Glossary of Terms

The definitions in this Glossary are for use with this Chapter and the references cited. They are refined as appropriate to relate to the contents of this Chapter. They are not necessarily definitions as established by case or statutory law.

ABC DEF GHI JKL MNO PQR STU VWXYZ

Active Channel: A waterway of perceptible extent that periodically or continuously contains moving water. It has definite bed and banks, which serve to confine the water and includes stream channels, secondary channels, and braided channels. It is often determined by the “ordinary high-water mark” which means that line on the shore established by the fluctuations of water and indicated by a clear natural line impressed on the bank, shelving, changes in the character of soil, changes in vegetation, the presence of litter and debris, or other markers.

Acre-Foot (ac-ft): A unit of measurement for volume of water. It is equal to the quantity of water required to cover one acre to a depth of one foot and is equal to 43,560 cubic feet or 325,851 gallons. The term is commonly used in measuring volumes of water used or stored.

Aggradation: General and progressive buildup of the longitudinal profile of a channel bed due to sediment deposition.

Allowable Headwater: Maximum design headwater, or ponding, at the upstream side of a culvert or bridge based on regulatory, bridge manual, or FDM requirements.

Annual Exceedance Probability (AEP): The probability of an event, such as an annual peak flood, being equaled or exceeded in a given year. It is the inverse of the return period.

Annual Flood: The maximum flood flow in one year (may be an average daily value or instantaneous peak value).

Antecedent Moisture/ Rainfall Condition: The antecedent moisture condition (AMC), also known as antecedent rainfall condition (ARC), is a parameter used in particular in NRCS methodology to reflect the moisture level in the soil prior to a rainfall event. AMC conditions are: 1 - I Dry, 2 - II Normal, 3 - III Wet, 4 – IV Frozen or Saturated. For most hydrologic calculations AMC 2 is used. Antecedent moisture condition will affect the amount of direct precipitation that will run off the ground in a storm event. The higher the number, the higher the runoff.

Apron: Protective material or structure placed in a stream bed to prevent scour from a drainage facility. Typically apron ends are placed on the upstream and downstream ends of culverts or storm sewer pipe outfalls. These ends are supplied by the pipe manufacturers and are typically made of the same material as the pipe they are attached to.

Aquatic Connectivity (ACONN): The transfer by water of matter, energy, and organisms within and between all natural resource components of a stream ecosystem and floodplain. For the purposes of the FDM and the design of hydraulic structures, ACONN and AOP are synonymous.

Aquatic Organism Passage (AOP): For the purposes of the FDM, AOP and ACONN are synonymous. AOP is the term used by many other states, FHWA, and other Federal Agencies. The latter is the term preferred by Wisconsin DNR. When designing for AOP/ACONN the hydraulic structure ideally does not impede movement or survival of aquatic species, sediments, woody debris, etc.

Average Discharge: In the annual series of the Geological Survey's reports on surface water supply, the arithmetic average of all complete water years of record, whether or not they are consecutive. Average discharge is not published for less than five years of record. The term "average" is generally reserved for averages of record and "mean" is used for averages of shorter periods, namely, daily mean discharge.

B-Structures

B-Numbered Structure: A “B-number” is assigned by Bureau of Structures to drainage facilities over 20 ft meeting the FHWA definition of a bridge. Structure length is measured along the roadway centerline between the inside faces of abutments or exterior walls. A set of nested pipes may be assigned as a bridge structure if the distance between the inside diameters of the end pipes exceeds 20 ft. and the clear distance between pipe openings is less than half the diameter of the smallest pipe. Refer to the Structure Inspection Manual for measurements used to define a bridge structure.

Backwater: An increase in water surface elevation relative to the elevation that would normally occur under unrestricted channel and floodplain conditions. It is often induced by a bridge or other structure that obstructs or constricts the free flow of water in a channel.

Bank: The lateral boundary of a stream confining water flow. The bank on the left side of a channel looking downstream is called the left bank and the bank on the right side of a channel looking downstream is the right bank.

Bankfull Flow: Bankfull Flow or Bankfull Discharge is the flow at which water completely fills the natural stream channel and where additional water would overflow into the floodplain. It is also referred to as the “channel forming” flow.

Bankfull Width: Bankfull Width (BFW) is a measurement of the width of the active stream channel at bankfull flow.

Base Flood Elevation: Base flood elevation (BFE) is the elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year. The 1% flood is also referred to as the 100-year flood.

Base Flow: Base flow represents the long-term average discharge of a stream when the watershed is not immediately responding to rainfall events. That is, base flow comes from sources other than surface runoff, primarily groundwater. Flooding occurs when base flow is exceeded.

Bed, Stream Bed: The bottom of a channel bounded by banks.

Bed Load: The part of sediment transport consisting of coarse material, such as sand or gravel, transported by rolling, sliding, or saltating along the channel bed. It does not include transport of fine materials in suspension.

Bed Material: Material found in and on the bed of a stream.

Bedrock: The solid underlying rock of the Earth’s crust below any erodible soils. Bedrock can be exposed at the surface or be miles underneath the Earth’s surface. Depth to bedrock can be important in designing drainage structures since it can be a limiting factor in design elevations of those structures. At times it may be necessary to remove bedrock for construction of a drainage facility, however, this can be costly.

Berm: A shelf or raised barrier usually constructed of compacted soil to separate areas. Sometimes used to direct flow or prevent flow from entering or exiting an area. Also, can be referred to as a dike or levee.

Bulking: The increase in volume of flow due to air entrainment, debris, bedload, or sediment in suspension.

C-Structures

C-Numbered Structure: In general, a “C-number” is assigned to small bridge structures (C-Structures) 20 ft. or less in structure length by Bureau of Structures that have a unique structural design and/or a heightened inspection interest. This includes bridge-like structures (deck girders, flat slabs, etc.), concrete box culverts with a cross-sectional opening greater than, or equal to 20 square feet, rigid frames (three-sided concrete structures), and structural plate structures (pipes, pipe arches, box culverts, etc.). Structures not meeting the bridge structure or small bridge structure criteria are then typically considered a roadway culvert as described in Facilities Development Manual (FDM) 13-1. Buried structures listed in FDM 13-1 are typically not assigned a structure number, except for closely nested pipes and structural plate structures. Refer to the Structure Inspection Manual for additional information on small bridge structures.

Capacity: The effective conveyance ability of a drainage structure. Generally measured in cubic feet per second.

Catch Basin: A drainage structure that collects water. May be either a structure where water enters from the side or through a grate on the top. On WisDOT facilities catch basins are essentially storm sewer inlet structures where the invert of the outflow pipe is one or more feet above the bottom slab of the structure. This creates with a sump which can settle out sediment, pollutants, and/or trash.

Catchment Area: (see Drainage Basin)

Channel, Main or Primary:

A channel or ditch designed to carry concentrated flow or stream flow, largely from offsite of WisDOT facilities or from an accumulation of flow from multiple roadside ditches, cross culverts, and other drainage facilities. These differ from side ditches (as defined below under "Channel/Ditch, Side"). In the cases where a designer needs to design a channel to carry a relocated stream contact the Bureau of Technical Services, Environmental Services Section or the Regional Environmental Coordinator assigned to the project.

Channel/Ditch, Median: A channel or roadside ditch designed to convey concentrated flow between separated lanes of a divided roadway. Generally, these channels are only conveying runoff from the roadway and median pavement or grass area and not from off-site drainage areas.

Channel/Ditch, Side: A channel or roadside ditch designed to primarily convey concentrated flow from a roadway with limited drainage from outside of the right of way. For instance, a side channel may convey roadside drainage and drainage from the front yards of the adjacent properties. A side channel would not convey water from an entire subdivision adjacent to the roadway or from stream flow.

Check Dam: A permanent or temporary structure constructed of rock, natural materials and/or artificial materials placed across a natural or man-made channel or drainage ditch. Check dams are relatively low structures designed to reduce scour and channel erosion by reducing flow velocity and increasing sedimentation.

Check Storm: A storm event that exceeds the standard design frequency required to determine the design flow for a drainage facility. The check storm is generally at least the next highest storm event but can vary depending on certain risk factors such as; highway routes having no practical detour, critical routes, deep fills, significant risk of damage to nearby structures, sites where watershed changes are likely, or when designing the repair or replacement of a facility damaged by flooding may require consideration of a higher design event or flow type than the standard. The required check storm can also vary by structure type. When performing a hydraulic analysis for a check storm, the drainage structure or system is not expected to meet all design criteria, rather the designer evaluates the drainage system under this higher flow condition and determines what improvements, including considering an increase in structure size, could be made to reduce risk, increase safety, and provide a more resilient system.

Concentrated Flow: Flowing water that has collected into a rill, swale, or channel.

Confidence Limits: Statistical limits that describe an interval in which the true value of a statistic is expected to lie with the stated probability. With rainfall and other hydrologic data there are often confidence limits or intervals representing a range of potential flows with the suggested value being close to the mean in many cases.

Cobble: Fragment of rock whose diameter is in the range of 2.5 to 10.1 in. (64 to 256 mm).

Confluence: A point in which two streams converge.

Critical Depth: In hydraulic analysis, the depth when flow has a Froude number of 1.0. The depth associated with the minimum total energy to pass a given flow through a given cross section. It also represents the transition point between subcritical and supercritical flow.

Critical Flow: The open-channel flow condition where the specific energy of flow is at a minimum and the Froude number for the flow is one.

Critical Shear Stress: The minimum amount of shear stress required to initiate soil particle motion.

Critical Slope: The channel slope at critical flow.

Critical Velocity: Mean velocity of flow when flow is at critical depth.

Cubic Feet Per Second (cfs):

A unit expressing rates of discharge passing through a given point per unit of time. One cubic foot per second is equal to the discharge of a stream of rectangular cross section, one foot wide and one-foot deep, flowing water an average velocity of one foot per second.

Culvert: A closed conduit, other than a bridge, that allows water to pass under a roadway. The Federal Highway administration defines a single culvert 20 feet wide or larger or certain configurations of closely spaced culverts as a bridge. See the Bridge Manual for further discussion on what defines a bridge.

Culvert, Cross: A mainline or sideroad cross culvert is a culvert that crosses under a roadway perpendicular to the direction of traffic and conveys a combination of roadway and off-site drainage.

Culvert, Side Drain: A side drain culvert is primarily intended to convey roadway drainage accumulated in a roadside ditch. Side Drain culverts do not convey streamflow or substantial offsite flow. A side drain is not used to convey water from one side of the mainline to the other. It is carrying ditch flow to the point of discharge to a waterway or to a cross culvert. Examples of side drain culverts are driveway culverts and culverts at an intersection that convey ditch flows only.

Curve Number: A dimensionless parameter used in hydrologic calculations to predict runoff. A drainage basins curve number is representative of the areas hydrologic soil group (HSG) and the combined effects of soil characteristics, land cover type, hydrologic condition, and antecedent soil moisture conditions.

Degradation: Removal of streambed material from scour and erosive forces that results in a lowering of the bed elevation throughout a reach. (Opposite of aggradation.)

