# Chapter 14

# STORM DRAIN SYSTEMS

MONTANA
Department of Transportation

*HYDRAULICS MANUAL*

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# Chapter 14
# STORM DRAIN SYSTEMS

## 14.1 INTRODUCTION

This chapter provides guidance for all elements of storm drain design — system planning, pavement drainage, gutter flow calculations, inlet spacing, pipe sizing, hydraulic grade line calculations, maintenance, and control of runoff from future development. The design procedures for storm drain design and analysis are based on HEC 22 (1). Stormwater storage facilities are designed using the practices and procedures in Chapter 15, "Storage Facilities."

The following summarizes the chapter guidance on storm drain design:

- Introduction (Section 14.1);
- MDT design practice (Section 14.2);
- Design criteria (Section 14.3);
- Design guidelines (preliminary layout) (Section 14.4);
- Design guidelines (inlets) (Section 14.5);
- Design guidelines (storm drains) (Section 14.6);
- Design guidelines (pump stations) (Section 14.7);
- Design procedure (Section 14.8);
- Documentation (Section 14.9);
- References (Section 14.10); and
- Storm Drain Recommendation and Report Templates (Appendix 14A).

### 14.1.1 Overview

A storm drain is defined as a system that receives runoff from inlets and conveys the runoff to some point where it is discharged into a channel, waterbody, or piped system.

Storm drain facilities should be designed to consider the potential for damage to adjacent property and to secure a degree of risk for traffic interruption by flooding that is consistent with the importance of the roadway.

Some communities have adopted Storm Water Design Manuals or Master Plans. When designing in these communities, the local criteria should be considered in addition to MDT criteria.

### 14.1.2 Definitions of Terms

The following definitions are important in storm drain analysis and design. The definitions will be used throughout this chapter to address different aspects of storm drain analysis:

1. Bypass. Carryover flow that bypasses an inlet on grade and is carried in the street or channel to the next inlet downgrade. Inlets can be designed to allow a certain amount of bypass for one design storm and larger or smaller amounts for other storms.

2. Curb Inlet. A drainage inlet composed of a curb-opening inlet and a grate inlet.

3. Composite Gutter. A gutter section with a cross slope steeper than the adjacent pavement.

4. Crown. The inside top of a pipe.

5. Curb Opening. An opening in the roadway curb.

6. Drop Inlet. A drainage inlet consisting of a grate that is placed in the flowline of a gutter, ditch, or valley gutter.

7. Equivalent Cross Slope. An imaginary straight cross slope having conveyance capacity equal to that of the given compound cross slope.

8. Flanking Inlets. Inlets placed upstream and on either side of an inlet at the low point in a sag vertical curve. These inlets limit the spread of water onto the roadway, intercept debris as the slope decreases, and act in relief of the inlet at the low point.

9. Frontal Flow. The portion of the flow that passes over the upstream side of an inlet grate.

10. Grate Perimeter. The sum of the lengths of all sides of an inlet grate, except that any side adjacent to a curb is not considered a part of the perimeter in weir-flow computations.

11. Gutter. That portion of the roadway section adjacent to the curb used to convey stormwater runoff.

12. Hydraulic Grade Line. A line joining the elevations to which the water would rise in successive piezometer tubes if the tubes were installed along a pipe run (a closed conduit). It is equal to the pressure head plus the elevation head. It is also equal to the energy grade line minus the velocity head. In an open conduit (e.g., stream, channel, river), the hydraulic grade line is the water surface profile.

13. Inlet Apron. A concrete feature that is constructed around an inlet grate when the grate extends beyond the gutter. The inlet apron provides a transition from the pavement slope to the grate. The inlet apron also improves the efficiency of the inlet.

14. Inlet Efficiency. The ratio of flow intercepted by an inlet to total flow.

15. Inlet Sump. Additional depth in an inlet below the pipe inverts to capture sediment.

16. Invert. The inside bottom of the pipe, manhole, or inlet.

17. Lateral. A pipe that connects inlets to the trunk line. It is a tributary to the trunk line.

18. Pressure Head. The height of a column of water that would exert a unit pressure equal to the pressure of the water.

19. Sag Point. A low point in a vertical curve.

20. Side-Flow. Flow that is along the side of a grate inlet, as opposed to frontal interception.

21. Spill Curb. A curb and gutter that do not collect water and spill to the adjacent roadway. Spill curbs are used around medians where the curb and gutter is located near the crown of the roadway.

22. Storm Drain. A closed or open conduit that conveys stormwater that has been collected by inlets to an adequate outfall. It generally consists of inlets, laterals, trunk lines, and an outfall.

23. Splash-Over. That portion of frontal flow at a grate that skips or splashes over the grate and is not intercepted.

24. Spread Width. The width of stormwater flowing along a gutter and/or street measured laterally from the roadway curb.

25. Trunk Line. The main storm drain line. Lateral lines may be connected at inlet structures, manholes, or with pipe tees.

26. Velocity Head. A quantity proportional to the kinetic energy of flowing water expressed as a height or head of water ($V^2/2g$).

### 14.1.3 Coordination with Road Design Section

The storm drain design is an iterative process between the roadway designer and the hydraulic engineer to establish a storm drain system that functions properly with the roadway grades, cross slopes, flow lines, and ADA features.

The hydraulic engineer is responsible for all work related to the hydraulic design of the storm drain system, including but not limited to:

- Flow calculations in the system,
- Pipe size and material (including optional material),
- Spacing, location, and type of inlets,
- Pipe slopes, and
- Outfall location and design.

In preliminary design, the roadway designer presents the proposed roadway design to the Hydraulics Section documenting, for example, pavement widths, cross slopes, longitudinal grades, and the location of intersecting roads and approaches, based on the criteria from the MDT *Roadway Design Manual*. The hydraulic engineer then recommends the locations and finished grade elevations at manholes and drop inlets, ensures that the trunk line and laterals have adequate cover, and identifies conflicts with existing utilities. At the end of prelimnary design, the hydraulic engineer also coordinates with the Utilities Section to request a Subsurface Utility Engineering Phase II (SUE Phase II) survey regarding utilities crossing the proposed storm drain system.

In final design, close coordination between the roadway designer and hydraulics is necessary to determine the exact location of inlets to ensure that the inlets are located at low spots and to avoid conflicts with utilities, curb ramps, etc. The roadway designer also calculates the quantities for the storm drain system.

For exisitng systems or ADA upgrade projects, the hydraulic engineer determines if existing storm drain inlets should be relocated or if new inlets or other drainage features are required to maintain roadway drainage.

## 14.2 MDT DESIGN PRACTICE

### 14.2.1 Storm Drain

MDT's storm drain design practice is to ensure that MDT funding is used for highway improvements and not for drainage systems that do not benefit the state highway system. The Department recognizes the desirability of and need for storm drain systems in cities and other built-up areas but, because of limited highway funding as compared to the vast needs, the non-highway portion of storm drain systems must be funded from other sources.

It is MDT's design practice to incorporate drainage facilities into highway construction projects to accommodate existing runoff and anticipated runoff resulting from future development of the highway system. These facilities shall be commensurate with the scope of work, available funding, and potential risks. In evaluating these facilities, consideration shall be given to potential maintenance problems, roadway stability, safety and convenience of the roadway user, and flood hazard potential for the highway and adjacent property.

When a highway project is proposed through an area with an existing storm drain system that has sufficient capacity to accommodate flow from the project, upgrades, adjustments, and improvements to the inlets and storm drain may be considered as part of the project, provided that the owner of the drainage system will allow the necessary revisions.

