CHAPTER 5

Surveying Standards and Methods

5.1 Purpose

The accuracy of BFE calculation and of floodplain and floodway delineation is highly dependent on the planning and conduct of field surveying. Of particular importance are benchmarks, location and orientation of channel-floodplain cross-sections, and acquisition of bridge and culvert information. The purpose of this chapter is to set forth surveying standards and suggest surveying methods likely to lead to determination of BFEs and plotting of floodways and floodplains that are acceptable to DNR.

5.2 Vertical Datum

The most important aspect of any survey for floodplain mapping and modeling is setting and documenting the vertical datum used in the survey. Two general vertical datums are prevalent, the National Geodetic Vertical Datum of 1929 (NGVD 1929) and the North American Vertical Datum of 1988 (NAVD1988). The two datums are related to each other based on the horizontal location of the survey points. The conversion can be computed using the Corpscon program available from the U. S. Army Topographic Engineering Center. It is essential that the datum of the survey and modeling is well documented in all documents and models.

5.3 Guidelines for Survey Benchmarks

Topographic data must be referenced to one or more accepted permanent benchmarks, such as those established by the National Geodetic Survey, USGS or DNR. Other benchmarks may be used, provided documentation is submitted that supports a tie back into a previously recognized benchmark. Wherever practical, use of more than one benchmark is recommended to provide a check on the elevations.

Measurements should be referenced to NGVD 1929 or North American Vertical Datum (NAVD) of 1988. If the project is along the Ohio River or shoreline of Lake Michigan, contact the DNR regarding the appropriate datum to use.

A description of the specific benchmark used in the survey, including benchmark location, should be included as a note on the plan view map. Questions regarding benchmark information should be directed to the DNR Surveying & Mapping Section.

5.4 Guidelines for National Geodetic Survey's OPUS System

The Online Positioning Service (OPUS) is a system that can be used for establishing benchmarks using GPS technology. An option within OPUS is called OPUS-DB for database. If this option is selected, NGS will archive the data and make them available

to the public. The NGS has adopted standards for OPUS-DB marks that it will archive and publish. These guidelines call for those same standards.

- Any new mark published by NGS using OPUS-DB is acceptable to the Division of Water.

- If the user chose not to share the mark using OPUS-DB, the GNSS solution and field procedures should match those minimums required by OPUS-DB, specifically,

    - > 4-hour duration

    - > 70% observations used

    - > 70% ambiguities fixed

    - < 0.04m horizontal peak-to-peak error

    - < 0.08m vertical peak-to-peak error

    - < 0.03m Overall RMS

    - IGS precise or rapid orbits (rapid available next day)

    - User properly identified the antenna height and antenna type per NGS instructions.

    - A copy of the OPUS report is submitted with the data.

5.5 Cross-Section Data

Station-elevation data for each cross-section should be submitted in tabular and graphical form (cross-section plots). For each surveyed point defining the cross-section, the cross-section table should indicate distance and elevation with the latter referenced to an acceptable noted vertical datum. Acceptable datums are discussed in Section 5.2 Vertical Datum.

5.5.1 Guidelines for Location and Orientation of Cross-Sections

The DNR prefers that full valley cross-sections be developed from detailed topographic mapping but recognizes that this may not always be practical or economically feasible. When justified, individual cross-sections may be used in lieu of detailed topographic mapping. Cross-section location and orientation should be discussed by the engineer responsible for the floodplain hydrologic-hydraulic assessment and the surveyor responsible for obtaining the cross-section data. Pre-survey discussion and coordination between engineer and

surveyor are necessary because cross-section surveys that provide input to hydrologic and hydraulic computer models are very different from those obtained for highway and other projects.

Figure 5-1 is a plan view of a hypothetical channel-floodplain reach. Included are typical cross-sections, each of which is numbered. Figure 5-1 is used to illustrate some of the following guidelines for locating and orienting channel-floodplain cross-sections. More specifically, consider the following:

1. Give each cross-section a unique name or label, preferably mile station upstream of the mouth of the river or stream.

2. Select each cross-section so that it represents “average” conditions for a reach. For example, ignore isolated depressions, ponds and other similar features. However, include objects or features that will significantly restrict flow.

