Section VIII: Appendix

Part A.

GLOSSARY OF TERMS

1% Annual Chance Storm
(also known as the 100-year storm) This size storm has a 1% chance of occurring in a given year. The 1% annual chance flood does not refer to a storm event that only happens once every 100 years.

Antecedent Moisture Content (AMC)
The quantity of moisture present in the soil at the beginning of a rainfall event. The Soil Conservation Service has three classifications, AMC I, II and III.

A.S.T.M.
American Society for Testing Materials

Backwater
The increased depth of water upstream of a restriction or obstruction, such as a dam, bridge or culvert.

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

Barrel
The concrete or corrugated metal pipe that passes runoff from the riser through the embankment, and finally discharges to the pond's outfall.

Base Flow
The portion of stream flow that is not due to runoff from precipitation, usually supported by water seepage from natural storage areas such as ground water bodies, lakes or wetlands.

Best Management Practices (BMP)
A practice or combination of practices that prevent or reduce stormwater runoff and/or associated pollutants.

Bioretention
A water quality practice that utilizes landscaping and soils to treat stormwater runoff by collecting it in shallow depressions before filtering through a fabricated soil medium.

Borings
Cylindrical samples of soil profile used to determine infiltration capacity.

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

Catch Basin
A collection structure below ground designed to collect and convey water into the storm sewer system. It is designed so that sediment falls to the bottom of the catch basin and not directly into the pipe.

Check Dam
1. An earthen, aggregate or log structure, used in grass swales to reduce velocity, promote sediment deposition, and enhance infiltration.
2. A log or gabion structure placed perpendicular to a stream to enhance aquatic habitat.

Cistern
Containers that store large quantities of stormwater above or below ground. They can be used on residential, commercial, and industrial sites.

County Drain
An open or enclosed stormwater conveyance system that is under the legal jurisdiction of the Water Resources Commissioner's Office for construction, operation and maintenance.

Culvert
A closed conduit used for the passage of surface water under a road, or other embankment.

Curve Number (CN)
Determines the volume of stormwater removed from rainfall before runoff begins. It's based on land cover type, hydrologic condition, antecedent runoff condition and hydrologic soil group (HSG). The CN is a component in the NRCS Curve Number method for calculating storm runoff.

Design Storm
A rainfall event of specified size and return frequency, (e.g., a storm that occurs only once every 2 years). Typically used to calculate the runoff volume and peak discharge rate to or from a BMP.

Section VIII: Appendix

Detention
The temporary storage of storm runoff, to control peak discharge rates and provide gravity settling of pollutants.

Detention Basin
A constructed basin that temporarily stores water before discharging into a surface water body. Basins can be classified into four groups:

1. Dry Detention Basin
   A basin that remains dry except for short periods following large rain storms or snow melt events. This type of basin is not effective at removing pollutants.
2. Extended Dry Detention Basin
   A dry detention basin that has been designed to increase the length of time that stormwater will be detained, typically between 24-40 hours. This type of basin is not effective at removing nutrients such as phosphorus and nitrogen, unless some type of treatment is incorporated into the lower stage of the design (i.e., forebay, shallow marsh, etc.).
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, typically between 24-40 hours.

Detention Time
The amount of time that a volume of water will remain in a detention basin.

Discharge
The rate of flow or volume of water passing a point in a given time. Usually expressed as cubic feet per second (cfs).

Disturbed Area
An area in which the natural vegetative soil cover has been removed or altered and is susceptible to erosion.

Drainage area
The area of a watershed usually expressed in square miles or acres.

Drawdown
The gradual reduction in water level in a pond BMP due to the combined effect of infiltration, evaporation and discharge.

Dry well
Small infiltration pits or trenches filled with aggregate that receive clean runoff primarily from rooftops.

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. The Water Resources Commissioner secures temporary and permanent easements adjacent to county drains for the purpose of construction and maintenance access. Easements are recorded on the title to the land and transfer with the sale of land.

Erosion
The wearing away of land surface by running water, wind, ice, or other geological agents.

Extended Detention
A stormwater design feature that provides for the holding and gradual release of stormwater over a longer period of time than that provided by conventional detention basins, typically 24-40 hours. Extended detention allows pollutants to settle out before stormwater is discharged from the basin.

Extended Detention Control Device
A horizontal pipe or series of pipes or vertical riser pipe designed to gradually release stormwater from a pond over a 24-40 hour interval.

Fill
Added earth that is designed to change the contour of the land.

Filter Fabric
Textile of relatively small mesh or pore size. The two major classifications are as follows:

1. Permeable. This allows water to pass through while holding sediment back.
2. Impermeable. This type prevents both runoff and sediment from passing through.

First Flush
The delivery of a highly concentrated pollutant loading during the early stages of a storm, due to the washing effect of runoff on pollutants that have accumulated on the land. For the purposes of these Rules, first flush is the runoff from the first inch of precipitation.

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

Section VIII: Appendix

Flow Path
The distance that a parcel of water travels through a stormwater detention pond or wetland. It is defined as the distance between the inlet and outlet, divided by the average width.

Flow Splitter
An engineered, hydraulic structure designed to divert a portion of stream flow to a BMP located out of the channel, or to direct stormwater to a parallel pipe system, or to bypass a portion of baseflow around a pond.

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

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

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

Gabion
A rectangular box of heavy gage wire mesh that holds large cobbles and boulders. Used in streams and ponds to change flow patterns, stabilize banks, or prevent erosion.

Green Roof
Conventional rooftops that include a thin covering of vegetation allowing the roof to function more like a vegetated surface. The layer thickness varies between 2-6 inches and consists of vegetation, waterproofing, insulation, fabrics, growth media, and other synthetic components.

Ground Water
Naturally existing water beneath the earth's surface between saturated soil particles and rock that supplies wells and springs.

Ground Water Table
The upper surface or top of the saturated portion of the soil or bedrock layer, indicates the uppermost extent of groundwater.

Hydraulic Radius
The area of a stream of conduit divided by its wetted perimeter.

Hydrograph
A graph showing the variation in stage or discharge in a stream or channel, over time, at a specific point along the stream.

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

Infiltration
The absorption of water into the ground expressed in terms of inches/hour.

Infiltration Capacity
The maximum rate at which the soil can absorb falling rain or melting snow. Usually expressed in inches/hour, or centimeters/second.

Infiltration Practices
Best management practices (bed, trench, basin, well, etc.) that allow for rainfall to soak into the soil mantle.

In-line Detention
Detention provided within the flow-carrying network.

Invert
The elevation of the bottom interior surface of a conduit at any given cross section.

Level-Spreader
A device used to spread out stormwater runoff uniformly over the ground surface as sheet flow i.e., not through channels. The purpose of level spreaders is to prevent concentrated, erosive flow from occurring, and to enhance infiltration.

Locally Adapted Plants
A species that will thrive in local conditions. Local conditions include the hydrology, soil types and sunlight availability. Locally adapted species are often, but not limited to Michigan natives or cultivars of native species. For more information on individual species, see "Plants for Stormwater Design: Species Selection for the Upper Midwest" by Daniel Shaw & Rusty Schmidt.

Low Impact Development (LID)
Activities that mimic a site's pre-development hydrology by using design techniques that are spatially distributed, decentralized micro-scale controls that infiltrate, filter, store, evaporate and detain runoff close to its source.

Manhole
A structure that allows access into the sewer system.

Section VIII: Appendix

Manning's Roughness Coefficient ("n")
A coefficient used in Manning's Equation to describe the resistance to flow due to the surface roughness of a culvert or stream channel.

Mean Storm
Over a long period of years, the average rainfall event, usually expressed in inches.

Mitigation
Making something less harsh or severe. LID mitigates by lessening the impacts of stormwater runoff from impervious surfaces.

Multiple Pond System
A collective term for a cluster of pond designs that incorporate redundant runoff treatment techniques within a single pond or series of ponds. These pond designs employ a combination of two or more of the following: extended detention, permanent pool, shallow marsh or infiltration.

Native Plants
Plants that historically co-evolved with the local ecology, geology and climate. Michigan Flora, mcihiganflora.net, classifies plants as native or non-native species.

Natural Wetland
Land characterized by the natural presence of water sufficient to support wetland vegetation.

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

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

Off-line BMP
A water quality facility designed to treat stormwater that has been diverted outside of the natural watercourse or storm sewer system.

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

One Hundred Year Flood (100-year flood)
The flood that has a 1 percent chance of occurring in any given year.

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

Orifice
An opening in a wall or plate.

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

Permeable
Allows liquid to pass through. Porous. Also pervious, the opposite of impervious.

Pervious See permeable.

Pervious Pavement
An infiltration technique that combines stormwater infiltration, storage, and structural pavement that consists of a permeable surface underlain by a storage reservoir.

Petition (Under P.A. 40 of 1956)
A legal request to the Water Resources Commissioner to perform maintenance or construction, or to establish a drainage district. Either the township or individual(s) can petition to have work performed or a district established.

Pilot Channel
A riprap or vegetated low flow channel that routes runoff through a BMP to prevent erosion of the BMP surface.

Planter Box
A device containing trees and plants near streets and buildings constructed to prevent stormwater from directly draining into sewers.

Plat, Platting Process
A legal procedure, and the document that depicts it, whereby a larger piece of property is divided into smaller sections, and is accompanied by a full description of the original property, the dimension of each lot to be subdivided, and all relevant deed restrictions and easements.

Section VIII: Appendix

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

Pocket Wetlands
A stormwater wetland design adapted for small drainage areas with no reliable source of baseflow. The surface area of pocket wetlands is usually less than a tenth of an acre. The pocket wetland is usually intended to provide some pollutant removal for very small development sites.

Pre-development
Time period before significant human change to the landscape. For the purpose of this manual, pre-development will follow the LID design calculations, where pre-development is further defined as either woods or meadow in good condition. This definition will not represent the actual pre-development condition of all land in Michigan. It does provide a simple, conservative value to use in site design that meets common LID objectives.

Pretreatment
Technique to capture or trap coarse sediments within runoff, before they enter a BMP to preserve storage volumes or prevent clogging. Examples include swales, forebays and micropools.

Proprietor
Any person, firm, association, partnership, corporation or any combination thereof.

Protected Wetland
Any wetland protected by state law or local government regulation.

Public Land Survey System (PLSS)
The PLSS is the surveying method used historically over the largest fraction of the United States to survey and spatially identify land parcels before designation of eventual ownership, particularly for rural, wild or undeveloped land. For the purposes of this document -- the drawing and legal description must follow the standards of MI Public Act 132 of 1970 - Certified Surveys and reference a PLSS corner. For platted subdivisions, the description must reference a lot corner with the name, liber and page of the subdivision. Note: Where PLSS corners do not exist, Private Claims corners may be accepted at the discretion of the WCWRC.

Rain Barrel
A barrel designed to retain small volumes of stormwater runoff for reuse for landscaping.

Rain Garden
Landscape elements that combine plantings and depressions that allow water to pool for a short time (e.g., a few days) after a rainfall and then be slowly absorbed by the soil and vegetation.

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

Release Rate
The rate of discharge in volume per unit time from a detention facility.

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

Retention Basin
A stormwater management facility designed to capture runoff that does not discharge directly to a surface water body. The water is “discharged” by infiltration or evaporation. Also known as a Wet Pond.

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).

Reverse Slope Pipe
A technique for regulating extended detention times that is resistant to clogging. A reverse slope pipe is a pipe that extends downward from the riser into the permanent pool and sets the water surface elevation of the pool. The lower end of the pipe is located up to one foot below the water surface.

Riparian Lands
Land directly adjacent to a surface water body (e.g., lake, stream, creek).

Riprap
A combination of large stones, cobbles and boulders used to line channels, stabilized banks, reduce runoff velocities or filter out sediment.

Riparian Buffer
An area next to a stream or river (sometimes also used for lakes) where development is restricted or prohibited. The buffers should be vegetated with herbaceous and woody native plants, or left in their natural state. Buffers filter stormwater before it reaches the water body and slows the stormwater velocity.

Section VIII: Appendix

Riparian Corridor
The area adjacent to a stream or river (sometimes also used for lakes) that preserves water quality by filtering sediments and pollutants from stormwater before it enters the waterbody, protects banks from erosion, provides storage area for flood waters, preserves open space, and provides food and habitat for wildlife.

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.

Routing
The derivation of an outflow hydrograph for a given reach of stream or detention pond from known inflow characteristics. The procedure uses storage and discharge relationships and/or wave velocity.

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

Runoff Coefficient
The ratio of the amount of water that is NOT absorbed by the surface to the total amount of water that falls during a rainstorm.

