PART XIII: HYDRAULIC/ HYDROLOGY SURVEYS

13.1 Purpose and Scope

Hydraulic surveys are required for flow analysis to determine bridge and culvert design characteristics. A hydraulic survey is usually but not necessarily required with a bridge survey. The extent and location of the hydraulic surveys are identified by an engineer from the MDOT Hydraulics Unit. The survey project manager shall schedule a site visit with an engineer from the Hydraulics Unit prior to starting the survey to discuss details of the survey and to clarify the intent of the survey. Among the items of discussion shall be clarification of vegetation points (VEGE), whether the engineer needs analysis of sheet flow or channel flow with over bank, actual locations of cross sections and the length of the cross sections.

Hydraulic surveys include the location and determination of all pertinent structure data including water surface elevations, flow lines and under clearance elevations upstream and downstream at any structure within the reach of the survey. Elevation view sketches should be included and annotated appropriately.

13.2 Vertical Datums

All elevations shall be referenced to the North American Vertical Datum of 1988 (NAVD 1988) or to an acceptable project datum. The specific datum to be used on site shall be coordinated with the survey project manager. If the hydraulic survey is being performed together with another survey, the vertical datums must coincide. Two benchmarks shall be established at the stream crossing, one on either side. All benchmarks must be accurately described. Loops must close to within an accuracy of

$0.06\,ft\sqrt{Dist}$ with the distance expressed in miles.

13.3 Horizontal Control

Horizontal control shall be tied into an alignment baseline or project coordinate system. A closed horizontal control traverse to include all strategically placed data collection points shall be established to a degree of precision consistent with that defined in the scope of work. Traverse control/data collection points should consist of P.K. nails and tags in hard surfaces, ferrous metal pins in ground or identifiable, chiseled marks in rock or concrete. If more substantial monumentation is required, it should be established. If the hydraulic survey is being performed together with another survey, datums must coincide. Horizontal coordinates shall be assigned to all traverse points and data collection points. Elevations shall be assigned to all data collection points. Specific stationing scheme and horizontal

datum shall be coordinated with the survey project manager. See **Part VIII, "Route Surveying"**.

13.4 Soundings

If soundings are required, location and density shall be coordinated with the survey project manager.

13.5 Currents

If current velocity is required, details shall be coordinated with the survey project manager.

13.6 Water Levels

Water surface elevations shall be taken at each cross section where the meniscus of the water meets the bank of the water course. Descriptors LWSEL (Left Water Surface Elevation) and RWSEL (Right Water Surface Elevation) shall be used. **All surface elevations should be taken on the same day, if possible.** If not possible, repeat observations on a significant sample of those previously taken and note any differences along with any events which may might affect a stream water surface profile. Note any high water marks and the date of occurrence, if available.

13.7 Cross Section Locations and Orientation

Cross sections are taken normal to the direction of flow. **Cross Section stationing increases as one looks upstream**. As one looks downstream, the left bank is on the observers left, the right bank is on the observer's right. Sections shall be extended to a minimum of 50 feet beyond the top of the river banks or as directed by the Hydraulics Engineer.

Expect the minimum number of observations in the stream bed to be five (5) for a stream less than 20 feet wide; five to ten (5-10) for a stream 20 to 50 feet wide; and ten to twenty (10-20) for a stream greater than 50 feet wide.

Typically, cross sections shall be taken as follows:

    a.   One cross section along the crown of any existing roadway.

Figure 13.1
River Action
(Source: FM 5-335 "Drainage", HQ, Department of the Army, 1985)
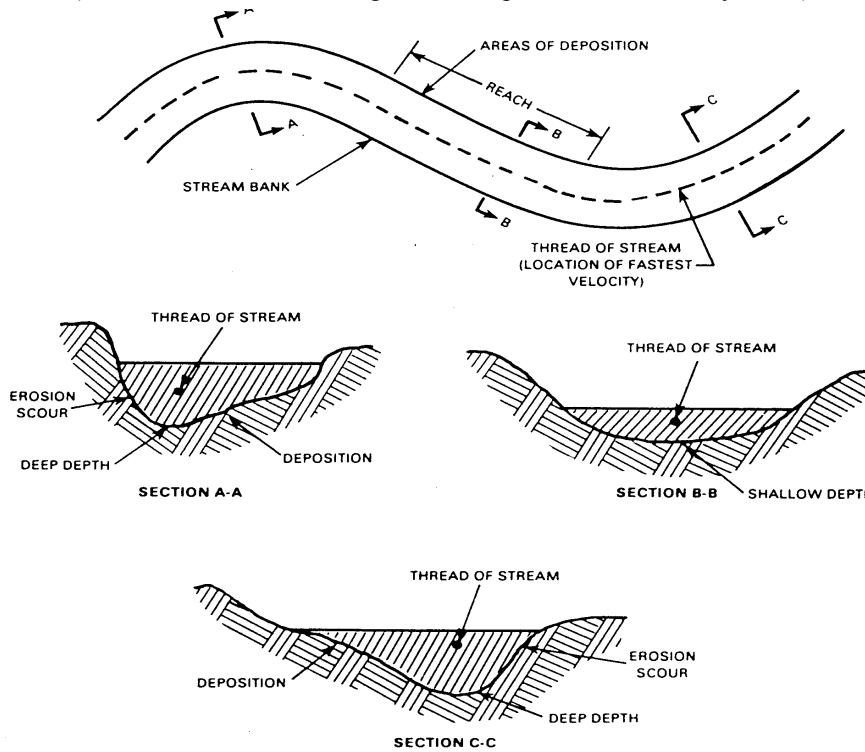
b. One cross section at the upstream face of the structure (excluding the roadway embankment), one cross section 100 feet upstream from the face of the structure, and a minimum of five cross sections at 100 foot intervals beginning 300 feet upstream from the structure, or as directed by the Hydraulics Engineer.

