FEMA Region 8 Quick Guide

2D Flood Profiles

August 2025

1.0 OVERVIEW

The purpose of this quick guide is to assist mapping partners in the development of mapping products for 2D modeled floodplains that meet the FEMA Working Standard ID 128 (SID 128). The following sections describe SID 128 and pull together the guidelines that have been documented by FEMA in various guidance documents on how to appropriately map and report water surface elevations for detailed study streams.

2.0 BACKGROUND (FEMA Guidelines & Standards):

Below are excerpts from FEMA Guidelines & Standards. Refer to the linked documents for the full text.

Working Standard ID 128:

> "For floodplains mapped from 2D models, evaluation lines and BFE lines on the FIRM must match modeled water surface elevations and **must be plotted at intervals sufficient to interpolate accurate BFEs in between BFE or evaluation lines**. If this is not possible, **separate Flood Profiles for significant flow paths and/or FIS Report inserts must also be created."**

Mapping Base Flood Elevations on FIRMs Guidance (November 2023):

> "Where BFEs and evaluation lines are the primary source of water surface elevation information on the FIRM, the mapping partner should confirm that the lines placed are sufficient to linearly interpolate the BFE **at any point in the floodplain within 0.1 foot of the true value from the model water surface elevation grid."**

Floodway Analysis and Mapping Guidance (November 2023):

> EVALUATION LINES GUIDANCE:
>
> - Evaluation lines in 2D floodway analysis may be thought of as virtual hydraulic cross sections similar to the physical cross sections used in 1D modeling and reported in the floodway data table. Evaluation lines should be placed on FIRMs where a detailed study included a floodway calculated based on 2D methods. Evaluation lines should also be used where a detailed study included a floodway calculated based on a hybrid 1D, 2D model where the cross sections do not cover the entire floodplain. In both cases, evaluation lines should be set at the critical locations as a reference point for floodway reporting and validating surcharge requirements. **Where a 2D or hybrid 1D, 2D model was used but no floodway is calculated, evaluation lines should not be included.**
> - Evaluation lines should typically represent a single water surface elevation and may have a contoured shape. While similar to a BFE line, an evaluation line is a separate line type used to report floodway or encroachment information and used to validate that the calculated floodway or encroachment modification meets the surcharge requirements. Evaluation lines should be reported in the S_XS database layer. On the FIRM, evaluation

lines can be either lettered or unlettered, and will have water surface elevation reported, similar to a lettered and mapped cross section line in a 1D model.

