Guidance for Flood Risk Analysis and Mapping

Profile Baseline Guidance

November 2015

FEMA

Requirements for the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) Program are specified separately by statute, regulation, or FEMA policy (primarily the Standards for Flood Risk Analysis and Mapping). This document provides guidance to support the requirements and recommends approaches for effective and efficient implementation. Alternate approaches that comply with all requirements are acceptable.

For more information, please visit the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage (www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping). Copies of the Standards for Flood Risk Analysis and Mapping policy, related guidance, technical references, and other information about the guidelines and standards development process are all available here. You can also search directly by document title at www.fema.gov/library.

Document History

Affected Section or Subsection	Date	Description
First Publication	November 2015	Initial version of new transformed guidance. The content was derived from the Guidelines and Specifications for Flood Hazard Mapping Partners, Procedure Memoranda, and/or Operating Guidance documents. It has been reorganized and is being published separately from the standards.

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1.0 Definition

A Profile Baseline shows the path of riverine flood flows on the Flood Insurance Rate Map (FIRM) and is an accurate representation of the distance between cross sections, structures, nodes or grids in the hydraulic model. The Profile Baseline serves as a link between hydraulic models developed for studied reaches and the FIRM, the Flood Profiles, and the Floodway Data Table (FDT). The Profile Baseline allows users to more easily reference information in the hydraulic model and the flood profile. Profile Baselines allow users to identify the corresponding location on the FIRM given a known location on the Flood Profile or vice versa, thereby enabling the identification of a Base Flood Elevation (BFE) that is accurate and usable for processing Conditional Letters of Map Amendment; Conditional Letters of Map Revision Based on Fill, Letters of Map Amendment; and Letters of Map Revision Based on Fill and providing critical information for floodplain managers.

Profile Baselines are shown on the FIRM panels and are included in the FIRM Database in the S_Profil_Basln layer.

2.0 FIRM Display

A Profile Baseline must be shown on FIRM panels for all flooding sources with profiles or otherwise established riverine BFEs (static elevations generally excluded), and for modeled riverine Zone A areas. A Profile Baseline must also be shown on FIRM panels when a Flood Risk Project is not being updated but the effective Profile Baseline still accurately represents conditions on the ground. The specifications for the symbolization and labeling of the Profile Baseline can be found in the FIRM Panel Technical Reference.

2.1 Profile Baselines vs. Hydrographic Features

Hydrographic features are included in the FIRM Database in the S_Wtr_Ln and S_Wtr_Ar feature classes and are used to communicate information on the location and attributes for surface water features. The S_Wtr_Ln and/or S_Wtr_Ar feature classes are required for any FIRM Database where vector surface water features are shown on the FIRM and some of these features are represented as lines in the spatial data. Per the *FIRM Panel Technical Reference*, the displays of line representations of hydrographic features (S_WTR_LN) are optional on ortho-based FIRM panels. They must not overlap the Profile Baseline and may be shown at the request of the FEMA Project Officer.

If the flood flow path follows the main channel of the stream, then the Profile Baseline and hydrographic feature representing the stream centerline will closely match. When a Profile Baseline and a water line are available for the same stream reach, only the Profile Baseline shall be shown on the FIRM in order to avoid obscuring the Profile Baseline symbology.

2.2 Along County Boundaries

Streams frequently make up the boundary between communities, including counties and states. Often the official boundary and the profile baseline of the stream that makes up the boundary are not coincidental and the profile baseline will extend beyond the limit of the county. In this case, the Profile Baseline is to be shown on the FIRM and included in the database beyond the limits of the county.

Figure 1: Profile Baseline Extended Beyond County Limit

In such a case, it should be noted that this and other features to be incorporated into the regional Flood Hazard Layer (rFHL) may fall outside or cross a Physical Map Revision (PMR) or county boundary. Profile Baseline, station start points, cross sections, BFEs, general structures, levees and other spatial and non-spatial features should be reviewed for incorporation into the rFHL beyond the PMR boundary.