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

Sheetflow
Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

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

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

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

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

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

Stormwater Runoff
Rainfall or snowmelt that runs off the land and is released into our rivers and lakes.

Stormwater Wetland
A conventional stormwater wetland is a shallow pool that creates growing conditions suitable for the growth of marsh plants. Stormwater wetlands are designed to maximize pollutant removal through wetland uptake, retention and settling. These constructed systems are not located within delineated natural wetlands.

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.

Structural BMPs
Devices constructed for temporary storage and treatment of stormwater runoff.

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

Tailwater
The depth of water at the downstream end of a culvert or crossing.

Time of Concentration
The time it takes for surface runoff to travel from the hydraulically farthest portion of the watershed to the design point.

Timing
The relationship in time of how runoff from subwatersheds combines within a watershed.

Section VIII: Appendix

Underdrain
Perforated pipe installed to collect and remove excess runoff.

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

Watershed
The complete area or region of land draining into a common outlet such as a river or body of water.

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

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

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

Wet Pond/Constructed Wetland
Surface or underground structures that provide temporary storage of stormwater runoff to prevent downstream flooding and the attenuation of runoff peaks.

Wetland Perimeter
The wetted surface of a stream or culvert cross-section that causes resistance to flow. The water to surface interface is a distance, typically expressed in feet.

Part B.

MAJOR CATEGORIES OF NON-POINT SOURCE POLLUTANTS AND ASSOCIATED IMPACTS

SEDIMENTS

Source: Construction sites, agricultural lands and other disturbed and/or non-vegetated lands, including eroding stream banks.

Impacts: Once deposited, sediment can decrease the storage capacity of a water body, as well as smother organisms that dwell on the bottom and destroy their habitat. Suspended sediment can lower the transmission of light through water, and interfere with animal respiration and digestion. Contaminated sediments act as a reservoir for particulate forms of pollutants, such as organic matter, phosphorus, or metals that can be released later.

NUTRIENTS (E.G. PHOSPHORUS & NITROGEN)

Source: Septic systems, fertilizers, animal waste, detergents and plant debris.

Impacts: Slow moving waters become choked with nutrient induced algae and weeds that take up dissolved oxygen in the water needed by fish and other aquatic life. This reduction in dissolved oxygen can also cause pollutants trapped within sediments to be released back into the water column.

TEMPERATURE ENHANCEMENT

Source: Impervious surfaces collect heat and warm stormwater as it passes over them and into receiving waterways. The creation of storage ponds and impoundments, and the removal of trees and other vegetation that shade streambanks increases the surface area of water exposed to solar heating.

Impacts: Temperature enhancement severely interferes with cold-water organisms such as trout and stoneflies, and may cause their extinction in intensively developed areas.

TOXIC COMPOUNDS

Source: Pesticides, road de-icing materials, motor vehicles, industrial activities, atmospheric deposition, and illicit dumping and sewage connections.

Impacts: Toxic substances can degrade the appearance of water surfaces, lower dissolved oxygen, stress sensitive flora and fauna, pose health risks and enter into the aquatic food chain.

BACTERIA

Source: Animal waste (including pets and birds), failing septic systems and illicit sewer connections.

Impacts: Increased bacteria levels can pose health risks and close or restrict the use of recreational areas.

LITTER & DEBRIS (ORGANIC & NON-ORGANIC)

Source: Urban and suburban landscapes contribute grass clippings and leaves. Non-organic debris is generated by careless disposal practices, e.g., street litter.

Impacts: Litter, leaves and trash wash through the storm drain system, clogging pond outlets and creating large debris jams within streams and floodplains. In addition, organic materials require oxygen to decompose and so lower the level of dissolved oxygen available to aquatic life.

Section VIII: Appendix

Part C.

STORMWATER POLLUTANT HOTSPOTS

The following land uses and activities are deemed stormwater hotspots:

- Vehicle salvage yards and recycling facilities *
- Vehicle service and maintenance facilities including gas stations
- Vehicle and equipment cleaning facilities *
- Fleet storage areas (bus, truck, etc.) *
- Industrial sites (for SIC codes outlined in Appendix D-6)
- Marinas (service and maintenance) *
- Outdoor liquid container storage
- Public works storage areas
- Facilities that generate or store hazardous materials *
- Commercial container nursery
- Other land uses and activities as designated by an appropriate review authority

* Indicates that the land use or activity is required to prepare a stormwater pollution prevention plan under the EPA Stormwater Multi-Sector General Permit Program (see http://www.epa.gov/npdes/pubs/msgp2008_appendixd.pdf).

Additional water quality measures must be installed at sites where land uses are identified as pollutant hotspots. The water quality treatment devices utilized must address the pollutants of concern for the site. For example, hydrocarbon filters will be required in all catch basins at gas stations; sediment removal devices will be required at commercial nurseries, etc.

Part D.

CONSTRUCTION, OPERATION & MAINTENANCE OF CLUSTER WASTEWATER TREATMENT SYSTEMS, COMMUNITY DRAIN FIELDS & OTHER SANITARY TREATMENT FACILITIES UNDER THE MICHIGAN DRAIN CODE

Section 280.433 of the Michigan Drain Code authorizes the establishment of county drainage districts for the purpose of construction, operation and maintenance of sanitary wastewater treatment facilities. Special assessment districts can be set up through procedures similar to those utilized for stormwater management (drainage) districts under the Code. The facilities may be constructed privately with jurisdiction subsequently assumed by the County Water Resources Commissioner for operation, maintenance and replacement or may be constructed by the Water Resources Commissioner. Once a drainage district is established and operating, all future costs and responsibilities rest with the special assessment district.

To date, the Washtenaw County Water Resources Commissioner has not been involved with the operation of sanitary treatment facilities. Because, however, inquiry has been made regarding policies relative to such systems, the following preliminary guidance has been drafted to describe the terms and conditions under which establishment of drainage districts to manage operations of sanitary facilities may be considered. (It is assumed that facilities will be constructed by the private developer, and jurisdiction subsequently assumed by the Water Resources Commissioner.)

- In order to be considered by the Washtenaw County Water Resources Commissioner, the system must be proposed to alleviate an existing health problem, or to allow clustering of development so as to preserve natural features and open space in a proposed new development. A minimum of 50% preserved open space will be required.

- Formal written request from the local government in which the district would be located is a prerequisite to consideration of establishment of a county drainage district for cluster systems, community drain fields or other waste treatment facilities. Private developers' proposals will not be considered unless accompanied by request of the affected community(ies).

- Approval must be obtained for system design and installation by the Office of the Water Resources Commissioner, County Environmental Health Division, as well as MDEQ where required.

- The private developer of the system will pay all administrative, technical review and inspection costs. The developer must fund the cost of review of plans, and supervision of installation, by an independent professional engineer under contract to the Office of the Washtenaw County Water Resources Commissioner.

- The system must be warranted, at the developer's expense, through 2 freeze-thaw periods.

- A maintenance program and a contract for ongoing maintenance with a private or public entity acceptable to the Office of the Water Resources Commissioner must be in place. Costs should be borne by the Condominium or Subdivision Association of the area served, though the Water Resources Commissioner will have necessary work performed and levy special assessments to cover the cost incurred should the homeowners' association fail to fulfill this obligation. A schedule for reporting to the Water Resources Commissioner, as well as a timeframe for response by the homeowners' group upon notification of needed maintenance must be specified in the Rules or Agreement governing its operation.

- A clear definition must be set forth in the Subdivision Agreement or Condominium Master Deed as to those facilities that remain the responsibility of individual property owners for operation, maintenance and replacement, verses those that fall under jurisdiction of the county drainage district. All property owners will bear equally in paying costs of any service, repair or replacement of the County portions of the system.

- Provision must be made for annual inspection of the system by the Washtenaw County Environmental Health Division, or its designee, at the property owners' expense.

- An escrow fund sufficient to cover replacement of the system shall be established in the name of the drainage district at the time the County assumes responsibility.

Other terms and conditions may be developed to serve site specific needs on a case-by-case basis.

Section VIII: Appendix

Part E.

ENGINEER'S CERTIFICATE OF CONSTRUCTION

Date:_____

Development Name:_____

Township of:_____ Section:_____

Washtenaw County, Michigan

I hereby certify that the construction of the drainage facilities of the subdivision known as_____ _____ is complete and that:

1. I have supervised inspection of the construction.
2. All improvements to date have been installed in accordance with construction plans approved by the Washtenaw County Water Resources Commissioner.
3. Reports of construction material tests have been filed with the Washtenaw County Water Resources Commissioner.

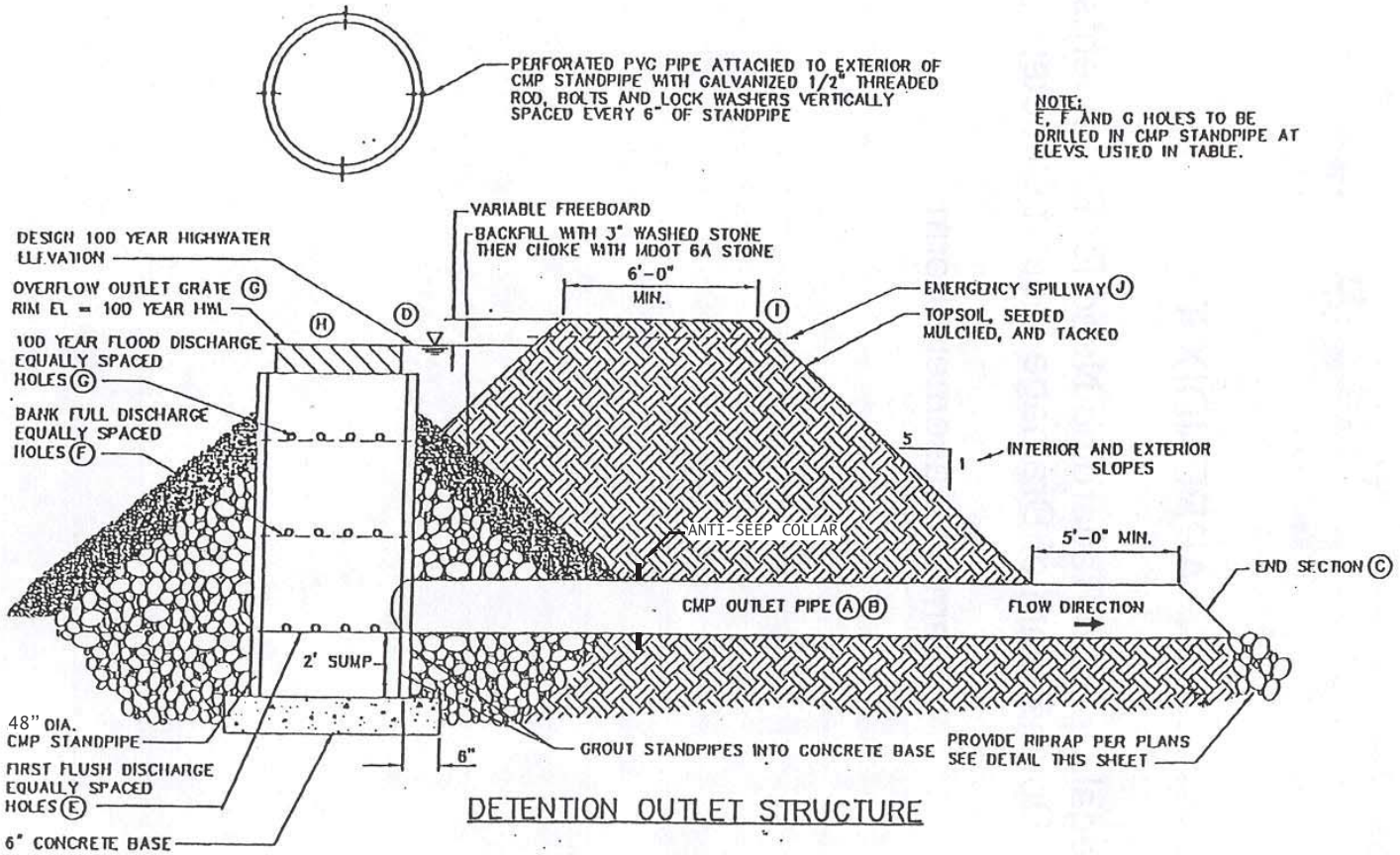
Signed: _____

Registered Professional Engineer

Note: The engineer's certificate must be stamped with the engineer's seal.
The certificate submitted must be the original.

Part F.