Deposition: (See aggradation).

Dendritic Watershed: A dendritic watershed is a network of interconnecting flowpaths resembling the branching pattern of a tree. It is the most common drainage pattern.

Depressional Storage: For the purposes of the FDM, depressional storage is defined as areas in the watershed that may not contribute flow, or significantly attenuate the flow, to the design point of discharge in the design storm event. These may include: large kettle areas that can reasonably be assumed will not be filled in by future development; mapped internally drained lakes or other waterbodies; or in certain circumstances large mapped and primarily internally drained wetland complexes.

Design Discharge: The design discharge is that portion of precipitation that produces direct runoff that the drainage facility is expected to accommodate during the required design storm event without exceeding design criteria.

Design Frequency: Design frequency is the return period of the design discharge/design event for a drainage structure.

Design Storm: Design Storm is the event having the design discharge at a specified design frequency. Also referred to as design flood or design event.

Detention Basin: See “dry pond” or “wet pond”.

Direct Runoff: The portion of precipitation (rainfall or snowmelt) that flows over the land surface and reaches streams or other water bodies promptly after a rainfall or snowmelt event. It excludes water that infiltrates into the ground or evaporates. Also see "Surface Runoff."

Discharge: A volume of water flowing out of a drainage structure or facility, or water flowing past a given point. Discharge is generally measured in cubic feet per second (cfs).

Discharge Rating Curve:

See "Stage-Discharge Relation."

Drainage Area (Drainage Basin) (Basin, Sub-Basin) (Watershed):

An area defined by drainage divides upon which falling precipitation flows to a given location. With respect to a roadway, this given location may be either a culvert, a channel, or an inlet to a roadway drainage system.

Drainage Divide: The rim of a drainage basin. A series of high points from which water flows in two directions, into the basin and away from the basin.

Drainage System: Usually a system of underground conduits and collector structures that flow to a single point of discharge.

Dry pond (Dry detention basin): A stormwater facility used to control peak flows during storm events by temporarily storing stormwater runoff. During dry periods of rainfall these basins remains dry as opposed to a wet pond which maintains a specific designed water surface elevation.

Dynamic Equilibrium: A stream channel is considered to be in dynamic equilibrium when channel dimensions, slope, and planform do not change radically even though they constantly adjust to changing inputs of water, sediment, and debris. A system is considered to be in dynamic equilibrium if its overall state remains relatively stable

Encroachment: Any fill, structure, equipment, use, or development in a regulated floodplain.

Embedded Culvert: A culvert installation that is depressed below the stream grade. It may or may not be filled with natural sediment or a design mix to mimic the adjacent streambed. It is a practice used in AOP design.

Energy Grade Line: A hydraulic term used to define a line representing the total amount of energy available at any point along a watercourse, pipe, or drainage structure. It is a sum of the elevation, velocity, and pressure heads. The energy grade line between two (or more) channel or conduit locations differs by energy losses. The slope of the energy grade line is often referred to as the friction slope.

Elevation Head: One of three components including velocity head and pressure head the sum of which make up total head.

Entrance Head: The head required to cause flow into a conduit or other structure. It includes both entrance loss and velocity head.

Entrance Loss: The head lost in eddies and friction at the inlet to a conduit or structure, expressed as H_e. For culvert calculations entrance loss is represented by the coefficient K_e. For culverts K_e is selected based on the geometry of the entrance.

Entrenched Stream: Stream incised into bedrock or consolidated deposits. Entrenched streams can often have nearly vertical banks and limited or no access to spill over to its floodplain during typical storm events.

Ephemeral Stream: Stream or reach of stream that does not flow for parts of the year. As used here, the term includes intermittent streams with flow less than perennial.

Equalizer: A drainage structure that it is not intended to pass a design flow in a single direction. Instead, it is often placed level (zero slope) to permit passage of water in either direction. It is generally used in low areas that are not connected to surface water conveyance facilities (ditches, streams, rivers, lakes, etc.) where there is no place for the water to go and the runoff water remains stagnant unless it infiltrates or evaporates. Its purpose is to maintain the same water surface elevation on both sides of the highway roadway embankment.

Erosion: The removal of soil and rock particles by water, wind, or ice.

Evaporation: The process by which water is changed from the liquid state to the vapor state.

Evapotranspiration: Surface evaporation of water and transpiration from plants.

Extreme Event: Severe and rare natural occurrence that may pose significant risks for damage and potentially loss of life. In FDM Chapter 13 “extreme event” precipitation or floods equal to or greater than the 100-year storm. “Extreme event” may also refer to projected intense precipitation less than a 100-year storm over an usually short timeframe.

FEMA: Federal Emergency Management Agency. In the context of drainage FEMA manages the National Flood Insurance Program (NFIP) and oversees the management of regulated floodplains by the State of Wisconsin.

Flood Frequency: The magnitude and frequency of flood discharges based on historic data. It is expressed as the average frequency for which it is expected a specific flood stage or discharge is equaled or exceeded. In the context of hydraulic design, it is often used interchangeably with design frequency.

Flood-Frequency Curve:

A graph indicating the probability of occurrence that the annual flood discharge equals or exceeds a given magnitude, or the recurrence interval corresponding to a given magnitude.

Flood fringe: That portion of the floodplain outside of the floodway which is covered by flood waters during the regional (base) flood and associated with standing water rather than flowing water. In Wisconsin fill can be added to a flood fringe in some circumstances without impacting the Base Flood Elevation of the floodplain.

Floodway: The channel of a river or stream and those portions of the floodplain adjoining the channel required to carry the regional flood discharge. Fills into a floodway will generally cause a rise in the Base Flood Elevation of the floodplain.

Flood Storage District: A Flood Storage District (FSD) is a unique form of a mapped and regulated floodplain. Flood storage is occasionally used in hydrologic modeling to attenuate peak flows. When flood storage is accounted for explicitly in a regulatory model, an associated flood storage district must be mapped as an FSD and adopted by a community. This regulatory FSD is meant to preserve that flood storage area and to ensure that the modeling using it remains an accurate representation of the ground conditions.

Flood Peak: The highest value of the stage or discharge attained by a flood, thus peak stage or peak discharge. Flood crest has nearly the same meaning, but since it primarily is used to reference the top of the flood wave, it is properly used only in referring to crest stage but not crest discharge.

Floodplain: Land adjacent to a waterway which is subject to frequent inundation by floods. (see also “Regulated Floodplain”).

Flood Profile: For the purposes of the FDM this is referring to a regulated flood profile. This is a graph of elevation of the water surface along the centerline of a stream. For National Flood Insurance Program purposes a flood profile can be used to find the Base Flood Elevation at a particular location in a riverine floodplain.

Flood Routing: The process of determining progressively the timing and shape of a flood wave at successive points along a river (see Carter and Godfrey, 1960).

Flood Stage: The elevation at which the water surface exceeds the bankfull condition of a stream.

Flow-Duration Curve: A cumulative frequency curve that shows the percentage of time that specified discharges are equaled or exceeded.

Flow Line: A term used to describe a line connecting the low points in a channel or pipe.

Flume: For WisDOT drainage design purposes, a flume is a drainage structure/channel built to safely convey flow from the roadway to a roadside ditch or other waterway. They may be constructed of asphalt, concrete, and/or riprap. They are also typically used to direct flow away from bridge abutments to prevent erosion of the structure.

Fluvial Geomorphology: Science dealing with morphology (form) and dynamics of streams and rivers.

Freeboard: The distance between the design water surface elevation and a point of concern. For roadways, berms, ditches, or channels the point of concern may be the point of overtopping or a set point like the subgrade shoulder point. For a bridge freeboard is the vertical clearance of the lowest structural member of the bridge superstructure above the design water surface elevation.

Free Outlet: A condition under which water discharges with no interference such as a pipe discharging into open air.

Froude Number: A dimensionless number (expressed as $V/(g\ y)^{1/2}$ - Where V is equal to the flow velocity, g represents the gravitational acceleration, and y represents the depth) that represents the ratio of inertial to gravitational forces. High Froude numbers can be indicative of high flow velocity and greater scour potential.

Gage Height: The water surface elevation on a stream or lake gage which is referred to a datum.

Gage height is often used interchangeably with the more general term stage.

Gaging Station: A particular site on a stream, canal, lake, or reservoir where systematic observations of gage height or discharge are obtained (also see "Stream Gaging Station").

Grade to Drain: A construction note often inserted on a plan for the purpose of directing the contractor to slope a certain area in a specific direction so that runoff will flow to a designated location.

Gradient (Slope): The rate of ascent or descent, expressed as a percent or as a decimal as determined by the ratio of the change in elevation to the length.

Groundwater: Subsurface water in the saturated zone beneath the water table. Groundwater is a source of base flow in streams and is typically withdrawn in wells for human use and consumption.

Groundwater Runoff: The part of the precipitation that has infiltrated into the ground, has become groundwater, and has then been discharged into a stream channel as spring or seepage water that helps establish base flow (also see "Direct Runoff").

Head: When used as a hydraulic term, this represents the energy of the water expressed as a height of water. This is the motivating force in effecting the movement of water. Total head is the sum of the elevation head, velocity head, and the pressure head of a fluid. Elevation head is the height of water above any point or plane of reference. Velocity head is the energy due to the fluid's velocity and pressure head is the energy due to the fluid's pressure. The term head can also be used in various compound expressions, such as energy head, entrance head, friction head, static head, lost head, etc.

Headcut/Headcutting: A channel degradation associated with abrupt changes in the bed elevation that generally migrates in an upstream direction. This can come as the result of a channel readjusting to a new drainage structure and aggregated sediment remobilizing.

Headwall: A structure built at the upstream and/or downstream ends of a pipe or series of pipes to protect the ends from damage and/or erosion. In Wisconsin, they are typically constructed of concrete. They can also improve hydraulic efficiency of the pipes.

Headwater: The water surface elevation on the upstream side of a culvert providing the energy to force water through the culvert.

Hydraulic Gradient: A line which represents the rate of change in hydraulic head between different points along a flow path. In any open channel, this line corresponds to the water surface. In a closed conduit, if several openings were placed along the top of the pipe and open tubes inserted, a line connecting the water surface in each of these tubes would represent the hydraulic grade line.

Hydraulic Jump: A hydraulic phenomenon in open channel flow where supercritical flow changes to sub-critical flow. This results in an abrupt turbulent rise in the water surface elevation.

Hydraulic Mean Depth: The area of the flow cross section divided by the water surface width in an open channel.

Hydraulic Radius: Hydraulic radius is a term used in many hydraulic equations that is determined by dividing the flow area by the length of the cross section in contact with the water (wetted perimeter). The hydraulic radius is in many of the equations to help take into account the effects of the shape of the cross section on the flow and can be used to show flow efficiency. A higher hydraulic radius generally can indicate a more efficient flow, with less friction losses. The hydraulic radius for a circular pipe flowing full is equal to the diameter of the pipe divided by four (D/4). For a channel it is the cross-sectional area of the water divided by the length of channel bottom wetted at the depth of flow; the ratio of area to wetted perimeter

Hydraulic Roughness: The resistance to flow caused by friction from the physical characteristics of a flow path whether natural or channelized. Manning's Roughness, expressed as a Manning's n-value, is coefficient that takes this into account.

