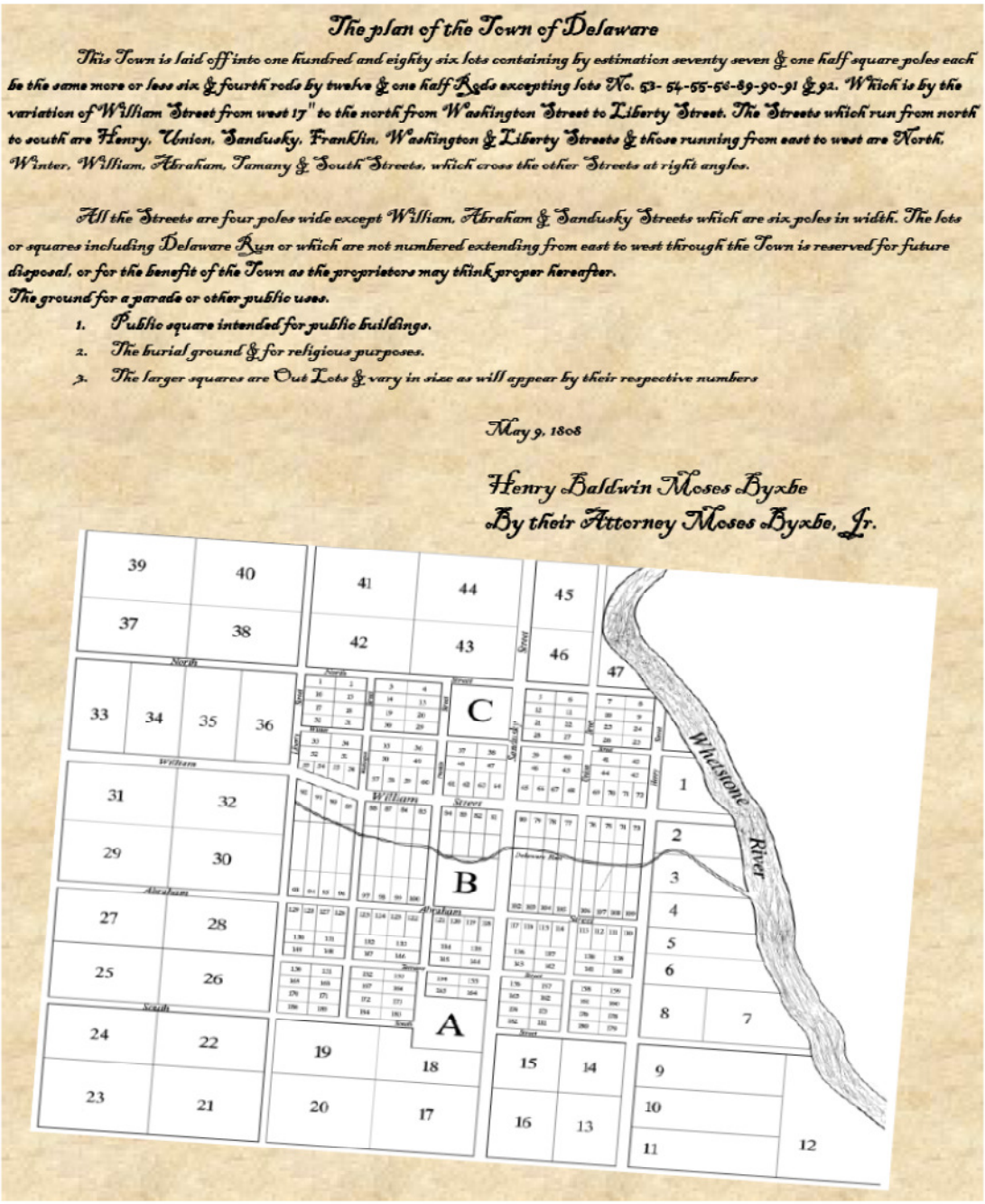
City of Delaware, Ohio
Infrastructure Design Guide
for
Land Development Activities



The plan of the Town of Delaware

This Town is laid off into one hundred and eighty six lots containing by estimation seventy seven & one half square poles each be the same more or less six & fourth rods by twelve & one half Rods excepting lots No. 53- 54-55-56-89-90-91 & 92. Which is by the variation of William Street from west 17" to the north from Washington Street to Liberty Street. The Streets which run from north to south are Henry, Union, Sandusky, Franklin, Washington & Liberty Streets & those running from east to west are North, Winter, William, Abraham, Tamany & South Streets, which cross the other Streets at right angles.

All the Streets are four poles wide except William, Abraham & Sandusky Streets which are six poles in width. The lots or squares including Delaware Run or which are not numbered extending from east to west through the Town is reserved for future disposal, or for the benefit of the Town as the proprietors may think proper hereafter.

The ground for a parade or other public uses.

1. Public square intended for public buildings.
2. The burial ground & for religious purposes.
3. The larger squares are Out Lots & vary in size as will appear by their respective numbers

May 9, 1808

Henry Baldwin Moses Byxbe
By their Attorney Moses Byxbe, Jr.

Infrastructure Design Guide

Chapter Index

I. Introduction & Adoption
II. Abbreviations
III. Engineering Plan Review Process
IV. Engineering Plan Format & Content
V. Record Plan and Digital Submissions
VI. Survey Standards
VII. Roadway Design
VIII. Traffic Impact Study Standards
IX. Access Management Guidelines
X. Traffic Calming Guidelines
XI. Traffic Signals
XII. Street Lighting
XIII. Fiber Optic Conduit and Cable
XIV. Street Tree Planting
XV. Stormwater Management
XVI. Stormwater Quality Regulations
XVII. Stormwater Pollution Prevention Plan (SW3P) Requirements
XVIII. Water and Sewer Service Policy
XIX. Water Distribution Design
XX. Sanitary Sewer Design

Appendixes

Chapter 1: Introduction & Adoption

Since the early 1990's, the City of Delaware has experienced significant growth in residential, commercial and industrial development activities, at levels never before experienced in the community. In order to properly manage the growth, and more specifically, the design and construction of miles of new roadway, water lines, and sanitary sewer and storm lines, it became necessary to increase the number of city staff dedicated to reviewing and overseeing such development activity, and to adopt more comprehensive design and construction regulations. The combination of improved staffing levels and better regulations has provided the necessary basis by which the city can ensure the adequacy and acceptability of the substantial expansion in public infrastructure being constructed.

More recently, an effort has been undertaken to publish the multiple engineering design and plan development policies, regulations, standards, and specifications implemented during the high growth period within a single document that is readily accessible to developers, contractors, and consultants. In doing so, the process of planning and designing the infrastructure for future development projects will be more efficient as the most current regulations governing such activities will be readily available and accessible to the development team through the Infrastructure Design Guide. The effort to include all design regulations in a single volume necessitated a thorough review of existing city code as well as the many practices and policies of other city departments in order to update and organize the information into a practical design manual. The Guide incorporates not only city policy, but also the most applicable regulations of other agencies, such as the Ohio Environmental Protection Agency (OEPA), Ohio Department of Transportation (ODOT), and Federal Aviation Authority (FAA) as it applies to development activity within the City of Delaware. Understanding that many regulations are subject to modification throughout a given period, updates to the Infrastructure Design Guide will be prepared and made available as required.

This Guide is not intended to be a design textbook. It assumes that the user has an understanding of the engineering concepts utilized here in. This manual provides a uniform design procedure for summarizing and submitting plans in an acceptable and understandable manner. It does not provide uniform solution to all engineering problems. The manual provides sufficient information to develop engineering systems in accordance with City of Delaware policy if paired with sound engineering judgment from a registered Professional Engineer licensed in the State of Ohio and in responsible charge of the design.

Section 903.01 of the City of Delaware Codified Ordinances states:

"The City Manager shall have the authority to adopt and periodically update standard construction specifications and regulations for all public improvements and connections thereto, and all developments in the City or under City jurisdiction. Such standards and any order of the City Manager issued in connection therewith shall have the same force and effect as duly enacted legislation".

Chapter 2: Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADF	Average Daily Flow
ADT	Average Daily Traffic
ANSI	American National Standards Institute
API	Acceptance of Public Improvements
ASSE	American Society of Safety Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
AWWA	American Water Works Association
BMP	Best Management Practice
CAD	Computer Aided Drafting
CBR	California Bearing Ratio
CGB	Compacted Granular Backfill
CGP	Construction General Permit
CLOMR	Conditional Letter of Map Revision
CMS	Construction Material Specifications
COC	City of Columbus
COD	City of Delaware
CWA	Clean Water Act
DelCo	DelCo Water Company, Inc.
DES	Department of Engineering Services
DIP	Ductile Iron Pipe
DXF	Drawing Interchange Format or Drawing Exchange Format
EDU	Equivalent Dwelling Unit
EGL	Energy Grade Line
EOR	Engineer of Record
EOS	End of Service
ESAL	Equivalent Single Axle Loads
FAA	Federal Aviation Administration
FBFM	Flood Boundary Floodway Map
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Association
FIS	Flood Insurance Study
GIS	Graphical Information System
HCS	Highway Capacity Software
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
HSG	Hydrologic Soils Group
IES	Illuminative Electrical Society
ITE	Institute of Traffic Engineers
LED	Light Emitting Diode
LEO	Law Enforcement Officer
LOMR	Letter of Map Revision
LOS	Level of Service
MDF	Maximum Daily Flow
MORPC	Mid-Ohio Regional Planning Commission
MOT	Maintenance of Traffic
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer System
MUTCD	Manual of Uniform Traffic Control Devices
NAD 83	North American Datum of 1983
NAVD 29	North American Vertical Datum of 1929
NAVD 88	North American Vertical Datum of 1988
NEMA	National Electrical Manufacturers Association
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent

NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
OMUTCD	Ohio Manual of Uniform Traffic Control Devices
ORC	Ohio Revised Code
OUPS	Ohio Utilities Protection Service
PDF	Portable Document Format
PFR	Project Finance Report
PO	Purchas Order
PSWMR	Preliminary Stormwater Management Report
PTI	Permit to Install
PTOE	Professional Traffic Operations Engineer
PVC	Polyvinyl chloride
RCC	Roller Compacted Concrete
RCN	Runoff Curve Number
RCP	Reinforced Concrete Pipe
RFI	Request for Information
RFP	Request for Proposal
RFQ	Request for Qualifications
ROW	Right of Way (R/W)
RPR	Resident Project Representatives
SAS	Sanitary Sewer
SDR	Standard Dimension Ratio (a pressure rating for pvc pipe)
SCS	Soil Conservation Service
SFHA	Special Flood Hazard Area
SOQ	Statement of Qualifications
SSV	Soil Support Value
SWP3	Storm Water Pollution Prevention Plan
TEM	Traffic Engineering Manual (ODOT)
TRB	Transportation Research Board
TIFF	Tagged Image File Format
TIS	Traffic Impact Study
WSDS	Water Supply Data Sheet

Chapter 3: Engineering Plan Review Process

1. General

A. All proposed developments in the City of Delaware are subject to review by the Department of Engineering Services to verify conformance to current City design and construction standards, specifications, and regulations. The information contained herein is updated per the revision date on the cover, and should be considered to supersede all previous communications, documents, etc. This document should, however, be construed as supplemental to the Codified Ordinances of the City of Delaware.

B. All information is to be submitted to the City of Delaware, Department of Engineering Services, Attention: Assistant City Engineer. In some cases, a particular set of engineering plans may be reviewed by an engineering consultant review agency. In this event, an additional set of construction drawings, as outlined in the Submission Requirements section, is to be submitted.

C. It is the City's goal to review and comment on complete sets of construction documents in accordance with Table 1 from date of submittal. If the documents are deemed incomplete, the applicant shall be notified in writing and shall have an opportunity to correct the deficiencies and resubmit the required plans for review. The city will not review partial plan submissions. All plans, calculations, and reports are to be signed and sealed by an engineer licensed in the State of Ohio. Each submittal shall be signed and sealed. Un-signed and un-sealed plans or documents will be deemed incomplete and may be returned to the design engineer without being reviewed. Plans are reviewed in the order received and pending workload, in general accordance with the following table:

Table 1-1: Review Times

Document		Submission		Review Time
Preliminary Technical Review		First Submission		2 weeks
Engineering Plans		First Submission		4 weeks
Engineering Plans		Subsequent Submissions		2 weeks
Stormwater Management Plans		Each Submission		2 weeks
Traffic Impact Study		Each Submission		2 weeks
Water Model		Each Submission		2 weeks
SWP3		Each Submission		2 weeks
Plan Revisions		Each Submission		1 weeks

D. If a Traffic Impact Study or Preliminary Stormwater Management Plan is required for the project, they shall be approved before the acceptance of final engineering plans will be accepted for review. After review of the submission by the Department of Engineering Services or consultant review agency, the plan submitter will receive a set of written review comments specifying required plan changes, modifications, or additional information. A subsequent submission is required to confirm that required

changes have been made. Each subsequent submission must be accompanied by a written item by item response to all comments. Comments that are ignored or "explained away" will cause the submission to be deemed incomplete and be returned to the design engineer. Questions regarding review comments are to be directed to the Assistant City Engineer and will be addressed in a timely manner consistent with department workload. Once a engineering plan is approved, a mylar copy of the title sheet must be submitted for appropriate city official signatures sized accordingly, ANSI D (22" x 34").The signature routing process takes approximately two (2) weeks from receipt of the mylar.

2. Department of Engineering Services Address

City of Delaware, Department of Engineering Services
20 East William Street
Delaware, Ohio 43015
Phone: 740-203-1700
Fax: 740-203-1749
www.delawareohio.net/departments/Engineering

3. Plan Review Fees

City of Delaware Codified Ordinance 04-196 establishes that the Department of Engineering Services shall collect plan review and construction inspection fees for the cost associated in providing these services. Fees are calculated per the current version of the Development Project Engineering Fee Calculation Sheet (See Appendix), due at the time an engineering plan is submitted for review and approval by the City, and are non-refundable.

4. Limitations on Plan Approval

Significant construction of improvements must commence within three (3) years of final engineering plan approval. Engineering Plan approval shall expire if the improvements have not commenced in this time frame and the plans must be resubmitted for approval with all relevant fees. Furthermore, the resubmitted plans shall be updated to the most current City of Delaware design standards. Simply resubmitting previously approved plans will not suffice.

5. Submission Requirements

A. The initial submission of an engineering plan for review must contain the items denoted below. Incomplete submittals will not be reviewed until all required materials have been received by the Department of Engineering Services.
   1. A signed and sealed traffic impact analysis. The City can issue a Letter of Waiver if it is determined that a traffic study is not warranted due to site-specific conditions. This waiver must be requested in writing by the design engineer.
   2. Two (2) sets of the signed and sealed Storm Water Management Plan (including all calculations) based on the requirements set forth in this manual.
   3. Two (2) sets of signed and sealed domestic water supply hydraulic calculations (water model) demonstrating conformance to City's fire prevention regulations.
   4. Five (5) sets of signed and sealed plans as further detailed below, submitted on ANSI D bond paper.

5. Two (2) copies of signed and sealed storm sewer calculations including a tributary drainage map identifying all on and off-site areas tributary to each of the proposed storm sewer inlets. The tributary map shall be submitted on ANSI D bond paper.
6. Two (2) sets of signed and sealed sanitary sewer calculations. The sanitary tributary map is to be delineated on the title sheet of the plan set.
7. All plan review fees must be paid before the City will commence the review process.

B. Final Approval - The following items must be submitted before the project is approved and released for construction activities to begin. This list included herein is not intended to be all-inclusive. It is the responsibility of the designer to submit any additional agency approvals prior to the pre-construction meeting (ODOT, FAA, etc.)
   1. One (1) copy of Notice of Intent to Discharge Stormwater (NOI) application and OEPA response letter containing the OEPA tracking number for all developments greater than one (1) acre.
   2. One (1) copy of Permission to Install (PTI) public utilities application for projects extending all sanitary sewer utilities.
   3. One (1) copy of Water Supply Data Sheets (WSDS) and the OEPA Project Summary Sheets for projects extending all water supply utilities.
   4. Two (2) copies of the SWP3 plan including narrative, plan sheets, and erosion control details.

6. Procedures for Plan Revisions

A. The City of Delaware reserves the right to require any plan submitted for revision to be updated to the most current City of Delaware design standards. The City of Delaware reserves the right to perform a complete review of any plan submitted for revisions. Any errors or omissions not previously noted may be required to be corrected as a part of the revision process.

B. The following procedure is to be adhered to for all changes to the engineering plan set after the plans are approved. The purpose of the revision process is to account for unexpected field conditions and not for value engineering after the plan approval process. Value engineering is crucial, but it must be performed prior to final plan approval.

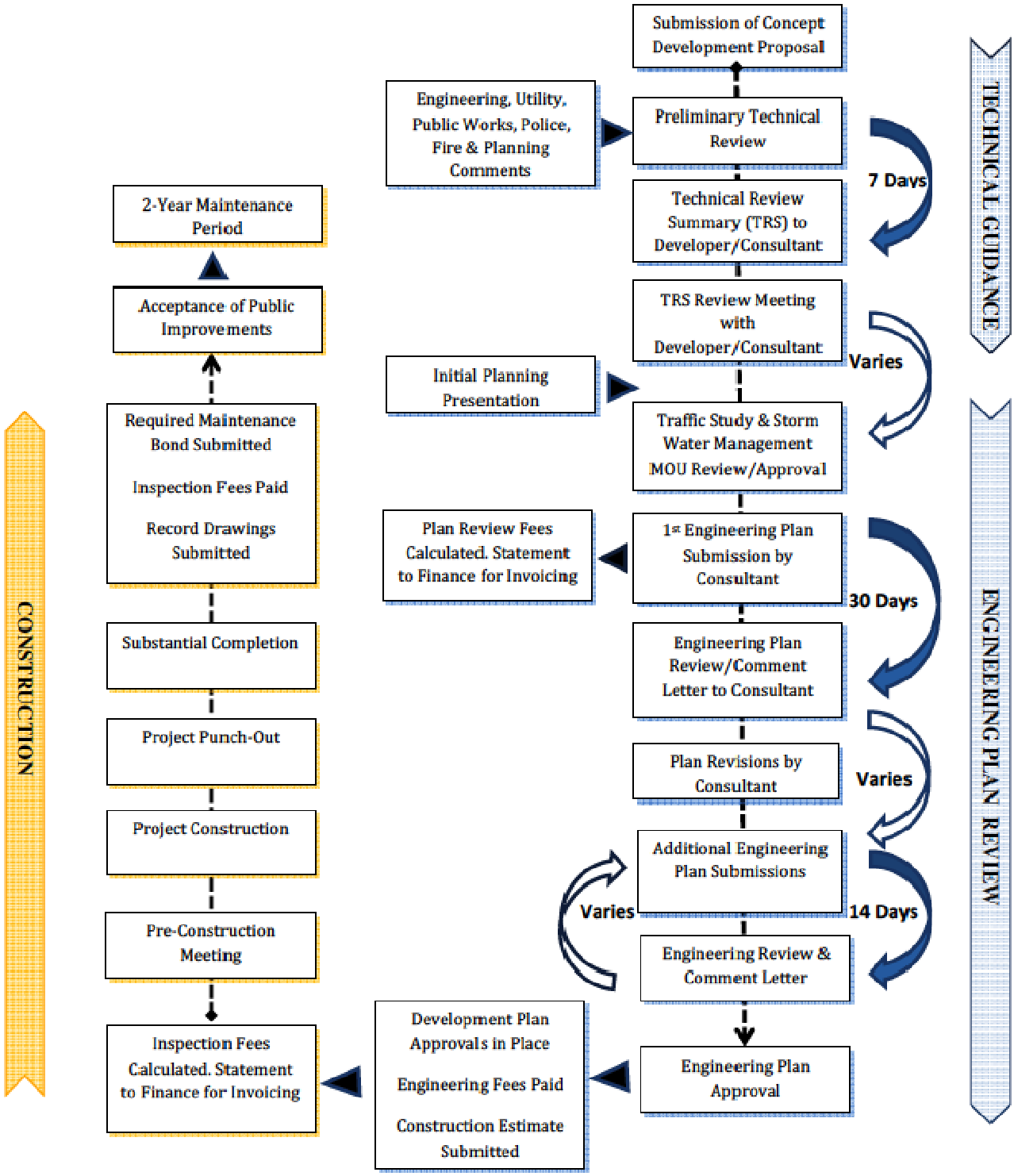
C. The engineer of record is to submit a draft of the requested changes with an accompanying written explanation to the Assistant City Engineer. The proposed changes shall be clearly indicated in red. Changes should be numbered both in the revision block on the title sheet, the sheet title block where the revision occurs, and on the plan sheet itself, in close proximity to where the revision is being shown. The change number shall be inscribed in a triangle to help distinguish it from surrounding figures.

D. A review fee, as specified in the fees section of this document shall be submitted before the Department of Engineering Services will review any proposed plan revisions

E. Upon approval of the plan revision, the mylar title sheet shall be marked with the change and submitted to the Assistant City Engineer for their approval.

F. The final step in the revision process is the submittal of one (1) complete, full sized copy of the revised plan set, three (3) full sized, and one (1) half sized copies of the revised sheets to the Department of Engineering Services. If the revision entails changes to more than 25% of the plan sheets, five (5) complete sets shall be submitted.

Figure 3-1: Engineering Plan Review Process



Chapter 4: Engineering Plan Format & Content

Engineering and construction plans shall be prepared and organized include the following information:

1. General, Sheet Information:
   A. All plan sheets must be ANSI D (22" x 34") bond paper. Oversized plan sheets will not be accepted.
   B. The minimum font size shall be 0.08.
   C. All drawings shall have the orientation of north, and lettering towards the top or to the right of the sheet.
   D. All plan sheets shall be titled and numbered with the Title Sheet being sheet No. 1.
   E. All sheets shall contain a horizontal and vertical graphical scale. Only engineering scales are permitted. Plans utilizing architectural scales will not be accepted and will be returned without being reviewed
   F. Plan sheets shall be drawn and plotted using computer aided drafting (CAD)
   G. North arrow
   H. Phasing lines with description
   I. Work limits shall be delineated
   J. Distinct separation between proposed and existing elements of the plan

2. Title Sheet: This sheet identifies the project and provides information for the project location. The title sheet shall have the following information:
   A. Project Name
   B. Location map (scale 1-in = 1000-ft), locating the project in the City's vicinity
   C. Site Index map (scale either 1-in = 100-ft or a maximum 1-in = 200-ft) showing:
   D. General site layout
   E. Centerlines and edges of pavement of all abutting streets
   F. Street names
   G. Municipal corporate boundaries
   H. Site boundaries with bearings and distances
   I. Identification of adjacent parcels, parcel number, property lines, and property owners
   J. Proposed and existing rights-of-way, property lines
   K. Project address
   L. Standard drawing list indicating applicable municipality or state agency
   M. Index of sheets
   N. OUPS contact information
   O. Benchmark list, referenced to NAVD 88
   P. Signature Approval block for City of Delaware staff
   Q. Signature, seal, date of signature, and registration number of the engineer of record.
   R. Plan release date
   S. City of Delaware standard revision block
   T. City of Delaware standard infrastructure ownership table
   U. Developer/Owner and design firm names, addresses, and telephone numbers
   V. Current utilities ownership and contact information list

3. General Notes Sheet

   The most current edition of City of Delaware standard notes for subdivision or commercial developments and special notes as required. These notes shall contain the Date of Issuance. No deletions or exceptions to the general notes shall be made. See Appendix.

4. Estimate of Quantities

   Estimate of Quantities are to be presented in tabular form using the City of Columbus Item Number or specifying otherwise. All phases must be clearly broken out in the quantity table and on all plan sheets. This table could be included on the General Note Sheet or a separate sheet along with other details. Placing this table on the title sheet is strongly discouraged. These quantities must contain, at a minimum:

   A. Lengths and sizes of all proposed utilities and their services
   B. Type and Class of all utility conduits
   C. Sidewalk and bikepath within public right-of-way
   D. All public and private roadway items.

5. Details Sheet

   The following details need to be provided on this sheet if they deviate from the COD standard detail. This sheet may also be used for any additional pertinent detail drawings needed to adequately describe the construction process.

   A. Entrance/approach details
   B. Typical pavement sections
   C. Show proposed curb
   D. Sidewalk

6. Site Demolition Plan

   This sheet shall be provided on an as-necessary basis to provide clarity for projects that will be removing existing buildings and structures. It may be combined with the Site Survey Plan at the discretion of the design engineer and with approval the Assistant City Engineer.

7. Site Survey Plan

   This sheet shall be provided all easements and boundary information as well as existing structures. It shall be provided on an as-necessary basis at the discretion of the City.

8. Site Dimension Plan

   The site dimension plans shall contain all information necessary for the establishment of the horizontal dimensions of the site including, but not limited to, the proposed building pad(s) location, pavement, setback, rights-of-way, property lines, easements, curb radii, sidewalks, and bike paths. Detailed site improvements such as on-site lighting, utility features, proposed landscaping, signs, grade spots and topographic contours must not be shown on the site dimension plan. This plan shall contain the following information with all appropriate elements clearly dimensioned and labeled:

   A. Site layout, to scale, showing existing/proposed buildings, structures, roads
   B. Driveway and parking areas
   C. Proposed and Existing Storm Water and Sanitary lines and structures
   D. Barricade locations
   E. Sidewalks

F. Light and power poles
G. Waterways
H. Detention/retention basins
I. Tree/vegetation limits
J. Clearing limits, property lines, utility easements,
K. All property lines, labeled with metes and bounds of the property
L. Identify all contiguous property owners
M. Label property size, subdivision name, and lot number (as applicable)
N. Label current zoning of the property and intended use of all proposed buildings
O. Show and label any FEMA designated floodway, 100-year floodplain ,or OEPA required setback (as applicable)
P. Note any required vehicular access restrictions to public streets
Q. Show and dimension any required emergency vehicle access
R. Show the intersection visibility triangle at all adjacent street intersections (refer to ODOT standards)
S. Show and label all existing and proposed rights-of-way, easements (including type), and no-build zones
T. Show and label centerline, edge of pavement and/or back of curb, and right-of-way of all adjacent public or private streets. Dimension the total width of the street (note EP – EP or BC – BC) and right-of-way (proposed and existing)
U. Dimension all pavement and parking lot areas and note where the dimensions are taken from (e.g. edge of pavement, face of curb, or back of curb). This should include the pavement width, radius returns of curbs, parking spaces, and aisle width
V. Label size, location, and type of all proposed sidewalks or bike paths including all ramps to be built on site or within the public right of way
W. Label location and proposed size of all dumpster enclosures and pads
X. Show and label all required front, side, and rear yard setbacks, including all building and pavement setbacks
Y. Show and label all proposed and/or existing ingress/egress, access, or cross access easement aisles, drives, or driveways

9. Composite Utility Plan

These sheets shall contain all information of the underground and above-ground utilities, easements, rights-of-way, and pipe alignments, including, but not limited to, storm sewer, sanitary sewer, waterline, field tiles, roof drains, gas lines, electric lines, fiber optic lines, cable lines, and associated services. This plan shall contain the following minimum information.

A. All existing (dashed) and proposed (solid) utilities including all field tiles and drainage ditches.
B. Size and type (water, sanitary, etc.) of proposed and existing utility services, mains, and tees.
C. Invert at proposed building and end of service elevations of sanitary services in tabular form
D. Proposed pad and finished floor elevations
E. Location of all fire hydrants, meters, valves, and related service taps
F. Gas lines, Utility Poles (including pole ownership)
G. Property Lines, Easements, and Right-of-ways

H. Bearing and Distance of storm and/or sanitary main lines, measured from center of structure to center of structure, in tabular form as appropriate to plan set
I. Provide a Chart with State Plane Coordinates that includes blank columns for as-built information for storm structure, water structures (valves and Fire Hydrants only), and sanitary manholes.

10. Storm Sewer Profiles

The following information is required on all storm sewer profile sheets:

A. The storm profiles shall state the size, slope, pipe material and class of proposed pipe
B. Existing and proposed grade above the storm sewer
C. All proposed utility crossings
D. The 5-year hydraulic grade line shall be shown on the profiles.
E. The permanent pool and 5-yr ponding elevations must be shown at all end of run locations where the storm system empties into a retention basin.
F. Storm sewer top of casting and invert elevations
G. Structure and Headwall type labeled
H. All backfill types and limits, denoted with hatching. Influence lines and CGB limits are to be shown and stationed
I. Profiles are required for all public and private storm lines
J. Bedrock and groundwater table elevation (if known) shall be shown in all profiles.

11. Grading Plan

These sheets shall contain all information necessary for establishing grades and elevations on the site. Pipe alignments and critical elevations necessary for layout shall be displayed. The proposed grades shall be blended with adjacent property grading. This plan shall contain the following minimum information:

A. Existing contours. (1-ft intervals) Contours shall be extended 50-ft (minimum) beyond the project work limits to show adequate tie-in.
B. Proposed elevation including spot grades and/or contours
C. All existing (dashed) and proposed (solid) storm sewer and other utilities
D. Proposed pad and finished floor elevations of all proposed structures
E. Sanitary and storm sewer top of casting elevations
F. Grading limits
G. Roadway slopes and grades
H. Top of curb and back of walk grades at all lot-lines and grade breaks
I. Proposed landscape mounding contours
J. Major flood routing arrows
K. Major flood routing cross sections with 100-yr flow elevation
L. Rear yard ponding limits and elevation for the major storm
M. Street ponding limits and elevation for the 5-year design storm
N. Ditch centerline including direction of flow and slope
O. Cross-sections of ditches in right-of-way (at 50-foot intervals)
P. Driveway slope(s) from building lines to right-of-way lines
Q. A pre-grade (interim) plan may be required in subdivisions because the final grading of the individual lots will not be done with the initial infrastructure improvements. The development must be well drained when the Developer requests the API; therefore, it must be clearly shown how the area will drain in the interim conditions.

R. Open channels - typical cross sections shall be shown for all proposed open channel systems including, but not limited to, flood routing swales, roadside ditches, and minor storm conveyance channels. Typical cross sections shall show the appropriate dimensions and side slope values for each channel.

12. Basin Details Sheet

Dimensioned cross sections and plan views for each water quality BMP selected shall be shown. A table showing the required WQv and drawdown time as well as the designed storage and designed drawdown time of the basin shall be shown.

A. Ponding tabulations
   1. Storage needed and provided for the 1- through 100-year return frequency events that were calculated in the stormwater management report.
   2. Elevation of ponding at each of the calculated storm events.
B. Orifice plate location and details
C. Spillway area details - emphasize critical spillway elevations such as top of bank, 100-yr ponding elevation, etc.
D. Outlet design details
E. Culverts - A profile for each roadway culvert shall be provided showing invert, roadway edge of pavement and/or top of curb, roadway centerline, and design storm and 100 year headwater and tail-water surface elevations. A table with each profile shall also be provided showing the Design and 100-year storm discharge values, head and tail water elevations and outlet velocities. Appropriate erosion control (i.e. rock channel protection type and size) must be shown.
F. Provide cut section through the pond. Cross sections of detention basins, wet or dry, shall be provided and dimensioned. Side slopes, basin bottom slope, the elevation of each inlet and outlet structure, and maximum water surface elevations for WQv storage, the critical storm, and the 100-year storm shall be annotated. An elevation view and plan view of each outlet riser structure shall be provided and annotated. Cross sections showing side slope, side slope information, bottom width dimensions, overflow weir elevations, bottom lining etc. shall also be shown.
G. For all basins provide the following information:
   1. 100-year Flood Pool Elevation
   2. Flood Limits
   3. Show pond contours - Max Side Slope 3:1 (4:1 Preferred)
   4. Emergency overflow location
H. Wet Basin
   1. Normal Pool Elevation
   2. 8-feet wide safety shelf elevation 2-feet below normal pool
   3. Pipe into pond may retain water to invert of first structure, however all submerged pipe must have watertight joints.
   4. Depth to bottom of basin from normal pool is 8-feet minimum
   5. 1-foot minimum freeboard from 100-year flood elevation to top of bank

13. Erosion & Sediment Control Plan

    These sheets are to be submitted as part of the plan set as well as the SWP3. The site grading shall serve as the base information for the erosion and sediment control plan. Erosion and sedimentation controls shall meet the minimum requirements of the OEPA and the City of Delaware. The erosion control plan may be combined with the grading plan. The erosion and sediment control plan shall contain the following minimum information:

    A. Inlet protection locations
    B. Silt fence locations
    C. Check dam locations
    D. Construction entrance location
    E. Staging area location
    F. Fuel storage location
    G. Concrete washout location
    H. Material and debris storage location
    I. Stream crossing locations
    J. Location and prevention measures take for any other construction activities that may impact stormwater runoff
    K. Temporary sediment settling basin locations

14. Erosion & Sediment Control Details Sheet

    A. To be submitted as part of both the plan set and the SWP3
    B. Standard erosion control notes including a sequence of construction
    C. Erosion control standard details
    D. Stream crossing details
    E. Sediment basin and temporary outlet structure details

15. Sanitary Sewer Plan

    This plan shall contain all information of the proposed sanitary sewer, services, and easements. The sanitary plan may be submitted as a separate submission, however, it must contain all elements of a plan set, including but not limited to, a title sheet, a complete set of general notes, quantities, detail drawings, etc. This plan shall contain the following minimum information:

    A. All existing (dashed) and proposed (solid) sanitary sewer and other utilities showing size, length, and type
    B. Sanitary sewer services, including station, size, riser height, extension length, slope, and elevation at end of service in tabular form
    C. All easements, ROW, edge or pavement, and building lines
    D. Proposed pad and finished floor elevations of all proposed structures
    E. Property lines, rights-of-way, and easements
    F. A tributary map shall be included either as a separate sheet or on the title sheet as part of the index map (title sheet) depending on the size of the project.
    G. Provide a Chart with State Plane Coordinates that includes blank columns for as-built information for all sanitary manholes.
    H. Provide stationing, bearings, and distances (center of structure to center of structure) for all sanitary main lines.

16. Sanitary Sewer Profiles
    A. All tie-in point elevations shall be field verified
    B. Sanitary sewer profile indicating size, slope, and type of proposed sanitary sewer
    C. Existing and proposed grade above the sanitary sewer
    D. All proposed utility crossings
    E. Sanitary sewer top of casting and invert elevations
    F. Locations of clay trench dams
    G. All backfill and lines of influence shall be shown and labeled with type and station. Areas backfilled with CGB shall be hatched or shaded.
    H. Bedrock and groundwater table elevation (if known) shall be shown in all profiles.

17. Roadway Improvement Plan and Profile Sheets (Including Waterline Details)

    This plan shall include all information necessary for the construction of the proposed roadway improvements within existing or proposed right-of-way or easements. This plan shall contain the following minimum information:

    A. Typical sections for all roadways that deviate from COD standard drawings
    B. The design speed and the posted speed for all roadways, public and private.
    C. Existing topographic features within development area
    D. Right-of-way and property lines information and neighboring property ownership
    E. Existing utility location of all known utilities, public and private
    F. Centerline stationing of proposed road
    G. Centerline bearing
    H. Horizontal curve data for proposed road
    I. Profile showing profile grade elevation and existing ground
    J. Vertical curve information
    K. All utility crossings
    L. Location, size, and type of any storm structure located in the ROW
    M. The public water main shall be shown on the street plan and profile sheet
    N. Locate all service taps, fire hydrants, and valves on both the plan and profile
    O. All backfill and lines of influence shall be shown and labeled with type and station. Areas backfilled with CGB shall be hatched or shaded
    P. Superelevation tables

18. Intersection Detail Sheets
    A. Intersection details that include curb return radii, intersection grading, curve data n
    B. Centerline bearing
    C. Centerline and gutter line (edge of pavement) slopes
    D. Angle between intersecting centerlines
    E. Proposed locations, spot elevations and slopes for all handicap ramps. The ramps shall comply with all ADA standards including

19. Roadway Cross-Sections

    Required at 50-ft intervals (minimum) when a ditch section is used or a ditch exists beyond the back of curb.

    A. Roadway cross-sections, showing existing and proposed utilities and right-of-way limits.

B. Right-of-Way lines and easements
C. Roadway center line and elevation
D. Existing and proposed cut and fill sections
E. Ditch side slopes
F. Grade tie-in points
G. Longitudinal ditch slope

20. Maintenance of Traffic Plan
    A. Traffic control and maintenance information during construction including all temporary signage, signals, pavement markings, barrel and barricade locations, etc.
    B. MOT phasing
    C. MOT Details and references to ODOT standard drawings
    D. Cut-sections showing lane widths

21. Signage and Striping Plan
    A. General street layout showing all existing and proposed streets and striping
    B. Street centerline and stationing
    C. Signage and striping station and offset
    D. Signage and Striping details and notes

22. Landscaping Plan
    A. Mounding
    B. Tree planting location and type
    C. Planting Notes
    D. Retail sign locations (monument signs only not building signs)

23. Lighting & Fiber Optic Line Plan
    A. Show isolux diagram
    B. General site layout
    C. Light pole locations (station and offset)
    D. Lighting Notes
    E. Street lighting control circuit diagram
    F. Lighting distribution diagram
    G. Lighting details
    H. Fiber optic line and pull box location per project design requirements

Chapter 5: Record Plans & Digital Submission

1. General information on Record Drawings

   Within ninety business days after the Engineer's final inspection, the Developer shall submit for record an updated "as-built" plan to the City of Delaware. The original construction drawings for the improvements shall be revised to reflect the actual construction. Prior to preparing record drawings, it will be the responsibility of the consulting engineering firm to obtain a copy of the City's redline construction drawing plan set. All changes from the approved plans to utility lines, structures or appurtenance locations, roadway, driveway or parking areas, or any other item must be noted on the plans accordingly. In addition to the requirements of these Standards, the information and data obtained for and presented on the "as-built" plan should conform to the "as-built" survey specifications currently accepted by the surveying profession. The "as-built" drawings shall become the "Record Drawings" for the project and must be clearly noted as such. All Record Drawings shall become the property of the Municipality and shall be on file in the Department of Engineering Services.

   Record drawings are required to be submitted in electronic format as well as mylar form. All electronic record drawing information shall be contained on a technology approved by the City Engineer. The computer aided design (CAD) drawings shall have a drawing (.DXF) file type. A separate CAD drawing with all utilities shall be drafted in State Plane Coordinates. Sanitary and storm flow calculations should be included on the electronic format. They shall be made accessible through Microsoft Word and Excel. Consult with the City Engineer's office as to which release of the software is acceptable for storage.

   Record Drawing sets must contain the same address as the approved development plan set including title sheet, general notes, details, utilities, site grading, etc. All files must be saved and submitted on a CD-ROM in a jewel case without using any file compression. The CD label shall include the following:

   A. Engineering Company Name
   B. Project Name
   C. Date the data is burnt to CD
   D. Designate CD is Record Drawing or Construction Plan.
   E. File names should make sense to viewer who may not be familiar with the consulting firms naming conventions and be indicative of the contents of the file.
   F. Name of file must be 8 characters and include the phase number (where exists) And no spaces included. An underscore may be used to attach letters where applicable.
      1. Ex: Kroger Phase 1 would be Kroger1.dxf Ex 2: Krgr_ph1.dxf
      2. If multiple sections of a project are being submitted, files shall be placed in separate directories on the CD.
   G. Coordinate System
      1. Projection shall be referenced to NAD 83 (86 Revision) Ohio State Plane Coordinate System Ohio North
      2. Elevations should be in the NAVD 88 Vertical Datum using U.S. Survey –Feet, Zone 4976.
      3. The coordinate location of the items listed below shall be obtained by a field survey and with vertical data that meets survey grade accuracy.
   H. Complete Record Drawing Submittal:
      1. A TIFF file shall be submitted of all Record Drawings.
      2. A DXF File shall be submitted of the Final Engineering Plans (plan view)

3. One (1) full sized (ANSI D) mylar set
4. One (1) electronic copy on disk or CD (a DXF file containing the base drawing and TIFF files of each of the plan sheets).

2. DXF (Digital Exchange Format) Files

The City of Delaware is responsible for maintaining a comprehensive Geographic Information System. The GIS is used primarily to make the process of data management and data sharing a smoother and faster transition. The Cities database is comprised of several layers such as: Schools, Townships, Major Hydrology, Commercial Building Footprints, 1991 and 1997 GPS points, Zoning, Land Use, Right-of-Way, Parcels, Road Center Line Data, Subdivisions, Flood Plains, Water Lines, Sewer Lines, Spot Elevation, and Topography.

One of the basic tasks involved in cadastral map maintenance is performing updates to property information. With the use of CAD and GIS software, a digital submittal drawing can be directly inserted into the GIS base map. In concept, the engineering CAD drawing should be easily placed in the map to afford these benefits. However, the migration of spatial data from CAD to GIS has its problems and is not a seamless procedure. It has to be planned and implemented so that the issues pertaining to the conversion can be addressed thereby having the maximum benefit.

The process includes setting standards for the submittal of digital plat and subdivision drawings and the technique of converting AutoCAD drawings to a format that is congruent with the ArcGIS database design managed by the City of Delaware's GIS office. In order to comply with our Digital Standards, a DXF (Digital Exchange Format) file shall be submitted to the Department of Engineering Services or the Department of Planning and Economic Development, as appropriate, at the conveyance stage (final plats and needed as-builts).

A Digital Submission Drawing should be created from the base drawing files for the project using the City of Delaware template in DXF format. Each DXF file should be for one section of development. Multiple sections will not be accepted in one file and care must be taken to clearly mark existing infrastructure facilities. Files must be in DXF format (generated in AutoCAD version 2000 or higher.) All pertinent drawing elements will reside in the primary drawing file. There should be no cells, nodes, blocks, or reference files (x-refs) attached to the drawing. This file will include features classified in the standard layers defined in Appendix N. If the drawing contains layers that are not included in Appendix N, then a list of these layers shall also be submitted as an ASCII text file labeled: 'subdivisionname_phasesXX_xlyrspec.txt'.

The completed DXF drawing file shall contain text in standard fonts that can be read without third-party software. All data shall be cleaned at a tolerance of .002 map units. No loop back, turn backs, undershoots or overshoots. No annotation shall be included in any feature layer and no feature shall be included in any annotation layer. Annotation for each layer shall be placed in annotation layers as specified in Appendix N. All City of Delaware required layers shall be made visible prior to submission - all other layers can be removed (preferred) or turned off

Closure is critical in converting CAD elements to GIS features. All polygonal features shall be closed polylines (i.e. parcel boundaries, subdivision boundary, buildings). The DXF file shall contain the following infrastructure Items:

A. Storm Conduit, Storm Water Manholes, Inlets, Catch Basins, Head Walls, End Walls, Junction Boxes, Etc.
B. Detention, Retention Basins
C. Flood Routing Swales
D. Sanitary Sewer Conduits, Manholes, Lift Stations, Force Mains, Junctions, Laterals, Etc.
E. Water Main Lines, Laterals, Junction box, Valves, Hydrants, Etc.
F. Street Lamps
G. Power poles and Lines
H. Traffic Signal Poles and associated items
I. Underground utilities including fiber optic cables, gas lines, electric lines
J. Underground Utilities Appurtenances (pedestals, junction boxes, etc.)
K. Street center lines, curbs, and edge of pavement
L. Sidewalks
M. Driveways
N. Parking lots
O. Buildings, if applicable (commercial and industrial)
P. Structures will be points (nodes) and have an appropriate Structure ID on the adjoining text layer.
Q. Storm and Sanitary sewer lines must be lines with a beginning and ending at a structure insertion point. Pipes are to be line segments connecting no more than two (2) structures. Pipes are to be drawn from upstream to downstream
R. All infrastructure pipes will have a length, pipe size (in inches) and material listed on a separate layer and
S. A comma-delimited ASCII text file (or)
T. An Excel file
U. Must have graphical representation of all off-site platted easements, right-of-ways, lot-lines, etc. encompassing infrastructure improvements as closed polylines.
V. Impervious Surface boundary lines must be shown for all buildings, parking lots, driveways, sidewalks, gravel areas, etc as closed polylines.
W. Comma-delimited Text Files for as-built information
    1. All elevation points shall be delivered in a single comma-delimited ASCII text file or an Excel file with the following columns. Each line of the file shall contain values in Ohio State Plane Coordinates for a single point as follows:

        (Easting, Northing, Elevation)

    2. All storm water and sanitary structures will have top of castings and invert elevations listed in a comma-delimited ASCII text file or Excel file as follows:

        (Structure Number, Easting, Northing, Invert in, Invert out, Top of casting)

    3. All infrastructure pipes will have as-built information for the pipe length, pipe size (in inches) and pipe material listed a comma-delimited ASCII text file or Excel file as follows:

        (Name, Length, Size, Material)

X. TIFF Files (Record Drawings) - A TIFF of the signed paper as-built construction plans must be submitted. It must be legible, contain all the as-built data including the profile sheets, and be reproducible to scale. The Record Drawing File must be revised to show the exact as-built location of all infrastructure. All storm water and sanitary structures will have top of castings and invert elevations. As-built Values for all structures shall be provided on the plan sheets and any design values will be crossed out but still legible with the as-built values written above it.

3. Record Drawings (Mylar Copies)

The City of Delaware requires that record drawing engineering plans be submitted to the City Engineering Department at the completion of each development project. Plans are to include the following:

A. Record Drawings must be clearly noted as such.
B. Record Drawing sets must contain the same address as the approved development plan set including title sheet, general notes, details, utilities, site grading, etc.
C. Prior to preparing record drawings, it is the responsibility of the Engineer of Record to obtain a copy of the City's redline construction drawing set. The information contained in this redline must be incorporated into the record drawings.
D. All changes from the approved plans to utility line, structures or appurtenance locations, roadway, driveway or parking areas, or any other item must be noted on the plans accordingly.
E. All sanitary and storm sewer structures located on the site, whether new or existing, must have top of casting and flowline elevations verified and recorded on the plans.
F. State Plane Coordinates for all newly constructed public utility structures, including fire hydrants and main line water valves.
G. Retention/Detention Basin Volume Calculations based on an as-built survey of the basin must be provided to verify that detention/retention facility was constructed per Stormwater Management Plans. The as-built survey sheets (11 x 17) must be included in the submittal.
H. All flood routing swales must be field verified prior acceptance of the Record Drawings

Chapter 6: Surveying Standards

1. Purpose

   These Standards are intended to define the minimum requirements for the practice of surveying within The City of Delaware. All surveys conducted for the purpose of designing or preparing plans and maps for improvements requiring approval by the City of Delaware shall be performed by or under the direction and close supervision of a Professional Surveyor.

2. Definitions:

   A. Photogrammetry: the science of making measurements on photographs.

      1. Terrestrial photogrammetry applies to the measurement of photographs that are taken from a ground station, the position of which usually is known or can be readily determined.
      2. Aerial photogrammetry applies to the measurement of photographs taken from the air and includes all operations, processes and products involving the use of aerial photographs. Among these are included the measurement of horizontal distances, the determination of elevations, the compilation of planimetric and topographic maps, the preparation of mosaics and orthophotos, and the interpretation and analysis of aerial photographs.

   B. Plat, Subdivision: a map of a subdivision of land prepared in accordance with State Plat statutes and the City of Delaware Subdivision Regulations, located in section 1111 of the city code.

   C. Plat, Survey: a graphical description drawn to scale showing all essential data pertaining to the boundaries and subdivisions of a tract of land.

   D. Professional Surveyor: a registered surveyor authorized to practice professional surveying by the Ohio State Board of Registration, as specified under Section 4733 (Adm. Code) ORC

   E. Property Surveying: the branch of surveying that involves "the art and science of: (1) reestablishing cadastral surveys and land boundaries based on documents of record and historical evidence; (2) planning, designing and establishing property boundaries; and (3) certifying surveys as required by statute or local ordinance such as subdivision plats, registered land surveys, judicial surveys and space delineation" (knowledge of both the weight-of-authority and statute law relative to the establishment of boundaries by both written and unwritten methods is imperative).

   F. Subdivision: (1) The division of any parcel of land shown as a unit or as contiguous units on the last preceding tax roll into two or more parcels, sites, or lots, any one of which is less than five acres for the purpose, whether immediate or future, of transfer of ownership provided, however, that the division or partition of land into parcels of more than five acres not involving any new streets or easements of access, and the sale or exchange of parcels between adjoining lot owners where such sale or exchange does not create additional building sites shall be exempted; or (2) The improvement of one or more parcels of land for residential, commercial or industrial structures or groups of structures involving the division or allocation of land for the opening, widening or extension of any street or streets, except private streets serving industrial structures; the division or allocation of land as open spaces for common use by owners, occupants or lease holders or as easements for the extension and maintenance of public sewer, water, storm drainage or other public facilities. (Section 711.001, ORC)

G. Surveying Practice: includes any professional service which requires the application of special knowledge of the principles of mathematics, the related physical and applied sciences, and the relevant requirements of law for the adequate performance of the art of surveying (included are all major categories of surveying practice, e.g., property, topographic, hydrographic, engineering, geologic, photogrammetric, environmental [remote sensing], and soil surveying, etc.).

3. As-Built Plan Requirements

   All final copies of plans and maps that are submitted for record shall conform to Section 5, Record Drawings and Digital Submission standards in this document.

4. Engineering Plan and Topographic Surveying

   Definitions as used herein:

   A. Master benchmark: shall be a vertical control monument which is durable, easily identifiable and permanently located within the development area in a position which affords the highest possible protection from disturbance. At least one "master benchmark" shall be established for each development area.
   B. Temporary benchmarks of a lesser nature and with elevations derived from the "master benchmark" may be used for control within the development area.
   C. Source benchmark: shall be an existing, permanently established, and undisturbed monument with a known elevation which is related to the "National Geodetic Vertical Datum" with a high level of certainty.
   D. Development area: is the area of land included within each individual subdivision (or phase of subdivision) as submitted for review and approval.
   E. Master Benchmark Standards - The elevation of each "master benchmark" shall be determined and established by measurements designed and executed with control over uncertainty, through use of well designed specifications.
      1. The following shall be on all final engineering plans:
         a. The location, description and elevation of the "master benchmark(s)" within the subject development area and the "source benchmark(s)", and
         b. The total expected error and its certainty (90% or greater) in vertical measurements between each "master benchmark" and its respective "source benchmark(s)" based on actual design or sound judgment.
   F. Topographic Standards
      1. The elevation of ninety percent (90%) of all identifiable points shall be in error not more than one-half contour interval.
      2. No point shall be in error more than a full contour interval.
   G. As-built Surveys

      These are surveys to determine positions of structures as actually constructed. "As-built" surveys are required to check the contractor's work, assure that the structures will function according to design, and provide a record of locations of structures for maintenance and other subsequent design purposes. In addition to the requirements of these Standards, the information and data obtained for and presented on the "as-built" plan should conform to the as-built survey specifications currently accepted by the surveying profession.

5. Surveys and Monuments
    A. General. Survey and monument activities shall meet “Minimum Standards for Boundary Surveys in the State of Ohio” set forth in Ohio Administrative Code Section 4733-37. Permanent monuments shall be tied to and referenced in the Ohio Plane Coordinate System.
    B. Lot Monuments (pins). A minimum of four permanent monuments. Iron pins must be set on the property corners at the street ROW line on each lot corner after construction of the house and final lot grading Lot pins shall be one-inch diameter iron pins thirty inches long, buried one foot below finish grade and bearing the identification mark of the surveyor or surveying company that set the marker.
    C. Boundary Monuments (pins). Subdivision boundary pins shall be composed of durable material, have a minimum length of thirty inches and a minimum cross-section area of 0.2 square inches. Every boundary monument shall be identified with a durable marker bearing the surveyor's Ohio registration number and/or name or company name. One such monument shall be placed at each corner and at each change of direction of the boundary. When it is impossible or impractical to set a boundary monument on a corner, the surveyor shall set a reference monument along one of the property lines which intersect at that corner. The datum shall be stated.
    D. Roadway Monuments. Roadway monuments shall be placed at the intersection of all newly constructed roadways in accordance with standard drawing RDWD-15.0. Additionally center punched railroad spikes shall be placed in the centerlines of all new roads at the limits of the subdivision, at points of curve and at points of tangency. The datum shall be stated.
    E. Certification: Before release of the surety, the subdivider’s surveyor shall certify by letter to the City Engineer that all monuments are in place and those disturbed during construction have been replaced

Chapter 7: Roadway Design

For the purpose of design, right of way and pavement width design values are specified for various capacities for each functional classification type of roadway. The basic design elements for arterial, collector and local streets are shown respectively. Wherever possible, the recommended pavement and right of way widths should be adhered to. However, it is understood that the right of way in already established City areas may continue to be less due to constraints such as existing structures or other geographical and or physical limitations. Minimum pavement widths can be utilized under special or restrictive conditions. It should be noted that local and collector roadways without curb and sidewalk are permitted in industrial areas only and require approval by the City.

The information contained in this section is intended to be utilized as guideline to acceptable roadway design within the City of Delaware and should not be construed as a substitute for other governing design standards and regulations such as the Ohio Department of Transportation Location & Design Manuals and the Ohio Manual of Uniform Traffic Control Devices (OMUTCD). For the purpose of roadway design within the City of Delaware, the designer shall follow ODOT CMS most current edition for all highway material item specifications with the exception of Items 604, 608, 609 and 901 where the City of Columbus Construction Materials Specifications (COC CMS) and/or the City of Delaware (COD) specifications are to be followed.

Table 7-1: General Design Parameters for Local Streets

	Local			
	Primary	Secondary	Cul de Sac	Alley
ADT	500 – 1,500	0-500	0-250	N/A
Street Width (Back/Curb to Back/Curb)	36	32	32	16
Pavement Width	32	28	R=56.5	16
Right of Way Width	62	58	R=67.5	32
Design Speed (MPH)	30	30	30	15
Minimum CL Radius (FT)	275	225	125	125
Minimum Turning Radius (FT)	20	20	20	20
Min/Max Street Grade (%) **	0.5/4.0	0.5/6.0	0.5/6.0	0.5/6.0
Minimum “K” Crest Curve	19	19	19	
Minimum “K” Sag Curve	37	37	37	
Treelawn Width (FT)	8	8	8	N/A
Parking Requirements	Permitted	Permitted	Permitted	Not Permitted

Table 7-2: General Design Parameters for Collector Streets	
	Collector
ADT	1,500 – 3,500
Street Width (Back/Curb to Back/Curb)	40
Pavement Width	36
Right of Way Width	70
Design Speed (MPH)	30 - 40
Minimum CL Radius (FT)	350
Minimum Turning Radius (FT)	35
Min/Max Street Grade (%) **	0.5/4.0
Minimum "K" Crest Curve	44
Minimum "K" Sag Curve	64
Tree lawn Width (FT)	10
Parking Requirements	Parking is permitted where collector streets serve a primarily residential area however may be restricted where dedicated turn lanes are required near intersections

Table 7-3: General Design Parameters for Arterial Streets				
	Minor Arterial		Major Arterial	
ADT	3,500 – 10,000		> 10,000	
	2-Lane	3 -Lane	4 - Lane	5 - lane
Street Width (Back/Curb to Back/Curb)	40	40	52	64
Pavement Width	36	36	48	60
Lane Width	14	12	12	12
Right of Way Width	100	100	100	120
Parking Requirements	Parking is typically prohibited for new arterial construction			
Note: The design of arterial streets shall be in conformance with the current edition of the Ohio Department of Transportation's Location & Design Manual Vol. 1.				

1. General Design Geometrics for Local & Collector Streets
   A. The length of a block for Local Street shall not exceed 1200ft.
   B. A minimum 100-ft tangent section of pavement is required between reverse curves.
   C. Public streets shall have a normal crown cross-section with 24-inch combination curb and gutter. Straight, 18-inch curb may be substituted on private streets. Approval for substitution shall be made on a case-by-case basis.
   D. Sidewalks are required on both sides of public streets unless exempted by the City.
   E. Sidewalks are to be 5ft wide and constructed of concrete. A combination bike/pedestrian path shall be 8ft in width and constructed with an asphalt surface.
   F. Bike paths and sidewalks wider than 5ft generally require the establishment of an access easement adjacent to the proposed right of way.
   G. Tree lawns shall be sloped at ¼-in per foot towards the street.
   H. A temporary "Tee" turn-a-round constructed per City Standard Drawing is required at the end of any stub street greater than 120 feet in length, measured from the intersection of the centerlines.
   I. Reference City of Delaware Standards for Typical Street Sections and Curb Details.

2. Cul-de-sacs Design
   A. Maximum length (L) is 700ft measured from the center of bulb to the centerline of the intersecting street.
   B. Paved radius is 40ft measured to the back of curb. (54.5ft for L>250ft)
   C. ROW radius is 53ft allowing for an 8-foot tree lawn and 5ft sidewalk. (67.5ft for L>250ft)
   D. Interior islands on larger cul-de-sacs require prior approval of the City Fire Chief
   E. Interior Island radius is 25.5ft measured to back of curb.
   F. Slope for inside of island is 2% min. to 8% max. to curb.
   G. Islands shall be constructed with 24" mountable curb.
   H. Parking is prohibited against the center island.
   I. Island landscaping and maintenance shall be the responsibility of the HOA.
   J. Island shall be landscaped with grass and trees as required by City.

3. Alley Design
   A. All alleys are to be constructed in public right of way or a public access easement.
   B. Alleys less than 16ft wide must be posted as "One Way."
   C. Minimum distance from edge of alley pavement to any structure is 8 ft.
   D. Curbs are not required on alleys except at the ends of alley where the intersecting street radius return ends.
   E. Inverted crown pavement section in alleys is acceptable and requires continuous centerline underdrain and storm sewer collection.

4. Curb Ramps & Crosswalks Design
   A. Curb ramps are required in all directions at intersecting street corners.
   B. Curb ramps are to be designed utilizing the most current ADAAG requirements, in addition to City of Delaware standards.
   C. The width of a curb ramp shall be as wide as the width of adjacent sidewalk, but never less than five feet.
   D. Mid-block pedestrian crossings are only permitted as approved by the City and must be appropriately signed and striped.

5. Industrial Roadway Design

Roadways in designated industrial areas shall be designated by the City as "Industrial Pavement" and designed to the following criteria:

A. The minimum pavement width is 28ft with two 12-ft lanes and 2ft paved shoulders.
B. Ditch drainage sections are permitted but not required.
C. No parking permitted on either side of the roadway
D. 50ft turning radii are required at all intersections.
E. Heavy pavement section is required as per the required pavement composition.