3. Place cross-sections at changes in longitudinal slope of the channel and/or floodplain.

4. Locate cross-sections at positions coincident with cross-sections used in previous floodplain studies to facilitate comparison of computed stages.

5. Cross-sections should never cross or intersect each other.

6. Place cross-sections at those locations where high-water marks are available so that computed and observed flood stages can be compared.

7. Place cross-sections immediately upstream and downstream of any culvert or bridge. If the roadway is built on an embankment, the cross-sections should be just outside the toe of the fill and the side ditch. If this is impractical, or the roadway does not appear to be higher than the adjacent ground upstream and downstream of the bridge/culvert, then the cross-sections should be taken at the culvert/bridge faces. Notes should be provided if the cross section is not taken just outside of the toe of the fill and side ditch explaining the reason and how the topography in the vicinity compares to the surveyed cross section location.

8. Locate cross-sections at county, city, and town and other corporate boundaries. Do this in anticipation of neighboring jurisdictions being concerned with possible stage increases as a result of floodplain development. Placing cross-sections at corporate limits facilitates responding to these inquiries.

9. Consider possible sites of future development in locating channel-floodplain cross-sections. For example, cross-sections should be located

at planned or anticipated residential or commercial areas, parks, streets/highways, and other floodplain developments. Placing cross-sections at these locations facilitates future evaluation of the hydraulic impact of proposed floodplain fill or other alterations.

10. Avoid placing cross-sections where they would intersect tributary swales and ravines.

11. Extend cross-sections left and right to represent the total area likely to convey discharges of up to at least the 100-year peak discharge. These are known as full valley cross-sections.

12. Orient the cross-section in the plan so all segments are perpendicular to flood flow. Angles and “dog legs” are likely to be necessary to accomplish this.

13. Take and present cross-section data from left to right across the valley with the left end or starting point being defined by looking downstream.

14. Include points at changes in grade across the cross-section.

15. Note how the stream bed portion of the cross-section was defined. Some possibilities are directly measuring, with a tape, rod or other method, and estimating the average depth to the bottom from the water surface. If average depth was estimated, explain how.

