

## Appendix B

### 2D Floodplain Mapping

#### January 2026

The application of two-dimensional (2D) modeling has proven especially beneficial for urban flooding analysis and is gaining popularity and support from local communities. This interim appendix has been prepared to supplement the April 2025 FHAD Guidelines with 2D mapping requirements and guidelines for MHFD projects.

The structure and flow of this appendix closely mirror the 1D FHAD Guidelines to maintain consistency and clarity. However, not all applicable content from the main document has been duplicated here. Unless a specific deviation or exception is noted, users should refer to the main document for standard procedures and requirements. Amendments to original figures with added 2D context are notated with “**B**” in the figure number. This appendix is intended to supplement—not replace—the core guidance and will be expanded upon and incorporated into the body of the FHAD Guidelines at a future date.

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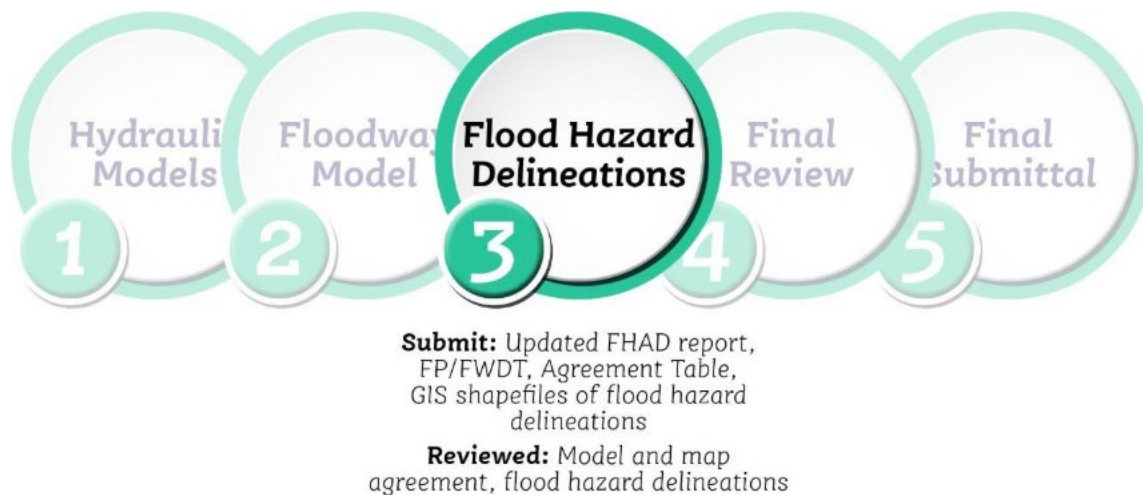
# 1.0 Introduction and Purpose

This section was purposely left blank. Refer to the main body of the FHAD Guidelines.

## 2.0 FHAD Review Process

### 2.3 Step 3 – Flood Hazard Delineations for Two-Dimensional (2D) Modeling

The 2D Flood Hazard Delineations submittal will follow the same timing and process as for a 1D analysis, with some variation in processing and spatial deliverables, as described below.



**Figure 2-5. Step 3 - Flood Hazard Delineations (from April 2025 FHAD Guidelines)**

This step is intended to translate the 2D HEC-RAS analysis results into flood hazard products that leverage the modeled Water Surface Elevation (WSEL) rasters for the 100- and 500-year floods and floodway. A floodplain boundary for the 1%-plus is not required. Base Flood Elevation (BFE) lines and Evaluation lines are created from the 100-year WSEL raster.

Some programs may generate auto-delineated floodplains, but these results alone are often insufficiently accurate and require additional post-model processing, even in 2D modeling. Post-processing is a refinement step that cleans up the raw inundation areas for the 100-year flood, 500-year flood, and floodway (when applicable). This refinement step helps ensure that mapped floodplains reflect hydraulically consistent behavior, avoiding artifacts that could misrepresent flow paths or elevations. This helps maintain the integrity of the mapped flood hazards that will inform community decision-making. This step should not require adjustments to the HEC-RAS models, but some comments may need to be addressed.

Delineations should be reviewed by the consultant prior to submittal. The consultant shall provide their evaluation lines (similar to 1D cross sections), BFE lines, and major flow paths (similar to the 1D centerline/profile baseline), and they should check that these shapefiles accurately represent the HEC-RAS model. While MHFD's FHAD Tools were designed specifically for 1D-modeled studies, FEMA's Floodplain Boundary Standard (FBS) (FEMA, latest version) is applicable to both 1D and 2D studies, and a modified FHAD Agreement Table (described in Appendix B Section 3.2.5) can be used for 2D mapping. The modified Agreement Table should be completed, checked, and submitted in Step 3. Consultants are

also encouraged to apply any in-house quality assurance tools they have available to ensure defensible and consistent mapping.

### 2.3.1 Step 3 Review

The following items are required for Step 3 2D Submittals, in alignment with Section 2.3.1 of the FHAD Guidelines:

- Brief response addressing the previous comment letter items.
- GIS comment file with response sections completed (if applicable)
- A completed Agreement Table (utilizing major flow paths and evaluation lines)
- Separate GIS shapefiles for each flood hazard delineation
  - Draft 100-year floodplain and shallow flooding boundary (GIS, polygon)
  - Draft 500-year floodplain boundary (GIS, polygon)
  - Draft floodway boundary (GIS, polygon)
  - Draft BFEs (GIS, polyline)
  - Draft evaluation lines (GIS, polyline)
- Draft 100-year WSEL grid (GIS, raster)
- Draft 500-year WSEL grid (GIS, raster)
- Draft Flood Hazard Figure (mxd)
- 100- and 500-year depth grids may be provided to support GIS-based review. Depth grids are non-regulatory flood risk products under FEMA guidance and are not required for FHAD Step 3 submittals unless requested by MHFD or the reviewing community.

The review of the 2D flood hazard delineations in Step 3 will focus on the following information:

- *Compare the HEC-RAS model with the Agreement Table and FP/FWDT.* Map values, report tables, database tables, and model values in each table should closely match HEC-RAS results.
  - **Any vertical differences greater than 0.1 feet** at a given evaluation line between the map and model reference line values should be documented in the Comments Column of the Agreement Table.
  - **Any vertical differences greater than 0.1 foot** between the BFE/evaluation lines and the model WSEL raster may require the creation of Flood Profiles and/or Report Inserts. Please see the latest FEMA Policy Standards for Flood Risk Analysis and Mapping: FEMA Policy #FP 204-078-1 Standard ID #128 (FEMA SID #128). These references will be referred to as FEMA SIDs hereafter.
- *Verify evaluation lines and BFE lines are created from the most recent model run.* If the wrong version of the WSEL grid was used to develop the mapping products, delineations may be incorrect. **If the reviewer identifies this issue, the submittal may be returned before a full review is completed.**
- *Verify flood hazard delineations follow topographic information.* Delineations should present reasonable WSELs across the floodplain according to the results of the HEC-RAS models. Please follow FEMA's FBS when verifying flood hazard results against topographic information.

### 2.3.2 2D Flood Hazard Boundaries

While 2D models automatically produce draft mapping outputs as part of their simulation, 2D results still require careful cleanup to ensure an accurate terrain-driven representation of flooding. This includes reviewing for isolated flood cells, smoothing jagged boundaries, verifying connectivity, ensuring consistency with terrain and infrastructure, and defining shallow flooding boundaries.

#### Shallow Flooding and Localized Ponding in 2D Models

Consistent with FEMA Guidance for Flood Risk Analysis and Mapping – Shallow Flooding Analyses and Mapping (2020) and as applied by MHFD in the FHAD Guidelines (April 2025), shallow flooding is defined as areas with an average 100-year flood depth of less than 3 feet, including areas of ponding. In 2D modeling, shallow flooding is identified based on computed water depths within individual grid cells rather than assumptions inherent to 1D channel-based modeling.