EXAMPLE THREE STAGE OUTLET DESIGN



DETENTION OUTLET STRUCTURE

DETENTION OUTLET SCHEDULE

OUTLET PIPE LENGTH (A)	OUTLET PIPE SLOPE (B)	END SECTION INVERT (C)	100-YEAR HWL (D)	FIRST FLUSH DISCHARGE INV/ORIFICE SIZE (E)	BANK FULL DISCHARGE INV/ORIFICE SIZE (F)	100 YEAR FLOOD DISCHARGE INV/ORIFICE SIZE (G)	TOP OF STAND PIPE ELEVATION (H)	POND CREST ELEVATION (I)	EMERGENCY SPILLWAY ELEVATION (J)

Section VIII: Appendix

Part G.

RAINFALL PRECIPITATION DATA

Precipitation Frequency Data: Washtenaw County, Michigan

The following table indicates the expected design precipitation for a particular duration and recurrence interval. The data was obtained from NOAA Atlas 14, Volume 8, Version 2, -- Point Precipitation Frequency Estimates for Michigan at the Ann Arbor weather station.

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

	AVERAGE RECURRENCE INTERVALS (YEARS)						
DURATION	1 YR.	2 YR.	5 YR.	10 YR.	25 YR.	50 YR.	100 YR.
30 min.	0.768	0.906	1.14	1.33	1.61	1.83	2.05
1 hour	0.969	1.14	1.44	1.70	2.07	2.38	2.69
2 hours	1.17	1.38	1.75	2.07	2.54	2.92	3.33
3 hours	1.30	1.53	1.93	2.29	2.82	3.27	3.74
6 hours	1.55	1.79	2.22	2.62	3.23	3.75	4.31
12 hours	1.82	2.06	2.50	2.91	3.54	4.09	4.68
24 hours	2.09	2.35	2.83	3.26	3.93	4.50	5.11

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

Part H.

HYDROLOGIC SOIL GROUPS FOR WASHTENAW COUNTY

Soil properties influence the process of generation of runoff from rainfall and must be considered in methods of runoff estimation. The soils are classified on the basis of water intake at the end of the long-duration storms occurring after prior wetting and after an opportunity for swelling, and without the protective effects of vegetation. The hydrologic soil groups, as defined by the NRCS are:

A. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission and low runoff potential.

B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay-pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission and high runoff potential.

SOIL SERIES	GROUP	SOIL SERIES	GROUP	SOIL SERIES	GROUP
Adrian	D/A	Kendallville	B	Pewamo	D/C
Blount	C	Kibbie	B	Riddles	B
Boyer	B	Kidder	B	Sebewa	D/B
Boyer-Kidder	B	Lamson-Colwood	D/B	Seward	B
Brookston	D/B	Macomb	B	Sisson	B
Cohoctah	D/B	Matherton	B	Sloan	D/B
Conover	C	Metamora	B	Spinks	A
Conover-Brookston	D/B	Miami	B	Spinks-Oshtemo	B
Dixboro-Kibbie	B	Morley	C	St. Clair	D
Edwards	D/B	Nappanee	D	Tedrow	B
Fox	B	Oakville	A	Thetford	A
Gilford	D/B	Oshtemo	B	Wasepi	B
Granby	D/A	Owosso	B	Wauseon	D/B
Houghton	D/A	Palms	D/A	Ypsi	C
Hoytville	D/C	Pella	D/B		

The first group letter (e.g., D in D/A) is the native or undrained classification when the water intake has not been changed by artificial drainage. The second group letter is the classification after artificial drainage improvements. For use in the determination of developed runoff only the undrained classification will be accepted.

Section VIII: Appendix

Part I.

REQUIRED EASEMENT & DISTRICT LANGUAGE FOR CHAPTER 18 DRAINAGE DISTRICTS

LANGUAGE REQUIRED FOR PLATTED SUBDIVISIONS

The following language shall be included in a section of the subdivision deed restrictions that describes the drainage district.

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

1. The easement shall be for the purposes of developing, establishing, constructing, repairing, maintaining, deepening, cleaning, widening and performing any associated construction activities and grading in connections with any type of drainage facilities or storm drains, in any size, form, shape or capacity;
2. The grantee shall have the right to sell, assign, transfer or convey this easement to any other governmental unit for the purposes identified in subsection (1) above;
3. No owner in the subdivision shall build or convey to others any permanent structures on the said easement;
4. No owner in the subdivision shall build or place on the area covered by the easement any type of structure, fixture or object, or engage in any activity to take any action, or convey any property interest or right, that would in any way either actually or threaten to impair, obstruct, or adversely affect the rights of grantee under the said easement;
5. The grantee and its agents, contractors and designated representative shall have right of entry on, and to gain access to, the easement property;
6. All owners in the subdivision release grantee and its successors, assigns or transferees from any and all claims to damages in any way arising from or incident to the construction and maintenance of a drain or sewer or otherwise rising from or incident to the exercise by grantee of its rights under the said easement, and all owners covenant not to sue grantee for such damages.

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

Section VIII: Appendix

LANGUAGE REQUIRED FOR SITE CONDOMINIUMS

The following language shall be included in a section of the Master Deed that describes the drainage district.

. . .subject to a perpetual and permanent easement in favor of the Washtenaw County Water Resources Commissioner, the _____Drainage District, (collectively referred to as "grantee"), and grantee's successors, assigns and transferees, in, over, under and through the property described on Exhibit B hereto, which easement may not be amended or revoked except with the written approval of grantee, and which contains the following terms and conditions and grants the following rights:

1. The easement shall be for the purposes of developing, establishing, constructing, repairing, maintaining, deepening, cleaning, widening and performing any associated construction activities and grading in connections with any type of drainage facilities or storm drains, in any size, form, shape or capacity;
2. The grantee shall have the right to sell, assign, transfer or convey this easement to any other governmental unit for the purposes identified in subsection (1) above;
3. No owner in the condominium shall build or convey to others any permanent structures on the said easement;
4. No owner in the condominium shall build or place on the area covered by the easement any type of structure, fixture or object, or engage in any activity to take any action, or convey any property interest or right, that would in any way either actually or threaten to impair, obstruct, or adversely affect the rights of grantee under the said easement;
5. The grantee and its agents, contractors and designated representative shall have right of entry on, and to gain access to, the easement property;
6. All owners in the condominium release grantee and its successors, assigns or transferees from any and all claims to damages in any way arising from or incident to the construction and maintenance of a drain or sewer or otherwise rising from or incident to the exercise by grantee of its rights under the said easement, and all owners covenant not to sue grantee for such damages.
   The rights granted to the Washtenaw County Water Resources Commissioner, the _____ _____Drainage District, and their successors and assigns, under Section _____of these restrictions may not, however, be amended without the express written consent of the grantee hereunder. Any purported amendment or modification of the rights granted there under shall be void and without legal effect unless agreed to in writing by the grantee, its successors or assigns.

Section VIII: Appendix

Part J.

THIS DOCUMENT IS GENERATED BY THE WATER RESOURCES COMMISSIONER'S OFFICE. THE FOLLOWING IS FOR REFERENCE ONLY AND SHOULD NOT BE GENERATED FOR FILING PURPOSES.

(SAMPLE AGREEMENT FORM ATTACHED)

This agreement must be recorded with the Washtenaw County Register of Deeds. Therefore, it must abide by the following recording requirements:

1. Use full names. For example, do not write "John and Mary Doe". Write "John Doe and Mary Doe".
2. Signatures must be original and names must be typed or printed beneath signatures. MCLA 565.201 Sec. 1(a)
3. No discrepancy shall exist between names printed in the notary acknowledgment and as printed beneath signatures. MCLA 565.201Sec. 1(b)
4. Instruments conveying or mortgaging property shall state the marital status of all male grantors/mortgagors. MCLA 565.221
5. The address of the grantees in each deed of conveyance or assignment of real estate shall contain the street number address or post office address. MCLA 565.201 Sec. 1(d)
6. The name and address of the person who drafted the document must appear on documents executed in Michigan. MCLA 565.201a, 565.203
7. Documents purporting to convey or encumber real estate executed in Michigan require an acknowledgement by a judge, clerk of a court of record or a notary public within this state. MCLA 565.8; form: LAND 565.47, MCLA 565.265; 565.267
8. A certified copy of the death certificate or proof of death must be recorded or have been recorded and referenced by Liber and Page on said document when "survivor" is indicated on the document. MCLA 565.48
9. Court orders must be certified and sealed by the clerk of the court. MCLA 565.401,; 565.411
10. The document submitted for recording must be legible. MCLA 565.201 Sec. 1(f)(iv).
11. Documents must have a margin of unprinted space at least 2 1/2 inches at the top of the first page and at least 1/2 inch on all remaining sides of each page. MCLA 565.201 Sec 1(f)(i)
12. Documents must display on the first line of print on the first page, a single statement identifying the recordable event that the instrument evidences. MCLA 565.201 Sec. 1 (f)(ii) Sec. 3
13. The type on the form must be printed with black ink; type size at least 10-point type. MCLA 565.201 Sec. 1 (f) (iii)(iv)
14. The paper on which the document is printed must be white and not less than 20-pound weight. MCLA 565.201 Sec. 1 (f)(iv)
15. The size of the document and any attachment thereto must be at least 8 1/2 inches by 11 inches; at most 8 1/2 inches by 14 inches. MCLA 565.201 Sec. 1 (f) (v)(vi)

NUMBER OF LOTS	FEE
1-50	$1,500
51-100	$2,000
101-150	$2,500
151-200	$3,000
201-250	$3,500
251-300	$4,000
301+	$5,000

AGREEMENT TO ESTABLISH THE PROJECT_NAME DRAIN DRAINAGE DISTRICT

THIS AGREEMENT, made and entered into this _____ day of _____, 20___, by and between EVAN N. PRATT, Washtenaw County Water Resources Commissioner, (COMMISSIONER) acting for and on behalf of the PROJECT_NAME DRAIN DRAINAGE DISTRICT (P.O. Box 8645, Ann Arbor, MI 48107), of the County of Washtenaw, State of Michigan, a municipal corporation, hereinafter referred to as the DISTRICT, and OWNER_DEVELOPER, (ADDRESS), hereinafter referred to as the DEVELOPER.

WITNESSETH:

WHEREAS, Section 433 of Act Number 40 of the Public Acts of 1956, Michigan, as amended, The Drain Code, authorizes the COMMISSIONER to enter into an agreement with a landowner and developer, if any, to establish an existing private drain which was constructed by the landowner or developer to service an area on his, or her own land as a County or Intercounty Drain; and

WHEREAS, COMMISSIONER, acting on behalf of the PROJECT_NAME DRAIN DRAINAGE DISTRICT, will have under his jurisdiction the PROJECT_NAME DRAIN (DRAIN); and

WHEREAS, the COMMISSIONER, through and by the DISTRICT, is in charge of operation and maintenance of the PROJECT_NAME DRAIN to service lands in the PROJECT_NAME DRAIN DRAINAGE DISTRICT; and

WHEREAS, the PROJECT_NAME DRAIN will be a County Drain located in TOWNSHIP_SECTION; and

WHEREAS, the DEVELOPER has provided storm drainage for the lands comprised within the PROJECT_NAME DRAIN DRAINAGE DISTRICT, described in Exhibit A as attached and made a part hereof.

WHEREAS, the DEVELOPER further understands that as the freeholder and owner of the lands included in this Agreement in the TOWNSHIP of TOWNSHIP_SECTION in which said PROJECT_NAME DRAIN and the lands to be drained thereby are located, that these lands as described in Exhibit A known as the PROJECT_NAME DRAIN DRAINAGE DISTRICT will be subject to assessments for the cost of construction, operation, inspection and maintenance of the DRAIN; and

WHEREAS, these lands being drained, thereby, and to be assessed, therefore, are in the PROJECT_NAME DRAIN DRAINAGE DISTRICT; and

WHEREAS, the DEVELOPER, pursuant to Section 433 of the Drain Code, as amended, desires to establish his or her private drain as a County Drain; and

WHEREAS, the DEVELOPER, has agreed to assume the total cost of said improvement; and

WHEREAS, a certificate has been obtained from a registered professional engineer retained by the DEVELOPER to the effect that the existing drain is the only reasonably available outlet for the drain and that there is sufficient capacity in the existing outlet for the proposed drain to serve as an adequate outlet, without detriment to or diminution of the drainage service that the outlet presently provides.

NOW, THEREFORE, in consideration of the premises and covenants of each, the parties hereto agree to as follows:

1. The DISTRICT agrees to establish the PROJECT_NAME DRAIN as a County Drain upon the execution of this Agreement by the DISTRICT and the DEVELOPER.

