

Chapter 5
DATA COLLECTION

SOUTH DAKOTA DRAINAGE MANUAL

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Chapter 5

DATA COLLECTION

5.1 OVERVIEW

5.1.1 Introduction

The hydraulic engineer should identify the types of data that will be required prior to conducting the hydraulic analysis. The effort necessary for data collection and compilation should be tailored to the importance of the project. Not all data discussed in this Chapter will be needed for every project.

Data collection for a specific project should be appropriate for the project scope and be tailored to:

- site conditions;
- scope of the hydraulic analysis;
- social, economic, environmental, historical and archaeological requirements;
- unique project requirements; and
- regulatory requirements.

5.1.2 Data Requirements

Chapter 5 outlines the types of data that are normally required for drainage analysis and design, possible sources and other aspects of data collection. The following subjects are presented:

- types of data,
- sources of data,
- drainage survey information,
- data collection processes,
- field reviews, and
- data reliability.

5.2 TYPES OF DATA NEEDED

5.2.1 General

The designer should compile the data that are specific to the subject site. Following are the major types of data that may be required:

- permit requirements;
- watershed characteristics;
- stream-reach data;
- other physical data within the vicinity of the facility (e.g., utilities, easements);
- hydrologic and meteorological data (stream-flow and rainfall data related to maximum or historical peak and low-flow discharges and hydrographs applicable to the site);
- existing and proposed land-use data in the subject drainage area and in the general vicinity of the facility;
- anticipated changes in land-use and/or watershed characteristics; and
- floodplain limits, environmental regulations and archaeological data.

Watershed, stream-reach and site characteristic data, and data on other physical characteristics can be obtained from a field reconnaissance of the site. Examination of available maps and aerial photographs of the watershed are also excellent methods of defining physical characteristics of the watershed.

5.2.2 Watershed

Following is a brief description of the major data topics that relate to drainage facility analysis and design. Additional information is discussed in Chapter 2 of the AASHTO *Highway Drainage Guidelines* ([Reference \(1\)](#)) and *HDS 2* ([Reference \(2\)](#)).

5.2.2.1 Watershed Characteristics

The following provides a brief description of the contributing size and slope characteristics of a watershed.

5.2.2.1.1 Contributing Size

The size of the contributing drainage area expressed in acres or square miles is determined from some or all of the following:

- digital elevation modeling software (e.g., WMS, Streamstats, ArcMap);
- use of USGS topographic maps and aerial photographs;
- direct field surveys with conventional surveying instruments;
- field checks to determine any changes in the contributing drainage area such as:
 - + urbanization,
 - + terraces,
 - + lakes and sinks,
 - + debris or mud flow barriers,
 - + reclamation/flood-control structures,
 - + irrigation diversions,
 - + storm sewer systems, and
 - + landowner alterations; and
- other topographic maps of the drainage area from local governments and developers.

When determining the size of the drainage basin, document any natural springs or subterranean flow loss zones (e.g., Karst formations) where flow is diverted from the surface waters. Karst is defined as “an irregular limestone region with sinks, underground streams and caverns.” Also define any areas outside the physical boundaries of the drainage area that have runoff diverted into the drainage area being analyzed or any flood waters that are diverted out of the basin before reaching the site.

In previous upstream developed areas, the contributing drainage area will generally be limited to approximately one block either direction of the State Highway for determining drop inlet locations and pipe sizing of the storm sewer system. Any additional contributing drainage area beyond this distance can be designed into the State Highway storm drainage system, however by agreement the Local Governing Agency will be required to reimburse the State for any additional cost to upsize the storm drainage system along the State Highway.

In circumstances where upstream drainage areas are either undeveloped or has a natural water course that approaches the State Highway, the drainage will be accommodated based on proper year design storm according to [Figure 7.6-A](#).

5.2.2.1.2 Slopes

Hydrologic and hydraulic procedures presented in this *Manual* are dependent on watershed slopes and other factors. Determine the stream slope in the vicinity of proposed structures that will be used for the hydraulic analysis and the average slope of the watershed that will be used for the hydrologic analysis.

5.2.2.2 Watershed Land Use

Define and document the existing and expected future land use, particularly the location, degree of anticipated urbanization and data source. This information may be obtained from:

- field reviews,
- aerial photographs (conventional and infrared),
- zoning maps and master plans,
- USGS and other maps,
- municipal planning agencies,
- landsat (satellite) images, and
- GIS data.

Specific information regarding particular tracts of land can often be obtained from owners, developers, realtors and local residents. Care should be exercised in using data from these sources because their reliability may be questionable, and these sources may not be aware of future development within the watershed that might affect specific land uses.

Existing land-use data for small watersheds can best be determined or verified from a field survey (see [Section 5.4](#)). Field surveys should also be used to update information on maps and aerial photographs, especially in basins that have experienced changes in development since the maps or photos were prepared. Infrared aerial photographs may be particularly useful in identifying types of urbanization at a point in time.

5.2.2.3 Streams, Rivers, Ponds, Lakes, Wetlands and Detention Basins

The hydraulic engineer should secure the following data at all streams, rivers, ponds, lakes and wetlands that will affect or may be affected by the proposed structure or construction. These data are essential in determining the expected hydrology and may be needed for regulatory permits:

- Determine the elevation of normal and high water for various frequencies.

- Prepare a detailed description of any natural or constructed spillway or outlet works including dimensions, elevations and operational characteristics, including emergency spillway works.
- Determine the classification of the water body.
- Document descriptions of adjustable gates, soil and water-control devices.
- Prepare a profile along the top of any dam and a typical cross section of the dam.
- Determine the use of the water resource (e.g., stock water, fish, recreational, power, irrigation, municipal or industrial water supply).
- Note the existing conditions of the stream, river, pond, lake or wetlands as to turbidity and silt.

5.2.2.4 Environmental Considerations

The need for environmental data in the hydraulic analysis and design stems from the need to investigate and mitigate possible impacts due to specific design configurations. The hydraulic engineer should coordinate with the SDDOT Environmental Office. Environmental data needs are briefly described in the following Sections.

5.2.2.4.1 Environmental Sensitivity

Identify the information necessary to define the environmental sensitivity of the facility's site relative to impacted surface waters (e.g., water use, water quality and standards, aquatic and riparian wildlife biology, wetlands information). Some of this information is available in the water quality standards and criteria published by the South Dakota Department of Environment and Natural Resources.