6. Private Streets, Parking Lots & Driveways

A. Private streets shall be constructed to the public street standards except as permitted under this section.
B. The minimum pavement width for two-way traffic shall be 20ft; 28ft if parking is permitted.
C. The minimum pavement width for an uncurbed private alley or one-way street is 12ft edge to edge of pavement.
D. In parking entrances and areas, curbing is required along all driveway entrances, travel lanes, parking lot pavement edges, and around all free-standing traffic or landscape islands. Curbing is not required around small landscape islands abutting a building.
E. Curbing maybe partially eliminated with City approval, as necessary to provide sheet flow storm drainage to meet an approved storm water management plan
F. Parking areas abutting a sidewalk shall be separated by a combination curb/sidewalk, or by a curb and tree lawn configuration. The tree lawn shall be a minimum of 3ft wide. If no tree lawn is present, then the walk must be at least 6ft wide to account for vehicle overhang. Parking blocks shall be installed in all uncurbed parking stalls.
G. The finished grade behind curb shall match the top of curb elevation.
H. Curbing in public right-of-way is to be combination curb/gutter or 18-in straight curb. Extruded concrete curbing is permitted along the perimeter of private parking lots, parking islands and at the end of parking stalls provided the curb is continuously backed by grade to the top of the curb. The curb shall be 7.5-in in height and shall be Class C, 4000 psi mix. with fiber reinforcement or continuous rebar reinforcement. The top course of asphalt shall be placed after the curb is installed to aid in anchoring the curb leaving a 6-inch reveal.
I. Inverted crown pavement sections in alleys are acceptable and shall be designed per the City Standard Drawings with 3/16-inch per foot minimum cross-slope. Perforated drain tile shall be installed along the centerline of the pavement and shall outlet directly to a storm sewer collection system.
J. The maximum algebraic difference in the slopes of pavement on either side of a sump or catch basin shall be less than 2.5%.
K. Private streets and alleys shall be constructed to the public street pavement composition standard.
L. Commercial parking lots should be paved with a minimum of 4.0-inch of asphalt over 6-inches of compacted granular base. Areas subject to heavy vehicles loads shall be constructed with 6-inches of asphalt over 6-inches of stone base.
M. All trench backfill and cover requirements for public streets shall apply to private streets and/or parking lots when utilities are located within paved areas.

N. Individual commercial and business driveway approaches shall be constructed of concrete per

the City Standard Drawings. At the direction of the City, private streets or high volume commercial or business driveways serving multiple tenants shall tie to the existing public street intersection with a flexible pavement section equivalent to the intersecting public street pavement section.

O. The location of dumpster pads is subject to the access requirements of the City and approval by the Public Works Director. Dumpster pads must be constructed to City Standard Drawings if City refuse service is desired.

P. See the Stormwater Management Section for limitations on ponding in paved areas

Q. Parking lot drive aisles must be a minimum of 24ft wide.

R. Parking stalls must be a minimum of 9ft by 19ft

S. All parking stalls, painted islands, and internal pavement markings must be striped in white paint unless otherwise required by ADAAG or Ohio Manual of Uniform Traffic Control Devices requirements.

7. Intersection Design

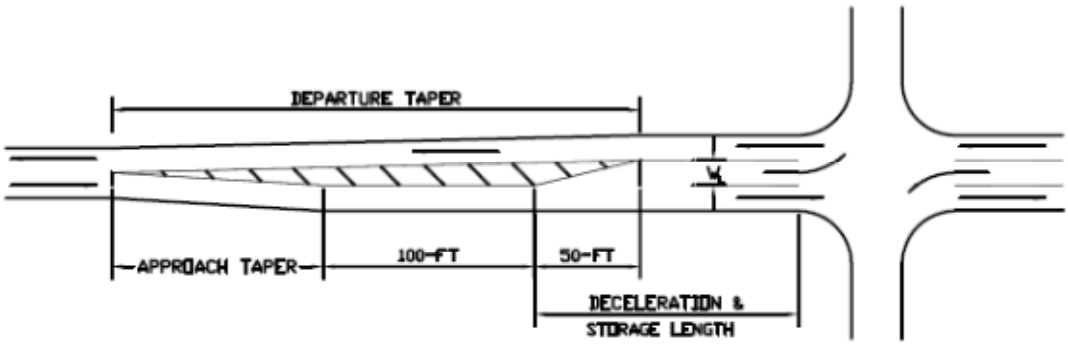
A. Turn Lanes – The single most influential parameter impacting intersection operation is the treatment of left turning vehicles. Left turn lanes are generally desirable at most intersections; however, cost and space requirements do not permit their inclusion in all situations. Intersection capacity analysis performed in conformance with the current edition of the Highway Capacity Manual should be used to determine the number and use of left turn lanes. For unsignalized intersections, left turn lanes may also be required if they meet warrants as provided in the Traffic Impact Study section of this document. Left turn lanes should be constructed opposite each other on opposing approaches to enhance sight distance. They are developed in several ways depending on the available width. In developing turn lanes, several types of tapers may be involved.

B. Approach Taper - An approach taper directs through traffic to the right. Approach taper lengths are calculated using the following:

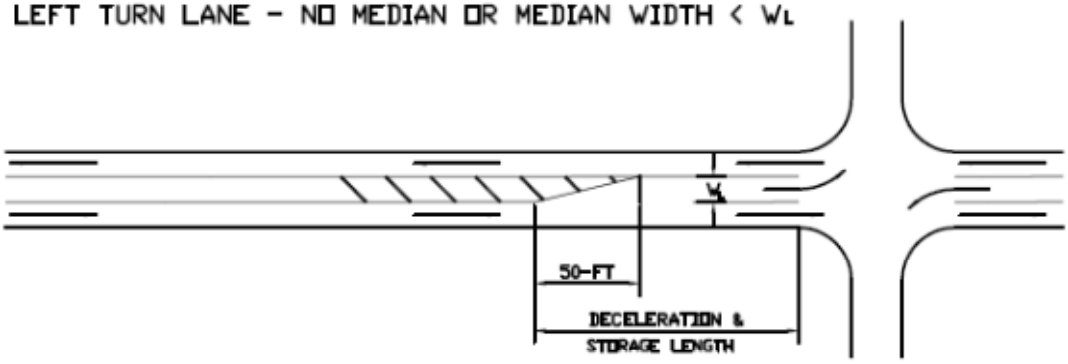
   a. Design Speed of 50 mph or more: $L= W S$
   b. Design speed less than 50 mph: $L=W S^2 / 60$
   c. Where: L = Approach taper length in feet
   d. W = Offset width in feet
   e. S = Design Speed

C. Departure Taper - The departure taper directs through traffic to the left. Its length should not be less than that calculated using the approach taper equations. Normally, however, the departure taper begins opposite the start of the full width turn lane and continues to a point opposite the beginning of the approach taper.

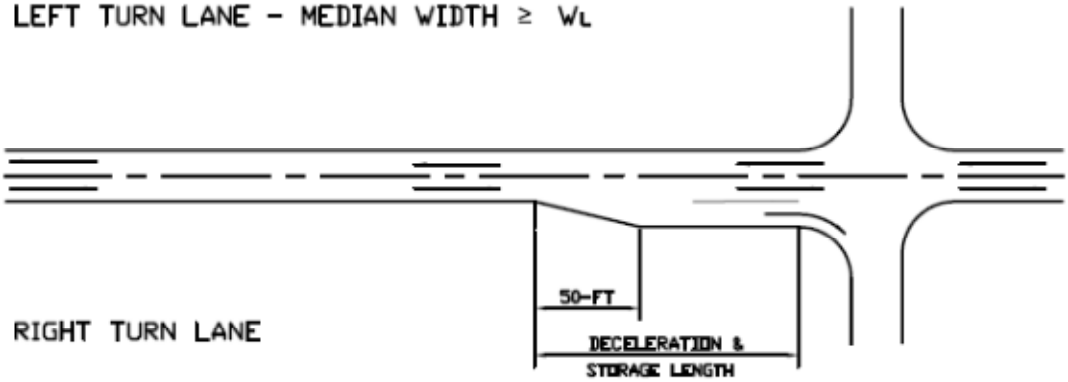
D. Diverging Taper - The diverging taper is the taper used at the beginning of the turn lane. The minimum recommended length of a diverging taper is 50 ft. Figure 8 has been included to aid in determining the required lengths of left turn lanes at intersections.



LEFT TURN LANE - NO MEDIAN OR MEDIAN WIDTH < W_L



LEFT TURN LANE - MEDIAN WIDTH ≥ W_L



RIGHT TURN LANE

Table 7-4: Basis for Computing the Length of Turn Lanes

Type of Traffic Control	Design Speed					
	30 - 35		40 – 45		50 - 60	
	Turn Demand Volume					
	High	Low *	High	Low *	High	Low *
Signalized	A	A	B or C **	B or C **	B or C **	B or C **
Unsignalized Stopped Crossroad	A	A	A	A	A	A
Unsignalized Through Road	A	A	C	B	B or C **	B
* Low is considered 10% or less of approach traffic volume						
** Whichever is greater						
Table from ODOT L & D Manual Vol. 1 (latest edition)						

Condition A: Storage Only Length = 50ft (diverging taper) + Storage Length

Condition B: High Speed Deceleration Only

Design Speed	Length (Including 50ft Diverging Taper
40	125
45	175
50	225
55	285
60	345

Condition C: Moderate Speed Deceleration and Storage

Design Speed	Length (Including 50ft Diverging Taper
40	111 + Storage Length (Table 7-5)
45	125 + Storage Length (Table 7-5)
50	143 + Storage Length (Table 7-5)
55	164 + Storage Length (Table 7-5)
60	181 + Storage Length (Table 7-5)

E. Storage Length - After determining the length of a left turn lane, the designer should also check the length of storage available in the adjacent through lane(s) to assure that access to the turn lane is not blocked by a backup in the through lane(s). The following table may be utilized using the average number of through vehicles per cycle, and the

required length read directly from the table. If two or more lanes are provided for the through movement, the length obtained may be divided by the number of through lanes to determine the required storage length of each lane; however, the designer is cautioned that this approach can only be followed if it is expected the turn lane traffic will be evenly distributed in both turn lanes. It is recommended that left turn lanes be at least 100ft. long, and the maximum storage length be no more than 600ft. Dual turn lanes should be considered when the length is greater than 600ft. The width of a left turn lane should preferably be the same as the normal lane widths for the facility. Through and turn lanes should be designed 12ft wide, with a minimum width of 11ft. possible with the City's written approval. Additional lane width should be provided whenever the turn lane is adjacent to a curbed median island.

Table 7-5: Storage Length at Intersections

* Average No. of Vehicles / Cycle	Required Length		* Average No. of Vehicles / Cycle	Required Length
1	50 ft		17	600 ft
2	100 ft		18	625 ft
3	150 ft		19	650 ft
4	175 ft		20	675 ft
5	200 ft		21	725 ft
6	250 ft		22	750 ft
7	275 ft		23	775 ft
8	325 ft		24	800 ft
9	350 ft		25	825 ft
10	375 ft		30	975 ft
11	400 ft		35	1125 ft
12	450 ft		40	1250 ft
13	475 ft		45	1400 ft
14	500 ft		50	1550 ft
15	525 ft		55	1700 ft
16	550 ft		60	1850 ft

* Average Vehicles per Cycle = DHV (Turning Lane) / Cycles per hour

If Cycles are unknown, assume:
For unsignalized or 2 Phase signal operation – 60 Cycles / HR
For 3 Phase signal operation – 40 Cycles / HR
For 4 Phase signal operation – 30 Cycles / HR

Table from ODOT L & D Manual (latest edition)

Additional information is provided in the current edition of the ODOT Location and Design Manual, Volume 1, Roadway Design. Section 400.

F. Channelizing Islands - An island is a defined area between traffic lanes used for control of vehicle movement. Islands also provide an area for pedestrian refuge and traffic control devices. Islands serve three primary functions: (1) to control and direct traffic movement, typically turning vehicles; (2) to divide opposing or same direction traffic streams vehicle movements; and (3) to provide refuge for pedestrians. Most islands combine functions.

1. Channelizing islands control and direct traffic into the proper paths for the intended use and are an important part of intersection design. They may be of many shapes

and sizes, depending on the conditions and dimensions of the intersection. A common form is the corner triangular shape for right-in / right-out at site access drives.

2. Channelizing Islands are used at intersections for the following reasons:
   a. Separation of conflicts.
   b. Control of angle of conflict.
   c. Reduction in excessive pavement areas.
   d. Indication of proper use of intersection
   e. Favor a predominant turning movement.
   f. Pedestrian protection.
   g. Protection and storage of vehicles.
   h. Location of traffic control devices.
3. These islands should be placed so that the proper course of travel is immediately obvious and easy for the driver to follow. Care should be given to the design when the island is on or beyond a crest of a vertical curve, or where there is a substantial horizontal curvature on the approach to or through the channelized area.
4. Properly placed islands are advantageous where through and turning movements are heavy. Islands must be designed to allow movement of the design vehicle through the intersection without the design vehicle riding up on the island.
5. Curbed islands are required in the City of Delaware. The smallest curbed island that should normally be considered is 75 sq. ft., a 100 sq. ft. island is preferred. The island shall have mountable curb and have a concrete surface.

G. Intersection Angles - Intersection angles are typically designed to intersect at 90 degrees, which may require minor realignment of existing streets. In no case should the angle of intersection be less than 70 degrees. The crossroad alignment should be as close to perpendicular as practicable.

H. Bifurcation - Combinations of pavement cross slopes and profile grades may produce unacceptable grade breaks on through intersections. This is especially true where a new roadway intersects an existing divided roadway. A centerline profile of a proposed new cross street centerline should developed in order to analyze the bifurcation through the intersection. The profile through the intersection should be designed to meet the design speed of the crossroad. Since the grade break across a normal crowned pavement is 1.9% or greater, it should be noted that the crown of the through street must be flattened. This will allow the vehicles on the cross street to pass through the intersection without significantly adjusting their speed. The maximum allowable grade break through an intersection without constructing a vertical curve and/or flattening the crown of the through road is speed dependent. The relationship between design speed and grade differential (algebraic difference) is given in the following table.

Table 7-6: Maximum Grade Change without a Vertical Curve	
Design Speed (mph)	Maximum Grade Change Rounded to Nearest 0.05% (Algebraic Difference)
25	1.85%
30	1.30%
35	0.95%
40	0.75%
45	0.55%
50	0.45%
55	0.40%
60	0.30%
65	0.30%
70	0.25%

8. Pavement Section Composition

The City of Delaware permits the following pavement composition for use in the city without further design calculation.

Table 7-7: Standard Pavement Section for Flexible Pavement							
ITEM #	Arterial	Collector	Local			Industrial	Alley
			Primary	Secondary	Cul de Sac		
448 Asphalt Concrete Surface Course, Type 1H, Heavy Traffic (PG 70-22)	1.5	x	x	x	x	1.5	x
448 Asphalt Concrete Intermediate Course, Type 2, Heavy Traffic (PG 64-28)	2.0	x	x	x	x	2.0	x
448 Asphalt Concrete Surface Course, Type 1, Medium Traffic (PG 64-22)	x	1.5	1.5	1.5	1.5	x	1.5
448 Asphalt Concrete Intermediate Course, Type 2, Medium Traffic (PG 64-22)	x	2.0	2.0	2.0	2.0	x	2.0
301 Asphalt Base, PG64-22	6.0	6.0	3.0	3.0	3.0	6.0	3.0
304 Compacted Granular Base	9.0	6.0	6.0	6.0	6.0	9.0	6.0
Asphalt Rejuvenating Agent per COC Supplemental Spec. 1540	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 7-8: Standard Pavement Section for Composite Pavement							
CMS ITEM	Arterial	Collector	Local			Industrial	Alley
			Primary	Secondary	Cul de Sac		
448 Asphalt Concrete Surface Course, Type 1H, Heavy Traffic (PG 70-22)	1.5	x	x	x	x	1.5	x
448 Asphalt Concrete Intermediate Course, Type 2, Heavy Traffic (PG 64-28)	2.0	x	x	x	x	2.0	x
448 Asphalt Concrete Surface Course, Type 1, Medium Traffic (PG 64-22)	x	1.5	1.5	1.5	1.5	x	2.0
448 Asphalt Concrete Intermediate Course, Type 2, Medium Traffic (PG 64-22)	x	2.0	2.0	2.0	2.0	x	x
ODOT 305 Concrete Base	9.0	7.0	6.0	6.0	6.0	9.0	6.0
Asphalt Rejuvenating Agent per COC Supplemental Spec. 1540	Yes	Yes	Yes	Yes	Yes	Yes	Yes

A. Item 305 - Portland Cement Concrete Base - Class "C" Concrete per ODOT CMS. A tack coat (Item 407) applied at 0.10 gallon per square yard, shall be required between Item 305 and Item 448, Asphalt Intermediate/wearing course.
B. Concrete base installed may be installed per RCC Supplemental Specification 1523 – Roller Compacted Concrete. A tack coat (Item 407) applied at 0.10 gallon per square yard, shall be required between concrete base and Item 448, Asphalt Intermediate/wearing course.
C. Asphalt Rejuvenating Agent, per COC supplemental specification 1540, is required on all public streets, alleys and bikeways
D. Asphalt binder grade PG 76-22M may be specified by the City for use in roadways subject to significantly high truck loadings.

9. Alternate Pavement Designs

For the design of new arterial and industrial highway pavement sections, alternative pavement design criteria may be used in determining minimum pavement composition and thickness. Such criteria and methodologies shall be submitted in advance to the City for approval. All pavement materials and construction shall conform to the ODOT CMS (latest edition), unless the City determines that additional requirements are needed for a particular project.

10. Pavement Markings & Signage

All pavement markings for public and private sites are to comply with Ohio Manual of Uniform Traffic Control Devices requirements, or as further specified by this manual. All pavement markings within commercial or industrial development parking areas shall be completed in white paint unless otherwise required by ADAAG or Ohio Manual of Uniform Traffic Control Devices requirements

.

If "No Parking" zones are required, they should be specified on the same side of the street as the fire hydrants. Approaches to intersections or major entry ways may require "No Parking" zones on both sides of the street. No Parking signs adjacent to an intersection must

include the text "From Here to Corner", and must have one arrow pointing towards the intersection. All pavement markings on public roadways are to conform to Item 644 Thermoplastic pavement markings. Temporary painted marking are permitted in cold weather, but they must be replaced with permanent thermoplastic markings before the roadway will be accepted.

11. Maintenance of Traffic (MOT)

A detailed Maintenance of Traffic Plan (MOT) is required for all construction activities within the public right-of-ways. The MOT plan is required as part of the plan set for major road improvements and widening projects but can be submitted separately by a contractor in advance of construction activities or in conjunction with the required Public Way permit. Construction plans shall include the note "*The Maintenance of Traffic plan is the responsibility of the contractor. A Maintenance of Traffic Plan must be submitted at the time of the Pre-Construction Meeting and be approved by the City in advance of any construction activities within the public right of way.*" MOT plans should be prepared in compliance with ODOT's Temporary Traffic Control Manual, current edition. Additional MOT plans and permitting may be required for projects within Delaware County, Townships, or ODOT jurisdictions.

12. Roundabouts

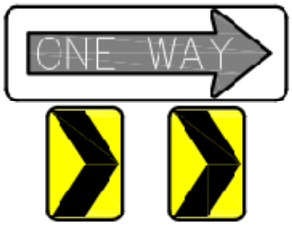
Modern Roundabout Intersections are circular intersections with specific design and traffic control features that serve as an alternative to signal controlled or 4-way stop controlled intersection configurations. These features include yield control of all entering traffic, channelized approaches, and appropriate geometric curvature. The term "modern roundabout" is used in the United States to differentiate modern roundabouts from the nonconforming traffic circles or rotaries that have been in use for many years. Modern roundabouts are defined by two basic operational and design principles:

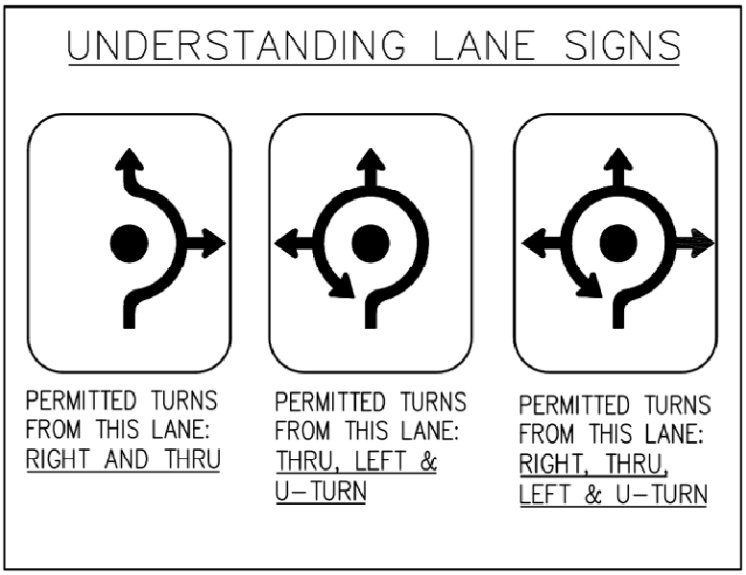
A. Yield-at-Entry: Yield-at-entry requires that vehicles on the circulatory roadway of the roundabout to have the right-of-way over all entering vehicles on the approaches that shall yield to traffic within the roundabout moving in a counterclockwise direction. To maintain free flow and high capacity, yield signs are used as the entry control. Modern roundabout intersections shall be designed for traffic to travel at 15 to 20 mph.

B. Deflection of Entering Traffic: Entering traffic is deflected to the right by the central island of the roundabout and by channelization at the entrance into an appropriate curved path along the circulating roadway. Thus, no traffic is permitted to follow a straight path through the roundabout.

Modern Roundabouts range in size from mini-roundabouts with inscribed circle diameters as small as 45ft, to multilane roundabouts with inscribed circle diameters greater than 180ft. Roundabouts in the City of Delaware shall be designed using the RODEL Software System or other pre-approved software. The decision to install a roundabout must be approved by the Department of Engineering Services at the planning stage of the project.

Typical signage details included in modern roundabout design and operation.





For additional information, see Federal Highway Administration's Roundabouts: An Informational Guide.

13. Bike and Pedestrian Paths

The City of Delaware requires the inclusion of new bicycle and pedestrian facilities with all new development activities in accordance with our Bikeway Master Plan. Not every development will include the construction of a new pedestrian facility; however, the following general criteria shall be considered when designing new bike/pedestrian paths.

A. Bikeways & Multi-Use Paths

1. Paths shall be a minimum of 8 foot wide where they generally run adjacent to an existing street, and 10 foot wide where access by emergency vehicles is required at locations away from the roadway network or parallel to an arterial street.
2. Bikeways shall be designed with a minimum 3 foot horizontal clearance from poles, sign posts, structures etc.
3. A maximum longitudinal grade of no greater than 5% is permitted, with exceptions allowed as approved by the City. No path shall exceed 8% grade.
4. The maximum grade on a curb ramp is 8.33% for a maximum of 30 inch rise. Provide a flat landing at the bottom and top of ramps.
5. Rest areas should be provided at intervals depending on the difficulty of the grade. See ADAAG requirements.
6. A 2% preferred cross-slope shall be utilized to provide adequate surface drainage, however 3% may be required at some locations. The maximum cross slope should not exceed 5%.
7. The minimum clear tread width for wheelchairs is 36-inches, with 32-inches allowed by exception. Passing space should be considered for two wheelchairs to pass each other, or for a single wheelchair to rotate in a circle of 60-inches.
8. Shared use paths should not have any protruding objects or tread obstacles. All utility covers and lids shall be provided with non-skid surfaces.
9. The minimum vertical clearance along a pathway is six feet-eight inches (6'-8") for pedestrians only, but shared use paths should have a minimum 8-foot clearance. If equestrians or emergency vehicles may use the path, then the vertical clearance should be as directed by the City.
10. Provide detectable warnings surfaces as required where paths or sidewalks meet roadways.

B. Roadway-Based Facilities:

With the increasing focus on designing "Complete Streets" i.e. roadways that safely accommodate multiple means of travel including motor vehicles, public transit, cycling, and pedestrians, a set of guidelines have been developed to address these considerations. It is noted that multiple design standards have been developed that regionally, vary significantly. The City of Delaware acknowledges the benefits in considering all modes of travel when designing new, or upgrading existing transportation facilities, and is committed to evaluating the inclusion of complete street improvements as a project goal.

1. Sharrows are designated travel lanes for use by both motor vehicle traffic as well as cyclists. It should be noted that cyclists can legally utilize most streets to travel on under the same operational rules as motor vehicles. Designated sharrow lanes should be limited to streets where a high demand for bicycle travel exists, and where there are no alternative routes, paths, sidewalks etc. for cyclists to travel. In many cases, sharrow lanes may be designated by appropriate pavement markings and signage to increase driver awareness of the presence of cyclists. Lanes utilized for sharrows shall be at least 14ft in width with sharrow markings placed along the outer edge. For lanes less than 14ft in width, the sharrow symbols should be placed in the middle of the travel lane. Sharrows are not recommended in urbanized areas where posted speed limits exceed 35 MPH, as the risk for conflicts between cyclists and motor vehicles increases significantly as the difference in speed between both travel modes increases.
2. Bike lanes may be added adjacent to a travel lane where pavement widths permit the designation of a 6ft wide bikeway lane that serves cyclists in both directions.
3. Roadway shoulders may be utilized as bike lanes in one direction where a minimum of 5ft of pavement exists beyond the travel lane edge line measured from the center of the white line to the edge of pavement.

C. Pavement Markings and Signage

Shown are examples of typical bike lane and sharrow lane signage and pavement markings. Though such signage varies significantly by state, region and community, it is important for any specific area to be uniform in the application of such signage and markings to minimize driver confusion, and to convey a message in as simple and concise a manner as possible. Additional design information can be obtained from the American Association of State Highway and Transportation Officials publication "Guide for the Development of Bicycle Facilities", current edition.

Table 7-9: Bicycle Paths / Multi-Use Paths Design Criteria

Minimum Centerline Radius for a Horizontal Curve	45 feet
Minimum Design Speed	12 mph
Vertical Curves	
Max. algebraic difference without a vertical curve	5.15 %
Minimum distance between vertical curves	50 feet
Profile Grades	
Minimum	0.6 %
Preferred	5.0 %
Maximum	8.0 %
Pavement Width	
Minimum Width	8.0 feet
Required Width (remote location)	10.0 feet
Concrete Residential Multi-use path	6.0 feet
Cross Slope	1.56 %
Vertical Clearance	
Minimum	8.5 feet
Preferred Minimum	10.0 feet
Clear zone from fixed objects	3.0 feet
Pavement Composition	
448 Asphalt Surface Course	1.5 inches
448 Asphalt Intermediate Course	1.5 inches
304 Aggregate Base	6.0 inches
1540 Rejuvenator Agent	0.10 gallons per sq. yard

Chapter 8: Traffic Impact Study (TIS) Standards

1. Purpose

   The primary objectives of TIS are the following:

   A. Provide a basis for assessing the transportation impacts of a new development or expansion of an existing development and the need for any improvements to the adjacent road system to provide satisfactory levels of service and address safety issues.

   B. Address relevant transportation issues associated with development proposals that may be of concern to neighboring residents, businesses, and property owners.

   C. Determine the appropriate location, spacing, and design of the access system for the proposed development in compliance with City standards and sound engineering judgment.

   D. Evaluate the internal circulation and connectivity of the proposed development to provide safe and efficient internal traffic flow and access(es) to and from the adjacent and nearby roadway system.

   E. Ensure compliance with the most current edition of the City of Delaware Transportation Plan.

   F. Provide a basis for improvement and funding discussions in conjunction with zoning, special permit, and subdivision plat approvals

2. Traffic Impact Study Warrants

   A traffic impact study shall be submitted when a new development or expansion of an existing development generates greater than 100 trip ends during the peak hour of the land use or the peak hour of the roadway. These trip ends are to be calculated using the latest Institute of Traffic Engineers (ITE) trip generation methodology and definitions. If the proposed development is to be implemented in phases, each major phase along with the total development trips shall be calculated for warrant purposes. The table below serves as a guideline to determine the minimum size of typical developments which would require a traffic impact study.

Table 1Guidelines for the Minimum Size of Typical Land Uses

Requiring a Traffic Impact Study*

ITE Land Use Code	Land Use	Size
210	Single Family Homes	100 DU
220	Apartments	150 DU
230	Residential Condominiums/Townhomes	200 DU
710	General Office	50,000 sf gfa
820	Shopping Center	all
832	High Turnover, Sit Down Restaurant	all
834	Fast Food Restaurant with Drive-Thru Window	all
845	Service Station with Convenience Market	all
850	Supermarket	all

* Actual requirement is based on trip ends greater than 100 during the peak hour of the land use or the roadway.

Traffic impact studies may also be required for the following situations unless in the opinion of a qualified traffic engineer, the development will generate less than 100 trips in the peak hour of the land use or the peak hour of the roadway:

A. All developments which are not addressed in the latest ITE Trip Generation Report
B. Mixed use developments
C. Proposed development and redevelopment at locations where the existing roadway network already functions at an unacceptable level of service.

The City of Delaware retains the right to request a TIS or other traffic study for a non-major development (less than 100 trip ends during the peak hour of the land use or roadway). Such a request shall be made within 30 days of the receipt by the City of the developer's application for rezoning, zoning variance, special permit, or preliminary subdivision plat.

The City shall be consulted to determine if a revised or new traffic impact study is required where development plans change significantly between the time that one rezoning, zoning variance, special permit, or preliminary subdivision plat approval is granted and another is sought.

3. TIS Preparer Qualifications

Engineers with specific training in traffic and transportation engineering shall prepare traffic impact studies under the supervision of a professional engineer registered in the State of Ohio. The registered professional engineer shall have experience in traffic engineering and shall sign and seal the report.

4. Methodology Meeting

Prior to commencing the TIS, the preparer shall schedule a meeting with appropriate city staff. Other participants in this pre-meeting may be Delaware County or ODOT staff, where deemed appropriate by City of Delaware personnel. The participants at the pre-meeting shall identify and agree upon the following issues and needs prior to the preparation of the traffic impact study:

A. Study Area
B. Opening and Design Year
C. Field data collection requirements
D. Acceptable volume, accident, signal and other traffic data
E. Development phasing, if applicable
F. Peak traffic hours (analysis hours)
G. Trip generation, trip distribution and assignment methods
H. Applicable planning documents
I. Other traffic impact studies prepared for developments in the study area
J. Utilization of MORPC Regional Transportation Model
K. Background traffic and growth factors
L. Acceptable Level-of-Service (LOS)
M. Analyses – i.e., capacity, signal warrant
N. Safety issues – i.e., sight distance and accident data
O. Existing geometrical issues
P. Committed and planned roadway improvements and schedule

Q. Existing Environmental issues that could affect roadway alignment
R. TIS submittal date

The preparer shall submit a Memorandum of Understanding (MOU) which details the assumptions and methodologies agreed upon in the pre-meeting and request City staff concurrence with its contents. The MOU shall be submitted to the City within one week after the meeting and shall be approved within one additional week.

5. Requirements
   A. Study Area: The minimum geographical area to be analyzed in the TIS shall be defined as an area which includes all site access drives and the major roadway intersections nearest to the subject development site. The City of Delaware retains the right to modify the minimum study area based on local or site-specific issues or development size. Any changes shall be clearly defined at the pre-meeting and in the MOU.

   B. Access Management: Unless otherwise justified, the recommendations made in the TIS shall comply with the standards and specifications contained in the:
      1. ODOT State Highway Access Manual for State Highways
      2. Access Management Standards set forth by the City of Delaware
      3. The City of Delaware South East Area Transportation Improvement Plan
      4. The City of Delaware South West Access Management Plan (Industrial Park)
      5. The Delaware County Thoroughfare Plan
      6. The ODOT District 6 Delaware US 23 Access Management Plan
      7. And any related, applicable transportation plans

   C. Design Year

Table 8-2: Vehicle Trips vs. TIS Design Year

Vehicle Trip Ends in the Peak Hour of the Proposed Development	TIS Design Year
100 but less than 400	10 years from the planned build-out of the development
400 or greater	20 years from the planned build-out of the development

Note**:** The planned build-out date is to be used as the default condition. Opening day may be used at the discretion of the City on a case-by-case basis.

   D. Existing Conditions: The TIS shall examine existing conditions using Synchro™ software and level-of-service (LOS) using traffic count data less than one year old unless otherwise agreed upon during the pre-meeting.

E. No Build/Build: The TIS shall examine "before and after", or No Build and Build, conditions in order to evaluate traffic impacts associated with the proposed development. No Build and Build conditions shall be calculated for the opening year and for the design year using the latest version of Synchro® Software from Trafficware® Ltd., based on the procedures of the most recent version of the *Highway Capacity Manual, TRB Special Report #209*. If the proposed development is to be implemented in phases, each major phase shall be analyzed and the conditions noted in the MOU.

F. Analysis Time Period - All analyses shall examine the weekday peak traffic hours of the adjacent roadway. However, land use classifications which experience their highest trip generation levels during periods other than weekday street peak hours shall require analyses of off peak conditions to determine proper site access and turn lane storage requirements. Examples of such land uses include but are not limited to shopping centers, discount stores, recreational uses, and special events. The peak traffic hours to be analyzed shall be decided at the pre-meeting and be clearly stated in the MOU.

G. Site Traffic - Trips generated by the proposed site development shall be calculated using the most current edition of the Institute of Transportation Engineers (ITE) *Trip Generation* manual and the methodologies contained therein including those relating to pass-by, internal and diverted trips. The engineer is cautioned not to automatically assume the least value assigned to any specific trip generation category.

   Distribution and assignment of the site traffic shall be based on the method agreed upon at the pre-meeting and on engineering judgment and take into account the following:

   1. Type of proposed development and the area from which it will attract traffic
   2. Size of the proposed development
   3. Surrounding land uses, employment centers, residential centers and population during both opening and design years
   4. Conditions on the surrounding street system
   5. Logical routings
   6. Projected roadway capacities
   7. Travel times

H. Non-site Traffic - All significant developments within the study area that have approved or TIS studies should be identified and incorporated into the study. The land use type and magnitude of probable future developments should be identified during the pre-meeting and enumerated in the MOU. The method of projecting non-site traffic shall depend upon the area of study. Use of the traffic volumes from the transportation model, historic growth rates, or the buildup method shall be agreed upon during the pre-meeting and documented in the MOU.

I. Level-of-Service (LOS) Criteria: It is the goal of the City of Delaware to maintain a LOS C or better for the 24-hour period and LOS D or better during peak traffic hours for the operation of all roadways. In any area where the current level of service is C or worse for a 24-hour period or D or worse during peak traffic hours, this baseline level of service must be maintained or improved after development.

J. Mitigation: Recommendations shall be made in the TIS for site access points, external roadway improvements such as additional through lanes and turn lanes, and traffic

control devices necessitated as a result of the proposed development. The developer will be required to mitigate the impacts of traffic generated by the project. The time period for the recommended improvements shall be identified, particularly if improvements are associated with various phases of the development. Identified improvements to the roadway system, unrelated to the proposed development, shall also be reported.

K. Traffic Signal Warrant: Traffic signal warrant analyses shall be conducted at un-signalized intersections in the study area for Opening Day and the Design Year and at all multi-movement access points to the proposed development. A full signal warrant analysis and an estimation of the year the warrant is met shall be done if the main site access appears to meet Traffic Signal Warrant 1 or Warrant 2 based on the guidelines in Table 11. Any proposed access or intersection which meets signal warrant thresholds but does not otherwise meet the spacing requirements and standards noted in the ODOT *State Highway Access Management Manual* for the access category assigned by the City of Delaware Transportation Plan may be required to be redesigned, reconstructed, and/or relocated.

Table 8-3: Signal Warrants

WARRANT 1 – Minimum Vehicular Volume*			
NUMBER OF APPROACH LANES		ADT	
MAJOR	MINOR	MINOR	MAJOR
1	1	8,300	5,000
2	1	10,000	5,000
2	2	10,000	6,700
1	2	8,300	6,700
WARRANT 1 – Interruption of Continuous Traffic*			
NUMBER OF APPROACH LANES		ADT	
MAJOR	MINOR	MINOR	MAJOR
1	1	12,500	2,500
2	1	15,000	2,500
2	2	15,000	3,000
1	2	12,500	3,000

* When the 85th percentile speed of major street traffic exceeds 40 mph in either an urban or rural area, or when the intersection lies within the built up area of an isolated community having a population of less than 10,000, the warrants are 70 percent of the guidelines above.

Warrants 3 through 8 may be required to be analyzed on a case-by-case basis at the discretion of the City. If a signal is warranted it may not be permitted if it conflicts with the City of Delaware Transportation Plan.

The City reserves the right to require access limitations to offset the warrant if adequate signal spacing cannot be accomplished. Conversely, the City may approve a signal where it is technically not warranted if it is in the public's best interest, is needed from a practical standpoint, and is justified by sound engineering judgment.

L. Turn Lane Criteria

1. A left turn lane at driveways or unsignalized movements at intersections should be provided under the following conditions:
    a. Per Graph 1, 2, or 3, which are the left turn lane warrant charts contained in the ODOT Location and Design Manual, Volume I.
    b. On major and minor arterial roadways with posted speed limits greater than 40 mph
    c. On major collector roadways with posted speed limits greater than 40 mph and more than 10 left turning vehicles during the peak hour for full build out of the development
    d. The size of left turn lanes shall be the minimum per based on the criteria contained in this Manual and/or the ODOT Location and Design Manual, Volume I, Section 400.

2. Right turn lanes should be provided:
    a. Per Graphs 4, 5, 6 or 7, which are the right turn lane warrant charts contained in the ODOT State Highway Access Management Manual
    b. Are not required for right turn volumes less than 10 vehicles during the peak hour for full build out of the development
    c. Are not required for less than 200 vehicles in the peak hour in the approach lane or curb lane for roadways with greater than 1 approach lane for full build out of the development.

Left or right turn lanes shall also be required when deemed necessary for safety as determined by the City of Delaware.

6. Report Contents: Each TIS shall have, along with the body of the report, the following unless a letter report is agreed upon at the pre-meeting:

A. Cover: Noting the name and location of the development, the applicant's name, preparer's name, and report date.
B. Title Page: Containing all information on the cover in addition to the applicant's street and email address, telephone and fax numbers; the preparer's street and email address, telephone and fax numbers and the preparer's signature and seal.
C. Table of Contents
D. List of Exhibits and Tables
E. Executive Summary
F. Summary of Revisions (for revised reports)
G. Body of Report
H. Proposed Site Development
I. Area Conditions
J. Existing Traffic
K. Trip Generation and Distribution
L. Site Traffic
M. Total Traffic – Opening Year and Design Year

N. Traffic Analyses
O. Capacity Analyses
P. Signal Warrant Analyses
Q. Turn Lane Warrant Analyses
R. Sight Distance
S. Accident Analyses
T. Conclusions
U. Recommendations – including the identification of responsibility for all recommended improvements
V. Appendix: The following figures and tables shall be included in the body of the report: The following illustrations or tables shall be included in the body of the report:
    1. Location Map
    2. Site Layout Map
    3. Site Trip Generation Factors and Volumes Table
    4. Site Traffic Distribution by Percent Map
    5. Existing Traffic Volumes Map
    6. Opening Year Traffic Volumes Map – use A + B + C + D = Total diagram where A is opening year background traffic, B is other site traffic (if applicable), C is site pass by traffic, D is site traffic
    7. Design Year Traffic Volumes Map – use A + B + C + D = Total diagram where A is design year background traffic, B is other site traffic (if applicable), C is site pass by traffic, D is site traffic
    8. Existing and Projected LOS Table
    9. Preliminary Site Plan Map - showing recommended improvements, both sides of streets and extending 1000 feet beyond the site.

7. Submittal

Two copies of the TIS shall be submitted to the City of Delaware Department of Engineering Services at the time of filing an application for zoning or rezoning. If zoning is already in place, the TIS shall be submitted to the Assistant City Engineer – Development at the time of application for Preliminary Plat approval or at the time of application for a Preliminary Development Plan, whichever occurs first.

It is the COD's goal to review and respond within 6 – 8 weeks of the submittal date of a TIS that is formatted in an acceptable manner to the Department. Upon review, if the document is deemed inadequate, the applicant shall be notified in writing and shall have an opportunity to correct the deficiencies and resubmit the report. Upon approval, two paper copies and one digital copy (including all Synchro® files) of the final TIS shall be provided.

8. Signal Warrant Figures:

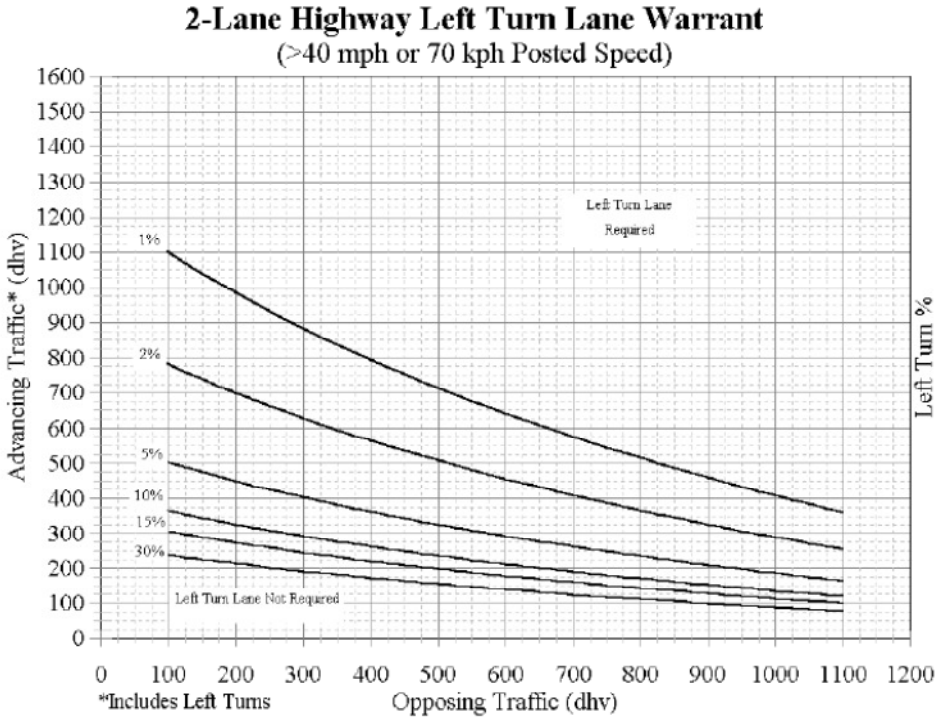


Figure 8-1: 2-Lane Highway Left Turn Warrant (> 40 mph)

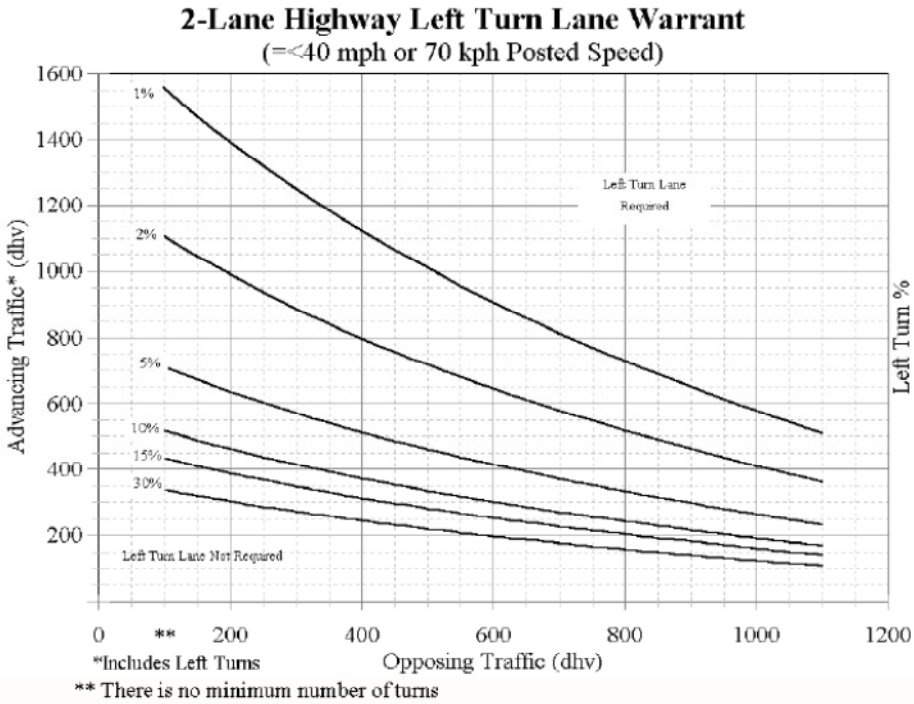


Figure 8-2: 2-Lane Highway Left Turn Warrant (< 40 mph)

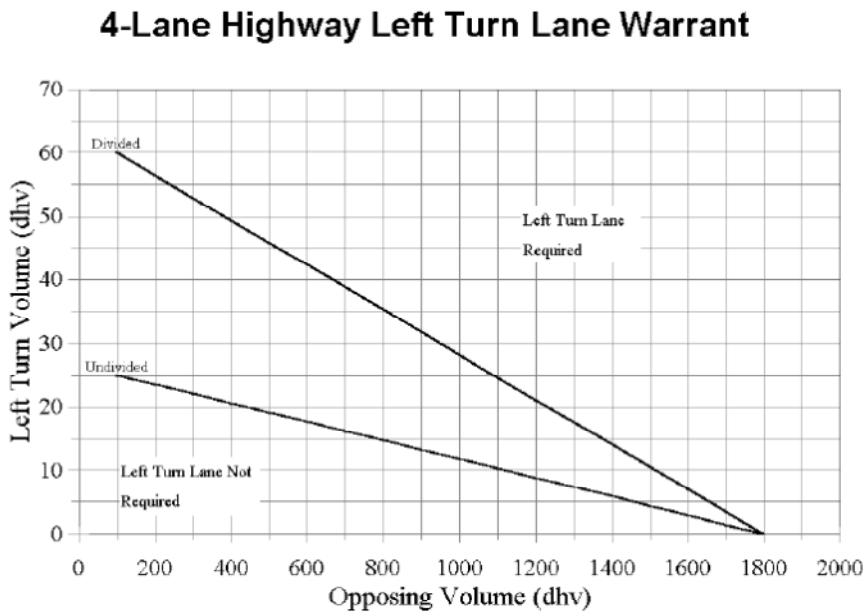


Figure 8-3: 4-Lane Highway Left Turn Warrant

Figure 8.-4-Lane Highway Right Turn Lane Warrant (<40 mph**)**

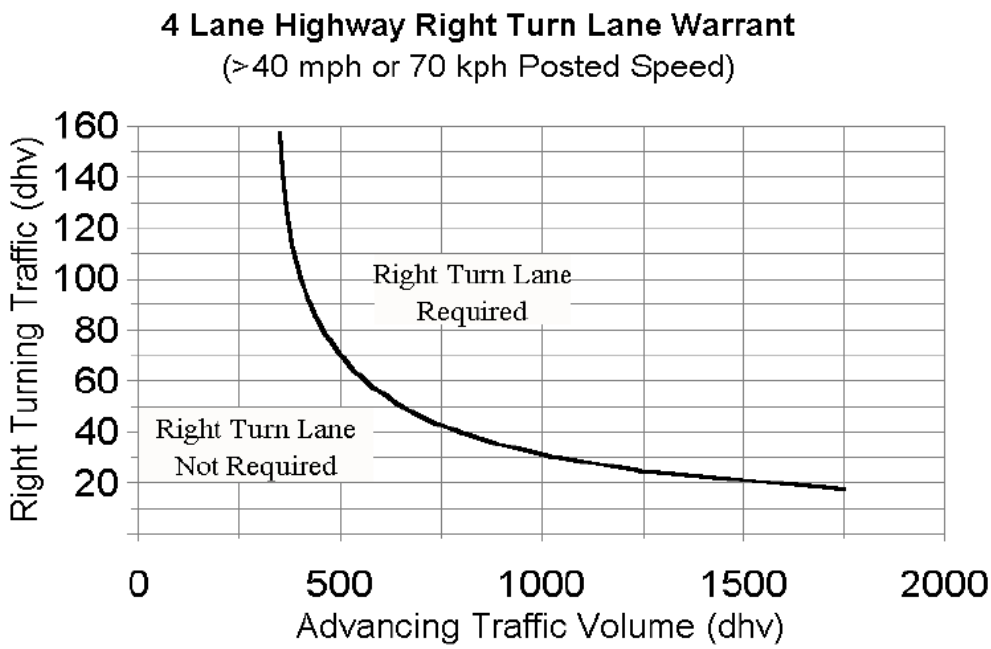


Figure 8-5: 4 Lane Highway Right Turn (>40 mph)

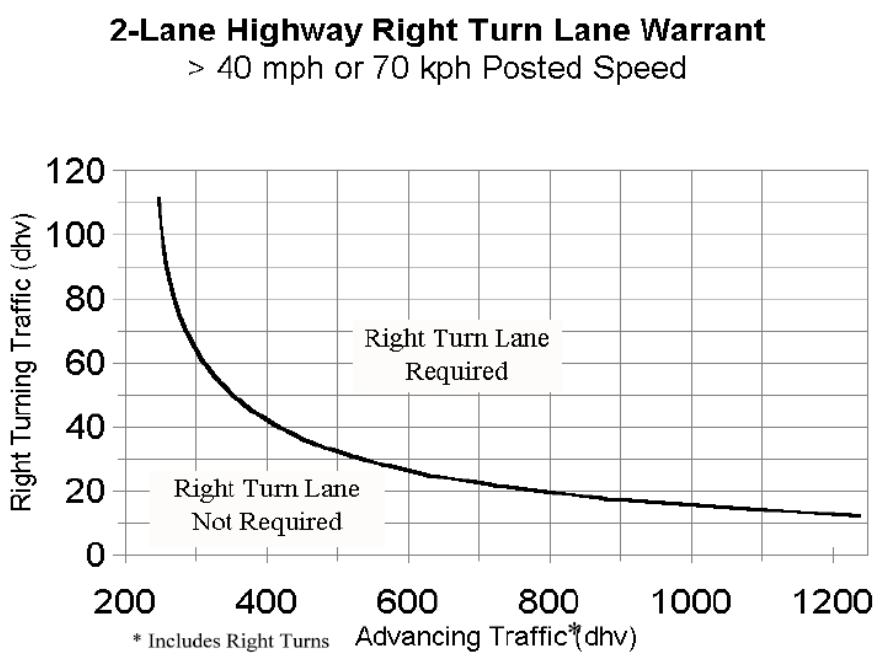


Figure 1-6: 2-Lane Highway Right Turn Warrant (> 40 mph)

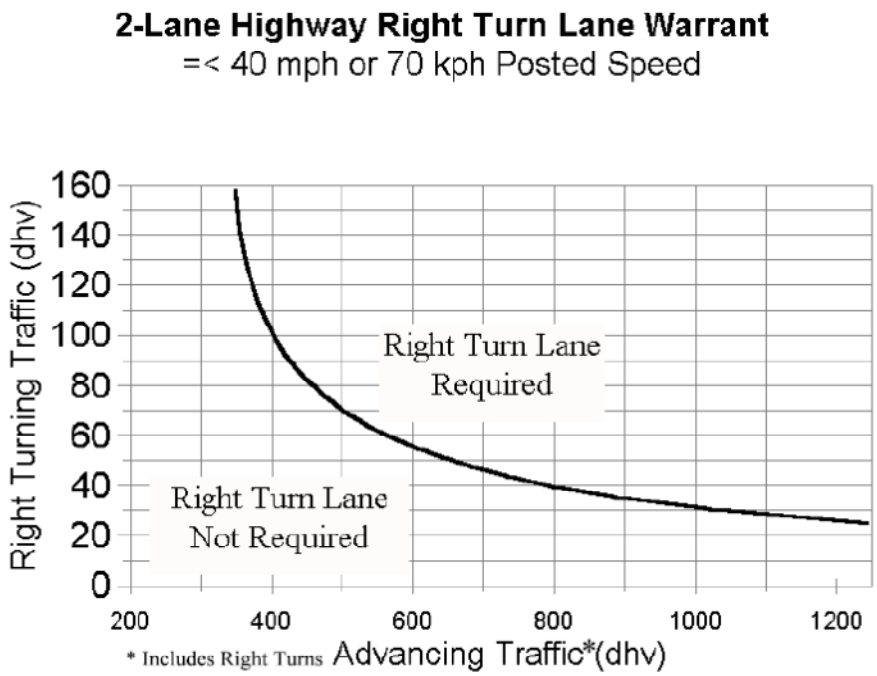


Figure 8-7: 2-Lane Highway Right Turn Warrant (< 40 mph)

Chapter 9: Access Management Guidelines

1. Purpose

The primary objective of establishing access management guidelines is to expedite the movement of traffic. This is achieved by clearly identifying access points, providing connections between adjacent properties to reduce trips on the through streets, reducing delay by minimizing the number of conflict points between opposing traffic flows, and separating turning movements from through movements wherever necessary and practicable. Successful application of access management techniques create a corridor with a uniform driving environment which improves traffic safety by providing sufficient sight distance and time to react to potential hazards. It also provides property owners and developers access to their site that is as quick, convenient, and reasonable as possible for the property owner's approved use.

Emphasis is on prevention, although correction of some existing conditions can be remedied as the use of a property changes. Such changes happen slowly but can be an essential part of a long-term plan for any community. If access points are allowed to occur at random along a roadway with little or no thought given to proper design or long term effects, it will be very costly, perhaps impossible to correct the situation once development along the corridor is complete. Sometimes, existing conditions can be corrected if a proposal to modify or otherwise redevelop a property is submitted to the City for consideration and approval. The City will consider each case individually and work closely with the property owners to improve access control while maintaining a viable development site for the owner. It should be noted that access management guidelines are not a solution to all traffic problems and do not negate the need for road widening or other geometric improvements.

2. Access Management Categories

There are five access management categories based on the functional classifications of roadways. Each classification defines the degree of mobility for motor vehicle traffic versus recommended access limitations to adjacent properties. The difference in the classifications demonstrates the relationship between the need to control property access and the management of adequate traffic flow. Access management guidelines should be applied to all roadways within the City as reasonably and practically as feasible. If it becomes apparent due to existing or future conditions that a particular roadway, or section of roadway, will be unable to attain the specifications for its assigned access management category, the City may assign a more applicable access management category or provide a site specific access plan.

There remains some difficulty in applying the access management guidelines to the central business district in downtown Delaware. Although the existing access conditions may be deficient according to current guidelines, the "Main Street" facilities in the fully developed urban areas should not have their access category changed. Such routes should have their access treatment accepted of "grandfathered" because upgrading would be disruptive to the local economy, downtown culture, and too costly to justify.

Access Category Description and General Guidelines		
Category	Characteristics	Guidelines
I	High speed (>50 MPH) and volume arterial freeways primarily utilized by interregional and interstate traffic.	Multi-lane facilities, some with medians; controlled access at interchanges; no direct property access permitted.
II	High speed (45-50MPH) and volume major arterials that primarily carry intercity, interregional and interstate traffic through the city while providing access to properties.	Access points limited to connecting streets at interchanges or public street intersections; Signals at public intersections to be coordinated to minimize through traffic delay; no direct private access permitted unless there are no reasonable alternative means to access property and then access may be restricted to RiRo.
III	Moderate to high speed (35-45MPH) and volume major and minor arterials, and collectors that primarily provide access to business and commercial properties and/or while carrying through traffic for moderate to longer distances through the city.	General provision is to provide one private access point for each parcel unless it can be shown that additional access points are necessary and would not be detrimental to the safety and operation of the roadway. Access may be restricted to right-in/right-out (Ri-Ro) where traffic conditions on abutting street pose substantial risk, congestion or delay in permitting a conflicting traffic movements or turns. Consideration to be given to provide access off side street connections and controlled intersection points. Full access may require provision of left turn lanes to minimize delay and improve safety on through street.
IV	Low to moderate speed (25-35MPH) and volume collector streets providing access to primarily residential areas with a mix of business uses, and carrying through traffic for short to moderate distances.	General provision is to provide one private access point for each parcel unless it can be shown that additional access points are necessary and would not be detrimental to the safety and operation of the roadway. Access points/driveways may be restricted away from intersecting higher classification streets and should be at least 150ft from street intersections to accommodate minimum vehicle reaction and stopping distances.
V	Low speed (25 MPH) and volume minor collector and local streets serving primarily residential areas, where speed limits are 25 MPH with little benefit to providing higher speed of travel.	Provide reasonable and safe direct access to all properties. Driveways should avoid alignment with utility structures, be spaced away from adjacent driveways and at least 100ft from street intersections to accommodate minimum vehicle reaction and stopping distances.

3. Number of Access Points

Each existing tract of land is entitled to one direct or indirect access point to the public roadway network provided the location and design meet the sight distance and design requirements of the City standards. Properties should not be denied all access to the public street system without appropriate compensation for loss in property value. Additional access points are approved on an individual case basis and only when it can be demonstrated that the access point will not adversely affect the capacity or safety of the roadway. In some cases, access points to a property may be restricted to right-in/right-out, left-in only, no left out etc. based on the condition of traffic volumes, speeds, pavement width, and available turn lanes to accommodate traffic ingress and egress movements.

4. Consolidation and Modification of Existing Access Points

Whenever the use of a parcel of land changes, is modified or otherwise upgraded, or where two or more parcels of land are assembled under one purpose, plan, entity, or usage, the existing driveway access becomes subject to review and approval against the current access category guidelines. Access to the modified or improved site should be based upon the developer/owner's plans to use one or more of the existing access points, and/or to close and relocate driveway access. Access points may have to be relocated or restricted based upon changes in traffic conditions of the adjacent street network that may not have posed the same concerns when the original development was initially constructed. In all cases, redeveloped properties shall start with the requirement of permitting a single access point for the property, with additional access points allowable if they can be shown that they are necessary and would not be detrimental to the safety and operation of the roadway.

