National Institute of BUILDING SCIENCES™

Panel Decision and Report

SRP COBC073021

Boulder County, CO

November 18, 2022

Innovative Solutions for the Built Environment

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Summary

Based on the submitted scientific and technical information, and within the limitations of the Scientific Resolution Panel (SRP), the Panel has determined that FEMA's data does not satisfy NFIP mapping standards defined in FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping and must be revisited.

1.0 Introduction

This report serves as the recommendation to the Federal Emergency Management Agency (FEMA) Administrator from the National Institute of Building Sciences (NIBS) Boulder County, CO Scientific Resolution Panel (SRP). SRPs are independent panels of experts organized, administered, and managed by NIBS for the purpose of reviewing and resolving conflicting scientific and technical data submitted by a community challenging FEMA's proposed flood elevation. SRPs are charged with helping to efficiently resolve appeal and protest issues between FEMA and communities by acting as an independent third party in an effort to obtain the best data possible for the community's Flood Insurance Rate Maps (FIRMs).

2.0 Panel

Panel ID: COBC073021

Panel Name: Boulder County, CO

FEMA Region: VIII

Panel Members:

- Avalisha Fisher, P.E., CFM, Principal and Project Manager with Driven Engineering, Inc., in the Mobile, Alabama area. Mrs. Fisher has over 30 years of experience as a civil engineer with specialized expertise in hydraulics and hydrology with most of her career including numerous projects involving remapping of floodplains and floodways. Mrs. Fisher began her career performing flood studies using HEC-2 and progressed to using other programs like HEC-RAS, and is very familiar with FEMA map revisions requirements. She founded Driven Engineering in 2006 and provides technical advice and training to their team of engineers as well as serving as the floodplain manager for the University of South Alabama and has been assisting the City of Semmes with joining the NFIP and obtaining their community rating.

- Todd Cochran, PE, CFM – Senior Vice President with House Moran Consulting, Inc. Atlanta, GA area. Mr. Cochran has 25 years of experience as a civil/water resources engineer and manager. His expertise includes advanced hydrologic and hydraulic modeling and design, including complex hydrologic studies, 1-dimensional (steady and unsteady), and 2-dimensional hydraulic modeling. Mr. Cochran's project experience includes FEMA Flood Insurance Studies, FEMA CLOMR/LOMR, stormwater master plans, stream stabilization design, stormwater BMP design, and hydrologic\hydraulic design of bridges and culverts.

- Siavash Hoomehr, PhD, P.E., CFM, Area market Sector Lead with HDR, in NYC, NY metropolitan Area. Dr. Hoomehr has over 17 years of combined experience in project management and water resources engineering analysis and design. He is responsible for the entire life cycle of projects including client relationship, proposal development and review, project management of multi-disciplinary teams, project controls, and technical delivery. He has managed various projects for clients ranging from federal, state, and local government to individual property owners, including USACE, FEMA, and NJDEP. He also has extensive experience in watershed assessment, development of flood protection alternatives, design and modeling of flood control projects; stormwater management and drainage design, advanced hydrologic and hydraulic modeling in support of USACE flood control projects and FEMA flood studies; dam break analysis, inundation mapping and Emergency Action Plan (EAP); levee superiority and interior drainage analyses; bridge scour analysis; and sediment transport modeling.

- Scott Lyle, PE, CFM - Senior Engineer with the City of Carlsbad, CA. Mr. Lyle has over 38 years of experience in the management and design of a wide variety of multi-objective water resources type projects including flood control channels, watershed analyses, detention basins, drainage master plans, and storm drain design. Specific technical skills include performing detailed hydrologic and hydraulic analysis (HEC-HMS, HEC-RAS, FLO-2D), sediment transport analyses, field surveys, floodplain mapping, flood control channel design and storm water quality design and management services. Mr. Lyle managed over $20 million of flood insurance study work as a FEMA study contractor during his tenure at Nolte Associates.

- Ismail Haltas, PhD, PE, M. ASCE - King's College, Wilkes-Barre, PA. Dr. Haltas has 20 years of experience in hydraulic and water resources engineering. His expertise covers watershed hydrology, open channel hydraulics, 1D and 2D flood routing, and flood hazard mapping in GIS. He has extensive experience in flood risk modeling and mapping that adhere to FEMA's Flood Risk Mapping program and standards. In addition, he has expertise in statistical analysis of hydrological data, Geographic Information Systems. Dr. Haltas is fluent in hydrologic, hydraulic, and statistical modeling and GIS software such as HEC-RAS, HEC-HMS, FLO-2D, R, MATLAB, AnyLogic, ArcGIS, and QGIS. Dr. Haltas also has experience in laboratory experimentation and physical modeling and familiar with field measurements. He authored a book chapter, dozens of journal papers, and conference proceedings on theoretical and engineering hydrology and flood modeling. He teaches undergraduate and graduate-level courses in Fluid Mechanics, Hydraulics and Hydrology, Water Resources Engineering, Environmental Engineering, Computer Applications for Civil Engineers (Excel, AutoCAD, GIS), and Engineering Statistics.

3.0 Basis for Appeal

By letters and/or email dated 6/22/2020 and 5/23/2021, on behalf of a group of Boulder County land owners, Coffey Engineering and Surveying submitted appeals to the Preliminary Flood Insurance Rate Maps (FIRM) for the Colorado Hazard Mapping Program (CHAMP).

The data used in the Boulder County Physical Map Revision (PMR) was initially funded by the Colorado Water Conservation Board (CWCB) in response to the floods in 2013. That data was used as leverage for the Boulder County PMR. AECOM was the FEMA study contractor who performed the initial data development and prepared the preliminary mapping. Compass took over the project at the appeal resolution. Two full 90-day appeal periods were run. The second appeal was due to COVID and the impacts COVID had on local governments.

General Summary of Study Timeline/Milestones:

- Fact Sheet / Study Memo – Outlines Proposed Scope of Study, Source of Hydrology and Topo data for whole study, including Lefthand Creek, concurrence signed by Boulder County on 11/20/2015
- Survey TSDN Dated 11/10/2017
- Flood Risk Review Meetings 2/1/2018
- Hydraulics TSDN Submitted 6/7/2018
- Base Map TSDN Submitted 6/7/2018
- Floodplain Mapping TSDN Submitted 9/30/2018
- Preliminary 9/30/2019
- Resilience Meeting 10/29/2019
- CCO Meeting 10/29/2019
- 1st Appeal Period 3/25/2020 to 6/23/2020, received 11 submittals.
- 6/22/2020 Lefthand Creek Appeal (8027 N. 41st Street) Submittal
- 10/1/2020 Initial Resolution Letter for Lefthand Creek
- 2nd Appeal Period 2/3/2021 to 5/4/2021, received 8 submittals (duplicates of original submittals)
- 5/3/2021 Lefthand Creek (8027 N. 41st Street) Submittal
- 5/6/2021 Acknowledgement letter
- 7/1/2021 2nd Appeal period resolution letter for Lefthand Creek

The appeals were supported by technical reports and supporting data. The appeals specifically address a portion of the Lower Lefthand Creek Floodplain located in unincorporated rural Boulder County, in Sections 19 and 20, Township 2 North, Range 70 West of the 6th P.M. The area of concern is generally west of North 41st Street, north of Nimbus Road, east of North 35th Street, and south of Ogallala Road. Completed Boulder

County Comment Appeal Forms for each of the landowners were signed and accompanied the appeal requests.

The first appeal contended that:

- FEMA's topographic data does not reflect more recent floodplain and channel conditions. It further contends that new, and more accurate, topography reflects extensive post-flood debris removal and channel improvements, both hydraulic and habitat, that were funded based on federal flood recovery grants, and as intended, should have been incorporated into the new flood modeling for Lefthand Creek.

- Technically incorrect BFEs, Special Flood Hazard Area zone designations and regulatory floodways are currently shown on proposed FIRM panels. The appellant contended that their review of the preliminary hydraulic HEC-RAS modeling and the proposed SFHA zone boundaries revealed discrepancies between the results of the hydraulic HEC-RAS modeling and the mapping of the floodplain zone boundaries as shown on the preliminary FIRM panels.

- The preliminary floodways shown on the proposed floodplain mapping does not appear to be based on the result of the hydraulic modeling, do not appear to be consistent with the accepted and current FEMA definition of a floodway, and appear to be placed in such as fashion as to place as many existing residential structures as possible in a regulatory floodway. The proposed floodways do not appear to be based on any currently accepted encroachment methodology. It is not at all clear, how the adoption of the Floodways as proposed would be in the best interest and provide for the health, safety and welfare of the citizens of Boulder County.