5.2.2.4.2 Water Quality Data

Physical, chemical and biological data for many streams are also available from State and Federal water pollution control agencies, USGS, municipalities, water districts and industries that use surface waters as a source of water supply. In unique cases, a data collection program possibly lasting several years and tailored to the site may be required.

Gather the information necessary to determine the most environmentally compatible design (e.g., circulation patterns, sediment transport data). Data on circulation, water velocity, water quality and wetlands are available from the USGS, USACE, South Dakota Department of Environment and Natural Resources, universities and local agencies and organizations. Information on sediment transport is vital in defining the

suitability of a stream for most beneficial uses including fish habitat, recreational and water supply. Data collection for projects in critical water-use areas (e.g., near municipal or industrial water supply intakes) should be accomplished early in project development to ensure proper coordination.

5.2.2.4.3 Mitigation

Information necessary to define the need for and design of mitigation measures should be obtained (e.g., fish characteristics (type, size, migratory habits), fish habitat (depth, cover, pool-riffle relationship), sediment analysis, water use, quality standards). Fish and fish habitat information is available from the USFWS and the South Dakota Department of Game, Fish and Parks.

Wetlands

Wetlands are unique and data needs can be identified through the SDDOT Environmental Office, which will then coordinate with the South Dakota Department of Environment and Natural Resources and the South Dakota Department of Game, Fish and Parks.

5.2.3 Site Characteristics

A complete understanding of the physical nature of the natural channel or stream reach is of prime importance to a good hydraulic design, particularly at the site of interest. Any work being performed, proposed or completed that changes the hydraulic efficiency of a stream reach should be studied to determine its effect on the stream flow. The designer should be aware of plans for channel modifications and any other changes that might affect the facility design. The stream may be classified as:

- rural or urban;
- improved or unimproved;
- narrow or wide;
- rapid or sluggish flow;
- stable, transitional or unstable;
- sinuous, straight, braided, alluvial or incised; and
- perennial or intermittent flow.

[HEC 20 \(Reference \(3\)\)](#) and [HDS No. 6 \(Reference \(4\)\)](#) present commonly used stream classification systems.

5.2.3.1 Geomorphological Data

Geomorphological data are important in the analysis of channel stability and scour. Types of needed data, if the stream reach needs to be analyzed, include:

- sediment transport and related data;
- stability of form over time (braided and meandering, pool-riffle relationship);
- scour history/evidence of scour; and
- bed and bank material identification.

5.2.3.2 Roughness Coefficients

Roughness coefficients, ordinarily in the form of Manning's n values, should be estimated for the entire flood limits of the stream. See [Chapter 9 "Roadside Channels"](#) for a tabulation of Manning's n values with descriptions of their applications.

5.2.3.3 Stream Profile

Stream-bed profile data should be obtained, and these data should extend sufficiently upstream and downstream to determine the average slope and to encompass any proposed construction or aberrations. Identification of "headcuts" that could migrate to the site under consideration are particularly important. Profile data on live streams should be obtained from the water surface. Where there is a stream gage relatively close, the discharge, date and hour of the reading should be obtained.

5.2.3.4 Stream Cross Sections

Stream cross section data should be obtained that represent the conditions at the structure site. Stream cross section data should also be obtained at other locations where stage discharge and related calculations will be necessary.

5.2.3.5 Existing Structures

The location, size, description, condition, observed flood stages and channel section relative to existing structures on the stream reach and near the site should be secured to determine their capacity and effect on the stream flow. Any structures, downstream or upstream, that may cause backwater or retard stream flow should be investigated. Also, note the history of how existing structures have been functioning regarding scour, overtopping, debris and ice passage, fish passage, etc. With bridges, these data include span lengths, types of piers and substructure orientation, which usually can be obtained from existing structure plans. The necessary culvert data includes size, inlet and outlet geometry, slope, end treatment, culvert material and flow-line profile. Highway construction plans may be available to obtain required bridge and/or culvert data. The hydraulic engineer should verify the documented as-built conditions through

field checks. Photographs and high-water profiles or marks of flood events at the structure and past flood scour data can be valuable when assessing the hydraulic performance of the existing facility.

5.2.3.6 Acceptable Flood Levels

Development and property use adjacent to the proposed site, both upstream and downstream, may determine acceptable flood levels. Note the ground elevations of buildings in the vicinity of structures. In the absence of upstream development, acceptable flood levels may be based on tailwater and freeboard requirements of the highway itself. In these cases, the presence of downstream development may determine appropriate overflow points when an overtopping design of the highway is considered.

5.2.3.7 Flood History

The history of past floods and their effect on existing structures are of exceptional value in making flood hazard evaluation studies, and they provide needed information for sizing structures. Information may be obtained from newspaper accounts, local residents, SDDOT maintenance files, flood marks or other positive evidence of the height of historical floods. Evaluate changes in channel and watershed conditions since the occurrence of the flood by relating historical floods to present conditions.

Recorded flood data may be available from USACE, USGS, NRCS, FEMA, US Bureau of Reclamation, South Dakota Department of Environment and Natural Resources, etc.

5.2.3.8 Debris and Ice

Investigate the quantity and size of debris and ice carried or available for transport by a stream during flood events. In addition, the times of occurrence of debris and ice in relation to the occurrence of flood peaks should be determined, and the effect of backwater from debris and ice jams on recorded flood heights should be considered when using stream flow records. Data related to debris and ice considerations can be obtained from maintenance personnel, maintenance records and bridge inspection reports.

5.2.3.9 Scour Potential

Scour potential is an important consideration relative to the stability of the structure over time. Scour potential will be determined by a combination of the stability of the natural materials at the facility site, tractive shear force exerted by the stream and sediment transport characteristics of the stream. Data can be obtained from the SDDOT bridge

hydraulic and geotechnical files, or USGS may have collected limited data at the site as an element of its stream gaging activities or as part of the Level 1.5 bridge scour analysis.

Bed and bank material samples sufficient for classifying channel type, stability and gradations are required. A geotechnical study to determine the substrata is also required for scour studies. The various alluvial river computer model data needs will help clarify what data are needed. Also, these data are needed to determine the presence of bed forms so that a reliable Manning's roughness coefficient and bed-form scour can be estimated.

[Chapter 14 "Bridge Hydraulics"](#) discusses hydraulic scour in more detail.

5.2.3.10 Controls Affecting Design Criteria

Many controls will affect the criteria applied to the final design of drainage structures including allowable headwater level, allowable flood level, allowable velocities and resulting scour and other site-specific considerations. Data and information related to these types of controls can be obtained from Federal, State and local regulatory agencies and site investigations to determine what natural or constructed controls should be considered in design. In addition, there may be downstream and upstream controls that should be documented.