Shallow flooding areas shall be retained within the 100-year floodplain delineation. Any classification or special treatment of shallow flooding (e.g., depiction as a shallow flooding layer) shall be coordinated with MHFD and the affected community. Localized ponding or disconnected inundation areas identified in 2D model results represent potentially valid hydraulic behavior and shall not be removed automatically. Any removal or modification of such areas must be supported by hydraulic justification and documentation and must be coordinated with MHFD and the affected community.

This appendix focuses on fluvial (riverine) 2D studies, where shallow flooding results from overbank flow or flow redistribution from the primary channel. Pluvial (rainfall-driven) shallow flooding involves different hydrologic and hydraulic mechanisms and is not addressed here; pluvial-specific guidance may be incorporated in future updates as these applications become more prevalent.

#### 100-Year and 500-Year Floodplains

Delineation of 2D-modeled 100-year and 500-year floodplains is similar to 1D, with a few additional considerations. The floodplain boundaries supported by a 2D hydraulic model should encompass the entire extent of the inundated area without separating shallow flooding areas at the floodplain fringes. Areas that are separate from the modeled flooding source should be connected either with overland flow or by modeled structures.

While 2D modeling can inherently produce isolated pockets that appear disconnected, the removal of any portion of the model output requires careful evaluation rather than wholesale deletion. Edits should be made using targeted cleanup techniques that are physically justifiable and documented for consistency and reproducibility. The new floodplain boundaries must not exclude any areas where there is existing mapping on the effective FEMA FIRM or LOMR, unless coordination and documentation have been provided to justify the change.

**In areas with no defined channel and average 100-year depths between 1 and 3 feet, shallow flooding may be considered on a case-by-case basis.** It is preferred that shallow-depth areas with ponding or urban sheet flow show BFEs rather than just the area's average depth. This allows for easier BFE estimation from the map.

In 2D modeling applications, very shallow flooding, or nuisance flooding, can also occur. MHFD defines nuisance flooding as 100-year average depths of less than 1 foot for areas less than 1 square mile where no history of significant flooding has occurred. These areas could be defined as Zone X (shaded, 100-year depths less than 1 foot) after discussion with MHFD. Areas larger than 1 square mile or that have a history of destructive flooding could be reflected as 100-year floodplain and should also be coordinated with MHFD. Areas should be retained in the shallow flooding layer of the FHAD Geodatabase.

**Any shallow flooding area shall be included in the 100-year floodplain delineation.** In addition to including this area within the 100-year floodplain, a separate shallow-flooding-only delineation shall be provided. The extent of a shallow flooding zone can be identified by averaging the 100-year flow depth at BFE lines. The average depth is obtained by dividing the flow area by the water-surface top width along the BFE line. A weighted average of each BFE line's average flow depth can then be calculated for the reach of interest.

Islands of dry, high ground smaller than 2,500 square feet should be filled in. However, depending on each community's specific regulatory needs, mapping engineers should confirm the appropriate threshold with MHFD and the respective communities before beginning the 2D mapping tasks. Adjustments should be made to the flood hazard boundaries only; adjustments to the HEC-RAS depth or WSEL grids are not necessary.

### Floodway

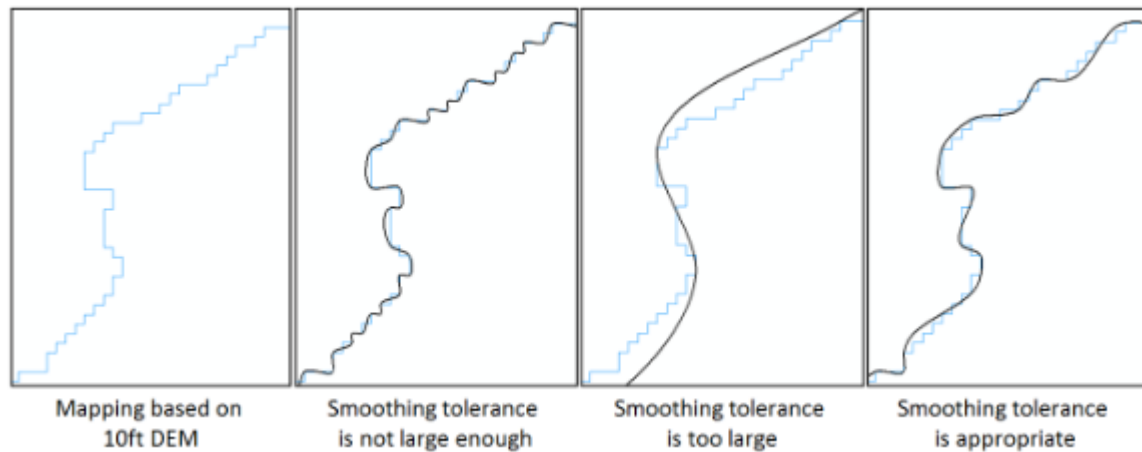
In 1D modeling, floodways are defined at cross sections by adjusting encroachment stations until surcharge limits are met, and the mapping step interpolates those encroachment points between sections. In 2D modeling, however, flow is simulated across a continuous grid, so floodway analysis is tied to a continuous polygon instead of discrete cross sections. This changes the mapping step from interpolating between cross sections to starting with a spatially continuous boundary.

The final mapped floodway should follow the calculated boundaries in the 2D model; no post editing of the floodway will be allowed, and all changes should be incorporated into the final model. The floodway boundary can be created by directly exporting the inundation polygon from RAS Mapper or by erasing the encroachment polygon from the perimeter polygon. Dry islands should only be designated within the floodway if modeling supports a split flow or significant flow path deviation. Floodway boundaries should be smoothed with a tolerance of 25-50 feet using the Polynomial Approximation with Exponential Kernel (PAEK) smoothing algorithm in GIS to improve cartographic clarity. It should be confirmed that the final mapped boundaries are equal to the boundaries within the model. FEMA SID #335 also requires that any smoothing does not alter the floodway in a way that exceeds allowable surcharge tolerances, ensuring the mapped boundary continues to reflect the underlying model results. **Note that the allowable tolerance for horizontal positional accuracy of edited floodplain and floodway widths is within either 5 percent of the map scale or 25 feet for a 1":500' FIRM.**

### Flood Hazard Delineation Best Practices

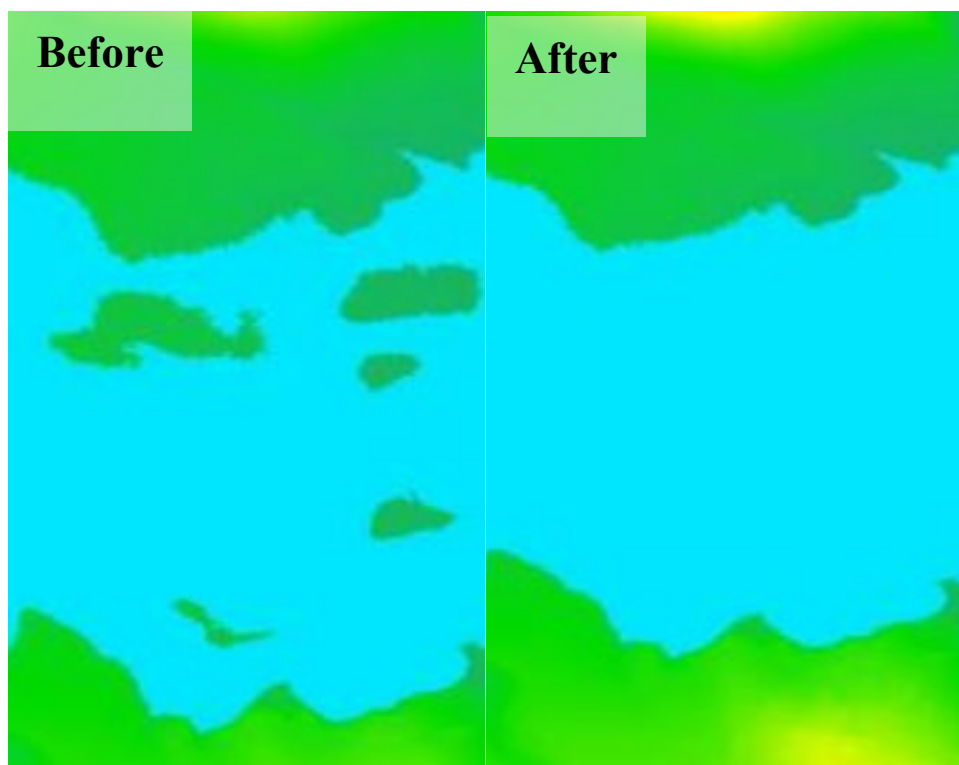
Please refer to FEMA Best Practice - Floodplain Boundary Processing (FEMA, latest version) for detailed recommendations on cleaning and smoothing flood hazard boundaries. Specific requirements for MHFD 2D flood hazard development are presented below.

