URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

Digital Flood Hazard Area Delineation (DFHAD) Guidelines

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1 INTRODUCTION AND PURPOSE

The Digital Flood Hazard Area Delineation (DFHAD) guidelines were written to offer guidance and direction for consultants developing FHAD studies in a digital PDF format. The guidelines cover the materials to be included in the DFHAD files, the process by which they are to be developed, and specific details for the final product.

1.1 Referenced Documents

The DFHAD guidelines reference several documents. When used in conjunction with these guidelines, these references offer important information for those developing the DFHAD. The following should be consulted routinely throughout the study:

- **Checklist –** The checklist identifies the information that is required for Flood Hazard Area Delineation (FHAD) reports and provides a general outline for the report. The consultant is to follow the checklist provided in the Agreement with UDFCD. An example checklist has been provided with these guidelines. The Checklist is discussed in more detail in Section 5.1.
- **Agreement Table –** The Agreement Table is to be completed to serve as an error checking device to ensure that the flood maps, flood profiles, and floodplain and floodway data tables correspond. The consultant is to use the agreement table included in the Agreement with UDFCD. An example Agreement Table has been provided with these guidelines. The Agreement Table is discussed in more detail in Section 5.1.
- **DFHAD Prototype –** A prototype has been developed to provide an example of completed DFHAD files and illustrate the end product from the DFHAD guidelines.
- **UDFCD Specifications for Electronic Submittal of FHAD and Master Plan Documents in PDF Format –** Date August 2006, this document was developed as guidance for creating PDFs of the traditional hard copy FHAD and Planning Study reports. These DFHAD guidelines provide additional criteria specific to DFHAD reports.

1.2 Digital FHAD vs. Traditional FHAD Report

By definition, the DFHAD is a digital format of the FHAD report. Traditionally, the end product of the FHAD report is a bound 11”x17” printed document. This meant that all of the content was formatted to fit on 11”x17” pages and still effectively illustrate the results of the flood study. Consequently, consultants would prepare plan and profile plan sheets presenting the flood map and flood profile. This broke up the floodplain and flood profiles into very small sections. This not only was a very time consuming process, but often poorly illustrated the results of the flood study from the big picture.

The DFHAD is essentially the traditional FHAD report, but produced in PDF format. The key difference between traditional printed FHAD reports and the DFHAD is that the final document is not printed and “bound”, thus the flood maps and flood profiles in the DFHAD can be formatted for sheet sizes larger than 11”x17”. This allows more freedom in the page size resulting in fewer sheets and a less fractured depiction of the floodplains. In addition, some of the content customarily included on the FHAD plan

and profile sheets (i.e. representative cross sections and structure sections) is now included in separate sections of the final PDF document.

2 DIGITAL FILE FORMATS

2.1 Hydraulic Analysis

The hydraulic analysis is based on the standard step-backwater method using the most recent version of HEC-RAS, or another method approved in writing by UDFCD.

2.2 Mapping Files

The drawing files may be created in either computer-aided design (CAD) format or geographical information system (GIS) format. The delivered CAD files must be compatible with AutoCAD 2000 or later. GIS files must be compatible with ArcView 3.x or ArcGIS 8.x or later.

2.3 DFHAD Report File

The DFHAD Report is one PDF file containing all elements of the FHAD report including the text, figures, tables, flood maps, flood profiles, and other supporting material. The PDF file is created from the native software that originally produced the content (i.e. Microsoft Word, AutoCAD, HEC-RAS, etc.). The majority of the report is formatted as 11"x17" similar to traditional FHAD reports except that the flood maps and flood profiles are formatted for larger sheet sizes as deemed necessary. See Sections 3.1 and 3.2 for additional information about formatting flood maps and flood profiles.

Consultants should refer to the "UDFCD Specifications for Electronic Submittal of FHAD and Master Plan Documents in PDF Format" written by CH2MHill dated August 2006. The criteria specified in these DFHAD guidelines take precedence for DFHAD electronic documents. It is important to make sure that the final DFHAD PDF document is well bookmarked and every item listed in the Table of Contents is linked to the appropriate page in the PDF document. This makes the DFHAD document easier to navigate and more user-friendly.

