City of Indianapolis Stormwater Design and Construction Specifications Manual

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Chapter 100. Policy and Procedures

Section 101. Introduction

101.01 Purpose

The City of Indianapolis Stormwater Design and Construction Specifications Manual (Manual) provides guidelines on the engineering design and construction standards for proper stormwater management for engineers, builders, contractors, land planners, and property owners undertaking land alteration within the City of Indianapolis, Marion County, Indiana (the "City"). Interlocal agreements may extend the jurisdiction of this Manual to excluded cities within Marion County.

The contents of this Manual have been adopted by the Board of Public Works (the "Board") in conformance with standard promulgation procedures listed in Section 561–321, Authorization to promulgate regulations, of the Marion County Code of Ordinances (the "City Code"), to accomplish the following objectives:

- Provide for consistent, high quality project evaluation and design by consolidating current departmental standards within a single, well organized, and easily referenced document.
- Provide a clear explanation of what is required for approval of stormwater management plan submittals.
- Improve the quality and consistency of installation of stormwater facilities, with a high level of workmanship, according to the approved stormwater management plan.
- Meet community needs for minimizing the impacts of new development and redevelopment projects on existing stormwater management facilities.

This Manual was developed with the assumption that its user will possess a basic understanding in the area of civil engineering design, construction, and / or land alteration. Readers of this Manual which are not qualified by education and/or experience in the field of construction, engineering, and / or land alteration should consult with a more qualified person or persons possessing professional expertise in one or more of these fields prior to application of the requirements set forth herein.

This Manual, together with all future revisions, shall be referred to as the "City of Indianapolis Stormwater Design and Construction Specifications."

101.02 Applicability

This Manual applies to all projects as stated and defined in Section 561–103, Land alterations to be accomplished in accordance with drainage requirements, and Section 561–109, Land alteration defined, of the City Code. These sections of the City Code state that any land alteration must be accomplished in conformity with stormwater requirements where the definition of land alterations shall mean any on-site or off-site action taken relative to land which either:

1. Changes the contour;
2. Changes the runoff rate or volume (e.g., the rate at which water is absorbed);
3. Changes the elevation;
4. Changes the drainage pattern;
5. Creates, removes, or changes a stormwater facility;
6. Involves construction, enlargement or location of any building on a permanent foundation;
7. Changes the delivery of point and/or non-point source pollution to streams;
8. Creates an impoundment; or
9. Disturbs soil on a levee, dam or within a levee or dam easement.

Land alteration includes (by way of example and not of limitation) terracing, grading, excavating, constructing earthwork, draining, installing drainage tile, filling and paving.

Each approved phase of a multi-phased project is considered a single project for the purposes of complying with this Manual. Master plan approval does not constitute automatic plan approval for each phase. Each phase shall comply with current requirements at the time of approval.

This Manual should be used in conjunction with Chapter 561 of the City Code. Additional requirements related to land alteration may be found in Chapters 740, 741, 742, 743 and 744 of the City Code, which are collectively known as the Zoning Ordinance for Marion County, Indiana. Exceptions to the provisions of this Manual are provided in Section 561–221(b), When drainage permits required; enforcement; exceptions, of the City Code.

101.03 Stormwater Manual Organization

The Manual is organized to present the technical and engineering procedures and criteria needed to comply with the City of Indianapolis' stormwater requirements and the Zoning Ordinance for Marion County, Indiana found in the City Code. In addition, general design policy and procedures are presented.

Each chapter contains an initial section that presents the policies and procedures that must be met for approval. These policies and procedures shall be considered as design criteria that are unique for approval within the City.

101.04 Administrative Procedure

The process of updating this Manual will be in accordance with Section 561–321, Authorization to promulgate regulations, of the City Code. This Manual will be updated and revised, as necessary, to reflect up-to-date engineering practices and information applicable to the City of Indianapolis' jurisdiction. Changes to the Manual will be posted on the City's website as they are produced.

101.05 Abbreviations and Definitions

Whenever in these Standards or in any documents or instruments where the Standards govern, the following terms, abbreviations, or definitions are used, the intent and meaning will be interpreted as follows:

Abbreviations	Definitions
AEP	Annual Exceedance Probability
ASTM	American Society of Testing and Materials
AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
BMP	Best Management Practice
BNS	Department of Business and Neighborhood Services
BOD	Biochemical Oxygen Demand
CADD	Computer Aided Design and Drafting
CCTV	Closed Circuit Television
CEG	Citizens Energy Group
CFS	Cubic Feet per Second
CMP	Corrugated Metal Pipe
CSGP	IDEM's NPDES Construction Stormwater General Permit
DDSS	Digital Data Submission Standards
DMD	Department of Metropolitan Development

DPW	Department of Public Works
ESCP	Erosion and Sediment Control Plan
EPA	Environmental Protection Agency
Ft	Feet
GIS	Geographic Information System
HDPE	High Density Polyethylene
HDPP	High Density Polyethylene Pipe
HGL	Hydraulic Grade Line
IAC	Indiana Administrative Code
IC	Indiana Code
IDEM	Indiana Department of Environmental Management
IDM	Indiana Department of Transportation Indiana Design Manual
IDNR	Indiana Department of Natural Resources
INDOT	Indiana Department of Transportation
IndyGIS	Indianapolis Graphic Information System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M	Operations and Maintenance
PP	Polypropylene
PVC	Polyvinyl Chloride
RCP	Reinforced Concrete Pipe
SWCD	Soil and Water Conservation District
SQU	Stormwater Quality Unit
SWPPP	Stormwater Pollution Prevention Plan
TIR	Technical Information Report
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids

ACCEPTANCE: The formal written acceptance by the Division or Department of an entire project which has been completed in all respects in accordance with the approved plans, specifications, and this Manual including any previously approved modifications thereof.

ADMINISTRATOR: Administrator of the Department of Business and Neighborhood Services (BNS), or their authorized representative.

ANNUAL EXCEEDANCE PROBABILITY: The probability that a flood of a given magnitude will occur within a period of one year.

ANTECEDENT SOIL MOISTURE CONDITIONS: Soil moisture conditions of the watershed at the beginning of a storm. These conditions affect the volume of runoff generated by a particular storm event. Notably they affect the peak discharge only in the lower range of flood magnitudes. As the frequency of a flood event increases, antecedent moisture has a rapidly decreasing influence on runoff.

APPLICANT: The property owner and/or their agent who requests and fills out an application for any type of permit or agreement required by this Manual.

APPROVAL: Decision that allows the applicant to proceed to the next step of the permitting process set out

in this Manual.

BACKFILL: Material used to replace material removed from trenches during construction which is above the bedding. The initial backfill (the fill from above the bedding to 12" above the pipe) may vary from structural fill to native soil depending on the pipe material and distance from the edge of pavement. (See Figures 501-03 through 501-11 in Appendix 500: Standard Details).

BEDDING: The material used in the trench to a minimum depth below the bell/barrel of the pipe for the purpose of properly supporting the pipe (See Figures 501-03 through 501-11 in Appendix 500: Standard Details).

BMP OWNER: The property owner.

BMP, GENERAL: Best management practice can refer to a structural stormwater management measure (e.g., wetland, pond, hydrodynamic separators, sand filter) or non-structural stormwater measure (e.g., restrictive zoning, reduced impervious areas). BMPs are designed for the benefit of water quality and/or quantity control.

BMP, MANUFACTURED: Manufactured BMPs are wholly or partially prefabricated and delivered to a construction site for incorporation into the drainage system. Hydrodynamic separators are examples of manufactured BMPs.

BMP, NATURAL: Natural BMPs are practices that utilize the infiltration and filtering processes of water flowing through vegetation, sand, soil, or other vegetated media to remove suspended and/or dissolved pollutants from runoff. Examples include biofilters, rain gardens, and vegetated swales.

BMP, NON-STRUCTURAL: Non-structural BMPs are comprised of a wide range of activities and/or practices that control or reduce pollutants at their sources. Practices can include the use of natural processes, such as increased infiltration and bio-filtration, good housekeeping practices such as street sweeping or catch basin cleaning, or reduction of directly connected impervious areas. Activity based BMPs include public education, outreach, and involvement activities, such as drain marking and creek clean ups.

BMP, STRUCTURAL: Structural BMP, for the purposes of this Manual, are BMPs that are constructed on site. Detention ponds, artificial wetlands, sand filters, and bio-filters are examples of structural BMPs.

BNS: The Department of Business and Neighborhood Services – City of Indianapolis.

BOARD: The Board of Public Works – City of Indianapolis.

BRIDGE: A conveyance structure that is hydraulically short and twenty (20) feet or larger in total span length.

CITY: The City of Indianapolis.

CLEAN FILL: Uncontaminated non-water-soluble, non-decomposable, inert solid, such as rock, soil, gravel, concrete, and/or clay products. Clean fill shall not mean processed or unprocessed mixed construction and demolition debris, including, but not limited to, wallboard, plastic, wood or metal. The non-water soluble, non-decomposable inert products generated from an approved Class B recycling facility are considered clean fill. Clean fill cannot include any hazardous material and must comply with environmental regulations.

CLEARING AND GRUBBING: The removal and disposal of trees, stumps, roots, logs, shrubs, grass, weeds, fallen timber and other undesirable surface materials.

CITY CODE: Municipal Code of the City of Indianapolis

COMBINED SEWER: A sewer which has been designed or intended to receive both surface runoff and sanitary sewage.

CONTRACTOR: Any Contractor who meets DPW's requirements and is licensed by BNS to enter into contracts for and to perform the work of installing storm sewers.

CONTRIBUTING DRAINAGE AREA: The total area that contributes runoff upstream of a point of interest, such as a development site.

COUNTY: The county of Marion, State of Indiana.

CRITICAL DEPTH: The depth of flow at which the specific energy is a minimum. An example of critical depth is the depth at which water flows over a weir when no other backwater forces are involved. For a given discharge and prismatic cross-section geometry there is only one critical depth.

CULVERT: A structure that conveys any flow collected in an open-ended pipe (i.e., headwall, flared end section, mitered end on both ends); a cross-drain. Typically, this is through a roadway embankment or past some other type of flow obstruction.

DEDICATION: The offering and acceptance of a storm sewer facility for public ownership, operation, and maintenance. Inspection, and if necessary, the rehabilitation of an existing storm sewer facility may be required.

DEPARTMENT: Department of Public Works, City of Indianapolis.

DEPRESSION STORAGE: The natural depressions within a watershed which store runoff. Generally, after the depression storage is filled runoff will commence.

DETENTION: Any process or facility that temporarily detains stormwater runoff, reducing the peak flow rate from the drainage area. Frequently, a detention facility will prolong the duration of the runoff event hydrograph.

DIGITAL DATA SUBMISSION STANDARDS (DDSS): Standards in which the City of Indianapolis can integrate CAD drawings into the GIS environment thus maintaining the integrity and positional accuracy of the data.

DIRECTOR: Director of the Department of Public Works, City of Indianapolis, or their authorized representative.

DIVISION: Division of Construction and Business Services of the Department of Business and Neighborhood Services, City of Indianapolis.

DRAINAGE FACILITIES: Ditches, drains, bioswales, rain gardens, channels, conduits, culverts, forebays, hydrodynamic separators, pervious and permeable pavements, pipes, retention or detention systems, tiles, swales, sewers, levees, dams, floodwalls and other natural or artificial means of conveying or draining stormwater from land, or for, controlling and managing quantity of stormwater or removing pollutants from stormwater.

EASEMENT: Areas along the line of drainage facilities which are outside the road easements or rights-of-way and are recorded and dedicated to the Department granting rights along the line of the drainage facility.

EFFECTIVE DRAINAGE AREA: The drainage area from a specific site, excluding offsite drainage, where offsite drainage either does not exist or bypasses the site through culverts or other means.

ENGINEER: The Engineer for the Owner.

ENVIRONMENTALLY SENSITIVE AREAS: Areas to be protected from sedimentation and other pollutants such as jurisdictional waterways (wetlands, creeks and the like) and storm sewer systems.

EXISTING CONDITIONS: The site conditions that existed on the property twelve (12) months prior to the date of application for a drainage permit. Pre-developed conditions may include conditions prior to any

development.

FIELD TILE/SUBSURFACE DRAIN: Under drain systems in fields that have been installed for the purpose of dewatering fields that are subject to seasonably high-water tables. Subsurface drains may also be employed in non-agricultural areas.

FINAL BACKFILL: Material used to replace material removed from trenches during construction which is above the structural backfill (See Figures 501-03 through 501-11 in Appendix 500: Standard Details).

FIRST FLUSH: The onset of the rainfall/runoff process wherein most loose, unattached pollutants on the land or street surface are readily entrained into the stormwater runoff and wash off the surface into the drainage facilities. For many pollutants, the highest concentrations during the runoff event will occur during the first flush. The first flush may be considered the runoff from rainfall up to a specified depth such as a one (1) inch of rainfall.

FLOATING DEBRIS (FLOATABLES): Any material that, due to its physical properties, will float on the surface of water. For the purposes of this Manual, the term does not include naturally occurring floatables, such as, but not limited to, leaves or tree limbs.

FOOTER DRAINS: Any network of pipes, pumps or drainage mechanisms located at, near, or under a footing, foundation or floor slab of any building or structure that intentionally or unintentionally conveys groundwater away from a building or structure.

FREE OUTLETS: Outlets where the tailwater is equal to or lower than critical depth. For culverts and storm drains having free outlets, lowering of the tailwater has no effect on the discharge or the backwater profile upstream of the tailwater.

FREEBOARD: An additional elevation regarded as a safety factor, above the peak design water elevation.

FREQUENCY: The average time interval between equal magnitude floods or rainfall events. For example, a twenty-five (25) -year flood has a four (4) percent chance of occurrence in any given year.

HAUNCHING: The area in the trench from the top of the bedding to the springline of the pipe. (See Figure 501-04 in Appendix 500: Standard Details).

HYDRAULIC ROUGHNESS: A composite of the physical characteristics that influence the flow of water across a surface, whether a natural, a channelized surface or an enclosed conveyance such as a pipe. It affects both the travel time of a watershed and drainage conveyance.

HYDROGRAPH: Graph of time vs. flow of runoff at a point.

HYETOGRAPH: Graph of time vs. rainfall.

IMPERVIOUS AREA: Areas where the land surface has been altered in a matter that decreases the amount of rainwater infiltration. Impervious surfaces include rooftops, roads, parking areas, patios, and other surfaces that retard the infiltration of rainwater or snowmelt into the ground.

INFILTRATION: The complex process of rainfall or runoff penetrating the ground surface and flowing through the upper soil surface. The infiltration curve is a graph of the time vs. infiltration.

INITIAL BACKFILL: Material used in the trench above the haunching. (See Figure 501-04 in Appendix 500: Standard Details).

INNOVATIVE BMP: Innovative BMPs, for the purposes of this Manual, are any BMPs that are not on the list of traditional structural BMPs identified in Section 702 of this Manual. Innovative BMPs are primarily, though not exclusively, manufactured stormwater quality units.

INSPECTION CONSULTANT: Firm contracted in a Professional Services Agreement with the City for the inspection of a public or private project.

INTERCEPTION: Storage or retention of rainfall on foliage and other intercepting surfaces during a rainfall event.

INVERT: Flowline of a culvert or pipe (inside bottom).

LAG TIME (T_l): The time from the centroid of the excess rainfall to the peak of the runoff hydrograph.

LAND DISTURBANCE: Any manmade change of the land surface, including: removal of vegetative cover that exposes the underlying soil, excavating, filling, transporting, and grading.

LAND SURVEYOR: A person registered as a professional land surveyor by the Indiana State Board of Registration as provided by Indiana Code (IC) 25-21.5.

MAINTENANCE: Maintenance activities include cleaning, spraying, removing obstructions from, cutting vegetation from, performing task in the Operations and Maintenance Manual, and making repairs in a drainage facility so that it will perform the function for which it was designed and constructed. Maintenance activities do not require a drainage permit as defined in Section 561-221 of the City Code.

MANHOLE: A structure used in a sewer system to provide access for maintenance.

MANUAL: The City of Indianapolis Department of Public Works Stormwater Design and Construction Specifications Manual.

MANUFACTURER: The producer of those materials required by this Manual having direct responsibility and authority for the satisfaction of those minimum material specifications set forth herein.

NEW CONNECTION: A connection to the drainage system, or a repair, replacement or modification to an existing drainage system element that increases the flow to the system.

OFFLINE STRUCTURE: BMPs that treat only a fraction of the site stormwater runoff for water quality purposes by diversion from another structure. Flows not treated by the BMP bypass the structure and re-enter the watercourse below the BMP.

OWNER: Any individual, partnership, firm, corporation or other entity who, as property owner, is initiating the Work.

PARTIALLY SUBMERGED OUTLET: An outlet whose tailwater is higher than critical depth and lower than the height of the pipe.

PEAK DISCHARGE (Q_p): The maximum rate of flow of water passing a given point during or after a rainfall event. Also called the Peak Flow.

PERMIT: Clearance to perform specific work under specific conditions at specific locations.

PLANS: Construction plans which show the location, character, dimensions, and details of the work to be done.

PROFESSIONAL ENGINEER: A person registered as a professional engineer by the Indiana State Board of Registration for Professional Engineers under IC 25-31.

RAINFALL EXCESS: Excess water available to runoff after interception, depression storage, and infiltration have been satisfied.

RECONSTRUCTION/REHABILITATION: Any change to the original design and construction of a drainage feature, including its capacity. Reconstruction/rehabilitation activities require a drainage permit.

RECORD DRAWINGS (AS-BUILTS): Plans certified, signed and dated by a professional engineer or land surveyor registered in the State of Indiana, indicating the Plans have been reviewed and revised, if necessary, to accurately show all as-built construction and installation details including, but not limited to, key elevations, locations and distances. Record Drawings shall comply with the DDSS and be inclusive of all submittal requirements within the DDSS and will include Record Digital GIS Data, Record Digital Plan Data, Record Reproducible Plans, and attribute tables.

REDEVELOPMENT: Any construction, land alteration, or improvement where structures are removed, expanded and/or replaced.

REGIONAL DETENTION/RETENTION: Regional facility which provides stormwater quality and/or quantity benefit for an area upstream of the property.

RETENTION: A practice or structure whose primary focus is to retain stormwater on-site through evapotranspiration or infiltration.

RIGHT-OF-WAY: All land or interest therein which by deed, conveyance, agreement, easement, dedication or process of law is reserved for or dedicated to the use of the general public, within which the Department shall have the right to install and maintain drainage facilities.

SEWER: A pipe for carrying wastewater (sanitary sewer), stormwater (storm sewer) or a combination of both (combined sewer). Wherever in this Manual the word “sewer” is used without distinguishing type, “sewer” shall mean storm sewer.

SPECIFIC ENERGY: The sum of the depth and velocity head of the flow. Sometimes called "specific head."

STAGE: The elevation of the water surface above a specified elevation datum.

STANDARD DRAWINGS (DETAILS): The drawing of structures, storm sewer lines or devices commonly used and referred to on the Plans and in this Manual.

STANDARDS: The City of Indianapolis Department of Public Works Stormwater Design and Construction Specifications Standards, also known as the Manual. The requirements for the design and construction of drainage facilities within the City of Indianapolis as contained herein and all subsequent additions, deletions or revisions.

STOP WORK ORDER: An order requiring the suspension of the pertinent construction activity for any construction project within the City.

STORM DRAIN: Underground pipe system designed to intercept and convey stormwater runoff to an adequate outlet.

STORMWATER FACILITIES: See DRAINAGE FACILITIES.

STORMWATER QUALITY MANAGEMENT: A system of natural BMPS, structural BMPS, and other measures that reduce or eliminate pollutants that might otherwise be carried by surface runoff.

STORMWATER: Any flow occurring during or following any form of natural precipitation and resulting therefrom.

STRUCTURE: See Section 740-202 of the City Code.

SUBMERGED INLET: An inlet having a headwater greater than 1.5 times the diameter.

SUBMERGED OUTLET: An outlet having a tailwater elevation higher than the crown of the pipe.

TAILWATER: Standing or running water, and specifically its elevation, outside the downstream or outlet end of a culvert or storm drain system.

TIME OF CONCENTRATION (t_c): The time required for water from the most remote point of the drainage basin to enter into the stormwater facilities being analyzed. Thus, the time of concentration is the maximum time for water to travel through the watershed, which is not always the maximum distance from the outlet to any point in the watershed.

TREATMENT TRAIN: A treatment train consists of more than one BMP in series treating stormwater runoff. Such configurations are necessary when BMPs individually cannot meet either the 80% TSS reduction and/or floatable control requirements.

UNIFORM FLOW: Flow in a conveyance of constant cross section having a constant discharge, velocity and depth of flow throughout the reach. In uniform flow, it is assumed that the depth of flow is the same at every section of the conveyance.

UNIT HYDROGRAPH: The direct runoff hydrograph resulting from a rainfall event which has a specific temporal and spatial distribution and which lasts for a specific duration of time (thus there could be a 5-, 10-, 15-minute, etc. unit hydrograph for the same drainage area). The ordinates of the unit hydrograph are such that the volume of direct runoff represented by the area under the hydrograph is equal to one inch of runoff from the drainage area.

WATERBODY: Any area that in a normal year has water flowing or standing above ground to the extent that evidence of an ordinary high-water mark, as defined by the IDEM, is established.

WATERSHED: A drainage area or region consisting of all the land from an identified, delineated or circumscribed drainage divide draining to a single identified drainage outlet or stream mouth.

WORK: All the activities to be done under the permit, in accordance with the approved plans, specifications, this Manual, and permit conditions.

101.06 Enforcement of Standards

Failure to comply with requirements set forth by this Manual may necessitate enforcement actions by the Administrator or Director of BNS in accordance with Sections 561–261 through 266 of the City Code.

101.07 Penalties

Any person violating any provisions of this Manual shall be subject to the penalties in accordance with Section 561-265 of the City Code and may be required to correct such violation at their expense.

Section 102. Plan Submittal Policy and Procedures

102.01 Professional Certification

Site plans, specifications, and supporting computations shall be prepared by a registered professional as defined in Section 561–224 of the City Code and submitted to BNS, for review and approval prior to the initiation of any on-site land alteration as required by Section 102.03, “Platted Subdivisions, Commercial, and Industrial Developments” of this Manual**.** The certification should be in the form: prescribed by the Division, in accordance

with Section 561-224 of the City Code.

102.02 Plan Submittal and Approval Process

A stormwater permit may be issued if the criteria listed in Section 561–222, Eligibility to obtain permit, and Section 561–223, Application, issuance, of the City Code have been met. As a general rule, all land alterations will require a:

1. Drainage Permit Application;
2. Stormwater Plans;
3. Technical Information Report;
4. Erosion and Sediment Control Plan or SWPPP;
5. Operation and Maintenance Manual for all detention, stormwater, water quality structures, and conveyances; and
6. Digital submittal in compliance with the Digital Data Submission Standards (DDSS).

Each of these is described in the following Sections. Every site development project is different in nature and scope and thus may result in the plan approval process being altered to accommodate the specific considerations of the project. Therefore, the designer should consider a pre-design meeting at which any alterations to the plan submittal process are discussed and documented.

Progress toward completion of approved drainage plans and associated drainage permits is subject to the time constraints defined in Section 561-224, Professionally prepared and certified drainage plans, and Section 561-226, Expiration of permit by operation of law; extensions, of the City Code.

The zoning of any properties for which drainage permits are applied must be consistent with the proposed land use before drainage permits will be approved.

Work and on-site land alteration, including clear cutting, stump removal, grading, and filling, shall not commence prior to approval of a drainage permit and installation of all sedimentation and erosion control devices required by the approved permit.

102.03 Platted Subdivisions, Commercial, and Industrial Developments

Stormwater plans shall be submitted to BNS for approval for sites that comply with the criteria listed in Section 561-222, “Eligibility to obtain permit,” and Section 561-223, Application, issuance, of the City Code. In addition to the requirements listed in Section 561-224(a) of the City Code, the following information must be submitted for approval:

1. Construction Features. The stormwater plan shall demonstrate and describe surface and subsurface drainage and include the following:

    a. Stormwater Plan: The stormwater plan shall be drawn to scale, preferably one (1) inch per fifty (50) feet, or a sufficient scale to accurately depict all features that affect stormwater design, and an arrow indicating north shall appear on each page. Plans shall be presented on standard architectural paper sizes. Due to filing limitations, if not submitted digitally, the stormwater plan shall be presented on a maximum plan sheet size of twenty-four (24) inch by thirty-six (36) inch. Existing land contours shall be shown, with one-foot contours for land with a slope flatter than ten (10) percent, two-foot contours for slopes equal to or greater than ten (10) percent but flatter than twenty (20) percent, and five-foot contours for slopes equal to or greater than twenty (20) percent. Proposed on-site land contours shall be shown at one-foot contour intervals except where slopes are steeper than twenty percent (20%). Off-site watershed boundary maps shall be submitted at an appropriate contour interval sufficient to depict drainage areas and slopes. A benchmark, which is easily accessible and relocatable, shall be shown.

The benchmark may be assumed at the discretion of BNS if the area contains less than three (3) acres, but otherwise shall be determined by USGS datum.

b. Cover Sheet: A cover sheet shall be provided, including location and vicinity map. A map that indicates the location and vicinity of the proposed land alteration shall be included in the stormwater plan. It shall reference a nearby major roadway intersection. The cover sheet shall also include site address, as assigned by BNS, the BNS Compliance Information Block and a stormwater structure summary table. The summary table shall provide each proposed pipe size and respective length with the number of proposed structures. The cover sheet shall also include a table listing all stormwater BMPs with their State Plane center coordinates.

c. Existing and Proposed Stormwater Facilities: The stormwater plan shall show the locations of all existing and proposed stormwater facilities. Storm drains, manholes and other structures shall be located by dimensions from traverse lines, property markers or road centerlines. Coordinates of manholes and bearings of storm drains shall be included and based either on the State of Indiana's coordinate system or latitude and longitude. Indiana's State Plane Coordinate System shall be used to identify the location of the outlet of each BMP included it the plan. If applicable, the stormwater plan shall show the direction of flow, elevation of inverts, gradient, materials and size of existing and proposed storm drains. If applicable, the drainage plan should show the direction of flow, elevation of inverts, gradient, and size of existing and proposed storm drains. The design calculations shall include the capacity of existing and proposed storm sewers.

d. Storm Drain Plan and Profile for all Class 1 pipe (within the right-of-way or conveying runoff from more than one parcel), a plan and profile shall be submitted. The plan shall be shown on the upper portion of the drawing. Generally, the plan shall be drawn on a scale that is clear and legible and not greater than one (1) inch equals fifty (50) feet.

   The plan shall show appropriate right-of-way and easement limits with instrument numbers, as applicable. The profile shall be shown under the plan and shall extend a sufficient distance downstream of the outlet to allow any pertinent information concerning the outfall channel to be shown. All invert elevations and pipe slopes shall be listed. For each pipe the length, size and material shall be annotated on the profile sheet near the dimension line. Detail title and/or number references shall be called out on the profile plan.

   Generally, the storm drain and inlet profile shall be drawn on a horizontal scale equal to the plan and with a vertical scale of one (1) inch equals five (5) feet. Where a storm drain is located inside the limits of an existing or proposed pavement or shoulder, the center line grade of the road shall be shown. Where a storm drain is located outside pavement or shoulder, the existing ground over the storm drain with proposed grading shall be shown. If the storm drain is to be constructed on fill, the profile of the undisturbed earth, at the storm drain location, shall be shown. All utility locations at intersections with the storm drain shall be shown.

e. Soil Type(s) and Location: The location of the predominant soil types on the site shall be described by a registered land surveyor or professional engineer. The description may be determined by the NRCS (Natural Resources Conservation Service) County Soil Survey or equivalent publication or by a certified professional soil scientist.

2. Additional Information. Administrator shall be empowered to require such additional information to be included in a drainage plan that is necessary to evaluate and determine the adequacy of the proposed drainage facility.

3. Certification Required. All stormwater plans submitted under this section to BNS for approval must be prepared by a registered professional engaged in storm drainage design, as specified in Section 561-224(a)(6) of the City Code, under whose supervision the plans were prepared. The certificate shall be in the form as prescribed by the Division in accordance with Section 561-224 of the City Code.

102.04 Technical Information Report

A completed Technical Information Report (TIR) which provides a summarization of calculations, existing site conditions, specific problem areas identified during site inspections, known neighborhood concern(s), zoning commitments related to stormwater management, downstream conditions/restrictions with a justification for the level of downstream analyses performed, and a brief description of the planned stormwater management techniques which will be utilized to address these conditions is required as part of the stormwater permit application. Each page and attachment of the TIR should be numbered and dated.

Included with this Technical Information Report shall be the following information:

1. Design Calculations. Design calculations are required as part of the stormwater plan and shall accord with the requirements of Section 561-224 of the City Code and, at a minimum, include:

    a. Estimation of stormwater runoff. Runoff rates during the design and 1% AEP(Q_{100}) return interval storms; C-values or runoff curve numbers; and computed times of concentration. A time-of-concentration and time-of-travel calculation sheet has been provided in Appendix 200. A C-value or runoff curve number computation sheet has been provided in Appendix 200. Guidelines for determination of basin times-of-concentration and runoff rates are presented within Chapter 200 Hydrology, of this Manual.

        (1) Drainage area calculations including both the gross and impervious area for each drainage basin/sub-basin;
        (2) Weighted curve number or runoff coefficient computations;
        (3) Time of concentration computation indicating overland flow time, shallow concentrated flow time, and flow time in the swale, gutter, pipe and/or channel.

    b. Inlet grate and gutter flow computations as described in Sections 305.07 and 305.08 of this Manual.
    c. Closed conduit and open channel design computations:

        (1) Size of pipe or channel cross section;
        (2) Pipe or channel inverts and slope in percent;
        (3) Material and roughness coefficient;
        (4) Flowing velocities in feet per second;
        (5) Design capacity in cubic feet per second as per Section 305.03 of this Manual.

    d. Storm drain flow and hydraulic grade line computations as described in Sections 305.03 and 305.04 of this Manual.
    e. Erosion control methods and design calculations shall conform to the standards of Section 102.05 of this Chapter and all regulations promulgated there under.
    f. BMP calculations illustrating the computation of TSS removal, water quality volumes, pollutant load removal, etc., shall be submitted in compliance with Chapter 700 of this Manual.
    g. Stormwater quality considerations including potential contaminates in compliance with Section 104.02 Stormwater Quality.
    h. Existing features. Verification that existing water quality and quantity features to remain anywhere on the parcel have been inspected and maintained to function as originally designed and permitted.
    i. The report should also address the existence of any environmentally sensitive areas, any steps for mitigation of those areas and all regulatory permits required.
    j. Drainage Area Map: A drainage area map shall be presented which indicates all existing and proposed on-site and off-site drainage areas and flow paths to stormwater facilities, and the limits of the FEMA floodplain for all areas with contributing drainage watersheds of five acres or greater in accordance with Chapter 300, Section 303.02 of this Manual;

2. An explanation of computer models used, where applicable, with information on input and output data.
3. Detention/retention summary information including existing and proposed release rates, storage volumes, etc.
4. Statement on existing contaminated soils, contaminants present, location and design considerations to

prevent contaminants from entering the storm sewer, waterways, or movement off-site both during construction and post-construction. The Designer shall include a statement when no existing contaminates are known to be present.

102.05 Erosion and Sediment Control Plans

As stated in Section 561-381, Conformance with minimum standards for land alterations, of the City Code and Chapter 600 of this Manual, erosion and sediment controls are required for all land disturbing activities of any size.

If the Owner or Operator is required to prepare a Stormwater Pollution Prevention Plan (SWPPP) per the CSGP, such plans shall fulfill the requirements of this Manual and Section 561 – DRAINAGE AND SEDIMENT CONTROL of the City Code. In this case, all applicable state and federal permits or notices for land disturbing activities shall be obtained or filed prior to commencement of land disturbing activities. All applicable state and federal standards shall be adhered to when conducting land disturbing activities. Copies of all applications, letters of intent submittals, plans and other erosion and sediment control related information developed for and/or submitted to state or federal authorities shall be included in the Drainage Permit Application.

Details concerning erosion and sediment controls can be found in Chapter 600 of this Manual. Details concerning the SWPPP can be found on the IDEM website.

102.06 Operations and Maintenance Manual

An operations and maintenance manual ("O&M Manual") for all public and private infrastructure, including but not limited to pipes, ponds, ditches, and stormwater quality and/or quantity BMPs, shall be submitted for the plan approval. The O&M Manual will become a maintenance guide for the drainage infrastructure once development is complete. The final O&M Manual will be provided to the City in a digital format. The O&M Manual and maintenance agreement shall be recorded prior to issuance of the drainage permit. The O&M Manual shall include the following:

1. Owner name, address, business phone number, home phone number, email address, cellular phone number;
2. Site drawings (8½" by 11" or 11" by 17"), showing both plan and cross-section views, showing the infrastructure and applicable features, including dimensions, easements, outlet works, forebays, all water quality and quantity BMPs inspection and maintenance features (ports, access drives and cleanouts), signage, etc., as well as an overall site map of the development showing all structures;
3. A stormwater management easement is required for each facility. The easement must include the BMP, all outlet structures and access to the BMP;
4. Requirement of current Owner to perform periodic inspections and maintenance, annually at minimum and as necessary to confirm the system is functioning as designed and permitted;
5. Frequency of required inspection and maintenance for each BMP;
6. Requirement of current Owner to keep logs and records of inspections and maintenance activities;
7. Requirement of current Owner to self-certify when requested by the City that inspections and maintenance was performed according to the O&M Manual;
8. Requirement of the current owner to remove and replace filter media as need, determined by infiltration rate, drain down time, percolation test, etc.;
9. Page numbers;
10. Guidance on owner-required periodic inspections and maintenance, including inspection and maintenance forms specific to each water quality and quantity BMP type. These forms shall include all applicable operations and maintenance concerns including, but not limited to:

    a. Address and general location of BMP
    b. Type of BMP
    c. BMP Unique ID (SWQ# will be assigned by City after construction is complete)
    d. Owner name, address and phone number

e. Name of inspector
f. Inspector company & contact information
g. Date and time of inspection
h. Weather conditions
i. Date of last maintenance
j. Note if items are satisfactory/unsatisfactory
k. Location for comments, actions required and additional notes.
l. Known complaints (residents, adjacent property owners, etc.)
m. Public hazards
n. Encroachments into the easements
o. Sediment, litter, floatables and/or debris
p. Sediment depth (specify depth at which cleaning is required)
q. Sediment depth marker
r. Channel erosion at inlet, outlet, emergency spillway, shoreline, etc.
s. Rill erosion on slopes (pond slopes, embankments, etc.)
t. Adequate and functional scour protection
u. Vegetation composition and size according to approved plan
v. Vegetation health
w. Grass and/or other vegetation height
x. Vegetation damage
y. Invasive species
z. Vegetation blocking the flow path, capacity or otherwise impeding function
aa. Animal burrows, blockages, etc.
bb. Water draining as designed and permitted (specify drain down time)
cc. Water at normal pool, evidence of seepage
dd. Clogging and/or blockage
ee. Flow path deviations
ff. Spalling, cracking, corrosion, structural damage
gg. Tampering and/or vandalism
hh. Elevations as designed and permitted (inverts, level spreaders, emergency spillways, etc.)
ii. Hardened forebay bottom as designed and permitted
jj. System functioning as designed and permitted
kk. Valves functional
ll. Embankment seepage, bulging, etc.
mm. Evidence of illicit discharges (Odors, colored liquids, unusual vegetation, oily sheen, foreign substances, etc.)
nn. Visible, notable pollution present
oo. Reporting protocol if illicit discharge is discovered

11. Guidance, including a checklist on routine maintenance, including mowing, litter removal, woody growth removal, signage, etc.;
12. Guidance on maintenance; such as inlet replacement, outlet works maintenance, etc.;
13. Guidance on sediment and trash removal, both narrative and graphical, describing when sediment removal should occur in order to ensure that BMPs and other infrastructure remain effective as water quality and/or quantity control devices;
14. A statement that the City's representatives have the right to enter the property to inspect the infrastructure;
15. A tabular schedule showing inspection and maintenance requirements; and
16. Identification of the property owner as the party responsible for all inspections and maintenance, including cost.

102.07 One- and Two-Family Dwellings

Site plans for one- or two-family dwellings, additions to one- or two-family dwellings and accessory structures

as described in Section 561-225 "When a professionally prepared and certified drainage plan is not required" shall indicate the nature and location of all work to be accomplished pursuant to the stormwater permit.

In general, the site plan shall be neat, accurate legible and include the following information:

1. The legal description of the property;
2. The exact, legal street address for the property;
3. The dimensions and borders of the parcel;
4. The name and address of the owner;
5. An arrow indicating north;
6. Location of all existing and proposed improvements, structures, paved areas, easements and rights-of-way on the site;
7. Existing and proposed grading showing positive drainage by contouring or sufficient spot elevations;
8. Location and elevation of all existing and proposed swales, ditches, culverts, drainage channels, surface or subsurface drainage devices and the direction of flow;
9. Adequate and appropriate stormwater quality controls including, but not limited to, erosion and sediment controls, dewatering filter, concrete and cementitious washout containment, pollution prevention and inlet protection;
10. Information necessary to demonstrate conformity with all drainage requirements of Section 561, Article III of the City Code; and
11. The plot map shall illustrate the surface drainage pattern of the site away from structures and the final distribution of surface water off-site, either preventing or planning for surface ponding.

All single-family residential construction with land disturbing activities less than one acre shall employ, at a minimum, perimeter type erosion and sediment control practices downslope from the disturbance including, but not limited to inlet protection, filter socks and/or silt fences and gravel construction entrances. Tracking of sediment onto streets is to be minimized through the use of perimeter controls and vehicle access controls and limitations. Other pollutants shall also be properly contained, controlled and disposed of including trash, concrete washout and cementitious washout.

102.08 Blank

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102.09 Deviations from Approved Plans

As stated in Section 561-227, Notice of change in permit information; amendment of permits and plans, of the City Code, material deviations from the approved site development plans and specifications shall not be made without written approval from BNS. Examples of material deviations from the approved plan shall include, but are not limited to, the following changes:

1. Pipe size changes.
2. Pipe grade changes that will affect the hydraulic capacity of the stormwater facilities.
3. Stormwater facility horizontal alignment changes greater than five (5) feet. Where the proposed stormwater facility has been required to be constructed within a right-of-way or stormwater easement, horizontal changes that place the stormwater facility outside of the limits of the right-of-way or stormwater easement area will not be accepted by BNS. Storm drains constructed on privately owned property, outside of public rights-of-way or stormwater easements may vary more than five (5) feet in the horizontal alignment, provided the hydraulic performance of the facility has not been altered, and no other portion of the approved construction plans has been changed. All stormwater quality and quantity BMPs shall continue to be entirely within an easement.
4. Construction materials and installation that are not in conformance with the requirements of this Manual.
5. Changes in grade of the site that will affect the stormwater direction, velocity, amount or concentration or may expose structures or streets to a greater risk of flooding than under approved plans.
6. Changes to stormwater quality and/or quantity BMPs.

102.10 Inspection and Maintenance Responsibilities

The responsibility of inspection and maintenance of stormwater facilities shall be as set forth by Section 561-211, Inspection and Maintenance of drainage facilities, and Section 561-252, Inspection and maintenance of drainage facilities; records, of the City Code.

Inspection and maintenance access shall be provided to stormwater facilities as set forth herein to assure continuous operational capacity of the stormwater facility. As a means of providing the necessary availability for access to stormwater facilities, sufficient stormwater easement areas or rights-of-way shall be required by the Department to achieve satisfactory present and future drainage of the parcel and the area surrounding the parcel as referenced in Section 561-232, Execution of covenant, and Section 561-233, Dedication of easement, of the City Code. In accordance with Section 561-211, Maintenance of drainage facilities, of the City Code, the granting of an easement to the City does not alter the property owner's duty to maintain the property's drainage facilities.

102.11 Performance Sureties

Performance bonds, properly conditioned irrevocable letters of credit or other accepted performance sureties, made payable to the Indianapolis Department of Business and Neighborhood Services, may be required to be submitted as described in Section 561-231, Posting of bond, of the City Code. In accordance with Section 561-231(b) of the City Code, the acceptance of properly conditioned irrevocable letters of credit or other accepted performance sureties is subject to the approval of departments and agencies whose interests are protected by the same bonding requirement. Such bonds or alternative forms of surety, acceptable in accordance with the standards of this Manual and Section 561-231 of the City Code shall name the City of Indianapolis and County of Marion as parties who can enforce the obligations thereunder. These bonds, properly conditioned irrevocable letters of credit, or other accepted performance sureties may be a part of the total bonding required by the plats committee of the City's Department of Metropolitan Development. Performance sureties shall be in a form approved by BNS, and may be based upon the contract amount for the cost to complete proposed site improvements, including:

1. Total installed cost for storm drain pipe, culvert, manhole, and box inlet installation, and
2. Total installed cost for stormwater quality BMPs such as, but not limited, to forebay, SQU, and bioswale installation, and
3. Total cost for site filling and grading, including construction of open drainage swales and detention/retention facilities.

A separate performance surety may be required for the installation of erosion and sediment control measures and regrading of minor drainage collector swales. Erosion and sediment control performance sureties shall be in a form approved by BNS, and may be based upon the contract amount for the cost to complete proposed sediment and erosion control installation including:

1. Re-establishment of erosion and sediment control devices,
2. Re-grading of the site,
3. Seeding or other stabilization of the entire denuded area,
4. Cleaning of the storm drain system, and
5. Reestablishing final grades and elevations for stormwater BMPs.

Prior to the release of the stormwater facility and erosion and sediment control performance sureties, a maintenance bond will be required. This surety will be in an amount not to exceed twenty (20) percent of the cost of construction and cover a period of three (3) years from the date of acceptance by BNS.