- **Boundary Smoothing:** Recommend a smoothing tolerance of 25 feet with the PAEK smoothing algorithm in GIS. This tolerance can be adjusted to make sure the resulting smooth boundary does not significantly alter the location of the flood boundary. PAEK smoothing should not exceed 50 feet. Simplifying/Generalizing vertices to 10 feet should be performed after smoothing is complete. Floodplains shall pass FEMA SID #369 and pass Floodplain Boundary Standards (FBS) checks. SID #369 requires that floodplain boundary lines must be generalized to no more than an average of one vertex every 10 feet. Any boundaries that are smoothed, simplified/generalized, or otherwise post-processed must still meet the FBS. Use of the Smooth Polygon PAEK method, ranging from 25-50 feet, helps maintain the general shape of the floodplain for those viewing maps at scale. **Figure 2-8** demonstrates the concept behind smoothing.



**Figure 2-8. Smoothing Tolerances**

- Islands in Floodplain:** Dry islands within the floodplain that are smaller than 2,500 square feet should be removed by filling in the polygonal area. The general threshold of 2,500 square feet can be used; however, the key consideration is whether the dry area is large enough to accommodate multiple structures based on the designated land use. Accessibility to the area may also be considered. **Figure 2-9** depicts island removal.



**Figure 2-9. Island Removal**

### 2.3.3 2D Evaluation Lines, BFE Lines, and Flood Profiles

To accurately depict the WSEL grid generated by a 2D model, a combination of evaluation lines and supplemental BFE lines should be captured in the FHAD database and depicted on the Flood Hazard Figure. Evaluation lines 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, like 1D cross sections, represent WSELs of the 100-year floodplain and locations where the results of a 2D floodway are evaluated. Like in 1D mapping, BFE lines are used to supplement WSELs, as needed. The combination of evaluation lines and BFE lines should allow for linear interpolation of the base flood elevation. In addition, evaluation lines are used to validate that a floodway analysis meets surcharge requirements. See **Table 2-2** for a comparison between evaluation lines and BFE lines.

**Table 2-2 Evaluation Lines vs. BFE Lines**

Aspect	Evaluation Lines	BFE Lines
Purpose	Extract WSELs from 2D model results to evaluate floodway delineation and report results in FP/FWDT and mapping	Depict regulatory BFEs on the Flood Hazard Figure and future FEMA FIRM; supplement WSEL around evaluation lines
When to Use	During post-processing of 2D model results to capture representative WSELs; required when mapping floodways or to meet FEMA SID #374	Depict regulatory mapping BFEs; show regular increases in WSEL within the 2D channel and overbank areas
Relation to Model Geometry	User-defined; contour created from the 100-year WSEL	User-defined; contour created from the 100-year WSEL
Rounding	Rounded to the nearest 0.1 foot for floodway surcharge analysis and mapping	Rounded to the nearest whole foot for mapping and 0.1 foot for any supplemental BFE derived to improve accuracy to meet FEMA SID #374

Evaluation lines are required along reaches with floodways and when a flood profile is required. According to FEMA SID #128, a flood profile is required if mapped BFE values cannot be plotted at intervals sufficient to allow modeled WSEL values to be interpolated within 0.1-foot accuracy between contour lines. Because evaluation lines function analogously to cross sections in 1D modeling, selected WSEL contours intersecting the profile baseline shall be attributed as evaluation lines where necessary to support floodway surcharge evaluation or to meet FEMA requirements for flood profile development and WSEL interpolation accuracy (e.g., FEMA SID #128 and SID #374).

Not every WSEL contour intersecting the profile baseline must be an evaluation line. To ensure evaluation line placement is consistent and non-arbitrary, evaluation lines intersecting the profile baseline should be selected based on hydraulic, regulatory, or interpolation need, including locations required to evaluate floodway surcharge, locations needed to support flood profile development, areas where mapped BFEs alone are insufficient to meet interpolation accuracy, and locations of significant hydraulic controls or changes in floodplain geometry.

Evaluation lines will provide users with the WSEL for all profiles, rather than just the 100-year WSEL captured along BFE lines, which can be mapped or unmapped on a future FEMA FIRM. Any WSEL contour lines that do not intersect the profile baseline should be included as BFE lines only. BFE line



usage should primarily be limited to clarification BFEs in adjacent areas that do not intersect the profile baseline or for supplementing evaluation lines to meet SID #374.

In addition to the conditions described above, flood profiles are not required for 2D-modeled floodplains unless specifically requested by the project sponsor or the community.

#### Evaluation Line and BFE Line Production

Both evaluation and BFE lines should reflect a single 100-year WSEL value extracted from the modeled WSEL raster in HEC-RAS and may have a contoured shape. It is recommended that evaluation lines follow whole-foot elevations, if possible. Supplemental evaluation lines and overbank BFE lines can be exported at a user-identified interval following the placement guidance below. Evaluation lines are populated in the cross-section feature class of the FHAD geodatabase.

#### Evaluation Line Placement

- The profile slope between any combination of evaluation lines and/or BFE lines should be relatively constant.
- Evaluation lines may be shown like “lettered” cross sections on FIRMs. MHFD does not require lettered cross sections for the FHAD products. However, these studies may be submitted to FEMA for PMR later. Evaluation lines should be placed frequently enough so that the following FEMA Floodway Guidance can be met: “lettered” evaluation lines should not be further than two inches of map distance apart (about every 1,000 feet).
- Evaluation lines should avoid complex areas such as confluences, when possible.
- Spacing of evaluation lines should follow these general guidelines:
  - Gentle Gradient – If WSELs rise less than 1 foot per 1 inch of map distance, the evaluation lines should be plotted at every whole foot of elevation rise.
  - Moderate Gradient – If WSELs rise more than 1 foot, but less than 5 feet per 1 inch of map distance, the evaluation lines should be plotted at approximately 1-inch intervals.
  - Steep Gradient – If WSELs rise 5 feet or more per 1 inch of map distance, the evaluation lines should be plotted at 0.5-inch intervals of map distance or at 5-foot intervals, whichever is greater (i.e., whichever results in a wider evaluation line spacing).
- The maximum vertical rise between plotted evaluation lines should not exceed 10 feet.
- Evaluation lines should be placed at key hydraulic locations to capture and report the resultant surcharge. Examples of key hydraulic locations will vary depending on the characteristics of the stream but will include:
  - Upstream and downstream of confluences with tributaries
  - Upstream and downstream of existing structures (bridge/culverts)
  - Upstream and downstream of significant hydraulic controls (weirs/dams)
  - Where significant changes occur in the modeled topography (inflection)
  - At the divergence and confluence of split flow paths or divided flow paths
  - Expansions and contractions in the floodplain
  - Urban development areas and future development areas

- A full summary of the recommended evaluation line placement is included in the *Guidance for Flood Risk Analysis and Mapping – Floodway Analysis and Mapping Guidance* (FEMA, latest version).

#### BFE Line Placement

- BFE lines supplement 1D cross sections or 2D evaluation lines at appropriate locations to allow map users to accurately interpolate flood elevations both horizontally and vertically. Because this requirement is results-focused, there are no specific or prescriptive standards regarding the spacing of BFE values or the elevation differences between them. BFEs should be strategically placed at reasonable intervals to achieve this intent.