2.3 Model-Backed Zone A

Profile baselines are required in new riverine Zone A areas with model backup. Unmapped cross sections should also be included in the FIRM Database for these model-backed, Zone A areas. No flood profiles are published in the Flood Insurance Study (FIS) Report for Zone A areas.

2.4 Backwater Tributaries

Profile Baselines are only required for backwater tributaries if they were modeled separately. If unmapped cross section were used to develop the backwater elevations, these cross sections should be included in the FIRM Database even if no flood profiles were developed or published for the tributary. A Profile Baseline would not be required in this instance.

3.0 Modeling Methods

3.1 One-Dimensional Models

In one-dimensional modeling, the profile baseline is the primary flow path of the 1-percent-annual-chance flood between cross sections and typically follows the stream channel centerline. If a flow path other than the stream channel centerline is more representative of the direction of flow, the case must be documented and the flow path shown and labeled on the FIRM as the "Profile Baseline". Flow path distances in one-dimensional models must be referenced to the Profile Baseline.

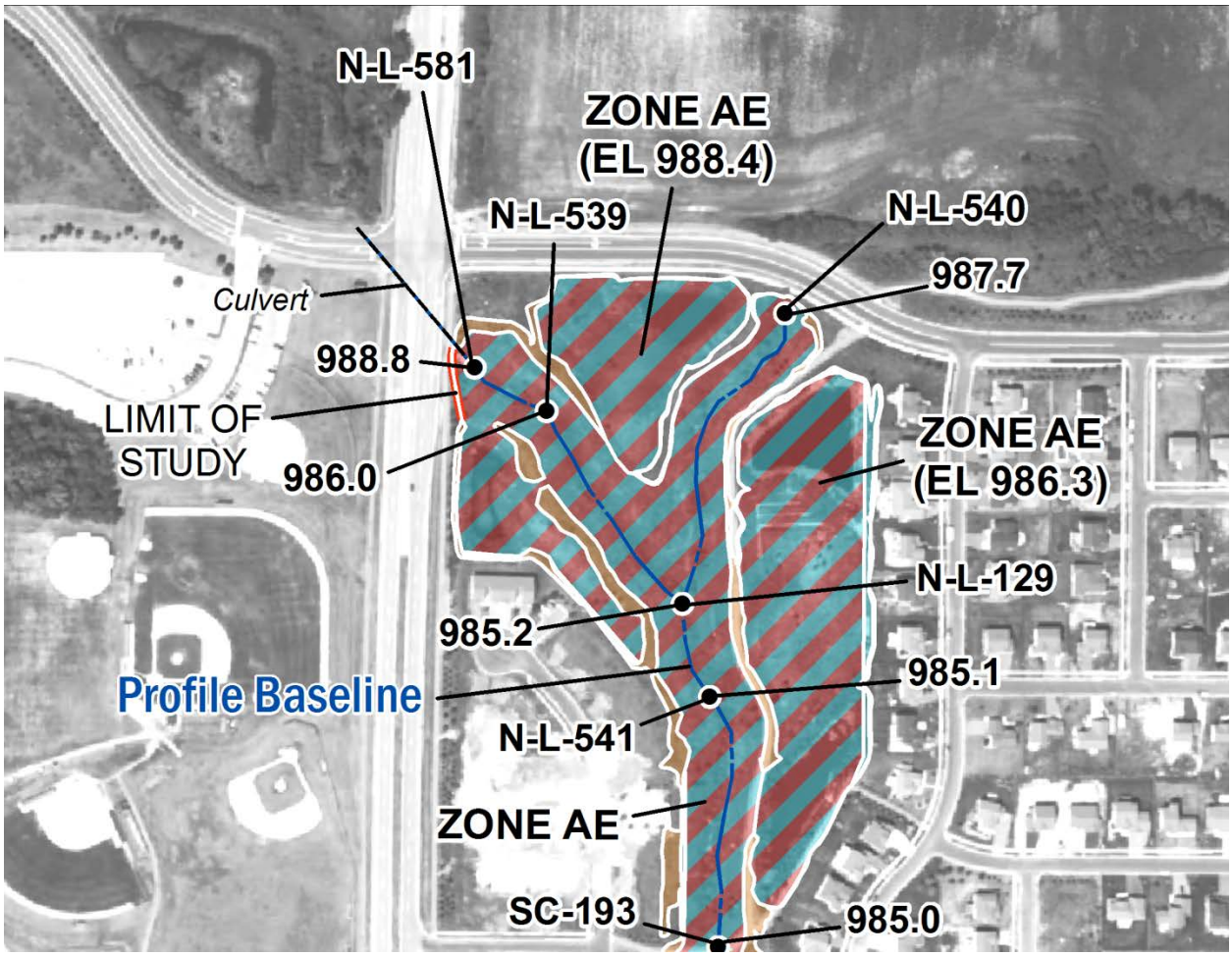
3.2 Two-Dimensional Modeling

Two-dimensional hydraulic models can more accurately simulate the movement of surface water over wide, flat floodplains and multiple flow paths or split flows. For floodplains mapped from two-dimensional models, separate Flood Profiles for significant flow paths must be created and each of these flow paths must have a corresponding Profile Baseline. Profile Baselines for two-dimensional models are typically created by manually drawing the general path of significant flows. The Profile Baseline is then overlaid on the final water surface grid data to generate a Flood Profile.

3.3 Node and Link Based Models

Some hydraulic modeling software, such as the Interconnected Channel and Pond Routing Model (ICPR) and Storm Water Management Model (SWMM), calculate water surface elevations along nodes and links to represent ponds and streams. The links represent sections of ditches, canals, rivers, or pipes along the conveyance system. Nodes can represent sub basin outlets, junctions, reservoirs, structures, sinks or diversions and are required at all hydraulically modeled flow change locations and are a computation point that is used to determine water surface elevations. In these cases, the hydraulic connectivity, or flow path between nodes or junctions is depicted by Profile Baseline. Together, the nodes and the Profile Baseline layer are used to represent the hydraulic connectivity of the network.

