Non-Structural Landuse Change Impacts on Structure Losses in Cedar River Communities

An Iowa Silver Jackets Non-Structural Flood Risk Management Study

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USACE National Flood Risk Management Program
for Iowa Silver Jackets Pilot Project

FINAL REPORT

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Flood Plain Management Services Special Study
Cedar River Basin, Iowa

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EXECUTIVE SUMMARY

The goal of this pilot was to better understand and communicate the effects of non-structural actions on community flooding and associated economic impacts. This pilot improved understanding of how climate and landuse changes may impact watershed hydrology and related flood risk. This effort included development of a planning level hydraulic model [approximate channel Hydrologic Engineering Center – River Analysis System (HEC-RAS) model] and non-structural measures analysis that a multi-disciplinary team could utilize to rapidly assess flood risk for multiple communities within a watershed or river-shed boundary and identify the types of non-structural actions that may be applicable to these communities. Evaluating how less rigorous HEC-RAS approximate models and Geographic Information System-based mapping methods, that use Flood Insurance Study (FIS) water surface profile information, impact the estimated extent of inundation and depth of flow at varying locations along the Cedar River, improved understanding of where less rigorous and quicker methods for evaluating flood risk may be applied for planning purposes. This evaluation included a comparison of the difference in extent of inundation and depth of flow between the methods and whether these differences translate into notable differences in economic damages[1]. The comparison between methods provided understanding on the level of accuracy of an approximate channel HEC-RAS hydraulic model and gave confidence to the pilot team to explore the economic impacts of differing flow rates associated with changes in hydrology resulting from a longer period of stream flow records. Results indicate that flood risk, as computed using updated hydrology and the above mapping techniques, associated with estimated economic damages in the Cedar River Basin are approximately 20% greater than that resulting from inundations represented in the latest published FIS and corresponding flood insurance rate maps for the 1% Annual Chance Exceedance event. Results uncover that some communities are more vulnerable to economic damages due to changes in hydrology and corresponding streamflow. Due to the resolution of the tools and techniques used this evaluation should be used to help screen which communities may warrant a higher priority in developing localized flood evaluations to inform local decision making.

Flood inundation and depth information along with economics data and spreadsheet tools were used to evaluate potential non-structural actions for a community determined to have a moderate flood risk based on the change in total damages and the percent change of damages resulting from updated hydrology and corresponding streamflow. The selected community was the City of Charles City, IA.

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[1] The purpose of the analysis is not to rigorously quantify all damages for the various communities, but to provide a reasonable estimate of damages suitable for comparison of the various hydrologic scenarios. The analysis only takes into account structure damage, content damage and vehicles. Inclusion of infrastructure, traffic detour, flood fighting, and other categories of damages would have required a significant increase in the effort and cost of this part of the report with limited value added. Estimated Economic Damage values were produced using USACE HEC-FIA version 3.0 software. Economic damage values originate from stock FEMA HAZUS based National Structure Inventory data and contain an undetermined amount of uncertainty. The main purpose of this data is to compare the various methodologies for depth grid production against a constant inventory of damageable elements.

There were a total of 204 structures that were identified within the floodplain in Charles City based on the new hydrology. Approximately 120 of these structures have a 1-foot flood depth and 20 more structures have a flood depth of 2 to 3 feet. Only 4 of the 140 structures less than 3-foot flood depth had a positive benefit-to-cost ratio (BCR) for elevating the structure and 0 of the structures had a positive BCR for relocation. These results indicate that structures with less than 3-foot flooding are best suited to non-structural mitigation actions such as low berms, masonry walls, dry proofing, and wet proofing.

Of the original 204 structures in the floodplain there were 41 structures that had flood heights between 3 and 8 feet and were able to be evaluated for elevation and/or relocation. One of these structures was eligible for elevation but not relocation due to the masonry structure type. A total of 35 of the 41 structures eligible for elevation and 13 of the 40 structures eligible for relocation were determined to have a BCR greater than 1:1, which is a metric that is often used to determine whether there is a Federal interest in a flood risk management action. Flood risk management actions often look at a systems approach so summing the total average annual damages and annual costs results in a 1.21 BCR to elevate all of the eligible structures and a 1.02 BCR to relocate all of the eligible structures.

The pilot team learned that each of the structures may be evaluated for non-structural measures at a community level. These evaluations may be based on laying out berms and walls for structures experiencing flooding less than 3 feet or may include elevations and/or relocations for those structures experiencing flooding between 3 and 8 feet of flood depth. Structures with flood depths exceeding 8 feet were not evaluated. The elevation and relocation methods are consistent with the Federal standard for estimating average annual costs and benefits and may serve as a valuable tool for helping communities understand where they may be able to receive state and/or Federal aid to reduce their flood risk in partnership with local planning and zoning activities to keep future structures out of harm’s way.

The methods explored in this pilot demonstrate that a multi-disciplinary team can quickly and effectively evaluate hydrology, hydraulics and non-structural measures including: landuse planning, zoning, structure elevation, and structure relocation for a community based on information that was generated at a watershed or river shed scale. This builds the case for the value in developing large regional systems based models which may provide tremendous value to state and local governments in long-term reductions in flood risk. These large regional systems models may serve as a foundation which can and should be built on by local governments to account for changes in stream infrastructure such as bridges and dams. Similarly, they may account for how future development plans may impact the system and/or how the system impacts may impact future development plans and other assets at risk. This approach is relevant to Midwest streams in the United States as they will all experience changes in hydrology over time due to landuse and climate changes and these changes may impact those structures located along that stream reach.

Results support the 2012 Silver Jackets conclusions that some of the smallest communities in the watershed have high flood risk on a percentage or per capita basis although their potential damages are relatively small compared to large urban centers. This may be due to limited resources, budgets and tools to adequately understand the risk or may be based on a desire to develop lands adjacent to the river as this is often the highest value lands according to comments documented from phone calls in 2012 pilot. Use of the information developed in this pilot allows for flood mitigation agencies and entities to utilize a two-pronged approach of addressing large urban centers to reduce overall flood damages and also to engage small communities in an effort to reduce the growing flood risk in these communities. This report along with presentations to various interagency forums will communicate the results of this pilot effort and help communities understand how they may conduct a meaningful non-structural evaluation within a relatively constrained budget by utilizing the approach that was explored in this pilot. This effort may also support communication of the value of approximate channel mapping efforts such as the statewide effort currently underway for the state of Iowa. Many approximate channel derived inundation maps have been generated for streams across Iowa although one did not exist for the Cedar River so this product may contribute to the statewide repository of approximate channel derived products developed to support inundation mapping activities.

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Nathan Young	Iowa Flood Center
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Non-Structural Landuse Change Impacts on Structure Losses in Cedar River Communities

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I. PURPOSE

The purpose of this Study is to improve risk-informed decision making by communities by improving their exposure to and understanding of how floodplain mapping and non-structural measures activities may help mitigate changes in flood risk due to climate and landuse changes. Specifically, the purpose is to build a planning level hydraulic model and conduct a non-structural measures analysis. This analysis determines the change in estimated structure losses that a community may incur due to changes in flood stage, as indicated by the observed flows at United States Geological Survey (USGS) flow gages, resulting from climate and/or landuse induced hydrologic variation in the Cedar River Basin.

II. INTRODUCTION

This project is a follow-on study from the information gathered in the 2012 Iowa Silver Jackets pilot, *Floodplain Management and Risk Communication in the Iowa-Cedar Rivers Basin* (Smith et al, 2013). Part of the 2012 pilot effort explored flood risk at a census and community level based on both total estimated structure losses and per capita estimated structure losses. Results from this pilot raised the question of how flood risk may change (increase or decrease) in a given community as various climate and landuse changes occur in the watershed as reflected in the observed flow records from USGS flow gages. This type of information is important in understanding which communities may be on the fringe of incurring major damages. Better understanding may allow communities to take actions to minimize damages of existing structures and preventing future damages to structures in the face of a changing landscape or climate.

This pilot will utilize existing data and techniques to develop new planning level tools (models, maps, etc.) to compare structure losses resulting from changes in flood stage and the associated landuse and/or climate change required to drive the change in flood stage. Namely, climate change could produce more variability in peaks and droughts, which translates into greater risk of hitting an extreme event. This new information will help the Silver Jackets with current and future floodplain planning, management and risk communication. This Study will not produce detailed designs or make project level recommendations.

III. BACKGROUND

A. Study Area. The Cedar River is a tributary to the Iowa River which includes some of the most fertile agricultural land in the nation. In recent years, high commodity prices and ethanol demand have contributed to landscape changes, most significantly, the conversion of low intensity agriculture (pasture and grassland) to high intensity row crops (corn and soybeans). This conversion has increased stress on fresh water systems and contributed to both Gulf of Mexico hypoxia and flooding. The Cedar River Basin contains two large urban areas and many smaller communities along the river who experienced record or near-record flood events in recent years, most notably 1993, 2002, and 2008. Figure 1 displays a map of the Cedar River Basin.

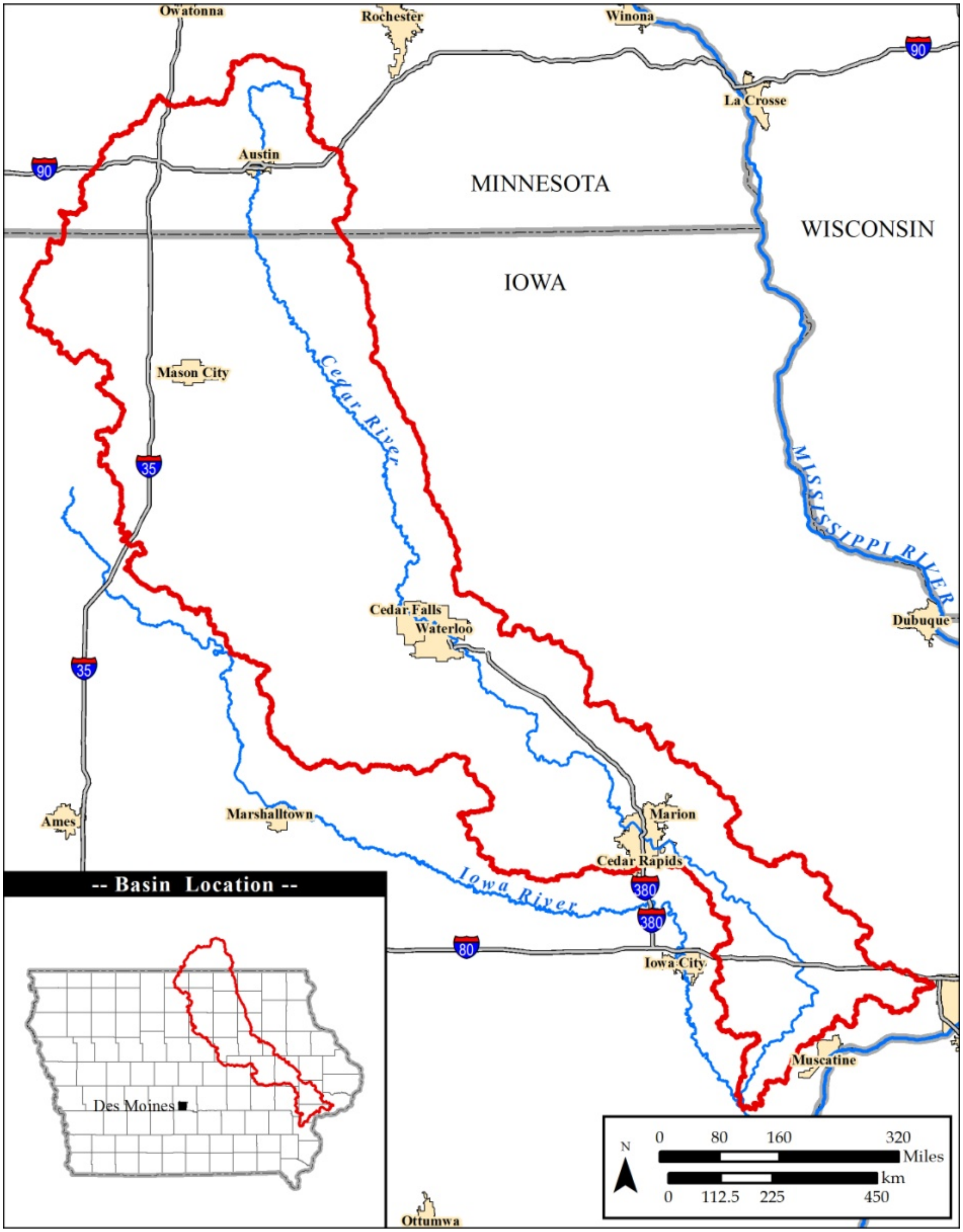

Figure 1: Map of the Cedar River Basin

B. Problems, Issues of Concern, and Opportunities. The primary problem is a lack of exposure and/or understanding of the current flood risk in the Cedar River Basin. This lack of exposure and/or understanding of flood risk is in part due to limited governmental budgets for those agencies responsible for updating flood inundation data, information, and maps. Therefore, communities rely on maps based on historic flood frequency information which may no longer be an accurate representation of the inundation extent of any given flood probability event. Hydrologic variation due to landuse and climate changes may be resulting in greater current flood risk then reported in currently available floodplain mapping products. Flood risk is contingent on how communities use available floodplain mapping products and other information to manage their current flood risk, including which actions (i.e. mitigation, adoption of ordinances and zoning regulations, watershed master plan, etc.) are taken to enhance the community's resiliency to flooding. The actions taken to manage current flood risk are then tied directly to future flood risk.