The second appeal contended that:

- The FEMA hydraulic HEC-RAS model utilizes an incorrect methodology. The FEMA hydraulic HEC-RAS model does not accurately estimate flow distribution between the main channel and the left and right overbanks, and thus does not generate correct BFEs (in either the main channel or overbank areas). Estimated flood flows and BFEs in the channel and both overbank floodplains are based on the total flow at each section distributed across the cross-section so that any low-lying areas (below the estimated BFE) are shown as conveying flood flows. This causes flows being conveyed by the main channel and overbank areas to vary widely from cross-section to cross-section. As an example, 100-year flows in the main channel at Station 64290 is 5,608 cfs but falls to 3,371 cfs at the next downstream cross-section at Station 64021 without any modeling of how the 2,237 cfs leaves (overtops) the main channel. The FEMA HEC-RAS model is essentially determining channel and overbank flows at each cross-section, even though there is no hydraulic connection between the main channel and the overbank flows, and there is no consistency from cross-section to cross-section in flow distribution. Proper modeling procedure would have been to initially

determine the 100-year flood elevations and profile for the main channel, then determine overflow locations and conditions (i.e., is it a stream junction or inline side-channel weir). They contended that when current channel and overbank conditions, including increased channel capacity and overflow spillway are considered as addressed above, estimated channel flows and overbank conditions will be substantially different from those currently modeled and shown on the proposed FIRM.

- The FEMA data does not appear to include the topography related to extensive channel improvements in the area of concern. Extensive improvements have been made to the Lefthand Creek main channel and overbanks, including removal of debris, channel widening, restoration of thalweg profile, restoration of overbank profiles, construction of an overflow spillway and channel on the right overbank, along with various scour and head-cutting countermeasures. All improvements were permitted by Boulder County in 2017 and 2018, with construction in 2018. Improvements were constructed based on plans developed Enginuity Engineering Solutions for the Lefthand Watershed Oversight Group and are titled Lefthand Creek Plains Reach Flood Recovery Projects, dated 12/8/16. A copy of the Enginuity plan set (stamped "Reviewed May 3, 2017 by Boulder County Building Safety") was included with the first appeal application report. Assumptions made in order to develop the HEC-RAS model do not reflect these improvements. The constructed channel improvements extend over most of the reach of the subject area of study and occurred from FEMA HEC-RAS River Station 60662 (just upstream of North 41st Street) to Station 64290 (just downstream from the Lefthand Water District diversion structure). Of special note would be the reinforced overflow spillway on the right over bank at approximately Station 64021, designed to spill channel overflows into an overflow channel in the right (south) overbank extending from Station 64021 to 63185. See figures below.

Figure 3-1 – HEC-RAS Cross-Section 62978 showing Preliminary Mapped Boundaries. Note that the mapping shows a single 1% floodplain, while the HEC-RAS output would map 3 or 4 separated floodplains.

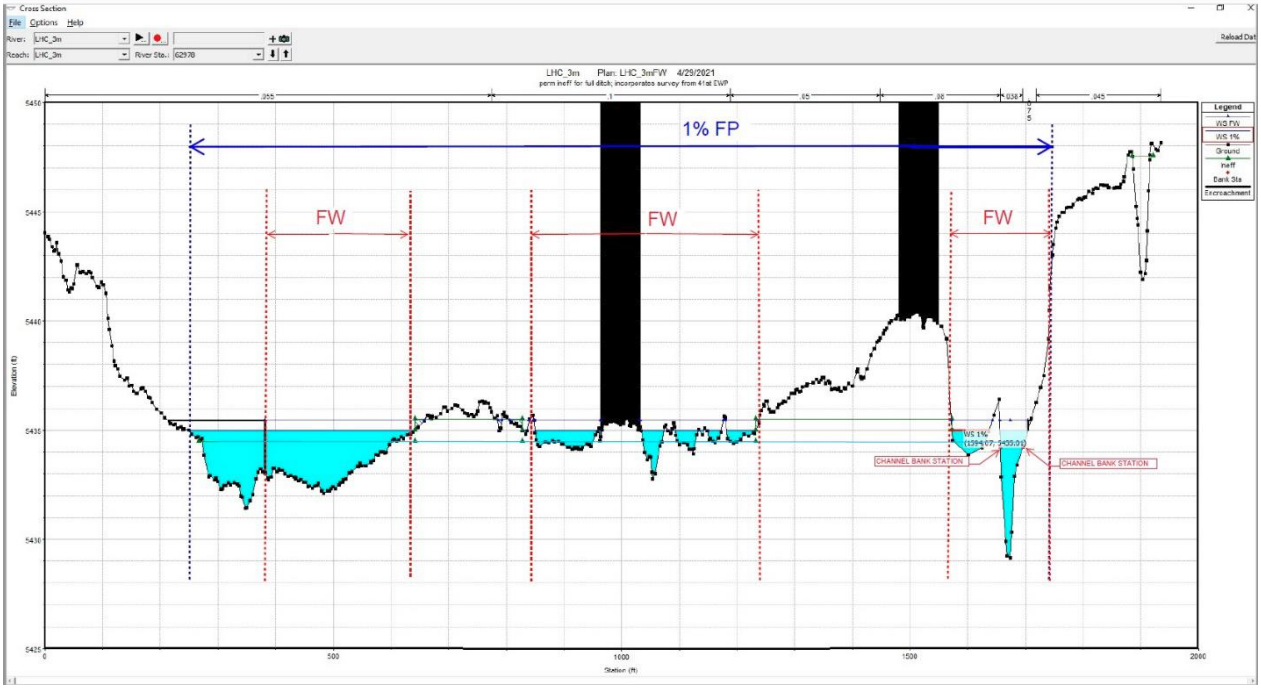
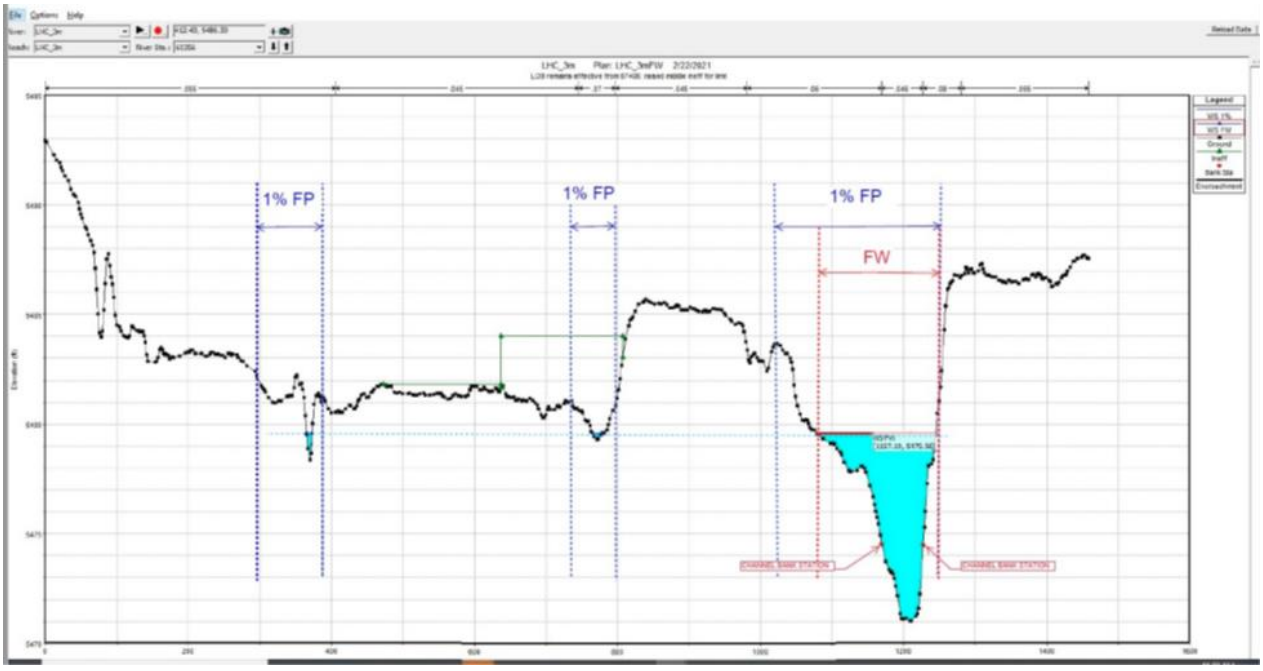
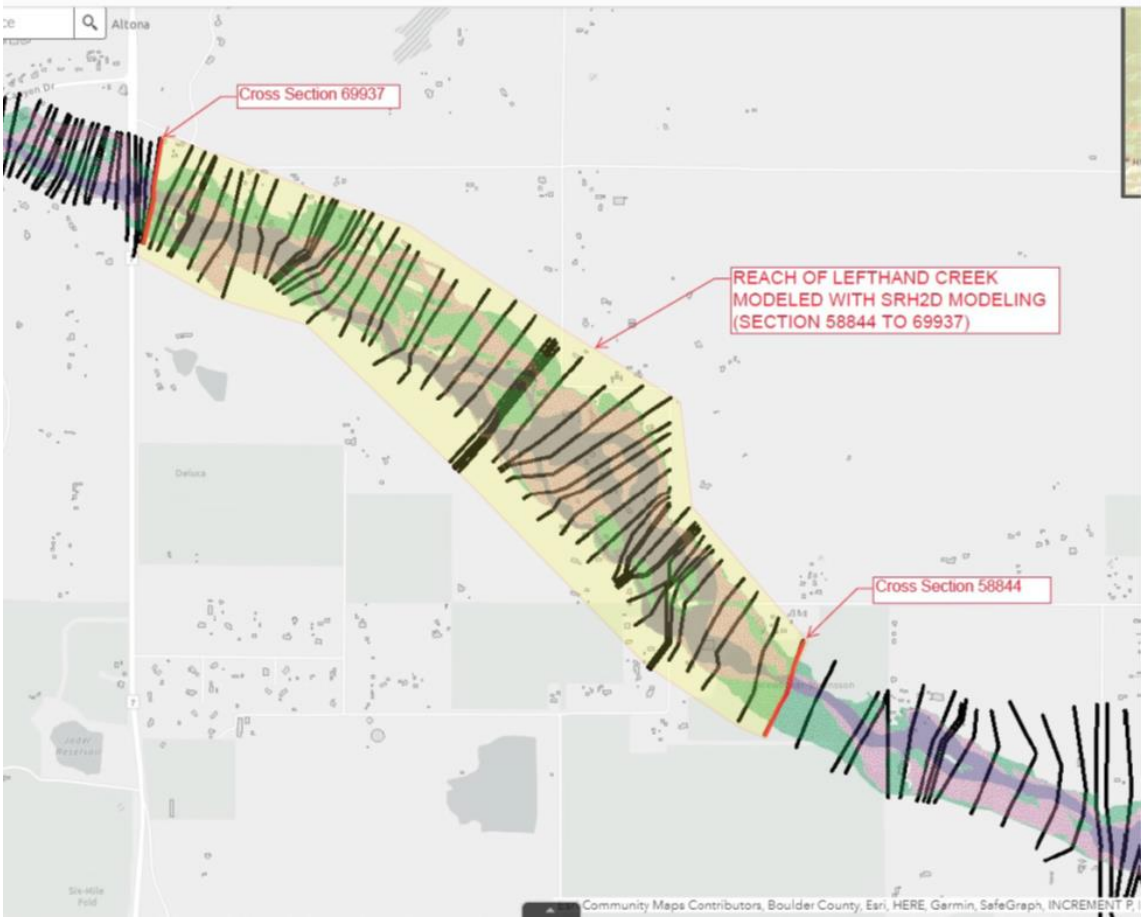