5.2.3.11 Downstream Control

Any ponds or reservoirs, including their spillway elevations and design levels of operation, should be noted because their effect on backwater and/or streambed aggradation may directly influence the proposed structure. Any downstream confluence of two or more streams should be studied to determine the effects of backwater or streambed change resulting from that confluence. In addition, the following may have an effect:

- landowner alterations downstream,
- highway crossings, and
- railroad crossings.

5.2.3.12 Upstream Control

Note any upstream control of runoff in the watershed and obtain its capacities and operational designs. Conservation and/or flood control reservoirs in the watershed may effectively reduce peak discharges at the site and may also retain some of the watershed runoff. NRCS; USACE; US Bureau of Reclamation; South Dakota Department of Game, Fish and Parks; South Dakota School and Public Lands and other

reservoir sponsors often have comprehensive reports on the operation and design of proposed or existing conservation and/or flood control reservoirs.

The redirection of flood waters can significantly affect the hydraulic performance of a site. Some actions that redirect flows are irrigation facilities, landowner alterations, debris and ice jams, mud flows and highways or railroads.

5.3 SOURCES OF DATA

5.3.1 Geographic Information Systems (GIS)

South Dakota's geographic information system (GIS) may be used as a source of georeferenced hydrologic data required in hydraulic design decision-making. For example, a GIS database has been developed containing the land cover, soil type and topography for the Department's entire area of jurisdiction. This database may then be used to produce the existing and ultimate-development hydrographs and an array of maps, graphs and tables needed to complete the hydrologic analysis.

5.3.2 National Flood Insurance Program

A number of streams in South Dakota have been analyzed for local flood insurance studies. In these cases, data collection requirements are normally reduced or unnecessary because the discharges and hydraulic models are normally available from FEMA. Although these studies are a good source of data, their technical content should be reviewed prior to using the data. Many of the studies are outdated and/or will not reflect changes that may have occurred in the study reach since its initial publication. See [Section 17.3](#) for more discussion on NFIP.

5.3.3 Sources

Much of the data and information necessary for the design of highway drainage facilities may be obtained from some combination of the sources listed in [Appendix 5A](#).

5.4 DATA COLLECTION PROCESSES

5.4.1 Field Data Collection

Field data collection is normally accomplished using electronic survey equipment including Total Station, Global Positioning System (GPS). Refer to the *SDDOT Survey Manual* for more details regarding data collection for drainage surveys.

5.4.2 Digital and Satellite Data Models

Several methods to use electronic data for hydraulic and hydrologic studies are available. Design of drainage systems can be accomplished using CADD software and electronic surface data. Hydrologic and hydraulic models can be developed using this data.

The types of data normally used by digital models are:

- elevation data;
- features (e.g., streams, roadways);
- land use; and
- soils and infiltration.

Some of the electronic data is readily available, though not always with the desired resolution. Elevation data is available from the USGS in DEM format. The data is normally available in UTM coordinates and in 10-m to 30-m resolution, depending on the location. NRCS maintains soil and land-use data bases in GIS formats in certain areas. Detailed hydraulic and hydrologic studies may require higher resolution elevation data than is normally available through USGS and NRCS. Higher resolution data is sometimes available through local municipalities.

Satellite imagery is available through commercial vendors. However, elevation data is not normally available through these sources. Satellite imagery can be used to determine land uses. Due to the scarcity or obsolescence of elevation data, the normal approach is to develop topographic surveys for a project.

5.4.3 Aerial Photogrammetry and Surveys

With this method, topographic mapping is developed using pictures of the ground taken from an aircraft or satellite. Ground controls are established using field survey methods, and contours are developed.

High-resolution satellite and multi-spectral imagery is available and may be substituted for other methods if necessary. Because satellite data is stored for a period of time, multi-spectral satellite imagery can also be used to investigate flooding after an event

has occurred. Potentially, the technology can be used to develop “before-and-after” images and topography to investigate a flood event or other significant change in an area of interest.

Another method of aerial topographic generation is using laser or radar beams from an aircraft carrying differential GPS. The laser-based method is called Light Detection and Ranging (LIDAR). LIDAR or radar-generated data have the advantage of being inexpensive when compared to traditional photogrammetry. However, the accuracy is highly dependent on the technology available to the vendor in aerial equipment and available software to filter trees and other covered land areas.

5.4.4 Data Merging

Merging of electronic surface data is common during highway design. Better data is usually collected within the highway area, while the data for the area outside the expected cut/fill lines is less precise. Because watershed limits fall well outside the highway cut/fill lines, hydraulic engineers should negotiate with the data that has multiple resolutions.

Electronic data is available in various forms differentiated by software products, type of data structure (DEMs and TINs), coordinate systems (UTM, State Plane, Latitude-Longitude), units (feet or meters), resolution and datums. When merging data in different forms, care should be taken to ensure proper conversion prior to merging. Standardizing all data to the most current format is the best way to ensure compatibility. There are tools available to accomplish the data “translation.”

A more serious issue in data merging is caused by differences in data resolution. For example, a digital surface model developed using a photogrammetric method is typically of a lower resolution compared to a surface model developed using a field data collection survey. When merging the data, elevation differences at the boundaries of the different data areas should be carefully reconciled.

There is often a problem with artificial pits and peaks due to the creation of DEMs and TINs. The data user should evaluate the data and correct these inconsistencies.

5.4.5 Accuracy of Data

In any hydraulic computation, it is important to understand the limitations in the accuracy of the computations based on the accuracy of the input data. In step-backwater computations using HEC-RAS, there are several factors that have significant effects on the accuracy of the results:

- accuracy of the survey data,
- spacing between cross sections,

- correct establishment of upstream and downstream study limits, and
- selection of roughness coefficients.

Most field surveys of channel and floodplain cross sections are recorded to an accuracy of 0.1 ft. If the survey truly represents the cross sections of the reach of the stream being studied to 0.1-ft accuracy, the greatest accuracy that would result from a step-backwater computation could be no more than 0.1 ft. Any results expressed more precisely than 0.1 ft are simply a function of the mathematics.

The accuracy of aerial survey technology for generating cross sectional coordinate data is governed by mapping industry standards. Cross sections obtained from contours of topographic maps developed by photogrammetric methods are generally not as accurate as those generated from field data collection methods. Aerial photography can supplement field survey cross sections. The use of aerial elevation survey technology permits additional coordinate points and cross sections to be obtained at only a small incremental cost, and the coordinate points may be formatted for direct input into water surface profile computer programs (e.g., HEC-RAS).

