city or village in which the parcel is situated.
5. The sidwell number and parcel description that includes the section number, Town and Range in which the parcel is situated.
6. The number of acres to be developed.
7. Contours, at 2-foot intervals or less, with stated benchmark and horizontal and vertical NAVD 88 datum. Include contour information for 100 feet off-site on adjacent properties.

8. The proposed street, alley, and lot layouts and approximate dimensions.
9. The location, name and description of all on-site and adjacent off-site features that may be relevant in determining the overall requirements for the subdivision. These features may include, but are not limited to the following:
    a. Adjoining roads, subdivisions, and other developments
    b. Schools, parks, and cemeteries
    c. Drains and drain name, sewers, water mains, septic fields, and wells
    d. High tension power lines, underground transmission lines, gas mains, pipelines and all other utilities
    e. Railroads
    f. Existing easements including recorded Liber and Page, if available. Existing and proposed County drain easements shall be indicated on the plats as well as the Certified True Copy and shall be designated as 'XX feet wide easement to the 'DRAIN NAME' Drainage District for drainage'.
    g. Natural and artificial watercourses, regulated wetlands, and wetland boundaries, floodplains, lakes, bays, and lagoons
    h. Designated natural areas
    i. Soils description in accordance with the USDA National Resource Conservation Service (NRCS) standard soils criteria
    j. Any proposed environmental mitigation features
    k. Current/proposed zoning classification

Tentative Preliminary Plat Review

The MCPWO will review and provide comment on a tentative preliminary plat within thirty (30) days of its submittal. If the MCPWO has comments on the proposed tentative preliminary plat as originally submitted, the MCPWO will notify the proprietor in writing. One copy of the tentative preliminary plat, with comments, will be returned to the proprietor. Submittal of the tentative preliminary plat is not required before the MCPWO will proceed with review of the final preliminary plat.

Final Preliminary Plat Submittal and Approval

Platted development Submittal Requirements & Procedures

The MCPWO will review the final preliminary plat to assure that adequate stormwater drainage will be provided and that the proposed stormwater management system adequately provides for water quantity and quality management to ensure protection of property owners, lands, and watercourses both within the proposed development and downstream. Following are the minimum submittal requirements for final preliminary plats:

1. For all projects to be reviewed by the MCPWO, the proprietor will submit two copies of the final preliminary plat with a letter of transmittal requesting review and approval.
2. The proprietor shall include a long-term maintenance plan for the development's stormwater management system (i.e. detention basin) and a signed maintenance agreement with the entity to assume responsibility of the maintenance.

In addition to all previously described submittal requirements, the final preliminary plat will include, at a minimum, the following information:

1. All information described in Appendix P for tentative preliminary plat approval except as modified herein.
2. The names of the proprietor and engineering firm, with mailing and e-mailing addresses, fax, and telephone numbers for each shall be included with the transmittal. Plats prepared will be in accordance with Part 1 of these standards, under the direction of, and sealed and signed by, a professional engineer registered in the State of Michigan.
3. For all projects, the proprietor will submit two complete sets of the final preliminary plat, drawn to a scale no smaller than 1" = 40', and on 24" x 36" sheets. The plat shall be sealed and signed by a professional engineer, and drawn to standard engineering scales. The submittal shall include all required information listed in the submittal requirements, as well as the following, where applicable:
    a) The proposed project layout with all dimensions, including the proposed drainage system for the project. Show all utility crossings.
    b) Topographic maps, at two-foot contour intervals or less on NAVD 88 datum, showing existing and proposed grades, as well as off-site topography over at least 100 feet of the adjoining property. Maps will also show all existing watercourses, lakes and wetlands, and the extent of all off-site drainage areas contributing flow to the development.
    c) The date the site topographic survey was performed. Where existing conditions, at the time of plan submittal, differ from conditions at the time of survey, the MCPWO may require an updated topographic survey.
    d) Plans and details of proposed retention/detention facilities. Soil borings are required at the sites of these facilities.
    e) Plan views, profiles and details of all roads and storm sewers. The storm sewer plans will include type, size, and class of pipe, length of run, percent of slope, invert elevations, rim

elevations, cover depth, backfill type, depth and compaction, and profile of the hydraulic gradient, as specified in these *Procedures and Design Standards for Stormwater Management*.

f) Storm sewer 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 cubic feet per second (cfs), and the flow velocities for enclosed systems. Refer to **Part V**. for calculation requirements.

g) A drainage area map, overlaid onto a copy of the site grading plan, which clearly shows the areas tributary to each inlet and/or storage basin. Any off-site drainage area boundaries tributary to a specific inlet and/or storage basin must be clearly mapped.