c. One cross section at the downstream face of the structure (excluding the roadway embankment), one cross section 100 feet downstream from the face of the structure and a minimum of five cross sections at 100 foot intervals beginning 200 feet downstream of the structure, or as directed by the Hydraulics Engineer.

If the hydraulic survey is for submittal for MDOT analysis, the following requirements must be met. Those using data collection routines other than those used by MDOT should contact the survey project manager for assistance in making appropriate translations.

1. Cross sections shall be submitted electronically in CaiCE format, or data file format acceptable to the Hydraulics Engineer for MDOT hydraulics software.

Figure 13-2
Stream Cross Section
(Source: FM 5-335 "Drainage", HQ Department of the Army, 1985)
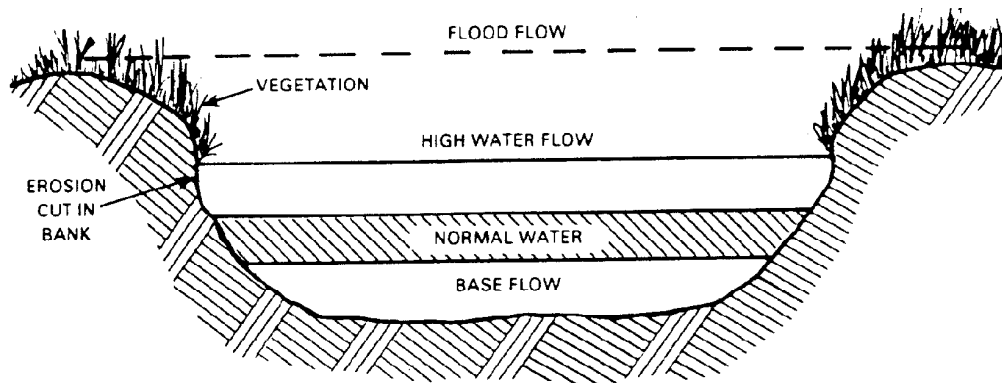
2. Each cross section shall be a separate chain in CaiCE labeled "HYDR1", "HYDR2", etc.

3. Each cross section shall be submitted with the points in the chain running all left to right, looking downstream.

4. The cross sections shall be submitted sequentially, beginning at the downstream end and proceeding upstream.

5. For each cross section, the vegetation break point (the "friction point" between the natural channel and the surrounding vegetation) shall be assigned a feature code of "RBANK" or "LBANK" on the right or left side of the waterway, respectively. It should have a comment or description of "break point".

6. Subsequent vegetation break points, if applicable, shall be assigned a feature code of "VEGE" with a comment or description of "break point".

7. Water surface elevations at each section must be provided, with the date taken. The water surface elevations at each cross section shall be assigned a feature code of "LWSEL" and "RWSEL", taken at the left edge of water and the right edge of water, respectively. Water surface elevations are not to be included in the cross section chains.

8. Required observations on a structure that carries a road over a stream shall be determined by the hydraulics engineer and coordinated with the survey project manager. These will typically include bridge seats, pier caps, pier width, etc. Detailed sketches correlated with field data shall be made. Cross sections taken at the facia of a structure shall begin and end with the low steel

13.4

elevation above each abutment.

9. On the cross section at the upstream face of the abutments, a shot is required on the ground at each abutment face on the stream side. These shots shall be described as "at abutment face".

10. If the structure is a culvert, the size and type of the culvert, its direction from the stream, and the stream flowline with an elevation shall be located and elevations determined.

11. If buildings are to be located a first floor elevation shall be determined.

12. A point list in ASCII format shall be provided, containing columns for point number, North (or y), East (or x), elevation (or z), and description.

13. One control sketch drawn to scale, or CAD drawing, shall be provided showing the relationship of the cross sections to the structure and the road, with the RBANK shots connected and the LBANK shots connected.

14. One control sketch drawn to scale, or CAD drawing, shall be provided of the area at the stream crossing showing a basic map of the bridge including abutments and cross section shots (numbered).