2. The stormwater drainage facilities of the PROJECT_NAME shall be constructed under the supervision, direction and control of the DISTRICT according to plans, specifications and project designs approved by the DISTRICT and on file in the Office of the Washtenaw County Water Resources Commissioner.

3. The DEVELOPER agrees hereto to assume the cost of the project set forth in the above-mentioned plans, specifications and project designs. Said cost shall include:

    a. Administrative Fees for the establishment of the PROJECT_NAME DRAIN
    b. Actual expenses incurred by the DISTRICT for inspection and construction of the DRAIN.
    c. A construction contingency item computed as ten percent (10%) of the construction cost as determined by the DISTRICT provided, should any balance remain in the contingency fund, such balance shall be refunded to the DEVELOPER upon the following terms and conditions:

        i. A period of one (1) year shall expire after final acceptance of the project by the DISTRICT at which time the DEVELOPER shall request that the DISTRICT make a final inspection.

        ii. The DISTRICT shall proceed with final inspection of the project, and following such inspection, the DISTRICT shall make the necessary correction of any defects on the project payable out of contingency funds.

        iii. At such time as the corrections have been completed by the DISTRICT, the DISTRICT shall issue a final acceptance of the project, and, the DEVELOPER shall file with the DISTRICT a sworn Statement that all claims for amounts due for labor, materials and equipment furnished for this work have been paid in full, or he or she shall so file in lieu thereof, a sworn statement showing in detail the nature and amount of all unpaid claims for said labor, materials and equipment. The Contractor shall also submit a Contractor's Declaration and Affidavit. The remaining contingency balance may then be refunded to the DEVELOPER.

d. The establishment of a permanent maintenance fund in an amount of 5% of the construction cost but not to exceed $2,500.00.

The DEVELOPER'S cost to the DISTRICT to establish the DRAIN, incidental of actual construction expenses, is hereby determined as follows:

i. Administrative fees $ _____

ii. Estimated Inspection $ _____
10% of project cost; unused monies to be returned to the DEVELOPER upon final acceptance
of the project. DEVELOPER may secure services of a certified professional engineer for inspection; in such cases, inspection procedures and schedule must be approved by the Office of the Washtenaw County Water Resources Commissioner.

iii. Contingency $ _____
10% of project cost.

iv. Permanent Maintenance Fund $ _____

Total Cost: $ _____

4. The DEVELOPER shall forthwith deposit said Balance Due with the DISTRICT, to be used only for the purposes herein set forth and agreed upon.

5. The DEVELOPER shall provide the COMMISSIONER and/or the DISTRICT with a Letter of Credit, or cash in the sum of 100% of the construction cost of the DRAIN, to remain in effect until construction acceptance of the project by the DISTRICT.

6. It is agreed that the DEVELOPER shall convey to the DISTRICT the final plat or condominium documents, description of the drainage district and such easement and Rights-of-Way as may be necessary to accomplish the purposes herein set forth, and legal description (referenced to a Public Land Survey System (PLSS) corner) of route and course of drain, and do so without charge therefore.

7. The DEVELOPER further agrees to provide, without charge, one (1) set of reproducible mylar (D-size; 24"x 36") and one (1) portable document format (pdf) "Record Drawings" of the drain as built, which shall include design calculations showing flow rates, imperviousness factors, drainage district and sub-districts and any other data needed by the DISTRICT for proper drain operation.

8. The DEVELOPER further agrees to provide to the DISTRICT, without charge, one (1) copy of the Master Deed Agreement, as recorded with the Washtenaw County Clerk/Register of Deeds for condominium developments.

9. The DEVELOPER further agrees to provide to the DISTRICT, without charge, one (1) copy of a video assessment of the as-built stormwater pipe network using a conditional assessment program as approved by the WCWRC prior to final acceptance of the project by the DISTRICT.

10. The foregoing payment of the cost of the project is agreed and understood as being for the sole benefit of the PROJECT_NAME DRAIN DRAINAGE DISTRICT at large or part thereof, and that such payment shall not relieve the subject property from any future assessments levied pursuant to the Michigan Drain Code of 1956, as amended, for construction, improvements and/or maintenance of the DRAIN arising by virtue of proper and legal petitions and hearings and procedures thereon.

11. It is agreed that the maintenance of these drainage facilities shall be consistent with the COMMISSIONER'S normal standards and requirements. This maintenance does not include such items as lawn cutting, litter pick-up, etc.

12. This Agreement shall become effective upon its execution by the DEVELOPER and by the DISTRICT and shall be binding upon the successors and assigns of each party.

IN WITNESS WHEREOF the parties hereto have caused this agreement to be executed by their duly authorized officers as of the day and year first above written.

PROJECT_NAME DRAIN DRAINAGE DISTRICT,
County of Washtenaw, State of Michigan, acting as Its governing body, the Washtenaw County Water Resources Commissioner

_____
By: Evan N. Pratt
Washtenaw County Water Resources Commissioner

OWNER_DEVELOPER

By:_____
(Print Here)

Its: _____

Drafted by: Deborah L. Shad
Office of the Water Resources Commissioner
P.O. Box 8645
Ann Arbor MI 48107-8645

When recorded, please return to:
Office of the Water Resources Commissioner
P.O. Box 8645
Ann Arbor MI 48107-8645

Section VIII: Appendix

ACKNOWLEDGMENT

STATE OF MICHIGAN)
)
COUNTY OF WASHTENAW)

On this _____ day of _____ 20__ before me, a Notary Public in and for said County, appeared EVAN N. PRATT, Washtenaw County Water Resources Commissioner, to me personally known to be the person described in and who executed the foregoing instrument and acknowledged the same to be her free act and deed.

_____
Ronald E. Mann, Notary Public
Washtenaw County, Michigan

Acting in: Washtenaw County
My Commission Expires: _____

ACKNOWLEDGMENT

STATE OF MICHIGAN)
)
COUNTY OF WASHTENAW)

On this _____ day of _____ 20___ before me, a Notary Public in and for said County, appeared _____, to me personally known, who being duly sworn did say that s/he is the _____ of _____, and that said instrument was signed in behalf of said _____ by authority of its Board of Directors and the said Board acknowledged said instrument to be the free act and deed of said signatory.

_____, Notary Public

_____County, Michigan

Acting in: _____

My Commission Expires _____.

Section VIII: Appendix

ATTACHMENT A.

DRAINAGE DISTRICT APPLICANT INFORMATION SHEET

The following are the sole owners of the following lands:

Tax Code Number/Parcel Number

Located in Section TOWNSHIP_SECTION, County of Washtenaw, State of Michigan which encompasses the lands in the proposed PROJECT_NAME DRAIN DRAINAGE DISTRICT.

Following are the names and addresses of all persons who are required to sign the final plat or master deed agreement as proprietors:

OWNER_DEVELOPER
Address

Part K.

MAINTENANCE PLAN & BUDGET

SAMPLE MAINTENANCE PLAN & BUDGET

"XYZ" Leasing Company
Stormwater Management System Maintenance Plan

1. Responsibility for Maintenance

- **a.** During construction, it is the developer's responsibility to perform the maintenance.
- **b.** Following construction, it will be the responsibility of "XYZ" Company to perform the maintenance.
- **c.** The Master Deed will specify that routine maintenance of the stormwater facilities must be completed within ___ _____days of receipt of written notification that action is required, unless other acceptable arrangements are made with the (Township of_____), (Washtenaw County Commissioner) or successors. Emergency maintenance (i.e. when there is endangerment to public health, safety or welfare) shall be performed immediately upon receipt of written notice. Should "XYZ" Company fail to act within these time frames, the (Township) (County) or successors may perform the needed maintenance and assess the costs against "XYZ" Company.

2. Source of Financing

"XYZ" Company is required to pay for all maintenance activities on a continuing basis.

3. Maintenance Tasks and Schedule

- **a.** See the charts on the next two pages: The first describes maintenance tasks during construction to be performed by the developer, the second describes maintenance tasks by "XYZ" Company.

- **b.** Immediately following construction, the developer will have the stormwater management system inspected by an engineer to verify grades of the detention and filtration areas and make recommendations for any necessary sediment.

Refer to the ***Low Impact Development Manual for Michigan*** for maintenance task checklists for permanent BMPs and create a table of applicable maintenance tasks and schedules for the project.

The BMP maintenance checklists in the LID Manual include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

MAINTENANCE TASKS AND SCHEDULE DURING CONSTRUCTION

	COMPONENTS										
TASKS	Storm Sewer System	Catch Basin Sumps	Catch Basin Inlet Casings	Ditches and Swales	Outflow Control Structure	Rip-Rap	Filtration Basins	Storm Detention Areas	Wetlands	Emergency Overflow	SCHEDULE
Inspect for sediment accumulation	X	X		X	X		X	X			Weekly
Removal of sediment accumulation	X	X		X	X		X	X			As needed* & prior to turnover
Inspect for floatables and debris			X	X	X		X	X			Quarterly
Cleaning of floatables and debris			X	X	X		X	X			Quarterly & at turnover
Inspection for erosion				X	X		X	X			Weekly
Re-establish permanent vegetation on eroded slopes				X			X	X			As needed & at turnover
Replacement of Stone					X						As needed* & prior to turnover
Mowing			X	X	X	X	X	X			0 to 2 times per year
Inspect Stormwater system components during wet weather and compare to as-built plans (by professional engineer reporting to XYZ Co.)				X	X		X	X			Annually and at turnover
Make adjustments or replacements as determined by annual wet weather inspection	X	X	X	X	X	X	X	X	X	X	As needed

*as needed means when sediment has accumulated to a maximum of one foot depth

PERMANENT MAINTENANCE TASKS AND SCHEDULE

	COMPONENTS								
TASKS	Catch Basin Inlet Casings	Ditches and Swales	Outflow Control Structure	Rip-Rap	Filtration Basins	Storm Detention Areas	Wetlands	Emergency Overflow	SCHEDULE
Inspect for sediment accumulation		X	X		X	X			Annually
Removal of sediment accumulation		X	X		X	X			Every 2 years as needed
Inspect for floatables and debris	X	X	X		X	X			Annually
Cleaning of floatables and debris	X	X	X		X	X			Annually
Inspection for erosion		X	X		X	X			Annually
Re-establish permanent vegetation on eroded slopes		X			X	X			As Needed
Replacement of Stone			X						Every 3-5 years as needed
Clean Streets									Semi-Annually
Mowing		X			X	X			0-2 times per year
Inspect Stormwater system components during wet weather and compare to as-built plans (by professional engineer reporting to XYZ Co.)	X	X	X	X	X	X	X	X	Annually
Make adjustments or replacements as determined by annual wet weather inspection	X	X	X	X	X	X	X	X	As needed
Keep records of all inspections and maintenance activities and report to XYZ Co.									Annually
Keep records of all costs for inspections, maintenance and repairs. Report to XYZ Co.									Annually

Section VIII: Appendix

TASKS	COST
Annual inspection for sediment accumulation	$100.00
Removal of sediment accumulation every 2 years as needed	$500.00
Inspect for floatables and debris annually and after major storms	$100.00
Removal of floatables and debris annually and after major storms	$150.00
Inspect system for erosion annually and after major storms	$100.00
Re-establish permanent vegetation on eroded slopes as needed	$350.00
Replacement of stone	$100.00
Mowing 0-2 times per year	$400.00
Inspect structural elements during wet weather and compare to as-built plans every 2 years	$150.00
Make structural adjustments or replacements as determined by inspection as needed	$400.00
Have professional engineer carry out emergency inspections upon identification of severe problems	$200.00
A. Total Annual Budget	**$2,550.00**

Note: Maintenance Plans and budgets vary widely due to the size and unique characteristics of each stormwater management system proposed. Appendix K is intended for use as a starting point in the development of an appropriate maintenance plan specific to the size and components of each system.

Part L.

ENGINEER'S CERTIFICATE OF OUTLET

Date: _____

Development Name: _____

City, Village or Township of _____ Section _____

Washtenaw County, Michigan

I hereby certify that the existing drain is the only reasonably achievable stormwater outlet for the proposed stormwater management system and that the existing drain has sufficient capacity to serve as an adequate outlet for the proposed system, without detriment to or diminution of the drainage serve that the existing outlet presently provides.

Signed: _____
Registered Professional Engineer

NOTE: The engineer's certificate must be stamped with the engineer's seal.
The certificate submitted must be the original.
The engineer's certificate should be accompanied by supporting calculations and documentation.