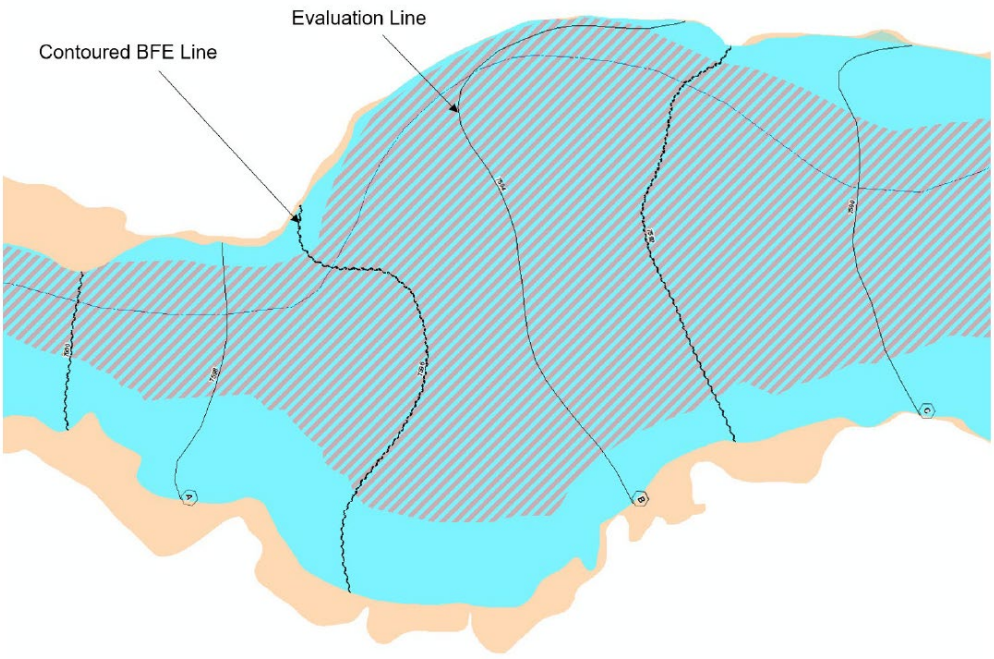

Figure 1. Example of BFE and Evaluation Lines Along a 2D Mapped Floodway

Mapping Base Flood Elevations on FIRMs Guidance (November 2023):

BFE LINES GUIDANCE:

- To accurately depict the water surface elevation grid generated by the 2D or hybrid 2D model, a combination of evaluation lines (if a floodway analysis is completed) and supplemental BFEs lines should be used on the FIRM. BFE lines will be placed along the profile baseline (where applicable) at inflection points not already captured by 2D evaluation lines, or as needed in areas of backwater, ponding complex flow areas, overflow areas off the profile baseline…or other areas needed per engineering judgement.

- In a 2D modeled floodplain, water surface elevations along the profile baseline may vary significantly from nearby areas. **BFE lines will be placed in areas where water surface elevations would be inaccurately estimated from the profile.**

- FEMA Risk MAP standards require that BFEs (i.e., 1D cross section or 2D evaluation lines supplemented with BFE lines where needed) must be shown at appropriate locations to allow map users to accurately interpolate flood elevations, both horizontally and vertically.

- The intent is that map users can accurately interpret flood elevations on the FIRM and that BFEs are placed strategically and at reasonable intervals to enable this intent.

- **Where differences exceed 0.1 foot, additional BFE lines should be placed at the required vertical interval (not to exceed a 0.1-foot resolution) to reduce the difference.**

3.0 REGION 8 APPLIED APPROACH:

In accordance with Regional preference and the FEMA Guidelines & Standards the following section outlines the Region 8 process for determining whether Flood Profiles[1] will be required for **2D modeled Zone AE floodplains** produced for Risk MAP studies. In order to standardize the processing steps, ensure repeatability, as well as minimize errors, Region 8 has developed a standalone ArcPy Toolbox which mapping partners can use to review their data before submitting to the FEMA Region 8 Enhanced Validation Review. Figure 2 outlines the workflow behind the tool and the decision model to determine if an FIS Profile is required. For more detailed instructions on how to run the tool and explore output files, please refer to the Appendix.

OVERVIEW:

STEP 1 | After placing BFEs and evaluation lines in accordance with FEMA's Guidelines & Standards, contractors should compare a water surface elevation (WSEL) grid generated from the mapped evaluation lines and BFEs to the raw WSEL grid output from the model to determine if the BFE and evaluation line spacing is adequate (i.e., that interpolated water surface elevations fall within 0.1 foot of the modeled results).

STEP 2 |The mapped WSEL grid can be compared to the modeled WSEL grid by extracting WSEL values to "Test Points" and calculating the difference between the two surfaces. The test points are created by first generating an evenly spaced mesh of 50-foot resolution then creating points within the mesh centroids.

STEP 3 | Once the difference in the WSEL grids at the test point locations has been calculated, the points are categorized as passing or failing depending on if the difference is within the 0.1-foot tolerance. The passing percentage should be calculated on a stream-by-stream basis. See Table 1 to determine the passing percentage required for your study, which depends on the scoped level of detail of the 2D model. If the stream passes and the community does not have a preference on developing a Flood Profile, no further action is needed besides the documentation mentioned in the following section.

Flood Zone	Passing Percentage
AE	90%
AE with Floodway	95%

Table 1. BFE Accuracy Standard for 2D Floodplain Mapping

STEP 4 |If the stream is not passing, the BFEs and evaluation lines should be supplemented until the 0.1-foot tolerance is achieved. The points can be symbolized by the unique pass/fail values in order to clearly see areas within the floodplain that are failing and need additional BFEs. Please refer to the Mapping Base Flood Elevations on FIRMs Guidance for further details on placing BFEs.