3 DFHAD REPORT

The engineering and hydrologic information in the DFHAD Report should be presented in an organized fashion so that it may be used for development of master drainage plan updates, road and bridge planning and design, design of channel modifications, and design of flood control structures.

The Report has two basic components: the textual discussion of the study process and the supporting figures, tables, and documents. The textual portion of the DFHAD Report provides the reader with background information and supports the hydraulic analysis of the study. The appendix contains the majority of the tables and figures referenced in the text as well as other supporting documentation.

The following is a brief outline of the report:

Section 1 Introduction
Section 2 Study Area Description
Section 3 Hydrologic Analysis
Section 4 Hydraulic Analysis
Section 5 References

Appendix A Meeting Minutes
Appendix B Hydrologic Analysis Supporting Documents
Appendix C Hydraulic Analysis Support Documents
Appendix D Floodplain and Floodway Data Tables
Appendix E Flood Maps
Appendix F Flood Profiles

The Checklist as defined in Section 1.1 outlines the content of the report for each section and appendix. The following sections provide additional direction for specific portions of the Report.

3.1 Flood Maps
3.2 Flood Profiles
3.3 Floodplain and Floodway Data Tables
3.4 Additional Information

3.1 Flood Maps

3.1.1 Map Projection

A major aspect of transportability of mapping or survey files to a geographic information system (GIS) is horizontal and vertical positioning on the earth. Mapping data must be controlled to a grid or geographic projection and referenced to horizontal and vertical datums. These positional references are established prior to the surveying process. Survey control is expressed in the form of horizontal and vertical position plotted on a geographic projection or control grid (State Plane). All planemetric and topographic features must be collected/compiled and referenced to this survey control.

The FHAD maps shall be delivered in Colorado State Plane, and the appropriate zone projection as specified in the contract, with a NAD83 horizontal datum, adjusted to ground (District-specified elevation) and NAVD88 vertical datum. The mapping source and projections are to be documented in the FHAD text and included as a note on the Flood Map.

Either the conversion factor from ground coordinates to State Plane or a table showing XY values for several known points in both grid and ground coordinates shall be included in the submittal. The amount of X and Y shift is also acceptable. This information is generally available from the organization providing the base data. This will allow the study area to be used with local government base data.

3.1.2 Base Mapping and Topography

Base mapping must show all current features, streets with correct names, railroads, airfields, etc. All streets and roads within or near the floodplain shall be shown and named.

The base mapping and topography must show and label:

- Existing ground contours (differentiating major and minor contours)
- Jurisdictional boundaries (City and County limits)
- Hydrographic features such as streams, rivers, canals, and flood control structures
- Major junctions and confluences
- Hydraulic structures (culverts, bridges, dams, levees, etc.)
- Streets, roadways, and other transportation features
- Houses and buildings
- Any other pertinent planemetric features located in, or directly adjacent to, the flood hazard area

3.1.3 Units

Units for all distances and elevations are in feet.

3.1.4 Map Scale and Size

Flood maps and flood profiles must be at the same horizontal scale. The minimum printed- scale of flood maps is 1" = 200'. The horizontal scale should be illustrated by a bar scale and text stating the print scale (e.g. 1" = 200'). The orientation of the printed flood map should be horizontal. The north arrow on the flood map should always point to the left, top, or right of the sheet and never towards the bottom or bottom corners.

Note that flood profiles must be oriented with the downstream end on the left side of the sheet regardless of the flood map orientation (see Section 3.2 for more information on flood profiles). There may be instances that the flood map and flood profile do not flow in the same direction (i.e. left on the flood map does not necessarily correspond to left on the flood profile).

The flood maps and flood profile layouts are to be created to minimize the number of sheets. The printed map size is not to exceed 36" x 120", but no smaller than 11"x17". If multiple sheets are necessary because the maximum map size would be exceeded, clearly indicate match lines between the multiple sheets to indicate breaks and provide a key map on each sheet.

