City of Rochester Hills

Engineering Design Standards

Adopted September 25, 2023

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

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ENGINEERING DESIGN STANDARDS

CHAPTER 1

General Requirements and Submittals

The items found in this Chapter contain the general requirements for the submittal of Engineering Construction Plans to the City of Rochester Hills for review, comment and approval. In addition, specific requirements pertaining to Water Mains, Sanitary Sewers, Storm Water Management, Paving and Grading follow this Chapter and apply as stated within their respective context.

Land Improvement Permit (LIP) Application

1. A properly completed Land Improvement Permit (LIP) Application shall be submitted to the Engineering Division. The application form is available at the Engineering Division. The required materials listed on the form must be submitted along with the application.

Submittal

1. Three sets of complete engineering construction plans, bearing the seal of a Professional Engineer, licensed to practice in the State of Michigan, shall be submitted to the Engineering Division for review. Each plan sheet shall contain the project name, the project owner, the City File Number (assigned by the City of Rochester Hills), and the section number.

2. A Certified Boundary Survey of the site, prepared and sealed by a Professional Surveyor, licensed to practice in the State of Michigan, or a copy of the complete plat, shall be submitted along with the Engineering Construction Plans.

3. Plans shall be submitted on twenty-four inches (24”) x thirty-six inches (36”) white plan sheets having black print, and shall be neatly and accurately prepared.

4. All engineering construction plans shall contain the latest version of the applicable City of Rochester Hills’ Standard Detail Sheets.

5. The cover sheet shall include a map showing the location of the proposed project, a symbol legend, a sheet index, a quantities table, and a permit schedule.

6. Existing information, topography, utilities, etc., shall be shown in gray or lighter line weight, while proposed improvements shall be shown in dark and heavy black lines. The legend shall clearly refer to all line symbols used.

7. For projects having more than one sheet of plans, a general plan having a scale of one inch (1”) equal to one-hundred feet (100’) shall be provided showing the overall project, and indicating the size and general location of all improvements shown in the detailed plans. Street names, street and easement widths, lot lines, lot dimensions, lot numbers, and ownership shall be shown on all plans.

8. Utilities shall be located in accordance with City Standards. Easement boundary lines shall be no closer than ten feet (10’) from the utility. Utilities shall typically be centered within easements and parallel to lot lines. Generally, utilities shall be constructed in the road right-of-way or in easements adjacent to the road right-of-way, and shall not be located under existing or proposed pavement, including pathways and sidewalks. Side yard easements should be avoided if possible.

9. Grading plans are required for all developments. Refer to *Grading and Rear Yard Drainage*, for specific requirements.

10. Engineering plans having a scale of no greater than one inch (1”) equals fifty feet (50’) horizontal and one inch (1”) equals five feet (5’) vertical (for profiles) shall be provided. Sanitary sewer and water main shall be shown on the same sheet. Plan and profile views are required on all gravity sewers. The profile should be shown below the plan view on the same sheet.

11. Storm sewer and pavement shall be shown on the same sheets. Plan and profile views are required for all storm sewers. A plan view with centerline stationing shown is required on all paving plans. Show the top-of-curb line on profile.

12. In the profile view, all crossings of utilities must be shown. When a water main crosses above a sewer, an invert elevation for the water main shall be shown. The minimum vertical clearance between utilities shall be eighteen inches (18”). Class II sand backfill compacted to at least ninety-five percent (95%) of maximum unit weight is required between utilities.

13. Profiles of sewers shall indicate the size, material type, and class of pipe, rim elevations of all structures, the length of pipe between structures, the slope of the pipe, numbering of structures, locations of service leads, and casting and cover type. Bedding shall be shown if it differs from the typical trench detail. The profile shall indicate the existing and proposed ground elevations above the route of the sewer. The inverts of all sewers, both existing and proposed, shall be given at manholes. The location of areas requiring compacted sand backfill shall be indicated on the profile.

14. Vertical controls shall be in accordance with the U.S.G.S. Datum, and horizontal controls shall be in accordance with State Planar Coordinates. A minimum of two project benchmarks for the vertical controls shall be indicated on each sheet. Two permanent benchmarks shall be included on the alignment and control sheet.

15. Any areas that are considered to be “wetland~~s~~” as defined by the City of Rochester Hills or the Michigan Department of Environmental Quality (MDEQ) shall be shown on the plans. Improvements will not be permitted in wetlands unless the MDEQ and the City issue a permit or a letter of “No Authority” for such activity. Refer to Wetland and Watercourse Determination Section (Section 126, Article IV, Division II) in the City Code of Ordinances.

16. Finished exterior elevations shall be shown at the corners of all buildings and for all utility structures. Lowest floor elevation, including basement, shall be shown on the plans.

17. The City encourages the incorporation of cross access agreements and may require them.

18. Plans for landscaping or tree planting required by either City Ordinance or City Standards, relating to such items as greenbelts, street islands, detention basins, or landscape and open space areas, shall conform to the City Standards and shall be submitted to the Department of Planning and Economic Development for review and approval prior to final site approval. The approved landscape plans shall also be attached to the construction plans.

19. All new grass areas that are required in the public right-of-way, by any City Ordinance or City Standard, and all existing grass areas that are disturbed by construction, shall be established or restored in conformance with the City's Standard Specifications.

20. Street names shall be approved by the City. The Department of Public Services charges a fee to the Developer for the installation of permanent street signs. All permanent street name and traffic control signs shall be installed by the City, and the cost of these signs shall be paid by the Developer.

21. The Developer's consulting engineer shall forward plans for approval to any public utility (gas, electric etc.) and to any Federal, State or County agency whose facilities or rights-of-way may be affected by the proposed construction. Permits for such construction, if required, shall be the responsibility of the Developer. The City shall approve all plans for public utilities.

22. After the plans are approved by the City and prior to any construction, six (6) complete sets of residential projects and seven (7) complete sets for commercial/industrial projects for field construction shall be submitted to the Engineering Division. The plans shall be sealed and signed on the cover sheet by the Licensed Engineer responsible for their preparation. The plans shall be rubber-stamped instead of embossed. All updated revisions from outside agencies shall be included on the plans. The City will stamp the construction plans approved and disperse as follows:

    Residential Development Project
    Three - City of Rochester Hills
    Two - Owner
    One - Engineer

    Commercial/Industrial Development Project
    Three - City of Rochester Hills DPS
    One - City of Rochester Hills Building Department
    Two - Owner
    One - Engineer

    These approved plans shall be the only plans used during construction.

23. Construction Plans shall include the following sheets (when applicable) and the order shall be maintained as indicated:

    Cover Sheet
    Overall Plan, General Notes & Legal Descriptions
    Existing Conditions
    Demolition Plans
    Construction Staging Plans
    Overall Grading Plans
    Detailed Grading, Soil Erosion Control Plans & Tree Protection Fencing Plans
    Sanitary Sewer & Water Main Plan & Profile Plans (including basis of design)
    Road & Storm Sewer Plan & Profile
    Drainage Area Map
    Traffic Staging/Signing/Paving
    Soil Boring Data Sheets
    Applicable Detail Sheets
    Landscape Plans & Details
    Natural Features Plan

    Revisions shall be identified if submitted after construction approval.

24. For all developments, a complete set of as-built plans including, but not limited to, sanitary sewers, storm sewers, water mains, detention basins, streets, roads, sidewalks, safety paths, grading, basis of designs, drainage maps and calculations, shall be provided by the Developer. The as-built set format shall be provided to the City as a PDF (Portable Document Format) version.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 2

Water Distribution System

A. Plans and Specifications – Submittal Procedure

1. The plans and specifications shall be submitted in accordance with *Chapter 1, General Requirements and Submittals.*

2. The Applicant may proceed with water main permitting once the City has conducted an initial review of the entire construction plan submittal and all revisions pertaining to the water main have been completed. The Applicant shall supply nine (9) sets of plans to the City for distribution to the Great Lakes Water Authority (GLWA) for approval, and forwarding to the Michigan Department of Environment, Great Lakes & Energy (EGLE) for approval and an EGLE construction permit. After, a copy of the approved permit will be provided to the applicant.

B. Plans and Specifications – Design Considerations; General

1. All water systems shall be designed conforming to the current edition of the "Recommended Standards for Water Works", published by Health Education Services, also known as the "Ten State Standards".

2. Plans shall consist of a cover sheet showing a plan view of the complete job, (split plan and profile sheets are required for water main sixteen inches (16") and greater), and the City's standard detail sheets.

3. Reference *Chapter 1*, *General Requirements and Submittal* for specific requirements pertaining to the presentation of plans.

4. The cover sheet shall contain a total quantity listing of the proposed water main improvements, indicating the lengths of pipe, type of pipe, and their respective sizes.

5. Provide continuous stationing. Identify all existing and proposed tees, valves, bends, hydrants, etc.

C. Benchmarks and Elevations

1. All elevations shall be on U.S.G.S. Datum.

2. Reference benchmarks, established at intervals not greater than 1,200 feet and convenient to the proposed construction, shall be noted on the plan and profile sheets, with identification, location, description and established elevation listed.

3. Street names and widths, subdivision names, lot numbers, addresses, legend, list of quantities, and other pertinent information (including proposed finish grade elevations at hydrants and gate wells) shall be shown on the plans.

D. Soil Conditions

1. Exploratory borings shall be provided by the developer, if requested by the City. Boring logs shall be indicated on the plans, if required.

2. Water main design, relative to pipe bedding and location, shall reflect the proper selection of materials and construction method compatible with the field conditions. Areas which show unsatisfactory ground material for pipe bearing, or possible chemical deterioration due to soils, shall be avoided or the pipe shall be suitably installed on adequately designed bedding and/or enclosed in protective wrap or coating.

3. Sand or other approved porous material shall be required for the full depth of trenches under all driveways and parking areas (private or commercial), streets, alleys, pathways and sidewalks.

E. Location and Layout

1. The distribution system in all developments requiring more than 600 feet of water main shall have a minimum of two (2) connections to a source of supply, and shall be a “looped” system on separate mains, if possible. If the looped system comes off the same water main, an isolation valve between the connection points is required.

2. Generally, water mains shall be installed in a public street right-of-way or in easements exclusively reserved for such use on the opposite side of the street from sanitary sewers. All easements shall be a minimum of twenty feet (20’) wide and shall be dedicated to the City of Rochester Hills.

3. Water main shall be installed parallel to the property lines, or building lines, with clearance distances to allow for a twenty-foot (20’) wide easement centered on the water main.

4. Preferably, water main should be constructed outside of paved parking areas, streets, and drives.

5. In new developments water mains shall be installed from boundary to boundary in abutting roads and interior streets, and at other locations as may be deemed necessary by the City, for future extensions.

6. All water mains shall be installed with a minimum cover of six feet (6’) below finish grade. When water mains must dip to pass under a storm sewer or sanitary sewer, the sections, which are deeper than normal shall be kept to a minimum length by the use of vertical 45 degree (45°) - 11¼ degree (11¼°) bends properly anchored with thrust blocks and restrained joints, as approved by the City Engineer.

7. Open Drain Crossings:
   At all open drain crossings, a separate enlarged scale view is required. A minimum of four-foot (4') clearance or as required by the Michigan Department of Environment, Great Lakes & Energy between the bottom of the drain and the top of the water main is required.

8. Connections to Existing Main:
   When connecting to an existing water main, a tapping sleeve, valve and well are required. Same size taps are **not** allowed. In this case, a cut-in-tee with an in-line gate valve and well is required. A full body sleeve is required for all taps made to ductile iron, cast iron, or PVC water main, or as directed by the City Engineer.

9. Finish Grades:
   The plans shall indicate the finish grades of all hydrants and gate well rims.

10. Horizontal Clearance:
    All water mains shall be located so as to provide a minimum of ten feet (10') horizontal clearance between the nearest edge of the water main and the nearest edge of any sanitary or storm sewer.

11. Vertical Clearance:
    A minimum vertical clearance of eighteen inches (18") shall be maintained between the bottom of any water main and the top of any sanitary sewer, or any other utility, crossing under the water main. Vertical clearance of less than eighteen inches (18") or crossing of a sewer over a water main will require the encasement of the sewer or for special measures to be taken to prevent contamination of the water supply. Details must be submitted with the plans for review and approval by the City Engineer. Class II sand compacted to ninety-five percent (95%) maximum density shall be used at all utility crossings in twelve inch (12") compacted lifts, to the top of the highest utility.

12. Tunneling:
    Where conditions require tunneling or boring, consult the City Engineer for specific requirements. These conditions may include road crossings or conflicts with trees, shrubs, structures, or other utilities. Where water mains cross an improved road of any type, the pipe shall be installed by tunneling or boring and be placed in a steel casing pipe, or as directed by the City Engineer.

13. Profiles:
    Profile view is required for sixteen inch (16") and larger water mains, and for other smaller sizes when determined necessary by the City Engineer. Water mains shall be kept on one side of the street for the entire length of the street. Water mains shall <u>not</u> be located under pavement.

F. <u>Easements</u>

1. Easements for possible extensions or looped connections shall be extended to the property line, at locations designated by the City Engineer.

2. The easement descriptions shall include the hydrant leads and shall extend a minimum of ten feet (10') beyond the hydrant on any lead. The easement documents shall contain a

provision prohibiting the construction of, or locating of, any above ground structures within the limits of such easements.

G. Pipe Sizes

1. Eight-inch (8”) diameter mains are the minimum size to be installed in single-family residential areas.

2. Twelve-inch (12”) mains are considered to be the minimum size in commercial, office, industrial, and multiple family residential areas, except in a looped system of 1,500 feet or less where eight-inch (8”) mains may be permitted, if approved by the City Engineer.

3. All single-hydrant lead longer than seventy-five feet (75’) must be a minimum of eight inches (8”) in diameter.

4. Water mains are to be looped whenever possible.

5. Ninety degree (90º) bends are not permitted.

H. Pipe Materials and Connections

1. Water mains sixteen inches (16”) in diameter or less shall be cement-lined, ductile iron pipe Class 54. An alternate of zinc coated ductile iron Class 52 pipe will be considered and is subject to approval by the City Engineer on a case-by-case basis.

2. Water mains larger than sixteen inches (16”) in diameter may be either ductile iron, or concrete lined cylinder pipe, conforming to AWWA C301, as determined by the City Engineer.

3. All ductile iron pipe shall be encased with a loose polyethylene wrap in tube or sheet form of 8 mils minimum thickness per the requirements of ANSI / ASTM standard specification D1248 and AWWA C105.

4. Crosses shall not be allowed, unless specifically approved by the City Engineer.

I. Valves – Location

1. A valve shall be provided at every connection to existing mains, unless otherwise approved by the City Engineer.

2. In general, valves on cross connecting mains shall be arranged so that no single line failure will require more than 800 feet of main to be out of service. Valves shall be so arranged that any section can be isolated by closing not more than four (4) valves.

3. A valve shall be provided on every dead-end line where required for future extension, at a location approved by the City Engineer.

4. Valves shall generally be located far enough back from the intersection of street rights-of-way lines for the gate well structure to clear crosswalks.

5. Sufficient valves shall be placed such that not more than twenty-four (24) homes, thirty (30) multiple family units, or two (2) hydrants shall be out of service within such section of water main, which can be isolated.

6. Where possible, gate valves shall be located at street intersections seven feet (7') from the intersecting street right-of-way line. All dead-end mains must include a valve at the tee. Valves should not be located under roadway pavement, pathways, sidewalks, or driveway approaches whenever possible.

J. Valves – Materials

1. Resilient Wedge or Resilient Seated type gate valves (East Jordan or U.S. Pipe) are required.

2. Valves shall be 'Left Hand Open' type.

K. Pressure Reducing Valves (PRV's)

1. In systems where two (2) or more pressure districts are to be connected for a "looped" supply, the plans shall include a PRV near the point of connection to the higher pressure district, to balance pressure across the new water system

2. A line gate valve shall be installed both upstream and downstream of each PRV to permit isolation of the PRV for maintenance or repair. If an alternative service ("looped" supply) to the water system is not available to permit repair on the PRV without a complete shutdown of the system, then a bypass line of equivalent size pipe as the water main and an additional bypass gate valve and well shall be provided.

L. Gate Wells

1. All valves shall be constructed within a gate well, as specified in the Standard Details for water mains.

2. A valve-in-box shall not be constructed unless specifically authorized by the City Engineer.

M. Fire Hydrants

1. In general, residential dwellings shall not be more than 250 feet from a fire hydrant, as measured along the street right-of-way line.

2. The Rochester Hills Fire Department will also review and approve the total number and location of fire hydrants for proposed developments based on building construction type and available pressure in the water system. For information regarding the number of hydrants and spacing, see part R.2., in this section.

3. A hydrant shall be installed at the end of every dead-end main. Temporary blow-offs may be allowed at the end of dead-end mains when future extension is imminent, as approved by the City Engineer.

4. In general, hydrants shall be located in the road right-of-way nine feet (9') from the right-of-way line, but not closer than six feet (6') to the back of curb. The location of hydrants with respect to the right-of-way line shall be indicated on the plans. Hydrant valves shall face the road, and hydrants shall be plumb and set to grade prior to final acceptance.

5. Hydrants, not located within a public road right-of-way, shall be located a minimum of five feet (5') from the edge of pavement or protected by bollards per City Detail Sheets.

6. A six-inch (6") gate valve with a three (3) piece cast iron valve box, and five and a quarter inch (5¼") diameter screw shaft, shall be placed forty-two inches (42") from the centerline of the valve to the centerline of the hydrant, at each hydrant.

7. Hydrants shall be as specified on the City Detail Sheets.

N. Pipe Restraints

1. Restraining glands shall be installed at all bends, dead ends, tees, and hydrants. Installation of thrust blocks is not permitted unless it is placed to supplement or provide redundancy to a restrained joint.

2. Vertical bends that exceed eleven and a quarter degrees (11¼º) shall be restrained with rods.

O. Services

1. Service lines are to be shown to all buildings, or each unit in a multi-tenant buildings, other than single-family detached dwellings.

2. Service lines shall be installed using K soft copper or 200 p.s.i. SDR-9 poly pipe. Tracer wire shall be required for any water service built on private property.

3. A valve-in-box for each service line shall be provided and located at five feet (5') from the edge of non-residential buildings.

4. The basis of design for size shall be considered using a flow rate of twenty (20) gpm per residential dwelling unit. The basis of size other than for residential use shall be determined by the developer's Engineer and submitted for approval by the City prior to submittal of final plans.

P. Fire Protection Lines

1. Fire protection lines, where applicable, are to be shown to all buildings.

2. A valve-in-box for each fire protection line shall be provided and located at five feet (5') from the edge of the building.

3. The domestic supply lead shall tee off from the fire protection line, prior to the valve-in-box. The valve-in-box shall be located five feet (5') from the building. A separate domestic supply lead is also acceptable.

Q. Design Geometry

1. Piping Arrangement:
   Any water main in excess of 1,600 feet in length between interconnections may be required by the City Engineer to be oversized. On dead ends where there is no possibility of a future extension a main may not exceed 600 feet in length. Where a dead end exceeds 600 feet in length, the developer will be required to extend the main to provide a loop or oversize the main, as directed by the Engineer. Dead-end mains shall not connect to a looping main of smaller size without City Engineer approval. Hydrants shall be installed at the end of all dead-end water mains.

2. Design Pressures:
   Pipe shall be sized to carry maximum day flow plus fire flow with minimum pressures at any hydrant of twenty (20) psi.

R. Fire flow design criteria:

1. The number of hydrants and spacing is determined by the currently adopted Fire Prevention Code (2006 International Fire Code). See tables B105.1 and C105.1 below.
   Water flow requirements may be increased or decreased based on individual circumstances. Please contact the City of Rochester Hills Fire Prevention Bureau, 248.656.4717, if further information is needed.