When a highway project is proposed in an area that has surface drainage or inadequate underground facilities, a new storm drain system may be designed and constructed as part of the project if the contributing drainage area is limited to the highway corridor. If there is a non-highway area contributing to the storm drain system, the city or county should share in the cost proportional to its portion of the estimated flows. Allowances can be made for existing and future surface runoff that naturally enters the highway right-of-way and which would require drainage features.

When a city or other local governing body desires to provide a storm drain system at approximately the same time that the Department is proposing a highway project, the highway project will fund the inlet and lateral facilities. The project may also contribute proportionately towards the cost of the trunk line and outfall that convey runoff from the highway system. The proportional share will be based on the estimated flow from the project as compared to the total estimated flow from the drainage project. Allowances can be made for surface runoff that naturally enters the highway right-of-way and which would require design features.

Cities are usually better able to perform the maintenance of storm drain systems and should be encouraged to do so in storm drain negotiations. If cities are willing to assume the maintenance of storm drain systems that include flow from the highway system, the maintenance agreement should be considered in the negotiations to determine the proportional share of highway funding. Additionally, the designer should coordinate with the city personnel during design to determine maintenance and material preferences.

After the facility is built and is in-service, care must be taken to ensure that the capacity of the system is maintained. Additional hook ups or tie ins, whether public or private, will not be allowed unless the system was originally designed to accommodate the additional flow and the applicant either shared in the cost of the system initially or is willing to pay at the time of the tie in the proportional cost of the original system.

### 14.2.2 Water and Sanitary Sewer Line Design

MDT typically performs very little water and sanitary sewer design. These limited designs are generally focused around conflicts with storm drains. On some urban reconstruction projects, the city will elect to include improvements to its utility lines in the MDT contract. In these situations, the design for city utilities are performed by the city (or by a consultant for the city), and the plans are incorporated into the MDT contract.

When designs are performed by MDT, the designs should follow the Montana Department of Environmental Quality (DEQ) "Water Quality Circulars," available online. Approval by DEQ is generally required for all water and sanitary sewer modifications.

Water mains are under the jurisdiction of DEQ, but water services are not. Generally, a water main serves multiple buildings and a water service serves a single building. Local authorities may have specific requirements for water service line installations.

### 14.2.3 Water Spread

The width of stormwater flowing along a gutter and/or street measured laterally from the roadway curb is considered the spread. In general, the water spread should be limited to a specified width (spread) for the selected design flood frequency (see Section 14.3.3). For storms of greater magnitude than the design flood frequency, the spread can be allowed to use more of the pavement as an open channel. The spread width may be adjusted if warranted by an assessment of the costs vs. risks. If the spread requirements in Section 14.3.3 result in very close inlet spacing (i.e., 100 ft or less), then alternative drainage interceptors could be considered. This may include allowing the spread to cover the outside lanes of a roadway with four lanes or more, depending on the project conditions.

### 14.2.4 Off-Site Development/System Impacts

When a development adjacent to a highway has been proposed to connect to the existing storm drain trunk line in the highway, MDT must approve the connection. Approval is contingent upon two criteria. First, the drainage area of the development must have been included in the original drainage area of the storm drain system. Second, the flow from the development must not exceed the flow from the drainage area prior to development. For specific criteria, see Section 14.3.6.

### 14.2.5 Storm Drain Outfall

Whether the outfall is enclosed in a conduit or is an open channel, the design flow should be conveyed without causing significant risk to the highway and surrounding property. In many locations, the State, local highway agencies, or developers, or all, are not permitted to increase peak flow rate when compared to existing conditions, thus, necessitating detention storage facilities. See Chapter 15, "Storage Facilities" for a discussion on detention storage.

If a storm drain discharges directly into a stream, check with the Environmental Services Bureau to determine water quality requirements.

### 14.2.6 Municipal Separate Storm Sewer System (MS4) Permit

A MS4 permit is required for storm sewer systems associated with MDT highways in urban areas within Montana that serve a population of at least 10,000 people. See Section 7.3.3 for a discussion on the municipal separate storm sewer systems (MS4) permit.

Coordinate with the MDT Environmental Services Bureau to determine if a MS4 permit is required. HEC 22 (1) provides an introduction to the types of BMPs that have been historically used to provide water quality benefits. In addition, the Montana *Post-Construction Storm Water BMP Design Guidance Manual,* September 2017, has been prepared for the Montana MS4 communities that provides BMP guidance.

## 14.3 DESIGN CRITERIA

### 14.3.1 Hydrology

The Rational Method is the most common method used for the design of storm drains when the momentary peak-flow rate is desired. Its use should be limited to systems with drainage areas of 200 acres or less. The NRCS TR-55 method may be used for larger contributing basins up to 25 $mi^2$. These methods are further described in Section 9.4.2. The minimum time of concentration is 5 minutes and is described further in Section 14.6.3.2.

Drainage systems involving detention storage, routing, pumping stations, and large or complex storm systems require the development of a runoff hydrograph. Hydrograph methods are described in Section 9.4.3.

The design frequency and spread criteria are discussed in Section 14.3.3.

### 14.3.2 Storm Drain Manning's n

The design Manning's n value for storm drain pipe should be 0.013 regardless if the pipe material is concrete or plastic.

## 14.3.3 Design Flood Frequency and Spread

The design spread for the design flood frequency should be limited to the allowable width shown in Figure 14.3-1.

**Figure 14.3-1 — MINIMUM DESIGN FLOOD FREQUENCY AND SPREAD**

| Road Classification and Design Speed | | Design Flood Frequency[1] | Design Spread[2,3, 4] |
|---|---|---|---|
| Interstate and Other Divided Highways | ≤ 45 mph<br>> 45 mph<br>Sag Point (all speeds) | 10-year<br>10-year<br>50-year | Shoulder + 3 ft<br>Shoulder<br>Shoulder + 3 ft |
| All Other Routes | ≤ 45 mph (< 1000 ADT)<br>≤ 45 mph (≥ 1000 ADT)<br>> 45 mph<br>Sag Point (all speeds) | 5-year<br>10-year<br>10-year<br>10-year | ½ Driving Lane<br>½ Driving Lane<br>Shoulder<br>½ Driving Lane |

1. *If the spread width criteria cannot be met in areas with high rainfall intensities, the rainfall intensity may be limited to 4.0 in/hr with approval of the State Hydraulic Engineer.*
2. *The criteria in this column apply to travel, turn, or auxiliary lanes adjacent to barrier wall or curb, in normal or superelevated sections.*
3. *For spread calculations in turn lanes, assume a turn lane entry speed of 10 mph less than the roadway design speed.*
4. *For roundabouts with a raised median, at least 8' of the outside travel lane must remain clear of water at the 10-year event.*

## 14.3.4 Review Flood Frequency

The review flood for storm drains is the 100-year event. During this event, runoff may exceed the design event spread and depth in the roadway or street and may exceed the capacity of the storm drain system, possibly resulting in storm drain surcharge. Street flooding may occur, and the street functions as an open channel. The hydraulic engineer must evaluate and design for the review flood regarding maintaining public safety and minimizing flood damages. Ensure that the review flood flow is contained within the right-of-way for the full length of the project.

## 14.3.5 Risk Evaluation

When MDT design criteria cannot be met or a site has especially high risk, complete a risk evaluation as discussed in Section 9.3.4.

### 14.3.6 Off-Site Development/System Impacts

Per MDT's design practice in Section 14.2.4, off-site flows contributing to a MDT system require MDT approval. The hydrology method used in the analysis must be an applicable method from Chapter 9, and storage facilities must follow the design criteria in Section 15.3.