3.1.5 Stream Centerline

Centerline alignment: The centerline alignment is the line that determines the flood profile. Generally, this is the flood channel centerline. It is important that the length of the channel along the alignment matches the modeled HEC-RAS channel length along the entire stream centerline alignment. The centerline should depict the flood flow path and generally follow the alignment of the channel stream bed, but not always. In some cases the low-flow channel may be very sinuous and have little flow capacity and the overbanks would convey the majority of the flood flows. With this situation, the flood channel centerline is different from the low-flow channel and the modeled length

of flood flow path between cross sections is different (most likely shorter) than the low-flow channel length between cross sections.

Stationing: All reaches in the study should have a unique station numbering sequence. The starting station should be the most downstream point of the study limit and increase going upstream. For instance, if the stationing of the main drainageway at the downstream limit of the study is numbered 0+00 then all stationing along the mainstem is higher (e.g. 0+00 to 80+00). For tributaries to the main drainageway, the downstream study would be higher than the upstream limit of the mainstem (e.g. 100+00 to 140+00).

3.1.6 Cross Sections

The locations of all cross sections used in the hydraulic model are shown on the flood maps. The lines drawn should correspond to the actual sections studied and should span the largest floodplain studied (i.e. 500-year floodplain). Locations of cross section lines on the flood map must correspond to the cross section location on the flood profiles.

Cross sections should be placed along the waterway in a manner that reflects the topography of the channel depicting changes in stream cross section geometry and changes in channel slope. In general for hydraulic flood models in urban areas, the distance between cross sections should not exceed 500 feet.

Distances between cross sections measured along the stream centerline, as defined in Section 3.1.5, must agree with corresponding distances shown on the flood profiles to within the maximum tolerance specified on the Agreement Table.

3.1.7 Floodplain and Floodway Boundaries

The 100-year (and 500-year if required in the scope of work) floodplain boundaries shall be delineated to depict the flood elevations from the HEC-RAS analysis. Floodway boundaries for the 0.5-foot and 1.0-foot rise floodways shall be developed to reflect the results of the floodway analysis. Note that floodway data is not required when the design flows are confined within a well-defined channel, but the condition shall be noted in the floodplain and floodway data table whenever it occurs.

The flood maps and flood profile layouts are to be created to minimize the number of sheets. The printed map size is not to exceed 36" x 120", but no smaller than 11"x17". If multiple sheets are necessary because the maximum map size would be exceeded, clearly indicate match lines between the multiple sheets to indicate breaks and provide a key map on each sheet.

3.1.8 Base Flood Elevations (BFEs)

BFEs represent 100-year flood elevations and are shown by contours drawn normal to the direction of flow of floodwater. BFEs must extend completely across the 100-year floodplain. BFEs should tie into the intersection of the floodplain boundary with the topography contours. BFEs should never crossover a cross section line.

The BFE objects must each be a continuous line/polyline with the minimum number of vertices to correctly represent the feature. BFEs on the flood map are to be shown as wavy lines by assigning a line style.

Each BFE must be recorded with its elevation above NAVD88 datum, measured to the nearest whole foot and assigned their elevation. In GIS, the BFE features are to be attributed with their elevation. In CAD, the BFE lines/polylines are to be assigned their appropriate elevation.

All BFEs must be labeled with an elevation value that is located above, below, or at the end of the line where it meets the 100-year floodplain. If the BFE label cannot be placed within 0.1 inch of the BFE line, a leader line must be used to connect the BFE label to the BFE line.

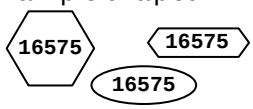
The following is an excerpt from FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* dated April 2003 for help in determining the spacing of BFEs.