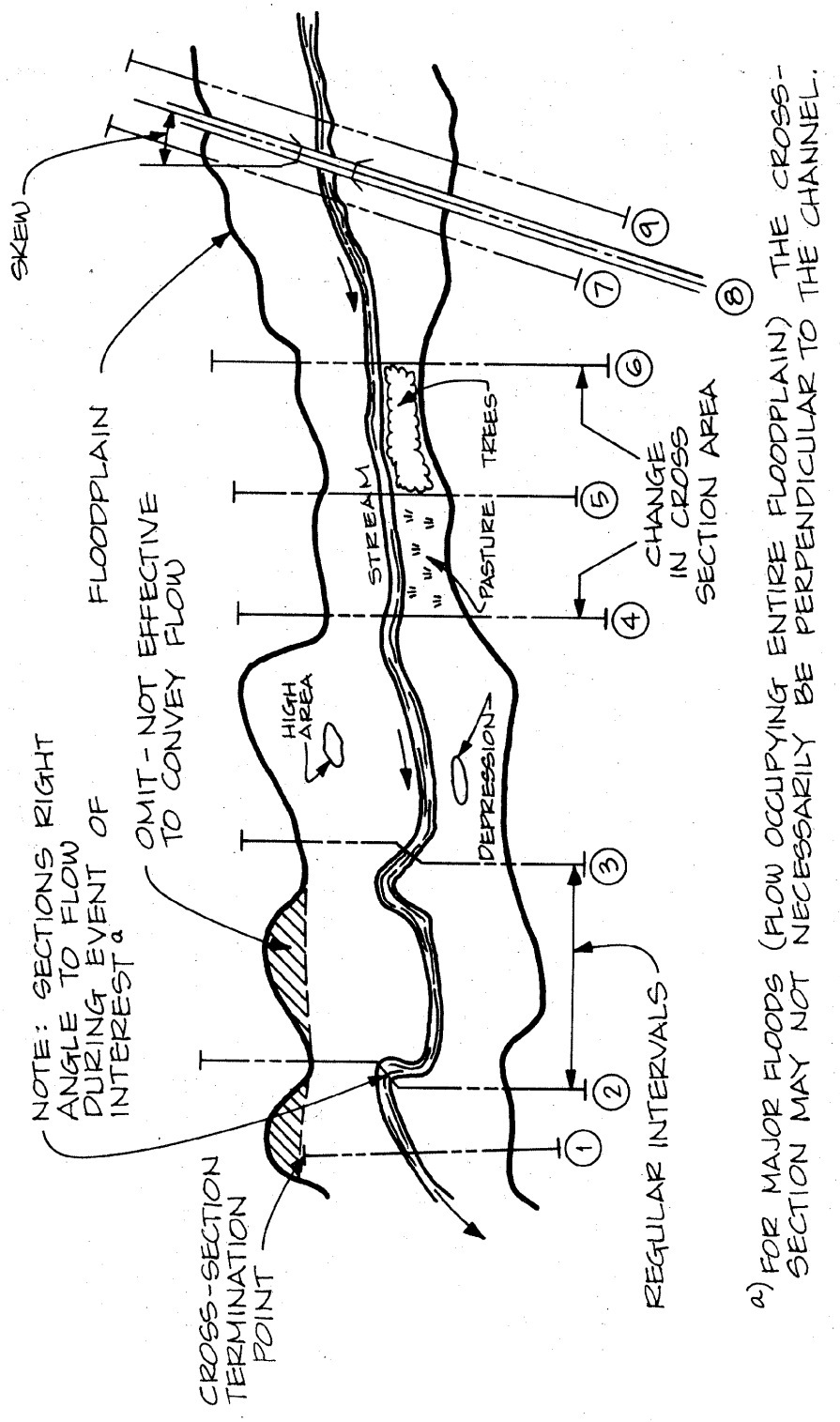
16. Indicate, on the plotted cross-section, the general ground cover observed in the channel, on the banks and on the floodplains.

    - Suggested channel ground cover categories: concrete, clean, some stones or weeds, large rock or weedy, very weedy, heavy timbers and brush, deep pools, and other as specified.

    - Suggested bank ground cover categories: grass, agricultural or light brush, medium brush and trees, heavy brush or many downed trees, and other as specified.

    - Suggested floodplain ground cover categories: grass, agricultural or light brush, medium brush and trees, heavy brush or many downed trees, buildings, and other as specified.

Figure 5-1. Cross-section location guide



5.5.2 Plans to be submitted with Cross-Section data

Plans should be prepared under the supervision of a land surveyor or engineer with knowledge of generally accepted survey principles. When FEMA approval is required, surveying must be performed under the direction of a licensed surveyor. Show features such as the following on the plan:

1. North arrow

2. Scale in both numerical and graphic format.

3. Horizontal and vertical control benchmarks used. For additional benchmark guidance refer to Section 5.3 Guidelines for Survey Benchmarks.

4. Horizontal and vertical datums.

5. Property limits; approximate boundaries are acceptable, unless flood surcharges exceed 0.14 feet at any point, in which case accurate boundary locations are required.

6. Existing and, as appropriate, proposed contours.

7. Rivers or streams and other water features.

8. Streets and roads.

9. Existing and proposed features such as buildings, parking lots, woodlands, and parks.

10. The full extent of each surveyed channel-floodplain cross-section, that is, location, orientation, and endpoints. Indicate the zero or other starting station.

5.6 Guidelines for Bridge and Culvert Information

Four photographs, two of bridges and two of culverts, are presented in Figure 5-2. The photographs suggest locations at which station-elevation data should be taken to define bridge and culvert cross-sections. More specific guidance follows.

5.6.1 General Information for both Bridge and Culvert Sections

- Bridges and culverts require valley sections at or near the upstream and downstream faces of the structure.