A secondary problem is that tools to evaluate flood risk often take considerable time and resources to develop. This is a problem because communities are making landuse decisions everyday based on the best available science, which may be outdated and no longer representative of the existing flood risk.

The primary opportunity is to develop products and processes that may help communities determine their flood risk. This opportunity includes matching desired levels of investment for understanding flood risk with the desired accuracy of the level of flood risk.

A secondary opportunity in the Basin is strengthening interagency cooperation through multiple partnership groups which help identify, communicate and mitigate flood risk at multiple jurisdictional levels. This includes the Iowa Silver Jackets and the Iowa-Cedar Interagency Watershed Coordination Team. The Iowa Silver Jackets partnership includes approximately 10 different Federal and state governmental organizations. The Iowa-Cedar Interagency Coordination Team is composed of approximately 20 different Federal and state governments and non-governmental organizations www.iowacedarbasin.org. The Interagency Team has an Iowa-Cedar Watershed Basin coordinator who works directly with local governmental entities such as the County Conservation Boards; Resource Conservation Districts; Soil and Water Conservation Districts; and townships and municipalities. This partnership with local governmental entities combined with agency level involvement of the Silver Jackets partners provides a unique opportunity to identify, communicate, and take flood risk actions at multiple jurisdictional levels.

IV. GOALS AND OBJECTIVES

The goal of this Study effort is to better understand and communicate the effects of non-structural actions on community flooding and associated economic impacts. The study has four objectives:

> **Objective 1:** Improve understanding of how climate and landuse change may impact watershed hydrology and related flood risk.
>
> **Objective 2:** Improve understanding where less rigorous and quicker methods for evaluating flood risk may be applied for planning purposes and where a high level of rigor for evaluating flood risk should always be applied.

2a: Evaluate how less rigorous hydraulic methods impact the estimated extent of inundation and depth of flow at varying locations.

2b: Evaluate if the difference in extent of inundation and depth of flow translates into differences in economic damages.

Objective 3: Increase awareness of which communities on the Cedar River main stem may experience large changes in estimated damages with relatively minor changes in flow.

Objective 4: Identify non-structural measures that may be taken by communities based on the tools they have available for decision making. Communicate these actions through the Silver Jackets partnership framework and other regional interagency networks.

V. SCOPE OF WORK

The scope of work includes five different and distinct activities required to achieve the goal and objectives:

1) Hydrologic Assessment of the Watershed;
2) Hydraulic Method Comparison;
3) Economic Assessment of Hydraulic Methods;
4) Community Sensitivity Analysis; and
5) Non-Structural Actions and Communication

The first element of the scope of work is a hydrologic evaluation that explores the contribution landuse change and climate change may have on flow rate, respectively. The second element compares an 'approximate channel' Hydrologic Engineering Center – River Analysis System (HEC-RAS) modeling approach with other methods. The third element evaluates the change in estimated structure losses based on the hydraulic method. The next element evaluates community sensitivity to changes in flow. The final element explores how techniques demonstrated in this effort may help identify structures at risk or areas with potential risk for communities to take non-structural actions (buy-outs, structure raises, zoning, etc.). This final element also includes communication of these results through various interagency forums, including the Silver Jackets team.

A. Activity #1 - Hydrologic Assessment of the Watershed. To achieve Objective 1— *Improve understanding of how climate and landuse change may impact the watershed hydrology and related flood risk*—data and information related to historical landuse (especially row crop agriculture) and meteorological conditions (especially precipitation) are collected. These historical data sets are compared with historical flow records at varying locations in the watershed and evaluated statistically to try and isolate what impact landuse changes and climate changes have on stream flow rate across a range of frequencies.

B. Activity #2 – Hydraulic Method Comparison. To achieve Objective 2a—*Evaluate how less rigorous hydraulic methods impact the estimated extent of inundation and depth of flow at varying locations*—the Pilot Team conducts a comparative analysis between a detailed (calibrated and validated) HEC-RAS model, a planning level HEC-RAS model ("approximate channel method") and two Geographic Information System (GIS)-based mapping methods that utilize the existing Flood Information Study data. This comparison explores the difference in estimated flood depth inundation on quicker and less costly methods and those that take more time to be developed and thus are often more expensive. Also, this comparison seeks to isolate certain channel conditions or characteristics that may be resulting in large differences between methods.

C. Activity #3 – Economic Assessment of Hydraulic Methods. To achieve Objective 2b—*Evaluate if the difference in extent of inundation and depth of flow translates into differences in economic damages*—the Pilot Team utilizes the USACE Hydrologic Engineering Center's Flood Impact Analysis (HEC-FIA) computer program which internally uses census level property valuation (structure/contents/vehicle) data from FEMA's HAZUS flood damage assessment program. Depth and inundation extents (depth grids) are imported into HEC-FIA which estimates property damage based on the depth of flooding on the structures. Estimated property losses are compared among methods—detailed Hydrologic Engineering Center -River Analysis System (HEC-RAS), approximate HEC-RAS; and Geographic Information System (GIS)-based methods—to determine if differences in the depth grids resulting from the method of floodplain delineation is translating into measureable and sizable differences in estimated economic damages.

D. Activity #4 – Community Sensitivity Analysis. To achieve Objective 3—*Increase awareness of which communities on the Cedar River main stem may experience large changes in estimated damages with relatively minor changes in flow*—the Pilot Team adjusts flood probabilities at designated gauge locations along the Cedar River main stem to account for the longer period of record [reference period of record is that used in the Flood Information Studies (FIS), typically done in the 1990s timeframe]. New discharges based on the longer period of flow record are then run through the planning level HEC-RAS model to generate new flood profiles and resulting inundation and depth extents. The new flood profiles and resulting inundation extents in the form of depth grids are evaluated in the HEC-FIA program to estimate structure losses for each of the respective communities on the Cedar River main stem. The team then compares and highlights the magnitude of difference in damages resulting from Activity #3 (perceived current flood risk) and those resulting in Activity #4 (actual current flood risk).

E. Activity #5 – Non-Structural Actions and Communication. To achieve Objective 4—*Identify non-structural measures that may be taken by communities based on the tools they have available for decision making. Communicate these actions through the Silver Jackets partnership framework and other regional interagency networ*ks—the Pilot Team explores techniques that may help identify structures at risk or areas with potential risk for communities to take non-structural actions (buy-outs, structure raises, zoning, etc.) and the estimated costs of those actions. This final element also includes communication of these results through various interagency forums, including the Silver Jackets Team and the Iowa-Cedar Interagency Coordination Team.

VI. METHODOLOGY AND RESULTS

A. Activity #1- Hydrologic Assessment of the Watershed. To increase understanding of how climate and landuse change may impact watershed hydrology the Pilot Team first collected FIS for available Cedar River stream reaches. The FIS results include information related to the probability of flows occurring based on the period of record to that point in history. Probabilities associated with the frequency of inundation are often displayed in floodplain mapping products such as Flood Insurance Rate Maps (FIRMs) which makes FIS outputs a good metric for use in identifying perceived current flood risk.

The Pilot Team then explored how flow probabilities may be changing over time to see if there has in fact been a measurable change in flow for a given probability. To conduct this evaluation the annual peak flow records at various USGS stream gages throughout the Cedar River Basin were collected and analyzed. This analysis used methods described in Bulletin #17B guidelines (USDOT, 1981) along with the Hydrologic Engineering Center - Statistical Software Package (HEC-SSP) to identify the peak flow associated with a range of probability events. The 17B analysis was performed by importing USGS period of record information without additional scrutiny for data quality (i.e. outliers).

This analysis resulted in FIS frequency flows being lower (by 3% to 40%) than the newly computed #17B bulletin frequency flows for all frequency events and gages, except the Cedar River at Janesville, IA. This is likely due to a general increase in peak annual flows that have occurred within recent years. By appending the period of record to include more recent events, an increase in frequency flows is realized except for the most recently updated FIS report for the Cedar River at Janesville, IA which was completed in 2012 and includes stream gauge data thru 2009. Other FIS reports were published in the 2000s but are based on gauge data terminating in the 1970s or 1980s which makes the hydrology outdated by several decades. Information in Table 1 displays the change in flow rate from the FIS and #17B bulletin analysis across a range of probability events at the designated gauge locations.

Changes in flow rate are a result of changing hydrology but the driver for the hydrologic change may be landuse (land cover and land management) or climate. In order to try and isolate the primary driver of the change in hydrology the Pilot Team conducted a statistical analysis following the process outlined in a study of the neighboring Turkey watershed basin (Villarini, G and A. Strong, 2014). The method developed a simplified relationship between precipitation and the interaction term which includes landuse changes. Applying this simplified statistical model in the Cedar River Basin determined that landuse changes may be decreasing flow during periods of low precipitation (drought) but during periods of high precipitation the interaction term nears zero so precipitation is driving the change in the flow rate for less probable events such as the 1% probability event (100-yr). Graphics associated with this statistical evaluation are located in Appendix B.

Table 1: Cedar River Period of Record Frequency Flow Analysis (FFA) Comparison

		Cedar River Near Austin, MN	**Cedar River at Charles City, IA**	**Cedar River at Janesville, IA**	**Cedar River at Waterloo, IA**	**Cedar River at Cedar Rapids, IA**	**Cedar River Near Conesville, IA**
	FFA Period of Record	1909-2012	1946-2012	1905-2012	1929-2012	1903-2012	1940-2012
	FIS Period of Record	1910-1983	1964-1976	1905-1970	1929-1980	1903-1973	1929-1982
	FIS Analysis Method	Bulletin 17b	Bulletin 17b	Bulletin 17b	Reference 18	Bulletin 11	Bulletin 17b
10% Annual Chance Exceedance (10-yr)	**FFA (Bulletin 17b)**	9,900	20,500	24,600	58,700	54,800	60,700
	FIS	7,200	18,900[1]	25,800	55,000	53,000	56,900
	% Difference	***38%***	***8%***	***-5%***	***7%***	***3%***	***7%***
2% Annual Chance Exceedance (50-yr)	**FFA (Bulletin 17b)**	15,100	30,900	39,100	91,500	83,400	90,700
	FIS	11,000	26,200[1]	40,500	83,000	77,000	82,700
	% Difference	***37%***	***18%***	***-3%***	***10%***	***8%***	***10%***
1% Annual Chance Exceedance (100-yr)	**FFA (Bulletin 17b)**	17,300	35,400	45,500	105,400	95,900	103,600
	FIS	12,500	28,800[1]	46,700	94,000	87,000	93,100
	% Difference	***38%***	***23%***	***-3%***	***12%***	***10%***	***11%***
0.2% Annual Chance Exceedance (500-yr)	**FFA (Bulletin 17b)**	22,200	45,500	60,600	137,300	125,300	133,300
	FIS	**15,600**	**39,000**[1]	**60,900**	**123,000**	**112,000**	**116,000**
	% Difference	***42%***	***17%***	***-0.4%***	***12%***	***12%***	***15%***

[1] Estimated from frequency-discharge graph in 2008 Floyd County FIS

Note: Floyd County FIS was updated in 2015; 2015 Floyd County FIS flows for Charles City are closer to the FFA flows, 10%-20,700 cfs; 2%-30,400 cfs; 1%-34,500 cfs; 0.2%- 43,800 cfs

B. Activity #2 - Hydraulic Method Comparison. The method of delineating floodplain extents may be an important part of determining flood risk. This pilot tested several different methods for delineating the floodplain based on GIS techniques as well as more standard HEC-RAS hydraulic modeling.