[1] *The development of a flood profile for a study should be discussed ahead of the project with community officials and the FEMA Project Officer. It could be possible a community would prefer to have a profile generated from a 2D model even if the placement of the BFE and evaluation lines satisfies the requirements.*

In some situations, it will not be possible to provide the required detail using BFE and evaluation lines due to spatial constraints and/or steep slope in the water surface profile. In these situations, especially if the water surface profile is not linear between mapped BFE or evaluation lines, the contractor and CTP should contact the Region 8 Engineer and PTS to determine whether Flood Profiles and/or FIS inserts[2] will be needed to provide the required detail for the product user. If a Flood Profile or FIS insert is considered inappropriate for the study reach, an exception to working standard ID 128 may be considered.

2D FLOOD PROFILE DECISION MODEL:

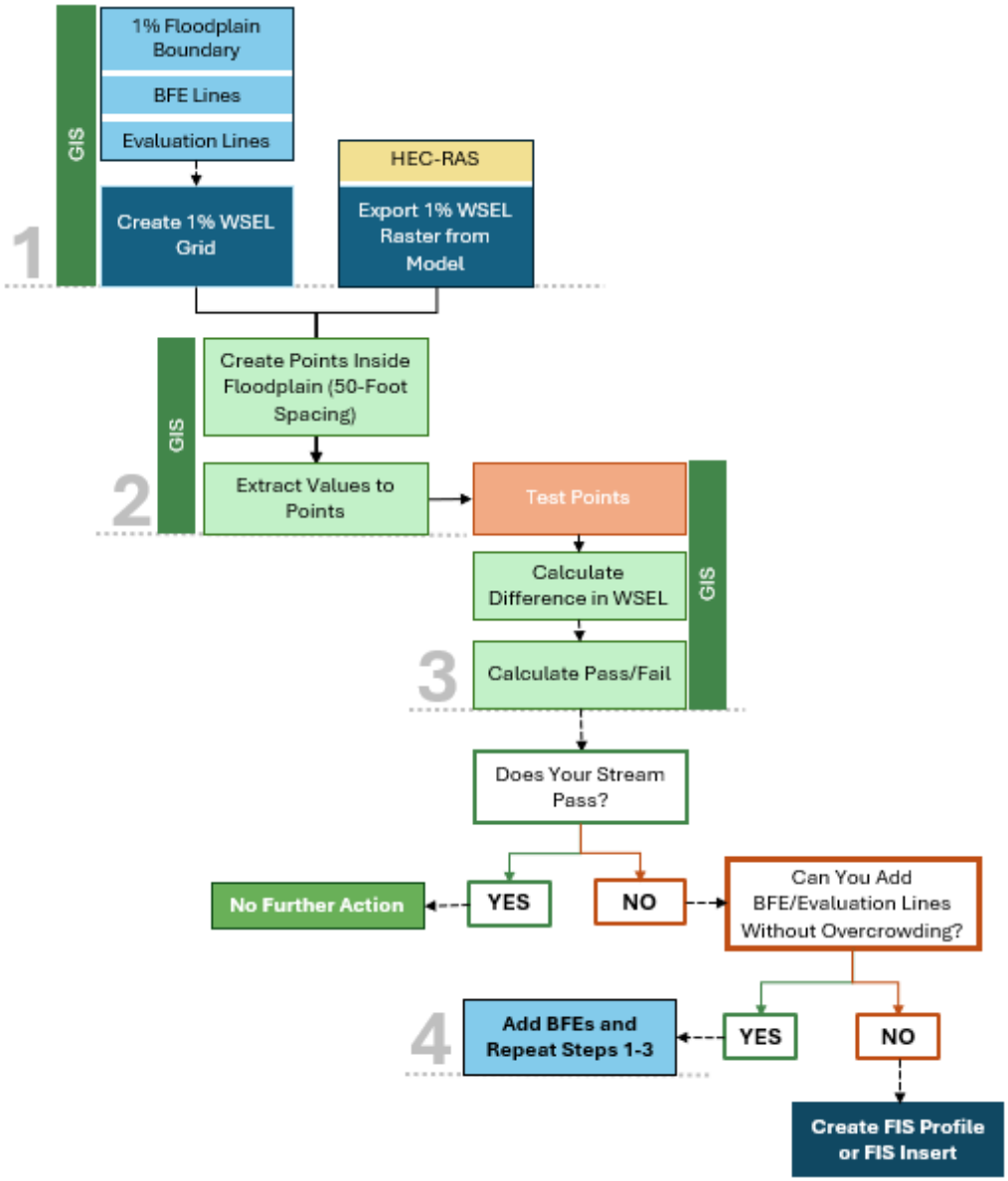

Figure 2. 2D Flood Profile Decision Model

[2] *If an FIS insert is needed to better convey the results of the 2D model, the appropriate FIS grid insert should be discussed with community officials and the FEMA Project Officer. (FEMA Flood Profiles Guidance Document, December 2020)*

DOCUMENTATION:

The final passing results of the tool shall be documented in the "**2D MAPPING SID 128 AUDIT REPORT**" (**ATTACHMENT A**). Any failing points that do not meet tolerance and are categorized as "excluded" should be documented and justifications or explanations for these discrepancies should be provided. For example, some factors could involve backwater or stillwater areas, terrain irregularities, or model constraints.

- This documentation, including spatial data inputs and outputs used for the analysis, should be provided in the Floodplain Mapping Data Capture "Supplemental_Data" folder under a subfolder called "**SID_128_Check**".

ATTACHMENT A – 2D MAPPING SID 128 AUDIT REPORT

1. Review type	2D Mapping SID 128		**4. Description of materials received**	*IE. S_XS, AE FLOODPLAINS, 1% WSEL GRID, S_TEST, S_EXCLUSION*
2. Mapping partner	*INSERT MAPPING PARTNER NAME*			
3. Final approver & date	*INSERT NAME*	*MM/DD/YYYY*	**5. Reference ID**	*FEMA Case #:*