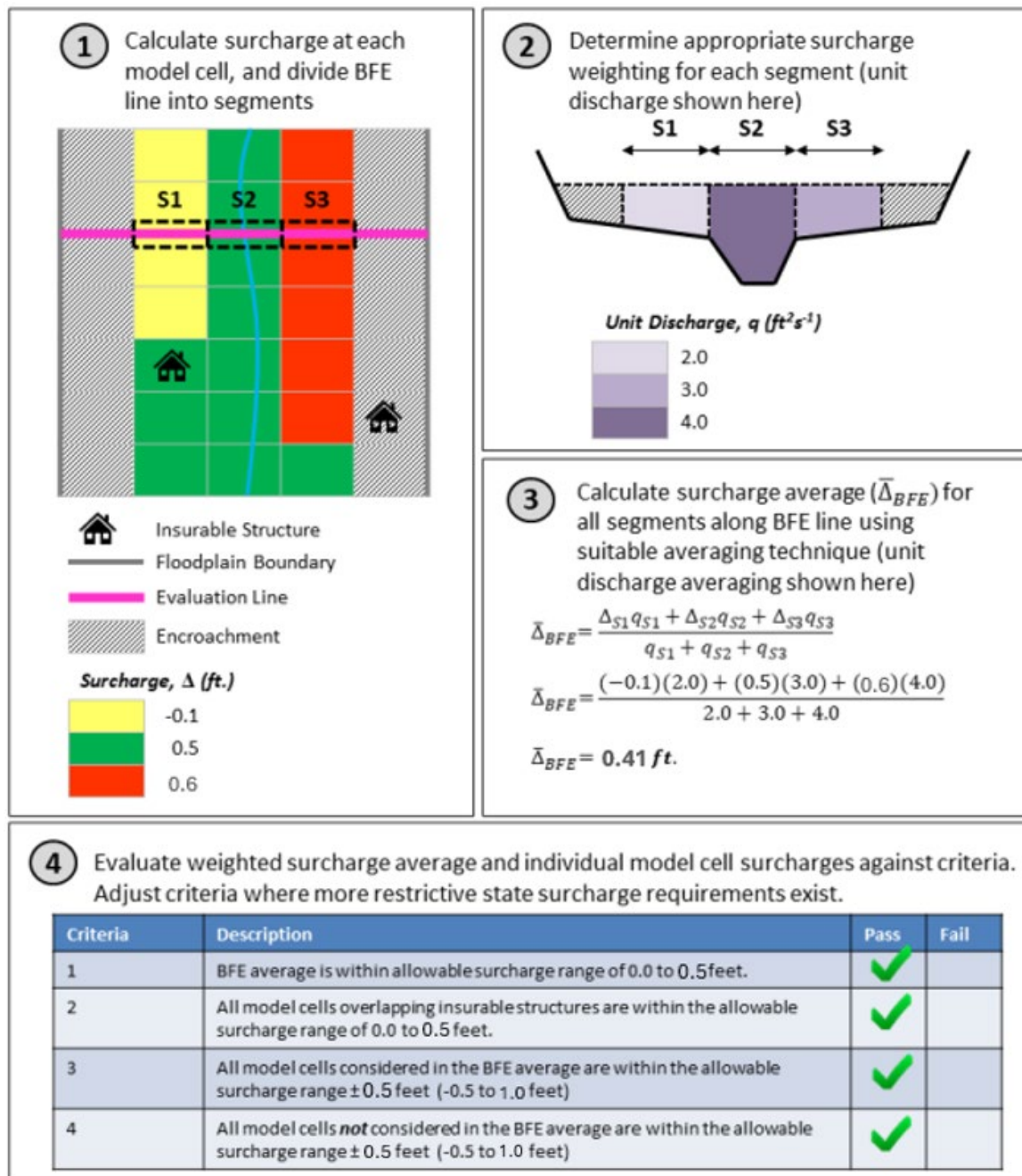
#### Floodway Surcharge Analysis Using Evaluation Lines

Floodway surcharge values shall be evaluated along the evaluation line within the floodway using an evaluation-line average surcharge, with localized cell or node-level surcharge behavior reviewed as a quality-control check.” For MHFD FHAD studies, surcharges may be no less than 0.0 feet with the maximum allowable value of 0.5 feet. The adjusted **Figure 2-10** outlines how these calculations should be completed.

For individual cells or nodes, surcharges shall reflect the change between the base and floodway WSEL. The 2D grid polygon cells intersecting a selected evaluation line may be reviewed to identify localized surcharge behavior during quality-control screening. Localized variability in individual 2D cell surcharge values may occur due to numerical and spatial effects inherent to 2D hydraulic modeling and shall not, by itself, determine regulatory compliance.

For MHFD FHAD studies, regulatory compliance is determined based on the evaluation-line average surcharge, which shall remain within the allowable range of 0.0 to 0.5 feet. Individual cell surcharge values that exceed (-0.5 – 1) ft may be acceptable only where they are isolated, hydraulically reasonable, and do not influence insurable structures, and where the evaluation-line average surcharge meets MHFD criteria. Any cell containing an insurable structure shall meet the regulatory surcharge range of 0.0 to 0.5 foot without exception.

For the entire evaluation line, surcharges shall be calculated using a representative weighted average surcharge along the evaluation line within the floodway. Flow-area-weighted and evaluation-line-length-weighted averaging methods are commonly used for 2D floodway analyses. For MHFD FHAD studies, flow-area-weighted averaging is preferred because it reflects the relative conveyance contributions of different portions of the floodway in a 2D model. Other weighted methods may be appropriate for specific circumstances and should be utilized in consultation with MHFD and the community and then documented in the technical report. Figure 2-10 shows an example of how to perform the flow-area-weighted average surcharge calculations. 2D modeling with levees often requires a Levee Plan and a Natural Valley Plan; in these instances, the floodway delineation and surcharge evaluation shall be performed relative to the Natural Valley Plan. FEMA provides guidance on these issues in Section 6.18 of *Guidance for Flood Risk Analysis and Mapping – Levees* (FEMA, latest version).



**Figure 2-10. Modified FEMA example of surcharge averaging across an evaluation line for a 0.5-foot floodway.**

#### Profile Baseline/Major Flow Path Production

A stream alignment (or profile baseline) should be created for 2D-modeled major flow paths when a flood profile is required. In these instances where mapped BFEs alone are inadequate, the profile baseline can serve as an important reference for regulatory mapping and documentation. It acts as a surrogate for the traditional 1D profile baseline, allowing users to interpret flood elevations spatially along the stream corridor, even when the hydraulic computations are grid-based rather than cross-section-based.

Profile baselines for 2D models are typically created by manually drawing the general path of significant flows. Typical model output grids, including water depth, velocity, and velocity vectors, can be used to

help determine the placement of the baseline. Like 1D applications, the profile baseline should follow the thalweg for channelized flow or represent the general path of overbank flow. In all cases, the profile baseline must be located entirely within the 100-year floodplain boundary. The profile baseline should be incorporated into the HEC-RAS model as either an enforced breakline or reference line, which enables the use of RAS Mapper. The profile baseline should start from a physical location such as a confluence or structure, per FEMA SID #278. Offsets and negative stationing should be avoided where possible, with zero stations indicating the most downstream location of the 2D model. Refer to *Guidance for Flood Risk Analysis and Mapping – Profile Baseline Guidance* for more details. (FEMA, latest version).

### Flood Profile Production

Flood profiles alone are not reliable for estimating BFEs in 2D-modeled areas because WSELs can vary significantly from adjacent mesh elements, particularly where flow is distributed across wide overbanks; therefore, profiles have limited utility for 2D studies. Flood profiles should only be developed after coordination with MHFD and if evaluation and BFE lines within the FHAD geodatabase are insufficient to interpolate the modeled WSEL within 0.1 foot. Flood profiles should be prepared to show the 10-, 25-, 50-, 100-, 500-year and 1%-plus events. The profiles depict the flood elevation at each evaluation line. Like 1D profiles, the digital profiles should be one continuous profile and should be oriented with stationing increasing from left to right.