5. Coordination of Access Points

Access points on opposite sides of category II, III or IV roadways shall be aligned with each other. Access points on opposing sides of a street that do not align may have turning movement restrictions imposed upon them as determined necessary, to maintain the safety and efficient operation of the street network. Access points and driveways shall be designed, located, and constructed in a manner to provide for the coordination of access between adjacent properties for current and future development. In some cases, shared or common access drives may be required to minimize impact to the roadway. Access connections between adjacent properties in the form of parking lot connectors, frontage or service roads shall also be considered to improve internal access with minimal disruption to through traffic flows along the adjacent public street network.

6. Temporary Access Points

In some circumstances, due to phased development or future roadway improvement plans, it is possible to permit an access point with a design or location which will ultimately interfere with the operation of traffic on the through street or is otherwise not in compliance with the access management guidelines, but for now remains the best practical alternative. Such access points must be designated as "Temporary" on all approved plans and documents relating to the development. Plans must also be submitted and approved by the City that address the timing, means, and responsibility associated with the eventual abandonment of the temporary access point and construction of the permanent access point, before the temporary access point is approved.

7. Minimum Driveway and Unsignalized Intersection Spacing

To minimize the potential for accidents and delay to through traffic, access points to businesses, and low volume unsignalized intersections on category II and III roadways should be separated by the minimum distance measured from the nearest edge of adjacent driveways as shown, and in accordance with the posted speed limit. Spacing of driveways between intersections should be as uniform as possible.

Minimum Driveway and Intersection Spacing for Access Management Category II & III	
Posted Speed Limit (MPH)	Minimum Driveway Spacing (Ft)
25	150
30	200
35	250
40	325
45	495
50	550
55	605

8. Minimum Signalized Intersection Spacing

Preserving the quality of traffic flow and safety requires the spacing of signals that assures the continuous, progressive movement of traffic. Uniform, or near uniform spacing is required for the most efficient flow of traffic. The optimal spacing of signals depends on the cycle length and posted speeds. Long cycle lengths combined with high speeds require long distances between signals, while shorter cycle lengths and lower speeds require closer signal spacing. The need for a signal shall be determined by a warrant analysis using the OMUTCD and conducted by a qualified traffic engineer.

Minimum Signalized Intersection Spacing for Access Management Category I, II, III			
	I	II	III & IV
Preferred Spacing	At grade intersections not permitted	1 mile	1 mile
Acceptable Spacing		½ mile	½ mile
Minimum Spacing		½ mile	¼ mile

9. Street Listing by Access Management Category

Category I - Major Arterial Streets
US23 (Cottswold Dr. to Pennsylvania Ave.)
US42 (London Road to US23)

Category II - Major Arterial Streets
US23 not included in Category 1
US36 (East of The Point)
US36 (West of Applegate)
SR37 (West of Lexington Blvd.)
SR521
Glenn Parkway
Sawmill Parkway

Category III - Major Arterial Streets
Central Avenue (SR37)
Lake Street (US42)
Sandusky Street
William Street (US36)

Category III - Minor Arterial Streets
Belle Ave
Cheshire Road
Hills Miller Road
Houk Road
Liberty Road
Liberty Street
London Road
Pennsylvania Avenue
Pittsburg Drive
Stratford Road
Troy Road

Category III - Collector Streets
Berlin Station Road
Bowtown Road
Braumiller Road
Curtis Street
Curve Road
Henry Street
Merrick Blvd.
Mill Run Crossing

Category III - Collector Streets (Cont.)
Nutter farms Lane
Ohio Health Blvd.
Olentangy Street
Peachblow Road
Slack Road
Warrensburg Road

Category IV - Collector Streets
Buehler Drive
Carson Farms Blvd.
Cheshire Street
Cobblestone Drive
Elizabeth Street
Euclid Avenue
Executive Blvd
Ferguson Drive
Firestone Drive
Fountain Avenue
Franklin Street
Hawthorne Drive
Hayes Street
Heffner Street
Hull Drive
Grand Circuit Blvd.
Lantern Chase Drive
Lexington Blvd
Lincoln Avenue
Locust Curve Drive
New Market Drive
North Street
Park Avenue
Pollock Road
Rockcreek Drive
Union Street
Washington Street
Winter Street

Category V Local Streets (All other streets not listed)

Chapter 10: Traffic Calming

1. Purpose

Traffic calming sometimes referred to as neighborhood Traffic Management, is not a new concept in the field of transportation engineering. Traffic calming responds to public concerns about speeding and cut-through traffic on neighborhood streets. The Institute of Transportation Engineers (ITE) has defined traffic calming accordingly:

"*Traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users*."

Motorists tend to drive faster when they feel the risk of doing so is minimal, such as along wide pavements with unobstructed views of intersections, driveways, and of pedestrians. When motorists have an increased sense of control, vehicle speeds are generally higher, regardless of posted speed limit. Streets without parking on one or both sides instill this feeling of reduced risk and increased control, and often result in higher average speeds than similar width streets with parking. When installed, traffic calming measures generally necessitate a heightened sense for driver awareness due to the perceived or actual increase in risk resulting from posted warning signs, pavement markings, or physical obstructions in the pavement, all of which can lead to some level of reduced speed.

Like Delaware, many communities stress the importance of providing adequate pavement width to allow for parking on both sides of residential streets, while still maintaining sufficient pavement width for the provision of city services including refuse collection, snow plowing and emergency response vehicles. Current residential development practices typically include homes with driveways and attached garages, leading to a reduced demand for on-street parking. As a result, local streets often have long sections of open pavement whereby motorists are comfortable driving above the speed limit. The majority of speeding complaints received are initiated from residential neighborhoods and in regards to local or collector streets.

It is important to address speeding issues as higher vehicle speeds lead to reduced safety for other motorists, cyclists, and pedestrians. The intent of traffic calming is to reduce the speed and volume of traffic to levels acceptable for the functional class of street and the nature of the bordering activity. Traffic calming measures are meant to be self-enforcing as opposed to traffic control devices such as stop signs and speed limit signs, which are regulatory and require enforcement. However, recent research has shown that the introduction of altered regulatory signage such as additional stop signs and reduced speed limits are typically well received by bordering property owners and reduce the perception of speeding issues as well. Additional research has further shown that introducing passive measures such as pavement markings that narrow travel lanes, or that require minor shifts in direction of vehicle travel, can be effective in reducing vehicle speeds.

The following benefits can be realized through the appropriate implementation of traffic calming measures:

- Reduced speeds for motor vehicles
- Reduce collision frequency and severity
- Increase safety and perception of safety for non-motorized users of the street
- Reduce need for police enforcement
- Enhanced neighborhood environment
- Increase access for all modes of transportation
- Reduce cut-through motor vehicle traffic

2. Traffic Calming Measures

The following is a list of traffic calming measures which may be considered singly, or in combination to address neighborhood speeding issues:

Self-Enforcing Measures:

- Speed Tables
- Raised Intersections
- Diverter Islands
- Choker (Bump outs)/Intersection Narrowing
- Travel lane Chicaning
- One Way Designation
- Closure to Through Traffic
- Permissible Parking on both sides of street

Regulatory Measures:

- Neighborhood Speed Watch Programs
- Speeding Enforcement
- Multi-Way Stop Signs
- Mid-Block Pedestrian Crossings
- Enhanced Pedestrian Crossings

A traffic calming method or combination of methods is best selected based on the results of a traffic study and engineering judgment. The purpose of the traffic study is to identify the existence, nature and extent of a traffic condition correctable through traffic calming. Determination of study area boundaries also assists in notification of residents and businesses that may be impacted by installation of a traffic calming method. The results of the traffic study identify the best traffic calming options for a study area. Ultimately, the residents of the study area must decide whether a traffic problem warrants the installation of traffic calming measures on their community street as such measure will impact their daily access as well.

3. Pre-Qualification for Calming Measures

The basic premise of the City of Delaware Traffic Calming Program is for City staff to assist, coordinate and facilitate the efforts of neighborhoods in implementing traffic calming plans. The approach to neighborhood traffic calming can be both reactive – in response to neighborhood complaints, and proactive – initiated by the City. In either case, the consideration and implementation process for traffic calming is similar and involves considerable consensus building in the community. Traffic calming devices are suitable in residential areas to manage speeds. Therefore, characteristics of the streets should be residential in nature. The street pre-qualifications are designed to ensure that the street segment is appropriate for considering traffic calming. Since there can be negative impacts associated with the implementation of certain traffic calming devices, some restrictions, in the interest of emergency and transit services, have been added to the list of pre-qualifications.

Streets pre-qualified for traffic calming must meet the following criteria:

- The street has a posted speed limit of 25 mph.
- The street is classified as a local, or neighborhood collector street.
- The 85th percentile speed is at least 5 MPH over the posted limit.
- The street has an ADT< 3500 vehicles per day.
- The street is not a cul-de-sac street.
- The street is not a primary emergency response route.

Enhanced pedestrian crossings may be considered on streets with higher functional classification and speed limit pending validation of a verifiable reoccurring safety issue involving pedestrian movements. Enhanced crossings should be limited to locations subject to high pedestrian activity, or along routes subject to school age children or elderly pedestrians requiring additional consideration when crossing a street. Pedestrian activated enhancement signage should only be considered at locations away from signalized and stop sign controlled intersections, and only after the installation of static enhancements, including pavement markings and advance warning signage, fails to modify driver behavior.

4. Neighborhood Petition Process

Following an initial request for traffic calming by an individual or neighborhood group, City staff will review the situation in the field to verify the presence of the safety issue as described. City staff will then establish a study area based on the information obtained during the preliminary request and review. This area is generally defined as those households and businesses fronting the affected segments of the project street. In the case of a single intersection request, the minimum area would be one block in all directions. The purpose of establishing a study area is to determine the level of agreement among area residents concerning the need for introducing traffic calming measures into their respective neighborhood.

City staff will prepare a petition describing the problem and the procedures to be followed if a traffic calming study is to be undertaken. The project requestor(s) is responsible for circulating the petition to all residents within the study area. Signatures representing seventy-five percent (75%) of the households and addresses located along the primary street within the defined study area, and fifty percent (50%) on affected connecting streets are required to move the project forward. This includes, but not limited to, businesses and schools. Each household, address, business, school, etc. is entitled to one signature. Non-resident property owners are not included in the petition-to-study process. However, non-resident property owners are notified concerning the project request to allow them to give input on the project.

5. Traffic Speed Study and Analysis

If the petition is returned with the majority of the homeowners in favor of traffic calming, the City will perform a comprehensive speed study and traffic analysis of the identified area. The study will include the collection of speed data, vehicle volumes, turning movements, determination of cut through traffic volumes, accident history, pedestrian crossing counts, and roadway condition and configuration geometrics.

The City will review the collected data to identify specific issues leading to excessive vehicle speeds, or the perception of speeding, and make a determination as to what calming measure(s) could be effective in addressing the issues. The request to install calming measures is reviewed by several City departments to identify the potential negative impacts associated with the installation of calming measures. Consideration is given to the impacts on the provision of emergency services, city refuse collection, highway maintenance, and snow removal operations. Additional consideration is given to the impact of traffic calming measures upon institutions such as local schools, hospitals and emergency care facilities. A final recommendation will be prepared by staff that summarizes the benefits and impacts of installing certain calming measures as requested.

6. Review and Approval of Calming Measures

The final staff recommendation is presented to the Parking & Safety Committee for further public discussion and consideration. The group initiating the request is invited to attend the meeting to present their concerns as well as to provide comments regarding the proposal as presented by staff. If the Parking & Safety Committee finds in favor of the proposed calming measures as presented by staff, or as modified by the Parking & Safety Commission, a recommendation is forwarded to City Council for final consideration and action. In cases where the traffic calming measures being proposed included the installation of regulatory signage, Council approval is required by Resolution before such measures can be installed.

Traffic Calming Measures - Comparative Effectiveness									
Calming Measure	Cost	Requires Regulatory Approvals	Impact on Reducing Speeding	Impact on Improving Intersection Safety	Improve Pedestrian Safety	Reduce Traffic Volume	Required Police Enforcement	Impedes EM Access	Notes
Speed Tables	High	No	High	Low	Low	Low	No	High	Not permitted on primary EM Routes
Raised Intersections	High	No	Mod	High	Mod	Low	No	High	Not permitted on primary EM Routes
Diverter Islands	High	No	Mod	High	Mod	Low	No	Mod	Not permitted on primary EM Routes
Curb Bump-out & chokers	Mod	No	Mod	Mod	Low	Low	No	Low	Parking prohibited in these areas
Chicane	Low	No	Mod	Low	Low	Low	No	Mod	Most effective with adjustments to curb line
One Way Designation	Low	Yes	High(1)	Low	Low	High	No	High	Requires development of alternate traffic routing plan
Closure to Through Traffic	Low	Yes	High(1)	Low	Low	High	No	High	Requires development of alternate traffic routing plan
Mid-Block Pedestrian Crossings	Low	Yes	Low	Low	High	Low	Yes	Low	For locations with high pedestrian volumes; along school routes; at non-signalized intersections
Enhanced Pedestrian Crossings	Mod	Yes	Low	Low	High	Low	Yes	Low	Limited to high risk crossing locations with reoccurring, observable problems.
Parking on Both Sides of Street	Low	No	Mod	Low	Low	Low	No	Low	Generally permitted on most streets except tight corners.
Multi-Way Stop Signs	Low	Yes	Mod	High	High(2)	Low	Yes	Low	For local streets only.
Neighborhood Speed Watch	Low	No	Mod	Low	Low	Low	Yes	Low	Requires substantial active neighborhood participation

Notes
(1) Assumes reduced traffic volume results in fewer number of speeding vehicles
(2) Improves pedestrian safety at stop controlled intersections

7. Design and Installation

The installation of certain calming measures can be expensive depending on the type and extent of installation recommended. Approval by the City for the installation of calming measures on a designated street or area does not guarantee funding of the measure by the City. Each request will be considered individually to identify the merits of the proposed installation in addressing safety concerns versus the estimated implementation costs. In some cases a calming measure may only require the installation of signage or pavement striping which can be completed by City staff at relatively low cost. However, other measures such as speed tables, deflector islands or curb bump-outs are costly and require design before installation. In each case, City Council will determine the level of City financial involvement in the process of designing and constructing a proposed calming measure. If the City is unable to fund part or any of a recommended traffic calming measure, area residents have the option of paying for the cost of the improvement directly or indirectly through property assessments.

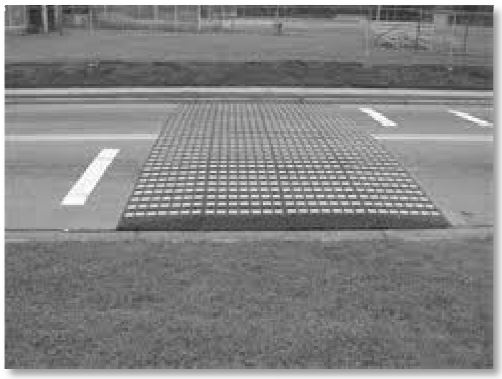
8. Review of Effectiveness and Removal

Following the installation of a particular traffic calming measure, the City will continue to monitor the study area to determine the level of effectiveness that a particular installation has on reducing vehicle speeding. In some cases, the impact on reducing vehicle speeding may be found to be negligible; However, a goal in the implementation of traffic calming can at times be measured by a neighborhood's perception that some level of success has been achieved. If following the installation of new calming measures, it is determined that the measures present a hazardous condition to the study area not previously identified during the review process, the City reserves the right to remove part or all of the calming measures to eliminate the hazard.

9. Traffic Calming Measures (Examples)

The following traffic calming measures are shown to provide some visual context pertaining to the layout and/or operation of individual measures.

Speed tables, more commonly referred to as speed bumps, provide an effective means to slow the majority of traffic to 25 MPH along a street section when installed in groups. Speed tables do result in an increase in noise from older vehicles, or vehicles carrying loads that rattle when negotiating the table. Emergency vehicles must also reduce speed to negotiate the tables and thus result in a minor increase in response times (3 seconds per hump).



Raised intersection islands, used in some Central Ohio Communities, are an effective means to slow traffic on through streets at intersections and along routes that carry significant pass-thru traffic in residential areas. The islands include appropriate pavement markings to warn drivers to slow while travelling over the island. Emergency response vehicles as well as snow removal operations are impacted by the islands.

Diverter Islands force motorists to slow and change course on thru-streets when passing through an intersection. The islands should be landscaped and appropriately signed to increase visibility to motorist. The islands do increase the difficulty for motorists making left turns, especially for larger trucks. Emergency response vehicles, as well as snow removal operations, are impacted by the islands

Intersection curb bump-outs provide a physical and visual narrowing of the street at the intersections of thru-streets and result in slower vehicle speeds both approaching and moving through the intersections. They also increase pedestrian safety by reducing the length of the pedestrian crossing path. Snow removal operations can be impacted by the islands

Mid-block curb bump-outs provide a physical and visual narrowing of the street between intersections resulting in slower vehicle speeds. The islands established by introducing curb bump-outs can be utilized for enhanced landscaping to provide further visual impairment to thru-traffic. Parking is restricted at bump-out locations to maintain the minimum lane widths for two-way traffic at all times. Snow removal operations, are impacted by the islands

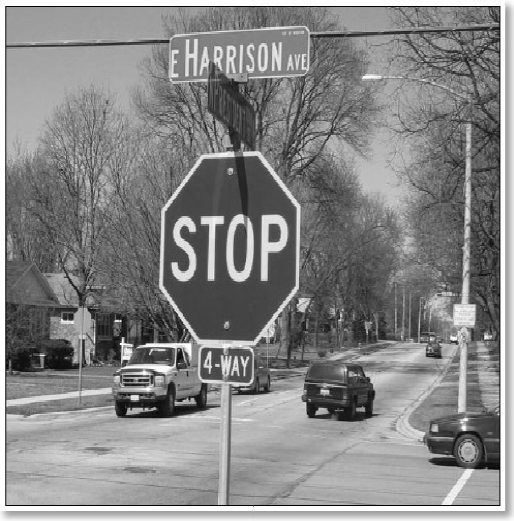
Pavement center and edge lines can be effectively and economically utilized to alter or narrow the appearance of the thru-lanes of a street. Motorists generally are more cautious when travelling along narrower streets and thus slow their speeds slightly. This application is best suited for streets where two lanes can be maintained with or without parking.

Pavement edge lines in combination with diverter islands visually and physically narrow the travel lanes of a street, and can be designed to force motorists to divert their direction of travel as they drive. Raised diverter islands though are subject to being hit by motorists not paying attention to changing roadway conditions, and require sufficient reflective signage to be maintained to minimize such occurrences.

Pavement markings that provide a visual restriction to motorists as to the available travel lane area effectively narrow the perceived travel lane width and can result in slower vehicle speeds. When implemented, it is important to identify the permissible uses of the striped area, and in many cases will require the installation of signage to identify such utility.

Lane Chicaning, introduced with pavement markings, provides a visual requirement for motorists to change direction of travel while travelling along a street. The perceived risk of having to follow the chicaning lane can result in some reduction in average vehicle speed. The same effect can be accomplished by constructing the curb line in a chicaning pattern.

Multi-way stop signs are utilized by many communities, generally at the insistence of neighborhood residents, as a means to slow traffic. Though stop signs are statutorily utilized to establish the right or way for motorists travelling in a particular direction at an intersection, the placement of multi-way stop signs does require traffic to stop in all directions. Research indicates that the installation of multi-way stop signs is not effective in reducing vehicle speeds between intersections and can also lead to motorist's tendencies to roll through the stop signs as the perceived risk from side street traffic interference can be very low. These should be limited to local streets applications.



Centerline crossing enhancement signage can be utilized to increase driver awareness of an increased presence of pedestrians at crossings located away from an intersection (mid-block), or at locations along a primary school walking route subject to a high volume of school age pedestrians. The use of these signs should be restricted to high pedestrian volume crossings to maintain effectiveness by remaining unique to the motorists. These signs are subject to vehicle collision as they are small, blend in with centerline striping, unlit, and difficult to see in the dark.

Pedestrian activated crossing signs provide real time warning to the motorists of the presence of a pedestrian entering or within a designated crossing. These applications though are expensive, relative to the cost of the typical enhanced pedestrian crossing signage and pavement markings. The use of these signs should be limited to locations away from signalized or stop controlled intersections; where a safety issue can be routinely observed; and where prior attempts to increase motorist awareness and address vehicle speeding have been unsuccessful.

Chapter 11: Traffic Signals

Traffic signals shall be designed in accordance with the current ODOT specifications, applicable ODOT standard drawings, and the following COD requirements. It is suggested that the ITE publication Traffic Access and Impact Studies for Site Development be used as a reference by TIS preparers.

1. Design Criteria

   The following concepts are to be considered in making engineering decisions in design and operation of traffic signal installations. Most of them are in addition to those of the Ohio Manual of Uniform Traffic Control Devices (OMUTCD). In any case, the intersection's condition must be taken into account as part of the decision-making process.

   A. Vehicular Signal Heads

      1. Size: Twelve (12) inch polycarbonate heads shall be used

      2. Number and Location:
         a. All signal head must be located a minimum of 40 feet and a maximum of 180 feet from the stop bar.
         b. A minimum number of two signal faces/heads for all approaches shall be provided. The final number of faces/heads will depend on the number of approach lanes: e.g. if two or three lanes exist, two heads may suffice; for four lanes, three heads; etc. The location of the faces/heads may either be on the lane lines or over the center of the lanes depending on the approach configuration.
         c. The signal faces/heads for any one approach must not be less than eight (8) feet apart measured horizontally between centers of faces/heads. The eight (8) feet is an absolute minimum; generally ten (10) feet should be used for minimum if at all possible.
         d. Arrows shall be used for protected movements only (not in conflict with any other signal indication including walk signals).
         e. Five section faces/heads should be used for leading left turn phases (protected/permissive). They shall be located on or to the right of the lane line between the left/right turn only lane and through lanes, except for split phase operation. In those instances where the lane is a through/left lane, the face/head location shall be on the lane line separation; it shall not be placed over the center of the lane.
         f. At T-intersections the perpendicular leg should use circular indications. If a field check shows potential problems due to background clutter or an accident analysis shows a problem with the movement, the larger, ground mount Arrow Warning Sign may be used. Overhead lane control signs or left and right arrow signal indications (as long as no signal conflicts occur) may be used if data shows a need for such control devices.

      3. Signalization of Protected Only Turn Movements
         a. Display: Use a three (3) section head with circular red, yellow arrow and green arrow indication. Two three (3) sections heads are to be used if two turn lanes exist.

b. Signage: Use the left turn signal sign when signalizing for protected left turn movement and the right turn signal sign when signalizing for a protected right turn movement.

c. Location:

i. For a single left-turn-only lane, the head should be placed 1.5 feet to the left of the center of the lane and the sign should be placed 1.5 feet to the right of the center of the lane.

ii. For a single right-turn-only lane, the head should be placed 1.5' to the right of the center of the lane and the sign should be placed 1.5 feet to the left of the center of the lane.

iii. For two left-turn-only lanes, the head should be placed over the center of each lane and the sign should be placed on the lane line between the two turn lanes.

iv. For two right-turn-only lanes, the head should be placed over the center of each lane and the sign should be placed on the lane line between the two turn lanes.

4. Height of Signal Heads:

a. The bottom of the housing for vehicular signal head mounted above the roadway must be at a minimum of 16 feet and a maximum of 18 feet but preferably set at 16.5 feet (+) or (-) 6 inches.

b. The bottom of the housing for a vehicular signal head not mounted over a roadway or driveway shall be at a minimum of 8 feet, but the preferred height is the same height as those signal heads over the roadway.

5. View Angle: The horizontal location of signal faces must be per Figure 4D-2 of the OMUTCD.

B. Pedestrian Signal/Heads

1. After considering location (whether rural or urban) and presence of pedestrian generators, pedestrian signal heads should be used in the following situations:

a. At an exclusive pedestrian signal.

b. At a signal meeting the pedestrian warrant.

c. At a signal meeting the school warrant; only those crosswalks on the safe way to school program or having twenty (20) students crossing per thirty (30) minute period must have pedestrian signal heads.

d. When visibility of the vehicular signal heads is reduced or obscured for a pedestrian (e.g. one-way streets, "T" intersections).

e. At a signal having multiple phases which may cause unsuspected conflicts (e.g. left turn phase).

f. When controlling pedestrian movement for:

i. increased intersection capacity

ii. reducing the time of pedestrian-vehicle conflict

iii. forcing pedestrians to cross at specified point of a signalized intersection (R9-3a signs are required at all locations where crossing is prohibited)

2. Marked crosswalks shall be installed where pedestrian signal units are installed. Other locations of marked crosswalks are at the discretion of the COD.

3. Type: All pedestrian signal heads shall be LED, Type D2 with countdown timer.

4. Pedestrian Interval Timing at Signalized Crosswalks
   a. The WALK indication should be seven (7) seconds or longer. In those instances when timing is critical, such as a local intersection with three (3) or more phases on a system with a short cycle length, the minimum WALK indication may be reduced to six (6) seconds.
   b. Pedestrian clearance timing:
      i. Is defined as equal to the countdown interval during the green phase; and in general shall not include the any part of the yellow interval or the all red interval.
      ii. Shall be determined by calculating the time necessary to traverse the entire crosswalk (whether painted or unpainted from curb to curb or edge of travel lane to edge of travel lane) at the appropriate walking speed:
         (1) A walking speed of 3.5 feet per second should be used.
         (2) A walking speed of 4.0 feet per second may be used:
            (a) If such walking speed is prevalent at the location.
            (b) If the constraints of intersection capacity and/or coordination timing require a reduction in time allowed for phase.
      iii. Consideration should be given for a walking speed of 3.0 feet per second if special conditions exist, such as:
         (1) Elementary school-age children crossing.
         (2) Senior citizen crossing.
         (3) Visually impaired or otherwise handicapped individuals crossing.
   c. The Count Down shall be a minimum of six (6) seconds.

5. Pedestrian Interval Timing at Unsignalized Crosswalks
   a. The minimum green phase timing for each phase accommodating a pedestrian movement shall be the pedestrian clearance time (as calculated using the walking speeds above) plus a pedestrian reaction time of two (2) to four (4) seconds for either of the following conditions:
      i. For a signalized location, without pedestrian units, that is controlled by a fixed time type controller.
      ii. For a signalized intersection, without pedestrian units and pedestrian push buttons, that is controlled by a NEMA actuated type controller.
   b. For intersections that are controlled by a NEMA actuated type controller that has pedestrian push buttons but no pedestrian units:
      i. In addition to Pedestrian Clearance time (as calculated using the walking speeds above) there shall be two (2) to four (4) seconds of Walk time allotted for pedestrian reaction time.

C. Yellow Interval: When determining yellow interval timing the figure below should be utilized. Use the higher of the posted speed limit or the 85th percentile speed (if available). Adjustments may be needed due to special site conditions, such as, street grade, high number of trucks, geometrics, or accident history.

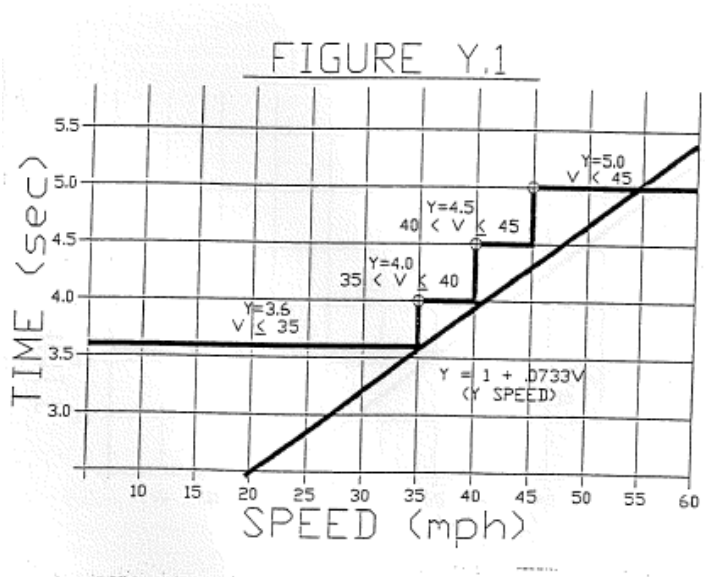


Figure 1 Yellow Interval Time

D. All Red Intervals: All intersections should be considered for an all red interval following each phase. If an all Red (AR) interval is used, the following calculation applies.

1. When calculating an all red interval, use the formula:

$$ARcalc=K+ID/Speed(fps)$$

Where: AR_{calc}=calculation for all red prior to possible reduction;

L=average vehicle length (approx. 20 feet fro standard car;

ID=intersection distance in feet (distance between curb line or pavement edge extensions);

Speed=speed limit or 85th % speed (if available) in feet per second (fps) for through vehicles and 29.33 feet per second (20 mph) for left turn vehicles.

2. Reductions of the calculated all red interval values may be made based on the following (one time reduction):
   a. No reduction is necessary if $AR_{calc} \leq 1.3$;
   b. Reduction optional if $1.3 \leq AR_{calc} \leq 1.5$;
   c. Reduce if $AR_{calc} > 1.5$ seconds;
   d. Use the difference in the yellow interval times between the controller yellow time and the time read from the slanted line (refer to Figure 1 Yellow Interval), which is to be rounded off to the next highest tenth.

$$\Delta AR=Y\varphi-Yspeed$$

   e. Reduce by an amount greater than ΔAR if investigation of intersection's history and/or present operation shows that systems or intersection efficiency will be sacrificed and no safety problem exists (e.g. angle accidents, left turn accidents).
3. The worst possible case should be used to calculate the all red interval. Therefore, the driver's reaction time, which would affect the all red interval by decreasing it, has been assumed to approach and become zero.

4. All calculations and/or documentation concerning the determination of an all red interval shall be recorded on the intersection's timing sheet.

E. Maintenance of Traffic (MOT) for Signals:
   1. Temporary detection must be provided if existing loops will be disturbed during construction. The type of temporary detection must be specified on the approved plans.

   2. ODOT Maintaining Traffic Standard Construction Drawing MT-120.00 shall be followed upon the installation of a new signal.

   3. A Signal Operation Changed Sign must be used when an existing signal has been modified (i.e. timing change, phasing change, etc.)

F. Traffic Control Signs at Signalized Intersections:
   1. Left Turn Only Sign (R3-5L) shall be used where traffic signal heads control exclusive left turn movements (protected phase)

   2. Right Turn Only Sign (R3-5R) shall be used where traffic signal heads control exclusive right turn movements (protected phase)

   3. No Turn on Red Sign (R10-11) may be used when an engineering study finds that one or more of the following conditions exist:
      a. Sight Distance to vehicles approaching intersection is inadequate.
      b. The intersection area has geometric or operational characteristics which may result in unexpected conflicts.
      c. Significant pedestrian-vehicle conflicts are resulting from RTOR (LTOR) movements.
      d. More than three (3) RTOR (LTOR) accidents per year have been identified for the particular approach.
      e. There is significant crossing activity by the elderly and/or handicapped.
      f. At major schools, defined by twenty (20) students per thirty minute crossing period, then day and time restrictions apply.

   4. The sign shall be placed on the span wire/mast arm adjacent to the appropriate signal head, preferably to the right of the right-most head and to the left of the left-most head (whichever is applicable).

G. Detector Design:
   1. Loop Detector
      a. Dimensions:
         i. Minimum width = 4 feet or as recommended by manufacturer
         ii. Maximum width = 6 feet or as recommended by manufacturer
         iii. Maintain minimum 2 feet from lane line to avoid adjacent lane detection. For 10 foot lanes use 4 to 5 foot width and for 12 foot use 6 foot width.
         iv. Use a quadrapole loop design for widths over 6 feet with maximum up to 10 feet width (5 foot x 5 foot); install a separate detector channel for each quadrapole loop

b. Presence detection for side street (non-lock operation):
   i. Install the front of all loops to within 15 feet of curb line or pavement edge extension.
   ii. Use a minimum of 20 feet of loop behind the stop line.
   iii. If the 15 foot distance between the curb line or edge of pavement and the front of any loop cannot be maintained, a Stop Here on Red sign (R10-6) shall be used. The sign post should be centered on the stop line and placed as close as possible to 3 feet behind the curb or 6 feet off the edge of pavement.
c. Left turn detection on main street:
   i. For presence operation (non-lock operation using 5-section head) of a left turn phase, second car detection should be utilized in most instances (front of loop 26 feet from center of stop line); if left turn lanes are offset such as on a divided highway, then first car detection should be used.
   ii. If the left turn phase is a protected only phase, presence loop operation should be used to avoid false calls during light traffic conditions when a driver may decide to disobey the signal (e.g. mid of the night).
d. Bad Pavement: If pavement is too bad for presence detection, non-lock operation may be sacrificed and point detection used.
e. Detector lead-in cable (from loop to pull box): When two or more loops are installed on an approach, the loop lead-ins should be in a lead-in slot (individually combined) separate from the actual loop detector slot. It should be noted to increase the slot depth when two or more lead-ins are installed together.

2. Dilemma zone detection:
   a. Purpose is to set up detection so that drivers have adequate time to decide when yellow indication is displayed, on whether to stop or continue on through the intersection. The drive should enter the intersection on green indication and not on yellow indication which builds disrespect for the change of right-of-way (under gap-out conditions).
   b. Determine the range of speeds for placing detection. Dilemma zone is generally where speeds are greater than 35 mph. The low end of the range determines the minimum gap and the upper end determines the far detector location. Use information from a spot speed check, if at all possible, to determine the 15th and 85th percentile speeds otherwise use 35 mph for the low value and the speed limit for the upper limit.
   c. Next determine the detector spacing and timing between detectors
      i. Dilemma zone range in terms of time is 2 to 5 seconds; use 5 seconds to determine the far detector location (e.g. 5 seconds x 50 mph x 1.467 = 367 feet = distance from stop line to the far detector).
      ii. Near detector is located at 110 feet (25 mph x 1.467 x 3 seconds) from the stop line to assure the queue is moving. The minimum gap is the vehicle headway which is the time to get a vehicle from the near detector into the intersection before the signal changes to yellow or another vehicle crosses the detector.
      iii. The detector extension function is used to get a vehicle from the far detector to the near detector at the low speed value of the dilemma range.

Example 1: Range 35 mph to 55 mph
Far detector @ 55 mph x 1.467 x 5 sec. = 403 feet
Near detector @ 110 feet
Time between detectors @ 35 mph
403 feet – 100 feet = 293 feet
293 feet/51 feet/sec (35 mph x 1.467) = 5.7 seconds
Minimum gap = 163 feet (near detector to vehicle into intersection)/51 feet/sec = 3.2 seconds
Extension timing = 5.7 seconds – 3.2 seconds = 2.5 seconds

d. ODOT's Traffic Engineering Manual (TEM), Section 400 can be used for specifics for dilemma zone loop placement for speeds 40 mph to 65 mph.

H. Signal Flash Operation: See General Notes.

I. Pullboxes: Size and location of all pullboxes must be specified on the plans. Those that are utilized are:
   1. Loop Lead-ins – 18" pullboxes
   2. Multiple conduits joining – 24" pullboxes (at the discretion of the Engineer)

J. Conduit: Specify the size of all conduit on the plans and verify the capacity of each conduit with respect the conductor(s) proposed to be within. The State of Ohio Department of Transportation Construction Inspection Manual of Procedures, page 820 can be used to assist in verifying the capacity of the conduit.

K. Interconnect: Interconnect communication shall be included with all new traffic signal installations and existing signal upgrades utilizing direct hard-wire connectivity or radio transmission as directed by the City.

L. Preemption: Preemption shall be required with all new signal installations utilizing Opticom Radio/GPS Model as manufactured by Global Traffic technologies, or approved equal. Preemption at signals in close proximity to active railway lines may be required on a case by case bases depending on the distance from the railway and and/or based on the Fire Departments requirements.

2. Signal Plan Format

These traffic signal plan sheets shall contain the following information with all appropriate elements clearly dimensioned and labeled:

A. Traffic Signal General Notes: (See Below)

B. Mast Arm and Signal Pole Color: All traffic signals in the City of Delaware shall be mounted on a mast arm. In special circumstances or in a phased project, a strain pole may be considered. The design engineer must submit the request for the waiver in writing and the variance must be approved by the Director of Engineering Services The color of the poles and arm shall be powder coated black or cocoa brown as directed by the City.

   i. Arm Types: The Arm types should be one of the following as shown below.

Figure 2-2: Arched Arm Type (Downtown District)

Figure 11-3: Straight Arm Type (Typical Installation)

ii. Luminaire Type: The Luminaire should be one of the following below.

Figure11-4: Conventional Box Luminaire

Figure 11-5: Cobra Head Luminaire

Figure 11-6: Decorative Luminaire (Downtown District)

Table 11-1: 1 Mast Arm and Luminaire Details

District	Mast Arm color	Arm Type	Luminaire Type
Downtown District	Black	Arched	Mainstreet
US 23 Corridor (except US 42)	Black	Straight	Cobra
US 42 Corridor west of US 23	Cocoa Brown	Straight	Cobra/Conventional
US 36 west of Downtown	Cocoa Brown	Straight	Cobra/Conventional
US 36/SR 37 east of US 23	Black	Straight	Cobra/Conventional
US 36 east of Downtown	Black	Straight	Cobra/Conventional

C. Quantities: All items associated with the installation and operation of the traffic signal shall be quantified in tabular form on the plan sheets. An extra mast arm and support shall be provided per installation. The size of this extra mast arm and support will be chosen by the Public Works Director.

D. Plan View: All items in plan-view shall be located in relation to the station and offset distances of the street centerlines. The items to be located in the plan view are:
   1. Loop Detectors
   2. Dilemma Zone Loops shall per installed
   3. Intersection pavement markings and striping
   4. Pedestal Locations
   5. Curb ramp locations
   6. Sidewalk
   7. Curb and edge of pavement
   8. Underground electric associated with signal installation
   9. Power source shall be located and labeled and must show connection back to power supply
   10. Controller cabinet location
   11. Signs (directly mounted to the support) – ex. no pedestrian crossing, pushbutton, street name, etc.

E. Plan Details:

   1. Mast Arm (COD standard for all intersections)
   2. Signal Pole Foundation Detail (Pole)
   3. Mast Arm and Signal Pole orientation schematic
   4. Signal Head Detail
   5. Elevation view of typical pole assembly showing pole, mast arm, luminaire, signal heads, etc. (See Figure 11-7: Support Detail))
   6. Strain Pole and Strain Wire Detail (Special Situations Only)

7. Pedestrian Head
8. Pedestrian Head Signage Legend
9. Pedestrian Head Detail (countdown timer)
10. Pedestrian Head Pole Detail
11. Pedestrian Head Pole Foundation Detail
12. Pedestrian pushbutton locations and orientations
13. Pedestrian Head orientation angles
14. Front View of Generator / Inverter Power Panel
15. Battery Backup
16. Electrical Hookup Detail for the Generator Power Panel
17. Generator Power Panel Enclosure Details
18. Material Specifications for Generator / Inverter Power Panel Equipment
19. Street Name Sign Detail

F. Required Tables and Diagrams

1. Support Detail Chart (showing orientation, location, luminaire, color, etc.) All Signal Hanger Assemblies shall be free swinging and the same color as the mast arm.

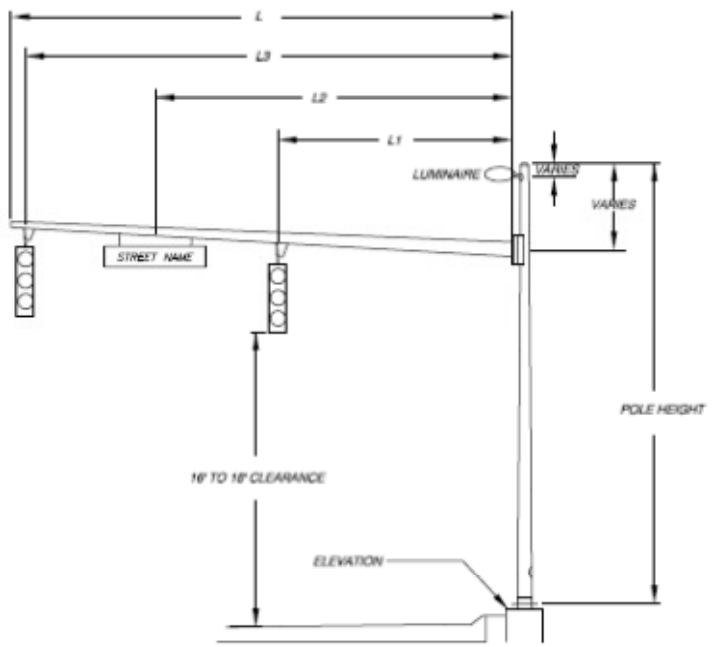


Figure 11-7: Support Detail

SUPPORT NUMBER	SIGNAL SUPPORT TYPE TC-81.20										ELEVATION (FT.)	INDEX LINE ANGLE (DEG.)	ORIENTATION ANGLES (DEG.) FROM INDEX LINE				
	STATION	OFFSET	DESIGN NO.	POLE HEIGHT(FT)	LUMINAIRE ATTACHMENT HEIGHT (FT.)	MAST ARM ATTACHMENT HEIGHT (FT.)	L (FT.)	L1 (FT.)	L2 (FT.)				PEDESTRIAN SIGNAL	PEDESTRIAN PUSHBUTTON	HANDHOLE OR T-BASE DOOR	ELBOWS (CAPPED ELL)	LUMINAIRE TENON
A																	
B																	
C																	
D																	

Figure 11-8: Support Detail Chart

2. Mast Arm Orientation

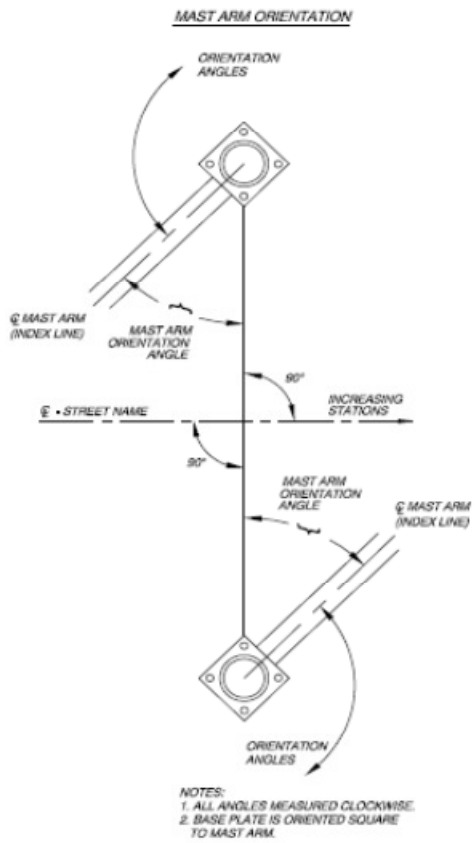


Figure 31-9: Mast Arm Orientation Detail

3. Color Chart: All wiring for the signal controller and signal heads must be per NEMA Standards.

COLOR CHART

PED UNIT FIELD WIRING HOOKUP

PED UNIT LOCATION	CROSSWALK DISPLAY	WIRE COLOR
SOUTH CROSSWALK	WALK	BLACK
	DONT WALK	ORANGE
WEST CROSSWALK	WALK	GREEN
	DONT WALK	RED
NORTH CROSSWALK	WALK	BLUE
	DONT WALK	WHITE W/BLACK TRACER
EAST CROSSWALK	WALK	GREEN W/BLACK TRACER
	DONT WALK	RED W/BLACK TRACER

SIGNAL HEAD & CABINET FIELD WIRING HOOKUP

SIGNAL DISPLAY	WIRE COLOR PER APPROACH
THRU R	RED
THRU Y	ORANGE
THRU G	GREEN
L/T R	BLACK (FUTURE USE ONLY)
L/T Y	WHITE W/BLACK TRACER
L/T G	BLUE
R/T R	NOT USED BY CITY
R/T Y	RED W/BLACK TRACER
R/T G	GREEN W/BLACK TRACER

WHITE SHALL BE USED FOR THE COMMON. SPLICE ALL WIRES IN THE SIGNAL HEAD OR PED UNIT. USE A #14 AWG 2 WIRE SPADE TERMINAL FOR EVERY 2 WIRES PER CONNECTION AND A #14 AWG 1 WIRE SPADE TERMINAL FOR EACH SINGLE WIRE CONNECTION TO CONNECT ALL WIRES TO ALL FIELD TERMINALS. USE BUTT SPLICES ON ALL THROUGH WIRES. ALL UNUSED WIRES SHALL BE SPLICED THROUGH AND SHALL HAVE A DEAD-END TERMINAL AT THE END OF THE WIRE.

Figure 11-10: Wiring Color Chart

4.Signal Head and Cabinet Field Wiring Hookup Chart

FIELD WIRING HOOK-UP CHART EXAMPLE

SIGNAL HEAD #	INDICATION	DRIVEN BY	FLASH
1,2 (SB)	R	Ø1	Y
	Y	Ø1	
	G	Ø1	
3 (NBLT)	R	Ø1	Y
	Y	Ø1	
	G	Ø1	
	←Y	Ø4	
	←G	Ø4	
4 (NB)	R	Ø1	Y
	Y	Ø1	
	G	Ø1	
5 (EB)	R	Ø2	R
	Y	Ø2	
	G	Ø2	
6 (EBRT)	R	Ø2	R
	Y	Ø2	
	G	Ø2	
	Y→	Ø4	
	G→	Ø4	
A,B (WEST)	W	Ø1 W	OUT
	DW	Ø1 DW	
C,D (NORTH)	W	Ø2 W	OUT
	DW	Ø2 DW	

Figure 11-11: Field Wiring Hook-up Chart Example

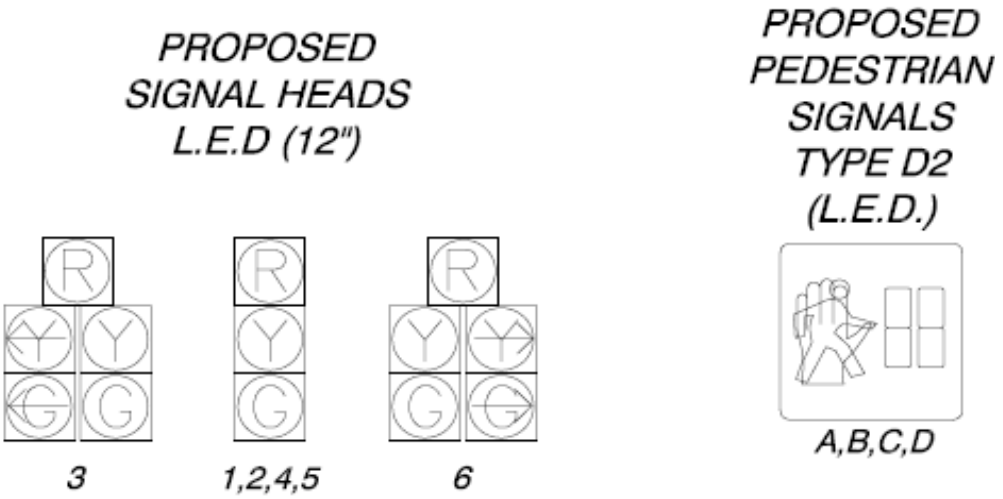


Figure 4Signal Head and Pedestrian Head Identification Example

*Note: The numbers for each head indicate head assignments and not phase assignments.

5. Phasing Diagram: Where Phases 1, 2, 5, and 6 are always assigned to the major road and Phases 1 and 6 will always be for the northbound and eastbound traffic. All Future Phases must be included.

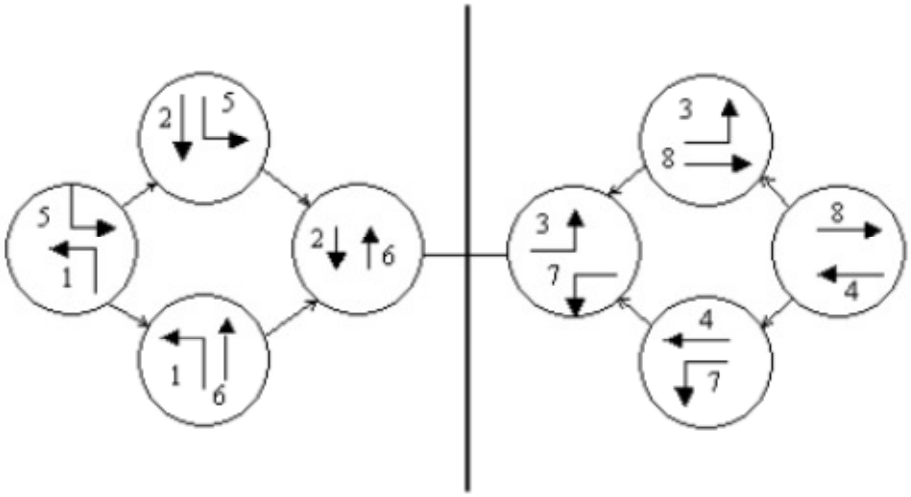


Figure 5Phase Diagram

6. Wiring Diagram

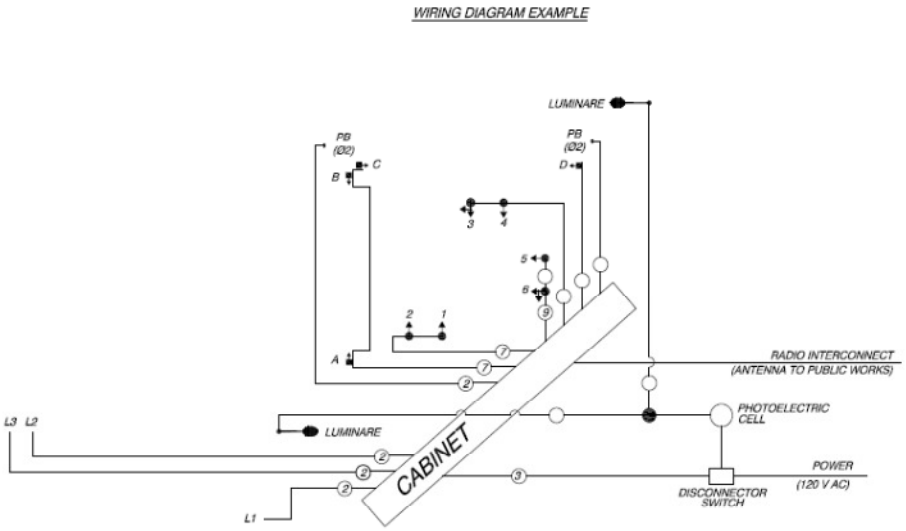


Figure 11-14: Wiring Diagram Example

7.Signal Timing Chart

TIMING CHART

PHASE	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8
MOVEMENT								
MIN INTIAL								
PASS TIME								
MAX GRN 1								
MAX GRN 2								
YELLOW								
RED CLR								
WALK								
PED CLR								
PED RECALL								
VEH RECALL								
MEMORY								

Figure 11-15: Signal Timing Chart

8. Detector Assignments Chart w/ Loop Description

DETECTOR SCHEDULE

DET #	DETECTOR ASSIGNMENT		PHASE	SIZE	TURNS	LOOP DELAY DATA	MODE
	UNIT #	CHAN #				DELAY IN SECONDS	

Figure 11-16: Detector Schedule

3. Signal Coordination: In order to facilitate traffic flow; all new traffic signals are to be coordinated with the existing adjacent signals as practicable. The following items are required on all coordination plans:
    a) Time-Space Diagram
    b) Signal Cycle Offset Chart for all timing plans (AM, Midday, PM, and Off-peak).
    c) All Equipment accounted for (i.e. radio linkage, generator hook-up, battery back-up, coaxial cable connections, etc.)
    d) Antenna Splitter Kit Schematic (As needed)
    e) Omni or Yagi Directional Antenna Schematic (As needed)

    On request, the City will provide the timing plans of any existing traffic signal under the direct jurisdiction of the City.

4. New Traffic Signal Installation:

    When installing a new traffic signal the following process must be followed:

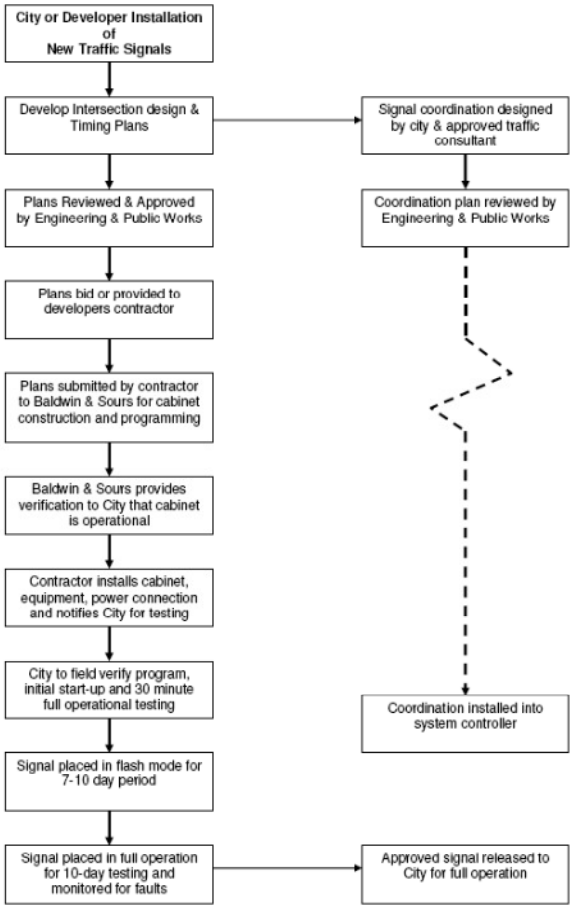


Figure 11-17: New Traffic Signal Installation Process

5. Signal Plans General Notes: The following notes shall be included on all traffic signal plans:

General

The contractor shall furnish and install traffic signal equipment, in conformance to these plans and specifications, and the 2006 state of Ohio Department of Transportation Construction and Material Specifications and all supplemental specifications, They shall install all traffic signal equipment in conformance to the Ohio Manual of Uniform Traffic Control Devices for streets and highways latest revision, and in conformance to the Ohio Department of Transportation standard construction drawings.

Each bidder, with his bid, shall submit two (2) complete sets of catalog cuts, diagrams, brochures, or other descriptive data for the items they intend to furnish. Each bidder shall also provide a detailed list of all variances from ODOT specifications and from the specifications contained herein for each item with the stated specifications. Any bidder that does not comply 100% with this requirement may be ruled ineligible and may not be awarded a contract. Unless otherwise stated by the bidder, the proposal will be considered as being in strict accordance with the specifications.

Wiring Diagrams

Two (2) wiring diagrams and two (2) each service /operation manuals for each different piece of equipment shall be provided. A heavy clear plastic envelope attached to the inside of the cabinet door shall be provide for storing wiring diagrams, (minimum of 9-inches by 12-inches in size)

Guarantee

The contractor shall guarantee that the traffic control equipment installed, as part of the contract, shall operate satisfactorily for a period of one (1) year following completion of the ten (10) day performance test, in the event of unsatisfactory operation, the contractor shall correct faulty installations, make repairs and replace defective parts with new parts from the same manufacturer. Material and labor costs incurred in correcting unsatisfactory operation shall be borne by the contactor. The guarantee shall cover the following items of the traffic signal installations: Controller, Loop Detector Units, Conflict Monitor, Radios, interconnect items, and all associated equipment. Any manufactures guarantees and warranties for equipment shall be provided to the public works department following acceptance of the equipment. The cost of guaranteeing the traffic control system will be incidental to and included in the contract unit price of the various items.

Ten Day Test Requirements

The City of Delaware requires a Ten (10) day test to start after the signal installation is 100% complete which includes establishing data communication if present. No partial tests will be conducted. The City shall monitor the test and shall be the sole agency to accept the signal installation. If less than 100% completion is detected upon inspection by the City or any malfunction is detected, the Ten (10) day test shall be completely restarted.

Transition to Signal Control

The Contractor shall notify the City of Delaware forty-eight (48) hours prior to the signal turn-on, the turn-on shall not begin until representatives from the City, Contractor, and signal equipment supplier are on-site to observe the turn-on. The signal installation shall be placed on flash for three (3) to seven (7) days prior to the start-up and testing.

New signals shall Flash for three (3) to seven (7) days prior to being placed on regular cycling operation. The signals will not be placed on flash until the permanent pavement markings and lane control signs have been installed with the exception of the intersection stop lines. Temporary pavement markings may be used in lieu of permanent markings if they reflect the permanent pavement marking layout. The stop lines shall be in place prior to the signal being placed on regular operation.

Standard construction drawing MT-120.00 by the Ohio Department of Transportation shall be invoked for transition to signal control. Existing stop controlled approaches shall be exempt from all signage.

Payment for all labor, equipment and materials necessary to complete this item of work shall be included in the Lump Sum price bid for Item 614, Maintaining Traffic.

Stop-and-Go signal actuation

The contactor shall notify the city forty-eight (48) hours prior to the signal turn-on and the turn-on shall not begin until representatives from the city, contractor, and signal equipment supplier are on-site to observe the turn-on. The signal installation shall be placed on flash for three (3) to seven (7) days prior to start-up and testing at the intersection of _____ and _____.

The contractor shall conform to standard drawing MT-120.00 for the new signal activation. With the exception of LEOS, permanent supports, and permanent "signal ahead" signs included as bid items in the plan, the cost of all labor, equipment and materials, etc. necessary to complete this item are included in item 614 maintaining traffic, as per plan. Because none of the signs shown on MT-120.00 will be permanent, all of the items needed to conform to MT-120.00 shall be part of the lump sum bid for item 614 maintaining traffic, as per plan. All signs must be bagged and ready. Any existing stop signs must come down immediately upon the Stop-and-Go.

Maintenance of Traffic Signal/Flasher Installations

The contractor shall be responsible for maintaining traffic signal/flasher installation within the project under the following conditions:

Existing signal/flasher installations which the plans require the contractor to adjust, modify, add onto or remove, or which the contactor actually adjusts, modifies or otherwise disturbs. The contractor shall be responsible for the entire installation (at an intersection) from the time his operations first disturb the installation until the installation has been subsequently removed or modified and the work is accepted.

New or reused signal/flasher installations or devices installed by the contractor. The contractor shall be responsible for maintenance of these from the time of installation until the work is accepted.

In the event new signals are damaged prior to acceptance, all damaged equipment except poles and control equipment shall be replaced by the contractor to the satisfaction of the engineer with the signal back in service within 8 hours after the contactor's notification of the outage. The contractor shall arrange for full traffic control until the signal is back in operation.