> The basic intent of plotting BFEs on the maps is to represent the Flood Profile to within 0.5 foot of elevation tolerance. If BFEs are plotted correctly, the maps can be used to recreate the Flood Profile within 0.5 foot. BFEs are to be plotted at significant profile inflection points, or as close to them as possible. These points are critical to the accuracy of the maps because the Flood Profiles could not be reproduced accurately without them.
>
> Intermediate BFEs are to be plotted between inflection points and required BFEs. Intermediate BFEs are placed at whole-foot elevations whenever possible. The main factor in determining the proper interval at which intermediate BFEs are to be plotted is the Profile slope (gradient). The general guidelines below are to be followed, keeping in mind that the profile slope should be relatively constant between inflection points.
>
> - Gentle Gradient – If BFEs rise less than 1 foot per 1 inch of map distance, the BFEs shall be plotted at every whole foot of elevation rise.
>
> - Moderate Gradient – If BFEs rise more than 1 foot per 1 inch of map distance, the BFEs shall be plotted at approximately 1-inch intervals.
>
> - Steep Gradient – If BFEs rise 5 feet or more per 1 inch of map distance, the BFEs shall 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 BFE spacing).
>
> To determine the proper method for the intermediate BFE interval, the amount of BFE is divided by the map distance over which it rises. For example, in the case where 10 inches of map distance has a 30-foot BFE rise, the gradient equals a 3-foot BFE rise per inch, and the Moderate Gradient method be used to plot the BFEs.

3.1.9 Feature Appearance and Layer Conventions

Flood map features should be formatted in accordance with Table 3.1 Flood Map Feature Appearance and Layer Conventions. Line styles (patterns, dashes, etc.) should be applied to the feature objects, and not drawn in. Annotation and leader lines must be on separate layers from geographic data.

TABLE 3.1
Flood Map Feature Appearance and Layer Conventions

FEATURE	LAYER NAME	APPEARANCE	OTHER
FLOODING ELEMENTS			
100-Year Floodplain	100-YEAR	Blue, solid outline	Label boundary
500-Year Floodplain* (if specified by contract)	500-YEAR	Green, broken outline	Label boundary
Floodways* (if specified by contract)	0.5-FLDWY 1.0-FLDWY	Distinct colored, broken outline	Label boundary
Cross Sections	XSECTION	Black, solid line	
Cross Section Text	XSECTXT	Black	
Cross Section Symbol	XSEC-HEX	Black, closed polygon	Example shapes: 
BFE	BFE	Red, zigzag linetype	
BFE Text	BFETEXT	Red, located on top of or at the end of BFE line	
Study Limits	LIMITSTUDY	Black, solid line	Label study limit
STRUCTURE ELEMENTS			
Stream Centerline	CHANNEL	Black, solid line	
Centerline Stationing	CHSTATION	Black	
Culverts	CULVERT	Black, solid line	
Bridges	BRIDGE	Black, solid line	
Foot Bridges	FOOTBRIDGE	Black, solid line	
Other Structures	OTHER_STRUCT	Black, solid line	
Structure Text	STRUCTEXT	Black	
BASE MAP ELEMENTS			
Roads	ROAD	Thin gray line	
Road Text	ROADTXT	Same color as Roads	
Railroads	RAILROAD	Thin gray cross hatch line	
Railroad Text	RAILROADTXT	Same color as Railroads	
Buildings	BUILDING	Thin gray line	
Major Contours	MJRCONT	Thin gray solid line	
Minor Contours	MNRCONT	Thin gray solid line, less prominent than Major Contours	
Water Bodies (Lakes, ponds, etc.)	HYDRO	Thin gray outline	
Matchlines	MATCHLINE	Thick black solid line	

* For Second Draft Review and Final Submission, do not show the 500-year floodplain or floodway delineations on flood map.

3.1.10 Additional Flood Map Components

Flood maps should include the following information:

- FHAD study name
- Date of FHAD (month and year)
- North arrow and scale (See Section 3.1.4 for more information)
- Legend including symbology for cross sections, floodplain boundary, BFEs, stream centerline, and contours.
- Information about mapping source including the date, horizontal datum, and vertical datum.
- Consultant's information
- Matchlines and key map if more than one flood map is produced.
- The following instructions for printing portions of flood map PDF to scale:

  Instructions to print an area smaller than the full page to scale:

  1. Using the "Snapshot" tool, select the desired area to print.
  2. Click File>Print...
  3. Select your printer from the printer dropdown menu.
  4. Set the desired paper size using the printer "Properties" menu.
  5. Choose the "Selected graphic" option under "Print Range".
  6. Select "None" from the "Page Scaling" dropdown menu.
  7. Unselect "Choose paper source by PDF page size".
  8. Click "OK" to print selection.