Hydrologic Cycle: Water movement from the atmosphere to the earth and return through various processes such as precipitation, condensation, interception, runoff, infiltration, percolation, storage, evaporation and transpiration.

Hydrologic Soils Group: A characterization of soils based on their potential to generate runoff from similar land cover under similar storm conditions. The NRCS express these as A-D ranging from lowest runoff potential to highest.

Hydrograph: A graph showing stage, flow, velocity, or other properties of water with respect to time.

Hydrology: The study of Earth's water: the scientific study of the properties, distribution, use, and circulation of the water on Earth and in the atmosphere in all of its forms. For highway designers, hydrology includes the analysis of precipitation and runoff used to determine peak flow rates and their frequency of occurrence for streams, channels, storm sewers, roadside ditches, culverts, bridges and stormwater retention and treatment facilities.

Hyetograph: Graphical representation of rainfall intensity over a specific period of time.

Incised Stream: A stream that is cutting and deepening its active channel. Often used interchangeably with entrenched stream, the stream is degrading and the floodplain terrace can sit high on the banks. This is a condition that is considered negative and is often a goal to correct in stream restoration.

Infiltration: The passage of water from the land surface into the soil.

Inlet control: Occurs when a culvert's capacity is restricted at the inlet, making it the limiting factor for the culvert's performance. In this condition, the rate of flow is controlled by the headwater elevation and the geometry of the inlet and not influenced by the barrel length, roughness, or tailwater.

Inlet Time (i.e., Time of Concentration): The time required for storm runoff to flow from the most remote point of a drainage area to the point where it enters a drain or culvert.

Intensity-Duration-Frequency (IDF): A graphical, tabular, or mathematical relation between the rainfall intensity, storm duration, and exceedance frequency.

Interception: The process of interrupting the movement of water in the hydrologic cycle; raindrops adhering to leaves and canopy.

Interstitial Flow: That portion of the surface water that infiltrates into the streambed and moves through the substrate interstitial spaces.

Invert: The elevation of the lowest point in a channel or drainage facility along which the lowest flows would travel.

Lag Time: The delay between occurrence of rainfall and peak discharge at a specific location.

Laminar Flow: That type of flow in which each particle moves in a direction parallel to every other particle (as opposed to turbulent flow).

Manning's Equation: An empirical formula for computing flow in open channels and pipes developed by Manning. It is represented as $v = (1/n)R^{2/3} S^{1/2}$, where v = velocity, n = Manning's roughness coefficient (see below), R = hydraulic radius, and S = hydraulic gradient.

Manning's n: Coefficient representing roughness in a channel or conduit used in determining velocity. It is the resistance to flow caused by friction from the physical characteristics of a flow path.

Mean Velocity: Average velocity of flow within a channel or pipe cross section.

Meander: A bend in a stream channel.

Meandering Stream: A stream having a sinuosity greater than some arbitrary value. The term also implies a moderate degree of pattern symmetry, imparted by regularity of size and repetition of meander loops. The channel generally exhibits a characteristic process of bank erosion and point bar deposition associated with systematically shifting meanders.

Median Ditch: (See Channel/Ditch, Median)

Navigable waterway: Wisconsin Department of Natural Resources (WDNR) defines this as any waterway that has a defined bed and bank, and on which it is possible to float a canoe or small watercraft at some time during the year (such as during spring runoff periods). Some, but not all, navigable waterways may be displayed on the WDNR Surface Water Data Viewer as solid or dashed blue lines. WDNR will perform navigability determinations upon request as it can influence the environmental requirements for a project if a navigable waterway is impacted.

Nonstationary: When the statistical properties of data are changing over time. In hydrologic terms it is where more recent rainfall and flooding trends are differing from the historic data and may limit or impact the use of past data to provide accurate estimates for use in design.

Normal Depth: The depth at which flow is steady and hydraulic characteristics are uniform.

Ordinary High Water Mark (OHWM):

As defined by the Wisconsin Department of Natural Resources (WDNR), the OHWM is the point on a bank or shore up to which the presence and action of water is so continuous that it leaves a distinct mark either by erosion, destruction of terrestrial vegetation, or other easily recognizable characteristics. This is not a fixed elevation, but a line identified by physical features indicating the limit of regular high water influence. It is used to define the regulatory-related water surface for a natural channel or the shore of standing water.

Orifice: An opening, typically in a structure wall or plate that is designed to control or measure water flow.

Outfall: Discharge or point of discharge from a drainage feature such as a culvert or stormwater management facility.

Outlet control: Occurs when a culvert's capacity is limited by the capacity of the barrel or the tailwater conditions. Controlling factors that influence barrel capacity include the shape, length, roughness, and slope. In this condition, the rate of flow is not controlled by the headwater elevation or the geometry of the inlet.

Peak Flow: Maximum instantaneous flow rate of a stream in a specific rainfall event or flood.

Peak Stage: Maximum instantaneous stage of a stream in a specific rainfall event or flood.

Perched Water Table: Groundwater located above the elevation of the water table and separated from it by a zone of impermeable material.

Perched Culvert: The definition of a perched culvert can vary based on the source. In the worst cases it represents a culvert where the outlet elevation sits above the downstream water surface elevation. In Wisconsin, the DNR defines a perched culvert as one where the invert is not sitting on the floor of the downstream channel. In the case of a scour hole at the outlet, it could be argued that this doesn't necessarily mean the culvert is perched. It may, however, indicate other issues such as excessive velocities from the culvert being undersized. Perched culverts are a concern as they can disrupt the aquatic connectivity of a waterway.

Permeability: The property of soils that permits the passage of any fluid. Factors that affect permeability are grain size, void ratio, shape, and arrangement of pores. Sands and gravels typically have high permeability while clay soils have low permeability.

Piping: Removal of soil material through subsurface flow of seepage water that develops channels or "pipes" within the soil bank or embankment. Piping can occur along the outside of a culvert walls and can lead to embankment failure.

Porosity: The ratio of the volume of pores in a soil to the total soil volume.

Precipitation: Rainfall, snow, sleet, fog, dew, and frost.

Precipitation, Point: Precipitation measured at a single geographic point within a given time period.

Precipitation, Area: Precipitation measured over a specific geographic area within a given time period. Examples of geographic areas can be watersheds, cities, regions, etc.

Rainfall Excess: The volume of rainfall available for direct runoff. It is equal to the total rainfall minus interception, depression storage, evapotranspiration, and absorption.

Rainfall Intensity: The amount of rainfall occurring in a unit of time, usually expressed as inches per hour.

Reach: The length of a channel uniform with respect to discharge, depth, area, and slope. More generally, any length of a stream, river, or drainage course.

Recurrence Interval: See "Return Period".

Reference Reach: A river or stream segment that represents the natural, stable channel and is used to develop crossing design criteria including bankfull width, slope, and other characteristics used in Aquatic Connectivity or stream restoration/mitigation design. It will often need to be located at a significant distance from the influence of a road-stream crossing. In some cases in heavily altered waterways the reference reach may need to be on a similar sized stream in the same area.

Regimen: The characteristic behavior of a stream during ordinary cycles of flow. Often referring to flow regimens.

Regulated Floodplain: A floodplain in which fill, encroachments, and development activities are regulated and the boundaries of which are defined by the municipality's adopted floodplain zoning maps. These maps include any floodplain on a regulatory FEMA floodplain map (Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map (FHBM)). Most regulated floodplains involve land which has been or may be covered by flood water during the 1% annual chance flood. They include a floodway and in some cases a flood fringe and may include other designated regulatory flood hazard areas zoned by the municipality such as areas downstream of dams or flood storage districts.

Resilience: In relation to drainage facilities, resilience means the ability to withstand changing and extreme conditions and recover rapidly from potential disruptions.

Return Period: Return Period is average length of time between occurrences in which the value of a random variable (e.g., flood magnitude) is equaled or exceeded. The actual time between occurrences may be longer or shorter. The return period is the inverse of the Annual Exceedance Probability (AEP). Also referred to as recurrence interval.

Riffle: A shallow flow area extending across a streambed in which the surface of flowing water is broken by waves or ripples. Typically, riffles alternate with pools along the length of a stream channel.

Riparian: Adjacent to or connected with the area along a waterway (e.g., rivers, perennial or intermittent streams, seeps or springs, ponds, lakes or bodies of open water) that contains elements of both aquatic and terrestrial ecosystems.

Road-Stream Crossing: A location where a roadway or path crosses a stream channel. This also includes crossings at intermittent streams that are dry during certain times of the year.

Roughness Coefficient: Numerical value representing the frictional resistance to flow in a channel or conduit. such as the Manning's coefficient. The most common roughness coefficient is the Manning's n coefficient which is a dimensionless parameter used in the Manning's Equation to estimate flow velocity and discharge.

Routing: The process of analyzing the change to a hydrograph as it combines with other runoff hydrographs from adjacent or downstream drainage subareas or as it flows through channels or storage basins.

Runoff: Excess precipitation from a drainage area which flows over the land surface and into surface streams of either perennial or intermittent form, or other bodies of water.

Runoff Coefficient: A dimensionless variable such as a curve number used to determine the portion of runoff resulting from a unit rainfall. Runoff coefficients are dependent on terrain, topography, slope, land use, and soil type.

Scour: Erosive removal of soil and rock from channel beds and from around hydraulic structures such as bridge piers, abutments, or costal structures, due to the velocity of flowing water. Scour may also be seen at the downstream ends of culverts or other pipe outlets when the exiting velocity is high.

Sediment Load: Amount of sediment being moved by a stream.

Shear Stress: Force per unit area of water created by its movement across a submerged surface such as a channel bed or channel bank. Determining shear stress can aid in determining the stability of a channel substrate or an erosion control measure.

Side Ditch: (See Channel/Ditch, Side)

Sinuosity: Ratio between the thalweg length and the valley length (straight line length) of a stream. It is a measure of the extent of meanders in a stream. A higher value indicates a more winding or meandering stream.

Skew: In drainage structure design, when a drainage structure is not perpendicular to the centerline of the roadway, it is said to be on a skew. The skew angle is the smallest angle between the perpendicular line and the axis of the structure. Bridges or culverts may be placed on a skew to minimize disruption to the normal flow path of the stream or river.

Slope: Refers to the steepness or incline/decline of two points on a line and is typically expressed as a ratio, percentage, or decimal. Slope can be used to describe the gradient of a streambed or land surface. It represents the difference of the vertical change (rise) to the horizontal change (run).

Specific Energy: The energy of a stream relative to the channel bed, calculated as the sum of the flow depth (potential energy) and the velocity head (kinetic energy) based on the mean velocity.