Figure 3-2- HEC-RAS Cross-Section 65356 showing Preliminary Mapped Boundaries. Note areas of split flows mapped do not match projected flow areas.



- The hydraulic HEC-RAS model results in 1% (100-year) Base Flood boundaries (shapefiles) that do not match those shown on the Preliminary floodplain mapping. It was the opinion of the appellant that this was because boundaries were determined by 2D mapping. As stated on page 20 of the AECOM Hydraulic Analysis TSDN for St. Vrain HUC-8 Watershed, Colorado, dated June 7, 2018: "An approximate model was created in SRH2D between cross sections 58844 and 69936 to inform the development of the 1D model and mapping of its results, particularly for the 1% and 0.2% profiles. Depth grids for these two profiles are included under Supplemental Data. Zone AOs were mapped based on the 2D modeling between cross sections 67446 to 65356 and 59822 to 59248". The results of the SRH2D modeling are shown on the Colorado Water Conservation Board's Colorado Hazard Mapping and Risk MAP Portal (coloradohazardmapping.com), including data and mapping of Depth Grids, Water Surface Elevation Grids, Velocity Grids, and overall Floodplain Mapping. Review of the CHAMPS maps show that the 100-year and 500-year boundaries (shapefiles) are identical to those shown on the proposed Preliminary floodplain maps, including the Zone AOs mapped between cross sections 67446 to 65356 and 59822 to 59248.

Figure 3-3 – Extent of SRH2D Modeling on Lefthand Creek.



The appellant further contended that the current 1-D HEC-RAS model was developed subsequent to the 2-D mapping in accordance with the procedures outlined in the Technical Memorandum by Rigel Rucker, AECOM Deputy Project Manager titled Calculating 2-Dimensional (2D) Floodways for Use on Regulatory Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FIS), dated January 25, 2017 and Revised May 1, 2017.

- The appellant suggested that the following options should be considered in order to comply with existing guidance, where appropriate:

  1. Remove floodways from FIRMs where 2D analyses are conducted. Communities would then be required to manage development by maintaining models or requiring developers to do so and verify that a cumulative surcharge in the floodplain is not resulting from new development.

  2. Develop a procedure to generate floodways in 1D, 1D/2D or 2D unsteady flow models.

  3. Develop and calibrate a steady state 1D model using the results of the 2D model that can then be used to generate a floodway. The 2D model will then become backup information for the regulatory model.

- The proposed Floodway is not based on encroachment method 4 (equal conveyance reduction) as stated in the Hydraulic TSDN. On page 14 of the "Colorado Hazard Mapping Program Hydraulic Analysis – Volume 2 Technical Support Data Notebook for the St. Vrain Watershed", it states that for 1-D floodway modeling encroachment analysis were initiated using an automated, equal conveyance reduction method (Method 4) based on a target surcharge of 0.5 foot. Review of the FEMA HEC-RAS Floodway model (Project Plan LHC_3mFW) however shows that only Method 1 (user enters left and right encroachment stations) was utilized. For the study area, it appears that the encroachment stations were chosen based upon the projected floodplain width, with no resulting surcharge. This apparently resulted in the mapping of proposed "split" floodways that are not associated with any existing channel or future conveyance improvements.
- Floodways are not based on existing channels and encompass several existing residential structures. Contrary to the statement on page 14 of the Hydraulic TSDN: "Special consideration is also given to areas where development has already occurred. If possible, floodways are moved away from existing buildings", it appears that the opposite has happened over the Coffey study area, with 7 residential houses being newly placed within the proposed floodways. Of particular concern is that by placing the houses in proposed floodways, they will lose the ability to make any site improvements to protect the houses from the relatively shallow (less than 1-foot) flooding that occurred during the 2013 flood events.

4.0 Data Submitted by the Community and FEMA

4.1 Appellant

Appeal One:

The appeal was stated to include:

- Data believed to be better than those used in the original hydrologic analysis

- Documentation of source for data

- Explanation for improvement resulting from the use of new data

- New hydraulic analysis based on the better data and original flood discharge values

- Revised Flood Profiles

- Revised SFHA boundaries and regulatory floodway boundary delineations.

However, the report stated that "Due to the time limitations of the 90-day appeal period, along with schedule, personnel and equipment impacts due to the Covid 19 Pandemic, Coffey was not able to acquire additional survey data (aerial LIDAR) and utilize that information for additional alternative hydraulic modeling upstream and downstream of the initial study area (additional LIDAR survey is currently scheduled for late June)."

The first appeal did not appear to include actual data for evaluation.

Appeal Two:

The second appeal stated "After considerable review of the multiple options and methodologies that would be applicable to the appeal request, it was determined that due to the extent, complexities, and number of properties potentially effected, that a completely new alternative "drop-in ready" model for approximately 2 miles of Lefthand Creek (Foothills Highway to Brubaker-Sorenson Open Space) was in all likelihood beyond the financial capabilities and responsibilities of the 5 property owners participating in this appeal." No new modeling was submitted for review. Instead, the appeal suggested that "because the currently proposed floodplain mapping for this reach of Lefthand Creek is actually based on the CHAMPS 2D hydraulic model, and that model includes the mapping and data required to regulate the floodplain, amend the preliminary FIS data tables and flood profiles, and could be used for future LOMR applications and reviews, it would be appropriate, and in compliance with FEMA regulations and policies to adopt the 2D mapping as the Effective model for this limited reach of Lefthand Creek." The appeal further requested that "We would therefore recommend that the most expeditious means of resolving this matter, and in accordance with accepted

FEMA and CWCB policies and practices, that Boulder County request revisions to the Preliminary Floodplain maps based on the adoption of 2D mapping for the reach of Lefthand Creek between Stations 58844 and 69936. Furthermore, Boulder County would regulate that portion of the Lefthand Floodplain without a mapped 2D floodway in accordance with the guidance document 2D Floodplains and Floodways for Floodplain Managers, dated October 25, 2018 and prepared for FEMA and the CWCB by AECOM." The following exhibits were provided as further details of this suggested solution.