This pilot developed an approximate channel HEC-RAS model and compared the results from this quicker and less costly method of floodplain delineation with a detailed HEC-RAS model that was developed for the Cedar River at Cedar Rapids, Iowa as part of a 2008 Army Corps of Engineers flood risk management feasibility study. An approximate channel HEC-RAS model is a hydraulic model that is constructed by utilizing readily available state LIDAR data to construct the channel overbank. This method does not attempt to account for the channel dimensions below the water surface nor does it attempt to account for bridges or other complex hydraulic phenomenon. The detailed HEC-RAS model, developed as part of a 2008 study for the City of Cedar Rapids, accounts for the channel dimensions below the water surface as well as bridges and other complex hydraulic phenomenon. This model is the more accurate model but only covers a small portion of the total river reach. In contrast, the limited complexity of the approximate channel HEC-RAS model allows the whole river to be modeled in a relatively short period of time and at a low relative cost to a more detailed HEC-RAS model.

Comparison of the results from these two different hydraulic models for a given flow rate provides insight to how much variation in the depth of flooding may occur due solely to the method of model development. This is important in understanding whether greater investment in the accuracy of the hydraulic model is important in making landuse decisions. For example, if the change in depth is relatively minor than a community may be able to adopt a landuse policy which allows a buffer to account for changes in climate and landuse without spending a great deal on developing a detailed HEC-RAS model. This is of growing importance for water resource agencies as well as these communities as funding and time to deliver sustainable water resource solutions continue to be strained.

Figures 2 through 5 display a map of the river section for model comparison along with the results of the approximate and detailed HEC-RAS model comparison for the 10%, 2% and 1% Annual Chance Exceedance (ACE) events for the FIS-based flow rate.

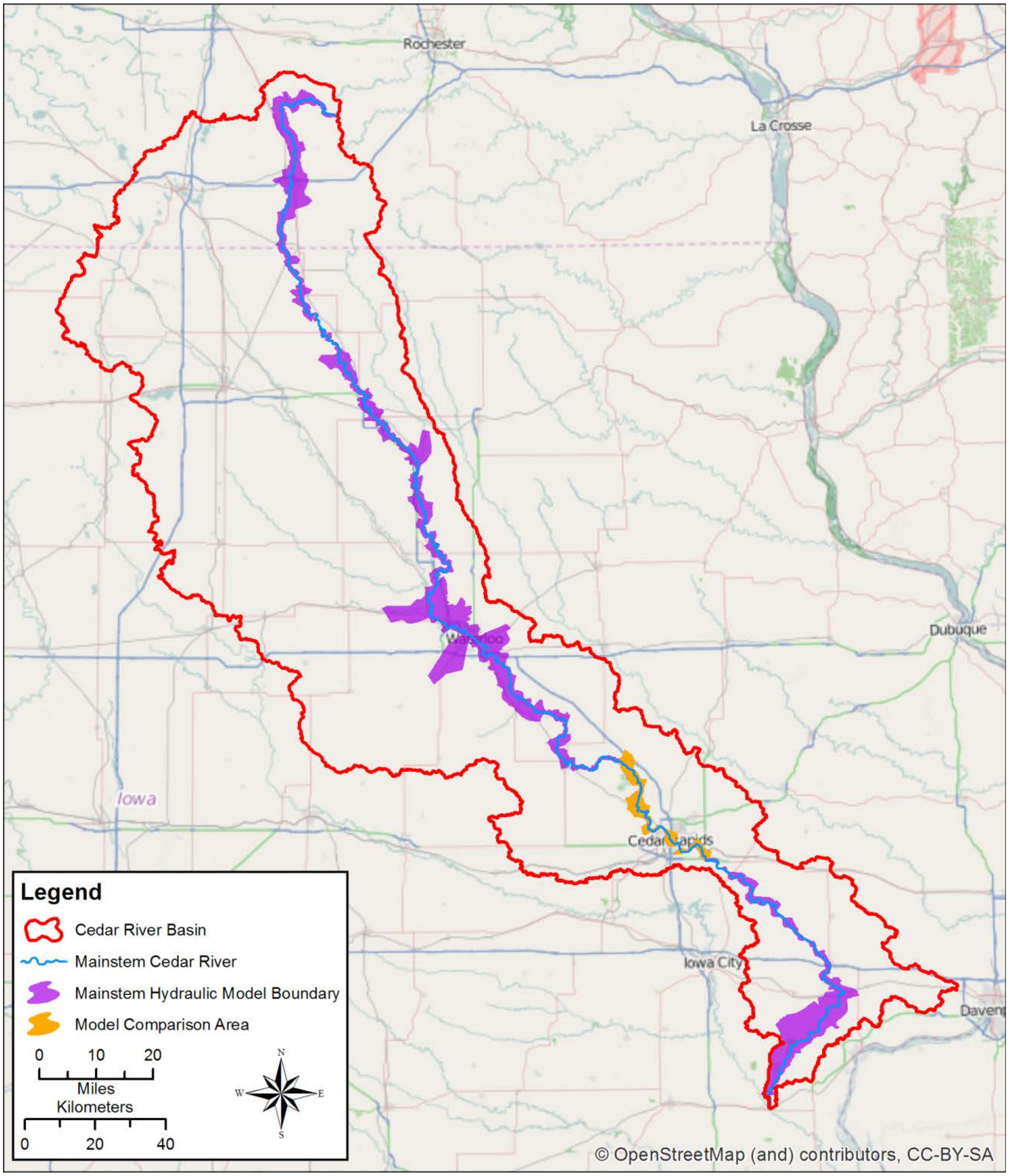

Figure 2. Map of River Section for Model Comparison

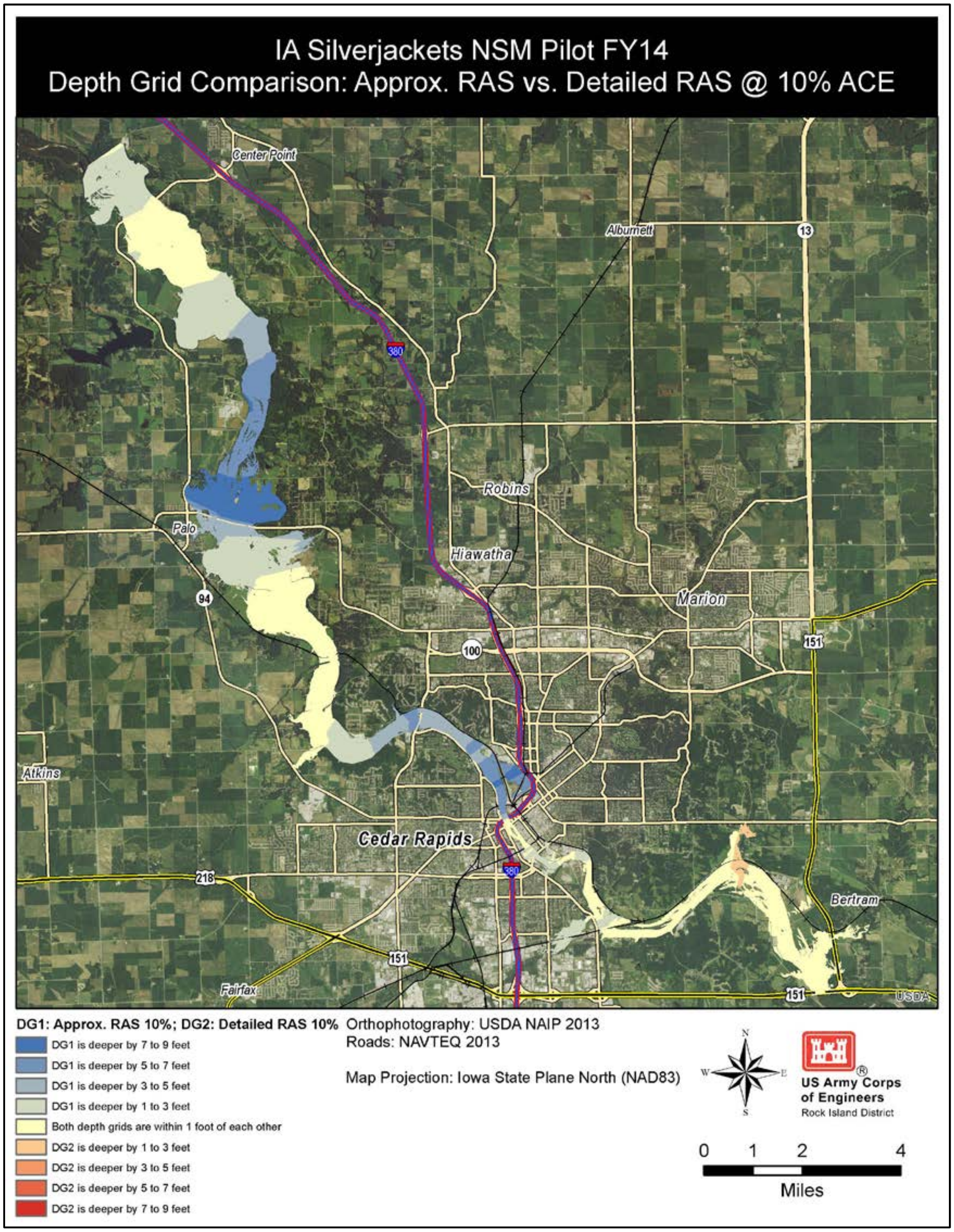

Figure 3. Depth Grid Comparison of Approximate and Detailed HEC-RAS @ 10% ACE Event

