CITY OF WHITEHALL
STORMWATER DESIGN MANUAL

September 14, 2018

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1.0 INTRODUCTION

This Manual establishes design criteria required for stormwater facilities within the City of Whitehall in conjunction with City Ordinance, Title Three, Chapter 901 and the Ohio Environmental Protection Agency's (OEPA) NPDES Phase II Stormwater Program. While adherence to this Manual will not stop flooding or prevent all damage caused by flooding, it does establish a basis for design which will:

- Minimize the damage and inconvenience of flooding;
- Provide drainage systems which continue to provide benefit over the long term;
- Minimize the expense of maintaining the drainage facilities within the City;
- Reduce non-point-source pollution;
- Minimize new impacts on engineered and natural drainage systems;
- Prevent or reduce impacts to stream and river ecosystems.

1.1 Administration

The Director of Public Service is authorized to administer, implement and enforce the provisions of this Manual. The Director shall serve as the principal executive officer for stormwater management for the purposes of fulfilling the requirements of the OEPA's NPDES Phase II Stormwater Program. Compliance with this Manual will be determined by the Director and his/her office. The Planning Commission shall not recommend for approval the final plat of any development or subdivision over which it has jurisdiction without documentation from the Director and the Engineer, that such the development or subdivision has been designed to be in compliance with the design requirements herein.

1.2 Drainage Policy

This drainage policy, control guidelines and criteria do not provide solutions to all drainage problems, nor is the Engineer restricted to these designs or procedures exclusively. Although the policies as stated will hold true for most development work, the City realizes that there may be individual projects involving special or unusual drainage design problems that should be reviewed prior to completing the drainage plans. Exceptions may be granted to the policies and criteria in such cases when engineering study(s) justify modification.

Experience has shown that most of the more serious flooding situations are "created". Development can lead to ever increasing flooding problems unless well-conceived, cooperative stormwater drainage and flood control programs are undertaken throughout the entire watershed. For this reason, the general policy of the City shall be:

a. All developments that disturbs more than 10,000 square feet, and/or creates more than 2,000 square feet of impervious surface will be required to control the peak flow rate of stormwater discharge prior to its release to off-site land, streams or the City's Municipal Separate Storm Sewer System (MS4).

The following exceptions from the Peak Flow Rate Controls are as follows:

1. Single-family residential lot not part of a larger common development or sale.
2. Two, three, or four unit multi-family structure not part of a larger common development or sale.
3. Managed open space associated with parks, golf courses, cemeteries, and other similar land uses including associated paved trails and roadways needed for the function of the land use.
4. Existing public right-of-way improvements including minor road widening increase in impervious area, and bridge crossings.
5. Linear utility line installations.
6. Land preparation for agricultural crops, orchards, woodlots, sod farms, and nursery operations.
7. Land subdivisions for residential purposes with a minimum lot size of five acres.
8. Properly permitted environmental restoration projects including wetlands, stream restoration, and other related activities.
9. Developments within previously approved Stormwater Master Plan.

b. It is the responsibility of the property owner to not change or alter any drainage course, ditch, flood routing path or drainage system on his/her property that will cause increased runoff, or will damage or cause flooding to adjacent, upstream or downstream property owners.

c. All stormwater drainage systems, including conveyances, within a development shall be designed to have capacity and depth, including sufficient invert elevations to permit future connections, to serve that total tributary area at the design storm frequency, and based on the rate of single family, residential runoff. The system for the upstream tributary area must be extended through the development.

d. All proposed development with a runoff rate greater than that which the downstream system has capacity for, or will be designed for, will be required to control the rate of stormwater discharge.

e. All information necessary shall be submitted to the City to determine how stormwater runoff should be controlled within the development prior to its release to downstream properties. The tributary area and the upstream watersheds should be determined using natural land divides unless man-made alterations are approved by the City's Engineer as the basis for watershed delineations.

f. Stormwater management facilities shall be designed to meet the requirements of this manual and submitted to the City Engineer for review. A stormwater management report including the supporting design calculations shall be included with the construction plans and shall be signed and sealed by an Ohio Professional Civil Engineer. The City shall not approve plans for any site improvement over which it has jurisdiction without documentation from the Director of Public Service and the City Engineer, that such plan of improvement has been designed to be in compliance with the design requirements herein.

1.3 Drainage Easements

In order to provide access for City personnel for inspection, the Developer is required to procure and convey to the City an easement for any tile, pipe, detention basin, drainage way, flood routing path, ditch, watercourse, natural stream, man-made stream, storm sewer, or other stormwater component or facility not already within the City right-of-way. The easement must be of sufficient width to allow cleaning, widening, deepening, replacing or other general maintenance of such drainage course or piped system.

When it is necessary to convey stormwater outside the property lines of a proposed improved area in order to discharge into an adequate outlet, the Developer:

a. is required to obtain easements and/or maintenance agreements, in a form and substance satisfactory to the Director, from abutting property owners,

b. is responsible for maintenance agreements of such drainage course unless the easements and/or maintenance agreements require the abutting property owners to repair and maintain the drainage course satisfactorily.

All drainage easements, preservation areas, reserves and other similar areas must be shown on the "final engineering and construction plan(s)". Drainage easements for all on-site drainage system improvements shall be recorded for public use by final plat and deed. For off-site drainage systems improvements, easements should be recorded for public use by either final plat or separate instrument. The maintenance of such drainage easements shall be undertaken in the manner specified in Section 1.4, below.

1.4 Operation and Maintenance of Stormwater Facilities

The City shall provide for inspection and routine maintenance of storm drainage facilities that have been accepted for maintenance by the City. City maintenance may include stormwater conveyance-related structure cleaning and repair. For other storm drainage facilities not accepted for maintenance by the City, the City may provide for remedial maintenance of such facilities based upon the severity of stormwater problems and potential hazard to public health and safety, through the abatement procedures described in below in Section 1.4.1. For the purposes of this Chapter, maintenance associated with <u>privately owned</u> detention basins including, but not limited to, mowing, rivulet repair, basin bottom fill, seeding, fertilizing and/or algae removal, are neither considered "potentially hazardous" to the public nor are they considered "severe" stormwater problems, and maintenance will not be provided by the City except in case of public emergency as determined by the City.

1.4.1 Operation and Maintenance Abatement Procedures

a. Notice To Correct Improper Drainage:

1. Whenever the City finds that (i) a tract of land is inadequately drained, or (ii) there is excessive erosion or sedimentation upon such land or (iii) that there is an obstruction to or from a culvert, or water course upon such land that interferes with water naturally flowing therein or (iv) that such culvert, storm sewer or watercourse is of insufficient capacity to reasonably accommodate the flow of water, as required by

this chapter, the City shall notify the owner or person having possession, charge, or management of such land to remove the obstruction, provide adequate drainage, fill or drain such land, enlarge the culverts, drains or watercourses, mitgate excessive erosion or sedimentation and/or accomplish any other act determined by the City's Engineer necessary to further the purposes of this chapter. Such notice shall be served to such persons by personal delivery, by registered mail at the last known place of residence, or by posting on the premises.

2. The owner must comply with the City's orders within the time specified and not to exceed 30 days. Failure to comply with such order shall constitute an unlawful act. Each additional day thereafter during which the owner fails to carry out the order of the City shall constitute a separate offense.

    A. In any case where a condition described above exists for more than 30 days after service of notice, the Director may direct the owner to fill or drain such land, remove any obstruction and, if necessary, enlarge the culverts, drains, or watercourses to meet the requirements of this chapter.

    B. In the event an owner fails or refuses to comply with the Director's directive, the City may provide for the performance of the required work and charge the owner the abatement costs.

    C. Each and every owner of real property in the City consents to the entry upon any real property in the City for all reasonable times during normal business hours for the purpose of inspection, repair or maintenance required by this chapter.

3. Non-action by the City to observe or recognize hazardous or unsightly conditions or to recommend denial of a permit or zoning change shall not relieve the owner or person having possession, charge or management of such land from the responsibility for the condition or damage resulting therefrom, and shall not result in the City, its officers or agents being responsible for any condition or damage resulting therefrom.

4. Nothing in this chapter shall be construed as authorizing any person to maintain a private or public nuisance on his property, and compliance with the provisions of this chapter shall not be a defense in any action to abate such nuisance.

5. Nothing in this chapter shall be construed to prevent immediate action by the City in emergency situations. In case of an emergency, the City may direct that action be taken immediately to correct the condition or abate the activity to protect the public health, safety, and welfare. The City may perform the required work and charge the owner the abatement costs.

2.0 STORMWATER RUNOFF CONTROL CRITERIA

2.1 Quantitative Control

This section provides guidance on the implementation of the peak flow control requirements consistent with the critical storm method. The NRCS runoff curve number (RCN) method is the preferred method to determine runoff volumes and peak flow rates to stormwater control facilitiesThe permissible peak rate shall be determined as follows:

a. Reference Section 3.4 for calculation methods requirements.

b. For the purpose of determining site pre-development condition a runoff curve number (RCN) of 77 shall be used.

c. Determine the total volume of runoff from a 1-year frequency 24-hour storm, occurring over the area before and after development.

d. Determine the percentage of increase in volume due to development and using this percentage, pick the critical storm from Table 1.

TABLE 1
Critical Storm for Stormwater Volume Calculations

If the percentage of increase in VOLUME of runoff is;		**The Critical Storm for discharge limitations will be:**
Equal to or greater than	**and less than**	
--	10	1 year
10	20	2 year
20	50	5 year
50	100	10 year
100	250	25 year
250	500	50 year
500	--	100 year

e. The peak rate of runoff from the critical storm occurring over the development shall not exceed the peak rate of runoff from a 1-year frequency storm occurring over the same area under predevelopment conditions. Storms of less frequent occurrence (longer return period) than the critical storm, shall have a peak rate of runoff not greater than for the

same storm under predevelopment conditions. As an example, if the total volume is to be increased by 35%, the critical storm is a 5-year storm. The peak rate of runoff for all storms up to this intensity shall be controlled so as not to exceed the peak rate of runoff from a 1-year frequency storm under predevelopment conditions in the area. The runoff from a more intense storm up to a 100-year storm need only be controlled so as not to exceed the predevelopment peak rate from the same frequency of storm.

2.2 Qualitative Control

Stormwater qualitative control shall be implemented into sites stormwater management design in accordance with general and specific requirements outlined in the current Ohio EPA's NPDES General Permit for stormwater discharges associated with construction activity. Water quality Best Management Practice's (BMP's) shall be designed according to the latest design standards as set forth within Ohio's Rainwater and Land Development Manual. The Ohio EPA refers to Ohio's Rainwater and Land Development Manual for technical design standards for individual BMP's to meet General Construction Permit requirements.

In addition to the minimum standards set forth by the Ohio EPA, the following additional requirements of the City shall be required:

a. Dry basins, sand filters, and infiltration basins, and trenches defined by the Ohio EPA and Ohio's Rainwater and Land Development manual are not permitted as a water quality BMP within the City unless otherwise approved by the Director of Public Service and the City Engineer.

b. Supplemental information associated with the design of bioretention basins is provided within Section 2.2.4.

2.2.1 Large Construction Sites

For all construction activities (involving the disturbance of two or more acres of land or will disturb less than two acres, but is a part of a larger common plan of development or sale which will disturb two or more acres of land), the post construction BMP(s) chosen must be able to detain stormwater runoff for protection of the stream channels, stream erosion control, and improved water quality. Structural (designed) post-construction stormwater treatment practices shall be incorporated into the permanent drainage system for the site.

<u>Water Quality Volume (WQv):</u>

The selected BMP(s) shall be sized to treat the WQv by either means of extended detention or infiltration and ensure compliance with Ohio EPA NPDES General Permit. The WQv shall be equivalent to the volume of runoff from a 0.90-inch rainfall using the following formula.

a. WQv Equation:

$$WQv = Rv^* P * A / 12 \text{ (Equation 1)}$$

Where:

WQv = water quality volume in acre-feet
Rv = the volumetric runoff coefficient calculated using equation 2
P = 0.90 inch precipitation depth
A = area draining into the BMP in acres

Rv = 0.0.5 + 0.9i (Equation 2)
i = fraction of post-construction impervious surface

b. Post-construction BMP's shall be sized to treat 100% of the WQv associated with their contributing drainage area.
c. An additional volume equal to 20 percent of the WQv shall be incorporated into the BMP for sediment storage.
d. Redevelopment projects water quality options:

    1. A 20 percent net reduction of the site's volumetric runoff coefficient through impervious area reduction, or
    2. Treat 20 percent of the WQv for the previous developed site conditions.

    Projects consisting of a combination of redevelopment and new development shall incorporate a water quality BMP to treat the WQv using the following equation:

    WQv = P * A * [(Rv1*0.2) + (Rv2 - Rv1)] / 12 (Equation 3)

    Where:

    P = 0.90 inches
    A = Area draining into the BMP in acres
    Rv1 = volumetric runoff coefficient for existing conditions (current site impervious area)
    Rv2 = volumetric runoff coefficient for proposed conditions (post-construction site impervious area)

BMPs shall be designed such that the drain time is long enough to provide treatment, but short enough to provide storage available for successive rainfall events as described in Tables 2 and 3.