Figure 4-1 – Screen capture of CHAMPS floodplain mapping for Lefthand Creek area of concern.

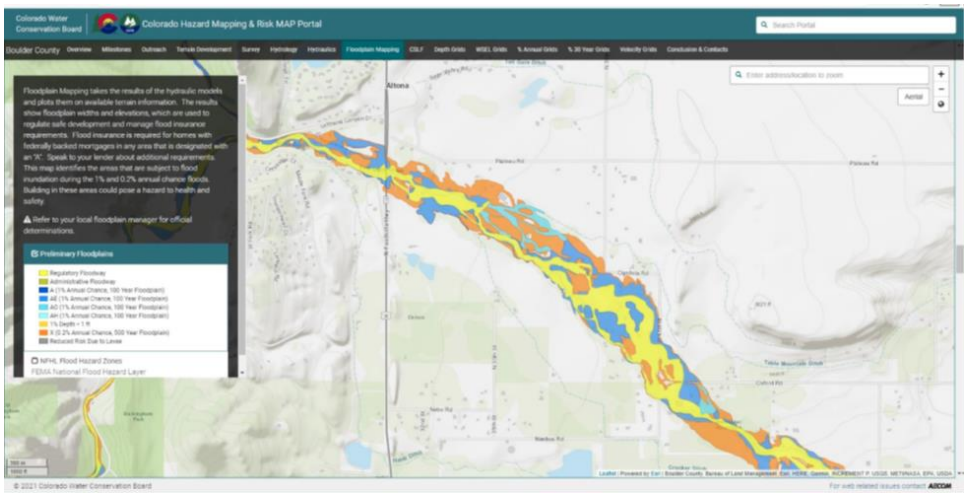


Figure 4-2 – Screen capture of CHAMPS floodplain mapping- Depth Grid of Lefthand Creek area of concern.

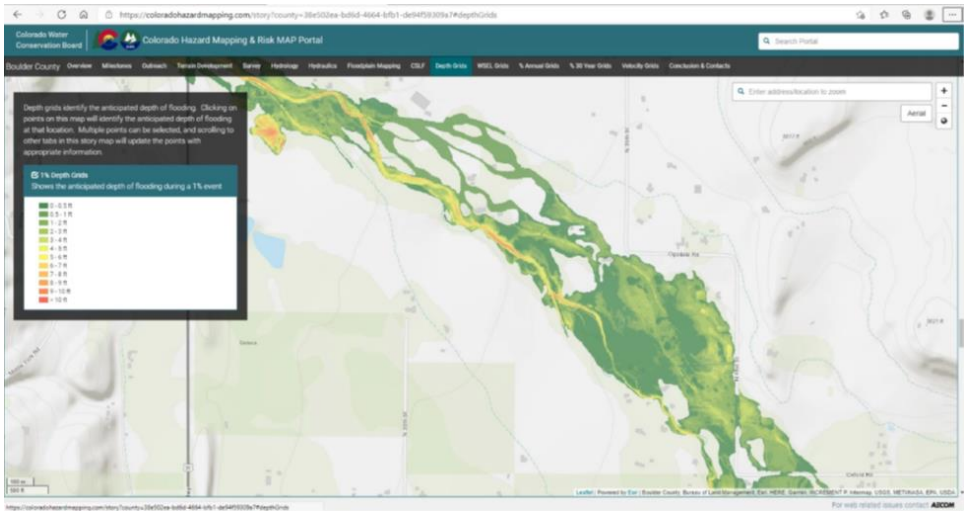
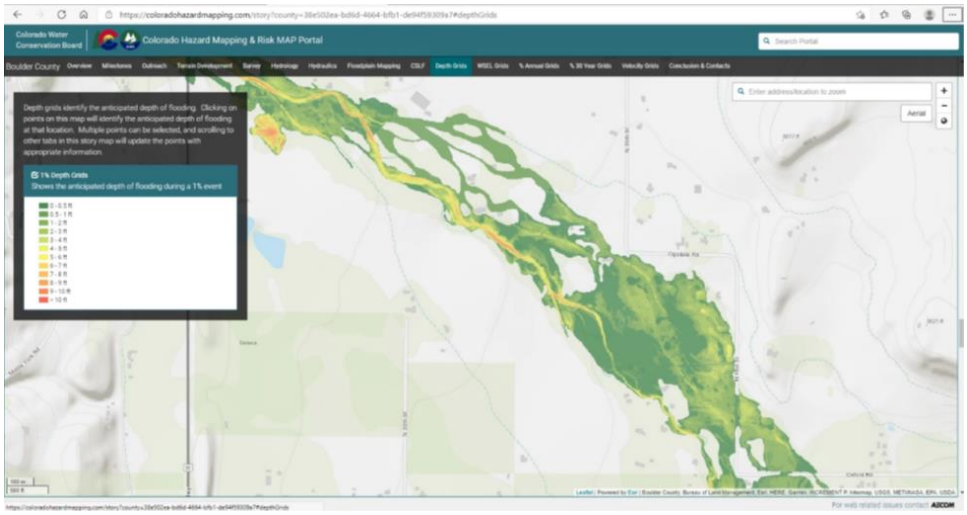


Figure 4-3 – Screen capture of CHAMPS floodplain mapping- WSEL Grid of Lefthand Creek area of concern. Note Base Flood Elevations shown for selected home locations.



The appeal suggested reasons for regulating without a pre-mapped floodway, and stated that "As a Class 5 FEMA Community Rating System (CRS) community, Boulder County should have the staffing and experience required to manage this small reach of Lefthand Creek without a floodway."

4.2 FEMA

Appeal One Response:

FEMA contended that the submission did not meet the requirements of an appeal and that the required FIS documentation was not provided. They indicated that technical comments focused on two key elements as outlined below:

1. Development of more detailed/accurate topographic data

a. Additional, more detailed topographic data would not improve the current submittal when combined with the submitted methodology.

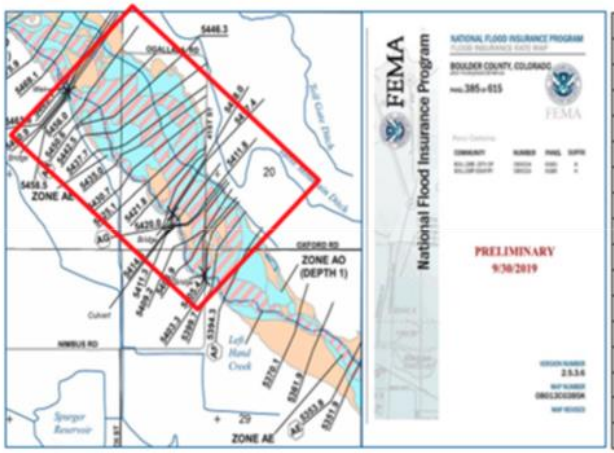
2. Technically incorrect BFEs, Special Flood Hazard Area zone designations and regulatory floodways are currently shown on proposed FIRM panels

a. The FEMA hydraulic HEC-RAS model is not based on current topography and hydraulic capacity of the main channel of Lefthand Creek

i. The methodology submitted does not support any changes to the preliminary products. As shown in Figure 1, because the submitted model's use of ineffective areas, the Base Flood Elevation (BFE) in the channel are being raised. The increase

in the BFEs illustrates the need for the areas of concern to be within the floodway rather than be removed. The preliminary model includes the areas of concern within the floodway.