3.2 Flood Profiles

Flood profiles should be developed for the flood frequencies specified in the scope of work. The profiles depict the flood elevation at each cross section. The digital profiles should be one continuous profile. Flood profiles should be oriented with increasing stationing from left to right so that the most downstream point begins to the left.

Note that flood maps must be oriented so that the north arrow points to the left, top, or right of the sheet regardless of the flood profile orientation (see Section 3.1 for more information on flood maps). There may be instances that the flood map and flood profile do not flow in the same direction (i.e. left on the flood map does not necessarily correspond to left on the flood profile).

3.2.1 Units

Units for all distances and elevations are in feet.

3.2.2 Map Scale and Size

Flood maps and flood profiles must be at the same horizontal scale. The minimum printed-horizontal scale of flood profiles is 1" = 200'. The minimum flood profile vertical scale is 1" = 10'. The horizontal scale should be illustrated by a bar scale and text stating the print scale (e.g. 1" = 200').

The flood maps and flood profile layouts are to be created to minimize the number of sheets. The printed map size is not to exceed 36" x 120", but no smaller than 11"x17". If multiple sheets are necessary because the maximum map size would be exceeded,

clearly indicate match lines between the multiple sheets to indicate breaks and provide a key map on each sheet.

3.2.3 Grid and Scale

The digital profiles shall be plotted on a grid. The horizontal scale of the profile should match the horizontal scale of the flood maps. The minimum vertical scale is 1" = 20'. Horizontal grid lines should be spaced every 0.5 inch on the printed flood profile. Major vertical grid lines should be spaced every 0.25 inch on the printed flood profile with minor vertical grid lines representing every 1-foot of vertical elevation.

Label the horizontal grid lines with the stations that correspond to the stations along the stream centerline in the flood maps at every major horizontal grid line. Label the vertical grid with elevations at 10' intervals. Elevation labels should be repeated at least every 10 inches on the printed flood profile.

3.2.4 Profile Lines

Flood profiles are to include lines for the thalweg (stream bed) and water surface elevations for the flood frequencies specified in the scope of work. Different line types should be used to differentiate the profiles. Flood profiles should be checked to ensure that the flood profile lines do not intersect or cross each other. See Table 3.2 for specific formatting requirements.

3.2.5 Cross Sections

Each cross section should be represented by a symbol (consistent with the symbol on the flood map) and the cross section number at the station that matches the cross sections location on stream centerline alignment.

3.2.6 Structures

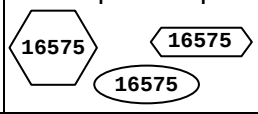
Bridges, culverts, and other hydraulic structures should be illustrated on the profile to depict the open area and length of the structure along the profile.

3.2.7 Feature Appearance and Layer Conventions

Flood profile features should be formatted in accordance with Table 3.2 Flood Profile Feature Appearance and Layer Conventions. Line styles (patterns, dashes, etc.) should be applied to the feature objects, and not drawn in. Annotation and leader lines must be on separate layers from geographic data.

TABLE 3.2
Flood Profile Feature Appearance and Layer Conventions

FEATURE	LAYER NAME	APPEARANCE	OTHER
100-Year Flood Profile	100-PROFILE	Blue, thick solid line	Label
Other Flood Profiles* (if specified by contract)	[Year]-PROFILE	Black, broken line different from 100-year	Label
Thalweg (Stream bed)	THALWEG	Black, solid line, ground hatch below line	Label
Cross Section Text	XSECTXT	Black	

FEATURE	LAYER NAME	APPEARANCE	OTHER
Cross Section Symbol	XSEC-HEX	Black, closed polygon	Example shapes: 
Structures	STRUCTURE	Black, closed polygon, shaded	
Grid Lines	GRID	Thin black or gray line	
Text (Stationing, elevations, structures)	TXT-PROFILE	Black	
Matchlines	MATCHLINE	Thick black solid line	

*For Second Draft Review and Final Submission, only show surface profiles for those specified by the contract on the flood profile.