TABLE 2
Extended Detention Water Quality BMPs and Target Drawdown (Drain) Times

Best Management Practice	Drain Time of WQv
Wet Extended Detention Basin[1,2]	24 Hours
Constructed Extended Detention Wetland[1,2]	24 Hours
Permeable Pavement – Extended Detention[1]	24 Hours
Underground Storage – Extended Detention[1,3]	24 Hours
Bioretention Basin – Extended Detention[1,4]	24 Hours

Notes:

1. The outlet structure shall not discharge more than the first half of the WQv in less than one-third of the drain time.
2. Provide a permanent pool with a minimum volume equal to the WQv and an extended detention volume above the permanent pool equal to 1.0 x WQv.
3. Underground storage must have pretreatment for removal of suspended sediments. This pretreatment shall concentrate sediment in a location where it can be readily removed. For non-infiltrating, underground extended detention systems, pretreatment shall be 50% effective at capturing total suspended solids according to the testing protocol established in the Alternative Post- Construction BMP Testing Protocol within the Ohio EPA's NPDES General Permit.
4. The WQv ponding area shall completely empty between 24 and 72 hours.

TABLE 3
Infiltration Water Quality BMPs and Target Drawdown (Drain) Times

Best Management Practice	Drain Time of WQv
Bioretention Area/Cell[1,2]	24 Hours
Permeable Pavement - Infiltration[3]	48 Hours
Underground Storage – Infiltration[3,4]	48 Hours

Notes:

1. Reference Section 2.2.4 for bioretention basin mulch, soil, and planting requirements. Bioretention cells must have underdrains unless in-situ conditions allow

for the WQv (surface ponding) plus the bioretention soil (to a depth of 24 inches) to drain completely within 48 hours.

2. Infiltrating practices with the WQv stored aboveground (bioretention, infiltration basin) shall fully drain the WQv within 24 hours to minimize nuisance effects of standing water and to promote vigorous communities of appropriate vegetation.
3. Subsurface practices designed to fully infiltrate the WQv (infiltration trench, permeable pavement with infiltration, underground storage with infiltration) shall empty within 48 hours to recover storage for subsequent storm events.
4. Underground storage must have pretreatment for removal of suspended sediments. This pretreatment shall concentrate sediment in a location where it can be readily removed. For non-infiltrating, underground extended detention systems, pretreatment shall be 80% effective at capturing total suspended solids according to the testing protocol established in the Alternative Post- Construction BMP Testing Protocol within the Ohio EPA's NPDES General Permit.

2.2.2 Small Construction Sites

For all small land disturbance activities (which disturb one or more, but less than two acres of land and which are not a part of a larger common plan of development which will disturb two or more acres of land), a description of the measures that will be installed during the construction process to control pollutants in stormwater discharges that will occur after the construction operations have been completed must be included in the Storm Water Pollution Prevention Plan (SWP3).

a. Justify within the SWP3 why the BMP's identified within Tables 2 and 3 are not feasible. The justification must address the limiting factors that would prohibit the proposed project from going forward.
b. Obtain approval from the Director of Public Service and City Engineer for the use of the proposed alternative BMP per the requirements outlined within Section 2.2.3.

Velocity dissipation devices shall be placed at discharge locations and along the length of any outfall channel to provide non-erosive flow velocity from the structure to a water course so that the natural physical and biological characteristics and functions are maintained and protected.

2.2.3 Alternative Best Management Practices

BMP's not identified within Tables 2 and 3 are considered alternative BMP's. Developer's proposing to use an alternative BMP must meet the following requirements:

a. Provide documentation to the City Director of Public Service indicating that the proposed alternative BMP meets the testing protocol as outlined within the Ohio EPA's NPDES General Permit.
b. Obtain approval from the Ohio EPA for the use of the alternative BMP and provide a copy of the approval to the City Director of Public Service.
c. Obtain approval from the City Director of Public Service.

2.2.4 Bioretention Basin Design Standards

For sizing and construction of bioretention basins, please refer to the latest version of Ohio's Rainwater and Land Development Manual.

For the materials to be used in a bioretention basin, supplemental information has been provided for the mulch and bioretention soil. The bioretention soil specification is the most important aspect of the design. An improperly designed soil that lacks sufficient infiltration capacity can have long periods of standing water rendering the basin ineffective and adding stress to the vegetation. Improper organics can also have detrimental consequences on the health of selected vegetation.

a. Mulch

Organic mulch: Mechanically chipped, shredded, hammered or ground raw wood material from either hard or soft timber. Mulch shall be free of mold, dirt, sawdust, and foreign and deleterious material and shall not be in an advanced state of decomposition. Mulch shall not contain chipped or shredded manufactured boards or chemically treated wood, including but not limited to wafer board, particleboard, chromated copper arsenate (CCA) or penta treated wood.

1. Color: Natural, undyed.
2. Size Range: 3 inches (76 mm) maximum, ½ inch (13 mm) minimum.
3. pH: 6.0 to 7.5.
4. Salinity: less than 3.0 millimhos per cm (mS /cm).
5. Carbon: Nitrogen Ratio: less than 36:1.

b. Bioretention Soil

Sand: Clean, natural sand meeting the requirements of ASTM C33 for fine aggregate. Other Graduation Characteristics shall fall within the limits specified below:

1. Fineness Modulus (FM) – 2.5 to 3.1.
2. Coefficient of Uniformity – 2.5 to 3.5 preferred (<4.1 acceptable).

Organic amendment: Mature/stable aerobically composted yard debris (green waste) compost, animal manure compost, biosolids compost or compost derived from a combination three of these feedstocks:

1. pH: 6.0 to 7.5
2. Salinity: less than 6.0 millimhos per cm (mS / cm).
3. Organic Matter: not less than 35% by weight.
4. Carbon: Nitrogen Ratio: less than 36:1.
5. Solvita® Maturity Index: between 6 and 7.

The compost shall meet all applicable state regulations based on the feedstock type or U.S. EPA 503 Regulations for bio solids compost.

Topsoil (optional): A loamy, friable soil essentially free from heavy or stiff clay lumps, stones, cinders, concrete, brick, roots, sticks, brush, litter, plastics, metals, refuse or other deleterious materials in accordance with ASTM D5268. The soil shall be free of herbicides, petroleum-based

materials or other substances of a hazardous or toxic nature which may inhibit plant growth. The soil shall be free of noxious weeds, seeds or vegetative parts of weedy plants that cannot be selectively controlled in the planting.

1. pH: 6.0 to 8.0.
2. Salinity: less than 1.5 millimhos per cm (mS /cm).
3. Organic Matter: 3 to 8% by weight.

The soil shall be taken from a well-drained site and have a USDA soil texture classification of a Clay Loam or Loam.

1. Existing topsoil at the site may be used provided it meets the requirements of this section for topsoils.
2. Off-site (borrow) topsoils may be used provided they meet the requirements of this section and their source or location is submitted to and approved by the Engineer or Landscape Architect.

Engineered soil mix: Mix Sand, Organic Amendment and Topsoil components by volume, to obtain Engineered Soil Mix meeting the specified requirements:

1. pH: 5.5 – 7.5 (ASTM D4972).
2. Salinity: less than 0.8 millimhos per cm (mS /cm).
3. Organic Matter: 2 - 10% by weight (ASTM F1647).
4. Phosphorus: Not to exceed 69 mg / kg.
5. Cation Exchange Capacity (CEC): Minimum of 10.
6. Infiltration Rate: 4 to 12 inches per hour (with soil compacted sample to 85% standard proctor), as determined by ASTM F1815 or ASTM D5856.

Mix Design Submittal: Contractor shall submit proposed mix to Director of Public Service for approval prior to final mixing and shipment to project site. Report percentage by volume of Sand, Organic Amendment and Topsoil. Furnish laboratory analysis and a written report, less than six months old, by a qualified testing laboratory stating compliance with the above parameters.

c. Basin Inlet and Outlet Structures

All headwalls, endwalls, catch basins or exposed structures (including basin outlet structures) within the basin are required to include natural or manufactured stone facing on the exposed faces of the structure. Stone is to be north shore buff limestone. Alternate selections must be approved by the City Service Director. A sample pallet is to be submitted to the City's Service Director for approval. Reference the structure details provided within Appendix A.

d. Plantings

See Appendix B for approved bioretention basin planting species.

2.2.5 Operation and Maintenance Plan

The owner/developer of a site that includes the implementation of structural and nonstructural BMPs to manage stormwater from the site and provide qualitative treatment shall prepare a stand-alone Operation and Maintenance (O&M) Plan. The O&M plan shall be submitted to the City for review and shall be approved prior to the commencement of construction activities. The O&M Plan shall meet the minimum requirements of the latest version of the Ohio EPA NPDES General Permit and City Code Chapter 901.08.

An O&M Agreement must be established per City Code Chapter 901.08 and signed by the owner/developer. Annual inspections shall be conducted by the post-construction operator identified within the agreement and reports provided to the City for review.

3.0 STORMWATER SYSTEM GENERAL DESIGN CRITERIA

3.1 Design Storms

a. The initial/minor drainage system is that part of the storm drainage system which is used regularly for collecting, transporting, and disposing of storm runoff from frequent and low magnitude storm events, snowmelt, and miscellaneous minor flows. The capacity of the initial drainage system should be equal to the maximum rate of runoff expected from a design storm of established frequency (i.e., Initial Storm). For purposes of design, the initial drainage system portion of the overall storm drainage system shall be designed to contain the runoff from a storm with a return period of not less than five-years.

b. The major drainage system is that part of the storm drainage system which carries the runoff which exceeds the capacity of the initial drainage system. The major drainage system shall have the capacity to carry runoff from a storm with a return period of not less than 100-years (i.e., Major Storm) without posing significant threat to property or public safety.

3.2 Initial Storm – Physical Design Criteria for On-Site Improvements

a. Depth of flow in natural channels shall not exceed bank full stage with backwater effects considered.

b. Depth of flow of the design storm in man-made ditches or swales shall not exceed 80% of the channel depth. Velocity of flow shall be determined in accordance with the design criteria for open channels in Section 4.4 c (3), and shall not exceed 5 feet per second, or a rate determined by the City's Engineer to be detrimental to the watercourse. Where flows exceed this rate, special channel lining and erosion protection shall be provided.

c. Depth of flow in road-side ditch swales shall not exceed one foot or be of such depth that flow would extend out of the right-of-way if the side ditch is less than one foot in depth. Velocity at this depth shall not exceed six feet per second for grass swales or ten feet per second for paved ditches.

d. Depth of flow in streets with curb and gutter shall not exceed the curb height. Velocity of flow in the gutter at design depth shall not exceed ten feet per second. In addition to the

above, the following are maximum encroachments of the minimum five-year initial design storm onto the pavement. See Section 4.3 for specific design criteria for curb inlet design.

e. For minor streets carrying traffic from the individual residence to collector and secondary streets, the flow may spread to the crown of the street.

f. For collector and secondary streets, one lane shall be free from water.

g. For primary streets, one lane in each direction shall be free from water.

h. For freeways, no encroachment is allowed on traffic lanes.

i. In design of a storm sewer pipe conduit, the conduit may be designed on the basis of flowing full with surcharge to gutter line. Backwater effects must be considered.

3.3 Major Storm – Physical Design Criteria for On-Site Improvements

a. The major storm floodway and floodway fringe for natural streams shall be as defined by the Federal Emergency Management Agency (FEMA), U.S. Army Corps of Engineers, the Ohio Department of Natural Resources, or where such determinations have not been made by these agencies, the major storm floodway and floodway fringe for natural streams may be estimated through a technical analysis by a registered Professional Engineer in the State of Ohio, in a manner found acceptable by the City.

b. Many of the drainage ways associated with the major storm system are in areas beyond those designated as floodway or floodway fringe. For these areas, the major storm flood limits shall be determined by the U.S. Army Corps of Engineers' HEC-RAS model or other accepted methods of determining water profiles using the major design storm runoff. One half foot of elevation must be added to the flood profile as freeboard to provide protection in the event of future encroachments into the floodway fringe or in the drainage way.

c. In order to protect the integrity of the non-street drainage rights-of-way, the design engineer is encouraged to design routing paths for multi-purpose functions. Pedestrian and bicycle paths lend themselves naturally to this application. Linear parks aligned along the major drainage corridor are also very effective, but usually require greater width than would normally be necessary for drainage purposes.

d. Where the street is designed as the major drainage system, the depth of flow shall not exceed 12-inches at gutter line for minor, collector and secondary streets, and shall not exceed 6-inches depth at crown for primary streets and freeways. The same maximum depth criteria will apply where a major drainage way crosses the street. Where a major drainage way is located outside the street, right-of-way easements will be provided.

e. In determining the required capacity of surface channels and other drainage ways provided for the major storm runoff, the street storm inlets and conduit provided for the initial design storm may be assumed to carry a portion of the total runoff volume, if appropriate. The following equation shall be used to determine the required capacity of surface channels and drainage ways in their design, when a portion of the runoff is conveyed within the initial piped system:

$$Q_{100} = C\ I_{10} A + 0.96 (I_{100} - I_{10}) A$$

and

$$Q_{\text{flood routing path}} = Q_{100} - Q_{\text{pipe}}$$

Where:

$Q_{\text{flood routing path}}$ = Design flow, major storm runoff (cfs)
Q_{pipe} = Peak flow within piped system (i.e., 5-year event) (cfs)

Q_{100} = Peak flow for 100-year event (cfs)

C = Rational runoff coefficient, site developed condition

I_{10} = rainfall intensity for 10-year storm event (inches/hour)

I_{100} = rainfall intensity for 100-year storm event (inches/hour)

A = Drainage area contributory to design point (acres)

f. Detention and Storage: Areas designed for storage of stormwater by detention should be incorporated into the natural features of the general area, when possible. Cooperative planning and joint owner construction of detention facilities and use of natural land contours is encouraged. No such facilities will be permitted which may be or become aesthetically unpleasing, or which may result in construction, or maintenance problems. The City encourages that detention facilities be designed as multipurpose spaces such as open space, recreation and/or scenic areas.