- Horizontal stationing at a bridge or culvert section must be consistent with the downstream and upstream channel-floodplain cross-sections, as well as all areas in between, including the roadway and culvert sections. This consistency enables the reviewer to align the culvert or bridge section with the upstream and downstream channel-floodplain cross-sections. The centerline station of a culvert should be provided and be consistent with the upstream and downstream cross-section stationing.

The roadway profile should include the elevation of the lowest points along the top of the road that would control the elevations at which weir flow could occur. These points are usually along the crown of the roadway. However, if there is curb and gutter, the “roadway” profile should be along the top of the curb if it is higher than the road crown.

- Indicate the length of the culvert or distance between bridge faces along with the width of the roadway.

- Note whether the bridge/culvert crossing is skewed. If it is, the surveyor should provide an estimate of the skew angle of both the roadway and the piers. A sketch of the angle of the road in relation to the stream and floodplain is helpful.

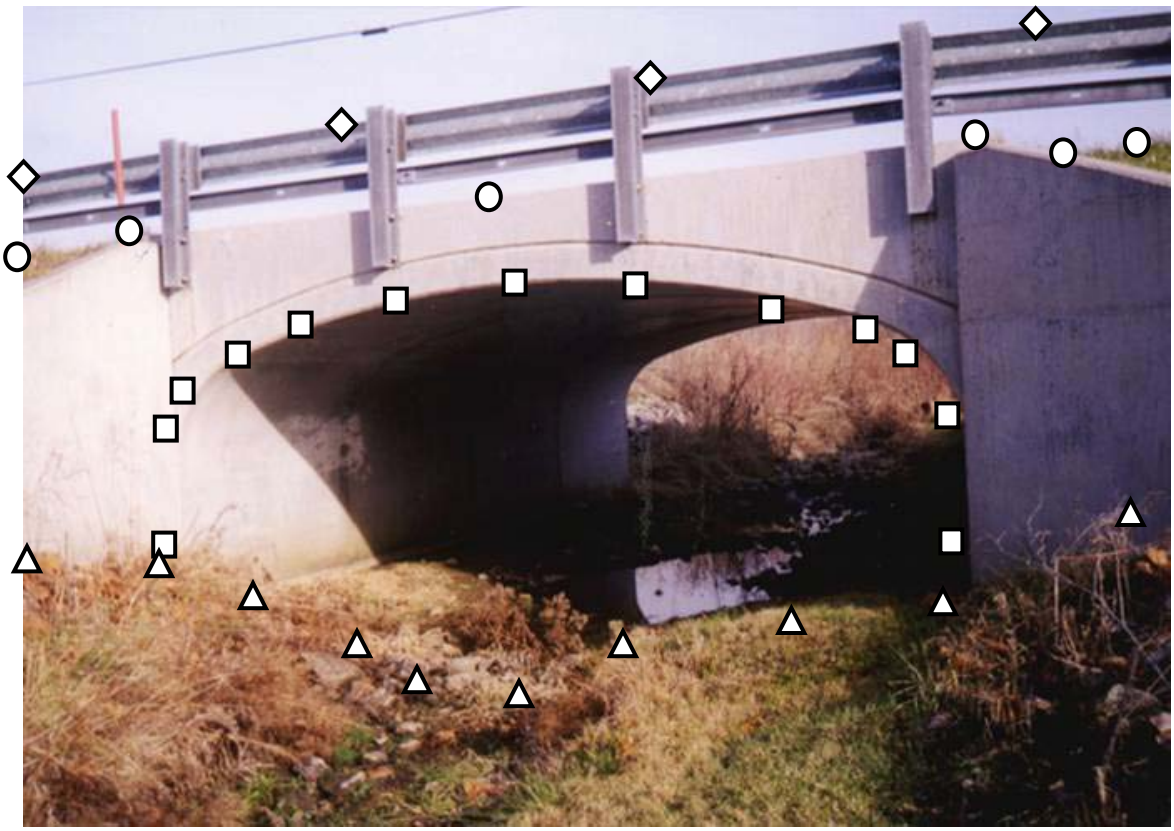
- If railing is present at the bridge or culvert, the surveyor should note the type of railing (e.g., solid concrete hand railing). In addition, the profile along the top of the rail should be provided and tied to the same horizontal control as used for roadway.