2. Design calculations, including hydrant flow tests and/or a simulated hydraulic analysis, shall be furnished upon request of the City Engineer to confirm that pressure is available.

TABLE B105.1

MINIMUM REQUIRED FIRE-FLOW FOR BUILDINGS

FIRE-FLOW CALCULATION AREA (square feet)					FIRE-FLOW (gallons per minute)
Type IA IB	Type IIA and IIIA	Type IV and V-A	Type IIB and IIIB	Type V-B	
0-22,700	0-12,700	0-8,200	0-5,900	0-3,600	1,500
22,701-30,200	12,701-17,000	8,201-10,900	5,901-7,900	3,601-4,800	1,750
30,201-38,700	17,001-21,800	10,901-12,900	7,901-9,800	4,801-6,200	2,000
38,701-48,300	21,801-24,200	12,901-17,400	9,801-12,600	6,201-7,700	2,250
48,301-59,000	24,201-33,200	17,401-21,300	12,601-15,400	7,701-9,400	2,500
59,001-70,900	33,201-39,700	21,301-25,500	15,401-18,400	9,401-11,300	2,750
70,901-83,700	39,701-47,100	25,501-30,100	18,401-21,800	11,301-13,400	3,000
83,701-97,700	47,101-54,900	30,101-35,200	21,801-25,900	13,401-15,600	3,250
97,701-112,700	54,901-63,400	35,201-40,600	25,901-29,300	15,601-18,000	3,500
112,701-128,700	63,401-72,400	40,601-46,400	29,301-33,500	18,001-20,600	3,750
128,701-145,900	72,401-82,100	46,401-52,500	33,501-37,900	20,601-23,300	4,000
145,901-164,200	82,101-92,400	52,501-59,100	37,901-42,700	23,301-26,300	4,250
164,201-183,400	92,401-103,100	59,101-66,000	42,701-47,700	26,301-29,300	4,500
183,401-203,700	103,101-114,600	66,001-73,300	47,701-53,000	29,301-32,600	4,750
203,701-225,200	114,601-126,700	73,301-81,100	53,001-58,600	32,601-36,000	5,000
225,201-247,700	126,701-139,400	81,101-89,200	58,601-65,400	36,001-39,600	5,250
247,701-271,200	139,401-152,600	89,201-97,700	65,401-70,600	39,601-43,400	5,500
271,201-295,900	152,601-166,500	97,701-106,500	70,601-77,000	43,401-47,400	5,750
295,901-Greater	166,501-Greater	106,501-115,800	77,001-83,700	47,401-51,500	6,000
		115,801-125,500	83,701-90,600	51,501-55,700	6,250
		125,501-135,500	90,601-97,900	55,701-60,200	6,500
		135,501-145,800	97,901-106,800	60,201-64,800	6,750
		145,801-156,700	106,801-113,200	64,801-69,600	7,000
		156,701-167,900	113,201-121,300	69,601-74,600	7,250
		167,901-179,400	121,301-129,600	74,601-79,800	7,500
		179,401-191,400	129,601-138,300	79,801-85,100	7,750
		191,401-Greater	138,301-Greater	85,101-Greater	8,000

Revised 3/27/2008

TABLE C105.1			
NUMBER AND DISTRIBUTION OF FIRE HYDRANTS			
FIRE-FLOW REQUIREMENT (gpm)	**MINIMUM NUMBER OF HYDRANTS**	**AVERAGE SPACING BETWEEN HYDRANTS (feet)**	**MAXIMUM DISTANCE FROM ANY POINT ON STREET OR ROAD FRONTAGE TO A HYDRANT**
1,750 or less	1	500	250
2,000-2,250	2	450	225
2,500	3	450	225
3,000	3	400	225
3,500-4,000	4	350	210
4,500-5,000	5	300	180
5,500	6	300	180
6,000	6	250	150
6,500-7,000	7	250	150
7,500 or more	8 or more	200	120

Revised 3/27/2008

S. Acceptance of Utilities

1. Preliminary Acceptance

   a. The installed mains must pass all required pressure tests and bacteriological tests as required by current City Standards, prior to the final connections.

   b. Prior to acceptance, water mains shall be flushed in accordance with City Standards. This consists of flowing all hydrants installed with the project.

   c. All structures must be clean and free of construction debris.

   d. The Engineer shall make first submittal of record drawings, which must include rim elevations, pipe size, and tie downs to all water main appurtenances.

2. Final Acceptance

   a. Approved as-built drawings shall be submitted to the City prior to final acceptance of the water main. The as-built set format shall be provided to the City as a PDF (Portable Document Format) version.

   b. Final Acceptance is based on a two (2) year maintenance inspection.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 3

Sanitary Sewer System

A. Plans and Specifications - Submittal Procedure

1. The plans and specifications shall be submitted in accordance with *Chapter 1, General Requirements and Submittals.*

B. Plans and Specifications – Design Considerations; General

1. All sanitary sewer designs shall be developed conforming to the current edition of "Recommended Standards for Wastewater Facilities", Published by Health Education Services, also known as the "Ten State Standards".

2. Prior to starting any sanitary sewer design, the applicant is encouraged to make use of maps and information available at the City offices. It shall be the responsibility of the applicant to field check and verify utility locations provided by the City.

3. Reference *Chapter 1, General Requirements and Submittals* for specific requirements pertaining to the presentation of plans.

4. An overall utility layout sheet shall include the following:

    a. Basis of Design for the service area, and any future service area that may be ultimately served by the proposed sewer. Include interceptor sewer sub-district.

    b. Overall layout of the sewer system with manhole numbers, pipe sizes and direction-of-flow arrows. Existing and proposed sewers shall be shown with different symbols and line types. Direction-of-flow arrows will only be required on larger projects with multiple sewer runs.

C. Plan and Profile Sheets

1. The Plan portion of the sheet shall include, at a minimum, the following:

    a. Existing topography and all existing or planned surface or underground improvements in streets or easements in which sewer construction is proposed, or in contiguous areas if pertinent to design and construction.

    b. Street names, street and easement widths, and all other street and easement survey information, including subdivision names, lot numbers and lot dimensions, and existing addresses.

    c. Location, length, and size of each section of the proposed sewer between manholes.

d. Locations of all manholes and other sewer appurtenances and special structures.

e. Sanitary sewer leads are to be constructed or installed concurrently with sewer construction, with locations two feet (2') beyond easement and/or property lines. Sanitary sewer leads shall be extended to the far side of any proposed franchise utility easements.

2. The profile portion of the sheet shall appear below the companion plan portion, generally projected vertically, and shall show at a minimum the following:

   a. Size, slope, type and class of pipe, and controlling invert elevations for each section of proposed sewer between manholes.

   b. Limits of special backfill requirements.

      i. Locations and limits of Class II sand backfill, where required.

      ii. Class of bedding material.

      iii. Backfill requirements will be in accordance with MDOT Standard Details.

   c. Location of existing or proposed utilities crossing the line of the sewer or otherwise affecting sewer construction.

   d. Location, by station, of every proposed manhole, with manhole number, invert elevation of all inlet or outlet pipes, top of casting elevation, and manhole type.

   e. Length of run between manholes (400 feet maximum).

   f. Location, by station from downstream manhole, of all sanitary sewer leads, to be constructed or installed concurrently with the proposed sewer construction.

   g. Existing and proposed ground elevation above the route of the sewer.

   h. Provide a minimum depth from top of curb (or road centerline if uncurbed) to the top of any sanitary sewer of ten feet (10') at local control points, or a minimum of ten feet (10') at locations where the sewer grade is parallel to the road grade. Under any design the sewer shall be deep enough to reasonably serve, by gravity, a standard depth basement.

   i. Required risers, with control elevations.

   j. Invert elevation at property line for sanitary sewer leads to be included with sewer construction.

   k. Manholes shall be identified by numbers assigned consecutively and increasing in direction opposite to direction of flow in each sewer.

   l. All elevations shall be on U.S.G.S. Datum.

m. Reference benchmarks, established at intervals not greater than 1,200 feet and convenient to the proposed construction, shall be noted on the Plan and Profile Sheets, with identification, location, description and established elevation listed.

n. Each Plan and Profile Sheet shall include a tabulated list of quantities of construction pay items appearing on those sheets, with a total quantity list on the coversheet.

D. Location of Sanitary Sewers

1. Sanitary sewers shall generally be located on opposite sides of streets from water mains, eight feet (8') from the back of the curb on the southerly and westerly side of the street.

2. Generally, sanitary sewers shall be installed in a public street right-of-way or in easements exclusively reserved for such use.

3. Easements for sanitary sewers shall have a minimum width of twenty feet (20'), centered upon the sewer. Such easements shall be deeded or dedicated to the City of Rochester Hills, with restrictions against use or occupation of easements, by the property owners and/or by other utilities, in any manner which would restrict sewer maintenance or repair operations.

4. Easements for possible extensions shall be provided to the property lines at locations designated by the City Engineer.

5. Sewers shall preferably be constructed outside of paved parking areas, streets, and drives.

6. Sewers shall be installed parallel to the property lines or building lines, with clearance distances to accommodate the full width of the proposed easement.

7. Sanitary sewers shall maintain ten feet (10') of horizontal separation from all parallel utilities.

8. Sanitary sewer crossings of other utilities shall have a minimum vertical clearance of eighteen inches (18"), with the sanitary sewer placed below the other utility.

E. Bedding

1. Sewer pipe shall be placed on Class "B" bedding or better, as indicated on the sewer detail sheet.

F. Drop Connections

1. Drop connections are required at manholes where the invert of the outlet pipe is eighteen inches (18") or more below the invert of the inlet pipe.

2. Internal drop connections are required to be constructed in accordance with the conditions stated on the Rochester Hills standard sanitary sewer detail sheet.

G. Tunneling and Boring

1. Where conditions require tunneling or boring, consult the City Engineer for specific requirements. Where sanitary sewers or sanitary sewer leads cross improved roads of any type, the pipe shall normally be installed by tunneling or boring, located within a steel casing pipe.

H. Extensions and Future Connections

1. Where the sanitary sewer must be extended from off-site, sanitary sewer leads extending two feet (2') beyond the property line of all adjacent property, on both sides of the right-of-way, the entire length of the off-site sanitary sewer installation, shall be provided.

I. Minimum Pipe Size

1. Minimum pipe size for sanitary sewers shall be eight inches (8") nominal internal diameter.

2. Minimum pipe size for sanitary leads shall be six inches (6") nominal internal diameter.

J. Sanitary Sewer Materials

1. The following materials may be used for public sanitary sewer construction. Approved pipe materials must conform to standards adopted by the Office of the Oakland County Drain Commissioner:

    a. For sewers eight inches (8") to fifteen inches (15"):

        i. PVC truss pipe, ASTM D-2680, with gasket joints, ASTM D-3212.

        ii. Other types of pipe as approved by the City Engineer.

    b. For six inch (6") sewer leads:

        i. Six inch (6") leads shall be PVC SDR 23.5 or PVC Sch 40, both solid walled. Gasketed or solvent-weld joints are acceptable. Pipe shall have a minimum pipe stiffness of 150 p.s.i., and a minimum deflection of fifteen percent (15%) at failure. The sewer lead material shall be compatible with sewer main material.

    c. For Sewers greater than fifteen inches (15"):

        i. Reinforced Concrete Pipe (RCP) shall conform to the current ASTM D C76, wall B. Joints shall be synthetic rubber and meet or exceed the requirements established by ASTM C361.

K. Backfill

1. Trench backfill shall be MDOT approved Class II sand under all proposed and existing paved areas, roads, streets, drives, pathways and sidewalks, or within the one-on-one (1-on-1) influence of the road. Sand shall be compacted to ninety-five percent (95%) maximum density.

L. Manhole Locations

1. Manholes shall be constructed at every change in sewer grade, alignment and pipe size, and at the end of each sewer line. Maximum distance between manholes shall not exceed 400 feet.

2. Manholes shall be constructed of precast reinforced concrete sections.

3. Where future connections to a manhole are anticipated, stubs with watertight bulkheads, shall be provided.

4. Monitoring manholes shall be required for connections associated with non-domestic uses, or as required by the City Engineer.

5. Consideration shall be given to installation of grease/oil separators during design where applicable.

M. Allowable Pipe Slopes

Pipe Diameter (inches)	Minimum Slope (feet per 100 feet)	Maximum Slope (feet per 100 feet)
8	0.40	8.36
10	0.28	6.22
12	0.22	4.88
15	0.15	3.62
18	0.12	2.84
21	0.10	2.32
24	0.080	1.94
27	0.067	1.66
30	0.058	1.44
36	0.046	1.14

N. Hydraulic Calculations

1. Calculations

   a. Gravity sanitary sewers, Manning's Formula, with n = 0.013 is required for concrete sewer pipes. A Manning roughness coefficient of n = 0.010 should be used for plastic sewer pipe.

   b. Low-pressure sewer systems and force mains, the Hazen-Williams formula with C=120 shall be used.

2. Minimum and Maximum Velocities

   Minimum design velocities for gravity and low-pressure sanitary sewers shall be two feet (2') per second, and a maximum design velocity shall be ten feet (10') per second, with pipe flowing full. The slope of the sewer between the last two manholes at the upper end of any gravity sewer lateral shall be increased above one percent (1%) to obtain cleansing velocity.

O. Allowances for Changes in Pipe Size

1. Maximum flow velocity for full pipe flow shall be maintained by continuity of the 0.80 diameter depth above invert for pipe size increases and also with intersecting sewer grade raised to compensate for head loss due to direction change.

P. Sanitary Sewer Leads

1. Unless otherwise approved by the City Engineer, construction of sanitary sewer leads from the public sewer to a point two feet (2’) beyond the easement and/or property line, for each fronting parcel, which the sewer is designed to serve, shall be included with the construction of each sanitary sewer.

2. Where construction of sanitary sewer leads to the property line is not required concurrently with sanitary sewer construction, a wye branch with riser, if required, and with water-tight stopper or plug with type of joint used for the sewer pipe, shall be installed for every lot or building site which the sewer is designed to serve.

3. Where depth of sewer from top of pipe to finished surface exceeds ten feet (10’), risers shall be installed from wyes to an elevation ten feet (10’) below finished surface. Additional riser height will be required when the observed ground water level during construction is above ten feet (10’) with a minimum of four feet (4’) of cover.

4. Minimum size for sanitary sewer leads shall be six-inch (6”) nominal internal diameter. Each building structure shall have a separate individual sanitary service lead connected to a public sanitary sewer.

5. Minimum slope for building sewers shall be one-percent (1%).

6. Sanitary sewer leads shall not be connected directly into manholes unless approved by the City Engineer.

Q. Sewer Capacity Design

1. Tributary Area

   a. Sanitary sewers shall be designed to serve all natural tributary areas, with due consideration given to topography, the master sanitary sewer plan, established zoning, and the adopted City Master Land Use Plan.

2. Population

   a. For design purposes, population shall be based on 2.44 persons per detached single-family home site (or equivalent single family unit), and 1.46 persons for each multiple-family dwelling unit (1,200 S.F. or less).

b. Submissions for review shall include a tabulation of occupancy (usage) types and the conversion of these into terms of equivalent single-family units. The area of the site, in acres, may be used to calculate dwelling units based on density allowed in the Zoning Ordinance. The most current unit assignment factors as published by the Office of the Oakland County Water Resources Commissioner (OCWRC) shall be used to convert the different usage types to equivalent single-family units.

3. Design Criteria

a. To determine the daily average flow (gal /day), a factor of one hundred (100) gal per capita per day as specified in the Recommended Standards for Wastewater Facilities (known as the Ten State Standards) as determined by the GLUMRB shall be utilized.

b. To determine the peak flow (gal per day), the peaking factor (PF) will be calculated by using the following formula as specified in the Recommended Standards for Wastewater Facilities.

$$PF = \frac{18 + (P)^{1/2}}{4 + (P)^{1/2}}$$, P, design population expressed in thousands

c. The peaking factor shall not be less than 2.5 or exceed 4.0.

R. <u>Acceptance of Utilities</u>

1. Preliminary Acceptance

a. Prior to acceptance, all sanitary sewers shall be flushed and cleaned in accordance with City Standards.

b. Air Test or Infiltration Test shall be completed in accordance with the current Standards of the Office of the Oakland County Water Resources Commissioner.

c. Televising: Prior to acceptance of new sanitary systems, a televised inspection of every section of the sewer shall be conducted from manhole to manhole. A videotape of this inspection shall be submitted to the City Engineer for review and approval prior to acceptance. The sewer shall be flooded prior televising.

d. As-built drawings require rim~~s~~ elevations, invert~~s~~ elevations, pipe sizes, and slopes.

2. Final Acceptance

a. As-built drawings shall be submitted to the City prior to final acceptance of the sanitary sewer. The as-built set format shall be provided to the City as a PDF (Portable Document Format) version.

b. Final Acceptance is based on a two-year maintenance inspection. This shall include a televised inspection, at the city's expense, of every section of the sanitary sewer from manhole (MH) to manhole (MH). This shall be witnessed by the City inspector, and a copy of the videotape must be given to the City Engineer prior to final acceptance. If a problem is found, the City reserves the ability to use the maintenance bond or project escrow account balance to have the developer pay for the expense of a second televising.

S. Permit Acquisition

1. Nine (9) sets of plans need to be submitted to the City, along with a completed MDEQ Part 41 permit application for request of issuance of sanitary sewer construction permit.

2. An OCWRC sanitary sewer tap permit is required unless the sanitary sewer is private or a service lead.

T. Private Sewers

1. Private owners are permitted only if one (1) legal owner is connected to the system. If parcel development is possible, private systems will not be permitted.

2. Private sanitary sewer materials and construction to be in accordance with all of the above standards.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 4

Stormwater Management

A. <u>Purpose</u>

In order to protect the health, safety, and general welfare of the residents of the City of Rochester Hills, to comply with our Rochester Hills' Municipal Separate Storm Sewer System (MS4) general permit, as well as to protect, sustain, and enhance the surface and ground water resources of the City of Rochester Hills, drainage and stormwater management practices shall be utilized as directed herein to achieve the following objectives:

1. Accommodate site development and redevelopment in a manner that protects public safety and is to the maximum extent practicable, consistent with (or re-establishes) the natural hydrologic characteristics of each watershed and sustains ground water recharge, stream baseflows, stable stream channel (geomorphology) conditions, the carrying capacity of streams and their floodplains, ground water and surface water quality, and aquatic resources and habitats.

2. Protect water quality by removing and/or treating pollutants prior to discharge to ground and surface waters throughout the City of Rochester Hills, and to protect, restore, and maintain the chemical, physical, and biological quality of ground and surface waters.

3. Reduce flooding impacts and prevent a significant increase in surface runoff rates and volumes, predevelopment to post-development, which could worsen flooding downstream in the watershed, enlarge floodplains, erode streambanks and create other flood-related health-welfare-property losses; in general, to preserve and restore the natural flood-carrying capacity of streams and their floodplains.

4. Ensure effective long-term operation and maintenance of all permanent stormwater management facilities.

B. <u>Applicability</u>

The following construction projects shall be regulated by these standards:

1. Land development, including but not limited to plats, single family detached site condos, commercial developments, industrial developments, and all other developments that are subject to site plan review and approval.

2. Redevelopment of existing improved land

   a. Redevelopment projects that change or alter the existing developed surface of one acre or more; or

b. Redevelopment that disturbs less than an acre but increases the impervious surface area by 10% or greater; flood protection and channel protection standards need to be met, at a minimum, for the increased impervious surface area.

c. Redevelopment of less than one acre, but disturbs greater than 50 % of the site and involves a site plan approval and use change;

d. Redevelopment that involves removal and/or installation of site storm sewer and/or detention system.

e. Redevelopment projects that change or alter the existing developed surface of less than one acre where the downstream conditions show evidence of negative impacts from excessive stormwater discharge rate. This in particular applies to existing developed sites that have no flood protection and/or channel protection controls.

f. If the proposed site use does not meet the above five types of redevelopment but is of a Heavy Traffic and Pollutant Load or Moderate Traffic and Pollutant Load as defined in Subsection 4.3.2 B2 "Catch Basin and Inlets," then the post development water quality standards apply.