3.4 Methods of Calculation

The following methods of calculation shall be used unless otherwise approved by the City's Engineer:

a. Rainfall volumes shall be in accordance with data for Central Ohio provided in "*Bulletin 71: Rainfall Frequency Atlas of the Midwest*", 1992 and any subsequent updates thereto.

b. Rainfall distribution for stormwater management systems is to be in accordance with SCS Type II Rainfall Distribution.

c. The appropriate Runoff Curve Number (i.e., "RCN" factor) may be determined by using Technical Release No. 55 (S.C.S.) or its Ohio Supplement.

3.5 Drainage Area Determination

The drainage area shall be determined from any of the following sources, which are listed in order of priority preference:

a. Actual field investigation;

b. County Auditor, topographic maps;

c. U.S. Geological Survey quadrangle (7.5 minute series) contour maps;

d. Soil Survey of Franklin County, Ohio, U.S.D.A.

4.0 STORMWATER SYSTEM SPECIFIC DESIGN SPECIFICATIONS

4.1 Roadway Culverts

a. General specifications. The size and shape of the culvert should be such that it will carry a predetermined design peak discharge need to specify without the depth of water at the entrance or the velocity at the outlet exceeding allowable limits.

b. Design procedure. The culvert design procedure recommended for use is Hydraulic Design Series No. 5, U.S. Department of Transportation.

c. Preferred construction. Single span culverts, including concrete box and slab top are preferred. Multiple cell pipe culverts, when they are the only structures that will meet the physical requirements introduced by rigid headwater controls, will be acceptable.

d. Material. The culvert material shall be concrete, at a minimum diameter of 12 inches. Corrugated steel or metal pipe material will not be allowed.

e. Drainage area. The drainage area in acres, and the estimated runoff or design discharge in cubic feet per second, and the storm frequency in years shall be shown on the plan for each culvert.

f. Inlet elevation. The flowline elevation at the culvert inlet should be set deep enough to provide an adequate outlet for future storm sewer improvements upstream.

g. Design storm frequency (roadway culverts), shall be:

1. 10-year frequency 24-hour storm event for private drives, local and collector streets.

2. 25-year frequency 24-hour storm event for arterial streets.

h. Design flow. For method of calculation, refer to Table 4.

1. storm shall not exceed or cause any of the following:
2. 18-inches below the top of curb
3. 12-inches below the edge of pavement
4. 1.2 times the diameter of culvert
5. Diameter or rise plus two feet, in deep ravines
6. Property Damage – 100-year frequency headwater plus 1-foot, shall not exceed any existing or proposed building first floor elevation

TABLE 4
Acceptable Methods of Calculation for Design Flow in Roadway Culverts

<table>
<tr><td rowspan="3">DRAINAGE AREA (ACRES)</td><td colspan="5">STORMWATER QUANTITY</td></tr>
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<tr><td>Less than 200</td><td>Rational or peak discharge</td><td>Peak discharge</td><td rowspan="2">(*) Tabular Hydro-Graph</td><td rowspan="2">Graphical</td><td rowspan="2">(*) STORAGE-INDICATION</td></tr>
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</table>

*Note: The "Tabular Hydrograph" and "Storage-indication" methods are preferred and are normally used to check drainage calculations submitted to the City Engineer

Method References:

Rational: (Q = CIA); MORPC, Stormwater Design Manual, 1977

Graphical: Ibid., Pg. 143

Peak Discharge: U.S. Department of Agriculture, Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release No. 55, 1986

Storage– Indication: MORPC, Stormwater Design Manual, 1977, Pg. 143.

SCS TR-20 and US Army COE HEC-1

Tabular Hydrography: SCS TR-55, Chap. 5 SCS TR-20, US Army COE's HEC-1

USGS regression equations for Central Ohio may be used where applicable, for estimating peak flows for culvert design and to estimate peak release rates

i. Manning's roughness coefficient (n). Manning's Roughness Coefficient (n) should be as given in Table 5 unless an alternate value is approved by the City Engineer.

j. Maximum allowable headwater. The maximum allowable headwater for the design storm shall not exceed or cause any of the following:

1. 18-inches below the top of curb;
2. 12-inches below the edge of pavement
3. 1.2 times the diameter of culvert; or
4. Diameter or rise plus two feet, in deep ravines.
5. Property Damage – 100-year frequency headwater plus 1-foot, shall not exceed any existing or proposed building first floor elevation.

k. Entrance loss coefficient (Ke). The Entrance Loss Coefficient (Ke) should be as given in Table 5 based upon the headwall configuration unless an alternative value is approved by the City Engineer.

l. Minimum cover to subgrade. Should be 30 inches from top of pipe to subgrade.

m. Maximum allowable outlet velocity, shall be:

1. Turf Channel 5 f.p.s.
2. Rock Protection 18 f.p.s

Notes:

a. When the outlet velocity exceeds 18-feet per second, a stilling basin or other such energy dissipation structure must be used.
b. The downstream channel must have the ability to handle the flow satisfactorily.

n. Structural design criteria. The structural design criteria for culverts shall be the same as that required by the Ohio Department of Transportation (ODOT).

o. Emergency flood routing. The emergency flood routing shall be capable of routing the 100-year storm over or around the culvert without creating a hazard or causing potential for erosion or personal property damage. Adequate scour protection must be included in the design.

p. End protection should be as follows:

1. 12-inch through 36-inch culverts – full-height headwall
2. 42-inch through 84-inch culverts – full height headwall with flared wings
3. Other special type headwalls must be approved before use

TABLE 5
Design Coefficients for Roadway Culverts

Type structure	Manning's roughness Coefficient (n)	Entrance loss Coefficient (ke)*
Concrete pipe	0.013	0.2
BOX: 4-sided BOX: 3-sided	0.013 Weighted by wetted perimeter Minimum 0.018	0.2 TO 0.5 0.2 TO 0.5
Slab top	0.03 to 0.05	0.2 to 0.5

* As a function of the headwall configuration.

4.2 Storm Sewers

The criteria for designing storm sewer systems are listed below:

a. No water will be allowed to cross a street intersection unless it is carried in a storm drain. All storm sewer systems shall be designed using Manning's Equation:

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

and

$$Q = AV$$

where :
Q = Rate of discharge (cfs)
A = Area of cross-section of flow (sq.ft.)
V = Mean velocity of flow (fps)

n = Manning's roughness coefficient
R = A/wp = Hydraulic radius (ft)
S = Slope of pipe or hydraulic grade line if surcharged (ft/ft)
wp = Wetted perimeter (ft)

b. Hydraulic Gradient Requirement shall be:

1. Based on a 5-year storm, shall not exceed window or grate elevation for an inlet or catch basin.

2. Grade line based on tailwater or 0.8 D at outlet (whichever is greater) or other critical points within the system.
3. The invert of the first storm drain appurtenance shall be above the computed floodplain elevation, unless otherwise permitted by the City Engineer.

c. Design Flow Determination:

1. Areas under 200 acres use Rational Method Q = CiA
2. Areas between 200 and 300 acres transition between Rational Method and Technical Release *55*
3. Areas over 300 acres use Technical Release *55*
4. Minimum times of Concentration:

- Curb inlet - 10 minutes
- Catch basin - 15 minutes

d. Runoff Coefficient

1. Based on Table 6, with 0.4 as a minimum.

e. Manning's "n" Value:

1. All storm sewers shall be based on pipe material and approved by the City Engineer.

f. Off-site Area: The sewer must be deep enough to receive the flow from all its sources within the watershed.

g. Size: The size of the storm sewer must be adequate for flowing full, based on the design storm (see Subsection 4.2 (b), listed above) with the 5-year storm hydraulic grade line contained to the system. Pipe for storm drains shall not be less than 12 inches in diameter.

h. Solids: The gradient of the sewer must be sufficient to avoid deposition of solids.

i. Material: All storm drainpipe shall be PVC, HDPE or reinforced concrete. Other materials may be approved at the direction of the City engineer. All pipes shall have sufficient strength to withstand an HS-20 live load.

j. Manholes: Manholes shall be provided at all changes in alignment and grade of storm drains and at such other locations as necessary to maintain a maximum interval of 400 feet between manholes or storm drains. The main conduit, if over 24-inches in diameter, will be required to be separated from all curb and gutter inlets unless a special design is approved by the City's Engineer. Furthermore, the main conduit will be required to be separated from all deep curb and gutter inlets, which have a depth greater than 6.5 feet from invert to the top-of-casting elevation.

All catch basins shall be constructed with flow restriction in the first section of pipe diameter for one (1) length of pipe. The use of orifice plates is not allowed unless otherwise approved by the City Engineer.

k. Flow Line: Unless otherwise approved by the City's Engineer, the flow line of pipes should be set such that the crown of pipes, at junctions, are at the same elevation; if the outlet elevation permits, the crown of the outlet pipe may be lower. The flowline elevations of sewers should be set to avoid using concrete encasement.

l. Specifications: Methods of construction and trench backfill shall be as per the requirements of the City and the City of Columbus "Construction and Materials Specifications", latest edition, as approved for use by the City's Engineer.

m. Submerged pipe outlets: The submergence of a permanent pool of water above the flowline invert elevation of a storm sewer at the outlet is discouraged and shall not be permitted to a depth greater than the ½ the pipe diameter or a depth of two-feet at the outlet, whichever is less. When submergence is allowed upon approval by the City's Engineer, special requirements shall include, but may not be limited to:

1. Submergence "zone" shall not extend beneath pavement;
2. Submergence "zone" shall not extend beyond the first manhole;
3. "O-ring" sealed gasketed pipe joints shall be installed along the storm sewer for the full length of the submergence zone;
4. Anti- seepage collars shall be installed in the submergence "zone".

n. End protection: Standard headwalls or endwalls are to be constructed at the inlet and outfall of all storm drains, and shall be pre-cast or poured in place and shown on the plan and profile. as follows:

1. 12-inch through 36-inch culverts – full-height headwall. If the outlet is not located within a channel bank or within the direct flow path of crossing floodwaters, half-headwalls at the outlet may be used if approved by the City's Engineer. In no instance will half-headwalls be allowed on non-concrete conduit
2. 42-inch through 84-inch culverts – full height headwall with flared wings
3. Other special type headwalls must be approved before use

o. Minimum cover to subgrade:

1. Desirable, under pavement and within influence of traffic load - 30 inches from top of pipe to subgrade.
2. Desirable, beyond influence of traffic load – 18 inches from top of pie to ground surface.

p. Maximum cover over pipe:

1. The supporting strength of the conduit, as installed, divided by a suitable factor of safety must equal or exceed the loads imposed upon it by weight of earth plus any superimposed loads.
2. The design procedure recommended for use in structural design of storm sewers is outlined within the Design Manual Concrete Pipe, available from American Concrete Pipe Association, wide trench installation.

q. Encasement: Class A concrete encasement shall be required within the limits of existing or proposed paved areas inside right of way, in areas influenced by traffic loading, or under paved driveway entrances adjacent to right of way as directed by the City's Engineer, where the minimum cover during construction or proposed cover over the outside top of the pipe to top of subgrade is 30 inches or less. In addition, all PVC and polyethylene pipe allowed to be installed in the right of way shall be concrete encased per CMS 910. Any concrete encasement of flexible pipe shall extend from structure to structure.

r. Velocity in sewer for design flow:

1. 3 fps Minimum
2. 7 fps Maximum
3. No minimum for outlets from ponding areas

s. Maximum Length between access structures:

1. Pipes under 60-inch – 350 feet
2. Pipes 60-inch and over 500 feet

TABLE 6
Runoff Coefficients "C" for Typical Land Uses in Whitehall

Cover Type and Hydrologic Condition	Average percent impervious area (5)	Runoff Coefficient for Hydrologic Soil Group (7)			
		A	B	C	D
Fully developed urban areas (vegetation established) (1)					
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		0.94	0.94	0.94	0.94
Open space (lawns, parks, golf courses, cemeteries, etc)					
Poor condition (grass cover, 50%)		0.29	0.48	0.63	0.70
Fair condition (grass cover 50% to 75%)		0.07	0.30	0.48	0.58
Good condition (grass cover >75%)		NA	0.19	0.39	0.50
Commercial and business (TND – TC) (6)					
Industrial					
Residential Districts by Average Lot Size (6):					
Multi-family (TND – NC)	80	0.63	0.75	0.80	0.83
1/12 to 1/6 acre lots (TND – NG)	75	0.56	0.70	0.77	0.83
1/8 acre (TND – NE)	65	0.44	0.60	0.72	0.77
1/4 acre	38	0.19	0.40	0.56	0.65
1/2 acre	25	0.11	0.32	0.50	0.60
1 acre	20	0.08	0.29	0.48	0.58
Undeveloped or agricultural lands(1)					
Cultivated Land:					
Without conservation treatment		0.35	0.52	0.67	0.75
With conservation treatment		0.21	0.34	0.46	0.52
Pasture, grassland, or range – continuous forage for grazing. (2)	Hydrologic condition:				
	Poor	0.29	0.48	0.63	0.70
	Fair	0.07	0.30	0.47	0.58
	Good	NA	0.19	0.39	0.50
Meadow – continuous grass, protected from grazing and generally mowed for hay.		NA	0.16	0.34	0.46
Brush – brush-weed-grass mixture with brush the major element. (3)	Poor	0.06	0.27	0.44	0.56
	Fair	NA	0.13	0.37	0.48
	Good	NA	0.06	0.25	0.37
Woods. (4)	Poor	0.04	0.26	0.44	0.56
	Fair	NA	0.18	0.37	0.48
	Good	NA	0.12	0.32	0.44
Farmsteads – buildings, lanes, driveways, and surrounding lots.	--	0.17	0.39	0.54	0.63

Notes:

NA – Method to derive value is not applicable for curve number values less than 40.