Section 103. Construction Inspection and Approval

103.01 Introduction

The installed storm sewer system shall not be accepted by BNS until all requirements for inspection and testing established by this Manual and Section 561 of the City Code, are completed. Inspection of the stormwater drainage system and associated land grading and erosion control measures shall be completed by BNS as set forth herein to monitor conformance with the approved site construction plan and supporting documents. Any portion of the stormwater facility not passing the tests prescribed herein shall be repaired or replaced to the extent required by BNS, and retested.

103.02 General Requirements

A pre-construction meeting to include a representative of BNS, the Inspection Consultant, the Contractor, and the Land Owner or Developer may be scheduled upon request of any party. This meeting will be scheduled by BNS before issuance of a Drainage Permit.

Once construction begins, the contractor shall be responsible for informing and/or notifying the Inspection Consultant assigned of the following:

Daily work schedule including any changes in schedule.
Prior notification if work is to be performed on weekends and/or holidays.
Date mandrel tests are to be performed.
Date post-construction BMPs are installed.
Date "as-built" verification is to be performed.

BNS, upon request of the Contractor and/or Owner, will schedule the Final Inspection.

All testing required shall be performed under the observation of the Inspection Consultant. It shall be the Contractor's responsibility to schedule the testing with the Inspection Consultant and/or BNS. Test results obtained in the absence of the Inspection Consultant will not be accepted.

103.03 Construction Observation Services

Construction observation services, testing, and Record Drawings as set forth in this Manual shall be provided for those developments meeting the following criteria:

1. All platted one- and two-family and all platted commercial/industrial developments;
2. All commercial/industrial developments that will not be subdivided and platted, which however, plan a disturbance of one-half (1/2) acre or more of land area;
3. All land alterations that involve installation of Class I and/or Class II stormwater systems; or
4. All land alterations that require stormwater quality or quantity BMPs.

The storm drain system shall not be accepted by BNS until all requirements for inspection and testing established by this Manual are completed. Any portion of the stormwater facility not passing the tests prescribed herein shall be repaired or replaced to the extent required by BNS, and retested.

Prior to issuance of an approved drainage permit and the commencement of construction of a storm drain system, the Owner shall make arrangements with BNS for construction observation services to be provided.

A pre-construction meeting to include a representative of BNS, the Inspection Consultant, the Contractor, and the Land Owner or Developer may be scheduled by BNS which will include a discussion and observation of the erosion and sediment control measures.
Subject to the exceptions outlined in Section 13-18-27-16(c) of the Indiana Code, a Stop Work Order shall be issued by the BNS for all projects that are proceeding without the required "Notification of Work."

103.04 Drainage Fees

The drainage permit fee schedule is posted on the City's website https://www.indy.gov/activity/license-and-permit-fees.

103.05 Testing and Inspection

Once constructed, all storm sewer pipes and manholes shall be soil tight. The Contractor shall repair to the satisfaction of BNS all visible points of possible bedding and/or backfill infiltration into the system. The method of repair shall be per the approval of BNS. When necessary, the Contractor shall remove and reconstruct as much of the work as is necessary to obtain a system that passes the minimum tests prescribed herein.

1. Mandrel Tests for Plastic Pipes

All storm sewers using flexible pipe shall be tested for deflection by means of a go/no-go mandrel gage or other methods as approved by the Department.

The mandrel deflection test shall be as follows:

1. Waiting Period: The mandrel deflection test shall be done no sooner than thirty (30) days after final backfill has been placed.
2. Equipment:

    a. Mandrels shall be constructed with nine (9) or ten (10) arms. Mandrels with fewer than nine (9) arms are not allowed.
    b. The Length (L) shall be measured between points of contact on the mandrel arm.
    c. The Diameter (D) mandrel dimension shall carry a tolerance of $\pm$ 0.01 inches.

3. Allowable Deflection:

    a. The allowable deflection shall be 5% based on the inside diameter as determined on a case-by-case evaluation of the pipe design.
    b. The Contractor shall provide proving rings to check the mandrel. The proving rings shall be clearly labeled with the dimensions and ASTM Standard.

4. Testing Procedure:

    a. The mandrel shall be hand pulled through all sections of the sewer lines.
    b. Determination of Line Acceptance. If the mandrel can be hand pulled through the entire length of the section tested, the section shall have passed the test.
    c. Determination of Line Failure:

        (1) If the mandrel cannot be hand pulled through the entire length of the section tested, the section shall have failed the test.
        (2) The Contractor shall be required to uncover, replace, or repair any section of sewer not passing the mandrel test.

2. CMP and RCP Inspections

Forty-two (42) inch diameter and smaller reinforced concrete pipe (RCP) and corrugated metal pipe (CMP) may be required to be inspected through closed circuit television viewing (CCTV) by BNS representative as described herein. In those instances, where CCTV is a required part of the drainage permit approval, this televised viewing shall be completed in conformance with these minimum guidelines.

All reinforced concrete and corrugated metal storm sewer pipes which are thirty-six (36) inch diameter and smaller and are located within a public right-of-way or drainage easement shall be visually inspected by lamping in the presence of the Inspection Consultant or other representative of BNS.

Those storm sewer systems of thirty-six (36) inch diameter and smaller which are found through lamping to possess greater than 3 defects noted per line segment during the above referenced visual inspection shall have that individual line segment further inspected by closed circuit television inspection (and recorded) between manholes as follows:

1. A camera equipped with remote control devices to adjust the light intensity and one thousand (1,000) lineal feet of cable shall be provided. The camera shall be able to transmit a continuous image to the television monitor as it is being pulled through the pipe. The image shall be clear enough to enable BNS to easily evaluate the interior condition of the pipe. The camera should have a digital display for lineal footage and project number and an audio voice-over shall be made during the inspection identifying any problems.
2. The pipe shall be thoroughly cleaned before the camera is installed and televising is commenced. Cleaning of the pipe shall be the responsibility of the Owner.
3. The video record of the entire storm sewer line and reproduction map indicating the pipe segment numbers of all the pipe that has been televised shall be submitted to the City for review and placement in their permanent file.

Any pipe and/or joint found to be defective as a result of the televised viewing shall be required to be repaired or replaced to the satisfaction and approval of BNS. A re-televising of that portion of the storm sewer line identified as needing repair or replacement shall be required.

All RCP and CMP storm sewer pipes and open culverts greater than 36" in diameter and located within a public right-of-way or drainage easement shall be visually surveyed along their entire length in the presence of the Inspection Consultant or other representative of BNS.

These inspections shall be required in order to identify, as examples, excessive sedimentation, joint failures, excessive deflections (CMP), damaged coatings or pavings (CMP), structural defects, misalignments, sags, or other system defects which have the potential of affecting the hydraulic performance, durability, or structural integrity of the line segment. Reference should be made to Chapter 400 of this Manual for guidance on criteria sufficient to warrant rejection of the installed storm sewer system.

Excessive deflection of CMPs shall be considered to exist under the following conditions: variations from a straight centerline; elliptical shape in a pipe intended to be round; dents or bends in the metal. Metallic or bituminous coatings that have been scratched, scraped, bruised, or otherwise broken shall be considered acceptable criteria for rejection of the installed system.

Any pipe and/or joint found to be defective as a result of the televised and recorded viewing shall be required to be repaired or replaced to the satisfaction and approval of BNS. A re-televising of that portion of the storm sewer line identified as needing repair or replacement shall be required.

3. Manhole and Box Inlet Inspection

Each manhole and/or box inlet structure within all storm sewer line segments shall be visually inspected by a representative of BNS for excessive leakage, backfill infiltration, or improper workmanship and materials. Manholes or box inlet structures which fail to meet minimum construction standards shall be repaired or, if necessary, replaced, and re-inspected.

4. Erosion and Sediment Controls

The Inspection Consultant shall inspect erosion and sediment controls for compliance with this Manual and Section 561 of the City Code weekly from when the project begins earth disturbance (clearing and grubbing, demolition, grading, etc.) until the drainage permit is closed.

103.06 Release of Sureties

Notice of the scheduled date for completion of construction shall be provided to BNS at least seventy-two (72) hours prior to its planned completion. The Contractor or Owner will schedule the final inspection with the Inspection Consultant. After successful completion of the final inspection, the storm drain and site grading performance sureties may be released after submittal and approval by BNS of the following information:

1. Record drawings prepared under the supervision of and certified by a Professional Engineer or Professional Land Surveyor registered in the State of Indiana and submitted in accordance with the DDSS.
2. For subdivided and platted or developments larger than five (5) acres, a copy of the storm drain maintenance bond in a form approved by BNS.
3. A "Certificate of Completion and Compliance" from the Inspection Consultant certifying that construction observed has been performed and completed in conformity with all requirements of Section 561-241 of Indianapolis City Code and this Manual. The certificate can be found on the City's website.
4. Recording of the O&M Manual(s) for all stormwater quality BMPs and stormwater quantity BMPs.

For platted one- and two-family developments, the performance surety for installation of required erosion and sediment control measures may be released only after construction has been completed on eighty-one percent (81%) or more of all one- or two-family homes proposed within each individual section of the development.

103.07 Record Drawings

As part of the final acceptance process, record drawings of the stormwater facilities must be submitted to BNS, as set forth herein, for the following types of developments:

all platted subdivisions
all public infrastructure
all projects with stormwater quality BMPs
all projects with stormwater quantity facilities
all projects with stormwater infrastructure (12-inch or larger pipe and/or 2-foot bottom or larger ditch)

Record drawings shall be certified by a Professional Engineer or Professional Land Surveyor registered in the State of Indiana, and provide the following information:

1. Building pad elevations.
2. Structure inverts, pipe inverts, top-of-castings, and the flowline of rear and/or side yard swales at fifty (50) foot intervals or at lot lines.
3. Horizontal alignment of storm drain pipes, culverts, BMPs, streets, and storm drain structures, to survey grade accuracy. All BMPs will be located by Indiana State Plane East Coordinates (NAD 1983, US Feet).
4. The as-built survey of all stormwater quantity management facilities as well as as-built profile of all drainage conveyances (ditches, swales, etc.).
5. The horizontal location and/or bank cross sections for all stormwater quantity management facilities or other information sufficient to verify that the constructed stormwater quantity management facility provides the required minimum runoff storage volume.

Record drawings for private and public projects shall meet the requirements of the DDSS and be submitted digitally in accordance with the City's DDSS. Submission documents such as standards, attribute tables, a CAD template, and a submission checklist are available at https://www.indy.gov/activity/public-works-specifications-and-manuals.

103.08 Enforcement of Standards

Failure to comply with those minimum guidelines set forth by this Manual may necessitate one or more of the

following actions to be taken by BNS:

1. Posting of a Stop Work Order on the project;
2. The procurement of performance sureties;
3. A denial of further drainage permits for the subject project in noncompliance with this Manual;
4. Necessary legal action by BNS to affect the implementation of the approved plan or restoration of the site;
5. Issuance of a fine; and/or
6. Revocation of permits pursuant to Section 561-262 of the City Code.

Section 104. Other Requirements

104.01 Floodplain Management

Floodplain management shall be in accordance with Sections 740-201, 740-202, 740-901, and 742-203 of the City Code. The City of Indianapolis has adopted floodplain regulations through the Flood Control District Zoning Ordinance of Marion County, Indiana. The most current effective Flood Control District Zoning Ordinance is on the Indy.Gov website. In addition, all levees constructed will be required to be designed and operated by the Owner in accordance with FEMA and USACE requirements at the time it is designed.

Notwithstanding any other requirements of this Manual or the provisions contained in Sections 740-201, 740-202, 740-901, and 742-203 of the City Code, the City of Indianapolis may, on a case-by-case basis, place additional requirements on developments and redevelopments in areas located in dam failure inundation zones, levee failure residual risk areas, or areas shown as protected by dams, levees, or other flood control facilities.

104.02 Stormwater Quality

The City of Indianapolis and Marion County are subject to the requirements of a Municipal Separate Storm Sewer System (MS4) permit that has been issued by the Indiana Department of Environmental Management (IDEM) under the National Pollutant Discharge Elimination System (NPDES). Under this permit, the City is required to establish regulations, standards, and policies that address the water quality impacts of stormwater runoff from redeveloping areas and areas of new development. The policies set forth in this section are intended to meet the requirements that the City address pollutants of concern in local stormwater runoff and comply with narrative standards in the permit.

Projects that have one half (1/2) acre or more of soil disturbance during construction activities shall install post-construction stormwater quality best management practices (BMPs) to treat stormwater runoff in compliance with Chapter 700 of this Manual.

The pollutants of concern that are to be addressed in stormwater runoff include:

Totals suspended solids (TSS). In 2001 the City adopted a policy that includes the control of stormwater runoff quality based upon the management of TSS. All post-construction best management practices (BMPs) approved for use in the City of Indianapolis are deemed to be capable of meeting or exceeding the TSS removal target when installed as approved.

Floatables. The City's MS4 NPDES Stormwater Permit (No. INS040001) states that floatables, or floating debris are not authorized stormwater discharges. The policy for floatable control in Indianapolis is that the runoff water quality control practices be designed to capture and retain floating material. Individual components of the stormwater control system do not have to comply with this policy, but the final discharge from the site must.

The water quality management program of the City of Indianapolis is performance-based. In a performance-based program it is essential that any approved BMP be properly maintained to ensure that the BMPs perform as designed. An O&M Manual for any approved BMP will be required (see Section 102.06). As will be stated in the O&M Manual, maintenance will be the responsibility of the property/BMP owner. The City encourages the use of high-efficiency, low maintenance BMPs that have the potential for removal of multiple stormwater pollutants.

BMPs defined in Chapter 700 of this Manual as being capable of meeting the specified performance criteria for pollutant removal will be acceptable if designed to the standard specifications in Chapter 700 of this Manual.

The applicant shall consider implications of stormwater on existing contaminated soils and address this concern in the design and Technical Information Report.

104.03 Redevelopment

Redevelopment shall adhere to the following requirements:

1. Redevelopment of sites within the Regional Center Secondary Zoning District that do not comply with current stormwater design standards must limit peak discharges to pre-project conditions or available downstream capacity for the 2- (50% AEP), 10- (10% AEP), 25- (4% AEP), and 100- (1% AEP)-year storm events, the more stringent requirement shall apply. For sites that have more than one (1) outlet under pre-project conditions, the allowable peak discharge to each proposed outlet shall be calculated based on the peak discharge to each pre-project outlet. Redevelopments within the Regional Center Secondary Zoning District that do not comply with current stormwater design standards and disturb less than a half (0.5) acre are exempt from current stormwater quality requirements if the cumulative disturbed area is less than a half (0.5) acre. The cumulative total disturbed area will be evaluated based on City records of permit activity from October 1, 2001.

2. Redevelopment and/or alteration of existing developments that do not comply with current stormwater design standards are exempt from current stormwater quality and detention requirements if the cumulative disturbed area is less than a half (0.5) acre. In-lieu of providing stormwater detention, redeveloped/expanded sites must limit peak discharges to pre-project conditions or available downstream capacity for the 2- (50% AEP), 10- (10% AEP), 25- (4% AEP), and 100- (1% AEP)-year storm events, the more stringent requirement shall apply. For sites that have more than one (1) outlet under pre-project conditions, the allowable peak discharge to each proposed outlet shall be calculated based on the peak discharge to each pre-project outlet. The cumulative total disturbed area will be evaluated based on City records of permit activity from October 1, 2001.

3. Redevelopment and/or alteration of existing developments that exceed a cumulative disturbed area of a half (0.50) acre will be required to comply with the current stormwater regulations for stormwater detention and quality by mitigating two times (2X) the area disturbed up to a maximum of the total site or property area. For example, if a property owner wants to add one (1) acre of parking and plans to disturb one and a half (1.50) acres to do it, the owner would be required to mitigate three (3) acres of development within the same on-site watershed to meet the current stormwater regulations. If there was only an additional three-quarters (0.75) acre of existing contributing drainage area on-site upstream of the disturbed area, the owner would be required to mitigate two and one-quarter (2.25) acres of development. The cumulative total disturbed area will be evaluated based on City records of permit activity from October 1, 2001.

Redevelopment projects that propose to deviate from the stormwater management standards in this Manual must apply for a variance in accordance with the process outlined in Section 561-271 of the City Code.

The complicating factor for many redevelopment projects is the lack of available land on which to develop detention and water quality control facilities. The following paragraphs are intended to provide some guidance on how redevelopment projects can be implemented while still meeting the stormwater design standards. The

Green Infrastructure Supplemental Document, which contains additional guidance on low impact development, can be found on indy.gov.

1. Minimize imperviousness. The best way to minimize the impact of stormwater design regulations on a development is to minimize the impact the development has on stormwater runoff. By building up (multi-story development) rather than out (sprawling one-story development) green space can be incorporated into the site plan resulting in reduced stormwater infrastructure needs, costs, and stormwater user fees. The use of green development techniques, as discussed in Section 104.04 of this Manual, can also result in lower infrastructure costs and reduced stormwater user fees.
2. Go to the rooftop. If the project has issues that would make ground level or below ground stormwater management infrastructure impractical it might be possible to address storage and/or water quality issues by looking at the rooftops for detention storage and/or water quality control. Rooftop detention can be employed in conjunction with stormwater quality units to meet the City's water quality standards. The green roof concept provides detention of stormwater runoff and reduces runoff by vegetative interception and evapotranspiration.
3. Go underground. If reduced imperviousness, rooftop alternatives, and green design are not practical, the on-site stormwater management program may be provided below ground. There are numerous storage system solutions for use under parking lots that can provide the detention capacity control and storage volume needed for most projects. These solutions can be integrated with in-ground stormwater quality units to also meet the water quality control requirements of the City.

104.04 Green Development Incentives

Green development techniques lessen the impact of development and redevelopment on downstream drainage area by reducing the amount of impervious surface. Although some of the "green" options do not recreate natural conditions, they approximate those conditions to the extent that they lower runoff curve numbers, reduce "heat island" effects, and help to reduce pollutants via infiltration and evapotranspiration. The net result is that less impervious surface may lower runoff peak flows, lower runoff volumes, and lower pollutant export. For the post-construction property owner, the reduced imperviousness may mean lower stormwater user fees.

Examples of the types of features that might be part of a green design approach include:

Green roofs
Roof gardens
Pervious pavement
Tree planting
Vegetated swales
Grassy swales
Street swales
Vegetated filter strips
Biofiltration
Rain gardens
Vegetated infiltration basins
Sand filters
Wet, extended wet, and dry detention ponds
Stormwater wetlands
Manufactured treatment technologies
Structural detention facilities
Rainwater harvesting
Drywells

Class V injection wells are not allowed within the Wellfield Protection Secondary Zoning District as defined in the City Code 742-204 and 40 CFR 146.

For more information on the incentives of green development, including example computations on infrastructure cost savings, please refer to the City of Indianapolis website, www.indy.gov and search for Green Infrastructure

Supplemental Document and Stormwater Credit Manual.

104.05 Stormwater Discharges to Combined Sewers

All projects, regardless of size, that drain to a combined sewer system or propose a new connection to a combed sewer system must obtain approval from Citizens Energy Group (CEG). The more stringent design standard regarding stormwater quality and quantity between this Manual and CEG requirements shall apply.

The first upstream structure from the combined sewer connection shall be designed to prevent the escape of sanitary sewer gases into the storm sewer or atmosphere.

104.06 Work within a Levee Influence Zone

All projects that are within a City owned parcel or easement having a levee embankment or floodwall influence zone or that impact a levee or floodwall on the same must obtain approval from the Department. The work that is done within the influence zone of the levee or floodwall must meet the guidance of the United States Army Corps of Engineer's (USACE) Standard Operating Procedures (SOP) as well as USACE's *Design and Construction of Levees* (EM 1110-2-1913). If the levee is under federal jurisdiction, a Section 408 Permit through the USACE in coordination with the Department is required and the review funded by the stakeholder completing the work.

104.07 Dam Embankment Construction or Rehabilitation

For all projects that construct or rehabilitate a regulated dam (applicability described in Indiana Code 14-27-7.5-1) or appurtenant spillway, the owner and/or applicant shall inform the Indianapolis Department of Public Works as well as IDNR of such proposed action(s). Construction/Rehabilitation must be designed and certified by a registered professional engineer in the State of Indiana and must meet the requirements outlined in Chapter 7.5, Regulation of Dams, Indiana Code 14-27-7.5. In addition, the stakeholder shall acquire a Construction in a Floodway Permit or other necessary regulated dam permit from the IDNR. State documentation of IDNR approval shall be sent to the Department of Public Works – City Engineer.

104.08 Waterway Enclosure

Waterways shall not be enclosed except for limited lengths needed to provide access to properties, for utility crossings or to convey a waterway under a street. Enclosure materials shall comply with Chapter 400 of this Manual. Additionally, waterways that have been previously enclosed for purposes other than those mentioned above, shall consider daylighting

Chapter 200. Hydrology

Section 201. Policies and Requirements

The following section provides a list of all design policies which must be applied during a hydrologic analysis performed within Marion County under the jurisdiction of DPW and BNS.

201.01 Alternative Methods

Many hydrologic methods are available. Recommended methods and the circumstances for their use are listed in Section 204 of this Manual. If other methods are used, they must first be tested for accuracy and reliability by a registered professional as defined in Section 561–224 of the City Code. In addition, complete source documentation must be submitted for review and approval.

201.02 Hydrologic Method

The same hydrologic method should be used for pre-developed runoff peak determination as will be used in the post-developed calculations.

Procedures to determine the quantity of runoff shall depend upon the size of the watershed, complexity of sub-watershed routing, and existing land use/land cover of the area under analysis are discussed as follows:

1. Rational Method

Rational Method may be used for peak runoff estimations when the total watershed area tributary to the design point is five (5) acres or less and with no existing depressional storage, provided analysis of regional detention facilities is not a required part of the computational procedure. However, all detention facilities must be analyzed using hydrograph methods.

2. Runoff Hydrographs and Flood Routing

Hydrograph generation and flood routing procedures shall be required when:

a. The total watershed area tributary to the design point is greater than five (5) acres.
b. The total watershed area tributary to the design point is less than five (5) acres but includes existing depressional storage.

   Existing depressional storage will require hydrograph analysis to determine existing runoff. Existing depressional areas should be modeled as storage with weir overflows at the lowest ground elevation at which flow exits the depressional area.

c. Combining runoff from two or more watersheds discharging to a common location in a complex drainage area. A complex drainage area includes, but is not limited to, multiple watersheds with different times of concentration, drainage patterns, land use/cover, and/or soil types. This is especially true when an off-site watershed is included in the analysis.

201.03 Time of Concentration Methodology

Time of concentration (t_c) is the time for runoff to travel from the hydraulically most distant point of the drainage area to a point of interest within the drainage area. t_c influences the shape and peak of the runoff hydrograph. Technical Release 55 Urban Hydrology for Small Watersheds (TR-55, June 1986) Chapter 3 provides the accepted procedure for calculating t_c. All t_c calculations shall be documented in a format similar to Figure 200-01 provided at the end of this section. The following requirements shall be applied when calculating t_c:

1) The minimum t_c for all computations shall be five (5) minutes.
2) The maximum length of sheet flow shall be 100 ft for all computations.

201.04 Off-site Hydrologic Analysis

Pursuant to Chapter 561 of the City Code, a stormwater facility shall be constructed which allows drainage of water runoff from each upper watershed area and from each portion of the parcel to a place or places adequate to receive it. Off-site watershed areas are those which by virtue of existing topography must outlet through the developing property. A complete analysis of those upstream watershed areas contributing flow to a proposed stormwater facility shall be required. The peak flow and/or runoff hydrographs from these areas shall be verified through submission of the following information:

1) A contour map of sufficient scale and detail to accurately depict the watershed boundaries.
2) The drainage area in either acres or square miles.
3) Runoff curve numbers and time of concentration estimates, with supporting computations, as applicable for each watershed basin.
4) The estimated peak discharge and/or runoff hydrograph for each sub-basin for each design storm AEP analyzed.
5) All pertinent information relating to procedures used to compute runoff within those guidelines set forth herein.

Stormwater facilities situated within a parcel shall meet the requirements of Sections 561-333 through 343 of the City Code and drain adequately each and every part of the parcel and shall be sufficient to accept the present water runoff from areas upstream. At least one appropriately sized conveyance shall be provided at each location at the upstream edge of the parcel where off-site runoff enters the site under existing conditions to accept upstream drainage.

Section 202. Rainfall

202.01 Rainfall Data

NOAA Atlas 14, Volume 2 (NOAA Atlas 2 Precipitation Frequency Estimates (weather.gov)) shall be the standard source for rainfall data. Utilize rainfall data for the station nearest to the project site and select precipitation intensity or depth in the Data Description based on the hydrologic method being used. Documentation / printouts must be included in the TIR. Complete documentation from Atlas 14 should be included in the TIR / Drainage Report.

202.02 Rainfall Distribution for Hydrographs

For runoff hydrograph computations the Huff storm distribution fifty percent (50%) probability shall be used. A critical storm duration analysis must be performed to determine peak discharges and flood stages. The critical storm duration analysis shall include the calculation of peak discharges and maximum flood stages for each storm duration listed on NOAA Atlas 14 from five (5) minutes to twenty-four (24) hours. The critical design storm is the duration that produces the highest peak discharges and flood stages for the appropriate design storm AEP. Table 200-02 can be referenced for the appropriate Huff distribution ordinates. A minimum of twenty (20) ordinates shall be used for the rainfall distributions.

The appropriate Huff quartiles shall be selected based on the storm duration as follows:

Table 200-01: Huff Quartile Storm Applications

Quartile	Storm Duration
1st	0 to 6.0 hours
2nd	6.1 to 12.0 hours
3rd	12.1 to 24 hours
4th	over 24 hours

Section 203. Peak Flow Computations

203.01 Introduction

Peak flow value estimates can be made using either peak-flow-only methods discussed in this section or methods which generate the total outflow hydrograph (peak, volume and timing of the flow) discussed further in the Section 204 of this Manual.

Peak discharges for watershed areas less than five (5) acres may be computed using the Rational Method. The Rational Method is based upon the following equation:

$$Q = C \cdot i \cdot A \qquad \text{(Equation 203.01)}$$

where:

Q = peak discharge (cubic feet per second or cfs),
C = the runoff coefficient, or the ratio of peak runoff rate to average rainfall rate over the watershed during the time of concentration (t_c),
i = the rainfall intensity (inches/hour, refer to Section 202.01), and
A = the contributing area of watershed under consideration (acres)

Where distinctive land use features are known, use of a composite or "weighted" C factor shall be required. Runoff coefficients for use within the Rational Method are summarized within Table 200-3.

Using the Rational Method assumes:

The rainfall intensity is uniform over the entire watershed during the entire storm duration,
The storm duration is equal to t_c, and
The t_c is the time required for the runoff from the most remote part of the watershed to reach the point under design.

Section 204. Hydrograph Generation Methods

204.01 Introduction

As opposed to peak rate of runoff, the hydrograph accounts for the variation in volume and flow rate over the duration of the storm event. Hydrograph computations are required when the total watershed area tributary to the design point is greater than five (5) acres but may be used for watersheds less than five (5) acres.

The standard NRCS dimensionless unit hydrograph method is preferred for hydrograph generation. Alternative hydrograph generation methods shall be approved by the City prior to use. Supporting documentation that clearly details model inputs and outputs must be provided for review.

Hydrologic modeling software shall be used to calculate runoff hydrographs. Engineers are responsible for understanding the limitations and correct application of modeling software used for hydrograph generation. Examples of acceptable modeling software that can generate hydrographs utilizing the NRCS dimensionless unit hydrograph include TR-20, HydroCAD, ICPR, HEC-HMS, XP-SWMM, PCSWMM and PondPack. The City does not limit the designer to particular modeling software; however, prior City approval of modeling software not listed is required before the software is utilized. The use of software not listed above is not guaranteed approval by the City.

In some cases, detailed hydrologic studies may have been completed for the area of interest, and can be used with approval from the City.

204.02 NRCS (SCS) Dimensionless Unit Hydrograph Method

Application of the NRCS dimensionless unit hydrograph method involves estimation of the response time of a drainage area and peak discharge. The hydrologic modeling software utilized shall be based on the application of:

TR-55 time of concentration, per Section 201.04
TR-55 curve number methods, per Section 204.03
NRCS Dimensionless Unit Hydrograph Ordinates provided in Table 200-04.
The modeling software shall calculate the peak discharge of the synthetic unit hydrograph using a unit conversion factor of 484 as described in Equation 204.02:

$$Q_p = \frac{484 \cdot A \cdot Q_v}{T_p} \qquad \text{(Equation 204.02)}$$

where:

Qp = peak discharge (cfs)
484 = unit conversion factor for standard NRCS Dimensionless Unit Hydrograph
A = watershed area (square miles)
Qv = direct runoff (inches)
Tp = time to peak (hours)

204.03 NRCS (SCS) Curve Numbers (CN)

The NRCS CN is used to estimate runoff volume from storm rainfall. The major factors that determine CN are the hydrologic soil group (HSG), cover type, land treatment, hydrologic condition, and antecedent runoff condition. An area weighted CN for all drainage areas within a proposed project shall be calculated utilizing the best available aerial imagery, and hydrologic soil information from the USDA NRCS Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/). Technical Release 55 Urban Hydrology for Small Watersheds (TR-55, June 1986) Chapter 2 provides the procedure for calculating CN.

The use of generalized curve numbers such as “Business”, “Commercial” or “Industrial” shall not be used for the actual project site runoff estimates. Curve numbers for residential developments shall be calculated based on the maximum proposed impervious area and not generalized based on lot size. Generalized curve numbers may be used for large off-site areas only. Table 200-05, Table 200-06 and Table 200-07 may be referenced for runoff curve numbers for various land uses and hydrologic soil groups. If a land use is not listed (i.e., solar panels), the designer shall propose a curve number for review. The proposed curve number shall be submitted and approved via a variance in accordance with the process outlined in Section 561-271 of the City Code. Full documentation and references for the use of other runoff curve numbers shall be included in the TIR/Drainage Report. Area weighted CN calculations shall be provided in a format consistent with the example provided in

Figure 200-02.

Pre-developed runoff calculations should use the CN that produces the minimum amount of runoff for the land use/cover and soil type. Post-developed runoff calculations should use the CN that produces the maximum amount of runoff for the proposed land use/cover and soil type. This approach should also be applied to off-site watersheds that drain through the proposed project site.

For example, when two soil types are listed (e.g., drained/undrained) drained soil conditions should be used for the pre-developed calculations and undrained conditions shall be assumed in the post-developed calculations for soils affected by the proposed construction.

Another example would be agricultural soils are crops in good condition for the pre-developed calculations and the surface is bare and has no cover, for the post-developed calculations for soils affected by the proposed construction.

Appendix 200

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By: _____ Date _____
Location _____ Checked: _____ Date _____

Circle One: Present Developed _____
Circle One: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet
Include a map, schematic, or description of flow segments

Sheet Flow (Applicable to Tc only)			Segment ID					
1	Surface description (table 3-1)							
2	Manning's roughness coeff., n (table 3-1)							
3	Flow Length, L (total <= 100 ft)		ft					
4	Two-yr 24-hr rainfall, P_2		in					
5	Land slope, s		ft/ft					
6	$T_t = 0.007(nL)^{0.8}/P_2^{0.5}\, s^{0.4}$	Compute T_t	hr		+		=	
Shallow concentrated flow			Segment ID					
7	Surface description (paved or unpaved)							
8	Flow Length, L		ft					
9	Watercourse Slope, s		ft/ft					
10	Average velocity, V (figure 3-1)		ft/s					
11	$T_t = L/3600V$	Compute T_t	hr		+		=	
Channel flow			Segment ID					
12	Cross sectional flow area, a		ft^2					
13	Wetted perimeter, P_w		ft					
14	Hydraulic radius, $r = a/P_w$		ft					
15	Channel slope, s		ft/ft					
16	Manning's roughness coeff., n							
17	$V = 1.49\, r^{2/3}\, s^{1/2}/n$	Compute V	ft/s					
18	Flow Length, L		ft					
19	$T_t = L/3600V$	Compute T_t	hr		+		=	
20	Watershed or subarea T_c or T_t (add T_t I steps 6, 11, and 19)						hr =	
							min =	

FIGURE 200-01: Time of Concentration or Travel Time Worksheet
(SOURCE: 210-VI-TR-55, Second Ed., June 1986)

Table 200-02: Indianapolis Huff Quartile Ordinates

(SOURCE: Bulletin 71, "Rainfall Frequency Atlas of the Midwest", 1992)

Cumulative Storm Time (percent)	Cumulative Storm Rainfall (percent)			
	First-Quartile	Second-Quartile	Third-Quartile	Fourth-Quartile
5	16	3	3	2
10	33	8	6	5
15	43	12	9	8
20	52	16	12	10
25	60	22	15	13
30	66	29	19	16
35	71	39	23	19
40	75	51	27	22
45	79	62	32	25
50	82	70	38	28
55	84	76	45	32
60	86	81	57	35
65	88	85	70	39
70	90	88	79	45
75	92	91	85	51
80	94	93	89	59
85	96	95	92	72
90	97	97	95	84
95	98	98	97	92
100	100	100	100	100

Table 200-03: Runoff Coefficients for Use in the Rational Method

Type of Surface	C
Non-Urban Areas	
Bare Earth	0.55
Steep Grassed Areas	0.60
Meadows	0.25
Forested Areas	0.20
Cultivated Fields	0.30
Urban Areas	
All watertight roof surfaces	0.90
Pavement	0.85
Gravel	0.85
Impervious soils (heavy)	0.55
Impervious soils (with turf)	0.45
Slightly pervious soil	0.25
Slightly pervious soil (with turf)	0.20
Moderately pervious soil	0.15
Moderately pervious soil (with turf)	0.10
Business, Commercial & Industrial	0.85
Apartments & Townhouses	0.70
Schools & Churches	0.55
Single Family Lots < 10,000 sq-ft	0.45
Lots < 12,000 sq-ft	0.45
Lots < 17,000 sq-ft	0.40
Lots > 1/2 acre	0.35
Park, Cemetery or Unimproved Area	0.30

TABLE 200-04: Unit Hydrograph Ordinates

(SOURCE: United States Department of Agriculture Natural Resources Conservation Service Part 630 Hydrology National Engineering Handbook Chapter 16 Hydrographs (210–VI–NEH, March 2007))

Table 16-1

Time Ratios (t/T_p)	Discharge Ratios (q/q_p)	Mass Curve Ratios (Q_a/Q)
0.0	0.000	0.000
0.1	0.030	0.001
0.2	0.100	0.006
0.3	0.190	0.017
0.4	0.310	0.035
0.5	0.470	0.065
0.6	0.660	0.107
0.7	0.820	0.163
0.8	0.930	0.228
0.9	0.990	0.300
1.0	1.000	0.375
1.1	0.990	0.450
1.2	0.930	0.522
1.3	0.860	0.589
1.4	0.780	0.650
1.5	0.680	0.705
1.6	0.560	0.751
1.7	0.460	0.790
1.8	0.390	0.822
1.9	0.330	0.849
2.0	0.280	0.871
2.2	0.207	0.908
2.4	0.147	0.934
2.6	0.107	0.953
2.8	0.077	0.967
3.0	0.055	0.977
3.2	0.040	0.984
3.4	0.029	0.989
3.6	0.021	0.993
3.8	0.015	0.995
4.0	0.011	0.997
4.5	0.005	0.999
5.0	0.000	1.000

TABLE 200-05: Runoff Curve Numbers for Urban Areas

(SOURCE: 210-VI-TR-55, Second Ed., June 1986)

Cover Description	Curve Numbers for Hydrologic Soil Groups				
Cover Type and Hydrologic Condition	Average Percent Impervious Area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[2]					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious Areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and Roads:					
Paved; curbs and storm drains (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Urban Districts:					
Commercial and Business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential Districts by Average Lot Size:					
0.125 acre or less (townhouses)	65	77	85	90	92
0.25 acre	38	61	75	83	87
0.33 acre	30	57	72	81	86
0.50 acre	25	54	70	80	85
1.00 acre	20	51	68	79	84
2.00 acre	12	46	65	77	82
Developing Urban Areas					
Newly graded areas (pervious area only, no vegetation		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in Table 200-06).					

[1] *Average runoff condition, and $I_a = 0.2S$*

[2] *The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: Impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the NRCS method*

has an adjustment to reduce the effect.

[3] *CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.*

TABLE 200-06: Runoff Curve Numbers for Undeveloped Areas

(SOURCE: 210-VI-TR-55, Second Ed., June 1986)

Cover Description	Curve Numbers for Hydrologic Soil Groups			
Cover Type and Hydrologic Condition	A	B	C	D
Cultivated Land (Row Crops)				
With conservation treatment	72	81	88	91
Without conservation treatment	62	71	78	81
Pasture or Range Land				
Poor condition	68	79	86	89
Good condition	39	61	74	80
Meadow				
Good condition	30	58	71	78
Wood or Forest Land				
Thin stand, poor cover, no mulch	45	66	77	83
Good cover	25	55	70	77

TABLE 200-07: Runoff Curve Numbers for Agricultural Lands

(SOURCE: 210-VI-TR-55, Second Ed., June 1986)

Cover Description	Curve Numbers for Hydrologic Soil Groups			
Cover Type and Hydrologic Condition	A	B	C	D
Pasture, grassland or range with continuous forage for grazing.				
Poor	68	79	86	89
Fair	49	69	79	84
Good	39	61	74	80
Meadow with continuous grass, protected from grazing and generally mowed for hay.	30	58	71	78
Brush/brush-weed-grass mixture with brush being the major element.				
Poor	48	67	77	83
Fair	35	56	70	77
Good	30	48	65	73
Woods and grass combination (orchard or tree farm).				
Poor	57	73	82	86
Fair	43	65	76	82
Good	32	58	72	79
Woods				
Poor	45	66	77	83
Fair	36	60	73	79
Good	30	55	70	77
Farmsteads	59	74	82	86

Worksheet 2: Runoff curve number and runoff

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Figure 2-3	CN 1/ Figure 2-4	Area ☐ acres ☐ mi² ☐ %	Product of CN x area
1/ Use only one CN source per line				Totals ➡		

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = _____ = _____ ; Use CN ➡ ☐

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr			
Rainfall, P (24-hour)	in			
Runoff, Q (Use P and CN with table 2-1, figure 2-1, or equations 2-3 and 2-4)	in			

Figure 200-02: Runoff Curve Number Worksheet
(SOURCE: 210-VI-TR-55, Second Ed., June 1986)

Chapter 300. Hydraulics

Section 301. Policies and Requirements

The following section provides a list of design policies which must be applied during a hydraulic analysis performed within Indianapolis under the jurisdiction of the DPW and BNS. These policies and requirements shall be considered minimum requirements.

301.01 Floodplain Regulations

In addition to the regulations provided in this Manual, the City of Indianapolis has adopted floodplain regulations, which are stated in Section 742-203, Flood Control Secondary Zoning Districts, of the City Code ("Floodplain Regulations"). In addition to those Floodplain Regulations, the following specific requirements shall apply:

1. Structures located in a Flood Control Secondary Zoning District established and regulated by Section 742-203, Flood Control Secondary Zoning Districts of the City Code, shall conform with all applicable standards and requirements of said Ordinance.
2. Structures to be constructed that are not located in a Flood Control Secondary Zoning District shall conform with the following requirements:

    a. The lowest finished floor elevation (FFE) of a new structure to be constructed adjacent to a surface drainage feature which drains areas between 150 and 640 acres shall be located at an elevation at least two (2) feet above the base flood elevation (BFE) and the lowest adjacent grade (LAG) shall remain above the BFE at least ten (10) feet horizontally from the perimeter of the building before sloping below the BFE. The BFE shall be established based on hydrologic and hydraulic analysis in accordance with regulations adopted by the Board of Public Works, IDNR and FEMA or by a site specific recommendation from IDNR through a Floodplain Analysis and Regulatory Assessment (eFARA).

Additional requirements for completing alterations to the land or existing structures within regulatory flood hazard areas may be found within the Zoning Ordinance of the City of Indianapolis.

301.02 Downstream Capacity Analysis

Evaluation of the capacity of the downstream facility that will be receiving runoff from the proposed project must be addressed in the Technical Information Report (TIR). Downstream capacity analysis shall be performed through the first pipe, open channel, or through the first detention pond on the adjacent parcel if the adjacent detention pond receives flow directly.

Analysis of the downstream stormwater conveyance system will *not* be required if the downstream facilities, after completion of the project, will not be accepting runoff from the redevelopment or land alteration.

301.03 Required Easements

Stormwater Infrastructure	Required Easement
Artificial Open Channel and bypass channels for off-site drainage	Channels draining greater than 5 acres must have an easement that encompasses the 25-year (4% AEP) floodplain and a minimum easement width of ten feet from the top of bank on at least one side which is accessible for maintenance. All artificial and bypass channels must have a minimum easement width of twenty (20) feet from top of bank on at least one side of the channel which is accessible for maintenance.
Swale (residential and non-residential)	Twenty (20) feet wide centered on flowline invert
Detention Facility	Twenty (20) feet horizontally outside of the area covered by the 100-year (1% AEP) water surface elevation of the facility.
Emergency Spillway	Easement width must contain the design flow from emergency spillway to the property line.
Storm Sewers & Culverts, Diameter ≤ 15 inches	Cover ≤ three (3) feet, Minimum easement width = twenty (20) feet on center ("O.C.")
	Cover > three (3) feet, Minimum easement width = twenty (20) feet O.C.
Storm Sewers & Culverts, Diameter > 15 inches	Cover ≤ three (3) feet, Minimum easement width = twenty (20) feet O.C.
	Cover > three (3) feet, Minimum easement width = twenty-five (25) feet O.C.

Section 302. Stormwater Detention Storage

302.01 Introduction

The design methods and criteria outlined within this section shall be used in the design and evaluation of detention systems within the jurisdictional boundaries of this Manual. Projects that propose to deviate from the stormwater management standards in this Manual require a variance request in accordance with the process outlined in Section 561-271 of the City Code.