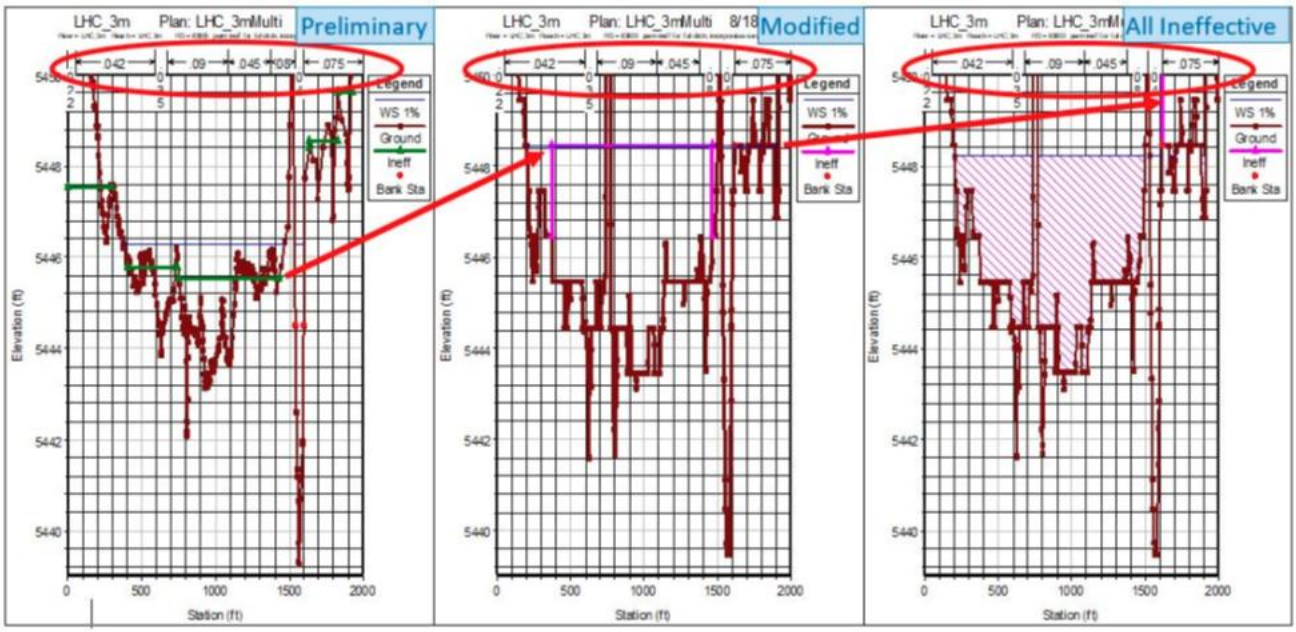
Figure 4-4: Lefthand Creek area of concern and submitted elevation comparison



LHC_3m	Prelim FIS	Appeal (Modified)		Appeal (All Ineffective)	
			Diff (ft)		Diff (ft)
River	W.S. Elev	W.S. Elev	(Mod-Pre)	W.S. Elev	(All Ineff-Pre)
64290	5458.5	5458.45	0.0	5458.45	0.0
64021	5456.0	5455.99	0.0	5455.99	0.0
63776	5450.6	5450.84	+0.2	5451.12	+0.5
63605	5446.3	5448.47	+2.2	5448.24	+1.9
63412	5442.5	5443.8	+1.3	5445.2	+2.7
63185	5437.7	5440.47	+2.8	5441.69	+4.0
62978	5435.0	5435.42	+0.4	5438.7	+3.7
62716	5430.7	5431.47	+0.8	5431.85	+1.2
62382	5425.1	5425.47	+0.4	5427.87	+2.8
62113	5421.8	5421.83	0.0	5421.83	0.0
61832	5420.0	5419.99	0.0	5419.99	0.0
61751	5418.0	5417.95	-0.1	5417.95	-0.1
61741					
61731	5417.4	5417.42	0.0	5417.42	0.0

ii. The BFEs provided by the submitter are higher than the preliminary due to the applied Ineffective Flow Area as compared in Figure 2. Both models support flow in the overbank. It is unclear why additional ineffective flow is being defined when active flow is demonstrated to occur. Since that area is part of the active flow path, adding additional ineffective areas demonstrates why additional encroachments are not warranted in the overbank as they would cause a rise in the water surface elevation above the state's allowed 0.5-foot surcharge. It is recommended to revisit the ineffective flow area stations and elevations designated by submitter to determine if they are reasonable and can be justified.

Figure 4-5: Cross Section comparison



b. The FEMA model does not correctly model what appears to be a split flow floodplain from approximately HEC-RAS cross-section 64290 to downstream cross-section 61751

i. The submitter indicates there is a split flow between river station 64290 and 61751 which was not modeled properly. However, no specific split reach was indicated or recommended in the HEC-RAS model provided by the submitter. Further specific split flow indicated by the submitter needs to be evaluated if it is warranted or adjust braided reach.

c. The proposed Floodway is not based on encroachment method 4 (equal conveyance reduction) as stated in the Hydraulic TSDN

i. The submitter brings out an issue with new floodway encroachment determination and methodology. It should be noted that most of new Map Modernization for a major river tends to include floodway encroachment limits for life and property protection purposes. It is assumed that floodway encroachments were initially determined based on Method 4 and imported to Method 1 in order to keep the encroachment limits fixed. Further floodway encroachment analysis review is recommended if surcharges and floodway widths were optimized. Floodways are not based on existing channels and encompass several existing residential structures.

Appeal Two Response:

The following scientific and/or technical data were submitted in support of this request:

- Cover letter and report regarding a portion of Lower Lefthand Creek near the properties at 7955, 8027, & 8075 N. 41st Street, 4114 Oxford Road, and 3920 Ogallala Road.
- Annotated cross-sections between the proposed Effective HEC-RAS model and the Preliminary map products.
- Recommendations for hydraulic analysis based on alternative data and original flood discharge values.

We received all data necessary to resolve this appeal by May 4, 2021. FEMA has completed their evaluation of the information provided in the submission. It was determined that a change to the model was not warranted for the preliminary study. This submission included a report with recommendations for alternative hydraulic analysis but did not include the following, which are required for valid appeal submittals:

- New hydraulic/floodway analysis, based on the original flood discharge values, in which the original methodology has been applied differently.
- Revised Flood Profiles, FDT, and other FIS Report tables, as applicable.
- Revised SFHA boundary delineations and, if applicable, regulatory floodway boundary delineations.

We have resolved this appeal in accordance with the requirements of 44 CFR Part 67. We have reviewed the submitted data and determined that the proposed regulatory floodway for the Lower Lefthand Creek is correct as shown on the Preliminary FIRM and in the Preliminary FIS report, and that no changes are warranted at this time.

5.0 Summary of Panel Procedures

The Panel was selected on July 29, 2022. At that time, the FEMA and Community data was available for review from NIBS secure file share portal. The Panel officially kicked off and convened on August 25, 2022, to review the purpose and scope of the Panel, and to step through an overview of the data received and the schedule. The following meetings were held for deliberation of each appeal item, review of the data, and development of questions for both FEMA and the appellants:

DATES

The Panel met on September 7, 2022 and September 16, 2022, to review and discuss data provided by FEMA and to prepare for upcoming oral presentations.

The Panel listened to oral presentations from both the FEMA and appellant teams on September 28, 2022.

The Panel then met additionally to further review the provided data, deliberate on each appeal item, and document the decisions.

- September 29, 2022
- October 6, 2022
- October 17, 2022
- October 24, 2022
- November 3, 2022
- November 10, 2022
- November 14, 2022

Report presented to NIBS on November 15, 2022.

6.0 Decision

The Panel recognizes the inherent complexities in the braided channel flow of the Left Hand Creek system and appreciate the effort by FEMA and the FEMA study contractor to create and update the detailed hydrologic and hydraulic models. The Panel reviewed the points made by the appellant as well as FEMA's responses to both appeals that are the subject of this review. Below is a list of the appellant's points made and the panel's response to each point. Based on the Panel's review of the appeals and responses from FEMA, this Panel recommends that FEMA revise the preliminary modeling and mapping based on the below issues:

The first appeal:

1. Point made: FEMA's topographic data does not reflect more recent floodplain and channel conditions.

   The appellant and FEMA both agreed that this was a non-issue.

2. Technically incorrect BFEs, Special Flood Hazard Area zone designations and regulatory floodways are currently shown on proposed FIRM panels.

   The Panel agrees with the appellant. See section 7 below.

3. The preliminary floodways shown on the proposed floodplain mapping do not appear to be based on the result of the hydraulic modeling, do not appear to be consistent with the accepted and current FEMA definition of a floodway, and appear to be placed in such as fashion as to place as many existing residential structures as possible in a regulatory floodway.

   FEMA's study contractor stated that Method 4 was initially used, then left/right encroachments were entered into Method 1. This is consistent with FEMA guidelines. However, the Panel agrees with the appellant that the mapping may not have been completed in accordance with FEMA standards (the expansion and contraction between sections appears random).

The second appeal:

4. The FEMA hydraulic HEC-RAS model utilizes an incorrect methodology.

   The Panel agrees with the appellant that the left overbank areas in the reach under appeal may have been more accurately modeled using split-flow analysis.

   Based on the Panel's review of aerial topography and photography and review of the hydraulic models, it does not appear that the left overbank flow is hydraulically connected to main channel flow. The provided HEC-RAS model allows flows to jump back and forth between low-lying areas

and main channel with no signs of hydraulic connectivity. Split-flow analysis appears to be more appropriate. It would define flow in the left overbank and be analyzed as a separate flow pathway (i.e., not hydraulically connected to main channel). Also, it's recommended that a separate 1D model should be developed for the left overbank using the discharges from the split-flow analysis to better capture the floodway for this area.