For MDT to properly evaluate system impact proposals, a hydraulic report and plan details stamped by a Montana-licensed professional engineer must be submitted that contains the following:

1. A description of the proposed design and the residual drainage effects that the proposed design will have on the highway system.
2. A description of the location including city, county, state highway route within or adjacent to the development, mile marker, and local streets.
3. A description of the property including area, ground cover, historic drainage patterns, streams, drainage-ways, ditches, irrigation facilities, and culverts.
4. A description of the project and the proposed drainage concept including land use, ground cover, drainage patterns, compliance with historical offsite runoff restrictions, detention storage, outlet design, and maintenance.
5. A drainage map including topography, existing and proposed drainage facilities, delineated drainage basins, flow patterns, proposed grading plan, highway right-of-way, and highway facilities.
6. Runoff calculations for historical and proposed peak flow rates for the 2-year and 100-year, events using the time of concentration to determine the intensity.
7. Pond volume calculations.
8. Outlet structure orifice and emergency spillway calculations if a detention pond is utilized. If a retention pond is used, include emergency spillway calculations.
9. Documentation that the applicable criteria in Section 15.3 has been met.

## 14.4 DESIGN GUIDELINES (PRELIMINARY LAYOUT)

When developing the preliminary storm drain layout, the following are important considerations:

- Location of the storm drain within the roadway (Section 14.4.1),
- The storm drain profile and control elevations (Section 14.4.2),
- Outfall location and requirements (Section 14.4.3), and
- Location and coordination of utilities within the corridor (Section 14.4.4).

The following sections describe the above considerations.

### 14.4.1 Location Guidelines

To facilitate future repairs and eliminate manhole covers in travel lanes, it is desirable to locate new storm drains outside the travel lanes if possible. Medians are often the most desirable storm drain location. In the absence of medians, a location beyond the curb line on state right-of-way or on easements is preferable. In the absence of a median or suitable unpaved area, storm drain location must be considered under the highway surface. There are several locations that could accommodate storm drain trunk lines, including:

- The center of the roadway, especially if there is a center turn lane;
- In the gutter, allowing for manholes to also be used as inlets; and
- Within the shoulder or parking lane, which keeps the manhole covers out of the travel lane.

Existing utilities may also determine the storm drain location. See Section 14.4.4.

### 14.4.2 Profile and Control Elevations

Develop a preliminary storm drain profile that shows all control elevations. Control elevations include anything that might affect the storm drain profile such as road grade (minimum cover), utilities, bedrock, and outfall limitations. With the proper designation of all control elevations on the profile, these elevations are more easily considered during the design.

Pipe gradients are usually approximately equal to the roadway grade. Minimum cover to protect the storm drain pipe from excessive loads must be provided along the storm drain pipes and at inlet connections; however, minimizing the depth of the storm drain may produce significant cost savings.

The outfall requirements and utility conflicts also control the profile and are discussed in the following sections.

### 14.4.3 Outfall Guidelines

An outfall is the end point of a storm drain design. New storm drain systems may tie into an existing storm drain but, ultimately, the storm drain will discharge into a natural drainage or other body of water. The water surface elevations at the receiving body of water must be considered when setting the tailwater control elevation and when designing the storm drain outfall.

Potential outfalls should be investigated early in the project development and before beginning the storm drain design. Consider the following to determine the feasibility of an outfall:

- Downstream capacity;
- Increased discharge;
- Downstream flooding risk;
- Storage requirements for peak discharge and volume;
- Grade and elevation;
- Right-of-way and/or easements;
- Interaction with irrigation facilities;

- Utility conflicts and spacing requirements;
- Railroad coordination;
- Maintenance and ownership;
- Erosion control/energy dissipation;
- Water quality/MS4; and
- Permitting (USACE, FWP, DEQ, BOR, floodplains).

When existing downstream conveyance facilities are inadequate to accommodate peak-flow rates from the proposed storm drain facilities, a reduction of peak flows may be necessary. Reducing peak flows can be achieved by the storage of runoff in detention basins, storm drain pipes, swales and channels, and other detention storage facilities. Additional benefits of storage may include the reduction of downstream pipe sizes and the improvement of water quality by removing sediment or pollutants or both. See Chapter 15, "Storage Facilities" for a discussion on detention storage.

### 14.4.4 Utility Coordination

Locate the storm drain to avoid conflicts with utilities, foundations, or other obstacles. Coordination with utility owners during the design phase is necessary to determine if an adjustment to the utilities or the storm drain system is required.

Early in project development, request a Subsurface Utility Engineering Phase I (SUE Phase I) survey to develop a plan map of the utilities in the project area. A SUE Phase I survey is based on the utilities that can be located, surveyed, and/or measured without excavation (gas mains, telephone and fiber optic lines, water mains, sewer mains, storm drains, manholes, fire hydrants, valves and valve boxes, pipe elevations in manholes, water valve measure down distance to top of valve nut, etc.).

After a preliminary storm drain layout has been developed, request a SUE Phase II survey to obtain the actual depths of utilities through excavation where there may be conflicts. Coordinate with the Utilities Section to determine if any utilities will be replaced by the project and, therefore, do not need to be avoided.

Additional methods to locate utilities are to check with the local city or municipality for utility maps and, when on site, to look for utility features (e.g., manholes, electrical and fiber optic boxes, gas line indicators, water valves, fire hydrants). Of special interest are sanitary sewers, fiber optic lines, water mains, and gas mains because these are more difficult and costly to relocate.

DEQ has stipulated horizontal and vertical requirements for water line clearances and separation for fire hydrant drains in Circular DEQ 1 (2), available online. DEQ may grant a deviation from a standard on a case by case basis provided that adequate justification for the deviation is provided as described in Circular DEQ-1.

## 14.5 DESIGN GUIDELINES (INLETS)

The term "inlets" refers to all types of storm drain inlets (e.g., drop inlets, curb inlets, median inlets). Inlets are sized and located to limit the water spread widths in accordance with the design criteria in

Section 14.3.3 and to intercept storm water before it crosses roadway and pedestrian features as described below.

### 14.5.1 MDT Practices

Follow these guidelines when locating and sizing inlets:

- Grate inlets and the depression of curb-opening inlets should be located outside of the traffic lanes. When necessary, portions of the inlet apron may extend a maximum of 12 in. into the traffic lanes.
- If the inlet grate extends beyond the gutter, use a concrete apron.
- All grates located on MDT roadway surfaces must be bicycle safe.
- Inlets placed on a slope will generally not intercept 100% of the gutter flow. Some water may flow past the inlet (bypass flow) if the frontal flow width is wider than the grate. Additionally, a portion of the flow may splash over the inlet if the velocity is high enough. In general, inlets should be designed to intercept at least 70% of the design flow reaching the inlet.
- When grate inlets are used at sag locations, assume that they are 50% plugged with debris and size accordingly.
- Place flanking inlets on each side of the low point inlet when in a depressed area that has no outlet except through the system. The flanking inlets act in relief of the inlet at the low point if it should become clogged or if the design spread is exceeded. The flanking inlets should be located so that they will receive all of the flow when the primary inlet at the bottom of the sag is clogged. They should do this without exceeding the allowable spread at the bottom of the sag.

### 14.5.2 MDT Inlet Types

The following discussion describes each inlet type used by MDT in storm drain applications and identifies the inlets' advantages and disadvantages. The inlet types with their specifications are shown in Figure 14.5-1. See also the *MDT Detailed Drawings*.

1. Types I and III Drop Inlets. Both of these inlets have the same straight bar grates, are used in sag locations, and have a large hydraulic capacity. Since the grate for these inlets extends beyond the gutter, a concrete apron must be specified. The grates are only bicycle safe when the bars are turned perpendicular to the curb line; however, when the bars are perpendicular to flow, the grate is significantly less efficient at capturing water in locations other than sags.