Figure 2: Example of Nodes and Profile Baseline



4.0 Redelineation & Digital Conversion

Redelineation and digital conversion are common methods of converting paper FIRMs to digital data. In the case of redelineation, the floodplain boundaries are revised to match updated topographic data based on the computed water surface elevations from effective models. In both cases, Profile Baselines are to be digitized from the effective study's work maps or latest FIRM, Flood Hazard Boundary Map (FHBM) and Letters of Map Revision, if applicable. Work maps obtained from the FEMA Engineering Library may contain the most accurate depiction of the profile baseline.

When capturing effective flood hazard data, the mapping partner should obtain copies of the backup data for the analysis shown on the effective FIRM, including hydraulic models and work maps from previous mapping projects and Letters of Map Change (LOMCs). Many effective FIRMs just show a stream centerline that was used as the Profile Baseline in the hydraulic modeling. Although there may be no labeled Profile Baseline on the effective FIRM, the stream centerline may be considered the same as the Profile Baseline and should be transferred to the FIRM database as a Profile Baseline. If effective data only depicts stream banks and work

maps depicting the Profile Baseline are unavailable, Mapping Partners may estimate the Profile Baseline down the middle of the double line banks.

Figure 3: Example of Profile Baseline Drawn Between Double Line Banks

When redelineating floodplains, Mapping Partners must use the complete set of cross sections to develop the required flood profiles and position the cross sections along the Profile Baseline as indicated by the flood profile station. If data are not available for all cross sections, the Mapping Partner must generate the missing data using the Flood Profiles exhibit in the effective FIS report and any applicable LOMCs. Since the Profile Baseline represents the flood flow path for the effective FIRM/hydraulic analyses, it may fall outside the redelineated Special Flood Hazard Area (SFHA).