For further information on determining the relationships between survey technology and accuracy employed for determining stream cross sectional geometry, degree of confidence in selecting Manning's roughness coefficients and the resulting accuracy of hydraulic computations, refer to the USACE publication, RD-26, [Accuracy of Computer Water Surface Profiles](#); see [Reference \(5\)](#)). This publication also presents methods of determining the upstream and downstream limits of data collection for a hydraulic study requiring a specified degree of accuracy. FHWA released the software HY-11 "Preliminary Analysis System for WSP" ([Reference \(6\)](#)) in 1989 to help determine these limits. The DOS-based software is no longer available.

5.5 FIELD REVIEWS

5.5.1 General

An on-site field review is organized and conducted by the Hydraulics Section to become familiar with the conditions along the project. The inspection team typically includes field and hydraulics personnel. The most complete survey data cannot adequately depict all site conditions or substitute for personal inspection by someone experienced in drainage design. Factors that most often need to be confirmed by the hydraulic engineer are:

- verify basin boundaries,
- selection of roughness coefficients,
- evaluation of apparent flow direction and diversions,
- flow concentration,
- observation of land use and related flood hazards,
- geomorphic relationships,
- high-water marks or profiles and related frequencies,
- existing structure size and type,
- existence of wetlands, and
- erosion and scour.

The Office of Road Design will also verify the drainage data for smaller basins (< 1000 acres) in the field. For basins \geq 1000 acres and before final design, a Preliminary Site Inspection will be conducted. This Inspection typically includes field, structural and hydraulics personnel. It represents another opportunity for the hydraulics engineer to verify and finalize drainage data issues that arise after the earlier inspection.

5.5.2 Preparation of Preliminary Drainage Data

5.5.2.1 **Transfer Road Alignment to Quadrangle Map**

To prepare for preliminary drainage data collection, the designer should first have the project's road alignment transferred to the appropriate quadrangle map. The Office of Road Design will provide a preliminary plan and profile for the proposed highway project. To transfer the road alignment, the designer should perform the following steps:

1. Obtain The Quadrangle Map. The quadrangle (topographic) map for the project site can be located either electronically or as a hard copy in the Bridge Office. For hard copies, a number-coded key map (according to drawer, folder and individual sheet) is available in one of the drawers and also on computer.
2. Obtain "Old Plans." The project's "Old Plans" for the existing highway are found by searching for Microfilm/Plans under "Applications" on the SDDOT Intranet

Site. “Old Plans” are stored in *.pdf format. Make copies of the plans and note the Microfilm code number on the title copy.

Transfer Road Alignment. Use an engineering scale, typically 1:20, to transfer existing drainage crossing locations and proposed highway alignment from the preliminary plan sheets to the quadrangle map. Delineate the proposed highway stationing for each crossing. Check with the old microfilmed plans to ensure that each existing crossing is in the correct location. The old plans may provide other useful hydraulics information for the preliminary hydraulics design.

5.5.2.2 Determine Drainage Areas

Before the field review, determine the drainage area for all drainage crossings within the project limits on the quadrangle map. This calculation will be verified during the field review. The drainage area can be determined using GIS-assisted methods, WMS software (see [Chapter 18 “Hydraulic Software”](#)) or traditional hand methods. The drainage area of non-contributing areas (see [Section 7.9.2.3](#)) should be determined. These area(s) will retain all rainfall from the design event.

5.5.2.3 Determine Channel Slopes

Calculate the channel slopes in feet or miles as defined by either of the following USGS publications:

- [US Geological Survey, Water-Resources Investigation 98-4055](#) “Techniques for Estimating Peak-Flow Magnitude and Frequency Relations for South Dakota Streams,” 1998.
- [US Geological Survey, Water-Resources Investigation 80-80](#) “Techniques for Estimating Flood Peaks, Volumes, and Hydrographs on Small Streams in South Dakota,” September 1980.

The user may use the engineering scale, the distance-measuring wheel or ArcView to determine the channel lengths. For WRI 98-4055, calculate slopes only for drainage areas in Subregion F for drainage areas less than or equal to 1000 sq mi. For WRI 80-80, calculate slopes only for drainage areas less than 100 sq mi.

The Office of Road Design currently requests drainage basin slopes for all crossings with drainage areas 150 acres or greater and documents the information in SDDOT’s “Drainage Memo.” See [Section 6.2.5](#) for a description of the SDDOT Drainage Memo.

5.5.3 Conducting the On-Site Inspection

The following questions should be addressed before making the field visit:

- Can any needed information be obtained from maps or aerial photos or by telephone calls?
- What type of equipment should be taken and, most important, what exactly are the critical items at this site?
- Should photos be taken looking upstream and downstream from the site and along the contemplated highway centerline in both directions?
- Should details of the streambed and banks be photographed?
- Are there structures in the vicinity both upstream and downstream?
- Should close-up photographs complete with a scale or grid be taken to facilitate estimates of the streambed gradation?

One of the following, as provided in [Appendix 5.B](#), should be used to document the visit:

- “Drainage Area Inspection Checklist (for Grading Projects),” or
- “Structure Site Information Form.”

5.6 DRAINAGE SURVEY INFORMATION

5.6.1 General

The hydraulic engineer should conduct an in-office review of the project to determine the required field and/or aerial drainage survey need for the hydraulic analysis and design. Survey requirements for small drainage facilities and/or small culverts are less extensive than those for bridges. However, the purpose of each survey is to provide an accurate picture of the conditions within the zone of hydraulic influence of the facility. Following are the types of data that can be obtained or verified:

- stream-reach data (e.g., cross sections, thalweg profile);
- existing structures;
- location and survey for development, existing structures, etc., that may affect the determination of allowable flood levels, capacity of proposed drainage facilities or acceptable outlet velocities;
- drift/debris characteristics; and
- high-water elevations including the date of occurrence.

Much of these types of data should be verified during the site inspection. It is often much easier to interpret published sources of data after an on-site inspection. Only after a thorough study of the area and a complete collection of all required information should the hydraulic engineer proceed with the final design of the hydraulic facility. All pertinent data and facts gathered through the survey should be documented as discussed in [Chapter 6 “Documentation”](#).

The hydraulic engineer should note that uniform or standardized drainage survey requirements for all projects may prove uneconomical or that the data is deficient for a specific project. Special instructions outlining data requirements may need to be provided to the survey party by the hydraulic engineer for unique sites.