   The difference between Types I and III drop inlets relates to the size and shape of the concrete structure below the grate. Type I has a standard barrel with a roof slab, and Type III has a square concrete structure without a roof slab for low cover situations. For Type III inlets, the pipe must enter and exit the barrel at 90 degrees so that the pipe does not impact the corner of the structure. See Detailed Drawings 604-14 and 604-16.

2. Types V and VI Drop Inlets. Both of these inlets have curved-vane grates, are used on grade. The grates are also bicycle-safe and have a large hydraulic capacity. Since the grate for these inlets extends beyond the gutter, a concrete apron must be specified.

   The difference between Types V and VI drop inlets relates to the size and shape of the concrete structure below the grate. Type V has a standard barrel with a roof slab, and Type VI has a square concrete structure without a roof slab for low cover situations. For Type VI inlets, the pipe must enter and exit the barrel at 90 degrees so that the pipe does not impact the corner of the structure. See Detailed Drawings 604-14 and 604-16.

3. Type IV Drop Inlet. These inlets are used on grade and have a medium hydraulic capacity. The inlet has a curved-vane grate that is bicycle safe. The grate is smaller than the Types V and VI grates. Since the grate extends beyond the gutter, a concrete apron must be specified. Type IV has a standard barrel with a roof slab. See Detailed Drawing 604-04.

4. Types A and B Curb Inlets. These inlets are used on narrow shoulders when it is not desireable to construct concrete aprons or have inlets extending into the travel lane. Type A inlet grates contain straight bars and should be used only in sags. Type B inlet grates contain curved vanes and a curb opening and should be used only on grade. Since these grates do not extend beyond the gutter, a concrete apron is not necessary. Types A & B curb inlets have a standard barrel with a roof slab. See Detailed Drawing 604-18.

5. Type II Curb Inlet. These low capacity inlets are used on-grade for narrow shoulders when it is not desireable to construct concrete aprons or have inlets extending into the travel lane. The inlet has a curved-vane grate that is bicycle safe. The Type II curb inlet has less hydraulic capacity than Types A and B curb inlets. The Type II curb inlet is typically used to capture incidental storm water. Since the grate does not extend beyond the gutter, a concrete apron is not necessary. Type II curb inlet has a standard barrel with a roof slab. See Detailed Drawing 604-03.

6. Median Inlet. These inlets are generally used in the Interstate median or in a roadside ditch. They have a very large hydraulic capacity but are neither bicycle nor pedestrian safe. MDT recommends using an apron around these grates to keep vegetation away from the inlet. See Detailed Drawing 604-00.

7. Combination Manhole/Inlet. In some locations, it is cost effective to use the manhole as a base for any of the drop inlets or curb inlets described above. This is accomplished by using a Type 3 manhole and placing the inlet frame and grate on the manhole roof slab instead of a standard manhole frame and lid. See Section 14.6.1.3 for manhole types.

## Figure 14.5-1 — INLET TYPE DATA

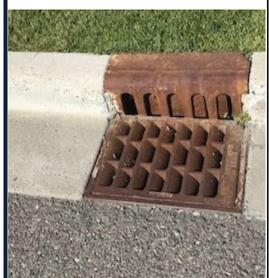
| Inlet Type | Casting | Location | Barrel Diameter or Square | StormCAD | SSA* |
|---|---|---|---|---|---|
| Type I Drop Inlet<br> | D&L I-3421-01<br>EJIW 5422 | Sag | Dia. 48″ to 144″ | Inlet Type = Grate<br>Grate Type = P-1⅞<br>Grate Width = 2.81 ft<br>Grate Length = 2.81 ft<br>Headloss Method = HEC 22 (Energy Losses) | Inlet Manufacturer = FHWA HEC 22 Generic<br>Inlet Type = Grate Inlet - Rectangular<br>Grate Type = Parallel Bar P-1⅞<br>Grate Length = 33.75 in<br>Grate Width = 33.75 in |
| Type II Curb Inlet<br> | D&L I-3559<br>Neenah R-3286-8V<br>EJIW 7222 | On Grade | Dia. 30″ to 144″ | Inlet Type = Combination<br>Curb Opening Height = 3.5 in<br>Curb Opening Length = 1.67 ft<br>Curb Local Depression = 0.6 in<br>Curb Depression Width = 15.63 in<br>Curb Throat Type = Vertical<br>Curb Throat Angle = 90 degrees<br>Grate Type = Curved Vane<br>Grate Width = 1.3 ft<br>Grate Length = 1.8 ft<br>Headloss Method = HEC 22 (Energy Losses) | Inlet Manufacturer = FHWA HEC 22 GenericInlet Type = Combination Inlet<br>Grate Type = Curved Vane<br>Grate Length = 21.625 in<br>Grate Width = 15.625 in |
| Type III Drop Inlet<br> | D&L I-3421-01<br>EJIW 5422 | Sag | Sqr. 32″×32″ | Inlet Type = Grate<br>Grate Type = P-1⅞<br>Grate Width = 2.81 ft<br>Grate Length = 2.81 ft<br>Headloss Method = HEC 22 (Energy Losses) | Inlet Manufacturer = FHWA HEC 22 Generic<br>Inlet Type = Grate Inlet - Rectangular<br>Grate Type = Parallel Bar P-1⅞<br>Grate Length = 33.75 in<br>Grate Width = 33.75 in |
| Type IV Drop Inlet<br> | D&L I-3425<br>Neenah R-3210-L<br>EJIW 5622 | On Grade | Dia. 30″ to 144″ | Inlet Type = Grate<br>Grate Type = Curve Vane/ P-1⅞-4<br>Grate Width = 1.99 ft<br>Grate Length = 1.99 ft<br>Headloss Method = HEC 22 (Energy Losses) | Inlet Manufacturer = FHWA HEC 22 Generic<br><br>Inlet Type = Grate Inlet - Rectangular<br>Grate Type = Curve Vane<br>Grate Length = 23.875 in<br>Grate Width = 23.875 in |
| Type V Drop Inlet<br> | D&L I-3421-02<br>EJIW 5422 | On Grade | Dia. 48″ to 144″ | Inlet Type = Grate<br>Grate Type = Curve Vane<br>Grate Width = 2.81 ft<br>Grate Length = 2.81 ft<br>Headloss Method = HEC 22 (Energy Losses) | Inlet Manufacturer = FHWA HEC Generic<br>Inlet Type = Grate Inlet - Rectangular<br>Grate Type = Curve Vane<br>Grate Length = 33.75 in<br>Grate Width = 33.75 in |
| Type VI Drop Inlet<br> | D&L I-3421-02<br>EJIW 5422 | On Grade | Sqr. 32″×32″ | Inlet Type = Grate<br>Grate Type = Curve Vane<br>Grate Width = 2.81 ft<br>Grate Length = 2.81 ft<br>Headloss Method = HEC 22 (Energy Losses) | Inlet Manufacturer = FHWA HEC 22 Generic<br>Inlet Type = Grate Inlet - Rectangular<br>Grate Type = Curve Vane<br>Grate Length = 33.75 in<br>Grate Width = 33.75 in |