302.02 Allowable Release Rates

Detention shall be required on all new developments. Redevelopment requirements are outlined in Section 104.03 of this Manual. All detention designs shall use computer generated hydrographs and routing techniques. The minimum hydraulic performance levels and accepted design methodologies for detention basins shall conform to the following:

$$Q_{2post} \leq 0.5Q_{2pre}$$
$$Q_{10post} \leq Q_{2pre}$$
$$Q_{25post} \leq 0.75Q_{10pre}$$
$$Q_{100post} \leq Q_{10pre}$$

where:

Q_{2pre} = 2-year (50% AEP) discharge rate, pre-project conditions

Q_{10pre} = 10-year (10% AEP) discharge rate, pre-project conditions
Q_{2post} = 2-year (50% AEP) discharge rate, post project conditions
Q_{10post} = 10-year (10% AEP) discharge rate, post project conditions
Q_{25post} = 25-year (4% AEP) discharge rate, post project conditions
$Q_{100post}$ = 100-year (1% AEP) discharge rate, post project conditions

Detention facilities which have a total drainage area, including on-site and off-site areas, of five (5) acres or larger shall meet the following velocity requirements downstream at the property boundary detention facility outlet:

$$V_{2post} \leq V_{2pre}$$
$$V_{10post} \leq V_{10pre}$$
$$V_{25post} \leq V_{10pre}$$
$$V_{100post} \leq V_{10pre}$$

where:

V_{2pre} = 2-year (50% AEP) velocity, pre-project conditions
V_{10pre} = 10-year (10% AEP) velocity, pre-project conditions
V_{2post} = 2-year (50% AEP) velocity, post-post project conditions
V_{10post} = 10-year (10% AEP) velocity, post- project conditions
V_{25post} = 25-year (4% AEP) velocity, post-project project conditions
$V_{100post}$ = 100-year (1% AEP) velocity, post-post project conditions

The above design flow rates and velocities shall be based on the pre-project watershed outlet conditions. If the pre-project runoff exits the property or site at multiple locations, pre-project flow rates and velocities at each discharge location shall be used to calculate the post-project flow rates and velocities.

302.03 Bypassing Off-Site Runoff

When stormwater detention is required, all parts of the developing site should drain through the detention facility, unless otherwise approved. Upstream off-site drainage areas may be bypassed around the detention facility and therefore not considered in the computations as long as the conditions set forth in Section 302.02 of this Manual are met and the combination of on-site and off-site runoff do not cause adverse impacts downstream.

Off-site drainage areas may be routed through the detention facility using the following approach:

1. The storage area and primary outlet control structure shall be designed to meet the standards outlined in Section 302.02 of this Manual considering only on-site runoff.
2. A bypass spillway elevation shall be set at the peak 100-year (1% AEP) stage considering only the 100-year (1% AEP) on-site runoff from the developed site only.
3. Next, both the on-site and off-site runoff are routed through the detention facility using the bypass spillway at the elevation determined in the previous step. The peak discharge from the detention facility considering on-site and off-site runoff through the pond shall not exceed the combination of allowable release rates per Section 302.02 of this Manual for the project site plus the existing off-site runoff at the detention facility outlet for each design storm event. When off-site runoff is routed through the detention facility the velocity requirements of Section 302.02 of this Manual must still be met. Off-site flow that is bypassed around the pond does not need to meet the velocity requirements.
4. The emergency spillway and freeboard shall be designed to account for on-site and off-site runoff.
5. All water quality systems must meet the allowable treatment flow rate requirements based on total

flow reaching the unit (i.e., both the on-site and the off-site contributing areas), as stated in Section 701.04, Stormwater Quality Design Methods, of this Manual.

302.04 Minimum Freeboard

Freeboard is the required horizontal and vertical distance between the computed 100-year (1% AEP) water surface elevation of the detention facility and other critical structures and/or improvements. The computed 100-year (1% AEP) water surface elevation for all detention facilities shall be a minimum ten (10) feet horizontally and two (2) feet vertically from the lowest ground elevation next to any permanent structure, such as a residential home or industrial/commercial building. In addition, where construction of an emergency spillway is required, the constructed detention basin top of bank elevation shall provide for a minimum of one (1) foot of freeboard above the maximum anticipated flow depth through the emergency spillway during the design flow rate.

302.05 Emergency Spillways

Emergency spillways shall be capable of handling one and one-quarter times (125%) the peak inflow resulting from the 100-year (1% AEP) design storm event runoff from the entire contributing watershed, assuming post-development conditions, draining to a detention facility. However, engineering judgment may dictate use of a higher design standard.

Vegetated emergency spillways shall be evaluated for erodibility based upon soil characteristics, entrance and exit slopes, and the potential depth and velocity of flow. Additional erosion control measures within these spillways in the form of rock rip-rap or armored channels may be required. All emergency spillways shall outlet to an easement containing a channel with acceptable capacity and no permanent obstructions shall be placed within the emergency spillway easement. An easement is only required to the property line. However, downstream capacity analysis must be performed to document whether the proposed emergency flow will or will not impact downstream structures. If a drainage way does not exist downstream, a variance request shall be submitted per Section 561-271 of the City Code. All calculations, easement boundaries, and cross sections for the emergency spillway are to be submitted for review.

302.06 Underground Detention

All underground detention facilities shall have visual inspection capability without entry into the system such as inspection ports.

1. Inspection ports shall be a minimum of 6 inches in diameter.
2. Inspection ports shall be located within 10 feet of each inlet into the system.
3. Inspection ports shall be located in each containment/isolator row.
4. Concrete collars shall be placed around inspection ports within pavement. Lids within pavement shall be minimum HS20 rated or as needed for the expected traffic load.
5. Inspection ports shall have solid lids. Stormwater shall not be allowed to enter the system via inspection ports. Inspection ports smaller than twenty inches (20”) are encouraged to have hinged lids.
6. The Operations and Maintenance Manual shall clearly label inspection port locations.

302.07 Additional Design Requirements

The minimum accepted bottom slope of dry detention basins shall be one percent (1.0 %). Vegetated bank side-slope shall be no steeper than 3 (horizontal) to 1 (vertical).

The flow path from all inflow points within a dry detention basin to the outlet of the basin shall be provided with an under-drain system when slopes to the outlets are less than one percent (1%).

Vegetated areas of wet detention basins shall have an earthen embankment constructed with side slopes no steeper than 3 (horizontal) to 1 (vertical). All earthen slopes shall be revegetated according to the guidelines set forth within Chapter 600 of this Manual.

All wet detention/retention facilities shall have a safety bench/shelf 1 foot below the normal pool level. The safety bench shall have a minimum width of ten (10) feet and a maximum slope of 2%.

The use of retaining walls in a detention facility shall require a variance.

For bermed detention facilities which generate three (3) feet or more of head pressure, the principal outlet pipe shall be provided with anti-seep devices. The construction material to be utilized for these devices shall be of like material as the pipe structure. The spacing of anti-seep collars shall be determined by the design consultant and, where required, be clearly shown on the plan/profile drawings of the construction plans.

The material used for bedding and backfill of pipe structures through an earthen embankment shall be the same soil material used in construction of the surrounding embankment utilizing suitable soil materials, at appropriate moisture levels and compaction determined by the design consultant. Earthen embankments shall be provided with a core trench (cutoff trench) of compacted soil, to prevent the piping of water either beneath the embankment, or around the embankment ends.

Minimum normal depth of a wet detention basin, calculated as the deepest point in the pond, shall be eight (8) feet.

Minimum normal pool area of a wet detention basin shall be 0.5 acre.

Prevention of bank erosion due to wave action, or extended detention times is required.

The maximum ponding depth for parking lot detention shall be six (6) inches for the 100-year (1% AEP) storm event runoff from the entire contributing watershed.

The minimum allowed orifice size is two (2) inches. When a smaller orifice is required to meet allowable release rates, the Technical Information Report must illustrate the detention volume has been sized per allowable release rates (with an orifice smaller than two inches) and what the proposed increased release rates will be utilizing the minimum allowed orifice size. Measures to prevent blockage must be provided for all orifices less than six (6) inches in diameter.

All underground detention facilities shall be designed with a positive gravity outfall or a certification from a licensed geotechnical engineer;

that the permeability of the surrounding soils will dissipate water at a rate required for the detention facility designed,
that no adverse impact to any subsurface systems (including septic systems) will be experienced, and
that the underground detention facility will not be subject to ground water surcharge during any time of the year.

Class V injection wells are not allowed within the Wellfield Protection Secondary Zoning District.

If the system is designed to use the storage volume of the stone surrounding the structure, a 40 percent porosity factor shall be utilized for the surrounding washed INDOT #8 Stone.

All stormwater shall be routed through a BMP meeting City Standards for 80% TSS removal upstream of the underground detention facility.

No stormwater shall be routed through the detention facility until the BMP is installed and fully functional and all construction erosion control for disturbed areas are installed to ensure no sediment build-up in the underground detention storage facility. The erosion control methods and BMP's must be inspected after each rain event and repaired or cleaned where necessary. The O&M Manual for all BMP's located prior to the underground detention storage facility require the BMP's to be inspected a minimum of four (4) times per year and cleaned as necessary to ensure maximum performance relative to sediment removal.

Draw-down time for all detention ponds is seventy-two (72) hours. Otherwise, the pond must be enlarged to provide the required storage volume for a second 100-year (1% AEP) event at seventy-two (72) hours.

Section 303. Open Channel Design

303.01 Introduction

For the purposes of this section, the open channel design criteria reference three (3) types of open channels; roadside ditches, artificial open channels, and natural channels. Roadside ditches are open channels adjacent to a roadway which intercept runoff from within the right of way and convey flow to drainage structures or a natural channel. Artificial open channels are constructed, typically with a regular geometric cross section, and convey runoff from drainage areas outside of the public right-of-way. Natural channels have an irregular cross section geometry and have been shaped by the long-term processes within their watershed. Water course improvements and encroachments to a Marion County Regulated Drain must abide by applicable Board of Public Works requirements.

303.02 Hydraulic Analysis

Manning's Equation (Eq 303.01) may be used to size proposed open channels where backwater effects created by obstructions within the channel, or elevated tailwater is not of concern such as roadway ditches and culvert tailwater conditions in uniform channels. Manning's equation may be solved directly from its standard form and iterated as necessary with various values of channel geometry to obtain the desired values of flow capacity, velocity, and depth.

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2} \qquad \text{(Equation 303.01)}$$

Engineering reference books, such as "Open-Channel Hydraulics" by V.T. Chow may be used as a guide for Manning's "n" values.

The step backwater method shall be used for natural channel analysis. Artificial open channel analysis shall use the step backwater method where uniform flow conditions are not maintained. A hydraulic modeling application such as HEC-RAS shall be used for step backwater computations.

303.03 Open Channel Design Requirements

Roadside ditches shall be designed for the 10-year (10% AEP) storm event. Artificial open channels that

convey drainage from areas beyond the road right-of-way shall be designed for the 100-year (1% AEP) storm event. Hydraulic computations must be performed to determine the maximum inundated area resulting from the 100-year (1% AEP) design storm event. No habitable structures may be located within this area.

The side-slope of grass lined channels shall be no steeper than 3 (horizontal) to 1 (vertical).

The side-slope of riprap lined open channels shall be no steeper than 1 ½ (horizontal) to 1 (vertical)

When the bottom width of a trapezoidal open channel exceeds four (4) feet, a low flow channel/invert or subsurface drain shall be provided to convey low flows. Lateral slopes draining to the low flow channel within the bottom of trapezoidal channel shall have a minimum slope of one percent (1%).

Minor drainage collector swales in rear and side yards and between homes shall possess a maximum channel length of 400 lineal feet and no off-site water unless an underdrain is also provided. Swales shall be grass lined; a subsurface drainage tile shall be required if the channel slope is less than two percent (2.0%); and, the minimum channel slope shall be three tenths of one percent (0.3%).

For basement residential lots a "tee" should be provided in the rear lot line's subsurface drain for the purpose of discharging sump pump water directly into the drain. The tee should include a surcharge device.

Privately owned open channels, including man-made ditches, swales, and natural streams, shall be repaired and/or reconstructed such that all woody vegetation has been cleared, and the channel banks are properly stabilized to prevent erosion.

Open channels with a slope less than one percent (1%) shall include an underdrain to prevent chronic wetness and have a minimum slope of three tenths of one percent (0.3%).

To prevent chronic wetness in the invert of open channels, subsurface tiles shall be installed a minimum of 1 ½ feet in depth (from the tile invert), with a INDOT #8 stone or equivalent size washed stone as a granular envelope, as follows:

1. <u>One- and Two-Family Residential Developments</u>

   Minor drainage collector swales in rear yards and between homes shall possess a maximum channel length of 400 lineal feet, unless subsurface tile is also provided. The maximum vegetated open channel side slope shall be 3 (horizontal) to 1 (vertical).

   The required channel slope and invert treatment for minor drainage collector swales shall be as follows: grass lined swale if slope is one percent (1%) or greater and length is less than 400 feet; subsurface drainage tile if channel slope is between three tenths of one percent (0.3%) and one percent (1.0%), and or length is greater than 400 feet. The minimum channel slope shall be three tenths of one percent (0.3%).

2. <u>Commercial and Industrial Developments and Other Open Land Uses (Golf Courses, Parks, Recreation Areas)</u>

   The maximum length of minor drainage collector swales shall be 800 lineal feet, unless subsurface drainage is also provided. The maximum vegetated open channel side slope shall be 3 (horizontal) to 1 (vertical).

   The required channel slope and invert treatment for minor drainage collector swales shall be as follows: subsurface drainage tile for channel slopes between three tenths of one percent (0.3%) and one half of one percent (0.5%). The minimum channel slope shall be three tenths of one

percent (0.3%).

303.04 Open Channel Lining Design Requirements

The peak discharge from the 10-year (10% AEP) design storm shall be used to design roadside ditch linings. If a natural stream or artificial open channel conveying drainage from other areas enters the roadside ditch the lining shall be designed for the 100-year (1% AEP) design storm. The final design should be consistent with permissible shear stress (τ_p) for the selected channel lining. Reference shall be made to the Federal Highway Administration (FHWA) publication HEC-15, Third Edition "Design of Roadside Channels with Flexible Linings" for a more detailed description of this analysis. Documentation of permissible shear stress for selected channel lining must be provided with the design calculations.

The summary of the process for channel lining design is as follows:

1. Select a lining and determine the permissible shear stress (τp), in lbs/ft^2.
2. Choose an initial Manning's "n" value and document the source.
3. Calculate normal flow depth (D), in ft, at design discharge using Manning's Formula.
4. Compute maximum shear stress (T_d), in lbs/ft^2, at normal depth as:

$$T_d = 62.4 \cdot D \cdot S \qquad \text{(Equation 303.01)}$$

Where:

T_d = maximum shear stress (lbs/ft^3)
D = normal flow depth (ft)
S = channel gradient (ft/ft)

If $T_d < T_p$, then the channel lining is acceptable. Otherwise consider the following options.
choose a more resistant lining
decrease channel slope
decrease slope in combination with drop structures
increase channel width and/or flatten side slopes

Section 304. Culverts and Bridges

304.01 Introduction

The design methods and criteria outlined or referred to within this section shall be used in the design and evaluation of culvert systems within the jurisdiction of this Manual. The following sections include guidance from the INDOT Indiana Design Manual (IDM) and the FHWA Hydraulic Design Series No. 5 "Hydraulic Design of Highway Culverts." .

304.02 Allowable Headwater

Open culverts on artificial open channels (refer to Section 303.01 of this Manual) within private developments shall be designed to safely pass the peak discharge from the 25-year (4% AEP) design storm event runoff from the entire contributing watershed without inundating any portion of the crossing or approach roadway. An easement must be recorded for the 25-year (4% AEP) storm event flow areas. During the 100-year (1% AEP) storm event, road overflow shall not exceed seven (7) inches above the

centerline crown elevation of the roadway. The 100-year (1% AEP) storm event must be checked to determine the flooded area so that a building restriction line can be shown on a recorded plat. The lowest elevation where water may enter any adjacent structures must be outside this delineation. Culverts under residential driveways shall be sized to cause no adverse impacts (i.e., no increase in water elevation nor flooding to adjacent properties or public right of way) to adjacent properties or public right of way for the 10-year (10% AEP) event.

Open culverts and bridges under public roadways and/or draining natural channels (refer to Section 303.01) shall be evaluated according to the allowable headwater criteria in the current version of the INDOTIDM.

304.03 Hydraulic Analysis

For hydraulic analysis, a culvert is considered a structure with a span length of 20 feet or less. A bridge is considered a structure with a span of more than 20 feet. Computer models such as FHWA HY-8 and the HEC-RAS culvert module may be used to model culverts. For bridges, the HEC-RAS bridge module should be used.

Open culverts which pose a threat of damage to property or a hindrance of public services due to backwater and/or road overflow (see Section 304.02 of this Manual above) shall be analyzed utilizing the step backwater method and modeling software (such as HEC-RAS) as described in Section 303.02 of this Manual. The designer shall determine the depth of flow over the culvert/roadway (if this occurs) backwater elevations, downstream flow velocities and resulting channel scour impacts. In addition to allowable headwater and applicable state agency requirements, the analysis shall include a summary of existing and proposed conditions illustrating no adverse impacts to upstream and downstream structures for the 2-year (50% AEP) through 100-year (1% AEP) storm events.

304.04 Outlet Protection/Energy Dissipation

Energy dissipaters shall be utilized whenever the velocity of flows leaving a stormwater management facility exceeds the erosive velocity of the downstream channel system. The design should be consistent with the permissible shear stress of the downstream channel lining. All calculations and supporting documentation shall be submitted for review. See Section 303.04 of this Manual for discussion of channel linings and stability and the Indiana Department of Transportation Indiana Design Manual (IDM) for additional guidance on energy dissipation.

Section 305. Storm Sewers and Inlets

305.01 Introduction

Storm sewers are storm drain piping systems consisting of networks of pipes, catch basins, manholes, inlets and outfalls designed and constructed to convey surface water runoff. The hydraulic analysis of flow within storm sewer systems typically involves analysis of flow caused by the natural forces of gravity ("gravity flow"), and hydraulic analysis of systems under pressure flow conditions.

305.02 Placement of Structures

A storm sewer manhole or inlet must be installed at the end of each line segment; at all changes in grade, size, materials, and/or alignment of the storm sewer pipe line; at all pipe intersections; and at intervals not greater than 500 feet for pipes twelve (12) to eighteen (18) inches in diameter or 800 feet for pipes twenty-one (21) inches in diameter or larger.

Catch basins to be maintained by the City of Indianapolis shall be located within easily accessible dedicated easement or right-of-way areas of sufficient size to facilitate the required maintenance of these structures.

Trench drains, slotted drains, and similar linear inlets shall only be approved for installation via a design exception or variance within the public rights-of-way or for stormwater management systems maintained by the City. However, the product may be used for private infrastructure located outside of the public right-of-way without individual approval.

305.03 Storm Sewer Capacity Requirements

The use of Manning's equation and Rational Method hydrology shall be considered acceptable for determination of storm drain pipe sizes when the 10-year (10% AEP) storm event design discharge is ninety percent (90%) or less of the capacity of a commercially available pipe as computed by Manning's equation.

Design computations for storm drain pipe systems using the Rational Method and Manning's equation shall be submitted in a tabular form such as the Storm Drain Flow Tabulation Form provided by Figure 305-01 or by suitable model output providing similar information. Typical Manning's "n" values for standard storm drain materials are provided in Table 305-1.

305.04 Hydraulic Grade Line (HGL)

The storm drain system must also be designed at a minimum to contain the hydraulic grade line (HGL) for the 50-year (2% AEP) storm event below the top of casting for each manhole, inlet, catch basin, or similar structure. Where an overland overflow route from an inlet to a detention basin is not possible, the 100-year (1% AEP) HGL shall be below the top of the casting. An appropriate tail water condition at the outlet shall be included with the HGL calculations. Losses at manholes, inlets, and catch basins must also be factored into the HGL calculations. Refer to HEC-22 Chapter 7 and the latest edition of the LTAP Stormwater Drainage Manual for appropriate methodologies.

305.05 Minimum Velocity

Minimum storm drain flowing velocity for full pipe flow shall be two and a half (2.5) feet-per-second (fps). The minimum slope for storm drains equal to or larger than forty-eight (48) inches in diameter shall be 0.001 feet/foot.

305.06 Non-Gravity Flow Systems

Stormwater facilities shall be designed to convey stormwater runoff by gravity flow unless otherwise approved by the Department.

Stormwater control systems that do not satisfy this goal would include stormwater pumping systems, and mechanical sluice gates, as examples.

Design options that do not rely upon gravity flow may be approved as a variance in accordance with Section 561-271 of the City Code, with documentation provided to the Department evidencing the infeasibility and/or undue hardship required to install available gravity flow design options. As a minimum, the following additional information shall also be submitted with the drainage permit application for non-gravity flow systems:

1) Identification of a lifetime maintenance schedule for the non-gravity flow system.
2) Covenants attached to the property deed which place sole responsibility for maintenance of the non-gravity flow system with the current property owner of record.
3) An indemnification of the City relative to the non-gravity flow design.

Pumping systems, where approved, shall be designed using the hydraulic methods that apply to storm drain pump systems, set forth within standard engineering texts. Non-gravity flow systems shall be designed such that should the system fail, damage to adjoining properties and facilities will be limited to the site only.

305.07 Inlet Grate Design Parameters

The design methodology used to compute the flow capacity of storm drain inlet grates shall utilize orifice and weir flow equations, with consideration given to grate open areas, and flow dimensions provided by the casting manufacturer. The grate casting shall provide sufficient grate open area to convey the 10-year (10% AEP) storm event with 50% of the sag inlet areas clogged. The potential maximum depth to which stormwater may pond above the inlet grate must not threaten surrounding permanent structures and public facilities and not exceed six (6) inches. Emergency overflow points shall be provided for inlets placed in a sumped condition.

Roll curb and gutter inlet grates, as a general rule, shall be placed at a maximum interval of 400 feet, provided a minimum 10-year (10% AEP) design storm flow capacity has also been provided.

305.08 Inlet Spacing and Spread

Inlets in roadway gutter lines must be spaced to prevent flow from entering public road intersections. In addition, inlets should be spaced intermediately in residential street gutter lines to allow one lane (based on the lane width of the road) of traffic to remain open during the 10-year (10% AEP) storm event. Multi-lane facilities may have one travel lane on each side of the roadway flooded during the 10-year (10% AEP) storm event. The 100-year (1% AEP) shall not exceed the curb and not threaten surrounding permanent structures or public facilities. The methods described in HEC 22 and the latest edition of the LTAP Stormwater Drainage Manual shall be used to determine inlet spacing and spread.

305.09 Drainage System Overflow Design

The ponding and overflow path resulting from the 100-year (1% AEP) storm event shall be identified in the Plans. The plans shall include spill over elevations for sag inlets and internal drainage features that are contained within the project's property boundary and illustrate the 100-year storm (1% AEP) event can be routed to the detention basin or acceptable outlet if detention is not required for the project. The overflow path water surface elevations must be below the lowest adjacent grade of all permanent structures along the overflow route.

305.10 End Treatments

Protection of storm sewer pipe ends is required**.** End treatments will include, but may not be limited to, stabilization of surrounding embankments, and provisions for end sections, footing supports, and end anchors and erosion control measures. Refer to Chapter 400, Section 407 of this Manual.

Appendix 300

TABLE 304-01: Inlet Coefficients

Type of Structure and Design of Entrance	Coefficients K_e
Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded [radius = 1/12 (D)]	0.2
Mitered to conform to fill slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to fill slope, paved or unpaved slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of [1/12 (D)] or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of [1/12(D)] or beveled top edge	0.2
Wingwalls at 10° or 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

*Note: End Sections conforming to fill slope, made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests, they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, incorporating a closed taper in their design have a superior hydraulic performance.

TABLE 304-02: Junction Ke Values

Junction Type	K_e Value
trunkline no bends at junction	0.5
trunkline with 45-degree bend	0.6
trunkline with 90-degree bend	0.8
trunkline with 1 small lateral	0.6
trunkline with 1 large lateral	0.7
2 equal entrance lines at 90-degrees	0.8
2 equal entrance lines at > 90-degrees	0.9
3 or more entrance lines	1.0

Structure		Length (ft)	Drainage Area "A" (Acres)		Runoff Coefficient "C"	"A" x "C"		Flow Time (minutes)		Rainfall Intensity (In/Hr)	Total Runoff (CFS)	Pipe Diameter (Inches)	Full Capacity (cfs)	Velocity (fps)		Invert elev.		Manhole Invert Drop	Slope of Sewer (ft/ft)
To	From		Increment	Total		Increment	Total	To Upper End	In Section					Flowing Full	Design Flow	Upper End	Lower End		

FIGURE 305-01: Example Storm Sewer Flow Tabulation Form

TABLE 305-01: Manning's "n" Values for Pipes

Pipe Material	Manning's "n"
Concrete Pipe	0.012
Concrete Boxes	0.012
Corrugated Metal Pipe or Pipe Arch	
2 2/3" x ½" Helical Corrugation	0.022
2 2/3" x ½" Annular Corrugation	
15" to 36"	0.025
42" to 96"	0.024
3" x 1" Corrugation	0.027
5" x 1" Corrugation	0.025
Structural Plate Pipe or Pipe Arch	
6" x 2" Corrugation	0.033
9" x 2 ½" Corrugation	0.035
Spiral Ribbed Corrugated Metal Pipe (7 ½" x 3/4" x 3/4")	0.013
Smooth High Density Polyethylene (HDPE) and smooth lined interior Polyvinyl Chloride (PVC)	0.012
Smooth Interior Corrugated HDPE	0.012
Ductile Iron Pipe	0.012

Chapter 400 Storm Sewer Pipe and Open Culvert Materials

Section 401. General

401.01 Approved Materials

The materials used in the construction shall be in full conformance with those guidelines set forth below and according to the applicable ASTM, AWWA, and ANSI specifications. The final approval of materials is determined by the City.

For the purposes of this Manual, a storm sewer shall be defined as a network of pipe conduits and concrete manhole and/or inlet structures which collect and convey surface and subsurface water through gravity flow.

Subsurface drainage tiles, building floor drains, downspout outlets, roof conductors and sump pump lines are not considered as part of the requirements for storm sewers. Section 406 of this Manual should be referenced for requirements relating to the connection of subsurface drainage tile systems to the enclosed storm sewer system. Stormwater conveyance systems which route an existing natural or man-made stream channel, open ditch, or storm sewer around or through a developing site shall be considered a storm sewer by the Department and shall comply with the requirements of this Section.

An open culvert shall be defined as a conduit open on both ends, intended to provide for free passage of surface water runoff under highways, streets, roads, shoulders, railroads and embankments.

These material requirements are minimum requirements and are in part restatements of requirements set forth within the referenced standards, with noted exceptions. The Engineer shall be ultimately responsible for designing and selecting the appropriate material for each specific application. Information from the referenced specifications has been included within this Chapter for the convenience of the reader. However, the Engineer, contractor, and manufacturer must also assume the responsibility of familiarizing themselves with these requirements. The City will not assume responsibility for noncompliance with the referenced specifications as a result of information not provided in this Manual.

401.02 Material Markings

Each length of pipe or culvert, subsurface drainage tile, and each manhole and box inlet structure shall be marked per the requirements of each respective ASTM Standard referenced within this Chapter.

401.03 Certification of Materials

The Department shall reserve the right to require material certification from the manufacturer prior to or during construction of the stormwater drainage facilities as deemed necessary to ensure the material supplied conforms to the prescribed requirements. Provisions for obtaining this certification shall be the responsibility of the permit applicant. The City of Indianapolis does not assume the responsibility for the expense of obtaining material certification.

401.04 Material Testing and Inspection

The Department shall reserve the right to require the manufacturer, at the expense of the manufacturer, to perform minimum inspections requirements. This testing may be conducted by the quality control section of each individual manufacturer or may be overseen or conducted by a qualified independent private testing laboratory. The manufacturer shall be defined as the producer of those materials required by this standard having direct responsibility and authority for the satisfaction of those minimum material specifications set forth herein. In those instances, where independent inspection and testing are deemed necessary by the Department, the responsibility for the expense of these services will be arranged on a case by case basis.

401.05 Jacking and Boring Operations

Jacking and boring operations shall be in full conformance with the Citizens Energy Group Sanitary Standards Manual (latest revision).

The pipe materials accepted for jacking and boring shall be as follows:

1. Iron Pipe

   Class 50, 51, 52, or 54 ductile iron pipe in conformance with AWWA C 151, and cast iron pipe in conformance with AWWA C151.

2. Steel Pipe

   Electric-fusion, arc-welded steel pipe in accordance with ASTM A 139, grade B, or approved equal.

3. Reinforced Concrete Pipe

   Reinforced concrete pipe of 30-inch inside diameter and over may be jacked, and shall be Class III or higher with gasketed, tongue and groove joints. All pipes shall have steel reinforcement concentric with the pipe wall, and additional reinforcement at the end of the pipe. The pipe shall be in accordance with ASTM C 76 and shall have a minimum 28-day compressive strength of 5000 psi.

   Joint steel shall extend as deep as possible into the bell and spigot without destroying the continuity of the pipe joint. Bentonite fittings of sufficient size and frequency shall be provided based upon an evaluation of site conditions by the contractor, with consideration given to criteria for final acceptance of the installed system by the Department. A steel ring joint may be used in lieu of tongue and groove.

4. Other Materials

   Other materials, such as HOBAS fiberglass pipe, will be approved for jacking and boring operations on a case-by-case basis by the Department, provided sufficient specifications and documentation of the accepted use of the alternative material has been reviewed and approved by the Department.

401.06 Underground Detention Storage Vaults

Underground detention storage shall be constructed of accepted storm sewer pipe materials and approved underground propriety storage products, manufactured, tested, and installed according to those guidelines set forth herein. Poured-in-place, reinforced concrete vaults for underground detention storage may also be approved on a case basis by the Department.

Underground detention storage within Wellfield Protection Secondary Zoning Districts shall require additional review by the Technically Qualified Person (TQP) per Section 740-202 of the City Code.

Section 402. Pipe Materials

402.01 Pipe Material Classes

The materials used in the construction of storm sewers and open culverts shall be in full conformance with those guidelines set forth below.

1. DPW Class No. 1 Pipe Material - Public Drainage Facilities

   All public facilities shall be constructed of Class No. 1 materials and have a minimum 75-year design service life. Public Facilities shall mean any storm-water facility located within the public right-of-way or a drainage easement, either existing or proposed, as required by any ordinance, rule, regulation, or policy of the City of Indianapolis, its departments, Boards, or agents. Refer to 715-DPW-000 Pipe Culverts, and Storm and Sanitary Sewers for specifications and acceptable materials. Refer to Indianapolis DPW specifications found on www.indy.gov.

2. DPW Class No. 2 Pipe Material – Open Culverts

   Open culverts, except those driveway culverts located within the public right-of-way shall be constructed of Class No. 2 materials and have a minimum 50-year service life. Open culverts shall be defined as those drainage conduits which are open on both ends and intended to provide for free passage of surface water runoff under highways, streets, roads, drives, shoulders, railroads, or other embankments. Refer to 715-DPW-000 Pipe Culverts, and Storm and Sanitary Sewers for specifications and acceptable materials.

3. DPW Class No. 3 Pipe Material – Private Drainage Facilities

   All privately owned and maintained stormwater facilities may be constructed of Class No. 3 pipe materials and have a minimum 35-year design service life. Private drainage facilities shall mean any stormwater system located outside any public right-of-way or drainage easement, either existing or proposed, as required by any ordinance, rule, regulation, or policy of the City of Indianapolis, or Marion County, or outside of any property owned by the City of Indianapolis, its Departments, Boards, or Agents. Acceptable materials are listed below:
   - Reinforced concrete pipe
   - Reinforced concrete elliptical pipe
   - Precast reinforced concrete box sections
   - 16-gauge metal pipe:
     - Corrugated steel pipe and pipe arch Precoated galvanized steel pipe and pipe arch
     - Aluminum Coated Type II corrugated steel pipe and pipe arch
     - Aluminum Coated Type II steel helical ribbed pipe (Type IR)
     - Corrugated aluminum alloy pipe and pipe arch
     - Aluminum alloy helical ribbed pipe (Type IR)
   - Steel structural plate pipe, pipe-arches, and long spans
   - Corrugated aluminum alloy box culvert
   - Corrugated galvanized steel box culvert
   - High density polyethylene pipe (HDPE), 12"-60"
   - Polyvinyl chloride pipe (PVC), 12"-36"
   - Dual-wall or triple-wall polypropylene pipe

The minimum pipe diameter for all pipe material (Class 1, 2 and 3) shall be 12", except for Class II metal which shall be fifteen inches (15").

Existing drive culverts which have reached the end of their effective service life and are proposed to be extended shall be replaced with those alternate open culvert materials specified by this Chapter.

Precast storm sewer manholes or box inlets will be required between steel pipes of equal size and shape but differing metal types. Section 404 of this Chapter should be referenced for additional requirements relating to placement of precast storm sewer manholes or box inlets.

To satisfy minimum structural requirements, aluminum-alloy pipe, aluminum coated steel pipe, precoated steel pipe, and galvanized steel pipe materials shall confirm to the gauge requirements of Tables 501-6, 501-7, 501-8, and 501-9 within Chapter 500 of this Manual.

The minimum gauge of aluminum-alloy pipe, aluminum coated steel pipe, precoated steel pipe, and galvanized steel pipe shall be the greater of those minimum gauges outlined above, or those minimum gauges required to satisfy structural limitations of this Manual.

The structural design of all pipe materials shall be in accordance with the most restrictive of either the manufacturer's recommendations or AASHTO structural design requirements.

For private development projects, the selected pipe material (from the above list) should be identified on the submitted plans.

Residential driveways and commercial and industrial entrance/exit drive culverts in public right-of-way shall be RCP for twelve to thirty inch (12"-30") diameters and Class 2 material for thirty-six inch (36") and larger diameters.

402.02 Bituminous Coatings and Paving

When used with coated pipe of 36 inch and larger diameter, corrugated metal connecting or coupling bands shall be the 2-piece type.

The bituminous material for coating and paving of corrugated metal pipe shall be in full conformance with the Indiana Department of Transportation Standard Specifications. When applied to the pipe, the bituminous material shall be free from impurities and the metal shall be free from grease, dust, moisture, or other deleterious material and in conformance with INDOT standards.

If paved invert is specified for circular pipe or pipe-arch, the pipe shall be fully or half coated as specified and additional bituminous material applied in the bottom section to form a smooth pavement. Except where the upper edges intersect the corrugations, the pavement shall have a minimum thickness of one eighth (1/8) of an inch above the crests of the corrugations. For circular pipe, the pavement shall be applied to the lower one quarter (1/4) of the circumference. For pipe-arches, the pavement shall be applied to the lower forty percent (40%) of the inside periphery.

Polymer precoated corrugated steel pipe shall be in full conformance with AASHTO M245 (or ASTM Designation A762) and AASHTO M246 (or ASTM Designation A742) Grade 10/10.

Bituminous coated and smooth lined galvanized corrugated steel pipe shall be coated as required herein and shall be lined on the inside of the pipe so that a smooth surface will be formed completely filling the corrugations to a minimum thickness of one eighth (1/8) of an inch above the crests and a maximum of one half (½) of an inch above the crest. The interior lining shall be applied by a centrifugal or other approved method and shall be free from sags and runs. The lining material shall meet the requirements of AASHTO M 190.

Fiber-bonded corrugated metal pipe shall be in full conformance with Section 908.08 of the Indiana Department of Transportation Standard Specifications, latest revision.

Section 403. Material Specifications

403.01 Introduction

This section outlines requirements for the manufacture of storm sewer and open culvert materials according to applicable American Association of State Highway and Transportation Officials (AASHTO) and American Society for Testing and Materials (ASTM) specifications. These material requirements are in part restatements of requirements set forth within the referenced standard, with noted exceptions. A summarization of information from the referenced ASTM and AASHTO specifications has been included within this section for the convenience of the reader, however, the designer, contractor, and manufacturer must also assume the responsibility of familiarizing themselves with these specifications as they apply to those guidelines set forth herein. The Department will not assume responsibility for noncompliance with the referenced specifications as a result of information not provided by this Manual.

Each storm sewer pipe or open culvert material has been separated into sections and, generally, each section will contain the following information: production and material standards; pipe joint replacements; criteria for rejection of damaged materials; and material markings.

403.02 Aluminum-Alloy Structural Plate Pipe, Pipe-Arches, Arches, Long-Spans, and Box Culverts

1. Production and Material Standards

   Aluminum-alloy structural plate culverts must be formed from aluminum-alloy structural plate in conformance with ASTM B 790, and ASTM B 746.

   The material used in the manufacture of aluminum-alloy structural plates must be as required within ASTM B 209, and secondary structural components must conform to ASTM B 221.

2. Rejection of Damaged Structural Plates

   Aluminum-alloy structural plates possessing the following defects may be rejected for installation: dents or bends in the metal; lack of integrity; illegible markings as specified herein on the aluminum sheet; ragged or diagonal sheared edges.

3. Aluminum-Alloy Structural Plate Markings

   Each plate shall be identified on the inside with the following information as a minimum: name or trademark of plate manufacturer; name of fabricator, if other than manufacturer; year and month of manufacture; and ASTM designation.

403.03 Galvanized Structural Plate Pipe, Pipe Arches, Arches, Long-Spans, and Box Culverts

1. Production and Material Standards

   Galvanized structural plate culverts must be formed from galvanized structural plate in conformance with ASTM A 761, and ASTM A 796.

   Steel sheet used for flat plate shall be galvanized by the hot-dip process according to ASTM A 444. Repair of damaged hot-dip galvanized coatings shall be in conformance with ASTM A 780.

2. Rejection of Damaged Galvanized Structural Plates

Galvanized structural plates possessing the following defects may be rejected for installation: dents or bends in the metal; lack of integrity; illegible markings as specified herein on the galvanized sheet; ragged or diagonal sheared edges.

3. Galvanized Structural Plate Markings

For galvanized structural plate products, each plate shall, at a minimum, be identified on the inside with the following information: name of manufacturer; specified zinc-coated thickness; specified coating weight (mass); identification showing heat number and coating lot number (may be omitted if fabricator's records tie the coating lot number to a specific heat number and manufacturer); and ASTM designation.

4. Exterior Field Coatings

Exterior field applied coatings of asphaltic mastic or tar base material shall be required for all galvanized structural plates with less than five (5) feet of cover in conformance with AASHTO M 243.

403.04 Corrugated Metal Pipe (CMP)

1. Production and Material Standards

Corrugated metal pipe (CMP) shall be of either riveted lap joint construction (annular corrugations) or be constructed with a continuous lock seam or welded seam from end to end of each length of pipe (helical corrugations).

Aluminum-Alloy Corrugated Pipe shall be fabricated in accordance with ASTM B745. This pipe shall be fabricated from aluminum-alloy sheet and plate as specified within ASTM B 209.

Aluminum Coated Steel Type 2 Corrugated Pipe shall be fabricated as specified within ASTM A 760, except that all pipe and pipe coupling bands shall be formed from aluminum coated steel conforming to ASTM A 929.

Galvanized Steel Pipe shall be manufactured according to those guidelines set forth within ASTM A 760, formed from zinc-coated steel sheet material conforming to ASTM A 444.

2. CMP Joints

External coupling bands conforming to those standards set forth within ASTM B 745 and ASTM A 760 will be accepted for use in the construction of corrugated metal pipe joints. All coupling bands shall be fabricated with annular corrugations to lap an equal portion of each adjoining pipe section and be of the same gage and coating material as the pipe structure. Each pipe end shall be reformed to have a minimum of two annular corrugations. A tightly closed joint shall be formed in order to create a soil-tight seal. The pipe ends shall be matched at the joint such that the difference in diameter between abutting pipes is no more than one half (½) of an inch around the entire pipe circumference. All corrugated metal pipe couplings will be required to be wrapped with a strip of nonwoven geotextile fabric around the entire pipe diameter to prevent infiltration of bedding and backfill materials. The minimum width of this fabric shall be one (1) foot plus the band width, to allow a minimum six (6) inches overlap of each band edge. Rubber O-ring gaskets may be used in place of geotextile fabric wrap at the corrugated metal pipe joint provided that O-rings are placed on each end corrugation and hugger type bands are used that seat into the second corrugation from the end of the pipe on both pipes at the joint. Bolted connectors are required on the bands such that compression of the O-rings occur. O-ring diameters shall be determined in accordance with the

manufacturer's recommendations.

3. Rejection of Damaged CMP

The completed pipe shall show careful, finished workmanship in all aspects of its production. Pipe which has been damaged may be rejected for any one of the following defects: variation from a straight centerline; elliptical shape in a pipe intended to be round; dents or bends in the metal; metallic coating or bituminous coating or liner which has been bruised, broken, or otherwise damaged; lack of rigidity; illegible markings on the steel sheet; ragged or diagonal sheared edges; uneven laps in riveted or spot welded pipe; loose, unevenly lined, or unevenly spaced rivets; defective spot welds or continuous welds; or loosely formed lock seams.

4. Corrugated Metal Pipe Markings

For corrugated metal pipe products, each corrugated sheet used in the fabrication of annular pipe, and every two (2) to five (5) feet of coiled sheet used in fabrication of helical pipe must be identified with the following information: name of sheet manufacturer; alloy and temper; specified thickness; ASTM designation; and heat number.

403.05 High Density Polyethylene Pipe (HDPE)

1. Production and Material Standards for HDPE

Corrugated High Density Polyethylene Type S (HDPE) pipe shall be manufactured in accordance with AASHTO M 294 and ASTM F2306. The flexibility factor of HDPE pipe shall not exceed 0.095.

Ribbed polyethylene pipe shall be in accordance with ASTM F 894 for the specified sizes, meeting the requirements for RSC 100 or RSC 160. Pipe manufactured under this specification shall have a minimum Cell Class of 334433C in accordance with ASTM D 3350.

Smooth wall polyethylene pipe shall be in accordance with ASTM F 714 for the specified sizes. Pipe manufactured under this specification shall have a minimum Cell Class of 35434C in accordance with ASTM D 3350.