(1) Average runoff condition, and Ia=0.2s.

(2) Poor: <50% ground cover or heavily grazed with no mulch.

Fair: 50 to 75% ground cover and not heavily grazed.

Good: >75% ground cover and lightly or only occasionally grazed.
(3) Poor: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
(4) Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.
(5) The average percent impervious area shown was used to develop the composite CN's which were then
used to derive runoff coefficient values. Other assumptions are as follows: impervious areas are
directly connected to the drainage system, impervious areas have a runoff coefficient of 0.94 (or CN of
98), and pervious areas are considered equivalent to open space in good hydrologic condition.
(6) Acronyms for zoning of residential districts are as follows:
TND – TC: Traditional Neighborhood Development – Town Center
TND – NC: Traditional Neighborhood Development – Neighborhood Center
TND – NG: Traditional Neighborhood Development – Neighborhood General
TND – NE: Traditional Neighborhood Development – Neighborhood Edge
(7) These runoff coefficients were calculated from CN's drawn from the NRCS (SCS) Peak Discharge
Method from TR-55 assuming a 10-year, 24-hour storm. For larger design storms, the runoff coefficients should be increased using the following C value correction factors:
1.0 for the 10-year design storm and less
1.1 for the 25-year design storm
1.2 for the 50-year design storm
1.3 for the 100-year design storm

4.3 Curb Inlets

a. General: The satisfactory removal of surface water from curbed pavement is as important as any other phase of stormwater control. The spread of water on the pavement for the design storm is considered as the best control for pavement drainage. The design procedure recommended for use is Hydraulic Engineering Circular No. 12, available from the Superintendent of Documents, U.S. Government Printing Office. On combined runs of over 600 feet contributing to a sag vertical curve, an additional inlet may be required near the low point, plus or minus two-tenths foot above the inlet at the sag.

b. Design storm (curb inlets). The following shall be used:

1. Two-year storm frequency
2. Rational method of calculation
3. Ten minutes for minimum time of concentration
4. 0.015 for roughness coefficient for composite roadway paved and gutter section

5. Maximum width of spread of flow:

Street Width	Width of Spread
$\leq$ 30 ft.	8 ft.
> 30 ft.	9 ft.

c. Underdrains: Four (4) inch curb drains connections shall be placed 30-inches below the top of the curb on the up-grade side of the inlet. It is desirable to have the storm sewers, draining to the inlets, set such that the elevation of the top of the sewer is not higher than the top of the 4-inch curb drain.

d. The maximum distance for overland flow shall be 300 feet before entering a surface yard inlet or 425 feet before entering a curb inlet. Except, that the maximum overland drainage area tributary to any yard inlet or curb inlet shall not exceed 1.5 acres. The maximum spacing for curb inlets shall not exceed 400 feet unless approved by the City.

4.4 Detention Facilities

Areas designed for storage of stormwater by detention should be incorporated into the natural features of the general area, when possible. Cooperative planning and joint owner construction of detention or retention facilities and use of natural land contours is encouraged. The City encourages that detention facilities be designed as multipurpose spaces such as open space, recreation and/or scenic areas.

a. Ownership and maintenance: The owner and thus responsible party to provide maintenance and operation of a stormwater management facility (i.e., detention, retention basin, etc.), whether public or private, shall be determined to the satisfaction of the City prior to the acceptance by the City's Council of the relevant subdivision plat and the acceptance of the final engineering and construction plan. No lot sales will be permitted until this is done.

b. Location: All stormwater management facilities will be located in a reserve/open space as shown on the preliminary plat and final plat and will be owned by a homeowners association or an entity otherwise approved by the City's Council.

c. The distance between the detention feature top of embankment and the property line, easement, or public right-of-way shall be a minimum 15 feet.

d. Types of facilities: In development and developing urban and suburban areas, several means for controlling stormwater runoff could be used. This usually involves storing runoff on or below the ground surface. The following types of storage facilities may be considered for detention and are subject to approval by the City Engineer: rooftops, parking lots, underground tanks, surface basins, and man-made stormwater wetland systems.

All surface detention shall be wet, permanent-pool, basins or bioretention basins. No dry detention basins, sand filters, or infiltration basins are permitted.

4.4.1 Parking Lot Storage

Parking lot storage is surface storage where shallow ponding is designed to flood specific graded areas of the parking lot. Controlled release features are incorporated into the surface drainage system of the parking lot. Parking lot storage is a convenient multi-use structural control method where impervious parking lots are planned. Design features include small ponding areas with controlled release by pipe-size and slope, and increased curb heights.

The major disadvantage is the inconvenience to users during the ponding function. This inconvenience can be minimized with proper design consideration. Clogging of the flow control device and icy conditions during cold weather are maintenance problems. Parking lot design and construction grades are critical factors. This method is intended to control the runoff directly from the parking area, and is usually not appropriate for storing large runoff volumes.

a. Ponding areas in parking or traffic areas shall be designed for a maximum potential depth of twelve (12) inches.

b. Flood routing or overflow must occur after the maximum depth is reached.

4.4.2 Underground Storage

Underground storage utilizes an underground tank or chamber, either prefabricated or constructed in place, which has a special controlled release feature. This method is most applicable where land area is valuable, such as in industrial and commercial areas. Construction cost and operation costs make this method relatively expensive. Storage trenches, a variation on basic tank storage, are rock-filled underground storage tanks. The storage is provided within the void spaces between the rock material.

4.4.3 Wet Detention Basins

Wet Detention Basins (Ponds) are permanent ponds where functional stormwater management storage is provided above the normal water level with special features for controlled release. Historically, wet detention basins have proven extremely effective in abating increased runoff and channel erosion from urbanized areas. Wet detention basins must be constructed outside of any existing stream channels.

Although every wet basin is unique and designed based on specific site conditions, the standards set forth within this section are intended to establish the guidelines for the layout and design of wet basins within the City.

The City has established two Types of basin design standards based upon the basin location.

- Type 1: Basin located within a setting that is adjacent to the public-right-of-way and/or is publicly visible
- Type 2: Basin located is a setting that is not adjacent to the public-right-of-way and is not publicly visible

General wet basin design requirements are outlined within the section and specific design requirements based upon the basin Type are provided within the basin design guidance document

located within Appendix A. The proposed stormwater management basin shall be designed based upon the basin Type approved by the City.

All wet detention basins must meet water quality and quantity detention criteria in Section 2 of this manual.

Some problems encountered with wet detention basins are: site reservation (land requirements), permanent easements, complexity of design and construction, safety hazards and maintenance problems. However, the recreational, aesthetic, and water quality benefits of permanent wet detention ponds justify their use in many applications. A five (5) foot chain link fence may be required where a wet retention basin is to be constructed adjacent to an existing single-family development for that part along the existing single-family section, if a sufficient submerged bench cannot be constructed in the basin (see Section 4.4.3 b below).

a. Wet basins are to include one fountain for every ¾ of an acre of surface area. In addition, the basin must include an air diffuser below the fountain to improve water circulation and quality. The infrastructure to be installed that is necessary to provide power to the fountain and aerator shall be installed in a manner to coincide with the overall basin landscaping aesthetics. Wet basins with a surface area of less than ¾ of an acre are required to include one fountain and air diffuser.

b. The side slopes for a Wet Detention basin should be:

   - A maximum slope of 2:1 horizontal to vertical below the permanent storage pool;
   - A minimum 5 foot wide, 2-foot maximum depth submerged bench at waters edge around perimeter of the permanent storage pool;
   - A maximum 4:1 horizontal to vertical above the submerged bench.

c. Unless otherwise approved by the City's Engineer, a minimum of 20 % of the pool area should be ten-feet deep for water-quality benefit.

d. Wetland Perimeter A wetland shelf may be constructed around the perimeter of the basin. The wetland shelf should have a minimum width of 10 feet, and a maximum depth of 8 inches, and be planted in wetland plants.

e. Debris-control structures: Debris-control structures may be required and should be considered as an essential part of the design. The procedure recommended for use is Hydraulic Engineering Circular No. 9, available from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. For dams and levies over ten feet in height, refer to Section 1521.062, O.R.C.

f. Submerged Outlet/Inlet Structures:

   1. The City permits the use of submerged storm outlets. Submerged Outlets may consist of a siphon pipe where such pipe is no smaller than 12- inches in diameter. For smaller outlet requirements, a bolted-on orifice plate may be used as the control feature, to be placed at the structure within the embankment. The siphon pipe material must be concrete. When using a submerged outlet, a stormwater detention basin must also

include one or more additional stage outlet(s) with sufficient capacity to convey the 100-year storm discharge without overtopping the pond embankment.

2. Inlet pipes that are equal to or larger in diameter than 36-inches must be submerged to at least the "springline" of the pipe (i.e., normal pool at a depth equal to the elevation at one-half the diameter of the pipe). When an inlet pipe is at least partially submerged at the pond, the conditions listed below must also be met.

3. Submergence of inlet pipes is limited to the next upstream manhole or catch basin along the storm sewer system.

4. All lengths of submerged storm pipe shall include "o-ring" sealed gasket pipe joints.

5. All lengths of the submerged storm pipe shall have bedding and backfill material consistent with the compacted embankment material.

6. Riser Outlet Structures: Catch basins/manholes used as the outlet structures may have a maximum elevation that is no more than 1.5 feet above the normal pool elevation and may include windows and grate-top openings. Where a catch basin is used as a second-stage outlet structure, the slope of the pond embankment must be graded to reduce the visibility of the structure.

   Calculations must show that the capacity of the window(s)/grate top does not exceed the capacity of the "barrel" of the riser structure (calculated using the orifice equation).

   All catch basins or exposed structures (including basin outlet structures) associated with a Type 1 basin design are required to include natural or manufactured stone facing on the exposed faces of the structure. Stone is to be north shore buff limestone. Alternate selections must be approved by the City Service Director. A sample pallet is to be submitted to the City's Service Director for approval. Reference the basin design guidance document provided within Appendix A.

7. Structure Requirements: All headwall structures shall be in accordance with City of Columbus Standard Drawing AA-S166 (36-inch diameter or less) or City of Columbus Standard Drawings AA-S167 (greater than 36-inch diameter). All riser structures shall be in accordance with City of Columbus Standard Drawing AA-S162. (modified as necessary.)

   All headwalls associated with a Type 1 basin design are required to include natural or manufactured stone facing on the exposed faces of the structure. Stone is to be north shore buff limestone. Alternate selections must be approved by the City Service Director. A sample pallet is to be submitted to the City's Service Director for approval. Reference the basin design guidance document provided within Appendix A.

8. Bedding/Backfill Material: The bedding and backfill material for all storm pipe outlets shall consist of 100 percent cohesive embankment material or controlled-density fill. Where inlet storm pipes are submerged, bedding and backfill material for those pipes shall consist of 100 percent cohesive embankment material to the next structure upstream along the storm sewer system.

9. Anti-Seep Collars:
    a. Anti-seep collars shall be used at all outlet storm pipe locations and shall be located (spaced) and sized in accordance with the criteria provided below. All anti-seep collars shall be constructed with material that provides a watertight connection to the pipe and is of a material that is compatible to the pipe. Anti-seep collars shall also be used along the submerged portion of any storm inlet pipes.

    b. The anti-seep collars shall be located along the length of the outlet pipe within the saturation zone of the embankment (refer to Exhibit No. 1), at approximately equal spacing and at intervals not exceeding 25 feet. The saturation zone is considered to extend through the embankment from the elevation of the riser (normal pool) to the downstream embankment toe.

    c. The anti-seep collars shall be designed to increase the length along the line of seepage (along the outlet pipe) by at least 15 percent. The proper design of the anti-seep collars may be achieved by either:

        - Selecting the number of collars and determining the minimum projection of the collar away from the outlet pipe: $V = 0.075 \times (L/N)$; or

        - Selecting the projection of the collar away from the outlet pipe and determining the minimum number of collars:

            $N = 0.075 \times (L/V)$

            Where:

            V = collar projection in feet
            N = number of collars
            L = length of outlet pipe within the saturation zone

10. Emergency Spillways: Emergency Spillways, when included in the designed pond outlet feature, must meet all of the following criteria:

    a. They shall not operate (convey flow) for any design storm less than the 50-year event.

    b. They shall be reinforced with concrete or designed erosion control materials (geotextiles) consisting of 100 percent synthetic, non-biodegradable materials [the plans should include a specification for the intended geotextile, referencing the required physical properties or the specific material. Reference the State of Ohio, Department of Transportation Construction and Material Specifications Section 712.11, Type "E."

c. They must include a designed "control section" that, when combined with the capacity of the principal spillway, will pass the major storm flood discharge up to the 100-year event [the plans must include a detail demonstrating the necessary dimensions of the control section, both width and breadth.