5.6.2 Survey Locations

A preliminary drainage survey should first identify the locations where drainage structures will be required. The hydraulic engineer may need to provide this information to the appropriate survey personnel.

This information may be provided as part of the project scope, or it may be requested by survey personnel when they initiate the field survey. Project corridor limits, as provided by the Office of Road Design, are needed by the hydraulic staff to identify the larger drainage basins. The hydraulic staff will provide a list of the locations that appear to be

over 200 acres and those over 1000 acres. This will identify the survey area limits required for each range of drainage basin.

5.6.3 Drainage Survey Needs

5.6.3.1 General

The basic information needed for all drainage surveys is as follows:

- Obtain any observed high water elevations and the date of the high water. It is important that this information be obtained because it can aid the hydraulic engineer in the calibration of the hydraulic model developed to analyze existing and to size future structures.
- For any existing box culvert or large culvert encountered, obtain the flow line (invert or top of floor) elevation and coordinates of the inlet and outlet ends. See [Section 5.6.5](#). The coordinates of all four corners should be recorded for box culverts. Additional elevations and coordinates at the end of any apron are optional. This data is important for any crossing, but especially important for any culverts that will be extended or for fish passage considerations.
- Obtain the low elevation of any upstream buildings.
- Obtain data approximately 500 ft to 600 ft both upstream and downstream to define the channel and any obstructions. Dams should always be documented because they may impact the highway crossing. For dams, provide the spillway crest elevation, width and shape.
- Obtain the waterway opening and height at roadway overtopping for any structure within 4 mi upstream and downstream of the project site on the same drainage channel. For bridges, obtain a channel cross section of the bridge opening. For culverts, provide the number, width and height of the culvert(s). If this information is available in some other source (e.g., bridge maintenance inspection files), reference that information. When crossing lake bed areas, the lake bed overflow outlet should be located and the overflow elevation established.
- Complete and submit the Drainage Data Information Sheet to the Hydraulic Engineer when the survey for the remainder of the project is transmitted. [Appendix 5.B](#) provides a sample Drainage Data Information Sheet, which is completed by the surveyor.

5.6.3.2 Drainage Basins

5.6.3.2.1 Drainage Basins Less than 200 Acres

Drainage basins with an area less than 200 acres normally do not require special survey needs.

5.6.3.2.2 Drainage Basins from 200 to 1000 Acres

The survey coverage limits for drainage basins from 200 acres to 1000 acres should include the area that defines the main channel for a distance of at least 500 ft upstream of the proposed crossing location to define any flood storage capacity in that area. The standard roadway corridor coverage is adequate coverage for the downstream channel. However, ensure that the channel flowline is defined within this corridor and coded accordingly.

5.6.3.2.3 Drainage Basins Greater than 1000 Acres

Drainage basins greater than 1000 acres require the most extensive survey coverage. The survey coverage limits should include:

- The area that defines the main channel for a distance of at least 1000 ft downstream to 1000 ft upstream of the proposed crossing location. Where the roadway alignment is uncertain, it may be necessary to increase the limits to ensure that adequate coverage is obtained. Define the center of the low channel and note any abrupt change in the channel flow line. When project scoping has been completed prior to commencing the survey and those areas of possible alignment shifts have been confirmed, the coverage limits do not need to be increased. For larger rivers, the survey limits may need to be increased to provide sufficient data for the hydraulic model. Hydraulics staff will advise when this is requested.
- Special emphasis should be given to ensure that the survey limits adequately define the main channel limits so that the flow capacity of the main channel can be analyzed. For those floodplains where the valley beyond the main channel is very wide and flat, the survey limits should include the main channel and a minimum distance of at least 50 ft beyond the top of the banks onto the floodplain. If the immediate area of the main channel is adequately covered by the ground survey, office personnel can extend the limits as needed by using other sources (e.g., digital elevation or quadrangle maps). Obtain sufficient ground points and include sufficient referencing lines to properly define the irregular geometry of natural waterways.

- Ensure that surveyed ground points near the existing structure are sufficient so that the structure (bridge) opening can be obtained from the survey data. This often requires obtaining underwater survey data.

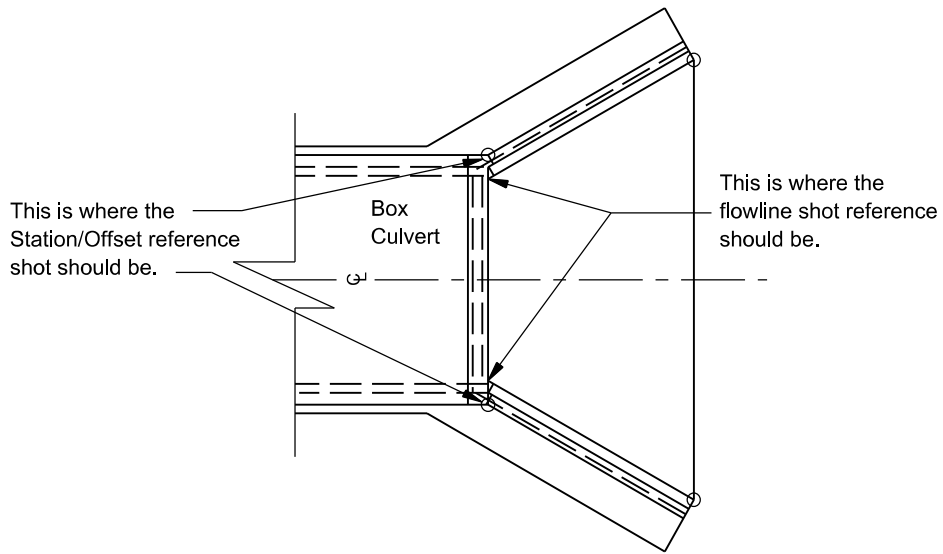
5.6.4 Survey Data Files

Usually, the survey should be provided in a format compatible with Department software. When the survey data is available to the Bridge Hydraulic Engineer, he/she will process the data to develop contour plots, channel profiles and hydraulic model cross sections. Where the survey data files are not compatible with Department software, the surveyor is responsible for plotting the drainage survey. The Bridge Hydraulic Engineer should be consulted for the required contents and plotting format prior to plotting the survey. Stationing of the channel profile will begin at the downstream end and proceed upstream.