All polyethylene pipe and fittings shall be made from high molecular weight, high density polyethylene material meeting the applicable Cell Class requirements. All polyethylene material used in storm sewer pipe manufacture shall be virgin resin.

2. HDPE Joints

High Density Polyethylene pipe shall possess male and female pipe ends which allow the construction of overlapping, gasketed pipe joints in conformance with the requirements of ASTM D 3212. The gasket material shall conform to all requirements of ASTM F 477. As an alternative, pipe joints utilizing external coupling bands will be accepted, provided the minimum AASHTO requirements for satisfying soil tightness are also achieved.

Manufactured wyes, tees, elbows, or adapters will not be accepted for use in place of precast storm sewer manholes and box inlets unless previously approved by the Department.

Precast concrete manholes and box inlets will be required within HDPE storm sewer systems at changes in grade, alignment, size and pipe material type, as outlined within Chapter 500 of this Manual unless previously approved by the Department.

3. Rejection of Damaged HDPE

High Density Polyethylene pipe possessing the following defects may be rejected for installation: variations from straight centerline; elliptical shape in pipe intended to be round; illegible markings as required herein; deep or excessive gouges or scratches on the pipe wall; fractures, punctures, or cracks passing through the pipe wall; damaged or cracked ends where such damage would prevent making a satisfactory joint.

4. HDPE Pipe Markings

For high density polyethylene pipe products, each length of pipe shall, at a minimum, be clearly marked with the following information: manufacturer's name or identification symbol; nominal pipe size; and production/extrusion code.

403.06 Polyvinyl Chloride Pipe (PVC)

1. Production and Material Standards

Polyvinyl Chloride (PVC) profile wall gravity flow storm sewer pipes shall be the integral wall bell and spigot types with elastomeric seal joints and smooth inner walls in accordance with AASHTO M 304. A minimum Cell Class of 12454C or 12364C as set forth by ASTM D 1784 shall be required.

Smooth wall PVC pipe shall be in accordance with ASTM F 679 or AASHTO M 278 for the specified sizes and shall have a minimum Cell Class of 12364C for pipes meeting specification ASTM F 679, or 12454C for pipes meeting specification AASHTO M 278. Cell class properties shall be as set forth by ASTM D 1784.

2. PVC Joints

Flexible, gasketed joints shall be compression type so that when assembled, the gasket inside the bell is compressed radially on the pipe spigot to form a soil tight seal. The assembly of joints shall be in accordance with the pipe manufacturer's recommendations and ASTM D 3212. The gasket shall conform to the requirements of ASTM F 477. All field-cutting of pipe shall be completed in a neat, trim manner using a hand or power saw.

Precast manholes and/or box inlets will be required within PVC storm sewer systems at all changes in grade, alignment, size and pipe material type as outlined within Chapter 500 of this Manual. Manufactured wyes, tees, elbows, or adapters will not be accepted for use in place of manhole or box inlet structures unless previously approved by the Department.

3. Rejection of Damaged PVC

Polyvinyl Chloride Pipe possessing the following defects may be rejected for installation: variation from straight centerline; elliptical shape in pipe intended to be round; illegible markings as required herein; deep or excessive gouges or scratches of the pipe wall; fractures, punctures, or cracks passing through the pipe wall; damaged or cracked ends where such damage would prevent making a satisfactory joint.

4. PVC Pipe Markings

For polyvinyl chloride pipe products, each length of pipe shall, at a minimum, be marked with the following information: name of manufacturer; tradename or trademark; nominal pipe size;

production/extrusion code; material and cell class designation; and ASTM designation.

403.07 Reinforced Concrete Pipe (RCP)

1. Production and Material Standards

Reinforced concrete pipe shall be Class lll, lV, or V in accordance with ASTM C 76, latest edition. A minimum "B" wall thickness will be required. Elliptical reinforced concrete pipe shall be a minimum Class HE-ll in full conformance with the requirements of ASTM C 507. Non-reinforced concrete pipe shall meet all requirements of AASHTO M86 for the specified diameter and strength classes.

Elliptical reinforcement shall be permitted only by written approval of the Department. Longitudinal reinforcement shall be continuous, and all reinforcement shall have a minimum concrete cover of 3/4-inch.

Upon request by the Department, the manufacturer shall furnish certification on the type of cement, aggregate, and steel used in the pipe furnished.

Lift holes will not be allowed for reinforced concrete pipe less than thirty-six (36) inches in diameter. A maximum of two (2) lift holes may be provided for each section of reinforced concrete pipe thirty-six (36) inches in diameter and larger. Lift holes must be repaired in a clean, workmanlike manner using a conical shaped precast concrete plug, properly sealed into place using mastic or non- shrink cement grout. Compliance with the Indiana Department of Transportation Standards and Specifications for completion of lift hole repair shall be required.

2. RCP Joints

Concrete pipe shall be furnished with a bell or grove on one end of a unit of pipe, and a spigot or tongue on the adjacent end of the adjoining pipe. All joints shall have a groove on the spigot for placement of a rubber gasket in conformance with ASTM C 443. The gasket shall be a continuous ring which fits snugly into the annular space between the overlapping surfaces of the assembled pipe joint to form a flexible soil tight seal. As an alternative, mastic joints installed in conformance with Manufacturer's recommendations will be accepted by the Department outside of the public right-of-way, however, mastic concrete pipe couplings shall be wrapped with a one (1) foot wide strip of non-woven geotextile fabric around the entire pipe diameter. Joint mastic material can be lost over time due to the external hydrostatic pressures of groundwater, allowing the migration of backfill materials into the storm sewer system through the open joint.

3. Rejection of Damaged RCP

Individual sections of reinforced concrete pipe may be rejected because of any of the following: fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint; defects that indicate proportioning, mixing, and molding not in compliance with Section 10.1 of ASTM C 76; surface defects indicating honey-combed or open texture; damaged or cracked ends where such damage would prevent making a satisfactory joint; any continuous crack having a surface width of greater than one hundredth (0.01) in., and extending for a length of twelve (12) inches or more, regardless of position in the wall of the pipe; visible spacers or longitudinal reinforcement used to position the reinforcing cage shall not be cause for rejection or reinforced concrete pipe sections.

4. Reinforced Concrete Pipe Markings

Each length of reinforced concrete pipe shall, at a minimum, be marked with the following information: date of manufacture; ASTM class of pipe and specification designation; size of pipe; tradename or the manufacturer; and plant identification.

403.08 Reinforced Concrete Box Sections

1. Production and Material Standards

Precast reinforced concrete box sections for open storm drainage culverts must be manufactured from a homogenous concrete mixture conforming to the test and design requirements of ASTM C1433. Box sections must be cured in such a manner that the specified compressive strength of the concrete is achieved in twenty-eight (28) days or less. Compressive strength tests must be conducted in accordance with Section 10 of ASTM C 1433 prior to shipment.

Reinforced concrete box sections are divided into three design types, dependent upon varying earth dead load and HS20 and Interstate live loading conditions. Each type of box section must be designated by type, span, rise and design earth cover. Precast reinforced concrete box sections manufactured in accordance with ASTM C1433 will also be accepted by the Department, under those minimum cover conditions for which this standard is intended to apply.

2. Reinforced Concrete Box Joints

Precast reinforced concrete box sections shall be produced with male and female ends, designed to allow box sections to be laid together in a continuous line. Reinforced concrete box joints shall be sealed using either trowelable grade butyl rubber or asphaltic mastic to form a soil tight seal. Reinforced concrete box joints shall be wrapped around their entire diameter with a one (1) foot wide non-woven geotextile fabric wrap.

3. Steel Reinforcement of Concrete Box Sections

The minimum cover of concrete over the steel reinforcement shall be one (1) inch. The inside steel reinforcement shall extend into the male portion of the joint. The outside steel reinforcement shall extend into the female portion of the joint. The clear distance of the end reinforcement steel wires must not be less than one half (½) inch or more than two (2) inches from the end of the box section.

4. Rejection of Damaged Concrete Box Sections

Individual box sections may be rejected because of any of the following: fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint; honeycombed or open texture that would adversely affect the function of the box sections; the ends of the box sections are not normal to the walls and center line of the box section, within the specified acceptable tolerances.

5. Reinforced Concrete Box Section Markings

For reinforced concrete box sections, each length of a reinforced concrete box shall, at a minimum, be marked with the following information: box section span and rise; ASTM table number; maximum and minimum design earth cover; specification designation; date of manufacture; name of trademark of manufacturer; and orientation of the top of the structure.

403.09 High Impact Polypropylene or High-Density Polyethylene Plastic Facilities

The plastic shall be resistant to environmental stress cracking and maintain adequate stiffness through higher temperatures experienced during installation and service. The chambers shall be designed to exceed the AASHTO recommended Load and Resistance Factor Design (LRFD) for earth loads and HS-20 live loads, with consideration for impact and multiple presence when installed per the manufacturer's minimum requirements. The plastic chambers shall have a design life of seventy-five (75) years. Refer to :Additional Approved Products on indy.gov for approved manufacturers. Designers must provide documentation from the manufacturer that selected products meet applicable AASHTO, ASTM, and HS-20 loading requirements.

Section 404. Manhole and Inlet Materials

404.01 Introduction

Storm sewer manholes and inlets shall be constructed of precast reinforced concrete. Material and construction shall conform to the latest edition of the INDOT Standard Drawings and Specifications, Section 702 and 720, in addition to the requirements and details provided in this Chapter.

Precast reinforced concrete or prefabricated corrugated metal wyes, tees, and elbows of the same diameter as the storm sewer or culvert pipes will be accepted at horizontal alignment changes within storm drainage systems of forty-eight (48) inch inside diameter or larger, provided precast or poured-in-place manholes or box inlets are also provided at the required maximum interval of eight hundred (800) feet.

Forty-eight (48) inch vertical precast reinforced concrete or prefabricated corrugated metal tees may be used in place of precast or poured-in-place manholes or box inlets within forty-eight (48) inch to one hundred and forty-four (144) inch inside diameter reinforced concrete or corrugated metal storm drainage systems.

Corrugated metal tees and risers shall be of the same material type and gauge as the connecting pipe, prefabricated by the pipe manufacturer, possessing continuous welded seams properly recoated with zinc galvanizing compound.

Precast or prefabricated wyes or tees may be utilized for attachment of lateral storm sewer or subsurface tile lines to forty-eight (48) inch inside diameter or larger drainage systems, however, at least one manhole structure as specified herein must be provided a maximum distance of two hundred and fifty (250) feet from the wye or tee location.

Chapter 100 of this Manual should be referenced for minimum required easement locations and widths.

In order to provide for adequate access to the enclosed storm sewer drainage system manholes or precast, concrete box inlets shall be provided at the following maximum intervals:

TABLE 404-01: Manhole Spacing

Size of Pipe (IN)	Maximum Distance (FT)
12 thru 18	500
21 and larger	800

Figures 400-01 through 400-04 in Appendix 400: Standard Details should be referenced for an illustration of accepted manhole and precast box inlet construction. The Department will accept the following types of storm sewer structures according to the standards and specifications outlined herein: Monolithic (Cast-in-Place) Storm Sewer Structures, Monolithic pour storm sewer manhole, and box inlet structures may be approved on a case-by-case basis by the Department provided plan specifications showing, at a minimum, the concrete mix, steel reinforcement details, pipe connections and manhole or box inlet dimensions are submitted and approved prior to construction. Substantial field changes of the approved construction drawings shall be certified by the design consultant and receive approval of the Department prior to completion of the proposed work. Failure to comply with this specification may necessitate the removal and reconstruction of that portion of the stormwater facility.

404.02 Precast Concrete Storm Sewer Manhole Structures

Precast reinforced concrete storm sewer manholes including bases, risers/barrels, cones and flat slabs shall be constructed of either wet or dry cast Class A concrete meeting or exceeding the requirements of ASTM C 478, latest revision. Precast reinforced concrete storm sewer manholes shall conform to current INDOT standards except as noted herein.

Precast reinforced concrete storm sewer manholes shall be manufactured, tested and marked in accordance with ASTM C 478, and may be constructed with the base and the first riser section as one complete precast unit, or as a separate base and riser section for diameters sixty (60) inches and larger. Alternative construction methods for connections to existing storm sewer lines will be approved on a case-by-case basis by the Department.

Precast reinforced concrete manhole cones shall be the eccentric cone type. Precast reinforced concrete flattop slabs may be used in place of eccentric ones, provided a minimum of six (6) inches of soil depth over the concrete slab is provided for establishment of permanent vegetation, in those areas where permanent vegetation is deemed necessary.

Precast reinforced concrete manholes shall have a minimum wall thickness of five (5) inches. The manhole base shall be set on six (6) inches of INDOT #8 or #2 Stone.

Lift holes must be repaired in a clean, workmanlike manner using a conical shaped precast concrete plug, properly sealed into place using mastic or non-shrink cement grout. As an alternative, lift holes may be repaired with one hundred percent (100%) non-shrink epoxy grout, which then shall be smoothed and covered, both inside and out, with a trowelable grade butyl rubber backplaster material to ensure a watertight seal.

Joints between precast storm sewer manhole elements shall be sealed utilizing one of the following alternatives: 1) An approved rubber gasket manufactured and installed in accordance with ASTM C 443, latest edition; 2) Trowelable grade butyl rubber; or 3) A one half (½) inch diameter non- asphaltic mastic (Kent Seal or approved equal) conforming to AASHTO M 198 and Federal Specifications SS-521-A.

All precast reinforced concrete storm sewer manholes shall be steam or heat and water mist cured and shall not be installed until at least five (5) days after casting. Exceptions to this "5-day" rule shall be considered by the Department on a case-by-case basis after written notification and submittal of subject structure test data verifying conformance to the twenty-eight (28) day specified compressive strength.

404.03 Precast Concrete Box Inlets and Catch Basins

Precast concrete box inlets and catch basins constructed in accordance with Indiana Department of Transportation (INDOT) Standard Specifications will be accepted for use except as noted herein. Inlet and catch basin Type "A" *, Type "B", Type "C", Type "E", Type "J", Type "K", and Type "M" may be used.

A modified Type “A” inlet may be used with inside dimensions of twenty-four (24) inches by twenty-four (24) inches as shown in Figure 400-02 in Appendix 400: Standard Details.

The structural design of precast concrete box inlets and catch basins shall be in full conformance with the requirements of ASTM C 890.

A maximum depth of four (4) feet from the bottom of casting to the outlet pipe invert shall be allowed for Type “A” precast box inlet structures.

Mortared brick or block will not be an accepted method of box inlet or manhole construction.

404.04 Bench Walls

The concrete base of reinforced concrete monolithic pour or precast manholes shall be of six (6) inch minimum thickness for four (4) foot diameter structures, and of eight (8) inch minimum thickness for larger diameter structures, and shall be constructed of Class A concrete having compressive strength of four thousand (4000) psi.

The wall and base thickness of precast concrete box inlet structures shall be as specified by the Indiana Department of Transportation Standard Specifications and must also be constructed of Class A concrete having a minimum compressive strength of four thousand (4000) psi.

Bench walls shall be shaped and formed for a clean transition with proper hydraulics to allow the smooth conveyance of flows through the manhole or box inlet. The bench wall shall form a defined channel, to a minimum height of eighty percent (80%) of the inside diameter of the inlet and outlet pipes to form a “U” shaped channel, constructed at a minimum one half (½) inch per foot slope to the manhole wall.

Where a flow channel is constructed as an integral part of the pre-cast base, it shall be shaped and formed as described above, with the exception that the bottom of the flow channel may be formed from the bottom of inlet and outlet pipes if the pipe wall thickness is not greater than one (1) inch.

For cast-in-place flow channels, the bottom invert of all pipes entering a manhole shall be at least three (3) inches above the top of the base slab to the outlet invert so the finished sewer channel may be installed and shaped.

For connections to existing storm sewer structures, flow channels shall be shaped, as specified herein, as if it were a new manhole or box inlet structure**.**

404.05 Manhole Precast Adjusting Rings

Where one (1) solid riser or barrel section cannot be used, final adjustments in elevation of the casting frame and grate for precast manholes shall be accomplished by the use of precast concrete adjusting rings of a minimum nominal thickness of two (2) inches, as shown in Figure 400-05 in Appendix 400: Standard Details, and conforming to ASTM C 478. The maximum number of adjusting rings shall be four (4), with the total height not exceeding twelve (12) inches.

A water tight seal shall be provided between the precast manhole and riser ring, each adjoining riser ring, and between the riser ring and casting by the use of either two (2) rows of one half (½) inch extrudable preformed gasket material, non-asphaltic mastic, or trowelable grade butyl rubber, as shown in Figure 400-05 in Appendix 400: Standard Details.

Concrete adjusting rings shall conform to ASTM C 478 and be free from voids, cracks, and other defects. The adjusting ring shall be from the same manufacturer as the manhole cone section to assure compatibility and a watertight seal per Figure 400-05 of Appendix 400: Standard Details.

404.06 Precast Concrete Box Inlets and Precast Spacers

For precast concrete box inlets, the adjustment of casting frame and grate shall be accomplished using precast concrete spacers of a minimal nominal thickness of six (6) inches. The maximum number of spacers allowed shall be four (4). A water-tight seal shall be provided between each component of the precast box inlet and precast concrete spacers by use of non-asphaltic mastic, or trowelable grade butyl rubber.

The adjustment of casting elevation for precast concrete box inlets may be accomplished using solid concrete block and mortar to a maximum height of six (6) inches. This type of casting adjustment shall be completed in conformance with the following:

1) No joint shall exceed three eighths (3/8) of an inch in width, and as nearly as practicable, adjoining courses shall break joints at one half (½) unit intervals.
2) Minimum constructed wall thickness shall be six (6) inches.
3) Mortar for laying brick shall be composed of one (1) part masonry cement and two (2) parts mortar sand.

Both the inside and outside of the adjustment area shall be plastered to at least one half (½) of an inch thick using the above mortar mix, or a mixture composed of one (1) part of a combination of Portland cement and hydrated lime and two (2) parts mortar sand. The lime portion of this mix shall not exceed ten percent (10%) of the sand. Plaster coats shall be smooth, clean, and watertight.

404.07 Box Inlet and Manhole Dimensions

The maximum inside diameter of pipe allowed to connect to precast box inlet walls shall conform to Table 404-02 below. Table 404-03 outlines those minimum manhole diameters for storm sewer pipes entering or exiting a storm sewer manhole at the given range of angles.

TABLE 404-02: Maximum Pipe Inside Diameters for Precast Box Inlets

Structure Type	Straight Connection (1)	Skew/Corner Connection (2)
A	15"	12"
B	Long Wall/Short Wall	Long Wall/Short Wall
C	24" / 15"	18" / 12"
E	18"	15"
J	Long Wall/Short Wall 24" / 15"	Long Wall/Short Wall 18" / 12"

Note:

1) Straight-out connections should not be made to either precast box inlet wall touched by a skew/corner connection unless sufficient box inlet wall area remains on each side of the connecting pipe to ensure structural integrity of the precast box.
2) A maximum of two (2) skew/corner connections will be allowed for each precast box inlet.

TABLE 404-03: Minimum Manhole Diameter's

Pipe Size	Pipes Entering/Leaving at 0-45 degrees	Pipes Entering/Leaving at 45-90 degrees
12"-21"	48"	48"
24"	48"	60"
27"-30"	60"	60"
33"-36"	60"	72"

Note:

1) Pipe sizes from twelve (12) inches to twenty-four (24) inches shall be installed as per Figure 400-1 in Appendix 400: Standard Details.
2) Pipes equal to and greater than thirty-six (36) inches, up to forty-eight (48) inches in diameter, shall be installed as per Figure 400-2 in Appendix 400: Standard Details.
3) Precast reinforced concrete pipes equal to and greater than forty-eight (48) inches in diameter may be installed as per Figure 400-3 in Appendix 400: Standard Details.

The number and entrance angle of pipe connections, with consideration given to outside pipe diameter(s), shall be limited to those guidelines established by Tables 404-1 and 404-2 of this Manual to ensure maintenance of the structural integrity of the manhole or box structure. If at any time the structural integrity of the manhole or box inlet cannot be maintained, a cast-in-place structure will be required. Shop drawings for cast-in-place structures showing concrete mix, steel reinforcement, and section dimensions shall be submitted to the Department for review and approval prior to construction.

Manhole steps shall be provided in all storm sewer structures forty-eight (48) inches in diameter or larger, as required to allow adequate access for completion of inspections, cleaning, and repairs.

The maximum distance from grade to the first manhole step shall be twenty-four (24) inches, the maximum distance between steps shall be sixteen (16) inches, and the maximum distance from the last step to the structural bench wall shall be twenty-four (24) inches.

Steps shall conform to the requirements of ASTM C 478. Steps shall be factory installed when the manhole is manufactured.

404.08 Pipe Connections

Inlet and outlet pipes shall extend through the box inlet or manhole walls a sufficient distance to allow for placement of grouting material around the pipe diameter both inside and outside of the structure wall, preventing leakage around the pipes outer surface. Inlet and outlet pipes shall not extend through the inlet or manhole wall to such a degree that flow is obstructed.

Holes for connection of storm sewer pipes shall be pre-formed by the manufacturer, or field cut or drilled. Preformed holes shall be the method preferred by the Department. At no time shall the pipe hole exceed the outer pipe diameter plus six (6) inches (O.D. + 6"), to ensure a proper connection is achieved. Should the contractor elect to use manhole or box inlet structures with preformed thin wall "knock-outs", the balance of the "knock-out" area not occupied by the pipe connection and all remaining unused "knock-outs" shall be filled with four thousand (4000) psi Class A concrete to a finished wall thickness not less than that required by these standards. The use of preformed "knock-outs" shall not relieve the manufacturer from compliance with the reinforcement, dimension, and strength requirements specified herein.

The annular space between the pipe and the precast manhole or box inlet wall shall be filled inside and outside with a grout mixture composed of two (2) parts of INDOT#23 fine aggregate and one (1) part of Portland cement.

As an alternative, pipe connections to manholes utilizing an approved rubber gasket manufactured and installed in accordance with ASTM C 923 will be accepted by the Department.

404.09 Subsurface Tile Connections and Stubs

Unless otherwise approved, perforated subsurface drainage tiles, footer drains, or sump pump lines shall attach at a storm sewer manhole or box inlet structure. At these connections, precast or drilled holes shall be provided to a maximum of two (2) inches larger than O.D. of the connecting line. These connections shall be made in a clean workmanlike manner, and properly sealed using either an approved mortar mix, non-asphaltic mastic, or trowelable butyl rubber plaster.

To relieve hydraulic groundwater pressure from around the enclosed storm sewer system, the Department may require provision of perforated subsurface drainage tile "T" stubs, with filter fabric wrap, to be installed with manhole and precast box inlet structures greater than four (4) feet in depth. These subsurface drainage lines shall be an approved subsurface drainage tile material, with end caps, and shall extend a minimum of ten (10) feet in each direction from the manhole structure, placed just above the bench wall, as illustrated within Figures 400-01, and 400- 02 in Appendix 400: Standard Details.

404.10 Rejection of Damaged Box Inlet and Manholes

Precast reinforced concrete manholes, risers and tops, and precast box inlets which possess any of the following defects shall be subject to rejection: fractures or cracks passing through the shell, except for a single end crack that does not exceed the depth of the joint; defects that indicate imperfect proportioning, mixing and molding; surface defects indicating honeycombed or open texture; damaged ends, where such damage would prevent making a satisfactory joint; the internal diameter of the manhole section shall not vary more than one percent (1%) from the nominal diameter; not clearly marked date of manufacture, tradename, size designation part number, and ASTM number; having a deviation more than one quarter (1/4) inch from the straight edge at any point across the top of the manhole cone section or riser ring; having any visible steel bars along the inside or outside surface of the manhole except for reinforcement stirrups or spacers used to position the cage during manufacture, and reinforcement bars visible at the manhole structure end, provided these reinforcement bar ends are properly grouted in conformance with applicable ASTM specifications.

Section 405. Castings, Frames and Covers

405.01 Introduction

The design engineer will be required to determine the feasibility of use and placement of each casting type, based upon required square footage of open area needed for proper conveyance of estimated stormwater flow.

405.02 Manholes

Storm sewer manhole covers shall be a solid lid casting as detailed within Figure 400-06 in Appendix 400: Standard Details. The words "Storm Sewer" and "City of Indianapolis" must be imprinted onto solid lid covers for those manholes placed within the public right-of-way or perpetual drainage easements.

405.03 Rejection of Castings

All castings shall also conform to the following requirements:

1) Casting shall be of uniform quality and free from blow holes, porosity, hard spots, shrinkage, distortion or other defects. They shall be smooth and well-cleaned by shot blasting or other

approved methods.

2) All castings shall be manufactured true to pattern; component parts shall fit together in a satisfactory manner. Round frames and covers shall be of non-rocking design or shall have machined horizontal bearing surfaces to prevent rocking and rattling under traffic. All castings shall be fully interchangeable.
3) All weights shall not deviate from the tolerances permitted by ASTM standards, as specified within ASTM A 48, "Standard Specifications for Gray Iron Castings."
4) All castings shall be manufactured in accordance with ASTM A 48 Class 35 B, and shall have a minimum tensile strength of thirty-five thousand (35,000) psi.
5) Storm sewer manhole covers shall have the words "Storm Sewer" cast in recessed letters two (2) inches in height.
6) All stormwater inlets and catch basins shall have the words “No Dumping, Drains to Stream”, or similarly approved message, cast in raised or recessed letters at a minimum of one (1) inch in height. In addition, a symbol of a fish shall also be cast with the letters.

Curb inlet castings which, possess open back or have grate bars parallel to traffic flow, are not “bicycle safe” and will not be accepted by the Department.

Section 406. Subsurface Tiles

406.01 Introduction

Subsurface tile as specified herein may be used to convey subsurface water collected in sump pits and footer drains to an acceptable drainage outlet, provided these drainage tiles are properly sized to accept these flows, and connections to the existing stormwater facility are made as specified herein.

Subsurface tiles will not be considered adequate to accept other types of surface water flows, intended to be collected by an enclosed storm sewer system. Under those instances where surface inlets are to be provided within a subsurface tile line, the minimum requirements for storm sewer size and pipe material outlined within Section 401 of this Chapter shall apply.

406.02 General Requirements

The following requirements shall be adhered to as a part of all subsurface tile installations:

1) Tile Perforations: The water inlet area of perforated subsurface drainage tiles shall be at least one (1) square inch per foot of conduit length. Round perforations shall not exceed three sixteenth (3/16) inch in diameter, except where fabric filters or other filtration protection is provided. Slotted perforations shall not exceed one eight (1/8) inch in width.

2) Joints and Fittings:

    a. Subsurface tile shall be joined using external coupling bands, bell and spigot joints, or solvent cement joints per both the referenced ASTM Standards and the manufacturer's recommendations. Pre-formed wyes, tees, elbows and other special pipe fittings will be accepted for use provided they are manufactured and installed per ASTM and manufacturer requirements.
    b. Solvent cement joints of polyvinyl chloride sewer pipe and fittings shall be installed using those methods and materials outlined within ASTM D 2564, ASTM F 493, and ASTM F 656. The recommended procedure for installation of solvent cement joints within Appendix X1 of ASTM F 493 shall be followed.
    c. Subsurface tile systems are required to be provided with a “Y” cleanout connector at a minimum interval of four hundred (400) feet.

3) Tile Markings: All polyvinyl chloride and polyethylene subsurface drainage tile specified herein shall be marked per the respective ASTM Standards.
4) Material Certification: The Department shall reserve the right to require the Contractor to provide written certification from the manufacturer that each subsurface tile material proposed to be used as required herein has been sampled, tested, and inspected in accordance with the provisions of each ASTM Specification.

5) Minimum size: The minimum size for all subsurface drains not under curbs will be six (6) inches.

6) End Treatment: All subsurface tile that drains to an open ditch or swale must provide animal guards as per Section 503.07 of this Manual.

406.03 Accepted Materials

The Department will accept those materials listed within Table 406-1 below, which meet or exceed the minimum requirements and ASTM specifications set forth herein, for installation of subsurface drainage tiles.

TABLE 406-01: Subsurface Drain Tile Materials

Material Type	ASTM Designation
Corrugated Polyethylene tubing and fittings, 3-6 inch (2)	ASTM F 405
Corrugated Polyethylene tubing and fittings, 8-24 inch (2)	ASTM F 667
Polyvinyl Chloride (PVC) corrugated sewer pipe with smooth interior walls and fittings, 4-18 inch	ASTM F 949
Polyvinyl Chloride (PVC) sewer pipe and fittings	ASTM D 2729
Polyvinyl Chloride (PVC) pipe	ASTM D 3034

Note:

1) Polyethylene pipe under this specification may be provided as a corrugated single wall, or double walled with a corrugated outer wall and smooth inner wall. All public infrastructure using HDPE must use double wall pipe. All public infrastructure using PVC shall meet ASTM 3034 specifications, at a minimum.

Double walled corrugated polyethylene tile manufactured under specification ASTM F 667 and PVC tile manufactured under specification ASTM F 949, ASTM D 3033, and ASTM D 3034 will be required for installation of subsurface drainage tile with less than eighteen (18) inches of earth or equivalent cover.

406.04 Limited Cover Installations

Installation of subsurface tiles shall be in accordance with the requirements of this Manual, and those guidelines set forth within ASTM F 449, "Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drainage or Water Table Control." Subsurface tiles shall be properly bedded with a INDOT #8 stone envelope. Chapter 500 of this Manual should be referenced for further information relating to the installation of subsurface tiles.

Section 407. Pipe End Treatments

407.01 Limited Cover Installations

Protection of storm sewer pipe and open culvert ends is required to ensure maintenance of free-flowing inlets and outflows, to prevent flotation of the structure, and to protect against a migration of backfill materials. End treatments will include, but may not be limited to, stabilization of surrounding embankments, and provisions for end sections, footing supports, and end anchors.

407.02 Embankment Protection

Embankment slopes surrounding storm sewer pipe and open culvert ends shall be graded and stabilized with permanent vegetation cover at no greater than a three (3) (horizontal) to one (1) (vertical) slope. Seeding specifications and additional erosion control measures necessary to facilitate the establishment of permanent vegetation as specified within Chapter 600 of this Manual will be required.

Embankment slopes steeper than three (3) (horizontal) to one (1) (vertical) shall be stabilized using materials appropriate for the proposed bank slopes and stream flow velocities. Design calculations shall be included in the TIR.

407.03 End Protection

The following end protection will be required by the Department for each pipe material type specified:

1. Reinforced Concrete

   End sections for concrete pipe shall be precast concrete, with end footing support. The formulation of the concrete mix, Portland cement, aggregates, and reinforcing steel used in the construction of reinforced concrete end sections, headwalls, and slope walls shall be in full conformance with the requirements of ASTM C 76.

   The pipe hole of precast concrete end sections shall be formed with a groove or tongue, for receipt of the reinforced concrete pipe end. Figure 400-07 in Appendix 400: Standard Details should be referenced for an illustration of standard dimensions of precast concrete end sections.

2. Plastic (PVC and HDPE and PP)

   The open ends of high density polyethylene, and polyvinyl chloride and polypropylene storm sewer pipes shall be protected using flared, prefabricated steel end sections. The connecting bands of steel end sections shall be formed to fit the standard outside diameter of the plastic pipe, so that a tight connection is achieved.

   Poured-in-place, reinforced concrete slope-walls may be utilized as an equal alternative to flared, prefabricated steel end sections. The formulation of the concrete mix, Portland cement, aggregates, and reinforcing steel used in the construction of reinforced concrete slope walls shall be in full conformance with the requirements of ASTM C 76. This method of thermoplastic pipe end protection will be preferred by the Department.

3. Corrugated Metal (CMP)

   The open ends of corrugated metal pipes shall be protected using flared, prefabricated steel end sections. The connecting bands of steel end sections must be formed to fit the standard outside diameter of the corrugated metal pipe to achieve a tight connection. Tables 407-01, 407-02, and 407-3 in this Manual should be referenced for an illustration of the standard dimensions of steel end sections.

Eighteen (18) inch toe plate extensions will be required for all metal end sections.

4. Box Sections and Structural Plate Arches

Reinforced concrete box sections and structural plate arch culverts shall be provided with sufficient reinforced concrete end anchors, footing supports, headwalls, and/or embankment protection as required to ensure stability of the surrounding embankments, and maintenance of the structural integrity and hydraulic performance of the culvert structure.

Use of poured-in-place reinforced concrete headwalls as end treatment in the rights-of-way will be allowed only as approved on a case-by-case basis.

TABLE 407-01: Dimensions of Galvanized Steel End Sections for Round Pipe, 2 2/3" x ½", 7 ½" x 3/4" x 3/4", 3" x 1" and 5" x 1" corrugations. (Figure 400-08)

Pipe- Arch. in.		Metal Thickness (IN)	Dimensions (IN)					Approximate Slope	Body
			A	B	H	L	W		
Span	Rise		(± 1 IN)	(max)	(± 1 IN)	(± 1 ½ IN)	(± 2 IN)		
17	13	0.064	7	9	6	19	30	2½	1 Pc.
21	15	0.064	7	10	6	23	36	2½	1 Pc.
24	18	0.064	8	12	6	28	42	2½	1 Pc.
28	20	0.064	9	14	6	32	48	2½	1 Pc.
35	24	0.079	10	16	6	39	60	2½	1 Pc.
42	29	0.079	12	18	8	46	75	2½	1 Pc.
49	33	0.109	13	21	9	53	85	2½	2 Pc.
57	38	0.109	18	26	12	63	90	2½	2 Pc.
64	43	0.109	18	30	12	70	102	2½	2 Pc.
71	47	0.109	18	33	12	77	114	2½	3 Pc.

TABLE 407-02: Dimensions of Galvanized Steel End Sections for Pipe-Arch, 2 2/3" x ½", and 7 ½" x 3/4" x 3/4" corrugations. (Figure 400-08)

Pipe Diameter (IN.)	Metal Thickness (IN.)	Dimensions (IN.)					Approximate Slope	Body
		A (± 1 IN)	B (max)	H (± 1 ½ IN.)	L (± 1 ½ IN.)	W (± 2 in.)		
12	0.064	6	6	6	21	24	2½	1 Pc.
15	0.064	7	8	6	26	30	2½	1 Pc.
18	0.064	8	10	6	31	36	2½	1 Pc.
21	0.064	9	12	6	36	42	2½	1 Pc.
24	0.064	10	13	6	41	48	2½	1 Pc.
30	0.079	12	16	8	51	60	2½	1 Pc.
36	0.079	14	19	9	60	72	2½	2 Pc.
42	0.109	16	22	11	69	84	2½	2 Pc.
48	0.109	18	27	12	78	90	2¼	2 Pc.
54	0.109	18	30	12	84	102	2	2 Pc.
60	0.109	18	33	12	87	114	1¾	3 Pc.

Note:

1) All three (3) piece bodies to have one hundred and nine thousandths (0.109) in. sides and one hundred and thirty-nine thousandths (0.138) in. center panels. Multiple panel bodies to have lap seams which are to be tightly joined by galvanized rivets or bolts.
2) For sixty (60) in. sizes, reinforced edges to be supplemented with galvanized stiffener angles. The angles to be attached by galvanized nuts and bolts.
3) Galvanized toe plate shall be required and shall be the same thickness as the End Section.

Pipes larger than sixty (60) inches or equivalent diameter shall be provided with pipe end anchors as specified herein.

407.04 Culvert End Anchors and Footing Supports

For pipes larger than sixty (60) inches, the applicable INDOT Standard Drawings and INDOT Standard Specifications shall be used for pipe end anchors. The formulation of the concrete mix, Portland cement, aggregates, and reinforcing steel used in the construction of reinforced concrete end sections, headwalls, and slope walls shall be in full conformance with the requirements of ASTM C 76. Eighteen (18) inch toe-plate extensions will be required for all galvanized steel end sections.