Spillway, emergency: A constructed channel area to allow floodwaters to safely be released from a designed detention pond or dam. Typically, this channel area will be a trapezoidal shape with its invert slightly above the required design storm event elevation in a pond. For example, if the design 100-year water surface elevation in a pond is 898.74 feet, the invert of the emergency spillway may be at 899.0 feet, and the remaining berm area may be 2 feet higher than the spillway invert to contain the overflow.

Spread: The lateral distance, in feet, of roadway ponding from the curb. This accumulation or flow of water can present an interruption to traffic flow and potential safety concern during rainstorms.

Stage: The elevation of a water surface above an established datum or reference point. Also referred to as gage height.

Stage-Storage Curve: A graph showing the relation between the surface elevation of the water (or gage height) in a storage reservoir, usually plotted as the ordinate, against the volume below that elevation (typically expressed as acre-ft or cubic feet), plotted as the abscissa.

Stage-Discharge Curve (rating curve):

A graph showing the relation between the surface elevation of the water (or gage height), usually plotted as the ordinate, and the amount of water flowing in a channel or from a point of discharge, expressed as volume per unit of time (typically expressed as cubic-feet per second or cfs), plotted as the abscissa.

Stationarity: When the statistical properties of data largely do not change over time. In hydrologic terms it is where more recent rainfall and flooding trends do not prevent historic data from being used to provide estimates, such as rainfall depth or peak flows, for use in design. Historically most rainfall and flood data assumed stationarity but increasing this may not be a reliable assumption.

Steady Flow: In steady flow, the flow velocity at a point or cross section does not change with time. The local acceleration is zero.

Storage: Containment of water on a temporary or long-term basis. Natural storage can occur in rivers, wetlands, lakes, oceans, groundwater, or in low-lying areas (depressional storage). Artificial storage includes detention ponds, underground stormwater storage facilities, reservoirs, and diversion channels.

Storage Basin: An area used for containment of water on a temporary or long-term basis. See "Storage" above for examples.

Stream:

Perennial: A stream that flows continuously under normal precipitation conditions.

Intermittent or Seasonal:

A stream that is often dry and flows only at certain times of the year. Flow is dependent on groundwater input, precipitation runoff or snowmelt.

Ephemeral: A stream or reach of stream that does not flow for parts of the year. As used here, the term includes intermittent streams with flow less than perennial. Typically, an Ephemeral stream only flows in direct response to a precipitation event and the streambed is located above the groundwater table.

Stream Crossing: A location where infrastructure (roadway, railroad, pipeline, etc.) crosses a stream channel. This includes crossings at intermittent streams that are dry during certain times of the year. For a road or path crossing the term “Road-Stream Crossing” is utilized in this Chapter.

Stream Gaging: The process of measuring the depths, areas, velocities, and rates of flow in natural or artificial channels.

Stream Gaging Station: A structure installed beside a stream or river that contains equipment that measures and records the water level (called gage height or stage) of the stream. Streamflow is then computed from the gage height measurements using a site-specific stage-discharge rating curve. Stage-discharge rating curves for gaging stations are developed from water level and streamflow measurements obtained in the field.

Subcritical Flow: Flow with a velocity head less than half the hydraulic mean depth of water. Froude number is less than 1 for subcritical flow. This flow can typically be described as slow moving (low velocity) deep water with a mild channel slope.

Supercritical Flow: Flow with a velocity head more than half the hydraulic mean depth of the water. Froude number is greater than 1 for supercritical flow. This flow can typically be described as fast moving (high velocity) shallow water with a steep channel slope.

Surface Runoff: Water that flows over the land’s surface after a precipitation or snowmelt event. This can be sheet flow over a large area, or concentrated flow in ditches, streams, rivers or collected by storm sewers.

Tailwater: The depth of water on the downstream side of a hydraulic structure outfall measured from the outlet invert.

Thalweg: The flow path of the deepest portion of a stream channel. It will often transition from the outside of one stream bend to the next.

Time of Concentration: The time required for storm runoff to flow from the most hydraulically distant point of a drainage area to the point under consideration. It is considered to be the time required for the entire watershed to contribute flow when calculating the peak flow for the watershed. The time of concentration is typically calculated as the sum of three types of flow through the watershed; sheet flow, shallow concentrated flow, and channel flow. Flow times are influenced by topography (slope), soil properties, surface roughness, and land uses.

Trash Rack: A device used to capture floating debris before it enters a drainage facility where it is harder to remove. Trash racks help maintain flow by preventing clogs in drainage systems.

Trunk (or Trunk Line): In a roadway drainage system, the main conduit for transporting the storm waters to the point of discharge. The trunk line is typically larger and deeper than the lateral lines that feed into it. Lateral lines typically consist of smaller pipes that connect inlets or catch basins to the main trunk line but can include smaller pipes from side roads as well.

Turbulent Flow: That type of flow in which any particle may move in any direction with respect to any other particle (as opposed to Laminar Flow). Particles move along chaotic irregular paths and can result in the observance of eddies or swirls which cause a high rate of mixing.

Underdrain: An underground system of perforated pipes, typically made of plastic, installed in trenches surrounded by filter fabric and crushed stone. Underdrains are installed under pavement, behind retaining walls, under building foundations, or in stormwater filtration devices used to collect and remove excess subsurface water.

Uniform Flow: Flow of constant depth, cross sectional area, velocity and discharge through a reach of channel at a given time. The slope of the energy grade line and the water surface are equal to the channel bed slope under conditions of uniform flow. The depth of flow under uniform flow conditions is referred to as “normal depth.”

Unsteady Flow: In unsteady flow, the flow, velocity, depth/pressure, and density of water at a point or cross section change over time. Opposite of steady flow.

Velocity Head: A term used in hydraulics to represent the kinetic energy of flowing water. This "head" is represented by a height of standing water that represents the kinetic energy of the moving water calculated as $V^2/2g$, where "V" represents velocity in feet per second and "g" represents potential acceleration due to gravity in feet per second per second (32.2 ft/s^2). Velocity head is a portion of total head.

Watershed: The land surface area drained by a specific stream or stream system. See also “Drainage Area”.

Water Year: The 12-month period from October 1 through September 30, with the water year taken as the calendar year of the January 1 to September 30 period. For example, the year ending September 30, 2025 is called the "2025 water year.".

Weir: A dam across a channel, or in a drainage structure or facility, that diverts, controls, or measures the flow.

Wet pond (Wet detention basin):

A stormwater facility used to control peak flows during storm events by temporarily storing stormwater runoff. A wet pond has a permanent designed water surface elevation year round to promote pollutant removal by sedimentation. Opposite of dry pond.

Wetted Perimeter: The total length of a channel or culvert cross section that is in contact with flowing water at a specific cross section, normal to the flow direction. In a channel this measurement includes the length of the bed and both banks in contact with the water and does not include the top of the water surface.

Alternate --------------------- **Schedule No.** --------------------- **District No.** ---------------------

Project No. --------------------- **County** --------------------- **Designer** ---------------------

Name of Road --------------------- **Hwy.** ---------------------

Design Frequency --------------------- **Date** ---------------------

Major Drainage Summary Sheet

Input						**Output**			**Remarks**
Sat. or Loc.	Drainage Area (Acres)	Chief Land Use or Cover	Description of Terrain	Head-Water Allow-able	Existing Facility Size & Type	Design Dis-charge	Proposed Facility Size & Type	Cost	Remarks Special Limita-tion, Channel Changes

Sample Stormwater-Drainage-WQ Report Spreadsheet: Drainage-Summary Worksheet
Download a zipped working copy of the spreadsheets at:
http://wisconsindot.gov/rdwy/fdm/files/WisDOT-Stormwater-Drainage-WQ-Channel-Spreadsheets.zip

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1 Basic Project Information

2	Project ID: XXXX-XX-XX
3	Title: Example Project
4	Designer/Checker:
5	DOT Region/Firm Name:
6	Date:

7	HIGHWAY:	
8	LIMITS:	
9	COUNTY:	
10	DESCRIPTION OF WORK:	
11	PROJECT MANAGER:	
12	PS&E DATE:	
13	DESIGN STAGE	☐ Planning ☐ 30% ☐ 60% ☐ 90% ☐ Final

14 ***Drainage Summary***

15 IS THERE A SIGNIFICANT FLOW INCREASE OR DECREASE WITHIN ANY SUB BASIN OF THE PROJECT? IF YES, DESCRIBE THE CAUSE OF THE CHANGE AND WHY IT IS NECESSARY.

16

17 IS THERE A SIGNIFICANT IMPERVIOUS AREA CHANGE TO ANY SUB BASIN OF THE PROJECT? IF YES, DESCRIBE THE CAUSE OF THE CHANGE AND WHY IT IS NECESSARY.

18

19 HAVE THE DRAINAGE SUB BASIN AREAS OR FLOW PATHS CHANGED SIGNIFICANTLY? IF YES, DESCRIBE THE CAUSE OF THE CHANGE AND WHY IT IS NECESSARY.

20

21 DESCRIBE THE PROPOSED DRAINAGE CONVEYANCE AND CONTROL SYSTEMS FOR THE PROJECT.

22

23 DESCRIBE THE AQUATIC ORGANISM PASSAGE ISSUES FOR THE PROJECT, IF ANY.

24

25 IF THE DESIGN DOES NOT MEET THE DOT FDM CHAPTER 13 DRAINAGE REQUIREMENTS, EXPLAIN HOW AND WHY.

26

27 DESCRIBE WDNR COORDINATION. PROVIDE NAME OF WDNR CONTACT AND DATE, AND ATTACH ANY CORRESPONDENCE.

28

29 IF THE DRAINAGE DESIGN MEETS LOCAL, MUNICIPAL OR REGIONAL GUIDELINES THAT EXCEED FDM CHAPTER 13 DRAINAGE REQUIREMENTS, EXPLAIN HOW AND WHY.

30

31 IF A SIGNIFICANT IMPACT TO THE PROJECT OCCURS DUE TO DRAINAGE, PROJECT MANAGER CONCURRENCE IS REQUIRED. (PM SIGN AND DATE)

32

Page 1

Sample Stormwater-Drainage-WQ Report Spreadsheet: Data Worksheet

(Use link on FDM 13-1 Attachment 10.1 to download a zipped working copy of the spreadsheets.