Figure 4: Example of Profile Baseline Outside of a Redelineated Floodplain

The following note should be included in the Notes to Users section of the FIRM and the FIS Report (Figure 2 of the report) when Profile Baselines fall outside of redelineated floodplains:

> The map reflects more detailed and up-to-date stream channel configurations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and FDTs may reflect stream channel distances that differ from what is shown on the map.

In the case that the redelineated floodplain data indicates that the effective hydraulic analyses are no longer valid, the Mapping Partner must coordinate further actions with the FEMA Project Officer. For more information related to redelineation considerations, see the Redelineation Guidance document.

As discussed in detail in Section 7.0 of this document, Profile Baselines are stored in the S_Profil_Basln FIRM Database layer. Unless specifically required by a Mapping Partner's contract, task order, or agreement, the Polyline ZM properties of the S_Profil_Basln are not required to be produced for digitally converted reaches. Developing these properties is required for redelineated stream reaches.

When a conversion between vertical datums is necessary, either countywide/community-based or flooding source-based vertical datum conversion factors may be computed. If flooding source-based vertical datum conversion was performed, the points included in S_Datum_Conv_Pt must fall on S_Profil_Basln features. The computed flooding source-based conversion factors are then entered into S_Profil_Basln for each profile baseline feature. Refer to the Vertical Datum Conversion Guidance document for a more detailed description of the

vertical datum conversion methodology. This document can be found on the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

5.0 Levees

Profile Baselines associated with accredited levee analyses are to be shown per the guidance associated with the modeling approach used in the analyses and would be located on the river side of accredited levees.

The specific Levee Analysis and Mapping Procedures (LAMP) modeling procedures used for the analysis of a non-accredited levee will dictate whether Profile Baselines are to be included in the FIRM database. When an alternate flow path is modeled landward of the levee based on Overtopping of Structural-Based Inundation Procedures one or more models or scenarios may be evaluated. The final mapped flood hazard boundaries landward of non-accredited systems will be a worst-case combination of composite SFHA resulting from the Overtopping, Structural Based Inundation, or Natural Valley procedures for each levee reach, the interior drainage analysis and the area submerged by the Natural Valley Procedure. In most cases, a Profile Baseline will not be shown landward of a levee for flow paths evaluated using these procedures.

For more information on the modeling approach and mapping requirements of non-accredited levees, refer to the LAMP (July 2013) document Analysis and Mapping Procedures for Non-Accredited Levees - New Approach, which outlines the new process used to analyze and map areas on the landward side of non-accredited levee systems that are shown on FIRMs. This document can be found on the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

6.0 Alluvial Fans

The modeling approach used for the analysis of an alluvial fan will dictate whether Profile Baselines are to be included. Generally, inactive alluvial fans may require the inclusion of a Profile Baseline and corresponding profile, while these may not be applicable to an active fan.

Please refer to the Alluvial Fan Guidance document for more information on the modeling approach and mapping requirements of fans. Note, this document is currently in development and the user may refer to the Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix G: Guidance for Alluvial Fan Flooding Analyses and Mapping (Apr 2003). This document can be found on the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

7.0 Database

The S_Profil_Basln layer in the FIRM database stores information about the Profile Baseline used in the hydraulic model. This includes information about the name of the flooding source, its study type, station start ID, a description of its start and end points, the vertical datum conversion factor for it if flooding source-based vertical datum conversion was performed, any flooding problems associated with it, and any special modeling considerations associated with it. The Profile Baseline layer must be defined as a Z- and M-aware layer.

The Profile Baseline shows the path of flood flows on the FIRM and should be an accurate representation of the distance between cross sections, structures, nodes or grids in the hydraulic model. The Profile Baseline can be used for replicating the stationing and water-surface elevations found in the FIS Report profiles but in GIS format. The spatial entities representing the profile baseline are lines.