6. Reviewer & date (list all reviews completed before final approval)	*INSERT NAME*	*MM/DD/YYYY*						

Repeat this table for each 2D flowpath studied

7. Number	8. Description	9. Results	10. Comments
1	Names of stream reach audited	*STREAM NAME*	
2	Number of floodplain boundary points audited	Total number of points: *X* Disqualified (missed) number of points: *X* Disqualified (excluded) number of points: *X* Number of points used to calculate statistics: *X*	Provide any comments on disqualified points or state to refer to another file.
3	Number of points passed (see attached shape file)	*X*	
4	Number of points failed (see attached shape file)	*X*	
5	Overall pass/fail percentages for study audit risk classes	*X%*	

4.0 APPENDIX

The following sections describe the overall workflow for running the tool, along with details on the inputs and outputs of the tool. **This tool works with any version of ArcPro; it does not work with ArcMap.**

2D FLOOD PROFILE DECISION MODEL WORKFLOW:

1. **If not already available, export the 1% annual chance WSEL grid from HEC-RAS.**
2. **Load the following input files to your map document:**
    a. **HEC-RAS 1% WSEL grid from previous step**
    b. **S_XS / Evaluation Lines (if applicable) for the stream you are testing**
    c. **S_BFE (if applicable) for the stream you are testing**
    d. **Dissolved (except static BFE polygons) Zone AE/AH floodplain for the stream you are testing**
3. **Add the Python Toolbox to your project catalog: FEMA_R8_SID_128_Check.pyt**

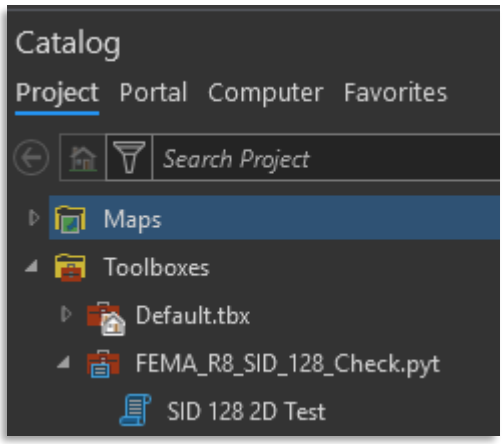

Figure 3. Example of the Toolbox added to the ArcPro Catalog

4. **Open the SID 128 2D Test tool and insert applicable files into the parameters and set output file location. See "Tool Inputs" and Figure 4 below for more details.**
5. **Run the tool. Tool processing steps are reported in the Messages dialog box.**
6. **Examine the output file "Results.txt". If the stream failed, examine the output results (S_S_Test_Centroid_Features.shp) to determine where extra BFE or Evaluation Lines are needed. See "Output Files" below for more information on output files.**
7. **If needed, place exclusion polygons around points that should be excluded from the test. See "Exclusion Polygons" for more information on exclusion polygons.**