Appendix 400: Standard Details

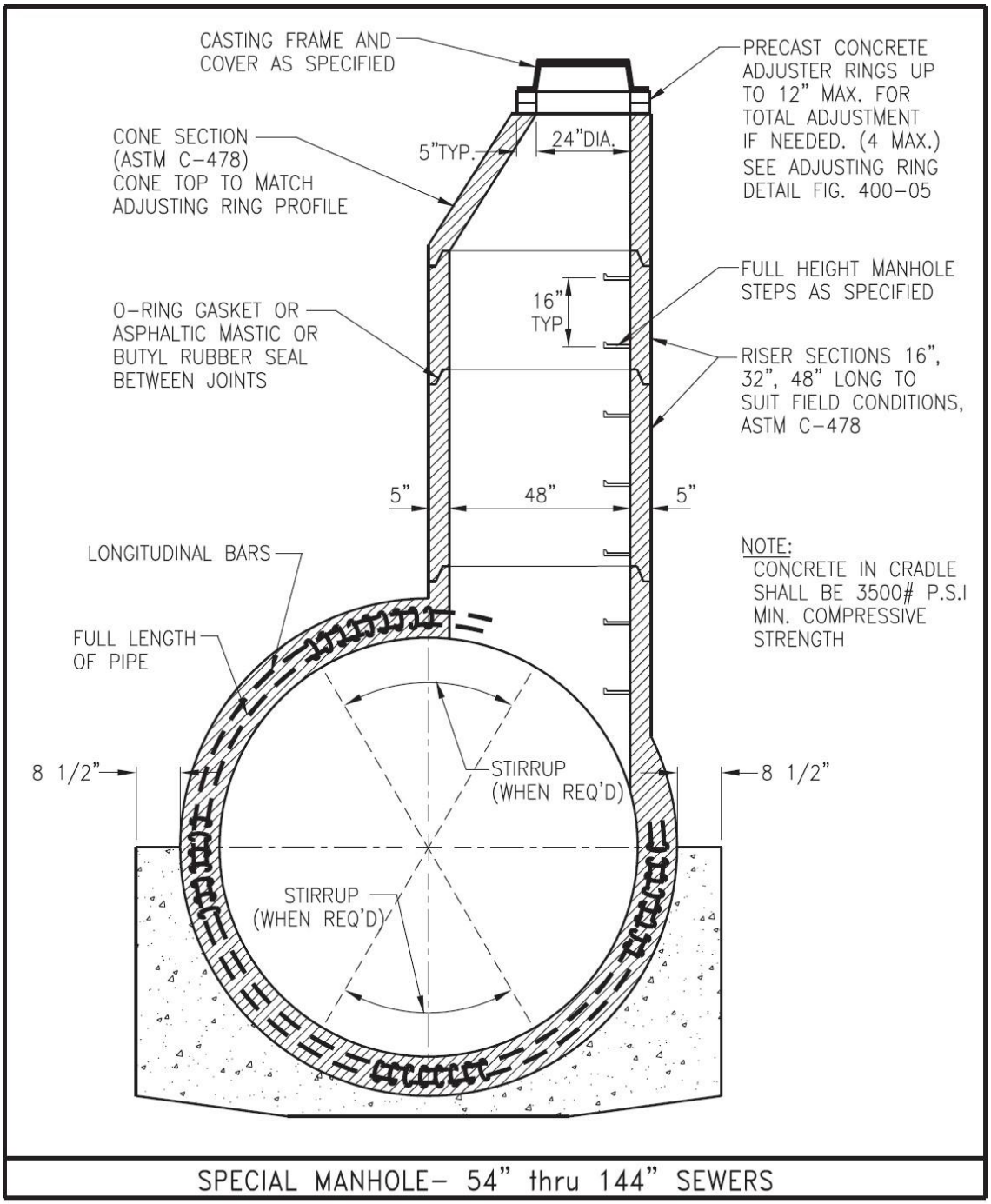


FIGURE 400-01: Special Manhole – 54" thru 144" Sewers

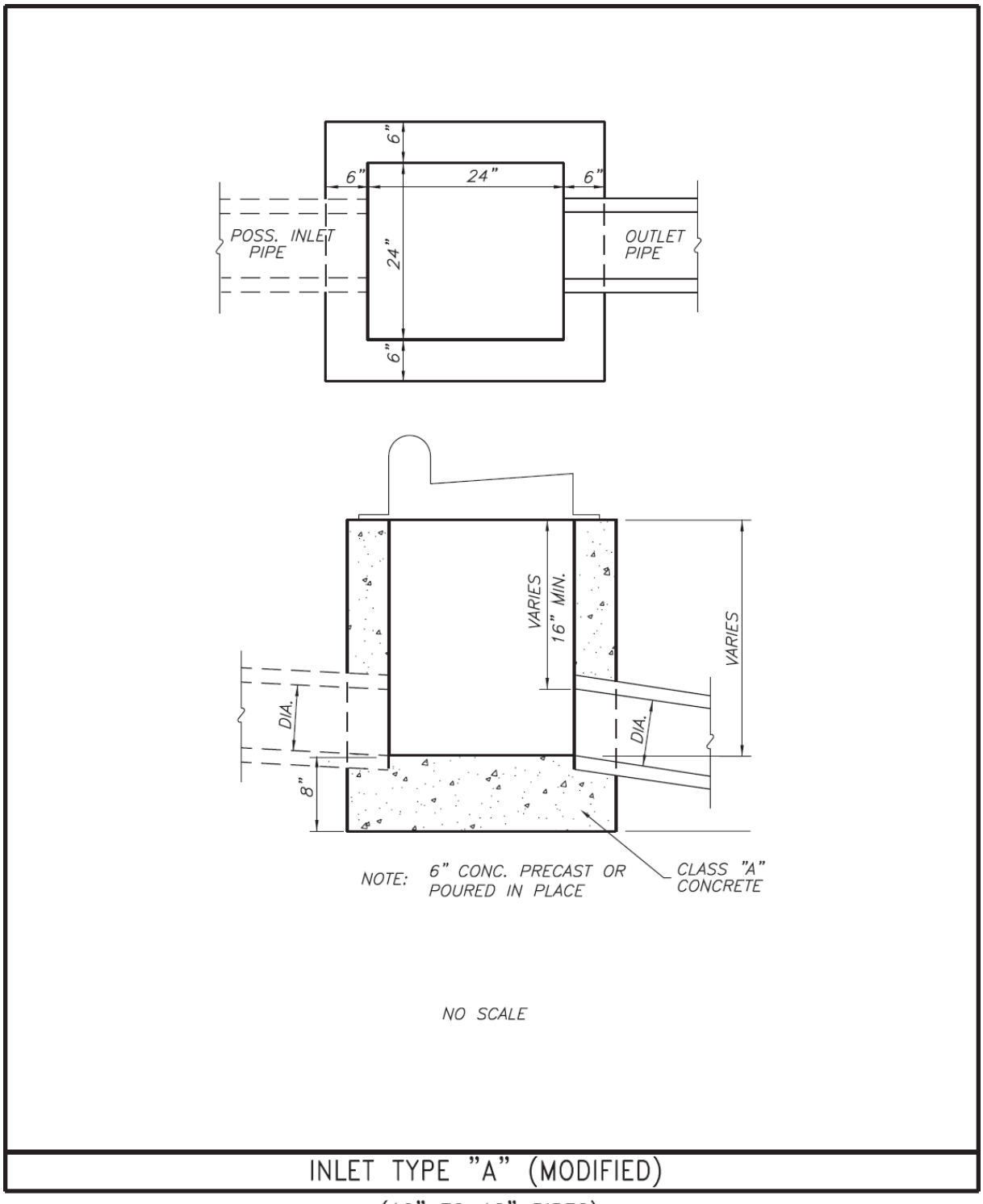


FIGURE 400-02: Inlet Type “A” (Modified)

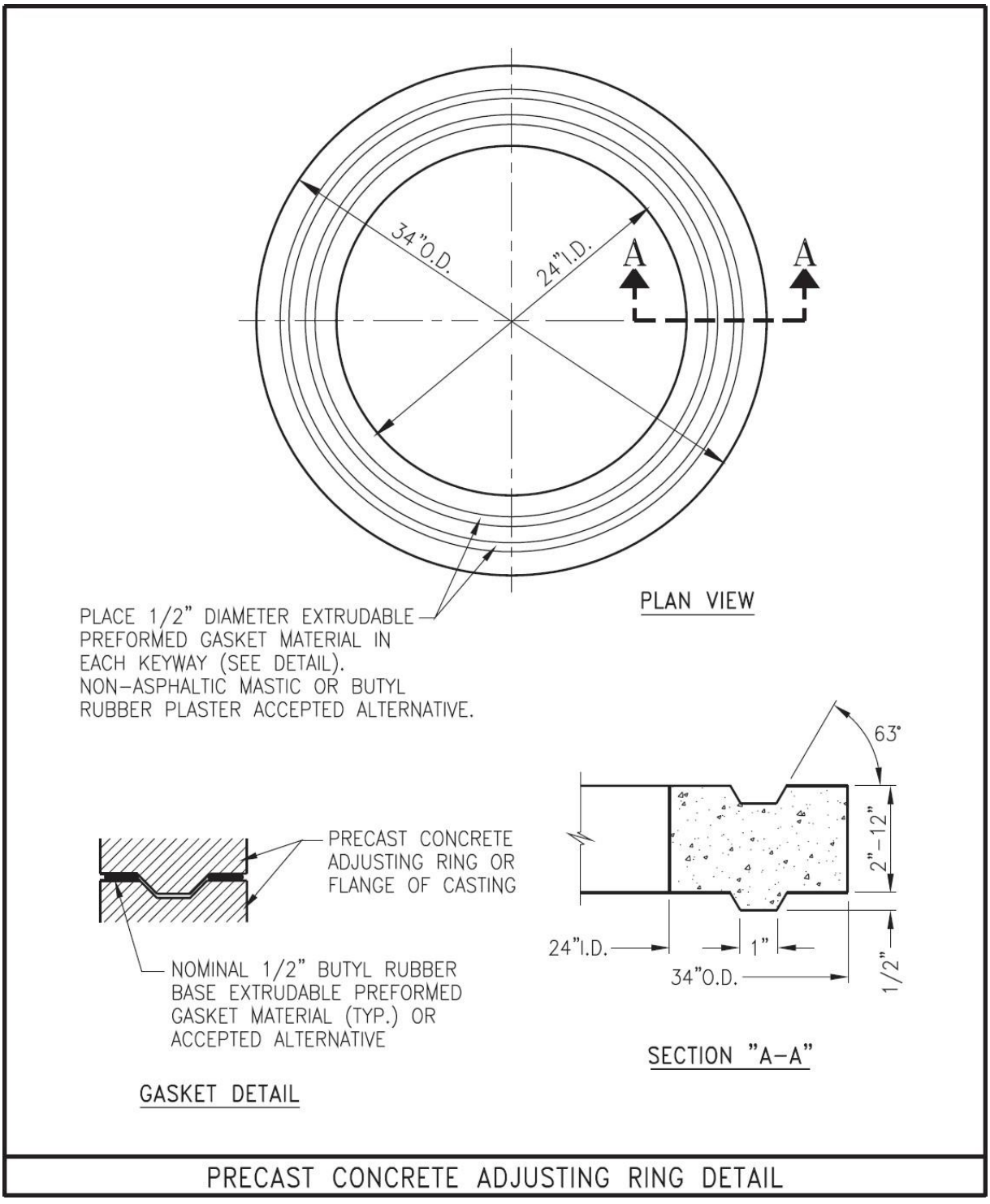


FIGURE 400-03: Precast Concrete Adjusting Ring Detail

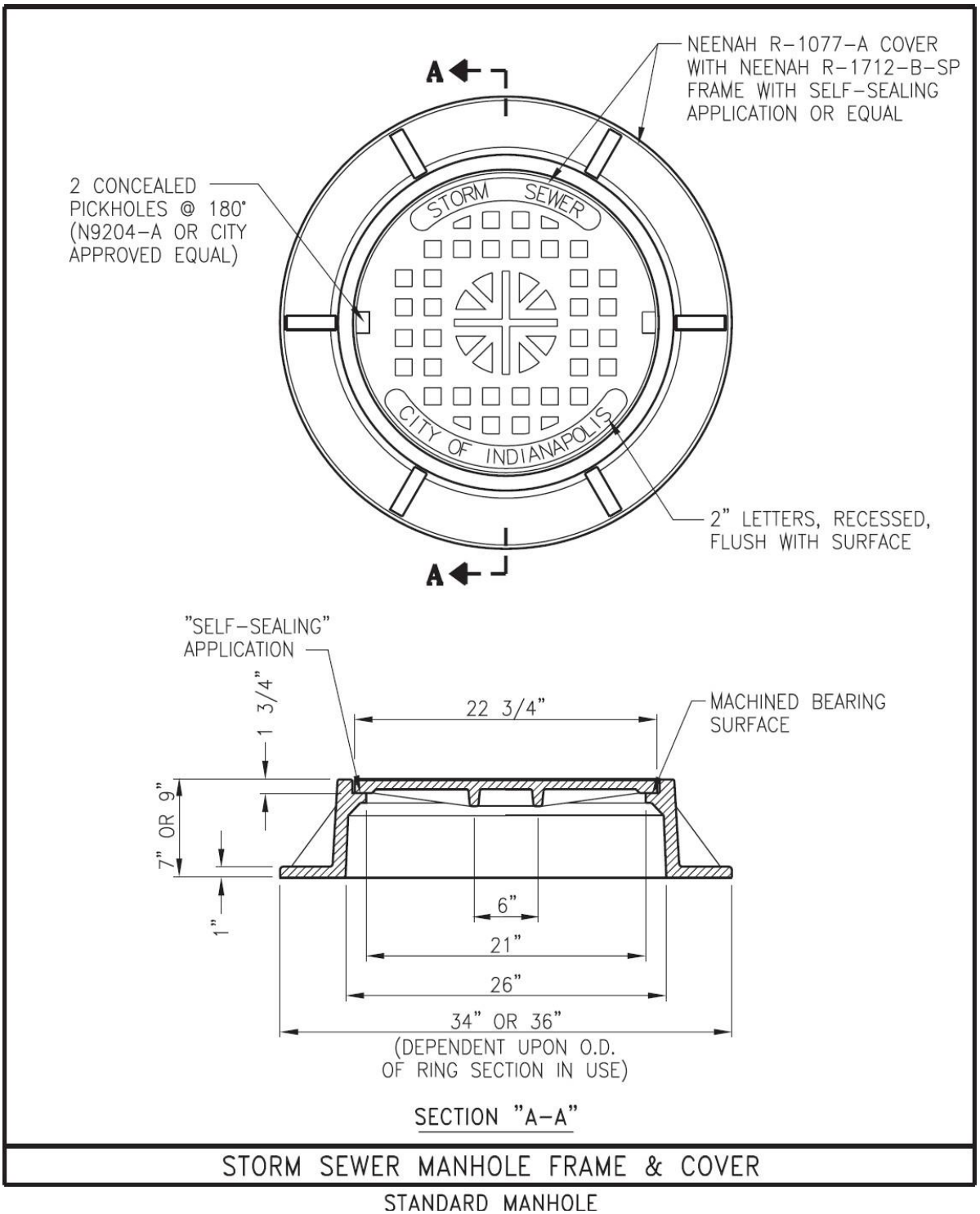
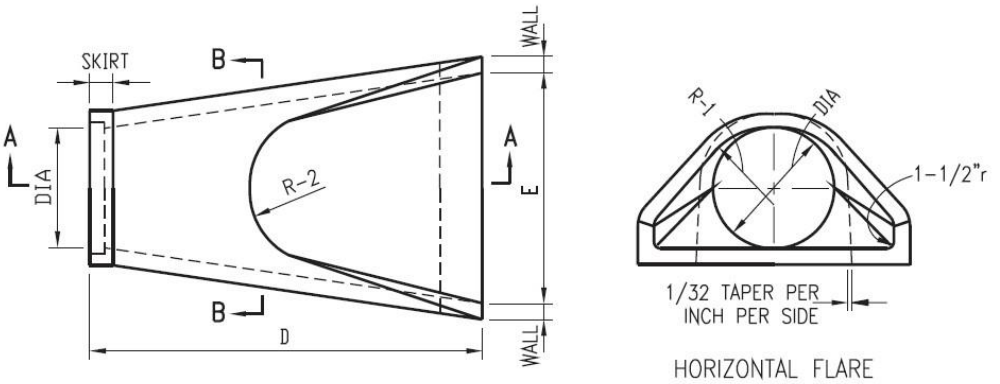
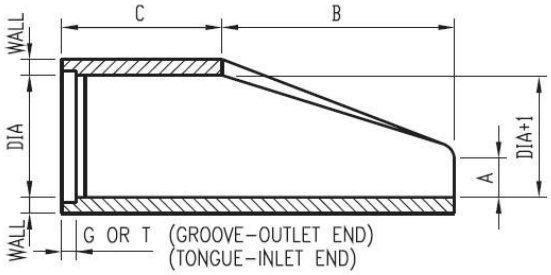


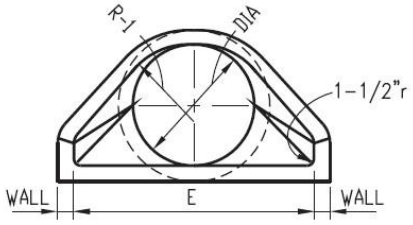
FIGURE 400-04: Storm Sewer Manhole Frame & Cover



HORIZONTAL FLARE



SECTION A-A



VERTICAL FLARE

SECTION B-B

DIA.	WALL	G or T	WT. SEC	A	B	C	D	E	DIA+1	R-1	R-2	SKIRT
12	2	1 1/2	530	4	24	48 7/8	72 7/8	24	13	10 1/16	9	3 1/2
15	2 1/4	2	740	6	27	46	73	30	16	12 1/2	11	3 1/2
18	2 1/2	2 1/2	990	9	27	46	73	36	19	15 1/2	12	4
21	2 3/4	2 1/4	1280	9	35	38	73	42	22	16 1/8	13	4
24	3	2 1/2	1520	9 1/2	43 1/2	30	73 1/2	48	25	16 11/16	14	4 1/2
27	3 1/4	2 1/2	1930	10 1/2	48	25 1/2	73 1/2	54	28	17 3/4	14 1/2	4 1/2
30	3 1/2	3	2190	12	54	19 3/4	73 3/4	60	31	18 5/16	15	5
33	3 3/4	3 3/8	3150	13 1/2	58 1/2	39 1/4	97 3/4	66	34	23 3/4	17 1/2	5 1/2
36	4	3 1/2	4100	15	63	34 3/4	97 3/4	72	37	24 1/16	20	5 1/2
42	4 1/2	3 3/4	5380	21	63	35	98	78	43	27 1/4	22	5 1/2
48	5	4 1/4	6550	24	72	26	98	84	49	28 1/8	22	5 3/4
54	5 1/2	4 3/4	8040	27	65	35	100	90	55	32 7/8	24	6 1/4
60	6	5	8750	30	60	39	99	96	61	36 3/4	24	6 3/4
66	6 1/2	5 1/2	10630	24	78	21	99	102	67	35 11/16	24	7 1/4
72	7	6	12520	34	78	21	99	108	73	38 5/8	24	7 3/4
78	7 1/2	6 1/2	14430	24	78	21	99	114	79	41 15/16	24	8 1/2
84	8	7	16350	24	78	21	99	120	85	44 13/16	24	9

NOTES: 1. MANUFACTURE OF END SECTION IS IN ACCORDANCE WITH APPLICABLE PORTIONS OF A.S.T.M. SPECIFICATION C76.

PRECAST CONCRETE FLARED HEADWALLS

FIGURE 400-05: Precast Concrete Flared Headwalls

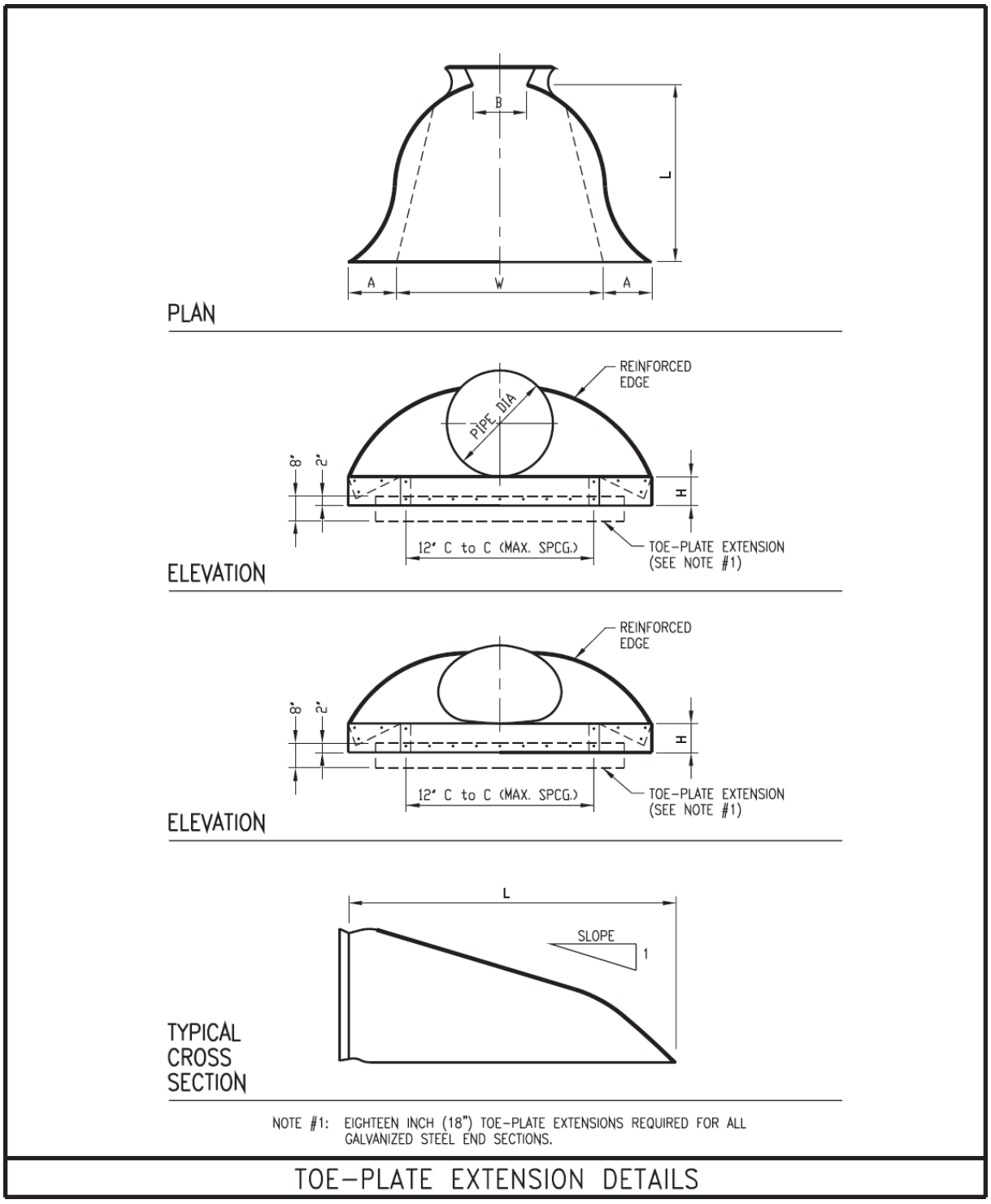


FIGURE 400-06: Toe-Plate Extension Details

CHAPTER 500 Installation of Stormwater Facilities

Section 501. Storm Sewer Pipe and Open Culvert Installation

501.01 Introduction

Storm sewer pipes and open culverts shall be laid to the lines and grade shown on the approved construction drawings, unless otherwise approved by the Department.

The design plans and specifications submitted to the BNS for issuance of a drainage permit shall include a detailed trench drawing showing placement of the storm sewer pipe or open culvert within the trench, trench walls, type and depth of bedding and backfill materials, and compaction levels in conformance with those guidelines set forth herein.

The standard proctor density referenced herein is intended to mean the maximum dry density of a backfill material as determined by those methods set forth within ASTM D 698. The percent standard proctor density refers to a ratio of the in-place dry density of a backfill material, determined by those methods set forth within ASTM D 1556, to the maximum dry density, determined by Test Method 698. The resulting quotient must be multiplied by one hundred (100), and the value obtained must meet or exceed those minimum values specified herein.

501.02 Point of Commencement and Direction of Laying

The point of commencement for laying of storm sewer pipe, open culverts, and subsurface drainage tiles should be the lowest point in the proposed line. Provisions for beginning construction at other than the lowest point in the proposed line shall be approved by the design consultant. All bell and spigot pipe shall be laid with the bell end, or with the receiving groove end of tongue and groove pipe pointing upgrade.

Each pipe shall be laid on an even firm bed throughout its length, so that no uneven strain will come to any single portion of the conduit. All bells of bell and spigot pipes shall be carefully placed into a receiving hole excavated into the pipe bedding material to prevent the total load from bearing on the pipe sockets.

All pipes shall be properly joined, utilizing the manufacturer's assembly marks, if provided. Adequate pressure shall be applied to the center of each bell and spigot pipe to ensure the proper joint seal is achieved.

501.03 Establishment of Line and Grade

A professional engineer or land surveyor registered in the State of Indiana will be required to set, or oversee the setting of, all bench mark stakes necessary for storm sewer pipe, open culvert, manhole, and subsurface drainage tile installation. Bench marks shall be set in strategic locations within the project to facilitate the installation of grade stakes. Horizontal and vertical control of storm sewer pipe structures, open culverts, manholes, and precast box inlets will be required to be provided with record drawings to be submitted to BNS (private projects) or DPW (public projects) upon completion of the project.

The accepted method of establishing and following line and grade in conformance with the approved construction plans may be determined by the Contractor.

501.04 Jetting or Flooding of Backfill

Jetting or flooding of the backfill shall *not* be used.

501.05 Multiple Pipe Installations and Skewed Culverts

When two or more conduits are to be installed in parallel lines, the following minimum spacings for pipe, pipe-arch, and arches must be provided between the outer most portion of the pipe walls:

Pipe		Pipe-Arches		Arches
Diameter (inches)	Spacing (inches)	Span (inches)	Spacing (inches)	Spacing (feet)
Up to 24	12	Up to 36	12	2
24 to 72	½ Pipe O.D.	36 to 108	1/3 Span	
Over 72	36	108 to 189	36	

Open culverts of seventy-two (72) inch diameter and larger placed at a skew of greater than fifteen (15) degrees must have the surrounding embankment contoured to provide side support along the total length of the pipe structure.

501.06 Steep Slope Applications

Use of flange bolted ductile iron pipe, reinforced concrete pipe with poured-in-place concrete anchors (one (1) per pipe section), or banded corrugated metal pipe with poured-in-place concrete anchors (one (1) per pipe section) shall be required on those slopes greater than fifteen (15) percent to prevent joint separations and consequent system failures. Due to the potential abrasive forces of flow within systems possessing fifteen (15) percent or greater slopes, corrugated metal pipes and pipe-arches used in these applications shall possess a minimum metal thickness of one hundred and nine thousandths (0.109) inches (12 gage), in addition to the required bituminous coating and invert paving specified within Chapter 400 of this Manual.

501.07 Material Handling

Suitable tools and equipment shall be used for the safe and convenient handling and installation of all stormwater facilities. All pipe shall be unloaded with care. Corrugated metal pipe shall not be rolled or dragged over gravel or rock and shall be prevented from striking or resting upon rock or other hard objects during installation. Great care must be taken to prevent pipe coatings or wrappings from being damaged. Each section of pipe shall be carefully examined for cracks and other defects prior to installation. Pipe or fittings found to be cracked, broken, or otherwise defective either before, during, or after installation, shall be removed and replaced with sound material.

All pipes, gaskets, and other fittings shall be thoroughly cleaned prior to installation. Failure to properly clean construction materials and appurtenances during all phases of installation and acceptance may result in a faulty completed system which will require replacement.

No portion of a storm sewer pipe, open culvert, manhole, inlet, or subsurface tile system may be installed indirectly onto frozen ground or with frozen backfill material.

501.08 Minimum Construction Cover

The minimum pipe cover shall be in compliance with Section 700 of the Indiana Department of Transportation Standard Specifications or the manufacturer's minimum cover requirements. The more stringent requirement shall

apply.

Until a minimum of four (4) feet of compacted fill material has been placed over installed storm sewer pipe or open culvert sections, the contractor shall not use heavy equipment in such a way as to cause damage to these structures.

501.09 Trench Box Pulling and Sheeting

When required by the Occupational Safety and Health Act (OSHA) to protect life, property, or the work, sufficient protective measures shall be utilized in accordance with CFR 1926. Upon completion of the work, all temporary forms, shores, and bracing, other than as specified herein, shall be removed. The minimum required density of structural backfill shall not be reduced during trench box pulling. All voids left by the removal of sheeting shall be carefully filled with properly compacted bedding material.

Any damage to pavement or other structures due to sheeting, shoring, or bracing shall be repaired by the Contractor at their own expense. Neither the City of Indianapolis, nor any agent thereof, shall assume any liability for the actions of the developer, or their agent(s), in the performance of the required sheeting, shoring and bracing operations.

Sheeting and bracing, which is to remain in place, shall be cut off at an elevation of one and one half (1.5) feet above the top of the storm sewer pipe or open culvert.

501.10 Trench Dewatering

Where groundwater is encountered, the Contractor shall make every effort necessary to secure a dry trench bottom prior to installation of the stormwater facility in conformance with Section 715 of the Indiana Department of Transportation Standard Specifications. The Contractor shall provide, install, and operate sufficient trenches, sumps, pumps, hoses, piping, wellpoints or other means necessary to depress and maintain the groundwater level below the base of the excavation.

The Contractor shall be responsible for diverting or removing surface runoff and other accumulations of surface water from excavations. The City will not assume any liability for the actions of the developer, or his agent(s), in the performance of the required dewatering operations. If pipe structures cannot be installed under trench conditions as outlined herein, all installation activities shall be terminated until acceptable conditions can be achieved. BNS shall reserve the right to terminate installation activities under those trench conditions which are not in conformance with this Manual.

Under no circumstances shall surface water and/or groundwater be discharged to, disposed of, or allowed to flow into the sanitary sewer system without approval from CEG. Discharges of excavation groundwater or incident surface water shall be in compliance with all federal, state and local requirements, including Chapter 600 of this Manual.

501.11 Abandoned Sewers

Stormwater conduits that are to be abandoned shall be bulkheaded with mortar and an eight (8) inch thick solid concrete brick wall. Stormwater conduits and appurtenant structures that are to be abandoned in place shall also be filled with sand or Cellular Concrete and plugged, unless otherwise indicated on the approved construction plans. Abandonment of sanitary and combined sewer conduits shall be in compliance with CEG standards.

No timber bulkheads shall be allowed. Unless otherwise specified, all abandoned manholes, catch basins and inlets shall be removed to a depth of three (3) feet below the proposed or established ground elevation, or existing street grade, whichever is lower.

501.12 Trench Installations

For trench installations, the supporting soil beneath the pipe structure shall be defined as the foundation material. The pipe bedding is that portion of the backfill material which is shaped to contact the sides and bottom of the conduit, to prevent lateral displacement, and for establishment of design grades. Initial backfill shall be defined as that material placed from the pipe springline (one half (½) the outside vertical pipe height) to twelve (12) inches over the crown of the pipe. Regular backfill shall be that material placed from the initial backfill to the ground or road surface.

Bedding and backfill material classes referenced within this Chapter shall be defined as follows:

Class I Angular, six to forty (6-40) millimeters (1/4 to 1 ½ inch) graded stone such as Indiana Department of Transportation (INDOT) Classification #5, #8, #9, #11, and #53 Stone. An INDOT #8 stone possessing a minimum fifty percent (50%) mechanical crush count, and meeting the following nominal sizes and percentages will be considered an equivalent Class I material: one hundred percent (100%) passing one (1) inch sieve; seventy-five to ninety-five percent (75-95%) passing three quarters (3/4) inch sieve; forty to seventy percent (40-70%) passing one half (½) of an inch sieve; and zero to fifteen percent (0-15%) passing No. 4 sieve.

Class II Coarse sands and gravel sand mixtures with a maximum particle size of forty (40) millimeters (one and one half (1 ½) inches), including variously graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil types GW, GP, SW and SP are included in this class. Indiana Department of Transportation (INDOT) Classification for "B" borrow material is included in this class.

Class III Fine sand and clay gravels, including fine sands, sand-clay mixtures and gravel-clay mixtures. Soil types GM, GC, SM and SC (as defined in ASTM D 2487) are included in this class. These materials will not be accepted as pipe bedding.

Class IV Silt, silty clays and clays, including organic clays and silts of medium to high plasticity and liquid limits. Soil types MH, ML, CH and CL (as defined in ASTM D 2487) are included in this class. These materials will not be accepted as pipe bedding.

These materials shall be utilized for installation of stormwater facilities in accordance with and in the manner specified by this Chapter.

Whenever pipe trenches are inadvertently excavated below the designed bedding bottom, the Contractor shall fill the over excavated area with Class I or Class II granular bedding material, compacted and shaped to form a firm, uniform trench base.

In those cases, where a firm foundation is not encountered at the required grade, the unstable material shall be removed to such depth that when replaced with suitable Class I or Class II material, compacted, and properly shaped, a uniform and stable foundation along the entire length of the pipe is established.

Bell holes shall be properly excavated for bell and spigot pipe, so that the entire barrel of the pipe rests directly upon the bedding material.

All rocks, boulders and stones six (6) inches in diameter and larger encountered in trenches shall be removed. Boulders or rocks are not to be used for any portion of the trench backfill.

All PVC, PP and HDPE pipes to be installed with perforations that are meant to infiltrate or exfiltrate must use INDOT #8 Stone as bedding and backfill material. All approved storm systems can use Class I bedding and backfill materials with the following compaction requirements: INDOT Classification # 5, # 8, # 9, and # 11 must be at least hand tamped or walked into place for pipes except PVC, PP, and HDPE; the bedding for these pipes must be mechanically compacted; And INDOT Classification # 53 must be mechanically compacted to ninety-five percent (95%) Proctor.

501.13 Minimum Trench Width

Except as provided herein, the minimum trench width for storm sewers of forty-two (42) inch or equivalent diameter and smaller shall be one and one quarter (1.25) times the outside diameter (Bc) of the pipe plus twelve (12) inches, and in no case shall provide less than nine (9) inches between the edge of the pipes and the trench wall.

The minimum trench width for storm sewers larger than forty-two (42) inch or equivalent diameter shall be one and one quarter (1.25) Bc plus twenty-four (24) inches, and in no case shall provide less than twelve (12) inches between the edge of the pipe and trench wall.

For flexible conduits, the lateral resistance of in-situ soils shall be of sufficient stiffness to provide the required pipe support. Where unstable trench sidewall conditions exist, or where trench depth dictates the use of a moveable trench box, the design consultant must determine the width of compacted bedding and backfill material necessary to provide adequate pipe or culvert side support.

The trench widths derived by these equations provide a minimum only. Exceptions to these minimums apply only to concrete pipes located at least five (5) feet outside of the edge of pavement. Under these conditions, the design consultant must assume responsibility for determining the appropriate minimum trench width based upon a structural evaluation of the pipe material.

501.14 Bedding and Backfill Materials

Figures 501-01 through 501-11, found in Appendix 500: Standard Details of this Manual, should be referenced for an illustration of storm sewer pipe and open culvert bedding and backfill materials required by the Department for each pipe material class. For the purpose of these specifications, the pavement zone shall be defined as that area within five (5) feet of any edge of pavement, curb, gutter, sidewalk, or similar structure in the public right-of-way. Bedding and backfill requirements for each type of pipe material are summarized as follows:

1. Corrugated Metal Pipe (CMP) (Figures 501-03 and 501-04 in Appendix 500: Standard Details)

   Bedding

   CMP conduits shall be provided with Class I granular bedding material from three to six (3-6) inches (based upon pipe diameter) below the pipe barrel, to twelve (12) inches above the crown of the pipe.

   Class I material shall be shovel sliced or otherwise carefully placed and mechanically compacted to ensure proper compaction and complete filling of all voids. Class II material shall be compacted to 40 percent (40%) Standard Proctor Density as a minimum, except where the edge of the pipe trench is located within the pavement zone as specified herein, where Class II material shall be compacted to ninety-five percent (95%) Standard Proctor Density.

   Bedding shall be placed in six to twelve (6-12) inches balanced lifts.

   Initial Backfill

   From the pipe springline, corrugated metal pipe conduits shall be backfilled with Class I material as shown in the in Appendix 500: Standard Details.

   Initial backfill shall be placed in six to twelve (6-12) inches balanced lifts.

   Regular Backfill

   Corrugated metal pipes located outside the applicable pavement zone may be backfilled from twelve (12)

inches above the crown with clean material, as shown in Appendix 500: Standard Details of this Manual.

2. Reinforced Concrete Pipe (RCP) (Figures 501-05, 501-06, and 501-07 in Appendix 500: Standard Details)

Bedding

RCP conduits shall be provided with Class I or granular bedding material. granular bedding material from three to six (3-6) inches (based upon pipe diameter) below the pipe barrel, to twelve (12) inches above the crown of the pipe.

Class I material shall be shovel sliced or otherwise carefully placed and mechanically compacted to ensure proper compaction and complete filling of all voids. Class II material shall be compacted to 40 percent (40%) Standard Proctor Density as a minimum, except where the edge of the pipe trench is located within the pavement zone as specified herein, where Class II material shall be compacted to ninety-five percent (95%) Standard Proctor Density.

Initial and Regular Backfill

RCP conduits located within the applicable pavement zone shall be backfilled from the haunch area with "B" Borrow backfill compacted to ninety-five percent (95%) Standard Proctor Density.

RCPs located outside of the pavement zone shall be backfilled from the haunch area with clean material as shown on the standard details in Appendix 500.

3. Plastic (PVC, HDPE, PP) Pipe (Figures 501-08 and 501-09 in Appendix 500: Standard Details)

Bedding and Initial Backfill

Plastic Pipe conduits (PVC, HDPE and PP) shall be provided with INDOT #8 Stone or approved Class I granular bedding material shovel sliced or otherwise carefully placed and mechanically compacted from four to six (4-6) inches (based upon pipe diameter) below the pipe barrel, to a minimum of twelve (12) inches above the crown of the pipe for 4-inch through 48-inch diameter pipe, and 18 inches above the crown of the pipe for 60-inch diameter pipe.

Bedding and initial backfill material shall be hand placed around the haunch and sides of the plastic pipe, to ensure proper compaction and complete filling of all voids.

All bedding and initial backfill shall be placed in six to twelve (6-12) inches balanced lifts.

Regular Backfill

Plastic pipe conduits located within the pavement zone shall be backfilled from twelve (12) inches above the crown of the pipe with "B" Borrow backfill compacted to ninety-five percent (95%) Standard Proctor Density.

Plastic pipes located outside of the pavement zone shall be backfilled from twelve (12) inches above the crown of the pipe with clean material as shown on the approved construction drawings.

4. Reinforced Concrete Box Sections (Figure 501-10 in Appendix 500: Standard Details)

Reinforced concrete box sections shall be placed on a minimum of six (6) inches of INDOT #8 Stone, or other approved equivalent Class I granular bedding material, "walked" or hand tamped into place.

The regular backfill of reinforced concrete box sections located within the applicable pavement zone shall be with "B" Borrow backfill compacted to ninety-five percent (95%) Standard Proctor Density.

Reinforced concrete box sections located outside of the pavement zone shall be backfilled with clean material as shown on the approved construction drawings.

The trench width for box sections shall be only as wide as is necessary to facilitate proper compaction of backfill material, provided the adjacent embankment material is structurally adequate to provide the necessary side support.

Verification of sufficient bearing strength of underlying soil foundation material, based upon manufacturer's recommendations, shall be required by the Department for all reinforced concrete box section installations. Soil boring report and bearing strength analysis shall be submitted with the drainage permit application.

5. Structural Plates (Figure 501-11 in Appendix 500: Standard Details)

The installation of structural plate pipe, pipe-arches and arches shall be in full conformance with ASTM A 807.

Structural plates located within the applicable pavement zone shall be backfilled with "B" Borrow backfill compacted to ninety-five percent (95%) Standard Proctor Density.

Structural plates located outside of the pavement zone shall be backfilled with clean material as shown on the standard details in Appendix 500.

A concrete footing that is either slotted to receive the corrugated shell or mounted with aluminum receiving angles will be the only accepted method for placement of aluminum arches and box culverts. The size of footing pads and steel reinforcement shall be established by a professional engineer registered in the state of Indiana, based upon anticipated loading and soil-bearing capacity. The depth of the bottom of the footing shall be established a minimum of eighteen (18) inches below the anticipated scour depth. Additional requirements may be made by the Department based upon an evaluation of the individual site conditions.

Verification of sufficient bearing strength of underlying soil foundation material, based upon manufacturer's recommendations, shall be required by the Department for all multi-plate drainage structures possessing a span of greater than fifteen (15) feet. Soil boring report and bearing strength analysis shall be submitted with the drainage permit application.

501.15 Height of Cover Tables

Minimum and maximum height of cover tables for flexible pipe conduits shall be in conformance with INDOT Pipe Height of Cover Limits. The structural design of rigid pipe materials shall also be in accordance with the most restrictive of either manufacturers' recommendations, or current AASHTO standards.

Structural design computations used to determine cover depths other than those specified herein shall be submitted to the Department for review and approval and shall be certified by professional engineer registered in the State of Indiana prior to submittal.

Section 502. Installation of Precast Manholes and Box Inlets

502.01 Introduction

The following information provides a summary of construction and installation procedures required by the

Department for installation of storm sewer manholes and concrete box inlets.

502.02 Preparation of Base and Backfilling

The bottom of the excavation/trench for the manhole or box inlet shall be filled with a minimum of six (6) inches stone bedding to form a stable base. Where poor or unstable soil conditions exist, or over excavation has occurred, additional INDOT #2 Stone or Class B concrete shall be used to form a stable base.

Manhole and box inlet backfilling and compaction levels shall comply with the minimum requirements and specifications as outlined herein for the adjacent storm sewer pipe structure.

502.03 Placement of Manhole Sections

Precast manhole sections shall be placed and aligned to provide vertical sides. The completed manhole shall be rigid, true to dimensions and soil tight.

The joints between manhole sections shall be properly sealed utilizing an approved rubber gasket in accordance with ASTM C 443, non-asphaltic mastic, or butyl rubber plaster material as specified within Chapter 400 of this Manual.

502.04 Placement of Adjusting Rings and Spacers

Precast concrete manhole and box inlet adjusting rings and spacers shall be installed as specified within Chapter 400 of this Manual. All adjusting ring and spacer joints shall be sealed utilizing one half (½) inch diameter cords of extrudable preformed gasket material, non-asphaltic mastic, or butyl rubber plaster. This material shall be placed in joints and keyways and be of sufficient quantity to completely fill the joint cavity.

502.05 Connections to Manholes

All storm sewer pipe connections to new or existing manholes and precast concrete box inlets shall be installed as outlined within Chapter 400 of this Manual. Connections of subsurface drainage tiles, or other subsurface drainage lines, to manholes and box inlets shall be accomplished using either precast, or drilled holes, properly sealed with non-shrink cement grout or trowelable grade butyl rubber plaster.

Where connections are made to existing manholes or box inlets, that structure shall be rehabilitated or replaced to those minimum standards outlined herein. This rehabilitation shall include the installation of bench walls, as well as prescribed measures to eliminate the potential for migration of backfill materials into the stormwater system.

Where connections of subsurface tiles to the storm sewer system cannot be made at a manhole or box inlet structure, blind “T” connections to storm sewer pipe structures will be allowed on a case-by-case basis by the Department, provided the connection holes are properly cut or core-drilled, and a minimum six (6) inch inside diameter cleanout connection is also provided.

Section 503. Installation of Subsurface Tiles

503.01 Introduction

The information outlined below is intended to summarize backfill materials and construction procedures accepted by the Department for the installation of subsurface drainage tiles. All subsurface tiles must be laid to the lines and

grade shown on the approved construction drawings, unless otherwise approved by the Department.

503.02 Trench Construction

The following trench construction requirements shall be adhered to as a part of the installation of all subsurface drainage tiles.

1. Trench Bottom

   The trench bottom shall be smooth and free of large (greater than three (3) inches in diameter) exposed rock. Where an unstable trench bottom is encountered, such as with silty or fine sandy soils, a firm trench bottom must be provided. Care must be taken to prevent silt or fine sand material from entering the tile system. This may be accomplished through the use of an envelope of INDOT #8 stone or comparable sized washed stone and a filter cloth barrier when silty or fine sandy soils are present. Unstable soil material shall be removed and replaced with a foundation and bedding of processed stone or gravel.

2. Trench Width

   The trench width below the top of the tile must be sufficient to provide adequate clearance for joining of tile ends with standard fittings, and for placement of required bedding materials. For placement of a gravel or washed stone envelope or filter as required, a minimum trench width of four (4) inches on both sides of the tile will be required.

3. Tile Grade

   Subsurface drainage tiles shall be designed and installed at a minimum grade of one tenth (0.1) percent, unless otherwise approved by the Department.

503.03 Gravel Envelopes and Backfilling

In order to improve the flow of ground water into the subsurface drainage tile, washed stone or gravel envelopes will be required for all subsurface drainage tile installations.

Subsurface tile gravel envelopes shall be of INDOT #8 stone, or an approved washed stone equivalent. Gravel envelope material shall be clean, hard, and durable, with less than five percent (5%) passing the No. 200 sieve, not more than thirty percent (30%) passing the No. 60 sieve and having a maximum size of one and one half (1 ½) inches. Figures 503-01 and 503-02 in Appendix 500: Standard Details should be referenced for the required methods of installation and backfilling of subsurface drainage tile.

503.04 Minimum Cover Requirements

A minimum cover depth of eighteen (18) inches of earth or equivalent cover over the top of the tile will be required, except as allowed by Chapter 400 of this Manual. A temporary earth fill may be required over the subsurface drainage tile in order to provide adequate protection of this system during construction.

503.05 Minimum Levels of Workmanship

The following minimum levels of workmanship shall be adhered to as a part of the installation of all subsurface drainage tiles.

1. Handling of Subsurface Tiles

Suitable tools and equipment must be used for the safe and convenient handling and placement of subsurface drainage tiles. Plastic tile and fittings must be protected from deformation or structural deterioration due to extreme temperatures or ultraviolet radiation. Each section of tile must be carefully examined for cracks or other defects prior to installation. Tile or fittings known to be defective must not be installed.

Each section of subsurface drainage tile must be laid on an even firm bed throughout its length, as specified herein, so that no uneven strain will come to any single portion of the tile. Suitable bedding material must be provided so that side walls are continuously and uniformly supported, and sufficient lateral restraint is provided to protect the tile against deflection and collapse during backfilling.

2. Joints and Fittings

All drainage tile fittings shall be installed in accordance with those instructions furnished by the manufacturer. Coupling bands shall be used at all joints and fittings, at all changes in direction, changes in diameter, junctions with other tile lines, and at the ends of tile lines. Hand-cutting of holes for tile connections shall be considered permissible, provided care is taken when making the connection not to create a means of obstructing flow, catching debris, or allowing soil to enter the tile line.

503.06 Outlet Protection

A minimum length of twenty (20) feet of polyvinyl chloride (PVC) *or* double walled high-density polyethylene (HDPE) pipe meeting the material specifications of this Manual shall be used at the surface outlet end of all subsurface drainage tiles, with at least two thirds (2/3) of the pipe length embedded in the bank to provide adequate support.

503.07 Rodent Protection

The outlet end of the subsurface drain tile must be equipped with an animal guard to protect the system from entry and damage by rodents or other animals. Where tiles are connected to old existing tile lines that may serve as animal runs, an animal guard must be installed within the newly constructed line to restrict animal travel. The guard opening shall be a minimum of fifteen one hundredths (0.15) square inch and a maximum of one quarter (0.25) square inch.