If poles and/or control equipment are damaged and must be replaced, the contractor shall make temporary repairs as necessary to bring the signal back into full operation within the allowed 8-hour period, and shall make permanent repairs or replacement as soon thereafter as possible.

None of the above shall be construed as collective or consecutive outage time periods at any one location. That is where more than one outage occurs at any one location, then the allotted time limit shall be for the worst single outage.

Where outages are the direct result of a vehicle accident the response of the contractor shall be as outlined above. The contactor shall be responsible for the collection of any compensation for this work from those parties responsible for the damage.

Where the contactor has failed to, or cannot respond to and outage or signal equipment malfunction at these locations within his responsibility, within period as specified above, the engineer may invoke the provisions of ODOT CMS Section 105.15 and any subsequent billings to the City of Delaware for police services and maintenance serves by city forces shall be deducted from moneys due or to become due the contractor in accordance with provision of section 105.15.

The contractor shall provide the maintenance service entirely with his forces or he may choose to enter into a cooperative understanding the local maintaining agency to provide the maintenance. The contactor shall inform the Department of Engineering Services, in writing, of the maintenance method selected.

The contractor shall be responsible for any damage to any traffic signal components required to be handled during the relocation of poles and revisions to the signal system.

When a traffic signal must be taken out of service by the contractor due to construction procedures, this outage shall not exceed 2 hours and shall not include the hours of 7-9 AM & 3-6 PM. Any signalized intersection, where the signal is out of service due to construction procedures, or due to an outage or malfunction of equipment as described above, shall be protected, by the contractor, by the installation of temporary "stop" signs.

Any vehicular traffic signal head, either new or existing, which will be out of operation, shall be covered in the manner described in ODOT CMS 632.25.

The contractor shall maintain complete records of malfunctions including:

Time of notification of malfunction

Time of work crews arrival to correct the malfunction

Action taken to correct the malfunction, including a list of parts repaired or replaced

A diagnosis of the reason for the malfunction and probability of reoccurrence

Time of completion of the repair and system restored to full service

A copy of these records shall be provided the Department of Engineering Services within three (3) working days following completion of each repair.

All cost resulting from the above requirements shall be considered to be included in the lump sum price bid for item 614, Maintaining traffic.

Grounding and Bonding

The requirements of the ODOT Construction and Material Specifications (CMS) and the ODOT HL and TC series of standard construction drawing s are modified as follows:

All metallic parts containing electrical conductors shall be permanently joined to form and effective ground fault current path back to the grounded conductor in the power service disconnect switch

Provide an equipment grounding conductor in metallic conduit (725.04) in addition to conductors specified and bond the conduit to this connector

When an equipment grounding conductor is required in plastic conduit (725.05), the installation shall include a separate equipment grounding conductor in addition the conductors specified.

Metallic conduit carrying the loop wires from the pavement to the pull box splice location will only be bonded at the pull box end, and will not contain an equipment grounding conductor

Metal pull box lids shall be bonded by attachment of the equipment grounding conductor to the frame as provided in HL-30.11.

If multiple conduit runs begin and end at the same points, only one equipment grounding conductor is used.

If an equipment grounding conductor is need in conduit between signalized intersections for underground interconnect cable, the grounding systems will be separated about midway between the intersections.

The messenger wire at signalized intersection will be used as the conductive path from corner to corner if conduit is not provided under the roadway. When conduit connects the corners of an intersection, an equipment grounding conductor shall be used in the conduit.

Conduits

All 725.04 and 725.05 conduit shall have brushings installed at termination points.

Brushings on 725.04 conduit shall be equipped with a grounding lug. The grounding lug material shall be compatible for use with copper wire. Threaded or compression type brushings may be used.

Both ends of metallic conduit shall be bonded to the equipment grounding conductor.

Metallic conduit may be bonded to metallic boxes through the use of conduit fittings UL approved for this type of connection, with the box bonded to the equipment grounding conductor.

Wire for Grounding and Bonding

Use insulated, copper wire for the equipment grounding conductor. Bonding jumpers in boxes and enclosures may be bare or insulated copper wire, wire size shall be as follows:

Use 4 AWG between the power service and supports, poles, pedestals, controller or flasher cabinets.

Use a minimum of 8 AWG between the loop detector pull boxes and the first conduit that requires a larger size as specified in 3.A.i above.

Use a minimum 8 AWG between the “Prepare to stop when flashing” installation (including support) and the first conduit that requires a larger size as specified in 3.A.i above.

In a highway lighting system, the equipment grounding conductor shall be the same wire size as the duct cable or distribution cable circuit conductors, with the minimum conductor size of 4 AWG .Bonding Jumpers will be a minimum size of 4 AWG.

Ground Rod

A ¾ -inch schedule 40 PVC conduit will be used in foundations and concrete walls for the founding conductor (ground wire) raceway to the ground rod. Should metallic conduit be used, both ends of the conduit shall be bonded to the grounding conductor.

The typical grounding conductor (ground wire) shall be 4 AWG insulated, copper.

All wiring for the signal controller and signal heads must be per NEMA Standards. Unused conductors shall be grounded in the cabinet.

Power service and disconnect switch

At the power switch location, the grounding conductor (ground wire) from the disconnect switch AC- Neutral bar to the ground rod shall be a continuous, un-spliced conductor. If spliced, it shall be an exothermic weld butt splice.

The AC- shall only be connected to ground at the primary power service disconnect switch

National electrical Manufactures ASSOCIATION (NEMA) controller cabinets: if a power service disconnect switch is located before the controller cabinet, the AC- (neutral) and the grounding bars in the controller cabinet shall not be connected together as shown in NEMA TS-2, Figure 5-4.

If secondary controller disconnect switches are connected after the primary disconnect switch, the AC- only shall only be grounded at the primary switch. Equipment grounding conductors shall be brought to the primary switch but shall be grounded at both secondary and primary switches.

Stricture Grounding: HL-50.21 shows a 1/0 AWG stranded copper cable used for structure grounding. Additionally, this cable shall be insulated and ay connection to bare copper strands exposed to concrete shall be covered with mastic to prevent contact with the concrete.

Payment

All materials and work required to complete the effective ground fault current path system are incidental to the conductors installed by contract.

Work on bridges may be included in the bid item for "Item 625, structure grounding".

In a 3-wire highway lighting system, the third conductor of the duct cable or distribution cable will be used as the equipment grounding conductor and may as such be part of the cabled bid item.

ITEM 614 – Law Enforcement Officer with Patrol Car

In addition to the requirements of ODOT CMS 614 and the latest edition of the Ohio Manual of Uniform Traffic Control Devices (OMUTCD), a uniformed law enforcement officer and official patrol car with working top mounted emergency flashing lights shall be provided for controlling traffic for the following tasks:

For lane closures: during initial set-up and tear down periods, substantial shifts of a closure point or when new lane closure arrangements are initiated.

During the entire advance preparation and closure sequence where complete blockage of traffic is required.

Law enforcement officers (LEO'S) should not be used where the OMUTCD intends that flaggers be used. The LEO'S are considered to be employed by the contractor and the contractor shall be responsible for their actions. Although they are employed by the contractor, the Department of Engineering Services shall have control over their placement. The official patrol car shall be a public safety vehicle as required by the Ohio Revised Code.

The Contactor shall make arrangements for these services with

The City of Delaware Police Department

(740) 203-1111

Law enforcement officers with patrol car required by the traffic maintenance tasks above shall be paid for on a unit price hourly basis under item 614 – Law enforcement officer with patrol car.

The following estimated quantities have been provided:

Item 614 – LEO with Patrol Car = ____HOURS

If the contractor wishes to utilize LEO's for flagging and traffic control other than for that required in these plans, the contractor may do so at the contractors own expense. Payment for the excess above the contract requirements will be included under item 614 – Maintaining Traffic.

Item 625 luminaire, conventional, As Per Plan

In addition to item 625 and 725, the luminaire shall be HADCO brand model PA3 (250 W HPS, Type III, 120V) or approved equal. The luminaire housing shall be coated with a dark bronze powder coating to match the signal supports and mast arms. The luminaire shall be attached to the signal supports and mast arms. The luminaire shall be attached by a tendon to the signal support at the orientation shown in the plans.

Payment for this item shall be at the unit price bid, complete and in place, connections tested and accepted.

Item 625 Trench, As Per Plan

In addition to the requirements of ODOT CMS 625.12 and the Standard Construction Drawings, within each trench, the location of underground cable or conduit shall be marked by the use of a continuous identifying tape buried in the trench above the line. One strip of marking tape shall be placed between 6-inches and 12-inches below finished grade with a tape length equal to length of the conduit or cable. The tap shall be placed parallel with the finished surface. The contractor shall take necessary precautions to insure that the tape is not pulled, distorted, or otherwise misplaced in completion the trench backfill.

The tape shall be an inert material highly resistant to alkalis, acids, and other chemical components likely to be encountered in soils. The tape shall be 3-inches to 6-inches wide, and a high visibility color such as orange or red. The tape shall be printed with the word "electric" approximately every six (6) feet in black letters with ink that will not change when exposed to acids and other destructive substances commonly found in soil. The tape shall be supplied in continuous rolls with the identifying lettering repeated continuously the full length of the tape.

This item shall be paid for per linear foot of item 625, trench, as per plan, complete and in place.

Item 630 Signs, As Per Plan [For New Signals Only]

The Contractor shall install the W3-3A "Signal Ahead" Signs and the OW-154-36 and OWP2-47-30 "New Signal" signs just prior to the signal being placed on flash. The "New Signal" and "Signal Ahead" signs shall be covered until the signal is placed on regular operation at which time the Contractor shall uncover them. The Contractor shall remove the signs and posts, if used, 3 weeks after the signal is placed on regular operation. Failure to remove the signs shall result in the City removing them and billing the Contractor for all costs involved in their removal. All removed material shall be considered forfeited to the City.

Item 632 Covering of Vehicular and Pedestrian Signal Head

All signal heads that are installed prior to being used to control traffic or pedestrians shall be covered. If plastic bags are used, only heavy duty plastic bags shall be permitted. Two bags per head shall be used. The bags shall be securely lashed down so that wind does no rip them from the signal head. All signal heads while covered shall be dark either by removing, unscrewing, or disconnecting the power to the bulbs. No covered head shall block the view of an operating head. Any existing vehicular or pedestrian head that is not functional shall be removed immediately or covered.

Item 633 controller unit, Type TS2/A2, with cabinet type TS2 Type, As Per Plan

The electrical control equipment provided shall meet the following specification and be manufactured by eagle traffic control systems. The equipment provided as part of this contract shall be the latest model currently under production and new. The controller cabinet and accessories shall meet the NEMA TS2 standard for actuated controller units. The cabinet shall be a 36-inch wide "M" cabinet. The cabinet shall be aluminum the natural aluminum finish inside and the outside shall be powder coated cocoa brown to match the color of the signal supports. A paint chip shall be submitted to the Department of Engineering Services for final approval. The load bay shall be the TF5012 or newer, with 12 load switch positions and 12 load switches provided (unused load switches shall be in a separate box in the cabinet). Each lad switch shall have light emitting diodes (LEDS) for the controller output and load switch output, 8 flash relay positions (unused flash relays shall be in a separate box in the cabinet). 1 NEMA 2-circuit flasher and a malfunction management unit (Eberly deign MMU16LE).

Each cabinet shall come equipped with EBERLY design oracle 4E detector units to accommodate the detection shown on the detail sheet.

There shall be no lag left operation. Phase omit shall be achieved through omitted call programming to prevent a leg left signal operation

A Meyers power back/BC 100 UPS battery backup cabinet PBM-2000ITS UPS module is to be installed per ODOT specifications. The battery backup shall be paid for separately.

A generator power panel and enclosure shall be mounted on the outside of the upper section of the controller cabinet, on the same side as the circuit breakers. The standard drawing for the generator power panel is included in this plan and shall meet those specifications.

The police panel on the inside of the cabinet door shall have vehicle detector and pedestrian detector pushbuttons to call phases 1 to 4 individually, a stop timing switch, cabinet light switch, and an auto flash switch shall also be supplied on the police panel on the outside of the cabinet door.

A cabinet door open switch and a cabinet light on / off switch shall also be supplied.

The controller shall have a liquid crystal display with adjustable backlight. The display shall be of sufficient size to display a minimum of four (4) lines of text with a minimum of 20 characters per line. The display shall be readable in direct light or darkness.

The following information shall be on all labels in the controller cabinet tot identify the wiring functions:

Loop detector lead-in cable: Phase number serviced, direction, movement type, and loop plan number.

Signal head field wiring: Phase number serviced, direction, movement type and color (red yellow, green Yellow arrow, green arrow) or pedestrian movement

The controller timer shall be the genesis epac300 (or most current model) NEMA TSA/A2 and come equipped with all internal components to make it fully system ready for the MARC system and the ACTRA system and shall have an internal spread spectrum modem. Each controller timer shall have 6 modes of coordination, adaptive traffic control, reports, preemption / priority, diagnostics and internal time base control.

Each conduit entrance to the cabinet shall be sealed with a rubber pipe/conduit seal gasket. The seal shall be of a material and type tightly fitting and able to seal out water, insects, rodents, and dirt. The seal shall be easily removed for service installations or cable replacements.

Payment for item 633 – controller unit type TSA/A2, with cabinet type TS2 Type 1, as per plan, will be at the contact bid price complete and in place including all connections tested and accepted.

Item 632 Vehicular Signal Head, (LED), (By Type and Size)

Signal heads shall be as per Item 632 and shall conform to the Equipment and Material Standards of the ITE as published by the Institute of Transportation Engineers and all indications shall use a light emitting diode (LED) light source conforming therewith and manufactured by Gelcore.

The signal body shall be polycarbonate and all bolts and washers for securing sections together, all mounting hardware for the lens, all door latching bolts, and all hinge pins shall be stainless steel.

Payment shall be as per Item 632.

Item 632 Cabinet Foundation, As Per Plan

The foundation area shall be extended to accommodate the cabinet for the battery back-up system. The orientation of the battery back-up cabinet in relation to the controller cabinet is shown on the plan sheet.

Item 632 controller work pad, As Per Plan

In addition to TC-83.20, the controller work pad shall extend 36-inches from the front of the cabinet and extend the entire width of the foundation.

Payment for this item shall be at the unit price bid for each.

Item 633 controller, miscellaneous: Battery backup Panel

It is the intent of these plans that a battery backup system be provided and shall meet the following:

The Unit shall be a Meyers brand power back/bc 100 ups battery backup cabinet pbm-2000its ups module or approved equal, in all cases, this item shall meet ODOT Specifications.

A manual by pass/disconnect switch internal to the cabinet shall be included.

The battery backup cabinet shall be attached to the left side of the controller cabinet (to the left of the cabinet door), and the exterior of the cabinet shall match the color of the controller cabinet. All hookups, cabling, attachment hardware, and miscellaneous materials for both attaching the cabinets and for full operation the battery backup system shall be included it unit price bid for this item

The backup cabinet shall be mounted on a foundation pad to match the height above grade of the adjacent controller cabinet. The work pad in front of the foundation shall match the 36-inch dimension for the controller work pad. The foundation and work pads shall be paid separately.

Payment shall be made at the unit price bid per each, complete and in place, all connections tested and accepted.

Item 633 spread spectrum radio, As Per Plan

The controller cabinet shall be fully equipped with a spread spectrum radio communication system including but not limited to: Yagi antenna, coax cable, ground strap for coax shield, poly phaser, MDS 9810 spread spectrum package including transceiver, battery backup, digital board, software and connections to program the radios including a hand held

programmer, and all attachment hardware, connectors, cables, and miscellaneous items necessary toe a have a complete and working compatible communication system. The contractor shall be responsible for the aiming and proper location of the antenna for achieving full communications. The contactor must calculate and determine the proper sizing of the coax cable to meet each specific application. The radio antenna shall be place on signal support A. The system shall maintain the availability of full time communication between the proposed signal installation and the master controller located in the City of Delaware Public Works Building.

Any item not used in the completed installation shall become the property of the City of Delaware. Items shall be carefully transported to a location within the city as directed by the Department of Engineering Services and carefully unloaded and stored as directed. The contractor shall call the Department of Engineering Services [(740)203-1700] to identify the delivery location within the city. Any items specifically designated as unusable by the city shall be properly disposed of tabby the contractor.

The contractor shall demonstrate radio communication is working properly. This item shall be paid for the unit price bed per each, complete and in place, all connections tested and accepted.

Chapter 12: Street Light Standards

1. Residential Street Lighting

Street lighting shall be required along all new residential streets and shall be included with the engineering plans as part of a development plan submittal for each new section under design. It is the developers responsibility to arrange for the extension of power lines in order to energize the lighting circuits.

A. Light Fixture:

Granville Series Luminaries, Leaf style housing, Model: GV100HP12FA3RSG

P DTLPR12A GV1A73A (Y539A), AOL 2003-Internal Up-light Shield Perforated

Granville, 100 W. High Pressure Sodium, Mogul Base, 120 Volt, Fluted housing for 7-inch capital, (Q015545) Painted to match color number, "Delaware Green" Y539A, Type 3, ribs and bands, standard finial painted cast aluminum, gold trim, protected starter, 120 v dark to light button type photocell, post capital, as specified finish "Delaware Green" Y539A, converts 3-inch post top tendon to flared 7-inch post capital.

Unique Solutions, A Division of Holophane
Newark, Ohio 43055
www.holophane.com

B. Installation

1. Height above Grade: All fixtures shall be installed at 14'-4" (fourteen feet-four inches) above finished grade, measured from the top of the finished concrete foundation support to the top of the lighting fixture.
2. Location: All street lighting poles shall be installed 3ft to center of foundation from back of curb and placed where noted on the approved lighting plan. In general the fixture shall not be installed above sanitary sewers, storm sewers, water mains or other utilities.
3. Plan required spacing of light fixtures:
   a. As a guideline, the spacing of fixtures shall not exceed 320 feet nor be less than 240 feet. Fixtures shall be alternately spaced within the public right of way on opposite sides of the street, including the areas in front of designated parks and open spaces.
   b. A minimum of one light fixture must be placed at the end of all cul-de-sacs, at intersections, and on curves exceeding 15 degrees.
   c. As part of the development plan submission, an isolux diagram with point-by-point foot-candle coverage shall be included. A minimum of 0.5 foot-candle average shall be designed for roadways including sidewalks, with a Luminance Uniformity "L" average to "L" minimum of 6 to 1 per American National Standard Practice for Roadway Lighting prepared by IES (Illuminating Engineering Society).
   d. The lighting plan must show the location of proposed streetlights, breakers, and 5ft wide minimum easements for all electrical source feeds between the light poles and power source.

4. Installation Requirements: Fixtures must be wired and installed per the current addition of the National Electrical Code (NEC- NFPA 70), manufacture's specifications and the following requirements:
   a. A 40 amp. rain-tight service panel with a 15 amp branch circuit over-current protection device must be installed at the top of a 4"x4" treated post buried at least 36 inches below finished grade and set in # 57 Stone. The support post must be cut on a 45-degree angle on its top and shall extend between 32-inches and 36-inches above finished grade.
   b. An 8-foot long grounding electrode must be installed adjacent to the service panel. A #6 copper grounding electrode shall ground the service. The grounding electrode conductor must be installed in a half-inch rigid metallic conduit to protect it from any physical damage.
   c. The feeder conductor (feed from disconnect to transformer or pedestal) must be a minimum #12-2 type UF. The conductor must be protected by a one-inch rigid conduit and be properly terminated with anti-chaffing bushings. Adequate length of the conductors must be provided to facilitate the installation to the transformer or pedestal, and the line must be buried at least 24-inches below grade to the transformer or pedestal.
   d. The branch circuit conductors that are buried must be installed in a one-inch rigid non-metallic conduit & installed a minimum of 18- inches below finished grade.
   e. The conduit must be changed to a rigid metallic conduit where above grade and entering the service panel. The conduit must terminate with proper anti-chaffing bushings. The branch circuit conductors shall be not less than # 12 AWG. copper THHN; Conductor colors shall include one black, one white and one green.
   f. Each fixture conductor shall be fused at the base of the pole in front of the access panel with a "Little Fuse, Power Guard LEB-AA 12/8 wire ring CU" and be fused with a "Power Guard KLK-5", or equivalent.
5. Fixture Post: The post shall be a "Martha Washington", manufactured by HAPCO, model 70603-002. The post is a twelve-foot high aluminum tube, tapered four-inches to three-inches and supplied with a two piece split base. The post shall be powder coated "Delaware Green" Y539A and match the Holophane fixture.
6. Post Support
   a. The light pole must be anchored to an round 14-inch by 40-inch deep concrete footing, using the three galvanized anchor bolts provided with the post. The top of the concrete footing must be formed into a 14" x 14" square base with edges chamfered to ¾ inches.
   b. The concrete footing must be installed approximately four-inches above top of curb to allow for easy trimming of grass.

7. Additional Fixtures Required: For every twelve fixtures required in a development or housing project, regardless of the number of phases to the project, one complete light fixture and pole assembly shall be provided to the City of Delaware for replacement stock.
8. Maintenance: After the complete installation of the required number of light fixtures in a development and the installation is approved by the building inspector, the Developer shall be responsible for the first two-years of maintenance. Streetlights installed in accordance with these standards shall become a Public Improvement after their acceptance by City Council resolution and shall be subject to Section 1111.06 of the Subdivision Regulations. This includes the repair of all of the components of the lighting system, such as the replacement of faulty or defective equipment, poles or luminaires and lamps. Repairs shall be made in a timely manner.
9. Required Inspections:
   a. Footings
   b. Underground conduit prior to backfill.
   c. Electrical service inspection.
   d. Final installation of fixtures.

2. Collector Street Lights

Collector street lighting shall include either a single luminaire or twin luminarie design, as directed by the City.

A. Light Fixture

Granville Series Luminaries, Leaf style housing, Model: GV150HP24FB5RSG P DTLPR12A GV1A73B,

AOL 2003-Internal Up-light Shield Perforated

GranVille, 100 W. High Pressure Sodium, Mogul Base, 120 Volt, Fluted housing for 7-inch capital, (Q015545) Painted black, 37031, unless specified to a different color by the City, Type 3, ribs and bands, standard finial painted cast aluminum, gold trim, protected starter, 120 v dark to light button type photocell, post capital, as specified finish to match housing, converts 3-inch post top tendon to flared 7-inch post capital.

Unique Solutions, A Division of Holophane
Newark, Ohio 43055
www.holophane.com

B. Installation

All installation requirements are to comply with 3B above and all electrical installations are to be provided with an approved plan, cut sheets, and voltage drops, and are to comply with the latest City of Columbus lighting installation standard.

1. Fixture Post
   a. Type A – Single Luminaire. The post shall be powder coated Black, 37031 (unless otherwise specified by the City) and match the Holophane fixture. The total length of the light pole shall be 15-feet, not including the luminaire. The light pole shall be Model # AATF1515 manufactured by "Main Street" Lighting

Company.

b. Type B – Double Luminaire. The post shall be powder coated Black, 37031 (unless specified another color by the City) and match the Holophane fixture. The total length of the light post shall be 13.5-feet, not including the luminaire. The post shall be model # CAA1503 with cast aluminum twin arms welded to a 3½ inch center tube, manufactured by "Main Street" lighting company.

C. Both Type A & Type B posts shall have the following modifications furnished on each light pole:

a. An access door over the hand hole with interior having a permanent label marker noting the voltage.

b. A cast brass flag bracket (installed perpendicular to the curb and positioned streetside.) The bracket shall be permanently installed 10-inches from the top of pole

c. The base shall be constructed of cast aluminum.

d. The pole shall have an approved cable grip on the top interior of the pole to support the weight of the wiring cables

e. The shaft shall be a formed tapered fluted shaft, tapering from approximately 7¼ to 4 ½ inches

Chapter 13: Fiber Optic Conduit & Cable Installation

1. General
   A. Fiber optic cables shall be installed in accordance with *NECA 301-2004, Installing and Testing Fiber Optic Cables, City of Columbus CMS section 1000 and* the following City of Delaware standards.
      1. NECA 301-2004, Standard for Installing and Testing Fiber Optic Cables (ANSI) - This standard describes practices for installing and testing fiber optic networks used for high-speed data connections. It is developed jointly with the Fiber Optic Association (FOA), the leading certifier of fiber optic installers. It is an update to standard NEIS 301-1997.
      2. National Electrical Installation Standards (NEIS) are the standards for electrical construction. NEIS are published by the National Electrical Contractors Association (NECA), developed in cooperation with other industry expert groups, and approved by the American National Standards Institute (ANSI).
   B. The contractor shall provide record drawings in the format specified by the City of Delaware upon completion and acceptance of the project.

2. Fiber Specifications
   A. 144 strand fiber optic cables are to be installed.
   B. All splicing must be color coded between different cables. i.e. red tube fibers must be spliced into red tube fibers, etc.
   C. All contractors that are to install fiber lines must be approved prior to the start of construction by the City.

3. Aerial Installation
   A. For an aerial installation, a slack loop is required every 500-feet and at logical location where a splice off the main fiber line may occur. The splice location will be determined by the Department of Engineering Services and the Department of Information Technologies.
   B. The contractor shall install riser "U-Guards" at all locations were the conduit is ascending or descending from any aerial construction.

4. Subsurface Installation
   A. For subsurface installation, two 1 ¼ inch (minimum) SDR 11 HDPE conduits shall be installed for each run of fiber line.
   B. The conduits are to be orange, and orange with a black stripe
   C. The minimum vertical and horizontal separation shall be 1.5 feet between the fiber conduits and public water and private utility lines; and 1.5 feet vertical and 5 feet horizontal between all sanitary and storm sewers.
   D. The bury depth is to be 36-inches below finish grade
   E. For new construction, all conduit crossing under roadways shall be concrete encased to the top of subgrade and extend from right-of-way line to right-of-way line, unless bored.
   F. When crossing existing roadways, the fiber conduit may be directional bored under the roadway with an appropriately sized steel casing pipe extending from right-of-way line to right-of-way line.

G. Distribution line pull-boxes are to be 60” x 36” x 36” polymer concrete box with a 20K metal or metal clad lid, bolted down with stainless steel hardware. Boxes are to be located so water drains away from the box.

H. Branch line pull-boxes are to be a New Basis 48” x 30” x 36” polymer concrete box, model # PCA3044836S. (or equivalent) The lid is to be gasket–sealed, hinged lid stamped with a label designating “FIBER”

I. Shop drawings of the pull-box and lid that differ from the ones specified above are to be approved by the City prior to installation

J. Pull-box shall have a spacing of no more than 400-feet between boxes. An additional pull-box shall be placed at logical locations where a splice off the main fiber line may occur.

K. Trace wire or a trace fiber shall be used throughout the system and is to be placed inside the solid orange conduit.

L. If trenching, plastic caution tape is to be placed over the conduit at a depth of 18-inches. Newly installed pull-boxes must be marked with 4” x 4” x full depth (bottom of box) wye poles painted orange at the top. The wye poles shall remain in place until fiber is installed with tracer wire.

M. Select projects may utilize 24-inch square pull boxes if no future splicing is anticipated, as approved by the City.

Chapter 14: Street Tree Planting Standards

The City of Delaware requires all new residential development to include the installation of street trees to be planted within the tree lawn area of the public right of way. The species to be planted will be selected by the City Shade Tree Commission in advance of project approval.

1. Notification

The City shall be notified five (5) days in advance as to location, time, and number of trees to be planted. The City reserves the right to inspect planting procedures for adherence to requirements regarding spacing, clearance, and obstructions as specified in Chapter 907.03 of the City code. It shall be the responsibility of the developer or his designee to contact OUPS to avoid underground utilities. The City of Delaware will spot tree planting locations by placing a white dot on the curb. Trees planted without prior City approval risk of having to be removed, relocated or replaced.

2. Site Preparation

The planting hole shall be excavated to a depth so that the root flare and first order of lateral roots will be 2-inches above grade. The planting hole shall be a minimum of one foot wider than the diameter of the root ball, and prepared with sloped sides.

3. Planting

Prepare the tree for planting by removing the top 1/3 of the wire basket, all plastic shipping collars and ropes. Remove burlap from top of root ball and tuck in hole. Treated or plastic burlap is not permitted. Care shall be taken to not damage the root ball when handling or back filling. Place the tree within the hole and adjust its position so that it is plum in the hole. Tree shall be planted so that the root flare is one to two inches above finished grade. Never plant trees deeper than existing grade. Backfill around the root ball with existing un-amended soil and thoroughly water. Tamp soil to remove air pockets. Apply two to three inches of hardwood mulch leaving a 2-inch open space around the trunk. When finished, the top of the mulch shall be not more than 5-inches above existing grade. Excess soil must be removed from the site and not piled on top of the root ball.

4. Maintenance

It is the responsibility of the developer to maintain the trees in a healthy condition until final inspection and acceptance by city officials.

5. Warranty and Final Inspection

The developer shall guarantee that all trees will be healthy and vigorously growing two-years after planting. The city will inspect all newly planted trees twice a year and report all unacceptable trees to the developer. A tree will be considered unacceptable if it is dead, has more than 33% dieback of lateral branches, or has more than 20% dieback of the terminal branch. Trees not 1.75-inches in caliper, wrong species, or that show poor quality or lack tags will be unacceptable. It will be the responsibility of the developer to remove all unacceptable trees within 30 days of notification. Replacement trees will carry the same two year warranty and the warranty will start when the tree is planted and inspected by the city. Nursery inspection certificates and documentation of plant origin will be provided prior to trees being planted. Only trees grown in zones 4 and 5 are deemed acceptable unless prior approval has been granted. Trees grown in zones 7 or greater will never be accepted by the City of Delaware.

Table of Contents

STORM WATER MANAGEMENT 3

PREFACE 3
PRELIMINARY STORMWATER MANAGEMENT PLAN 3
General 3
Preliminary Stormwater Plan Content 3
FINAL STORM WATER MANAGEMENT PLAN 5
Plan Format and Content 5
General Design Considerations: 9
Hydrology 10
DESIGN OF MINOR STORMWATER CONVEYANCES 45
Methodology 45
General Requirements 45
Flood Routing Path 46
Culvert Design 49
General 49
Design Procedure 49
Storm Sewer System Design Requirements 51
Open Watercourses 55
Rock Channel Protection 58
REFERENCES 63

List of Tables

Table 1: Example Determination of the Basin Development Factor 12
Table 2: Runoff Coefficients for the Rational Formula 13
Table 3: Roughness coefficients (Manning's n) for Sheet Flow 16
Table 4: Shallow Concentrated Flow Intercept Coefficient (k) 17
Table 5: C Values for Excavated Channels 19
Table 6: C Values for Roadside Ditches 20
Table 7: C Values for Lined Channels 21
Table 8: C Values for Natural Channels 22
Table 9: Runoff Curve Numbers (CN) for Typical Land Uses in the City of Delaware 24
Table 10: Bulletin 71: Sectional Mean Frequency Distributions for the City of Delaware 25
Table 11: Bulletin 71 – Selected Design Rainfall Intensities 27
Table 12: NOAA Atlas 14: Precipitation Frequency Estimates for the City of Delaware 29
Table 13: NOAA Atlas 14: Precipitation Intensity Estimates for the City of Delaware 29
Table 14: Critical Storm 32
Table 15: Design Year Flows 49
Table 16: Minimum Slope for all Storm Conduits 52
Table 17: Selected COD & COC Basin Grate & Curb Inlet Dimensions 54
Table 18: Maximum Velocities for Channel Lining Materials 56
Table 19: Allowable Shear Stress for Rock Channel Protection 57
Table 20: Rock Riprap Size 59
Table 21: Requirements for Geotextiles 60

List of Figures

Figure 1: Bulletin 71: I-D-F Curve for Central Ohio 26
Figure 2: NOAA Atlas 14: I-D-F Curve for the City of Delaware 30
Figure 3: Schematic of a Typical Bioretention Facility 44
Figure 4: Rock Channel Protection 61
Figure 5: Plan and Profile for Typical Rock Outlet Protection 61

Storm Water Management

Preface

This section of the City of Delaware design manual is not a text of hydrology or hydraulic design. It assumes that the user has an understanding of hydrology and hydraulic engineering. This manual provides a uniform design procedure for summarizing and submitting plans in an acceptable and understandable manner. It does not provide uniform solution to all drainage problems. This section of the design manual provides sufficient information to develop drainage systems in accordance with city policy.

Preliminary Stormwater Management Plan

General

The City of Delaware requires a preliminary stormwater management plan to be submitted for review showing basic hydrology prior to submittal of the final Stormwater Plan. This requirement may be waived at the discretion of the City upon written request by the design engineer for commercial outlots that are a part of a larger development and incorporated in and existing, approved Stormwater Management Plan.

All Runoff Curve Numbers are to be per appropriate tables contained within this manual and using best engineering judgment and are subject to review by the Department of Engineering Services.

It is highly recommended that the design engineer contact the Department of Engineering Services as early in the design process as practicable. The purpose of this meeting is to come to an agreement on methodology, Runoff Curve Numbers, site specific constraints and other pertinent details before the Design Engineer invests a significant amount of time and resources in a design that will ultimately be un-approvable.

Centralized storm water detention is required for all developments for all developments over one (1) acre in size. This may include but is not limited to retention and detention basins, parking lot detention, bio-swales, underground detention, etc.

Preliminary Stormwater Plan Content

The City of Delaware requires that a preliminary storm water management plan for a proposed development site be submitted to the Department of Engineering Services for review and approval prior to proceeding with a full storm water management plan design. The preliminary review material must include:

- Project Name & Location:
- Development Owner/Address/Telephone/email:
- Engineer/Address/Telephone/email:
- Topographic tributary area(s) map for both the entire site and offsite areas tributary to the property
- Conceptual development site layout
- Existing County and local field tile systems and drainage ditches as identified on current Delaware Water and Soil Conservation District office records.

- Total property acreage & proposed pre-developed runoff coefficients
- Proposed post development runoff coefficients
- Identify proposed major flood routing, storm sewer outfall points, and off-site improvements
- Identify downstream capacity concerns or limitations to the existing system
- Critical storm calculation, pre-developed 1-year and 100-year flows
- Required detention volumes for 1-year, critical, and 100-year events
- Design methodology being implemented
- Proposed detention and/or retention basin locations
- Identify all EPA and Army Corp of Engineers permits applicable to the project.

Final Storm Water Management Plan

Plan Format and Content

Existing Conditions Tributary Map

- ANSI D bond paper
- Existing contours
- Delineated Existing Tributary Area
- On site acreages for each tributary area
- Offsite acreages for each tributary area
- Flow line with sheet, shallow concentrated and channel flow areas labeled along with the slope of each section of the flow line and Time of Concentration for each tributary area
- Label existing outfalls for each area
- Existing storm structures and other infrastructure such as roads, buildings, sidewalks, parking lots, etc. that will impact the stormwater runoff.
- RCN or C values for each area
- The one year flow generated by each tributary area
- Existing Field Tiles per SCS, ODNR, County Records

Proposed Conditions Tributary Map

- ANSI D bond paper
- Proposed and existing contours as appropriate
- Delineated Proposed Tributary Area and offsite areas that are passing through the site
- On site acreages for each tributary area
- Offsite acreages for each tributary area
- Flow line with sheet, shallow concentrated, pipe flow and channel flow sections labeled along with the slope of the flow line and time of concentration for each tributary area.
- RCN or C values for each area
- Detention/Retention Basin locations
- Label proposed outfalls for each area
- Existing and proposed storm structures as well as other infrastructure; such as roads, buildings, sidewalks, parking lots, etc.
- Existing Field Tiles per SCS, ODNR, and/or County Records and details of the tie in points to new structures

Soils Map

- ANSI D bond paper
- Soil boundary line, soil type, and hydrological group
- Site boundaries

Proposed Storm Structure Tributary Map

- ANSI D bond paper
- Proposed storm structures as well as other infrastructure such as roads, buildings, sidewalks, parking lots, etc.
- Delineated tributary area to each structure
- Structure tributary acreages
- Structure number
- Composite C values or C values from chart for each tributary area
- Tc for each area
- Use 10 minutes to inlet for paved areas and 15 minutes to inlet for grassy areas for Tc to structures taking in onsite flow.
- Structures taking in offsite flow will use the Tc generated during the existing tributary analysis
- Existing storm structures

Report Body

The design engineer should provide a written general summary of the stormwater management plan. The body of the report should have a minimum of seven (7) sections. More may be needed on a case by case basis.

- Site Description
- Hydrologic Methodologies used to determine the runoff
- Existing Hydrologic conditions
- Developed Hydrologic conditions
- Storm water management plan – how the runoff is being moved through the site
- Applicable permits
- Calculation sheets and hydrograph printouts

Report Body Tables

The design engineer should provide a summary table for all onsite and offsite tributary areas for the pre-developed conditions in the Existing Conditions Section of the report. Use the following format:

Tributary Area Name	Area	CN	Tc	Q1	Q2	Q5	Q10	Q25	Q50	Q100

The design engineer should provide a summary table for all onsite and offsite tributary areas for the post-developed conditions in Developed Conditions Section of the report. Use the following format:

Tributary Area Name	Area	CN	Tc	Q1	QCrit	Q50	Q100

The design engineer should provide a summary table for all allowable release rates for each area. Use the following format:

Tributary Area Name	Q1-allowable	Q2-allowable	Q5-allowable	Q10-allowable	Q25-allowable	Q50-allowable	Q100-allowable

The design engineer should provide a table for each basin showing the required detention volumes and peak Water Surface Elevation for each named storm event in Developed Conditions Section of the report. Use the following format:

Storm Event	Water Surface Area (acre **or** sq ft)	Peak Water Surface Elevation (feet)	Detention Storage Volume (ac-ft **or** cubic feet)
1-Yr			
2-Yr			
5-Yr			
10-Yr			
25-Yr			
50-Yr			
100-Yr			

Calculations and Exhibits

The calculations and exhibits need to be arranged so an accurate comparison of the pre-developed and post-developed conditions can be accomplished. A partial list of calculations that may be required follows. All of these calculations may not apply to every project. Appropriate calculations to document and justify the engineering design of the project shall be submitted for review. The calculations shall be signed and sealed by the Design Engineer.

- Composite C and/or RCN numbers - Documenting existing and design C and RCN values
- MORPC Critical Storm Calculations
- Time of Concentration Calculations- Documenting Existing and Design time of concentration
- Storage Calculations indicating the amount of storage required and amount provided
- Water Quality Volume Calculations per OEPA NPDES permits.
- Downstream Capacity Calculations identifying any downstream “choke points” and verifying capacity of downstream systems as determined at the pre-design meeting for the Preliminary Stormwater Management Plan.
- Storm Sewer Design Calculations indicating drainage to, and capacity of, any proposed storm sewers
- Overland Flow and Flood-routing Calculations. The maximum elevation for the 100-yr flow shall be 1-ft below the Finished Floor elevation.
- Culvert Design Data Sheet Calculations indicating:
    - Drainage area to the culvert
    - Inlet or outlet control
    - Headwater or tail-water (if applicable)
    - Capacity of the proposed culverts
- Channel Calculations indicating drainage area, shape, slope, and capacity of all channels
- Weir Calculations indicating sizing for all weirs including the emergency spillway
- Orifice Calculations Orifice Calculations showing the size and number of orifices for the basin outlet structure
- Spread Calculations-Indicating the gutter capacity of streets and amount of pavement flooded for the 5-yr design storm
- Grate Calculations-Indicating the capacity of inlet grates to handle 5-yr design storm
- Pump curves for stormwater lift stations (assumes pre-approval of a stormwater lift station by the City)
- Construction Sedimentation Basin calculation
- Temporary outlet structure calculations per OEPA NPDES & ODNR

General Design Considerations:

The City of Delaware has implemented MS4 community requirements in regards to considering Phase II storm water quality and design. All development activity within the City is subject to the regulations of OEPA's General Permit OHCO00001.

Discharge Point

Onsite stormwater systems must discharge to one of the following offsite stormwater systems:

- A USGS "Blue Line" stream,
- An open channel system (including roadside ditches)
- A storm sewer system adequately sized for the intended flows

If none of the options above is feasible, then the Applicant must demonstrate that only sheet flow is being discharged with adequate quantity and quality controls in place, since concentrated flow may cause offsite erosion

The Applicant shall use an accepted hydrologic method to demonstrate that the existing offsite stormwater system can convey existing offsite flows and projected onsite flows in a manner that does not increase downstream peak water surface elevations during the 1-year through the 100-year design storms and satisfies the various design criteria in this design manual.

Stormwater Diversions

The diversion of stormwater runoff from one watershed or receiving stormwater system to another is generally prohibited because such diversions have the potential to cause or exacerbate flooding, erosion, or water quality problems in receiving watercourses. For the purposes of this manual, stormwater diversions are defined as the relocation of stormwater discharges from original receiving streams or stormwater systems to other systems that did not receive such discharges prior to construction. While it is recognized that stormwater runoff from small, onsite, tributary areas must be conveyed between catch basin sub-catchments, the City of Delaware will not allow the diversion of stormwater runoff from one major storm sewer system or open watercourse to another without proper documentation that includes proof of benefit. Stormwater system diversions may be considered on a case-by-case basis under circumstances where it can be shown that flooding and erosion will not increase and benefits to each watercourse can be achieved as a result of diverted flows. The diversion of any stormwater runoff from one stormwater system or watercourse to another shall be at the sole discretion of the Director of Engineering Services or their designee.

Field Tiles

Agricultural field tiles are for agricultural drainage purposes only and, in general, may not be used as an outlet of any development or stormwater facility. Field tiles that are discovered or intercepted during construction and do not exhibit evidence of conveying septic effluent shall be reconnected or connected into the proposed stormwater system. Field tiles that exhibit evidence of conveying septic effluent shall not be used for stormwater conveyance and shall be reported to the Delaware County Health Department for resolution upon discovery.

Designers preparing plans for development on existing agricultural lands shall, at a minimum, contact the Delaware County Engineer's office and the Delaware Soil and Water Conservation District to confirm the existence and location of existing tile systems. All visible field tile outlets

and locations shall be field located and shown on the stormwater management plans. Any plan information for field tile systems received from county agencies shall also be shown.

All field tiles discovered either through preliminary investigation or during construction shall be shown on as-built drawings.

Hydrology

Methodologies for Determining Runoff Volume and Peak Flows

Rational Method

Rational Method: $Q = CiA$

This method should only be used for drainage areas of 1 acres or less. This method is not acceptable for runoff attenuation. (Retention/Detention Basin Design) The most outstanding limitation of the Rational Method is that the only product of the method is peak discharge. The method provides only an estimate of a single point on the runoff hydrograph and, therefore, does not permit estimation of runoff volume - a computation that is mandatory for the design of stormwater storage facilities. As such, the rational method is more appropriately used in the sizing to stormwater conveyance systems.

Q = the maximum rate of rainfall runoff in cubic feet per second (cfs)
C = the runoff coefficient which is the ratio between the maximum rate of runoff from the area and the average rate of rainfall on the area during the time of concentration.
i = the average rainfall intensity, in inches per hour, for a duration equal to the time required for the runoff to flow from the most remote part of the drainage area to the point under design.
A = the drainage area in acres tributary to the point under design.

Under the rational method, it is assumed that the rate of runoff to each point under design consideration is a function of the average rainfall rate during the time required for water to flow from the most distant part in the tributary area to the point. This time of flow is called the "time of concentration". The rational method assumes that the peak rate of rainfall occurs within the time of concentration.

The runoff coefficients as shown in Table 2: Runoff Coefficients for the Rational Formula shall be used to determine the values for use with the rational method.

NRCS (SCS) Methods

For drainage areas over 1 acre, the methods explained in "Urban Hydrology for Small Watersheds", Technical Release No. 55, latest edition, and/or Technical Release No. 20, latest edition shall be used to calculate runoff volumes and peak rates of flow. Technical Releases No. 55 & No. 20 can be obtained from the United States Department of Agriculture, Natural Resources Conservation Service.

USGS Regression Equations

The regression equations presented in USGS Report 93-135 is an accepted method for estimating design peak-discharge values for streams with drainage areas between 17 and 2,600 acres. ** The application of this method is limited to the estimation of peak discharges for City funded culvert installation and replacement projects. The following equations shall be used for the various design storms:

$$Q_2 = 155\,(A)^{0.68}\,(P - 30)^{0.50}\,(13 - BDF)^{-0.5}$$

$$Q_5 = 200\,(A)^{0.71}\,(P - 30)^{0.63}\,(13 - BDF)^{-0.44}$$

$$Q_{10} = 228\,(A)^{0.74}\,(P - 30)^{0.68}\,(13 - BDF)^{-0.41}$$

$$Q_{25} = 265\,(A)^{0.76}\,(P - 30)^{0.72}\,(13 - BDF)^{-0.37}$$

$$Q_{50} = 293\,(A)^{0.78}\,(P - 30)^{0.74}\,(13 - BDF)^{-0.35}$$

$$Q_{100} = 321\,(A)^{0.79}\,(P - 30)^{0.76}\,(13 - BDF)^{-0.33}$$

where: Q_N = peak discharge rate in cfs,
A = the drainage area in square miles,
P = average annual precipitation in inches = 36.6* inches for Delaware, Ohio
BDF = the basin development factor.

* Data derived from The National Climatic Data Center (NCDC) Cooperative Stations. 58 complete years between 1931 and 1995.

** See USGS Report 93-135 pg. 22 for the statistical limitations for this method

The basin development factor (BDF) is determined by subdividing the drainage basin into thirds (lower, middle, and upper) with two lines drawn across the basin that are perpendicular to the main channel and principal tributaries. Four aspects of the drainage system are then evaluated within each third of the basin and assigned a value of 1 or 0:

- Channel improvements include any straightening, enlarging, deepening, and clearing made in the main drainage channel and principal tributaries. If at least 50 percent of the upstream channels in the basin are improved, then a value of 1 is assigned.
- Channel linings include any length of the main drainage channels and principal tributaries that have been lined with an impervious material such as concrete. A value of 1 is assigned if at least 50 percent of the upstream channels have been lined.
- Storm drains or storm sewers are defined as enclosed drainage structures (usually pipes) frequently used on secondary tributaries where drainage is received directly from streets or parking lots. A value of 1 is then assigned when more than 50 percent of the upstream secondary tributaries consist of storm drains.
- Curb and gutter streets frequently empty into storm drains. If more than 50 percent of the upstream basin is developed with streets and highways constructed with curbs and gutters, then a value of 1 will be assigned.

The following table provides an example for calculating the overall BDF for the entire basin that has channel improvements throughout, no channel linings, and storm drains with curb and gutter streets in the lower 2/3rds of the basin:

Table 1: Example Determination of the Basin Development Factor

Portion of Basin	Channel Improvements	Channel Linings	Storm Drains	Curb & Gutter Streets	Basin Development Factor
Lower 1/3	1	0	1	1	3
Middle 1/3	1	0	1	1	3
Upper 1/3	1	0	0	0	1
				Total :	7

Software

List any software used in the methodology section of the Stormwater Management Report. Common software programs that are acceptable to the Department of Engineering Services are:

- ODOT's CDSS, used primarily for culvert design, inlet spacing, and ditch design
- Hydra-Flow, Computer program by "intelSOLVE", Program is based on the Rational Method and used primarily for storm sewer design
- Haestad Methods POND 2 Software, which includes the U.S. SCS TR-55
- Win-TR-55 - Hydrology design
- HydroCAD Software Solutions LLC – Hydrology design
- TR-20 - Hydrology design
- HEC-RAS – The US Army Corps of Engineers river analysis program

Other software may be approved after review by the Department of Engineering Services

Drainage Area Determination

The drainage area shall be determined from one or more of the following sources:

- USGS maps
- Photogrammetrics
- Field investigations & Surveys
- Soil Survey of Delaware County
- Delaware County topographical maps and/or GIS contours.

Table 2: Runoff Coefficients for the Rational Formula

Cover type and hydrologic condition	Coefficients for hydrologic soil group:		
C Values for Urban Areas	B	C	D
Fully developed urban areas (vegetation established)			
Open space (lawns, parks, golf courses, cemeteries, etc.)			
Poor condition (grass cover < 50%)	0.45	0.61	0.69
Fair condition (grass cover 50% to 75%)	0.28	0.45	0.50
Good condition (grass cover > 75%)	0.16	0.36	0.47
Impervious areas:			
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)	0.96	0.96	0.96
Retention Basins, Ponds, River and Streams	0.96	0.96	0.96
Streets and roads:			
Paved; curbs and storm sewers (excluding right-of-way)	0.96	0.96	0.96
Paved; open ditches (including right-of-way)	0.69	0.77	0.80
Gravel (including right-of-way)	0.59	0.69	0.74
Dirt (including right-of-way)	0.52	0.64	0.69
Urban districts:			
Commercial and business (85% Impervious)	0.77	0.83	0.86
Industrial (72% Impervious)	0.66	0.74	0.80
Residential districts by average lot size:			
1/8 acre or less (town houses) (65% Impervious)	0.59	0.72	0.77
1/4 acre (38% Impervious)	0.37	0.54	0.64
1/3 acre (30% Impervious)	0.32	0.50	0.61
1/2 acre (25% Impervious)	0.29	0.47	0.59
1 acre (20% Impervious)	0.26	0.45	0.96
2 acres (12% Impervious)	0.21	0.41	0.52
C Values for Developing Urban Areas	B	C	D
Newly graded areas (pervious areas only, no vegetation)	0.61	0.74	0.83
C Values for Undeveloped or Agricultural Areas	B	C	D
Cultivated Land:			
With conservation treatment	0.37	0.47	0.59
Without conservation treatment	0.30	0.43	0.50
Pasture, grassland, or range - continuous forage for grazing			
Poor hydraulic condition (<50% ground cover)	0.39	0.52	0.61
Fair hydraulic condition (50 to 75% ground cover)	0.28	0.45	0.50
Good hydraulic condition (> 75% ground cover)	0.16	0.36	0.47
Meadow - continuous grass, protected from grazing, and mowed for hay	0.13	0.30	0.43
Brush - brush, weed, and grasses with brush the major element			
Poor hydraulic condition (<50% ground cover)	0.24	0.41	0.54
Fair hydraulic condition (50 to 75% ground cover)	0.11	0.29	0.41
Good hydraulic condition (> 75% ground cover)	0.05	0.39	0.34
Woods, Poor: forest litter, small trees & brush w/ regular grazing & burning	0.23	0.41	0.54
Fair: Woods are grazed but not burned, some forest litter covers the soil	0.15	0.34	0.45
Good: Woods are protected from grazing, litter & brush cover soil	0.10	0.29	0.41
Farmsteads - buildings, lawns, and driveways	0.36	0.52	0.61

Offsite Tributary Area

Stormwater runoff from offsite upstream tributary areas that discharge to or across a development site shall be accommodated within the stormwater facilities planned for the development site. No stormwater management plans will be approved until it is demonstrated that offsite runoff will be adequately conveyed through the development site in a manner that will not cause or contribute to hazardous or detrimental upstream and downstream flooding and erosion. The estimation of the offsite flows must be done separately from the estimation of onsite flows (i.e., separate hydrographs for offsite areas must be determined). Detention / Retention is not required for the offsite flows unless downstream condition warrant it. Offsite flows must be treated for water quality per Ohio EPA requirements.

The allowable release rate from a site that is "passing through" offsite runoff shall be the allowable release rate for the site plus the pre developed offsite flow for the design storm.

Time of Concentration (Tc)

Time of concentration (T_c) for a drainage area is defined as the time a drop of water takes to drain from the hydraulically most remote point in the watershed to the point of interest. T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge rate. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading. In general, higher and faster peak discharge is associated with smaller T_c. The time of concentration determines the average rainfall rate on the rainfall intensity-duration-frequency curve.

Different methods are available for computing T_c for a drainage area. Acceptable methods in the City of Delaware are the TR-55 tabular method and SCS Lag method

Factors affecting Time of Concentration (T_c) and Travel Time (T_t)

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development. The flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

SCS Lag Method for Computing T_c

This method was proposed by the Soil Conservation Services (SCS) and evaluates the drainage basin based on the average land slope, curve number (CN) and the hydraulic length.

From the known CN, the available storage (S) is computed using:

$$S = \frac{1000}{CN} - 10$$

The basin lag is then estimated using:

$$Lag = \frac{L^{0.8} \times (S+1)^{0.7}}{1900 \times (s \times 100)^{0.5}} hours$$

Where: Lag = basin lag in hours
L = hydraulic length in feet
S = available storage
s = average slope of the drainage area in ft/ft (It is not the slope of a specific flow path, but rather the average slope of the watershed area.)

The time of concentration (Tc) for the drainage basin is then computed using:

T_c = 1.67 x Lag (hours)
T_c = 1.67 x Lag x 60 (minutes)

TR-55 Tabular Method for Computing T_c

The TR-55 tabular method of computing T_c divides it into travel time for three different segments of flow. Travel time for each segment are computed and summed to arrive at the time of concentration. Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Time of concentration (T_c) is the sum of time of travel values for the various consecutive flow segments:

$$T_c = t_{sheet} + t_{shallow} + t_{channel} + t_{conduit}$$

Sheet flow

Sheet flow is flow over plane surfaces. Generally the depth of sheet flow is less than 0.1 feet and is a steady, uniform flow. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, rocks, erosion and transportation of sediment. Table 3: Roughness coefficients (Manning's n) for Sheet Flow gives Manning's n values for sheet flow for various surface conditions. Typically sheet flow length is less than 100-feet for paved areas with a maximum of 300-feet in length for unpaved areas, and is less than 20 minutes in duration. In general, sheet flow will not exceed 1-inch in depth.

For Sheet flow of less than 300 feet, use Manning's Kinematic Solution (Overton and Meadows 1976) to compute T_{sheet}

$$t_{sheet} = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

where: t_{sheet} = travel time (hr),
n = Manning's roughness coefficient (table 3)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following assumptions:

- Shallow steady uniform flow,
- Constant intensity of rainfall excess (that part of a rain available for runoff),
- Rainfall duration of 24 hours, and
- Minor effect of infiltration on travel time.

Rainfall depth can be obtained from the rainfall runoff equations.

Table 3: Roughness coefficients (Manning's n) for Sheet Flow

Surface Description	n [1]
Smooth Surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short Grass Prairie	0.15
Dense Grasses [2]	0.24
Bermuda Grass	0.41
Range (natural)	0.13
Woods [3]	
Light Underbrush	0.40
Dense Underbrush	0.80
[1] The n values are a composite of information compiled by Engman (1986)	
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures	
[3] When selecting n, consider cover to a height of about 0.1 feet. This is the only part of the plant cover that will obstruct sheet flow.	

Shallow Concentrated Flow

Sheet flow is assumed to occur for no more than 300 feet after which water tends to concentrate in rills and then gullies of increasing proportion. This type of flow is classified as shallow concentrated flow. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope. The velocity of shallow concentrated flow can be estimated using the following equation:

$$V = 3.281 \cdot k \cdot s^{0.5}$$

where: V = Velocity in fps
k = Intercept coefficient (see Table 4)
s = Overland slope (percent)

Table 4: Shallow Concentrated Flow Intercept Coefficient (k)

Types of Surface	Intercept Coefficient "k"
Forest with heavy ground litter	0.076
Minimum tillage cultivated; woodland	0.152
Short grass pasture	0.213
Cultivated straight row	0.274
Poor grass; untilled	0.305
Grassed waterways	0.457
Unpaved area; bare soil	0.491
Paved area	0.619

For slopes less than 0.005 ft/ft, use equations given below.

V = 16.1345 s (Unpaved)
V = 20.3282 s (Paved)

Where: V = average velocity (ft/s), and
s = slope of hydraulic grade line (watercourse slope, ft/ft)

These two equations are based on a solution of the Manning equation with different assumptions for n (Manning roughness coefficient) and r (hydraulic radius, ft). For unpaved areas, n is 0.05 and r is 0.4; for paved areas, n is 0.025 and r is 0.2.

After determining average velocity the following equations below, use the $t_{shallow}$ equation to estimate travel time for the shallow concentrated flow segment. The travel time for shallow concentrated flow is calculated as follows:

$$t_{shallow} = \frac{L}{3600 \cdot V}$$

where: $t_{shallow}$ = Travel time for shallow concentrated flow in hours
L = Flow length in feet
V = Velocity in fps

Open Channel Flow

Shallow concentrated flow generally empties into pipe systems, drainage ditches, or natural channels. The velocity of flow in an open channel or pipe can be estimated using the Manning's equation. Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Manning's equation is:

$$V = \frac{1.49 r^{2/3} s^{1/2}}{n}$$

where: V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to a/ p_w
a = cross sectional flow area (ft^2)
p_w = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow. (See tables below)

After average velocity is computed using the above equation, $t_{channel}$ (for both channel and conduit flow) can be determined using the following equation:

$$t_{channel} = \frac{L}{3600 \cdot V}$$

where: $t_{channel}$ = Travel time for shallow concentrated flow in hours
L = Flow length in feet
V = Velocity in fps

Given varying cross-sections of flow paths, and varying peak rates of flow and resulting varying depths of flow for different return periods, it is expected that each return period would result in a different t_c. In order to help simplify the modeling process the City will accept an average cross-section of the open channel in segments of 250-ft in length, with a depth of flow determined by the 2-year return period event. This simplification is for determining the t_c only, and is not to be used for the design of new open channels. New channels are to be designed using the design storm specified in the section on Open Watercourses.