TOOL INPUT:

See Figure 4 for the tool's input parameters. **At least one WSEL input parameter from either 1 (S_XS) or 2 (S_BFE) is required for the tool to run.** These do not need to be in the FEMA DCS schema at this time, only the water surface elevation (WSEL) is required to be populated. Each 2D modeled flooding source is required to be evaluated individually. If multiple flooding sources are modeled together, this might require the data be divided into individual files for each flooding source. Table 2 describes the

tool's inputs for each flooding source evaluated. All input files are required to be submitted in the SID_128_Check folder as indicated in the "Documentation" section above.

Figure 4. Toolbox Input Parameters

Table 2. Toolbox Input Parameters

	Label	Explanation	Data Type
1	**S_XS or S_BFE and WSEL field (required)**	Cross-sections (Evaluation Lines) or BFE lines and the water surface elevation field. Evaluation Lines are only required for floodway studies. If the study does not need evaluation lines, BFE lines will be input here. *These are required inputs.*	Line feature and numeric WSEL field input
2	**Additional S_BFE and WSEL field (optional)**	If the user has both BFE and Evaluation Lines, whatever was not input in the first input parameter will be input here. If the study does not need both BFE lines and evaluation lines, this input parameter can be blank. *These are optional inputs.*	Line feature and numeric WSEL field input
3	**S_Fld_Haz_Ar (required)**	1% Special Flood Hazard Area (SFHA). Includes Zone AE and Zone AH, if applicable. Do not include Zone AO or X. If the SFHA has a static BFE populated, that field name is also supplied. The floodway should be dissolved, however polygons with static BFEs should not be dissolved. *The S_Fld_Haz_Ar is a required input. The Static BFE field is an optional input.*	Polygon feature and numeric WSEL field input
4	**Modeled 1% WSEL Grid (required)**	This is the 1% WSEL grid exported from HEC-RAS that was used to determine WSEL for the database. *This is a required input.*	Raster
5	**Testing Tolerance and Grid (required)**	The Testing Tolerance is automatically set at 0.1 feet. The Testing Grid is automatically set at a 50-foot resolution. This is the default spacing of the points generated for testing. Do not change these parameters unless otherwise noted by FEMA Region 8.	Numeric
6	**Output Directory (required)**	This is the directory that will store your output files and results. Files will be overwritten if using same directory for multiple runs. *This is a required input.*	Workspace
7	**Exclusion Polygon Areas (optional)**	After running the tool for the first-round check, the mapping partner can create a polygon shapefile around points that are failing due to inaccurate interpolation in the tool's creation of the WSEL grid. The polygon feature needs to have a comment field that briefly describes why the points are being excluded. The tool will exclude failing points within the exclusion polygon from the results passing percentage. This file, if used as an input, is required to be submitted along with the results to the FEMA Region 8 EVR. *These are optional inputs.*	Polygon feature and text comment field input

TOOL OUTPUT:

See Figure 5 for the list of output files that are generated from the tool. The following lists what each file represents and information within each file. All output files are required to be submitted in the SID_128_Check folder as indicated in the "Documentation" section above.