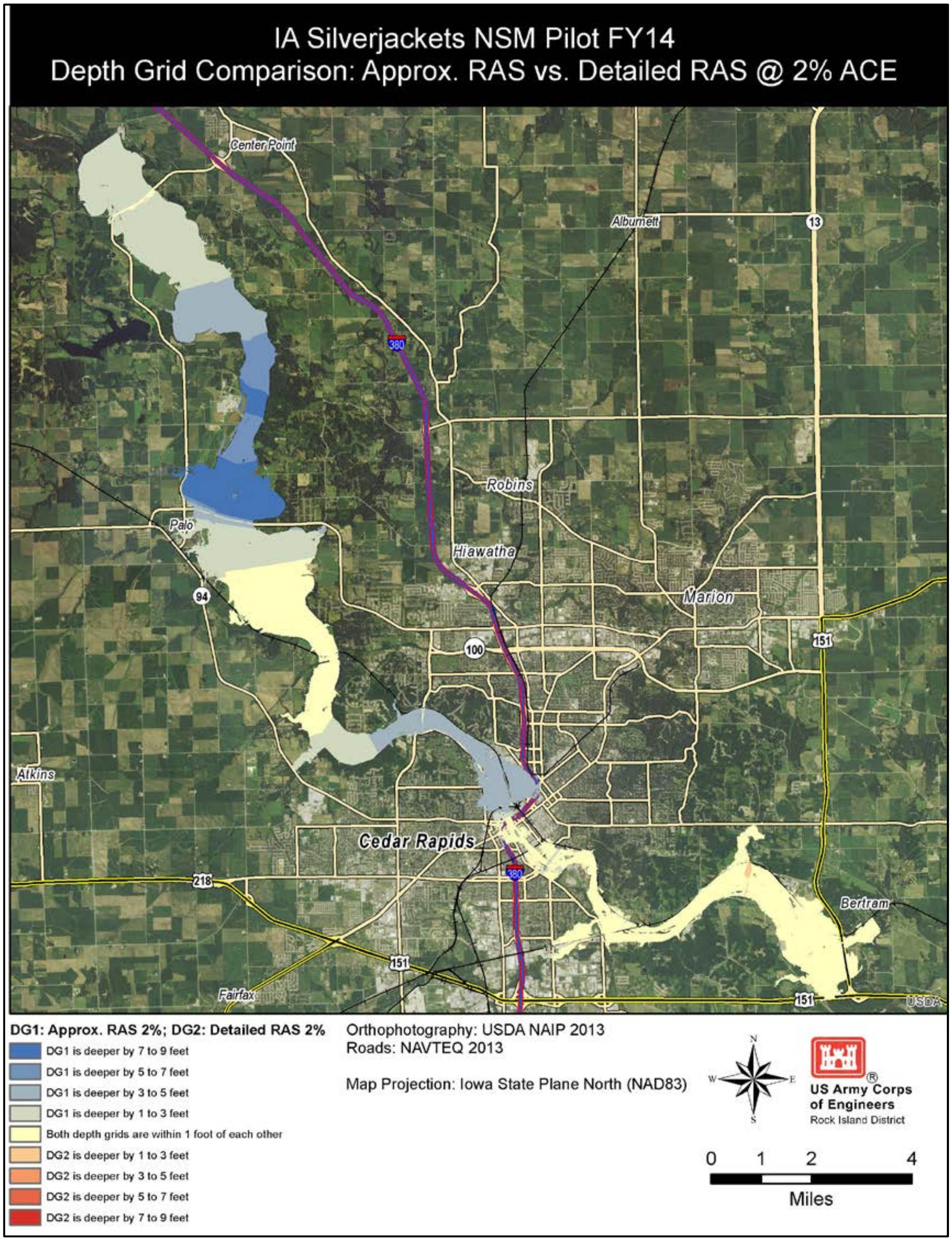

Figure 4. Depth Grid Comparison of Approximate and Detailed HEC-RAS @ 2% Probability Event

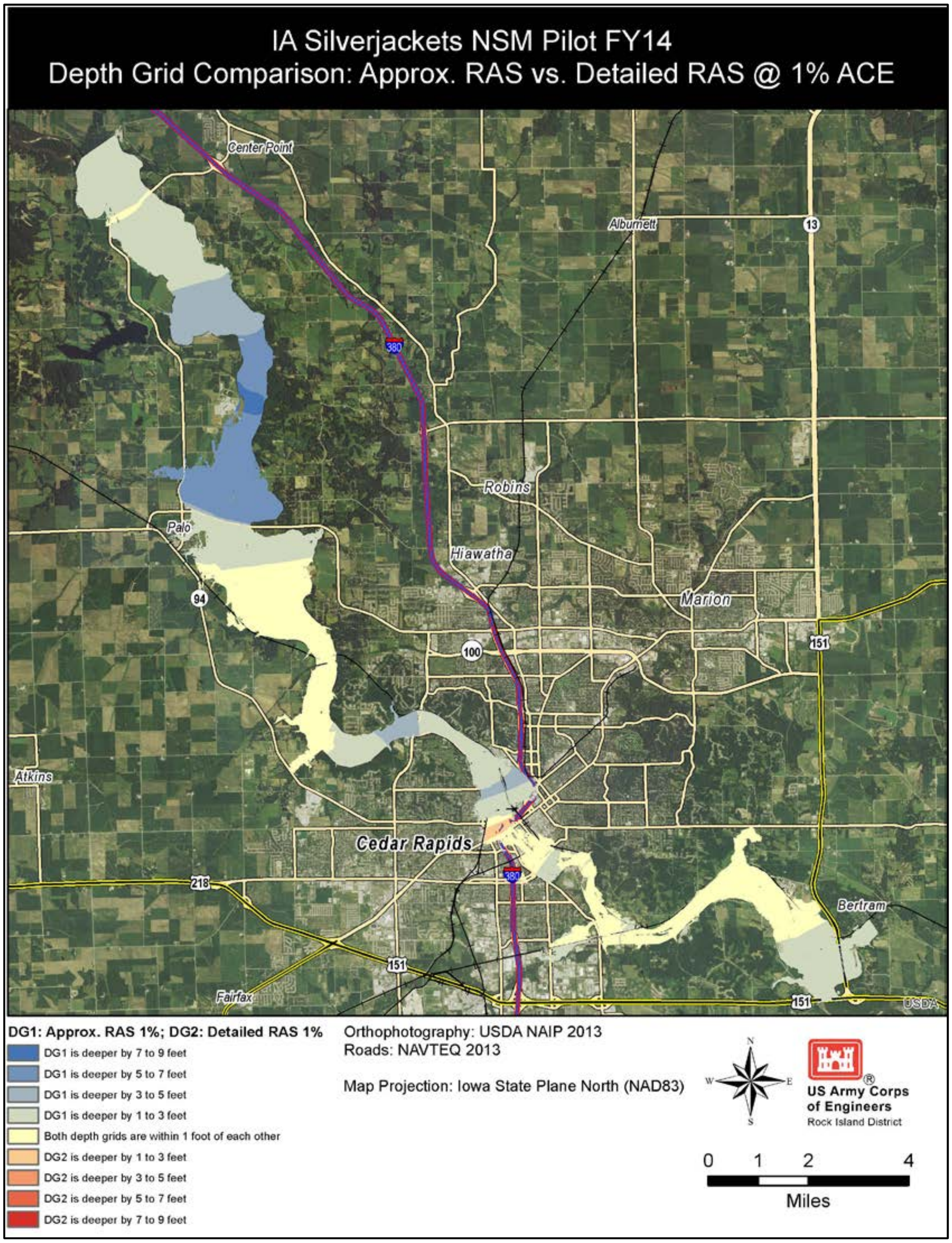

Figure 5. Depth Grid Comparison of Approximate and Detailed HEC-RAS @ 1% Probability Event

According to Figures BB through DD, the greatest difference between the approximate channel HEC-RAS model and the detailed HEC-RAS model occurs immediately upstream of road bridges. Other differences occur at a low head dam near the intersection of Interstate 380 and the Cedar River which includes split channel flow in this area. This complex hydraulic phenomenon results in an over-simplification and an over estimate of depth resulting from the approximate channel HEC-RAS simulation versus the detailed HEC-RAS model simulation. The exception to this is the 1% ACE where the approximate channel method is underestimating the depth by between 1 and 3 feet.

In addition to the approximate and detailed hydraulic models the Pilot Team also developed and compared two GIS-based methods. The GIS-based methods delineate the floodplain based on FIS and Iowa Highway Research Board data to construct a flood elevation centerline associated with the FIS published flow rates by probability event. The GIS-based methods tested an offset technique along with a cross-section method. These methods may provide the lowest cost option for delineating a floodplain extent for a whole river section but are limited to the availability of FIS data and information. The main limitation to a GIS-based approach is that the stage may not be adjusted to reflect changes in hydrology. Further information on the GIS-based methods and assumptions in developing approximate channel HEC-RAS model may be located in Appendix C.

C. Activity #3 – Economic Assessment of Hydraulic Methods. Activity #3 focused on exploring how the changes in flow and inundation extent presented in Activity #2 may impact estimated economic damages for communities along the Cedar River.

The HEC-FIA program uses grid-based hydraulics inputs to deterministically analyze an event (e.g. a dam failure, historic floods, or hypothetical floods) and determine the resulting consequences (ref: http://www.hec.usace.army.mil/software/hec-fia/features.aspx). One of the key features of HEC-FIA version 3.0 is the incorporation of point based structure inventories. These inventories can be imported from the HAZUS database, Parcel Data, or existing Point structure inventory shapefiles. The census block polygons are clipped to the landuse categories in the national land cover dataset. The points are then statistically distributed over that specified area. The number of structures, structure type and values are from the HAZUS database, however placement of the structures by occupancy type is random.

This pilot utilized the HAZUS census databases for structure values. The HEC-FIA program overcomes the area weighted average calculation, which challenged the 2012 Silver Jackets effort, by restricting the structure points within the National Land Cover Database (NLCD) defined landuse areas. This method assures that structures are only evaluated for structure damages and content loss if the developed area is within the floodplain extent. This is an improvement from how the HAZUS database was able to be used in the 2012 Silver Jackets pilot but does not provide the level of accuracy gained from receiving the actual structure inventory from a community that has digitized each structure in its exact spatial location. For use as a screening tool this approach is acceptable. Figure 6 displays the structure points within the NLCD defined landuse classes and the floodplain extent for the City of Charles City, Iowa.

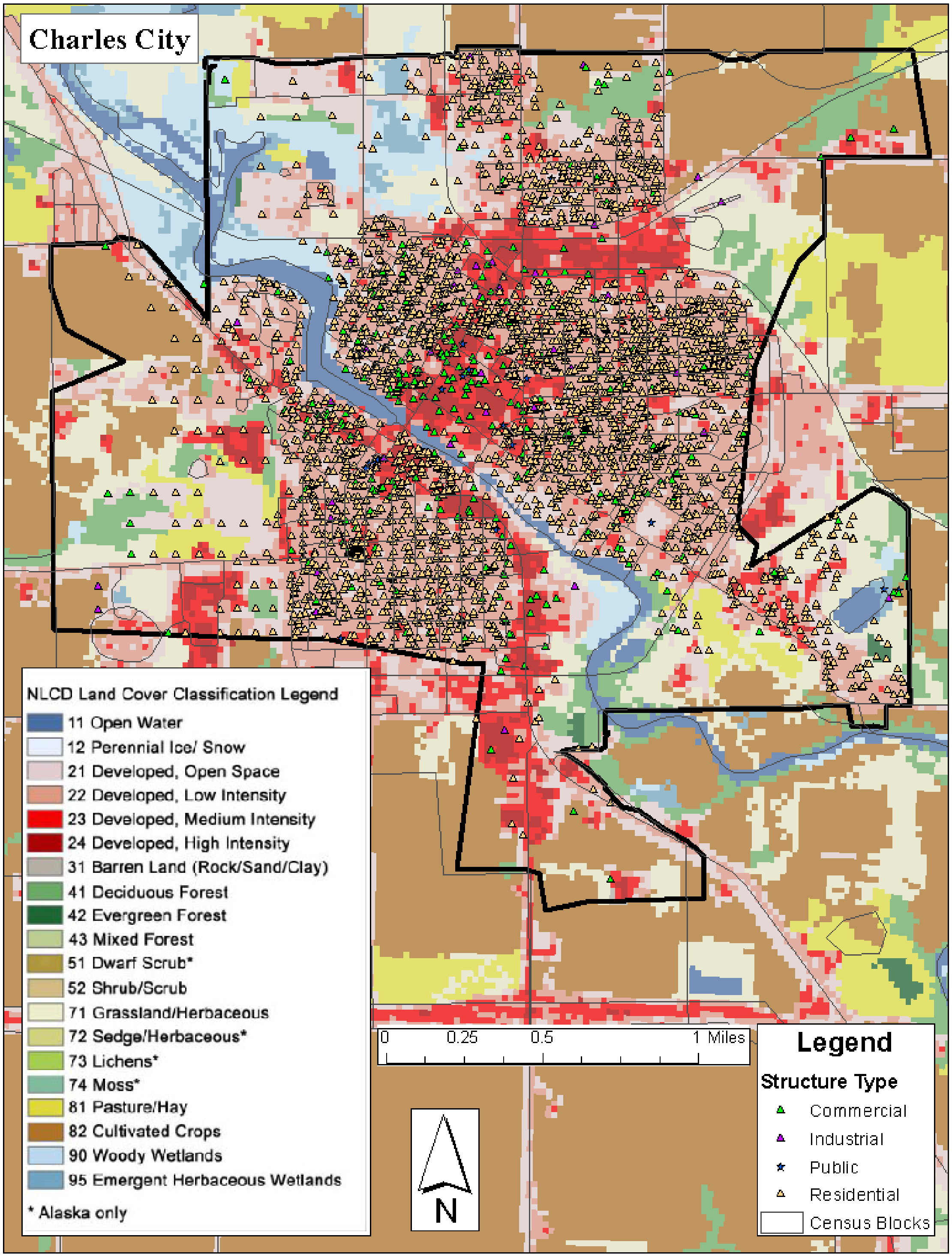

Figure 6. HEC-FIA Screen Capture of HAZUS Structures Evaluated for Potential Structure Damage

Next, the Pilot Team furthered the comparison of the approximate channel and detailed HEC-RAS models by exploring how differences in the depth grids associated with the hydraulic modeling method translate into differences in estimated economic damages. Figure 7 displays a graphical comparison of the estimated damages between the two HEC-RAS models as well as the two GIS-based approaches for the whole comparison reach. The two GIS-based approaches are presented to provide context to which methods are relatively close in estimated damages.