1	**Drainage Data**						
2	**Project ID: XXXX-XX-XX**						
3	**Title: Example Project**						
4	**Designer/Checker:**						
5	**DOT Region/Firm Name:**						
6	**Date:**						
7	**OUTFALL INFORMATION**						
8	Outfall number	**1**	**2**	**3**	**4**	**5**	**6**
9	Outfall discharges to:						
10	Waterway crossing type	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
11	If discharging to environmentally sensitive area, what kinds of buffers were used at outfall?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
12	Previous flooding issues or flow restrictions?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
13	Is the drainageway in the DOT ROW a navigable waterway?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
14	Classify the drainageway in the DOT ROW	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
15	**BASIC SUB BASIN DRAINAGE INFORMATION**						
16	Outfall number	**1**	**2**	**3**	**4**	**5**	**6**
17	Stormwater conveyance type	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
18	Outfall station						
19	Subbasin starting station						
20	Subbasin ending station						
21	Proposed roadway length (ft)	0	0	0	0	0	0
22	Flow conveyance change						
23	Flood design frequency (yrs)						
24	Check design frequency (yrs)						
25	Is the check design storm safely passed?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
26	DOT right-of-way area (acres)						
27	Subbasin drainage area (acres)						
28	DOT right-of-way compared to subbasin drainage area (%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
29	DOT impervious area - existing (acres)						
30	DOT impervious area - proposed (acres)						
31	Change in impervious area (acres)	0	0	0	0	0	0
32	Percent change in DOT impervious area	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
33	Design software used						
34	Method used to estimate peak flows						
35	*Complete lines 36-46 for culverts only*						
36	Existing peak flow (cfs)						
37	Proposed peak flow (cfs) (before detention)						
38	Proposed peak flow (cfs) (after detention/in-line storage/other)						
39	Change in peak flow (cfs)	0	0	0	0	0	0
40	Percent change in peak flow	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
41	Existing 2-yr peak flow (cfs)						
42	Proposed 2-yr peak flow (cfs) (before detention)						
43	Proposed 2-yr peak flow (cfs) (after detention/in-line storage/other)						
44	Change in 2-yr peak flow (cfs)	0	0	0	0	0	0
45	Percent change in 2-yr peak flow	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
46	Existing Tc (min)						
47	Proposed Tc (min)						
48	C or CN (existing)						
49	C or CN (proposed)						
50	Rainfall intensity (in/hr) (rational method only)						
51	Rainfall depth used for design storm, if applicable (in)						

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52	**CULVERT DESIGN**						
53	**Existing Culvert**						
54	Outfall number	1	2	3	4	5	6
55	Culvert present? (Yes or No)	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
56	Existing culvert shape	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
57	Existing culvert material	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
58	Existing culvert size (ft)						
59	Existing number of culverts						
60	Existing Manning's n						
61	Inlet entrance type	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
62	Inlet loss coefficient (Ke)						
63	Upstream invert (ft)						
64	Downstream invert (ft)						
65	Length (ft)						
66	Slope (%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
67	**Floodplain Management**						
68	Is culvert in a mapped floodplain?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
69	Will proposed culvert increase water surface profile?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
70	**Drainage District Issues**						
71	Is culvert in a drainage district?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
72	Drainage District Name						
73	Will proposed culvert raise the culvert invert or increase water surface profile?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
74	Has drainage board approved increases?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
75	**Aquatic Organism Passage**						
76	Is aquatic organism passage a concern?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
77	Does WDNR agree with AOP design?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
78	**Proposed Culvert Design**						
79	Design ADT						
80	Design flow						
81	Design year frequency						
82	Hydrological method used						
83	Assumed tailwater condition						
84	Maximum allowable headwater						
85	Maximum allowable headwater design criteria	DDMenu	DDMenu	DDMenu	DDMenu	DDMenu	DDMenu
86	Proposed culvert shape	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
87	Proposed culvert material	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
88	Proposed culvert size						
89	Proposed number of culverts						
90	Manning's n						
91	Type of endwalls	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
92	Inlet loss coefficient (Ke)						
93	Proposed upstream invert (ft)						
94	Proposed downstream invert (ft)						
95	Proposed length (ft)						
96	Proposed slope (%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
97	Embedment depth (ft)						
98	Embedment material						
99	Discharge velocity (ft/s)						
100	Riprap outfall (Size riprap or None)						
101	Station of lowest subgrade shoulder point in subbasin (0+00)						
102	Elevation of lowest subgrade shoulder point in subbasin (ft)						
103	Headwater distance below subgrade shoulder point (ft)						
104	Headwater to pipe diameter ratio						
105	Design software used						
106	Proposed tailwater condition						
107	Discharge pipe end submerged?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
108	Assumed tailwater elevation (ft)						

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109	**CULVERT LINER DESIGN**						
110	**Existing Culvert**						
111	Outfall number	**1**	**2**	**3**	**4**	**5**	**6**
112	Does WDNR agree with use the of a liner?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
113	Existing culvert size (ft)						
114	Pipe material						
115	Pipe condition						
116	Any collapse?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
117	Any deflection?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
118	Are ends crushed?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
119	*n* value existing pipe						
120	Pipe geometry (i.e. circular)	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
121	Pipe inlet invert elevation (ft)						
122	Pipe outlet invert elevation (ft)						
123	Length (ft)						
124	Slope (%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
125	Depth of cover over culvert (ft)						
126	Is overtopping an issue?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
127	Are there hydraulically sensitive structures or property up-stream that could be flooded if water surface profile is increased?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
128	If existing culvert diameter > 48", hydraulic design is required. Has this been done?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
129	Are any of the culverts greater than 48" in diameter?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
130	Field verify dimension?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
131	**Floodplain Management**						
132	Is culvert in a mapped floodplain?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
133	Will proposed liner increase water surface profile?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
134	**Drainage District Issues**						
135	Is culvert in a drainage district?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
136	Drainage District Name						
137	Has drainage board approved use of a liner?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
138	**Aquatic Organism Passage**						
139	Is aquatic organism passage a concern?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
140	Does WDNR agree with AOP design?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu

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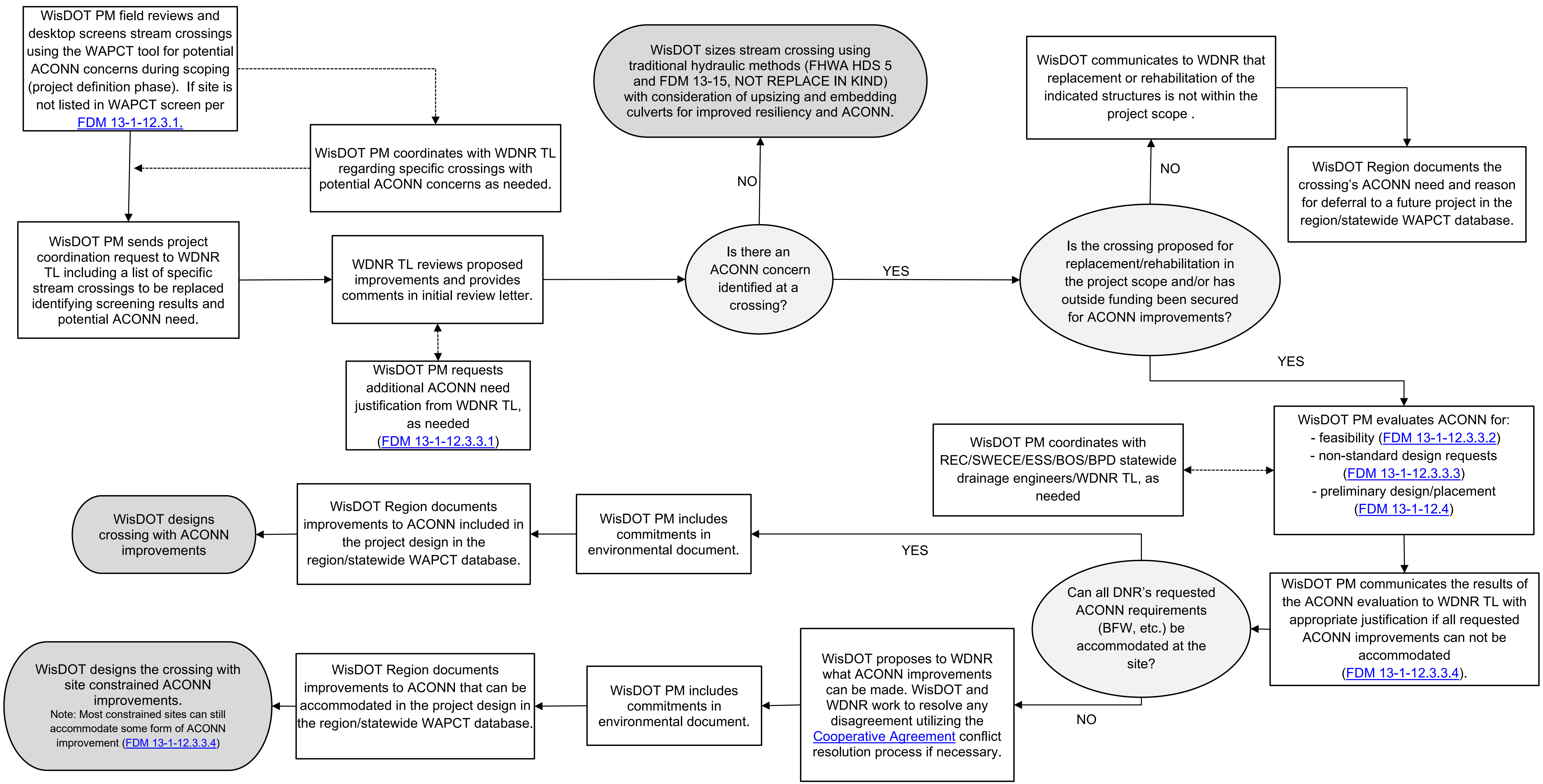
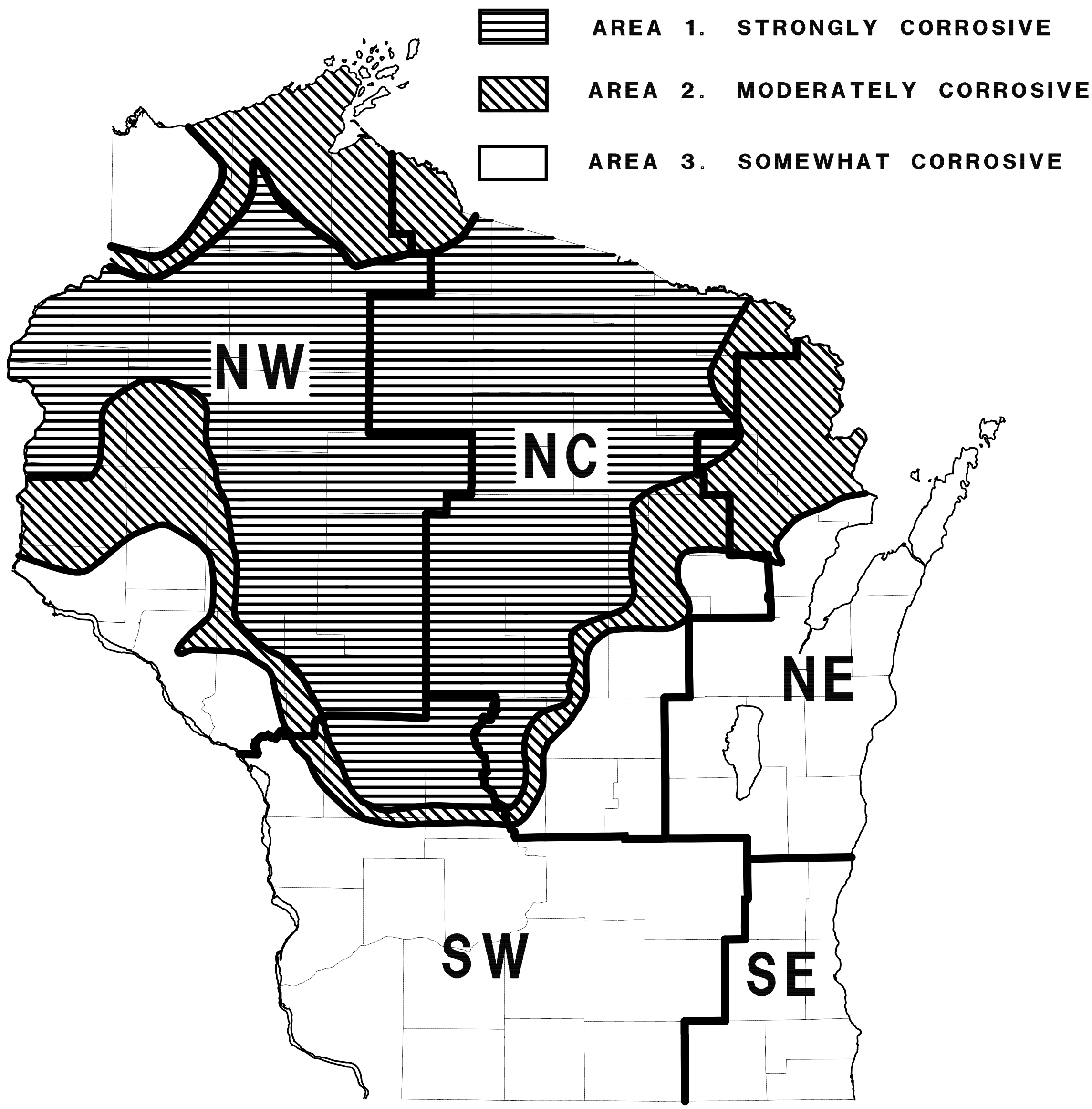
AQUATIC CONNECTIVITY COORDINATION PROCESS