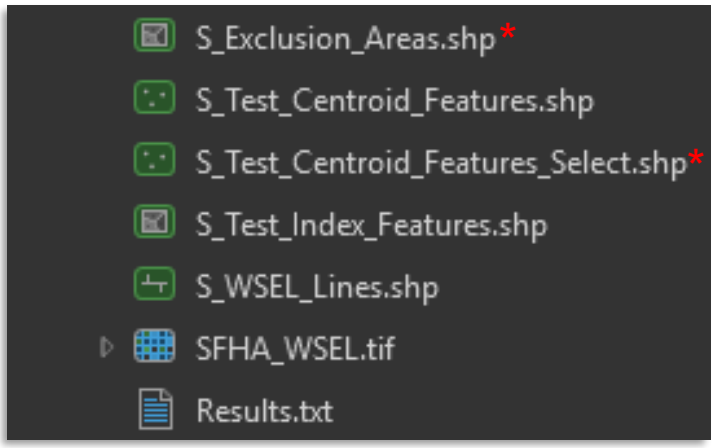

Figure 5. Tool Output Files (*these output files are only included if exclusion areas are provided as input)

1. **S_Test_Centroid_Features.shp:** This is a point shapefile that is created by the tool. The tool creates a point inside the center of the 50-foot resolution grid index (S_Test_Centroid_Features.shp) then extracts the WSEL from the HEC-RAS WSEL grid and the interpolated SFHA WSEL grid at each point and stores the WSEL as attributes (see Table 3 below). The tool calculates the difference between those two elevations at each point and stores the result into another attribute. Lastly, an attribute is populated whether the difference is within the 0.1-foot tolerance, indicating if it is passing or failing the check. If the point is attributed as "Missed", that means there was not a difference calculated because one of the WSEL surfaces had a null value[3]. The user can symbolize by the "valid_diff" field to determine areas where additional BFE or evaluation lines are needed to improve the accuracy.

Table 3. Attribute Descriptions of the S_Test_Centroid_Features.shp

Field Name	Description
RAS_WSEL	Water surface elevation extracted from the HEC-RAS 1% WSEL grid input. Elevations rounded to the tenth of a foot.
SFHA_WSEL	Water surface elevation extracted from the SFHA_WSEL.tif, which is created by the input cross-sections and/or BFE lines and the static BFE, if provided. Elevations rounded to the tenth of a foot.
abs_diff	The calculated difference between the rounded RAS_WSEL and the SFHA_WSEL.

[3] *If more than 10% of points are "Missed" the tool will fail. This indicates a possible issue with the input data.*

Field Name	Description
valid_diff	Text field indicating if the point is passing or failing the 0.1 foot tolerance, or if the point is missed.

2. **S_Test_Index_Features.shp:** This is a polygon feature of the 50-foot grid index created by the tool. A 50-foot grid index is created around the extent of the input S_Fld_Haz_Ar and then intersected with the shape of the S_Fld_Haz_Ar. The test points are then placed at the centroid of the intersected grid index.

3. **S_WSEL_Lines.shp:** This is a line feature of the combined input cross-sections and BFE lines. This is the feature that is used to create the SFHA_WSEL.tif.

4. **SFHA_WSEL.tif:** This is a raster that is developed by the tool input cross-sections, BFE lines, and if applicable static BFE.

5. **Results.txt:** This is a text file that displays the summary results of the SID 128 Check tool. It notes the mesh (grid index) test size, and the vertical test tolerance. The results note how many test points were created, and how many were missed. If more than 10% were missed, the tool will fail the study and the results will state: "Missed Percentage too High (more than 10%), Failed". The results summary then notes how many valid points (not missed) and how many pass or fail, along with the percentage. Additionally, a statement is given if the study passes or fails based on the BFE accuracy standard noted in Table 1 and Table 4. Lastly, if exclusion areas are provided as input, the results will show the comment provided in the exclusion polygon attribute table and the number of points excluded for each unique comment.

Table 4. Study Pass/Fail Percentage and Results.txt Message

Passed (%)	Study Type Passed	Study Type Failed	Results Message
95% ≥	All Studies	--	Passed More than 95% Detailed with Floodway, Passed
90% to <95%	Detailed without Floodway	Detailed with Floodway	Passed Between 90% and 95% Detailed with Floodway: Failed Detailed without Floodway, Passed
90% <	--	All Studies	Detailed with or without Floodway (less than 90%), Failed

6. **Additional Output Files if Exclusion Areas are Used in Input:**

    a. **S_Exclusion_Areas:** A copy of the input exclusion area polygon feature

    b. **S_Test_Centroid_Features_Select:** A selection of the test points that do not include points within the exclusion areas.