Section VIII: Appendix

Part M.

RAIN GARDEN PLANT LIST

Refer to the Low Impact Development Manual for Michigan, Appendix C - for extensive plant information.

PERENNIALS							
Scientific Name	Common Name	Bloom Color	Height	Bloom Time	Native?	Sun/Shade	Moisture
Actaea rubra	Red Baneberry	White	12-36"	May	N	Sh	M, Ms
Adiantum pedatum	Maidenhair Fern	n/a	12"	n/a	N	P, Sh	M, Ms
Allium cernuum	Nodding Wild Onion	Lt. Lavender	12"	Sept-Oct	N	Sn, P	D, M, Ms
Anemone canadensis	Canada Anemone	White	12"-20"	May-July	N	Sn, P, Sh	M, Ms
Anthyrium filex-femina	Lady Fern	n/a	24"-36"	n/a	N	Sn, P	M, Ms
Aquligea canadensis	Columbine	Red/Yellow	12-36"	May	N	P, Sh	D, M, Ms
Asarum canadense	Wild Ginger	Maroon	8"	May	N	P, Sh	M, Ms
Asclepias incarnata	Swamp Milkweed	Pink/Purple	3-4'	July	N	P, Sh	M, Ms, W
Aster dumosis 'Woods Light Blue'	Woods Blue Aster	Lavender	1-2'	Aug-Oct	C	Sn, P	D, M, Ms
Aster laevis	Smooth Aster	Lt. Blue/Lavender	4-5'	Sept-Oct	N	Sn, P	D, M, Ms
Aster novae-angliae	New England Aster	Deep Purple	4-5'	Sept-Oct	N	Sn, P	D, M, Ms
Baptisia australis	Baptisia or False Indigo	Blue	3-4'	June	N	Sn	D, M, Ms
Carex grayii	Gray's Sedge	n/a	18"	May/June	N	P, Sh	M, Ms
Carex hystericina	Porcupine Sedge	n/a	2-3'	June-Oct.	N	Sn, P	Ms, W
Carex muskingumensis	Palm Sedge	n/a	2-3'	June-Oct.	N	Sn, P, Sh	M, Ms, W
Carex sprengelii	Sprengel's Sedge	n/a	18"	May/June	N	P, Sh	D, M, Ms
Carex stipata	Common Fox Sedge	Green	24"	May	N	Sn, P, Sh	D, M, Ms
Carex vulpinoidea	Brown Fox Sedge	n/a	2-3'	June-Oct.	N	Sn, P, Sh	D, M, Ms, W
Caulophyllum thalictroides	Blue Cohosh	Green	24"	April	N	Sh	Ms
Chelone lyonii 'Hot Lips'	Hot Lips Turtlehead	Pink	2-3'	Aug-Sept	C	Sn, P	D, M, Ms
Echinacea purpurea	Purple Coneflower	Pink/Lavender	3'-3.5'	July-Aug	N	Sn, P	D, M, Ms
Eryngium yuccifolium	Rattlesnake Master	White/Lt. Green	3'	July-Sept.	N	Sn	D, M, Ms
Eupatorium maculatum	Joe Pye Weed	Dusky Pink	5-6'	July-Aug	N	Sn, P	D, M, Ms
Eupatorium rugosum	White Snakeroot	White	2'-4'	July-Sep	N	P, Sh	M
Fragaria virginiana	Wild Strawberry	White	6-12"	May-June	N	Sn, P, Sh	D, M, Ms
Geranium maculatum	Wild Geranium	Lavender	12"-24"	May-June	N	Sn, P, Sh	D, M, Ms
Helianthus divaricatus	Woodland Sunflower	Yellow	3'-5'	Jul-Aug	N	Sn, P	D, M, Ms
Helianthus grosseserratus	Sawtooth Sunflower	Yellow	5'-8'	Aug-Oct	N	Sn	D, M, Ms

Native Plant: N = Native plant, as defined by Michigan Flora, which can be obtained from members of the Michigan Native Plant Producers Association: www.mnppa.org
C = Cultivar of a native

Sun/Shade: Sn = Sun P = Part Sun Sh = Shade

Moisture: D = Dry M = Medium Ms = Moist W=Wet

PERENNIALS (CONT'D)							
Scientific Name	Common Name	Bloom Color	Height	Bloom Time	Native?	Sun/Shade	Moisture
Hibiscus moscheutos	Rose Mallow	Pink	4'-6'	Aug-Sept	N	Sn	M, Ms, W
Hydrophyllum virginianum	Virginia Waterleaf	Lavender	1-1.5'	May-June	N	Sh	M, Ms, W
Iris virginica	Blue Flag Iris	Lt. Blue/Lavender	2-3'	May-June	N	Sn, P, Sh	M, Ms, W
Liatris spicata	Blazing Star	Pink/Purple	3-5'	July	N	Sn, P	M, Ms
Liatris spicata 'Kobold'	Kobold Blazing Star	Pink/Purple	2'	July	C	Sn, P	M, Ms
Lobelia cardinalis	Cardinal Flower	red	3'	July-Aug	N	P, Sh	M, Ms
Lobelia siphilitica	Blue Lobelia	blue purple	30"	July-Sept	N	Sn, P, Sh	M, Ms
Matteuccia struthiopteris	Ostrich Fern	n/a	36"	n/a	N	P, Sh	M, Ms
Monarda punctata	Horsemint	White-Pink	18-30"	July-Aug	N	Sn, P	D, M, Ms
Onoclea sensibilis	Sensitive Fern	n/a	12-24"	n/a	N	Sn, P, Sh	M, Ms, W
Osmunda claytoniana	Interrupted Fern	n/a	12-24"	n/a	N	P, Sh	M, Ms, W
Panicum virgatum	Switch Grass	n/a	4-6'	Aug.-Sept.	N	Sn	D, M, Ms, W
Penstemon digitalis	White Beardtongue	White	3-4'	June	N	Sn, P	D,M,Ms
Phlox divaricata	Woodland Phlox	Blue	.5-1'	April-June	N	P, Sh	M, Ms
Physostegia virginiana	Obedient Plant	Pink	2-3'	Sept-Oct	N	Sn, P	D, M, Ms
Potentilla simplex	Common cinquefoil	Yellow	6-12"	May-June	N	Sn, P	D, M
Ranunculus hispidus	Swamp Buttercup	Yellow	1'	May	N	Sn, P	M, Ms, W
Ratibida pinnata	Yellow Coneflower	Yellow	4-6'	July-Oct.	N	Sn	D, M, Ms
Rudbeckia hirta	Black-eyed Susan	Yellow	1-3'	July-Oct	N	Sn, P	D, M, Ms
Silphium laciniatum	Compass Plant	Yellow	4-7'	July-Aug.	N	Sn	D, M, Ms, W
Silphium terebinthinaceum	Prairie Dock	Yellow	8'	Aug.	N	Sn	D, M, Ms
Smilacena stellata	Starry-false Solomon's Seal						
Solidago flexicaulis	Zig Zag Goldenrod	Yellow	2-3'	Aug.-Oct.	N	P, Sh	D, M, Ms
Solidago riddellii	Riddell's Goldenrod	Yellow	3-4'	Aug	N	Sn	Ms, W
Solidago rigida	Rigid Goldenrod	Yellow	3-4'	July	N	P, Sh	D, M, Ms, W
Sporobolus heterolepis	Prairie Dropseed	n/a	2'	Aug.-Sept.	N	Sn	D, M, Ms
Stylophorum diphyllum	Wood Poppy	Yellow	1-2'	April-June	N	P, Sh	M, Ms
Thalictrum dioicum	Early Meadow Rue	Pale Green	1.5-2'	April-May	N	P, Sh	M, Ms
Verbena hastata	Blue Vervain	Purple	4-6'	June-August	N	Sn	D, M, Ms
Veronicastrum virginicum	Culver's Root	White	4-6'	July-August	N	Sn, P, Sh	D, M, Ms

Native Plant: N = Native plant, as defined by Michigan Flora, which can be obtained from members of the Michigan Native Plant Producers Association: www.mnppa.org
C = Cultivar of a native

Sun/Shade: Sn = Sun P = Part Sun Sh = Shade

Moisture: D = Dry M = Medium Ms = Moist W=Wet

Section VIII: Appendix

SHRUBS AND TREES							
Scientific Name	Common Name	Bloom Color	Height	Bloom Time	Native?	Sun/Shade	Moisture
Cercis canadensis	Red Bud	Pink	25'	May	N	Sn, P, Sh	D, M, Ms
Cornus sericea	Red-twig Dogwood	White	5-8'	May-June	N	Sn, P	D, M, Ms, W
Ilex verticillata	Winterberry-Male	White	4-6'	June-July	C	Sn	M, Ms, W
Itea virginica	Sweetspire	White	4'	May-June	C	Sn, P, Sh	M, Ms
Nyssa sylvatica	Blackgum	White	30'-60'	May-June	N	Sn, P	D, M, Ms, W
Potentilla fruiticosa	Potentilla	Yellow	3-4'	June-July	C	Sn	D, M, Ms
Sambucus candensis	Elderberry	White	5-10'	June-July	N	Sn, P	D, M, Ms, W
Viburnum dentatum	Arrowwood Viburnum	White	3-4'	May-June	C	Sn, P	D, M, Ms, W
Viburnum lentago	Nannyberry	White	5-7'	June	N	Sn, P	M, Ms, W

Native Plant: N = Native plant, as defined by Michigan Flora, which can be obtained from members of the Michigan Native Plant Producers Association: www.mnppa.org
C = Cultivar of a native

Sun/Shade: Sn = Sun P = Part Sun Sh = Shade

Moisture: D = Dry M = Medium Ms = Moist W=Wet

Section VIII: Appendix

PLANTS FOR BIO-RETENTION AREAS ONLY (NOT SUITABLE FOR RESIDENTIAL-SCALE RAIN GARDENS)							
Scientific Name	Common Name	Bloom Color	Height	Bloom Time	Native?	Sun/Shade	Moisture
Aesclepias syriaca	Common Milkweed	Pink	3'-4'	Jun-Aug	N	Sn	D, M, Ms
Andropogon gerardii	Big Bluestem	Green	5'-7'	Jul-Aug	N	Sn	D, M, Ms, W
Euaptirum perfoliatum	Boneset	White	3'-5'	Jul-Sep	N	Sn, P	M, Ms, W
Helianthus giganteus	Tall Sunflower	Yellow	5'-8'	Aug-Oct	N	Sn, P	M, Ms, W
Monarda fistulosa	Bee-balm	Lavender	2'-4'	Jul-Aug	N	Sn	D, M, Ms
Ratibita pinnata	Yellow Coneflower	Yellow	3'-5'	Jul-Sep	N	Sn	M, Ms
Solidago caesia	Blue-stemmed goldenrod	Yellow	2'-3'	Aug-Oct	N	Sn, P, Sh	D, M
Tradescantia ohiensis	Spiderwort	Blue	2'-3'	May-Jul	N	Sn, P	D, M, Ms
Vernonia missurica	Ironweed	Purple	4'-6'	Aug-Sep	N	Sn, P	M, Ms, W

Native Plant: N = Native plant, as defined by Michigan Flora, which can be obtained from members of the Michigan Native Plant Producers Association: www.mnppa.org
C = Cultivar of a native

Sun/Shade: Sn = Sun P = Part Sun Sh = Shade

Moisture: D = Dry M = Medium Ms = Moist W=Wet

Recommended annual seeds to be used as a cover crop are Wild Canada Rye, Seed Oats and Annual Rye

Section VIII: Appendix

Part N.

LEGAL OPINION REGARDING NEED FOR EASEMENTS DOWNSTREAM OF DRAINAGE DISTRICT OUTLETS

LAW OFFICES OF

HUBBARD, FOX, THOMAS, WHITE & BENGTSON, P.C.

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OF COUNSEL:
ALLISON K. THOMAS

Via Fax 734-994-2459 & US Mail

Ms. Janis A. Bobrin
Washtenaw County Drain Commissioner
Courthouse Annex Bldg.
P.O. Box 8645
Ann Arbor, MI 48107-8645

Dear Ms. Bobrin:

You have asked our opinion as to what a Drainage District should require under a 433 Agreement to protect the Drainage District from liability due to sheet flow from a development's drainage district.

As a general rule an upland owner has the right to natural drainage flow over and across the adjacent lower properties. Any instance where the natural surface-flow of water is increased or concentrated, and a neighboring property receives more surface water resulting from the change, the increase in flow constitutes a trespass. If there is an increase in water on neighboring lands, the Drainage District could be liable for damages under tie cause of action of trespass- nuisance. Therefore, to protect the Drainage District from future liability, flooding easements should be required for adjacent properties of a development when the development's drainage "sheet flows" onto neighboring properties.