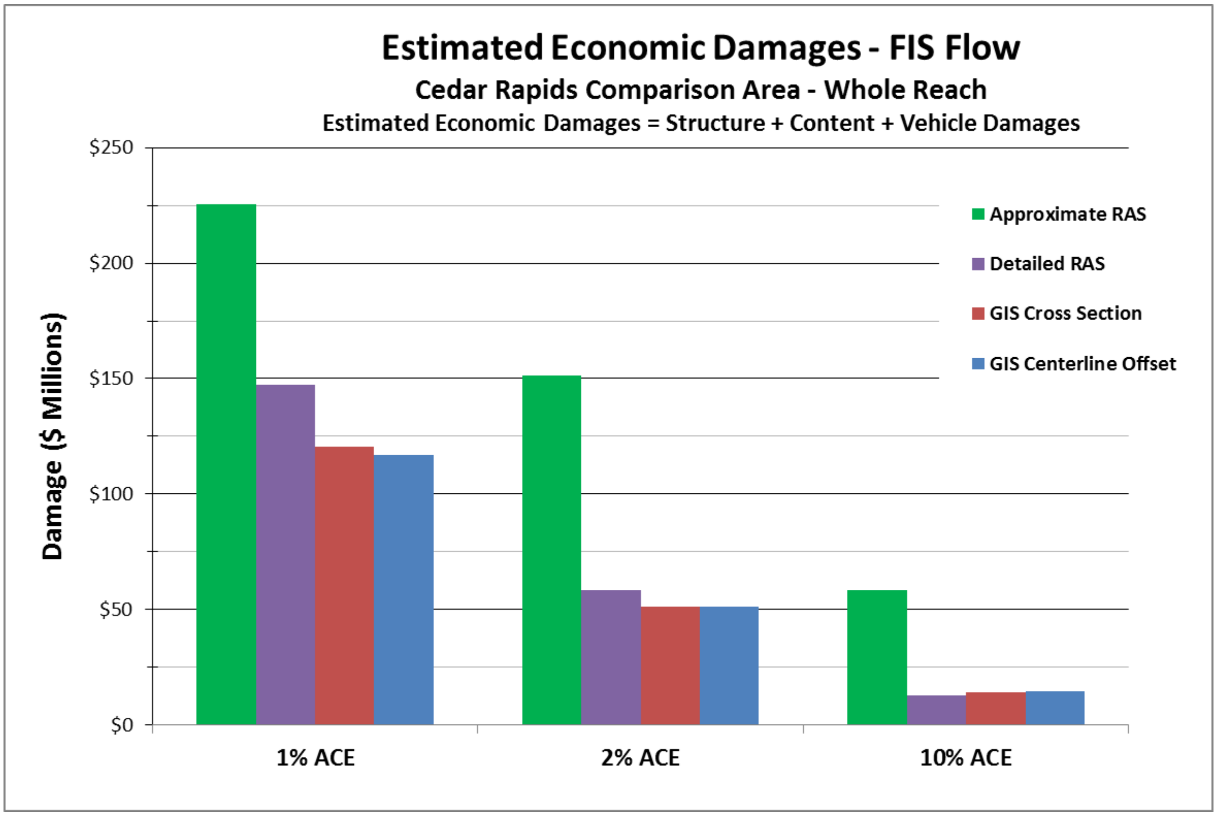

Figure 7: Comparison of Estimated Economic Damages for the HEC-RAS Models and GIS-Based Methods for the Full Comparison Area

Recognizing sizeable differences in the estimated economic damages for the approximate channel HEC-RAS model versus the other methods, the Pilot Team investigated the source and identified that the low head dam and complex hydraulic elements upstream from Interstate 380 were driving the large departure in estimated damages. The team isolated the two areas and reran the economic evaluation to determine how much the results were skewed by the complex hydraulics. Figures 8 and 9 display the estimated economic damages for the HEC-RAS and GIS-based methods for the areas upstream and downstream of Interstate 380, respectively.

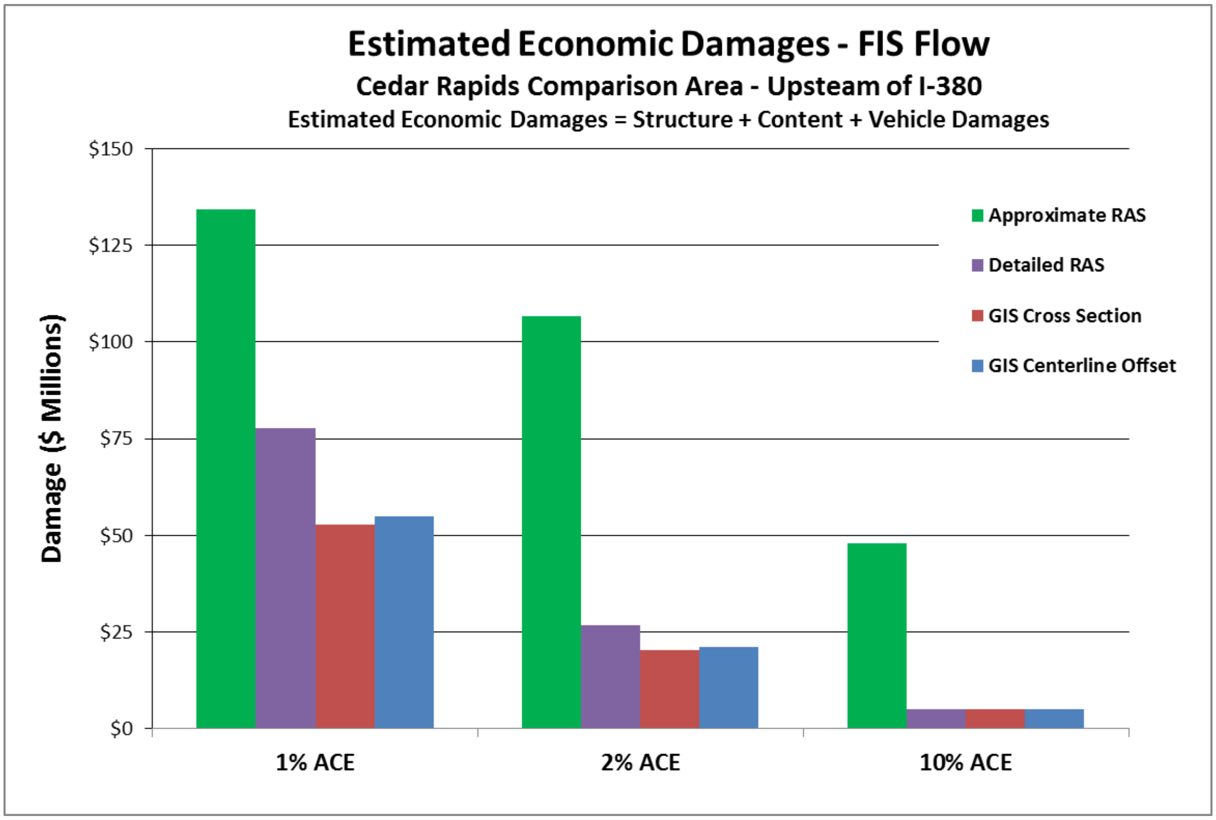

Figure 8: Comparison of Estimated Economic Damages for the HEC-RAS Models and GIS-Based Methods for the Area Upstream of Interstate 380

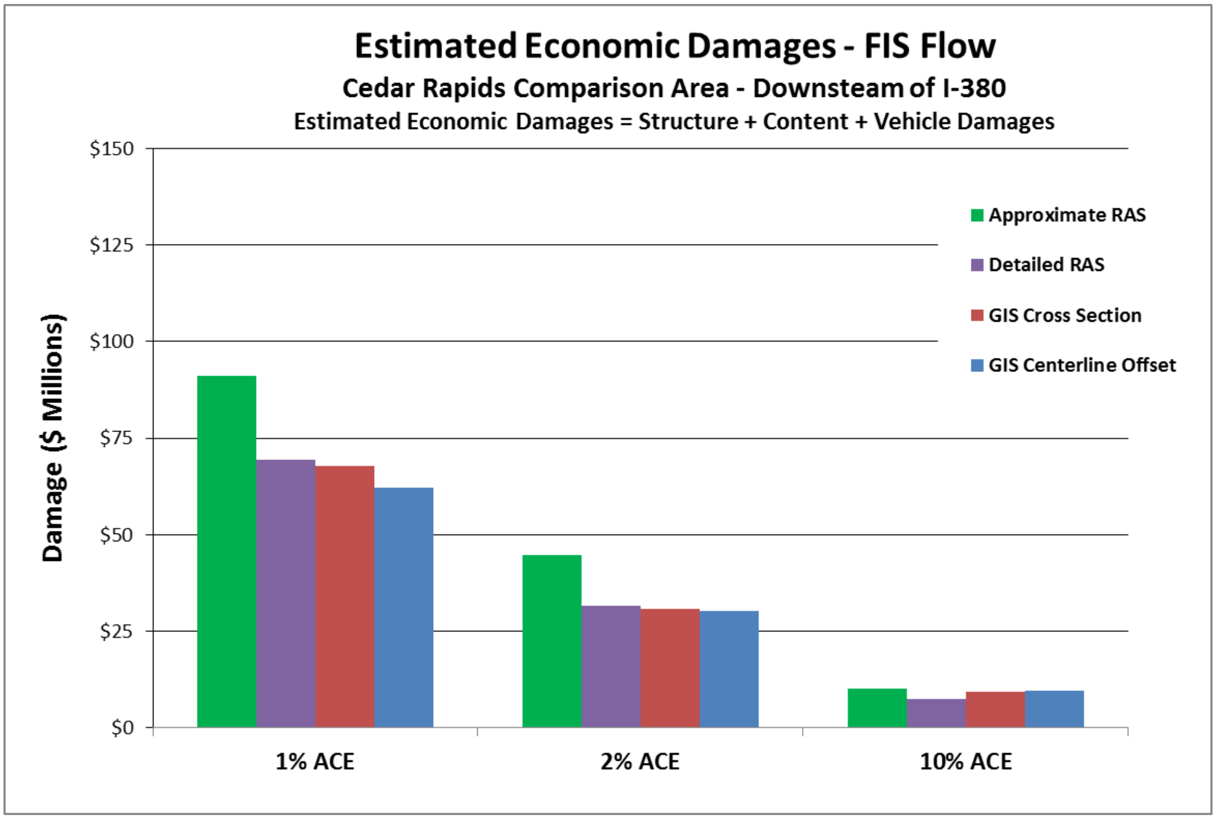

Figure 9: Comparison of Estimated Economic Damages for the HEC-RAS Models and GIS-Based Methods for the Area Downstream of Interstate 380

The estimated damages for the area downstream of Interstate 380 were relatively close between the methods. The area downstream of Interstate 380 is more representative of the entire Cedar River so the Pilot Team felt confident in extending the approximate channel HEC-RAS economic evaluation to the entire Cedar River. In order to evaluate flood risk for communities along the Cedar River, depth grids were generated from the approximate channel HEC-RAS model for both the FIS and new hydrology flows for the 1%, 2% and 10% ACE. These depth grids were then run through the HEC-FIA program in order to estimate economic damages for each community.