11. Miscellaneous: The following general criteria must be met:

a. Roof drain (downspout) outlets directly to the pond are not permitted

b. All orifice plates shall conform to the requirements of City of Columbus Standard Drawing, No. AA-S145.

c. All inlet structures (e.g., pipe headwalls) must be recessed into the adjoining pond grading to diminish the amount the structure is visible.

4.4.4 Alternative Detention Facilities

Several alternative BMP's have been approved for use in stormwater management by the Ohio EPA (OEPA NDPES General Permit) that additionally can be used to provide stormwater detention in conjunction with providing water quality treatment. Such practices include Stormwater Treatment Wetlands, Bioretention, Infiltration Basins. Design criteria for these BMP's can be found in Ohio's *Rainwater and Land Development Manual* . The use of alternative stormwater detention facilities must be approved by the City Engineer and Public Service Director.

5.0 STORMWATER POLLUTION PREVENTION PLAN (SWP3)

The developer shall prepare a stand-alone Stormwater Pollution Protection Plan (SWP3) in accordance with the general and specific requirements outlined in the Ohio EPA's NPDES General Permit for stormwater discharges associated with construction activity or its subsequent OEPA-issued revision. SWP3's are required to be prepared for projects consisting of land disturbing activities of 1 acre or more, or that will disturb less than one acre of land but are part of a larger common plan of development or sale that will ultimately disturb one or more acres of land. The SWP3 shall include erosion and sediment structural and non-structural BMPs to address the management of construction site stormwater runoff throughout land disturbing activities. The SWP3 shall be submitted to the City for review and shall be approved prior to the commencement of land disturbing activities. A copy of the Ohio EPA Notice of Intent (NOI) submission shall be made available to the City.

A copy of the approved SWP3 shall be maintained onsite in a location easily accessible by the City at all times during construction activities. The owner/developer is required to modify the SWP3 as necessary during construction activities to appropriately manage the construction site stormwater runoff during the various phases of construction. The SWP3 required to be kept on-site shall be modified and revised to reflect the installed BMPs at all times.

It shall be the responsibility of the owner/developer to provide notification to the City 48 hours prior to commencement of initial site earth disturbance. No construction activity such as grading, cutting, or filling shall be commenced until erosion and sedimentation control devices have been installed to the satisfaction of the City.

No person shall cause or allow earth disturbing activities on a development area except in compliance with the standards set out in this manual and the applicable items below:

For projects resulting in land disturbing activities of less than 1 acre of disturbance that are not classified as part of a larger common area of development, an erosion and sediment control plan is required to be designed and incorporated into the overall site improvement plan to demonstrate how the construction site runoff will be managed prior to discharging into the City's MS4 or waters of the State. Erosion and sediment controls are to be designed per the specifications outlined within Ohio's Rainwater and Land Development manual.

6.0 GLOSSARY

The following definitions shall apply to this Manual:

Best Management Practice (BMP): Measures including structural and non-structural BMPs that are determined to be the most effective, practical means of preventing or reducing point source or non-point source pollution inputs to storm water runoff and water bodies (see Practices).

Channel: Natural or artificial watercourse of perceptible extent, with a definite bed and banks to confine and conduct continuously or periodically flowing water. Channel flow thus is that water which flows by gravity and is characterized by a free water surface within the banks of a defined channel.

Water Quality Volume (WQv): The volume of storm water runoff which shall be captured and treated prior to discharge from the developed site after construction is complete. WQv is equivalent to the volume generated by a 0.90 inch rainfall.

City: The City of Whitehall.

City Engineer: The City of Whitehall City Engineer.

Conveyance: Any pipe, channel, inlet, drain, or other structure that facilitates the movement or removal of water.

Design Storm: A rainfall event of specified size and return frequency (e.g., a storm that occurs only once every 2 years), which is used to calculate the runoff volume and peak flow rate.

Detention: Runoff enters an area of detention faster than it leaves. It occurs in depressions, the natural landscape, or constructed stormwater facilities. While detention can be designed into ponds with or without a permanent pool, dry ponds often are referred to as detention ponds.

Detention Basin: a facility designed for the temporary storage of stormwater runoff for the purpose of delaying and attenuating flow to the downstream receiving system.

Detention Storage: Storm runoff collected and stored for a short period of time and then released at a rate much less than the inflow rate. (e.g. a dry reservoir)

Development: Any action in preparation for construction activity which results in an alteration of either land or vegetation, including but not limited to clearing, grubbing, grading, filling, excavation or any other development operations and the construction of new facilities, buildings, parking areas, recreational areas, etc.

Discharge: Any substance introduced to the Waters of the State or to surface runoff which is collected or channeled by the MS4 which do not lead to treatment works and/or the addition of any pollutant to the Waters of the State from a point source.

Disturbed: Earth surface subject to erosion due to the removal of vegetative cover and/or earthmoving activities.

Ditch: An open channel constructed for the purpose of drainage or irrigation with intermittent flow.

Drainage: A general term applied to the removal of surface or subsurface water from a given area, either by gravity or by pumping, commonly applied herein to surface water.

Drainage System or Drainageway: The surface and subsurface system for the removal of water from the land, including both the natural elements of streams, marshes, swales and ponds, whether of an intermittent or continuous nature, and man-made elements which include culverts, ditches, channels, storage facilities and the storm sewer system.

Easement: Property titled to the City for the operation and maintenance of storm water drainage and management systems.

Engineer: A Professional Engineer registered in the State of Ohio as required by Chapter 4733 of the Ohio Revised Code.

Erosion: The general process whereby soil or surface material is moved by flowing surface or subsurface water or is worn away by the action of wind, water, ice or gravity.

Erosion control: Measures that reduce or prevent erosion.

Extended Detention: A stormwater design feature that provides for the gradual release of a volume of stormwater (typically 0.25 - 0.75 inch per impervious acre) over a 24 to 48-hour interval to increase settling of urban pollutants and protect channels from degradation.

Facility: Any operation, including construction sites, required by the Federal Clean Water Act to have a permit to discharge storm water associated with activities subject to NPDES Permits as defined in 40 CFR, Part 122.

Flood: A temporary rise in the level of rivers, streams, watercourses and lakes which results in

inundation of areas not ordinarily covered by water.

Flood Plain: The relatively level land to either side of a channel, which is inundated during high flows. It is often used to reference the 100-year flood plain.

Geotextile: A woven or nonwoven, water-permeable fabric generally made of synthetics such as polypropylene. It's used to slowly pass runoff or as bedding for rock to keep the rock separate from adjacent soil.

Grading: Changing the ground surface condition, elevation, and/or slope through excavation or fill of material.

Hydrologic Soil Group: One of four classifications of soil based on the minimum infiltration characteristics for bare soil after prolong wetting as used by the United States Department of Agriculture Natural Resources Conservation Service *Technical Release No. 55, Urban Hydrology for Small Watersheds.*

Impervious Surface: Any constructed surface; including but not limited to, rooftops, sidewalks, roads, and parking lots; covered by impenetrable materials such as asphalt, concrete, brick, and stone. These materials seal surfaces, repel water and prevent precipitation and runoff from infiltrating soils. Soils compacted by urban development are also highly impervious.

Infiltration: The gradual downward flow of water from the surface through soil to groundwater.

Landscape: To mow, seed, sod, plant, and to do other activities which are not earth changes.

Larger common plan of development or sale: means a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules under one plan.

Material: Soil, sand, gravel, clay, or any other organic or inorganic material.

Municipal Separate Storm Sewer System (MS4): As defined at 40 CFR 122.26(b)(8), "means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

A. Owned or operated by a State, City, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)…including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity.

B. Designed or used for collecting or conveying storm water;
C. Which is not a combined sewer; and
D. Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2."

National Pollutant Discharge Elimination System (NPDES): A national program under Section 402 of the Clean Water Act for regulation of discharges of pollutants from point sources to Waters of the United States. Discharges are illegal unless authorized by an NPDES permit.

NPDES Permit: A permit issued by the EPA (or by a State under authority delegated pursuant to 33 USC § 1342(b)) that authorizes the discharge of pollutants to Waters of the United States, whether the permit is applicable on an individual, group, or general area-wide basis.

Ohio EPA: The Ohio Environmental Protection Agency.

Operate: To drive, conduct, work, run, manage, or control a tool, piece of equipment, vehicle, or facility.

Owner: Any person with a legal or equitable interest in a piece of the land or parcel.

Permeability: The capacity for transmitting runoff through a material or into soil. The relevant soil property is the saturated hydraulic conductivity, that is the amount of water that would move vertically through a unit of saturated soil per unit time under hydraulic gradient.

Permittee: The applicant in whose name a valid permit is duly issued.

Pollutant: Anything which causes or contributes to pollution

Pollution: The alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any Water of the State or Water of the United States, that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property, or to the public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

Practices: Schedules of activities, prohibitions of practices, maintenance procedures and other management practices and techniques (both structural and non-structural) used to lessen the environmental impacts of land use and to prevent or reduce the pollution of Waters of the State. BMPs also include treatment requirements, operating procedures and practices to control facility and/or construction site runoff, spillage or leaks, sludge or waste disposal or drainage from raw material storage. Techniques may involve basins, vegetation, altering construction operations, open space development, riparian buffers or other means of limiting environmental impacts.

Rainwater and Land Development Manual: A manual describing construction and post-construction best management practices and associated specifications prepared by the Ohio EPA. A copy of the manual may be obtained by contacting the Ohio EPA.

Return period: Also known as the *recurrence interval*, it is the average period between precipitation events or flood events of a certain size based on the records and statistics.

Runoff: The portion of rainfall, precipitation, melted snow or irrigation water that flows across the ground surface and is eventually returned to streams.

Runoff Coefficient: The fraction of total rainfall that will appear at the conveyance as runoff.

Sediment: Soils or other surface materials (including, but not limited to rock, sand, gravel and organic material or residue associated with or attached to the solid) that can be transported or

deposited by the action of wind, water, ice or gravity as a product of erosion or sedimentation.

Sediment Pollution: Degradation of Waters of the State by sediment as a result of failure to apply management or conservation practices to abate wind or water soil erosion, specifically in conjunction with earth-disturbing activities on land used or being developed for commercial, industrial, residential or other non-farm purposes.

Sediment Settling Pond: A sediment trap, sediment basin or permanent basin that has been temporarily modified for sediment control, as described in the latest edition of the Rainwater and Land Development manual.

Sedimentation: The processes that operate at or near the surface of the ground to deposit soils, debris and other materials either on the ground surfaces or in water channels or the action of deposition of sediment that is determined to have been caused by erosion.

Site: The entire area of land surrounding the discharge activity.

Stabilization: Vegetative or structural soil-cover controlling erosion (including but not limited to permanent and temporary seed, mulch, sod, pavement, etc.) or the use of vegetative and/or structural practices that prevent exposed soil from eroding.

State: The State of Ohio.

Storm Drainage System: All facilities, channels, and areas which serve to convey, filter, collect and/or receive storm water, either on a temporary or permanent basis.

Stormwater: Water runoff resulting from precipitation, snow melt, or irrigation runoff as defined in 40 Code of Federal Regulation 122.26(b)(13).

Stormwater Conveyance System: All storm sewers, channels, streams, ponds, lakes, etc. used for conveying concentrated storm water runoff or storing storm water runoff and filtering pollutants

Stormwater Pollution Prevention Plan (SWP3): A set of plans and specifications, prepared and approved in accordance with the specific requirements of the City Engineer and the Ohio EPA, NPDES General Permit associated with construction site discharges. The SWP3 shall be certified by an Engineer, and shall indicate the storm water management strategy, including the specific measures and sequencing to be used to manage storm water on a development site before, during and after construction and shows the details of any earth-disturbing activity on the site.

Stormwater Detention BMPs: Retention storage and detention storage that control storm water by gathering runoff in wet ponds and slowly releasing it to receiving waters or drainage systems. These practices can be designed to both control storm water volume and settle out particulates for pollutant removal.

Stormwater Runoff: Surface water runoff which converges and flows primarily through water conveyance features such as swales, gullies, waterways, channels or storm sewers.

Stormwater Treatment: The removal of pollutants from urban runoff and improvement of water quality, accomplished largely by deposition and utilizing the benefits of natural processes.

Stream: A system including permanent or seasonally flowing water, often with a defined channel (bed and bank), flood plain, and riparian ecosystem.

Structure: Anything manufactured, constructed or erected which is normally attached to or positioned on land, including, but not limited to buildings, portable structures, earthen structures, roads, parking lots, and paved storage areas.

Topography: The relative slopes, positions and elevations of the landscape's surface.

Watercourse: any natural or constructed conveyance of water including, but not limited to lake, pond, stream, river, creek, ditch, channel, canal, conduit, gutter, culvert, drain, gully, swale, or wash in which water flows either continuously or intermittently.

Water Quality Volume: The extended detention volume captured for the purposes of treating pollutants and protecting stream stability downstream. This volume is prescribed by the Ohio EPA Construction General Permit.

Watershed: A region draining to a specific river, river stream or body of water.