503.08 Location of Existing Tiles

All plans and specifications submitted to the Department for review and approval shall delineate the approximate location of existing agricultural or other subsurface drainage tiles. All existing subsurface drainage tiles shall be perpetuated across the construction site. Extreme care must be taken to prevent damage to these existing lines. Any existing tile lines that are inadvertently damaged or cut during construction shall be repaired or replaced.

Section 504. Open Channel Construction

504.01 Introduction

The cross sectional configuration of stormwater conveyance channels may be V-shaped, parabolic or trapezoidal. Typical open channel cross sections and linings are illustrated within Figure 504-01 in Appendix 500: Standard Details.

Open channels shall be constructed to the line, grade, and cross section shown on the approved construction plans.

Earthen fills beneath rock riprap lined channels shall be compacted to nine-five percent (95%) Standard Proctor Density.

For relatively large open channels and perennial streams, minimum channel slopes and the provision of subsurface drainage shall be approved on a case-by-case basis by the Department.

504.02 Open Channel Stabilization

The types of treatments used to stabilize open channels may vary with flow velocities and individual site conditions within the following guidelines:

1. Grass-lined Channels

   The grass mixture chosen for stabilization of open conveyance channels shall be based upon specific site conditions, such as but not limited to: drainage tolerance; shade tolerance; and maintenance requirements. Grass-lined stormwater conveyance channels shall be permanently seeded within seven (7) days after finish grading.

   To facilitate vegetative establishment, the flowline of grass lined stormwater conveyance channels shall be protected utilizing an approved erosion control blanket designed and installed according to the applicable manufacturer's specifications. The blanket shall extend from top of bank to top of bank or one (1) foot above the ten (10) year (10% AEP) water surface elevation along each bank, whichever is less.

Appendix 500: Standard Details

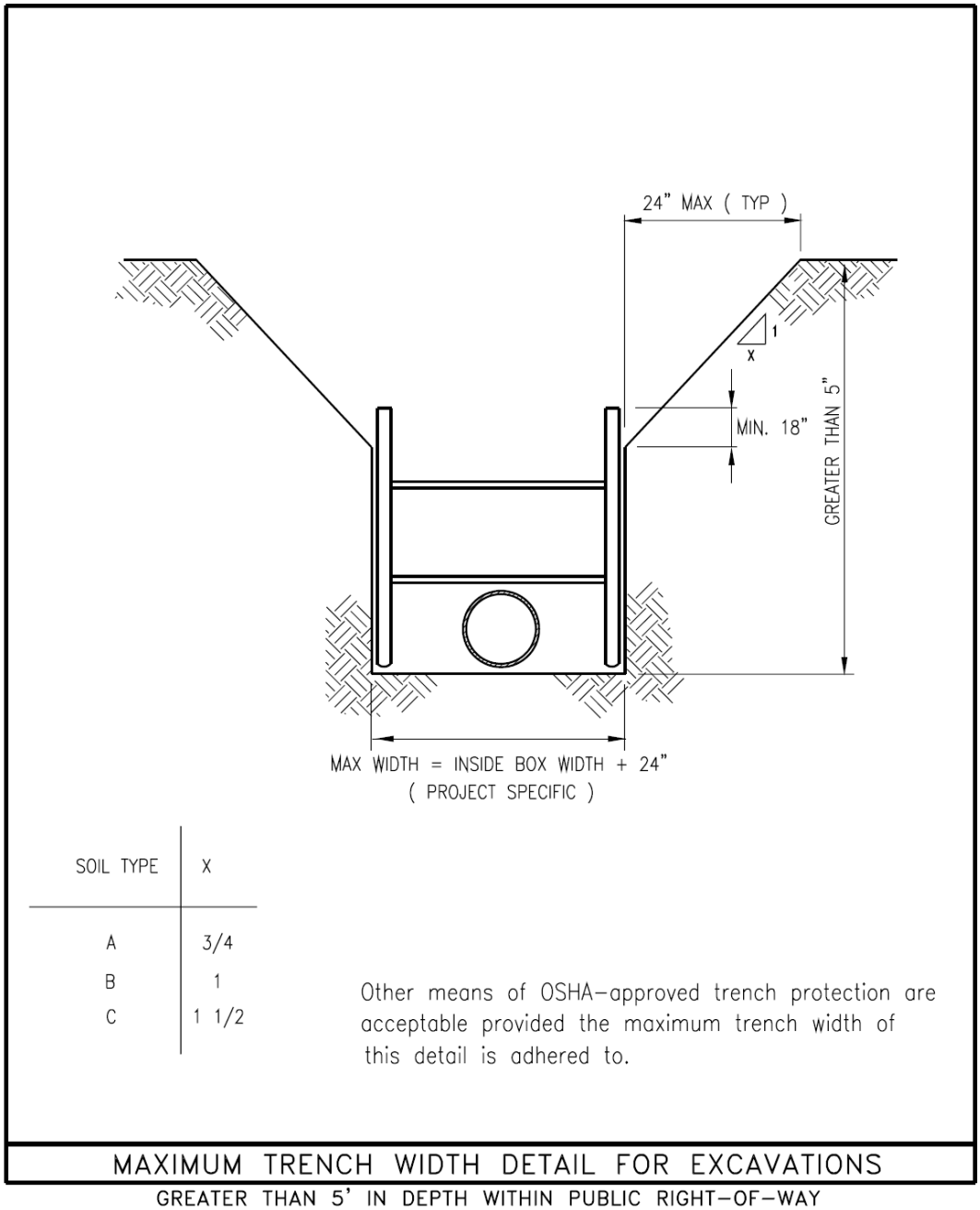


FIGURE 501-01: Maximum Trench Width Detail for Excavations – greater than five feet from edge of pavement

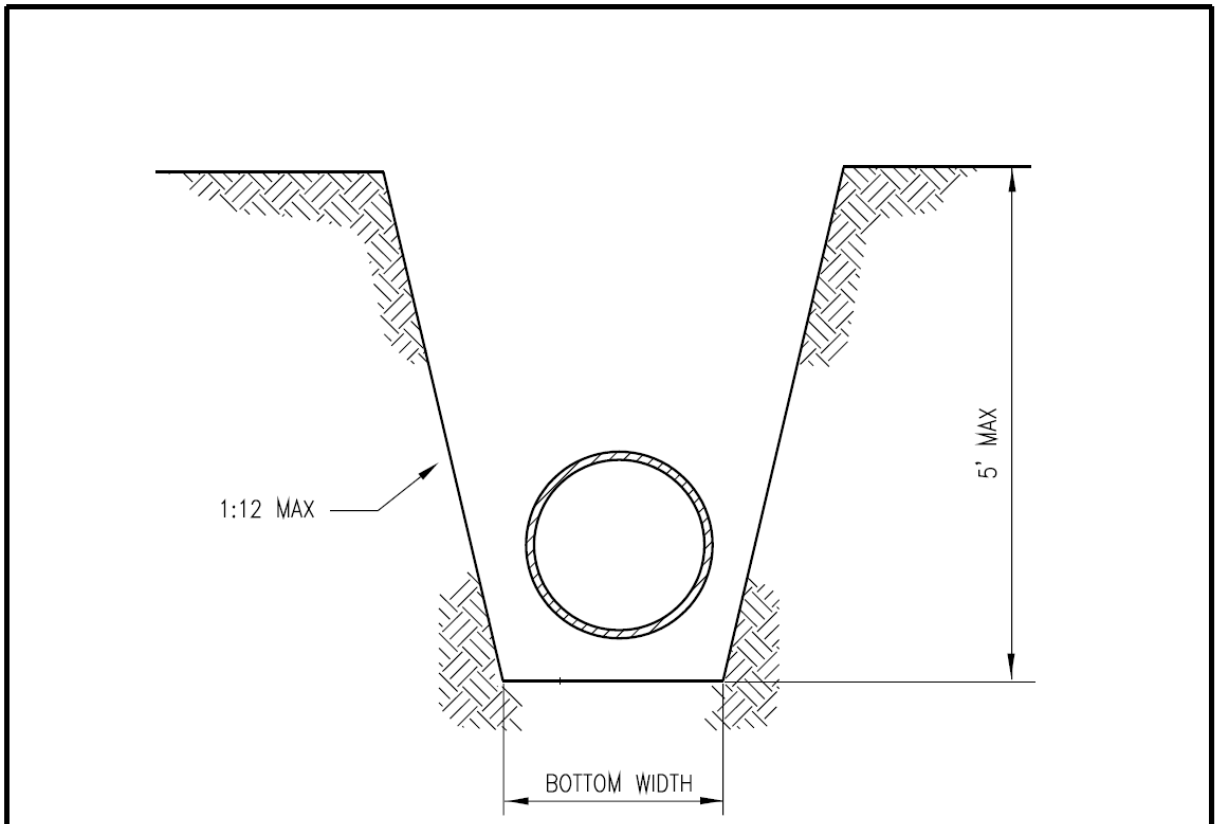


FIGURE 501-02: Maximum Trench Width Detail for Excavations – within five feet of edge of pavement

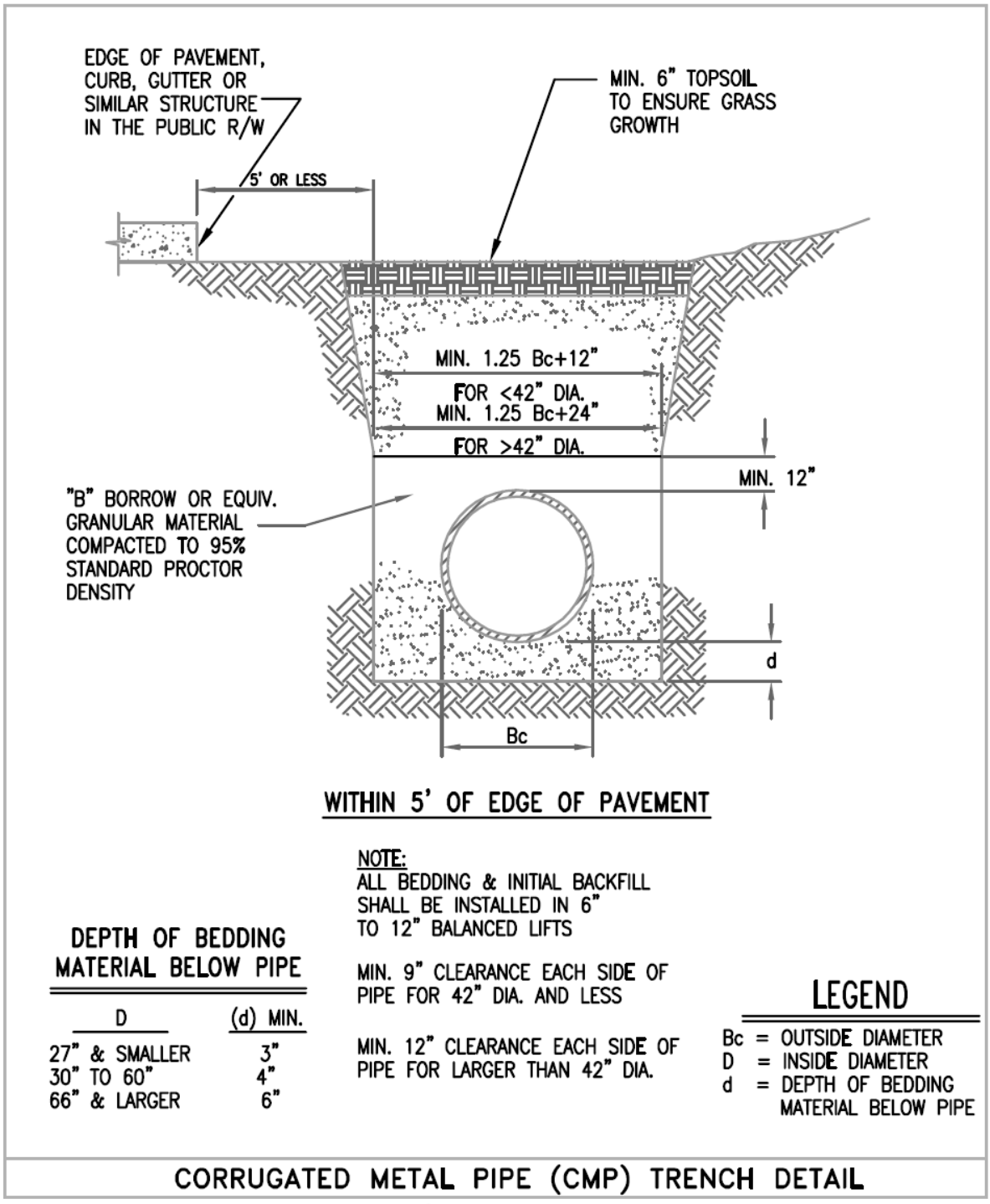


FIGURE 501-03: Corrugated Metal Pipe (CMP) Trench Detail – within five feet of edge of pavement

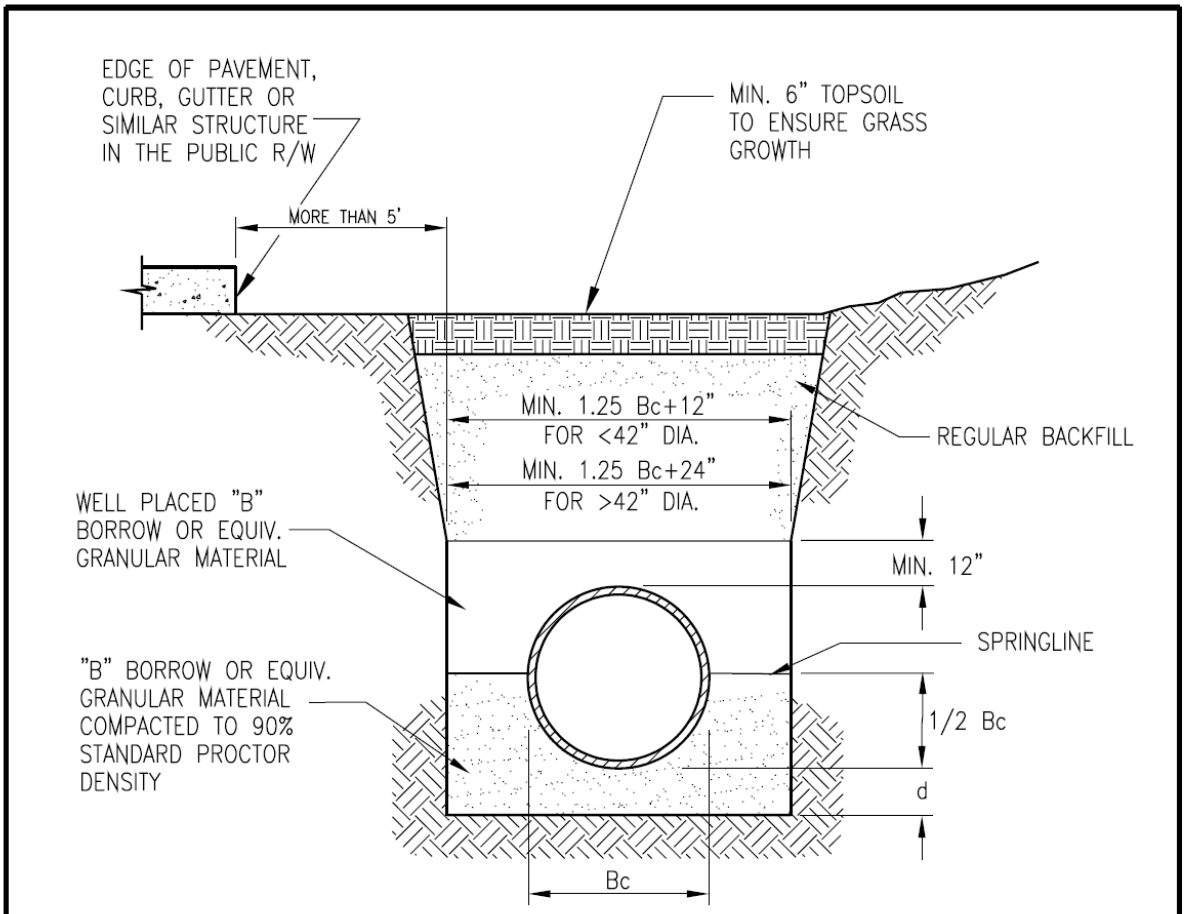


FIGURE 501-04: Corrugated Metal Pipe (CMP) Trench Detail – greater than five feet from edge of pavement

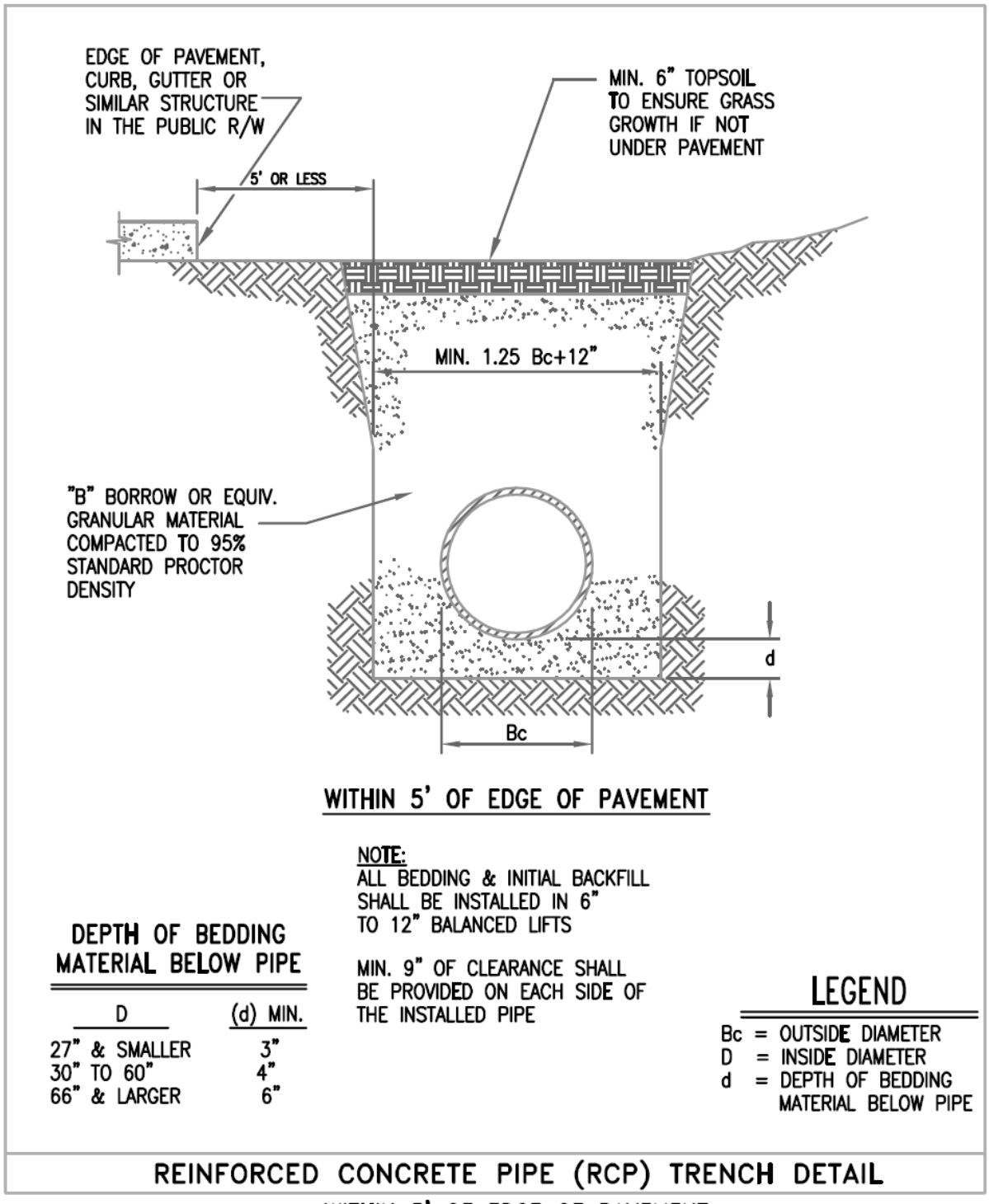


FIGURE 501-05: Reinforced Concrete Pipe (RCP) Trench Detail – within five feet of edge of pavement

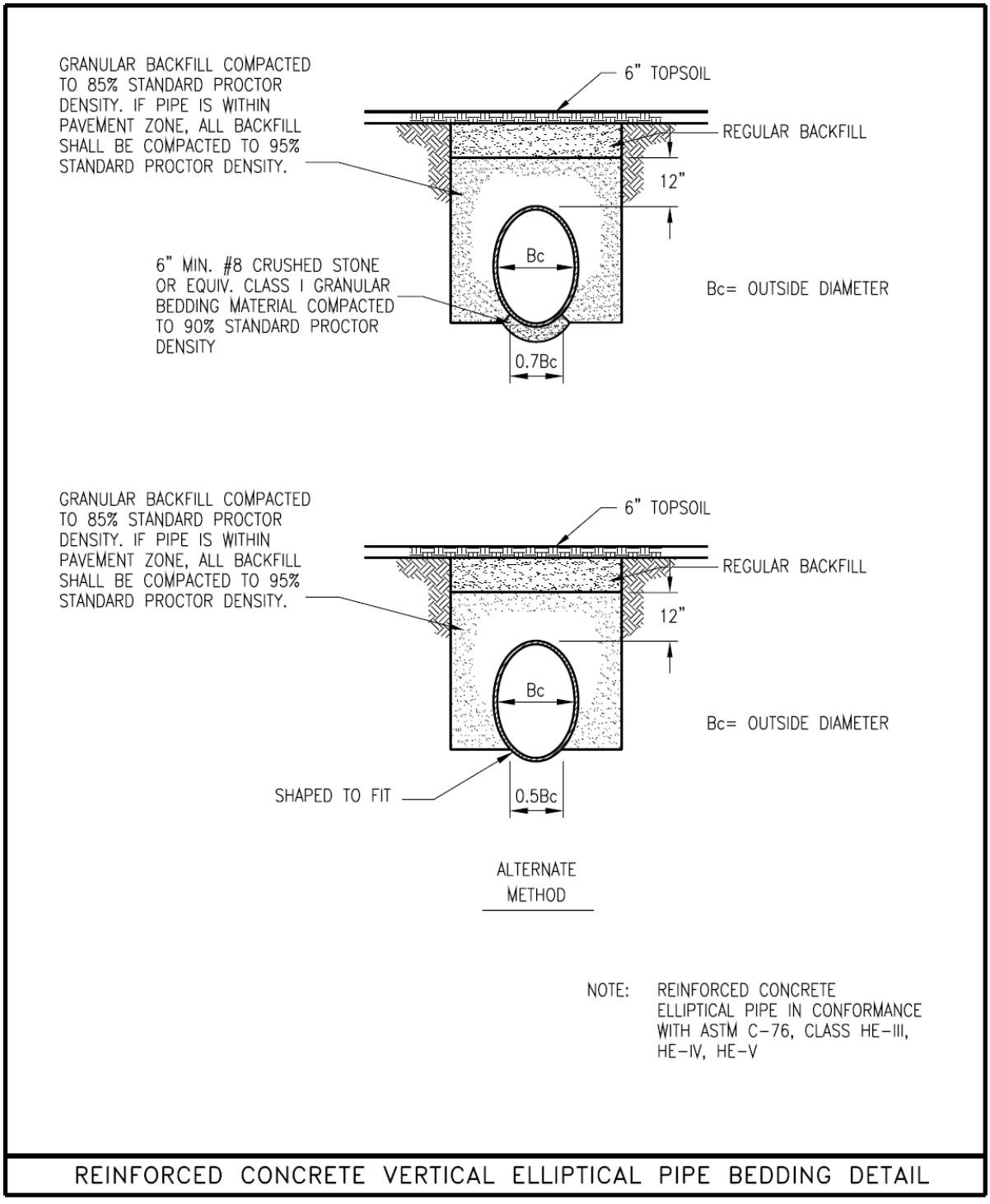


FIGURE 501-06: Reinforced Concrete Vertical Elliptical Pipe Bedding Detail

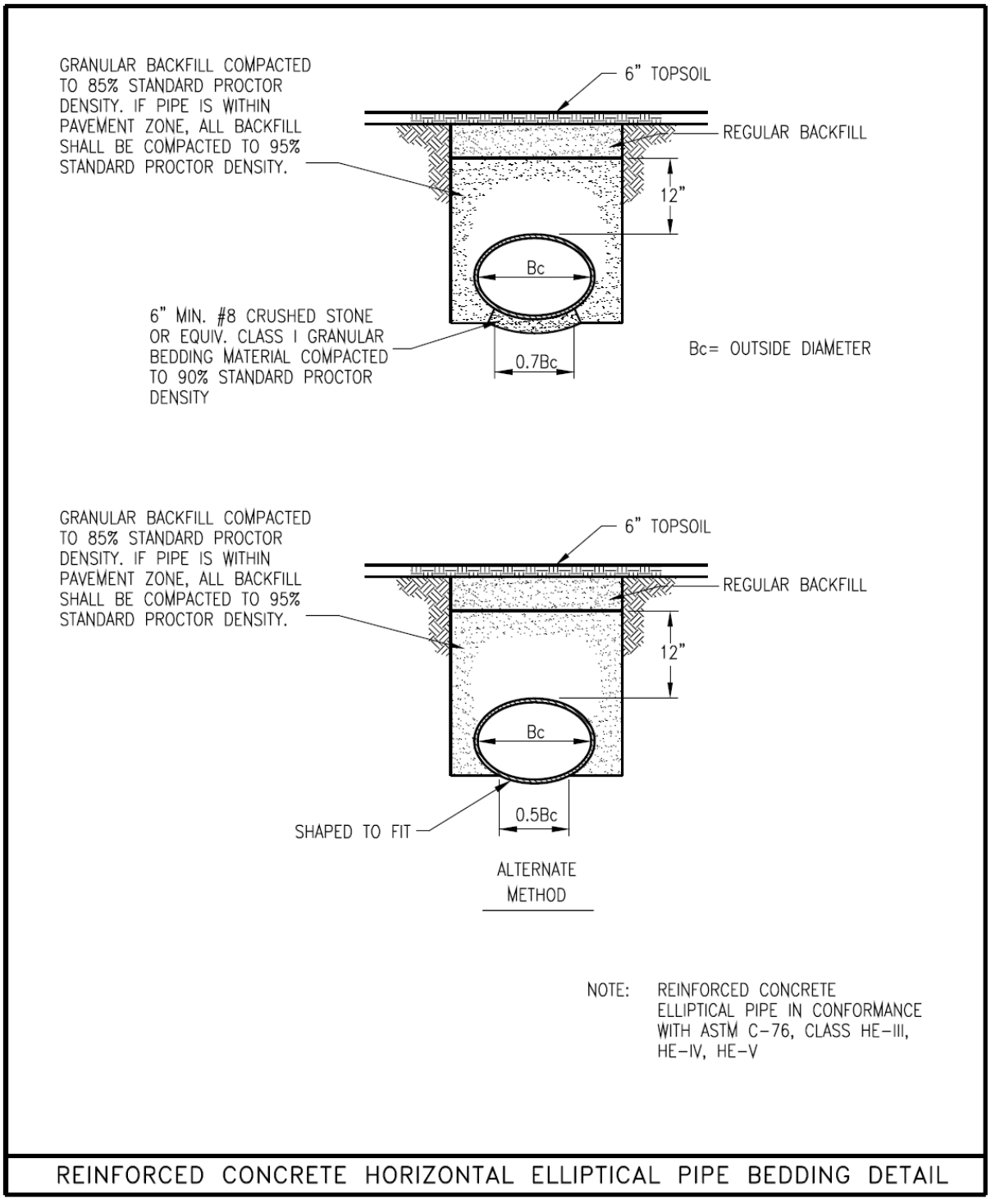


FIGURE 501-07: Reinforced Concrete Horizontal Elliptical Pipe Bedding Detail

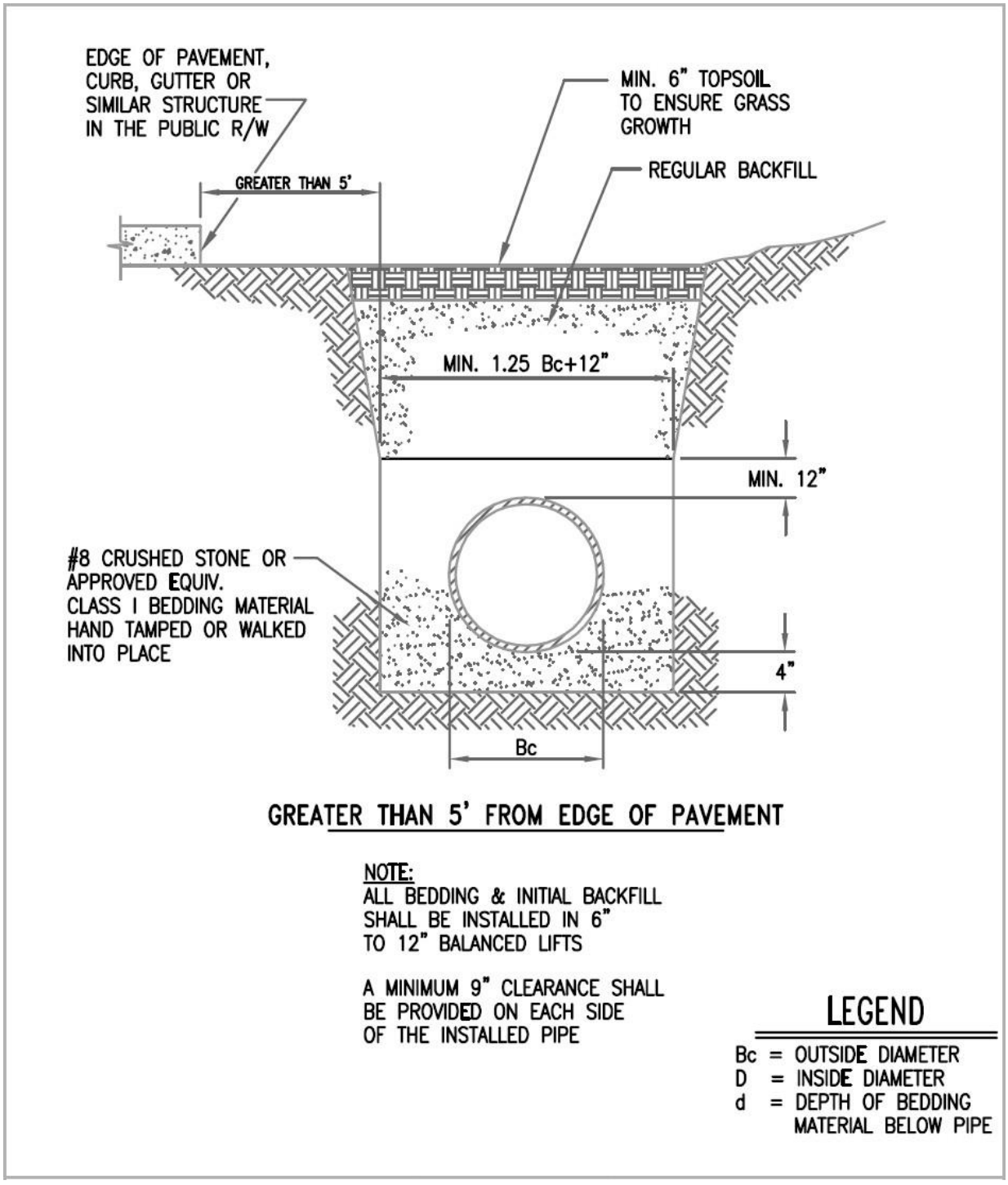


FIGURE 501-08: Plastic Pipe (PVC, PP & HDPE) Trench Detail –greater than five feet from edge of pavement

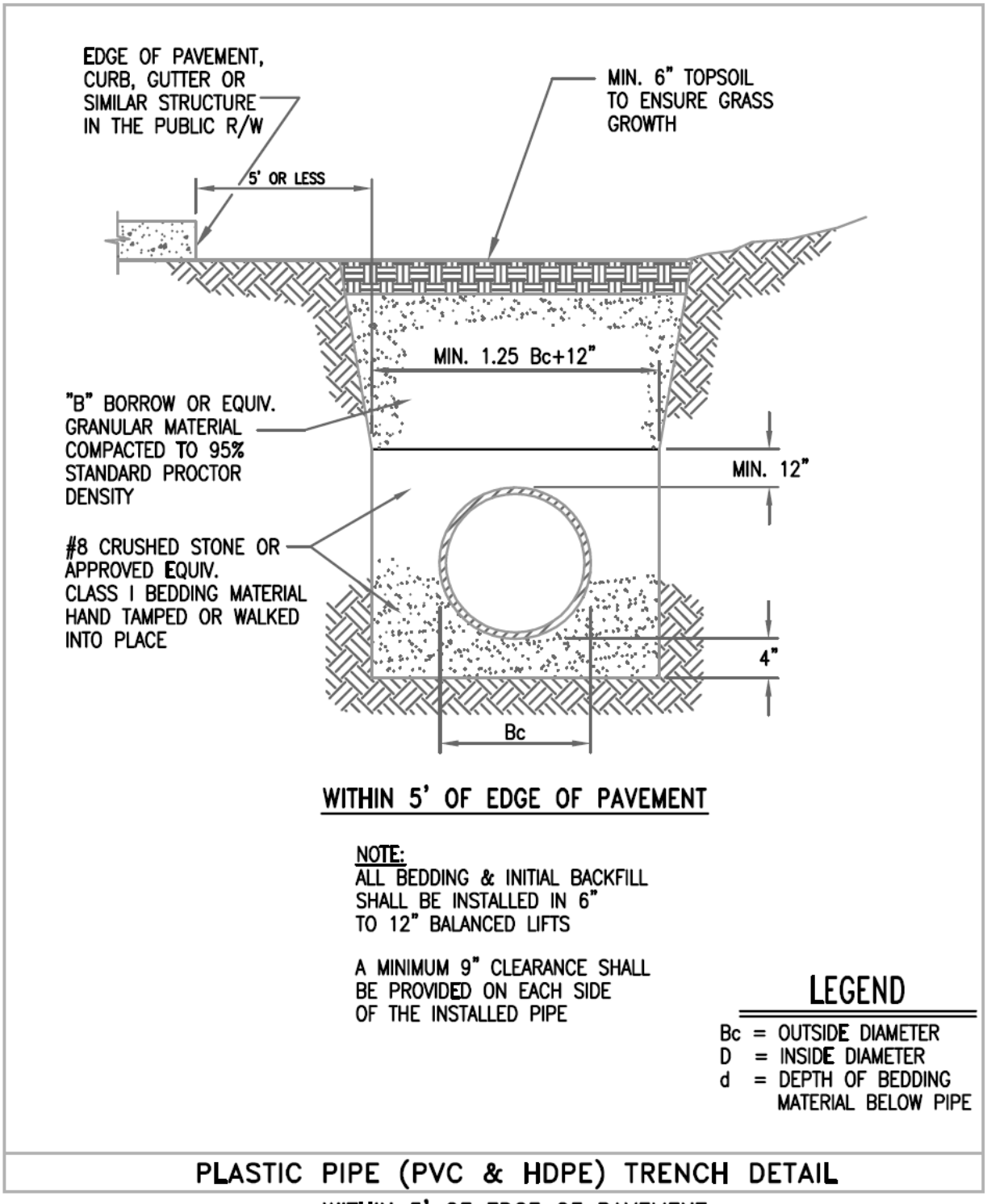


FIGURE 501-09: Plastic Pipe (PVC & HDPE) Trench Detail – within five feet of edge of pavement