Table 5: C Values for Excavated Channels

Roughness Coefficient for Excavated Open Channels			Manning's n Range		
Type	Characteristics		Minimum n	Normal n	Maximum n
Earth, straight and uniform	clean, recently completed		0.016	0.018	0.020
	clean, after weathering		0.018	0.022	0.025
	gravel, uniform section		0.022	0.025	0.030
	clean with short grass, few weeds		0.022	0.027	0.033
Earth, winding and sluggish	no vegetation		0.023	0.025	0.030
	grass, some weeds		0.025	0.030	0.033
	dense weeds or aquatic plants in deep channels		0.030	0.035	0.040
	earth bottom and ruble sides		0.028	0.030	0.035
	stony bottom and weed banks		0.025	0.035	0.040
	cobble bottom and clean sides		0.030	0.040	0.050
Dragline-excavated or dredged	no vegetation		0.025	0.028	0.033
	light brush on banks		0.035	0.050	0.060
Rock cuts	based on design section		0.035	0.045	0.050
	based on actual mean section	smooth and uniform	0.025	0.035	0.040
		jagged and irregular	0.035	0.040	0.050
Channels not maintained, weed and brush uncut	dense weed high as flow depth		0.050	0.080	0.120
	clean bottom, brush on sides		0.040	0.050	0.080
	clean bottom, brush on sides, highest stage of flow		0.045	0.070	0.110
	dense brush, high stage		0.080	0.100	0.140

Table 6: C Values for Roadside Ditches

Roadside channels and swales with maintained vegetation (Values shown are for velocities of 2 and 6 ft/sec)			Manning's n Range		
			Minimum n	Normal n	Maximum n
Depth of flow up to 0.7 ft	Bermuda grass, Kentucky bluegrass, buffalo grass	Mowed to 2 in	0.045	0.058	0.070
		Mowed to 6 in	0.050	0.070	0.090
	Good stand, any grass	Length about 12 inches	0.090	0.135	0.180
		Length about 24 inches	0.150	0.225	0.300
	Fair stand, any grass	Length about 12 inches	0.080	0.110	0.140
		Length about 24 inches	0.130	0.190	0.250
Depth of flow 0.7 - 1.5 ft	Bermuda grass, Kentucky bluegrass, buffalo grass	Mowed to 2 in	0.038	0.044	0.050
		Mowed to 6 in	0.040	0.050	0.060
	Good stand, any grass	Length about 12 inches	0.070	0.095	0.120
		Length about 24 inches	0.100	0.150	0.200
	Fair stand, any grass	Length about 12 inches	0.060	0.080	0.100
		Length about 24 inches	0.090	0.130	0.170

Table 7: C Values for Lined Channels

Roughness Coefficient for Lined Open Channels		Manning's n Range		
Type	Characteristics	Minimum n	Normal n	Maximum n
Cement	neat surface	0.010	0.011	0.013
	mortar	0.011	0.013	0.015
Concrete	trowel finish	0.011	0.013	0.015
	float finish	0.013	0.015	0.016
	finished, with gravel on bottom	0.015	0.017	0.020
	unfinished	0.014	0.017	0.020
	gunite, good section	0.016	0.019	0.023
	gunite, wavy section	0.018	0.022	0.025
	on good excavated rock	0.017	0.019	0.020
	on irregular excavated rock	0.022	0.025	0.027
Concrete bottom float finished with sides of :	dressed stone in mortar	0.015	0.017	0.020
	random stone in mortar	0.017	0.020	0.024
	cement rubble masonry, plastered	0.016	0.020	0.024
	cement rubble masonry	0.020	0.025	0.030
	dry rubble or riprap	0.020	0.030	0.035
Gravel bottom with sides of:	formed concrete	0.017	0.020	0.025
	random stone in mortar	0.020	0.023	0.026
	dry rubble or riprap	0.023	0.033	0.036
Brick	glazed	0.011	0.013	0.015
	in cement mortar	0.012	0.015	0.018
Masonry	cemented rubble	0.017	0.025	0.030
	dry rubble	0.023	0.032	0.035
Dressed ashlar	--	0.013	0.015	0.017
Asphalt	smooth	0.013	0.013	0.013
Vegetal lining	--	0.030	0.040	0.500

Table 8: C Values for Natural Channels

Natural Stream Channels			Manning's n Range		
Type	Characteristics		Minimum n	Normal n	Maximum n
Minor Streams (surface width at flood stage is less than 100 feet)	Fairly regular section	Some grass and weeds, little or no brush	0.030	0.033	0.035
		Dense growth of weed, depth of flow materially greater than weed height	0.035	0.043	0.050
		Some weeds, light brush on banks	0.040	0.045	0.050
		Some weeds, heavy brush on banks	0.050	0.060	0.070
		Some weed, dense willows on banks	0.060	0.070	0.080
	For trees within the channel, with branches submerged at high stage, increase all above values by:		0.010	0.015	0.020
	For irregular section, with pools, slight meander, increase value for fairly regular sections by about:		0.010	0.015	0.020
	Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage	Bottom of gravel, cobbles and few boulders	0.040	0.045	0.050
		Bottom of cobbles, with large boulders	0.050	0.060	0.070

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Typically sheet flow length is less than 100-feet for paved areas with a maximum of 300-feet in length for unpaved areas. It takes approximately 20 minutes of rainfall at the 2 year intensity for measurable runoff to occur. In general, sheet flow will not exceed 1-inch in depth.

Manning's Kinematic Equation was developed for use with the four standard SCS rainfall intensity-duration relationships.

In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate Tc. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or non-pressure flow.

The minimum T_c used in TR-55 is 0.1 hour.

A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

SCS Runoff Curve Numbers (CN)

The major factors that determine CN are the hydrologic soil group, cover type, treatment, hydrologic condition, and antecedent runoff condition. Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected).

Table 9: Runoff Curve Numbers (CN) for Typical Land Uses in the City of Delaware is provided to aid in selecting the appropriate figure or table for determining curve numbers for the City of Delaware. The CN values in table 9 represent average the runoff condition for urban, developing urban, and predeveloped agricultural land uses typical to area in and around the City of Delaware. The values in table 9 are to be used in all projects in the city and may be vary slightly from those found in other publications. In all cases the values found in table 9 supersede those found in other publications. Table 9 assumes impervious areas are directly connected to a suitable outlet.

Hydrologic Soil Groups (HSG)

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. The vast majority of the soils in Delaware County fall into the C or D group. The soils in the area of interest may be identified from the Delaware County Soil Survey, which can be obtained from the Delaware Soil and Water Conservation office.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. In areas where soil has been previously disturbed by construction activities in the urban environment an HSG of D shall be used.

Ground Cover

Table 9 addresses most cover types typically found in the City of Delaware, such as common native and cultivated vegetation, bare soil, water surfaces and impervious surfaces. There are a number of methods for determining existing cover type for the proposed development. The most common are field reconnaissance, aerial photographs, and land use maps. Ponds are considered impervious and must be included at a CN of 98 or a C of 0.96

SCS Type II Storm

Different rainfall distributions can be developed to emphasize the critical rainfall duration for the peak discharges. To avoid the use of a different set of rainfall intensities for each drainage area size, a set of synthetic rainfall distributions having “nested” rainfall intensities was developed. The set “maximizes” the rainfall intensities by incorporating selected short duration intensities within those needed for longer durations at the same probability level.

For the size of the drainage areas for which NRCS usually provides assistance, a storm period of 24 hours was chosen the synthetic rainfall distributions. The 24-hour storm, while longer than that needed to determine peaks for these drainage areas, is appropriate for determining runoff volumes. Therefore, a single storm duration and associated synthetic rainfall distribution can be used to represent not only the peak discharges but also the runoff volumes for a range of drainage area sizes. For the City of Delaware, the synthetic storm to be used in modeling rainfall events is the NRCS (SCS) Type II Storm.

Table 9: Runoff Curve Numbers (CN) for Typical Land Uses in the City of Delaware

Cover type and hydrologic condition	Curve numbers for hydrologic soil group		
Runoff Curve Numbers for Urban Areas	B	C	D
Fully developed urban areas (vegetation established)			
Open space (lawns, parks, golf courses, cemeteries, etc.)			
Poor condition (grass cover < 50%)	79	86	89
Fair condition (grass cover 50% to 75%)	69	79	84
Good condition (grass cover > 75%)	61	74	80
Impervious areas:			
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)	98	98	98
Retention Basins, Ponds, River and Streams	98	98	98
Streets and roads:			
Paved; curbs and storm sewers (excluding right-of-way)	98	98	98
Paved; open ditches (including right-of-way)	89	92	93
Gravel (including right-of-way)	85	89	91
Dirt (including right-of-way)	82	87	89
Urban districts:			
Commercial and business (85% Impervious)	92	94	95
Industrial (72% Impervious)	88	91	93
Residential districts by average lot size:			
1/8 acre or less (town houses) (65% Impervious)	85	90	92
1/4 acre (38% Impervious)	75	83	87
1/3 acre (30% Impervious)	72	81	86
1/2 acre (25% Impervious)	70	80	85
1 acre (20% Impervious)	68	79	98
2 acres (12% Impervious)	65	77	82
Runoff Curve Numbers for Developing Urban Areas	B	C	D
Newly graded areas (pervious areas only, no vegetation)	86	91	94
Runoff Curve Numbers for Undeveloped or Agricultural Areas	B	C	D
Cultivated Land:			
With conservation treatment	75	80	85
Without conservation treatment	71	78	81
Pasture, grassland, or range - continuous forage for grazing			
Poor hydraulic condition (<50% ground cover)	76	82	86
Fair hydraulic condition (50 to 75% ground cover)	69	79	84
Good hydraulic condition (> 75% ground cover)	61	74	80
Meadow - continuous grass, protected from grazing, and mowed for hay	58	71	78
Brush - brush, weed, and grasses with brush the major element			
Poor hydraulic condition (<50% ground cover)	67	77	83
Fair hydraulic condition (50 to 75% ground cover)	56	70	77
Good hydraulic condition (> 75% ground cover)	48	76	73
Woods , Poor: forest litter, small trees & brush w/ regular grazing & burning	66	77	83
Fair: Woods are grazed but not burned, some forest litter covers the soil	60	73	79
Good: Woods are protected from grazing, litter & brush cover soil	55	70	77
Farmsteads - buildings, lawns, and driveways	74	82	86

Rainfall Intensity Duration Curves

Acceptable rainfall intensities for use in culvert, storm system, and Hydrological design are those provided in NOAA Atlas 14 (Delaware, Ohio [33-2119]; 40.3175 N, 83.0739 W, 898 feet) or the "Rainfall Frequency Atlas of the Midwest" by Floyd A. Huff and James R. Angel (Bulletin 71).

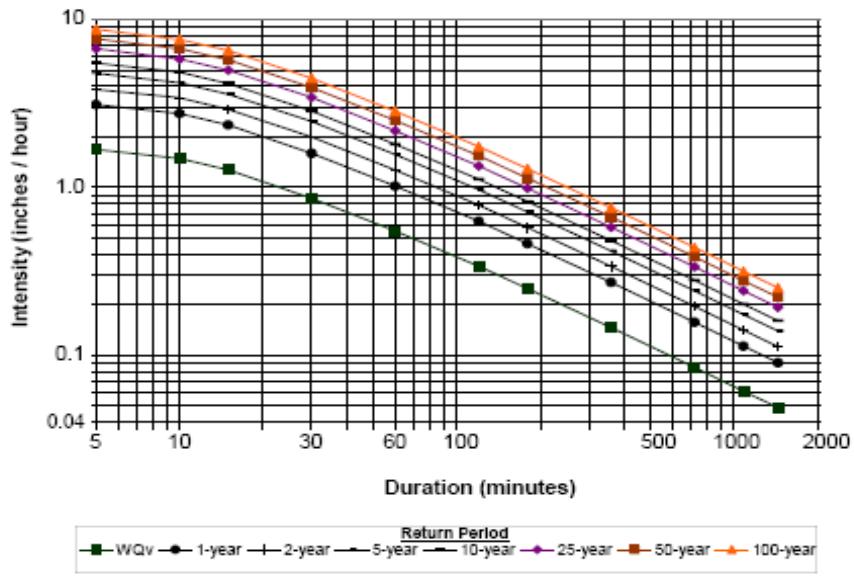
A tabulation of rainfall intensities for the 1-, 2-, 5-, 10-, 25-, 50-. and 100-year recurrence intervals, and for duration ranging from 10 through 200 minutes, has been developed for Delaware and is shown in table 11. This data supersedes the rainfall data from Technical Paper No. 40. Intensities for durations not shown shall be calculated by the rainfall intensity equations provided.

Total rainfall amounts for Delaware are presented in table 10 (below) for selected rainfall durations and recurrence intervals. The 24-hour rainfall amounts are to be used with the NRCS TR-55 methods.

Table 10: Bulletin 71: Sectional Mean Frequency Distributions for the City of Delaware

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	3-hr	6-hr	12-hr	18-hr	24-hr	48-hr	72-hr	5-day	10-day
2-month	0.14	0.25	0.32	0.44	0.56	0.69	0.76	0.90	1.04	1.12	1.19	1.27	1.36	1.49	1.81
3-month	0.17	0.29	0.38	0.51	0.65	0.81	0.89	1.04	1.21	1.31	1.39	1.48	1.59	1.78	2.18
4-month	0.18	0.32	0.41	0.56	0.71	0.88	0.97	1.14	1.32	1.43	1.52	1.65	1.80	2.01	2.51
6-month	0.21	0.37	0.48	0.65	0.83	1.02	1.13	1.32	1.53	1.65	1.76	1.91	2.09	2.34	2.95
9-month	0.24	0.42	0.54	0.74	0.94	1.16	1.28	1.50	1.74	1.88	2.00	2.20	2.40	2.69	3.39
1-year	0.26	0.46	0.59	0.80	1.02	1.26	1.39	1.63	1.89	2.04	2.26	2.39	2.61	2.92	3.69
2-year	0.32	0.57	0.73	1.00	1.27	1.57	1.73	2.03	2.35	2.54	2.70	2.97	3.23	3.67	4.69
5-year	0.40	0.70	0.90	1.24	1.57	1.94	2.14	2.51	2.91	3.15	3.35	3.67	3.99	4.65	5.93
10-year	0.46	0.81	1.04	1.43	1.81	2.24	2.47	2.89	3.36	3.63	3.86	4.21	4.54	5.39	6.78
25-year	0.56	0.97	1.25	1.72	2.18	2.69	2.97	3.48	4.04	4.36	4.64	5.02	5.36	6.37	7.82
50-year	0.64	1.12	1.44	1.97	2.51	3.09	3.41	4.00	4.64	5.01	5.33	5.72	6.09	7.11	8.56
100-year	0.73	1.27	1.64	2.24	2.85	3.51	3.88	4.55	5.27	5.70	6.06	6.50	6.92	7.89	9.27

Figure 1: Bulletin 71: I-D-F Curve for Central Ohio



Revised Rainfall Intensity Equations incorporating Bulletin 71 Data

$$I_{1\,year} = e^{\left[0.0219-(0.6891(\ln T))-(0.0416(\ln T)^2)+(0.0077(\ln T)^3)+(0.0012(\ln T)^4)-(0.0006(\ln T)^5)\right]}$$

$$I_{2\,year} = e^{\left[0.2510-(0.7155(\ln T))-(0.0194(\ln T)^2)+(0.0106(\ln T)^3)-(0.0041(\ln T)^4)+(0.0003(\ln T)^5)\right]}$$

$$I_{5\,year} = e^{\left[0.4818-(0.7082(\ln T))-(0.0274(\ln T)^2)+(0.0054(\ln T)^3)-(0.0042(\ln T)^4)+(0.0010(\ln T)^5)\right]}$$

$$I_{10\,year} = e^{\left[0.6299-(0.7173(\ln T))-(0.0485(\ln T)^2)+(0.0141(\ln T)^3)+(0.0007(\ln T)^4)-(0.0007(\ln T)^5)\right]}$$

$$I_{25\,year} = e^{\left[0.7932-(0.7078(\ln T))-(0.0350(\ln T)^2)+(0.0129(\ln T)^3)-(0.0025(\ln T)^4)+(0.0000(\ln T)^5)\right]}$$

$$I_{50\,year} = e^{\left[0.9206-(0.6933(\ln T))-(0.0357(\ln T)^2)+(0.0105(\ln T)^3)-(0.0025(\ln T)^4)+(0.0002(\ln T)^5)\right]}$$

$$I_{100\,year} = e^{\left[1.0494-(0.6891(\ln T))-(0.0467(\ln T)^2)+(0.0119(\ln T)^3)-(0.0012(\ln T)^4)-(0.0001(\ln T)^5)\right]}$$

Where:

I = Rainfall Intensity in inches per hour
e = constant (approximately equal to 2.718282)
ln = natural logarithm
T = time in hours

Table 11: Bulletin 71 – Selected Design Rainfall Intensities

Duration (minutes)	Rainfall Intensity (in/hr) for recurrence interval of :						
	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
10.0	3.01	3.90	4.81	5.47	6.35	7.09	7.81
10.5	2.93	3.82	4.71	5.34	6.23	6.95	7.66
11.0	2.86	3.74	4.61	5.23	6.11	6.82	7.52
11.5	2.80	3.66	4.52	5.12	5.99	6.69	7.38
12.0	2.73	3.59	4.43	5.01	5.88	6.56	7.25
12.5	2.67	3.51	4.35	4.91	5.77	6.44	7.12
13.0	2.62	3.45	4.26	4.82	5.66	6.33	7.00
13.5	2.57	3.38	4.18	4.73	5.56	6.21	6.88
14.0	2.51	3.31	4.11	4.64	5.46	6.10	6.77
14.5	2.47	3.25	4.03	4.56	5.37	6.00	6.66
15.0	2.42	3.19	3.96	4.48	5.28	5.90	6.55
15.5	2.38	3.13	3.89	4.40	5.19	5.80	6.45
16.0	2.34	3.08	3.82	4.33	5.10	5.71	6.35
16.5	2.30	3.03	3.76	4.26	5.02	5.62	6.25
17.0	2.26	2.97	3.69	4.19	4.94	5.53	6.16
17.5	2.22	2.92	3.63	4.13	4.87	5.44	6.07
18.0	2.19	2.88	3.57	4.06	4.79	5.36	5.98
18.5	2.15	2.83	3.52	4.00	4.72	5.28	5.89
19.0	2.12	2.78	3.46	3.94	4.65	5.21	5.81
19.5	2.09	2.74	3.41	3.89	4.58	5.13	5.73
20.0	2.06	2.70	3.36	3.83	4.52	5.06	5.66
21.0	2.00	2.62	3.26	3.72	4.39	4.92	5.51
22.0	1.95	2.55	3.17	3.63	4.27	4.79	5.37
23.0	1.89	2.47	3.08	3.53	4.16	4.67	5.24
24.0	1.85	2.41	3.00	3.44	4.06	4.55	5.11
25.0	1.80	2.35	2.93	3.36	3.96	4.44	4.90
26.0	1.76	2.29	2.86	3.28	3.56	4.34	4.88
27.0	1.72	2.23	2.79	3.21	3.78	4.24	4.77
28.0	1.68	2.18	2.72	3.13	3.69	4.15	4.67
29.0	1.65	2.13	2.66	3.07	3.61	4.06	4.58
30.0	1.61	2.08	2.60	3.00	3.53	3.97	4.48
32.0	1.55	1.99	2.49	2.88	3.39	3.82	4.31
34.0	1.49	1.91	2.40	2.77	3.26	3.67	4.15
36.0	1.44	1.84	2.31	2.67	3.14	3.54	4.01
38.0	1.39	1.77	2.22	2.58	3.03	3.42	3.87
40.0	1.34	1.71	2.15	2.49	2.93	3.30	3.74
42.0	1.30	1.65	2.08	2.41	2.83	3.20	3.63
44.0	1.26	1.60	2.01	2.33	2.74	3.10	3.52
46.0	1.22	1.55	1.95	2.26	2.66	3.01	3.42
48.0	1.19	1.51	1.89	2.20	2.58	2.93	3.32

Duration (minutes)	Rainfall Intensity (in/hr) for recurrence interval of :						
	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
50.0	1.16	1.46	1.84	2.14	2.51	2.85	3.23
52.0	1.13	1.42	1.79	2.08	2.44	2.77	3.15
54.0	1.10	1.39	1.74	2.02	2.38	2.70	3.07
56.0	1.07	1.35	1.70	1.97	2.32	2.63	2.99
58.0	1.05	1.32	1.66	1.92	2.26	2.57	2.92
60.0	1.02	1.29	1.62	1.88	2.21	2.51	2.86
65.0	0.97	1.21	1.53	1.77	2.09	2.37	2.70
70.0	0.92	1.15	1.45	1.68	1.98	2.25	2.57
75.0	0.87	1.09	1.38	1.60	1.88	2.15	2.44
80.0	0.84	1.04	1.32	1.52	1.80	2.05	2.33
85.0	0.80	1.00	1.26	1.45	1.72	1.96	2.23
90.0	0.77	0.96	1.21	1.39	1.65	1.89	2.14
95.0	0.74	0.92	1.16	1.34	1.59	1.81	2.06
100.0	0.71	0.89	1.12	1.29	1.53	1.75	1.99
110.0	0.66	0.83	1.04	1.20	1.42	1.63	1.85
120.0	0.62	0.78	0.98	1.12	1.34	1.53	1.74
130.0	0.59	0.73	0.92	1.05	1.26	1.44	1.64
140.0	0.56	0.69	0.87	1.00	1.19	1.37	1.55
150.0	0.53	0.66	0.83	0.94	1.13	1.30	1.47
160.0	0.50	0.63	0.79	0.90	1.08	1.24	1.40
170.0	0.48	0.60	0.75	0.86	1.03	1.18	1.34
180.0	0.46	0.58	0.72	0.82	0.99	1.13	1.28
190.0	0.44	0.55	0.69	0.79	0.95	1.09	1.23
200.0	0.43	0.53	0.67	0.76	0.91	1.05	1.19

NOAA Atlas 14

The Rainfall Intensity-Duration-Frequency curves are based upon data obtained from National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Volume 2.

Table 12: NOAA Atlas 14: Precipitation Frequency Estimates for the City of Delaware

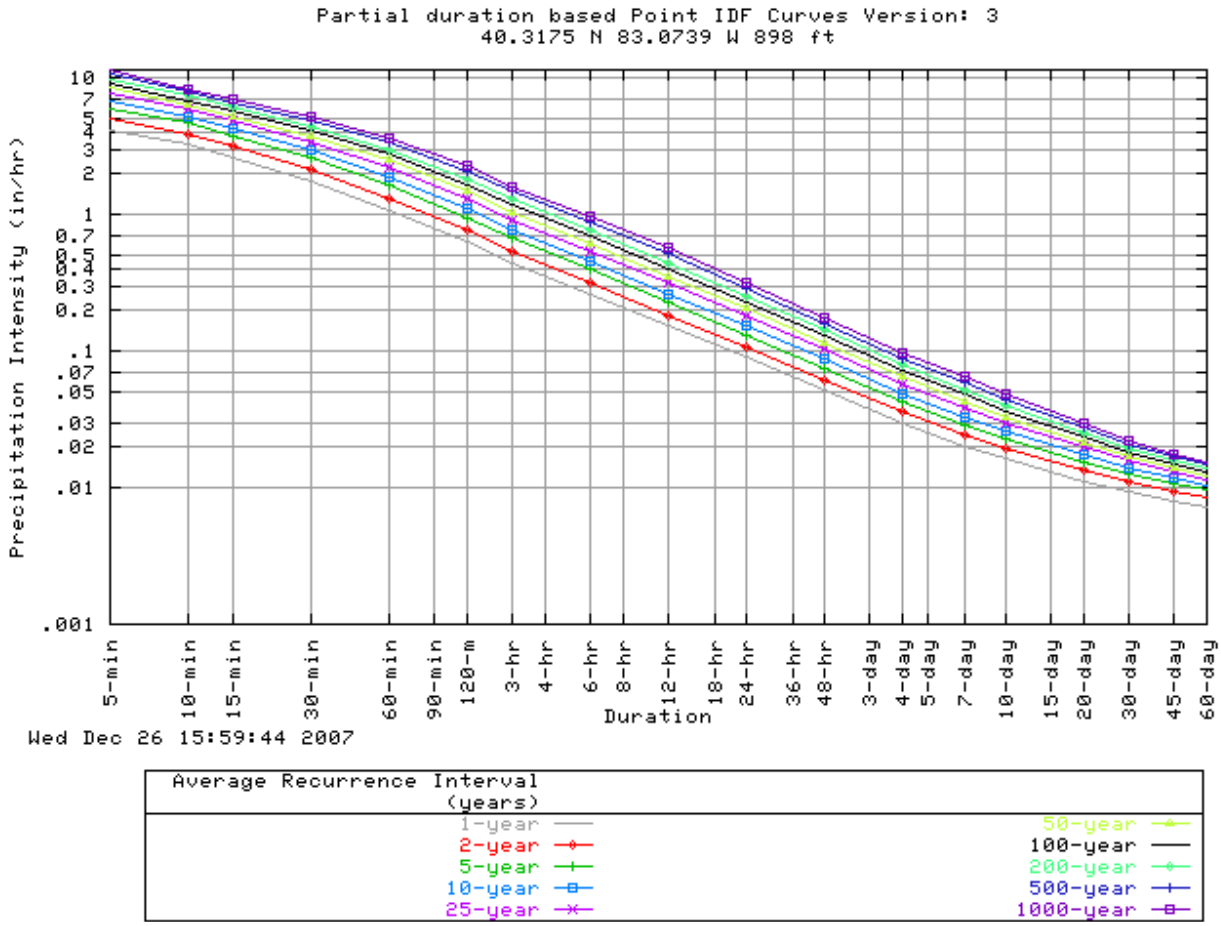
Precipitation Frequency Estimates (inches)																		
ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.35	0.54	0.66	0.88	1.07	1.25	1.33	1.57	1.84	2.16	2.50	2.86	3.39	3.88	5.39	6.73	8.57	10.35
2	0.42	0.65	0.79	1.06	1.30	1.52	1.60	1.89	2.20	2.58	2.98	3.41	4.04	4.60	6.36	7.91	10.06	12.12
5	0.50	0.77	0.95	1.30	1.63	1.90	2.01	2.36	2.73	3.16	3.64	4.13	4.88	5.50	7.45	9.17	11.55	13.82
10	0.56	0.87	1.07	1.48	1.89	2.21	2.33	2.73	3.16	3.65	4.17	4.72	5.56	6.22	8.31	10.12	12.66	15.08
25	0.64	0.98	1.21	1.71	2.22	2.62	2.78	3.27	3.77	4.32	4.92	5.53	6.50	7.19	9.45	11.34	14.04	16.68
50	0.70	1.07	1.32	1.89	2.48	2.95	3.13	3.70	4.27	4.88	5.53	6.18	7.26	7.97	10.32	12.25	15.06	17.85
100	0.76	1.15	1.42	2.06	2.75	3.29	3.50	4.16	4.80	5.46	6.16	6.85	8.04	8.75	11.18	13.12	16.00	18.94
200	0.82	1.22	1.52	2.22	3.02	3.64	3.89	4.64	5.37	6.06	6.81	7.54	8.84	9.55	12.04	13.96	16.90	19.96
500	0.90	1.32	1.65	2.44	3.38	4.12	4.41	5.32	6.16	6.91	7.72	8.48	9.96	10.64	13.15	15.00	17.99	21.22
1000	0.95	1.39	1.73	2.60	3.65	4.49	4.82	5.86	6.79	7.60	8.45	9.22	10.83	11.48	13.98	15.76	18.77	22.10

*ARI is the Average Recurrence Interval

Table 13: NOAA Atlas 14: Precipitation Intensity Estimates for the City of Delaware

Precipitation Intensity Estimates (in/hr)																		
ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	4.18	3.25	2.65	1.75	1.07	0.63	0.44	0.26	0.15	0.09	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01
2	4.99	3.89	3.18	2.13	1.30	0.76	0.53	0.32	0.18	0.11	0.06	0.04	0.02	0.02	0.01	0.01	0.01	0.01
5	5.98	4.65	3.80	2.60	1.63	0.95	0.67	0.39	0.23	0.13	0.08	0.04	0.03	0.02	0.02	0.01	0.01	0.01
10	6.74	5.21	4.27	2.97	1.89	1.11	0.78	0.46	0.26	0.15	0.09	0.05	0.03	0.03	0.02	0.01	0.01	0.01
25	7.72	5.90	4.86	3.43	2.22	1.31	0.92	0.55	0.31	0.18	0.10	0.06	0.04	0.03	0.02	0.02	0.01	0.01
50	8.45	6.41	5.29	3.78	2.49	1.48	1.04	0.62	0.36	0.20	0.12	0.06	0.04	0.03	0.02	0.02	0.01	0.01
100	9.16	6.89	5.71	4.12	2.76	1.65	1.17	0.70	0.40	0.23	0.13	0.07	0.05	0.04	0.02	0.02	0.01	0.01
200	9.88	7.37	6.11	4.46	3.02	1.82	1.29	0.78	0.45	0.25	0.14	0.08	0.05	0.04	0.03	0.02	0.02	0.01
500	10.81	7.95	6.62	4.90	3.39	2.06	1.47	0.89	0.51	0.29	0.16	0.09	0.06	0.04	0.03	0.02	0.02	0.01
1000	11.48	8.36	6.96	5.22	3.67	2.25	1.61	0.98	0.57	0.32	0.18	0.10	0.06	0.05	0.03	0.02	0.02	0.02

Figure 2: NOAA Atlas 14: I-D-F Curve for the City of Delaware



Development of Equations for Rainfall Intensity-Duration

If it is necessary to develop equations for the rainfall intensity-duration curves in the format shown below for the various frequencies using either the Bulletin 71 or the Atlas 14 data, the methodology outlined in Federal Highway Administration Hydraulic Engineering Circular No. 12, Appendix A shall be used. The methodology is for converting I-D-F data points to an equation of the general form. This format is especially useful for computer solutions of runoff rates in storm system design. All calculations and equations developed using this method must be submitted to the City of Delaware for review. The equation for intensity curves shall be of the form:

$$i = \frac{a}{(t+b)^c}$$

Where: i = rainfall intensity (inches/hour)
t = time of concentration (minutes)
a = constant
b = constant
c = constant

Critical Storm Calculation

Stormwater runoff control addresses both peak rate and total volume of runoff.

The peak rate of runoff from an area after development shall not exceed the peak rate of runoff from the same area before development for all storms up to a 100-year frequency, 24-hour storm. In addition, if it is found a proposed development will increase the volume of runoff from an area, the peak rate of runoff from certain more frequent storms must be controlled further.

There are two reasons why increases in volume of runoff require a control standard more restrictive than controlling to the predevelopment condition. First, increases in volume mean runoff will be flowing for a longer period of time. When routed through a watershed, these longer flows may join at some point or points downstream thereby creating new peak flows and the problems associated with peak flow (flooding). This is known as the "Routing Problem." Second, longer flow periods of large runoff quantities place a highly erosive stress on natural channels. Reducing the rate of discharge can minimize this stress. The permissible peak rate shall be determined as follows:

Determine the total volume of runoff from a 1-year frequency 24-hour storm, occurring over the area before and after development. The following are the equations used in the TR-55 method for determining runoff volume. Alternative methods can be used if they (a) give a runoff volume, and (b) are pre-approved by the Department of Engineering Services. The rational method does not produce a runoff volume and cannot be used to determine either the critical storm or detention/retention requirements.

$$q = \frac{[I - (0.2 \times S)]^2}{I + (0.8 \times S)}$$

Where, q = Direct surface runoff in inches
I = Storm rainfall in inches
S = Maximum potential difference between rainfall and runoff in inches

$$S = \frac{1000}{RCN} - 10$$

$$Q = \frac{q}{12} \times A$$

Where, Q = volume of flow in acre-feet
A = area in acres

Determine the percent of increase in volume due to development

$$Increase = \left(\frac{Q_{post}}{Q_{ex}} - 1 \right) \times 100\%$$

Using this percentage, pick the critical storm from the following table:

Table 14: Critical Storm

If the percentage of increase in the volume of runoff is:				The Critical Storm for discharge limitation will be:
Equal to or greater than		and less than		
0%	~	10%		1 year critical storm
10%	~	20%		2 year critical storm
20%	~	50%		5 year critical storm
50%	~	100%		10 year critical storm
100%	~	250%		25 year critical storm
250%	~	500%		50 year critical storm
500%	~	-		100 year critical storm

The peak rate of runoff from the critical storm occurring over the development shall not exceed the peak rate of runoff from a 1-year frequency storm occurring over the same area under predevelopment conditions. Storms of less frequent occurrence (longer return period) than the critical storm shall have peak rate of runoff not greater than for the same storm under predevelopment conditions. As an example, if the total volume is shown to be increased by 35%, the critical storm is a 5-year storm. The peak rate of runoff for all storms up to this intensity shall be controlled so as not to exceed the peak rate of runoff from a 1-year frequency storm under predevelopment conditions for the area. The runoff from a more intense storm need only be controlled so as not to exceed the predevelopment peak rate from the same frequency of storm. The critical storm shall be computed for each sub-catchment of a parcel. The allowable release rates are to be based on the individual sub-catchment. If the development has multiple outlets it may have differing critical storms for each outlet.

Storage volume does not have to be provided for off-site upstream flows. Flow from such areas will be routed through the drainage system in the development under consideration at a rate determined in the same manner as the on-site system. Off-site land uses prevailing at the time of development shall be considered as the predevelopment condition for the purpose of calculating changes in runoff.

Retention / Detention Basins

Stormwater runoff controls are required on all land development and redevelopment projects that greater than or equal to one (1) acre. This section provides design criteria for facilities that control stormwater discharges to prevent flooding, stream bank erosion, and water quality impairment downstream of development / redevelopment projects. Separate design criteria are provided for stormwater quantity and quality control facilities; however, in many cases quantity and quality controls are integrated into a single facility. This section provides criteria in three (3) major sections:

- General Criteria
- Stormwater Quantity Controls
- Post-Construction Stormwater Quality Controls. Construction Stormwater Quality Controls are discussed in the SWP3 section of the design manual.

General Criteria

Centralized storm water detention is recommended for all developments wherever possible.

Rear yard or enlarged drainage swale detention basins are not recommended unless no other option is available to the property.

Stormwater control facilities shall not be located within the Stream Corridor Protection Zone defined using OEPA Criteria

Stormwater control facilities shall not be located within designated Federal Emergency Management Agency (FEMA) floodplain boundaries

Discharges from stormwater control facilities shall be directed into an approved discharge point as previously defined in this design guide.

Stormwater runoff shall not be diverted from an existing naturally occurring wetland that is not approved for filling and/or removing (as necessary) via an approved Section 404 permit issued by the U.S. Army Corps of Engineers. Wetland hydrology shall be sustained to the extent possible. The quantity and quality of this runoff shall be controlled prior to its release to the wetland system.

Stormwater Quantity Controls

Detention structures can be categorized as dry basins, permanent (wet) ponds, underground storage chambers, stormwater wetlands, vegetated swales, bioretention facilities, multi-use storage areas such as rooftops, parking lots, and other shallow holding areas. The objective of control structures is to reduce the peak rate of discharge by storage and controlled release.

General Design Criteria for Retention/Detention Basins

All proposed dry and wet detention basins shall be designed according to the general criteria in this section, as well as the specific criteria for stormwater quantity basins stormwater quality basins or both.

NOTE: There are special considerations for basins in the vicinity of Delaware Airport (see City of Delaware Standard Details SEWD 28.0 through 28.2)

Layout and Geometry Requirements

The following criteria shall be used to define the layout and geometry of all stormwater basins in the City:

Detention basins shall not be located on uncompacted fill, on slopes greater than 3:1, or where infiltrating groundwater could adversely impact slope stability.

Where berms constructed of fill which will be over 6 feet high are proposed, calculations supporting the stability of the fill berms are to be submitted by a Geotechnical Engineer.

Detention basins shall be designed such that they readily accommodate flow from a site's major flood routing path(s) Overland flow from a site shall be directed to a site's detention basin(s), to ensure that all site runoff is controlled.

The basin shall be designed with an emergency spillway for storms that exceed the 100-year, 24-hour storm event. The emergency spillway shall be designed to direct the flow to a suitable downstream flood routing path without erosion, scouring, or soil undermining, and to meet other pertinent Ohio Dam Safety requirements. A cut section detailing the emergency spillway showing elevations and cross sections is required as a part of the plan set.

The basin shall be designed so that the peak water surface elevation in the basin does not overtop the basin embankment or flood structures around the basin. One foot (1-ft) of freeboard is required on all earthen basins, measured from the peak 100-yr 24-hour storm event to the top of embankment.

Side slopes within and adjacent to the basin must not exceed 3:1, with a 4:1 slope or flatter preferred at all locations to prevent bank erosion and minimize safety risks when the basin is full.

All basins shall have a 10-foot wide vehicle access way or berm adjacent to the entire perimeter of the basin to provide access for maintenance vehicles. The maximum cross slope for the vehicle access way shall be 10:1.

Basins shall be designed to limit the migration of groundwater from the basin towards sanitary sewers and building basements. No sanitary lines may pass under the basin or within the 100-year ponding limits of the basin.

All inflow pipes to the detention basin shall be designed with full height headwalls.

Rock channel protection shall be used to minimize erosion around the headwall, as well as along the side slopes of the basin under each inflow pipe or open channel.

Woody vegetation may not be planted or allowed to grow on the embankment, within 15 feet of the toe of the embankment, and within 25 feet from the principal spillway structure. The establishment of woody vegetation in other areas around the basin is encouraged to provide shade and moderate surface water temperatures.

Permanent stormwater quantity control basins, as defined herein, may be used as temporary sedimentation basins designed to control sedimentation during construction as long as collected sediments are removed, the design grade of the facility is restored, permanent vegetation is established, the temporary outlet is removed, and permanent outlet structure is constructed as designed.

Debris Control Requirements

Debris control structures (trash racks) for both wet and dry basins may be required at the basin outlet if the potential exists for large debris to enter the detention basin through an open watercourse or large diameter inlet pipe. Debris control structures shall be designed using Hydraulic Engineering Circular No. 9, available from the U.S. Department of Transportation, Federal Highway Administration.

Outlet Control Structure and Outfall Protection Requirements

The basin shall be designed with an outlet control structure sized to meet the stormwater quantity and quality control requirements

The outlet structure shall be designed to minimize the transport of floating debris, oil, and grease through the detention facility. The design of the facility shall also include adequate provisions to minimize erosion in the vicinity of the inlet and outlet, and on the side slopes of surface facilities. Open channels receiving discharges from the facility shall be protected with rock channel protection.

Seepage along any conduit that extends through the basin embankment to the downstream slope shall be controlled using an approved, engineered anti-seep collar or clay dam.

The minimum orifice size is 4 inches in diameter. Required orifice openings of less than 4-inches in diameter must conform to current control structure specifications per ODOT STD DWG WQ-1.1 & W-Q1.2. Alternative outlet designs (e.g., V-notch weir, perforated riser pipes, etc.) may be permitted upon the approval of the Department of Engineering Services and if acceptable design practice is proven for site conditions.

Useful Equations for Basin Routing

Weir Equation ~ Broad-crested Weirs and Spillways

Typically a basin emergency spillway is a broad-crested weir or an ogee spillway. A weir is considered broad-crested if the weir thickness is greater than half of the head (H). An ogee spillway is one that is designed with an ogee shaped bottom to minimize cavitation of the overflow. The flow through both of these weirs can be approximated by the following equation:

$$Q = \frac{2}{3} \cdot C_s \cdot b \cdot \sqrt{2 \cdot g} \cdot H^{3/2}$$

where, C_s = 0.50 to 0.57 (broad-crested)
C_s = 0.60 to 0.75 (ogee spillway)
b = bottom width
H = head
g = 32.2 ft/sec^2

Orifice Equation

$$Q = C_d \cdot A \cdot \sqrt{2 \cdot g \cdot h}$$

where, C_d = discharge coefficient
A = cross-sectional area of the orifice
h = elevation of the water surface above the center of the orifice
g = gravitational constant (32.2 ft/sec^2)

Additional Layout Requirements for Dry Detention Basins

The following additional requirements shall apply to the design of dry detention basins for stormwater quantity control:

Dry detention basins shall be designed to drain toward the outlet or micro-pool in order to minimize standing water and saturated soil conditions that impede maintenance and mowing of the facility.

The detention basin bottom shall be sloped to drain, and such slopes shall be sufficient to militate against "flat spots" developing due to construction errors and soil conditions. The minimum transverse slope for the bottoms of such facilities shall be 2%. Basins with less fall across the bottom shall include a paved low flow channel from each inlet pipe or open channel to the basin's outfall.

Low flow channels shall be designed per the following requirements:

- Bottom width – minimum width shall be 4 feet
- Side slopes – shall not be steeper than 4:1,
- Channel slope – minimum slope toward the basin outlet shall be 0.5 percent for channels with paved bottoms, and
- Channel depth – minimum depth of channel shall be 0.5 feet
- The bottom and side slopes of the paved channel shall be Class C concrete reinforced with steel mesh a minimum of 6 inches thick,
- Weep holes shall be designed in the concrete side walls.

The minimum bottom width for dry detention basins, other than the low flow channel, shall be 12 feet.

Dry detention basins shall be provided with topsoil, and shall be seeded and mulched to prevent erosion. Grasses seeded within the basin should be able to survive 48 hours under water. Jute and Excelsior matting shall be used as required to stabilize slopes and prevent erosion.

Additional Layout Requirements for Wet Detention Basins

The following additional requirements shall apply to the design of wet basins for stormwater quantity control:

The permanent pool must have adequate depth to during the dry season. The minimum depth of from the normal pool elevation to the bottom of the basin shall be 8-feet. The depth of wet detention basins shall be no more than 12 feet below the basin's normal water elevation. The minimum bottom width of wet basins shall be 12 feet.

The perimeter of all permanent pool areas deeper than 4 feet shall be surrounded by an aquatic bench that extends at least 8 feet and no more than 15 feet outward from the normal water edge. The aquatic bench shall have an average depth of 24 inches below the permanent pool to promote the growth of aquatic vegetation. The maximum slope of the aquatic bench shall be 10:1

The City prohibits the construction of wet detention basins and stormwater wetlands 5,000-ft from the municipal airport, as recommended by the Federal Aviation Administration (FAA), Advisory Circular Number 150/5200-33. As an alternative stormwater best management practice that does not maintain a permanent pool of water and is not as likely to attract large numbers of waterfowl is required in the vicinity of the airport. An access easement that extends 12 feet from the top of bank outward for any BMP in this zone shall be dedicated to the City of Delaware to ensure that proper maintenance is performed. See standard details SEWD-28.0 through 28.2 for additional details.

Submerged Outlets

- Submerged outlets may be permitted provided a structure is constructed between the outlet at the retention basin and the main storm system. The pipe can be submerged to this first structure only. This structure must also be after the last pavement crossing. The structure shall have a grated cover
- The pipe from the pond outlet to the first manhole shall have watertight joints.
- The invert elevation of the pipe entering into this first structure will be at least 0.5-feet above the normal pool elevation.
- The slope of the basin at the outlet shall be no flatter than 2:1 to avoid siltation at the outlet.

Parking Lot Storage

Parking lot storage is a stormwater quantity control method allowing shallow ponding within paved portions of the parking lot during the design storm event. Parking lot storage is a convenient multi-use structural control method where impervious parking lots are planned. The following criteria shall apply to parking lot storage facilities:

Ponding in parking or traffic areas shall be designed for a maximum ponding depth of twelve (12) inches for all storms up to and including the 100-year event. Flood routing or overflow to a designed conveyance system must occur after the maximum depth is reached.

Runoff from specific graded areas within a parking lot shall be controlled by orifices. The release rate of the flow from a parking lot storage facility shall meet the allowable post-development runoff criteria. The minimum size outlet device shall be a 4-inch single orifice for water quantity control. Alternative outlet designs of smaller diameter may be permitted with Department of Engineering Services approval.

A site with a parking lot storage facility shall employ a separate water quality treatment This BMP may be located either downstream of the parking lot or integrated into the medians, landscaping, or other pervious areas of the parking lot.

Ponding areas must also be designed so that a minimum of 8 feet of traveled way is provided during a critical-year storm if a storm structure is located in a drive aisle or along an inverted crown

Underground Storage Units

Underground storage is a stormwater quantity control method that employs a series of underground pipes or chambers and has a designed release feature to control stormwater discharge. This method is most applicable where land is valuable or the site is constrained,

such as in industrial, commercial, and redevelopment areas. Construction costs and operation costs, which may include pumps, make this method relatively expensive.

If underground storage is to be used for a site, a plan for long term maintenance of the facility shall be provided to the Department of Engineering Services, including a health and safety plan for confined space entry.

The release rate of the flow from an underground storage facility shall meet the calculated allowable post-development runoff rate.

A site with an underground storage facility shall employ a separate water quality BMP that meets all of the water quality treatment criteria.

Stormwater Quality Controls

Post Construction Storm Water Best Management Practices (BMP) are provided for perpetual management of runoff quality and quantity so that a receiving stream's physical, chemical and biological characteristics are protected and stream functions are maintained.

For all projects with one or more acre of development or projects that are a part of a larger common plan of development which will have one or more acre of development, BMP shall be incorporated into the permanent drainage system for the site.

Stormwater Wetlands

Stormwater wetlands are similar in design to wet basins. Constructed wetlands treat stormwater by providing an extended detention zone above shallow permanent pools that are sized to capture and release the calculated WQv over a minimum time of 24 hours. Stormwater wetlands are heavily planted, depressed areas that are designed to maintain flow during dry periods in order to support aquatic vegetation. The amount of surface area required for a stormwater wetland is typically larger than that of a wet basin due to the limited allowable depths required for wetland design. The following criteria shall apply to the design of stormwater wetlands.

- Owners of wetland systems must agree to provide a mosquito monitoring and control plan within the maintenance plan.
- The recommended minimum drainage area of 20 acres is proposed to avoid wetlands where the permanent pool completely evaporates during dry weather conditions.
- The permanent pool of any proposed stormwater wetland shall be at least two times the volume of evapotranspiration during a thirty day drought at summer evaporation rates or 0.75 WQv, whichever is greater.
- An extended detention volume equal to the WQv shall be provided above the permanent pool of the stormwater wetland. The outlet structure of the stormwater wetland shall be designed with a WQv draw-down time of not less than 24 hours.
- The minimum length-to-width ratio for a constructed wetland shall be 2:1. Where site conditions allow, basins should be wedge-shaped, narrowest at the inlet and widest at the outlet, to achieve the required length-to-width ratio. Where site conditions do not allow this configuration, the length-to-width ratio shall be increased by relocating the basin inlet or outlet where possible, or by installing berms or baffles within the basin to the full depth of the WQv to avoid short-circuiting and to increase travel time to the outlet.

- Approximately 50 percent of the permanent pool volume, plus a sediment storage volume equal to at least 20 percent of the WQv, shall be placed in deep water zones (areas with depths between 4- and 12-feet) to sustain fish communities and provide wave action to control mosquito populations. At a minimum, deep water zones shall be placed (1) within the forebay and (2) around the primary outlet.
- The remainder of the facility shall consist of shallow water zones. Dry weather depths in shallow water zones (i.e., areas less than 18 inches deep) should vary depending on the vegetation selected. Permanent pool depths shall be 6 inches or less within at least 35 percent of the shallow water zone.
- The bottom of the permanent pool between the deep and shallow water zones shall be sloped no steeper than 3:1.
- The maximum depth of the extended detention zone above the permanent pool shall not exceed 2 feet to reduce stress on herbaceous wetland plants.
- Permanent pool areas of wetlands that are deeper than 4 feet shall be provided with an aquatic safety bench. Wetland plants shall be placed along the aquatic bench and other shallow pool areas (less than 4 feet).

Due to the sensitivity of wetland vegetation to sedimentation, a forebay, or other pretreatment feature, shall be provided at the inlets of all stormwater wetlands. Wetland forebays shall be three feet to six feet in depth and shall meet the following minimum requirements:

- Wetland forebays shall be sized to provide at least 10 percent of the WQv. The storage volume provided within the forebay will count toward the total WQv requirement.
- The forebay shall consist of a separate cell, formed by an acceptable barrier such as a rock weir.
- Direct maintenance access shall be provided to the forebay at a slope no steeper than 10:1.
- Forebay side-slopes shall not exceed 3:1.
- A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time. The maintenance schedule must address the dredging of accumulated sediment from the forebay.
- A landscaping plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of landscaping zones, selection of appropriate plant species, planting plan, sequence for preparing the wetland bed (including soil amendments, if needed), and sources of plant material. The width of the vegetation zones and amount of emergent vegetation shall be limited to no more than 50 percent of the wetland area in order to control mosquitoes. If a minimum vegetative coverage of 50 percent is not achieved in the planted wetland zones after the second growing season, a reinforcement planting will be required. All landscaping and reinforcement plans shall be signed by a landscape architect, with direction provided by an experienced wetland scientist.

Vegetated Swales

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade.

Vegetated swales are designed to treat the entire WQv from the tributary area. Since treatment occurs as stormwater "flows through" the swale, it is necessary to develop a design peak flow for the WQv representative of flow conditions that maximize treatment and retard flow. The following procedure shall be used to develop the design peak flow:

- Determine the time of concentration for the area draining into the swale.
- Define the peak intensity of the design storm producing the WQv using the intensity-duration-frequency curve
- Use the rational method to determine the peak flow through the swale.

The topography of the site shall be used or re-graded as needed to design a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls.

Swales are generally recommended for drainage areas less than 5 acres, with a total drainage area of 1 to 2 acres preferred.

Trapezoidal channels are normally recommended, but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.

If the design peak for the WQv is larger than 1 cfs, then more than one swale shall be provided in order to maintain sheet flow and shallow flow depths within the swale. Flow shall be distributed among the swales to keep peak flows during the WQv design event less than 1 cfs in each.

Use Manning's Equation to design the swale under peak WQv design storm conditions, using criteria within this section to establish design limits for the swale.

The swale shall be designed so that the water level does not exceed 3 inches at the design peak flow for the WQv.

It is recommended that longitudinal slopes along the swale shall not exceed 2.5 percent, and shall be milder if necessary to keep the peak velocity within the swale less than 0.9 feet/second. However, longitudinal slopes may range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.
The width of the swale should be determined using Manning's Equation, at the peak flow during the water quality design storm, using a Manning's "n" of 0.25. The maximum bottom width shall not exceed 10 feet unless a dividing berm is provided.

The swale shall have a length that provides a minimum hydraulic residence time, or the time it takes for the water to pass through the swale, of at least ten minutes. Regardless of the hydraulic residence time, the length of the swale shall not be less than 100 feet.

Swales may be designed to safely convey storms generating more than the WQv. The peak velocity of the 10-year design storm through the swale shall be non-erosive for the soil and vegetative cover provided Three inches of freeboard should be provided. The side slopes of the swale shall be no steeper than 3:1.

Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

The surface shall be graded flat prior to placement of vegetation. Initial establishment of vegetation shall receive attentive care, including appropriate watering, fertilization, and prevention of excessive flow, until vegetation completely covers the area and is well established.

Runoff shall enter swales as sheet flow. Use of a level spreading device (vegetated berm, sawtooth concrete border, rock trench, etc.) to facilitate overland sheet flow may be allowed, but is not normally recommended because of maintenance considerations and the potential for standing water.

Bioretention Facilities

A bioretention system consists of a soil bed planted with native vegetation located above an underdrained gravel layer. Stormwater runoff entering the bioretention system is filtered first through the vegetation and then the soil bed before being conveyed downstream through the underdrain system, slowing the runoff velocity and treating stormwater runoff by absorption, decomposition, and filtration. Bioretention facilities are often sited adjacent to and used to treat runoff from paved surfaces such as parking lots. Sites utilizing bioretention facilities for water quality control must also meet the stormwater quantity control requirements. Stormwater quantity controls may either be integrated into the bioretention system or provided in a separate downstream facility.

Bioretention facilities shall be designed to capture and store the WQv prior to filtration and shall provide a filtration time of no less than 24 hours (when the filter media is new) and no more than 40 hours (when the filter media is clogged and requires maintenance). A drawdown time of 40 hours shall be used for facility design. The following criteria shall apply to the design of bioretention facilities.

The recommended maximum total drainage area of a bioretention facility is 5 acres, with drainage areas of one acre or less preferred in order to maximize sheet flow into the facility and to minimize ponding depth.

Bioretention systems may be constructed on-line or off-line. On-line systems receive runoff from all storms, providing treatment of the WQv, with runoff from larger storms conveyed and/or stored within the bioretention system and discharged through an overflow. In off-line bioretention systems, most of the runoff from storms larger than the

WQv bypasses the system through an upstream diversion and is directed toward a stormwater quantity control device.

Bioretention facilities shall not be allowed in areas where the water table or bedrock is above the invert of the underdrain system.

In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosion as sheet flow is conveyed to the treatment area.

Runoff from the tributary area of the bioretention facility shall be directed into a swale or other storage area sized to contain the entire WQv. This swale shall partially or completely overlay the bioretention facility, as long as the maximum depth of water over the filtering media is no more than 12 inches. Water shall not cover the media longer than 72 hours after a precipitation event.

The surface area of the bioretention soil bed shall be determined based on the following equation:

$$A = \frac{WQv \cdot d}{\left[3600 \cdot K \cdot T \cdot (h + d)\right]}$$

where: A = surface area of the bioretention planting soil bed (acre)
WQv = water quality volume (acre-ft)
d = depth of the planting soil bed (ft)
T = drawdown time (hours) = 40 hours
K = permeability of the planting soil within the soil bed (feet/sec) = 1.2×10^{-5} feet/sec (minimum), which is equivalent to 0.5 inches/hr
h = average depth of water above filter bed (ft) = half the maximum depth of water (maximum depth = 12 inches)

The minimum dimensions of the bioretention facility shall be 15 feet wide by 40 feet long, with facility widths of 25 feet preferred. These width criteria are established to allow enough space for a dense, randomly-distributed area of trees and shrubs to become established, enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations.

The side slopes for bioretention facilities shall not exceed 3:1.

The function of a bioretention facility is largely dependent on the characteristics of the planting soil (filter media) through which the runoff passes. The following criteria shall be used:

- The planting soil for bioretention facilities shall consist of a mixture of sand, topsoil, and compost with a pH range of 5.5 and 6.5, a range where pollutants such as organic nitrogen and phosphorus can be absorbed by the soil and microbial activity can flourish. In addition, the soil shall have infiltration rates no less than 0.5 inches per hour, achieved through the following standards:
    - 4 parts sand
    - 2 parts topsoil, and
    - 2 parts compost.

- Additional recommendations for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.
- If the existing soil does not meet the above characteristics, then it shall either be adjusted to meet the criteria or removed and replaced with an acceptable planting soil. Soil tests shall be performed for every 500 cubic yards of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area.
- To prevent root intrusion into the underdrain system, the depth of the planting soil shall be no shallower than the root zone of the vegetation planted in the bioretention cell. The minimum depth shall be 2.5 feet. In addition, the depth shall be at least 4 inches below the largest root ball.
- Planting soil depths of greater than 4 feet may require additional construction practices such as shoring measures. Planting soil shall be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached.
- An 8-inch thick sand layer shall be placed along the sides of the trench, starting 12 inches below the final grade level and extending to the gravel layer in the bottom of the trench. The sand shall comply with CMS 703.06, and shall be surrounded with a filter fabric.

Bioretention facilities shall be planted with a mixture of grass and other hardy, vegetation that can withstand prolonged periods in a wet environment, and be tolerant to road salts if receiving runoff from areas to be treated with deicing materials. Vegetation may include a mix of grasses and woody species, or may include woody species only with bare ground covered with mulch. Approximately one tree or shrub per 50-ft^2 (or 1000 per acre) of bioretention area should be included. It is recommended that three species each of both trees and shrubs are planted. Trees with high branching or open habits of growth are recommended to avoid shading and loss of grass cover. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. The shrub-to-tree ratio shall be 2:1 to 3:1.

A mulching layer 2 to 3 inches thick shall be provided above the planting soil when grass is not used, and shall be composed of shredded hardwood material to avoid floating. Mulch plays an important role in the bioretention facility. It helps maintain soil moisture, prevents erosion and helps to trap finer sediments.

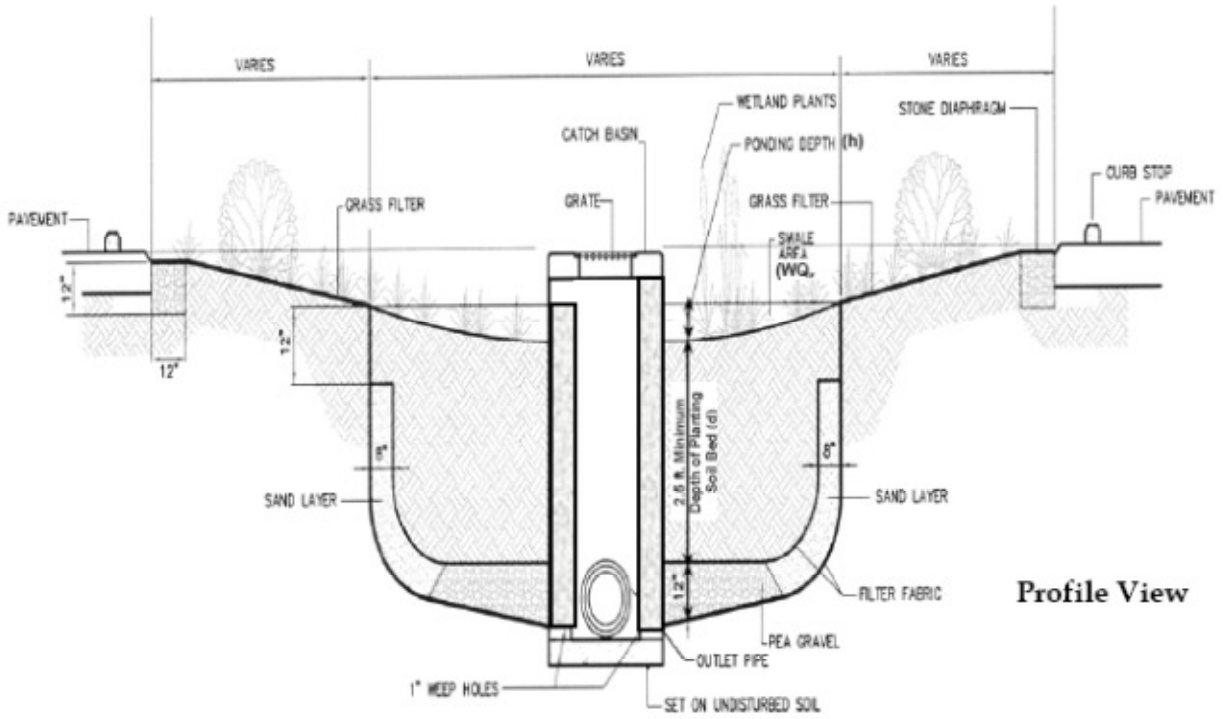
A perforated pipe underdrain shall be provided beneath the planting soil. The underdrain shall have a minimum grade of 0.5 percent. The perforated pipe shall have a diameter of 4 or 6 inches. A granular backfill of durable No. 57 aggregate shall be provided up to a minimum of 4 inches above the outside diameter of the pipe.