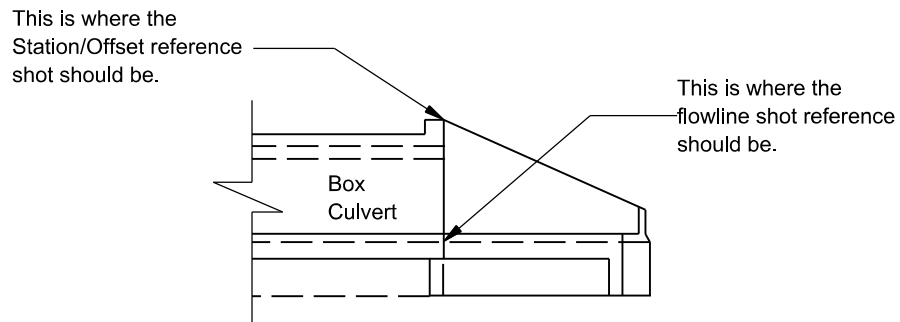
For local government projects, where the survey is not required to be in the Department's software format, the surveyor will provide the drainage survey data in a format as required by those who will be using the data.

5.6.5 Location of Shots on Drainage Culverts

Required flowline shots are taken at the end of the culvert. Flowline shots are not taken at the end of the apron. See [Figure 5.6-A](#) for a graphic illustration.



PLAN



ELEVATION

Figure 5.6-A — LOCATION OF SHOTS ON DRAINAGE CULVERTS

5.7 DATA

5.7.1 Objective

Once the needed data have been collected, the next step is to compile it into a usable format. The hydraulic designer and the hydraulic engineer should ascertain whether the data contains inconsistencies or other unexplained anomalies that might lead to erroneous calculations or results. The primary reason for analyzing the data is to draw all of the various pieces of collected information together and to fit them into a comprehensive and accurate representation of the hydrologic and hydraulic characteristics of a particular site.

5.7.2 Reliability

Data should always be subjected to careful study by the hydraulic engineer for accuracy and reliability. Experience, knowledge and judgment are important components of data evaluation. It is in this phase that reliable data should be separated from that which is less reliable and historical data combined with that obtained from measurements. The data should be evaluated by the hydraulic engineer for consistency and to identify any changes from established patterns. Reviews should be made of such items as previous studies and old plans for types and sources of data, how the data were used and any indications of accuracy and reliability. Historical data should be reviewed to determine whether significant changes have occurred in the watershed and whether these data can be used. Data acquired from the publications of established sources (e.g., USGS) can usually be considered as valid and accurate. Data should always be subjected to careful study by the hydraulic designer and the hydraulic engineer for accuracy and reliability.

Basic data (e.g., streamflow data derived from non-published sources) should be evaluated and summarized before use. Compare maps, aerial photographs, Landsat images and land-use studies with one another and with the results of the field survey and resolve any inconsistencies. General references should be consulted to help define the hydrologic character of the site or region under study and to aid in the analysis and evaluation of data.

5.7.3 Sensitivity

Sensitivity studies may be used to evaluate data and establish the relative importance of specific data items to the final design. Sensitivity studies consist of conducting a design with a range of values for specific data items. The effect on the final design can then be established. This is useful in determining what specific data items have major effects on the final design and the importance of possible data errors. Time and effort can then be dedicated to the more sensitive data items ensuring that these data are as accurate as possible. This does not mean that inaccurate data are accepted for less

sensitive data items, but it allows prioritization of the data collection process given a limited budget and time allocation.

The results of this type of data evaluation should be used so that as reliable a description as possible of the site can be made within the allotted time and the resources committed to this effort. The effort of data collection and evaluation should be appropriate for the importance and extent of the project and/or facility.

5.8 REFERENCES

1. AASHTO, *Highway Drainage Guidelines*, Chapter 2 “Hydrology,” Task Force on Hydrology and Hydraulics, 2005.
- Federal Highway Administration, *Highway Hydrology*, [Hydraulic Design Series No. 2](#), FHWA-SA-96-067, 1996.
- Federal Highway Administration, *Stream Stability at Highway Structures, Third Edition*. [Hydraulic Engineering Circular No. 20 \(HEC 20\)](#), FHWA NHI-01-002, Washington, DC, 2001.
- Federal Highway Administration, [River Engineering for Highway Encroachments — Highways in the River Environment](#), Hydraulic Design Series No. 6, FHWA-NHI-01-004, December 2001.
- US Army Corps of Engineers, [Accuracy of Computer Water Surface Profiles](#), RD-26, Hydrologic Engineering Center, 1986.
- Federal Highway Administration, [Preliminary Analysis System for WSP](#), Hydraulics Software No. 11 (HY-11), 1989.

Appendix 5.A

DATA SOURCES

5.A.1 PRINCIPAL WATERSHED DATA SOURCES

1. National Meteorological Data
 - National Oceanic and Atmospheric Agency (NOAA)
National Climatic Data Center
37 Battery Park Avenue
38 Federal Building
Asheville, North Carolina 28801
(704) 271-4800 FAX (704) 271-4876

2. Regional And Local Flood Studies
 - USGS Water Science Center
1608 Mt. View Road
Rapid City, South Dakota 57702
(605) 394-3200

 - US Army Corps of Engineers
Omaha District Office
1616 Capital Avenue, Suite 9000
Omaha, Nebraska 68102
(402) 995-2417

 - US Army Corps of Engineers
St. Paul District Office
190 5th Street, East
St. Paul, Minnesota 55101-1638
(651) 290-5200

 - Bureau of Land Management
South Dakota Field Office
310 Roundup Street
Belle Fourche, South Dakota 57717-1698
(605) 892-7000

 - US Bureau of Reclamation
575 9th Street, Room 101
Rapid City, South Dakota 57701
(605) 394-9757

- NRCS South Dakota State Office
200 4th Street, SW
Federal Building, Room 203
Huron, South Dakota 57350
(605) 352-1200

5.A.2 PRINCIPAL WATERSHED DATA SOURCES

1. USGS Maps (“Quad Sheets”)

- South Dakota US Geological Survey
414 East Clark Street
Vermillion, South Dakota 57069-2390
(605) 677-5227
- US Geological Survey (Western Regional Office)
Rocky Mountain Mapping Center
Mail Stop 504
Denver Federal Center
Denver, Colorado 80225
(303) 236-5829

2. Aerial Photographs

- US Geological Survey
Mundt Federal Building
47914 252nd Street
National Center for Earth Resource Observation & Science (EROS)
Sioux Falls, South Dakota 57198-0001
(605) 594-6511