RASPLOT does not produce flood profiles for 2D results in the way it does for 1D because generating cross-sectional profiles is not a supported function for 2D output in HEC-RAS. Profiles for 2D models instead must be created manually. The profile baseline should be used to extract the WSELs for each event. In RAS Mapper, this can be done by using the Profile Lines feature. Copy the desired profile baseline into the Profile Lines layer, right-click on the profile line, select “Plot Profile,” and select “WSE” to get the graph and station elevation table for any displayed WSEL grid.

Manual adjustments, such as filtering vertices, impacts from drawdowns and backwater, should be incorporated into the final deliverable, as needed. When filtering vertices along profile baselines or flood profiles generated from 2D model results, vertices should be retained at hydraulically significant locations, including evaluation lines, structures, confluences, changes in channel or floodplain slope, and other key inflection points. Intermediate vertices may be reduced using a spacing- or elevation-based tolerance to improve profile readability, provided the filtered profile continues to accurately represent the modeled WSE. The filtering approach used shall be documented.

Localized drawdowns may occur in flood profiles generated from 2D model results due to physically valid spatial variations in water-surface elevation inherent to 2D hydraulic modeling. Unlike 1D profiles, such drawdowns do not necessarily indicate modeling error and may be retained where they are hydraulically reasonable and consistent with mapped flood hazard information. Drawdowns that are inconsistent with floodplain mapping, regulatory BFEs, or floodway evaluations should be reviewed and addressed as part of QA/QC.

### Evaluation Lines

Each evaluation line should be represented by the symbology used for 1D cross sections using the number at the station that matches the evaluation line location on the stream centerline alignment. Stations can be determined in RAS Mapper’s Layer Properties table, which has an option to draw stationing tick marks from the starting point of a feature line. Stations can also be determined by using other GIS tools.

As described in the *Profile Baseline/Major Flow Path Production* section above, stationing should be referenced to a zero station along the profile baseline, per FEMA SID #278.

### Structures

Bridges, culverts, and other modeled hydraulic structures should be illustrated on the profile like a 1D profile. Information should be provided at the upstream and downstream faces of bridges and culverts. The structure symbology of 1D profile should be used on the 2D profile. For bridges, include bridge high chord, bridge low chord, channel thalweg, and WSEL. For culverts, include culvert high chord, top of culvert opening, bottom of culvert opening, channel thalweg, and WSEL. For events contained within a structure, the WSEL should not be shown over the structure in the flood profile. Structure information is also captured spatially within the Hydro\_Struct feature class of the FHAD geodatabase.

## 3.0 QA/QC and Error-Checking

### 3.1 2D Mapping Quality Assurance

There are several items to check prior to making a submittal to MHFD. Several of these items are listed in **Table 3-1B**, which has been amended from Table 3-1 in the FHAD Guidelines specifically for 2D mapping. Please ensure that QA has been performed **by a registered Professional Engineer** before submitting 2D mapping products to MHFD for review.

**Table 3-1B. FHAD 2D Mapping Quality Assurance Items**

The stream centerline (profile baseline) delineation follows the thalweg or is informed by the modeled significant flow paths and approved by MHFD.
The combination of evaluation lines and BFE lines can be used to interpolate flood elevations to within 0.1 foot of the 100-year modeled WSEL. This can be checked by creating a WSEL raster from the evaluation and BFE lines and comparing it to the model raster in HEC-RAS.
Existing online detention facilities that were accounted for in the hydrologic analysis are to remain un-encroached by the flood pool elevations.
Clearly identify both the upstream and downstream study limits on the topographic work map.
Conduct an FBS audit by comparing the computed flood elevation to the ground elevation at the mapped floodplain boundary. Complete a FBS Self-Certification Audit Report and provide backup data with calculations.
For a given evaluation or BFE line, ensure that the plotted floodplain boundaries intersect the ground at the same WSEL on both sides. The FBS audit will help identify problem areas.
Verify that the evaluation line or BFE line locations in the hydraulic model are consistent with those shown on the topographic work map and water surface profile.
Make sure that an existing regional detention facility has been accounted for in the hydraulic model to produce consistent results with those computed in the hydrologic study for all storm events modeled (i.e., actual geometry for outlet structure, rating curve, boundary condition, known WSEL, etc.). Verify that the existing detention facility is reflected in the resulting water surface profile from the hydraulic model results.
Verify whether overtopping occurs at roadways or railroad crossings along the drainageway and make sure the water surface profile and topographic work map clearly indicate if overtopping occurs.
Verify whether leaking cells exist in the model and determine their hydraulic purpose. Any leaking cells should be addressed and filled during the floodplain mapping process.
Verify that the final mapped floodway has not deviated from the modeled floodway outside of acceptable tolerance.
Shallow flooding areas shall be included within the 100-year floodplain delineation.
No future detention facilities are to be shown on the topographic work maps for the FHAD. These proposed facilities are to be shown in the related master planning documents for the drainageway.

Make sure that relative top widths make sense (i.e., the floodway top widths are not greater than the 100-year floodplain top width at a given location).
Use consistent significant digits for the values in the FP/FWDT and Agreement Table.
Note differences in floodplain or floodway top widths between the hydraulic model results and the topographic work map delineations in the FP/FWDT.
Verify floodway results have WSEL surcharges that meet criteria.
Even though the 500-year floodplain is not regulatory, it must be mapped accurately to match the hydraulic model results. The District requires the same level of review for the 500-year mapping as for the 100-year floodplain.
Review water surface profiles for unreasonable crossings or drawdowns between multiple storm events. For 2D-modeled profiles, localized drawdowns may be acceptable where hydraulically reasonable and consistent with mapped flood hazard information. Any unreasonable drawdowns/crossings that affect regulatory BFEs, floodway evaluations, or floodplain delineations shall be evaluated and addressed as part of QA/QC.
Make backwater adjustments to water surface profiles and adjust the floodplain/floodway boundaries and FP/FWDT accordingly.

## 3.2 2D Mapping Quality Control

The following QC tools and guidance are provided to support the QA process.

### 3.2.1 Checklists

The FHAD Report Checklist identifies the information that is required for FHAD studies. A copy of the FHAD Report Checklist should accompany the Final Review and the Final Submittal.

The completed FHAD Deliverables Checklist shall be included with the Final Review and the Final Submittal. The FHAD Submittal Form shall be included with all submittals to document what needs to be submitted and what has been approved.

### 3.2.2 cHECK-RAS

The cHECK-RAS tool is not compatible with 2D models.

### 3.2.3 FHAD Tools

The FHAD Tools are currently compatible with 1D studies only. Updates may be incorporated to include 2D analysis considerations in the future.

### 3.2.4 Floodplain and Floodway Data Table

The FP/FWDT lists information at each evaluation line for the floodplains and floodways studied. Floodway data are required even when the model flows are confined within a well-defined channel. Floodway data values reported in the table will be taken from the floodway hydraulic model. A notation in the Comments Column of the FP/FWDT should be added whenever the floodway is equal to the floodplain. **Table 3-3B**, adapted from Table 3.3 in the FHAD Guidelines for 2D modeling, lists the required and optional information to include in the table.