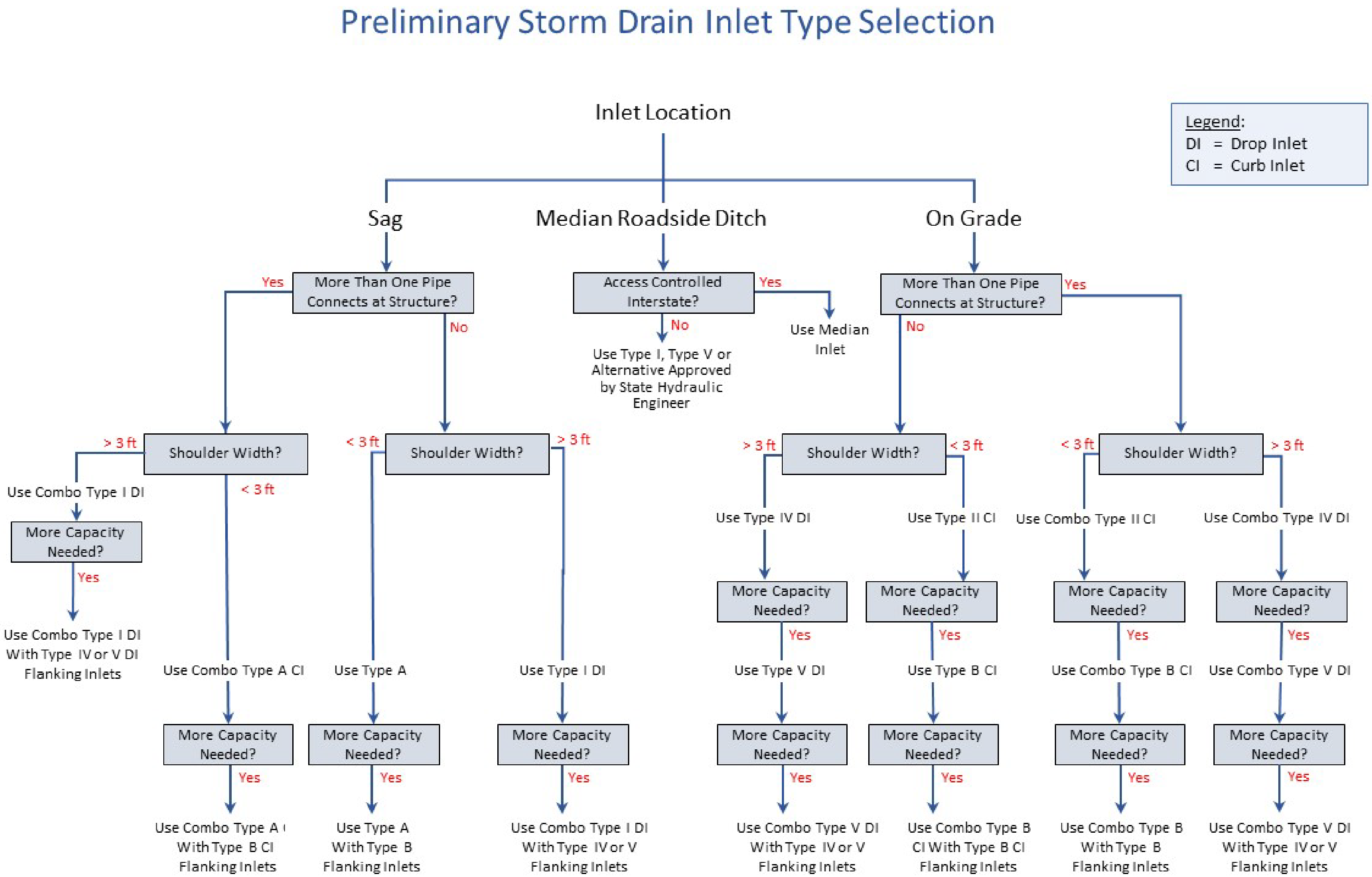
**Figure 14.5-1** *(Continued)*

| Inlet Type | Casting | Location | Barrel Diameter or Square | StormCAD | SSA* |
|---|---|---|---|---|---|
| Type A Curb Inlet<br> | D&L I-3519<br>Neenah R-3067<br>EJIW 7030 | Sag | Dia. 48″ to 144″ | Inlet Type = Combination<br>Curb Opening Height = 4.4 in<br>Curb Opening Length = 2.93 ft<br>Curb Local Depression = 1.6 in<br>Curb Depression Width = 17.75 in<br>Curb Throat type = Vertical<br>Curb Throat Angle = 90 degrees<br>Grate Type = P-1⅞<br>Grate Width = 1.48 ft<br>Grate Length = 2.93 ft<br>Headloss Method = HEC 22 (Energy Losses) | Inlet Manufacturer = FHWA HEC 22 Generic<br><br>Inlet Type = Combination Inlet<br>Grate Type = Parallel Bar P-1⅞<br>Grate Length = 35.25 in<br>Grate Width = 17.75 in<br>Curb Opening Length = 35.25 in<br>Curb Opening Height = 4.4 in |
| Type B Curb Inlet<br> | D&L I-3517<br>Neenah R-3067 L<br>EJIW 7030 | On Grade | Dia. 48″ to 144″ | Inlet Type = Combination<br>Curb Opening Height = 4.4 in<br>Curb Opening Length = 2.93 ft<br>Curb Local Depression = 1.6 in<br>Curb Depression Width = 17.75 in<br>Curb Throat type = Vertical<br>Curb Throat Angle = 90 degrees<br>Grate Type = Curve Vane<br>Grate Width = 1.48 ft<br>Grate Length = 2.93 ft<br>Headloss Method = HEC 22 (Energy Losses) | Inlet Manufacturer = FHWA HEC 22 Generic<br><br>Inlet Type =Combination Inlet<br>Grate Type = Curved Vane<br>Grate Length = 35.25 in<br>Grate Width = 17.75 in<br>Curb Opening Length = 35.25 in |

**SSA Headloss Method is hard coded as HEC-22.*

Figure 14.5-2 provides a decision tree for identifying preliminary inlet selection. The capacity of the inlet at a specific location should be calculated using the methods in HEC 22 (1). The final inlet type selction and location should be based on the spread width. If additional capacity is needed, larger inlets may be used on narrow shoulders if the concrete apron does not extend more than 12 in. past the shoulder stripe and into the traffic lane.

**Figure 14.5-2 — PRELIMINARY STORM DRAIN INLET TYPE SELECTION**




Note: *This figure provides a decision tree for identifying preliminary inlet selection. The capacity of the inlet at a specific location should be calculated using the methods in HEC 22(1). The final inlet type selection and location should be based on the spread width. If additional capacity is needed, larger inlets may be used on narrow shoulders if the concrete apron does not extend more than 12 in. past the shoulder stripe and into the traffic lane.*

### 14.5.3 Location

Inlets are located where the gutter flows exceed the spread width. However, there are many locations where inlets may be necessary without regard to the contributing drainage area. Place inlets at the following locations:

- At all low points in the gutter grade;
- Immediately upstream of median breaks, entrance/exit ramp gores, cross walks, and street intersections; i.e., at any location where water could flow onto the travelway;
- At a maximum of the manhole spacing shown in Figure 14.6-1 for inlets on grade;
- On horizontal curves where a change from normal crown to superelevation may cause water to sheet across the highway or be trapped in a low spot;
- Upstream of traffic intersections unless a valley gutter is present; and
- Where lay-down curb may allow the storm water to escape and cause flooding.

In addition, consider inlets at the following locations:

- Prior to pedestrian cross walks and bulb outs;
- Upstream of a public approach entrance;
- Where significant flow from off the right-of-way (e.g., from side streets, parking lots) is expected;
- Behind curbs, shoulders, or sidewalks to drain low areas; and
- As flanking inlets in sag vertical curves; see Section 14.5.1;

Do not place inlets:

- In the middle of an approach,
- In front of an ADA ramp, or
- In the traffic lane.

### 14.5.4 Median Barriers

Median barriers for traffic separation can also block surface flow. Where median barriers are used, especially on horizontal curves with associated superelevation, it is necessary to provide for some relief for the water that accumulates against the barrier. This can be accomplished with cut outs under the barrier, although these can become clogged with sanding material. To minimize flow across traveled lanes, the preferred method of relief is to collect the water into a subsurface system with inlets and storm drains.