HUBBARD LAW FIRM

Please note that Section 433 of the Drain Code envisions the requirement of securing an adequate outlet. Subsection (7) of Section 433 states that a registered engineer must certify that the outlet for the existing drain is the only reasonable available outlet for the drain and that there is sufficient capacity in the existing outlet for the proposed drain to serve as an adequate outlet without detriment or diminution of the drainage service which the outlet presently provides.

Should you have any questions relative to these issues, please do not hesitate to contact Geoff Seidlein or myself.

Sincerely,

HUBBARD, FOX, THOMAS,
WHITE & BENGTSON, P.C.

Stacy L. Hissong

Section VIII: Appendix

Part O.
ORDER OF ADOPTION OF RULES

ORDER OF ADOPTION OF RULES

WHEREAS, Section 105c of Act 288 of the Public Acts of Michigan of 1967 as amended provides for the promulgation and publication of rules by the Water Resources Commissioner (formerly the Drain Commissioner) to govern stormwater drainage facilities of new subdivisions, and

WHEREAS, the Washtenaw County Water Resources Commissioner conducted a review of previously adopted rules (2000 as amended), and

WHEREAS, pursuant to this review, changes and modifications were proposed and reviewed, and

WHEREAS, comments were received and carefully considered from technical peers, municipalities, the public and the Michigan Department of Environmental Quality (MDEQ)..

NOW, THEREFORE, IT IS HEREBY ORDERED, that the Washtenaw County Water Resources Commissioner's "Rules and Guidelines – Procedures & Design Criteria for Stormwater Management Systems", pursuant to Section 105(c) of Act 288 of the Public Acts of Michigan of 1967, as Amended, dated August 6, 2014, shall be adopted on that date and shall be followed in the processing of all subdivision plats and other developments that come under the jurisdiction of the Washtenaw County Water Resources Commissioner, including site condominiums, developments on lands discharging directly to County Drains, and other developments per local governments' ordinances.

IT IS FURTHER ORDERED, that this order be published in a newspaper of general circulation in the County of Washtenaw prior to the effective date of the rules.

IT IS FURTHER ORDERED, that the Rules be published in a booklet form and be made available to all interested parties for the cost of reproduction from the Office of the Water Resources Commissioner.

Evan N. Pratt
Washtenaw County
Water Resources Commissioner
705 N. Zeeb Road
PO Box 8645
Ann Arbor, MI 48107
734/222-6860

Dated this 17th day of July, 2014.

ORDER OF ADOPTION OF RULES

WHEREAS, Section 105c of Act 288 of the Public Acts of Michigan of 1967 as amended provides for the promulgation and publication of rules by the Water Resources Commissioner to govern stormwater drainage facilities of new subdivisions, and

WHEREAS, the Washtenaw County Water Resources Commissioner conducted a review of previously adopted rules (August 6, 2014, as amended), and

WHEREAS, pursuant to this review, changes, clarifications and modifications were proposed and reviewed,

NOW, THEREFORE, IT IS HEREBY ORDERED, that the Washtenaw County Water Resources Commissioner's "Rules and Guidelines – Procedures & Design Criteria for Stormwater Management Systems", issued August 6, 2014 pursuant to Section 105(c) of Act 288 of the Public Acts of Michigan of 1967, as Amended October 17, 2016, shall be adopted on that date and shall be followed in the processing of all subdivision plats and other developments that come under the jurisdiction of the Washtenaw County Water Resources Commissioner, including site condominiums, developments on lands discharging directly to County Drains, and other developments per local governments' ordinances.

IT IS FURTHER ORDERED, that this order be published in a newspaper of general circulation in the County of Washtenaw prior to the effective date of the rules.

IT IS FURTHER ORDERED, that the Rules be published in a booklet form and be made available to all interested parties for the cost of reproduction from the Office of the Water Resources Commissioner.

Evan Pratt
Washtenaw County
Water Resources Commissioner
705 N. Zeeb Road
PO Box 8645
Ann Arbor, MI 48107-8645
734/222-6860

Dated this 27th day of September, 2016.
Published October 2, 2016

Section VIII: Appendix

Part P.

OUTLET DESIGN EXAMPLES

3-STAGE OUTLET

This example is also applicable when a portion of the first flush storm is infiltrated.

Area = 80,128 sf or 1.84 ac
First flush volume: 3,842 cf
Bankfull volume: 8,286 cf
100-year detention volume: 20,106 cf
(should include additional 20% volume if required infiltration is not provided)

Storage Provided

ELEVATION	AREA (SF)	DEPTH (FT)	VOLUME (CF)	TOTAL VOLUME (CF)
813.0	13,524	1	12,834	43,962
812.0	12,144	1	11,490	31,128
811.0	10,836	1	10,218	19,638
810.0	9,600	1	5,952	9,420
809.0	2,304	1	2,010	3,468
808.0	1,716	1	1,458	1,458
807.0*	1,200	0	0	0

* x_{bot}

Storage Elevations

First Flush $\frac{810.0-809.0}{9{,}420-3{,}468} = \frac{x_{ff}-809.0}{3{,}842-3{,}468}$ x_{ff} = 809.06

Bankfull $\frac{810.0-809.0}{9{,}420-3{,}468} = \frac{x_{bf}-809.0}{8{,}286-3{,}468}$ x_{bf} = 809.81

100-year $\frac{812.0-811.0}{31{,}128-19{,}638} = \frac{x_{100}-811.0}{20{,}106-19{,}638}$ x_{100} = 811.04

The allowable release rate is 0.15 cfs/acre

$$Q_{allow} = \left(0.15\frac{cfs}{acre}\right)(A)$$

$$Q_{allow} = \left(0.15\frac{cfs}{acre}\right)(1.84\ acres)$$

$$Q_{allow} = 0.276\ cfs$$

3 STAGE OUTLET DESIGN EXAMPLE

FIRST FLUSH DISCHARGE

The first flush storm must be released in a minimum of 24 hours.

$$Q_{ff}^{min} = \frac{V}{T_{24}}$$

$$Q_{ff}^{min} = \frac{3{,}842}{(24hr)\left(\frac{3{,}600\ sec}{1\ hr}\right)}$$

$$Q_{ff}^{min} = 0.0445\ cfs$$

A. To determine the appropriate size orifice to release the first flush volume, an average head value is used in the orifice equation.

$$h_{ave} = \frac{2}{3}(x_{ff} - x_{bot})$$

$$h_{ave} = \frac{2}{3}(809.06 - 807.00)$$

$$h_{ave} = 1.37\ ft$$

$$A_{ff} = \frac{Q_{ff}}{0.62\sqrt{2gh_{ave}}}$$

$$A_{ff} = \frac{0.0445\ cfs}{0.62\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(1.37\ ft)}}$$

$$A_{ff} = 0.0076\ ft$$

If the basin can be modelled as trapezoidal in shape, 2/3 of the total head is an acceptable approximation for the average head.

B. The number and size of orifices to meet the area requirements is variable, so many acceptable solutions are possible. In general, larger holes are preferable if multiple orifices can be used (to reduce incidences of clogging). For this example we chose a 1.00" diameter orifice (area = 0.0055 sf).

$$Maximum\ \#_{orif} = \frac{A_{ff}\ sf}{A_{orif}\ sf}$$

$$Maximum\ \#_{orif} = \frac{0.0076\ sf}{0.0055\ sf}$$

$$Maximum\ \#_{orif} = 1.40$$

C. The number of orifices used in the outlet design should be equal to or less than the calculated maximum number of orifices and may depend on allowable release rate and detention time conditions being met, so in this example we use one – 1.00" diameter orifice at elevation 807.00' (x_{bot}).

$$Q_{ff}^{act} = (0.62)(\#_{orif})(A_{orif}^{act})\sqrt{2gh_{ave}}$$

$$Q_{ff}^{act} = (0.62)(1)(0.0055\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(1.37\ ft)}$$

$$Q_{ff}^{act} = 0.0318\ cfs$$

$$T_{ff}^{act} = \frac{V_{ff}}{Q_{ff}^{act}}$$

$$T_{ff}^{act} = \frac{3{,}842\ cf}{(0.0318\ cfs)\left(\frac{3{,}600\ sec}{1\ hr}\right)}$$

$$T_{ff}^{act} = 33.6\ hr$$

The actual detention time for one – 1.00" diameter orifice: Since T_{ff}^{act} is greater than 24 hours, the size and number of orifices meets the detention time criteria.

3 STAGE OUTLET DESIGN EXAMPLE

BANKFULL DISCHARGE

A. The bankfull storm must be detained between 36 and 48 hours. The first flush orifices should be checked to see if they are adequate or if additional orifices are necessary.

$$h_{ave} = \frac{2}{3}(x_{bf} - x_{bot})$$

$$h_{ave} = \frac{2}{3}(809.81 - 807.00)$$

$$h_{ave} = 1.87ft$$

$$Q_{bf} = (0.62)(\#_{orif})(A_{orif}^{act})\sqrt{2gh_{ave}}$$

$$Q_{bf} = (0.62)(1)(0.0055\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(1.87\ ft)}$$

$$Q_{bf} = 0.037\ cfs$$

$$T_{bf} = \frac{V_{bf}}{Q_{bf}}$$

$$T_{bf} = \frac{8{,}286\ cf}{(0.037\ cfs)\left(\frac{3{,}600\ sec}{1\ hr}\right)}$$

$$T_{bf} = 62.0\ hr$$

B. Because the holding time exceeds the maximum allowable 48 hours, additional orifices are required. The release rate is approximated by considering two circumstances; the release rate when both the first flush and bank full orifices are contributing and the release rate when the water elevation is below the bank full orifice (which is set at the first flush elevation). Since the time for the first flush volume to release was calculated at 33.3 hours, the remaining volume (bank full volume – first flush volume) must be released so the total detention time falls between 36 and 48 hours. A target time of 44 hours was chosen in this case.

$$V_{rem} = V_{bf} - V_{ff}$$

$$V_{rem} = 8{,}286\ cf - 3{,}842\ cf$$

$$V_{rem} = 4{,}444\ cf$$

$$T_{rem} = T_{target} - T_{ff}^{act}$$

$$T_{rem} = 44.0\ hr - 33.6\ hr$$

$$T_{rem} = 10.4\ hr$$

C. The volume release by one – 1.00” diameter orifice in 10.4 hours should be calculated

$$h_{ave}^{ff} = \frac{2}{3}(x_{bf} - x_{ff}) + (x_{ff} - x_{bot})$$

$$h_{ave}^{ff} = \frac{2}{3}(809.81 - 809.06) + (809.06 - 807.00)$$

$$h_{ave}^{ff} = 2.56\ ft$$

Q_{ff+bf} will be defined as the discharge through the first flush orifices when both the first flush and bank full holes are contributing.

$$Q_{ff+bf} = (0.62)(\#_{orif})(A_{orif}^{act})\sqrt{2gh_{ave}^{ff}}$$

$$Q_{ff+bf} = 0.62(1)(0.0055\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(2.56\ ft)}$$

$$Q_{ff+bf} = 0.044\ cfs$$

$$V_{ff+bf} = (T_{rem})Q_{ff+bf}$$

$$V_{ff+bf} = 10.4\ hr(0.044\ cfs)\left(\frac{3{,}600\ \text{sec}}{1\ hr}\right)$$

$$V_{ff+bf} = 1{,}632\ cf$$

3 STAGE OUTLET DESIGN EXAMPLE

BANKFULL DISCHARGE

D. The leftover volume will be released by the bankfull orifice(s). Vbf will be defined as the amount of water to be discharged by the bank full orifices in 10.4 hours.

$$V_{bf} = V_{rem} - V_{ff+bf}$$

$$V_{bf} = 4{,}444\ cf - 1{,}632\ cf$$

$$V_{bf} = 2{,}812\ cf$$

$$Q_{bf} = \frac{V_{bf}}{T_{rem}}$$

$$Q_{bf} = \frac{2{,}812}{(10.4\ hr)\left(\frac{3{,}600\ sec}{1\ hr}\right)}$$

$$Q_{bf} = 0.075\ cfs$$

$$h_{ave}^{bf} = \frac{2}{3}\left(x_{bf} - x_{ff}\right)$$

$$h_{ave}^{bf} = \frac{2}{3}(809.81\ ft - 809.06\ ft)$$

$$h_{ave}^{bf} = 0.50\ ft$$

$$A_{bf} = \frac{Q_{bf}}{0.62\sqrt{2gh_{ave}^{bf}}}$$

$$A_{bf} = \frac{0.075\ cfs}{0.62\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(0.50\ ft)}}$$

$$A_{bf} = 0.0213\ sf$$

A 1.75” diameter orifice has an area of 0.0167 sf

$$Maximum\ \#_{orif} = \frac{A_{bf}\ sf}{A_{orif}\ sf}$$

$$Maximum\ \#_{orif} = \frac{0.0213\ sf}{0.0167\ sf}$$

$$Maximum\ \#_{orif} = 1.27$$

E. The number of orifices used in the outlet design should be equal to or less than the calculated maximum number of orifices and may depend on allowable release rate and detention time conditions being met. In this example we use one – 1.75” diameter orifice at elevation 809.06’ (x_{ff}). The actual detention time for one – 1.75” diameter orifice:

$$Q_{bf}^{act} = (0.62)(\#_{orif})(A_{orif}^{act})\sqrt{2gh_{ave}^{bf}}$$

$$Q_{bf}^{act} = (0.62)(1)(0.0167\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(0.50\ ft)}$$

$$Q_{bf}^{act} = 0.059\ cfs$$

$$T_{bf}^{act} = T_{ff}^{act} + \frac{V_{rem}}{(Q_{ff+bf} + Q_{bf}^{act})\left(\frac{3{,}600\ sec}{1\ hr}\right)}$$

$$T_{bf}^{act} = 33.6\ hr + \frac{4{,}444\ cf}{(0.059\ cfs + 0.044\ cfs)\left(\frac{3{,}600\ sec}{1\ hr}\right)}$$

$$T_{bf}^{act} = 45.6\ hr$$

Since T_{bf}^{act} is greater than 36 hours but less than 48 hours, the size and number of orifices meets the detention time criteria.