h) Plans, profiles, names, easements, and details of all open drains, drainage swales, and drainage structures. Approved 'Ours to Protect' and 'Report a Polluter' signage shall be required for the development at road crossings for open county drains. (See **Appendix D** for sign information.)

i) Plans and details of the proposed soil erosion and sedimentation control (SESC) measures, both temporary (during construction) and permanent, as required by, P.A. 451, Part 91 Public Acts of 1994, as amended and the Macomb County SESC ordinance.

j) All construction specifications for the stormwater management facilities, including design data and criteria used for designing detention/retention basins and sizing all drainage structures and channels including weighted runoff coefficient calculations.

k) Open drains and watercourses shall be shown with a typical ditch cross-section and matching contours. Proposed cross-sections shall be shown with existing and proposed elevations and labeled with appropriate stations.

l) Locations of all septic/drain fields as approved by the Macomb County Health Department and of all reserve areas. Septic/drain fields and reserve areas shall not be located within County drain drainage easements.

m) A single sheet showing all proposed storm drainage facilities with drainage easements shall be submitted. This sheet shall be overlaid on the overall road and utility plan and drawn to a scale no smaller than 1" = 100'.

n) Drain easement sign locations within the county drain easement for open county drains. See **Appendix D** for sign information.

Platted Development Drainage Information Requirements

Development projects are required to provide access and capacity for any existing drainage tributary to the site. The increased volume of water discharged due to development of the site must not create adverse impacts to downstream property owners and watercourses. These adverse impacts may include, but are not limited to, flooding, excessive soil saturation, crop damage, erosion, and/or degradation in water quality or habitat. Proposed drainage for the development will conform to any established county drainage districts.

The increased volume of water discharged due to development of the site must not create adverse impacts to downstream property owners and watercourses.

The proposed drainage plan will, in every way feasible, respect and conform to the natural drainage patterns within the site and the watershed in which it is located or conform to drainage patterns approved by the MCPWO. All final preliminary plats will include the following required stormwater management information:

1. All calculations used in designing components of stormwater management systems.
2. The overall stormwater management system for the proposed development, indicating how stormwater management will be provided and where the drainage will outlet.
3. The location of any on-site and/or off-site stormwater management facilities and appropriate easements that will be dedicated to the entity responsible for future maintenance. Easement information will be consistent with Section III.5.
4. A description of the off-site outlet and evidence of its adequacy. Additional/adequate off-site easement may be required.
5. A map, at the USGS scale, showing the drainage boundary of the proposed development and its relationship with existing drainage patterns.
6. Provide a cross section of the existing drain with existing and proposed elevations.
7. Any natural watercourses and/or county drains passing through the proposed development, along with the following:
    a. Area of upstream watershed and current zoning.
    b. Preliminary calculations of runoff from the upstream area for both the 100-year and 2-year, 24-hour design storms, for fully proposed developed conditions according to the current land use plan for the area.

- Any natural watercourses or county drains that are adjacent to the development. If discharging to an adjacent watercourse or county drain, then 7a & 7b (of this list) requirements apply.
- If development is proposed in an area where special drainage problems exist or are anticipated at the site, on adjacent properties, or downstream, more stringent design requirements than contained in these *Procedures and Design Standards for Stormwater Management* may be

required. If any part of the site lies within a floodplain, then it shall satisfy local, state and federal requirements for subdivisions within a floodplain.

Final Preliminary Plat Approval

Approval of the final preliminary plat by the MCPWO is valid for two calendar years. If an extension beyond this period is needed, the proprietor will submit a written request to the MCPWO for an extension. The Macomb County Public Works Commissioner may grant one year extensions of the approval, and may require updated or additional information, if needed.

Should significant modifications be made to the plans after approval is granted from the MCPWO, a new set of plans must be submitted for review and approval. A cover letter shall be included with the plans which states the changes made to the plans.

Final Plat Submittal and Approval

Approval of the final plat and Certified True Copy (CTC) is required. Final plat review will be completed by the MCPWO within a reasonable timeframe following submittal by the proprietor. If the plat is not acceptable, written notice of rejection and the reasons therefore will be given to the proprietor. If the Commissioner approves the plat, s/he will affix his/her signature to it and the plat will be executed. As a condition of final plat approval, the Public Works Commissioner will require the following (See Appendix E for a Final Plat Checklist):

1. The municipal governing body in which the proposed development is located must approve the final preliminary plat. Evidence of this approval will be submitted to the MCPWO with the final plat.
2. On sites containing a county drain, complete subdivision agreements (including deed restrictions) and appropriate easement language must be submitted for the Public Works Commissioner's review and approval prior to submitting the final plat.
3. All provisions and drain improvements for County drains are required prior to approval.
4. A final plat, when submitted to the Public Works Commissioner for signature, will include the Public Works Commissioner's Certificate (see Appendix F for the Macomb County Public Works Commissioner's Certificate).