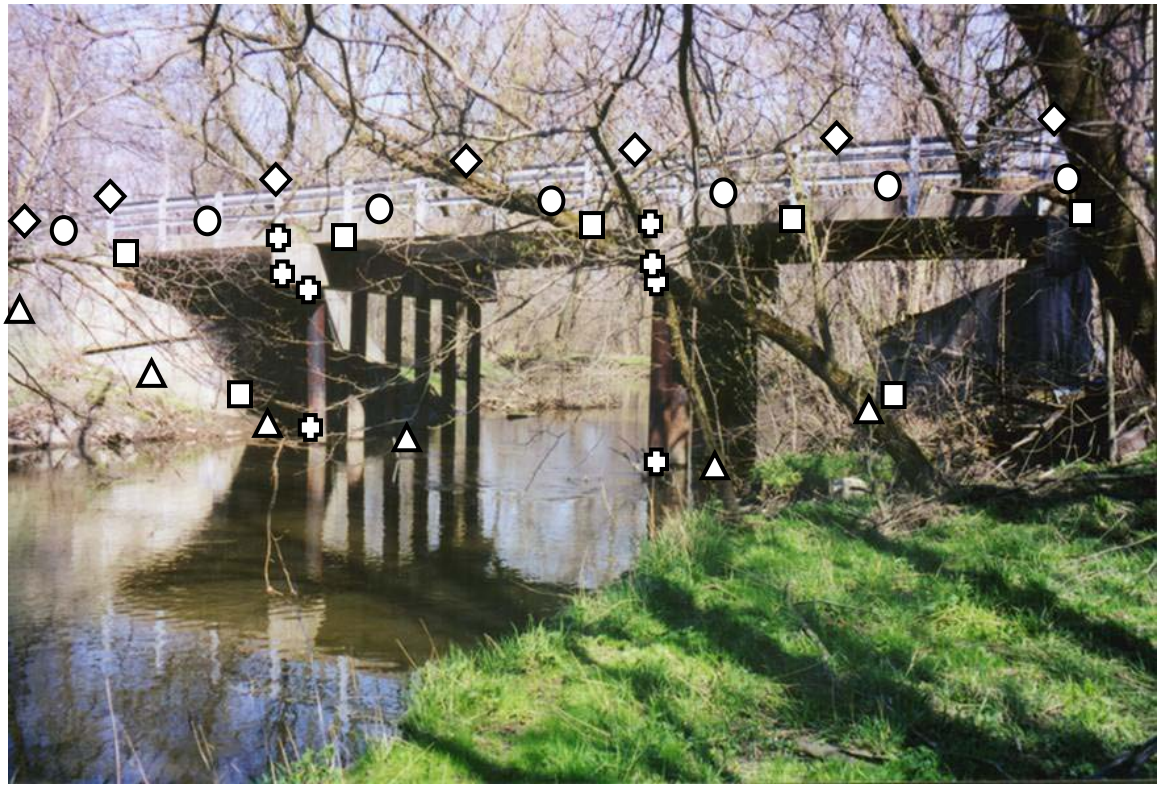
- If wingwalls or a headwall are present, the material and configuration should be noted.