3.2.8 Labels

Label the flood elevation lines and the thalweg line on the profile. Label structures with the street name or other identifier with vertical text near the appropriate station. Label jurisdictional boundaries with vertical text near the appropriate station. Vertical labels are typically placed above the flood profile, but may be placed below the thalweg if space requires it. Also label the study limits.

3.2.9 Additional Flood Profile Components

Flood profiles should include the following information:

- FHAD study name
- Date of FHAD (month and year)
- Horizontal and vertical scale (See Section 3.2.3 for more information)
- Legend including symbology for flood profile lines and cross section symbols
- Consultant's information
- Matchlines and key map if more than one flood profile is produced.
- The following instructions for printing portions of flood profile PDF to scale:

  Instructions to print an area smaller than the full page to scale:
  1. Using the "Snapshot" tool, select the desired area to print.
  2. Click File>Print...
  3. Select your printer from the printer dropdown menu.
  4. Set the desired paper size using the printer "Properties" menu.
  5. Choose the "Selected graphic" option under "Print Range".
  6. Select "None" from the "Page Scaling" dropdown menu.
  7. Unselect "Choose paper source by PDF page size".
  8. Click "OK" to print selection.

3.3 Floodplain and Floodway Data Tables

Floodplain and floodway data tables list information at each cross section for the floodplains and floodways studied. Note that floodway data is not required when the design flows are confined within a well-defined channel, but the condition shall be noted in the floodplain and floodway data table whenever it occurs. Table 3.3

Floodplain and Floodway Data Table Contents lists the required and optional information that should be included in the table.

TABLE 3.3
Floodplain and Floodway Data Table Contents

ITEM	LOCATION	CONTENT
Title	Top Center	Table #, FHAD Study Name, Floodplain and Floodway Data Table
Reach	Row Heading	River/Reach
Reference Location	Column 1	Location or other identifier like streets, structures, or other features
River Station	Column 2	Station along stream centerline
Cross Section	Column 3	Cross section number from hydraulic model
Thalweg Elevation (ft)	Column 4	Thalweg elevation
Peak Flow (cfs) 10-, 50-, 100- & 500-Year	Columns 5-8	Peak flow data from hydraulic model for 10-, 50-, 100- & 500-year storm events
Water Surface Elevation (ft) 10-, 50-, 100- & 500-Year (specified by contract)	Columns 9-12	Flood water surface elevations from hydraulic model for storm frequencies specified by contract
100-Year Floodplain Width (ft) Energy Grade Line	Columns 13-14	Floodplain width, average velocity of flow, and the wetted cross-sectional area for the 100-year storm event
100-Year Floodway (0.5 ft rise in EGL) Floodway Elev (ft) Width (ft) Dist. Left (ft) Dist. Right (ft) Area (sq ft) Velocity (ft/s)	Columns 15-20	100-year 0.5 feet floodway water surface elevation, width of floodway, and left and right distance from stream centerline to floodway
100-Year Floodway (1.0 ft rise in EGL) same columns as 0.5 ft floodway	Columns 21-26	100-year 1.0 feet floodway water surface elevation, width of floodway, and left and right distance from stream centerline to floodway
Comments	Column 27	Use to note specific details or how the values may differ from hydraulic model and reason for the difference
Footnotes	Below table	Additional notes or way to note specific details are particular cross sections

3.3.1 Additional Descriptions and Information

Thalweg Elevation (ft) – Defined as the minimum channel elevation. In HEC-RAS 4.0, "Min Ch El" is the minimum channel elevation.

Peak Flow (cfs) – Defined as the peak flood flow for the given storm event. In HEC-RAS 4.0, "Q Total" is the total flow in cross section.

Water Surface Elevation (ft) – Defined as the flood water surface elevation for the given storm event. In HEC-RAS 4.0, "W.S. Elev" is the calculated water surface from energy equation.

100-Year Floodplain Width (ft) – Defined as the width of the floodplain as shown on the flood maps, regardless of islands (whether mapped or not) and other obstructions. When different from results in the hydraulic model, note it in the Comments and state why. In HEC-RAS 4.0, "Top Width" is the top width of the wetted cross section, but does not include islands or obstruction. "Top Width Act" is the top width of the wetted cross section ("Top Width"), not including ineffective flow.