ACONN – Aquatic connectivity
BFW – Bank Full Width
BPD – Bureau of Project Development
BOS – Bureau of Structures
ESS – Environmental Services Section
PM – Project Manager
REC – Region Environmental Coordinator
SWECE – Stormwater Erosion Control Engineer
TL – Transportation Liaison
WACPT – WisDOT Aquatic Connectivity Project Tracking

POTENTIAL FOR BACTERIAL CORROSION OF ZINC GALVANIZED STEEL CULVERT PIPE



INDIVIDUAL SITES IN AREA 3 MAY BE STRONGLY TO MODERATELY CORROSIVE DUE TO LOCAL CONDITIONS SUCH AS FARM RUNOFF, ANAEROBIC BACTERIA IN THE SOIL, ETC.

STORM SEWER - FILL HEIGHT TABLE FOR CONCRETE PIPE

Type/Class of Pipe	AASHTO Materials Designation	Pipe Size I.D. (inches)	Maximum Height of Cover Over Top of Pipe (feet)
Reinforced Concrete Class II	M 170	12- 108	11
Reinforced Concrete Class III	M 170	12- 108	15
Reinforced Concrete Class IV	M 170	12- 84	25
Reinforced Concrete Class V	M 170	12- 72	35

Surface Loadings

The minimum concrete pipe class required based on depth to subgrade is as follows:

Depth of Subgrade Cover (feet)	0 to 2	2 to 3	3 to 6
Minimum Class of Concrete Pipe Required	IV	III	II

The desired minimum cover is 2 feet below subgrade. Where less than two feet of cover is provided special measures may be required during construction to minimize equipment loading impacts on the pipe. At a minimum, locations with reduced subgrade cover should be identified on the plans so that the contractor can take precautionary measures.

Design Criteria

The above table refers to Class C bedding using sand/gravel backfill weighing 120 lb/ft^3 with zero projecting embankment condition and trench widths as specified Standard Spec 608.

FILL HEIGHT TABLE 1

Corrugated Steel, Aluminum, Polyethylene, Polypropylene and Reinforced Concrete Pipe

HS20 Loading 2" x 2/3" Corrugations - Standard Specification Bedding Unless Otherwise Noted

		Height of Cover Over Top Pipe in Feet - "H"																	
		Min. to 15' **(2)**			16' to 20'			21' to 25'			26' to 30'			31' to 35'			36' to 40'		
Dia. In. **(5)**	Area S.F.	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe
		Steel	Alum		Steel	Alum		Steel	Alum		Steel	Alum		Steel	Alum		Steel	Alum	
12 *	0.8	0.064	0.060	III	0.064	0.060	IV	0.064	0.060	IV	0.064	0.060	V	0.064	0.060	V	0.064	0.075	V **(4)**
15 *	1.2	0.064	0.060	III	0.064	0.060	IV	0.064	0.060	IV	0.064	0.060	V	0.064	0.075	V	0.064	0.105	V **(4)**
18 *	1.8	0.064	0.060	III	0.064	0.060	IV	0.064	0.060	IV	0.064	0.075	V	0.064	0.105	V	0.064	0.135	V **(4)**
21 *	2.4	0.064	0.060	III	0.064	0.060	IV	0.064	0.075	IV	0.064	0.105	V	0.064	0.135	V	0.079	X	V **(4)**
24 *	3.1	0.064	0.075	III	0.064	0.075	IV	0.079	0.075	IV	0.079	0.105	V	0.079	0.164	V	0.079	X	V **(4)**
30 *	4.9	0.079	0.075	III	0.079	0.075	IV	0.079	0.105	IV	0.079	0.135	V	0.109	X	V	0.109	X	V **(4)**
36 *	7.1	0.079	0.105	III	0.079	0.105	IV	0.109	0.135	IV	0.109	0.164	V	0.138	X	V	0.138	X	V **(4)**
42	9.6	0.109	0.105	III	0.109	0.135	IV	0.109	0.164	IV	0.138	0.164	V	0.138	X	V	0.168	X	V **(4)**
48	12.6	0.109	0.105	III	0.109	0.135	IV	0.138	0.164	IV	0.168	X	V	0.168	X	V	0.138 E	X	V **(4)**
54	15.9	0.109	0.105	III	0.138	0.135	IV	0.168	0.164	IV	0.168	X	V	0.109 E	X	V	0.138 E	X	V **(4)**
60	19.6	0.138	0.164	III	0.138	X	IV	0.168	X	IV	0.138 E	X	V	0.138 E	X	V	0.168 E	X	V **(4)**
66	23.8	0.138	0.164	III	0.168	X	IV	0.168	X	IV	0.138 E	X	V	0.138 E	X	V	0.168 E	X	V **(4)**
72	28.3	0.138**(3)**	0.164	III	0.168	X	IV	0.168	X	IV	0.138 E	X	V						
78	33.2	0.168	X	III	0.168	X	IV	0.168 E	X	IV	**(1)**								
84	38.5	0.168	X	III	0.168	X	IV												

E = Elongated, Vertical Axis 5% greater than Horizontal.

(1) Any pipe under the heavy line will require a special design.

(2) 12" minimum cover, top of pipe to top of subgrade for steel, aluminum and concrete. 24" required minimum cover for Class IIIA and IIIB pipe under Standard Spec 520 or 608, or as polyethylene and polypropylene pipe under Standard Spec 530.

(3) A thickness of 0.138" may be used for fill heights of minimum to 10 Ft. a thickness of 0.168" may be used for fill heights of greater than 10 Ft. but less than 26 feet.

(4) Class "B" Bedding required.

NOTE: For steel and aluminum pipe in the shaded portion of the table (>60 in. dia.), a corrugation size of 3" by 1" is generally more economical than 2 2/3" by 1/2". See Tables 2 and 7.

X = Do not use

(5) For corrugated steel pipe in a 6", 8", or 10" diameter, the minimum thickness is 0.052" and 0.064" respectively.
For corrugated aluminum pipe in 6", 8" or 10" diameter, the minimum thickness is 0.048", 0.048" and 0.06" respectively.

* Corrugated polyethylene and corrugated polypropylene pipe in these diameters are available for use under the Class III-A and Class III-B bid items as specified in FDM 13-1-15 and FDM 13-1-17. Minimum fill height shall be 24 inches and maximum fill height shall be 11 feet for polyethylene (Class III-A) and 15 feet for polypropylene (Class III-B). It is not necessary to specify thickness for polyethylene or polypropylene pipe.

FILL HEIGHT TABLE 2 (1)
Corrugated Steel Pipe - 3" x 1" Corrugations - H20 Live Load

Pipe Dia. In.	Waterway Area Sq. Ft.	Min. Cover In. (3)	Maximum Height of Fill - Ft.				
			Metal Thickness in Inches (2)				
			0.064	0.079	0.109	0.138	0.168
60	19.6	12	24	30	44	53	58
66	23.8	12	22	27	40	48	53
72	28.3	12	20	25	37	44	49
78	33.2	12	18	23	34	40	45
84	38.5	12	17	22	32	37	42
90	44.2	12	16	20	29	35	39
96	50.3	12	X	19	28	33	37
102	56.7	24	X	17	26	31	34
108	63.6	24	X	X	24	29	32
114	70.9	24	X	X	23	27	31
120	78.5	24	X	X	X	26	29

FILL HEIGHT TABLE 3 (1)
Structural Plate Pipe 6" x 2" Corrugations - H20 Live Load

Pipe Dia. In.	Waterway Area Sq. Ft.	Min. Cover In. (3)	Maximum Height of Fill - Ft. (4)						
			Metal Thickness in Inches (2)						
			0.10	0.138	0.168	0.188	0.218	0.249	0.280
60	19.6	12	35	51	67	77	87 (93)	96 (110)	106 (120)
72	28.3	12	29	43	54	57 (64)	62 (77)	67 (91)	73 (100)
84	38.5	12	25	36	44	46 (55)	49 (66)	53 (78)	56 (85)
96	50.3	12	22	32	39	40 (48)	42 (58)	44 (68)	47 (75)
102	56.7	24	20	30	37	38	40 (55)	42 (64)	43 (70)
108	63.6	24	19	28	35	36	38 (52)	39 (61)	41 (66)
120	78.5	24	17	25	33	34	35 (46)	36 (55)	37 (60)
132	95.0	24	16	23	30	32	33 (42)	34 (50)	35 (54)
144	113.1	24	14	21	28	31	32	32 (45)	33 (50)
156	132.7	24	13	19	25	29	31	31 (42)	32 (46)
168	153.9	24	12	18	24	27	30	31	31 (42)
180	176.7	24	11	17	22	25	30	30	30 (40)

(1) Table 2 is valid for 5” x 1” corrugations which may be used in lieu of 3" x 1" corrugations for fill heights to 30 feet.
(2) The steel thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified.
(3) Minimum cover top of pipe to top of subgrade.
(4) Maximum fill heights shown in parentheses are permitted if the pipe is elongated - Vertical axis 5% greater than the horizontal axis.
NOTE: Corrugated steel pipe (CSCP) is normally more economical to use than structural plate pipe (SPP) for installations where either type will satisfy fill height requirements. The potential cost savings of the CSCP is possible because CSCP is factory assembled into transportable lengths whereas SPP must be field assembled from plates.