2D analysis may also be more appropriate as it takes into account the geomorphology of the overbank area and does not force flows into low lying areas across a section while potentially under-calculating flow volume and depth in the main channel. See FEMA Guidance for Flood Risk Analysis and Mapping, Floodway Analysis and Mapping – Guidance Document No. 79, November 2019.

5. The FEMA data does not appear to include the topography related to extensive channel improvements in the area of concern.

   The appellant and FEMA both agreed that this was a non-issue. Panel agrees with FEMA response.

6. The hydraulic HEC-RAS model results in 1% (100-year) Base Flood boundaries (shapefiles) that do not match those shown on the Preliminary floodplain mapping.

   The Panel agrees with the appellant. See Rationale section 7-C below.

7. The appellant suggested that the following options should be considered in order to comply with existing guidance, where appropriate (appellant requested removal of floodways from the subject area):

   The Panel agrees with FEMA. The Community (Boulder County Community) requested floodways for regulatory reasons, so the appeal alone would not be sufficient reason to remove regulatory floodways from the subject area.

8. The proposed Floodway is not based on encroachment Method 4 (equal conveyance reduction), as stated in the Hydraulic TSDN.

   FEMA's study contractor stated that Method 4 was initially used, then left/right encroachments were manually entered into Method 1. This is consistent with FEMA guidelines; however, the Panel agrees with the appellant that the mapping may not have been completed in accordance with FEMA standards (the expansion and contraction between sections as well as the apparent discrepancy between flood widths in section versus mapped widths.

9. Floodways are not based on existing channels and encompass several existing residential structures.

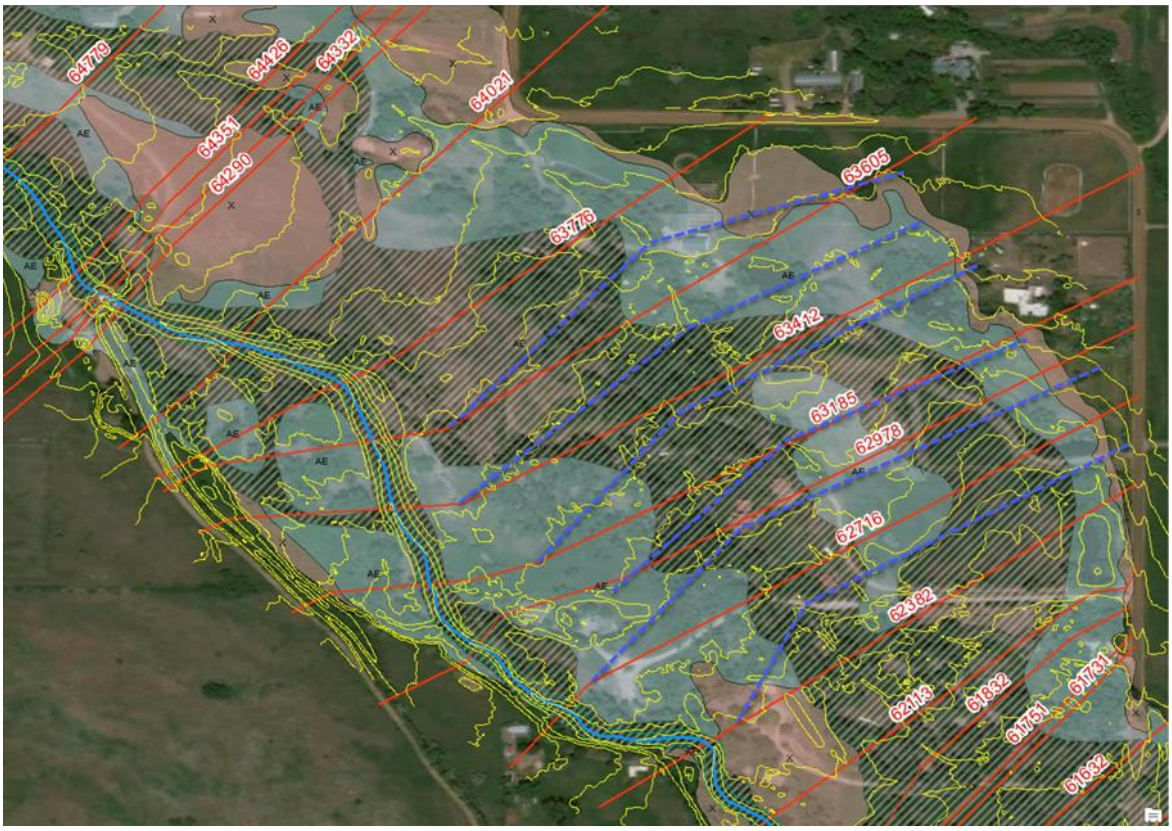
   The Panel agrees with the appellant. The Panel is of the opinion that we are tasked with addressing established guidelines for delineating floodway boundaries. The floodway delineation does not match the HEC-RAS model in several locations. The floodway delineation is wider than the modelled floodway width at the upstream and downstream cross sections.

7.0 Rationale for Findings

A) Orientation of cross sections

Per FEMA guidelines (FEMA, 2020) and the current HEC-RAS Hydraulic Reference Manual (HEC, 2022), "the cross sections must traverse the floodplain and be oriented perpendicular to the direction of flow," "every effort should be made to obtain cross sections that accurately represent the stream and floodplain geometry." In the vicinity of the disputed area, several cross sections are not perpendicular to the flow path (not aligned with the contour lines). Multiple breaking points could be used to assure cross sections are properly oriented across the floodplain. A couple of examples are shown (with blue dashed lines) on Figure 7-1. The Panel believes that should the cross sections be oriented more like the guidelines specify and as generally indicated below; the resultant calculated water surface elevations would be very different in the eastern areas of the subject area.

Figure 7-1: Cross section orientation



B) Split flow upstream of properties - why no split-flow analysis?

A split-flow analysis or at a minimum a sensitivity analysis between cross sections XS65077 and XS65356 is important to understand the maximum discharge and flow volume diverted to the left overbank. Also, this area could have been modeled as a separate reach (1D Model) using the flow discharges from the split-flow analysis. This would result in more accurate mapping of the floodplain and better delineation of the floodway.

2D analysis would also be more appropriate as it takes into account the geomorphology of the overbank area and does not force flows into low lying areas across a section while potentially under-calculating flow volume and depth in the main channel.

See FEMA Guidance for Flood Risk Analysis and Mapping, Floodway Analysis and Mapping – Guidance Document No. 79, November 2019, Section 5.2.3. TRIBUTARY, SPLIT AND DIVERTED FLOWS.

C) Applicability of using 2D modeling results within the appeal reach

FEMA's study contractor, AECOM, prepared a 2D model using SRH2D between cross sections 58844 and 69936. AECOM used the 2D modeling results to map Zone AO limits in the left overbank areas between cross sections 67446 to 65356 and 59822 to 59248. However, AECOM used 1D modeling results to map floodway and floodplain limits between cross sections 65356 and 59822, which represents the mapping reach subject to this appeal. AECOM did state that the 2D modeling results were used as a check on the 1D modeling results in this reach.

Based on the panel's review of the provided materials (i.e., aerial photos, photographs, topography, HEC-RAS models), the geomorphology of the left overbank appears very similar within the entire 2D modeling limits. The abrupt change from 2D to 1D modeling and mapping through the appeal reach does not appear to accurately represent the divided flow in the left overbank. It is the Panel's opinion that the 2D modeling results should have also been used in the appeal reach to more accurately model and map shallow flooding areas in the left overbank.

See Federal Emergency Management Agency, Guidance for Flood Risk Analysis and Mapping, Riverine Mapping and Floodplain Boundaries Guidance, December 2020.

C) Floodplain delineation- mismatch between top widths and mapping

Per FEMA guidelines (FEMA, 2020) Section 3.0 Mapping of One-Dimensional Riverine Analyses, "The flood boundaries are delineated by finding the intersection of the ground surface defined by the underlying digital terrain model and the flood surface. Floodplain boundaries are delineated on the best available topographic mapping using the water-surface elevations determined at cross sections." There are discrepancies between the HEC-RAS model and the flood map in top width measurements for 100-yr floodplain extend. For example, at Cross Section 65356 the HEC-RAS model shows a top width of about 8 ft on the most left flow area. Yet, on the map at Cross Section 65356, the mapped left floodplain width measures about 85 ft.