See the Technical Reference: Flood Insurance Rate Map (FIRM) Database (May 2015) for additional information on the S_Profil_Basln layer.

7.1 Attributes

The attribute information stored in the S_Profil_Basln is used in the following tables within the FIS Report: Flooding Sources Included in this FIS Report, Principal Flood Problems, Summary of Hydrologic and Hydraulic Analyses, Summary of Topographic Elevation Data Used in Mapping, the Stream-by-Stream Vertical Datum Conversion and Summary of Contracted Studies Included in this FIS Report.

The S_Profil_Basln attribute table stores Principal Flood Problem and Special Consideration data for use in the FIS text. Due to the limitations in the Esri Shapefile DBF format, text fields are limited in size. Several fields have been provided but in the event that the description of principal flood problems or special considerations exceeds the number of characters provided, a tab separated value text file may be submitted instead. The first row of the text file must include a header as follows: WTR_NM <TAB> FLD_PROB <TAB> SPEC_CON <CR>

Each row after the header would have the name of the studied reach/stream followed by a tab, the principal flood problem text followed by a tab and special considerations for that reach, followed by a carriage return.

When required, principal flood problem and special consideration files should be named using the following convention: <DFIRM_ID>_FIS_Fld_Problems_Spec_Considerations.txt

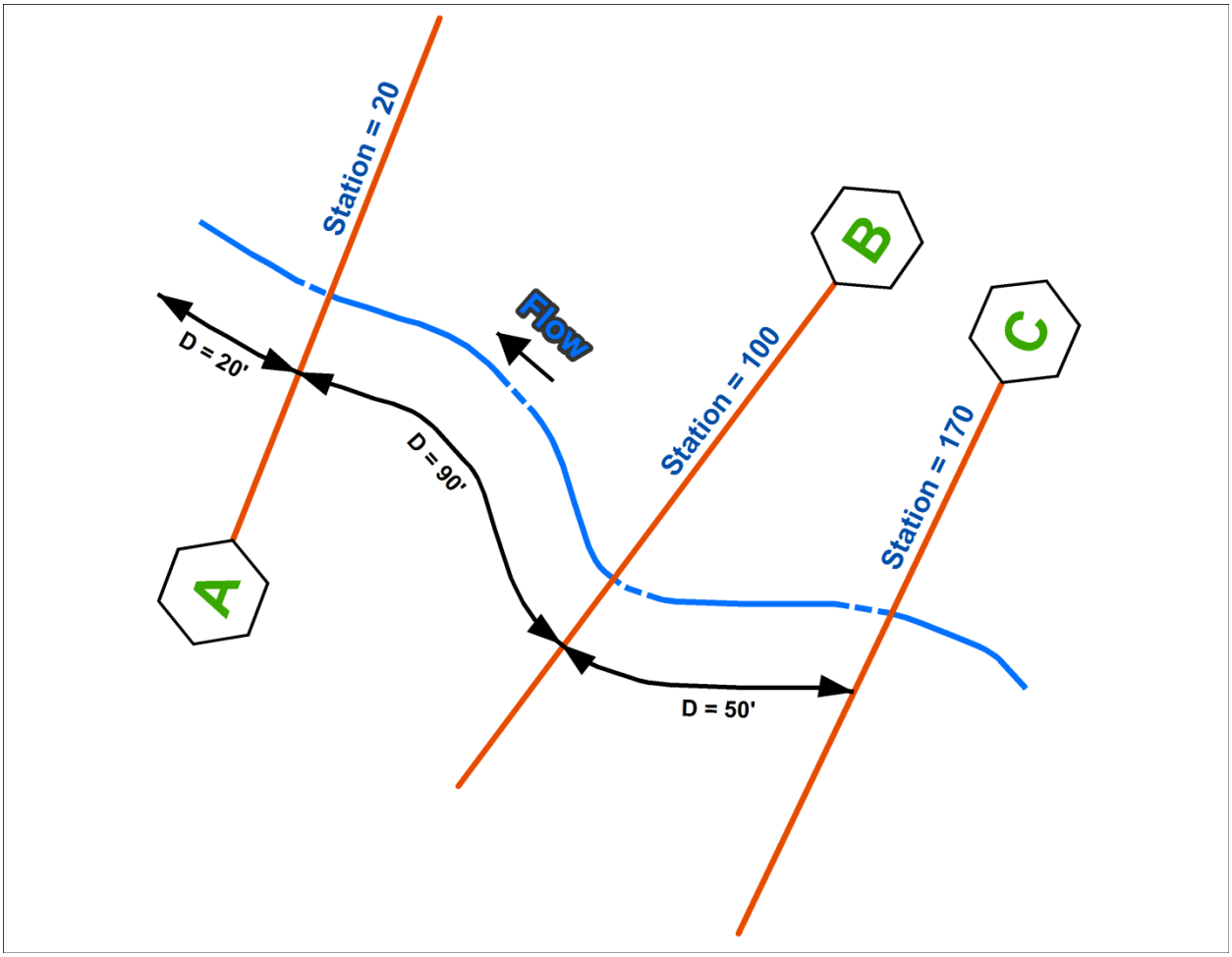
7.2 3D Profile Baseline Z- and M- Values