Exception:

i. If the redevelopment is part of a larger development with a private regional stormwater system that includes detention and there is no net increase in impervious surface with the redevelopment.

ii. An alternate method acceptable to the City Engineer is proposed that will address post development water quality and the channel and flood protection objectives of the City of Rochester Hills.

C. Stormwater Management Plan

For all activities regulated by these Standards in accordance with the above sub-section, B. Applicability, the Applicant shall submit a stormwater management plan and report prepared by a Professional Engineer licensed in the State of Michigan, which shall contain, but not be limited to, the following:

1. Suitable maps and drawings showing all existing natural and constructed drainage facilities affecting the subject property.

2. Hydrologic (watershed) and water feature boundaries, including all areas flowing to the proposed project, existing streams (including first order and intermittent streams), springs, lakes, ponds, or other bodies of water within the project area.

3. Sufficient topographical information with elevations to verify the location of all ridges, streams, etc. (two-foot contour intervals within the project's boundaries and for proposed offsite improvements.

4. Notes pertaining to and locations of existing standing water, areas of heavy seepage, springs, wetlands, streams, and hydrologically sensitive areas.

5. A drainage area map showing all sub-watershed areas, runoff coefficients, acreage of drainage area, general type of soils with hydrologic soil group (HSG) noted, estimated permeability in inches per hour, location and results of all soil tests and borings, and proposed stormwater management system in plan view shall be included with the plans.

6. 100-year flood elevations for any Special Flood Hazard Areas on or within one hundred feet (100') of the property.

7. Description of current and proposed ground cover and land use. The total area and runoff coefficient for each drainage area noted.

8. A plan of the proposed stormwater drainage system attributable to the activity proposed, including runoff calculations, stormwater management practices to be applied both during and after development, and the expected project time schedule.

9. The design computations for all proposed stormwater drainage systems, including storm-drain pipes, inlets, runoff control measures and culverts, drainage channels, and other features, facilities, and stormwater management practices

10. A grading plan, as required under *Chapter 5* of the City of Rochester Hills Engineering Design Standards; including all areas of disturbance, of the subject activity. The total area of disturbance shall be noted in square feet and acres.

11. A plan of the erosion and sedimentation procedures to be utilized as required under *Chapter 11* of the City of Rochester Hills Engineering Design Standards and/or as required by the Oakland County Water Resources Commission (OCWRC).

12. A route delineation of all concentrated flow (that is, flow other than overland sheet flow).

13. The effect of the project (in terms of runoff volumes and peak flows) on adjacent properties and on any other stormwater collection system that may receive runoff from the project site and specifics of how erosion and flooding impacts to adjacent properties will be avoided or otherwise mitigated.

14. An operation and maintenance plan consistent with the requirements of Section E (WRC or RH Section E) of this chapter. Such a plan should clearly explain how the proposed facilities operate and the functions they serve.

15. The name of the development, the name and address of the property owner and Applicant, and the name and address of the individual or firm preparing the plan.

16. A north arrow, submission date, scale and revision dates as applicable shall be included on each page of all plans submitted.

17. Construction details sufficient to completely express the intended stormwater design components consistent with these standards.

D. Stormwater Management Design Standards

The City of Rochester Hills Department of Public Services has adopted the following portions of the Oakland County Water Resources Commissioner (OCWRC) Stormwater Engineering Standards, dated November 22, 2021, into this Rochester Hills Stormwater Management Design Standards section:

Section 1, Parts A, D, E, F and G
Section 3 in its entirety
Appendices A, C, E and F

The above noted OCWRC Sections, Parts and Appendices have been imported and unchanged into this Chapter 4 document. Chapter 4 is a combination of Rochester Hills and OCWRC criteria required for ensuring stormwater design consistency and community submission specificity for Rochester Hills. It is the City intention to maintain consistency with OCWRC and other southeast Michigan communities regarding the design, implementation and management of stormwater facilities. However, it should also be noted that the City of Rochester Hills has its own engineering division that performs site plan reviews and the City does not contract or utilize OCWRC to issue permits and construction plan approvals for new and redeveloped properties.

The existing stormwater infrastructure within the City of Rochester Hills includes physical assets with differing owners. For example, manhole, pipe, structure cover, and detention basin ownership can vary from Rochester Hills, OCWRC, subdivision homeowner associations and a public school or university. The ownership of an asset will ultimately dictate the requirements for a specific item. For example, a stormwater drainage manhole may be required to include lettering stating the City of Rochester Hills, and not OCWRC, if the manhole will be owned by Rochester Hills.

Section I - Oakland County Stormwater Standards

Part A: Standards

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

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

1. Provide a comprehensive framework for managing stormwater that addresses surface water quality, channel and infrastructure protection, localized flood control and long-term operations and maintenance.

2. Incorporate design standards that control both the quantity and quality of stormwater runoff.

3. Require volume reducing Low Impact Development (LID) design measures, or Best Management Practices (BMPs), such as infiltration, preservation of natural areas, enhanced vegetation, and reduced imperviousness to control runoff volume to the Maximum Extent Practicable (MEP).

4. Strengthen the protection of natural features.

5. Protect public health, safety and welfare.

6. Promote economic development using straightforward and uniform drainage standards for site development throughout Oakland County, as well as across Southeast Michigan.

7. Provide guidelines and additional resources for the selection of effective structural and vegetative stormwater BMPs for development sites.

8. Enhance the sustainability of stormwater management practices in Oakland County including performance, longevity, safety, maintenance, community acceptance, and environmental benefits.

9. Establish a framework to increase the likelihood of long-term operation and maintenance of the stormwater management practices.

10. Use the most currently published, relevant rainfall statistics.

11. Promote a consistent design process by using a set of simple equations to determine runoff rates, detention volumes, water quality treatment and infiltration requirements.

Part B: Authority - not adopted by the City of Rochester Hills

Part C: Applicability - not adopted by the City of Rochester Hills

Part D: Channel Protection Volume Control

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

For underground infiltration BMPs that are not easily accessible for inspection and maintenance, such as underground detention system infiltration, this Channel Protection Volume is generally not credited and will be evaluated on a case-by-case basis by the City of Rochester Hills Engineering Department.

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

Part E: Channel Protection Rate Control: Extended Detention

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

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

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

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

Part F: Water Quality Control

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

WQC can be achieved one of several ways:

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

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

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

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

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

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

4. The following treatment methods are effective at meeting the OCWRC water quality requirements:

   a. Bioretention BMPs (infiltration), discharging to a conventional detention basin* (wet or dry)

   b. Mechanical separator(s), discharging to a conventional detention basin* (wet or dry)

   c. Sediment forebay(s), discharging to a conventional detention basin* (wet or dry)

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

Part G: Detention & Flood Control

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Section II Submittal and Review Procedures – Not Adopted by the City of Rochester Hills

Section III General Design Criteria

Part A: Determination of Surface Runoff

Rational Method

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

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

Coefficient of Runoff

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

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

*HSG = Hydrological Soil Group

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

Modified Rational Method

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

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

Rainfall Depths

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

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

Time of Concentration

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

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

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

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

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

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

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

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

Rainfall Intensity

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

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

Regional* 24-Hour Average Rainfall Amounts

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

Part B: Stormwater Conveyance

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

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

Drainage Structures

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

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

Drainage inlets or manholes shall be located as follows:

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

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

Stormwater Outlets

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

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

Enclosed Storm Drains

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

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

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

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

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

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

Open Watercourses

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

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

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

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

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

Determination of Culvert Size

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

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

Part C: Channel Protection Volume Control

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

Non-Structural BMPs

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

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

Structural BMP General Requirements

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

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

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

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

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

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

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

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

e. In areas there are routinely wet.

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

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

Technical Infeasibility

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

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

1) The conditions on the site preclude the use of infiltration practices due to the presence of shallow bedrock, contaminated soils, high ground water or other factors, such as underground facilities, utilities or location of the development within a wellhead protection area.
2) The design of the site precludes the use of soil amendments, plantings of vegetation or other designs that can be used to infiltrate and evapotranspirate stormwater runoff.
3) Water harvesting and reuse are not practical or possible due to the volume of water used for irrigation, toilet flushing, industrial make-up water, wash-waters, etc. is insignificant to warrant the application of water harvesting and use systems.
4) Modifications to an existing building to manage stormwater are not feasible due to structural or plumbing constraints or other factors.
5) Sites where the site area is too small to accommodate adequate infiltration practices for the impervious area to be served.
6) Soils that cannot be sufficiently modified to provide reasonable infiltration rates.

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

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

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

* Adapted from EPA Section 438 Technical Guidance December 2009.

Infiltration Testing

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

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

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

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

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

d. Guelph permeameter

e. Constant head permeameter (Amoozemeter)

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

3. Soil Borings

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

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

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

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

BMP Volume Calculations

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

Bioretention Basin/Rain Garden

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

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

Volume Calculations

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

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

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

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

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

Bioswale

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

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

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

Infiltration Basin/Trench

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

Porous Pavement

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

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

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

Vegetated Roofs

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

Water Reuse

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

The consideration of other volume reducing BMP's will be evaluated by City of Rochester Hills, Engineering Department on a case-by-case basis.

Part D: Water Quality Control

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

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

The Water Quality Volume can be calculated as follows

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

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

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

Manufactured Stormwater Treatment Systems

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

1. MSTS must be installed upstream of the stormwater detention system. If the site is not required to provide stormwater detention, a manufactured treatment system must be installed upstream of the connection to the receiving system.

2. The MSTS shall be designed off-line to allow continuance of flow in the event the manufactured treatment system becomes obstructed.

3. Calculations for sizing mechanical treatment devices shall be based on the following:

   a. The 1-year peak flow rain event (2.07" rainfall) using the Modified Rational Method as shown in Eq. III-3.

   b. Site specific time of concentration (T_c) and associated rainfall intensity (I)

   c. The area shall include all post-developed, disturbed areas contributing to the MSTS.

   d. Tributary areas to volume reducing BMPs, located within the overall contributing drainage area to the manufactured treatment system, may be subtracted from the manufactured treatment system's contributing drainage area for design purposes.

4. The MSTS shall conform to the standards set forth and certified by the New Jersey Department of Environmental Protection (NJDEP) for manufactured treatment systems, as defined at http://www.njstormwater.org/treatment.html, including offline use, manhole diameter size, and custom or multiple units.

5. The NJDEP certified treatment flow rate (cfs) for a manufacturer and model shall be higher than the calculated peak discharge for a particular site and documentation of how the MSTS meets the WRC water quality control standards shall be submitted.

6. Please refer to WRC construction specifications for approved manufacturers of manufactured treatment systems installed on County Drains.

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

Forebay Design

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

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

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

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

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

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

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

Part E: Channel Protection Rate Control: Extended Detention

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

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

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

Part F: Detention & Flood Control Facilities

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

General Detention System Design Requirements

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

General Detention Basin Requirements

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

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

Detention System Outlet and Overflow Structure Design

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

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

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

The following equations will be used to check weir design:

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

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

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

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

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

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

Underground Detention Facilities

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

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

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

Retention Basin Design

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

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

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

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

Part G: Maintenance Requirements

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

The maintenance plan must include the following:

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

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

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

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

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

Easements

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

5. This office must also be provided with one set of digital As-Built engineering drawings, cleaned of all background debris, showing plan, profile and the new easement of the drain.

6. Proposed County Drain easements shall be indicated on the plans as well as the mylar plat and shall be designated as 'permanent private easement for the "Name" (County) Drain'. In addition, the following note must be added to the mylar plat:

   a. The use of the word "private" does not limit in any way the scope of the easement granted to the "Name" (County) Drain Drainage District"

Drainage Service Areas (Districts)

1. A Drainage Service Area and Special Assessment District are each a legally established boundary for the area served by a County Drain. Drainage Service Areas do not always match the topographical area tributary to a County Drain. Drainage Service Areas shall not be violated when designing a drainage system.

2. Alterations to a Drainage Service Area and/or a Special Assessment District may be made by following the procedure established in the Drain Code. Approval must be granted by the Water Resources Commissioner or the Drainage Board.

Connections to County Drains

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

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

Crossing County Drains

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

Soil Erosion and Sediment Control

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

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

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

Part I: Assets Under Local Jurisdictions

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

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

:

Pipe Diameter (inches)	Minimum Slope (feet per 100 feet) > 2.5 fps	Maximum Slope (feet per 100 feet) < 10 fps
12	0.32	4.88
15	0.24	3.60
18	0.20	2.84
21	0.16	2.32
24	0.14	1.92
27	0.12	1.64
30	0.10	1.44
36	0.08	1.12
42	0.06	0.92
48	0.05	0.76
54	0.04	0.64
60	0.04	0.56

ii. Location

In-line catch basins on storm lines greater than eighteen-inches (18”) are prohibited.

Storm sewers shall generally be located on the same sides of streets as water mains, and generally within the street right-of-way, 7 ½ feet from Northerly and Easterly street right-of-way lines.

Easements for sewers not located within a street R.O.W. shall have a minimum width of twenty feet (20’), centered upon the sewer. Such easements shall be reserved with restrictions against use or occupation by other utilities, in any manner, which would restrict sewer maintenance or repair operations.

For subdivisions, storm sewers shall be located in the public road right-of-way or in easements adjacent to the public road right-of-way. Storm sewers shall not be located in rear yards except to pick up rear yard drainage or in unusual circumstances or for sump pump discharge lines.

The horizontal alignment of sewers which are not proposed to generally follow street, drive, or parking area pavements, shall parallel property lines or building lines, with clearance distances sufficient to accommodate the full width of the proposed easement.

Horizontal clearance between storm pipes and sanitary sewer and water lines shall be a minimum of ten feet (10’).

Horizontal separation from buildings shall be a minimum of ten feet (10’) or distance, which will allow a 1:1 slope to the base of the foundation, whichever is greater.
All storm sewers located beneath pavement or a traveled portion of a roadway shall have a minimum of three and a half feet (3½’) of cover.

Vertical separation distances between storm sewers and other buried storm sewers and other buried utility lines should be at least eighteen inches (18”).

c. Catch Basin and Inlets

Catch Basin outlet pipes located in pavement areas will incorporate a floatable trap device that captures floatable debris and oils, provides for pipe maintenance access, stainless steel hardware, oil and gas resistant gaskets, and is designed to prevent siphoning according to the following:

i. In “Heavy Traffic and Pollutant Load” areas a floatable trap outlet in every catch basin is required. This includes, but is not limited to, gas stations, convenience stores, fast foot restaurants, vehicle repair facilities, stores with “drive through” service (i.e. banks, drug stores, dry cleaners, coffee shops), loading docks, distribution facilities, hospitals, school bus loading areas, maintenance facilities, light industrial sites, “dumpster areas”, parking and roadway areas of shopping centers close to the stores, etc. The exception will be where a catch basin cannot be maintained. An oil-absorbing boom may also be required in structures that receive heavy hydrocarbon loading.

ii. In "Moderate Traffic and Pollutant Load" areas, floatable trap outlets will be located in catch basins so as surface water passes through no more than one (1) catch basin that does not have a floatable trap. This includes, but is not limited to, office buildings, multi-residential complexes, schools (other than bus areas), most shopping mall parking areas, mixed retail commercial facilities, municipal/government buildings, athletic/entertainment/recreational facilities, non-fast food restaurants, special event/remote parking areas, etc. The downstream structures (prior to discharge) are most critical, and oil-absorbing booms may be useful if heavier hydrocarbon loading is expected.

iii. In "Low Traffic and Pollutant Loading" areas, floatable trap outlets will not be required for the following developments due to their low intensive use to the environment. . This includes, but is not limited to, grassy or vegetated areas, single family residences, parks, parking for offices within residences, flow excess from permeable paving areas, etc.

NOTE: A large site may have different areas, just like it may have different runoff coefficients. For instance, a shopping mall may have a heavy traffic roadway and loading/unloading areas as well as a remote parking area. Therefore, apply the appropriate placement criteria to each area of the site to arrive at the total number of floatable traps equipped catch basins for the project.

Minimum sump depth is two-feet (2') for catch basins that do not require a floatable trap outlet.

Minimum sump depths for catch basins equipped with floatable trap outlets is thirty-six inches (36").
Surface water flows shall not exceed the intake capacity of the structure casting.

At all low points in gutters, and in swales and ditches, where applicable.

At the upstream curb return, if more than two hundred feet (200') downstream of a high point in the gutter.

At maximum intervals of six hundred feet (600') along a continuous slope.

Such that there is a maximum pavement length per structure as follows:

- 300 lineal feet for a catch basin or inlet at a low point; and

- Vane grates shall be provided on relief basins when the longitudinal slope of road is four percent (4%) or greater.

Such that, where low point exists in the gutter line, no more than two relief basins shall be used in either direction in advance of the low point, (i.e., 4 relief basins would be possible). When a total of two or more relief basins are used in such a system, a double catch basin will be placed at the low point.

At tee intersections, catch basins may only be installed at the property line extended, on the leg of the tee.

Drainage structures shall not be located in line with sidewalks.

Typically, depending on surface types, no more than one (1) acre of area should be tributary to one standard catch basin. Catch basins may be doubled in order to provide for additional capacity.

d. Manholes

i. Depending on pipe size, manholes should be located at:

All changes in alignment

Points where the size of the sewer changes

Points where the grade of sewer changes

The junction of sewer lines

Street intersections or other points where catch basins or inlets are to be connected.

ii. Manhole spacing for storm sewers shall be as follows:

Diameter of Sewer	**Maximum Manhole Spacing**
12" – 18"	400 ft.
21" – 30"	450 ft.
36" & 42"	500 ft.
48"	550 ft.
54"& 60"	600 ft.
66" & larger	650 ft.

Where future connections to a manhole are anticipated, stubs with watertight bulkheads shall be provided.

e. Materials

i. Covers for Manholes, Catch Basins and Inlets

Manhole frame and cover shall be EJIW 1040, Type A cover, or equivalent.

Manhole and catch basin covers shall include "Dump no waste! Drains to Waterways" or approved similar message.

Catch basin and inlet frame and cover shall be as follows:

- EJIW 7045, or equal, for use with barrier curb and gutter, and with concrete pavement with integral curb.

- EJIW 7065, or equal, for use with mountable curb and gutter, and with concrete pavement with mountable integral curb.

- EJIW 7085, or equal, for use with B-2 or rolled curb.

- EJIW Type O Beehive Grate, or equal, for use on open ditch structures and catch basins located in swales in easements outside the public street right-of-way.

- Vane grates, EJIW 7010 with type M6 vane grate and T1 back, shall be provided when the longitudinal slope of road is four percent (4%) or greater.

ii. Pipe/Structure Type

Minimum pipe size for sewers, catch basin leads and inlet leads shall be twelve inches (12") nominal internal diameter.

Reinforced Concrete Sewer Pipe shall conform to the requirements of ASTM Designation: C76. Joints shall conform to the requirements of ASTM Designation. C443 Joints and Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets. All catch basin leads and inlet leads shall be ASTM C76-Class IV pipe.

Roof and sump leads shall be Schedule 40 PVC or SDR 23.5.