An overflow designed to convey all storms up to and including the 100-year event shall be provided. Use of a vertical stand pipe or catch basin is recommended. For on-line facilities, this overflow may be designed to achieve the water quantity control criteria.

Flow entering the bioretention facility shall be limited to sheet flow to prevent eroding the side slopes of the facility. If flow has been concentrated prior to entering the bioretention facility, it shall be converted to sheet flow using a level spreader. In addition, the frequency of maintenance for bioretention facilities may be reduced by providing vegetated swales or filter strips around the facility. The purpose of the filter strip is to trap course sediments before they

reach filter media, thereby reducing maintenance and increasing media longevity. Vegetated swales and filter strips can also be used as holding areas for the WQv prior to filtration.

Figure 3: Schematic of a Typical Bioretention Facility



Design of Minor Stormwater Conveyances

Methodology

The design of minor stormwater conveyances shall be performed utilizing the rational method (Q = CiA).

Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the most remote part of the drainage area under consideration to the design point. For urban storm sewers, the time of concentration consists of an inlet time, or time required for runoff to flow over the surface to the nearest inlet, and time of flow in the sewer to the point under consideration. Inlet time will vary with surface slope, depression storage, surface cover, antecedent rainfall and infiltration capacity of soil, as well as distance of surface flow. Pipe flow time can be calculated by Manning's Formula.

$$V = \frac{1.49 r^{2/3} s^{1/2}}{n}$$

where: V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to a/ p_w
a = cross sectional flow area (ft^2)
p_w = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow.

$$Q = V \times A$$

Where Q = flow in cfs
V = velocity
A = Cross sectional area of the pipe

General Requirements

All drainage calculations, drainage area outlines, and contributing areas used in drainage design shall be furnished.

All stormwater calculations to be signed, stamped and dated

Easements are required for all drainage ways that pass from one parcel to another or which contain public storm systems, either surface or subsurface, on private property. Where an open watercourse is used, an easement shall be provided at least equal to the area required for the 100-year rainfall. The easement shall be shown on the final plat as a "Drainage and Utility Easement." Restrictions as to the use of this easement shall be shown on the final plat. If a plat is not recorded, a recorded easement is necessary.

Flood Routing Path

The routing path for the major drainage system is that part of the storm drainage system which carries the runoff which exceeds the capacity of the designed drainage facilities. The major drainage system shall have the capacity to carry runoff from a storm with a return period of not less than 100 years without causing significant threat to property or public safety. The peak water surface elevation of the flow shall be at least one-foot below the first floor elevation of the structures within and adjacent to the development. The major storm routing path shall begin along swales located between structures that drain individual properties, be directed to either roads, other public rights-of-way , or constructed open watercourses through the development, to the stormwater detention facility serving the development. This detention facility shall be designed to control the 100-year event without overtopping its embankment.

Generally, it is not economically feasible to size a storm sewer system to collect and convey more than the frequent storm runoff. Essentially, the complete drainage system of an urban area contains two separate drainage elements. While the storm sewers belong to the initial system, surface drainageways must be provided for the major flow from more intense storms. The intent of planning for the major drainage element is to ensure stormwater runoff which exceeds the capacity of the initial drainage system has a route to follow which will not cause a major loss of property or any loss of life. It should be remembered that the major drainage system exists even when it is not planned and whether or not development exists with respect to it. To get in the way of the major storm is careless and costly.

A hydraulic analysis shall be required to verify that the peak water surface elevation during the 100- year design storm meets the design criteria cited in this section. For preliminary design purposes, the flow in the major drainage system during the 100-year design storm event shall equal the design capacity of the major system.

The use of normal flow depths derived using the Manning's Equation will suffice for estimating inundation limits along streets. At culverts, the major storm shall be designed to flow across streets at low areas or in sags of vertical curves. Street elevations shall be set to permit the major storm to flow across the street and to prevent damage to any existing or proposed building structure. Backwater calculations shall be performed along USGS Blue Line streams where a roadway crossing over these streams is proposed as part of the development. The backwater analysis shall proceed upstream from the roadway crossing to the boundary of the development site.

Where a major drainage way is located outside of a street right-of-way, easements shall be provided. The 100-year flood routing path shall be shown on the master drainage plan that is to be submitted with the Stormwater Management Report. Routing path illustrations shall include elevations along the routing path and other elevations necessary to show that the major storm is contained within the planned area and dedicated easements.

Street rights-of-way are a common choice for conveying major drainage flows. Again, such use must be anticipated when the street layout is established. Side and rear lot lines offer one alternative to the street. The problem with this alternative is the possibility that individual property owners may encroach on the major drainage easement. Rarely is the problem recognized until the infrequent rainstorm occurs and the major system fails to operate properly. Where the street is designated as the major drainage way, the depth of flow shall not exceed 12 inches at the gutter line for local and collector streets and shall not exceed 6 inches of depth at the crown for arterial streets. The same maximum depth criteria will apply where a major

drainageway crosses the street. Where a major drainageway is located outside of a street right-of-way, easements should be provided and a grading plan should be submitted with detailed engineering plan submission. The grading plan will include elevations along the routing path and other elevations necessary to show the major storm is contained within the planned area.

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

The major storm runoff is routed through the drainage system to determine if the combined capacity of the routing path and storm sewer system is sufficient. The capacity of the conduit at any given point is assumed to be the same for the major storm as for the initial storm. (the flood route capacity shall equal the 100-yr flow minus the 2-year flow) Routing of the major storm at culvert locations shall be at low areas or sags of vertical curves of streets. Elevations for the design of the street shall be such to permit the major storm to flow across the street and to prevent damage to any existing or proposed building structure.

Certain limited areas of the City lie within the floodplain of the Olentangy River or its tributaries. The City shall maintain on file for public examination current maps delineating the boundaries within the City of all lands designated "100-year Floodplain" by the Federal Emergency Management Agency (FEMA). All improvements in a floodplain shall be in compliance with the City of Delaware regulations pertaining to floodway districts.

Culvert Design

General

A culvert is a relatively short segment of conduit that is typically used to transport water underneath a roadway or other type of earthen embankment. Two types of flow may occur in culverts: flows with inlet control and flow with outlet control. The design engineer shall determine the appropriate flow conditions for each culvert in the project. Culvert Design should be according to the principles outlined in the Ohio Department of Transportation, Location and Design Manual, Volume 2, Drainage Design, current edition. The publication, Hydraulic Design of Highway Culverts, Hydraulic Design Series No. 5, Federal Highway Administration 1985 by J. M. Normann, R. J. Houghtalen, and W. J. Johnston, also outline an acceptable design procedure.

Design Procedure

The design must account for the ability of the downstream channel to handle the flow satisfactorily. Additionally, in order to minimize property damage, the 100-year frequency head water shall not exceed any existing or proposed building first floor elevation.

Culverts are to be designed to transport the flows from the design year storm listed in the following table.

Table 15: Design Year Flows

Roadway Type	Design Storm Event
Interstate Highways, Other Freeways and Expressways	50-Year
Major Arterials (ADT>10,000)	25-Year
Minor Arterial and Collectors (ADT 3,501 – 10,000)	25-Year
Local Streets and Roads (ADT ≤ 3,500) and Parking Lots	10-Year

In addition to conveying the design year flows, the design of the culvert must take into account the maximum allowable headwater for the 100-year event. The maximum headwater on all public streets and bike paths is 1-foot below the near, low edge of pavement or 18-inches below the top of curb elevation. The maximum allowable headwater is at or below the near edge of pavement for driveway culverts conveying runoff along roadside ditches.

The maximum allowable outlet velocity for culverts is as follows:

- Bare Earth Channel 6 fps
- Engineered Rock Protection 18 fps
- Stilling Basin Over 18 fps

Culverts shall have full height headwall with flared wings at upstream and downstream ends. Other special type headwalls must be approved before use.

The structural design criteria for culverts will be as required by the City of Delaware together with the City of Columbus, Ohio, Construction and Material Specifications, including all specifications thereto.

Storm Sewer System Design Requirements

Methodology

The method outlined herein will provide a general guide as to the criteria and procedures to be used for storm sewer design.

Storm sewer pipe sizes are to be determined by using Manning's Formula with a minimum coefficient of roughness n = 0.13 for all pipe laid to proper line and grade

The rational method shall be used for all storm sewer design (closed system.)

The following rainfall frequency curves shall be used for design:

- Storm Sewer Capacity - 2-year rainfall
- Strom Sewer Hydraulic Grade Line – 5-year event below the top of casting

The minimum post-development time of concentration for storm inlets is 15 minutes in grassy areas and 10 minutes in paved areas.

- All future and offsite flows must be accounted for.
- Match crowns where possible for all storm systems. If matching crowns is not feasible due to site constraints match 0.80 diameters.

General Requirements

A chart with State Plane Coordinates Including blank columns for as-builts must be provided for all public and private storm structures.

Minimum cover for storm sewer pipe shall be 30-inches from the top of pavement to the outside top of the pipe except as approved by the Department of Engineering Services. If minimum cover is not met under any private or public street the conduit shall be concrete encased from structure to structure per City of Delaware standards. Under no circumstances will less than 9-inches of cover to the bottom of subgrade be permitted. A minimum of 1.5-feet of cover from the finished ground surface to the outside top of the pipe for any storm sewer system located beyond the limits of street right-of-way must be maintained.

There must be 1.5-ft vertical and 10-ft horizontal separation (outside wall to outside wall) from all sanitary and water lines

Standard full height headwalls are to be constructed at the inlet and outfall of all daylighted storm sewers, and shall be shown on the plan and profile. Half height headwall may be permitted for large (36-inch and greater) pipes that are submerged outlets to a retention basin.

Erosion control shall be provided at the outfall of all storm sewers, and shown on the plan and profile. In addition, measures approved by the City shall be taken to control erosion during construction in accordance with the current Water Pollution and Sediment Runoff Control Regulations.

The invert of the first downstream storm sewer outlet shall be above the computed floodplain elevation.

Pipe for all storm sewers (public and private) shall not be less than 12-inches in diameter unless solely serving as roof drain collector.

All structures are to be; City of Delaware, ODOT, or City of Columbus standard structures with the exception of combined curb and gutter inlets, which must be City of Delaware standard structures only. The inverts of all curb inlets, manholes, yard inlets, and other appurtenances shall be formed to reduce turbulence to a minimum.

Blind taps are not permitted.

The maximum distance for overland flow shall be 300 feet before entering a surface yard inlet or 425 feet before entering a curb inlet. Except that the maximum overland drainage area tributary to any yard inlet or curb inlet shall not exceed 1 acre. At the discretion of the City and on a case by case basis, an exception may be made where there is phased construction or for structures that are receiving large amounts of offsite flow.

The maximum spacing of storm access structures is 300-feet for pipes 12-inches to 60-inches in diameter and 500-feet for pipes greater than 60-inches in diameter.

Rear yard swales must be designed at a 2% minimum slope and have storm structures constructed on every other property line.

The minimum allowable velocity shall be 3 feet per second (fps) in all storm pipes in the just full condition and the minimum Manning's "n" value shall be 0.013. (See table below) The maximum allowable velocity shall be 15 fps.

Table 16: Minimum Slope for all Storm Conduits

Pipe Size (inches)	Pipe Size (feet)	Minimum Slope for a Velocity of 3 FPS	Capacity of Pipe At Minimum Slope (cfs)	Elliptical Equivalent (inches)
4	0.34	1.89%	0.26	---
6	0.50	1.10%	0.59	---
8	0.67	0.75%	1.05	---
10	0.83	0.56%	1.64	---
12	1.00	0.44%	2.36	---
15	1.25	0.32%	3.68	---
18	1.50	0.25%	5.30	14 x 23
21	1.75	0.21%	7.22	---
24	2.00	0.17%	9.42	19 x 30
27	2.25	0.15%	11.93	23 x 34
30	2.50	0.13%	14.73	24 x 38
36	3.00	0.10%	21.21	29 x 45
42	3.50	0.08%	28.86	34 x 53
48	4.00	0.07%	37.70	38 x 60
54	4.50	0.06%	47.71	43 x 68
60	5.00	0.05%	58.90	48 x 76
66	5.50	0.05%	71.27	53 x 83
72	6.00	0.04%	84.82	58 x 91
78	6.50	0.04%	99.55	63 x 98

Profiles

- Profiles are required for all Public and Private storm sewers
- The storm conduit material and class is to be listed on both in the quantities and on the profiles.
- The 5-year hydraulic grade line shall be shown on the profile sheet. The hydraulic grade line shall be calculated based on an observed or calculated tailwater depth in the receiving channel or basin determined through downstream analysis or the following equation, whichever is greater:

$$T_w = (d_c + D)/2$$

where: T_w = Tailwater depth (feet)
d_c = Critical depth in the pipe (feet)
D = Inside pipe diameter (feet)

Backfill Requirements

- Compacted granular backfill, COC Item 912, is required beneath all paved areas, including public and private roadways and parking lots.
- COC Item 911 is required outside of the pavement influence, but inside the Right-of-Way. A minimum of 95% compaction for all fill material is to be maintained.
- Storm Sewers between homes shall have no granular backfill or bedding, instead “O” ring rubber gasket joints (ASTM C-136) are to be used.

Curb and Gutter Inlets

The satisfactory removal of surface water from curbed pavement is as important as any other phase of stormwater control. Gutter flow in streets serves to transport runoff from surface areas to storm inlets or to open drainage channels. The primary function of the street inlet is to provide stormwater runoff flow from the gutter into the storm sewer. Spread of water on the pavement for the design storm is considered as the best control for pavement drainage. Standard City of Delaware curb and gutter structures and frames are to be used for all land development projects.

Maximum spread of flow

Spread Calcs are required for all public curb and gutter inlets. The design storm is the 5-yr event for local and collector roads and the 10-yr event for Arterials.

- 28-foot local streets from back of curb to back of curb or less, the flow may spread to a width of 8 feet from face of curb.
- 28-foot to 38-foot local streets from back of curb to back of curb, the flow may spread to a width of 9 feet from face of curb.
- Major Collectors, a minimum of one lane in each direction, to remain passable to traffic.
- Arterials are per current edition of ODOT’s Location and Design Manual, Volume II.

Design Criteria for Curb and Gutter inlets

The maximum spacing for curb inlets shall not exceed 400 feet unless approved by the City.

Sag or Sump at Adverse Slopes - Curb and gutter inlets are required at all sag locations. On combined runs of over 300 feet contributing to a sag curve, an additional inlet may be required near the low point, 0.2 + or - feet above the inlet at the sag.

Continuous Grade - Curb inlets shall be located at all points where the maximum pavement encroachment is reached and at the low points of street intersections. No cross street flow is permitted. The City may require additional inlets at intermediary points if the flow in the gutter at design conditions might create a hazard to vehicular traffic, public safety, or property flooding. The rational method and a minimum time of concentration of 10 minutes shall be used to determine the amount of runoff that will be collected by the proposed inlet structures. Hydraulic analyses used to size and space inlets and catch basins shall be based on the methods presented in (FHWA) Hydraulic Engineering Circular No. 12: "Drainage of Highway Pavements" and Hydraulic Engineering Circular No. 22: "Urban Drainage Design Manual." The following table summarizes the dimensions of the inlets and catch basins that are provided in the City of Delaware's standard drawings. These dimensions may be used with the design aids (i.e., charts, graphs, nomographs, etc.) provided in the references cited above to assist in determining the capacity and spacing of the inlets and catch basins under different pavement and flow conditions.

Table 17: Selected COD & COC Basin Grate & Curb Inlet Dimensions

Standard Drawing	Description	Clear Opening Area, A (ft^2)	Grate Length, L (ft)	Grate Width, W (ft)	Inlet Length (ft)	Inlet Height (ft)**
SEWD 09*	Combination Curb & Gutter Inlet*	3.27	2.95	1.48	-	-
SEWD 11	Square Catch Basin	2.5	1.9	1.9	-	-
AA-S115	Round Catch Basin	2.9	3	3	-	-
AA-S116	Round Catch Basin	2.7	3	3	-	-
AA-S123	42 inch Curb Inlet	-	-	-	3.5	>4
AA-S123	60-inch Curb Inlet	-	-	-	5	>4
AA-S126	Standard Curb Inlet	-	-	-	2.33	6.25
AA-S133	Square Catch Basin	2.5	3.9	2.1	-	-
AA-S138	Round Catch Basin	0.9	1.9	1.9	-	-
AA-S139	Square Catch Basin	1.9	13.6	2	-	-
AA-S140	Rectangular Catch Basin	1.1	1.8	1.2	-	-
AA-S141	Square Catch Basin	1.9	1.9	2	-	-

* The capacity of combination curb & gutters shall be calculated as a grate inlet. The additional capacity for the curb inlet is to serve as overflow when the grate becomes blocked with debris.

** Depth of inlet opening can vary depending on the height of curb and capacity needs. A depression should be provided to achieve an inlet height of at least 4-inches.

The projected gutter flow approaching each basin/inlet, the flow projected to enter each basin/inlet, and the flow projected to bypass each basin/inlet shall be provided in the Stormwater Management Report.

Open Watercourses

The requirements in this section are applicable to newly constructed open watercourses. A constructed channel shall be shaped or graded to the required dimensions and established with a suitable lining as necessary to convey stormwater runoff without allowing channel erosion. All open watercourses having less than 3% longitudinal (running) slope shall have a 4-inch (minimum) diameter perforated underdrain. Underdrains are to be outleted to storm structure if practicable, or if this is unfeasible the underdrain is to be daylighted before the termination of the channel. The crown of the underdrain shall be 12-inches below the bottom of the watercourse. The underdrain ditch shall be a minimum of 16-inches by 16-inches, backfilled with #57 stone, and lined with filter-fabric. Watercourses that are engineered to be used as bio-swales to help treat water quality should follow the design criteria outlined in the **Vegetated Swales** section of this manual

Constructed open watercourses shall be designed to convey the 10-year design storm without causing erosion, sedimentation, or overbank flooding within and along the channel. Criteria outlined in the Flood Routing Section shall be used if the channel will also serve as a flood routing channel for the 100-year design storm. Open watercourses may also be designed for stormwater quality control.

A ditch computation sheet shall be used to present open channel calculations.

Parabolic and trapezoidal channel shapes shall be used for open watercourses within development projects. Side slopes shall be 3:1 or milder, with a minimum 2-foot bottom width for trapezoidal channels, unless alternative dimensions are approved by the City due to specific project conditions. Channel cross sections shall be designed such that erosion and sediment deposition is minimized.

An open channel is categorized by its lining. There are three main types of channel linings:

- Vegetated - A vegetative lining, such as grass with mulch and sod and lapped sod, is required where site constraints and flow velocity conditions allow.
- Flexible - Flexible linings include rock channel protection and cellular soil retaining mats and are typically less expensive than a rigid lining. The use of flexible linings, however, may require the installation of a filter fabric or other means to protect the underlying soil, prevent washout, and prevent soil piping through the rock when using channel protection.
- Rigid - Rigid linings include concrete and rigid block and are usually used where high velocities are unavoidable.

Final design of constructed open channels should be consistent with velocity limitations for the selected channel lining. Maximum velocity values for selected vegetated and non-vegetated lining categories are presented in the table below. The Manning's Equation shall be used to design an open channel that satisfies the maximum velocity criteria in the previous sections:

Open Watercourse Profile

All open watercourses that are to be constructed or modified with the project shall be profiled. The profile shall include:

- Profile of the top of bank on both sides where difference in elevation exists

- Profile of flow line (invert) of streambed.
- Profile of the computed water elevation.
- Where land included is subject to flood, cross-sections, topography, and spot elevations are required.

Table 18: Maximum Velocities for Channel Lining Materials

Channel Lining Material	Maximum Allowable Velocity (ft/s)
Vegetated Channels	
Seed mixtures for urban areas	2.5
Other seed mixtures	2.5
Crown vetch	2.5
Established Seed or Sodded Channels	6.0
Flexible Linings	
Slope Erosion Protection	Follow manufacturer's criteria
Erosion Control Matting	
Rock Channel Protection	Use shear stress analysis
Rigid linings	
Concrete	18
Concrete block mat	18

Open channels shall be designed to flow under subcritical flow conditions at all times. A subcritical flow regime is characterized by a Froude Number less than 1:

$$F = \frac{V}{(g \cdot D)^{0.5}} < 1$$

where: F = Froude Number
D = hydraulic depth (ft) = A / T
A = cross-sectional area of flow (ft^2)
T = top width of water surface (ft)
V = flow velocity (ft/sec)
g = acceleration due to gravity = 32.2 $feet/sec^2$

The Stormwater Management Report shall demonstrate that the calculated Froude Number is less than 1 over the anticipated range of flow conditions within the channel.

Rock Channel Protection Shear Stress Analysis

Type B, C or D rock channel protection shall be provided in accordance with CMS Section 601.08. Type B, C or D rock channel protection shall only be placed outside of guardrails, barriers or other unobstructed areas provided outside of the traveled way for vehicles to stop safely or regain control. The actual shear stress (r_{ac}) must be less than or equal to the allowable sheer stress (r_a) listed in the following table for the rock channel protection type used. The actual shear stress shall be determined for the channel slope and the depth of flow during a 10-year design storm. The following equation is valid for discharges less than 50 cfs and with slopes less than 10%:

$$\tau_{ac} = 62.4 \cdot D \cdot S$$

where: D = depth of flow (feet)
S = channel slope (feet/feet)
r_{ac} = actual shear stress (lbs/feet^2)

Table 19: Allowable Shear Stress for Rock Channel Protection

Type of Rock Channel Protection	r_a (lbs/feet^2)
B	6
C	4
D	2

In extreme site conditions, Type B or C rock channel protection shall be utilized for lining channels with steep grades (slopes 10%-25%) that carry flow from the end of a cut section down to the lowest elevation on the bottom of the channel. Federal Highway Administration's HEC-15 procedures for steep gradient channels shall be used with a safety factor of 1.5. The Department of Engineering Services shall be consulted if rock channel protection is proposed in instances where the peak flow during the 10-year design storm is greater than or equal to 50 cfs.

All constructed open watercourses shall have a structurally sound and stable outlet with adequate capacity to prevent ponding or flooding damage.

Rock Channel Protection

Description

A rock or riprap apron is typically needed at the outlet of storm drains, culverts, or open channels. Rock Outlet Protection provides an erosion resistant transition area where concentrated or high velocity flows enters less modified channels or natural streams.

Conditions Where Practice Applies

This practice applies where discharge velocities from channels, storm drains or culverts are high enough to erode receiving streams or areas. Suggested areas of application are:

- Outfalls of stormwater detention facilities or sediment traps or basins.
- Constructed channel outlets
- Culvert outlets

This practice is not intended for use on slopes greater than 10%, or at the top of cut or fill slopes. Caution should be used when design flows exceed 100 cubic feet per second (cfs) from a 10-yr.-frequency storm.

Planning Considerations

Rock Outlet Protection may be used in conjunction with other practices, such as level spreaders. Rock Outlet Protection and Level Spreaders can both be used at the end of pipe outlets. This practice should be used alone where flow will continue as concentrated flow. Level Spreaders can be used with Rock Outlet Protection only when flow can be converted to and continue as sheet flow.

Permits

The U.S. Army Corps of Engineers and the Ohio Environmental Protection Agency, through Sections 404 and 401, respectively, of the Clean Water Act, may require a permit for an outlet protection that is located adjacent to a stream.

Water Quality

Rock outlet protection may also provide water quality benefits by providing for channel stability, prevention of excessive erosion, and limiting subsequent downstream sedimentation.

Design Criteria

Runoff

Runoff computation will be based upon the most severe soil and cover conditions that will exist in the area draining into the channel during the planned life of the structure. NRCS Technical Release 55 (TR 55) or other approved method shall be used to determine peak rate of runoff.

Velocity

Outlet protection shall be designed to be stable for discharge velocity expected from a 10-year frequency storm. Where high-hazard conditions exist, higher frequency storms should be chosen to provide protection compatible with conditions. Outlet protection shall meet the following criteria:

Design Velocity

Outlet protection shall be designed to be stable for the velocity of flow expected from a 10-year frequency storm. Outlet protection shall be designed to meet the criteria below or by other accepted engineering methods.

Width

The width of the outlet protection shall be the greater of either the width of the headwall or 4 feet wider than the pipe diameter (2 feet on each side of the edge of pipe).

Bottom Grade

The outlet protection should be constructed with no slope along its length. The elevation on the downstream end of the outlet protection shall be equal to the elevation of the receiving stream or channel.

Length of Rock Outlet Protection and Rock Size

Use the velocity calculated at the pipe outlet, the pipe diameter, and Figure 4 (or standard drawing SEWD-17.3). Outlet Protection Length, to find the length of outlet protection needed and rock size to use.

Rock Lining

The outlet protection shall consist of the rock riprap layer and an underlying filter or bedding. Minimum thickness of the rock riprap layer shall be the maximum stone size. Stone used for riprap shall be dense and hard enough to withstand exposure to air, water, freezing and thawing. Rock riprap must have a well-graded distribution and be placed to obtain a solid, compact layer of riprap. This may require some hand placing and tamping with construction equipment. Spreading gravel over top of the placed riprap surface will fill the voids by interlocking the riprap together.

Table 20: Rock Riprap Size

Type of Rock or Riprap (ODOT)	"n" Value	Size of Rock	
		50% by weight	95% by weight
Type D	.036	> 6 inches	3 – 12 inches
Type C	.040	> 12 inches	6 – 18 inches
Type B	.043	> 18 inches	12 – 24 inches
Type A	.045	> 24 inches	18 – 30 inches

Filter or Granular Bedding

Filter or granular bedding must be placed beneath all riprap to prevent the underlying soil from eroding and undermining the riprap, and to collect seepage and base flow. Minimum bedding thickness shall be 4 inches. Use of large size riprap may necessitate the use of a thicker bedding layer or 2 differently sized bedding layers. Care should be taken to select granular bedding that that is suitable with the subgrade material.

Geotextile

Geotextile may be used as a filter to be placed beneath the riprap to prevent piping of the soil where wetness, seepage, or prolonged base flow is the reason for lining the channel with riprap. If design of the outlet protection results in high velocities and steep grades, granular bedding should be used instead of geotextile. Care should be taken to properly anchor the geotextile to prevent unraveling under flowing water. Geotextile shall be woven or nonwoven monofilament yarn and shall meet Class I criteria in the attached table "Requirements for Geotextile".

Table 21: Requirements for Geotextiles

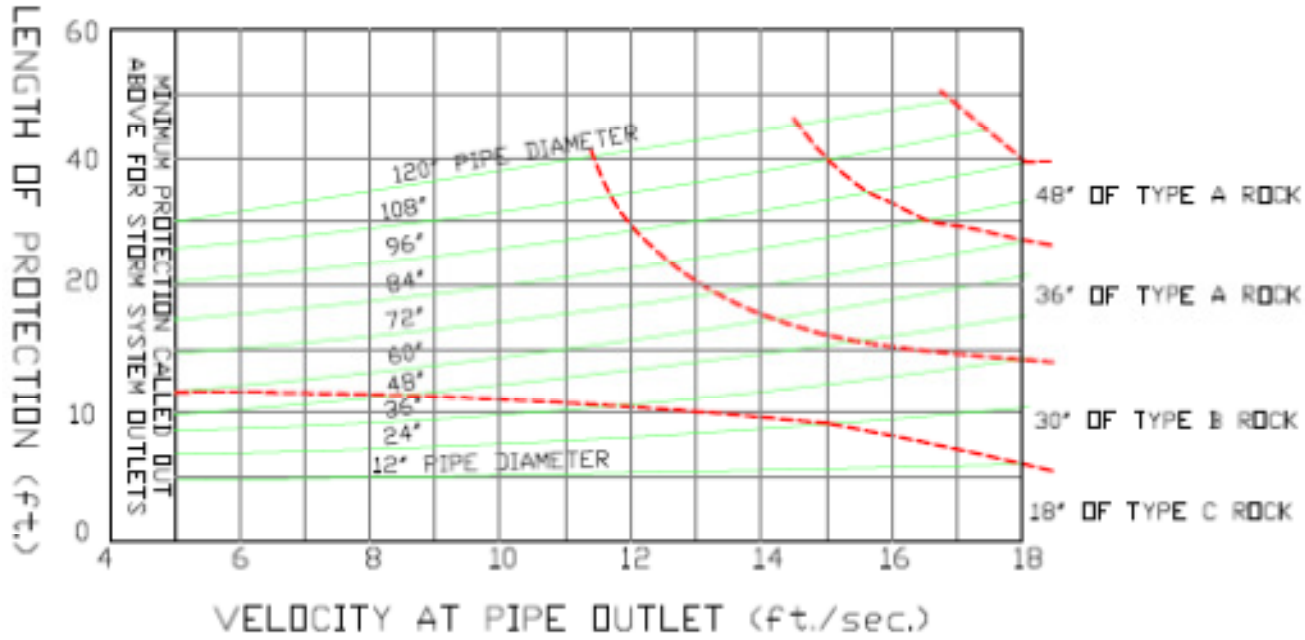
Property	Test Method	Woven - Class 1	Nonwoven – Class 1
Tensile strength (pounds) 1/	ASTM D 4632 grab test	200 minimum in any direction	180 minimum
Elongation at failure (percent) 1/	ASTM D 4632 grab test	< 50	≥ 50
Puncture (pounds) 1/	ASTM D 4833	90 minimum	80 minimum
Ultraviolet light (% residual tensile strength)	ASTM D 4355 150-hr exposure	70 minimum	70 minimum
Apparent opening size (ADS)	ASTM D 4751	As specified, but no smaller than 0.212 mm (#70) 2/	As specified max. #40 2/
Percent open area (percent)	CWO-02215-86	4.0 minimum	---
Permittivity sec-1	ASTM D 4491	0.10 minimum	0.70 minimum
1/ Minimum average roll value (weakest principle direction)			
2/ U.S. standard sieve size			
Note: CWO is a USACE reference			

Maintenance

A maintenance program shall be established to maintain riprap, vegetative cover above the riprap, and associated structural components such as pipe outlets, and tile lines. Items to consider in the maintenance program include:

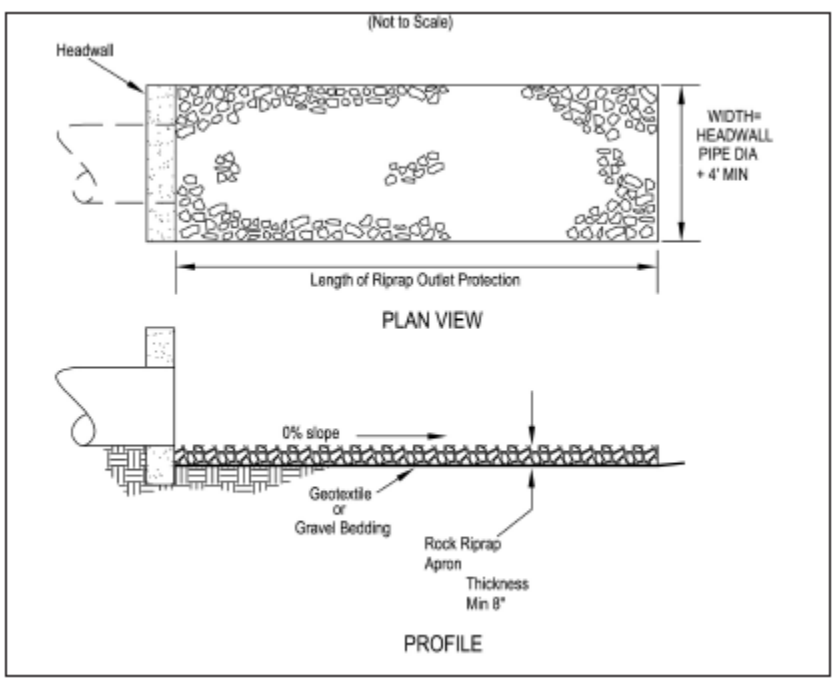
- Determine responsible party to inspect and maintain the outlet protection after construction
- Missing riprap should be replaced as soon as possible.
- Protect the outlet protection from damage by equipment and traffic
- Fertilize the vegetated area annually to and maintain a vigorous stand of grass
- Mow the vegetated area to maintain a healthy and vigorous stand of grass.
- Seed and mulch any bare areas that develop.
- Remove sediment and debris that have accumulated.
- Easements, or other means, should be obtained to ensure the channel is maintained as constructed

Figure 4: Rock Channel Protection



Specifications for Rock Outlet Protection

Figure 5: Plan and Profile for Typical Rock Outlet Protection



- Subgrade for the filter or bedding and riprap shall be prepared to the required lines and grades as shown on the plan. The subgrade shall be cleared of all trees, stumps, roots, sod, loose rock, or other material.
- Riprap shall conform to the grading limits as shown on the plan.
- Geotextile shall be securely anchored according to manufacturers' recommendations.
- Geotextile shall be laid with the long dimension parallel to the direction of flow and shall be laid loosely but without wrinkles and creases. Where joints are necessary, strips shall be placed to provide a 12-in. minimum overlap, with the upstream strip overlapping the downstream strip.
- Gravel bedding shall be ODOT No. 67's or 57's unless shown differently on the drawings.
- Riprap may be placed by equipment but shall be placed in a manner to prevent slippage or damage to the geotextile.
- Riprap shall be placed by a method that does not cause segregation of sizes. Extensive pushing with a dozer causes segregation and shall be avoided by delivering riprap near its final location within the channel.
- Construction shall be sequenced so that outlet protection is placed and functional when the storm drain, culvert, or open channel above it becomes operational.
- All disturbed areas will be vegetated as soon as practical.

References

City of Columbus. Stormwater Drainage Manual. March 2006, City of Columbus, Division of Sewerage and Drainage Department of Public Utilities

Lindeburg, P.E., Michael R. 2006. Civil Engineering Reference Manual, Tenth Edition. Belmont, CA: Professional Publications Inc.

Ohio Department of Natural Resources, Division of Soil and Water Conservation, 2006. Rainwater and Land Development, Third Edition.

Ohio Department of Transportation, Location and Design Manual Volume 2, Drainage Design. January 2007. State of Ohio.

Soil Conservation Service (now the Natural Resources Conservation Service), US Department of Agriculture. August 1972. National Engineering Handbook, Section 4, Hydrology.

United States Department of Agriculture, Natural Resources Conservation Service, Conservation Engineering Division. June 1986. Urban Hydrology for Small Watersheds. Technical Release 55 (TR-55).

United States Department of Agriculture, Natural Resources Conservation Service, Conservation Engineering Division. July 2004. Technical Release 20 (TR-20).

United States Department of the Interior, Bureau of Reclamation. 1977. Design of Small Dams, A Water Resources Technical Publication, Second Edition. Washington: United States Government Printing Office.

United States Department of Transportation, Federal Highway Administration. September 1985. "Hydraulic Design of Highway Culverts." Hydraulic Design Series No. 5, FHWA-IP-85-15. Sept. 1985. Available through the National Technical Information Service, Springfield, VA 22161.

United States Department of Transportation, Federal Highway Administration. October 2005. Debris Control Structures Evaluation and Countermeasures, Hydraulic Engineering Circular No. 9, Third Edition. Publication No. FHWA-IF-04-016. Arlington, VA: National Highway Institute.

United States Department of Transportation, Federal Highway Administration. March 1984. Drainage of Highway Pavements, Hydraulic Engineering Circular No. 12, Publication No. FHWA-TS-84-202. Arlington, VA: National Highway Institute.

United States Department of Transportation, Federal Highway Administration. July 2001. Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, Second Edition. Publication No. FHWA-NHI-01-021. Arlington, VA: National Highway Institute.

United States Geological Survey, USGS Report 93-135 Estimation of Peak-Frequency Relations, Flood Hydrographs, and Volume-Duration-Frequency Relations of Ungaged Small Streams in Ohio.

16. Stormwater Quality Regulations

The City of Delaware is committed to the protection of the natural waterways that exist throughout the community, as well as improving the quality of these waterways through responsible and practical development practices and the establishment of protective easements and covenants as required. Strict enforcement of these regulations is made possible through the combined efforts of the City Planning and Community Development, Engineering Services, and Utility Departments, each of which employs full time staff dedicated to the enforcement of current zoning and construction regulations.

Recognizing the potential impact of uncontrolled silt laden storm water runoff to the local perennial, intermittent, and ephemeral streams in the immediate proximity of construction sites, and the longer term impacts to the Olentangy River from unregulated and prolonged community wide runoff, the City has adopted the Ohio Environmental Protection Agencies "General permit Authorization for Storm Water Discharges Associated with Construction Activity Located within Portions of the Olentangy River Watershed Under The National Pollutant Discharge Elimination System. (OHCO00001)", as revised herein and approved by the OEPA, as the City's storm water quality regulations. The permit as revised, in combination with the City's codified ordinances, shall be considered the applicable and enforceable storm water quality standards and regulations for the City of Delaware.

Olentangy River, just downstream of the City of Delaware

The information contained within this section meets the intent of OHCO0001 and is to be considered the governing regulations for construction site storm water management within the City of Delaware. The City's Construction/Post-Construction Program is deemed to be acceptable by OEPA. The City will review and pre-approve all NPDES regulated construction activity documents including SWP3's and enforce the regulations contained within. All NOI applications, related documents, and SWP3 plans remain subject to final approval by the OEPA as indicated within these regulations.

I. PART I. COVERAGE UNDER THESE REGULATIONS

A. Regulation Area.

These regulations cover only land annexed to the City of Delaware and land owned by the City of Delaware outside of the corporation limits. (**Note**: for the remainder of this chapter, the term "permit" is used in the regulations to maintain consistency with standard OEPA permit language, however "permit" means "City regulations".

B. Eligibility.

1. **<u>Construction activities covered</u>. Except for storm water discharges identified under Part I.B.2 this permit may cover all new, initiating ground disturbances as of the effective date of this permit, discharges composed entirely of storm water discharges associated with construction activity that enter surface waters of the state or a storm drain leading to surface waters of the state.**

   For the purposes of this permit, construction activities include any clearing, grading, excavating, grubbing and/or filling activities that disturb the threshold acreage described in the next paragraph. Discharges from trench de-watering are also covered by this permit as long as the de-watering activity is carried out in accordance with the practices outlined in Part III.G.2.i.iv of this permit.

   Construction activities disturbing one or more acres of total land that are located fully or partially within the permit area will be eligible for coverage under this permit. The threshold acreage includes the entire area disturbed in the larger common plan of development or sale.

   This permit also authorizes storm water discharges from support activities (e.g., concrete or asphalt batch plants, equipment staging yards, material storage areas, excavated material disposal areas, borrow areas) provided:

   a. The support activity is directly related to a construction site that is required to have NPDES permit coverage for discharges of storm water associated with construction activity;

   b. The support activity is not a commercial operation serving multiple unrelated construction projects and does not operate beyond the completion of the construction activity at the site it supports;

   c. Appropriate controls and measures are identified in a storm water pollution prevention plan (SWP3) covering the discharges from the support activity; and

   d. The support activity is on or contiguous with the property defined in the NOI (off-site borrow pits and soil disposal areas, which serve only one project, do not have to be contiguous with the construction site).

2. **<u>Limitations on coverage</u>. The following storm water discharges associated with construction activity are not covered by this permit:**

   a. Storm water discharges that originate from the site after construction activities have been completed, including any temporary support activity, and the site has achieved final stabilization. Industrial post-construction storm water discharges may need to be covered by an NPDES permit;

   b. Storm water discharges associated with construction activity that the director

has shown to be or may reasonably expect to be contributing to a violation of a water quality standard; and

c. Storm water discharges authorized by an individual NPDES permit or another NPDES general permit;

3. **<u>Prohibition on non-storm water discharges</u>. All discharges covered by this permit must be composed entirely of storm water with the exception of the following: discharges from fire fighting activities; fire hydrant flushings; potable water sources including waterline flushings; irrigation drainage; lawn watering; routine external building wash-down which does not use detergents; pavement wash-waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where detergents are not used; air conditioning condensate; springs; uncontaminated ground water from trench or well point de-watering and foundation or footing drains where flows are not contaminated with process materials such as solvents. De-watering activities must be done in compliance with Part III.G.2.i.iv of this permit. Discharges of material other than storm water or the authorized non-storm water discharges listed above must comply with an individual NPDES permit or an alternative NPDES general permit issued for the discharge.**

   Except for flows from fire fighting activities, sources of non-storm water listed above that are combined with storm water discharges associated with construction activity must be identified in the SWP3. The SWP3 must identify and ensure the implementation of appropriate pollution prevention measures for the non-storm water component(s) of the discharge.

4. **<u>Spills and unintended releases</u> (Releases in excess of Reportable Quantities). This permit does not relieve the permittee of the reporting requirements of Title 40 of the Code of Federal Regulations ("CFR") Part 117 and 40 CFR Part 302. In the event of a spill or other unintended release, the discharge of hazardous substances in the storm water discharge(s) from a construction site must be minimized in accordance with the applicable storm water pollution prevention plan for the construction activity and in no case, during any 24-hour period, may the discharge(s) contain a hazardous substance equal to or in excess of reportable quantities.**

   40 CFR Part 117 sets forth a determination of the reportable quantity for each substance designated as hazardous in 40 CFR Part 116. The regulation applies to quantities of designated substances equal to or greater than the reportable quantities, when discharged to surface waters of the state. 40 CFR Part 302 designates under section 102(a) of the Comprehensive Environmental Response, Compensation and Liability Act of 1980, those substances in the statutes referred to in section 101(14), identifies reportable quantities for these substances and sets forth the notification requirements for releases of these substances. This regulation also sets forth reportable quantities for hazardous substances designated under section 311(b)(2)(A) of the Clean Water Act (CWA).

C. Requiring an individual NPDES permit or an alternative NPDES general permit.

1. **<u>The director may require an alternative permit</u>. The director may require any operator eligible for this permit to apply for and obtain either an individual NPDES permit or coverage under an alternative NPDES general permit in accordance with OAC Rule**

3745-38-04. Any interested person may petition the director to take action under this paragraph.

The director will send written notification that an alternative NPDES permit is required. This notice shall include a brief statement of the reasons for this decision, an application form and a statement setting a deadline for the operator to file the application. If an operator fails to submit an application in a timely manner as required by the director under this paragraph, then coverage, if in effect, under this permit is automatically terminated at the end of the day specified for application submittal.

2. **<u>Operators may request an individual NPDES permit</u>. Any owner or operator eligible for this permit may request to be excluded from the coverage of this permit by applying for an individual permit. The owner or operator shall submit an individual application with reasons supporting the request to the director in accordance with the requirements of 40 CFR 122.26. If the reasons adequately support the request, the director shall grant it by issuing an individual NPDES permit.**

3. **When an individual NPDES permit is issued to an owner or operator otherwise subject to this permit or the owner or operator is approved for coverage under an alternative NPDES general permit, the applicability of this permit to the individual NPDES permittee is automatically terminated on the effective date of the individual permit or the date of approval for coverage under the alternative general permit, whichever the case may be.**

D. Permit requirements when portions of a site are sold

If an operator obtains a permit for a development, and then the operator (permittee) sells off lots or parcels within that development, permit coverage must be continued on those lots until a Notice of Termination (NOT) in accordance with Part IV.B is submitted. For developments which require the use of centralized sediment and erosion controls (i.e., controls that address storm water runoff from one or more lots) for which the current permittee intends to terminate responsibilities under this permit for a lot after sale of the lot to a new owner and such termination will either prevent or impair the implementation of the controls and therefore jeopardize compliance with the terms and conditions of this permit, the permittee will be required to maintain responsibility for the implementation of those controls. For developments where this is not the case, it is the permittee's responsibility to temporarily stabilize all lots sold to individual lot owners unless an exception is approved in accordance with Part III.G.4. In cases where permit responsibilities for individual lot(s) will be terminated after sale of the lot, the permittee shall inform, in writing, the individual lot owner of the obligations under this permit and ensure that the Individual Lot NOI application is submitted to Ohio EPA.

E. Authorization

1. **<u>Obtaining authorization to discharge</u>. Operators that discharge storm water associated with construction activity must submit an NOI application form and SWP3 in accordance with the requirements of Part II of this permit to obtain authorization to discharge under this general permit. As required under OAC Rule 3745-38-06(E), the director, in response to the NOI and SWP3 submission, will notify the applicant in writing that he/she has or has not been granted general permit coverage to discharge storm water associated with construction activity under the terms and conditions of**

this permit or that the applicant must apply for an individual NPDES permit or coverage under an alternate general NPDES permit as described in Part I.C.a.

2. **<u>No release from other requirements.</u> No condition of this permit shall release the permittee from any responsibility or requirements under other environmental statutes or regulations. Other permit requirements commonly associated with construction activities include, but are not limited to, section 401 water quality certifications, isolated wetland permits, permits to install sanitary sewers or other devices that discharge or convey polluted water, permits to install drinking water lines, single lot sanitary system permits and disturbance of land which was used to operate a solid or hazardous waste facility (i.e., coverage under this NPDES general permit does not satisfy the requirements of OAC Rule 3745-27-13 or ORC Section 3734.02(H)). The issuance of this permit is subject to resolution of an antidegradation review. This permit does not relieve the permittee of other responsibilities associated with construction activities such as contacting the Ohio Department of Natural Resources, Division of Water, to ensure proper well installation and abandonment of wells.**

II. PART II. NOTICE OF INTENT REQUIREMENTS

A. Deadlines for notification.

Initial coverage: Operators who intend to obtain initial coverage for a storm water discharge associated with construction activity under this general permit must submit a complete and accurate NOI application form, approvable SWP3 and appropriate fee that has been reviewed and pre-approved by the City of Delaware prior to the commencement of construction activity. If more than one operator, as defined in Part VII of this general permit, will be engaged at a site, each operator shall seek coverage under this general permit. Coverage under this permit is not effective until an approval letter granting coverage from the director of Ohio EPA is received by the applicant. Where one operator has already submitted an NOI prior to other operator(s) being identified, the additional operator shall request modification of coverage to become a co-permittee. In such instances, the co-permittees shall be covered under the same facility permit number. No additional permit fee is required.

Individual lot transfer of coverage: operators must each submit an individual lot notice of intent (Individual Lot NOI) application form (no fee required) to Ohio EPA at least seven days prior to the date that they intend to accept responsibility for permit requirements for their portion of the original permitted development from the previous permittee. The original permittee may submit an Individual Lot NOT at the time the Individual Lot NOI is submitted. Transfer of permit coverage is not granted until an approval letter from the director of Ohio EPA is received by the applicant.

B. Failure to notify.

Operators who fail to notify the director of their intent to be covered and who discharge pollutants to surface waters of the state without an NPDES permit are in violation of ORC Chapter 6111. In such instances, Ohio EPA may bring an enforcement action for any discharges of storm water associated with construction activity.

C. Where to submit an NOI and SWP3.

Operators seeking coverage under this permit must submit a signed NOI form, provided by Ohio EPA, and an approvable SWP3 to the City of Delaware for review and pre-approval in advance of submission to the OEPA, to the address found in the associated instructions.

D. Additional notification.

The permittee shall make NOIs and SWP3s available upon request of the director of Ohio EPA, local agencies approving sediment and erosion control plans, grading plans or storm water management plans, local governmental officials, or operators of municipal separate storm sewer systems (MS4s) receiving drainage from the permitted site. Each operator that discharges to a NPDES permitted MS4 shall provide a copy of its Ohio EPA NOI submission to the MS4 in accordance with the MS4's requirements, if applicable.

E. Re-notification.

Upon renewal of this general permit, the permittee is required to notify the director of his or her intent to be covered by the general permit renewal. Permittees shall submit a letter within 90 days of receipt of written notification by Ohio EPA of the general permit renewal expressing their intent that coverage be continued. There is no fee

associated with these letters of intent for continued coverage. Permit coverage will be terminated after the 90-day period if the letter is not received by Ohio EPA. Ohio EPA will provide instructions in its notification of permit renewal on the contents of the letter of intent and where it is to be sent.

III. PART III. STORM WATER POLLUTION PREVENTION PLAN (SWP3)

A. Storm Water Pollution Prevention Plans.

A SWP3 shall be developed for each site covered by this permit. For a multi-phase construction project, a separate application package (NOI and approvable SWP3) shall be submitted when a separate SWP3 is prepared for subsequent phases. SWP3s shall be prepared in accordance with sound engineering and/or conservation practices by a professional experienced in the design and implementation of standard erosion and sediment controls and storm water management practices addressing all phases of construction. The SWP3 shall identify potential sources of pollution which may reasonably be expected to affect the quality of storm water discharges associated with construction activities. The SWP3 shall be a comprehensive, stand-alone document, which is not complete unless it contains the information required by Part III.7 of this permit. The SWP3 shall clearly identify all activities which are required to be authorized under Section 401 and subject to an antidegradation review. In addition, the SWP3 shall describe and ensure the implementation of best management practices (BMPs) that reduce the pollutants in storm water discharges during construction and pollutants associated with post-construction activities to ensure compliance with ORC Section 6111.04, OAC Chapter 3745-1 and the terms and conditions of this permit.

B. Timing

An approvable SWP3 shall be completed and submitted **with** the NOI and updated in accordance with Part III.D. The SWP3 must be implemented upon initiation of ground disturbance.

Permittees having coverage from NPDES general permit numbers OHC000003 that have initiated construction activity prior to the receipt of written notification from the Director instructing them to obtain coverage under this alternative general permit (OHCO00001), are not required to update their SWP3 as a result of this alternative general permit (OHCO00001).

C. SWP3 Signature and Review.

1. **<u>Plan Signature and Retention On Site</u>. The SWP3 shall include the certification in Part V.H, be signed in accordance with Part V.G. and retained on site during**
2. **Plan Availability**
   a. On-site: The plan shall be made available immediately upon request of the director or his authorized representative during working hours. A copy of the NOI and letter granting permit coverage under this general permit also shall be made available at the site.
   b. By written request: The permittee must provide the most recent copy of the SWP3 within 7 days upon written request of any of the following:
      i. The director or the director's authorized representative;
      ii. A local agency approving sediment and erosion plans, grading plans or storm water management plans; or
      iii. In the case of a storm water discharge associated with construction activity which discharges through a municipal separate storm sewer system with an NPDES permit, the operator of the system.

c. To the public: All NOIs, general permit approval for coverage letters, and SWP3s are considered reports that shall be available to the public in accordance with the Ohio Public Records law. The permittee shall make documents available to the public upon request or provide a copy at public expense, at cost, in a timely manner. However, the permittee may claim to Ohio EPA any portion of an SWP3 as confidential in accordance with Ohio law.

3. **<u>Plan Revision</u>. The director or authorized representative and/or City authorized representative may notify the permittee at any time that the SWP3 does not meet one or more of the minimum requirements of this part. Within 10 days after such notification from the director or authorized representative and/or City authorized representative (or as otherwise provided in the notification), the permittee shall make the required changes to the SWP3 and, if requested, shall submit to Ohio EPA the revised SWP3 or a written certification that the requested changes have been made. Failure to comply with these requirements may result in penalties to the permittee as established in City Codified ordinances.**

D. Amendments

The permittee shall amend the SWP3 whenever there is a change in design, construction, operation or maintenance, which has a significant effect on the potential for the discharge of pollutants to surface waters of the state or if the SWP3 proves to be ineffective in achieving the general objectives of controlling pollutants in storm water discharges associated with construction activity. Amendments to the SWP3 may be reviewed by the City or Ohio EPA in the same manner as Part III.3.

E. Duty to inform contractors and subcontractors

The permittee shall inform all contractors and subcontractors not otherwise defined as "operators" in Part VII of this general permit who will be involved in the implementation of the SWP3 of the terms and conditions of this general permit. The permittee shall maintain a written document containing the signatures of all contractors and subcontractors involved in the implementation of the SWP3 as proof acknowledging that they reviewed and understand the conditions and responsibilities of the SWP3. The written document shall be created and signatures shall be obtained prior to commencement of work on the construction site.

F. Total Maximum Daily Load (TMDL) allocations

This general permit requires control measures/BMPs for construction sites that reflect recommendations set forth in the Olentangy River TMDL.

G. SWP3 Requirements

Operations that discharge storm water from construction activities are subject to the following requirements and the SWP3 shall include the following items:

1. **<u>Site description</u>. Each SWP3 shall provide:**

   a. A description of the nature and type of the construction activity (e.g., low density residential, shopping mall, highway, etc.);

   b. Total area of the site and the area of the site that is expected to be disturbed (i.e., grubbing, clearing, excavation, filling or grading, including off-site borrow areas);

c. A calculation of the runoff coefficients for both the pre-construction and post construction site conditions;

d. An estimate of the impervious area and percent imperviousness created by the construction activity;

e. Existing data describing the soil and, if available, the quality of any discharge from the site;

f. A description of prior significant land uses at the site;

g. A description of prior channelization at the site;

h. An implementation schedule which describes the sequence of major construction operations (i.e., designation of vegetative preservation areas, grubbing, excavating, grading, utilities and infrastructure installation) and the implementation of erosion, sediment and storm water management practices or facilities to be employed during each operation of the sequence;

i. The name and/or location of the immediate receiving stream or surface water(s) and the first subsequent named receiving water(s) and the areal extent and description of wetlands or other special aquatic sites at or near the site which will be disturbed or which will receive discharges from disturbed areas of the project. For discharges to an MS4, the point of discharge to the MS4 and the location where the MS4 ultimately discharges to a stream or State surface water must be indicated;

j. For subdivided developments where the SWP3 does not call for a centralized sediment control capable of controlling multiple individual lots, a detail drawing of a typical individual lot showing standard individual lot erosion and sediment control practices. This does not remove the responsibility to designate specific erosion and sediment control practices in the SWP3 for critical areas such as steep slopes, stream banks, drainage ways and riparian zones

k. Location and description of any storm water discharges associated with dedicated asphalt and dedicated concrete plants covered by this permit and the best management practices to address pollutants in these storm water discharges;

l. A copy of the permit requirements (attaching a copy of this permit is acceptable);

m. A cover page or title identifying the name and location of the site, the name and contact information of all construction site operators, the name and contact information for the person responsible for authorizing and amending the SWP3 preparation date, and the estimated dates that construction will start and be complete;

n. A log documenting required SWP3 grading and stabilization activities as well as amendments to the SWP3, which occur after construction activities commence, and which contractor is responsible for implementation (e.g., contractor A will clear land and install perimeter controls and contractor B will maintain perimeter controls until final stabilization); and

o. Site map showing:

i. The location of any delineated boundary for required riparian setbacks;

ii. Areas designated as open space or conservation easements and will not have any earth disturbing activities;

iii. Limits of earth-disturbing activity of the site including associated off-site borrow or spoil areas that are not addressed by a separate NOI and associated SWP3;

iv. Soils types for all areas of the site, including locations of unstable or highly erodible soils;

v. Existing and proposed contours. A delineation of drainage watersheds expected during and after major grading activities as well as the size of each drainage watershed, in acres;

vi. Surface water locations including springs, wetlands, streams, lakes, water wells, etc., or within 200 feet of the site, including the boundaries of wetlands or stream channels and first subsequent named receiving water(s) the permittee intends to fill or relocate for which the permittee is seeking approval from the Army Corps of Engineers and/or Ohio EPA;

vii. Existing and planned locations of buildings, roads, parking facilities and utilities;

viii. The location of all erosion and sediment control practices, including the location of areas: to be constructed in different phases; to have temporary or permanent preservation of vegetation or land; and areas likely to require temporary stabilization during the course of site development;

ix. Sediment and storm water management basins noting their sediment settling volume and contributing drainage area. The outfalls of all sediment settling ponds associated with the site identified as three digit numbers (e.g. 001, 002, etc.);

x. The location of permanent storm water management practices to be used to control pollutants or provide infiltration of storm water after construction operations have been completed.

xi. Areas designated for the storage or disposal of solid, sanitary and toxic wastes, including dumpster areas, areas designated for cement truck washout, and vehicle fueling;

xii. The location of designated construction entrances where the vehicles will access the construction site;

xiii. The location of any areas of floodplain fill, floodplain excavation, stream restoration or stream crossings.

2. **<u>Controls</u>. The SWP3 must contain a description of the controls appropriate for each construction operation covered by this permit and the operator(s) must implement such controls. The SWP3 must clearly describe for each major construction activity identified in Part III.G.1.h: (a) appropriate control measures and the general timing (or sequence) during the construction process that the measures will be implemented;**

The City requires that the primary site operator review the SWP3 with the primary contractor prior to commencement of construction activities.

Ohio EPA recommends that the erosion, sediment, and storm water management practices used to satisfy the conditions of this permit, should meet the standards and specifications in the most current edition of Ohio's Rainwater and Land Development (see definitions) manual or other standards acceptable to Ohio EPA unless otherwise specified as a condition of this permit. The controls shall include the following minimum components:

a. **Non-Structural Preservation Methods.** The SWP3 must make use of practices which preserve the existing natural condition as much as feasible. Such practices may include: preserving existing vegetation and vegetative buffer strips, phasing of construction operations in order to minimize the amount of disturbed land at any one time and designation of tree preservation areas or other protective clearing or grubbing practices.

b. **Riparian Setback Requirements (within the Olentangy Watershed).** The SWP3 shall clearly delineate the boundary of required stream setback distances. The stream setback shall consist of a **streamside buffer** and an **outer buffer** area. No construction activity shall occur, without appropriate mitigation, within the streamside buffer except activities associated with storm water conveyances from permanent treatment practices and restoration or recovery of floodplain and channel form characteristics as described in the Attachment. Storm water conveyances must be designed to minimize the width of disturbance. For the **Olentangy Mainstem**, no impervious surfaces shall be constructed in the outer area without appropriate mitigation, and moderate to substantial fill activities with no impervious surface **may** require appropriate mitigation pending an individual approval by the City and Ohio EPA. For **perennial streams**, no impervious surfaces, structure, fill, or activity that would impair the floodplain or stream stabilizing ability of the outer area shall occur without appropriate mitigation.

   If intrusion within the delineated setback boundary is necessary to accomplish the purposes of a project then mitigation shall be required in accordance with Part III.G.2.c of this permit. **Streams requiring protection under this section have a defined bed, bank, or channel and are defined as follows:**

   • The Olentangy Mainstem;

   • **Perennial streams** flow at least 9 months of a typical climate year;

   • **Intermittent streams** flow for less than 9 months of a typical climate year; and

   • **Ephemeral streams** flow only in response to storm events.