Figures 10 through 14 display the community results graphically for the respective flows and probability events. These figures allow for a visual comparison of the relative change. For example, the City of Waterloo has what appears to be a typical stair-step type increase in economic damages across the range of frequency events for both respective flows. In contrast the City of Waverly has a typical stair-step type increase in damages for the 2% and 10% ACE probability events but the 1% ACE event has a disproportionate increase for the new hydrology. Similarly, this phenomenon is observed for the small communities of Elk Run Heights and La Porte City. Activity #4 investigates this phenomenon further.

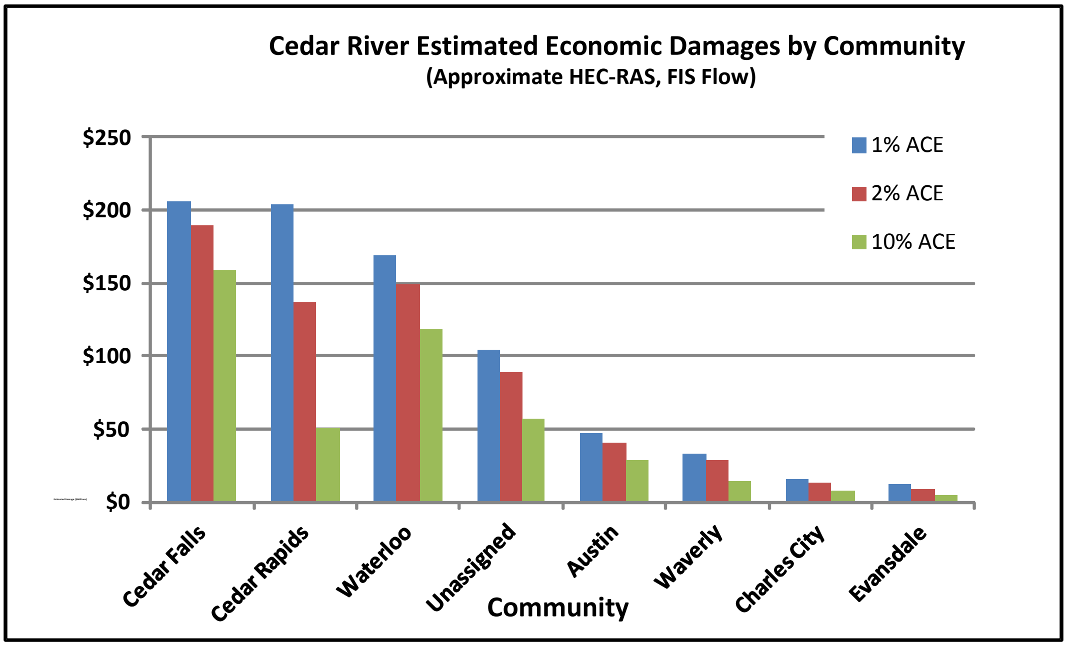

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Figure 10: Estimated Economic Damages of Cedar River Communities Based on Approximate Channel HEC-RAS Modeling of FIS Flows – Group 1

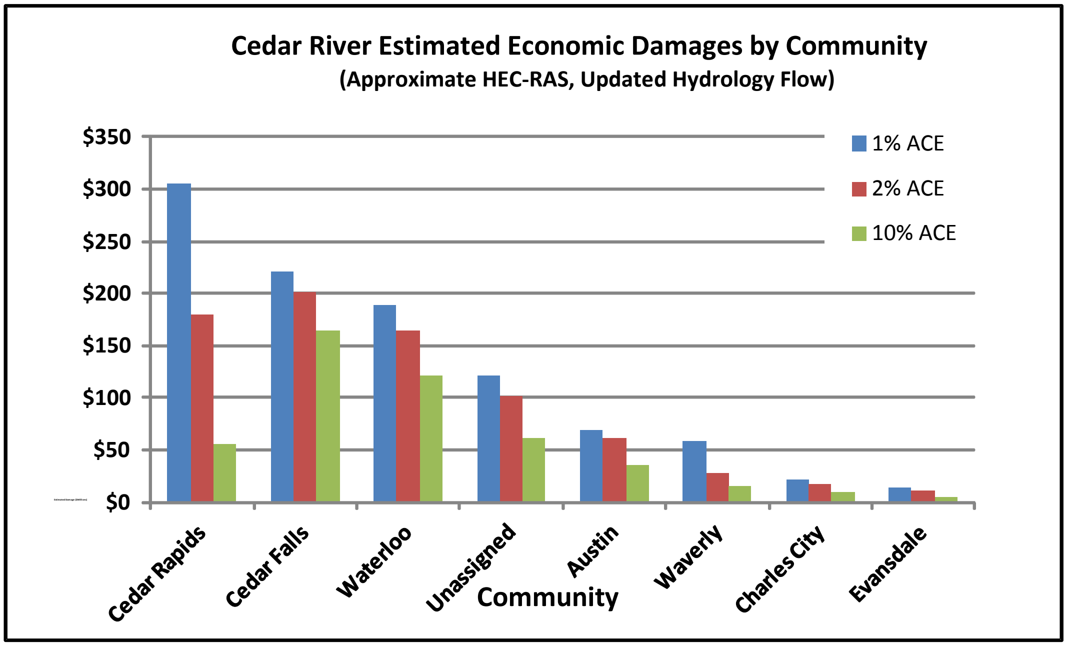

Figure 11: Estimated Economic Damages of Cedar River Communities Based on Approximate Channel HEC-RAS Modeling of Updated Hydrology Flows – Group 1

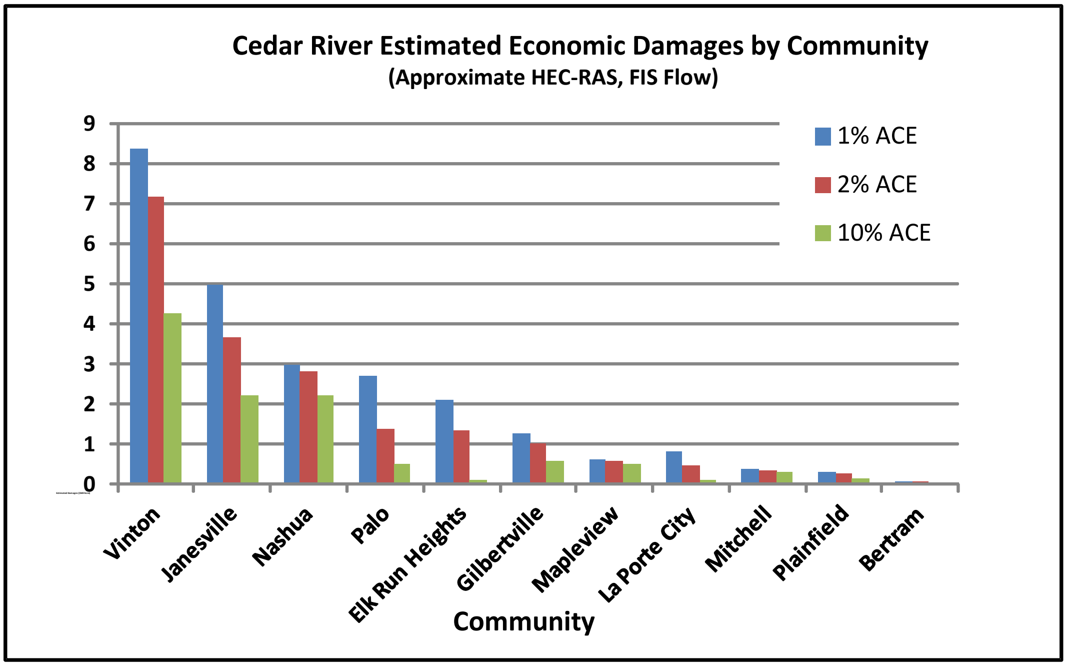

Figure 12: Estimated Economic Damages of Cedar River Communities Based on Approximate Channel HEC-RAS Modeling of FIS Flows – Group 2

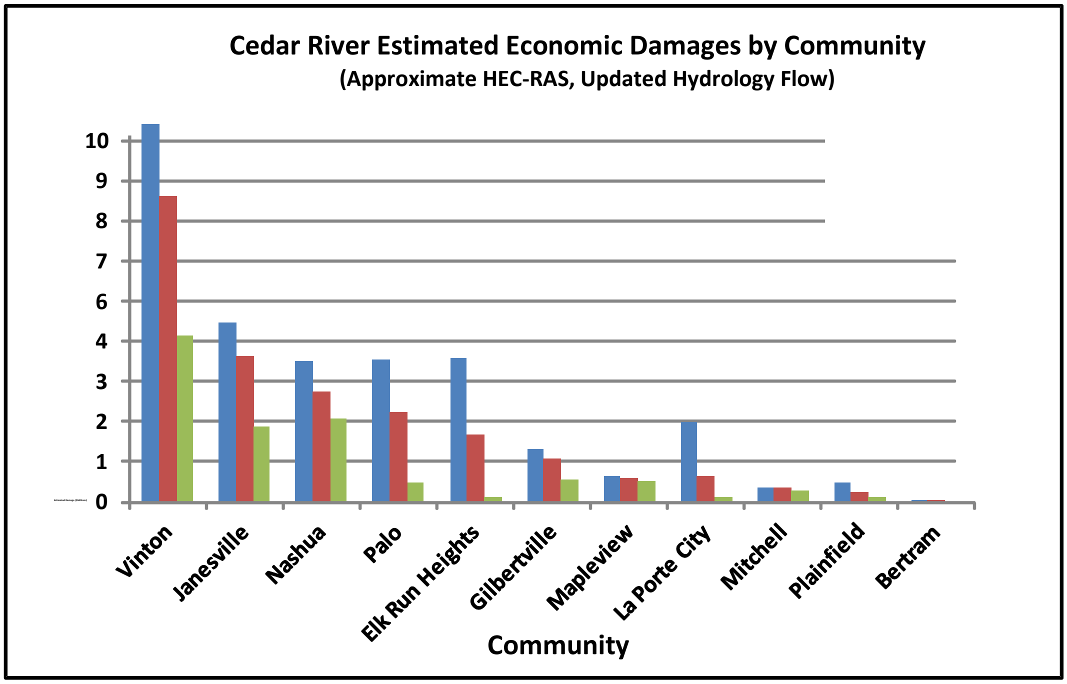

Figure 13: Estimated Economic Damages of Cedar River Communities Based on Approximate Channel HEC-RAS Modeling of Updated Hydrology Flows – Group 2

Quantification of economic damage based flood risk at a community level is important but it is also important to understand how the total flood risk has changed in the Cedar River Basin due to updating the hydrology. Figure 14 displays the total change in economic damage based flood risk for all communities along the Cedar River main stem due to updating the hydrology. Both of the estimated economic damages were generated using the approximate channel HEC-RAS model; therefore, any over or under estimation of depth should be consistent between the economic estimates and thus provides a meaningful relative comparison.