Eccentric cones shall be provided on all structures, regardless of the material used (precast reinforced concrete, manhole block, or brick), to provide a true vertical face for placement of manhole steps. Manhole steps shall be steel, encased with polypropylene plastic, equivalent to M.A. Industries, Inc. PS1 or PS1-B, as appropriate. A minimum of four inch (4") and a maximum of twelve inch (12") HDPE or concrete grade rings shall be placed on the cone section of all precast concrete, and concrete block, structures.

f. Miscellaneous

i. Bar Grates

A pre-fabricated bar screen should be designed to be self-cleaning so as to minimize plugging with debris and be installed on all storm sewers eighteen inch (18") in diameter and larger. Except when dealing with an open channel to enclosed system (i.e. cross culvert), where it is a straight pass through transition, in such case, the city engineer shall determine if bar grates are necessary.

ii. Special Drainage Structures

Preliminary plans for special structures and appurtenances required for storm sewer systems shall be submitted to the City Engineer for review and comment, prior to their inclusion in the construction drawings.

iii. Taps

Connections must be made at manholes, except when the receiving storm sewer pipe is twenty-seven inch (27”) or larger.

iv. Roof Leads and Sump Lines

Sump pump discharge lines are required to be connected to an approved drainage system.

Residential roof leads are not permitted to discharge to the sanitary sewer or storm sewer system.

i. Plan Criteria

i. Plan and Profile General

All storm sewers shall be shown in Plan and Profile, with the profile generally shown below the plan view. All structures and end-sections shall be sequentially labeled in both plan and profile views.

Scale of plan portion of sheet shall be no smaller than one inch (1”) = fifty feet (50’), with scale of profile portion of sheet one inch (1”) = fifty feet (50’) horizontal and one inch (1”) = five feet (5’) vertical.

All elevations shall be on U.S.G.S. datum.

ii. Plan View

Existing topography and all existing and planned surface and underground improvements in streets and easements in which sewer construction is proposed, and in contiguous areas if pertinent to design and construction.

Street names, street and easement widths, all other street and easement survey information, subdivision names, lot numbers and frontage dimensions, and permanent parcel numbers and frontage dimensions for all unplatted parcels.

Location, length, size, material type, and direction of flow of each section of proposed sewer between manholes.

Locations of all manholes and other sewer appurtenances and special structures, with proposed rim elevations for all inlets and catch basins.

Reference benchmarks, established at intervals not greater than 1,200 feet and convenient to the proposed construction, with identification, location, description and established elevation listed. Generally, at least two benchmarks shall be noted on each sheet.

A tabulated list of quantities of construction pay items appearing on that sheet.

iii. Profile View

Profile portion of sheet shall appear below companion plan portion, generally projected vertically, and shall show at least the following:

- Size, slope, type and class of pipe, and controlling invert elevations for each section of proposed sewer between manholes.
- Limits of special backfill requirements.
- Profile, over centerline of proposed sewer, of existing and proposed finished ground and pavement surfaces.
- Profile of hydraulic grade line staring at the elevation of 0.80 x pipe diameter of the outlet pipe or the HWL of the pond, whichever is greater.
- Location of existing and proposed utilities crossing the line of the sewer or otherwise affecting sewer construction.
- Location, by station, of every proposed manhole, with manhole number, invert elevation of all inlet and outlet pipes, and top of casting elevation.
- Show end section footing detail.

Manholes shall be identified by numbers assigned consecutively, and increasing in magnitude in the direction opposite to the direction of flow.

All catch basin and inlet leads shall be laid on slope no flatter than one percent (1%).

Types of covers and grates for structures shall be shown.

5. Stormwater Ponds/Basins

a. General

i. Wet ponds are preferred to extended dry basins.

ii. Stormwater Ponds/Basins shall be located on common-owned property in multi-ownership developments such as subdivisions and site condominiums, and not on private lots or condominium units.

iii. Stormwater Ponds/Basins shall discharge to a natural watercourse, established drainage system, or drainage area where a dedicated easement exists for the purpose of drainage. In no case shall a pond/basin or system discharge onto adjacent property without an easement or the property owner's permission.

iv. Sediment Forebay

- A sediment forebay should be used to isolate gross sediments as they enter the storm water storage facility and to simplify sediment removal. The sediment forebay should consist of a separate cell formed by an earthen berm.

- The sediment forebay shall be sized to contain the water quality volume and be a minimum of three feet (3') deep.

- Exit velocities from the forebay shall not be erosive.

- Direct maintenance access shall be provided to the forebay.

v. In-line detention ponds/basins are not permissible. Except in the event there is no practicable alternative or it is demonstrated that the use of an inline basin is an enhancement to the environment, it may be considered for approval by the City Engineer.

vi. Interior side slopes of dry basins should not exceed 1:6 (V:H), unless unfeasible, steeper slopes are permissible under the following conditions: Side slopes steeper than 1:6 (V:H) require a safety bench starting at the design surface water elevation (25 year), sloping inward at a maximum of 6% slope, and at a minimum width of 5'. The side slope, below the downward slope end of the safety bench, shall not be steeper than 1:3 (V:H). Chain link fence may be substituted for the safety bench. For the purpose of providing safety protection and maintenance access the minimum standard for fences is 6 feet high vinyl clad chain link with a locking access gate, 8 feet wide. Alternate types of fencing or safety protection accepted by the Planning Commission may be permitted, for aesthetic purposes, subject to approval by the Engineering Division.

vii. Stormwater management systems incorporating pumps shall not be permitted. Variances of this requirement will be considered only as a measure of last resort, subsequent to demonstration that no alternative system designs are feasible. Where pumps are absolutely necessary, an alternate method of draining shall be provided.

viii. A minimum one-foot (1') freeboard is required above the 25-year stormwater elevation on all stormwater ponds/basins.

ix. All ponds/basins must be designed with a 100-year storm overflow to control flooding. The overflow shall discharge to an existing drainage system. If a weir overflow is used sufficient erosion protection must be incorporated into the design. Calculations for the overflow design must accompany the plans.

x. The principal spillway will be sized to pass the maximum design flow tributary to the pond/basin.

xi. Vegetative Plantings Associated with Stormwater Ponds/Basins.

Ponds/basins and wetland designs will be accompanied by a landscaping plan that incorporates native plants and indicates how aquatic and terrestrial areas will be vegetated, stabilized, and maintained.

Whenever possible, native wetland plants should be encouraged in the pond/basin design, either along the aquatic bench, fringe wetlands, safety shelf and side slopes or within shallow areas of the pools

A permanent buffer strip of natural vegetation extending at least twenty-five feet (25') in width beyond the freeboard elevation will be maintained or restored around the perimeter of all stormwater ponds/basins. No lawn care chemicals shall be applied to the buffer area.

xii. Easements and Access

For all new residential development, the property in which the pond/basin is located upon must be contained in an easement reserved or dedicated for detention purposes only.

A minimum twenty-foot (20') wide maintenance access easement shall be provided.

At a minimum, a twelve-foot (12') wide gravel access drive shall be located within the above easement for maintenance purposes.

b. Pond/Basin Inlet/Outlet Design

i. Velocity dissipation measures will be incorporated into pond/basin designs to minimize erosion at inlets and outlets, and to minimize the resuspension of pollutants.

ii. To the extent feasible, the distance between inlet and outlets will be maximized. The length and depth of the flow path across ponds/basins shall be maximized by:

Increasing the length to width ratio of the entire design.

Increasing the dry weather flow path with the system to attain maximum sinuosity.

Inlets and outlets should be offset at opposite longitudinal ends of the basin.

iii. Storage shall be required for all site runoff. Detention is not required for flows originating offsite that flow through the site. The restrictor size, designed for onsite runoff storage, shall not be upsized to pass through offsite flows.

iv. The use of dual outlets, risers, V-notched weirs or other designs that assure an appropriate detention time for all storm events is required.

v. The outlet will be protected from clogging. Methods, such as a weir, or incorporating self cleaning trash racks, or using proprietary flow control devices (i.e. Hydro-Brakes and Reg-U-Flow) or other innovative designs shall be used. A reverse slope submerged orifice with trash rack or a hooded, broad crested weir is recommended options. If a reverse-slope pipe is used, an adjustable valve may be necessary to regulate flows and the invert of the pipe drawing from the pool should be at least eighteen inches (18”) from the bottom to prevent sediment discharge.

vi. Where a pipe outlet or orifice plate is to be used to control discharge, it will have a minimum diameter of four inches (4”). If this minimum orifice size permits release rates greater than 0.2 cfs/acre, an alternative outlet design that incorporates self-cleaning flow restrictors will be required. Examples include perforated risers, proprietary flow control devices, and “V” notch orifice plates that provide the required release rate. Calculations verifying this rate will be required for approval.

vii. The hydraulic grade (H.G.) of the receiving waterway must be investigated to assure it is not higher than the pond/basin outlet H.G. If the H.G. of the receiving waterway is higher, the design engineer shall provide a method to allow a positive outflow at the required discharge rate.

viii. OCWRC SO-2 (Riser) detail and design standards shall be adhered to.

ix. The riser shall be placed near or within the embankment to provide for ready maintenance access.

x. Orifices used to maintain a permanent pool level shall withdraw at least one foot (1’) below the surface of the water.

xi. Where feasible, a drain for completely de-watering wet ponds should be installed for maintenance purposes.

xii. All outlets will be designed to be easily accessible for heavy equipment required for maintenance purposes.

xiii. Anti-seep collars shall be installed on any piping passing through the sides or bottom of the pond/basin to prevent leakage throughout the embankment.

xiv. Storm sewers serving as an outlet for stormwater ponds/basins shall be designed in accordance with the standard requirements for other storm sewers in the design.

c. Wet Ponds

i. Facility Sizing

The volume of permanent pool shall equal or greater than twice the water quality volume.

ii. Pond Configuration

The wet basin shall be configured as a two-stage facility with a sediment forebay and a main pool.

The outlet should be located at the opposite and farthest end of the pond from the inlet.

The minimum length to width ratio shall be 3:1 where feasible. If it is not feasible to construct a pond with such dimensions, baffles or islands should be used to achieve the flow path length.

iii. Depth

The depth of the pond should be variable, with the average depth between three (3) and six (6) feet.

The deep section of the pool should have a minimum depth of three feet (3’). This prevents resuspension of sediments by wind turbulence.

The maximum depth of the permanent pool shall be ten feet (10’). Ponds deeper than this depth may be subject to stratification and promote anoxic conditions at the pond bottom, releasing sediment-bound pollutants into the water column.

iv. Pond Side Slopes/Benches

Interior side slopes of wet ponds should not exceed 1:6 (V:H), unless unfeasible, steeper slopes are permissible under the following conditions: Side slopes steeper than 1:6 (V:H) require two safety benches. One should start at the design surface water elevation (25 year). The other should extend from the wet pool elevation and slope inward to a maximum depth of 18 inches (also considered an aquatic bench). Both benches should be a maximum of 6 % slope and a minimum width of five-feet (5'). The aquatic bench should be landscaped with appropriate native plantings. Slopes below the safety/aquatic benches shall not be steeper than 1:3 (V:H). Chain link fence may be substituted for the safety bench located above the design surface elevation, which eliminates the need for the aquatic bench. Fences shall be a minimum of 6 feet (6’) high vinyl clad chain link with a locking access gate, 8 feet (8’) wide. Alternate types of fencing may be permitted, for aesthetic purposes, subject to approval by the Engineering Division.

d. Extended Detention Basins

i. A two-stage design is required, with separate outlet controls to detain both the first flush volume and larger rain events.

Lower Stage: The lower stage should contain a shallow, permanent pool designed to store and treat the water quality volume. This pool should be managed as a shallow marsh or wetland and average six to twelve inches (6”-12”) in depth. A sediment basin upstream for the lower stage must also be incorporated into the design.

Upper Stage: The upper stage should be sized for the 25-year storm event, as defined by the Oakland County Water Resources Commissioner (OCWRC), and should be graded to remain dry except during large storms.

- A low flow channel, constructed of natural permeable material (no cunettes permitted), stabilized against erosion, will be provided through the dry portion of the pond. This channel should have a minimum grade of one half percent (0.5%) and the remainder of the pond should drain toward this channel at a grade of at least one percent (1%). The low flow channel should end at the lip of the lower stage, where riprap or gabion baffles should be placed to prevent scour and resuspension of pollution particles.

6. Underground Detention Facilities

a. General

Underground detention is a less preferred method of meeting the City's stormwater storage requirements, however, if the developer determines that underground detention is the development's best alternative, the following design considerations will need to be addressed:

b. Design Considerations

g. Applicability

These standards are appropriate for all underground pipe or vault detention, whether intended to detain flood and/or channel protection volume, or temporarily store a portion of the water quality volume. Pipes or vaults may be located below vehicular or non-vehicular areas, and must be a minimum of ten feet (10') horizontally from other utilities. Underground detention is generally not acceptable in single-family residential or multi-unit condominium developments. Approval by the City Engineer may be granted on an individual case basis in coordination with the Planning Department.

ii. Design Storm

The facility must be sized to provide storage for the channel protection volume, flood protection volume, and/or recharge volume, with safe conveyance of larger flows through the facility. In addition, the hydraulic grade (H.G.) of the receiving water way must be investigated to assure it is not higher than the pond/basin outlet H.G. If the H.G. of the receiving waterway is higher, the design engineer shall provide a method to allow a positive outflow at the required discharge rate.

One (1) foot of freeboard is required.

iii. Groundwater

In general, underground storage should not be located in areas of shallow groundwater. In situations, where groundwater is encountered, additional design requirements may be necessary.

iv. Geotechnical Analysis

Soil borings must be performed in the location of the proposed detention facility in order to determine presence and location of fill materials, soil type, or groundwater. Borings must extend to a minimum of two feet (2') below a facility.

v. Pretreatment

Stormwater must be pretreated prior to entering the underground system.

The pretreatment BMP must be located so as to provide ease maintenance accessibility.

vi. Inspection accessibility

An adequate number of inspection manholes need to be provided to inspect all of the cells in the system.

c. Specifications and Details

i. Outlet Structure

The outlet structure shall be composed of concrete, and may be cast in place or precast. Precast structures must be monolithic, including the control weir. Structures must be designed for HS20 loading at a minimum. Direct access to both side of the control structure is required.

ii. Overflow Weir Sizing Criteria

The overflow weir in the control structure must be designed to safely pass larger flows through the facility.

iii. Low Flow Outlet Orifice

The low flow orifice may be no smaller than four inches (4") in diameter and must be protected by a trash rack. Expanded metal or perforated half-round CMP should be used. All trash racks must be removable. The surface area of the trash rack perforations must exceed the low flow orifice area by a ratio of at least 5:1. For orifice sizes.

iv. Storage Pipe

All storage pipes must be circular, and must be a minimum of forty-eight inches (48") in diameter. Metal, HDPE, or concrete may be used. Crossover connections must be provided between storage pipes, and these must be a minimum of forty-eight inches (48") in diameter, also. Pipes may not be closer together than one half (½) the inside pipe diameter or three feet (3'); whichever is greater. Minimum cover must be per the manufacture's specifications, based on the design load and considering flotation where required. PH and resistivity test may be required if metal pipe is proposed, on a case-by-case basis, wherever soil acidity is a concern.

v. Metal Pipe

Metal storage pipe must be aluminized, Type 2, and must be designed for the appropriate loading (pipes may not be less than 14-gauge). Pipe ends must be matched and numbered by the manufacturer. Coupling bands must be per the City of Rochester Hills Engineering Construction Specifications, Materials – Storm Drain Pipe.

vi. Concrete Pipe

Concrete pipe must meet ASTM C76. Joints must meet ASTM C443.Only circular pipe may be used.

vii. HDPE Pipe

High Density Polyethylene pipe is acceptable for use in underground storage facilities. Concrete manholes must be used at all HDPE pipe connections. Pipe installation must comply with ASTM D2321.

viii. Concrete Vaults

Concrete vaults may be used for underground detention, with design approved by the Engineering Division on a case by case basis.

ix. Pipe Bedding

Must be per the bedding details on the storm system detail sheets or the manufactures specification/details, whichever is greater.

x. Access

All facility access manholes must be thirty-six inch (36”) diameter. Manhole steps shall be provided. Concrete manholes must be used for access to HDPE pipes. Manhole access is required at least in corners of the system and where necessary to allow proper jetting operations and entry for maintenance.

7. Manufactured Treatment Devices (MTD)

a. General Performance and Design Specifications

i. If a manufactured treatment device (MTD) is proposed to help achieve better stormwater quality, it must be capable of treating the peak stormwater quality flow rate, which is, the one inch (1.0”) rain event which occurs within 15 minutes using the rational method. Use a 15-minute time of concentration for commercial sites and a 20-minute time of concentration for residential sites.

ii. The MTD must remove eighty percent (80%) or more of OK 110 (110 um sized particles) based on test results indicated on the third party testing selection guide, provided in Section 4.3.5 (Plan Submittals, B).

iii. Rain events larger than the 1 year, 15 minute rain event shall bypass without causing any resuspension of trapped sediments and without causing re-entrainment of floatable contaminants.

iv. All MTDs should be configured as off-line units unless a detailed hydraulic analysis is provided. The analysis must demonstrate the up- and downstream pipes will have capacity and surcharging created by high rainfall storms will not result in loss of previously captured material.

v. The treatment system must prevent oil and floatable contaminants from entering downstream piping during routine maintenance and during rain events. The use of a floatable trap should be used to meet this requirement.

vi. Direct vehicular access must allow complete and unrestricted access to the entire bottom of the chamber from the top.

vii. The private manufactured treatment device (MTD) should be located outside the City right-of-way.

viii. There can be no points of constriction in the system to cause plugging or flooding.

ix. System must be built to withstand HS-20 loads.

b. Maintenance Guidelines

i. The treatment system shall be maintained according to the manufacturer's recommendations. An Operations and Maintenance Manual (O&M manual) must be provided for review specific to the model. See notes below for information to include in the O&M manual.

The following notes/maintenance items should be included in an Operations and Maintenance Manual (O&M manual):

The maximum sediment depth should be clearly specified.

Graphical and written description of sediment measuring procedure. This should include the use of a dipstick tube equipped w/ a ball valve. (e.g. sludge judge).

Oil removal procedure during routine cleanout.

The O&M manual should specify if entry into the manufactured treatment device (MTD) should be considered an OSHA confined space and guidelines followed.

The inspection frequency should be according to the manufacturer recommendation and approved by the Engineering Division. In no case should it be less than six (6) months.

Off-line configurations must include inspection and maintenance of connecting manhole and diversion weir.

Detail drawing of proposed MTD should be included.

Note in manual to clean unit immediately if there is a hydrocarbon spill (e.g. gasoline or oil).

A note should be provided indicating disposal of all sediment must be in accordance with all federal, state and local requirements.

c. Plan Submittals

i. Calculations associated with the sizing and selection of the appropriate model for the selected type of treatment system shall be included in all plan submissions.

8. Construction Specifications

a. Storm Drain Pipe Materials

i. General

The purpose of this specification is to establish provisions for substitution of the storm drain pipe and joint that has been specified on the Plans. Substitutions may be approved by the Owner, provided the flow capability and pipe (external load supporting) strength is equal to or exceeds that of the pipe specified on the Plans.

Alternate type of storm sewer pipe is allowable under the following conditions:

- Location of the storm sewer is on private property.
- The alternate pipe must meet or exceed the performance requirements of this section.
- The City Engineer reserves the right to accept or reject the use of alternate pipe proposes in non-residential developments.
- Aluminized CSP will be permitted after an on site soil analysis indicates pH ranges of 5.0-9.0 and resistivity of 1500 ohm-cm and greater.

ii. Video Inspection

As a means of insuring proper installation of the storm sewer pipe, at the discretion of the City Engineer, the contractor shall video inspect, according to the city of Rochester Hills video inspection standards, up to 100% of the storm sewer pipe 12" and larger in diameter. If video inspection is required by the City Engineer the contractor shall provide 24 hours notice to the City of Rochester Hills prior to video inspection, so a representative may be present. Rochester Hills will be provided with a digital copy of the video inspection and log in accordance with the City of Rochester Hills video inspection standards.