Profile Baselines are stored as ArcGIS Polyline ZM features. The stream stationing values are stored as M-values, and one-percent-annual-chance water surface elevations are stored as Z-values. These Z- and M-values are calculated at cross sections, structures, and other modeled inflection points along the Profile Baseline. The S_Profil_Basln Z- and M-values should agree with the S_XS stream station and regulatory water surface elevation values at those intersect locations. The first vertex of each Profile Baseline should be the downstream most point on the profile, which should correspond to the S_Stn_Start point.

Vertices along the Profile Baseline located between modeled cross section locations should be calibrated using linear referencing/dynamic segmentation tools in GIS. The calibration of the M- and Z-values is typically only required when recreating Profile Baselines from effective data during redelineation or digital conversion tasks. This calibration step is likely not required for newly created hydraulic models where the Profile Baseline would exactly match the modeled reach lengths if created using GIS processes. ArcGIS refers to the process of storing M-values as linear referencing and of Polyline M features as Routes.

Calibrating the M- and Z-values means that the distance along the Profile Baseline between cross sections is divided up based on the stream stationing at the cross section intersections, not based on the length of the line. Similarly, the elevation difference between cross sections will be apportioned along the Profile Baseline. The figure below shows how stream station values at cross sections are used to calibrate the M-values on Profile Baselines.