FILL HEIGHT TABLE 4
Corrugated Steel Pipe Arch - 2" x 1/2" Corrugations - H20 Live Load

Size: Span x Rise (Inches)	Min. Thickness In. (1)	Min. Cover In. (2)	Max. Height of Fill Ft. (3)	Waterway Area Sq. Ft.	Round Pipe of Equal Periphery	
					Waterway Area Sq. Ft.	Dia. Inches
17 X 13	0.064	18	13	1.1	1.23	15
21 x 15	0.064	18	12	1.6	1.77	18
24 x 18	0.064	18	10	2.2	2.41	21
28 x 20	0.064	18	9	2.8	3.14	24
35 x 24	0.079	18	9	4.4	4.91	30
42 x 29	0.079	18	7	6.4	7.07	36
49 x 33	0.109	18	7	8.7	9.62	42
57 x 38	0.109	18	7	11.4	12.57	48
64 x 43	0.109	18	7	14.3	15.90	54
71 x 47	0.138	18	7	17.6	19.64	60
77 x 52	0.168	18	7	21.3	23.76	66
83 x 57	0.168	18	8	25.3	28.27	72

FILL HEIGHT TABLE 5
Corrugated Steel Pipe Arch (4) - 3" x 1" Corrugations - H20 Live Load

Size: Span x Rise (Inches)	Min. Thickness In. (1)	Min. Cover In. (2)	Max. Height of Fill Ft. (3)	Waterway Area Sq. Ft.	Round Pipe of Equal Periphery	
					Waterway Area Sq. Ft.	Dia. Inches
40 x 31	0.064	18	12	6.4	7.07	36
46 x 36	0.064	18	12	8.7	9.62	42
53 x 41	0.064	18	12	11.4	12.57	48
60 x 46	0.064	18	12	14.3	15.90	54
66 x 51	0.064	18	12	17.6	19.64	60
73 x 55	0.064	18	15	22.0	23.76	66
81 x 59	0.079	18	15	26.0	28.27	72
87 x 63	0.079	18	14	31.0	33.18	78
95 x 67	0.109	18	12	35.0	38.48	84
103 x 71	0.109	24	11	40.0	44.18	90
112 x 75	0.109	24	10	46.0	50.27	96
117 x 79	0.109	24	10	52.0	56.74	102
128 x 83	0.138	24	9	58.0	63.62	108

(1) The steel thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified.
(2) Minimum cover top of pipe to top of subgrade.
(3) Allowable fill heights are computed on the basis that corner bearing pressure will not exceed two tons per square foot.
(4) Table 5 is also valid for the metric 125 mm x 25 mm corrugation which may be used in lieu of the 3" x 1" corrugations.

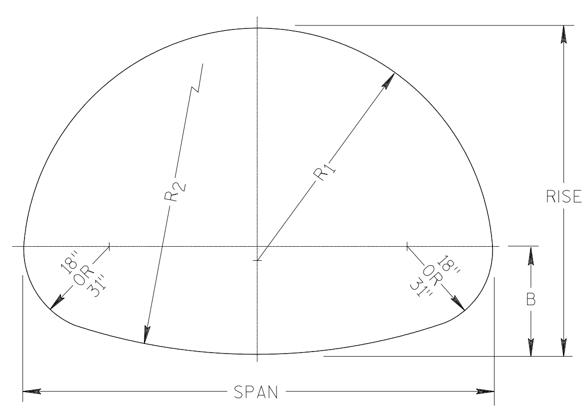
Fill Height Table 6
Structural Plate Pipe Arch - 6" x 2" Corrugations - H20 Live Load

Bid Item Number	Size	Waterway Area	Min. Thickness	Min. Cover Inches	Max. Height of	Corner Radius	Lay out Dimensions		
	Span x Rise (Ft. - Inches)	Sq. Ft.	Inches (1)	(2)	Fill Ft. (3)	Inches	B Inches	R_1 Feet	R_2 Feet
527.0305	6-1 x 4-7	22	0.109	18	15	18	21.0	3.07	6.36
527.0310	7-0 x 5-1	28			15		21.4	3.53	8.68
527.0315	8-2 x 5-9	38		24	12		20.9	4.08	15.24
527.0320	8-10 x 6-1	43			11		21.8	4.24	14.89
527.0325	9-9 x 6-7	52			10		21.9	4.86	18.98
527.0330	11-5 x 7-3	64			8		27.4	5.78	13.16
527.0335	11-10 x 7-7	71			7		25.2	5.93	18.03
527.0340	12-10 x 8-4	85			6		24.0	6.44	26.23
SPV.0090	13-3 x 9-4	97		36	13	31	38.5	6.68	16.05
SPV.0090	14-2 x 9-10	109			12		38.8	7.13	18.55
SPV.0090	15-4 x 10-4	123	0.138		11		41.8	7.76	17.38
SPV.0090	16-3 x 10-10	137			10		42.1	8.21	19.67
SPV.0090	17-2 x 11-4	151			10		42.3	8.65	22.23
SPV.0090	18-1 x 11-10	167	0.168		9		42.4	9.09	24.98
SPV.0090	19-3 x 12-4	182			8		45.9	9.75	23.22
SPV.0090	19-11 x 12-10	200			7		42.5	9.98	31.19
SPV.0090	20-7 x 13-2	211	0.188		6		43.7	10.33	31.13

(1) The metal thickness shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified at least for the bottom plates.

(2) Minimum cover top of pipe to top of subgrade.

(3) Allowable fill heights are computed on the basis that corner bearing pressure will not exceed two tons per square foot.



LAYOUT DIMENSIONS

FILL HEIGHT TABLE 7
Corrugated Aluminum Pipe 3" x 1" Corrugations - H20 Live Load

Pipe Dia. In.	Waterway Area Sq. Ft.	Min. Cover In. (2)	Maximum Height of Fill - Ft. Metal Thickness in Inches (1)				
			0.060	0.075	0.10	0.13	0.164
60	19.6	12	12	17	23	31	32
66	23.8	12	13	16	21	31	31
72	28.3	12	12	14	19	30	30
78	33.2	18	X	13	18	30	30
84	38.5	18	X	X	17	29	30
90	44.2	18	X	X	16	29	29
96	50.3	18	X	X	16	29	29
102	56.7	18	X	X	X	27	29
108	63.6	18	X	X	X	25	28
114	70.9	18	X	X	X	X	28
120	78.5	18	X	X	X	X	28

FILL HEIGHT TABLE 8
Aluminum Alloy, Structural Plate Pipe 9" x 2 1/2" Corrugations - H20 Live Load

Pipe Dia. In.	Waterway Area Sq. Ft.	Minimum Cover In. (2)	Maximum Height of Fill - Ft. Metal Thickness in Inches (1)						
			0.10	0.12	0.15	0.17	0.20	0.22	0.250
60	19.6	15	22	29	37	44	55	59	61
72	28.3	21	18	24	31	37	44	46	48
84	38.5	21	15	21	26	31	37	39	40
96	50.3	24	14	19	23	28	35	35	36
102	56.7	24	13	17	22	26	34	34	35
108	63.6	27	12	16	21	24	33	33	34
120	78.5	27	11	14	19	22	31	32	32
132	95.0	30	X	13	17	20	28	31	31
144	113.1	30	X	12	15	18	25	29	30
156	132.7	30	X	11	14	17	24	27	30
168	153.9	30	X	X	13	16	22	25	28
180	176.7	30	X	X	X	15	20	23	26

Note: X = Do not use - design strengths exceeded.

(1) The metal thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thickness should be specified.

(2) Minimum cover top of pipe to top of subgrade.

FILL HEIGHT TABLE 9
Corrugated Aluminum Pipe Arch, 2 - 2/3" X 1/2" Corrugations - H20 Live Load

Size					Round Pipe of Equal Periphery	
Span x Rise Inches	Min. Thickness In. (1)	Min. Cover In. (2)	Max. Height of Fill ft. (3)	Waterway Area Sq. Ft.	Waterway Area Sq. Ft.	Dia. Inches
17 x 13	0.060	18	12	1.1	1.23	15
21 x 15	0.060		10	1.6	1.77	18
24 x 18	0.060		8	2.2	2.41	21
28 x 20	0.075		7	2.8	3.14	24
35 x 24	0.075		6	4.4	4.91	30
42 x 29	0.105		6	6.4	7.07	36
49 x 33	0.105		5	8.7	9.62	42
57 x 38	0.135		6	11.4	12.57	48
64 x 43	0.135		6	14.3	15.90	54
71 x 47	0.164		7	17.6	19.64	60

(1) The metal thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified.

(2) Minimum cover top of pipe to top of subgrade.

(3) Allowable fill heights are computed on the basis that corner bearing pressure will not exceed two tons per square foot.

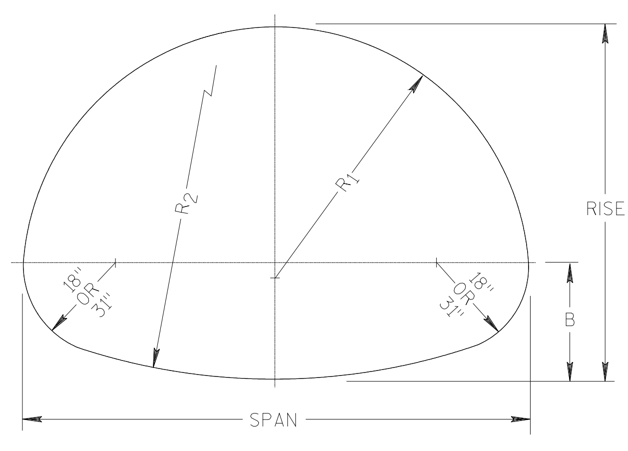
FILL HEIGHT TABLE 10
Aluminum Alloy Structural Plate Pipe Arch - 9" X 2 1/2" Corrugations - H20 Live Load

Size	Waterway Area Sq. Ft.	Min. Thickness, In. (1)	Min. Cover (2)	Max. Height of Fill (3)	Corner Radius	Layout Dimensions		
Span x Rise Ft-In						B Inches	R_1 Feet	R_2 Feet
6-2 x 5-0	25	0.100	24 Inches	18	27 Inches	27.2	3.25	24.93
6-7 x 5-8	30			16	31.8 Inches	32.5	3.46	5.82
8-1 x 6-1	39			13		33.5	4.44	9.00
8-10 x 6-4	44		30 Inches	11		35.6	5.27	7.75
9-11 x 6-8	53			10		34.2	5.53	15.72
11-5 x 7-1	64			9		35.3	6.51	18.50
12-3 x 7-3	70		36 Inches	8		38.4	7.57	13.77
13-1 x 8-4	87			8		42.0	7.40	11.97
14-0 x 8-7	94	0.125		10		39.4	7.52	17.92
14-8 x 9-8	110	0.125		10		44.0	7.57	13.85
15-7 x 10-2	123	0.150		10		44.4	8.03	15.80
16-9 x 10-8	137	0.150		10		47.9	8.75	15.52
17-9 x 11-2	152	0.175		9		48.2	9.20	17.40
18-8 x 11-8	167	0.175		8		48.5	9.65	19.44
19-10 x 12-1	183	0.225		8		52.3	10.39	18.97
20-10 x 12-7	200	0.250		8		52.5	10.83	20.93
21-6 x 12-11	211	0.250		7		53.9	11.23	21.43

(1) The metal thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified at least for the bottom plates.