Projects that the City Engineer may impose these requirements are:

- All public projects or projects being constructed on public property.
- Any project involving a development, subdivision, site condominium, condominium, or association.
- Any project that will result in more than one owner responsible for the operation and maintenance of the complete storm drainage system.

iii. Plastic Pipe Testing

All pipe shall be certified by the manufacturer to meet applicable ASTM specification requirements. Certification forms, together with a report of the test results, shall be provided the inspector with pipe deliveries and copies shall be forwarded to the Engineer or Owner.

Certification forms shall include project name, location, contractor and test lot number. Lot sizes shall be acceptable to the Engineer.

All pipefittings shall be suitably marked to provide manufacturer's name, lot or production number. ASTM Designation, PVC, nominal diameter, and SDR number, where applicable. Fittings, however, need not contain lot or production number. Pipe shall have a "home" mark. Truss Pipe with an absence of filler material at the ends greater than one-fourth (1/4") inch deep shall be subject to rejection or acceptable repair.

The completed installation shall at no point have out-of-round pipe deflections greater than 5%. Deflectometer or go/non-go gauging tests may be required prior to acceptance of pipelines, at the discretion of engineer. No more than 50% of installed lines will be mandrel tested unless deflection tests results are unsatisfactory.

b. Products

v. Reinforced Concrete Pipe

Shall be in accordance with ASTM C76 standards. Modified groove tongue joint with approved rubber gasket (current ASTM C443, except as such Specifications relate to infiltration limitations).

Lubricant, as supplied by the pipe manufacturer, shall be used on the groove and on the tongue in making up joints. The joints shall be coupled in accordance with the pipe manufacturer's requirements.

b. Reinforced Concrete Elliptical Culvert Storm Drain

Shall be in accordance with ASTM Designation C-507-79, Class HE-1 through HE-IV or VE-II through VE-VI.

Tongue and groove bituminous (DeWitt #10) joint with inside cement pointing.

c. Corrugated Steel Pipe

All corrugated steel pipe for storm sewers shall be Aluminized Type 2 formed with an external spiral rib. Hydraulic capacity must be equivalent to concrete pipe (N=0.013) for storm sewer calculations.

- For underground detention systems, pipe materials must be Aluminized Type 2, and may be either $2^{2}/_{3}$" x ½" corrugation, or 3" x 1" corrugation with gauge as specified by design engineer.

All corrugated steel pipe shall be joined together with a watertight circumferentially corrugated steel-coupling band furnished with two (2) rubber gaskets or bell and spigot end. Gasket shall be manufactured from an elastomeric material and shall meet the requirements of MTM 723.04, (MDOT): Where field jointing of non re-rolled end pipe is required. A 12" wide flat gasket with a minimum 12" wide flat or dimple band will be required. All pipe entering a concrete or block manhole shall be sealed with a minimum 12" wide external gasket. Additionally, all joints in storm sewers and underground detention systems will be wrapped with an 18" wide non woven (4 oz. min.) geotextile.
In underground detention systems, a 12" wide flat gasket with a flat band may be used as an alternate to rubber gasket system.

Gauge thickness shall be as specified on the plans, but in no case be less than the following:

18"-30" = 16ga; 36"-48" = 14 ga; 54"-60" = 12ga; 66"-78" = 10ga.

All pipe connections to the side wall of main-line corrugated steel pipe shall be of the diameter specified on the plans, and shall consist of similar steel pipe that connects or taps into the main-line pipe wall using a pre-fabricated steel saddle plate or factory welded connection.

c. Polyvinyl Chloride (PVC) Pipe

i. (4") to (36")

Material shall be PVC Composite (Contech Truss) Pipe - ASTM D-2680 or PVC Solid Plastic Pipe - ASTM D-3034, SDR 35 or PVC (Contech A2000) Pipe - ASTM F949. Pipe to be made of PVC compound having a minimum cell classification of 12454.

Gaskets for PVC pipe and fittings shall be of the elastomeric type. Gasket joints shall be installed in accordance with procedures specified by the pipe manufacturer. Joints shall meet the requirements of MTM 723.04 (MDOT). Care should be taken to insure all joints being pushed to the full home position and held tightly in home position during any grade or line adjustments.

Haunching, bedding, and backfill materials for pipe (4"-36") shall be as shown on the detail sheet.

d. High Density Polyethylene (HDPE) pipe

i. (8" – 48")

HDPE – ASTM F-2306; AASHTO M-294.

Joints to be bell and spigot with gaskets to be elastomeric type. Joint performance to meet the requirements of MTM 723.04 (MDOT).

Haunching, Bedding, and backfill materials for HDPE (8”- 48”) shall be as shown on the detail sheet and must consist of class I (crushed stone) meeting MDOT 21a,22a, or 6a gradation.

e. Manhole, Catch Basin and Inlet Block and Brick

Brick shall be made of clay or shale, and shall be whole, thoroughly and evenly burned, of close and uniform texture, free from cracks and warps, with true even faces and uniform in shape and size. Brick shall show a minimum average compressive strength of 2,000 pounds per square inch and an average absorption of water in twenty-four (24) hours of not more than 25% of the dry weight.

Concrete brick shall conform to the requirements for concrete building brick of ASTM C-55-75, Grade N-1.

Concrete block for manholes, catch basins, and inlets shall conform to ASTM C139-73 with the following exceptions:

The blocks shall be solid curved blocks with the inside and outside surfaces curved to the required radii. The blocks shall have tongue and groove or other approved type of joint at the ends so that the units interlock to form a strong, rigid structure. Curved blocks shall have the inside and outside surfaces parallel.

The nominal dimensions of the block shall be 18 inches maximum for length, 8 inches maximum for depth (height), and 6 inches minimum for width (thickness). The length shall be measured along the chord on the convex face of the block. The tolerances of ASTM C 129-73 shall apply. Where the specified wall thickness on the standard plans is 12 inches, a multiple block wall of two 6-inch wide blocks is permitted. All blocks in one structure shall be of the same height dimension. The blocks shall be designed for length so that only full length or half-length blocks are required to lay the circular wall of any one course.

Blocks intended for use in the cones or tops of manholes or other structures shall have such shape as may be required to form the structure as shown on the plans with inside and outside joints not to exceed 1/4 inch in thickness.

The mortar shall be composed of one (1) part of a combination of Portland Cement and hydrated lime and three (3) parts of fine aggregate, by volume. The combination of cement and lime shall consist of 90% of Portland Cement and 10% of hydrated lime, by volume. In lieu of the above combination of cement and lime, a standard brick mortar cement may be used if approved by the Engineer.

All Manhole, Catch Basin, or Inlet Structure Steps shall be M.A. Industries, Inc., Numbers PS-1-B or PS-2-PFS or approved equal.

f. Precast Manholes

All precast manhole sections and bases shall be 4000 lbs per square inch concrete as determined by core test or cylinders.

Unless otherwise noted on the drawings or in the Supplemental Specifications, precast reinforced concrete manhole sections shall meet the requirements of current ASTM C-478.

Precast manhole tees for forty-eight inch (48”) and larger storm drains shall be the same class pipe as that specified on the plans, but shall be a minimum ASTM C-76-79 Class IV. The manhole riser shall meet the requirements of current ASTM C-478.

g. Storm Drain Stubs

Four inch (4”) to ten inch (10”) diameter stubs shall be PVC Composite (Contech Truss) Pipe or PVC Solid Plastic Pipe as specified under Section 8, Construction Specifications, Item c, or approved alternate. Stubs twelve inches (12”) and larger shall be ASTM C76 Class IV Reinforced Concrete Pipe or as otherwise noted. Maximum pipe length of stubs shall be eight feet (8’).

E. <u>Operation and Maintenance Responsibilities</u>

1. General Responsibilities

a. The Owner/Developer of a property is responsible for the proper installation and initial function of the stormwater management system in accordance with the approved Stormwater Management Plan. All temporary soil erosion and sedimentation control measures shall be removed or converted to their permanent configuration in accordance with an approved erosion control plan. It is required that the Oakland County Water Resources Commissioner (OCWRC) determine and approve when sufficient stabilization has occurred on a site in order to convert to the permanent stormwater management facilities.

b. The Owner/Developer is responsible for the proper operation and maintenance of the stormwater management system during and after construction. An Operation and Maintenance Plan consistent with the requirements of Section E shall be prepared for review and approval by the engineering division. The operation and maintenance plan will become an exhibit to the operation and maintenance agreement. See Section 3 and 4 for further detail.

c. Approval and Transfer of Stormwater Operation and Maintenance (O&M) Responsibilities.

i. The City of Rochester Hills requires that the stormwater management system is operated and maintained by the individual property owners or an owners/homeowners association or similar entity, or an organization capable of carrying out maintenance responsibilities. However, the Developer is responsible for O & M until:

Evidence of final approval by OCWRC is received indicating the site has been sufficiently stabilized to convert to the permanent stormwater management system.

The stormwater management system is cleaned and free of sediment, as well as defects and/or damage corrected.

Evidence that the stormwater management system has been transferred to an association or relevant owner, as well as approval of the transfer by the City of Rochester Hills.

2. Ownership and Maintenance

All stormwater management systems identified within an approved Stormwater Management Plan shall be owned and maintained by one of the following entities:

a. Individual On Property Stormwater Management Systems

i. Where individual on-property stormwater management systems are proposed, the land development plan shall contain a note designating the entity responsible for operation and maintenance of the on-property system consistent with an approved Operation and Maintenance Plan.

b. Owners, Homeowners or Condominium Association Ownership

Where an association is created to own and manage the stormwater management system, the subdivision and/or land development plan shall contain a note designating the entity responsible for construction and/or maintenance of the stormwater management system consistent with an approved Operation and Maintenance Plan.

3. Operation and Maintenance Plan

An Operation and Maintenance Plan shall be prepared to identify the ownership, operation and maintenance responsibilities and as-built conditions for all stormwater management systems. At a minimum, the operation and maintenance plan shall include the following:

a. Any obligations concerning perpetuation and/or maintenance of natural drainage or infiltration facilities, and other facilities identified within the Stormwater Management Plan. Ownership of and responsibility for operation and maintenance of stormwater management systems, including names and contact information, shall be required.

b. A description of the permanent stormwater management practices on the site, explaining how each practice is intended to function and operate over time. All drainage and access easements shall be depicted and any site restrictions to be recorded against the property shall be identified on the plan. All such easements and restrictions shall be perfected to run with the land and be binding upon the landowner and any successors in interest.

c. A description of the actions, budget and schedule for operating and maintaining the stormwater management system. This description should be written in a clear manner, consistent with the knowledge and understanding of the intended user.

d. A general description of operation and maintenance activities and responsibilities for systems held in common or on-property, including but not limited to: lawn care, vegetation maintenance, clean out of accumulated debris and sediment (including from grates, trash racks, inlets, etc.), liability insurance, maintenance and repair of stormwater management systems, landscaping and planting, payment of taxes and construction of any kind associated with the use, benefit and enjoyment of the facilities by the owners. In particular, a description of routine facility operation and day-to-day management requirements (as needed) and a description of routine maintenance actions and schedules necessary to ensure proper operation of stormwater management systems shall be submitted.

e. Assurances that no action will be taken by any property owner to disrupt or in any way impair the effectiveness of any stormwater management system, setting forth in deed restrictions the ability of the City of Rochester Hills to take corrective measures if it is determined, at any time, that stipulated permanent stormwater management systems have been eliminated, altered, or improperly maintained.

f. Parties responsible for the long term operation and maintenance of stormwater management systems shall make records of the installation and of all maintenance and repairs, and shall retain the records for at least ten (10) years. These records shall be submitted to the City of Rochester Hills as established by the Operation and Maintenance Plan or if otherwise required by the City of Rochester Hills.

4. Operation and Maintenance Agreement

a. The owner of any land upon which permanent stormwater management systems and/or BMPs will be placed, constructed or implemented, as described in an approved Stormwater Management Plan and the Operations and Maintenance Plan, shall provide the City of Rochester Hills a Stormwater System Operations and Maintenance Agreement that includes:

The Operations and Maintenance Plan, or a summary thereof,

Legal Description of the development property and,

Map of the development with the Stormwater System depicting components and access and/or drainage Easements.

In cases where the predevelopment offsite drainage is dependent on draining through the development, the agreement shall provide for that right of flow.

b. The Operation and Maintenance Agreement shall be submitted to the City Engineering Division, executed and in recordable form, acceptable to the City for acceptance and recording.

c. Other items or conditions may be included in the Operation and Maintenance Agreement if determined necessary to guarantee the satisfactory operation and maintenance of all permanent stormwater systems and BMPs. The agreement shall be subject to review and approval of the City of Rochester Hills.

Appendices

Appendix A: Terms and Definitions

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

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

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

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

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

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

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

1. **Buffer Strip:** A zone that is used for filtering direct stormwater and stormwater runoff into a stormwater management system and for providing maintenance access to a stormwater management system.
2. **Cistern:** Containers that store large quantities of stormwater above or below ground. They can be used on residential, commercial, and industrial sites.
3. **Dry well:** Small infiltration pits or trenches filled with aggregate that receive clean runoff primarily from rooftops.
4. **Green infrastructure (GI):** Management of wet weather flows using BMPs that use or mimic natural processes and result in improved water quality, evapotranspiration, or infiltration. This is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits, reducing and treating stormwater at its source while delivering environmental, social, and economic benefits.
5. **Green Roof:** Rooftops that incorporate a covering of vegetation allowing the roof to function more like a vegetated surface, with thickness varing between 2-6 inches and consisting 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 or porous soils.
7. **Planter Box:** A device containing trees and plants near streets and buildings constructed to intercept 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 point source areas and downstream receiving waters.
11. **Vegetated Swale:** A conveyance, open to the atmosphere, consisting of a broad, shallow channel lined with vegetation to slow and filter stormwater runoff and promote infiltration. (Note: this swale has no in-soil storage)
12. **Bioretention:** A water quality practice that utilizes landscaping plantings and soil media to treat stormwater runoff by collecting it in shallow depressions before being absorbed by the soil and vegetation. There are three main types of bioretention.
    a. **Rain Garden:** A small, simple bioretention system associated with single family homes or small commercial development. This system has no regulated infiltration rate and as such only qualifies for the water quality requirement. However, as such this system does not require infiltration testing to construct or maintain.
    b. **Bioretention Basin:** A large bioretention system associated with commercial and industrial development. This system has water quality, volume reduction capabilities, and requires infiltration testing.
    c. **Bioretention swale:** A linear bioretention system associated with stormwater conveyance and check dams to slow, filter, and infiltrate the stormwater. This system has both water quality and volume reduction capabilities and requires infiltration testing.

CFS: Cubic feet per second.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Flow Restrictor: A structure, feature, or device in a detention system or pretreatment system that is used to retard 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 transported to the basin.

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

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

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

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

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

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

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

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

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

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

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

Native Plants: Plant species that occurs naturally in any particular ecosystem without human introduction.

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, or could be occurring at locations scattered throughout the drainage basin. Typical sources include erosion, agricultural activities, and runoff from urban lands.

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

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

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

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

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

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

Pervious or Porous Pavement: A porous surface composed of materials which allow infiltration through to a sublayer of open graded stone, and then infiltration into the ground.

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, and may also provide some pre-treatment.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Soil Erosion: The increased loss of the land surface that occurs as a result of the wearing away of land by the action of wind, water, gravity, or a combination of wind, water, gravity or human activities. Soil types range from "A Soils" which are very permeable and produce little runoff, to "D Soils" which are relatively impermeable and produce much more runoff.

Soil Group, Hydrologic: A classification of soils by the NRCS into four runoff potential groups. The groups

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

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

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

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

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

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

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

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

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

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

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

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

Adapted from EPA Section 438 Technical Guidance December 2009.

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

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

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

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

Watercourse: A natural or artificial channel for flowing water.

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

Waters of the State (Michigan): Any groundwater, lake, including the Great Lakes bordering the state, river, stream, and other water course and body of water within the jurisdiction of the State of Michigan, including wetlands.

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

Wetland: An area that is saturated by surface or groundwater with vegetation adapted for life under those hydric 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 wetlands.

Appendix B: Lot Grading – Not Adopted by the City of Rochester Hills

Appendix C: Reference Materials

Site Plan Example 1

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

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

Infiltration Feasibility

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

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

Land Use Summary

must be included on the COVER SHEET for all site plans

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

Pervious Area Land Use Data

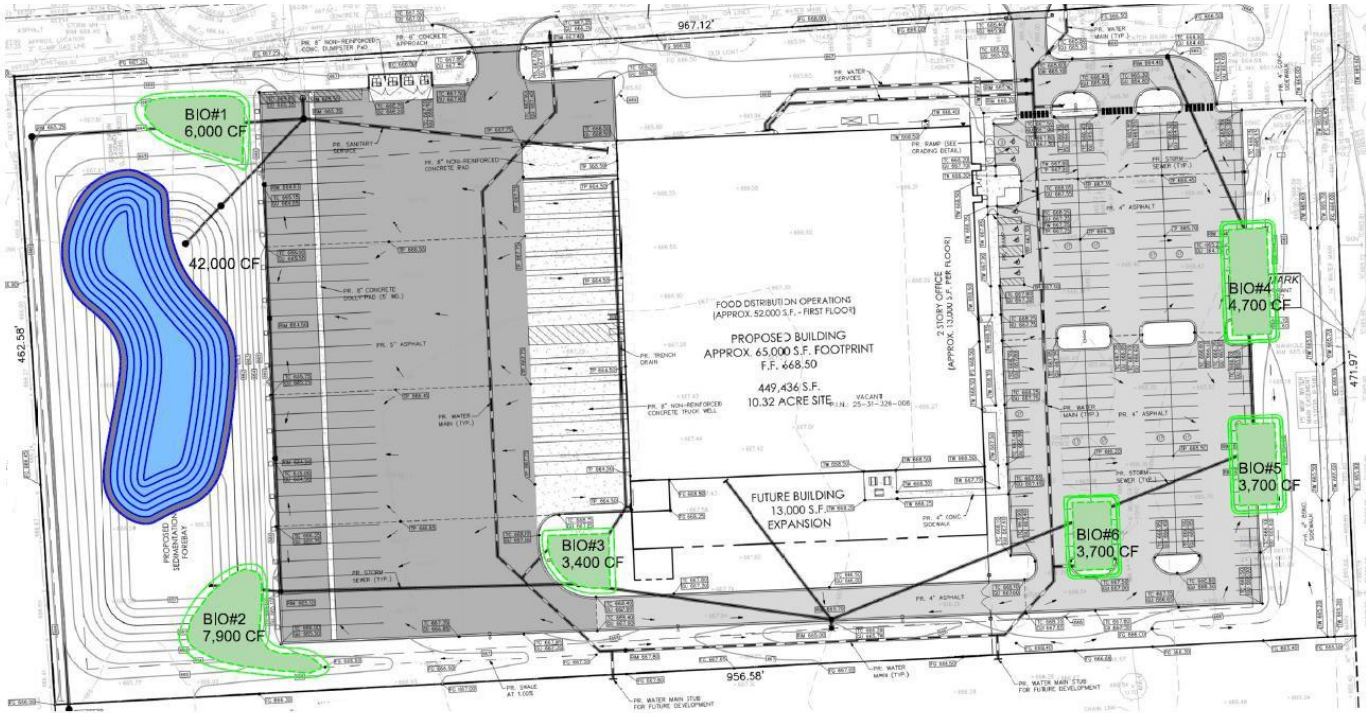


Figure 1 - Example 1 Commercial Site

Calculate the Composite Runoff Coefficient

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

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

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

Calculate Time of Concentration

Sheet Flow

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

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

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

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

<u>Waterway Flow</u>

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

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

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

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

<u>Pipe Flow</u>

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

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

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

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

<u>Calculate 100-year Peak Intensity</u>

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

$T_c = 15.1\ minutes$

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

<u>Calculate Channel Protection Volume</u>

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

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

Calculate Channel Protection Rate Control: Extended Detention

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

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

Calculate 100-year Peak Inflow

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

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

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

Determine the Peak Allowable 100-year Discharge

Q_{100P} is the lesser of:

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

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

Calculate the Variable Release Rate

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

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

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

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

Calculate Storage Curve Factor

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

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

Calculate the 100-year Runoff

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

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

Calculate the 100-year Storage Volume

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

$$R = 0.474 \text{ (Calculated on Previous Page)}$$

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

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

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

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

Outlet Calculations

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

Calculate the Extended Detention Release Rate

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

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

Orifice Calculations

Extended Detention Orifice Design

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

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

0.62 used for standard orifice opening

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

2” orifice opening will need additional protection from clogging.