When the cross section indicates islands or obstructions in the floodplain, the top widths reported in HEC-RAS will not produce the proper top width to list in the Floodplain and Floodway Data Table. The top width from left to right floodplain lines can be calculated by using HEC-RAS's "Sta W.S. Lft" and "Sta W.S. Rgt" fields which list the left and right station where water intersects the ground. Tables can be defined in HEC-RAS that include a column that will calculate the difference between them. Define the table with "Sta W.S. Rgt", "Sta W.S. Lft", and "Diff" and the top width will be displayed in the "Diff" column.

Note that islands are not allowed in the floodway. Also note that islands within a floodplain must be treated on a case-by-case basis and the Engineer should consult with UDFCD when islands occur within the floodplain limits for further guidance.

Floodway Elev (ft) – Defined as the floodway water surface elevation with encroachments that cause the energy grade line to rise by 0.5/1.0 feet.

Floodway Width (ft) – Defined as the floodway width (irregardless of islands and other obstructions) with encroachments that cause the energy grade line to rise by 0.5/1.0 feet. Refer to the definition of 100-Year Floodplain Width for additional information on reporting widths.

Floodway Dist. Left and Dist. Right (ft) – Defined as the distance to the left and right floodway boundary from the channel center line looking downstream. Because floodways are not shown on the flood maps, this information provides the reader with a way to locate the floodway boundary relative to the channel centerline.
Floodway Area (sq ft) – Defined as the total area of cross section active flow. When different from results in the hydraulic model, note it in the Comments and state why. In HEC-RAS 4.0, "Area" is the flow area of the entire cross section including ineffective flow. "Flow Area" is the total area of cross section active flow which does not include ineffective flow areas. "Flow Area" should be listed for the Floodway Area.

Floodway Area (sq ft) – Defined as the total area of cross section active flow. When different from results in the hydraulic model, note it in the Comments and state why. In HEC-RAS 4.0, "Flow Area" is the total area of cross section active flow which does not

include ineffective flow areas. "Area" is the flow area of the entire cross section including ineffective flow. "Flow Area" should be listed for the Floodway Area.

Floodway Velocity (ft/s) – Defined as the average velocity of the flow in the cross section. In HEC-RAS 4.0, "Vel Total" is the average velocity of flow in the total cross section.

Discrepancies between table values and HEC-RAS model

The values published in the Floodplain and Floodway Data Table must match the Flood Maps (within acceptable tolerances), but there may be situations where floodplain/floodway does not match the geometry 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 and further describe it in the text of the FHAD report.

3.3.2 Final HEC-RAS Floodway Model – Method 1

It is important that the floodway encroachments, floodway elevations, and floodway widths agree between the flood map, flood profile, and the HEC-RAS hydraulic model. The final HEC-RAS model submitted to the District must be saved as a Method 1 floodway, where the exact location of the encroachment stations is specified for each individual cross section.

3.4 Additional Information

3.4.1 Drainage Structure Cross-Sections

Cross sections of each of the drainage structures (culverts and bridges) should be included in the Appendix C (Hydraulic Analysis Supporting Documents). This information should include the structure's location, station, dimensions, material, and elevations of the invert, low chord, and overtopping weir (road low point elevation). See the example in the DFHAD Prototype.

3.4.2 Cross Sections

Appendix C (Hydraulic Analysis Supporting Documents) includes cross sections from the HEC-RAS model illustrating the 100-year storm event water surface elevations. Create a PDF file from HEC-RAS formatted for multiple cross sections per 11"x17" page at a scale that can be easily read. Cross sections should be in color and include the 100-year water surface elevation, reach name, and river station. It is recommended that each page contain 9-12 cross sections and that the pages are numbered. See the example in the DFHAD Prototype.

4 DRAFT SUBMITTAL REQUIREMENTS

Two separate review submissions are required. The first is submitted to the UDFCD for review of the floodplain analysis methods, flood maps, and flood profiles. The second review submission will be reviewed by UDFCD and each of the project sponsors.