3 STAGE OUTLET DESIGN EXAMPLE

100 YEAR STORM (1% STORM)

Q_{allow}=0.276 cfs

A. Q_{allow} is a peak, or maximum, flow rate. Calculate the maximum flow passing through the first flush and bank full orifices using the total head, and subtract Qallow to determine the orifice size to release the 100-year storm volume.

$$Q_{ff} + Q_{bf} = 0.62(\#_{orif}^{ff})(A_{orif}^{ff})\sqrt{2g(x_{100} - x_{bot})} + 0.62(\#_{orif}^{bf})(A_{orif}^{bf})\sqrt{2g(x_{100} - x_{ff})}$$

$$Q_{ff} + Q_{bf} = 0.62(1)(0.0055\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(811.04 - 807.00)} + 0.62(1)(0.0167\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(811.04 - 809.06)}$$

$$Q_{ff} + Q_{bf} = 0.055\ cfs + 0.117\ cfs = 0.172\ cfs$$

$$Q_{100}^{max} = Q_{allow} - (Q_{ff} + Q_{bf})$$

$$Q_{100}^{max} = 0.276\ cfs - 0.172\ cfs$$

$$Q_{100}^{max} = 0.104\ cfs$$

$$A_{100}^{max} = \frac{Q_{100}^{max}}{0.62\sqrt{2g(x_{100} - x_{bf})}}$$

$$A_{100}^{max} = \frac{0.104\ cfs}{0.62\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(811.04 - 809.81)}}$$

$$A_{100}^{max} = 0.0189\ sf$$

The number and size of orifices to meet the area requirements is variable, so many solutions are possible. For this example we chose to use 1.75” diameter orifices (area = 0.0167 sf).

3 STAGE OUTLET DESIGN EXAMPLE

100 YEAR STORM (1% STORM)

$$Maximum\ \#_{orif} = \frac{A\ \ sf}{A_{orif}\ \ sf}$$

$$Maximum\ \#_{orif} = \frac{0.189\ sf}{0.0167\ sf}$$

$$Maximum\ \#_{orif} = 1.13$$

Therefore use one - 1.75" diameter orifice at elevation 809.81' (x_{bf}).

B. Check to confirm that the allowable flow rate has not been exceeded by the actual number of orifices selected.

$$Q_{ff} + Q_{bf} + \ 0.62\#_{orif} A_{100}\sqrt{2gh_{tot}^{100}} < \ Q_{allow}$$

$$0.055\ cfs + 0.117\ cfs + \ 0.62(1)(0.0167\ ft)\sqrt{2\left(32.2\ \frac{ft}{sec^2}\right)(811.04 - 809.81)} < \ 0.276$$

0.264 cfs < 0.276 cfs

C. The 100-year storm volume has to discharge in less than 72 hours. The time can be approximated by considering two circumstances; the time for the basin to discharge the 100-year volume down to the bankfull elevation (when all three sets of orifices are contributing) in addition to the time to discharge when the bankfull volume remains (which was already calculated at 45.3 hours).

Q_{all} will be defined as the discharge through the first flush orifices when the first flush, bankfull, and 100-year holes are contributing.

$$h_{ave}^{all} = \frac{2}{3}\left(x_{100} - x_{bf}\right) + \left(x_{bf} - x_{bot}\right)$$

$$h_{ave}^{bf} = \frac{2}{3}(811.04 - 809.81) + (809.81 - 807.00)$$

$$h_{ave}^{all} = 3.63\ ft$$

Section VIII: Appendix

3 STAGE OUTLET DESIGN EXAMPLE

100 YEAR STORM (1% STORM)

$$Q_{all} = (0.62)(\#_{orif}^{ff})(A_{orif}^{ff})\sqrt{2gh_{ave}^{all}}$$

$$Q_{all} = 0.62(1)(0.0055\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(3.63\ ft)}$$

$$Q_{all} = 0.052\ cfs$$

D. Q_{bf+100} will be defined as the discharge through the bankfull orifices when the first flush, bankfull, and 100-year holes are contributing.

$$h_{ave}^{bf} = \frac{2}{3}(x_{100} - x_{bf}) + (x_{bf} - x_{ff})$$

$$h_{ave}^{bf} = \frac{2}{3}(811.04 - 809.81) + (809.81 - 809.06)$$

$$h_{ave}^{bf} = 1.57\ ft$$

$$Q_{bf+100} = (0.62)(\#_{orif}^{bf})(A_{orif}^{bf})\sqrt{2gh_{ave}^{bf}}$$

$$Q_{bf+100} = 0.62(1)(0.0167\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(1.57\ ft)}$$

$$Q_{bf+100} = 0.104\ cfs$$

E. The average discharge through the 100-year storm orifice(s) when the other orifice(s) are contributing should be determined.

$$h_{ave}^{100} = \frac{2}{3}(x_{100} - x_{bf})$$

$$h_{ave}^{100} = \frac{2}{3}(811.04 - 809.81)$$

$$h_{ave}^{100} = 0.82ft$$

$$Q_{ave}^{100} = (0.62)(\#_{orif}^{100})(A_{orif}^{100})\sqrt{2gh_{ave}^{100}}$$

$$Q_{ave}^{100} = (0.62)(1)(0.0167)\sqrt{2(32.2)(0.82)}$$

$$Q_{ave}^{100} = 0.075\ cfs$$

F. Check to confirm that the 100-year storm volume is discharged in less than 72 hours.

$$V_{rem} = V_{100} - V_{bf}$$

$$V_{rem} = 20{,}106\ cf - 8{,}286\ cf$$

$$V_{rem} = 11{,}820\ cf$$

$$T_{100} = T_{bf} + \frac{V_{rem}}{Q_{all} + Q_{bf+100} + Q_{ave}^{100}}$$

$$T_{100} = 45.6\ hr + \frac{11{,}820}{(0.052cfs + 0.104\ cfs + 0.075\ cfs)\left(\frac{3600\ sec}{1\ hr}\right)}$$

$$T_{100} = 45.6\ hr + 14.2\ hr = 59.8\ hr$$

$T_{100} \leq 72$ hr

59.7 hr ≤ 72 hr

Therefore, the design meets both the time of detention and the flow rate requirements.

OUTLET DESIGN EXAMPLES

2-STAGE OUTLET

In instances where the on-site infiltration is provided, the volume infiltrated will be equal to or greater than the first flush volume. This eliminates the need for first flush orifices, and the outlet structure can use a two-stage orifice system to discharge the required detention volumes.

Area = 80,128 sf or 1.84 ac
First flush volume: 3,842 cf
Bankfull volume: 8,286 cf
On-site infiltration requirement: 6,581 cf
100-year detention volume : 10,173 cf

ELEVATION	AREA (SF)	DEPTH (FT)	VOLUME (CF)	TOTAL VOLUME (CF)
811.0	10,836	1	10,218	24,366
810.0	9,600	1	7,528	14,148
809.0	5,455	1	4,174	6,621
808.0	2,893	1	2,447	2,447
807.0*	2,000	0	0	0

* X_{bot}

Storage Elevations
The bankfull volume to be detained consists of the calculated bankfull volume minus the volume infiltrated

Bankfull detained =8,286 cf – 6,581 cf
Bankfull detained = 1,705 cf

Bankfull $\frac{808.0-807.0}{2,447-0} = \frac{x_{bf}-807.0}{1,705-0}$ $x_{bf} = 807.70$

100-year $\frac{810.0-809.0}{14,148-6,621} = \frac{x_{100}-809.0}{10,173-6,621}$ $x_{100} = 809.47$

The allowable release rate is 0.15 cfs/acre

$$Q_{allow} = \left(0.15\frac{cfs}{acre}\right)(A)$$

$$Q_{allow} = \left(0.15\frac{cfs}{acre}\right)(1.84\ acres)$$

$$Q_{allow} = 0.276\ cfs$$

Section VIII: Appendix

2 STAGE OUTLET DESIGN EXAMPLE

BANKFULL DISCHARGE

The bankfull storm must be detained between 24 and 36 hours on sites where the minimum required infiltration is achieved.

A. To determine the appropriate size orifice to release the bankfull detained volume, an average head value is used in the orifice equation. If the basin can be modelled as trapezoidal in shape, 2/3 of the total head is an acceptable approximation for the average head.

$$h_{ave} = \frac{2}{3}(x_{bf} - x_{bot})$$

$$h_{ave} = \frac{2}{3}(807.70 - 807.00)$$

$$h_{ave} = 0.47\ ft$$

$$A_{bf} = \frac{Q_{bf}}{0.62\sqrt{2gh_{ave}}}$$

$$Q_{bf} = \frac{V_{bf}}{T_{bf}}$$

$$Q_{bf} = \frac{1{,}705\ cf}{24\ hr(\frac{3{,}600\ sec}{hr})}$$

$$Q_{bf} = 0.01974\ cfs$$

$$A_{bf} = \frac{0.01974\ cfs}{0.62\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(0.47\ ft)}}$$

$$A_{bf} = 0.0058\ ft$$

B. The number and size of orifices to meet the area requirements is variable, so many acceptable solutions are possible. In general, larger holes are preferable if multiple orifices can be used (to reduce incidences of clogging). For this example we chose a 1.00" diameter orifice (area = 0.0055 sf).

$$Maximum\ \#_{orif} = \frac{A_{bf}\ sf}{A_{orif}\ sf}$$

$$Maximum\ \#_{orif} = \frac{0.0058\ sf}{0.0055\ sf}$$

$$Maximum\ \#_{orif} = 1.06$$

C. The number of orifices used in the outlet design should be equal to or less than the calculated maximum number of orifices and may depend on allowable release rate and detention time conditions being met, so in this example we use one – 1.00" diameter orifice at elevation 807.00' (x_{bot}).

The actual detention time for one – 1.00" diameter orifice:

$$Q_{bf}^{act} = (0.62)(\#_{orif})(A_{orif}^{act})\sqrt{2gh_{ave}}$$

$$Q_{bf}^{act} = (0.62)(1)(0.0055\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(0.47\ ft)}$$

$$Q_{bf}^{act} = 0.0188\ cfs$$

$$T_{bf}^{act} = \frac{V_{bf}}{Q_{bf}^{act}}$$

$$T_{bf}^{act} = \frac{1{,}705\ cf}{(0.0188\ cfs)\left(\frac{3{,}600\ sec}{1\ hr}\right)}$$

$$T_{bf}^{act} = 25.6\ hr$$

2 STAGE OUTLET DESIGN EXAMPLE

100 YEAR STORM (1%) STORM

$$Q_{allow} = 0.276\ cfs$$

D. Q_{allow} is a peak, or maximum, flow rate. Calculate the maximum flow passing through the bank full orifices using the total head, and subtract Q_{allow} to determine the orifice size to release the 100-year storm volume.

$$Q_{bf} = 0.62(\#_{orif}^{bf})(A_{orif}^{bf})\sqrt{2g(x_{100} - x_{bot})}$$

$$Q_{bf} = 0.62(1)(0.0055\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(809.47 - 807.00)}$$

$$Q_{bf} = 0.043\ cfs$$

$$Q_{100}^{max} = Q_{allow} - Q_{bf}$$

$$Q_{100}^{max} = 0.276\ cfs - 0.043\ cfs$$

$$Q_{100}^{max} = 0.233\ cfs$$

$$A_{100}^{max} = \frac{Q_{100}^{max}}{0.62\sqrt{2g(x_{100} - x_{bf})}}$$

$$A_{100}^{max} = \frac{0.233\ cfs}{0.62\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(809.47 - 807.70)}}$$

$$A_{100}^{max} = 0.0352\ sf$$

E. The number and size of orifices to meet the area requirements is variable, so many solutions are possible. For this example we chose to use 1.5” diameter orifices (area = 0.0123 sf).