   National Resources Conservation Service (NRCS) soil survey maps should be used as one reference and the presence of a stream requiring protection should also be confirmed in the field. Any required setback distances shall be clearly displayed in the field prior to any construction related activity. Riparian setbacks shall be delineated based upon one of the following methods:

   i. The required setback distances shall vary with stream type as follows:

(1) The setback distances associated with the mainstem of the **Olentangy Mainstem** shall consist of:

(a) A **streamside buffer** width of **100 feet** as measured horizontally from the ordinary high water mark per side; and

(b) An **outer buffer** sized to match the outer line of the regulatory **100 year floodplain** based on FEMA mapping, or to the edge of right-of-way of roadways that exist at the time these regulations are adopted as approved by the City and Ohio EPA on a case-by-case basis or via a pre-approved graphical representation.

(2) Perennial streams for the purpose of this permit include but are not limited to Delaware Run, Horseshoe Run, Mill Run, and Sugar Run. The setback distance associated with these perennial streams shall consist of:

(a) A **streamside buffer** width of **80 feet** per side measured horizontally from the ordinary high water mark; and

(b) An **outer buffer** width of **80 feet** per side measured horizontally from the streamside buffer or to the edge of the right-of-way of roadways that exist at the time these regulations are adopted as approved by the City and the Ohio EPA on a case-by-case basis of via a pre-approved graphical representation.

(3) The setback distance associated with **intermittent** and **ephemeral** streams shall be a streamside buffer width of **30 feet** per side measured horizontally from the centerline of the stream. **No outer buffer is required for intermittent and ephemeral streams**.

No structural sediment controls (e.g., the installation of silt fence or a sediment settling pond) or structural post-construction controls shall be used in a stream or the streamside buffer. Activities and controls that would not impair the floodplain or stream stabilizing ability of the outer area can be considered.

Redevelopment projects (i.e., developments on previously developed property) located within the delineated setback boundary are exempt from Riparian Setback Mitigation (Part III.G.2.c) provided the proposed project does not further intrude the delineated setback boundary.

c. **Riparian Setback Mitigation.** The mitigation required for intrusion into the riparian setback of the **Olentangy Mainstem or perennial streams** shall be determined by the horizontal distance of the intrusion. Up to three zones will be used in determining the required mitigation. Zone 1 extends out from the ordinary high water mark 30 feet. Zone 2 extends from the edge of Zone 1 to the outer edge of the streamside buffer. Zone 3 extends from the edge of the streamside buffer to the edge of the outer buffer. **Intrusion into these zones will require the following mitigation within the watershed of the immediate receiving stream:**

i. Two (2) times the total disturbed area in the stream and within Zone 1 (2:1 mitigation) shall be mitigated within a Zone 1

ii. One and one-half (1.5) times the total disturbed area within Zone 2 (1.5:1 mitigation) shall be mitigated within a Zone 1 and/or Zone 2

iii. One (1) times the total area of new structures, impervious area, or moderate to substantial fill (per Part II.G.2.b of this permit) within Zone 3 shall be mitigated within any Zone.

The mitigation required for intrusion into the riparian setback of an **intermittent stream** shall be two (2) times the total disturbed area within the riparian setback (2:1 mitigation throughout). The mitigation must occur in the watershed of the immediate receiving stream and shall be mitigated within any Zone.

The mitigation required for intrusion into the riparian setback of an **ephemeral stream** shall be one (1) times the total disturbed area within the riparian setback (1:1 mitigation throughout). The mitigation must occur in the watershed of the immediate receiving stream and shall be mitigated within any Zone.

Mitigation resulting from State or Federal environmental regulations may be adjusted in recognition of these requirements. All mitigation shall, at a minimum; include conserved or restored setback zone, and should be designed to maximize the ecological function of the mitigation. Including mitigation at the stream edge along with associated setback areas is one way to maximize ecological function. Mitigation shall be protected in perpetuity by binding conservation easements or environmental covenants for the **Olentangy Mainstem, perennials, and intermittent streams**. The City and OEPA will consider drainage easements as mitigation for **ephemeral streams** if the language is approvable by both entities and drainage easement meets the intent of protecting the water quality of the stream perpetually. **Granting of binding easements or covenants in perpetuity for land outside of disturbed area, but within any required riparian setback, in and of itself, counts towards required mitigation. Likewise, granting of easements or covenants over land outside of riparian setbacks, in itself, counts towards required mitigation as long as the land provides ecological or water quality benefit to be evaluated on a case-by-case basis by the City and Ohio EPA.**

d. **Erosion Control Practices.** The SWP3 must make use of erosion controls that are capable of providing cover over disturbed soils unless an exception is approved in accordance with Part III.G.4. A description of control practices designed to maintain vegetative cover or restabilize disturbed areas after grading or construction shall be included in the SWP3. The SWP3 must provide specifications for stabilization of all disturbed areas of the site and provide guidance as to which method of stabilization will be employed for any time of the year. Such practices may include: temporary seeding, permanent seeding, mulching, matting, sod stabilization, vegetative buffer strips, phasing of construction operations, use of construction entrances and the use of alternative ground cover.

i. **Stabilization.** Disturbed areas must be stabilized as specified in the following tables below. Permanent and temporary stabilization are defined in Part VII.

Table 1: Permanent Stabilization

Area requiring permanent stabilization	*Time frame to apply erosion controls*
Any areas that will lie dormant for one year or more	*Within seven days of the most recent disturbance*
Any areas within 50 feet of a surface water of the state and at final grade	*Within two days of reaching final grade*
Any other areas at final grade	*Within seven days of reaching final grade within that area*

Table 2: Temporary Stabilization

Area requiring temporary stabilization	Time frame to apply erosion controls
Any disturbed areas within 50 feet of a surface water of the state and not at final grade	Within two days of the most recent disturbance if the area will remain idle for more than 21 days
For all construction activities, any disturbed areas that will be dormant for more than 21 days but less than one year, and not within 50 feet of a surface water of the state	Within seven days of the most recent disturbance within the area For residential subdivisions, disturbed areas must be stabilized at least seven days prior to transfer of permit coverage for the individual lot(s).
Disturbed areas that will be idle over winter	Prior to the onset of winter weather

Where vegetative stabilization techniques may cause structural instability or are otherwise unobtainable, alternative stabilization techniques must be employed.

ii. **Permanent stabilization of conveyance channels**. Operators shall undertake special measures to stabilize channels and outfalls and prevent erosive flows. Measures may include seeding, dormant seeding as defined in the most current edition of the Rainwater and Land Development manual, mulching, erosion control matting, sodding, riprap, and natural channel design with bioengineering techniques.

e. **Runoff Control Practices.** The SWP3 shall incorporate measures which control the flow of runoff from disturbed areas so as to prevent erosion from occurring. Such practices may include rock check dams, pipe slope drains, diversions to direct flow away from exposed soils and protective grading practices. These practices shall divert runoff away from disturbed areas and steep slopes where practicable.

f. **Sediment Control Practices.** The plan shall include a description of structural practices that shall store runoff allowing sediments to settle and/or divert flows away from exposed soils or otherwise limit runoff from exposed areas. Structural practices shall be used to control erosion and trap sediment from a site remaining disturbed for more than 14 days. Such practices may include, among others: sediment settling ponds, silt fences, earth diversion

dikes or channels which direct runoff to a sediment settling pond and storm drain inlet protection. All sediment control practices must be capable of ponding runoff in order to be considered functional. Earth diversion dikes or channels alone are not considered a sediment control practice unless those are used in conjunction with a sediment settling pond.

The SWP3 must contain detail drawings for all structural practices.

i. Timing. Sediment control structures shall be functional throughout the course of earth disturbing activity. Sediment basins and perimeter sediment barriers shall be implemented prior to grading and within seven days from the start of grubbing. They shall continue to function until the up slope development area is restabilized. As construction progresses and the topography is altered, appropriate controls must be constructed or existing controls altered to address the changing drainage patterns.

ii. Sediment settling ponds. A sediment settling pond is required for any one of the following conditions.

- concentrated storm water runoff (e.g., storm sewer or ditch);
- runoff from drainage areas, which exceed the design capacity of silt fence or other sediment barriers;
- runoff from drainage areas that exceed the design capacity of inlet protection; or

runoff from common drainage locations with 5 or more acres of disturbed land.

The permittee may request approval from the City of Delaware and Ohio EPA to use alternative controls if the permittee can demonstrate the alternative controls are equivalent in effectiveness to a sediment settling pond.

The volume of the dewatering zone shall be a minimum of 1800 cubic feet (ft^3) per acre of drainage (67 yd^3/acre) with a minimum 48-hour drain time for sediment basins serving a drainage area over 5 acres. The volume of the sediment storage zone shall be calculated by one of the following methods:

Method 1: The volume of the sediment storage zone shall be 1000 ft^3 per disturbed acre within the watershed of the basin. OR

Method 2: The volume of the sediment storage zone shall be the volume necessary to store the sediment as calculated with RUSLE or a similar generally accepted erosion prediction model.

The accumulated sediment shall be removed from the sediment storage zone once it's full. When determining the total contributing drainage area, off-site areas and areas which remain undisturbed by construction activity must be included unless runoff from these areas is diverted away from the sediment settling pond and is not co-mingled with sediment-laden runoff. The depth of the dewatering zone must be less than or equal to five feet. The configuration between inlets and the outlet of the basin must provide at least two units of

length for each one unit of width (> 2:1 length: width ratio), however, a length to width ratio of 4:1 is recommended. When designing sediment settling ponds, the permittee must consider public safety, especially as it relates to children, as a design factor for the sediment basin and alternative sediment controls must be used where site limitations would preclude a safe design. The use of a combination of sediment and erosion control measures in order to achieve maximum pollutant removal is encouraged.

iii. Silt Fence and Diversions. For sites five or more acres in size, the use of silt fence as a primary sediment control is prohibited. Centralized sediment basins shall be used for sites 5 or more acres in size. Diversions shall direct all storm water runoff from the disturbed areas to the impoundment intended for sediment control. The sediment basins and associated diversions shall be implemented prior to the major earth disturbing activity.

iv. For sites less than 5 acres silt fence may be used. Sheet flow runoff from denuded areas shall be intercepted by silt fence or diversions to protect adjacent properties and water resources from sediment transported via sheet flow. Where intended to provide sediment control, silt fence shall be placed on a level contour downslope of the disturbed area. This permit does not preclude the use of other sediment barriers designed to control sheet flow runoff. The relationship between the maximum drainage area to silt fence for a particular slope range is shown in the following table:

Table 3: Silt Fence Maximum Drainage Area Based on Slope

Maximum drainage area (in acres) to 100 linear feet of silt fence	*Range of slope for a particular drainage area (in percent)*
0.5	*< 2%*
0.25	*> 2% but < 20%*
0.125	*> 20% but < 50%*

Placing silt fence in a parallel series does not extend the size of the drainage area. Storm water diversion practices shall be used to keep runoff away from disturbed areas and steep slopes where practicable. Such devices, which include swales, dikes or berms, may receive storm water runoff from areas up to 10 acres.

v. Inlet Protection. Other erosion and sediment control practices shall minimize sediment laden water entering active storm drain systems, unless the storm drain system drains to a sediment settling pond. All inlets receiving runoff from drainage areas of one (1) or more acres will require a sediment settling pond.

vi. Modifying Controls. If periodic inspections or other information indicates a control has been used inappropriately or incorrectly, the permittee must replace or modify the control for site conditions.

g. Post-Construction Storm Water Management Requirements.

So that receiving stream's physical, chemical, and biological characteristics are protected and stream functions are maintained, post-construction storm water practices shall provide perpetual management of runoff quality and quantity. To meet the post-construction requirements of this permit, the SWP3 must contain a description of the post-construction BMPs that will be installed during construction for the site and the rationale for their selection. The rationale must address the anticipated impacts on the channel and floodplain morphology, hydrology, and water quality. Structural post-construction BMPs cannot be installed within State surface water (e.g., wetland or stream) unless it's authorized by a CWA 401 water quality certification and/or CWA 404 permit.

Detail drawings and maintenance plans must be provided for all post-construction BMPs. Maintenance plans shall be provided by the permittee to the post-construction operator of the site (including homeowner associations) upon completion of construction activities (prior to termination of permit coverage). For sites located within a community with a regulated municipal separate storm sewer system (MS4), the permittee, land owner, or other entity with legal control of the property may be required to develop and implement a maintenance plan to comply with the requirements of the MS4. Maintenance plans must ensure that pollutants collected within structural post-construction practices are disposed of in accordance with local, state, and federal regulations. To ensure that storm water management systems function as they were designed and constructed, the post construction operation and maintenance plan must be a stand-alone document, which contains: (1) a designated entity for storm water inspection and maintenance responsibilities; (2) the routine and non-routine maintenance tasks to be undertaken; (3) a schedule for inspection and maintenance; and (4) any necessary legally binding maintenance easements and agreements. Permittees, except for those regulated under the small MS4 program, are not responsible under this permit for operation and maintenance of post-construction practices once coverage under this permit is terminated.

This permit does not preclude the use of innovation or experimental post-construction storm water management technologies. However, the director may require discharges from such structures to be monitored to ensure compliance with Part III.G.2.g of this permit. The installation of structural controls in certain scenarios may also require a separate permit under section 404 of the CWA. Permittees are only responsible for the installation and maintenance of storm water management measures prior to final stabilization of the site and are not responsible for maintenance after storm water discharges associated with construction activity have been eliminated from the site. However, post-construction storm water BMPs that discharge pollutants from point sources once construction is completed, may in themselves, need authorization under a separate NPDES permit.

Construction activities which do not include the installation of any impervious surface (e.g., soccer fields), abandoned mine land reclamation activities regulated by the Ohio Department of Natural Resources, stream and wetland restoration activities, and wetland mitigation activities are not required to comply with the conditions of Part III.G.2.g of this permit. Linear construction

projects, (e.g., pipeline or utility line installation), which do not result in the installation of additional impervious surface, are not required to comply with the conditions of Part III.G.2.g of this permit. However, linear construction projects must be designed to minimize the number of stream crossings and the width of disturbance and achieve final stabilization of the disturbed area as defined in Part VII.L.1.

Large Construction Activities. For all large construction activities (involving the disturbance of five or more acres of land or will disturb less than five acres, but is part of a common plan of development or sale which will disturb five or more acres of land), the post construction BMP(s) chosen must be able to detain storm water runoff for protection of the stream channels, stream erosion control, and improved water quality. The BMP(s) chosen must be compatible with site and soil conditions. Structural (designed) post-construction storm water treatment practices shall be incorporated into the permanent drainage system for the site. The BMP(s) chosen must be sized to treat the water quality volume (WQv) and ensure compliance with Ohio's Water Quality Standards in OAC Chapter 3745-1. The WQv shall be equivalent to a) The volume of runoff from a 0.75-inch rainfall as calculated by an Ohio EPA and ODNR approved SCS Methodologies that is conveyed to an associated BMP or b) The volume of runoff from a 0.75-inch rainfall as determined according to the following equation:

$$WQv = C * P * A / 12$$

where:

WQv = water quality volume in acre-feet

C = runoff coefficient appropriate for storms less than 1 inch (Either use the following formula: $C = 0.858i3 - 0.78i2 + 0.774i + 0.04$, where i = fraction of post-construction impervious surface or use Table below)

P = 0.75 inch precipitation depth

A = area draining into the BMP in acres

Table 4: Runoff Coefficients Based on the Type of Land Use

Land Use	*Runoff Coefficient*
Industrial & Commercial	*0.8*
High Density Residential (>8 dwellings/acre)	*0.5*
Medium Density Residential (4 to 8 dwellings/acre)	*0.4*
Low Density Residential (<4 dwellings/acre)	*0.3*
Open Space and Recreational Areas	*0.2*

Where the land use will be mixed, the runoff coefficient should be calculated using a weighted average. For example, if 60% of the contributing drainage area to the storm water treatment structure is Low Density Residential, 30% is High Density Residential, and 10% is Open Space, the runoff coefficient is calculated as follows (0.6)(0.3) + (0.3)(0.5) + (0.1)(0.2) = 0.35.

An additional volume equal to 20 percent of the WQv shall be incorporated into the BMP for sediment storage and/or reduced infiltration capacity. Ohio EPA recommends that BMPs be designed according to the methodology included in the Rainwater and Land Development manual or in another design manual acceptable for use by Ohio EPA.

The BMPs listed in the Table below shall be considered standard BMPs approved for general use. However, communities with a regulated MS4 may limit the use of some of these BMPs. BMPs shall be designed such that the drain time is long enough to provide treatment, but short enough to provide storage available for successive rainfall events and avoid the creation of nuisance conditions. The outlet structure for the post-construction BMP must not discharge more than the first half of the EDv in less than one-third of the drain time. The EDv is the volume of stormwater runoff that must be detained by a structural post construction BMP. The EDv is equal to 75 percent of the WQv for wet extended detention basins, but is equal to the WQv for all BMPs listed in the table below.

Table 5: Target Drain Times for Structural Post-Construction BMPs

Best Management Practice	*Drain Time of WQv*
*Infiltration Basins^*	*24 - 48 hours*
Enhanced Water Quality Swale	*24 hours*
*Dry Extended Detention Basin**	*48 hours*
*Wet Extended Detention Basin***	*24 hours*
Constructed Wetland (above permanent pool)+	*24 hours*
Sand & Other Media Filtration	*40 hours*
*Bio-retention Cells^*	*40 hours*
Pocket Wetlands#	*24 hours*
Vegetated Filter Strips	*24 hours*
*Use of Alternative BMPs****	

* Dry basins must include forebay and micropool each sized at 10% of the WQv

** Provide both a permanent pool and an extended detention volume above the permanent pool, each sized at 0.75 * WQv

*** The use of Alternative BMPs is subject to review and approval on a case-by-case basis.

+ Extended detention shall be provided for the full WQv above the permanent water pool.

^ The WQv shall completely infiltrate within 48 hours so there is no standing or residual water in the BMP.

Pocket wetlands must have a wet pool equal to the WQv, with 25% of the WQv in a pool and 75% in marshes. The extended detention volume above the permanent pool must be equal to the WQv.

The permittee may request approval from the City of Delaware and the Ohio EPA to use alternative post-construction BMPs if the permittee can demonstrate that the alternative BMPs are equivalent in effectiveness to those listed in Table 2 above. Construction activities shall be exempt from this condition if it can be demonstrated that the WQv is provided within an existing structural post-construction BMP that is part of a larger common plan of development or if structural post-construction BMPs are addressed in a regional or local storm water management plan. A municipally operated regional storm water BMP can be used as a post-construction BMP provided that the BMP can detain the WQv from its entire drainage area and release it over a 24 hour period.

Transportation Projects The construction of new roads and roadway improvement projects by public entities (i.e., the state, counties, townships, cities, or villages) shall implement post-construction BMPs in compliance with the current version (as of the effective date of this permit) of the Ohio Department of Transportation's "Location and Design Manual, Volume Two Drainage Design" that has been accepted by Ohio EPA as an alternative to the conditions of this permit.

Offsite Mitigation of Post-Construction Ohio EPA may authorize the offsite mitigation of the post-construction requirements of Part III.G.2.g of this permit on a case by case basis provided the permittee clearly demonstrates the BMPs listed in Table 2 are not feasible and the following criteria is met: (1) a

maintenance agreement or policy is established to ensure operations and treatment in perpetuity; (2) the offsite location discharges to the same HUC-14 watershed unit. Requests for offsite mitigation must be received prior to receipt of the NOI applications.

Redevelopment Projects For redevelopment projects (i.e., developments on previously developed property), post-construction practices shall either ensure a 20 percent net reduction of the site impervious area, provide for treatment of at least 20 percent of the WQv, or a combination of the two. Where projects are a combination of new development and redevelopment, the total WQv that must be treated shall be calculated by a weighted average based on acreage, with the new development at 100 percent WQv and redevelopment at 20 percent WQv.

Non-Structural Post-Construction BMPs The size of the structural post-construction can be reduced by incorporating non-structural post-construction BMPs into the design. Practices such as preserving open space will reduce the runoff coefficient and, thus, the WQv. Ohio EPA encourages the implementation of riparian and wetland setbacks. Practices which reduce storm water runoff include permeable pavements, green roofs, rain barrels, conservation development, smart growth, low impact development, and other site design techniques contained in the Ohio Lake Commission's Balanced Growth Program (see http://www.epa.state.oh.us/oleo/bg1/index.html). In order to promote the implementation of such practices, the *City and* Director may consider the use of non-structural practices to demonstrate compliance with Part III.G.2.g of this permit for areas of the site not draining into a common drainage system of the site, i.e., sheet flow from perimeter areas such as the rear yards of residential lots, for low density development scenarios, or where the permittee can demonstrate that the intent of pollutant removal and stream protection, as required in Part III.G.2.g of this permit is being addressed through non-structural post-construction BMPs based upon review and approval by Ohio EPA.

Use of Alternative Post-Construction BMPs This permit does not preclude the use of innovative or experimental post-construction storm water management technologies. However, the City or Director may require these practices to be tested using the protocol outlined in the Technology Acceptance Reciprocity Partnership's (TARP) Protocol for Stormwater Best Management Practice Demonstrations (see http://www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp).

The City or Director may require discharges from such structures to be monitored to ensure compliance with Part III.G.2.g of this permit. Permittees must request approval from the City and Ohio EPA to use alternative post-construction BMPs if the permittee can demonstrate that the alternative BMPs are equivalent in effectiveness to those listed in Table 2 above. To demonstrate this equivalency, the permittee must show that the alternative BMP has a minimum total suspended solids (TSS) removal efficiency of 80 percent. Also, the WQv discharge rate from the practice must be reduced to prevent stream bed erosion and protect the physical and biological stream integrity unless there will be negligible hydrological impact to the receiving surface water of the State. The discharges will have a negligible impact if the permittee can demonstrate that one of the following four conditions exist:

i. The entire WQv is recharged to groundwater;

ii. The larger common plan of development or sale will create less than one acre of impervious surface;

iii. The project is a redevelopment project within an ultra-urban setting (i.e., a downtown area or on a site where 100 percent of the project area is already impervious surface and the storm water discharge is directed into an existing storm sewer system); or

iv. The storm water drainage system of the development discharges directly into a large river (fourth order of greater) or to a lake and where the development area is less than 5 percent of the watershed area upstream of the development site, unless a TMDL identified water quality problems in the receiving State surface waters.

The City and Director shall consider the use of alternative BMPs on projects where the permittee can demonstrate that the implementation of the BMPs listed in Table 2 is infeasible due to physical site constraints that prevent the ability to prevent functional BMP design. Alternative practices may include, but are not limited to, underground detention structures, vegetated swales and vegetated filter strips designed using water quality flow, natural depressions, rain barrels, permeable pavements green roofs, rain gardens, catch basin inserts, and hydrodynamics separators. The Director may also consider non-structural post-construction approaches where no local requirement for such practices exist.

Small Construction Activities. For all small land disturbance activities (which disturb one or more, but less than five acres of land and is not part of a larger common plan of development or sale which will disturb five or more acres of land), a description of measures that will be installed during the construction process to control pollutants in storm water discharges that will occur after construction operations have been completed must be included in the SWP3. Structural measures should be placed on upland soils to the degree attainable. Such practices may include, but are not limited to: storm water detention structures, flow attenuation by use of open vegetated swales and natural depressions, infiltration of runoff onsite, and sequential systems (which combine several practices). The SWP3 shall include an explanation of the technical basis used to select the practices to control pollution where flows exceed predevelopment levels

h. **Surface Water Protection.** If the project site contains any streams, rivers, lakes, wetlands or other surface waters, certain construction activities at the site may be regulated under the CWA and/or state isolated wetland permit requirements. Sections 404 and 401 of the Act regulate the discharge of dredged or fill material into surface waters and the impacts of such activities on water quality, respectively. Construction activities in surface waters which may be subject to CWA regulation and/or state isolated wetland permit requirements include, but are not limited to: sewer line crossings, grading, backfilling or culverting streams, filling wetlands, road and utility line construction, bridge installation and installation of flow control structures. If the project contains streams, rivers, lakes or wetlands or possible wetlands, the permittee must contact the appropriate U.S. Army Corps of Engineers District Office. (CAUTION: Any area of seasonally wet hydric soil is a

potential wetland – please consult the Soil Survey and list of hydric soils for your County, available at your county's Soil and Water Conservation District. If you have any questions about Section 401 water quality certification, please contact the Ohio Environmental Protection Agency, Section 401 Coordinator.)

U.S. Army Corps of Engineers (Section 404 regulation):

Huntington, WV District (304) 399-5210 (Muskingum River, Hocking River,

Scioto River, Little Miami River, and Great Miami River Basins)

Buffalo, NY District (716) 879-4191 (Lake Erie Basin)

Pittsburgh, PA District (412) 395-7154 (Mahoning River Basin)

Louisville, KY District (502) 315-6733 (Ohio River)

Ohio Environmental Protection Agency (Section 401 regulation):

Columbus, OH (614) 644-2001 (all of Ohio)

Concentrated storm water runoff from BMPs to natural wetlands shall be converted to diffuse flow before the runoff enters the wetlands. The flow should be released such that no erosion occurs downslope. Level spreaders may need to be placed in series, particularly on steep sloped sites, to ensure non-erosive velocities. Other structural BMPs may be used between storm water features and natural wetlands, in order to protect the natural hydrology, hydroperiod, and wetland flora. If the applicant proposes to discharge to natural wetlands, a hydrologic analysis shall be performed. The applicant shall attempt to match the predevelopment hydroperiods and hydrodynamics that support the wetland. The applicant shall assess whether their construction activity will adversely impact the hydrologic flora and fauna of the wetland. Practices such as vegetative buffers, infiltration basins, conservation of forest cover, and the preservation of intermittent streams, depressions, and drainage corridors may be used to maintain wetland hydrology.

i. **Other controls.** The SWP3 must also provide BMPs for pollutant sources other than sediment. Non-sediment pollutant sources, which may be present on a construction site, include paving operations, concrete washout, structure painting, structure cleaning, demolition debris disposal, drilling and blasting operations, material storage, slag, solid waste, hazardous waste, contaminated soils, sanitary and septic wastes, vehicle fueling and maintenance activities, and landscaping operations.

    i. **Non-Sediment Pollutant Controls.** No solid or liquid waste, including building materials, shall be discharged in storm water runoff. The permittee must implement all necessary BMPs to prevent the discharge of non-sediment pollutants to the drainage system of the site or surface waters of the state. Under no circumstance shall concrete trucks wash out directly into a drainage channel, storm sewer or surface waters of the state. No exposure of storm water to waste materials is recommended.

    ii. **Off-site traffic.** Off-site vehicle tracking of sediments and dust generation shall be minimized.

iii. **Compliance with other requirements.** The SWP3 shall be consistent with applicable State and/or local waste disposal, sanitary sewer or septic system regulations, including provisions prohibiting waste disposal by open burning and shall provide for the proper disposal of contaminated soils to the extent these are located within the permitted area.

iv. **Trench and ground water control**. There shall be no turbid discharges to surface waters of the state resulting from de-watering activities. If trench or ground water contains sediment, it must pass through a sediment settling pond or other equally effective sediment control device, prior to being discharged from the construction site. Alternatively, sediment may be removed by settling in place or by dewatering into a sump pit, filter bag or comparable practice. Ground water which does not contain sediment or other pollutants is not required to be treated prior to discharge. However, care must be taken when discharging ground water to ensure that it does not become pollutant-laden by traversing over disturbed soils or other pollutant sources.

v. **Contaminated Sediment.** Where construction activities are to occur on sites with contamination from previous activities, operators must be aware that concentrations of materials that meet other criteria (is not considered a Hazardous Waste, meeting VAP standards, etc.) may still result in storm water discharges in excess of Ohio Water Quality Standards. Such discharges are not authorized by this permit. Appropriate BMPs include, but are not limited to:

• The use of berms, trenches, and pits to collect contaminated runoff and prevent discharges;

• Pumping runoff into a sanitary sewer (with prior approval) or into a container for transport to an appropriate treatment/disposal facility; and

• Covering areas of contamination with tarps or other methods that prevent storm water from coming into contact with the material.

Operators should consult with Ohio EPA Division of Surface Water prior to seeking permit coverage.

j. **Maintenance.** All temporary and permanent control practices shall be maintained and repaired as needed to ensure continued performance of their intended function. All sediment control practices must be maintained in a functional condition until all up slope areas they control are permanently stabilized. The SWP3 shall be designed to minimize maintenance requirements. The applicant shall provide a description of maintenance procedures needed to ensure the continued performance of control practices.

k. **Inspections.** At a minimum, procedures in an SWP3 shall provide that all controls on the site are inspected at least once every seven calendar days and within 24 hours after any storm event greater than one-half inch of rain per 24 hour period. The inspection frequency may be reduced to at least once every month if the entire site is temporarily stabilized or runoff is unlikely due to weather conditions (e.g., site is covered with snow, ice, or the ground

is frozen). A waiver of inspection requirements is available until one month before thawing conditions are expected to result in a discharge if all of the following conditions are met: the project is located in an area where frozen conditions are anticipated to continue for extended periods of time (i.e., more than one month); land disturbance activities have been suspended; and the beginning and ending dates of the waiver period are documented in the SWP3. Once a definable area has been finally stabilized, you may mark this on your SWP3 and no further inspection requirements apply to that portion of the site. The permittee shall assign "qualified inspection personnel" to conduct these inspections to ensure that the control practices are functional and to evaluate whether the SWP3 is adequate and properly implemented in accordance with the schedule proposed in Part III.G.1.g of this permit or whether additional control measures are required.

Following each inspection, a *report* must be completed and signed by the qualified inspection personnel representative. At a minimum, the inspection report must include:

i. the inspection date;

ii. names, titles, and qualifications of personnel making the inspection;

iii. weather information for the period since the last inspection (or since commencement of construction activity if the first inspection) including a best estimate of the beginning of each storm event, duration of each storm event, approximate amount of rainfall for each storm event (in inches), and whether any discharges occurred;

iv. weather information and a description of any discharges occurring at the time of the inspection;

v. location(s) of discharges of sediment or other pollutants from the site;

vi. location(s) of BMPs that need to be maintained;

vii. location(s) of BMPs that failed to operate as designed or proved inadequate for a particular location;

viii. location(s) where additional BMPs are needed that did not exist at the time of inspection; and

ix. corrective action required including any changes to the SWP3 necessary and implementation dates.

Disturbed areas and areas used for storage of materials that are exposed to precipitation shall be inspected for evidence of or the potential for pollutants entering the drainage system. Erosion and sediment control measures identified in the SWP3 shall be observed to ensure that those are operating correctly. Discharge locations shall be inspected to ascertain whether erosion and sediment control measures are effective in preventing significant impacts to the receiving waters. Locations where vehicles enter or exit the site shall be inspected for evidence of off-site vehicle tracking.

The permittee shall maintain for three years following the submittal of a notice of termination form, a record summarizing the results of the inspection, names(s) and qualifications of personnel making the inspection, the date(s) of the inspection, major observations relating to the implementation of the

SWP3 and a certification as to whether the facility is in compliance with the SWP3 and the permit and identify any incidents of non-compliance. The record and certification shall be signed in accordance with Part V.7. of this permit.

x. **When practices require repair or maintenance.** If the inspection reveals that a control practice is in need of repair or maintenance, with the exception of a sediment settling pond, it must be repaired or maintained within three days of the inspection. Sediment settling ponds must be repaired or maintained within 10 days of the inspection.

xi. xi. **When practices fail to provide their intended function.** If the inspection reveals that a control practice fails to perform its intended function and that another, more appropriate control practice is required, the SWP3 must be amended and the new control practice must be installed within 10 days of the inspection.

xii. xii. **When practices depicted on the SWP3 are not installed.** If the inspection reveals that a control practice has not been implemented in accordance with the schedule contained in Part III.7.a.h of this permit, the control practice must be implemented within *5* days from the date of the inspection. If the inspection reveals that the planned control practice is not needed, the record must contain a statement of explanation as to why the control practice is not needed.

3. **Approved State or local plans. All dischargers regulated under this general permit must comply, except those exempted under state law, with the lawful requirements of municipalities, counties and other local agencies regarding discharges of storm water from construction activities. All erosion and sediment control plans and storm water management plans approved by local officials shall be retained with the SWP3 prepared in accordance with this permit. Applicable requirements for erosion and sediment control and storm water management approved by local officials are, upon submittal of a NOI form, incorporated by reference and enforceable under this permit even if they are not specifically included in an SWP3 required under this permit. When the project is located within the jurisdiction of a regulated municipal separate storm sewer system (MS4), the permittee must certify that the SWP3 complies with the requirements of the storm water management program of the MS4 operator.**

4. **Exceptions. If specific site conditions prohibit the implementation of any of the erosion and sediment control practices contained in this permit or site specific conditions are such that implementation of any erosion and sediment control practices contained in this permit will result in no environmental benefit, then the permittee shall provide justification for rejecting each practice based on site conditions. Exceptions from implementing the erosion and sediment control standards contained in this permit will be approved or denied on a case-by-case basis.**

   The permittee may request approval from the City and Ohio EPA to use alternative methods to satisfy conditions in this permit if the permittee can demonstrate that the alternative methods are sufficient to protect the overall integrity of receiving streams and the watershed. Alternative methods will be approved or denied on a case-by-case basis.

IV. PART IV. NOTICE OF TERMINATION

A. Failure to notify

The terms and conditions of this permit shall remain in effect until a signed Notice of Termination (NOT) form is submitted. Failure to submit an NOT constitutes a violation of this permit and may affect the ability of the permittee to obtain general permit coverage in the future.

B. When to submit an NOT

1. **Permittees wishing to terminate coverage under this permit must submit a NOT form in accordance with Part V.G of this permit. Compliance with this permit is required until an NOT form is submitted. The permittee's authorization to discharge under this permit terminates at midnight of the day the NOT form is submitted. Prior to submitting the NOT form, the permittee shall conduct a site inspection in accordance with Part III.G.2.i of this permit and have a maintenance agreement is in place to ensure all post-construction BMPs will be maintained in perpetuity.**
2. **All permittees must submit an NOT form within 45 days of completing all permit requirements. Enforcement actions may be taken if a permittee submits an NOT form without meeting one or more of the following conditions:**
   a. Final stabilization (see definition in Part VII) has been achieved on all portions of the site for which the permittee is responsible (including, if applicable, returning agricultural land to its pre-construction agricultural use);
   b. Another operator(s) has assumed control over all areas of the site that have not been finally stabilized;
   c. Failing to demonstrate that a maintenance agreement is in place to ensure all post construction BMP's are adequately maintained in perpetuity;
   d. For residential construction only, temporary stabilization has been completed and the lot, which includes a home, has been transferred to the homeowner. (Note: individual lots without housing which are sold by the developer must undergo final temporary stabilization prior to termination of permit coverage.); or
   e. An exception has been granted under Part III.G.4.

C. How to submit an NOT

Permittees must use Ohio EPA's approved NOT form. The form must be completed and mailed according to the instructions and signed in accordance with Part V.G of this permit.

V. PART V. STANDARD PERMIT CONDITIONS

A. Duty to comply.

1. **The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of ORC Chapter 6111 and is grounds for enforcement action.**

2. **Ohio law imposes penalties and fines for persons who knowingly make false statements or knowingly swear or affirm the truth of a false statement previously made.**

B. Continuation of an expired general permit.

An expired general permit continues in force and effect until a new general permit is issued.

C. Need to halt or reduce activity not a defense.

It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

D. Duty to mitigate.

The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

E. Duty to provide information.

The permittee shall furnish to the City or director, within 10 days of written request, any information which the City or director may request to determine compliance with this permit. The permittee shall also furnish to the City or director upon request copies of records required to be kept by this permit.

F. Other information.

When the permittee becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in the NOI, SWP3, NOT or in any other report to the director, he or she shall promptly submit such facts or information.

G. Signatory requirements.

All Notices of Intent, Notices of Termination, storm water pollution prevention plans, reports, certifications or information either submitted to the City or Director (and/or the operator of a municipal separate storm sewer system (MS4) with an NPDES permit), or that this permit requires be maintained by the permittee, shall be signed.

1. **These items shall be signed as follows:**

   a. For a corporation: By a responsible corporate officer. For the purpose of this section, a responsible corporate officer means:

      i. A president, secretary, treasurer or vice-president of the corporation in charge of a principal business function or any other person who performs similar policy or decision-making functions for the corporation; or

ii. The manager of one or more manufacturing, production or operating facilities, provided, the manager is authorized to make management decisions that govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations and initiating and directing other comprehensive measures to assure long-term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures;

b. For a partnership or sole proprietorship: By a general partner or the proprietor, respectively; or

c. For a municipality, State, Federal or other public agency: By either a principal executive officer or ranking elected official. For purposes of this section, a principal executive officer of a Federal agency includes (1) the chief executive officer of the agency or (2) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrators of U.S. EPA).

2. **All reports required by the permits and other information requested by the City or Director shall be signed by a person described in Part V.G.1 of this permit or by a duly authorized representative of that person. A person is a duly authorized representative only if:**

   a. The authorization is made in writing by a person described in Part V.G.1 of this permit and submitted to the director;

   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of manager, operator of a well or well field, superintendent, position of equivalent responsibility or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and

   c. The written authorization is submitted to the City or Director.

3. **Changes to authorization. If an authorization under Part V.G.2 of this permit is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of Part V.G.2 of this permit must be submitted to the City or Director prior to or together with any reports, information or applications to be signed by an authorized representative.**

H. Certification.

Any person signing documents under this section shall make the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

I. Oil and hazardous substance liability.

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities or penalties to which the permittee is or may be subject under section 311 of the CWA or 40 CFR Part 112. 40 CFR Part 112 establishes procedures, methods and equipment and other requirements for equipment to prevent the discharge of oil from nontransportation-related onshore and offshore facilities into or upon the navigable surface waters of the State or adjoining shorelines.

J. Property rights.

The issuance of this permit does not convey any property rights of any sort, nor any exclusive privileges, nor does it authorize any injury to private property nor any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations without mitigation credit or consideration for appropriate compensation.

K. Severability.

The provisions of this permit are severable and if any provision of this permit or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected thereby.

L. Transfers.

Ohio NPDES general permit coverage is transferable. Ohio EPA must be notified in writing sixty days prior to any proposed transfer of coverage under an Ohio NPDES general permit. The transferee must inform Ohio EPA it will assume the responsibilities of the original permittee transferor.

M. Environmental laws.

No condition of this permit shall release the permittee from any responsibility or requirements under other environmental statutes or regulations.

N. Proper operation and maintenance.

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit and with the requirements of SWP3s. Proper operation and maintenance requires the

operation of backup or auxiliary facilities or similar systems, installed by a permittee only when necessary to achieve compliance with the conditions of the permit.

O. Inspection and entry.

The permittee shall allow the City or director or an authorized representative of Ohio EPA, upon the presentation of credentials and other documents as may be required by law, to:

1. **Enter upon the permittee's premises where a regulated facility or activity is located or conducted or where records must be kept under the conditions of this permit;**
2. **Have access to and copy at reasonable times, any records that must be kept under the conditions of this permit; and**
3. **Inspect at reasonable times any facilities or equipment (including monitoring and control equipment).**

VI. PART VI. REOPENER CLAUSE

A. If there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with construction activity covered by this permit, the permittee of such discharge may be required to obtain coverage under an individual permit or an alternative general permit in accordance with Part I.C of this permit or the permit may be modified to include different limitations and/or requirements.

B. Permit modification or revocation will be conducted according to ORC Chapter 6111.

VII. PART VII. DEFINITIONS

A. "Act" means Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub. L. 92-500, as amended Pub. L. 95-217, Pub. L. 95-576, Pub. L. 96-483, Pub. L. 97-117 and Pub. L. 100-4, 33 U.S.C. 1251 et. seq.

B. "Bankfull channel" means a channel flowing at channel capacity and conveying the bankfull discharge. Delineated by the highest water level that has been maintained for a sufficient period of time to leave evidence on the landscape, such as the point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial or the point at which the clearly scoured substrate of the stream ends and terrestrial vegetation begins.

C. "Bankfull discharge" means the streamflow that fills the main channel and just begins to spill onto the floodplain; it is the discharge most effective at moving sediment and forming the channel.

D. "Best management practices (BMPs)" means schedules of activities, prohibitions of practices, maintenance procedures and other management practices (both structural and non-structural) to prevent or reduce the pollution of surface waters of the state. BMP's also include treatment requirements, operating procedures and practices to control plant and/or construction site runoff, spillage or leaks, sludge or waste disposal or drainage from raw material storage.

E. "Channelized stream" means the definition set forth in Section 6111.01 (M) of the ORC.

F. "Commencement of construction" means the initial disturbance of soils associated with clearing, grubbing, grading, placement of fill or excavating activities or other construction activities.

G. "Concentrated storm water runoff" means any storm water runoff which flows through a drainage pipe, ditch, diversion or other discrete conveyance channel.

H. "Director" means the director of the Ohio Environmental Protection Agency and/or his/her designated agent.

I. "Discharge" means the addition of any pollutant to the surface waters of the state from a point source.

J. "Disturbance" means any clearing, grading, excavating, filling, or other alteration of land surface where natural or man-made cover is destroyed in a manner that exposes the underlying soils.

K. "Drainage watershed" means for purposes of this permit the total contributing drainage area to a BMP, i.e., the "watershed" directed to the practice. This would also include any off-site drainage.

L. "Final stabilization" means that either:

1. **All soil disturbing activities at the site are complete and a uniform perennial**

vegetative cover (e.g., evenly distributed, without large bare areas) with a density of at least 70 percent cover for the area has been established on all unpaved areas and areas not covered by permanent structures or equivalent stabilization measures (such as the use of landscape mulches, rip-rap, gabions or geotextiles) have been employed. In addition, all temporary erosion and sediment control practices are removed and disposed of and all trapped sediment is permanently stabilized to prevent further erosion; or

2. **For individual lots in residential construction by either:**
   a. The homebuilder completing final stabilization as specified above or
   b. The homebuilder establishing temporary stabilization including perimeter controls for an individual lot prior to occupation of the home by the homeowner and informing the homeowner of the need for and benefits of, final stabilization. (Homeowners typically have an incentive to put in the landscaping functionally equivalent to final stabilization as quick as possible to keep mud out of their homes and off sidewalks and driveways.); or
3. **For construction projects on land used for agricultural purposes (e.g., pipelines across crop or range land), final stabilization may be accomplished by returning the disturbed land to its pre-construction agricultural use. Areas disturbed that were previously used for agricultural activities, such as buffer strips immediately adjacent to surface waters of the state and which are not being returned to their pre-construction agricultural use, must meet the final stabilization criteria in (1) or (2) above.**

M. "Individual Lot NOI" means a Notice of Intent for an individual lot to be covered by this permit (see parts I and II of this permit).

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

O. "MS4" means municipal separate storm sewer system which means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains) that are:

1. **Owned or operated by the federal government, state, municipality, township, county, district(s) or other public body (created by or pursuant to state or federal law) including special district under state law such as a sewer district, flood control district or drainage districts or similar entity or a designated and approved management agency under section 208 of the act that discharges into surface waters of the state; and**
2. **Designed or used for collecting or conveying solely storm water,**
3. **Which is not a combined sewer and**
4. **Which is not a part of a publicly owned treatment works.**

P. "National Pollutant Discharge Elimination System (NPDES)" means the national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits and enforcing pretreatment requirements,

under sections 307, 402, 318 and 405 of the CWA. The term includes an "approved program."

Q. "Natural Channel Design" means an engineering technique that uses knowledge of the natural process of a stream to create a stable stream that will maintain its form and function over time.

R. "NOI" means notice of intent to be covered by this permit.

S. "NOT" means notice of termination.

T. "Operator" means any party associated with a construction project that meets either of the following two criteria:

1. **The party has operational control over construction plans and specifications, including the ability to make modifications to those plans and specifications; or**
2. **The party has day-to-day operational control of those activities at a project which are necessary to ensure compliance with an SWP3 for the site or other permit conditions (e.g., they are authorized to direct workers at a site to carry out activities required by the SWP3 or comply with other permit conditions).**

As set forth in Part II.1, there can be more than one operator at a site and under these circumstances, the operators shall be co-permittees.

U. "Ordinary high water mark" means that line on the bank or shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.

V. "Owner or operator" means the owner or operator of any "facility or activity" subject to regulation under the NPDES program.

W. "Permanent stabilization" means the establishment of permanent vegetation, decorative landscape mulching, matting, sod, rip rap and landscaping techniques to provide permanent erosion control on areas where construction operations are complete or where no further disturbance is expected for at least one year.

X. "Percent imperviousness" means the impervious area created divided by the total area of the project site.

Y. "Point source" means any discernible, confined and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or the floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

Z. "Qualified inspection personnel" means a person knowledgeable in the principles and practice of erosion and sediment controls, who possesses the skills to assess all conditions at the construction site that could impact storm

water quality and to assess the effectiveness of any sediment and erosion control measures selected to control the quality of storm water discharges from the construction activity.

AA. "Rainwater and Land Development" is a manual describing construction and post-construction best management practices and associated specifications. A copy of the manual may be obtained by contacting the Ohio Department of Natural Resources, Division of Soil & Water Conservation.

BB. "Riparian area" means the transition area between flowing water and terrestrial (land) ecosystems composed of trees, shrubs and surrounding vegetation which serve to stabilize erodible soil, improve both surface and ground water quality, increase stream shading, and enhance wildlife habitat.

CC. "Runoff coefficient" means the fraction of total rainfall that will appear at the conveyance as runoff.

DD. "Sediment settling pond" means a sediment trap, sediment basin or permanent basin that has been temporarily modified for sediment control, as described in the latest edition of the Rainwater and Land Development manual.

EE. "State isolated wetland permit requirements" means the requirements set forth in Sections 6111.02 through 6111.029 of the ORC.

FF. "Storm water" means storm water runoff, snow melt and surface runoff and drainage.

GG. "Stream edge" means the ordinary high water mark.

HH. "Streamway" means a zone including the main channel of a stream and attached floodplain wide enough to accommodate meander migration over time.

II. "Surface waters of the state" or "water bodies" means all streams, lakes, reservoirs, ponds, marshes, wetlands or other waterways which are situated wholly or partially within the boundaries of the state, except those private waters which do not combine or effect a junction with natural surface or underground waters. Waters defined as sewerage systems, treatment works or disposal systems in Section 6111.01 of the ORC are not included.

JJ. "SWP3" means storm water pollution prevention plan.

KK. "Temporary stabilization" means the establishment of temporary vegetation, mulching, geotextiles, sod, preservation of existing vegetation and other techniques capable of quickly establishing cover over disturbed areas to provide erosion control between construction operations.

LL. "Water Quality Volume (WQv)" means the volume of storm water runoff which must be captured and treated prior to discharge from the developed site after construction is complete. WQv is based on the expected runoff generated by the mean storm precipitation volume from post-construction site conditions at which rapidly diminishing returns in the number of runoff events captured

begins to occur.

VIII. PART VIII. ATTACHMENT

A. Stream Assessment

This assessment will determine if a stream is considered a previously modified, lowgradient headwater stream (a drainage ditch) which would be applicable for stream restoration in lieu of protecting an outer 'no build' setback as per Part III.G.2.b.iii.

In the event the assessment of the stream meets all the criteria listed below, restoration using "Over-wide Channel Design" as depicted in Part 2 of this attachment or natural channel design could be performed.

Previously modified, low-gradient headwater streams shall, for the purposes of this permit, be defined as having all of the following characteristics:

• Less than 10 square miles of drainage area;

• Low gradient and low stream power such that incision (down-cutting) is not evident;

• Entrenched such that the ratio of the frequently flooded width to the bankfull width is less than 2.2; and

• Straight with little or no sinuosity present such that the ratio of the bankfull channel length to the straight-line distance between two points is less than 1.02.

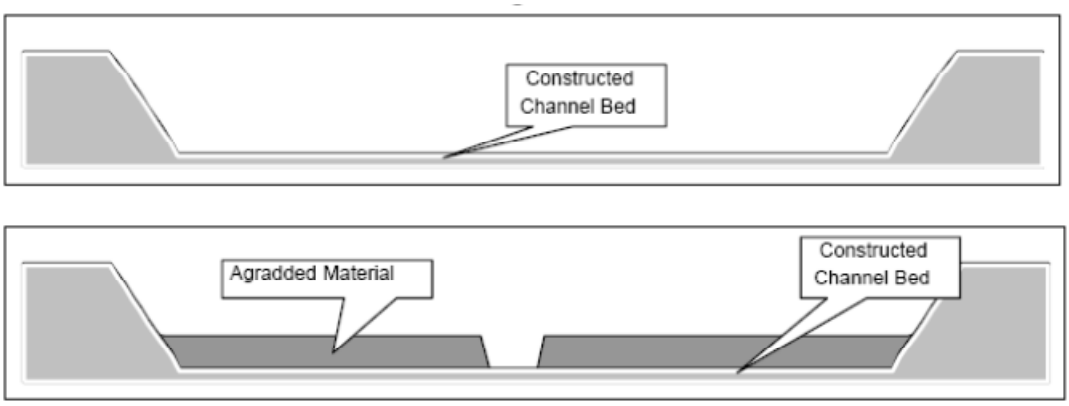
B. Restoration

Restoration shall be accomplished by any natural channel design approach that will lead to a self-maintaining reach able to provide both local habitat and watershed services (e.g. selfpurification and valley floodwater storage).

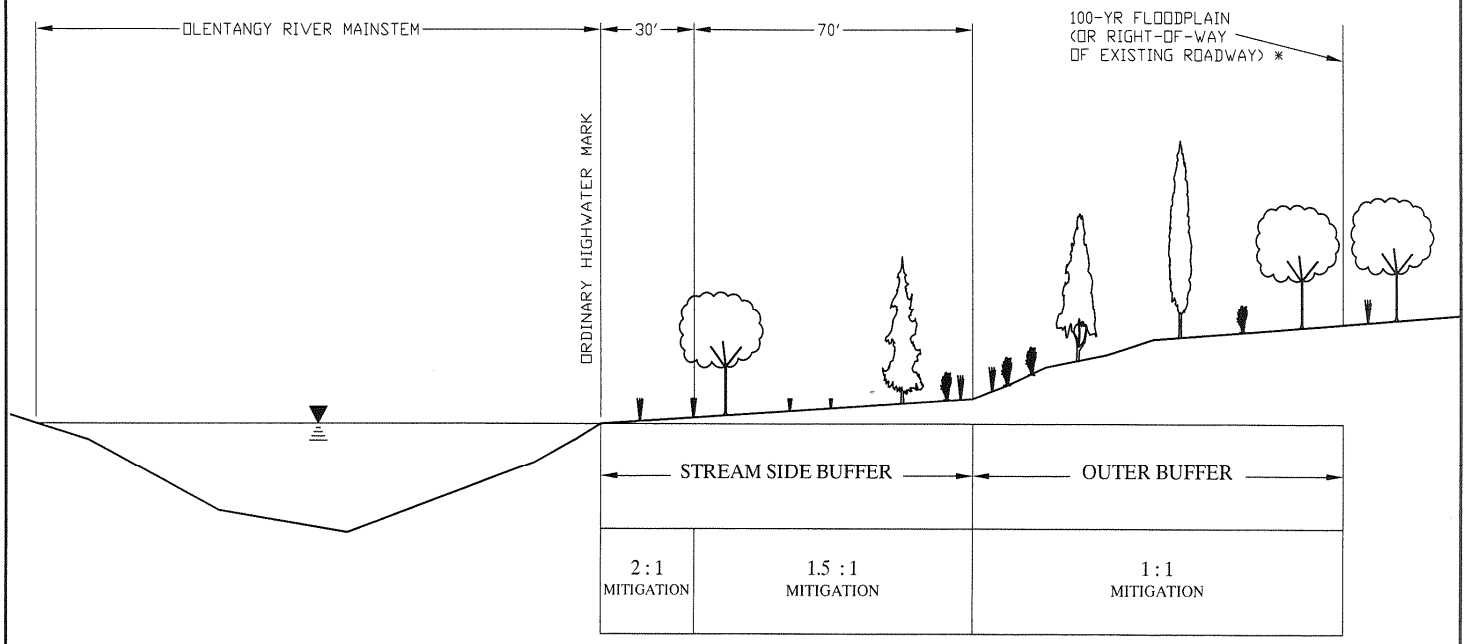
1. **Construction of a floodplain, channel and habitat**
2. **Over-wide channel design by excavation down to the elevation of the stream bed uniformly across the entire frequently flooded width (see Figure 1)**
3. **Floodplain excavation necessary to promote interaction between stream and selfforming floodplain**
4. **Include a water quality setback on each side approvable by the City and Ohio EPA.**

The primary target shall be a frequently flooded width of 10 times the channel's self-forming width. Five times the self-forming channel width may be acceptable if sufficient elements of natural channel design are included in the restoration project.

Table 6: Typical cross-section of an over-wide channel.



The darkly shaded areas are the floodplain bars that will form through aggradation along the constructed channel bed, while the lightly shaded area is the constructed channel.



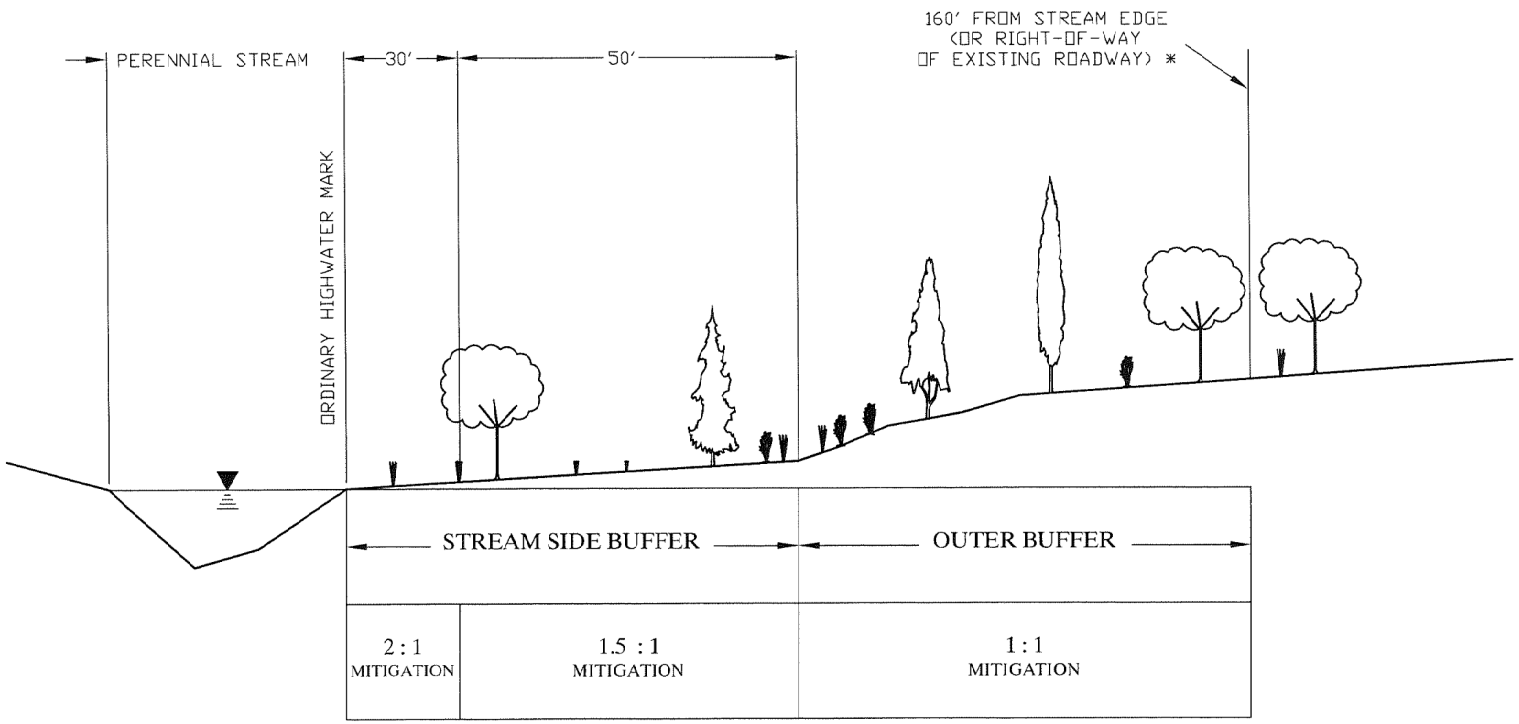
* SUBJECT TO THE CONDITIONS OUTLINED IN THESE REGULATIONS.

ENGINEERING
DEPARTMENT OF ENGINEERING SERVICES

FIGURE 1

OLENTANGY RIVER MAINSTEM RIPARIAN SETBACK

S:\ENGINEERING\ENGINEERING DEPARTMENT\STANDARDS AND SPECIFICATIONS (DRAFT)\2008 DRAFT STANDARD DRAWINGS\06 FIGURES FOR DESIGN MANUAL\HYDRO-1.0_RIPARIAN SETBACK - OLENTANGY MAINSTEM.DWG - 1/9/09



* SUBJECT TO THE CONDITIONS OUTLINED IN THESE REGULATIONS.