### 14.5.5 Inlet Calculations

Use HEC 22 (1), the FHWA Hydraulic Toolbox, or software that uses the HEC 22 methodology (see Chapter 8, "Hydraulics Software") to analyze the flow in gutters and the interception capacity of all types of inlets on continuous grades and sags. HEC 22 also contains guidance on placing flanking inlets at sag locations. See also Section 14.6.3.2 for a discussion on time of concentration for both inlet and storm drains.

## 14.6 DESIGN GUIDELINES (STORM DRAINS)

This section provides an overview of MDT practices for storm drain system design.

### 14.6.1 Manholes

#### 14.6.1.1 Location

Manholes are used to provide entry to continuous underground storm drains for inspection and cleanout (see Section 14.4.1). Typical locations where manholes should be specified are:

- Where two or more storm drains converge,
- At intermediate points along tangent sections,
- Where the pipe size changes,
- Where an abrupt change in alignment occurs,
- Where an abrupt change of the grade occurs, and
- Where inlet connections are made.

Where space is limited, combination manhole/inlets may be used; however, using the grate opening to access the storm drain for maintenance must be considered in the design and approved by the facility owner responsible for maintenance of the storm drain system.

Manholes should generally not be located in traffic lanes; however, when it is impossible to avoid locating a manhole in a traffic lane, exercise care to ensure that it is not in the normal vehicle wheel path.

#### 14.6.1.2 Spacing

Manhole spacing on trunk lines should not exceed the criteria in Figure 14.6-1.

**Figure 14.6-1 — MAXIMUM SPACING FOR MANHOLES**

| Size of Pipe (in.) | Maximum Distance (ft) |
|---|---|
| $\leq 48$ | 300 |
| $> 48$ | 600 |

### 14.6.1.3 Types

MDT uses two types of concrete manholes — a Type 1 and a Type 3. The Type 1 has a 48-in. barrel with a concentric cone section. The Type 3 has a variable diameter barrel with a flat slab roof. The Type 1 should be used when it will satisfy the site requirements (generally where there is enough depth to accommodate the cone section). The Type 3 is necessary when used in combination with an inlet or when the manhole diameter exceeds 48 in.

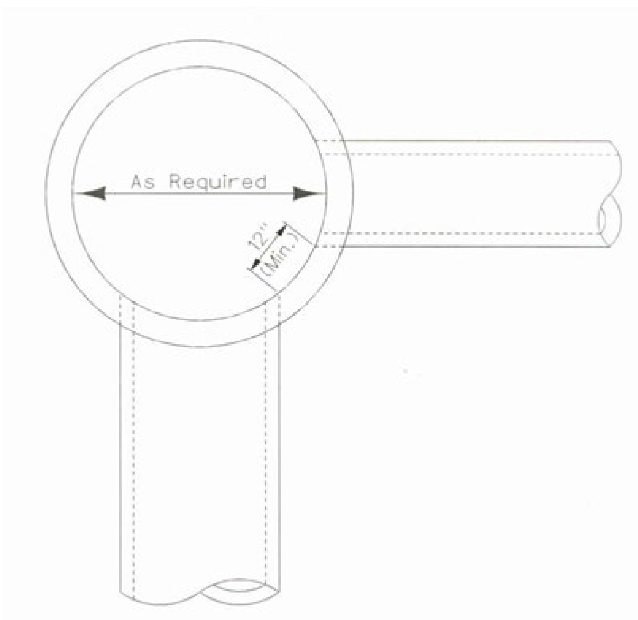
In some instances, vertical box culverts with a floor slab may be used for manholes. Ensure that the outside diameters of all pipes entering the junction box do not conflict with the box culvert fillets.

On concrete storm drains 36 in. and larger, tee connections may be used in lieu of manholes to provide storm drain access. Tee connections are prefabricated by the pipe manufacturer and consist of a riser pipe that extends vertically above the trunk line to the surface. A standard manhole frame and lid is placed on the riser pipe at the surface.

### 14.6.1.4 Sizing

The manhole should be large enough to maintain a minimum of 12 in. of clearance (horizontally and vertically) between all pipes, as indicated in Figure 14.6-2.

**Figure 14.6-2 — MINIMUM PIPE SPACING FOR MANHOLES**




### 14.6.1.5 Shaping Inside of Manhole

Proper shaping of the manhole invert will reduce eddying and head losses. See the *MDT Detailed Drawings*.

## 14.6.2 Storm Drain Trunk Lines and Laterals

### 14.6.2.1 Minimum Pipe Size

The minimum diameter of pipe used shall be 12 in. for laterals and 18 in. for trunk lines. Round pipe diameters increase in 6-in. increments. Equivalent arch pipes can also be used, if proper cover cannot be attained using round pipe.

### 14.6.2.2 Slope, Size, and Velocity

Pipe gradients should be approximately equal to the roadway grade. The same size of pipe will run until the depth of flow in the pipe exceeds 75% of the pipe diameter during the design event (which is approximately 91% of full-pipe capacity). After this capacity is reached, the next larger size pipe should be used. Storm drain pipes should not decrease in size in a downstream direction regardless of the available pipe gradient.

When an abrupt reduction in gradient is encountered, an increase of more than one pipe size larger may be required.

#### 14.6.2.2.1 Minimum Velocity

All storm drain systems should be designed such that the design event has a velocity greater than 3 ft/s to ensure that there is sufficient velocity to deter settling of particles. If the minimum velocity cannot be met, discuss with the State Hydraulic Engineer.

#### 14.6.2.2.2 Maximum Velocity

The maximum velocity in the pipe should be limited to 10 ft/s, where feasable. Where velocities exceed 10 ft/s, consider providing a drop in elevation between the inlet pipe and outlet pipes at a manhole. The drops in elevation allow flatter pipes and slower velocities into and out of the manhole. Provide energy dissipation for storm drain outfalls that exceed 10 ft/s.

### 14.6.2.3 Pipe Material and Watertight Joints

MDT pipe material guidelines are found in Figure 11.4-2, "Guidelines for Optional Pipe Material Selection." Specify watertight joints on all storm drains. Several types of gaskets are available, including some that are resistant to oils and gases.

### 14.6.2.4 Minimum Pipe Cover and Clearance

Minimum and maximum pipe cover requirements are provided in Appendix 11A "MDT Culvert Fill Height Tables." Pipe class must be selected to fit the cover provided.

Generally, a minimum clearance of 1 ft should be provided between storm drain pipes and other underground facilities (e.g., sanitary sewers); however, coordination with the MDT Utility Section is recommended. DEQ has stipulated horizontal and vertical requirements for water line clearances in Circular DEQ 4.

#### 14.6.2.5 Invert Elevation and Head Loss

If the storm drain system has a trunk line or more than one inlet/mahole, complete a storm drain model to analyze the system. A minimum drop of 0.1 ft between the inlet and outlet of a manhole is used to offset the head losses that occur at each junction.

When increasing the size of pipe, two alternatives are available for design at the junction:

- Align the inside top of the pipe (crown) with an abrupt drop in the flow line (preferred), or
- Align the pipe inverts (bottom of pipe) with a continuous flow line (see below).

Aligning the crowns is the MDT preferred method and should be used when possible. The hydraulic characteristics generally are better when the tops of the pipes are aligned. Also, this approach is better where there is a problem with minimum allowable cover over the pipes.

In contrast, there may be situations in relatively flat terrain where it is necessary to conserve the elevation of the flow line. Under these conditions, it may be better to avoid the abrupt drops by aligning the pipe inverts at the junction.