Figure 7-2: Mapped top width for XS 65356

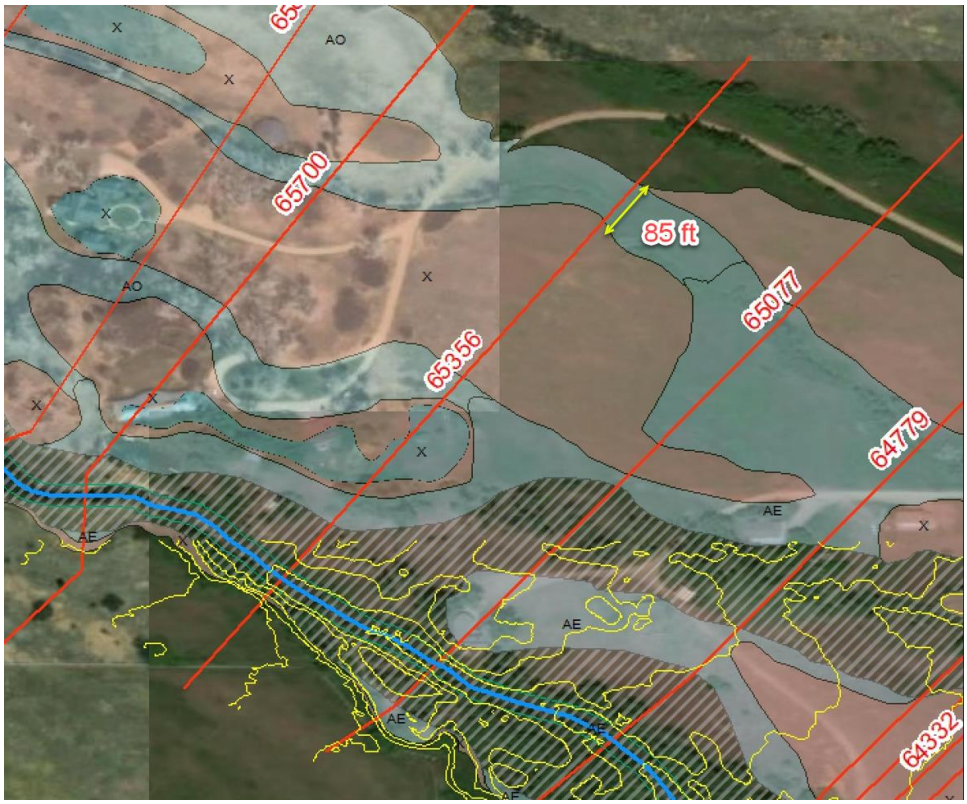
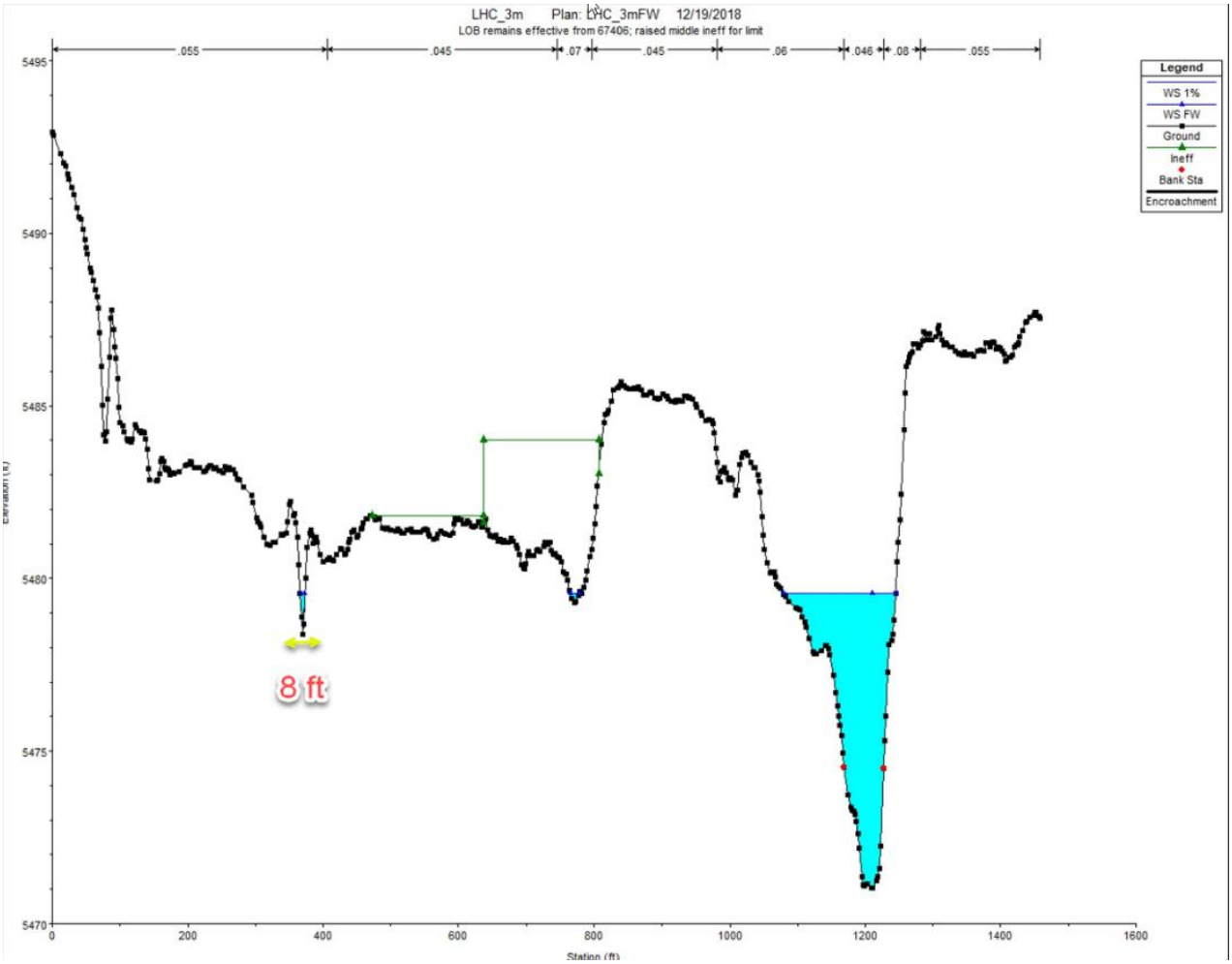
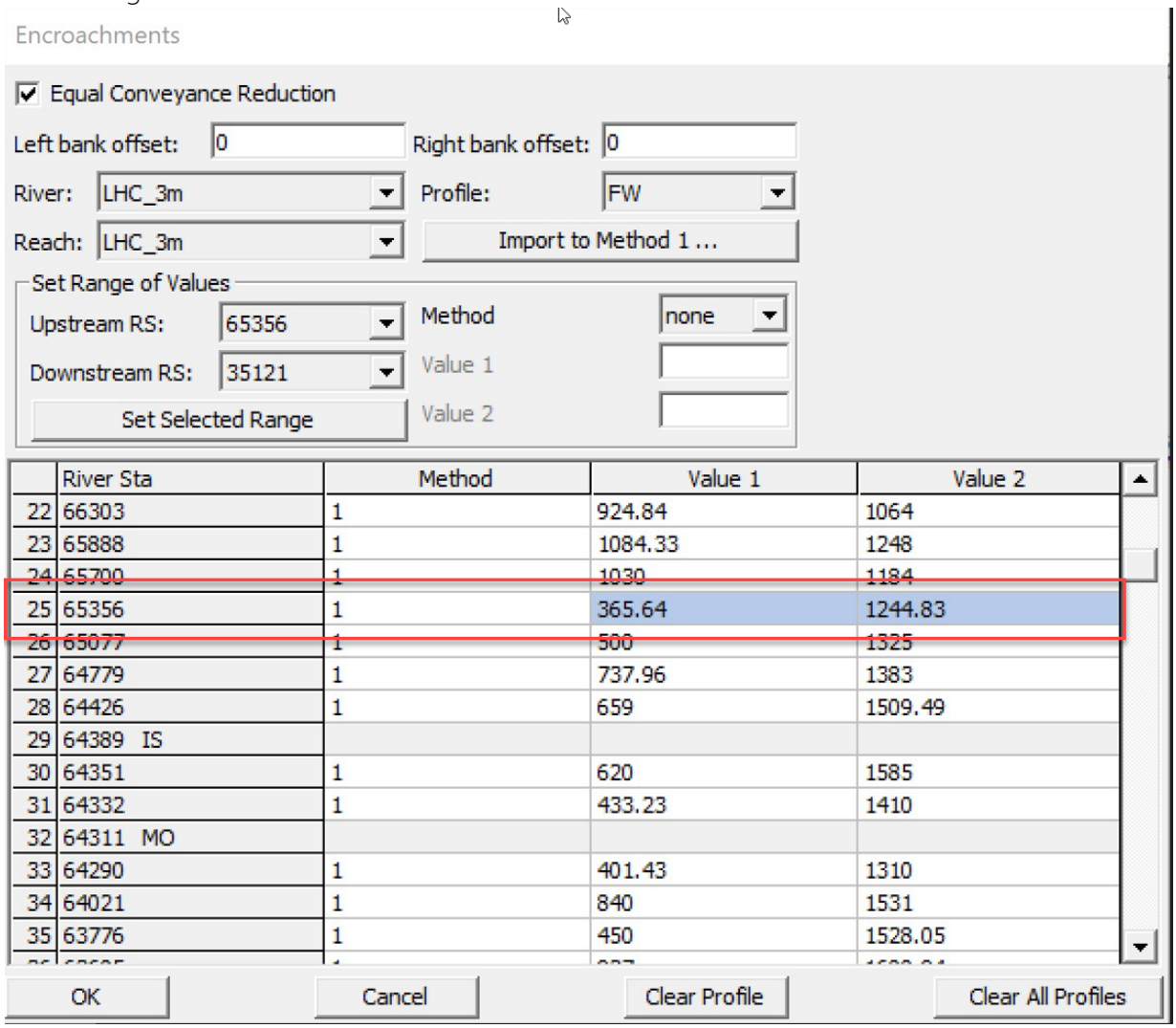