Wetland: An area that is inundated or saturated by surface or ground-water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated or hydric soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

APPENDIX A:

Wet Basin Design Standards

MINIMUM PLANT SIZE REQUIREMENTS:

1. Deciduous Trees: per 1130.09, 1.5" caliper
2. Ornamental Trees: Deciduous Trees per 1130.09, 1.5" caliper and with ornamental features such as flowers, foliage color or bark texture.
3. Evergreen Trees: per 1130.09, 5' height
4. Shrubs: per 1130.09, 18" height, deciduous or evergreen
5. Ornamental Grasses: minimum of #2 container size
6. Perennial Plants: minimum of #2 container size
7. All plantings shall be sized per the current edition of ANSI Z60.1- American Nursery Stock Standard

CALCULATIONS:

1. Measure linear footage of basin edge at Normal Pool Elevation (NPE)

MATERIAL SPECIFICATIONS:

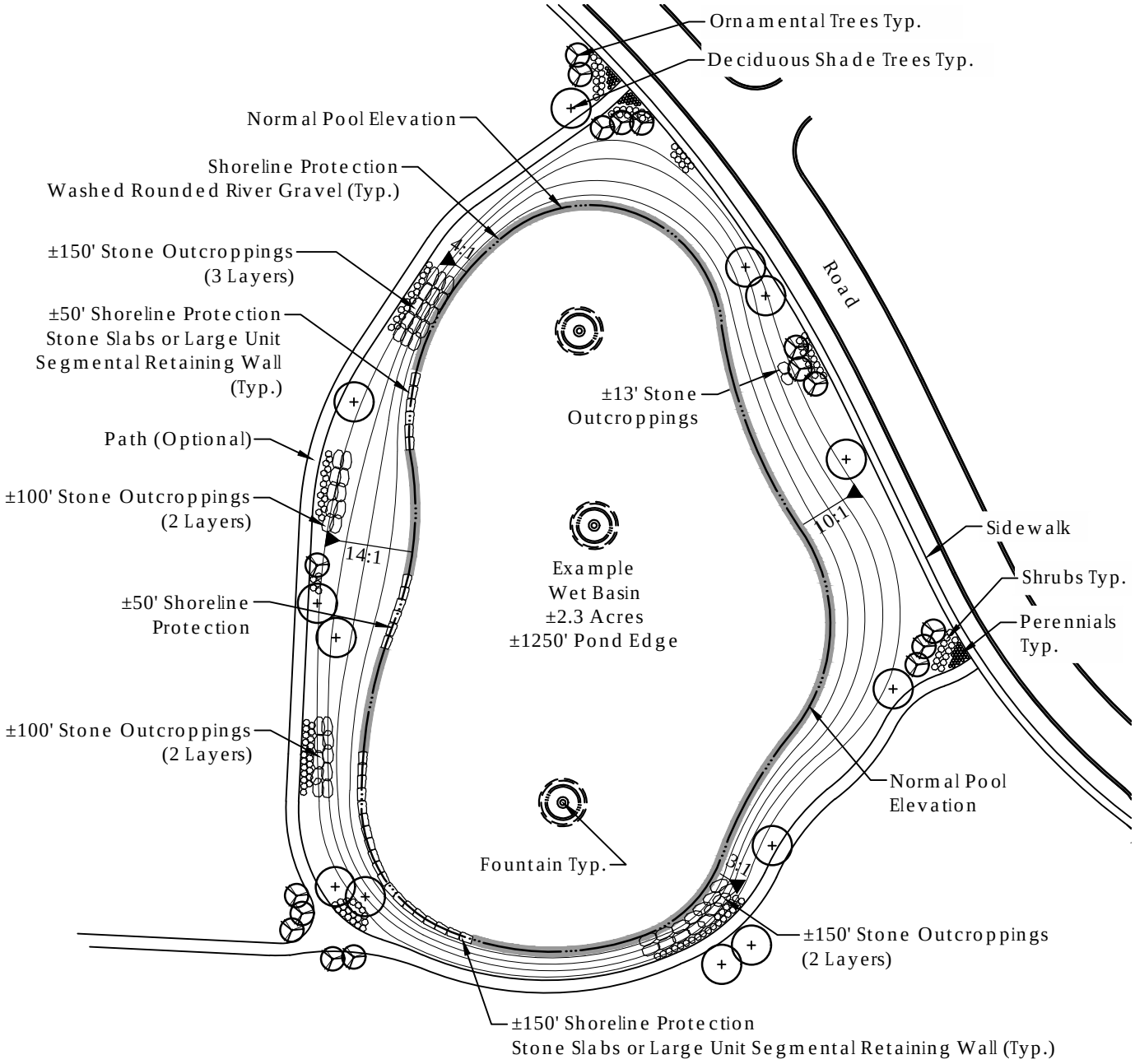
2. Stone Slabs for Shoreline Protection and Stone Outcroppings:
    a. Material: limestone or sandstone horizontal landscape slabs
    b. Approximate size of individual slabs: 8" to 18" high, 18" to 36" deep, minimum 30" length
    c. Texture: Naturally split or cleft with no exposed sawn faces
    d. Color: Natural grays, browns and tans
    e. Subject to compliance with the requirements above, examples of available products include, but are not limited:
        1 Castlewood, Blue River Ledge and Delaware Gray Slabs by Semco Outdoor
        2 Beaverdam Slabs, Olen Valley Slabs, Ottawa Buff Slabs by Lang Stone
        3 Canyon Tan Outcroppings, Rustic Buff Outcroppings by Wholesale Stone Supplies

3. Large Unit Segmental Retaining Wall
    a. Material: Wetcast concrete units designed to simulate natural stone slabs, ledges and outcroppings
    b. Approximate minimum unit size: 6" high, 18" deep, 24" long
    c. Texture: Simulated natural stone slabs, ledges and outcroppings. Exposed sawn faces or smooth cast faces are not permitted.
    d. Color: Natural grays, browns and tans
    e. Subject to compliance with the requirements above, available products include, but are not limited to:
        1 Outcropping Collection by Rosetta Hardscapes
        2 Ledgestone by Redi-Rock
        3 ReCon Weathered Edge by Reading Rock

4. Washed Rounded River Gravel
    a. Material: Rounded river gravel, washed and clean of dust and fines. Crushed stone or concrete is not permitted.
    b. Size range: 2" minimum to 8" maximum
    c. Color: Natural greys, browns and tans

LANDSCAPE REQUIREMNTS FOR WET BASINS

1. Shore protection:
    a. Provide stone slabs or large units segmental retaining walls for a minimum of 20% of the basin perimeter with remainder to be washed rounded river gravel.
    b. A minimum of 12" and maximum of 24" of stone slabs or walls shall be visible above NPE.
2. Slopes:
    a. Where feasible, provide two separate areas of the slope surrounding the basin of 6:1 or flatter.
    b. No slope shall be steeper than 3:1
    c. Provide stone slab outcroppings on slopes equal to a minimum of 40% of the basin perimeter. A minimum of 18" of stone slab outcropping shall be visible above grade.
3. Landscape:
    a. 1 Shrub / 8 linear feet of basin perimeter (minimum of 3 species required)
    b. 1 Perennial Plant or Ornamental Grass / 20 linear feet of basin perimeter
    c. 1 Deciduous Tree / 100 linear feet of basin perimeter. Trunk to be located min. of 2' above NPE.
    d. 1 Ornamental Tree or Evergreen Tree / 75 linear feet of basin edge. Trunk to be located min. of 2' above NPE.
    e. Place shrubs, ornamental grasses and perennial plants in planting beds covered with shredded hardwood mulch.
4. Ground cover:
    a. Mowed lawn from top of bank to shoreline protection except for mulched landscape beds.