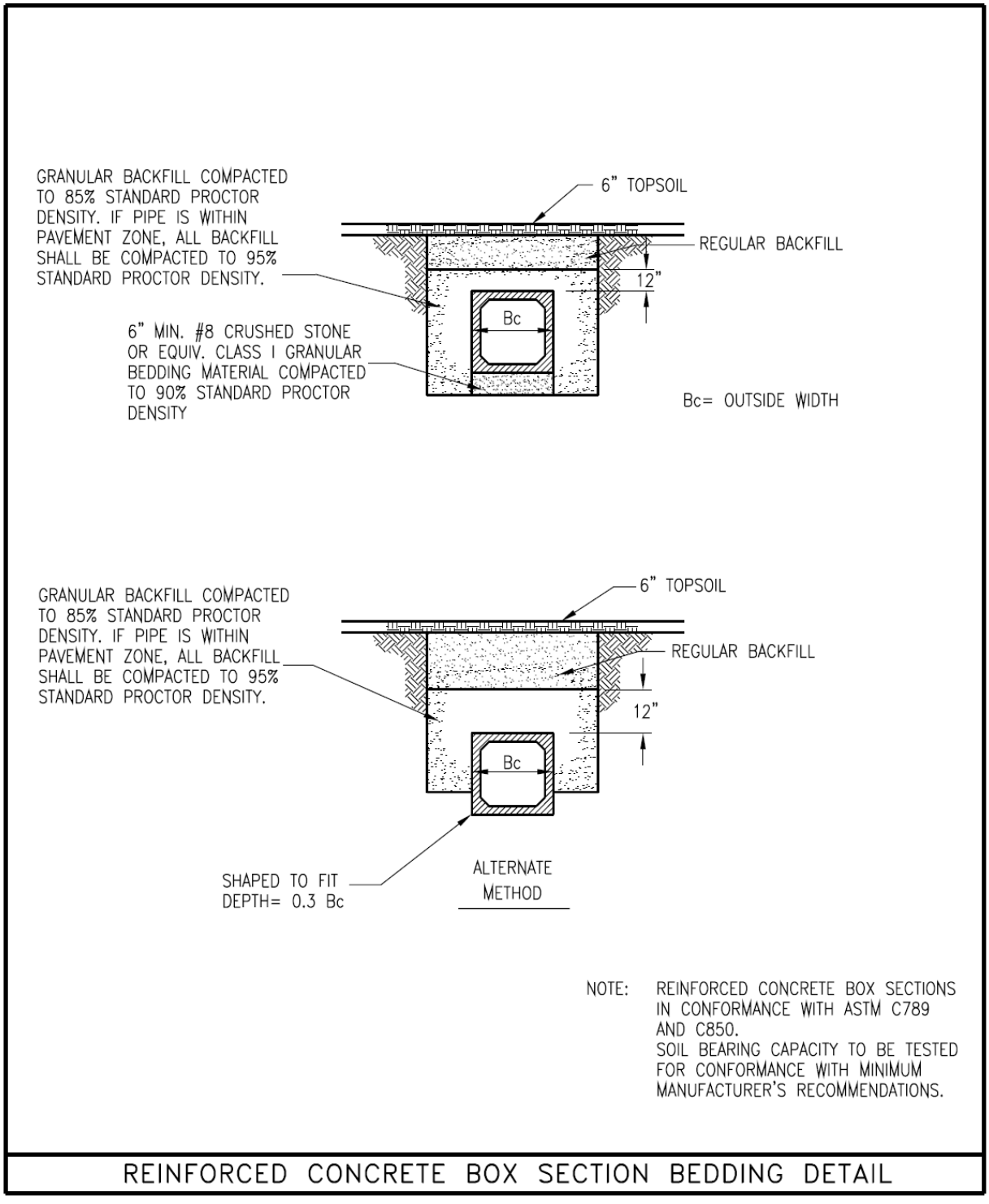


FIGURE 501-10: Reinforced Concrete Box Section Bedding Detail

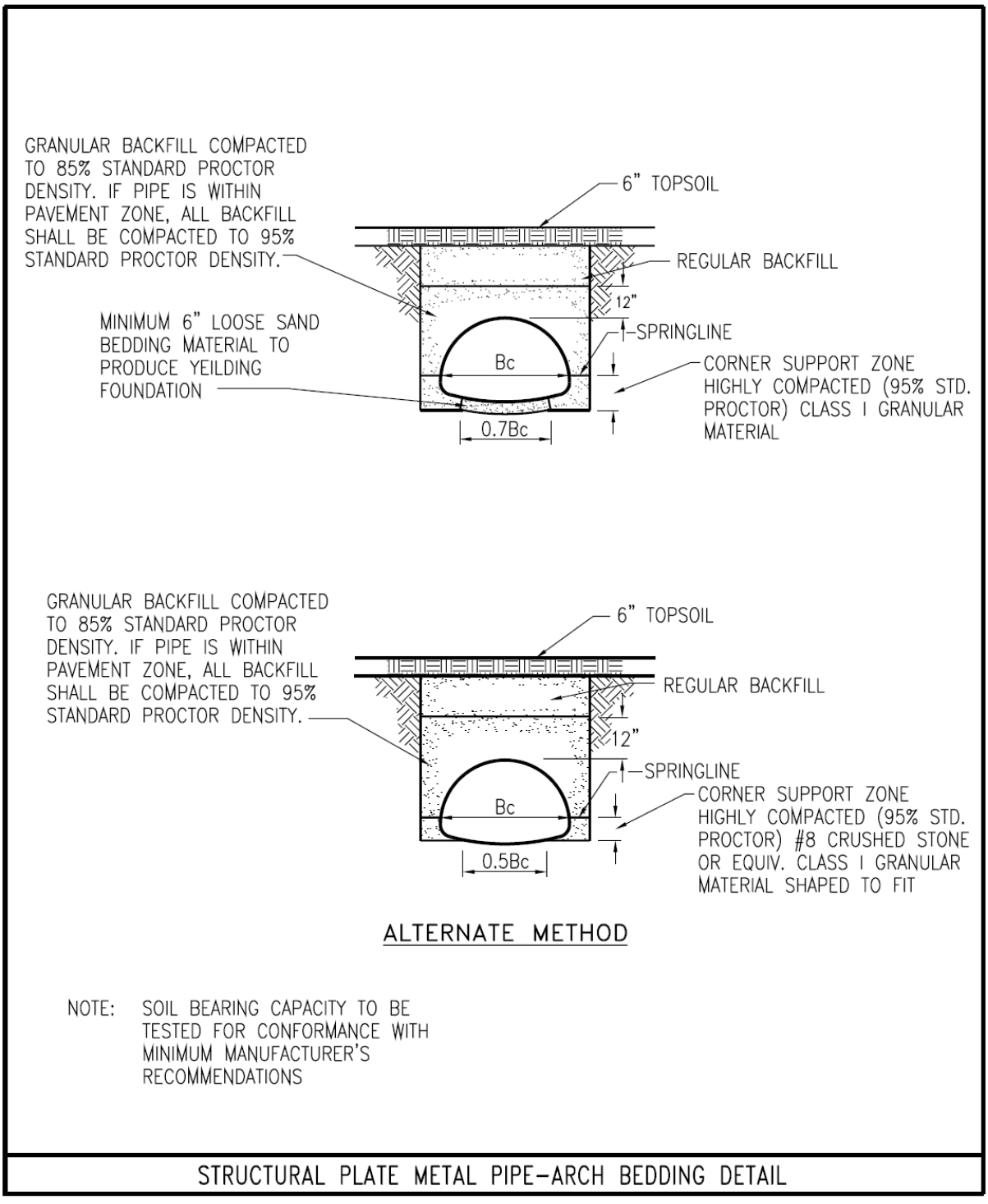


FIGURE 501-11: Structural Plate Metal Pipe-Arch Bedding Detail

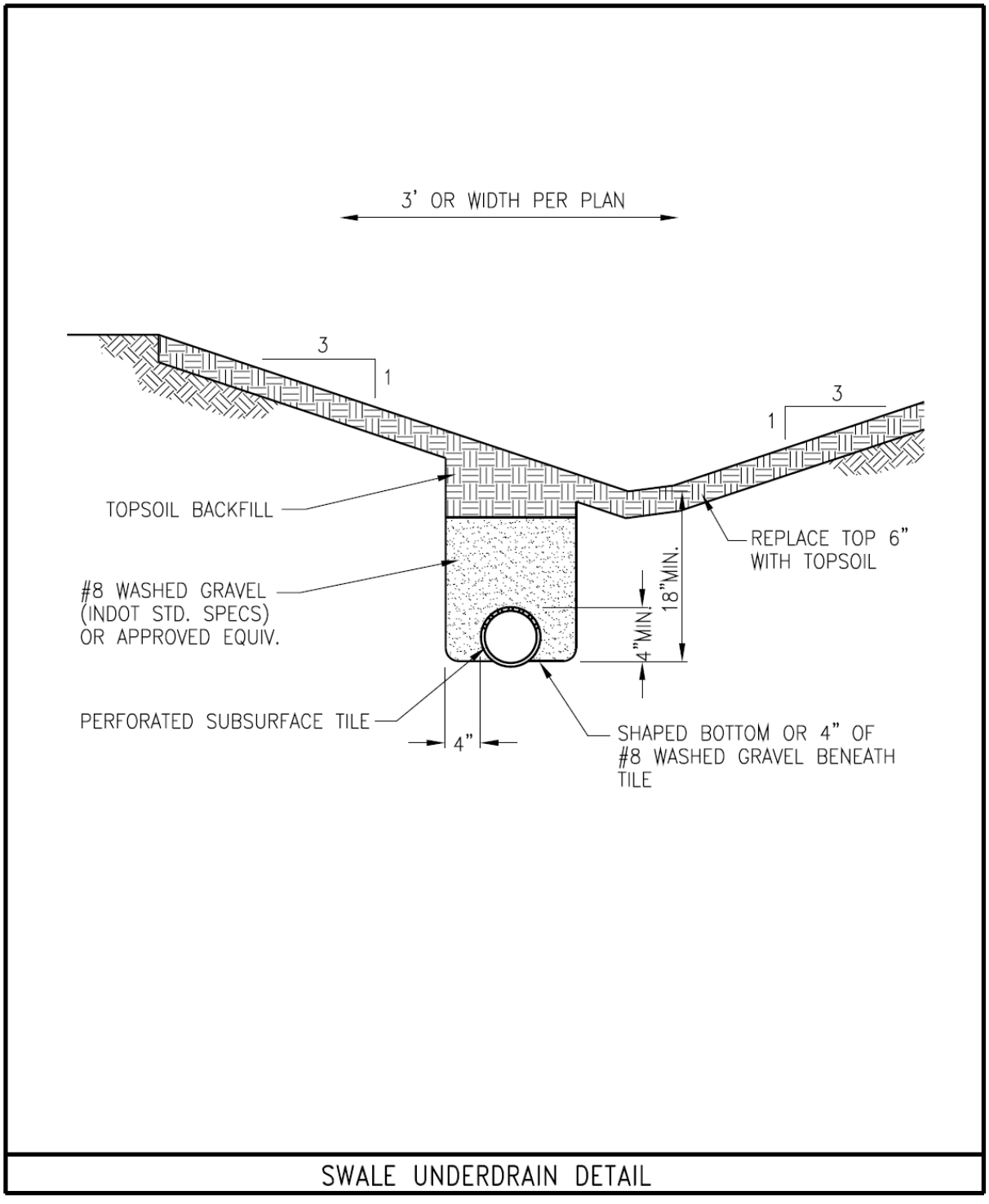


FIGURE 503-01: Swale Underdrain Detail

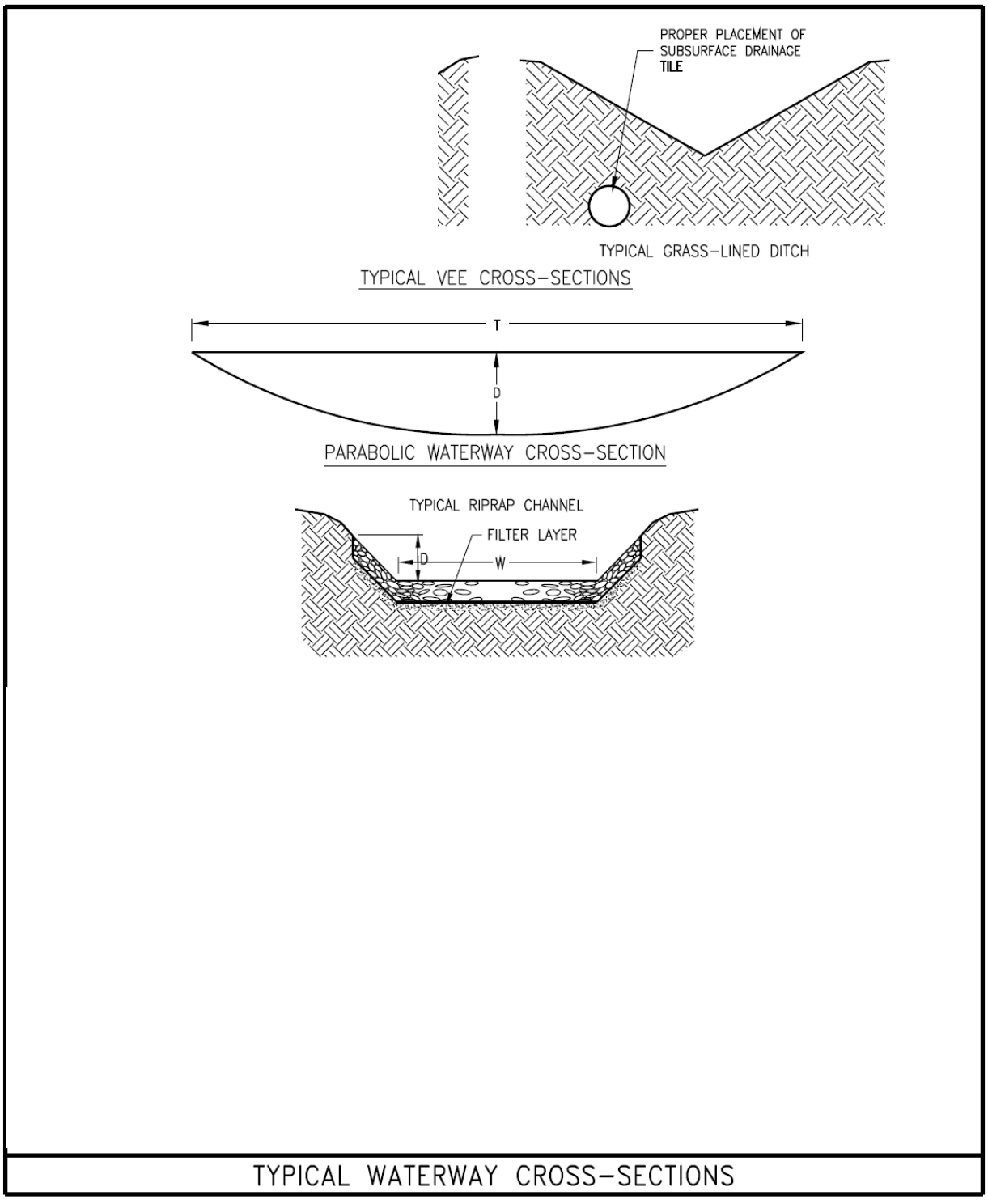


FIGURE 504-01: Typical Waterway Cross-Sections

Chapter 600. Stormwater Pollution Prevention & Erosion and Sediment Control

Section 601. General

601.01 Purpose and Background

This Chapter is intended to establish minimum standards for the design and construction of stormwater pollution prevention including erosion and sedimentation control practices required by DPW as a part of land disturbing activities, as specified herein. The goals and policies of DPW, practice standards and specifications, and plan submittal information is included.

Construction activities required as a part of land development may necessitate the removal of natural ground cover, creating the potential for erosion. The major impacts of erosion from a construction site include, but are not limited to, the movement of soil off the site, impacts on water quality, and impacts on the ability of stormwater facilities to function properly.

601.02 Authority

The ability to require the installation of erosion and sediment control practices is provided within Section 561 of the City Code. As set forth in Chapter 561 of the City Code, land alterations within the jurisdictional boundaries of this Manual shall be accomplished in accordance with those standards and specifications outlined herein.

The information outlined within this Manual establishes performance criteria for stormwater pollution prevention in compliance with the provisions of the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 (33 U.S.C. 1251, et seq., the "Act"), Title 13 of the Indiana Code, Articles 5 and 15 of Title 327 the Indiana Administrative Code, regulations adopted by the Environmental Rules Board, and CSGP issued by the Indiana Department of Environmental Management (IDEM) to regulate discharges of stormwater from construction activities into surface waters of the State of Indiana. All sites where construction activity disturbs one acre or more must comply with these provisions and Chapter 561 of the City Code.

Through an Interlocal Agreement with the City, the Marion County Soil and Water Conservation District (MCSWCD) is responsible for reviewing the Stormwater Pollution Prevention Plans (SWPPP) as required by the CSGP for City agency projects. BNS, via the drainage permit review and approval process, shall review SWPPPs for projects subject to the CSGP and erosion and sediment control plans for all other projects that require a drainage permit.

Additional guidance for providing stormwater pollution prevention practices on construction sites may be found within IDEM's "Indiana Stormwater Quality Manual."

Section 602. Introduction

602.01 General

All land alterations, regardless of extent or type, shall be accomplished in such a way as to control and limit, to the maximum extent practicable, stormwater pollution, including erosion and sediment discharge, from construction sites using, but not limited to, applicable methods and standards established by these regulations. The goals of such erosion and sediment controls are to:

1. Minimize the extent and duration of disturbed soil exposure;
2. Protect off-site and downstream locations, drainage systems and natural watercourses from pollution, including construction waste and sedimentation;
3. Limit exit velocities, from the site, to non-erosive; and
4. Implement a thorough ongoing inspection and maintenance program.

Control of pollution, including sedimentation from construction sites, may be accomplished through utilization of a variety of erosion and sediment control practices. The complexity of the erosion and sediment control plan will vary depending upon individual site conditions.

The goal of implementing the erosion and sediment control plan is to limit the dislodging of soil particles and, as result, the quantity of sediment leaving the construction site. This may be accomplished partially through installation of erosion controls and sediment controls which trap sediment prior to leaving the site. Due to the high clay content of soils in Marion County, however, sediment trapping practices typically remove only a small portion of the total suspended solids, and must be used in combination with erosion control practices such as temporary and permanent seeding, flow diversions, and streambank protection which minimize the dislodging of soil particles.

Prevention of sediment leaving the site is a general performance goal which may be used as a guide to the use of erosion and sediment control practices, however, this guideline must be applied by the design consultant with caution. Although the designer will be allowed to retain a certain degree of flexibility when deciding which erosion and sediment control practices should be used on the developing site, BNS reserves the right to require additional practices as necessary to provide a comprehensive erosion and sediment control plan which addresses each form of pollution prevention including erosion and sedimentation.

602.02 Requirements

As stated above, it is the intent of the City of Indianapolis that *all* land alterations be considered for erosion and sediment controls. Land alteration falls into one of three categories with differing requirements as follows:

1. Land alterations which disturb one (1) or more acres are required to be in compliance with the CSGP, Chapter 561 of the City Code, and these regulations;
2. All land disturbing activities relative to non-one-family or two-family residential dwellings or accessory structures are required to be in compliance with Chapter 561 of the City Code and these regulations;
3. All land disturbing activities of less than one (1) acre relative to one- or two-family residential dwelling or accessory structures are required to be in compliance with Section 561 of the City Code and these regulations and shall employ, at a minimum, perimeter type erosion and sediment control practices downslope from the disturbance such as inlet protection, concrete and cementitious washout containment and/or other practices as needed to prevent pollutants from entering the storm sewers and surface waters. Gravel access drives may also be required at the discretion of the Director of BNS or their representative. Perimeter erosion control shall be employed outside of completed easement areas. Established easement areas are not to be disturbed during construction process.

602.03 Erosion and Sediment Control Plans (ESCP)

Land alteration which strips the land of vegetation, including regrading, clearing and grubbing, shall be done in a way that will minimize erosion and off-site sedimentation, in accordance with Section 561-382 of the City Code. An ESCP is required for all land disturbing activities relative to non-one family or two-family residential dwelling or accessory structures of any size as part of the Drainage Permit Application. Stormwater pollution prevention (erosion and sediment) controls must be included in Drainage Permit Application. If the owner or operator is required to prepare a Stormwater Pollution Prevention Plan (SWPPP) in compliance with the CSGP, such compliance with the permit and plan shall be deemed to fulfill the requirements of Chapter 561 of the City Code and the regulations promulgated in this Manual. In this case, all applicable state and federal permits or notices for land disturbing activities shall be obtained or filed prior to commencement of land disturbing activities. All applicable state or federal standards shall be adhered to when conducting land disturbing activities. Copies of all applications, letters of intent, submittals, plans and other erosion and sediment control related information developed for and/or submitted to state or federal authorities shall be included in the Drainage Permit Application.

The ESCP should be presented on one or more plan sheets, where appropriate, and should clearly portray the methods and means whereby erosion and sediment controls are implemented. It shall be prepared under the supervision of, and certified by, a Registered Professional—as specified in Section 561-224 of the City Code, and shall include, at a minimum, the following site development information (Note: projects subject to the CSGP shall comply with the CSGP requirements and submit a SWPPP using guidance provided by IDEM. Additional requirements will apply.):

1. A map of the site in adequate detail to show the site and adjacent areas including: site boundaries, and location map;
2. Lakes, streams, channels, ditches, wetlands and other water courses on and adjacent to the site;
3. 100-year (1% AEP) floodplains, floodway fringes and floodways;
4. Location of the predominant soil types, which may be determined by the United States Department of Agriculture (USDA) National Resource Conservation Service (NRCS) County Soil Survey or an equivalent publication or as determined by a certified professional soil scientist;
5. Location and delineation of vegetative cover such as grass, weeds, brush, and trees. Indicate areas both in which vegetative cover are being disturbed and those vegetation areas which are not being disturbed and used as buffers;
6. Location and approximate dimensions of stormwater drainage systems and natural drainage patterns on, and immediately adjacent to, the site;
7. Locations and approximate dimensions of utilities, structures, roads, highways and paving, including any off-site improvements;
8. Site topography, both existing and proposed, from the stormwater plan;
9. Potential areas where point source discharges of stormwater may enter ground water, if any;
10. Locations and approximate dimensions of all proposed land disturbing activities;
11. Potential locations of soil stockpiles, borrow sites, disposal sites, materials storage and staging areas;
12. Construction entrance locations, details and specifications;
13. Sequencing of activities including installation and removal of erosion and sediment controls;
14. Dewatering filter methods;
15. Concrete and cementitious washout containment detail and location, if applicable;
16. Temporary and permanent surface stabilization controls;
17. Other state or federal water quality permits required;
18. Details and specifications of erosion and sediment controls;
19. Locations and approximate dimensions of all erosion and sediment controls (indicate perimeter controls to be installed downslope of the disturbance prior to the initiation of land disturbing activity);
20. Schedule of anticipated initiation and completion dates of each land disturbing activity, including the installation of erosion and sediment controls;
21. Schedule for inspection and maintenance of the erosion and sediment controls during construction;

22. Detailed design and construction drawings and written specifications for each standard erosion and sediment control practice, with appropriate supporting computations and assumptions; and the person or persons responsible for the installation, inspection and maintenance of erosion and sediment control practices, their business address, and daytime telephone number should be included. If such person(s)'s name(s) is (are) not known at the time of plan completion such name(s) can be submitted at a later date, but before commencement of land disturbing activities.

602.04 Sureties

The Administrator of BNS may, as prerequisite to the issuance of a drainage permit, require the posting to the City Controller, of cash or a performance surety from a company licensed by the State of Indiana to provide such surety upon which the principal may be the owner of the affected land, the developer, or any other party or parties the Director of BNS believes necessary. Such surety shall name the City of Indianapolis and the County of Marion the party who can enforce the obligations thereunder, and shall be in an amount established by the Director of BNS as adequate to provide surety for the satisfactory completion of the improvements required by the drainage permit. In the instance of platting, such surety may be a part of the total surety required by the Plat Committee of the Metropolitan Development Commission. Separate sureties may be required for stormwater facilities and erosion and sediment control facilities.

602.05 Perimeter Controls

No land disturbing activity, including clearing and grubbing, shall proceed until prescribed perimeter sediment controls are installed downslope of the disturbance in conformance with the approved ESCP.

602.06 Permanency of Grades

Land alteration shall be accomplished in such a way that the grades left at the time work is completed will be permanent and stable. The angle of vegetated cut and fill slopes shall not exceed three (3) (horizontal) to one (1) (vertical) unless a detailed slope stability plan is provided and approved by the Administrator.

602.07 Buried Materials

At the discretion of the Director of BNS or their representative, non-polluting construction materials (such as brick, stone and/or wood scrap) or natural debris may be buried in the ground outside the right-of-way, building structure foundation areas and stormwater facility installation areas provided:

1. Material placement will clearly not interfere with the stability of fill areas,
2. Material used for fill or grading can be properly compacted in order to avoid future settlement of fill areas or structures/facilities erected over such fill,
3. No material, which due to its size or character, would prevent proper compaction or would cause later settlement of the ground surface shall be buried, and
4. Buried material pit areas or locations must be clearly delineated on the required record drawings.

Burial of materials shall, where applicable, be accomplished in conformance with the City Code and the Code of the Health and Hospital Corporation of Marion County, Indiana.

602.08 Inspections

Inspections shall be carried out in accordance with Section 561-251 of the City Code in one of the following ways as determined by the Administrator as assigned by the deputy director of the Division of Construction and Business Services of the Department of Business and Neighborhood Services and/or his or her authorized representatives:

1. Execution of an agreement with BNS
2. Qualified personnel provided by the owner or operator.

For projects subject to the CSGP, the qualified person, as defined by the CSGP, and the contractor shall inspect all: disturbed areas that are not finally stabilized; storage areas of possible polluting agents such as soil and other stockpiles, paints, solvents, fuels, fertilizers and pesticides that are exposed to precipitation; structural controls and locations of vehicle entrance and exit. At a minimum, the qualified person and the contractor shall inspect erosion and sediment controls weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection.

Inspections will continue until all disturbed areas are stabilized, structural controls are removed or converted to stormwater management facilities, no additional land disturbing activities are anticipated, stored materials are removed from exposure and Notice of Termination, as applicable, is forwarded to the IDEM.

The City shall also have the right to inspect any site of land disturbance at any reasonable time and to require compliance with regulations and the ESCP or state stormwater pollution prevention plan, and to take appropriate enforcement action under Chapter 561 of the City Code.

Section 603. Technical Design Criteria

603.01 The Erosion Process

The types of erosion intended to be controlled through the installation of standard erosion and sediment control practices specified herein include:

1. The dislodging of soil particles as a result of the impact of raindrops;
2. Sheet and rill erosion, which develops as shallow surface flow becomes channelized within the low-lying areas of the landscape;
3. Gully erosion, which occurs as rills, collect large quantities of runoff, developing high flow velocities; and
4. Streambank and channel erosion that occurs as the volume and velocity of flow causes movement of the channel bottom, streambed and/or bank materials.

603.02 Design Principles

In order to fully achieve an acceptable level of erosion and sediment control on the construction site, the following design principles should be fully adhered to during site analysis and development of the ESCP:

1. Existing site contours should be followed as close as reasonably possible in order to minimize cut and fill;
2. Existing natural vegetation should remain undisturbed for as long as possible during site construction activities. Naturally vegetated areas, which can serve as buffers during construction along edges of the disturbed area's property line wetlands, lakes, and watercourses, both natural and man-made, should be left undisturbed during all phases of the site construction. These vegetative filter strips may be required at the discretion of BNS;
3. A recommended sequencing of site construction activities must be provided in order to minimize the size of exposed land areas, and the length of time land areas are left without some form of temporary or permanent soil protection;

4. Soil stockpiles shall be stabilized and contained utilizing vegetative establishment, sediment trapping barriers, and/or erosion controls such as, but not limited to, mulching;
5. Storm sewer inlets, which are made operable either before or during the construction phase of development, shall be provided with protection from siltation. Inlet protection shall have an overflow, be maintainable without releasing sediment into the storm sewer system and not impede active traffic;
6. Stable, properly maintained construction entrances, haul roads and stream crossings shall be identified on the site ESCP. These construction access routes shall be installed as part of the site perimeter sediment control barriers, prior to the initiation of on-site land alteration activities. Where sediment is transported onto public street or road surfaces, these streets or roads shall be cleaned thoroughly, at minimum at the end of each day, or as needed. Sediment shall be removed by either scraping, shoveling or sweeping and be transported to a controlled fill area. Street washing will be allowed only if wash water flows to a controlled sediment trapping area;
7. Runoff velocities shall be non-erosive; and
8. A thorough inspection and maintenance program, which identifies the person(s) responsible for its implementation will be required.

603.03 General Criteria for Erosion and Sediment Control Practices

The latest edition of the Indiana Stormwater Quality Manual shall be used for detailed technical guidance for all erosion and sediment control practices. The following general practice guidance applies to the development of all ESCPs:

1. Perimeter control and other sediment trapping controls shall be installed as specified on the approved plan, including but not limited to: construction access drives, filter socks, silt fencing, temporary sediment traps, sediment basins, inlet protection and diversions;
2. Disturbed areas, which are at finish grade, shall be permanently stabilized. Stabilization shall be initiated by the end of the seventh (7th) day the area was left idle. Stabilization must be completed within fourteen (14) days after initiation. Vegetation must be established within one hundred eighty (180) days with uniform density of seventy percent (70%) across the disturbed area or reseeded;
3. Un-vegetated areas that are scheduled or likely to be left inactive must be temporarily stabilized to minimize erosion potential. Stabilization shall be initiated by the end of the seventh (7th) day the area was left idle. Stabilization must be completed within fourteen (14) days after initiation. Slope protection shall be provided by use of diversion dikes, vegetative cover, and/or slope drains. Concentrated stormwater flows shall not be allowed to flow down cut or fill slopes without proper slope stabilization.
4. Concentrated stormwater runoff leaving a development site shall be outletted to an open channel, storm sewer pipe inlet or culvert which is capable of receiving this discharge. Runoff velocities shall be controlled during all storm events, up to the one hundred- (100) year (1% AEP) return interval storm, so that the peak runoff velocity during and after the completion of the land alteration is non-erosive and in compliance with this Manual;
5. Appropriate measures shall be taken to minimize or eliminate wastes, unused building materials and all pollutants from being carried from the site by runoff. Proper storage, handling and use of all potentially polluting substances shall be employed; and
6. Roadways - Public and private roadways shall be kept cleared of accumulated sediment. Bulk clearing of accumulated sediment shall not include flushing the area with water. Projects subject to IDEM's CSGP shall remove sediment from public rights-of-way not exclusive of construction traffic at the end of each day per the CSGP requirements.

At a minimum, the contractor shall inspect erosion and sediment controls weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP, as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection.

603.04 Details on Specific Practices

The principles and practices provided by the IDEM within the Indiana Storm Water Quality Manual and the provisions of the CSGP are to be followed in the development of all ESCPs. The CSGP does not give specific requirements for use of various practices, and is therefore left to the localities to determine. This section gives details on specific requirements for all sites that must develop an ESCP. Individual practices can be modified or waived upon request to the Director of BNS based on special site characteristics and conditions.

The designer and operator should rely on the Indiana Stormwater Quality Manual for detailed design, construction and maintenance criteria for all erosion control practices. Such criteria shall be required by BNS unless waived in writing by the Director. The manual can be obtained on IDEM's website at http://www.in.gov/idem/stormwater/2363.htm or from:

Indiana Department of Environmental Management
Office of Water Quality
100 N. Senate Ave.
MC65-42 IGCN 1255
Indianapolis, IN 46204-2251
317-232-4180

603.05 Construction Access Drives and Parking Areas

The purpose of construction access drives and parking areas is to reduce the transport of silt and other debris onto the public rights-of-way and to reduce the erosion of roadbeds by construction vehicles.

Construction access drives and parking areas must have a minimum size of twenty feet (20') by fifty feet (50') in width and length, respectively, and must be placed at all ingress and egress points used by vehicles to enter and leave the perimeters of projects. If the property is adjacent to an approved alley, then the construction access shall be from the alley. Construction access drives may be made using two to three inch (2"-3") stone, placed on a prepared subgrade of geotextile fabric and/or properly compacted subgrade, or a product such as rumble racks or access mats. Construction access drives must have a rough surface capable of removing soil from construction equipment tires. Smooth surfaces are not acceptable as construction access drives.

Temporary parking areas shall be stabilized using two to three inch (2"-3") or larger stone or INDOT #2 Stone placed onto a properly compacted or otherwise prepared subgrade, at a minimum depth of six (6) inches and installed immediately after grading. Temporary parking areas shall be located within relatively flat terrain, and be provided with sufficient grading to facilitate surface drainage.

Construction access drives and parking areas shall be maintained in a condition that will prevent the tracking of soil onto public rights-of-way. Construction access drives and parking areas shall require periodic top dressing with stone as conditions demand. Projects subject to IDEM's CSGP shall remove sediment from public rights-of-way not exclusive of construction traffic at the end of each day per the CSGP requirements.

Provisions for proper dust control shall be required as deemed necessary by BNS and the IDEM CSGP, as applicable.

The contractor's inspector shall monitor tracking onto roadways and other off-site surfaces, accumulated sediment in the stone and overall function of the erosion and sediment controls. The inspector shall also monitor that the erosion and sediment controls are not blocking the flow of stormwater, particularly in ditches and that the entrance is in a safe location. At a minimum, the contractor shall inspect the erosion and sediment controls weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP as applicable.

Deficiencies shall be corrected within twenty-four (24) hours of inspection.

603.06 Perimeter Protection

The purpose of perimeter protection is to intercept and retain sediment from disturbed areas of limited size, preventing this sediment from leaving the construction site. Perimeter protection may also be used to decrease the velocity of sheet flows. There are many types of perimeter protection including silt fence, filter socks and rip rap with INDOT #5 or #8 filter stone.

Perimeter protection shall be installed as needed at the toe of slope of disturbed areas subject to sheet and rill erosion and which drain to abutting offsite properties, waterways or streets. Perimeter protection shall be installed parallel to the contour. This practice shall be applied as necessary to prevent offsite sedimentation.

Synthetic filter fabric barriers (silt fence) shall be trenched into the ground a minimum of six (6) inches and installed with wooden or reinforcement bar stakes at a maximum spacing of six (6) feet for reinforced barriers and four (4) feet for non-reinforced barriers. BNS may require the use of fence backed (reinforced) silt fencing.

Filter berms can be made of materials such as stone or filter socks. Filter berms shall be placed parallel to the contour in sheet flow areas. The material and size of the filter shall be determined by the size of the area draining toward the filter berm. Stone filter berms shall be made from riprap and INDOT #5 or #8 filter stone placed on geotextile fabric. Filter sock filter berms shall be securely staked into the ground.

At a minimum, the contractor shall inspect perimeter protection weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection. Barriers that become decomposed or inoperable prior to the end of their effective use shall be promptly replaced. Sediment deposits shall be removed upon reaching approximately one half (½) the height of the barrier at its lowest point or once a silt fence begins to bulge and the sediment should be deposited at a controlled fill area. The fence shall not be undermined during clean out operations. During use, the silt fence shall be trenched in and free of tears.

The inspector shall monitor for sediment buildup behind the perimeter protection and remove sediment when it reaches one half (½) the height of the measure. The inspector shall also check to ensure water is not able to bypass the measure whether underneath or around the sides as well as assess its overall function. The inspector shall monitor filter stone on filter berms and the contractor shall replace the layer if clogged.

603.07 Inlet Protection

The purpose of providing storm drain inlet protection is to prevent sediment from entering storm drainage systems prior to permanent stabilization of the upstream disturbed site construction areas.

Inlet protection shall be provided in and/or around all operating storm sewer inlets, during that period prior to permanent stabilization of the disturbed upstream drainage area.

Storm drain inlet protective controls should be constructed in a manner that will: facilitate cleanout and disposal of trapped sediment without releasing sediment into the storm sewer system, minimize interference with construction activities, include an overflow to prevent inconvenience or damage from ponding waters, and not impede active traffic.

Storm drain inlet protection shall be inspected and maintained after every rain event and at least weekly. Except for maintenance, inlet protection must not be removed until such time as the upstream disturbed area has been properly stabilized. Inlet protection must be removed once the site is stabilized as defined in Section 603.03 of this Manual.

If sediment has entered the system, it shall be removed within twenty-four (24) hours or before the next rain event, whichever is sooner.

603.08 Temporary Sediment Traps

The purpose for installation of temporary sediment traps is to detain sediment laden runoff from small disturbed areas for a length of time sufficient to allow the majority of sediment to settle out.

Temporary sediment traps will be accepted as sediment barriers within minor drainage channels which drain to abutting off-site properties, or around operating storm sewer inlets.

Temporary sediment traps, along with other perimeter controls, shall be installed prior to the initiation of any land disturbing activities.

The required volume of storage within a sediment trap shall be approximated using the following equation:

$$V = 0.4 \times A \times D \qquad \text{(Equation 603.01)}$$

where:

V = storage volume, ft^3
A = surface area of the flooded area at the crest of the outlet, ft^2
D = maximum depth, measured from the low point in the trap to the crest of the outlet, ft.

The contractor's inspector shall monitor the overall effectiveness of the sediment trap, inspect for scour and sediment buildup. If the trap does not drain within seventy-two (72) hours of the end of the rain event, the clogged filter stone shall be replaced. At a minimum, the contractor shall inspect erosion and sediment controls weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection.

603.09 Temporary Sediment Basins

Sediment basins shall be constructed where sediment control is needed for watersheds of five (5) acres or more to detain runoff from disturbed areas for a length of time sufficient to remove the majority of sediment within the stormwater runoff. Water must be withdrawn from the surface of the water column or equivalent as required by the CSGP and IDEM guidance. Details on how to construct a sediment basin can be found in the Indiana Storm Water Quality Manual found on IDEM's website.

Sediment basins, along with other required perimeter controls, shall be installed prior to the initiation of any land disturbing activities.

The ability of the contractor to install on-site soil stabilization and sedimentation practices such as temporary and permanent seeding, sediment barriers, and flow diversions in a timely manner may be used to determine the need for installation of sediment basins. Effective use of these other available erosion and sediment control practices within a defined construction sequence may be considered by the designer when evaluating potential site applications for sediment basins.

The contractor's inspector shall monitor the overall effectiveness of the sediment basin. The inspector shall look for sediment buildup and scour, especially at the outlet and overflow. If the basin does not drain within seventy-two (72) hours of the end of the rain event, the outlet shall be maintained or redesigned. At a minimum, the contractor

shall inspect erosion and sediment controls weekly and within twenty-four (24) hours of a rain event or as required by the CSGP as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection.

603.10 Diversions

Diversions are stormwater controls that guide stormwater around or through the construction site to reduce erosion potentials. Some examples of diversions are diversion terraces, diversion channels, slope drains, coffer dams and pump around systems and are discussed below.

Diversion Terraces

Diversion terraces are temporary or permanent berms constructed with a ridge along their downstream side, placed across the slope, in order to reduce the slope length and intercept and divert stormwater runoff to a stabilized outlet.

Diversion terraces shall be installed where sheet flow must be diverted from disturbed areas so that permanent vegetation may be established, or where slope lengths must be reduced in order to prevent sheet, rill, and gully erosion.

Stabilization of all disturbed areas upstream of the diversion terrace must be completed concurrently with installation of the diversion terrace and flow channel.

Diversion Channels

Diversion channels shall be provided with adequate outlets that convey concentrated flow without erosion. This outlet may be provided as a properly stabilized developed stormwater conveyance channel, storm sewer pipe, temporary slope drain or culvert.

The flow velocity of open channels may be determined utilizing Manning's equation, as outlined within Chapter 300 of this Manual. The channel shall be designed to be non-erosive.

Slope drains

Slope drains collect stormwater at the top of a slope, often at the end of a diversion terrace or diversion channel, and direct the flow to the bottom of the slope to prevent erosion and aide in slope stabilization. Slope drains may be constructed with a flexible plastic pipe anchored to the slope. The outlet shall have an energy dissipater such as riprap to prevent erosion.

Coffer Dams

Coffer dams are used to isolate waterbodies from work activities in lakes, streams, and rivers. Coffer dams shall be made from materials that are impermeable and non-erodible such as, but limited to metal sheet piling or sandbags. The height of the coffer dam shall be designed to prevent flooding upstream and have a stable overflow channel. Placement of facilities within the Ordinary High Water Mark (OHWM) of regulated waterways such as streams and rivers shall comply with all local, state and federal permitting requirements.

Pump Arounds

Pump arounds, such as installation or replacement of a culvert, are an option to divert water where construction activities are within a jurisdictional water, such as a stream or river. Pumps are used to divert waterbodies around work activities and the outlet shall have an energy dissipater to prevent scour downstream. The pump around water does not need to be filtered. Coffer dams shall be installed upstream and downstream of the construction activities. A second dewatering system shall be used as needed to dewater the work site. Dewatering water must be filtered

prior to discharge into the waterbodies or storm sewer system. If a filter bag is used, the filter bag shall be placed on a flat stable surface behind secondary containment such as a filter berm above the OHWM. Placement of facilities within the OHWM of jurisdictional waterways, such as streams and rivers, shall comply with all local, state and federal permitting requirements.

Pump around pumps shall be monitored at minimum every four (4) hours during their operation. Additional monitoring may be necessary during rain events to monitor capacity, prevent overflows through the work area, and/or prevent flooding upstream.

Diversions

Diversions, including channels, dikes, coffer dams, slope drains, stabilized upstream areas, and outlet channel shall be inspected after every rainfall. Sediment deposits shall be removed, damaged and eroded areas repaired, and reseeding accomplished within either twenty-four (24) hours of the inspection or as soon as the soil dries sufficiently to allow work to proceed.

Diversions shall be inspected for overall effectiveness, including verifying the diversion is sized to accommodate the watershed. The inspector shall monitor for scour, including at the outlet.

603.11 Temporary and Permanent Seeding; Mulching and Erosion Control Blankets

Definitions:

Temporary Seeding: Temporary seeding consists of the establishment of temporary vegetative cover for stabilization of disturbed areas, including stockpiles, with rapidly growing plants where final grades have not yet been established per guidance in Section 603.03 of this Manual. Dormant seeding is a type of temporary seeding required when soil temperatures are below fifty degrees Fahrenheit (50 °F).

Permanent Seeding: Permanent seeding involves the establishment of perennial vegetative cover on areas that have been brought to finished grade elevation. Permanent seeding shall be required after finish grade is established on all disturbed areas, particularly along natural stream channel banks, within the flowlines of drainage swales, on retention/detention pond banks, and on fill slopes pursuant to Section 603.03 of this Manual.

Topsoil: The application of at least a minimum depth of topsoil shall be required in adequate depths to establish vegetation and shall be stabilized.

The following requirements shall be adhered to as a part of top soiling operations:

Topsoil: Topsoil shall be evenly spread to a minimum depth of four (4) inches. All areas to be utilized for soil stockpiles shall be clearly identified on the approved ESCP. The topsoil stockpile shall be located so as not to interfere with site work and shall be provided with adequate temporary erosion and sediment controls and shown on the approved ESCP. Surface roughening must be completed to allow proper bonding of topsoil to the soil material below. Application of mulching material immediately after temporary and permanent seeding will be required. Seed and mulch may be applied together, such as via hydro seeding, in accordance with the manufacturer's recommendation.

Mulch: Straw mulching shall be at an adequate area density to stabilize the soil until vegetation is established.

Erosion Control Blankets: Installation of erosion control blankets shall be required in addition to permanent seed within the flowline of all drainage swales, on all retention/detention pond banks, and on all fill slopes of four (4)

(horizontal) to one (1) (vertical) or steeper. Erosion control blankets shall be installed according to manufacturer's specifications for the proposed flow depth and velocity.

Sod: Establishment of permanent vegetation by sodding will, generally, not be required by BNS. In those areas where the immediate establishment of permanent turf is deemed necessary, sodding will be an acceptable means of providing vegetative cover for erosion control. When placed within the flowlines of defined drainage ways, staking of sod to prevent undermining will be required. Sod in good condition must be placed on the required topsoil, at an elevation in compliance with the grading plan, and kept watered for a minimum of two (2) weeks with twice daily, minimum watering required until vegetative establishment.

At a minimum, the contractor shall inspect erosion and sediment controls weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection. The contractor or responsible party shall monitor for overall vegetation growth and reseed and mulch as necessary. The contractor or responsible party should look for rills and other types of erosion and bare areas. The contractor or responsible party shall check that sod is installed with tight seams and watered. The sod shall be permanently established and not lift when tugged. Erosion control blankets shall be anchored firmly in place. Inspections shall continue until the entire site is stabilized to at a minimum of seventy percent (70%) uniform density vegetation cover.

603.12 Buffers

Vegetation including grass, trees and shrubs shall remain in place when possible as erosion control. Vegetation upstream of construction activities reduces the velocity of stormwater flowing through the site. Vegetation downstream of construction activities reduces velocity and filters sediment from stormwater. Flat wide buffers in sheet flow areas are more effective than narrow buffers or buffers on steep slopes or channel flows.

Projects subject to the CSGP shall preserve natural buffers as required by the permit. More information can be found on IDEM's website. Construction stormwater discharges to the buffer shall be treated with erosion and sediment controls prior to entering the buffer. The buffer shall not be used as construction site sediment control.

The contractor or responsible party shall monitor buffers for erosion and sediment buildup. At a minimum, the contractor shall inspect buffers weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection.

603.13 Scour Protection

The installation of rock riprap provides a permanent, erosion resistant ground cover through use of large, loose, angular stone. Approved commercial products may be used in place of rock riprap where applicable. Proposed alternative products must include complete design documentation (e.g., design calculations and manufacturer's design limitations).

Rock riprap shall be required by BNS as a means of protecting the soil surface from the erosive forces of concentrated stormwater runoff and as a means of stabilizing eroding streambanks and slopes with seepage problems and/or non-cohesive soils. Riprap shall not be installed in such a manner which impedes drainage. Some examples of where rock riprap may be utilized would include storm sewer outlets, at culvert ends, on channel banks and/or bottoms, on ditches, as rock chute structures, and for slope stabilization.

Placement of the rock riprap must follow immediately after installation of geotextile, and a dense, well graded mass of stone with minimal voids must be produced.

Crushed, discarded concrete shall be an acceptable alternative to rock riprap provided it is well graded, a density adjustment is made, and meets all other requirements of this Manual. The minimum thickness of the riprap layer shall be no less than six (6) inches.

Rock riprap installations shall be inspected to determine if high flows have caused undermining, or if stones have been dislodged. At a minimum, the contractor shall inspect scour protection weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection.

603.14 Check Dams

Check dams are used primarily on ditch bottoms to prevent channel erosion and to provide secondary sediment control benefit. Check dams shall be spaced along the ditch so that the top of the downstream check dam is at the same elevation as the bottom of the next upstream check dam. Each check dam shall have a weir in the center so that stormwater flows do no scour ditch side slopes.

Check dams may be made from stone (riprap with INDOT #5 or #8 filter stone) placed on geotextile fabric. The geotextile fabric shall extend downstream of the check dam approximately four feet to prevent scour.

Check dams may also be made from materials such as filter socks, staked securely into the ground, as long as the practice effectively prevents channel scour.

At a minimum, the contractor shall inspect erosion and sediment controls weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP, as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection. Check dams shall be inspected for sediment buildup and scour, both on the ditch side slopes and channel bottoms. If scour is present on side slopes, the weir shall be adjusted to guide water over the dam. If channel erosion is present, the dams should be increased in height or placed closer together. Filter materials such as filter stone shall be replaced when clogged.

603.15 Temporary Stream Crossings

The purpose of temporary stream crossings is to provide a means for construction traffic to cross flowing streams without damage to the channel or banks, and to keep sediment generated by construction traffic out of the stream.

Temporary stream crossings shall be provided for all natural and man-made open channels that have continuous flow and are to be crossed by construction equipment. Placement of facilities within the OHWM of regulated waterways such as streams and rivers shall comply with all local, state and federal permitting requirements. Placement of stormwater facilities within or near channels which possess greater than one (1) square mile of drainage area will require the approval of the Indiana Department of Natural Resources, Division of Water.