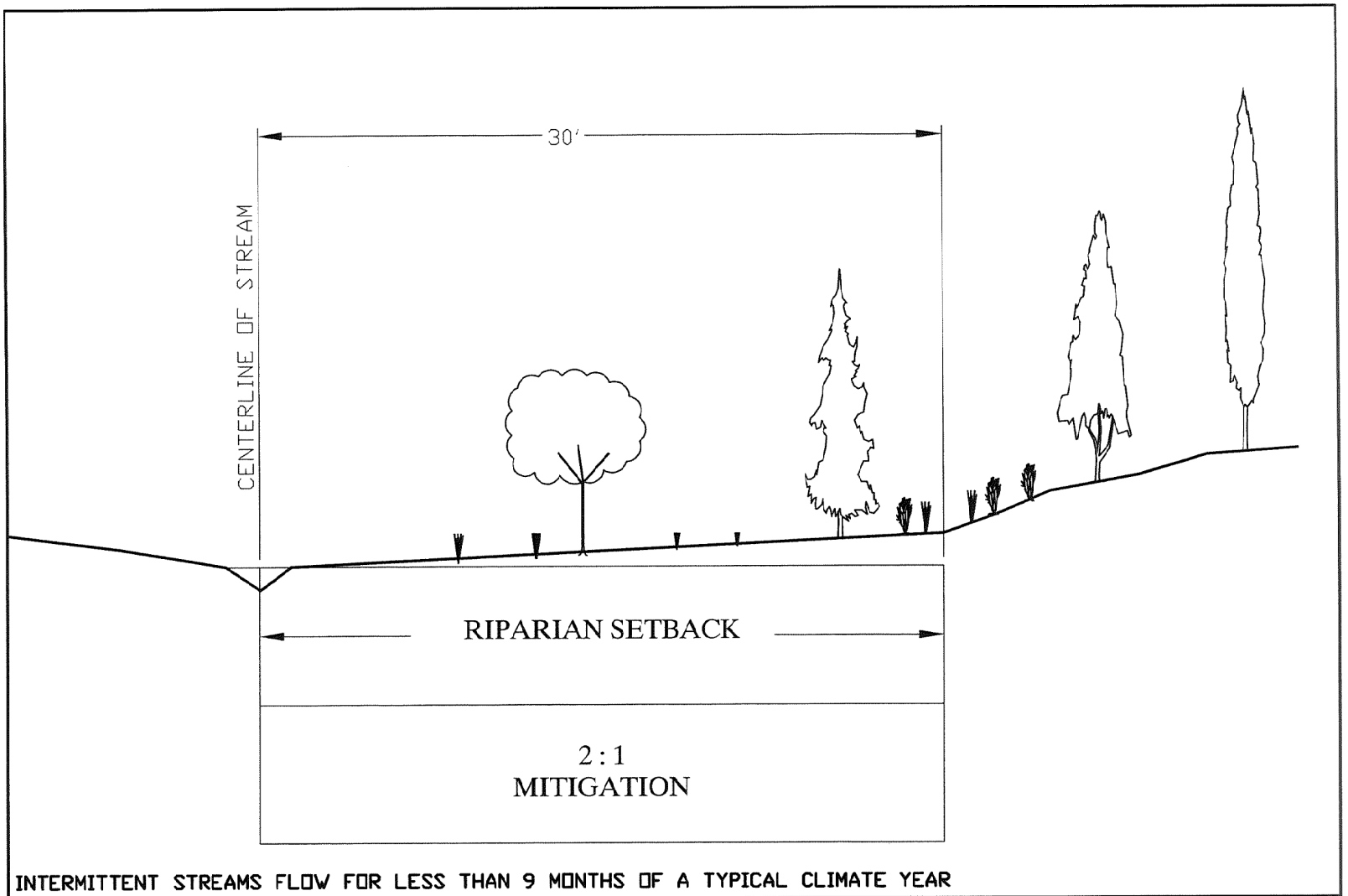
PERENNIAL STREAMS FLOW AT LEAST 9 MONTHS OF A TYPICAL CLIMATE YEAR

ENGINEERING
DEPARTMENT OF ENGINEERING SERVICES

FIGURE 2

PERENNIAL STREAMS RIPARIAN SETBACK

S:\ENGINEERING\ENGINEERING DEPARTMENT\STANDARDS AND SPECIFICATIONS (DRAFT)\2008 DRAFT STANDARD DRAWINGS\06 FIGURES FOR DESIGN MANUAL\HYDRO-2.0_RIPARIAN SETBACK - PERENNIAL STREAMS.DWG - 1/9/09



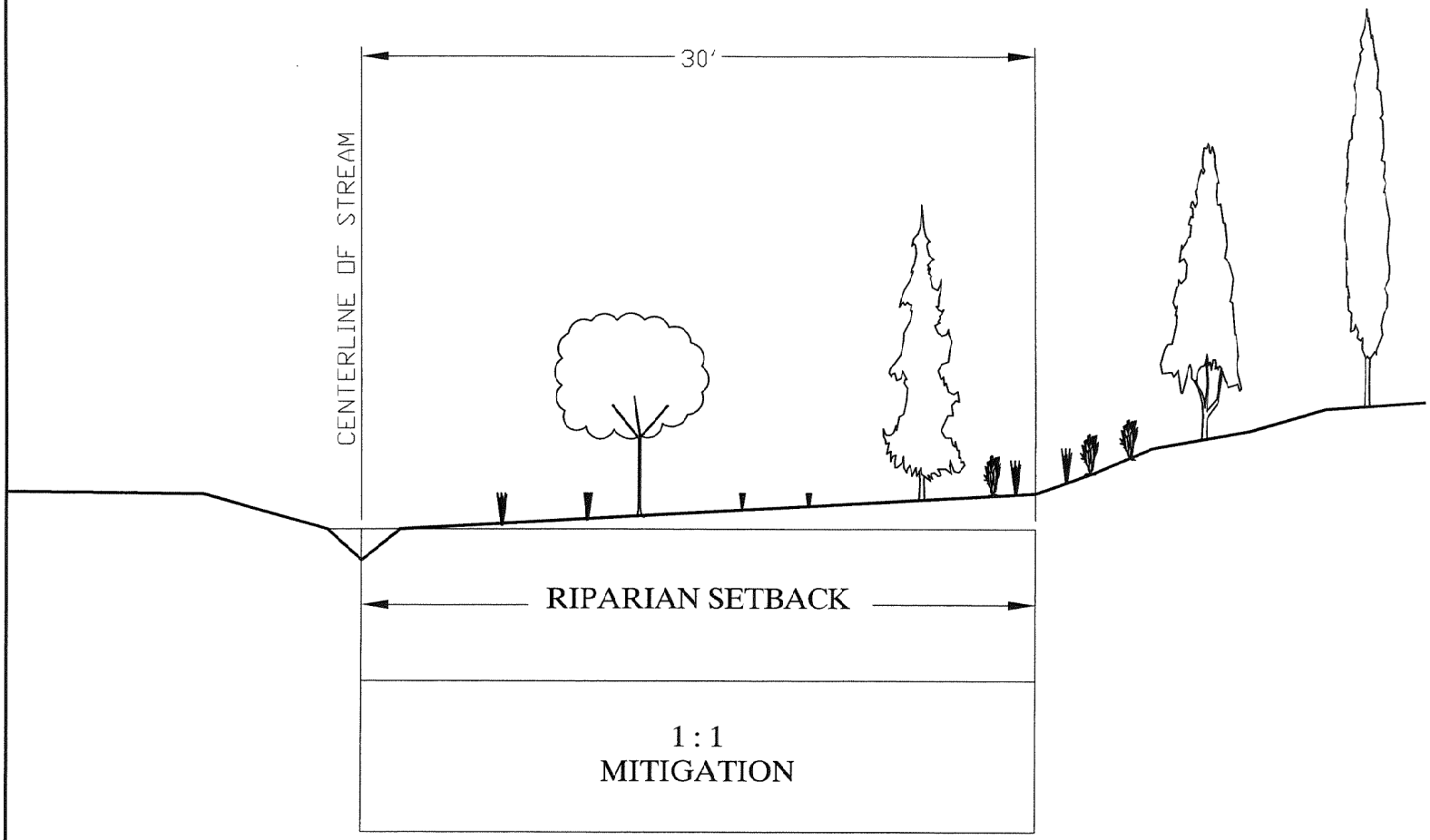
INTERMITTENT STREAMS FLOW FOR LESS THAN 9 MONTHS OF A TYPICAL CLIMATE YEAR

ENGINEERING
DEPARTMENT OF ENGINEERING SERVICES

FIGURE 3

INTERMITTENT STREAMS RIPARIAN SETBACK

S:\ENGINEERING\ENGINEERING DEPARTMENT\STANDARDS AND SPECIFICATIONS (DRAFT)\2008 DRAFT STANDARD DRAWINGS\08 SPECIAL DRAWINGS\HYDRO-3.0_RIPARIAN SETBACK - INTERMITTENT STREAMS.DWG - 1/°



EPHEMERAL STREAMS FLOW ONLY IN RESPONSE TO STORM EVENTS

ENGINEERING
DEPARTMENT OF ENGINEERING SERVICES

FIGURE 4

EPHEMERAL STREAMS RIPARIAN SETBACK

S:\ENGINEERING\ENGINEERING DEPARTMENT\STANDARDS AND SPECIFICATIONS (DRAFT)\2008 DRAFT STANDARD DRAWINGS\08 SPECIAL DRAWINGS\HYDRO-4.0_RIPARIAN SETBACK - EPHEMERAL STREAMS.DWG - 1/9/0

Chapter 17: Erosion Control / Water Quality

(NPDES Phase II Requirements)

NPDES Construction Storm Water General Permit (CGP) Requirements

The CGP requires an SWP3 to be completed prior to the submittal of a Notice of Intent (NOI) application to obtain coverage under the CGP. The SWP3 contents are described in Part III of the CGP. The City of Delaware requires that the SWP3 and a sediment and erosion control plan be approved by the City prior to initiation of construction activities. The SWP3 does not need to be submitted to Ohio EPA to obtain coverage under the CGP. However, it must be retained at the construction site at all times during the construction activity.

Minimum Standards

The City of Delaware, Ohio has developed a Storm Water Management Plan that identifies Best Management Practices (BMPs) which satisfy the Phase II of the National Pollutant Discharge Elimination System (NPDES) Construction Storm Water General Permit which is overseen by the Ohio Environmental Protection Agency (OEPA).

The Department of Engineering Services staff is responsible for administration of the Phase II NPDES Storm Water Program as related to Commercial and Residential Land Development as well as Capital Improvement Projects. The staff inspects the drainage and erosion control on construction projects throughout the City of Delaware to ensure that surface waters are not contaminated by sediment and runoff from construction sites. The department coordinates waterway and stormwater permits for the construction activity done by other city departments.

A Storm Water Pollution Prevention Plan (SWP3) must be submitted to the Department of Engineering Services for all construction projects in the City of Delaware as a part of the plan approval process. A SWP3 must address all minimum components of the NPDES Construction Storm Water General Permit and conform to the specifications of the latest edition of the Rainwater and Land Development Manual. This manual describes Ohio's standards for storm water management, land development, and urban stream protection. To obtain a copy of this manual, contact the Ohio Department of Natural Resources (ODNR), Division of Soil and Water Conservation at (614) 265-6610.

To help you develop the narrative section of your construction site SWP3, the City of Delaware has created an electronic SWP3 template. The template is designed to help guide you through the SWP3 development process and help ensure that your SWP3 addresses all the necessary elements stated in the General Permit for the State of Ohio. The SWP3 Template is available as a word document posted on the City of Delaware, Department of Engineering website:
http://www.delawareohio.net/departments/Engineering

The OEPA checklist is another resource to help ensure that the SWP3 is complete can be found at the OEPA, Division of Surface Water, Storm Water's website:
http://www.epa.state.oh.us/dsw/storm/swp3_cgp_checklist2.pdf .

The SWP3 must contain the following items:

- A Plan Narrative (the instruction boxes as well as any non-applicable sections should be deleted from the template)
- Calculations for sediment settling ponds (Sediment settling ponds are required for all land disturbances of 10 acres or greater or where the design capacity of silt fence or inlet protection has been exceeded.)
- Settlement pond outlet structures and details.
- General Location Map
- Site Maps / Erosion Control Plan and Detail Sheets showing location and design of BMPs
- A Copy of the State of Ohio Construction General Permit (downloadable from the OEPA website)
- Signed Notice of Intent (NOI) and Acknowledgement Letter from OEPA
- Blank Notice of Termination form (NOT)
- Inspection Reports issued by the City of Delaware and OEPA
- Corrective Action Log
- SWP3 Amendment Log or Modification Report
- Designation of Signatory Authorization
- Delegation of Authority Form
- General Contractor Certification
- Subcontractor Certifications/Agreements
- BMP Implementation Schedule
- Project Stabilization Schedule
- Grading and Stabilization Activities Log
- Training Log
- Project Rainfall Logs
- Construction Site Notice
- Reportable Quantity Release Form
- Any additional pertinent information (i.e., Endangered Species and Historic Preservation Documentation)
- Final Stabilization / Termination Checklist

Sublots

For residential or commercial developments with sublots, NPDES permit coverage must be continued on every lot until the lot achieves final stabilization as defined in Part VII of the CGP. For developments with a centralized control (i.e., sediment settling ponds or inlet protection), which receives drainage from multiple lots, the developer may be required to maintain the centralized control until all of the homes are built with the land temporarily stabilized.

- If a developer either decides or is required to maintain permit responsibility on lots where structures are being built, the developer's SWP3 must include a detailed drawing of a typical sublot showing standard best management practices (BMPs) with notes specifying measures for critical areas that must be included in the SWP3.
- If a developer opts to transfer permit responsibility to the new lot owner or operator building the structure (homebuilder) once the lot is sold, the new lot owner must submit an Individual Lot Notice of Intent (Individual Lot NOI) application at least 7 days prior to initiating construction activities. The developer must allow the new lot owner access to the developer's SWP3. The new owner must then maintain and/or install any lot specific sediment controls and develop a site map indicating the location of the BMPs. Once the Individual Lot NOI is processed, the new lot owner is responsible for complying with the CGP on his or her lot.

Final Stabilization

Once a construction site reaches final stabilization, a permittee must submit a Notice of Termination (NOT) form to Ohio EPA within 45 days of completion of all permitted land disturbance activities. A NOT form can only be submitted when one or more of the following conditions are met:

- Final stabilization (as defined in Part VII of the CGP) has been achieved on all portions of the site for which the permittee is responsible (including, if applicable, returning agricultural land to its pre-construction agricultural use);
- Another operator(s) has assumed control over all areas of the site that have not been finally stabilized;
- For residential construction only, temporary stabilization has been completed and the lot, which includes a home, has been transferred to the homeowner. (Note: individual lots without housing which are sold by the developer must undergo final stabilization prior to termination of permit coverage.); or
- An exception has been granted under Part III.G.4 of the CGP.

Chapter 18: Water and Sewer Service Policy

It is the mission of the City of Delaware to provide potable water and sanitary sewer service within its service area. (See appendix for map of current utility service areas)

1. Annexation Agreement**:** Agreement to annex into the City of Delaware is required to receive water or sewer service, unless a separate agreement is in place.
2. Service and Fees: To receive sewer or water service, an application for connection must be submitted to the Planning and Community Development Department. Upon approval, a capacity fee (including any additional applicable fees) must be paid. Sewer and water line extensions from existing City lines to the building are the customer's responsibility.
3. Rates: Sewer and water rates are paid on a monthly basis and adjusted annually. Current rates and application instructions are provided on the City's website at www.delawareohio.net .
4. Non-Resident Customers: Customers whose property is not currently within the corporate boundaries of the City are required to pay a 50% surcharge on monthly rates until the property is annexed.
5. Establishing Connection: To connect to City sewer, a connection to City water must be established as the City bases sewer billing on water meter readings. For customers who are currently connected to DelCo Water and wish to connect to City sewer, an arrangement must be made for the City to collect water meter readings from DelCo for sewer billing purposes – At such time that City water is available, connection must be made to City water, subject to DelCo approval. City water customers are required to connect to City sewer when such service is available and within 200 feet of the property.
6. Oversizing: Line sizes may need to be larger than the minimums required by the water model to be in conformance with the City's proposed master water distribution plan sizes. Waterlines extended through the site that are oversized to accommodate future service areas may qualify for a cost contribution from the City at the discretion of the City Manager. The rate of contribution is 1.25 times the difference in material costs only.
7. Capacity Fees: The Chief Building Officer is to collect water and sanitary sewer capacity fees at the time of issuance of a building permit. The Utility Fees Calculation Worksheet (located in the appendix) was developed to facilitate the calculation of these fees and is to be submitted to the Department of Public Utilities for approval prior to the issuance of a building permit by the Chief Building Official.

   A. City Codified Ordinance 913.20 provides for the collection of Water Capacity Fees. The water capacity fee is five thousand six hundred fifty dollars ($5,650) per EDU effective from and after January 1, 2007.

      1. No person shall make a service connection to the City's water system or any part thereof, unless a permit to do so has been issued by the City.
      2. All properties connecting to the City of Delaware water system shall be assigned an Equivalent Dwelling Unit (EDU), or multiple thereof, with one (1) EDU being equal to average daily water consumption of 400 gallons.

a) All single-family residential properties connecting to the water system are assigned one (1) EDU.

b) All master metered multi-family residential properties connecting to the water system shall be assigned, by the Public Utility Director (Director), an EDU multiple calculated by multiplying the number of multi-family residential units by the Single Family Equivalent value that follows:

Single-Family Equivalent Values

1 bedroom	0.63
2 bedrooms	0.75
3 bedrooms	0.88
4 + bedrooms	1.0

c) All properties connecting to the water system which are not residential properties are to be assigned by the Director, an EDU multiple based upon the properties' estimated daily water consumption (in gallons) divided by 400 gallons (one EDU). This division will be calculated to the second decimal place and rounded according to mathematical convention. In no event shall a non-residential property be assigned an EDU of less than one (1).

3. The EDU multiple established for non-residential properties based on estimated water consumption shall be reviewed twelve (12) months after occupancy is obtained to determine if the estimated daily water consumption is accurate. The Director may extend this 12-month time period if accurate consumption data is not available. Any increase or decrease in the EDU multiple based on actual water consumption which results in a capacity fee charge adjustment of more than one thousand dollars ($1,000) shall be communicated to the property owner in writing. Any additional capacity fee charge or any refund of a previously paid capacity fee charge shall be made within forty-five (45) days of the date of the amended EDU determination letter. An owner may contest the amended EDU assigned to the property by filing an appeal with the Director within forty-five (45) days of the date of the amended EDU determination letter. The appeal shall be in writing and shall state the grounds for the appeal. The Director shall cause an appropriate investigation to be made to determine whether an adjustment of the EDU multiple for the property is warranted. The appellant shall be notified in writing of the Director's determination with respect to the appeal and any resulting adjustment in the amount of the capacity fee charge. Any additional capacity fee charge or any refund of a previously paid capacity fee charge shall be made within forty-five (45) days or the date of the Director's written response to the appellant.

4. The water utility system capacity fee charge for all properties connecting to the water system which are not residential properties and whose estimated daily water

consumption is greater than 50,000 gallons per day shall be determined based on an evaluation made of the specific impact on the water utility system for said connection.

5. Existing customers or new water connection permits issued for properties located outside of the City limits will be charged the above mentioned fee on condition that the owner of the property to be served shall, within sixty days of the time said property becomes contiguous to the City of Delaware, prepare and file or join in the preparation and filing of an annexation petition pursuant to Ohio Revised Code 709.02 for such property to be annexed to the City of Delaware. The failure of any such non-resident water customer to comply with this condition shall be grounds for immediate termination of water service to the property. This provision may be waived by the City Manager, with the concurrence of City Council, upon a finding of the existence of a specific necessity.

6. In the event a meter is enlarged, the difference between the charges for the two meter sizes shall be paid.

B. City Codified Ordinance 917.21 provides for the collection of Sanitary Sewer Capacity Fees. The fees are to be calculated in accordance with the worksheet located in the appendix of this manual. The sanitary sewer capacity fee is five thousand three hundred eighty-five dollars ($5,385) per EDU which shall be effective from and after June 1, 2006.

1. No person shall make a service connection to the City's sanitary sewer system or any part thereof, unless a permit to do so has been issued by the City.

2. All properties connecting to the City of Delaware sanitary sewer system shall be assigned an Equivalent Dwelling Unit (EDU), or multiple thereof, with one (1) EDU being equal to average daily water consumption of 400 gallons.

   a) All single-family residential properties connecting to the sanitary sewer system are assigned one (1) EDU.

   b) All master metered multi-family residential properties connecting to the sanitary sewer system shall be assigned, by the Public Utility Director (Director), an EDU multiple calculated by multiplying the number of multi-family residential units by the Single Family Equivalent value that follows:

Single-Family Equivalent Values	
1 bedroom	0.63
2 bedrooms	0.75
3 bedrooms	0.88
4 + bedrooms	1.0

c) All properties connecting to the sanitary sewer system which are not residential properties are to be assigned by the Director, an EDU multiple based upon the properties' estimated daily water consumption (in gallons) divided by 400 gallons (one EDU). This division will be calculated to the second decimal place and rounded according to mathematical convention. In no event shall a non-residential property be assigned an EDU of less than one (1).

3. The EDU multiple established for non-residential properties based on estimated water consumption shall be reviewed twelve (12) months after occupancy is obtained to determine if the estimated daily water consumption is accurate. The Director may extend this 12-month period if accurate consumption data is not available. Any increase or decrease in the EDU multiple based on actual water consumption which results in a capacity fee charge adjustment of more than one thousand dollars ($1,000) shall be communicated to the property owner in writing. Any additional capacity fee charge or any refund of a previously paid capacity fee charge shall be made within forty-five (45) days of the date of the amended EDU determination letter. An owner may contest the amended EDU assigned to the property by filing an appeal with the Director within forty-five (45) days of the date of the amended EDU determination letter. The appeal shall be in writing and shall state the grounds for the appeal. The Director shall cause an appropriate investigation to be made to determine whether an adjustment of the EDU multiple for the property is warranted. The appellant shall be notified in writing of the Director's determination with respect to the appeal and any resulting adjustment in the amount of the capacity fee charge. Any additional capacity fee charge or any refund of a previously paid capacity fee charge shall be made within forty-five (45) days or the date of the Director's written response to the appellant.

4. Existing customers or new sanitary sewer connection permits issued for properties located outside of the City limits will be charged the above mentioned fee on condition that the owner of the property to be served shall, within sixty days of the time said property becomes contiguous to the City of Delaware, prepare and file or join in the preparation and filing of an annexation petition pursuant to Ohio Revised Code 709.02 for such property to be annexed to the City of Delaware. The failure of any such nonresident wastewater customer to comply with this condition shall be grounds for immediate termination of sanitary sewer service to the property.

5. In the event a meter is enlarged, the difference between the charges for the two meter sizes shall be paid.

6. Special Sanitary Sewer Fee Districts: The City of Delaware has two special sanitary fee districts. The districts are known as the Southeast Highland Sewer Project and The South Central Delaware Sewer Project. Exhibits of these districts are located in the appendix of this manual. The special sanitary fees are in addition to normal capacity fees. Nothing in either agreement shall waive or mitigate the normal tap fee charges or other City associated sewer fees as to each structure, building, parcel, or lot in the specified tributary areas.

a. The South East Highland Sewer Project: The City and Developers of subdivisions within the City have pursuant to various agreements established Sanitary Sewer Equivalent Residential Unit (ERU) fees to help offset the construction of the Southeast Highland Sewer Project. Pursuant to City of Delaware Resolution No. 05-75, the Equivalent Residential Unit (ERU) Fee for all units served by the Southeast Highland Sewer is $3200.00. The Chief Building Officer is to collect payment of the ERU fees as directed by the City Manager at the time of issuance of a building permit for each lot affected by said agreements.

b. The South Central Delaware Sewer Project: Upon being notified by an owner of a subject premises in the sewer tributary area (see exhibit in appendix), the City or the City Building and Inspection Department will notify the Delaware County Bank and Trust Company of the name and address of the owner. The Delaware County Bank and Trust Company will contact the potential sewer user and notify them of the deed requirements, execute a Sewer Extension and Cost Reimbursement Agreement and collect the reimbursement fee based on the formula outlined in the South Central Delaware Phase V Sanitary Trunk Sewer Agreement. Preparation of all deed and agreements shall be at the expense of the potential sewer user.

Chapter 19: Water Distribution

1. Administrative Policy

   A. Waterlines shall be designed and operated in accordance with all applicable Local, State and Federal codes, rules and regulations.

   B. All water line in the City of Delaware are to be public and centered within a 15-ft wide (minimum) easement outside of the public right of way. Waterlines should be a minimum of 20 feet from the closest part of any structure.

   C. All public waterlines require an OEPA PTI prior to construction. The PTI application can be filled out by the Consultant, however, the City must be listed as the Owner (and Applicant) of the sewer, and the Utility Director must review and sign the application prior to submission to the OEPA. The City does not participate in the concurrent review process with the OEPA for PTIs. The OEPA water supply number for the City of Delaware is 2100311.

   D. Private waterlines are permitted only as approved by the City and are to be constructed to the same public standards.

   E. Developers are required to extend waterlines to adjacent property lines, at their own expense, in order to provide for future service area.

   F. The City of Delaware requires the use of Ductile Iron Pipe for all public water lines. Ten (10) inch in diameter waterline is not permitted.

   G. The decision of using a master meter shall be determined by the Department of Engineering Services with agreement from the Department of Public Utilities.

   H. All commercial, industrial and institutional water services must incorporate an ASSE 1013 RPP device in a hot box (regardless of access or distance from the road) Grading and installation details are required on all meter pits for services greater than 2-inches.

   I. Meter pits, where approved, shall be within 100-ft of the right-of-way.

   J. A minimum six-inch meter is required if fire hydrants are being served through the meter.

   K. A Chart with State Plane Coordinates including blank columns for as-built information (coordinates) for all main line valves and fire hydrants must be provided in the plan set.

2. Backflow Prevention Policy

   A. All new commercial/industrial/institutional sites shall incorporate an ASSE #1013 Reduced Pressure Principle Backflow Preventer after the meter as a containment backflow device on the domestic water service. This is required, regardless of degree of hazard associated with current use, with no exceptions. All ASSE #1013 containment devices must be installed downstream of the meter in a location approved by the Public Utilities Department. Additional backflow isolation devices may still be required depending on what processes are taking place in the facilities for the protection of those within the building, but the distribution system will remain protected regardless.

   B. Any renovation of an existing commercial, industrial, or institutional facility shall include the installation of an ASSE #1013 device on the domestic water line after the meter as part of the renovation process, regardless of degree of hazard associated with current use. The Planning Department should notify the Public Utilities Department of all renovations as

they are occurring so that the Backflow installations can be included into the backflow database.

C. No meters shall be placed inside the buildings on new construction. All meters shall be in pits or vaults outside. The water lines will be public to the curb valve or 60' from the water main and copper is required to the meter with one meter and one backflow device per building.

D. All outside hose bibs must have a hose connection vacuum breaker installed.

E. All backflow containment devices must be approved by the Public Utilities Department as to type and location of installation and installed in a horizontal position between 12" to 48" off the floor with test cocks readily accessible for testing purposes. An ASSE 1013 or 1047 device shall not be installed in a pit. All ASSE 1020 or 1021 devices used for irrigation shall not have a shut off valve after the device. If any chemicals are used in the irrigation system (i.e. antifreeze) an ASSE 1013 device is required.

F. Existing homes wanting to use well or cisterns for outside watering shall install backflow prevention devices to prevent contamination of the public main by well or cistern water.

3. General Water Line Requirements

All water lines shall be installed in accordance with the standards outline in the Great Lakes - Upper Mississippi River Board (GLUMRB) of State and Provincial Public Health and Environmental Managers, Recommended Standards for Water Works, Current Edition.

A. Air Relief Valves: At high points in water mains 12-inch diameter and larger where air can accumulate, provisions shall be made to remove the air by means of hydrants or manual air relief valves.

B. Blocking: All tees, bends, plugs, and hydrants shall be provided with reaction blocking and tie rods, or joints designed to prevent movement. Tie rods shall be coated with two coats of bitumastic material equal to Inertol No. 49 thickness.

C. Cover: The minimum cover shall be 48 inches. Excessive bury depth is to be avoided.

D. Separation of Water Mains and Sewers: Water mains shall be laid at least 10-feet horizontally from any existing or proposed sanitary sewer, force main, or storm sewer. The distance shall be measured edge to edge.

E. Crossings: Water mains crossing sewers shall be laid to provide a minimum vertical distance of 18-inches between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. At crossings, one full length of water pipe should be located so both joints will be as far from the sewer as possible. Special structural support for the water and sewer pipes may be required.

F. Pipes: All public water mains greater than 2-inches in diameter shall be ductile iron pipe. K-copper may be used for lines 2-inches in diameter or less.

G. Stream Crossings

1. Above-water crossings: The pipe shall be adequately supported and anchored, protected from vandalism, damage, and freezing, and accessible for repair or replacement.

2. Underwater crossings*:* A minimum cover of five feet shall be provided over the pipe. When crossing water courses which are greater than 15 feet in width, the following shall be provided; The pipe shall be of special construction, having flexible, restrained or welded watertight joints; Valves shall be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves shall be easily accessible, and not subject to flooding; Permanent taps or other provisions to allow insertion of a small meter to determine leakage and obtain water samples on each side of the valve closest to the supply source.

4. Hydrant Testing Requirements: When it is necessary to test flow an existing hydrant for the purposes of determining the capacity of the water distribution system as specific locations, the following minimum data shall be collected and provide the City when submitting such analysis.

A. Effective Point (location of hydrant GPS coordinates)
B. Test point (hydrant) elevation
C. Date of test
D. Who performed the test
E. Static Pressure, psi
F. Residual Pressure, psi
G. Flow (pitot) pressure, psi
H. Hydrant Flow, gpm
I. Fire flow corrected to a 20 psi residual pressure
J. Residual pressure corrected to a 2250 gpm flow
K. Elevation of the water storage tank at time of test

5. Modeling Process

A. A water distribution model is required for all developments served by new mainline extensions. If the development is on an existing main, at a minimum, fire service calculations are required to verify the adequacy of the existing line proposed to be tapped.

B. The water model must be signed and sealed by the Ohio Registered Professional Engineer of record.

C. Multiple analyses should be performed using the Maximum Daily Flow (MDF) without fire flows as well as the Peak Hour Flow without fire flows in order to determine pressures and flows at nodes throughout the system. Once the area of lowest pressure is identified, the fire flow should be added at multiple areas to determine the worst case scenarios under those conditions. The analysis should include pressures and demand flows throughout the system. This process shall be documented in the report summery.

D. Check that the correct elevation used for water in the tank and that the model calibrated from the flow metering point (hydrant) back to the tie-in point. Evaluate the critical point(s) of the model. This point(s) should be described and defended in the report summary and is most likely a dead end or the point furthest from the tie-in.

E. It is City of Delaware policy to promote looping and redundant sources of water in the event of a major failure in one main line.

F. Hazen-Williams coefficient should be between 120-140 (130 is typical for ductile iron). A lower coefficient must be used if minor losses are not accounted for in the model. As the system ages, the Hazen-Williams coefficient should be reduced to account for deterioration in the hydraulic capacity of the pipe.

G. Pressures and Flow Requirements

1. Minimum residual pressure: 20 psi
2. Minimum Static Pressure: 35 psi
3. Average Daily Flow (ADF)
4. Single Family 400 gpd
5. Multi-Family 300 gpd
6. Retail 0.2 gpd per 1.0 sq ft of floor space
7. Demand can be calculated flows based on AWWA design standards or historical data for commercial and industrial users. Additionally, the values in Table 12 for estimating the demand of various facilities in the water model.
8. Maximum Daily Flow (MDF) is 2.0 times the Average Daily Flow (ADF)
9. Peak Hour Demand Factor is 3.0.
10. Meet Fire Flows Requirements in this guide or Appendix B of 2007 Ohio Fire Code

H. Water Tap Sizing: It is the responsibility of the engineer to determine the appropriate service tap size and metering arrangement to meet both the domestic and fire suppression needs of each development. Table 19-1 lists typical sizes for various developments.

Residential Building Service Tap Size	
Number of Units	Minimum Service Size
Single Family	3/4-Inch
Two (2) Family Units	1-Inch
Three (3) through Six (6) Family Units	1 1/2-Inch
Seven (7) through Twelve (12) Family Units	2-Inch
* This chart is based on the City of Columbus Water Service Manual. (2004 ed.)	

Table 19-1: Tap Sizes for Building Type

Table 19-2: Water Usage for Planning

WATER USAGE SUGGESTED GUIDE *		
PLACE	Gallons/Day	OCCUPANCY
Apartments / Condominiums	300	per unit
Assembly Halls	2	per seat
Bowling Alleys (no food service)	75	per lane
Churches (small)	3 - 5	per sanctuary seat
Churches (large with kitchen)	5 – 7	per sanctuary seat
Country Clubs	50	per member
Dance Halls	2	per person
Drive-in Theaters	5	per car space
Factories (no showers)	25	per employee
Factories (with showers)	35	per employee
Food Service Operations		
Ordinary Restaurant (no 24 hour)	35	per seat
24 – Hour Restaurant	50	per seat
Banquet Rooms	5	per seat
Restaurant along Freeway	100	per seat
Tavern (very little food service)	35	per seat
Curb service (drive-in)	50	per car space
Vending Machine Restaurants	100	per seat
Homes in Subdivisions	400	dwelling
Hospitals (no resident personnel)	300	per bed
Institutions (residents)	100	per person
Laundries (coin operated)	400	per standard size machine
Mobile Home Parks	300	per mobile home space
Motels	100	per unit
Nursing and Rest Homes	150	per patient
Nursing and Rest Homes	100	per resident employee
Nursing and Rest Homes	50	per non-resident employee
Office Buildings	20	per employee
Recreational Vehicle Parks and Camps	125	per trailer or tent space
Retail Store	20	per employee
Schools		
Elementary	15	per pupil
High School and Junior High	20	per pupil
Service Stations	1000	first bay or pump island
	500	additional bay or pump island
Shopping Centers (no food service or laundries)	0.2	per 1-sq. ft. of floor space
Swimming Pools (average)	3 – 5	per swimmer
With Hot Water Showers	5 – 7	per swimmer
Travel Trailer Parks and Camps	125	per trailer or tent space
Vacation Cottages	50	per person
Youth and Recreation Camps	50	per person

*From the Ohio EPA publication Guidelines for Design of Small Public Water Systems, 1991.

6. City of Delaware Elevated Water Storage Tanks Data

A. Cheshire Road (Southeast Highlands) Elevated Water Tank (Fluted)

1.	Storage available:	2 MG
2.	Overflow Elevation:	1100.0-ft
3.	Minimum Water Elevation (bottom of the bowl):	1060.0-ft
4.	Typical Operating Elevation:	1090.0-1094.0-ft
5.	Diameter of Bowl:	100.0-ft
6.	Existing Ground Elevation:	941.0-ft
7.	Outlet Pipe (Ductile Iron):	16.0-in

B. Sunbury Road (East Side) Elevated Water Tank (Fluted)

1.	Storage available:	1 MG
2.	Overflow Elevation:	1100.0-ft
3.	Minimum Water Elevation (bottom of the Bowl):	1060.0-ft
4.	Typical Operating Elevation:	1085.0 – 1100.0-ft
5.	Diameter of Bowl:	100.0-ft
6.	Existing Ground Elevation:	933.0-ft
7.	Outlet Pipe (Ductile Iron):	16.0-in

C. London Road (West Side) Elevated Water Tank (Fluted)

1.	Storage available:	1 MG
2.	Overflow Elevation:	1100.0-ft
3.	Minimum Water Elevation (bottom of the Bowl):	1160.0-ft
4.	Typical Operating Elevation:	1085.0 – 1100.0-ft
5.	Diameter of Bowl:	100-ft
6.	Existing Ground Elevation:	940.0-ft
7.	Outlet Pipe (Ductile Iron):	16-in

Note: All elevations are based on NAVD 88

7. Fire Suppression

A. All plans shall be reviewed by the Fire Chief or his representative for the purpose of insuring compliance with applicable Local, State and federal Fire Codes, Rules and Regulations for hydrant spacing, area fire flows, and fire vehicle access. Plans will be drafted with sufficient detail to allow the reviewer to determine code compliance. Approved plans shall be on file prior to the start of construction. Plans that are altered or revised after initial approval shall be resubmitted for review and approval.

B. On commercial buildings if a post indicating valve is installed it must be monitored by the Fire Alarm Control Panel. NFPA 13 requires that on each source of water supply a post indicating valve be installed. The key is the valve must be listed and it must be a listed indicting valve. The sprinkler supply and hydrant water pass through a meter pit with a backflow preventer with two Outside Screw and Yoke Valves. If these two valves are indicating valves then the code is satisfied. These two valves will have to be monitored by the Fire Alarm Control Panel.

8. Fire Hydrants - General Requirements

A. All fire hydrants are to be installed a minimum of 40-ft away from any building and outside the "collapse zone" whichever is greater.

B. Fire hydrants shall be located in the center of the frontage of any proposed lot.

C. A fire hydrant is required within 50-feet of any roadway intersection.

D. Fire Hydrants adjacent to roadways are to be located 2-ft off the back of curb of 8-ft off edge of pavement for uncurbed roads. Hydrants should not be located in the flowline of any drainage ditch.

E. All fire hydrants shall be first line hydrants and shall conform to the requirements of the latest City specifications adopted by the American Water Works Association. The hydrants shall be manufactured by the Mueller Company (Safety Flange Model) or the M & H Valve and Fittings Company (Traffic Model). Hydrants shall have a main valve opening at least five inches in diameter; two, two and one-half (2-1/2) inch hose nozzles and a four and one-half inch pumper nozzle with bronze National Standard male threads. Public fire hydrants are to be painted with 2 coats of Federal Safety yellow, Sherwin Williams B54Y37 per COD 1507.08(A)(1). Private fire hydrants are to be painted Federal Safety Red and White caps and bonnets per COD 1507.14(B) (4). Hydrants that are part of an industrial looped system (served by a pumping station) shall be painted all Federal Safety Red. All hydrants are to be fitted with a 5-inch Stortz fitting with a locking coupling. All hydrants shall be installed with watch valves mechanically connected directly to the hydrant and adjusted to finished grade

F. The location of fire hydrants on both public and private property shall be approved by the Fire Chief before a building permit is issued. Any deviation from the approved location of any new fire hydrant shall be approved by the Fire Chief or his authorized representative.

G. The minimum size water line to serve a hydrant shall be six (6) inches. An eight (8) inch water main is required if the line is dead-ended and exceeds 600 feet in length, the line serves more than two hydrants, or serves one hydrant and a standpipe system.

H. The finished grade for fire hydrants shall not be less than eighteen inches from the center of the four and one-half outlet. The Hydrant Flange elevation is to be 2-inches above finished grade

I. The direction the outlets face shall be approved by the Fire Chief or his authorized representative. In General the largest outlet shall face the adjacent street or driveway.

J. Upon completion of new water main and fire hydrant installations, the Fire Department shall be notified and the contractor will demonstrate to the Fire Chief, or his authorized representative, that all main valves and fire hydrant valves are open. If it becomes necessary for the contractor to close any main or hydrant valves after he has demonstrated to the Fire Chief, or his authorized representative, that they are open, he shall notify the Fire Department so that the above procedure may be repeated, insuring that all fire hydrants and mains are placed back in service.

9. Fire Hydrant Spacing
   A. Where a condition exists in a development area with more than one Ohio Building Code Use Group, the greater requirements shall apply.

   B. The maximum hydrant spacing shall be 300 feet, with one hydrant provided within 150 feet from the terminus of any dead end street for Industrial Development-Use Groups F and H; Commercial Development-Use Groups R-1, A, B, E, I, M, and S; Multi-family Development-Use Groups R-2, R-3, and Multi-single Family:

   C. The maximum distance between adjacent fire hydrants is 400 feet, with one fire hydrant provided within 200 feet of the terminus of dead-end streets for Single-Family Development use Group R-4.

   D. The distance from fire hydrants to buildings, or parts thereof, shall be the unobstructed distance as measured by hose laid from fire apparatus within a paved surface.

   E. A minimum of two public fire hydrants must be within 500 feet of every building or part thereof. If the spacing requirements cannot be accomplished, on-site fire hydrants shall be provided and the following spacing requirements shall prevail: A minimum of one fire hydrant shall be within 300 feet of every building or part thereof, with a minimum of one additional hydrant within 500 feet of every building or part thereof.

   F. Fire hydrants shall be located and/or protected from possible mechanical damage. The means of protection shall be arranged in such a manner which will not interfere with the connection to, operation of, and the maintenance of hydrants. Bollards used to protect hydrants shall be at least three feet from the hydrant on all sides. Fire hydrants shall be located so as not to be obstructed by parking spaces, dumpsters, signs, mailboxes, utility poles, bushes, and any other structures and materials.

   G. Fire hydrants shall be located on all public streets and required fire apparatus access roads.

   H. Existing fire hydrants on public streets are allowed to be considered as available for new development. Existing hydrants on adjacent properties shall not be considered available unless fire apparatus access roads extended between the properties and easements are established to prevent obstructions of such roads.

   I. Where new water mains are extended along streets where hydrants are not needed for protection of structures or similar fire problems, fire hydrants shall be provided at spacing not to exceed 1,000-feet. A hydrant shall be provided within 50-feet of all street intersections, public and private.

10. Fire-Flow Requirements
   A. Per City of Delaware Ordinance 07-85, the procedure for determining fire-flow requirements for commercial and residential buildings shall be in compliance with State of Ohio Fire Code adopted July 1, 2007.

   B. The minimum acceptable residual pressure available for firefighting is 20 psi.

   C. One- and Two-Family Dwellings: The minimum fire-flow for one- and two-family dwellings having an area less than 3,600 square feet is 1,000 gpm. The fire-flow and duration for dwellings with an area greater than 3,600 square feet is specified in the Fire Flow Table. A

reduction of 50% is allowed when the dwelling is equipped with an approved automatic sprinkler system, as approved by the Fire Chief.

D. Buildings other than one- and two-family dwellings: For buildings other than one- and two-family dwellings the fire-flow and duration time is specified in the Fire Flow Table. A reduction of 75% is allowed when the dwelling is equipped with an approved automatic sprinkler system, as approved by the fire chief. The resulting fire-flow shall not be less than 1,500 gpm for the duration specified in the Fire Flow Table.

E. The floor area, measured in square footage, is to be used to determine the required fire flow. The calculation area shall be the total floor area of all floor levels within the exterior walls and horizontal projection of the roof of a building. Area separated by firewalls without openings and constructer per the International Building Code, are allowed to be considered as separate fire-flow calculation areas. For Type I-A and Type I-B construction, the area for the three largest successive floors shall be used for the area calculation. Exception**;** For open parking garages the area of the largest floor shall be used.

F. Construction Types: All buildings are classified according to their construction type. Type I is least combustible and Type V is most combustible. The more combustible a building is and the more hazardous the use is, the more the maximum allowable area is limited. All construction types and use groups are allowed to have increased areas by using sprinklers. Below is a brief summary of Construction Types. For a complete and more detailed description please consult the International Building Code.

1. Type I (I-A or I-B): Typically these are concrete frame buildings made of noncombustible materials. All of the building elements (structural frame, bearing walls, floors and roofs) are fire resistance rated.

2. Type II (II-A or II-B): These buildings are constructed of noncombustible materials. Typically these are masonry bearing wall structures with steel studs for walls and steel bar joists for floor and roof structures. II-A has fire rated building elements (structural frame, bearing walls, floors, and roofs). II-B is the most common construction type for commercial buildings because the building elements are not required to be fire resistance rated but still must be non-combustible.

3. Type III (III-A or III-B): Type III construction permits the exterior walls to be of noncombustible materials and the interior building elements of any material permitted by the code (combustible or non-combustible). This is typical of buildings with masonry bearing walls and wood roofs or floors. Fire-retardant-treated wood framing shall be permitted within exterior wall assemblies of a 2-hour rating or less.

4. Type IV (IV-A or IV-B): Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. Fire-retardant-treated wood framing shall be permitted within exterior wall assemblies with a 2-hour rating or less. This construction is not common in Ohio except perhaps in some worship facilities.

5. Type V (V-A or V-B): Type V construction is typically wood frame construction. V-A requires fire rated assemblies for all building elements (structural frame, bearing walls, floors, and roofs); this is often seen in older construction that predates sprinklers but still not commonly used. V-B is very common because it does not require any fire rating.

Table 19-3: FIRE-FLOW CALCULATION AREA (square feet)

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

Chapter 20: Sanitary Sewer (SAS) Design

The following design parameters are derived mainly from the Great Lakes and Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers: (GLUMRB) Recommended Standards for Wastewater Facilities, a reference manual widely known as "Ten State Standards." In addition, requirements of the City of Columbus Sanitary Sewer Design Manual and current City of Delaware policy are included in this section.

1. Administrative Policy

   A. All sanitary sewers serving more than one building are to be public.

   B. All public SAS require an OEPA PTI prior to construction. The PTI application can be filled out by the Consultant, however, the COD must be listed as the Owner (and Applicant) of the sewer, and the Utility Director must review and sign the application prior to submission to the OEPA. The COD does not participate in the concurrent review process with the OEPA for PTIs.

   C. Whenever possible, all SAS should be located outside of right of way centered within Utility Easements granted to the City. Minimum easement width for SAS is 20 feet for standard installations. Deeper and/or larger sewers may require wider easements.

   D. Developers are required to extend SAS through their site, at their own expense, in order to provide for future upstream tributary area service connections.

   E. SAS lift stations will not be permitted without written permission from the City. In the event a lift station is permitted, and the station will serve a single-entity ownership development, the lift station shall be considered privately owned and maintained. However, the lift station still must be built to public standards. If the lift station serves multiple ownership developments, the lift station shall be considered public, and will be maintained the City. The public designation does not preclude the City from assessing a monthly maintenance fee to such organizations as homeowner's associations. Lift stations are not common enough in the City to publish standards and specifications for their design. Requirements for lift stations will be developed by the Department of Engineering Services and approved by the Department of Public Utilities on a case-by-case basis.

   F. Temporary holding tanks will not be permitted in areas capable of being served by City sanitary sewer system. In the event a temporary holding tank is necessary to serve a property while a SAS is being built, the Owner must first obtain permission from the Utility Director, OEPA, and the Delaware County General Health District.

   G. Aerial sewers and inverted siphons (if deemed appropriate by the Director of Public Utilities) shall be designed per OEPA and Ten State Standards.

   H. When SAS are proposed in the vicinity of any water supply facilities, requirements of the GLUMRB Recommended Standards for Water Works must be used to confirm acceptable isolation distances in addition to the following requirements.

   I. The sub-divider shall provide the City with all required OEPA submittals and pay all OEPA review fees.

2. Technical Requirements

   A. SAS must maintain a minimum separation of 20 feet from any part of any building or structure. More foundation separation may be required for deeper SAS.

   B. SAS shall be constructed on the opposite side of the street from water lines in new subdivisions.

   C. SAS may be built under proposed residential subdivision streets if the Developer can absorb the cost of compacted granular backfill (COC Item 912 – no exceptions) for the entire trench depth, and only by City approval on a case-by-case basis.

   D. SAS must maintain a minimum separation of 10 feet from all water lines and stormwater management systems (i.e., sewers, channels, etc.) SAS should not be aligned under any part of a detention/retention facility. If no other feasible alternative exists, then SAS near these facilities and the water pipe and/or storm pipe must be specified as slip-on or mechanical joint pipe complying with potable water supply requirements and be pressure tested to 150 psi to assure water tightness prior to backfilling.

   E. All water supply structures (public and private) within 200 feet of a proposed sewer must be highlighted and shown on the plans

   F. All SAS mains must be kept at an elevation to provide basement gravity service to the entire tributary area, regardless of the proposed development plan (generally, 10-foot minimum depth). A critical horizontal/vertical alignment to the end of the tributary boundary may be required as part of any development, in order to determine the appropriate depth of the SAS through a proposed development.

   G. State Plane Coordinates must be provided for all manholes in a tabular format. Provide blank columns for coordinates to be entered as part of the conversion to Record Drawings.

   H. Buoyancy of sewers shall be considered and the flotation of the pipe shall be prevented with appropriate design considerations wherever high groundwater conditions are anticipated.

3. Manholes: Manholes are required at the following locations:

   A. Change in pipe slope, size, or alignment

   B. Change in pipe material

   C. At intermediate intervals not exceeding 400 feet

   D. Upstream of all service connections (i.e. no stubs with service connections)

   E. At the end of a sewer stub greater than 50 feet in length (even if no services are proposed into the stub)

   F. Manholes for proposed sewers are to be pre-cast and the appropriate size per the City of Delaware Standard Drawings.

   G. Manholes over existing flexible SAS 8 to 12 inches in diameter shall be Type C with flexible connections. Otherwise, manholes over existing SAS shall be Type E manholes (cast-in-place base) unless otherwise approved by the City.

H. Manhole bases shall provide a minimum of 0.1 foot drop between the inlet and outlet pipes.

I. Sewers entering proposed manholes 2-feet or more above the invert of the manhole must be designed with an outside drop per Standard Drawings.

J. Proposed sewers entering existing manholes 2-feet or more above the invert of the manhole shall be designed with an inside drop per the Standard Drawings. Only one inside drop is allowed per manhole for accessibility reasons.

K. Drops within the 0.5 to 2.0 feet range should be avoided in the design as they are undesirable from a maintenance standpoint. Avoid such drops by adjusting the grade of the run of sewer to enter the manhole, or design the drop to be greater than 2.0 feet and specify an outside drop. It is understood that 0.5 to 2.0 foot drops cannot always be avoided when attempting to match pipe crowns. Under these circumstances, the invert shall be filleted to prevent solids deposition. A note should appear on the plans to this effect.

L. Cleanouts are not permitted on SAS mains.

M. Manhole castings must be 1 foot above the 100-year floodplain elevation.

4. Materials/Bedding/Backfill

A. SAS pipe materials shall be per COC CMS Section 900.

B. Flexible sewers are subject to deflection testing requirements per COC CMS Section 900. Rigid pipe should be considered when the SAS must be put into use soon after installation.

C. When flexible SAS is deeper than 20 feet, PVC SDR 26 must be specified for pipe and fittings.

D. Bedding per COC Standard Drawings. Type of bedding must be specified in the quantities table.

E. COC Item 912 (compacted granular material) is required full depth of the trench under pavement and up to the pavement influence line (when not directly underneath pavement). See RDWD Standard Drawings for definition of pavement influence line. Vertical limits of the Item 912 must be shown in profile view.

F. Large aggregate backfill material (No. 4 stone) is not an acceptable alternative to Item 912.

G. Outside of the pavement influence, but within ROW or easements, COC Item 911 is the backfill requirement.

H. If neither Item 911 nor 912 requirements apply, then backfill must be compacted to 95% (Standard Proctor) within +/- 2% of optimum moisture content.

I. If a flexible sewer is required to be encased in concrete, it must be encased from structure to structure.

J. The decision to jack-n-bore versus open cut a roadway for sewer installation will be made by the City Engineer on a case-by-case basis. Criteria that affect the decision are ADT, roadway width, number of lanes, pavement condition, etc. Reference the Standard Drawings for a jack-n-bore casing detail.

K. Trench dams shall be installed between each pair of manholes utilizing native compacted clay soil or Benonite Clay material. No granular bedding is permitted at the locations of trench dams.

5. Capacity

A. The minimum diameter for any SAS main is 8-inch; The minimum diameter for any SAS lateral is 6-inch.

B. If velocities exceed 15 feet/second, special provisions shall be made to protect against displacement by erosion and impact.

C. SAS on 20% slopes or greater shall be anchored per Ten States Standards

D. When smaller sewers outlet into larger sewers, attempt to match 0.8 D

E. Reduction in pipe size in the downstream direction will not be permitted regardless of the slope of the downstream pipe.

F. SAS should not be oversized in order to accommodate flatter design slopes.

G. SAS design shall utilize the following hydraulic design criteria:

Table 20-1: Sanitary Sewer Hydraulic Design Criteria

Pipe Diameter (Inches)	Minimum Grade (%)
8	0.4
10	0.28
12	0.22
14	0.17
16	0.14
18	0.12
21	0.10
24	0.08
27	0.067
30	0.058
36	0.046
Population Density	12 capita/acre*
Average Sanitary Flow	120 gpd/capita OR 600 gpd/acre for select areas
Greenspace Factor	10%
Peaking Factor (P = population in thousands)	18+ P^(1/2) 4+P^(1/2)
I/I Allowance	969.5 gpd/acre
Minimum Velocity	2.0 feet/second
Manning's "n" value	0.013 (all materials)
Peak Flow	(Peaking factor) x (Avg. Flow)
Design Flow	Peak flow + I/I Allowance
Design Capacity	Flowing Full %
8"-15"	50
18"-27"	75
30" and up	92

* For areas of greater population density of 12 persons per acre, the design flow shall be determined on a basis of population instead of area.

6. Services:

A. No services into manholes, or within 8 feet of a manhole.

B. Service schedule must be provided on the plans showing: stationing, riser height, length, and end of service elevation.

C. All wyes must have a minimum 2-foot riser or extension to reduce the risk of future damage to the SAS main.

D. The length of riser called out in the plan view/service schedule shall be the distance from the pipe invert to a point +/- 9 feet below the existing or proposed ground surface, whichever is higher. This means the Quantities table does not have to match the sum of the riser heights in the plan view/service schedule.

E. Services under new subdivision streets shall be paired per the Standard Drawings.

F. Cleanouts should be specified every 100 feet on a service.

G. Services must extend at least 2 feet beyond other buried utilities.

7. Stream and Utility Crossings

A. SAS crossing open channels must be designed to cross as nearly perpendicular to the channel as possible. Also, stream crossings are to be kept to an absolute minimum within a development.

B. The depth from the channel bed to the crown of the pipe shall be a minimum of 4 feet. Trench backfill shall be in accordance with COC Item 911, with the exception of the upper portion of the trench which must be per COC Item 919 (Watercourse Erosion Protection).

C. If the above requirement cannot be met, 6-inch concrete encasement on all sides of the pipe will be required for all pipe materials. A special detail of the encasement must be included in the plans.

D. All additional requirements as set forth by the OEPA for the stream crossing must be strictly adhered to.

E. Where the SAS crosses under a proposed storm sewer or water line (and minimum clearance is maintained), specify COC Item 912 backfill to the bottom of the storm sewer or water line.

F. Sewers crossing other buried utilities shall be designed and laid to provide a minimum vertical distance of 18 inches (measured from outside of pipe to outside of pipe). The crossing shall be arranged such that the sewer joints are equidistant and as far away as possible from the other utility (especially for crossings of water mains and storm sewers). If it is impossible to meet the 18-inch clearance requirement, then the SAS shall be designed and constructed equal to water main pipe and shall be pressure tested at 150 psi to assure water tightness prior to backfilling.

G. In the rare case where a SAS crosses over a water main, adequate structural support must be provided for the sewer to maintain line and grade. A special detail must be included in the plans. Either the water main or the SAS may be enclosed in a casing pipe which extends 10 feet on both sides of the crossing (measuring perpendicular to the water main). The carrier pipe shall be ductile iron.

City of Delaware

Department of Engineering Services

Plan Review & Construction Inspection Fees

Project: Project # Date

PLAN REVIEW FEES

Traffic Studies:			Non-Complex Review		$1,500	☐
			Complex Review		$3,500	☐
Storm Water Management Plan:			Level - I Review		$700	☐
			Level - II Review		$3,500	☐
			Level - III Review		$7,500	☐
Residential Developments:	$350/SHT	X	_____ SHTS	=	$ _____	☐
Commercial/Industrial:						
0 to 5 Acres	$350/SHT	X	_____ SHTS	=	$ _____	☐
>5 to 15 Acres	$400/SHT	X	_____ SHTS	=	$ _____	☐
>15 to 75 Acres	$450/SHT	X	_____ SHTS	=	$ _____	☐
>75 Acres	$550/SHT	X	_____ SHTS	=	$ _____	☐
Off-Site Public Infrustructure:	$350/SHT	X	_____ SHTS	=	$ _____	☐

Sub-Total Engineering Review Fees $

Plan Changes following final Engineering Approval shall be invoiced at $250 Per Revision

CONSTRUCTION INSPECTION FEES

Single-Family Residential: 7.5 % X Value of Public Infrastructure Improvements

0.075 X _____ = $ _____ ☐

Multi-Family Residential: 7.5 % X Value of Public Infrastructure Improvements

3.0 % X Value of Private Infrastructure Improvements

0.075 X $ _____ + 0.03 X $ _____ X = $ _____ ☐

Commercial/Industrial: 7.5 % X Value of Public Infrastructure Improvements

1.5 % X Value of Private Infrastructure Improvements

0.075 X $ _____ + 0.015 X $ _____ X = $ _____ ☐

Off-Site Public Improvements: 7.5 % X $ Value of Public Infrastructure Improvements

0.075 X $ _____ = $ _____ ☐

Additional Inspections Required: _____ $ _____ ☐

Sub-Total Engineering Construction Inspection Fees $

TOTAL PLAN REVIEW & CONSTRUCTION INSPECTION FEES $

Appendix B – City of Delaware Standard Signature Block

APPROVED BY:

CITY OF DELAWARE, OHIO

_____

DAVID M. EFLAND, AICP DATE
DIRECTOR OF PLANNING AND COMMUNITY DEVELOPMENT

_____

WILLIAM L. FERRIGNO, P.E. DATE
DIRECTOR OF ENGINEERING SERVICES
OHIO REGISTERED PROFESSIONAL ENGINEER NO. 56942

_____

JENNIFER S. STACHLER, P.E. DATE
LAND DEVELOPMENT ENGINEER
OHIO REGISTERED PROFESSIONAL ENGINEER NO. 61629

_____

ALLEN ROTHERMEL DATE
PUBLIC WORKS DIRECTOR

_____

BRAD STANTON DATE
DIRECTOR OF PUBLIC UTILITIES

Approval of these plans does not constitute assurance to operate as intended. The reviewer does not accept responsibility for the integrity of the plans.

Appendix C – Storm Sewer Utility Rate Calc Sheet

City of Delaware Department Of Engineering Services 20 East William Street Delaware, Ohio 43015 (740)203-1700 Fax: (740)203-1749 www.delawareohio.net	STORM SEWER UTILITY RATE CALCULATION SHEET

PROJECT NAME: _____

ADDRESS: _____

PARCEL NUMBER(S): _____

SUBMITTED BY: _____ OF _____

IMPERVIOUS AREA CALCULATION

A) Total Roof Area: _____ SF B) Total Sidewalk Area: _____SF C) Total Parking Area: _____SF D) Total Driveway Area: _____SF E) Total Impervious Area: _____ SF (A+B+C+D)	EQUIVALENT RESIDENTIAL UNIT (ERU) Total Area (E) ÷ 2,773 SF = ERU's _____ / 2,773 = _____ ERU's

NOTE: Must Provide Scale Site Drawing(s) 8½ x 11 – With Impervious Area Delineated By Rooftop, Sidewalk, Parking, Driveway and Gravel areas.

FOR OFFICE USE ONLY

□ NO CREDITS APPLICABLE:	Monthly Base Rate = $2.50
□ 25% DETENTION/RETENTION CREDIT:	Monthly Base Rate = $1.88
□ 50% DIRECT DISCHARGE CREDIT:	Monthly Base Rate = $1.25

ANNUAL UTILITY FEE CALCULATION

FEE = BASE RATE X 12 Months X No. ERU's

FEE = $_____/ Month X 12 X _____ERU's

FEE = $_____/ Year