4.1 First Draft Review Submission

The following should be submitted for the first draft review submittal:

- One set of color hardcopy roll plots of the working Flood Maps and Flood Profiles
- One hardcopy of the Floodplain and Floodway Data Tables
- One hardcopy of the Agreement Tables
- One hardcopy of any other pertinent supporting materials
- One CD containing HEC-RAS output tables and cross sections

4.1.1 Flood Maps

In addition to the 100-Year Floodplain Delineation and the other requirements listed in Section 3.1 on Flood Maps, the following information should be included on the draft working flood maps submitted to UDFCD for the first review.

- 500-Year Floodplain Delineation
- 0.5-Foot Rise Floodway Delineation
- 1.0-Foot Rise Floodway Delineation

Use distinct line styles and colors that differentiate between the 4 delineations. Provide a legend illustrating the different line types.

4.1.2 Flood Profiles

In addition to the 10-Year and 100-Year Flood Profile and the other requirements listed in Section 3.2 on Flood Profiles, if the scope of work specifies additional flood frequencies, then flood profiles for those flood frequencies should be included on the draft flood profiles submitted to the UDFCD for the first review.

The flood profiles should be printed in color and use distinct line styles that differentiate between multiple flood profiles. Provide a legend illustrating the different line types.

4.1.3 Floodplain and Floodway Data Tables

Refer to Section 3.6 for the requirements of the Floodplain and Floodway Data Tables.

4.1.4 Agreement Tables

Refer to Section 5.2 below for information about Agreement Tables.

4.2 Second Draft Review Submission

A CD containing electronic PDF file(s) of the report text, appendices, flood maps, flood profiles, floodplain and floodway data tables will be submitted to UDFCD and each of the project sponsors for review. This review set represents the final report as much as possible and should contain all items required by the checklist.

The flood maps and flood profiles should follow the requirements as listed in Section 3.1 and 3.2, respectively. Unlike the First Draft Review Submission, the flood map should only show the 100-year floodplain and the other floodplain and floodway delineations should be turned off prior to creating the PDF file. The flood profile too, should only show the 100-year surface profile and those specified by the contract and all other frequencies should be turned off.

Clearly mark the PDF pages with "DRAFT" and use the words "Draft" in the PDF file name to distinguish it from the final DFHAD PDF file.

The contract will indicate the number of CDs to be submitted for review. This is typically one set for each reviewing agency.

5 QUALITY CONTROL AND ERROR CHECKING

5.1 Checklist

The checklist identifies the information that is required for DFHAD reports and provides a general outline for the report. A copy of the completed checklist (provided in the Agreement with UDFCD) should accompany the second draft and final submissions to ensure all pertinent materials have been included in the DFHAD report. A sample checklist accompanies these guidelines.

5.2 Agreement Tables

The Agreement Tables serve as an error checking device to ensure that the flood maps, flood profiles, floodplain and floodway data tables, and HEC-RAS models agree and document the reasons for any discrepancies. Each submission is to be accompanied by completed Agreement Tables.

The Agreement Table lists every cross section and compares the distances between sections, the cumulative distance, floodplain and floodway widths, and water surface elevations. The allowable differences between the map, profile, and table are listed at the bottom of the Agreement Table.

The values in the Floodplain and Floodway Data Table, Flood Map, Flood Profile, and HEC-RAS model must agree within the tolerances specified at the bottom of the Agreement Table. Note that the allowable tolerance for Floodplain and Floodway Widths is within either 25 feet or 5% of the measured width of the floodplain/floodway. In other words, if the measured width is less than 500 feet, then the two values in the Agreement Table must not vary more than 25 feet. If the measured width of the floodplain/floodway on the map is greater than 500 feet, then the values must agree within 5% of the map width.

When more than one floodway is mapped, the Engineer should check with UDFCD prior to completing the Agreement Table for guidance on which one(s) to include in the Agreement Table check.

An example Agreement Table template is included with these guidelines.

6 CDs AND DUPLICATION

The CD is to contain one PDF file that contains all components of the DFHAD report. Follow the directions in the "UDFCD Specifications for Electronic Submittal of FHAD and Master Plan Documents in PDF Format" written by CH2MHill dated August 2006 for production of CDs.