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

Infiltration BMP Calculations

Average Infiltration Area (Bioretention Cell 1)

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

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

Surface Storage Volume (Bioretention Cell 1)

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

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

Subsurface Storage Volume (Bioretention Cell 1)

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

Void ratio 0.30 (max)

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

Infiltration Storage (Bioretention Cell 1)

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

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

Bioretention Total Storage Volume (Bioretention Cell 1)

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

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

Rounded to 6,000 cubic feet.

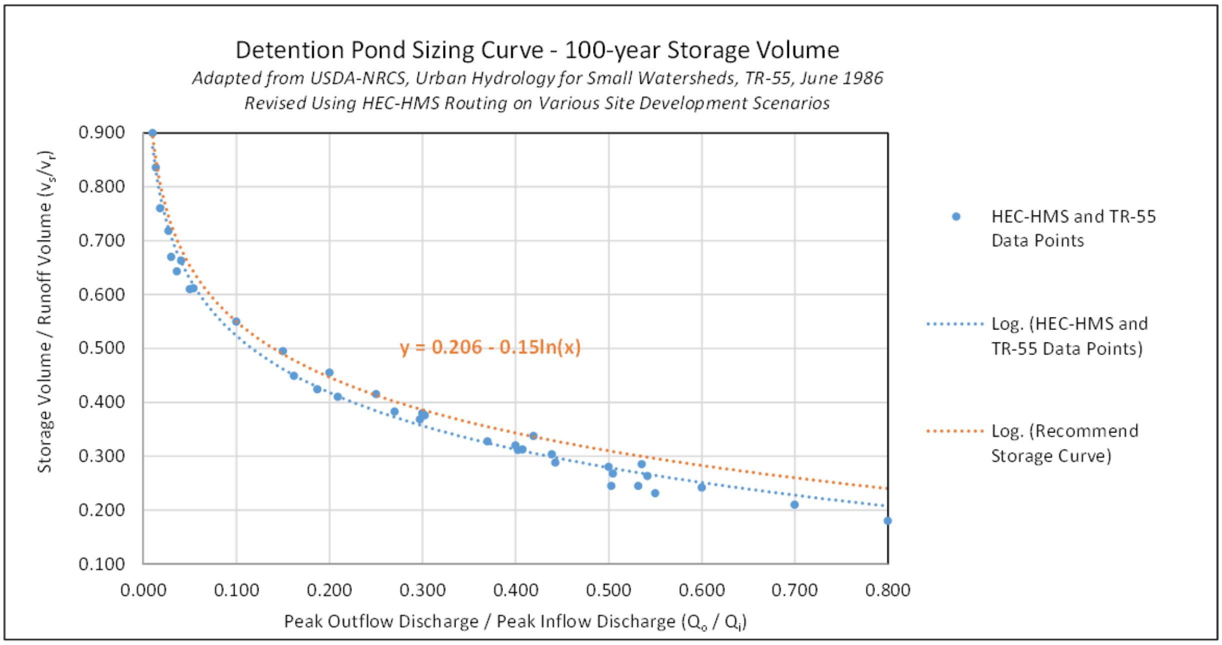
Summary of Bioretention Cell Storage

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

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

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

Detention Pond Sizing Curve



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

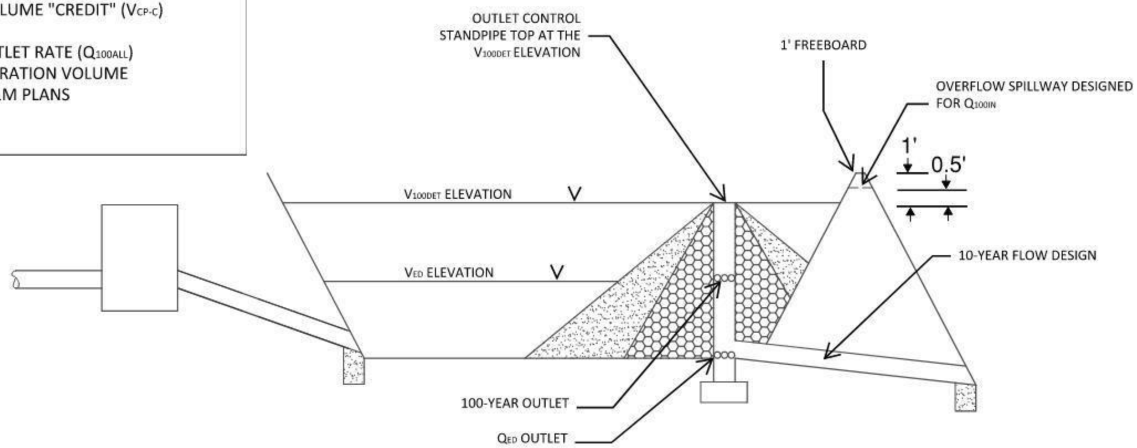
Additional values added using HEC-HMS routing, including Qo/Qi values less than 0.10

Typical Detention Basin/Forebay Cross Sections

TYPICAL DETENTION BASIN WITH MECHANICAL SEPERATOR

REQUIRED PROFESSIONAL ENGINEER CERTIFICATIONS

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



MECHANICAL SEPARATOR

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

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

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

REPLACES FOREBAY REQUIREMENT

INSTALLED OFFLINE AND UPSTREAM OF ANY DETENTION OR RETENTION BASIN

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

EXTENDED DETENTION VOLUME (V_{ED})

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

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

EXTENDED DETENTION OUTLET RATE

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

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

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

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

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

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

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

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

- -OCWRC RESTRICTED RATE FOR THE DRAIN (Q_R)
- -PRO-RATED SHARE OF THE DRAINS CAPACITY (Q_P)

OR
- -THE VARIABLE RELEASE RATE (Q_{VRR})

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

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

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

R=STORAGE CURVE FACTOR

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

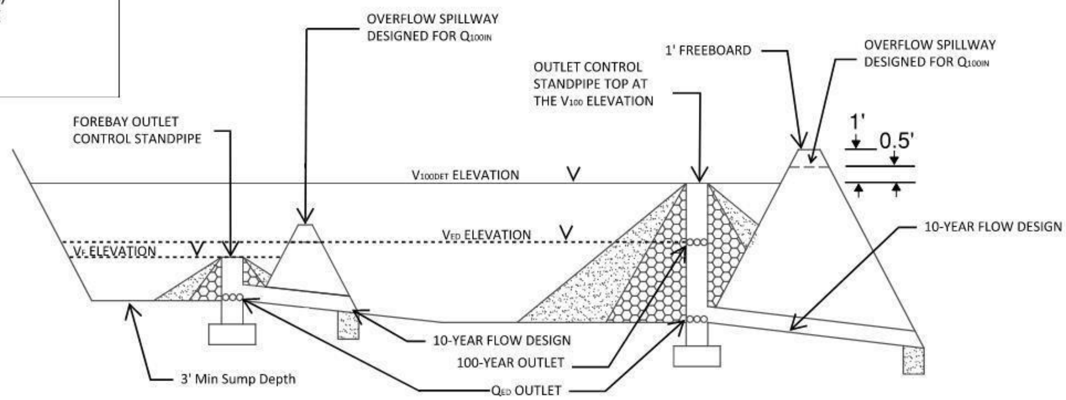
V_{100DET}=(V_{100RUN})(R)-V_{CP-C}

REV-11/22/2021

TYPICAL DETENTION BASIN WITH FOREBAY

REQUIRED PROFESSIONAL ENGINEER CERTIFICATIONS

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



FOREBAY VOLUME (V_F)

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

V_F =(545)(C)(A)

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

FOREBAY OUTLET SIZE

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

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

EXTENDED DETENTION VOLUME (V_{ED})

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

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

EXTENDED DETENTION OUTLET RATE

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

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

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

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

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

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

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

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

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

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

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

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

R=STORAGE CURVE FACTOR

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

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

REV-11/22/2021

List of County Drains with Hydraulically Restricted Outlets

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

Appendix D: George W. Kuhn Combined Sewer District Requirements – Not Adopted by the City of Rochester Hills

Appendix E: Standard Variables

TC: Contributing Area Time of Concentration (Minutes)

A: Contributing Area (Acres)

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

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

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

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

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

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

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

Q_{VRR}: Variable Release Rate (CFS)

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

R: Storage Curve Factor

V_F: Forebay Volume (CF)

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

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

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

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

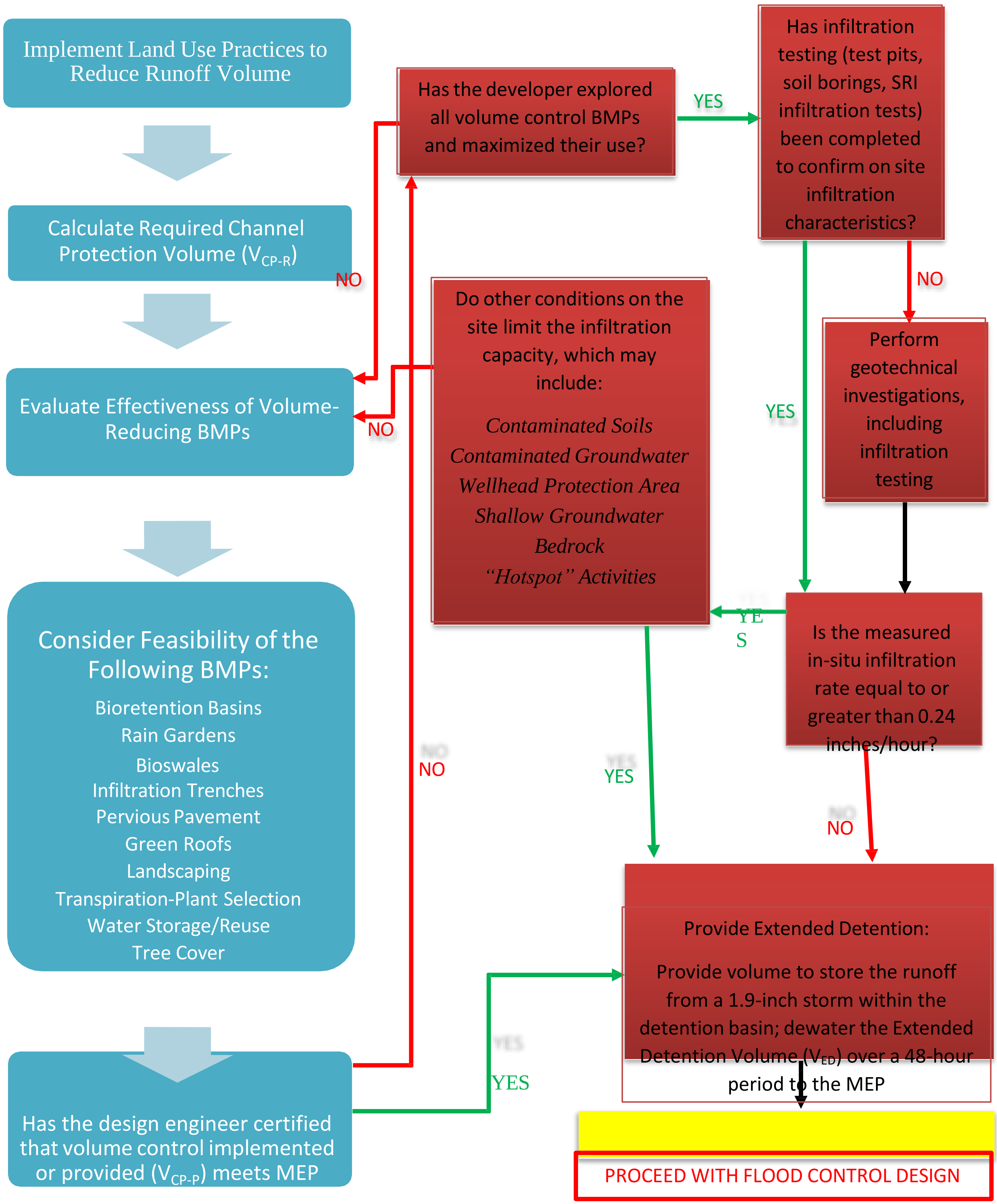
V_{CP-R}: Channel Protection Volume - Required (CF)

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

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

V_{WQ}: Water Quality Volume (CF)

Appendix F: Channel Protection Flow Chart



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

Appendix G: Maintenance Agreement – Not Adopted by the City of Rochester Hills

APPENDIX H, previously RH appendix A

Non-Structural Stormwater Management Practices Alternative Approach for Managing Stormwater Runoff

Stormwater Discussion

Land development can dramatically alter the hydrologic cycle of a site, and ultimately, an entire watershed. Prior to development, native vegetation can either directly intercept precipitation or draw that portion that has infiltrated into the ground and return it to the atmosphere through evapotranspiration. Development can remove this beneficial vegetation and replace it with lawn or impervious cover, reducing the site's evapotranspiration and infiltration rates. Clearing and grading a site can remove depressions that store rainfall. Construction activities may also compact the soil and diminish its infiltration ability, resulting in increased volumes and rates of stormwater runoff from the site. Impervious areas that are connected to each other through gutters, channels, and storm sewers can transport runoff more quickly than natural areas. This shortening of the transport or travel time quickens the rainfall-runoff response of the drainage area, causing flow in downstream waterways to peak faster and higher than natural conditions. These increases can create new and aggravate existing downstream flooding and erosion problems and increase the quantity of sediment in the channel. Filtration of runoff and removal of pollutants by surface and channel vegetation is eliminated by storm sewers that discharge runoff directly into a stream. Increases in impervious area can also decrease opportunities for infiltration, which, in turn, reduce stream base flow and groundwater recharge. Reduced base flows and increased peak flows produce greater fluctuations between normal and storm flow rates, which can increase channel erosion. Reduced base flows can also negatively impact the hydrology of adjacent wetlands and the health of biological communities that depend on base flows. Finally, erosion and sedimentation can destroy habitat from which some species cannot adapt.

In addition to increases in runoff peaks, volumes, and loss of groundwater recharge, land development often results in the accumulation of pollutants on the land surface that runoff can mobilize and transport to streams. New impervious surfaces and cleared areas created by development can accumulate a variety of pollutants from the atmosphere, fertilizers, animal wastes, and leakage and wear from vehicles. Pollutants can include metals, suspended solids, hydrocarbons, pathogens, and nutrients.

In addition to increased pollutant loading, land development can adversely affect water quality and stream biota in more subtle ways. For example, stormwater falling on impervious surfaces or stored in detention or retention basins can become heated and raise the temperature of the downstream waterway, adversely affecting cold water fish species such as trout. Development can remove trees along stream banks that normally provide shading, stabilization, and leaf litter that falls into streams and becomes food for the aquatic community.

Alternative Approach

The recommended alternative approach is to promote practices that will minimize post-development runoff rates and volumes, which will minimize needs for artificial conveyance and storage facilities. To simulate pre-development hydrologic conditions, forced infiltration is often

necessary to offset the loss of infiltration by creation of impervious surfaces. The ability of the ground to infiltrate depends upon the soil types and its conditions.
Preserving natural hydrologic conditions requires careful alternative site design considerations. Site design practices include preserving natural drainage features, minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces, and protecting natural depression storage. A well-designed site will contain a mix of all those features. The following describes various techniques to achieve the alternative approach:

Preserving Natural Drainage Features. Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate and attenuate flows and to filter pollutants. However, this objective is often not accomplished in land development. In fact, commonly held drainage philosophy encourages just the opposite pattern **--** streets and adjacent storm sewers typically are located in the natural headwater valleys and swales, thereby replacing natural drainage functions with a completely impervious system. As a result, runoff and pollutants generated from impervious surfaces flow directly into storm sewers with no opportunity for attenuation, infiltration, or filtration. Developments designed to fit site topography also minimizes the amount of grading on site.

Protecting Natural Depression Storage Areas. Depressional storage areas have no surface outlet, or drain very slowly following a storm event. They can be commonly seen as ponded areas in farm fields during the wet season or after large runoff events. Traditional development practices eliminate these depressions by filling or draining, thereby obliterating their ability to reduce surface runoff volumes and trap pollutants. The volume and release-rate characteristics of depressions should be protected in the design of the development site. The depressions can be protected by simply avoiding the depression or by incorporating its storage as additional capacity in required detention facilities.

Avoiding introduction of impervious areas. Careful site planning should consider reducing impervious coverage to the maximum extent possible. Building footprints, sidewalks, driveways and other features producing impervious surfaces should be evaluated to minimiz***e*** impacts on runoff.

Reducing the Hydraulic Connectivity of Impervious Surfaces. Impervious surfaces are significantly less of a problem if they are not directly connected to an impervious conveyance system (such as storm sewer). Two basic ways to reduce hydraulic connectivity are routing of roof runoff over lawns and reducing the use of storm sewers. Site grading should promote increasing travel time of stormwater runoff, and should help reduce concentration of runoff to a single point in the development.

Routing Roof Runoff Over Lawns. Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. By routing roof drains and crowning the driveway to run off to the lawn, the lawn is essentially used as a filter strip.

Reducing the Use of Storm Sewers. By reducing use of storm sewers for draining streets, parking lots, and back yards, the potential for accelerating runoff from the development can be greatly reduced. The practice requires greater use of swales and may not be practical for some development sites, especially if there are concerns for areas that do not drain in a “reasonable” time. The practice requires educating local citizens and public works officials, who expect runoff to disappear shortly after a rainfall event.

Reducing Street Widths. Street widths can be reduced by either eliminating on-street parking or by reducing roadway widths. Municipal planners and traffic designers should encourage narrower neighborhood streets, which ultimately could lower maintenance.

Limiting Sidewalks to One Side of the Street. A sidewalk on one side of the street may suffice in low-traffic neighborhoods. The lost sidewalk could be replaced with bicycle/recreational trails that follow back-of-lot lines. Where appropriate, backyard trails should be constructed using pervious materials.

Using Permeable Paving Materials. These materials include permeable interlocking concrete paving blocks or porous bituminous concrete. Such materials should be considered as alternatives to conventional pavement surfaces, especially for low use surfaces such as driveways, overflow parking lots, and emergency access roads.

Reducing Building Setbacks. Reducing building setbacks reduces driveway and entry walks and is most readily accomplished along low-traffic streets where traffic noise is not a problem.

Constructing Cluster Developments. Cluster developments can also reduce the amount of impervious area for a given number of lots. The biggest savings is in street length, which also will reduce costs of the development. Cluster development clusters the construction activity onto less-sensitive areas without substantially affecting the gross density of development.