### 14.6.3 Hydraulic Analysis

MDT requires a hydraulic analysis for storm drains on MDT projects. The level of analysis can range from simple calculations using the FHWA Hydraulic Toolbox to a complete network assessment using storm drain software (see Chapter 8, “Hydraulics Software”). It is important for the hydraulic engineer to understand the role that time of concentration has in the storm drain design and the difference between the inlet time of concentration and the storm drain time of concentration (see Section 14.6.3.2). In addition, the calculation of the hydraulic grade line allows the hydraulic engineer to evaluate the performance of the storm drain and to test the storm drain for resiliency.

#### 14.6.3.1 HEC 22 Design Method

Use the hydraulic methodology in HEC 22 (1) for the hydraulic analysis and design of all MDT storm drain systems. HEC 22, Chapter 7 provides a comprehensive step-by-step procedure and worksheets for storm drain design for a simple system. For complex systems, use storm drain software for the analysis; see Chapter 8, “Hydraulics Software.”

### 14.6.3.2 Time of Concentration

The designer is usually concerned with two different times of concentration — one for inlet spacing and the other for pipe sizing. The time of concentration for inlet spacing is the time required for water to flow from the hydraulically most distant point of the unique drainage area contributing only to that inlet. Typically, this is the sum of the times required for water to travel overland to the pavement gutter and along the length of the gutter between inlets. If the total time of concentration to the upstream inlet is less than five minutes, a minimum time of concentration of five minutes is used as the duration of rainfall. The time of concentration for each successive inlet should be determined independently in the same manner as was used for the first inlet. For additional information, see HEC-22.

The time of concentration for pipe sizing is defined as the time required for water to travel from the most hydraulically distant point in the total contributing watershed to the design point. Typically, this time consists of two components (1) the time for overland and gutter flow to reach the first inlet, and (2) the time to flow through the storm drain system to the point of interest.

The design concentration time for a point below the junction of two or more storm drain branches is not necessarily the longer of the two periods. A larger flow could easily result with a smaller concentration time. All conditions must be investigated when determining the appropriate time of concentration for any multiple branch storm drain design. The junction of flows from more than one inlet may require a recalculation of discharges, depending upon which time of concentration controls the combined flow.

### 14.6.3.3 Hydraulic Grade Line

The hydraulic grade line (HGL) is the final important feature to be established for the hydraulic design of a storm drain system. This grade line aids the hydraulic engineer in determining the acceptability of the proposed system by establishing the elevations along the system to which the water will rise when the system is operating at the design flood frequency and review flood.

In general, if the HGL is above the crown of the pipe, the pipe is in pressure flow. If the HGL is below the crown of the pipe, the pipe is in open channel flow. A special concern with storm drain systems operating under pressure-flow conditions is that inlet surcharging and possible manhole lid displacement can occur if the hydraulic grade line rises above the ground surface.

### 14.6.3.4 MDT Practice (HGL & EGL)

For all MDT projects, the HGL and EGL must be calculated. Plot the HGL and EGL on the storm drain profile and evaluate for the following conditions.

<u>Design Flood Frequency</u>.

- The HGL should be below the crown of the pipe so that the system operates in open channel flow.
- The EGL must remain below the proposed ground surface for the design event, even if the HGL exceeds the crown of the pipe.

Review Flood Frequency.

- Verify that the HGL is inside the right-of-way.
- Identify manholes susceptible to surcharging, and consider an open grate to avoid manhole lid displacement.

## 14.7 DESIGN GUIDELINES (PUMP STATIONS)

In difficult to drain locations, such as underpasses or adverse outfalls, a pump station may be necessary. Detailed guidance on the design of pump stations is provided in HEC 22 (1) and in HEC 24 "Highway Storm Water Pump Station Design." (3). Before designing a pump station, consult with the State Hydraulic Engineer.

## 14.8 DESIGN PROCEDURE

The following design procedure provides the general guidelines, steps, and documentation necessary for storm drain design for MDT projects. This procedure is not all inclusive; the hydraulic engineer must ensure the accuracy and completeness of the design. Additionally, the procedure does not address the effect of storage, which is discussed in Section 11.9.2, "Storage Routing" and Chapter 15, "Storage Facilities."

Deviations from MDT manuals, procedures, and/or guidelines need to be documented and rationalized.

Step 1: Assemble site data and project file in addition to the material collected for the LHSR (see Chapter 5, "Location Hydraulic Studies").

a. The minimum data are:

- LSHR;
- As-built plans;
- Project and hydraulic survey data;
- Topographic mapping;
- Aerial and ground photographs;
- Proposed roadway alignment, profile, and cross sections; and
- SUE Phase I utility data.

b. Studies by other agencies including:

- Municipal storm drain master plans,
- Existing storm drain hydraulic models,
- Floodplain studies, and
- Canal information (when being considered for a storm drain outfall) — DNRC, USBR, BIA, or private irrigation districts.

c. Historical performance of existing storm drain or drainage patterns:

- Contact MDT Maintenance, county/state/federal officials (such as the public works director and city engineer), local road maintenance, landowners, and/or residents concerning historical flooding patterns and areas of concern.

d. Environmental constraints including:

- Municipal Separate Storm Sewer System (MS4) Permit if located within an MS4 area (see Section 14.2.6), and
- Aquatic resource impacts as defined in the Biological Resources Report.

e. Design criteria:

- Review Section 14.3 for applicable criteria, and
- Prepare risk evaluation, if needed.

Step 2: Determine hydrology.

a. See Chapter 9, "Hydrology".
b. See Section 14.3.1, "Hydrology".
c. Determine contributing drainage areas and develop a map of drainage areas.

Step 3: Determine the preliminary layout of the storm drain per Section 14.4.

a. Locate the storm drain within the roadway corridor.
b. Establish the outfall location and requirements.
c. Develop a preliminary storm drain profile that shows all control elevations including:

- Road grade (minimum cover),
- Utilities from SUE Phase I, and
- Outfall limitations.

Step 4: Determine the location of the storm drain inlets per Section 14.5.

a. Place the inlets at the locations specified in Section 14.5.3.
b. Analyze the spread width and add more inlets as necessary to meet the spread width criteria in Section 14.3.3.

Step 5: Size the storm drain trunk line and laterals per Section 14.6.

a. Locate the manholes. See Section 14.6.1.1.
b. Starting upstream and working downstream, use the time of concentration (Section 14.6.3.2) to size the storm drain to meet the flow conditions described in Section 14.6.2.2.
c. Size the manholes based on the pipe sizes and number of connections (Section 14.6.1.4).
d. Calculate the hydraulic grade line (HGL) for the storm drain network per Section 14.6.3.3, and adjust the design as necessary to meet the hydraulic conditions and EGL requirements.

Step 6: Adjust the design for utility conflicts.

a. Identify potential utility conflicts based on the SUE Phase I utility map and the preliminary layout.
b. For conflicts requiring utility elevation information, request a SUE Phase II survey through the project manager.
c. Adjust the storm drain layout and design based on the SUE Phase II survey as necessary.
d. Re-analyze the system for hydraulic conditions and adjust as necessary.
e. Finalize the design.

Step 7: Prepare plans, details, and specials.

Step 8: Document analysis and assumptions.

a. See Section 14.9.

## 14.9 DOCUMENTATION

Use the templates provided in Appendix 14A to document design assumptions and decisions.

## 14.10 REFERENCES

1. **FHWA.** *Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, Third Edition.* Washington, DC : Federal Highway Administration, 2009 (revised 2013). FHWA-NHI-10-009.

2. **MDEQ.** *Montana Standards for Subsurface Wastewater Treatment Systems.* Helena, MT : Montana Department of Environmental Quality, 2013. Circular DEQ 4.

3. **FHWA.** *Highway Stormwater Pump Station Design, Hydraulic Engineering Circular No. 24.* Washington, DC : Federal Highway Administration, 2001. FHWA-NHI-01-007.