Multiple culvert installations shall be approved on a case-by-case basis, provided the minimum pipe diameter proposed is eighteen (18) inches, and sufficient space is provided between culverts to allow for soil compaction, as required by Chapter 500 of this Manual.

Culverts shall have a slope equal to the stream bed being crossed, and extend the full width of the crossing, including side slopes.

Temporary stream crossings shall be inspected after every rainfall, and at least weekly for assessment of damages due to stormwater flows or construction equipment. Necessary repairs shall be accomplished within twenty-four (24) hours of inspection. All work shall comply with all applicable permits.

603.16 Concrete and Cementitious Washout Containment

Concrete and cementitious washout wastewater shall be completely contained. Containers shall be watertight or completely lined with a single piece of plastic free from holes and secured to prevent slippage. Concrete and cementitious washout wastewater shall not be allowed onto ground, in storm sewers, in sanitary sewers, in waterways, in foundation base material, or anywhere that is not completely contained for proper disposal. Concrete and cementitious washout wastewater shall be disposed of properly by allowing it to harden prior to disposal. Alternatively, the liquid may be recycled back into concrete mixers or removed and disposed of by a waste collection company.

Concrete and cementitious washout containers shall be placed in a convenient location, such as along the construction entrance, and locations clearly posted. Concrete and cementitious washout containers shall not be located near or immediately upslope of environmentally sensitive features such as ponds, storm inlets, streams, wetlands and tree protection areas. Stormwater runoff shall be directed around concrete and cementitious washout containers. Multiple washout stations may be necessary for projects with a large quantity of concrete and/or with multiple construction entrances.

Concrete and cementitious washout containers shall be inspected daily when in use. The inspector shall monitor for leaks, spills and capacity and the contractor shall correct deficiencies within twenty-four (24) hours of the inspection. In the event of a wastewater spill, the contaminated soil shall be removed and disposed of properly. Displaced soil shall be replaced with uncontaminated material.

603.17 Staging

Staging areas shall be placed in locations away from environmentally sensitive areas whenever possible. Staging areas shall be stable and include perimeter protection downslope of disturbed areas.

Materials shall be stored so that they are not exposed to stormwater by placing them inside, keeping lids on containers, covering with geotextile or other methods to contain pollutants. Temporary toilet facilities shall be placed in a location safe from operating equipment and vehicles and where, in the event of an overturn, liquid would not flow into a storm drain, creek, or other waterway. Construction debris and litter shall be placed in containers and covered with lids. Vehicles and equipment shall be free of leaks. Refueling areas shall be free of spills. In the event of a spill, the contaminated soil shall be removed and disposed of properly.

At a minimum, the contractor shall inspect staging areas weekly and within twenty-four (24) hours of a rain event of one half (½) inch or greater or as required by the CSGP, as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection. The inspector shall monitor staging areas for litter, other debris, equipment leaks, concrete and cementitious washout containment, fuel spills and other pollutants. In the event of a spill, the contaminated soil shall be removed and disposed of properly. Displaced soil shall be replaced with uncontaminated material. Temporary toilet facilities shall be maintained, waste completely contained, and waste disposed of properly by a waste collection company.

603.18 Stockpiles

Stockpiles of soil, asphalt millings and other materials shall be placed in locations away from environmentally sensitive areas whenever possible. Soil stockpiles shall be stabilized with seed and mulch or other method(s) within seven (7) days of stockpiling. Stockpile areas shall have perimeter protection installed downslope prior to stockpiling activities.

At a minimum, the contractor shall inspect stockpiles weekly and within twenty-four (24) hours of a rain event of

one half (½) inch or greater or as required by the CSGP as applicable. Deficiencies shall be corrected within twenty-four (24) hours of inspection. The inspector shall monitor stockpiles for erosion, perimeter protection and overall function. Owner shall not allow sediment to leave the stockpile area, nor enter environmentally sensitive areas.

603.19 Dewatering

Discharge water from dewatering of ground water from excavations such as but not limited to trenches and foundations shall be directed to an appropriate stormwater quality measure that minimizes the discharge of sediment regardless of discharge location. Dewatering operations:

- Shall not cause erosion from the discharge. Dewatering water shall discharge to stable, erosion-resistant surfaces, such as but not limited to clean stone or well-vegetated grassy areas;
- Shall not have a discharge with a visible sheen, foam and/or pollutants at a level that requires additional treatment and/or an alternate permit;
- Shall route dewatering water through a sediment control (e.g., sediment trap or basin, pumped water filter bag) designed to prevent discharges with visual turbidity;
- Shall not be placed on steep surfaces; and
- Shall not use the receiving water or MS4 as part of the treatment area;

All SWPPPs, as required by the CSGP, shall include dewatering practices.

603.20 Polymers

Projects may use anionic polymers for erosion and sediment control per IDEM and the manufacturer's guidance. Cationic polymer use is prohibited. If polymers are used on CSGP projects, the permittee must indicate such on the Storm Water Pollution Prevention Plan (SWPPP). If polymer use is added to the project after permits are issued, the SWPPP must be redlined with the applicable information. Polymer use shall be indicated on the erosion and sediment control plan sheet(s) as part of the drainage permit application for projects not subject to the CSGP.

Chapter 700. Stormwater Quality

Section 701. Introduction

701.01 Chapter Description

This chapter provides design criteria for stormwater quality best management practices, or BMPs that are required in order for newly developed or redeveloped properties to comply with the City's policies for managing the post-construction quality of stormwater runoff found in Section 104.02 of this Manual.

701.02 Purpose and Background

BMPs discussed in this chapter refer to post-construction BMPs, intended to control the quality of stormwater runoff after construction has been completed and the site has been stabilized. Installing certain BMPs, such as bioretention areas and sand filters, prior to stabilization can cause failure of the measure due to clogging from construction site run-off sediment. However, with a strict construction sequence and appropriate construction site erosion and sediment controls, detention ponds can be installed initially, during construction, and used as sediment control measures. In those instances, the construction sequence must require that the pond(s) are cleaned out with pertinent elevations and storage and treatment capacities reestablished as designed and permitted.

701.03 Stormwater Quality Control Requirements

The City of Indianapolis has adopted a stormwater runoff quality policy (Section 104.02 of this Manual) based on the control of total suspended solids and floatables in stormwater runoff. In addition, designers may be required to include the control of other pollutants as required by the City's MS4 NPDES permit. The water quality design requirements are as follows:

1. Total Suspended Solids (TSS). BMPs must be capable of removing eighty percent (80%) of the TSS load from post-construction runoff. Constructed BMPs listed in this section are approved to meet this requirement and manufactured BMPs approved in accordance with the City's Stormwater Quality Unit (SQU) Evaluation Criteria are also acceptable to meet this requirement. For the purposes of this requirement, TSS is defined as particles smaller than one hundred twenty-five (125) microns in diameter. Larger material is considered to be part of the total solids load of the stormwater runoff.

2. Floatables. BMPs shall incorporate floatables control. The goal of this requirement is to capture floating debris and remove it as part of the routine maintenance of the BMPs. Standalone BMPs must include floatables control. For BMP systems, or treatment trains, at least one of the components of the BMP system, located after the last inflow point to the system, must provide control of floatables.

Development and redevelopment projects shall be required to comply with this chapter if the construction activity disturbs one half (½) acre or more land, as noted in Section 104.02 of this Manual.

701.04 Stormwater Quality Design Methods

There are two categories of design methods currently in use in the City of Indianapolis: performance-based design for pre-approved BMPs, and proprietary design for innovative BMPs.

1. Performance-Based Design

This family of design standards is based on the common physical properties of numerous BMPs whose pollutant removal performance were measured by comparing inlet and outlet samples collected from the devices. The underlying assumption for this type of BMP design is that if a BMP is designed and constructed according to performance-based design criteria, and the BMP is properly maintained, then the BMP is expected to perform at or near the efficiency reported in the design standards.

In order to meet the TSS removal goals, performance-based BMPs must be designed to treat the first flush runoff. The first flush runoff volume is estimated by computation of the water quality volume (WQ_v), which represents the runoff volume from a storm of one-inch (1") depth over the drainage area. Based on precipitation record estimates, BMPs designed to treat the first flush runoff of one inch in the Indianapolis area would treat the total runoff of up to seventy-five percent (75%) of the storms annually because the total storm depth of those storms is less than one (1) inch.

The following equation is used to calculate WQ_v (in acre-feet):

$$WQ_v = \frac{(P)(R_v)(A)}{12} \qquad \text{(Equation 701.01)}$$

where:

WQ_v = water quality volume (acre-feet)
P = 1 inch of rainfall
R_v = 0.05 + 0.009(I) where I is the percent impervious cover
A = area in acres

Structural BMPs that may be designed using performance-based design criteria are discussed in detail in Section 702 of this Manual.

2. Proprietary Design

Innovative BMPs, for the purpose of this Manual, are any BMPs that are not considered traditional structural BMPs for which performance-based design standards are provided in Section 702 of this Manual. Examples of innovative BMPs would be manufactured BMPs such as hydrodynamic separation units, oil and floatable debris skimmers, and cartridge filter systems. All innovative BMPs must be professionally certified, approved through the New Products Committee and be in compliance with the City's SQU Evaluation Criteria.

The design process for an innovative BMP that is approved for use in the City of Indianapolis may be based on design flow capacity, on design volume, or other testing procedures approved by the City. The process for applying for approval of innovative BMPs is described on the City of Indianapolis Department of Public Works website (https://www.indy.gov/activity/public-works-specifications-and-manuals).

The following materials must be submitted in support of the application to approve a new BMP or process for use in the City of Indianapolis:

1. Narrative description of the practice or unit and its working principle(s).
2. Detailed description of the maintenance procedures.
3. Detailed drawings of the practice or unit.
4. Detailed description of the practice or unit's testing procedures.

5. Results of all tests.

The following performance criteria must be met by the proposed new BMPs. The BMPs:

1. Must meet the TSS removal requirement;
2. Must meet the floatable removal requirement;
3. Must be able to be inspected and maintained;
4. Must have a low to medium maintenance requirement to be considered by the City for use on public projects.

Testing to establish the TSS removal rate must be certified by an independent third-party engineer.

The most current list of pre-approved innovative/manufactured BMPs can be found in Section 703 of this Manual. Products approved since the last publication of this Manual can be found on the DPW website. Go to Public Works Specifications and Manuals and search for "Approved SQU Selection Table."

701.05 Inspection and Maintenance

Each BMP or BMP system (a single practice or combination of practices that meet the treatment goal) on a site must be identified in the O&M Manual as specified in Section 102.06 of this Manual. The O&M Manual must be submitted with the stormwater management plan and approved by BNS. The approved O&M Manual must be recorded at the Marion County Recorder's Office.

As outlined in the O&M Manual requirements, Section 102.06 of this Manual, inspections of permanent BMPs shall be performed by the BMP owner to ensure BMPs function as designed and permitted. The owner is also required to perform maintenance activities. Upon request by BNS, the owner shall self-certify, with BNS, that inspections and maintenance activities were completed at least annually, in accordance with the O&M Manual and that the BMP functions as designed and permitted. Each BMP in the system shall be considered individually for inspection, maintenance and self-certification purposes. A BMP system will have multiple BMPs for the purpose of inspection, maintenance and self-certification. Each BMP shall have access and features, such as inspection ports, clean outs, easements and drives necessary for inspection and maintenance. Easements must extend to public right-of-way for access.

Routine inspections and maintenance are the responsibility of the current BMP owner. The approved O&M Manual, inspection forms and maintenance form(s) should be used as guidance for performing such activities. Completed inspection forms and maintenance records must be maintained by the current BMP owner and produced upon request by BNS within forty-eight (48) hours.

701.06 Operations and Maintenance Manual

The designer shall submit, for review and approval, an O&M Manual for stormwater infrastructure pursuant to Section 102.06 of this Manual.

701.07 Invasive Species

No plant species listed on the Indiana Invasive Species Council Invasive Plant List (all Invasive Rank categories) shall be planted on the site including within any post-construction water quality or quantity feature. Invasive species removal shall be included in the O&M Manual and be removed entirely as part of maintenance operations.

701.08 Green Infrastructure Supplemental Document

The most recent version of the Green Infrastructure Supplemental Document, found on the City's website, can be used as reference on advantages, disadvantages, applicability, examples and design information for BMPs in this chapter and other green infrastructure practices. Inclusion in the Green Infrastructure Supplemental Document does not necessitate approval as a stormwater BMP.

Section 702. Performance-Based Structural Best Management Practices

702.01 Performance-Based Structural Best Management Practices

Table 702-1: Pre-Approved BMPs identifies pre-approved structural BMPs that can be used in Indianapolis for water quality control. The BMPs included in this table are pre-approved for use if designed, constructed and maintained according to the criteria set forth in this chapter. Note that many of these measures can also be designed to meet the water quantity control requirements. For proposed BMPs utilizing infiltration, the designer may refer to the Green Infrastructure Supplemental Document Attachment 1 for infiltration testing and hotspot investigation procedure guidance. Specific water quality design requirements are presented in the following sections.

TABLE 702-01: Pre-Approved BMPs

BMP Type	Description	Quantity control	WQv and 80% TSS removal	Floatables Control
Stormwater Ponds Wet pond Wet extended detention pond Micropool extended detention pond Multiple pond systems	Stormwater ponds are constructed stormwater detention basins with a permanent pool (or micropool) of water retained. Runoff from each rain event is captured and treated in the pool.	Yes	Yes	Yes
Stormwater Wetlands Shallow wetland Extended detention wetland Pond / wetland systems Pocket wetland	Stormwater wetlands are constructed, artificial wetland systems used for stormwater management. They consist of a combination of shallow marsh areas, open water and semi-wet areas above the permanent pool.	Yes	Yes	Yes

Bioretention Areas	Bioretention areas are shallow stormwater basins or landscaped areas that utilize engineered soils and vegetation to capture and treat stormwater runoff.	Yes	Yes	Yes
Sand Filters Surface sand filter Perimeter sand filter	Sand filters are multi-chamber structures designed to treat stormwater runoff through filtration, using a sand bed as its primary filter media.	No	Yes	Yes
Water Quality Swales Dry swale	Water Quality swales are vegetated open channels that are designed and constructed to capture and treat stormwater runoff within dry cells.	No	Yes	No
Biofilters Filter strip Grass channel	While biofilters provide some filtering of stormwater runoff, by themselves they cannot meet the 80% TSS removal performance goal. *These measures can only be used as pre-treatment measures or as part of a treatment train.*	No	No	No

702.02 Stormwater Ponds

Wet detention ponds can be designed to meet both water quality and water quantity requirements. If the detention pond is to be designed for only water quality purposes, then the pond shall be designed to capture the water quality volumes as noted in Section 701.04 of this Manual. If the stormwater pond is also to be designed for water quantity, refer to Chapter 300 of this Manual. The designer shall provide sufficient information in the construction documents to show compliance with this Manual, including but not limited to, plans, sections, easements, grading, wet pool elevation, 10- and 100-year (10% and 1% AEP) pool elevations, spillway elevation, vegetation specifications, planting specifications, scour protection and details such as the outlet structure, forebay sediment marker detail, forebay hardened bottom detail and anti-seep collar detail.

Dry detention ponds designed for water quantity shall include another approved BMP to address water quality. This BMP can be placed either upstream or downstream of the dry detention pond.

Site and Design Considerations
Chapters 300 and 500 of this Manual and the following design and site considerations must be followed when designing a stormwater pond:

1. Design the wet detention pond with a minimum length to width ratio of three to one (3:1) (preferably expanding outward toward the outlet), measured from *each* pond inlet to the pond outlet.
2. Maximize flow length between each inlet and outlet structure. Use baffles if short-circuiting cannot be prevented with inlet-outlet placement.
3. Design the BMP for the contributing impervious drainage area.
4. Provide a sediment forebay, or other pretreatment, upstream from *each* pond inlet.
5. The forebay must be sized to contain one tenth (0.1) inches of runoff per impervious acre of contributing drainage. The forebay storage volume counts toward the total water quality storage requirements. Other pretreatment should be designed per its respective requirements.

6. Exit velocities from the forebay must be non-erosive and calculations provided.
7. Direct maintenance access for appropriate equipment must be provided to the pond, forebay and/or another pretreatment(s). Restrictions such as fences without gate access, steep slopes, spillways and structures shall not block access for maintenance of the BMP features.
8. The bottom of the forebay shall be hardened (e.g., using concrete, paver blocks or similar) to make sediment removal easier.
9. A fixed vertical sediment depth marker must be installed in the forebay and permanent pool to measure sediment deposition over time. The O&M Manual shall indicate the required maintenance elevations of fifty percent (50%) of the forebay and permanent pool capacity and that the marker be replaced if missing or damaged.
10. Sediment removal in forebay shall occur when fifty percent (50%) of the total capacity has been lost.
11. Rip-rap protection must be provided (or other suitable erosion control means) for the outlet and all inlet structures into the pond.
12. A wet stormwater pond is characterized by a permanent wet pool. The designer must evaluate both the soils and the hydrology of the site to ensure that the pond will maintain a permanent wet pool.
13. Anti-seep collars or filter diaphragms must be provided for the barrel of principal spillway.
14. If reinforced concrete pipe is used for the principal spillway, O-ring gaskets (ASTM C361) shall be used to create watertight joints.
15. Provide a one (1) foot minimum freeboard above the maximum anticipated flow depth through the emergency spillway.
16. Emergency spillway shall be designed to pass one and one quarter (1.25) times the peak *inlet* flow rate and peak flow velocity from the 100-year (1% AEP) storm event for the entire contributing drainage area (unless bypassed), assuming post-development conditions (see Section 302.10 of this Manual).
17. Provide trash racks, filters, hoods or other debris control at the outlet structure to meet the floatable capture requirements.
18. The principal spillway/riser system must incorporate anti-floatation, anti-vortex, and/or trash-rack designs.
19. To prevent drawdown of the permanent pool, an impervious soil boundary may be needed.
20. Construction debris cannot be disposed of within the facility or used as fill in the embankment.
21. If the pond is used as a sediment control measure during active construction, the performance sureties will not be released until sediment has been cleaned out of the pond and elevations and grades have been reestablished as noted in the approved stormwater management plan for post-construction runoff control.
22. Tall plantings in the aquatic bench are desirable as a means to deter waterfowl from the site. Waterfowl are bacteria sources and are to be discouraged from inhabiting wet ponds. Long, narrow, irregularly shaped ponds with tall plantings are encouraged in order to minimize attractiveness of the pond to waterfowl.

Variations

1. **Multiple pond systems**: Multiple pond systems consist of constructed facilities that provide water quality and quantity volume storage in two or more cells. The additional cells can create longer pollutant removal pathways and improved downstream protection.

Maintenance

Each BMP must have an operations and maintenance plan submitted to the City for approval and maintained by the current BMP owner. Refer to Section 102.06 of this Manual for a checklist for routine operation, inspection and maintenance requirements for the current BMP owner. The current BMP owner is responsible for the cost of maintenance and annual inspections.

702.03 Stormwater Wetlands

Stormwater wetlands are artificial wetlands created for the purposes of stormwater pollutant removal and quantity control. The designer shall provide sufficient information in the construction documents to show compliance with this Manual, including but not limited to, plans, sections, easements, grading, wet pool elevation, 10- and 100-year (10% and 1% AEP) pool elevations, spillway elevation, vegetation specifications, planting specifications, scour

protection and details such as the outlet structure, forebay sediment marker detail, forebay hardened bottom detail and anti-seep collar detail.

Site and Design Considerations

Prior to stormwater management plan approval, the following design and site considerations must be followed:

1. A water balance must be performed to demonstrate that a stormwater wetland could withstand a thirty (30) day drought at summer evaporation rates without completely drawing down. Also, inflow of water must be greater than that leaving the basin by infiltration or exfiltration. The following water balance equation should be used in calculations:

$$S = Q_i + R + Inf + Q_o - ET \qquad \text{(Equation 701.02)}$$

Where:

S = net change in storage
Q_i = stormwater runoff inflow
R = contribution from rainfall
Inf = net infiltration (infiltration – exfiltration)
Q_o = surface outflow
ET = evapotranspiration

2. The wetland must be designed for a minimum extended detention time of forty-eight (48) hours for the WQ_v (Equation 701.01). Orifices shall be protected against blockage from plant material with non-corrodible wire mesh, stone-protected filter fabric or similar measure.
3. The outlet control structure shall have a minimum two (2) inch orifice.
4. The frequently flooded zone surrounding the wetland must be located within the permanent twenty (20) foot easement.
5. The surface area of the wetland must account for a minimum of one percent (1%) of the area of the watershed draining into it (1.5 percent (1.5%) for a shallow marsh design). The length to width ration must be at least two to one (2:1) to incorporate long flow paths through the wetland.
6. A forebay shall be established at the pond inflow points to capture larger sediments and be four to six feet (4'-6') deep. The forebay area shall contain approximately ten percent (10%) of the water quality. Direct maintenance access to the forebay must be provided with access twenty (20) feet wide minimum and five to one (5:1) slope maximum. Permanent sediment depth markers must be provided. Exit velocities from the forebay must be non-erosive and documented with calculations. The bottom of the forebay shall be hardened (e.g., using concrete, paver blocks or similar) to make sediment removal easier.
7. If high water velocity is a potential problem, an energy dissipation device must be installed.
8. Site preparation: Soil types conducive to wetland vegetation shall be used. A list of hydric soils, developed by the NRCS, can be found on the NRCS website. The wetland must be designed to allow slow percolation of the runoff through the substrate (add a layer of clay for porous substrates).
9. Planting: The designer must maximize use of existing- and post-grading pondscaping design to create both horizontal and vertical diversity and habitat. A minimum of two (2) aggressive wetland species of vegetation shall be established in quantity on the wetland. Three (3) additional wetland species of vegetation shall be planted on the wetland, although in far less numbers than the two (2) primary species. Thirty to fifty percent (30%-50%) of the shallow (twelve (12) inches or less) area of the basin shall be planted with wetland vegetation. Approximately fifty (50) individuals of each secondary species must be planted per acre; set out in ten (10) clumps of approximately five (5) individuals and planted within six (6) feet of the edge of the pond in the shallow area leading up to the ponds edge; spaced as far apart as possible, but no need to segregate species to different areas of the wetland. Wetland mulch, if used, shall be spread over the high marsh area and adjacent wet zones to mulch depths of three to six inches (3"-6"). A minimum twenty-five (25) foot buffer, for all but pocket wetlands, must be established and planted with riparian and upland vegetation. In addition, the wetland must be located within a twenty (20) foot wide easement.

10. Neither the wetland area nor sediment forebay shall be used as a sediment control measure during active construction.
11. Surrounding slopes must be stabilized by plantings to aid in trapping pollutants and preventing them from entering the wetland.
12. The O&M Manual shall include inspection and maintenance requirement to prevent loss of the area of ponded water available for emergent vegetation due to sedimentation and/or accumulation of plant material.
13. Long, narrow, irregularly shaped micropools with tall plantings along the perimeter are encouraged in order to minimize attractiveness of the facility to waterfowl.
14. Construction debris cannot be disposed of in the facility or used as fill in the embankment.
15. Stormwater wetlands must be designed with the recommended proportion of depths noted in Table 702-03 (below). The four basic depths and descriptions are:
    Deepwater: one and a half (1.5) feet or more below normal pool elevation. Includes the outlet micropool and deep-water channels through the wetland. This zone supports little emergent wetland vegetation but may support floating or submerged vegetation.
    Low marsh: Six to eighteen inches (6”-18”) below normal pool elevation or water surface elevation. This zone is suitable for the growth of several emergent wetland species.
    High marsh: Six (6) inches or less below normal pool elevation. This zone will support a greater density and diversity of wetland vegetation than the low marsh. The high marsh area shall have a greater surface area to volume ratio than the low marsh area.
    Semi-wet zone: Areas above normal pool elevation inundated by larger storm events. This area supports vegetation that can survive periodic flooding.

TABLE 702-02: Minimum Required Design Configuration for Stormwater Wetlands

Design Criteria	Shallow Wetland	Pond/Wetland	Pocket Wetland
Length to width ratio (min)	2:1	2:1	2:1
Allocation of WQ_v (pool/marsh) in %	25/75	70/30 (includes pond volume)	25/70
Allocation of surface area (deepwater/low marsh/high marsh/semi-wet) in %	20/35/40/5	45/25/25/5 (includes pond surface area)	10/45/40/5
Forebay	Required	Required	Required
Micropool	Required	Required	Required

Outlet configuration	Reverse-slope pipe or hooded broad crest weir	Reverse-slope pipe or hooded broad crest weir	Hooded broad crest weir

Modified from Massachusetts DEP, 1997; Schueler, 1992

Operation and Maintenance Recommendations
Each BMP must have an operations and maintenance plan submitted to the City for approval and maintained by the BMP owner. Refer to Section 102.06 of this Manual for a checklist for routine operation, inspection and maintenance requirements for the BMP owner.

702.04 Bioretention

Bioretention, including micro-bioretention and rain garden areas, are structural stormwater controls that capture and temporarily store the WQ_v using soils and vegetation in landscaped areas to remove pollutants from stormwater runoff.

Bioretention areas are designed for intermittent flow and to drain and aerate between rainfall events. Sites with continuous flow from groundwater, sump pumps or other areas must be avoided.

Bioretention facilities can provide a limited amount of water quantity control, with the storage provided by the facility included in the design of any downstream detention structures.

When designed according to the guidance below, the contributing impervious area may be subtracted from total impervious cover when calculating WQ_v. Post development CN's for areas served by rain gardens may be assumed to be "open space in good condition" when computing WQ_v.

Bioretention areas shall have all of the following features:
- Pretreatment
- Flow entrance/inlet
- Surface storage
- Organic layer
- Planting soil mix
- Vegetation
- Aggregate infiltrative layer
- Perforated pipe underdrain system
- Positive overflow
- Inspection and maintenance access

The designer shall provide sufficient information in the construction documents to show compliance with this Manual, including but not limited to, plans, sections, easements, grading, 10- and 100-year (10% and 1% AEP) pool elevations, spillway elevation, vegetation specifications, planting specifications, soil specifications, scour protection and details such as the outlet structure, forebay sediment marker detail, forebay hardened bottom detail and anti-seep collar detail.

Pretreatment
Pretreatment is required, such as a forebay or grass filter strip, between the contributing drainage area and the

ponding area. Pretreatment shall be designed to trap sediment and trash prior to entering the ponding area. The pretreatment area shall dissipate energy that results in non-erosive flows through the organic layer and system. Velocities entering the organic layer shall be less than or equal to one and a half (1.5) ft/s.

Flow entrance/inlet
It is recommended that runoff is conveyed to the bioretention area(s) via sheet flow over a vegetated or gravel filter level spreader strip.

Surface storage
The maximum ponding depth in bioretention areas shall be 24 inches and shall be sized to contain the WQ_v. The bioretention facility shall be capable of providing safe overflow capacity for the 100-year (1% AEP) storm event.

Organic layer
The organic layer shall be two to four inches (2"-4") of organic material such as fine shredded hardwood mulch or shredded hardwood chips.

Planting soil mix
The planting soil filter bed is sized using a Darcy's Law equation with a filter bed drain time of forty-eight (48) hours maximum and a coefficient of permeability (k) of one half (0.5) ft/day. The planting soil bed must be at least two (2) feet deep. The soil must have an infiltration rate of at least one half (0.5) inches per hour and a pH between five and one half (5.5) and six and one half (6.5). Planting soils must be sandy loam, loamy sand or loam texture with a clay content rating from ten to twenty-five percent (10%-25%), one and a half to three percent (1.5%-3%) organic content and a maximum five hundred (500) ppm concentration of soluble salts.

Vegetation
Vegetation shall be appropriate for bioretention areas and be adaptable to periodic hydric inundation. Vegetation shall be native to Indiana, appropriate for the local hardiness zone and tolerant of hydric soil conditions. Vegetation shall not be invasive pursuant to Section 701.07 of this Manual.

Aggregate infiltrative layer
Gravel for the underdrain system shall be clean, washed, and free of fines. The depth from the bottom of the bioretention facility to the documented seasonally high-water table must be a minimum of two (2) feet. The seasonal high-water table must be field determined by a soil scientist or geotechnical investigation. The aggregate infiltrative layer shall be sumped a minimum of six (6) inches below the bottom of the underdrain.

Perforated Pipe Underdrain System
A perforated pipe underdrain system is required unless the base soils have an infiltration rate of greater than one inch per hour (>1"/hour). Infiltration may not be permitted in the Wellfield Protection Secondary Zoning District or locations with high water tables, contaminated soils, leaking basements, etc. If no perforated pipe underdrain system is used, a geotechnical investigation, soil infiltration testing, and a hotspot investigation must be completed.

The perforated pipe underdrain system shall be a six (6) inch perforated pipe in an eight (8) inch gravel layer for private systems, or an eight (8) inch perforated pipe in a ten (10) inch gravel layer for systems in the Right-of-Way. The pipe must have three eighths (3/8) inch perforations, spaced on six (6) inch centers with a minimum of four (4) holes per row, or equivalent. The pipes shall be spaced at a maximum of ten (10) feet on center, and a minimum grade of one half of one percent (0.5%) must be maintained. A permeable filter fabric or a gravel lens (3/4-1/4 inch, crushed rock two to three (2-3) inches deep), is placed between the gravel layer and the planting soil bed. The upstream ends of the underdrain pipe should be capped with a cleanout provided.

Positive overflow
The ponding area shall have an inflow diversion or an overflow structure to carry flows greater than designed hydrologic capacity. An overflow structure and a non-erosive overflow channel shall be provided to safely pass the

flow from the bioretention area that exceeds the storage capacity to a stabilized downstream area.

Inspection and maintenance access
The system, including the underdrain system shall be accessible to inspection and maintenance activities. Underdrains shall have inspection and maintenance port(s), at minimum, at the outlet.

Site and Design Considerations
The following design and site considerations must be incorporated:

1. Slope of the site can be no more than six percent (6%).
2. All components of the BMP shall be located within a twenty (20) foot easement. Twenty (20) foot wide access to the BMP must be located within the easement.
3. The bioretention area shall not be used as a sediment control measure during active construction. The contributing drainage area shall be stable before runoff can be diverted into the facility.
4. Bioretention practices shall be located down gradient and setback at least ten (10) feet from structures. Bioretention located adjacent to structures shall include an impermeable liner and shall require a variance.
5. Bioretention practices shall be located at least thirty (30) feet from water supply wells and twenty-five (25) feet from septic systems. If designed to infiltrate, then the practice shall be located at least fifty (50) feet from confined water supply wells and one hundred (100) feet from unconfined water supply wells.

Maintenance
Each BMP must have an operations and maintenance plan submitted to the City for approval and maintained by the current BMP owner. Refer to Section 102.06 of this Manual for a checklist for routine operation, inspection and maintenance requirements for the current BMP owner. The current BMP owner is responsible for the cost of maintenance and annual inspections.

702.05 Sand Filters

Sand filters are structural stormwater controls that temporarily store stormwater and pass it through a filter bed of sand. Sand filter systems shall contain a minimum of two (2) chambers. The first chamber is a sedimentation chamber that removes floatables and heavy sediments. The second and subsequent chambers are the filtration chambers, which remove additional pollutants by filtering the runoff through a sand bed. The filtered runoff is typically collected and returned to the conveyance system, though it can be partially or fully exfiltrated into the surrounding soil in areas with porous soils.

Sand filters are primarily designed as off-line structures for stormwater quality and typically need to be used in conjunction with another structural BMP to provide water quantity control.

The designer shall provide sufficient information in the construction documents to show compliance with this Manual, including but not limited to, plans, sections, easements, grading, soil specifications, scour protection and details.

Site and Design Considerations
1. The maximum effective drainage area to an individual stormwater filtering system is less than ten (10) acres.
2. The design volume must be based on the WQ_v (Equation 701.01) and must be designed to fully empty in thirty-six (36) hours.
3. Adequate pretreatment is required in the first chamber to prevent sediment from overloading the filters. The inlet structure to the filtration chamber must be designed to spread the flow uniformly across the surface of the filter media. Stone riprap or other dissipation devices must be installed to prevent gouging of the sand media and to promote uniform flow.
4. The allowable minimum head is one (1) foot. The maximum allowable head is six (6) feet.

5. Sand bed shall be a minimum depth of eighteen (18) inches.
6. Underdrain pipes must consist of main collector pipes and perforated lateral branch pipes. Reinforce the underdrain piping to withstand the weight of the overburden. Internal diameters of lateral branch pipes must be six (6) inches or greater (eight (8) inches preferred) and perforations should be one eighth (1/8) inch. Space perforations a maximum of six (6) inches between rows. All piping must be schedule forty (40_ polyvinyl chloride or greater strength or similarly rated HDPE pipe. The minimum grade of piping should be one eighth (1/8) inch per foot (one percent (1%) slope). Provide access for cleaning all underdrain piping.
7. Surface filters may have a grass cover to aid in pollution adsorption.
8. Establish vegetation over the contributing drainage areas before runoff can be accepted into the facility.

Two allowable surface sand bed filter configurations are:

a. Sand Bed with Gravel Layer

1) Top layer of sand must be a minimum of eighteen (18) inches of two one hundredths to four one hundredths (0.02 - 0.04) inch diameter sand or smaller.
2) A layer of one-half to two inch (1/2”-2”) diameter gravel under the sand must be provided for a minimum of two (2) inches of cover over the top of the under-drain lateral pipes.
3) No gravel is required under the lateral pipes.
4) A layer of geotextile fabric must separate the sand and gravel.

b. *Sand Bed with Trench Design*

1) Top layer of sand is to be twelve to eighteen inches (12”-18”) of two one hundredths to four one hundredths (0.02 - 0.04) inch diameter sand or smaller.
2) Laterals to be placed in trenches with a covering of one-half to two inch (1/2”-2”) gravel and geotextile fabric.
3) The lateral pipes are to be underlain by a layer of drainage matting.
4) A maximum spacing of ten (10) feet between lateral underdrain pipes is recommended.

Allowable Sand Filter Variations

There are two primary sand filter system designs, the surface sand filter and the perimeter sand filter.

1. **Surface Sand Filter** - The surface sand filter is a ground-level open-air structure that consists of a pretreatment sediment forebay and a filter bed chamber. This system can treat drainage areas up to ten (10) acres in size and is typically located off-line. Surface sand filters can be designed as an excavation with an earthen embankment or as a concrete structure.
2. **Perimeter Sand Filter** - The perimeter sand filter is an enclosed filter system typically constructed just below grade in a vault along the edge of an impervious area such as a parking lot. The system consists of a sedimentation chamber and a sand bed filter. Runoff flows into the structure through a series of inlet grates located along the top of the control.

Maintenance

Each BMP must have an operations and maintenance plan submitted to BNS for approval and maintained by the current BMP owner. Refer to Section 102.06 of this Manual for a checklist for routine operation, inspection and maintenance requirements for the current BMP owner. The current BMP owner is responsible for the cost of maintenance and annual inspections.

702.06 Dry Water Quality Swales

Dry water quality swales are vegetated channels designed and constructed to capture and treat stormwater runoff within dry cells formed by check dams or other means. These swales are designed with a limited slope for slow, shallow flow to allow particulates to settle out and to promote infiltration. Dry water quality swales are limited to areas with low impervious acreage, such as residential l developments.

Dry water quality swales are channels designed with a filter bed and underdrain system. They are designed to filter

and infiltrate the entire WQ_v (Equation 702.01) through the bottom of the swale. Runoff is collected by a perforated pipe and discharged at the outlet. Water quality swales are dry most of the time and are therefore well suited for residential areas.

The designer shall provide sufficient information in the construction documents to show compliance with this Manual, including but not limited to, plans, sections, easements, grading, vegetation specifications, planting specifications, soil specifications, scour protection and details.

Site and Design Considerations

The following site and design criteria must be followed:

1. Dry water quality swales treat only the WQ_v. An additional measure is needed to provide detention in conjunction with the water quality swale. The swales can be designed as on-line or off-line structures. Larger storms shall pass non-erosively through the channels.
2. Dry water quality swales are limited to peak discharges generally less than five to ten (5-10) cfs and runoff velocities less than two and a half (2.5) ft/second for all storm design events. The maximum drainage area is five (5) acres. The maximum ponding time must be less than forty-eight (48) hours, and a minimum ponding time of thirty (30) minutes is recommended.
3. The maximum design flow depth is one (1) foot, for all storm events, with a ponding depth of eighteen (18) inches at the end of the channel.
4. Swale cross-section must have side slopes of three to one (3:1) (h:v) or less. Bottom widths must be between two to eight feet (2'-8') wide.
5. Underlying soils shall have a high permeability (fc > one-half (0.5) inches per hour). Seasonal high-water table must be greater than three (3) feet below the bottom of the swale. The seasonal high-water table must be determined by a practicing soil scientist or geotechnical investigation.
6. Water quality swales must have a minimum length of one hundred (100) feet.
7. Provide a sediment forebay at the inlet to the swales.
8. The underdrain must have a minimum of two (2) feet of planting soil above the crown.
9. The underdrain minimum internal diameter is six (6) inches for private systems, and eight (8) inches in the Right-of-Way.
10. Locate the swale and all of its components within a drainage twenty (20) foot easement. The easement should include twenty (20) foot wide access drive to the BMP.

Maintenance

Each BMP must have an operations and maintenance plan submitted to the City for approval and maintained by the current BMP owner. Refer to Section 102.06 of this Manual for a checklist for routine operation, inspection and maintenance requirements for the current BMP owner. The current BMP owner is responsible for the cost of maintenance and annual inspections.

702.07 Biofilters

Biofilters are densely vegetated sections of land, designed to treat runoff from and remove pollutants through vegetative filtering and infiltration. Biofilters must receive runoff from adjacent areas as sheet flow. The vegetation slows the runoff and filters out sediment and other pollutants. However, the TSS removal provided is less than eighty percent (80%). Therefore, biofilters must be used in a treatment train in conjunction with other management practices to provide the eighty percent (80%) performance goal.

The designer shall provide sufficient information in the construction documents to show compliance with this Manual, including but not limited to, plans, sections, easements, grading, vegetation specifications, planting specifications, soil specifications, scour protection and details.

Allowable Biofilter Variations

1. Filter strip: A filter strip is a uniformly graded and densely vegetated strip of land. The vegetation can be

grasses or a combination of grass and woody plants. Pollutant removal efficiencies are based upon a fifty (50) foot wide strip. Uniform sheet flow must be maintained through the filter strip to provide pollutant reduction and to avoid erosion.

2. Riparian buffer: A riparian buffer is a strip of land with natural, woody vegetation along a stream or other watercourse. Besides the undergrowth of grasses and herbaceous vegetation, the riparian buffer includes deep rooted trees. The twenty (20) foot zone closest to the stream or watercourse (Zone 1) contains the trees, while the outer thirty (30) feet of the riparian buffer contains a dense stand of grasses. Uniform sheet flow must be maintained through the filter strip to provide pollutant reduction and to avoid erosion.

Site and Drainage Considerations

The following site and drainage considerations must be included in the BMP plan:

1. To ensure sheet flow into the filter strips and riparian buffers, flow spreaders or level spreaders must be designed and installed where concentrated runoff flows into filter strips or riparian buffers.
2. Level Spreader: The grade of a level spreader shall be zero percent (0%). The channel grade for the last twenty (20) feet of the dike or diversion entering the level spreader must be less than or equal to one percent (1%) and designed to provide a smooth transition into the spreader. The depth of a level spreader as measured from the lip must be at least six (6) inches. The level spreader lip must be constructed on undisturbed soil (not fill material) to uniform height and zero (0) grade over length of the spreader. The maximum drainage area to the level spreader shall be ten (10) acres or less with the optimal size being less than five (5) acres. The maximum flow into the level spreader must be thirty (30) cfs or less.
3. Appropriate length, width, and depth of level spreaders shall be selected from the Table 702-03.

TABLE 702-03: Level Spreader Sizing Criteria

Design Flow (cfs)	Entrance Width (ft)	Depth (ft)	End Width (ft)	Length (ft)
0-10	10	0.5	3	10
10-20	16	0.6	3	20
20-30	24	0.7	3	30

4. Capacity of the spreader, filter strip and riparian buffer length (perpendicular to flow) must be determined by estimating the volume of flow that is diverted to the spreader for water quality control.
5. The released runoff to the outlet must be on undisturbed stabilized areas in sheet flow and not allowed to re-concentrate below the structure.
6. Slope of the biofilter from a level spreader must not exceed ten percent (10%).
7. All disturbed areas must be stable prior to flow passing through the biofilter.
8. The minimum biofilter width is fifty (50) feet.
9. Filter strips must be designed for slopes between two to six percent (2%-6%).
10. Ensure that flows in excess of design flow move across and around the filter strip without damaging it.
11. Filter strips can be used effectively as pretreatment measures. The minimum sizing criteria are in Table 702-04.

TABLE 702-04: Filter Strip Sizing Criteria

Parameters	Impervious Area				Pervious Area (lawns, etc.)			
Maximum inflow approach length (ft)	35		75		75		100	
Filter strip slope (max = 6%)	<2%	>2%	<2%	>2%	<2%	>2%	<2%	>2%
Filter strip minimum length (ft)	10	15	20	25	10	12	15	18

Source: Claytor and Schueler, 1996

12. The use of riparian buffers is limited to drainage areas of ten (10) acres or less with the optimal size being less than five (5) acres.
13. Top edge of buffer must directly abut the contributing impervious area and follow the same elevation contour line.
14. Biofilters and level spreaders must be located within a twenty (20) foot drainage easement.

Maintenance

Each BMP must have an operations and maintenance plan submitted to BNS for approval and maintained by the current BMP owner. Refer to Section 102.06 of this Manual for a checklist for routine operation, inspection and maintenance requirements for the current BMP owner. The current BMP owner is responsible for the cost of maintenance and inspections based on the frequency outlined in the approved operations and maintenance manual.

Section 703. Proprietary Structural Best Management Practices

A list of structural BMPs that can be used in Indianapolis for water quality control can be found at Public Works Specifications and Manuals and search for "approved SQU Selection Table."