   A soil erosion permit under the guidelines of the Macomb County SESC Ordinance and the Michigan Soil Erosion and Sedimentation Control Act, P.A. 451, Part 91 Public Acts of 1994, as amended, must be obtained from the MCPWO, or other appropriate agency, prior to any construction.

Final Plat Recirculation

Upon recirculation of a final plat, the proprietor must provide in writing the reason(s) to the MCPWO for resigning. The proprietor shall provide any information to support such a request.

Appendix Q – Infiltration Testing Methodology

Open Pit Falling Head Procedure

The open pit falling head procedure is performed in an open excavation and therefore is a test of the combination of vertical and lateral infiltration.

1) Excavate a hole with bottom dimensions of approximately 2 feet wide by 2 feet deep into the native soil to the elevation of the proposed facility bottom. The test can be conducted in a machine-excavated pit.

2) Fill the hole with clean water a minimum of 12 inches, and maintain this depth of water for at least 4 hours (or overnight if clay soils are present) to presoak the native material.

3) Determine how the water level will be accurately measured. The measurements should be made with reference to a fixed point. A lath placed in the test pit prior to filling or a sturdy beam across the top of the pit are convenient reference points. The tester and excavator should conduct all testing in accordance with OSHA regulations.

4) After the pre-saturation period required by #2 above, refill the hole with water to 12 inches and record the draw-down time. Alternative water head heights may be used for testing provided the pre-saturation height is adjusted accordingly and the water head height used in infiltration testing is no more than 50 percent of water head height in the proposed stormwater system during the design storm event. Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower draining soils) or until all of the water has drained. In faster draining soils (sands and gravels), it may be necessary to shorten the measurement interval in order to obtain a well-defined infiltration rate curve. Constant head tests may be substituted for falling head tests at the discretion of the professional overseeing the infiltration testing.

5) Repeat the infiltration test until the change in measured infiltration rate between two successive trials is no more than 10 percent. The trial should be discounted if the infiltration rate between successive trials increases. At least three trials must be conducted. After each trial, the water level must be readjusted to the 12 inch level. Enter results into the data table (see Table VI-7).

6) The average infiltration rate over the last trial should be used to calculate the design infiltration rate without a factor of safety applied. Alternatively, the infiltration rate measured over the range of water head applicable to the project stormwater system design may be used at the discretion of the professional overseeing the testing. The final rate must be reported in inches per hour.

7) Upon completion of the testing, the excavation must be backfilled.

8) For very rapidly-draining soils, it may not be possible to maintain a water head above the bottom of the test pit. If the infiltration rate meets or exceeds the flow of water into the test pit, approximate the area over which the water is infiltrating, measure the rate of water discharging into the test pit (using a water meter, bucket or other device), and calculate the infiltration rate by dividing the rate of discharge (cubic inches per hour) by the area over which it is infiltrating (square inches).

Encased Falling Head Procedure

The encased falling head procedure is performed with a 6-inch diameter casing that is embedded approximately 6 inches into the native soil. The goal of this field test is to evaluate the vertical infiltration rate through a 6-inch plug of soil, without allowing any lateral infiltration. The test is not appropriate in gravelly soils or in other soils where a good seal with the casing cannot be established.

1) Embed a solid 6-inch diameter casing into the native soil at the elevation of the proposed facility bottom (see figure below). Ensure that the embedment provides a good seal around the pipe casing so that percolation will be limited to the plug of the material within the casing. This method can also be used when testing within hollow stem augers, provided the driller and tester are reasonably certain that a good seal has been achieved between the soil and auger.