13.8 HEC-2 Formats

The HEC2 Water Surface Profiles computer program and bridge report is used by the Hydraulics/Hydrology Unit for design purposes. The following guidance is provided to assist the surveyor using a total station and data collector in providing properly formatted files that can be translated for input into the HEC2 program.

HEC2 requires cross section data to be input in a specific sequence. The sequence is from **downstream** to **upstream** and from **left** to **right** as the observer is facing downstream. Raw data, however, may be collected in nearly any order provided that certain guidelines are adhered to. These guidelines involve the use of point codes and line numbers that will tell the processing software where, and in what direction, the data were collected.

1. Cross sections shall be numbered such that the furthest downstream section is assigned the lowest number. The line number assigned in the field is not necessarily the number that it will have after processing by CAiCE. The survey crew determine the various section numbers in advance to allow it to observe cross sections in any order by assigning an appropriate number. Processing software will sort the data and place it in the proper order.

2. Section data may be collected from left to right or from right to left. This applies to all sections except the centerline of any roads crossing the stream. The following convention is used to orient the direction of a section:

    a. When facing downstream, the bank on the left is the left bank, the bank on the right is the right bank.

    b. Sections taken from left to right shall be given the point code **95**.

    c. Sections taken from right to left shall be given the point code **96**. The processing routine will sort the data to reverse the sequence.

    d. Road centerline shall be given the point code **71** and shall always be taken from left to right as the observer is facing downstream. The point code used for bridge seats, piers, etc., should be **97** and must include a **BR** in the point description field separated by spaces.

    These point codes shall be so stored in the data collector.

3. Additional line items that may be required

In HEC-2, the format begins at the left most point and proceeds to the right. A sample format follows:

Typical HEC-2 File Format

X1   20 10 1013.6 1010.7 45.35   40.11   37.77
GR336.68 1000.0   336.71 1010.3   336.54 1010.7   336.19 1012.5   336.49 1013.6

Explanation of first line of code.

X1   Description of a card for data

20   Cross section number

10   Number of points in the cross section defined by the X1 card

1013.6 Station of the LSWEL from the first point of the cross section

1010.7 Station of the RSWEL from the first point of the cross section

45.35   Distance between station and previous station at most left over bank point

40.11   Distance between station and previous station at most right over bank point

37.77   Distance between station and previous station at centerline of channel.

Explanation of second line of code

GR336.68 GR starts the actual cross section line code, beginning left for the first point. The number
            following GR defines the elevation for that position.

1000.0 defines the station beginning left for each point

For additional information on HEC-2 files, refer to the HEC-2 reference manual.

13.9 Quantifying the Flood Plain

Cross sections may be required to extend to the limits of the flood plain. Generally, flood condition analysis begins at the 50 year event and is analyzed to the 500 year event. Exact requirements and definitions are coordinated with the Hydraulics Engineer.

13.10 Deliverables

13.10.1 Portfolios

Each hydraulic survey must be packaged in a separate divided portfolio or portfolios being 10" (254 mm) by 12" (305mm) in size with a flap cover. If the bridge survey is part of a larger road project, control and mapping data in the area of the bridge shall be duplicated in the bridge survey portfolio. Each portfolio shall be labeled on the outside using the following format.

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Survey Notes for:

Location and Project Limits [                              ]

Control Section [              ] Job Number [              ] Date of Submittal [        ]
By [ Name of Firm ]              Route [              ]
Michigan Professional Surveyor [                              ]
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13.10.2 Sections

Each submittal shall contain six separate sections: **Administrative, Control, Alignment, Property, Mapping,** and **Miscellaneous**. Sections may not be combined.

A. Administrative.

The administrative section contains the survey order or letter, MDOT Form 222 "Survey Notes, Receipt and Transmittal", survey scope, surveyor's project report, written minutes of meetings and where applicable any information requested by the prime consultant.

B. Control

The control section contains data collected and copies of all research documents used to establish the horizontal and vertical reference systems for the project, including a thoroughly written explanation of how the systems were established.

C. Alignment

The alignment section contains witnesses and stationing of alignment points set or found, an explanation of how the alignment was determined, and all supporting documentation.

D. Property

The property section contains all information that may be required regarding the real property affected by the project and all required property ties. This may include copies of all land corner recordation certificates for all government corners used or reestablished, recorded plats, recorded

surveys, tax maps, tax descriptions and riparian ownership.

E. Mapping

The mapping section contains all survey notes, research documents and collected data used to plot the maps necessary for the project. All plots for topography, elevations, utilities and drainage are to be placed in this section.

F. Miscellaneous

The miscellaneous section contains any information not included in the previous sections. The surveyor's project report should specify any items included in this section.

13.10.3 Data Formats

All paper sheets in the portfolio shall be marked with the control section, job number, section number, date of submittal and page number.

All diskettes shall be labeled with the control section, job number, data type and file names.

The following information shall be submitted on 3.5" (88.9mm) HD diskettes:

Text files in ASCII format containing the witness lists for the horizontal alignment ties, bench marks and government corners.

Cross sections and structures information..