3. NRCS Soils Maps and Studies

- NRCS South Dakota State Office
200 4th Street, SW
Federal Building, Room 203
Huron, South Dakota 57350
(605) 352-1200

4. BLM Soils Maps

- Bureau of Land Management
South Dakota Field Office
310 Roundup Street

Belle Fourche, South Dakota 57717-1698
(605) 892-7000

5. USGS Reports

- South Dakota US Geological Survey
1608 Mt. View Road
Rapid City, South Dakota 57702
(605) 394-3200
- US Geological Survey (Western Regional Office)
Rocky Mountain Mapping Center
Mail Stop 504
Denver Federal Center
Denver, Colorado 80225
(303) 236-5829

5.A.3 PRINCIPAL SITE DATA SOURCES

- SDDOT files
- SDDOT aerial surveys
- SDDOT files of aerial stereoscopic photographs
- SDDOT files of existing drainage structures
- SDDOT site visits

5.A.4 PRINCIPAL REGULATORY DATA SOURCES

1. Federal Floodplain Delineations and Studies

- Federal Emergency Management Agency, Region VIII
Denver Federal Center
Building 710, Box 25267
Denver, Colorado 80225-0267
(303) 235-4800
- Federal Emergency Management Agency
Flood Map Distribution Center
6930 (A-F) San Tomas Road
Baltimore, Maryland 21227-6227
(800) 358-9616

2. South Dakota Floodplain Delineations and Studies

- South Dakota Division of Emergency Management
118 West Capitol
Pierre, South Dakota 57501
(605) 773-3231

3. FHWA Hydraulic Engineering Publications

- US Department of Transportation
<http://isddc.dot.gov/>
- Federal Highway Administration
www.fhwa.dot.gov/engineering/hydraulics

4. Other

- 40 CFR Part 230
- South Dakota drainage laws (see [Chapter 2 “Legal Aspects”](#))
- local drainage ordinances and master plans

5.A.5 PRINCIPAL ENVIRONMENTAL DATA SOURCES

1. USEPA Data and Studies

- USEPA Region 8 Office
999 18th Street, Suite 300
Denver, Colorado 80202-2466
(303) 312-6312

2. USACE Data and Studies

- US Army Corps of Engineers
Omaha District Office
1616 Capital Avenue, Suite 9000
Omaha, Nebraska 68102
(402) 995-2417
- US Army Corps of Engineers
St. Paul District Office
190 5th Street, East
St. Paul, Minnesota 55101-1638
(651) 290-5200

3. USGS Water Quality Data

- USGS Water Science Center
1608 Mt. View Road
Rapid City, South Dakota 57702
(605) 394-3200

4. South Dakota Water Quality Data

- South Dakota Department of Environment and Natural Resources
Joe Foss Building
523 E. Capitol
Pierre, South Dakota 57501
- SDDOT Environmental Office
700 E. Broadway Avenue
Becker-Hansen Building
Pierre, South Dakota 57501

5.A.6 OTHER DATA SOURCES

- South Dakota Game, Fish and Parks
523 East Capitol Avenue
Pierre, South Dakota 57501
(605) 773-3485
- US Fish and Wildlife Service (USFWS)
South Dakota Ecological Service Field Office
420 S. Garfield Avenue, Suite 400
Pierre, South Dakota 57501-5408
(605) 224-8693
- US Bureau of Reclamation (USBR)
304 East Broadway Avenue
Bismarck, North Dakota 58501
(701) 250-4242
- US Forest Service (USFS)
Rocky Mountain Region
740 Simms Street
Golden, Colorado 80401
(303) 275-5350

- National Oceanic and Atmospheric Administration (NOAA)
National Weather Service
1325 East West Highway
Silver Spring, Maryland 20910

Appendix 5.B

CHECKLISTS

Appendix 5.B presents the following Checklists:

1. Drainage Area Inspection Checklist. This Checklist applies to grading projects. It is used for planning purposes and for conducting the inspection of the drainage area.
2. Structure Site Information Form. This Checklist is a data collection form for larger drainage sites (DA > 1000 acres) for which the Hydraulics Section will be performing the hydraulic analysis.
3. Drainage Information Data Sheet for Survey. This Checklist is completed by the surveyor, and it is submitted to the Hydraulic Engineer when the survey for the remainder of the project is transmitted.

SDDOT Office of Road Design
DRAINAGE AREA INSPECTION CHECKLIST
 (Applies to Grading Projects)

PROJECT INFORMATION

Project Number:		PCN No.:	
County(s):		Highway Number:	
State Route No.:			
Location Description:			
Station:			
Stream Name:			
Legal Description (Sect./Twp/Range):			
FEMA Floodplain?	<input type="checkbox"/> Yes <input type="checkbox"/> No Current Mapping Status: _____		
Other Floodplain Studies/Info?	<input type="checkbox"/> Yes <input type="checkbox"/> No Identify: _____		
Projected Letting Date:			

SITE INSPECTION INFORMATION

Date of Inspection:		Time:	<input type="checkbox"/> AM <input type="checkbox"/> PM
Names of Individuals at Site Inspection:		Office:	
Photographs taken during inspection?	<input type="checkbox"/> Yes <input type="checkbox"/> No		No. of Photographs: _____
Form Completed By:			

Activity	Completed
1. Collect the project location information. Obtain plans for the existing roadway to identify current drainage crossings. One may also collect bridge maintenance file information.	<input type="checkbox"/>
Depending upon the method used for delineation, WMS or other, identify the project location on a map, identify the drainage crossings, and delineate the limits of each basin. Include locations with longitudinal flows along the project, and any entrance or intersecting road crossing of at least 10 acres or more.	<input type="checkbox"/>
When completing the preliminary delineation of the drainage basin(s) for the project, contact the Area Engineer (or representative) to schedule an on-site field inspection. Encourage participation by appropriate field (maintenance) personnel who have familiarity with drainage history of the project area.	<input type="checkbox"/>
Send a notice of the inspection to the Area Office and others involved documenting the time and place and travel plans. to schedule a vehicle.	<input type="checkbox"/>
Before departing for the inspection, the designer should prepare sufficient working copies of the basin delineation map, draft of the drainage area document (Drainage Memo), any project aerial photos and preliminary roadway plans and cross sections for use during the inspection. It is often desirable to also include plots of the site surveys for the larger drainage sites so that the survey can be reviewed on-site. Ensure that the vehicle has flashing amber light, a camera is taken for photographs and each person has access to a safety vest.	<input type="checkbox"/>
Upon arrival on the project, visit with the field personnel to determine general drainage history for the project. Suggest that they offer input either then or while traveling along the project. This input can be problem areas, high-water observations, dates of events and ice/debris impacts.	<input type="checkbox"/>
Using the available maps, plans and documents, travel through the project reviewing basin limits and flow paths. Any identified changes to the preliminary delineation or flow paths should be documented for office follow-up.	<input type="checkbox"/>
The preliminary plans and cross sections should be reviewed for possible impacts to drainage.	<input type="checkbox"/>
Note locations where the preliminary roadway design will require the use of ditch blocks to maintain existing conditions.	<input type="checkbox"/>
Review drainage needs at existing cattle passes that also serve as drainage crossings to determine whether they are still used for livestock, or if they can be removed and replaced by drainage-only structures.	<input type="checkbox"/>
For some small basin sites, one may consider if the crossing is still needed, or if it can be eliminated with the flow diverted. This option should be used with caution.	<input type="checkbox"/>