Figure 5: Profile Baseline Calibration



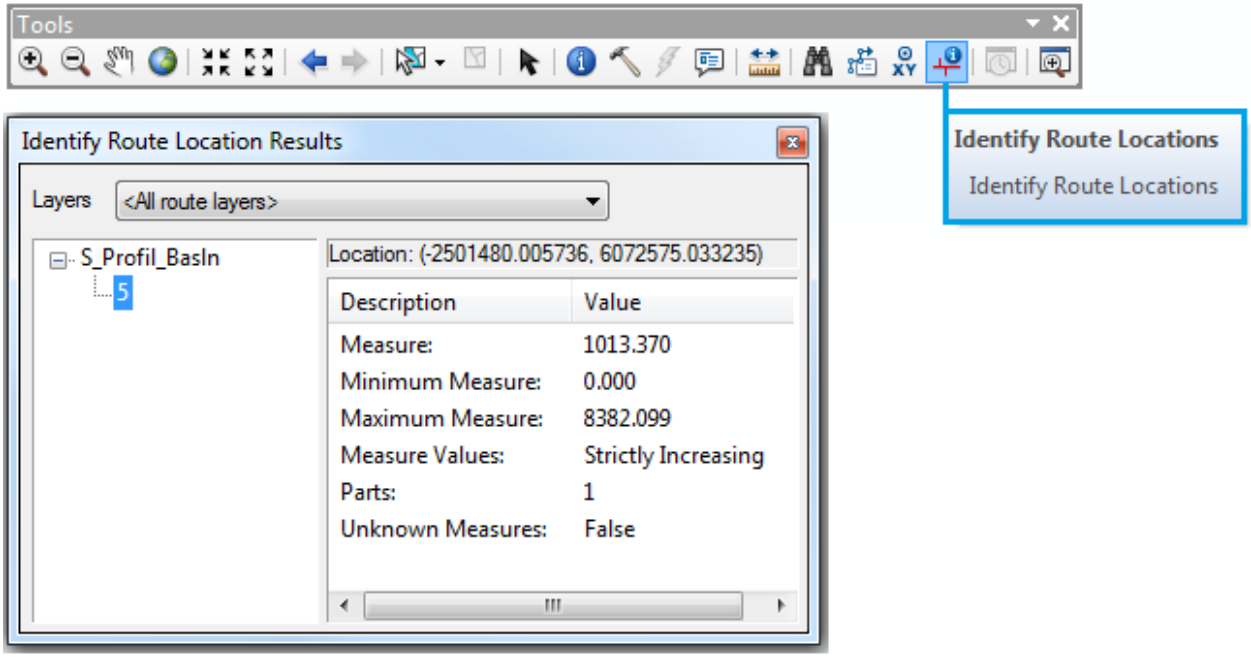
The table below demonstrates how the M-value can be populated either based on the distance of the line between points or calibrated to match the station value of the cross section.

Table 1: Profile Baseline Calibration

Cross Section	Station Value	Measure (M) Value By Distance	Calibrated M Value
A	20	0+20 = 20	20
B	100	20+90 = 110	100
C	170	110+50 = 160	170

Once 3D Profile Baselines with Z- and M- values have been created, the ArcGIS 3D Analyst Profile Graph tool can be used to view or edit the Profile Baseline Z- and M-values via a chart. Additionally, the Identify Route Locations tool can be used to request the Z- and M- values along any point along the stream, thereby enabling the user to identify the one–percent-annual-chance water surface elevation (BFE) and the profile station at any point along the Profile Baseline. This is very valuable in allowing GIS users to support the determination of BFEs for LOMCs and similar inquiries.

Figure 6: Viewing Profile Baseline Values



8.0 Quality Control

Since Profile Baselines serve as the link between hydraulic models, the FIRM, the Flood Profiles, and the FDT, it is a key component in many of the quality reviews used to ensure consistency between these study products. Stream distances reported in the FDTs, Profiles, and FIRM database must be measured along the Profile Baseline; therefore the Profile Baseline itself should be reviewed prior to conducting these consistency checks.

Profiles Baselines that are a direct output of new hydraulic modeling should accurately and precisely match what is in the hydraulic model, especially if the model is able to export to GIS or other digital data formats. The capturing of Profile Baselines from effective FIRM, FHBM or work maps should be reviewed to ensure the effective data was both georeferenced and digitally captured correctly.

Consistency checks should include the following:

- Lettered/Numbered Cross section placement on the FIRM agrees with Flood Profiles
- FIRM flood elevations agree with Flood Profiles, FDTs, and Summary of Stillwater Elevation tables.

Note, with the increased use of RASPlot V.3 or higher, the FIRM database will store the information required to directly generate flood profiles and tables in the FIS report from the FIRM database, thereby reducing the chance of inconsistent data between the FIRM, database FIS tables and Flood Profiles.

Once published, the Flood Profile Guidance document will contain additional guidance regarding the creation and display of flood profile information for select flooding sources in the FIS Report.