In summary, a careful consideration of the existing topography and implementation of a combination of the above mentioned techniques may avoid construction of costly stormwater control measures. Other benefits include reduced potential of downstream flooding, water quality degradation of receiving streams/water bodies and enhancement of aesthetics and reduction of development costs. Beneficial results include more stable base flows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs for conveyance and storage.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 5

Grading

A. Requirements for Master Grading Plans

A Master Grading Plan is required for all developments. Master grading plans shall accompany the set of engineering construction plans and shall include the following:

1. Benchmark locations, descriptions and elevations (USGS) to be used for the development.

2. The minimum scale for grading plans is one-inch (1”) = fifty feet (50’).

3. The grades of existing adjacent houses, buildings, drainage structures, and streets shall be shown. The actual surveyed grades of existing adjacent ground and yards shall be shown as necessary to clearly define off-site drainage patterns for one hundred feet (100’) from the property line. The drainage pattern of all adjacent existing land shall be indicated. All off-site drainage flowing onto the site shall be clearly labeled and identified.

4. Meet existing ground at the property boundaries. Construct an intercepting swale to prevent drainage from development improvements onto adjacent property.

5. Grading plans shall correspond with proposed landscape, tree protection and soil erosion requirements. Any revisions in the grading plan may require Planning and Economic Development Department approval if it directly or indirectly affects the approved landscape or tree protection plans.

6. The grading plan shall be designed to ensure that if a failure occurs in the storm system, water will drain away in overland swales without flooding structures.

7. Show proposed building finish floor grade and top of curb grade at the center of each lot to tenths of a foot. Also include grades at the mid-point of the building, at each lot corner, and at the midpoints on lot lines. Place house grades on the plan view of the typical building(s) to be built in the development. Front yard setbacks shall be drawn to scale.

8. The finish grade shall be compatible with the grades of surrounding buildings and yards.

9. Show grade changes at proposed sidewalks and at driveway crossings.

10. Rear yard storm drainage is required in all residential developments where adjacent lots drain to the rear. Twenty-foot (20’) easements shall be established for the required storm drains.

11. Indicate rear yard catch basins. Show the proposed rim elevation to hundredths of a foot. Catch basins are required to be at a lot corner and the catch basin rim grade shall be the only grade shown at that corner.

12. Indicate perforated plastic rear yard underdrains and tees for sump pumps where they are called for in the storm sewer plans. Use different symbols for plastic underdrains and concrete storm sewer on the plans.

13. All existing and proposed earth grades are to be in tenths (10ths) of a foot.

14. Rear yard swales shall be, in general, no longer than 400 feet before being intercepted by a catch basin, and shall have a minimum grade of one percent (1%).

15. Rear yard storm drain piping shall be concrete, at twelve inches (12") minimum diameter.

16. Show the proposed side yard swale elevation between all buildings. This elevation must be a minimum of one-half feet (0.5') below the lower adjacent building grade. The side yard swale must have a minimum slope of one percent (1%) to the front and rear.

17. Where topography prevents rear yard drainage from being practical, rear to front or rear to side drainage may be allowed. The following swale elevations must be shown:

    a. The high point of the swale(s), located generally behind the building, a minimum of fifteen feet (15') from the building, and one foot (1') below the building brick ledge grade.

    b. The side swale elevation located even with the front and back of the building.

18. The general direction of flow of the rear yard drainage and all swales must be indicated with arrows. Swales need not be otherwise labeled. Arrows need not be drawn for front yards with standard building to street drainage.

19. Additional grades shall be shown under Special Conditions as required.

20. The lot number, address or Tax ID (Sidwell) shall be shown for each lot.

21. All easements, drawn to scale and properly labeled, shall be shown, including natural feature setbacks.

22. Master grading plan must include a note stating that the site must be balanced and certified by a licensed professional surveyor within one foot (1') of finished grade prior to underground utility installation.

23. Existing moderate steep slopes, very steep slopes or bluff slopes as defined by Rochester Hills City zoning ordinance Section 138, Chapter 2, shall be shown on the plans along with any association setback lines.

B. Requirements for Individual Grading Plans

The following general grading requirements shall be applied in the design of the individual site grading plans (plot plan or single lots):

1. Drainage shall be adequately discharged off-site, to either the street or a dedicated storm drain.

2. No upstream drainage shall be restricted.

3. The developed portion of the site in general shall drain without standing water, unless specifically designed for retention and/or detention.

4. Elevations representing the brick ledge, finished grade, and the first floor grade shall be indicated. Basement and lowest opening grades shall be shown.

5. Lots with rear-to-front drainage shall have swales shown around each building or structure. Elevations of swales shall be called out at high points and low points.

6. No berms shall be placed over any water main, sanitary sewer, or storm drain, or within the designated easements for such facilities.

7. Grading plans shall be prepared by a licensed professional engineer or surveyor, signed and sealed, and shall conform with the following minimum requirements, with the final sufficiency of such plan to be determined by the Department of Public Services:

    a. A scale of not less than one inch (1”) equals fifty feet (50’). Scales of one-inch (1”) equals twenty feet (20’) are preferred.

    b. Date, north arrow, and scale must be called out.

    c. The dimensions of all property lines, showing the relationship of the subject property to abutting properties.

    d. All required zoning setbacks shown and property labeled.

    e. All existing and proposed ground grades in tenths (10ths) of a foot.

    f. General direction of the rear yard drainage and swales indicated with arrows.

    g. Additional grades shown under special conditions as required by the Department of Public Services.

    h. The location of all utility leads (water, sanitary, sump pump).

8. Proposed driveways shall be shown with grades called out at the house and at the street. Driveway slopes shall be shown in percent (%). The minimum allowable slope is two percent (2%) with maximum allowable slopes of eight percent (8%) along roads with posted speed limits of 40 MPH or greater and ten percent (10%) along roads with a posted speed limit of 35 MPH or less. Note: driveway slopes shall not exceed two percent (2%)

through the portion of the driveway that is to be utilized for existing and/or proposed pedestrian facilities, i.e., pathways and sidewalks, in order to meet American with Disabilities Act (ADA) requirements.

9. All public and private easements, drawn to scale and properly labeled, shall be shown, including natural features setbacks.

10. Existing moderate steep slopes, very steep slopes or bluff slopes as defined by Rochester Hills City zoning ordinance Section 138, Chapter 2, shall be shown on the plans along with any association setback lines.

C. <u>Retaining Walls</u>

1. Retaining walls should be used when adequate grading cannot be accomplished.

2. Retaining walls exceeding forty-two inches (42") in height should include protective fencing on top.

3. Retaining walls exceeding forty-eight inches (48") in height shall be designed by a licensed professional engineer. Design calculations shall be submitted with the construction plans.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 6

Roads

A. Plans & Specifications – Submittal Procedure

1. The plans and specifications shall be prepared in accordance with Chapter 1, *General Requirements and Submittals*.

2. Paving designs, including soil borings (minimum of five feet (5') deep) may be required with particular paving submittals.

B. Requirements for New Public Roadways

1. Paving width and thickness shall conform to the following requirements for public roadways:

   a. Concrete roads shall be eight inches (8") 3,500 psi concrete over four inches (4") 21AA aggregate base course materials (crushed limestone or crushed concrete). Alternate recycled asphalt product (RAP) base course materials may be considered upon approval of the City Engineer. Alternate RAP materials must meet equivalent structural strength of 21AA aggregate (crushed limestone or concrete).

      Extend four inches (4") of base course material to one foot (1') beyond edge drain. All industrial subs shall be constructed with concrete to meet all weather conditions.

   b. Asphalt roads shall be nine inches (9") deep strength asphalt over six inches (6") of 21AA aggregate base course materials (crushed limestone or crushed concrete). Alternate recycled asphalt product (RAP) base course materials may be considered upon approval of the City Engineer. Alternate RAP materials must meet equivalent structural strength of 21AA aggregate (crushed limestone or concrete). The nine inches (9") shall consist of two inches (2") of HMA 5E3 (wearing), two and-one half inches (2-1/2") HMA 4E3 (leveling), four and one-half inches (4-1/2") HMA 3E3 (base course). Extend six inches (6") base course material to one foot (1') beyond edge drain. Asphalt binder shall be PG 64-22.

   c. Asphalt road sections for projects that follow the special assessment district (SAD) paving program will be in accordance with the design standards for that policy. Furthermore, reconstruction of City local roads may be rebuilt with a section less than the requirements identified in items a. or b. above if approved by the City Engineer.

2. Other alternative paving and drainage designs may be submitted to the Department of Public Services for consideration, following review and recommendation by the City's Engineer, in limited areas where such alternative paving and drainage designs would be more consistent with the character and construction of existing paving and drainage

facilities in the area. Such alternative paving and drainage facilities shall only be acceptable in those instances where the City finds that the proposed design will provide an acceptable level of serviceability, ease of maintenance, and facility life, consistent with public paving and drainage facilities in similar areas, elsewhere in the City.

3. The minimum radius of cul-de-sacs is as follows:

   a. With island, the minimum outside radius of a cul-de-sac from back-of-curb (b/c) shall be fifty-seven feet (57’). The inside radius shall be thirty feet (30’) (b/c). All right-of-way radii shall be seventy-three feet (73’) minimum.

   b. Without island, the minimum outside radius of a cul-de-sac (b/c) shall be forty-seven feet (47’). All right-of-way shall be sixty-three feet (63’) minimum.

4. Pavement widths for residential streets shall be twenty-seven feet (27’) (b/c to b/c). Pavement widths for streets in an industrial subdivision shall be thirty-six feet (36’) (b/c to b/c). Streets that are developed as part of a flex business overlay district per zoning ordinance section 138.8.302 – Street Design will be given consideration to deviate from the above road width standards as agreed upon by the Department of Public Services Engineering Division and Planning and Economic Development department.

5. A boulevard section may be allowed in an enlarged right-of-way. Pavement widths shall be at least twenty-four feet (24’) (b/c to b/c) for all boulevard streets within residential subdivisions. The minimum island width shall be sixteen feet (16’). Within industrial subdivisions the pavement sections should be increased to twenty-seven feet (27’) (b/c to b/c). The nose of the median shall be offset at least eight feet (8’) from the edge of pavement of the intersecting street.

6. The minimum longitudinal pavement slope shall be one percent (1%), and a maximum of six percent (6%) for major roads, and eight percent (8%) for local roads. A grade in excess of the standard will not be allowed. Vertical curves are necessary when a change in grade of one percent (1%) or more occurs. The minimum length of vertical curve shall be one hundred feet (100’). Cross slope shall be at two and one-half percent (2.5%).

   The pavement profile view must include:

   a. Elevations at top of curb, or at centerline if not curbed.
   b. Existing ground elevations at the center of the right-of-way, and at other locations as required for review.
   c. Station and elevations of all high points, low points, grade-breaks, curb returns intersecting property lines, and necessary information at vertical curves.
   d. Top of curb (or centerline) elevations at each station. Grade in vertical curves must be indicated at twenty-five foot (25’) intervals.
   e. The station and top of casting grade of all pavement catch basins and inlets.

7. The pavement radius at all intersections of all roads shall be a minimum twenty-five feet (25’). Allow for a minimum of one-half foot (0.5’) drop in elevation around the curb return for twenty-five foot (25’) radius. For larger radii, a proportionately greater amount of fall must be provided.

8. The Michigan Department of Transportation and/or Road Commission for Oakland County design requirements shall be met for intersecting roads under their jurisdictions. Passing lanes, center left-turn lanes, acceleration, and deceleration lanes shall conform to the requirements as outlined under *Chapter 8, Widening Lanes*.

9. All horizontal curves shall be consecutively numbered and indicated in the plan view. Curve data shall be given for the respective curve on the same sheet as it occurs.

10. Finish grade of all structures shall be indicated in the plan view.

11. All pavement in residential areas shall have thirty-inch (30") mountable concrete curb and gutter with a three-inch (3") curb height. All island curbs and street intersections shall have MDOT B-2 modified curbing with a five and one-half inch (5.5") curb height. In either case, the face of gutter depth shall be nine inches (9") thick. Curb height through driveway locations shall be reduced to one-inch or less.

12. City major roads shall have B-2 modified curbing. A five-foot (5') transition area is required where the curb changes from MDOT B-2 modified to four-inch (4") mountable curb and gutter. Curb height through driveway locations shall be reduced to one-inch or less.

13. A detail of all intersections and cul-de-sacs must be provided. The detail shall show jointing and detailed grades. Maximum scale of the detail shall be one inch equals thirty feet (1" = 30'). On intersections where jointing is shown on the pavement Standard Detail sheet and where grades are completely determined by additional notes on the plans, separate details need not be shown.

14. At the end of a street that may be extended in the future, indicate a one-foot (1') end header, barricade and signs (end of roadway object marker ("OM4-3") and a "Road Ends" sign ("W-14-2-a").

15. Edge drains shall be placed one foot (1') offset from the back of curb and placed with three and a half feet (3.5') of cover (from top of curb) for the full length of all curb. Edge drains in open ditched sections where the ditch slope is less than one percent (1%) will require a solid wall perforated in a fabric/sock pipe under the ditch. Edge drain, six inches (6") in diameter, perforated or slotted, shall be constructed in the back of curb line for the full length of curb, backfilled with either 2NS sand or pea stone. Perforated pipe shall be Smooth-Wall PVC Plastic Edge Drain with 3/16 inch to 3/8-inch perforations. Slotted pipe shall be A-2000 (Contech or equivalent approved by the City Engineer) sewer pipe, with slotted perforations. The pipe shall be installed with the protective geotextile sock wrap. Roadway rehabilitation or reconstruction projects may consider the use of flexible piping for common sump pump collection lines.

16. Temporary access roads shall be sixteen feet (16') wide minimum. Construction plans shall identify a method to prevent site development vehicles and equipment from tracking mud and/or dirt onto roadways.

17. Streetlights – The City may require street lighting at street intersections or other locations to serve purposes of safety and/or security. When required, the intensity and type of illumination, location and types of poles, bases, etc. shall be coordinated with the existing and future street lighting within that area and conform to the latest version of the American Association of State Highway and Transportation Officials (AASHTO) Roadway Lighting Design Guide.

18. The owner/developer shall provide and properly maintain until accepted by the City all traffic and pavement markings, which the City may determine necessary, for the proper operation of the roadway/driveway/curb cut. Only those traffic signs and pavement markings specified by the City (or jurisdictional authority) may be used within the road right-of-way. All signs and pavement markings shall conform to the current Michigan Manual of Uniform Traffic Control Devices (MMUTCD).

19. All plans are to clearly identify public or private dedication.

20. Private roads are to be designed to City Public Road Standards.

21. Shared driveways can be proposed to the Planning and Economic Development Department and the Department of Public Services. The applicant must demonstrate that the incorporation of any shared driveways provides a measurable benefit and better aligns with the development intent and surrounding environmental characteristics. Ingress/egress agreements for the shared operation, maintenance and future replacement are required.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 7

Widening Lanes

A. Plans and Specifications – Submittal Procedure

1. A Traffic Impact Study (TIS) or a Traffic Impact Assessment (TIA) may be required by the City prior to site plan approval, and shall conform to the MDOT Geometric Design Guidance document sections 1.2.4 and 1.2.5 dated September 2017. https://mdotjboss.state.mi.us/TSSD/getSubCategoryDocuments.htm?prjNumber=1403850&category=Geometrics&subCategory=Correspondence/Guidelines&subCategoryIndex=subcat0Geometrics&categoryPrjNumbers=1403850,140385

   The requirement for a TIS may be waived/modified by the City's Engineering Division provided that documentation is submitted considering and verifying the following factors:

   a. Roadway improvements are scheduled, which are expected to mitigate any impacts associated with the proposed project.
   b. The existing level of service along the roadway is not expected to drop below C due to the proposed project.
   c. The existing level of service is not expected to be significantly impacted by the proposed project due to specific conditions at this location.
   d. A similar traffic study was previously performed for the site and is still considered applicable.

2. Widening Lane Improvement Plans and Specifications must be submitted to and approved by the Department of Public Services prior to receiving approval for construction in accordance with *Chapter 1, General Requirements and Submittals,* and must illustrate the following:

   a. All improvements required by the appropriate road agency maintaining jurisdiction of the particular road section, i.e. Road Commission for Oakland County (RCOC), Michigan Department of Transportation (MDOT), or the City of Rochester Hills.
   b. Proposed treatment of drive/street entrances and exits to and from public roads, which comply with typical RCOC, MDOT and City details.
   c. Existing and proposed public right-of-way throughout the extension of proposed improvements, if any.

B. Plans and Specifications – Design Criteria

1. Any development that will contribute traffic flow on existing RCOC, MDOT, or City roads may be required to construct widening lane improvements based on RCOC, MDOT, and City guidelines. City guidelines shall typically conform to the RCOC requirements.

However, City requirements may exceed those of RCOC and MDOT based upon projected or forecasted traffic volumes.

2. The widening lane improvements of existing roads at the intersections of new streets and driveways may include, but are not limited to:

   a. Right-turn acceleration and deceleration lanes.
   b. Center left-turn lanes.
   c. Left-turn passing lanes.
   d. Ultimate road re-alignment.
   e. Storm drainage.
   f. Road base drainage upgrades.
   g. Traffic signage and/or pavement markings.
   h. All other items necessary to facilitate the construction of the required pavement section.

   Note: Center left-turn lanes are strongly encouraged over left-turn passing lanes as determined by the City.

3. Additionally, off-site road improvements may be required, if warranted by traffic studies and/or RCOC, MDOT, or City guidelines, to provide the necessary capacity and safety requirements.

4. The proposed widening improvements shall match existing pavement type, concrete or hot mix asphalt (HMA), and pavement thickness; unless approved otherwise by City Engineer or other applicable road agency.

5. Geometric configurations shall be in accordance with applicable road agency guidelines for widening lane improvements, including MDOT's *Access Management Guidebook.*

6. A review of fixed object clear zones may be required to verify that appropriate clearances are maintained from objects such as trees, utility poles, hydrants, etc. When such objects are within the appropriate clear zones they shall be required to be removed/relocated, unless otherwise approved by the City Engineer or other applicable road agency.

B. <u>Proposed Improvements within Limited Rights-of-Way</u>

1. When sufficient public right-of-way does not exist for the construction of required widening lanes, the owner or builder shall dedicate the necessary right-of-way to the road agency owning the roadway to facilitate the construction, at the developer's cost, of the proposed improvement.

2. When the required improvements extend beyond the ownership of the subject site(s) and public right-of-way is insufficient, the owner shall obtain the necessary off-site easements/right-of-way. If the owner has exhausted all avenues for obtaining the easements/right-of-way, then the owner shall deposit the cost of providing these widening lane improvements with the City's Treasury Department. The cost of the required improvements shall be subject to review and approval by the City. These funds will be used at a later date when the right-of-way becomes available to place the required widening lanes.

3. As an alternative, these funds may be used at a later date as a contribution toward a larger project. If deemed appropriate by the City, a recordable agreement to be in favor of a future special assessment project for road improvements may be substituted for the cash deposit.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 8
Driveway Approaches and Drainage Ditches

A. Plans and Specifications – Submittal Procedure

1. The plans and specifications shall be prepared in accordance with *Chapter 1, General Requirements and Submittals*.

B. Requirements for Residential Driveway Approaches

1. Pavement cross-sections shall conform to the following requirements:

   a. Concrete driveway approaches shall be six inches (6") 3,500 psi concrete over four inches (4") 21AA aggregate base course materials (crushed limestone or crushed concrete). Alternate recycled asphalt product (RAP) base course materials may be considered upon approval of the City Engineer. Alternate RAP materials must meet equivalent structural strength of 21AA aggregate (crushed limestone or concrete).

   b. Asphalt driveway approaches shall be six inches (6") hot mix asphalt (HMA) over four inches (4") 21AA aggregate base course materials (crushed limestone or crushed concrete). Alternate recycled asphalt product (RAP) base course materials may be considered upon approval of the City Engineer. Alternate RAP materials must meet equivalent structural strength of 21AA aggregate (crushed limestone or concrete). The cross-section shall consist of two inches (2") HMA 13A wearing course over four inches (4") HMA 3C leveling course (two (2) two inch (2") lifts.