(2) Minimum cover top of pipe to top of subgrade.

(3) Allowable fill heights are computed on the basis that corner bearing pressure will not exceed two tons per square foot.



LAYOUT DIMENSIONS

Dimensions for Reinforced Concrete Arch and Elliptical Pipe

	Arch			Vertical Elliptical			Horizontal Elliptical		
Equivalent Round Size (Inches)	**Rise x Span (Inches)**	**Waterway Area (Sq. Ft).**	**Minimum Wall Thickness (Inches)**	**Rise x Span (Inches)**	**Waterway Area (Sq. Ft.)**	**Minimum Wall Thickness (Inches)**	**Rise x Span (Inches)**	**Waterway Area (Sq. Ft.)**	**Minimum Wall Thickness (Inches)**
15	11 x 18	1.1	2.25						
18	13 x 22	1.6	2.5				14 x 23	1.8	2.75
21	15 x 26	2.2	2.75						
24	18 x 28	2.8	3.0				19 x 30	3.3	3.25
27							22 x 34	4.1	3.5
30	22 x 36	4.4	3.5				24 x 38	5.1	3.75
33							27 x 42	6.3	3.75
36	27 x 44	6.4	4.0	45 x 29	7.4	4.5	29 x 45	7.4	4.5
39				49 x 32	8.8	4.75	32 x 49	8.8	4.75
42	31 x 51	8.8	4.5	53 x 34	10.2	5.0	34 x 53	10.2	5.0
48	36 x 58	11.4	5.0	60 x 38	12.9	5.5	38 x 60	12.9	5.5
54	40 x 65	14.3	5.5	68 x 43	16.6	6.0	43 x 68	16.6	6.0
60	45 x 73	17.7	6.0	76 x 48	20.5	6.5	48 x 76	20.5	6.5
66				83 x 53	24.8	7.0	53 x 83	24.8	7.0
72	54 x 88	25.6	7.0	91 x 58	29.5	7.5	58 x 91	29.5	7.5
78				98 x 63	34.6	8.0	63 x 98	34.6	8.0
84	62 x 102	34.6	8.0	106 x 68	40.1	8.5	68 x 106	40.1	8.5
90	72 x 115	44.5	8.5	113 x 72	46.1	9.0	72 x 113	46.1	9.0
96	77 x 122	51.7	9.0	121 x 77	52.4	9.5	77 x 121	52.4	9.5
102				128 x 82	59.2	9.75	82 x 128	59.2	9.75
108	87 x 138	66.0	10.0	136 x 87	66.4	10.0	87 x 136	66.4	10.0
114				143 x 92	74.0	10.5	92 x 143	74.0	10.5
120	97 x 154	81.8	11.0	151 x 97	82.0	11.0	97 x 151	82.0	11.0
132	106 x 169	99.1	10.0	166 x 106	99.2	12.0	106 x 166	99.2	12.0
144				180 x 116	118.6	13.0	116 x 180	118.6	13.0

Fill Height Table 11

Reinforced Concrete Arch and Elliptical Pipe (All Sizes)

Type of Pipe	**Maximum Height of Fill - Ft.**			
	Class of Pipe (0.01" Crack D-Load)			
	Class A-III Class VE-III Class HE-III (1350 D)	**Class A-IV Class VE-IV Class HE-IV (2000 D)**	**Class VE-V (3000 D)**	*Class VE-VI* **(4000 D)**
Arch	15	25		
Vertical Elliptical	15	25	35	45
Horizontal Elliptical	15	25		

NOTES:

(1) Minimum cover excluding pavement shall be 1 ft.

(2) Fill Heights were computed assuming Class "C" bedding. If Class "B" bedding is used, increase maximum height of fill by 20%.

Materials shall conform to AASHTO designation M206 for reinforced concrete arch pipe and AASHTO designation M207 for reinforced concrete elliptical pipe. Requires special provision. Use SPV.0090 Bid Item.

Guidelines for Determining a Rural Area

The following is meant to assist in the defining a “rural area” for the purposes of “in-kind” culvert replacement. This guidance is not all inclusive. Good engineering judgement should be employed in determining rural versus urban or urbanizing areas of a project.

A Rural Area is:

A project area that is not within a defined municipal boundary, or an area where the population density averages 1000 or more persons per square mile of urban area.

- The population density must correlate to the project area. If the project area covers only part of a populated area or municipal boundary, only those culverts within those areas require full H&H analysis.
- For annually revised population estimates, refer to the Wis. Department of Administration, Division of Inter-Governmental Relation’s Website at: https://doa.wi.gov/demographics and reference the applicable population or population estimates. Other population projections may be obtained from the applicable Regional Planning Commission.

An area of the project in which the adjacent land is not used for commercial or industrial land uses.

- This includes a variety of commercial land uses such as strip commercial, office parks, shopping centers and downtown commercial.
- This classification also includes governmental, institutional, transportation and recreational uses that contain source areas (such as parking lots, streets, storage areas, large landscaped areas) generating an above average amount of rainfall runoff volumes and/or pollutant loads.

An area that is not surrounded by an area described above. Island parcels of land that are completely surrounded by urban land covers may also be considered urban, even though the existing land cover may be something else.

Culvert Sizing Quick Check

To confirm field observations, or where visual observation of a culvert is inconclusive, these tables in offer a check of culvert size for "replace in kind" structures. The tables trend towards being conservative and are intended for small watersheds typical to the maximum "replace in kind" culvert size described in this part. These tables shall not be used to size culverts requiring complete hydrology and hydraulic analysis. The tables can be used however as part of the QA/QC of the H&H drainage design.

The tables require the user to have a general idea of land cover, soil type, and watershed area. This does not have to be an extensive delineation and characterization of the watershed. Only the basic characteristics of the watershed are required. The tables assume a time of concentration based on the size of the watershed. For additional information on selection of a curve number ("C") refer to FDM 13-10-5.3 and FDM 13-10 Attachment 5.2 Runoff Coefficients (C), Rational Formula; and Runoff Coefficients for Specific Land Uses.

This check should also be only part of the evaluation of "in kind" replacement. The tables are not meant to dictate the need to increase or reduce the size of an existing culvert, they are intended as a check. Still, in the event the in-place culvert size and the tabulated size are substantially different, a full H&H analysis may be appropriate.

Typical Culvert Sizing – Western and Southwestern Wisconsin – Corrugated Metal Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	30	36	36
5-10	30	36	42	48
10-15	30	36	42	48
15-20	30	42	48	Perform H&H
20-30	36	48	Perform H&H	Perform H&H
30-40	36	48	Perform H&H	Perform H&H
40-50	42	Perform H&H	Perform H&H	Perform H&H
50-75	48	Perform H&H	Perform H&H	Perform H&H
75-100	Perform H&H	Perform H&H	Perform H&H	Perform H&H

Additional Notes:

1. Assumes 25-year storm for rural class roadway with ADT <7,000.
2. 25-year rainfall was derived from typical volumes in updated IDF curves, NOAA Atlas 14, Volume 8.
3. Time of concentration is assumed to increase and therefore design rainfall intensity decreases with drainage area size.
4. The pipes are assumed to not be completely submerged by backwater.
5. A maximum HW/D of 1.5 is assumed per FDM 13-15-5.5.
6. For culverts up to 100 feet.

Typical Culvert Sizing – Far Northwestern and Southeastern Wisconsin – Corrugated Metal Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	30	30	36
5-10	30	36	42	48
10-15	30	36	42	48
15-20	30	42	48	Perform H&H
20-30	36	48	Perform H&H	Perform H&H
30-40	36	48	Perform H&H	Perform H&H
40-50	42	48	Perform H&H	Perform H&H
50-75	48	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Typical Culvert Sizing – Northeast Wisconsin – Corrugated Metal Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	24	30	36
5-10	24	36	42	42
10-15	30	36	42	48
15-20	30	36	48	48
20-30	36	42	Perform H&H	Perform H&H
30-40	36	42	Perform H&H	Perform H&H
40-50	36	48	Perform H&H	Perform H&H
50-75	42	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Additional Notes:

1. Assumes 25-year storm for rural class roadway with ADT <7,000.
2. 25-year rainfall was derived from typical volumes in updated IDF curves, NOAA Atlas 14, Volume 8.
3. Time of concentration is assumed to increase and therefore design rainfall intensity decreases with drainage area size.
4. The pipes are assumed to not be completely submerged by backwater.
5. A maximum HW/D of 1.5 is assumed per FDM 13-15-5.5.
6. For culverts up to 100 feet.

Typical Culvert Sizing – Western and Southwestern Wisconsin – Concrete and Thermoplastic Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	24	30	36
5-10	24	36	42	48
10-15	30	36	42	48
15-20	30	36	48	Perform H&H
20-30	36	48	Perform H&H	Perform H&H
30-40	36	48	Perform H&H	Perform H&H
40-50	42	48	Perform H&H	Perform H&H
50-75	48	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Typical Culvert Sizing – Far Northwestern and Southeastern Wisconsin – Concrete and Thermoplastic Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	24	30	36
5-10	24	30	42	42
10-15	24	36	42	48
15-20	30	36	48	48
20-30	36	42	Perform H&H	Perform H&H
30-40	36	48	Perform H&H	Perform H&H
40-50	36	48	Perform H&H	Perform H&H
50-75	42	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Additional Notes:

1. Assumes 25-year storm for rural class roadway with ADT <7,000.
2. 25-year rainfall was derived from typical volumes in updated IDF curves, NOAA Atlas 14, Volume 8.
3. Time of concentration is assumed to increase and therefore design rainfall intensity decreases with drainage area size.

4. The pipes are assumed to not be completely submerged by backwater.
5. A maximum HW/D of 1.5 is assumed per FDM 13-15-5.5.
6. For culverts up to 100 feet.

Typical Culvert Sizing – Northeast Wisconsin – Concrete & Thermoplastic Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	24	30	30
5-10	24	30	36	42
10-15	24	30	42	42
15-20	30	36	42	48
20-30	30	42	48	Perform H&H
30-40	36	42	Perform H&H	Perform H&H
40-50	36	48	Perform H&H	Perform H&H
50-75	42	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Additional Notes:

1. Assumes 25-year storm for rural class roadway with ADT <7,000.
2. 25-year rainfall was derived from typical volumes in updated IDF curves, NOAA Atlas 14, Volume 8.
3. Time of concentration is assumed to increase and therefore design rainfall intensity decreases with drainage area size.
4. The pipes are assumed to not be completely submerged by backwater.
5. A maximum HW/D of 1.5 is assumed per FDM 13-15-5.5.
6. For culverts up to 100 feet.