Activity	Completed
When the basin contains a dam or impoundment either upstream or downstream, one should consider the impacts it will have on the project drainage. Diversions away from downstream dams may violate water rights.	<input type="checkbox"/>
When located in developed (or developing) areas, one should consider the impacts that have been (or will be) made to the basin. One may suggest use of optional hydrologic methods for such sites.	<input type="checkbox"/>
Identify and document flow parallel along the project. Encroachment into these areas may require hydraulic analysis for capacity or stability.	<input type="checkbox"/>
Review the drainage basin of any intersecting road or approach crossing which passes drainage of 10 or more acres.	<input type="checkbox"/>
For the larger drainage basins (over 1000 acres), review the available survey for the site to ensure that it is reasonable and usable for hydraulic modeling. In addition, complete the separate structure site data form for each applicable site.	<input type="checkbox"/>
When encountering wetlands along the proposed roadway, identify the location of the overflow outlet from the wetland and request surveyed elevation of outlet if it has not been obtained earlier.	<input type="checkbox"/>
Once back in the office, complete the drainage area process by reviewing any sites noted during the inspection and completing the Drainage Memo (document).	<input type="checkbox"/>
The final Drainage Memo is distributed to the Project Identification Coordinator (PIC), roadway designer, Area office, and Region office with a copy retained in the office file.	<input type="checkbox"/>

SDDOT Office of Bridge Design, Hydraulics Section

STRUCTURE SITE INFORMATION FORM

(Applies to Structure Sites Where DA > 1000 Acres)

PROJECT INFORMATION

Project Number:		PCN No.:	
County(s):		Highway Number:	
State Route No.:			
Location Description:			
Station:			
Structure No.:			
Stream Name:			
Legal Description (Sect./Twsp/Range):			
FEMA Floodplain?	<input type="checkbox"/> Yes <input type="checkbox"/> No Current Mapping Status: _____		
Other Floodplain Studies/Info?	<input type="checkbox"/> Yes <input type="checkbox"/> No Identify: _____		
Projected Letting Date:			

SITE INSPECTION INFORMATION

Date of Inspection:		Time:	<input type="checkbox"/> AM <input type="checkbox"/> PM
Names of Individuals at Site Inspection:		Office:	
Photographs taken during inspection?	<input type="checkbox"/> Yes <input type="checkbox"/> No		No. of Photographs:
Form Completed By:			

SURVEY DATA

Is project survey available and plotted? Yes No
 Does survey correctly define the structure site? Yes No
 If not, what additional survey or editing is needed? _____

EXISTING BASIN, STREAM & STRUCTURE CHARACTERISTICS

Define Channel: _____
 Define Bank Condition: _____
 Define Vegetation: _____
 Define Stability: _____
 Define Channel Degradation/Aggradation: _____
 Define Land Use: _____
 Evidence of Fishery? Yes No
 Cattle Passage? Yes No
 Existing Erosion Protection? Yes No
 Need for Skew? Yes No
 Evidence of Previous Channelization? Yes No
 Evidence of High Water? Yes No
 Upstream Development (buildings, etc.)? Yes No
 Downstream Development? Yes No
 Nearby Utilities: Yes No
 Evidence of Overtopping? Yes No
 Location of Overtopping: _____
 Identify Detour Considerations: _____

Using recognized stream classification charts (Roesgen or other), define the stream: _____

Define streambed material if visible: _____
 Define channel/floodplain "n" values: _____
 Are there signs of lateral channel migration? Yes No
 Are channel banks stable? Yes No
 (If eroding, where: _____)
 Channel alignment with centerline alignment. Is skew needed, desirable? Yes No
 For large culverts, does the downstream channel match the culvert? Yes No
 Upstream channel? Yes No

EXISTING STRUCTURE DATA

Bridges:

Approximate Year Built: _____

Skew: _____ degrees, LHF or RHF

Number of Spans: _____

Type of Piers: _____

Type of Abutments: _____

Visible Pier Scour? Yes No

Box Culvert(s) or Culvert(s):

Approximate Year Built: _____

Number of Barrels: _____

Size of Barrels: _____

Skew: _____ degrees, LHF or RHF

Wingwall Flare: _____ degrees

Discuss culvert flowline elevation compared to channel flowline elevation: e.g., is culvert perched or depressed in channel: _____

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION
DRAINAGE DATA INFORMATION SHEET FOR SURVEY

Drainage Basins > 1000 Acres

Project No. _____ County _____ PCN: _____
 Station _____ Section _____ Township _____ Range _____
 Project Location & Description _____
 Surveyed by _____ Date _____ Structure No. _____
 Stream Name: _____
 Insurable Buildings Upstream? _____
 Observed High-Water Elevation: _____ Date of High Water: _____
 Source of H.W. Information: _____
 Have ice jams/debris been a problem? _____ Observed Max. Elev. with debris: _____
 For large streams/ivers, max. observed ice thickness: _____
 Does local scour exist at the existing structure? _____ What are the limits? _____
 Does stream reach appear stable? _____ What is the bed material? _____

Existing Water Openings

At each of the below locations, provide the location of, the hydraulic adequacy of and the size of the structure. For culverts, provide measured barrel sizes and number of barrels. For bridges, provide a surveyed section at the bridge:

Existing Structure _____
 Upstream Structure _____
 Downstream Structure _____
 Opening width and spillway elevation of upstream or downstream dam and any other additional remarks: _____

DRAINAGE INFORMATION DATA SHEET FOR SURVEY