Therefore use two – 1.5” diameter orifices at elevation 807.70’ (x_{bf}).

$$Maximum\ \#_{orif} = \frac{A\ sf}{A_{orif}\ sf}$$

$$Maximum\ \#_{orif} = \frac{0.0352\ sf}{0.0123\ sf}$$

$$Maximum\ \#_{orif} = 2.86$$

F. Check to confirm that the allowable flow rate has not been exceeded by the actual number of orifices selected.

$$Q_{bf} + 0.62(\#_{orif}^{100})(A_{orif}^{100})\sqrt{2gh_{tot}^{100}} < Q_{allow}$$

$$0.043\ cfs + 0.62(2)(0.0123\ ft)\sqrt{2\left(32.2\ \frac{ft}{sec^2}\right)(809.47 - 807.70)} < 0.276$$

$$0.206 \text{ cfs} < 0.276 \text{ cfs}$$

G. The 100-year storm volume has to discharge in less than 72 hours. The time can be approximated by considering two circumstances; the time for the basin to discharge the 100-year volume down to the bankfull elevation (when both sets of orifices are contributing) in addition to the time to discharge when the bankfull volume remains (which was already calculated at 25.6 hours).

Q_{both} will be defined as the discharge through the bankfull orifices when the bankfull and 100-year holes are contributing.

2 STAGE OUTLET DESIGN EXAMPLE

100 YEAR STORM (1% STORM)

$$h_{ave}^{both} = \frac{2}{3}\left(x_{100} - x_{bf}\right) + \left(x_{bf} - x_{bot}\right)$$

$$h_{ave}^{bf} = \frac{2}{3}(809.47 - 807.70) + (807.70 - 807.00)$$

$$h_{ave}^{both} = 1.88\ ft$$

$$Q_{both} = (0.62)(\#_{orif}^{bf})(A_{orif}^{bf})\sqrt{2gh_{ave}^{both}}$$

$$Q_{both} = 0.62(1)(0.0055\ sf)\sqrt{2\left(32.2\frac{ft}{sec^2}\right)(1.88\ ft)}$$

$$Q_{both} = 0.037\ cfs$$

A. The average discharge through the 100-year storm orifice(s) while the other orifice(s) are contributing should be determined.

$$h_{ave}^{100} = \frac{2}{3}(x_{100} - x_{bf})$$

$$h_{ave}^{100} = \frac{2}{3}(809.47 - 807.70)$$

$$h_{ave}^{100} = 1.18\ ft$$

$$Q_{ave}^{100} = (0.62)(\#_{orif}^{100})(A_{orif}^{100})\sqrt{2gh_{ave}^{100}}$$

$$Q_{ave}^{100} = (0.62)(2)(0.0123)\sqrt{2(32.2)(1.18)}$$

$$Q_{ave}^{100} = 0.133\ cfs$$

B. Check to confirm that the 100-year storm volume is discharged in less than 72 hours.

$$V_{rem} = V_{100} - V_{bf}$$

$$V_{rem} = 10{,}173\ cf - 1{,}705\ cf$$

$$V_{rem} = 8{,}468\ cf$$

$$T_{100} = T_{bf} + \frac{V_{rem}}{Q_{both} + Q_{ave}^{100}}$$

$$T_{100} = 25.6\ hr + \frac{8{,}468}{(0.037cfs + 0.133\ cfs)\left(\frac{3{,}600\ sec}{1\ hr}\right)}$$

$$T_{100} = 25.6\ hr + 13.8\ hr = 39.4\ hr$$

$T_{100} \leq 72$ hr

39.4 hr $\leq$ 72 hr

Therefore, the design meets both the time of detention and the flow rate requirements.

Section VIII: Appendix

Part Q.
INDEX

100-year Recurrence *8*, *10*, *18*, *19*, *21*, *46*, *47*, *50*, *52*, *69*

A

Above Ground Tank *28*, *94*
Aggregate *26*, *27*, *61*, *69*, *70*, *71*, *72*, *74*, *75*, *79*, *80*, *81*, *82*, *83*, *84*, *88*, *101*, *102*, *103*

B

Bankfull *1*, *8*, *18*, *19*, *21*, *23*, *24*, *26*, *30*, *43*, *47*, *50*, *51*, *54*, *100*, *140*, *141*, *143*, *144*, *145*, *146*, *147*
Bioretention Areas *18*, *54*
Bioswales *18*, *54*

C

Catch Basins *11*
Check Dams *3*, *11*, *27*, *88*, *89*, *90*, *96*
Cistern *28*, *94*, *101*
Clean Water Act *4*, *99*
County Drains *4*, *8*, *11*, *15*, *102*
Credits *9*, *40*
Culvert *8*, *46*, *101*, *103*, *106*, *107*
Curb and Gutter System *3*
Curve Number *21*

D

Design Storm *45*, *52*, *58*, *79*, *82*, *97*, *103*, *104*, *106*
Detention Basin *50*, *69*, *102*, *103*
Detention Volume *4*, *19*, *21*, *22*, *23*, *27*, *39*, *47*, *92*, *138*, *145*
Disturbed Area *75*, *78*, *81*, *84*
Downspout *29*, *94*
Drainage Area *6*, *11*, *26*, *27*, *44*, *60*, *63*, *64*, *67*, *68*, *70*, *73*, *74*, *76*, *78*, *80*, *83*, *86*, *87*, *90*
Drain-Down Time *75*, *78*, *81*, *84*
Dry Retention/Detention *3*, *50*, *99*
Dry Wells *18*, *19*, *26*, *54*

E

Erosion Control *2*, *12*, *71*, *78*, *89*, *100*
Extended Detention *3*, *99*, *104*, *105*

F

Fees *7*, *9*, *10*, *11*, *12*, *14*, *15*, *16*, *17*, *99*, *120*
Filter Fabric *50*, *79*, *81*, *82*
Final Plat *13*
First Flush *8*, *18*, *19*, *21*, *26*, *30*, *47*, *50*, *51*, *52*, *54*, *67*, *77*, *100*, *102*, *138*, *139*, *140*, *142*, *144*, *145*
First Flush Volume *18*, *138*, *145*
Flow Path *22*, *50*, *51*, *53*
Forebay *48*, *50*, *52*, *53*, *61*, *64*, *68*, *102*
Freeboard *46*, *52*, *53*, *96*

G

Geotextile *60*, *71*, *74*, *75*, *79*, *80*, *81*, *82*, *83*, *84*, *100*
Green Roofs *11*, *27*
Groundwater *1*, *4*, *51*, *53*, *54*, *59*, *69*, *103*, *107*

H

Hot Spots *59*, *60*, *69*, *74*, *76*, *80*, *83*
Hydrograph *21*, *103*
Hydrologic Soil Groups *23*, *114*
Hydrology *1*, *4*, *18*, *25*, *103*

I

Impervious *24*, *29*, *30*, *34*, *36*, *38*, *43*, *103*, *108*
Infiltration Area *26*, *27*, *63*, *67*, *70*, *75*, *78*, *81*, *84*, *90*
Infiltration BMPs *4*, *18*, *26*, *49*, *54*, *55*, *58*, *60*
Infiltration Capacity *62*, *95*, *101*
Infiltration Trenches *8*, *11*, *18*, *54*, *82*, *83*, *84*
Infiltration Volume *26*, *27*, *40*, *42*, *63*, *67*, *71*, *74*, *78*, *80*, *83*, *90*
Inlets *11*, *51*, *69*, *83*
Invert *8*, *11*, *26*, *27*, *46*, *52*, *55*, *63*, *67*, *68*, *74*, *96*

L

Loading Rate *26*, *63*, *67*
Locally Adapted *53*, *61*, *65*, *86*
Low Impact Development Manual *1*, *19*, *61*, *62*, *65*, *66*, *67*, *86*, *88*, *126*, *131*

N

National Pollutant Discharge Elimination System *4*
Native Plant *vii*, *49*, *131*, *132*, *133*, *134*
Natural Features *2*, *3*, *6*, *41*, *110*
Natural Resources Environmental Protection Act *4*
Non-Structural BMPs *29*
NRCS Method *18*, *19*
Nutrients *3*, *102*

O

Oil/Grit Separators *2*, *60*
Outlet Structures *11*
Overflow Structures *11*

P

Peak Rate *27*, *28*, *92*, *94*
Perforated Pipes *69*, *79*, *82*
Pervious *18*, *30*, *33*, *35*, *38*, *54*, *69*, *70*, *72*, *104*
Pervious Asphalt *18*, *54*
Phosphorus *19*, *60*, *99*, *102*, *108*
Plan Review *6*, *10*, *17*
Ponding Depth *26*, *63*, *67*
Post Development Bankfull *19*, *47*
Pre-Application Meeting *4*
Pre-Development Bankfull *19*, *23*, *24*, *43*, *47*, *50*
Preliminary Plan *7*, *8*, *10*
Preliminary Plat *6*, *7*, *9*, *10*, *13*
Pretreatment *50*, *60*, *61*, *64*, *68*, *69*, *73*

R

Rain Barrel *28*, *94*, *105*
Rain Gardens *8*, *11*, *18*, *26*, *54*, *66*, *67*
Rational Method *18*, *21*, *30*
Release Rate *20*, *21*, *22*, *51*, *138*, *139*, *140*, *141*, *145*, *146*
Required Infiltration Volume *4*, *19*, *39*, *42*, *47*, *51*
Retention/Detention *2*, *3*, *8*, *11*, *12*, *19*, *50*, *51*, *52*, *53*, *60*, *61*, *99*
Review Fees *7*, *10*, *15*, *17*
Riparian *29*, *41*, *105*
Riprap *45*, *64*, *68*, *96*, *97*, *100*, *104*
Runoff Coefficient *11*, *44*, *105*
Runoff Curve Number Method *21*

S

Sediment Removal *3*, *48*, *61*, *109*
Sediment Traps *65*
Sheet Flow *37*, *62*, *77*, *89*
Soil Borings *8*, *11*, *19*
Soil Storage Volume *26*, *63*, *67*
Soil Test Pits *19*, *55*
Soil types *4*, *6*
Spill Response Plan *100*
Standard Method Site Runoff Calculations *23*
Storage Facilities *49*, *50*, *52*, *53*, *96*, *99*
Storage Reservoir *69*, *104*
Structural BMPs *29*, *40*, *106*
Subsurface Infiltration Beds *8*, *11*, *18*, *54*, *79*, *80*, *81*
Subsurface Storage *26*, *67*
Sump Pump *97*
Surface Infiltration Basins *18*, *54*
Surface Storage Volume *26*, *63*, *67*

T

Total Maximum Daily Load *99*

U

Underdrain *27*, *61*, *78*, *80*, *83*, *88*

V

Vegetated Filter Strips *18*, *54*, *60*, *126*
Vegetative Buffers *2*, *48*
Void Space *69*, *74*, *79*, *80*, *82*, *83*

W

Water Quality *1*, *4*, *8*, *18*, *19*, *47*, *50*, *54*, *60*, *69*, *77*, *82*, *91*, *96*, *100*, *101*, *104*, *105*, *109*
Water Quantity *3*, *4*, *10*, *47*
Water Reuse *11*, *27*, *94*
Water Table *2*, *23*, *55*, *59*, *114*
Wetlands *1*, *2*, *7*, *10*, *23*, *41*, *49*, *51*, *53*, *55*, *59*, *60*, *61*, *101*, *105*, *106*, *107*, *126*
Wet Meadow *62*, *77*
Wet Retention/Detention *2*, *3*, *19*, *50*, *52*, *61*, *99*