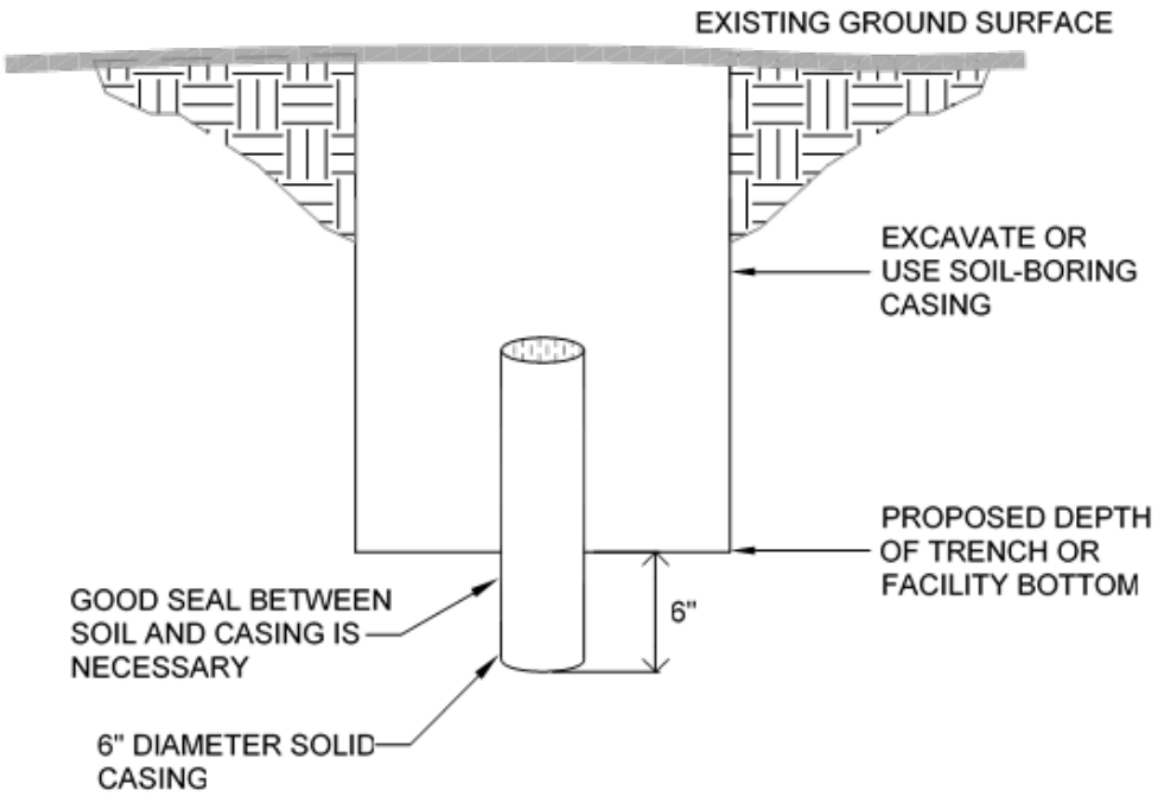
2) Fill the pipe with clean water a minimum of 1 foot above the soil to be tested, and maintain this depth for at least 4 hours (or overnight if clay soils are present) to presoak the native material In sandy soils with little or no clay or silt, soaking is not necessary. If after filling the hole twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.

3) To conduct the first trial of the test, fill the pipe to approximately 12 inches above the soil and measure the water level to the nearest 0.01 foot (⅛ inch). Alternative water head heights may be used for testing provided the pre-saturation height is adjusted accordingly and the water head height used in infiltration testing is 50 percent or less than the water head height in the proposed stormwater system during the design storm event. The level should be measured with a tape or other device with reference to a fixed point. The top of the pipe is often a convenient reference point. Record the exact time.

4) Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower soils) or until all of the water has drained. In faster draining soils (sands and gravels), it may be necessary to shorten the measurement interval in order to obtain a well defined infiltration rate curve. Constant head tests may be substituted for falling head tests at the discretion of the professional overseeing the infiltration testing. Successive trials should be run until the percent change in measured infiltration rate between two successive trials is minimal. The trial should be discounted if the infiltration rate between successive trials increases. At least three trials must be conducted. After each trial, the water level is readjusted to the 12 inch level. Enter results into the data table (see **Table VI-7**for an example infiltration test data table).

5) The average infiltration rate over the last trial should be used to calculate the un-factored infiltration rate. Alternatively, the infiltration rate measured over the range of water head applicable to the project stormwater system design may be used at the discretion of the professional overseeing the testing. The final rate must be reported in inches per hour.

6) Upon completion of the testing, the casing should be pulled and the test pit backfilled.



Double-Ring Infiltrometer Test

The double-ring infiltrometer test procedure should be performed in accordance with ASTM 3385-94. The test is performed within two concentric casings embedded and sealed to the native soils. The outer ring maintains a volume of water to diminish the potential of lateral infiltration through the center casing. The volume of water added to the center ring to maintain a static water level is used to calculate the infiltration rate. The double-ring infiltrometer is appropriate only in soils where an adequate seal can be established.