**Table 3-3B. Floodplain and Floodway Data** *Table Contents*

Item	Location	Content to Add
Study Name	Top Center	Table #, FHAD Study Name.
Reach	Row Heading	River/Reach (Repeat at each River/Reach break)
Reference Location	Column 1	Downstream starting location or other identifier (physical location: street, structure, confluence, etc.)
River Station	Column 2	Station along stream centerline/profile baseline starting from Reference Location (0 ft or continue from a known 1D or 2D station).
Evaluation Line	Column 3	Evaluation line ID (Formatted "River_Station")
Thalweg Elevation (ft)	Column 4	Lowest terrain elevation along the profile baseline at the intersection with the evaluation line or BFE line, extracted from the same DEM used in the 2D hydraulic model.
Peak Flow (cfs) (storm events from Vendor Agreement)	Columns 5-9	Peak Flow data from hydraulic model for 10-, 25-, 50-, 100-, 500-year, or as otherwise specified by Vendor Agreement.
WSEL (ft) (storm events from Vendor Agreement)	Columns 10-14	Flood WSEL extracted from 2D MAX WSEL rasters for 10-, 25-, 50-, 100-year (with all drawdowns eliminated), and 500- events at each evaluation line. WSEL is the average of the MAX cell values that intersect the evaluation line. If event is not scoped these values may be shown as N/A.
100-Year Floodplain Width (ft)	Columns 15-16	Total width of mapped floodplain as defined below for the 100-year storm event. EGL is not applicable to the 2D model and should be marked as N/A.
100-Year Floodway; Floodway WSEL (ft) EGL (FT) Width (ft) Area (sq ft) Velocity (fps)	Columns 17-21	100-year, 0.5-foot floodway WSEL, total top width of mapped floodway including high ground and ineffective flow area, flow area of the entire evaluation line including ineffective flow area, and the average velocity of flow in the total evaluation line. EGL is not applicable to the 2D model and should be marked as N/A.
$\Delta$ HGL ( $\leq 0.5'$ HGL and no negative surcharge)	Columns 22-23	Change in HGL. Average difference between the floodway WSEL and 100-year floodplain WSEL. For 2D analyses where $\Delta$ HGL is not applicable, the corresponding columns may be reported as N/A.
Note	Column 24	Use numbers from footnotes to note typical comments regarding specific details or how the values may differ from the hydraulic model and the reason for the difference.
Comments	Column 25	For unique or special characteristics, conditions or other supplemental information beyond the typical conditions specified in Column 24, provide details here. In general, the comments in Column 22 of the Agreement Table should be replicated here when applicable.
Footnotes	Below table	Typical notes or a way to note specific details for particular evaluation lines or pertinent for a particular project.

Note: cfs = cubic feet per second, ft = feet, fps = feet per second, sq ft = square feet

Beginning with Step 2 – Floodway Model, each submittal is to be accompanied by a completed FP/FWDT.

**Please limit values within the FP/FWDT to reasonable significant digits, as defined in Section 3.2.4 Table 3-4 in the FHAD Guidelines. These significant digit requirements apply to both 1D- and 2D-modeled FHAD studies. WSELs exported from the HEC-RAS output at the thousandth of a foot should be rounded to the nearest hundredth of a foot. For example, if the HEC-RAS WSEL is 5200.145, the BFE in the Agreement Table should be 5200.15. Surcharges should also be rounded to the nearest hundredths of a foot, maintaining the same level of precision as the elevations.**

This information should be included as Appendix D of the FHAD Report. An example of the required significant digits is provided in Section 3.2.4 of the FHAD Guidelines.

#### Additional Data Descriptions and Information

**Thalweg Elevation (ft)** – For 2D analysis, defined as the lowest terrain elevation along the profile baseline at the evaluation line (or BFE line) intersection, extracted from the same DEM used in the hydraulic model.

**Peak Discharge (cfs)** - Defined as the peak flood flow (as specified in the MHFD Vendor Agreement) for the given storm event. In HEC-RAS, the maximum flow can be determined using Reference Lines using the Plot Stage and Flow Hydrographs from the View menu. They can also be determined using RAS Mapper. To extract, turn on the relevant layers for visualizing flow, such as velocity or depth. Right-click and select the flow option to get plot and tabular data to determine the peak discharge.

**WSEL (ft)** - Defined as the flood WSEL for the given storm event. In HEC-RAS, the 2D WSEL should be determined from the 100-year WSEL raster (and derived contours). Averaged WSELs for non-100-year events may be calculated by the modeler for internal review or diagnostic purposes but are not required for FHAD reporting in 2D analyses unless specified by the Vendor Agreement.

**100-Year Floodplain Width (ft)** - Defined as the total mapped width of the floodplain as shown on the Flood Hazard Figure, regardless of islands (whether mapped or not) and other obstructions. The total modeled top width can be calculated by using the calculated length of the evaluation line clipped and snapped to the final 100-year boundary delineation. Since the floodplain and floodway values in the MHFD FHAD typically reflect the total width of the floodplain/floodway regardless of ineffective flow, islands, and other obstructions, a note should be added to the Comments Column of the FP/FWDT to indicate what is included. These notations will help explain discrepancies in future FIS updates since the Floodway Data Table in the FIS reports active top width and can be calculated from the length of the evaluation line within the floodway.

An exception to this rule would be for areas where existing on-site detention facilities are located adjacent to the main channel. For these areas, the floodplain top width shown in the FP/FWDT adjacent to the detention facilities needs to reflect the top width for actual conveyance without the ineffective flow area.

Note that for FHAD studies, islands are not typically mapped (shown as high ground) in the floodway. Also note that islands within a floodplain or floodway must be treated on a case-by-case basis, and the consultant should coordinate with MHFD when islands occur within the floodplain or floodway limits for further guidance.

**Floodway Elevation (ft)** - Defined as the floodway WSEL with encroachments that cause the HGL to rise to the allowable 0.5-foot surcharge.



**Floodway Width (ft)** - Defined as the total floodway width (regardless of islands, other obstructions, or ineffective flow area) with encroachments that cause the HGL to rise to an allowable maximum of up to 0.5 foot. The total modeled top width can be calculated using the length of the evaluation line within the floodway. Review the 100-year Flood Profile run to confirm that the floodway encroachment polygons are not set on dry land, particularly where high ground exists within the main channel. The modeled floodway top width must be equal to or smaller than the modeled 100-year floodplain top width. For additional details on reporting and mapping widths, refer to the definition of 100-year Floodplain Width.

**Floodway Area (sq ft)** - Defined as the flow area of the entire evaluation line, including ineffective flow. This can be computed by determining the average depth across the evaluation line times the length of the evaluation line. This should be done across each modeled cell within the floodway model. Then, all areas can be added together for the total floodway area.

**Floodway Velocity (fps)** - Defined as the average velocity of the flow in the total evaluation line. In HEC-RAS, this can be exported from RAS Mapper using the maximum velocity raster. The average velocity value across the evaluation line should be determined.

#### Discrepancies Between Table Values and HEC-RAS Model

The values published in the FP/FWDT must match the Flood Hazard Figure and flood profiles. There may be situations where flood hazard mapping does not match the top width of the HEC-RAS output. For instance, a rapid change in geometry, such as the downstream side of an overtopped roadway, may result in the floodplain delineation differing from the HEC-RAS output, or a floodplain delineation line around a small island may be omitted to simplify the floodplain limits. In these situations, it is imperative that the discrepancy be well documented. Record the reason for the discrepancy in the Comments Column of the FP/FWDT and further describe it in the text of the FHAD Report.

Like Table 3-5 in the April 2025 FHAD Guidelines, **Table 3-5B** lists several examples of typical comments used to describe or explain discrepancies between the hydraulic model, water surface profile, and topographic work map values that can be used in the FP/FWDT (**Section 3.2.4**) and Agreement Table (**Section 3.2.5**). Additionally, use other comments that may be more appropriate to describe the specific situation at a given evaluation line.

**Table 3-5B. Example Comments for the FP/FWDT and Agreement Table**

Floodway Equal to Floodplain
Floodplain top width includes high ground or obstruction, and ineffective flow area
Floodway top width includes high ground or obstruction, and ineffective flow area
Floodway top width includes high ground or obstruction
Floodplain top width includes ineffective flow area
Floodway top width includes ineffective flow area
Adjacent on-site detention pond was excluded from floodplain top width
Island located within 100-year floodplain not shown because it falls within the floodway
Roadway overtopping of "Street Name," top width adjusted for Flood Hazard Figure delineations
Floodplain delineation includes backwater area not reflected in the hydraulic model
WSEL is influenced by backwater from "Flooding Source Name"
WSEL is influenced by flooding effects from "Flooding Source Name"

### 3.2.5 Agreement Table

The Agreement Table serves as a QC and error-checking tool to ensure that data and results for the Flood Hazard Figure, flood profiles, FP/FWDT, and HEC-RAS models agree. **Note that the allowable tolerance for floodplain and floodway widths is within either 5 percent of the map scale or 25 feet for a 1":500' FIRM.** The reasons for any valid discrepancies, if they exist, must be noted in the Comments Column of the FP/FWDT. **Table 3-6B**, aligned with Table 3-6 in the main document, lists the required and optional information that should be included in the table. Beginning with Step 3 – Review, each submittal is to be accompanied by a completed Agreement Table. The Agreement Table will not be included in the FHAD report but will be included in the final FHAD Technical Appendix to accompany the final hydraulic model files.