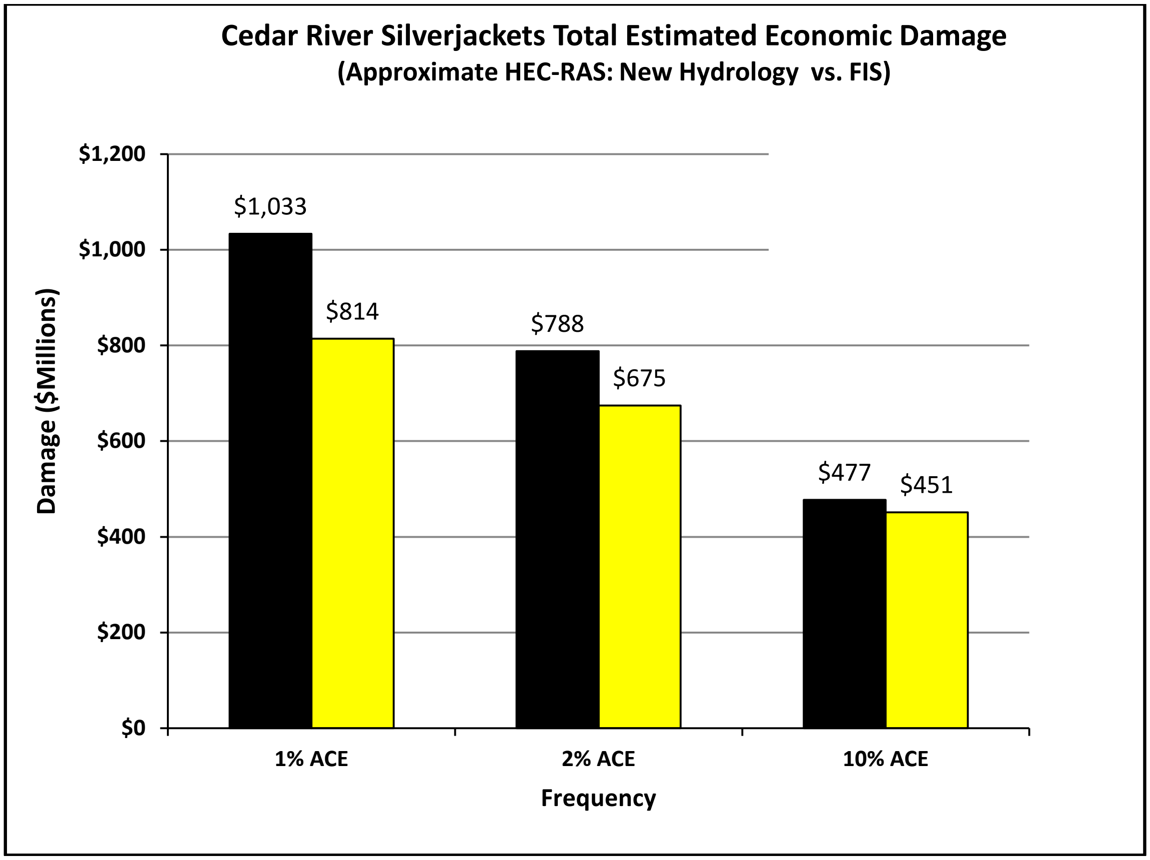

Figure 14: Total Estimated Economic Damages for Cedar River Communities for FIS and Updated Hydrology Flows

Additional information related to the estimated economic damages for the 1%, 2% and 10% ACE events; the annualized damages for each of the respective flows; and information on the loss ratio for each community and probability event may be found in Appendix D.

D. Activity #4 – Community Sensitivity Analysis. The economic evaluation conducted in Activity #3 identified situations where flood risk in certain communities increased disproportionately due to the new hydrology. The Pilot Team approached this Activity as a sensitivity analysis. The Pilot Team evaluated the total change in damage by dollars and percentage for a community in order to identify break-points that might help Silver Jackets partners focus flood mitigation efforts. Figures 16 and 17 display the total change and percent change in annualized damages that occurred for each of the Cedar River communities due to updating the hydrology.

By comparing the communities in Figures 15 and 16 one might observe that some communities are small and thus have a small total damage change but when evaluated based on percent change they may be considered one of the higher risk communities. The Cities of Bertram and La Porte City are examples of this phenomenon. Inversely, larger cities like Cedar Rapids may have a large change in total damage but the relative change in damages is moderate. By evaluating communities based on their total damages and their percent change the Silver Jackets Team can better focus flood mitigation strategies on those communities that have a high flood risk based on total damages but also those communities whose flood risk is growing at a disproportional rate of change in terms of economic damages.

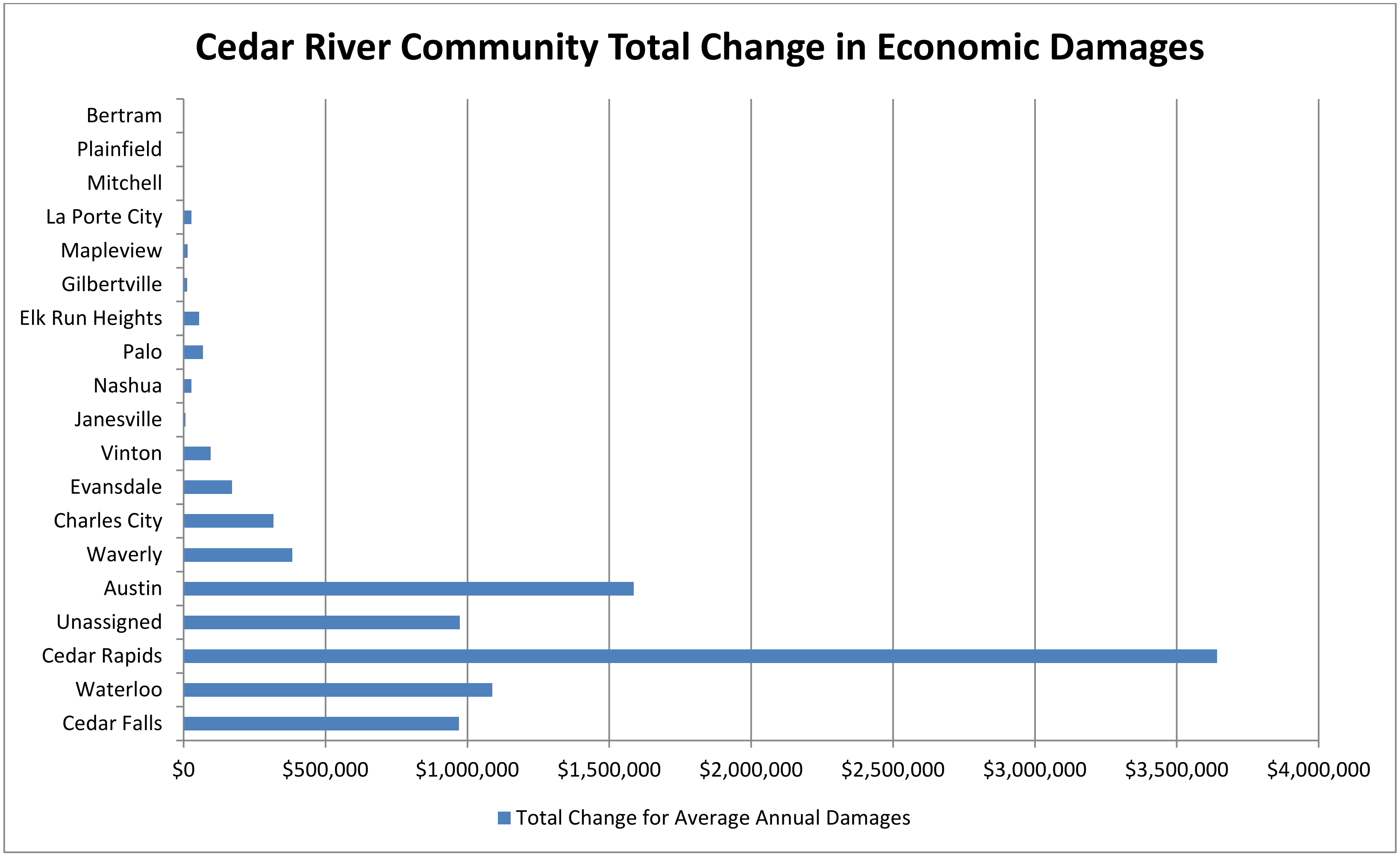

Figure 15: Total Change in Estimated Average Annual Damages for Cedar River Communities

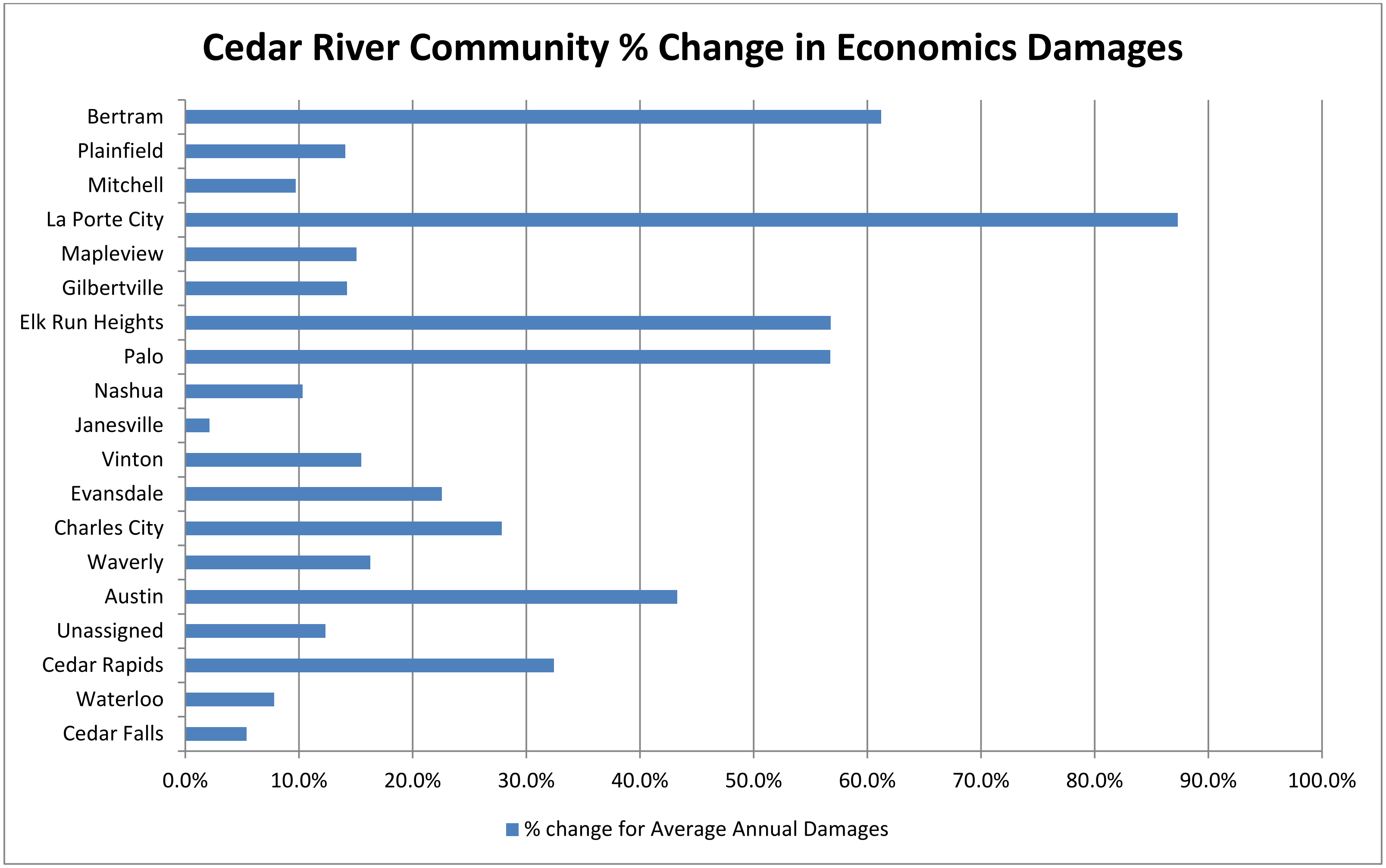

Figure 16: Percent Change in Estimated Average Annual Damages for Cedar River Communities

Figure 17 displays a "heat map" of relative change in economic damages resulting due to updating the hydrology. This figure is useful in identifying the spatial location of communities that may warrant a more detailed investigation of flood risk with more refined tools.