## Appendix 14A — STORM DRAIN RECOMMENDATION MEMO & REPORT TEMPLATES

*Montana Department of Transportation*
*PO Box 201001*
*Helena, MT 59620-1001*

*(Letterhead provided as an example and may be updated to current letterhead or consultant letterhead.)*

### *Memorandum*

To: "Click here and type name" P.E. *(Design Project Manager)*
"Click here and type title"

From: Name, P.E.
"Click here and type title"

Thru: Name, P.E.
State Hydraulics Engineer

Date: DRAFT until signed

Subject: [Project Number]
[Project Name]
[UPN]
**Storm Drain Recommendation Memo**

This memo describes the storm drain recommendations for the above project. Please incorporate the following storm drain information into the plans and cross sections.

*(For complex storm drain projects, include the information below. List the files with descriptions related to storm drains that have been uploaded to PCMS for the project)*

- The following Special Provision is uploaded to PCMS.
    - XXXXXXXHYSPC001.docx (description)
- Include the following Standard Special Provision.
    - 603-7 Reinforced Concrete Pipes, Boxes, Inlets and Manholes
- The following details are uploaded to PCMS. Descriptions of the files are also included below.
    - XXXXXXXHYDET001.DGN (Storm Drain Plan and Profiles)

.

    - XXXXXXXHYDET002.DGN (Details)
        - Detention Pond *(example)*
        - Special Curb Inlet Design *(example)*
        - Trashguard *(example)*
        - Drainage Siphon Detail *(example)*
    - XXXXXXXHYDET003.DGN
        - *(additional details with descriptions if needed)*
- The following excel spreadsheet is uploaded to PCMS. A description of the file is also included below.
    - XXXXXXXHYQMG001.xlsx
        - Hydraulic Quantities/Storm Drain Summary Sheets

*(For simple storm drain projects, such as intersection improvements, describe the storm drain features that should be shown on the plans. Example text is included below, but the information will be site specific and will need to be developed for each project.)*

**Sta. 102+88.53, 32.25-ft RT**

New Type IV Drop Inlet Frame and Grate
Grate Elevation = 3937.19 ft

Replace the existing Type II curb inlet frame and grate with a Type IV drop inlet frame and grate.

**Sta. 110+37.62, 13.50-ft RT**

New Type B Curb Inlet
Grate Elevation = 3908.53 ft

New 48-in. × 48-in. RCP Tee
Centered Invert Elevation = 3895.68

- Include the following special provisions:
  - New Drop Inlet Connections
  - Field Verify Drainage Pipes and Structures (XXXXXXXHYSPC001.DOCX)

- Include the following standard special provision:
  - 603-7 Reinforced Concrete Pipes, Boxes, Inlets and Manholes

If you have any questions regarding this memo, please contact (Person writing memo) or by e-mail (email address).

e-copies: *Distribution List may be adjusted as needed.*

Highways Engineer
Hydraulics Engineer
Hydraulics Operations Engineer
Road Design Engineer *(Headquarters Design)*
Road Design Designer
District Design Supervisor *(District Design)*
District Engineering Services Supervisor
District Projects Engineer
Geotechnical Engineer
District Geotechnical Engineer
District Biologist
District Development Engineer
District Right-of-Way Supervisor
District Utility Engineering Specialist
Highways File

*Montana Department of Transportation*
*PO Box 201001*
*Helena, MT 59620-1001*

**Storm Drain Report**
**Project Name:**
**Project Number:**
**UPN:**
**By:**
**Date:**

## INTRODUCTION

This report describes…

## GENERAL PROJECT INFORMATION

*(Can copy and paste this from the Hydrology report.)*
Provide a brief description of the project location, route, project limits, and scope of work. Include a general description of the project area (terrain, land use, etc.).

## HYDROLOGY

### Design Flood Frequency and Design Spread

Based on the Road Classification of XXX and the Design Speed of XXX, the Design Flood frequency is the XX-year event, and the Design Spread is XXX.

### Hydrologic Methods

Describe the hydrologic methods considered for the project. Describe the variables used for each method and include the precipitation data source used and why.

State which hydrologic method was chosen for this project.

*Note: Drainage basin/contributing area maps are included in the existing Conditions and Proposed Conditions sections.*

## HYDRAULIC MODELING

Describe the hydraulic modeling method used for this project. If software was used, include the software name and the version number.

### Existing Conditions

Describe the existing drainage system including, pipes, structures, outfall locations and upstream and downstream open channels. Include performance information for the system such as known or expected bottlenecks, known ponding or surcharging, etc.

Include in the appendix or body of the report a map of the existing drainage areas with delineated sub-basins draining to each inlet. If an existing storm drain is present, show the outfall and label the existing feature types, sizes, and materials, age, and condition.

Describe the existing conditions hydraulic model and the performance of the existing system. Provide information on the spread width, inlet performance, and trunk line capacity including the hydraulic grade line, velocities, and invert elevations. Clearly state any assumptions.

### Proposed Conditions

Describe the proposed drainage system including inlet types, pipes, structures, outfall locations, upstream and downstream open channels, and other storm drain features if used.

Include a map of the proposed drainage areas with delineated sub-basins draining to each inlet. Provide a layout of the proposed storm drain system and label the inlets, manholes, laterals, trunk lines, pipe sizes, and outfall location.

Describe the proposed conditions, design flood frequency, hydraulic model, and the performance of the proposed system. Provide information on the spread width, inlet performance, and trunk line capacity including the hydraulic grade line, velocities, and invert elevations. Clearly state any assumptions.

If detention or retention storage facilities are used, describe the design, analysis, and results. Include a figure and description of the peak inflow and outflow, storage volume, outfall structure, and emergency spillway. Show the outlet structure will limit the peak outflow to the allowable outflow.

Describe the outfall and the downstream analysis. The peak flow rate at the outfall should be same as the existing conditions unless drainage easements are proposed and other drainage impacts are evaluated.

Describe the Review Flood Frequency evaluation and results. Include a discussion of maintaining public safety and minimizing flood damages and risk. If storage facilities are included in the design, discuss the emergency spillway design, function, and discharge path.

If the storm drain is located in an MS4 area, describe the design features used to address the MS4 regulations.

## UTILITIES

Include a description of the utilities near the storm drain and a discussion of SUE Phase II results. If applicable, discuss any utility relocations needed.

# APPENDICES

## Appendix A. Existing Conditions

Drainage Basin Map

Hydrology Calculations

Existing Conditions Modeling Results for Design Flood and Review Flood
- Spread Width
- Inlet Performance
- Trunk Line Analysis (at a minimum include)
  - HGL & EGL
  - % Full
  - Velocities
  - Invert Elevations

## Appendix B. Proposed Conditions

Drainage Basin Map

Hydrology Calculations

Proposed Conditions Modeling Results for Design Flood and Review Flood
- Spread Width
- Inlet Performance
- Trunk Line Analysis (at a minimum include)
  - HGL & EGL
  - % Full
  - Velocities
  - Invert Elevations

Storage Facility Calculations Documenting Storage Design for Design Flood and Review Flood (at a minimum include)
  - Peak Inflow
  - Peak Outflow
  - Storage Volume
- Calculations for the Outfall Structure Design
- Calculations for the Emergency Spillway Design for Review Flood

Outfall Design Calculations

Review Flood Analysis
- Flooding Extents
- Water Overland Flow Paths
- Comparison to the Existing Condition

**Appendix C. Details**

***(This will vary by project but may include the following.)***

Storm Drain Details
- Plan and Profiles
- Special Inlets
- Trash Racks
- Outlet Protection
- Outfall Structure

Storage Facility Details
- Grading Plan
- Outlet Structure Detail