The Agreement Table lists every evaluation line and compares the floodplain and floodway top widths and WSELs. The allowable differences between the map, profile, and table are listed at the bottom of the Agreement Table, and check columns are provided to give a visual indication of values that do not meet tolerances.

**Please limit values within the Agreement Table to reasonable significant digits. Provide distances and top widths to the nearest foot. BFEs should be rounded to the tenth of a foot from HEC-RAS output given to the thousandth of a foot. For example, if the HEC-RAS WSEL is 5200.145, the BFE shown in the Agreement Table should be 5200.1.**

All width, elevation, and verification checks in this table are based on evaluation lines. BFE lines are used for mapping and labeling purposes only and are not used as controlling geometry for agreement checks from the model.

**Table 3-6B. Agreement Table Contents**

Column	Contents
1	Reference Location—Specify the River/Reach and, if needed, a location or other identifier like streets, structures, or other physical features.
2	Evaluation Lines—The evaluation line number/identifier should be assigned where it intersects with the profile baseline. Since evaluation lines are not directly used or named in the hydraulic model, the number/identifier should never differ from the actual river station. Start at the downstream of the profile baseline (0 ft or continue from a known 1D or 2D station) and work upstream.
3	River Station—Actual station along the stream alignment corresponding to the evaluation line.
4 - 7	Floodplain Width (ft)—By using the endpoints of the evaluation lines, the distance should be computed to both the original model-computed inundation area's boundary and the final floodplain boundary. Column 12 checks to see if model and map values are within 25 feet, and Column 13 checks to see if they are within 5%.
8 - 11	Floodway Width (ft)—The evaluation lines should first be intersected with the final floodway polygon. Then, the evaluation lines should use the model encroachment polygons to erase non-floodway parts of the line. The lengths between the two datasets should be compared. Column 16 checks to see if floodway and encroachment values are within 25 feet, and Column 17 checks to see if they are within 5%.
12 - 14	1% WSEL (ft)—The 100-year WSEL for the evaluation line to the nearest tenth of a foot. Column 20 checks to see if model grid and FHAD Database values are within 0.1 foot.

15	Evaluation Line Loc—This is a verification that the BFE/Evaluation lines plotted on the topographic work map are located correctly relative to the modeled 2D WSEL surface. This check may be performed by comparing mapped values to the 2D WSEL raster in HEC-RAS or GIS. Where profile or reference lines are available, they may be used to support this verification. .
16	Comments and/or Explanations—A description and/or reasoning for any discrepancies between values from the model/map/profile that occur at the evaluation line (see <b>Table 3-3</b> in the main document for Example Comments for the Floodplain and Floodway Data Table).

### 3.2.6 Common Mistake Examples

To expedite the submittal and review process, MHFD has compiled a list of common mistakes that have been identified during FHAD reviews. The common mistakes document is currently written for 1D and 2D HEC-RAS modeling and 1D mapping. A future update may include 2D mapping considerations to assist consultants in their QA/QC process.

## 4.0 FHAD Report and Flood Hazard Figure

### 4.4 Flood Hazard Figure

Refer to the body of the FHAD Guidelines for Flood Hazard Figure formatting requirements. Evaluation lines should use the same symbology and labeling as cross sections.

### 4.5 FHAD Geodatabase

The following changes to the FHAD geodatabase are required for 2D analysis:

- BFE feature class add “Is2D” = T/F field to capture whether BFE is from a 2D analysis. Also, “IsBackwtr” = T/F to determine if the WSEL value in the “ELEV” field is the modeled 2D WSEL or a backwater elevation. Also, “IsShown” = T/F field to keep all relevant features on the flood maps and what may be turned off to reduce map clutter.
- Cross\_Section feature class add “Is2D” = T/F field to capture whether feature is a cross section or an evaluation line. Also, “IsBackwtr” = T/F to determine if the WSEL value in the “WSEL” field is the modeled WSEL or a backwater elevation. Also, “IsShown” = T/F field to keep all relevant features on the flood maps and what may be turned off to reduce map clutter.
- Hydro\_Struct add field “STRUCT\_TYP” to inform whether the structure is doing something, such as ‘flood event contained in structure.’ Indicate if the structure is a culvert or channel and the highest flood event being contained. All hydraulic features modeled in the 2D analysis shall be captured in Hydro\_Struct feature class of the FHAD geodatabase. For channels or culverts shown on the FIS Flood Profile that contain either the floodway or the 100- or 500-year floodplain, the STRUCT\_TYP field of Hydro\_Struct should capture the appropriate level of containment as shown on the flood profile and in the model - e.g., ‘Floodway Contained in Structure,’ ‘1-Percent-Annual-Chance Flood Discharge Contained in Structure,’ or ‘0.2-Percent-Annual-Chance Flood Discharge Contained in Structure.’ Also, “IsShown” = T/F field to keep all relevant features on the flood maps and what may be turned off to reduce map clutter.
- Stream\_Centerline feature class add “Is2D” = T/F to capture if the stream centerline. 2D models do not require the stream centerline to be modeled, while they are often included in the model as either a break line or reference line within the model to define the major flow paths or reaches modeled.

- For the Floodplain\_100yr and Shallow\_Flooding feature classes add “STATIC\_BFE” field to indicate ponding areas elevations where sloping BFEs are not appropriate or accurately capture static areas.

Within the current FHAD geodatabase is a required feature class called Insurable Structure. To determine which structures to include in this feature class for 2D analysis, use the refined floodplain polygons for the 100-year, 500-year, and floodway for spatial intersect, not the 2D modeled WSEL and Depth grids. This is because the 2D analysis will have wetted areas beyond the flood hazard identification polygons and should not be included.

Also added to the database is the L\_XS\_Elev lookup table. This table contains information for the Cross\_Section and Evaluation Line (when applicable) features where multiple event profile elevations should be recorded.

- Required: The “XS\_LN\_ID” field should relate to the unique ID for the cross-section (evaluation lines) (i.e., XSEC\_ID field of the Cross\_Section) feature class described in Table 4-3 below. XSEC\_ID is the primary key or unique ID to match XS\_LN\_ID in L\_XS\_ELEV. The “WSEL” field should contain the appropriate elevation based on the flood event for each row recorded in the “EVENT\_TYP” field. Since 2D models develop evaluation lines based on 100-year WSEL contours, other event profile elevations may be determined by the average WSEL across the other event profile WSEL grids. For the 100-year event, the “WSEL\_FLDWY” records the floodway elevation while the “WSEL\_INCRS” field should show the floodway surcharge if a floodway was developed. Also, the “XS\_AREA” and “VELOCITY” should be used to document the floodway cross-section area and velocity.
- Optional: All other fields in the L\_XS\_ELEV table may be filled in based on the most recent FEMA “FEMA Flood Insurance Rate Map Database Technical Reference.” Appropriate values or null values are also found in the technical reference.

Error! Reference source not found. **4-3** outlines revisions to the fields and types in the FHAD geodatabase necessary for 2D analysis and future integration into the FEMA FIRM geodatabase. Modifications and additions are marked in green.