Figure 7-3: Top width for XS 65356 in the HEC-RAS model



Per FEMA guidelines (FEMA, 2019) Section 5.0 Floodway Mapping, "For one-dimensional riverine analyses, floodways are delineated at encroachment stations (limits of conveyance) at cross sections and delineated between cross sections." There are multiple discrepancies between the encroachment stations in the HEC-RAS model and floodway boundary shown on the map. As an example, the left encroachment for XS 65356 is noted as 365.64 (Figure 7-4) while the left boundary of the floodway is about XS station 1080 ft.

Figure 7-4: Encroachment stations with Method 1 for XS 65356 in the HEC-RAS model



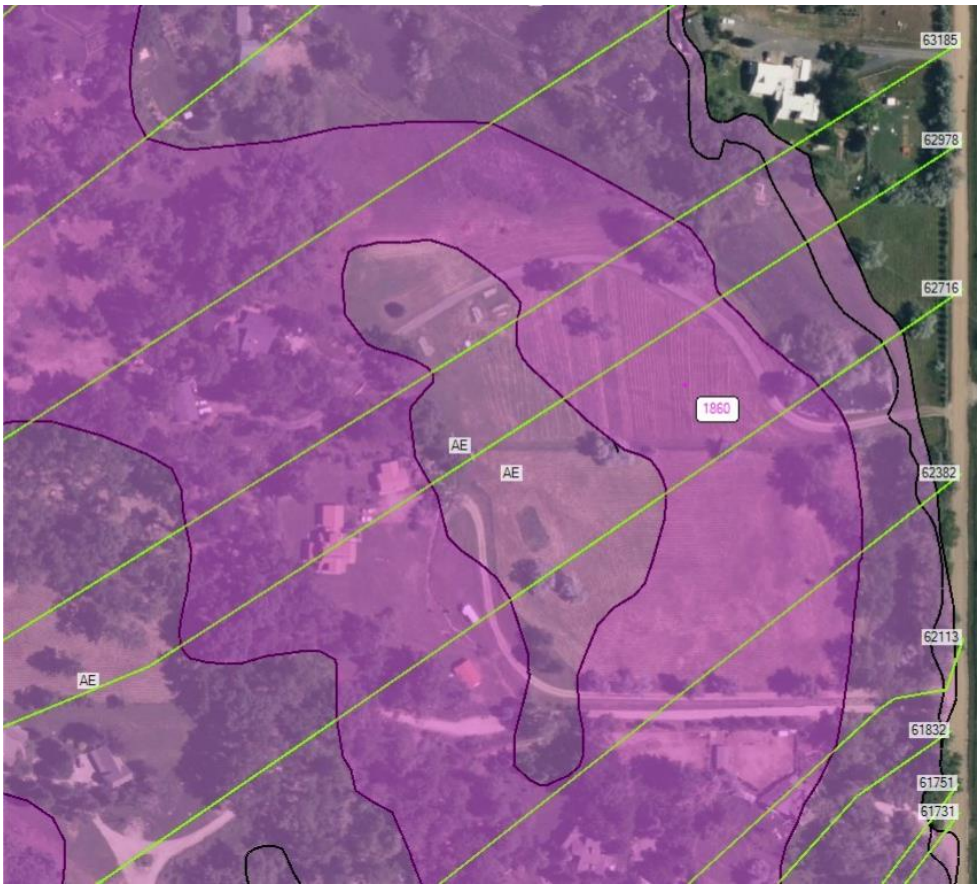
	River Sta	Method	Value 1	Value 2
22	66303	1	924.84	1064
23	65888	1	1084.33	1248
24	65700	1	1030	1184
25	65356	1	365.64	1244.83
26	65077	1	500	1325
27	64779	1	737.96	1383
28	64426	1	659	1509.49
29	64389 IS			
30	64351	1	620	1585
31	64332	1	433.23	1410
32	64311 MO			
33	64290	1	401.43	1310
34	64021	1	840	1531
35	63776	1	450	1528.05

D) Floodway encroachments - should not widen and narrow between cross sections without justification

The floodway delineation process begins with hydraulic analysis by placing encroachments on the left and right overbanks of the 100-yr floodplain and gradually encroaching, following encroachment Method 4 requirements, until reaching the allowable rise in water surface elevation above the BFE (usually 1 ft). This model provides the baseline floodway encroachments, but since a floodway is a regulatory designated area, FEMA can expand it beyond the hydraulically defined boundaries to identify high hazard areas for insurance purposes. After reviewing the preliminary FIRMS, the Panel noted that floodway boundaries on the preliminary FIS maps were expanded between hydraulic cross sections XS63185-XS62716 at a few locations without any obvious underlying topographic features or obstructions. The Panel recommends review of these locations for potential re-delineations of floodway boundaries.

See FEMA Guidance for Flood Risk Analysis and Mapping, Floodway Analysis and Mapping – Guidance Document No. 79, November 2019, Section 5.1.

Figure 7-5: Floodway delineation near the subject properties



E) Inconsistency in including/not including areas in the floodplain

The floodplain mapping for the reach of Left Hand Creek that is the basis of the appeals includes areas where the LiDAR ground data is higher than the calculated 1% annual chance flood elevation or BFE. FEMA Standard #140 in Flood Risk Analysis and Mapping states, "Shallow flooding areas shall not contain non-SFHA islands based on small scale topographic variations." However, Left Hand Creek was mapped as a Zone AE with floodway, not a shallow flooding hazard zone (i.e., Zone AO or AH). It is typical for small "islands" that are created during the automated floodplain mapping process to be filled in for Zone AE floodplain mapping. During the presentation, the FEMA contractor also stated that the areas included in the floodplain and floodway were only slightly higher than the BFE. As shown in Figure 6 (cross section 62978), the "island" created at between stations 1232.6 and 1272.4 is approximately 5 feet higher than the BFE. While the floodway is not mapped in this high area, this high area is included in the 1% annual chance flood zone. In contrast, a similar high area just left of the main channel is not included in the 1% annual chance flood zone or floodway at cross sections 62113 and 62382. The highest ground elevation is approximately 1 foot above the BFE at these cross sections. It seems reasonable that the 1% annual chance flood zone would be revised near cross section 62978 to remove the existing house.

See Federal Emergency Management Agency Policy Standard for Flood Risk Analysis and Mapping Policy, December 2019.

8.0 References

1. Federal Emergency Management Agency, FEMA Policy Standards for Flood Risk Analysis and Mapping – FEMA Policy #204-078-1, December 22, 2020.
2. Federal Emergency Management Agency, Guidance for Flood Risk Analysis and Mapping, General Hydrologic Considerations, February 2019.
3. Federal Emergency Management Agency, Guidance for Flood Risk Analysis and Mapping, Floodway Analysis and Mapping – Guidance Document No. 79, November 2019.
4. Federal Emergency Management Agency, Guidance for Flood Risk Analysis and Mapping, Riverine Mapping and Floodplain Boundaries Guidance, December 2020.
5. Hydrologic Engineering Center, HEC-RAS Hydraulic Reference Manual, November 2022.
6. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System, User's Manual (Version 5.0), February 2016.