PLANT KEY

+	DECIDUOUS TREES	13
⊗	ORNAMENTAL OR EVERGREEN TREES	17
○	SHRUBS	157
•	PERENNIALS / ORNAMENTAL GRASSES	63

GRAPHIC SCALE

0 50 100 200

1 inch = 100 feet

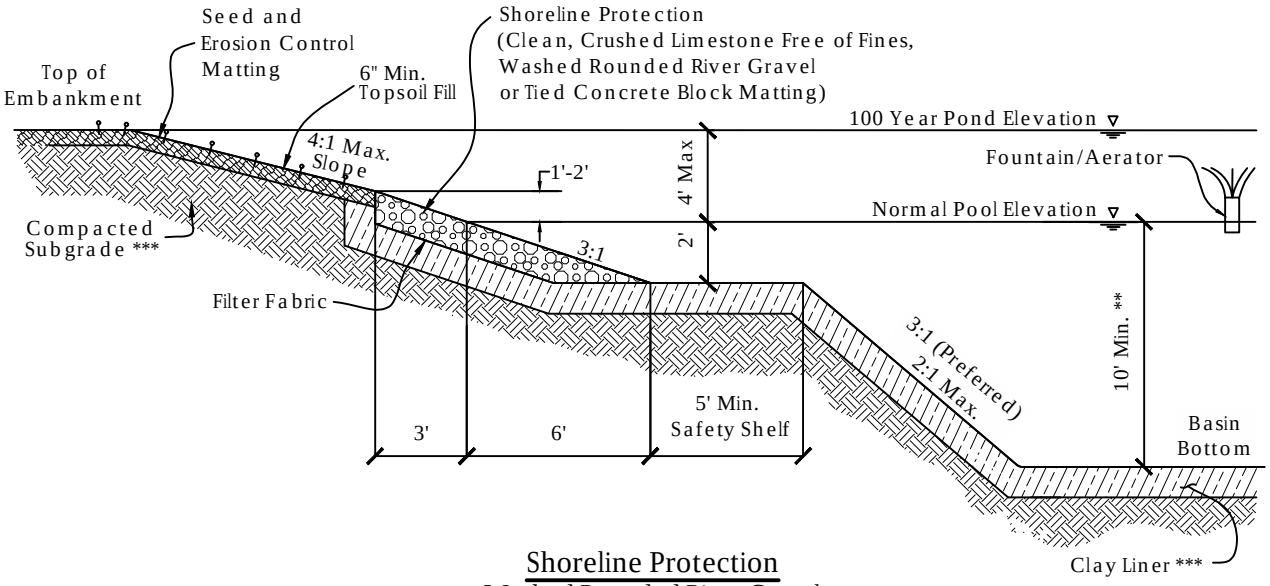
STANDARD DETAILS
FOR

STORMWATER MANAGEMENT
BASIN LANDSCAPE
TYPE 1

CITY OF
WHITEHALL, OHIO

STANDARD CONSTRUCTION
DRAWING

1/3

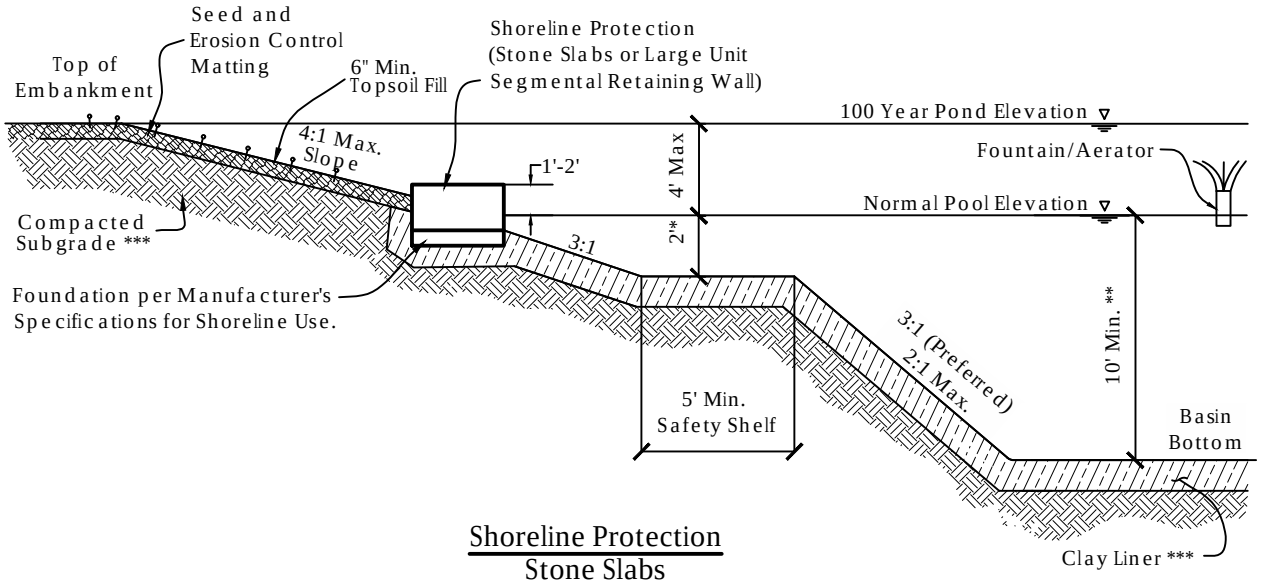


Shoreline Protection
Washed Rounded River Gravel

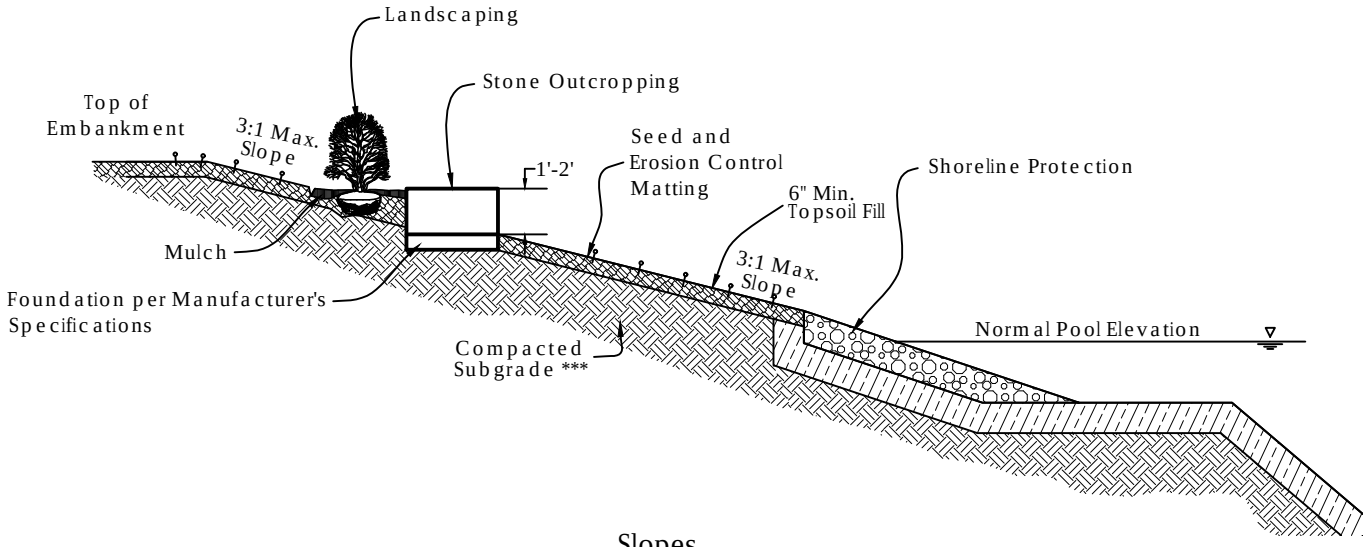
** For at least 25% of total pond area

*** Pond liner - geotechnical recommendations required, confirming adequacy of existing sub-grade material or identifying criteria for a constructed liner.

	STANDARD DETAILS FOR STORMWATER MANAGEMENT BASIN (TYPE 1) POND EDGE SECTION - SECTION 1	CITY OF WHITEHALL, OHIO STANDARD CONSTRUCTION DRAWINGS 2/3



Shoreline Protection
Stone Slabs

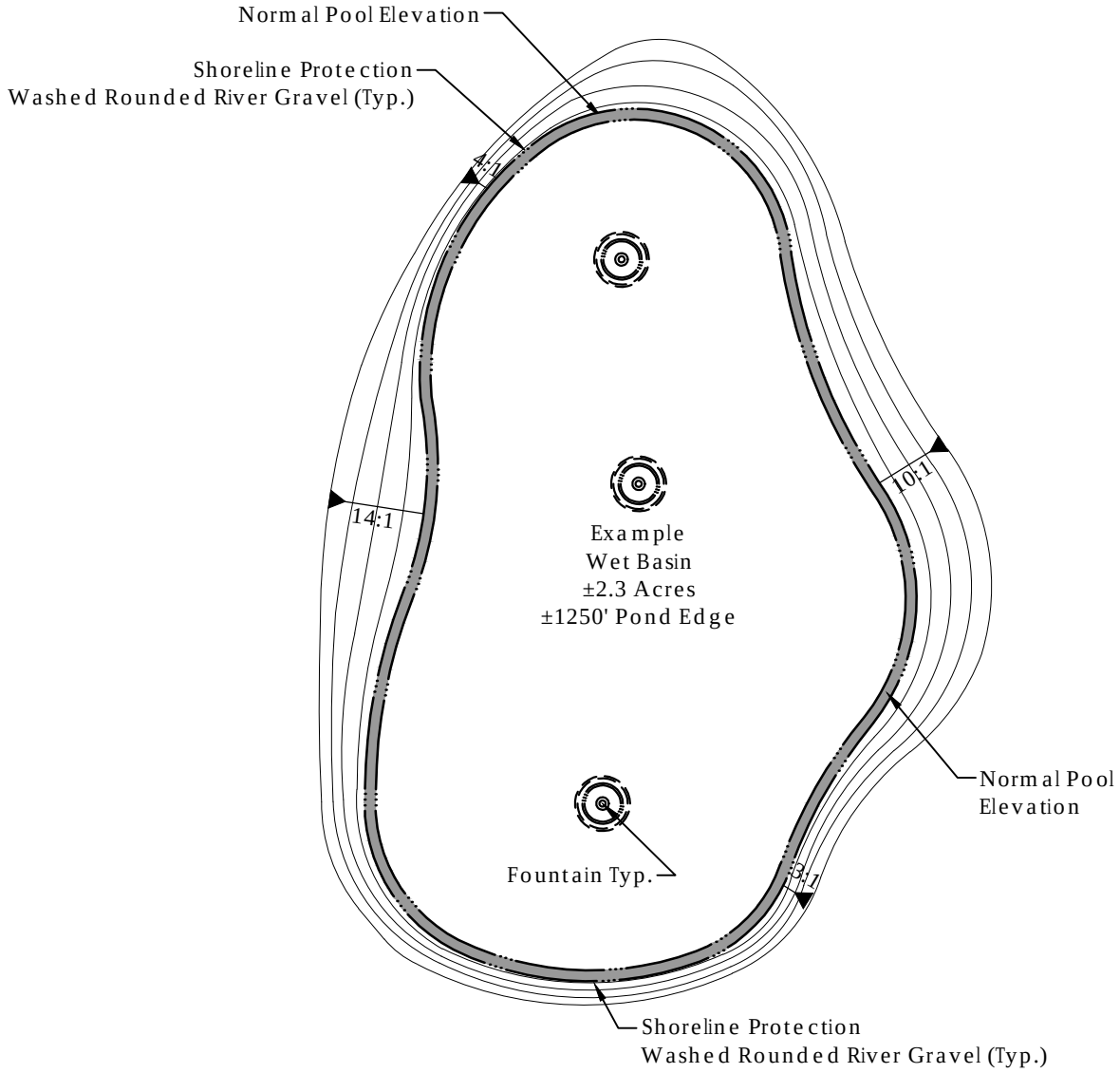


Slopes
Stone Ourcropping

** For at least 25% of total pond area

*** Pond liner - geotechnical recommendations required, confirming adequacy of existing sub-grade material or identifying criteria for a constructed liner.

	STANDARD DETAILS FOR STORMWATER MANAGEMENT BASIN (TYPE 1) POND EDGE SECTION - SECTION 2 & 3	CITY OF WHITEHALL, OHIO STANDARD CONSTRUCTION DRAWINGS 3/3

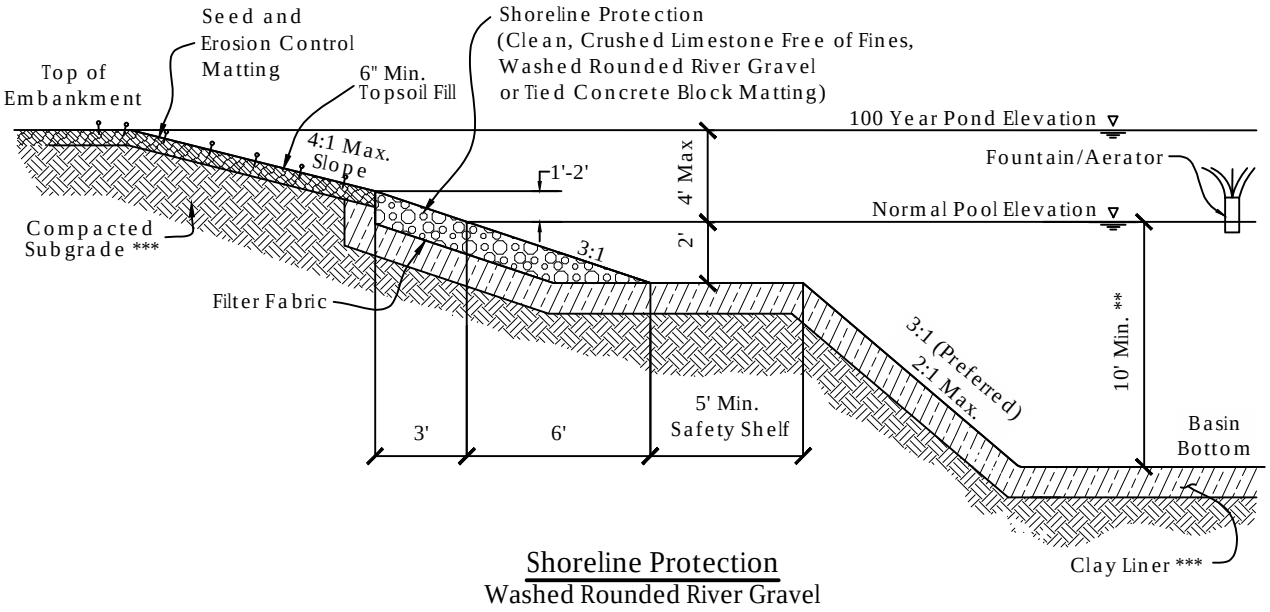


GRAPHIC SCALE

0 50 100 200

1 inch = 100 feet

	STANDARD DETAILS FOR STORMWATER MANAGEMENT BASIN LANDSCAPE TYPE 2	CITY OF WHITEHALL, OHIO STANDARD CONSTRUCTION DRAWING 1/2



Shoreline Protection
Washed Rounded River Gravel

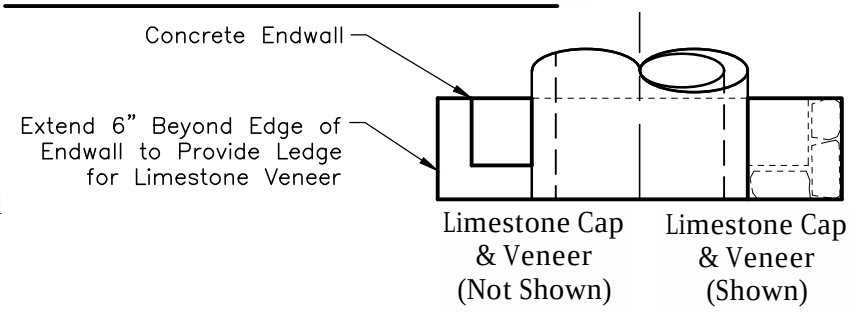
** For at least 25% of total pond area

*** Pond liner - geotechnical recommendations required, confirming adequacy of existing sub-grade material or identifying criteria for a constructed liner.

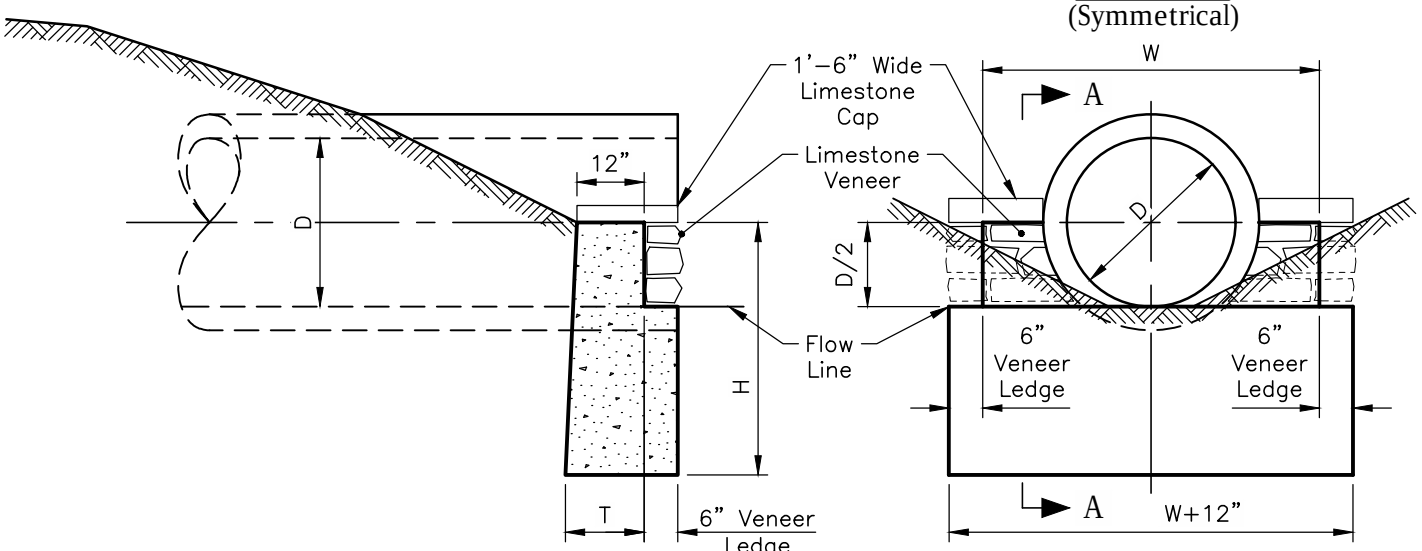
	STANDARD DETAILS FOR STORMWATER MANAGEMENT BASIN (TYPE 2) POND EDGE SECTION - SECTION 1	CITY OF WHITEHALL, OHIO STANDARD CONSTRUCTION DRAWINGS 2/2