**Table 4-3. FHAD Geodatabase Schema Table**

Feature	FieldName	FieldType	Usage	Change	Purpose
<b>BFE</b>	Shape	Geometry	Linestring		
	DWAY_NAME	String	Foreign Key	++	Associate WSEL with flooding source
	ELEV	Double	100-year Regulatory WSEL (rounded to 0.1 foot)	++	Define exact WSEL that should be used
	Is2D	String	T/F	++	Identify BFE line for 2D model
	IsBackwtr	String	T/F	++	Distinguish if backwater was calculated in ELEV
<b>Cross_Section</b>	Shape	Geometry	Linestring		
	DWAY_NAME	String	Foreign Key		
	DWAY_ID	String	Foreign Key		
	XSEC_ID	String	Key		

Feature	FieldName	FieldType	Usage	Change	Purpose
<b>Cross_Section (continued)</b>	STREAM_STN	Double	Station On Profile Line	++	Evaluation Line Profile Station to relate to FP/FWDT table
	WSEL	Double	Regulatory Elevation		
	STRMBED_EL	Double	Channel Thalweg/Streambed Elevation	++	Identify lowest elevation in channel along profile line
	Surcharge	Double	If FW is developed and surcharge calculated, report increase in floodway WSEL	++	Floodway increase value
	Is2D	String	T/F	++	Identify evaluation line for 2D model vs a 1D cross section
	IsBackwtr	String	T/F	++	Distinguish if backwater was calculated in WSEL
	IsShown	String	T/F	++	Identify evaluation line for intended display on work map and later FIS FIRM
<b>Stream_Centerline</b>	Shape	Geometry	Linestring		
	DWAY_NAME	String	Foreign Key		
	DWAY_ID	String	Foreign Key		
	Is2D	String	T/F	++	Identify profile baseline for 2D model vs a 1D model
<b>Floodplain_100yr</b>	Shape	Geometry	Polygon		
	FP_Type	String	Zone		
	STATIC_BFE	Double	Static Base Flood Elevation	++	If BFE is ponding, add static elevation
<b>Floodplain_500yr</b>	Shape	Geometry	Polygon		
	FP_Type	String	Zone		
<b>Floodway</b>	Shape	Geometry	Polygon		
	FP_Type	String	Zone		
<b>Shallow_Flooding</b>	Shape	Geometry	Polygon		
	DPTH	Double	Average Depth		Average depth less than 3 feet, rounded up to the nearest foot
	FP_Type	String	Zone		
	STATIC_BFE	Double	Static Base Flood Elevation for Shallow Flooding	++	If BFE is ponding, add static elevation
<b>Hydro_Struct</b>	SHAPE	Geometry	Linestring		
	DWAY_NAME	String	Foreign Key		

Feature	FieldName	FieldType	Usage	Change	Purpose
<b>Hydro_Struct (continued)</b>	STRUCT_TYP	String	Structure type: use domain values provided in STRUCT_TYP. If flood event is contained by structure in model, use proper event contained in structure domain (e.g., floodway, 1%, 0.2%). Use the highest magnitude flood event contained in structure as determined in the hydraulic model.	++	Define structure type (bridge, culvert, etc.)
	STRUCT_DESC	String	Structure Description: This is required for structures that have a contained structure type in the STRUCT_TYP field, to describe the type of structure that has contained flooding (e.g., culvert, channel).	++	Only populate with the type of structure if the hydraulic structure contains a flood event.
	STRUCT_NM	String	Key		
	STREAM_STN	Double	Station On Profile Line	++	Evaluation Line Profile Station to relate to FP/FWDT table
	Is2D	String	T/F	++	Identify structure for 2D model vs a 1D structure
	IsShown	String	T/F	++	Identify hydraulic structures for intended display on work map and later FIS FIRM

++ denotes a change in the database from previous versions to account for 2D FHAD studies

## 5.0 References

\*Federal Emergency Management Agency (FEMA). Latest Version. *Best Practice–Floodplain Boundary Processing*. September 2018 version available at [https://rmd.msc.fema.gov/site/GSSC/\\_layouts/15/DocIdRedir.aspx?ID=5CS6DA4W4HX6-240072140-6](https://rmd.msc.fema.gov/site/GSSC/_layouts/15/DocIdRedir.aspx?ID=5CS6DA4W4HX6-240072140-6)

\*Federal Emergency Management Agency (FEMA). Latest Version. *Guidance for Flood Risk Analysis and Mapping: Flood Profiles*. December 2020 version available at [https://www.fema.gov/sites/default/files/documents/fema\\_flood-profiles-guidance.pdf](https://www.fema.gov/sites/default/files/documents/fema_flood-profiles-guidance.pdf)

\*Federal Emergency Management Agency (FEMA). Latest Version. *Guidance for Flood Risk Analysis and Mapping: Floodway Analysis and Mapping*. November 2023 version available at [https://www.fema.gov/sites/default/files/documents/fema\\_rm-floodway-analysis-and-mapping-nov-2023.pdf](https://www.fema.gov/sites/default/files/documents/fema_rm-floodway-analysis-and-mapping-nov-2023.pdf)

\*Federal Emergency Management Agency (FEMA). Latest Version. *Guidance for Flood Risk Analysis and Mapping: Levees*. October. November 2023 version available at [https://www.fema.gov/sites/default/files/documents/fema\\_levee\\_guidance\\_nov\\_2023.pdf](https://www.fema.gov/sites/default/files/documents/fema_levee_guidance_nov_2023.pdf)

\*Federal Emergency Management Agency (FEMA). Latest Version. *Guidance for Flood Risk Analysis and Mapping: Mapping Base Flood Elevations on Flood Insurance Rate Maps*. November 2023 version available at [https://www.fema.gov/sites/default/files/documents/BFE\\_Mapping\\_Guidance\\_Nov\\_2023.pdf](https://www.fema.gov/sites/default/files/documents/BFE_Mapping_Guidance_Nov_2023.pdf)

\*Federal Emergency Management Agency (FEMA). Latest Version. *Guidance for Flood Risk Analysis and Mapping: Profile Baseline Guidance*. November 2024 version available at [https://www.fema.gov/sites/default/files/documents/fema\\_guidance\\_profile\\_baseline\\_guidance\\_nov2024.pdf](https://www.fema.gov/sites/default/files/documents/fema_guidance_profile_baseline_guidance_nov2024.pdf)

\*Federal Emergency Management Agency (FEMA). Latest Version. *Guidance for Flood Risk Analysis and Mapping: Riverine Mapping and Floodplain Boundaries*. November 2024 version available at [https://www.fema.gov/sites/default/files/documents/fema\\_guidance\\_riverine\\_mapping\\_and\\_floodplain\\_boundaries\\_nov2024.pdf](https://www.fema.gov/sites/default/files/documents/fema_guidance_riverine_mapping_and_floodplain_boundaries_nov2024.pdf)

\*Federal Emergency Management Agency (FEMA). Latest Version. *Guidance for Flood Risk Analysis and Mapping: Shallow Flooding Analyses and Mapping*. December 2020 version available at [https://www.fema.gov/sites/default/files/documents/fema\\_shallow-flooding-guidance.pdf](https://www.fema.gov/sites/default/files/documents/fema_shallow-flooding-guidance.pdf)

\*Federal Emergency Management Agency (FEMA). Latest Version. *Guidance for Flood Risk Analysis and Mapping: Flood Depth and Analysis Rasters*. November 2024 version available at [https://www.fema.gov/sites/default/files/documents/fema\\_guidance\\_flood\\_depth\\_and\\_analysis\\_rasters\\_nov\\_2024.pdf](https://www.fema.gov/sites/default/files/documents/fema_guidance_flood_depth_and_analysis_rasters_nov_2024.pdf)

Mile High Flood District (MHFD). *Flood Hazard Area Delineation (FHAD) Guidelines*. January 2022 (April 2025 updated) version available at [https://www.mhfd.org/files/0346eafe7/FHAD\\_Guidelines\\_January\\_2022.pdf](https://www.mhfd.org/files/0346eafe7/FHAD_Guidelines_January_2022.pdf)

\*FEMA guidance documents are updated regularly. These references should always be reviewed to ensure the latest guidance document is being referenced. A link is provided to the most recent version as of January 2026.