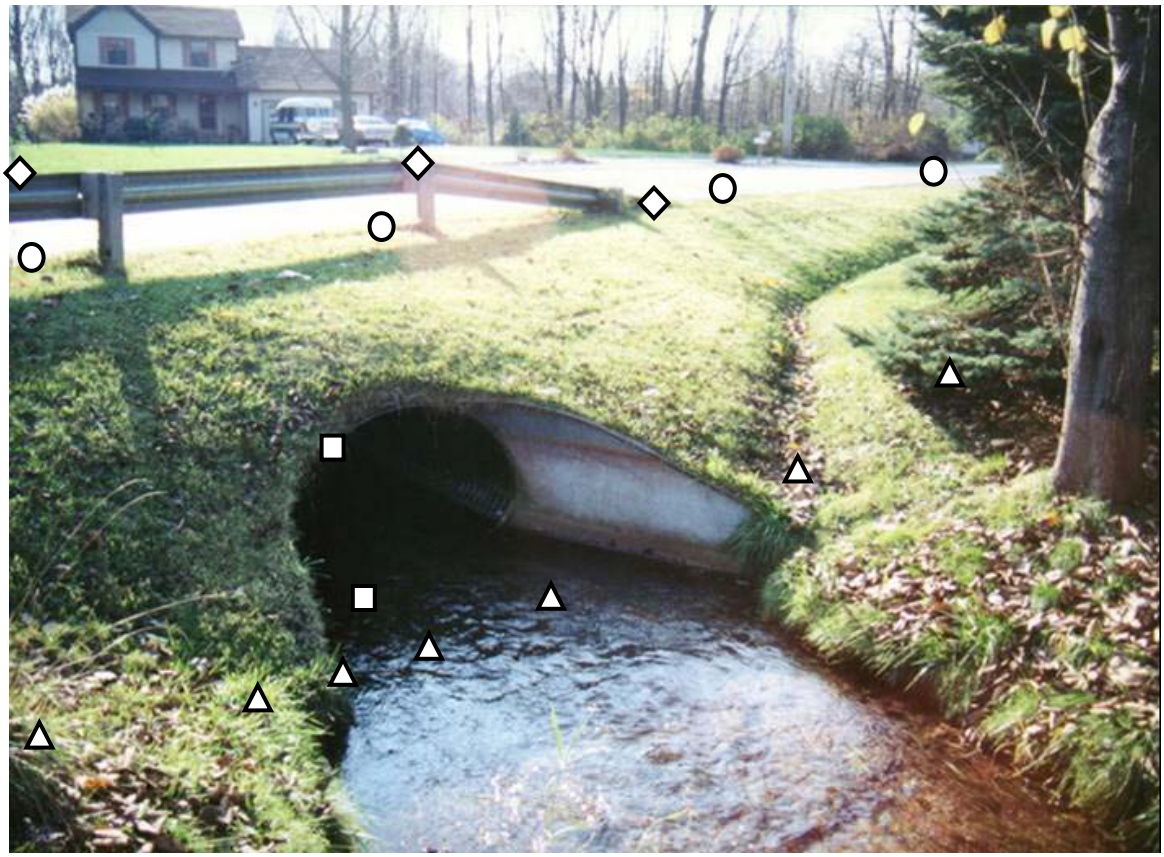
Figure 5-2. Suggested locations at which station-elevation data should be taken to define bridge and culvert cross-sections.

Legend

Symbol	Description
△	**Valley cross-section data point**
□	**Bridge opening low chord profile data point**
○	**Road profile data point**
◇	**Guardrail profile data point**
⯐	**Pier station/elevation/width data point**







5.6.2 Information Particular to Bridge Sections

- The low chord or low steel profile (that is, the top of the flow area through the bridge opening. This may mean the bottom of pipes that cross the stream on the bridge.) should be provided using the same horizontal and vertical control as the roadway.

- Provide pier width, shape, and stationing. In cases where the pier width changes as a function of elevation, provide sufficient additional data points needed to define pier shape.

- Abutments should be surveyed at bridge sections. In most cases, a constant slope abutment can be defined with two station/elevation pairs; one at the top of the abutment and one at the toe of the abutment.

5.6.3 Information Particular to Culvert Sections

- Specify culvert shape (e.g., round, rectangular, pipe-arch, etc.), dimension (ignoring any sediment/riprap that block the bottom of the culvert), and material (e.g., 48-inch corrugated metal pipe or four foot wide by 5-foot-high reinforced concrete box culvert). Also note the configuration such as projecting from fill, flush with headwall, or mitered with embankment.

- Indicate the depth of sediment/riprap within the culvert near its upstream and downstream faces.

- Provide invert elevations (with and without the sediment/riprap) at the upstream and downstream ends of culverts and indicate culvert length.