PIPE ENDWALL WITH STONE VENEER

D = Diameter of Pipe
W = Width of Endwall
H = Height of Endwall
T = Thickness at Bottom ot Endwall



PLAN VIEW
(Symmetrical)

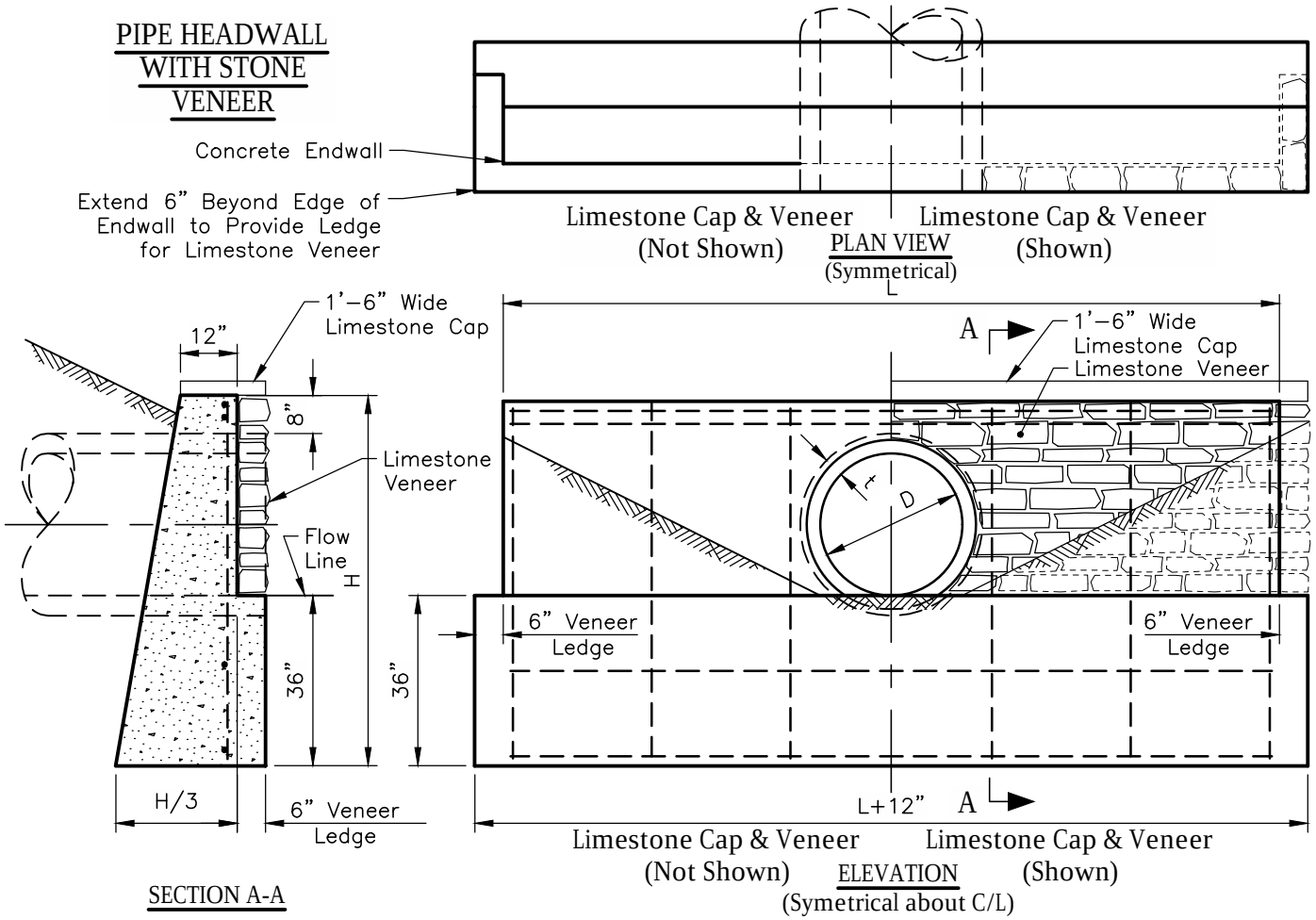


SECTION A-A

ELEVATION

	STANDARD DIMENSIONS FOR PIPE ENDWALL	CITY OF WHITEHALL, OHIO

PIPE HEADWALL WITH STONE VENEER



	STANDARD DIMENSIONS FOR PIPE HEADWALL	CITY OF WHITEHALL, OHIO

APPENDIX B:

Bioretention Basin Plantings

PLANTING PALETTE OPTIONS

Botanical Name	Common Name	Basin Size			Plant Selection Features			
		Small	Medium	Large	Shade	Sun	Wet	Native
Shrubs								
Aronia melanocarpa 'Morton'	Iroquois Beauty Black Chokeberry	■	■	■		■	■	■
Aronia melanocarpa 'Viking'	Viking Black Chokeberry			■		■	■	■
Cornus sericea 'Kelseyi'	Kelsey Dwarf Dogwood	■	■	■		■		■
Fothergilla gardenii	Dwarf Fothergilla	■	■		■	■		■
Hypericum kalmianum 'Blue Velvet'	Blue Velvet St. John's Wort	■	■			■		■
Hypericum frondosum 'Sunburst'	Golden St. John's Wort	■	■		■	■		■
Ilex verticillata 'Red Sprite'	Red Sprite Winterberry	■	■			■	■	■
Itea virginica 'Little Henry'	Little Henry Dwarf Sweetspire	■	■		■	■	■	■
Itea virginica 'Henry's Garnet'	Henry's Garnet Sweetspire	■	■	■	■	■	■	■
Rhus aromatica 'Gro-lo'	Gro-Lo Fragrant Sumac	■	■	■		■		■
Ribes alpinum 'Green Mound'	Green Mound Alpine Currant	■	■		■	■		
Spiraea nipponica 'White Carpet'	White Carpet Spirea	■	■			■		
Spiraea nipponica 'Snowmound'	Snowmound Spirea			■		■		
Syringa meyeri 'Palibin'	Meyer Lilac		■	■		■		
Syringa patula 'Miss Kim'	Miss Kim Lilac			■		■		
Viburnum dentatum	Arrowwood Viburnum			■	■	■	■	■
Viburnum dentatum 'Christom'	Blue Muffin Viburnum	■	■		■	■	■	■
Viburnum nudum 'Winterthur'	Winterthur Viburnum		■	■		■	■	■
Perennials								
Amsonia tabernaemontana 'Blue Star'	Blue Star Amsonia	■	■			■		■
Amsonia x 'Blue Ice'	Blue Ice Amsonia	■	■			■		■
Asclepias tuberosa	Butterfly Weed	■	■			■		■
Boltonia asteroides 'Snowbank'	False Aster	■	■			■	■	■
Echinacea purpurea 'Kim's Knee High'	Kim's Knee High Purple Coneflower	■	■			■		■
Liatris microcephala	Small-headed Blazing Star	■	■			■		■
Polygonatum odoratum 'Variegatum'	Variegated Solomon's Seal	■	■		■		■	
Rudbeckia fulgida var. sullivantii 'Goldsturm'	Black-eyed Susan	■	■			■		■
Sedum spectabile 'Autumn Joy'	Autumn Joy Stonecrop	■	■			■		
Solidago x 'Solar Cascade'	Solar Cascade Goldenrod	■	■			■		■
Grasses								
Calamagrostis x acutiflora 'Karl Foerster'	Karl Foerster Feather Reed Grass	■	■	■		■	■	
Calamagrostis x acutiflora 'Overdam'	Overdam Feather Reed Grass	■	■			■	■	
Carex morrowii 'Ice Dance'	Ice Dance Sedge	■	■		■		■	
Liriope muscari 'Big Blue'	Big Blue Lily Turf	■	■		■	■		
Miscanthus sinensis 'Little Zebra'	Dwarf Zebra Grass	■	■			■		
Panicum virgatum 'Heavy Metal'	Heavy Metal Switch Grass	■	■	■		■	■	■
Pennisetum alopecuroides	Fountain Grass	■	■	■		■		
Pennisetum alopecuroides 'Hameln'	Dwarf Fountain Grass	■	■			■		
Schizachyrium scoparium 'The Blues'	The Blues Little Bluestem	■	■			■		■
Sporobolus heterolepis	Prairie Dropseed	■	■			■		■
Sporobolus heterolepis 'Tara'	Dwarf Prairie Dropseed	■	■			■		■

Legend

■	= Suitable Plant
Native	= Native to Ohio region or Eastern United States
Small	= Typically installations with a total planting area less than 300 square feet
Medium	= Typically installations with a planting area width greater than 10 feet and/or total area greater than 300 square feet
Large	= Typically installations with a planted area greater than 1000 square feet
Wet	= May be suitable for use at locations within the basin near inlets or in basins with large runoff ratios (impervious runoff area to area of basin > 10:1)
Sun	= Plant performs well in full sun to part shade
Shade	= Plant performs well in part shade to full shade

City of WHITEHALL
Opportunity is Here

Bioretention Planting Options

Plant Palette

October 2018

Calamagrostis x acutiflora
'Karl Foerster'
Karl Foerster Feather
Reed Grass

Calamagrostis x acutiflora
'Overdam'
Overdam Feather Reed
Grass

Carex morrowii 'Ice Dance'
Ice Dance Sedge

Liriope muscari 'Big Blue'
Big Blue Lily Turf

Miscanthus sinensis 'Little Zebra'
Dwarf Zebra Grass

Panicum virgatum 'Heavy Metal'
Heavy Metal Switch Grass

Pennisetum alopecuroides
Fountain Grass

Pennisetum alopecuroides 'Hameln'
Dwarf Fountain Grass

Schizachyrium scoparium
'The Blues'
The Blues Little Bluestem

Sporobolus heterolepis
Prairie Dropseed

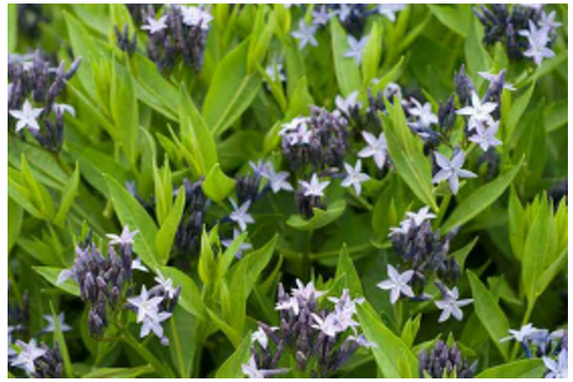
Sporobolus heterolepis
Dwarf Prairie Dropseed

City of WHITEHALL
Opportunity is Here

Bioretention Planting Options
Plant Photos: Grasses

October 2018

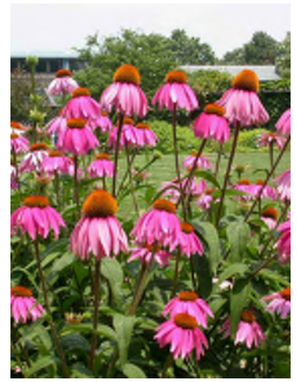
Amsonia tabernaemontana 'Blue Star'
Blue Star Amsonia



Amsonia x 'Blue Ice'
Blue Ice Amsonia

Asclepias tuberosa
Butterfly Weed

Boltonia asteroides 'Snowbank'
False Aster



Echinacea purpurea
'Kim's Knee High'
Kim's Knee High
Purple Coneflower

Liatris microcephala
Small-headed
Blazing Star

Polygonatum odoratum 'Variegatum'
Variegated Solomon's Seal

Rudbeckia fulgida var. sullivantii 'Goldsturm'
Black-eyed Susan

Sedum spectabile 'Autumn Joy'
Autumn Joy Stonecrop

Solidago x 'Solar Cascade'
Solar Cascade Goldenrod

City of WHITEHALL
Opportunity is Here

Bioretention Planting Options
Plant Photos: Perennials

October 2018

Aronia melanocarpa 'Morton'
Iroquois Beauty Black Chokeberry

Aronia melanocarpa 'Viking'
Viking Black Chokeberry

Cornus sericea 'Kelseyi'
Kelsey Dwarf Dogwood

Fothergilla gardenii
Dwarf Fothergilla

Hypericum kalmianum 'Blue Velvet'
Blue Velvet St. John's Wort

Hypericum frondosum 'Sunburst'
Golden St. John's Wort

Ilex verticillata 'Red Sprite'
Red Sprite Winterberry

Itea virginica 'Little Henry'
Little Henry Dwarf Sweetspire

Itea virginica 'Henry's Garnet'
Henry's Garnet Sweetspire

Rhus aromatica 'Gro-Lo'
Gro-Lo Fragrant Sumac

Ribes alpinium 'Green Mound'
Green Mound Alpine Currant

Spiraea nipponica 'White Carpet'
White Carpet Spirea

Spiraea nipponica 'Snowmound'
Snowmound Spirea

Syringa meyeri 'Palibin'
Meyer Lilac

Syringa patula 'Miss Kim'
Miss Kim Lilac

Viburnum dentatum
Arrowwood Viburnum

Viburnum dentatum 'Christom'
Blue Muffin Viburnum

Viburnum nudum 'Winterthur'
Winterthur Viburnum

City of WHITEHALL
Opportunity is Here

Bioretention Planting Options
Plant Photos: Shrubs

October 2018