2. Driveway approach dimensions shall conform to the following requirements:

Garage Size	Approach Width At ROW	Local/Collector Approach Width at Street	Flare Width	Major Street Approach Width at Street	**Radius**
1 Car	12 Ft	18 Ft	3 Ft	32 Ft	10 Ft
	13 Ft	19 Ft	3 Ft	33 Ft	10 Ft
	14 Ft	20 Ft	3 Ft	34 Ft	10 Ft
	15 Ft	21 Ft	3 Ft	35 Ft	10 Ft
2 or More Cars	16 Ft	22 Ft	3 Ft	36 Ft	5 Ft to 10 Ft
	18 Ft	24 Ft	3 Ft	36 Ft	5 Ft to 10 Ft
	20 Ft	25 Ft	2.5 Ft	36 Ft	5 Ft to 10 Ft
	22 Ft	25 Ft	1.5 Ft	36 Ft	5 Ft to 10 Ft
	24 Ft	25 Ft	0.5 Ft	36 Ft	5 Ft to 10 Ft
	25 Ft	25 Ft	0.0 Ft	36 Ft	5 Ft to 10 Ft

3. Circular Driveways

    a. The property shall have a minimum of eighty feet (80') of road frontage.

    b. The minimum spacing between driveway approaches shall be forty-five feet (45') from centerline to centerline.

    c. Entering driveway approach angle from street shall be ninety degrees (90º).

4. Proposed driveways shall be shown with grades called out at the house and at the street. Driveway slopes shall be shown in percent (%). The minimum allowable slope is two percent (2%) with maximum allowable slopes of eight percent (8%) along roads with posted speed limits of 40 MPH or greater and ten percent (10%) along roads with a posted speed limit of 35 MPH or less. Note: driveway slopes shall not exceed two percent (2%) through the portion of the driveway that is to be utilized for existing and/or proposed pedestrian facilities, i.e., pathways and sidewalks, in order to meet American with Disabilities Act (ADA) requirements.

5. Additional requirements shall be in accordance with the City Standard Details.

C. Requirements for Commercial Driveway Approaches

1. Pavement cross-sections shall conform to the following requirements:

    a. Concrete driveway approaches shall be eight inches (8") 3,500 psi concrete over four inches (4") 21AA aggregate base course materials (crushed limestone or crushed concrete). Alternate recycled asphalt product (RAP) base course materials may be considered upon approval of the City Engineer. Alternate RAP materials must meet equivalent structural strength of 21AA aggregate (crushed limestone or concrete).

    b. Asphalt driveway approaches shall be nine inches (9") hot mix asphalt (HMA) over six inches (6") 21AA aggregate base course materials (crushed limestone or crushed concrete). Alternate recycled asphalt product (RAP) base course materials may be considered upon approval of the City Engineer. Alternate RAP materials must meet equivalent structural strength of 21AA aggregate (crushed limestone or concrete). The cross-section shall consist of two inches (2") HMA 13A wearing course over two inches (2") HMA 3C leveling course over five inches (5") HMA base course two (2) two and a half inch (2-1/2") lifts.

2. Driveway locations and geometrics shall at a minimum meet the Road Commission for Oakland County (RCOC) *Permit Rules, Specifications & Guidelines*, Michigan Department of Transportation (MDOT) *Administrative Rules Regulating Driveways Banners & Parades,* and MDOT *Access Management Guidebook*. City requirements may exceed those of RCOC and MDOT.

3. Driveway grades shall not exceed six percent (6%) within the right-of-way. Note: driveway slopes shall not exceed two percent (2%) through the portion of the driveway that is to be utilized for existing and/or proposed pedestrian facilities, i.e., pathways and sidewalks, in order to meet American with Disabilities Act (ADA) requirements.

4. Curb heights must be reduced to 1-inch or less height through a driveway opening.

5. Additional requirements shall be in accordance with the City Standard Details.

D. Drive Culverts and Drainage Ditches

1. Drive culverts shall meet the following requirements:

   a. Minimum of twelve inches (12”) in diameter.

   b. Material shall be sixteen (16) Gauge Galvanized Corrugated Metal Pipe (CMP).

   c. A minimum of one foot (1’) of cover must be provided between top of culvert pipe and top of driveway pavement.

   d. The culvert shall extend a minimum of three feet (3’) beyond driveway width on each side and shall meet the minimum side slopes of 1 on 2 for local streets, and 1 on 3 for major roads.

2. Ditches shall meet the following requirements:

   a. The maximum ditch depth shall be two and a half feet (2.5’) from bottom of centerline of ditch to top of road pavement.

   b. The desired maximum roadside ditch slope shall be 1 on 4.

   c. The desired maximum property side ditch slope shall be 1 on 3.

3. The minimum depth required for ditch enclosures is two and a half feet (2.5’) from the top of road pavement to bottom of ditch centerline.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 9

Sidewalks

A. Plans and Specifications – Submittal Procedure

1. Plans and Specifications for Sidewalks may be submitted either as part of a site development package, or as a separate entity for a specific location in accordance with *Chapter 1, General Requirements and Submittals*.

B. Plans and Specifications – Design Criteria

1. Sidewalks shall, in general, be located completely within the right-of-way, and be located one foot (1') from the edge of the City's Master Plan right-of-way.

2. Sidewalks shall generally conform to the grade of the existing topography. Transverse slopes shall not exceed two percent (2%), and longitudinal slopes shall not exceed eight percent (8%) for mainline sidewalks, with five to seven percent (5% - 7%) being the recommended range. Sidewalk ramps shall not exceed five percent (5%) longitudinal slope or two percent (2%) cross-slope.

3. Mastic expansion joints shall be provided wherever the sidewalk abuts existing pavement.

4. Sidewalks shall have smooth transitions and gentle curves. Sharp edges or abrupt changes in alignment are not allowed.

5. Plans for sidewalks shall include existing contours at a minimum of two-foot (2') intervals. Proposed grades along the centerline of the sidewalk shall be at twenty-five foot (25') intervals.

6. In general, sidewalks shall be at a higher elevation than the street, and slope transversely toward the street at a minimum half percent (0.5%) and a maximum slope of two percent (2%).

7. Where sidewalks meet driveways, they shall run continuously through the driveways. The slope of the driveways shall be designed to meet the sidewalk.

8. At street intersections sidewalk ramps shall be used to meet the existing street grade. If existing curb is involved, the curb shall be removed and the sidewalk ramped to meet the pavement. Curb cuts shall not be used. All sidewalk ramps shall conform to the latest MDOT sidewalk ramp and detectable warning detail R28 Series, and the latest American with Disabilities Act (ADA) requirements.

9. All existing trees, public utilities, utility poles, signs, guy wires, hydrants, driveways and any aboveground structures in the right-of-way shall be accurately shown.

10. All underground utilities in the right-of-way shall be shown.

11. The distance from the edge of the sidewalk to the back of curb or edge of the road shall clearly be called out on the plans. Sidewalks shall not be placed any closer than ten feet (10’), unless otherwise approved by the City Engineer.

12. A minimum three-foot (3’) lateral clearance should be maintained on either side of the sidewalk to fixed objects such as utility poles, trees, hydrants, etc.

13. A minimum eight-foot (8’) vertical clearance should be maintained above the surface of the sidewalk to fixed objects such as utility poles, trees, signs, etc.

14. Public sidewalk construction within Rochester Hills typically consists of 5-foot square panels by and intended for public use. Maintenance of sidewalks located in right-of-way or easement per City ordinance is the responsibility of the adjacent property owner.

C. Materials

1. Sidewalks shall be four inches (4”) thick, air-entrained concrete, at 3,500 psi compressive strength. Sidewalk thickness shall be increased to six inches (6”) through driveways and at ramps.

2. Sidewalk base shall be six inches (6”) of MDOT Granular Material Class II Sand, compacted to ninety-five percent (95%) maximum density.

3. Two-foot (2’) wide shoulders shall be sloped away from the sidewalk at a maximum of two percent (2%).

4. ADA detectable warning plates shall be color contrasted and consist of pre-formed plastic/fiberglass materials. Pre-formed plastic detectable warning plates shall be brick red in color. Stamped concrete is not acceptable.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 10

Pathways

A. <u>Plans and Specifications – Submittal Procedure</u>

1. Pathway Plans and Specifications must be submitted to and approved by the Department of Public Services prior to receiving approval for construction in accordance with Chapter 1, *General Agreements, and Submittals*.

2. If the pathway is proposed as part of a general development or site improvement, then the details of the pathway and its location can be incorporated into the overall site plan.

3. If the proposed pathway is within the right-of-way of another agency or entity having jurisdiction over such right-of-way, then the applicant will be responsible for acquiring any necessary permits after first having the plans approved by the City, for permit processing.

B. <u>Plans and Specifications – Design Criteria</u>

1. Plans shall show the entire proposed pathway in plan view, and shall be presented at a scale to clearly identify grades and spot elevations at twenty-five foot (25') intervals along the pathway.

2. Pathways shall, in general, be located completely within the right-of-way, and be located one foot (1') from the edge of the City's Master Plan right-of-way.

3. Pathways shall be eight feet (8') wide. In some instances where constraints exist (e.g. within historic districts, steep adjacent grading, limited room due to utility poles and/or trees), the pathway width may be reduced down to a minimum width of six feet (6') if approved by the City Engineer. Pathway widths for new construction or proposed for overlay that are adjacent to existing gravel driveways shall be constructed at a 10-foot width (10') thru the driveway limit. A 10-foot (10') mill shall be performed at each existing asphalt driveway for a pathway overlay project in accordance with the typical details attached to the end of this section.

4. The distance from the edge of the pathway to the back of curb or edge of the road shall clearly be called out on the plans. Pathways shall not be placed any closer than ten feet (10'), unless otherwise approved by the City Engineer.

5. In general, longitudinal slopes of proposed paths shall not exceed eight percent (8%), and shall follow the natural contour of the land. Transverse slopes shall be a minimum of one percent (1%) and not exceed two percent (2%).

Pathway ramps shall not exceed five percent (5%) longitudinal slope, with two percent (2%) maximum transverse slope. A minimum eight-foot (8') by five-foot (5') level landing area shall be constructed adjacent to the pathway ramp. The slope shall not exceed two percent (2%) in any direction within the level landing area.

At street intersections, concrete pathway ramps shall be used to meet the existing street grade. If existing curb is involved, the curb shall be removed and the pathway ramped to meet the pavement. Curb cuts shall not be used. All pathway ramps shall conform to the latest MDOT sidewalk ramp and detectable warning detail R28 series, and the latest American with Disabilities Act (ADA) requirements.

6. Pathways shall freely drain and not pond water. Appropriately sized culverts shall be used where crossing streams or ditches. Calculations for sizing such culverts shall be submitted along with the plans for approval. In general, pathways shall drain toward the roadway.

7. Crossings of wetland areas or other special, natural features, as determined by the City, may require special structures such as wooden pedestrian bridges. Such designs will need to comply with City typical designs in regard to railings, construction, and cross section. The traveled width shall be a minimum of ten foot (10') wide, and designed to accommodate a four (4) ton vehicle loading. The proposed structure will be reviewed by the City Engineer on a case-by-case basis.

8. Detailed construction drawings of such structures shall be submitted to the City Department of Public Services for review and approval prior to construction.

9. Existing and proposed land contours shall be clearly shown and labeled on the plans at two-foot (2') intervals.

10. Any other grades, slopes, or details, where requested by the City Engineer, shall be clearly shown on the plans.

11. All existing trees, public utilities, utility poles, signs, guy wires, hydrants, driveways and any aboveground structures in the right-of-way shall be accurately shown.

C. <u>Crossings</u>

1. At all street intersections, pathways shall be ramped to meet the street at grade. Horizontal curb cuts shall not be allowed unless approved by the City Engineer. Curbs shall be cleanly sawcut, removed, and replaced with a dropped curb section to meet the existing grade, and comply with MDOT Ramp Detail R-28 Series.

2. At all driveway crossings, pathways shall go through the drive. Existing drives shall be cleanly sawcut and the pathway shall continue through the drive uninterrupted. In general, the transverse slope of the pathway shall not exceed two percent (2%).

D. <u>General</u>

1. All construction of pathways shall conform to the City of Rochester Hills' Construction Standards and approved details.

2. A three-foot (3') shoulder shall be graded to smoothly drain away from the pathway. Shoulders shall be seeded or sodded.

3. Minimum ten-foot (10') vertical clearance from the base of the pathway to any object shall be maintained, unless otherwise approved by the City.

4. Minimum three-foot (3') horizontal clearance from the edge of the pathway to any object shall be maintained, unless otherwise approved by the City.

5. Where the adjacent cross slope exceeds the acceptable 1:3 slope, a safety fence or railing shall be constructed when required by the City Engineer. The fence or railing shall be designed and constructed as approved by the City Engineer.

6. Alignment of pathway shall be designed to avoid existing and proposed utility structures being located in the pathway. If this cannot be avoided, alignment should be established to minimize the encroachment or locate the structure(s) along the center of the pathway.

7. Significant grade changes may require the use of retaining walls to construct the pathway. Keystone walls or equivalent (full block) may be used. Block color shall be as approved by the City. Timber retaining walls are not acceptable.

8. All rights-of-way areas shall be fully restored to original or better condition, and be properly graded after pathway construction.

9. All tree roots shall be cut and removed within the influence of the pathway.

10. During pathway construction, signs shall be placed in accordance with the latest edition of the Michigan Manual of Uniform Traffic Control Devices, providing notification that the pathway is closed. Pedestrians shall not be detoured into the roadway.

E. Materials and Forms

1. Pathways shall be four inches (4") thick, hot mixed asphalt (HMA) comprised of one and a half inches (1.5") of HMA 5E03 (PG 58-22) over two and a half inches (2.5") of HMA 4E03 (PG 58-22). Pathways shall consist of an additional two inches (2") of HMA 4E03 through existing and proposed drives and pathway ramps abutting proposed commercial drives. Pathway ramps located at public and private streets and signalized drives shall be constructed in concrete with ADA detectable warning plates. Concrete pathway ramps shall be six inches (6") thick, air-entrained concrete, at 3,500 psi compressive strength.

2. The aggregate base shall be four inches (4") MDOT 21AA materials (crushed limestone or crushed concrete). Alternate recycled asphalt product (RAP) base course materials may be considered upon approval of the City Engineer. Alternate RAP materials must meet equivalent structural strength of 21AA aggregate (crushed limestone or concrete), compacted to ninety-seven percent (97%) maximum density, placed on base treated with a soil sterilant. The base shall have all existing topsoil removed as well as be firm and compact. The base shall at a minimum be extended to one-half foot (0.5') wider then the proposed pathway on each side.

3. Pathways shall have smooth, curved transitions, minimum ninety-foot (90’) centerline radius. Sharp angles or abrupt changes in direction are prohibited unless the only feasible option.

4. The width of the pathway shall be constant and uniform throughout its entire length, including curves and transitions.

5. In general, pathways shall be placed to parallel the right-of-way line. Curving the pathway to avoid trees and landscaping is encouraged, but in general the pathway should follow a straight line if at all possible.

6. ADA detectable warning plates shall be color contrasted and consist of pre-formed materials, either steel or plastic/fiberglass. Pre-formed plastic detectable warning plates shall be brick red in color. Stamped concrete is not acceptable.

CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 11

Soil Erosion and Sedimentation Control (SESC) Plan

A. Submittal Procedure

1. Soil Erosion and Sedimentation Control Plans must be incorporated into any plans submitted along with a Land Improvement Permit Application. A soil erosion control permit, administered through the Oakland County Water Resources Commissioner's Office, is required.

B. Plan Requirements

1. The Soil Erosion and Sedimentation Control (SESC) plans shall contain the following data on twenty-four inch by thirty-six inch (24" x 36") sheets, using the USGS Vertical Datum.

   a. Public and private roads in the area and all adjacent properties, the extent of site grading, all to at least one hundred (100') outside site boundaries.

   b. All lakes or streams within five hundred feet (500') of site boundaries shall be shown.

   c. Topographic plan, scale one inch equals fifty feet (1"=50'), to one-hundred feet (100') beyond site boundaries showing:

      i. Existing ground elevations, with either two-foot (2') contour intervals or spot elevations on a fifty-foot (50') grid.

      ii. Existing structures and significant features including trees six inches (6") in diameter or larger, existing ground cover, extent, and condition.

      iii. Existing drainage and soil information.

   d. Site Grading and Development Plans as required under other Chapters of City of Rochester Hills Design Standards for all proposed utilities on the site.

   e. The SESC plan shall include the following:

      i. Description and location of the limits for all proposed earth changes.

      ii. Description and location of all soil erosion measures (e.g. silt fence, inlet filters, straw bales, etc).

      iii. Show all trees to be preserved and describe and show the location of all associated tree protection fencing.

iv. The timing and sequence of all proposed earth changes.

v. Information as to how excavated material will be handled and stored to prevent erosion.

vi. Information on trench backfill restoration including schedule of placement.

vii. Information concerning the existing drainage system, including a provision for maintenance.

C. Principles of Erosion and Sediment Control

1. Plan the development to fit the topography, soils, waterways, and natural vegetation at a site with the least necessary earth disturbance or change.

2. Expose the smallest practical area of land for the shortest practical time through staging the work and early application of temporary or permanent erosion control measures.

3. Apply soil erosion control measures as a first line of defense against on-site damage, to prevent sediment from being produced. These measures included special grading methods, run-off control structures, temporary and permanent vegetation.

4. Apply sedimentation control measures as a perimeter protection to prevent off-site damage. These measures include, but are not limited to, diversion ditches, sediment traps, vegetative filters, and sediment basins.

5. Dust control measures shall be maintained at all times.

6. Apply follow-up and periodic maintenance for continued effectiveness of control measures.

D. Design Standards

1. Riprap is required at all locations where storm water velocities may be erosive to soils. Riprap shall be placed at all storm water inlets and outlets and basin outlets. Riprap shall be a nominal four inches (4”) to six inches (6”) minimum diameter and be clean of any foreign material.

2. Newly constructed storm water facilities shall be constructed to control flow velocities to limit erosion.

3. The plans shall, based on the nature of the proposed development, contain a time schedule for the installation of permanent soil erosion control measures.

4. As a basis of design, the standards set in the Oakland County *Soil Erosion Control Manual* shall be used.

E. Notes

The following notes shall appear on the plans:

1. All erosion and sediment control work shall conform to standards and specifications of the Oakland County Water Resources Commissioner.

2. All temporary and permanent (post construction) SESC measures shall conform to the City of Rochester Hills current MS4 permit. Any conflict between these standards and the MS4 permit, the permit's conditions shall take precedence.

3. Daily inspections shall be made by the Contractor for effectiveness of erosion and sedimentation control measures, and any necessary repairs shall be performed without delay.

4. Any sedimentation from work on this site shall be contained on the site and not allowed to collect on any off-site areas or in waterways.

5. Contractor shall apply temporary erosion and sedimentation control measures when required and as directed on these plans. Temporary measures shall be removed as soon as permanent stabilization of slopes, ditches, and other earth changes have been accomplished per Oakland County Water Resources Commissioner's standards. This would include temporary sedimentation ponds and temporary SO2 filters.

6. Staging the work will be done by the Contractor as directed in these plans and as required to ensure progressive stabilization of disturbed earth.

7. Soil erosion control practices shall be established in the early stages of construction by the Contractor. Sediment control practices will be applied as a perimeter defense against any transporting of silt off the site.

8. Failure to comply with approved soil erosion and sedimentation measures may result in work stoppage by appropriate authority.

9. Exceptions to timing of control measures' installation will only be permitted where trees and stumps need to be removed to install SESC measures.

10. Contractor is to provide the City with permit renewals, violation corrections, and/or releases.