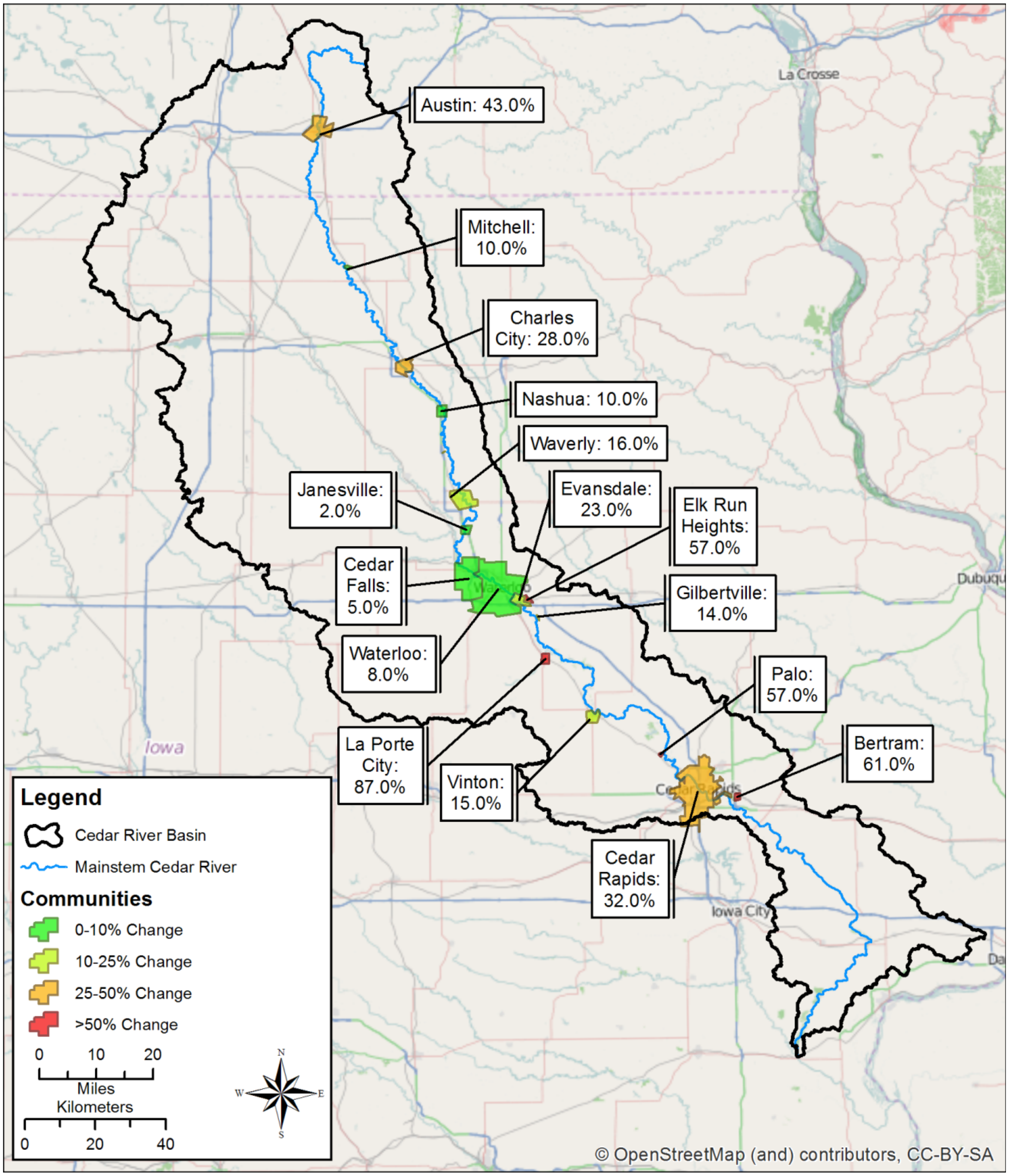

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Figure 17: Relative Change in Estimated Economic Damages Resulting From Updated Hydrology

E. Activity #5 – Non-Structural Actions and Communication. There are a variety of non-structural actions that a community might take in order to reduce flood risk. This pilot explored in detail how updating hydrology and associated inundation maps could improve community awareness of existing flood risk. At a minimum this understanding may allow for the community to take non-structural actions related to community planning and zoning to prevent new structures from being constructed in the newly designated floodplain boundary. Communities with a greater desire to take actions may explore additional non-structural measures such as dryproofing, wetproofing, structure elevation and/or structure relocation.

In order to evaluate the types and estimated costs associated with non-structural actions within the limited scope of this pilot study the Pilot Team selected the community of Charles City to conduct a proof of concept evaluation. Charles City was selected because it represents a community that had a moderate change in total damages and moderate change in percent a change of economic damages in Activity #4.

The 1993 Corps of Engineers Non-Structural publication titled *Flood Proofing How to Evaluate Your Options (USACE,1993)*, hereafter referred to as the 1993 Corps Nonstructural Flood Proofing report, states that “If a building is subject to flooding depths greater than 3 feet, elevating or relocating the structure are the most effective measures of flood proofing.” The Pilot Team identified those structures less than 3 feet of flooding depth, those between 3 and 8 feet of depth, and those greater than 8 feet of flood depth. Figure 19 displays the structures in Charles City based on these three estimated flood depth categories.

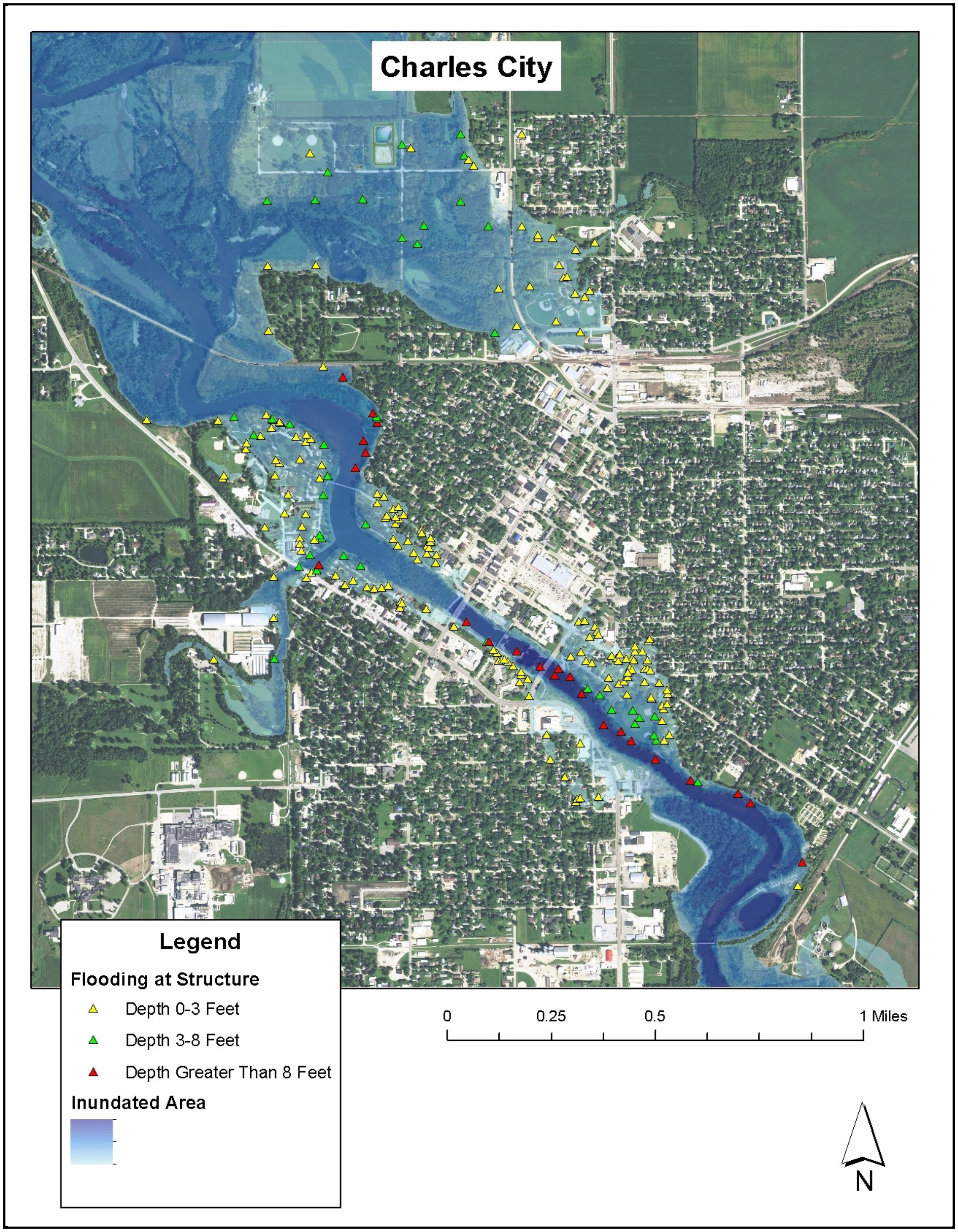

Figure 18: Map Depicting Structures With Flood Depths Less Than 3 Feet; 3 to 8 Feet; and Greater Than 8 Feet

A total of 204 structures within the floodplain in Charles City were identified based on the new hydrology. Approximately 120 of these structures have a 1-foot flood depth which could be mitigated with a small berm. Approximately 20 more structures have a flood depth of 2-3 feet which may be mitigated with berms or dry-proofing measures such as masonry walls. No quantitative cost evaluation was conducted as part of this pilot because it is believed that the largest costs associated with non-structural measures are related to structure elevations and relocations. In addition, the methodology used places residential points within the national land cover defined landuse categories but does not necessarily represent the spatial location of this particular residence. For these reasons the Pilot Team determined that there is more value in using the limited time and resources of this pilot project to explore a method for calculating rough order magnitude costs and benefits for elevating and/or relocating structures.

To estimate a rough order of costs to elevate or relocate the structures greater than 3-foot in height the type of building material and square footage of the structure were obtained from the HAZUS program. Appendix A of the 1993 Corps Non-Structural Flood Proofing Report provides flood proofing costs by area and structure type. These costs were adjusted from July 1993 price levels to January 2015 price levels. Information from Zillow and Trulia was obtained to determine an average home value per square foot. Costs were annualized over a 30-yr return period at a 3.375% Discount Rate. Benefits were based on the estimated damages resulting from the 10%, 2% and 1% annual exceedance probability events.

In order to conduct an economic assessment of the structures the Pilot Team had to make some assumptions based on the information provided in the cost tables located in Appendix A. The team assumed that all structures are in good or excellent condition. The Pilot Team made an assumption that all structures that are Masonry are too complex to relocate so these structures were determined to not be eligible for relocation but only for elevation. However, elevation of structures was limited to no more than 8 feet in height for wood or masonry structures. Based on these criteria 23 structures were determined to be ineligible for elevation or relocation. Of the original 204 structures in the floodplain there were 41 structures remaining that had flood heights between 3 and 8 feet and were able to be evaluated for elevation and/or relocation. One of these structures was eligible for elevation but not relocation due to the masonry structure type. Structures less than 3 feet were evaluated for elevation and relocation as well. Only four of the structures with flood depths less than 3 feet, only had a benefit-to-cost ratio (BCR) greater than 1:1 for elevation, and none of the structures had a BCR greater than 1:1 for relocation. These results further support the recommendation in the 1993 Corps Non-Structural Flood Proofing Report to evaluate structures greater than 3 feet for elevation and relocation.

Table 2 displays the estimated costs, benefits and BCR for elevating or relocating the 41 identified structures at risk of flooding.

Table 2: Table of Estimated Costs To Elevate or Relocate Structures With Flood Depths Between 3 and 8 Feet

Structure Name	Type of Construction	Estimated ft^2	Estimated Value/ft^2 [1]	Total Estimated Value	Elevation Req'd For 1% ACE Level of Protection (ft)	Avg Annual Damages (Benefits)	Elevation Annual Cost[2]	Elevation BCR	Avg Annual Damages (Benefits)	Relocation Annual Cost[2]	Relocation BCR
RES1-2SWB 19067 4635	Wood Frame	1060	$75.50	$80,000	4	$3,047	$2,964	1.03	$3,047	$3,556	0.86
RES1-1SWB 19067 4622	Wood Frame	1060	$75.50	$80,000	4	$3,226	$2,964	1.09	$3,226	$3,556	0.91
RES1-1SWB 19067 4619	Wood Frame	1060	$75.50	$80,000	4	$3,257	$2,964	1.10	$3,257	$3,556	0.92
RES1-1SWB 19067 4602	Wood Frame	1060	$75.50	$80,000	4	$2,853	$2,964	0.96	$2,853	$3,556	0.80
RES1-2SWB 19067 1513	Wood Frame	1020	$75.50	$77,000	4	$3,153	$2,867	1.10	$3,153	$3,437	0.92
RES1-1SNB 19067 3449	Wood Frame	1020	$75.50	$77,000	4	$3,276	$2,867	1.14	$3,276	$3,437	0.95
RES1-1SWB 19067 3450	Wood Frame	1020	$75.50	$77,000	4	$3,343	$2,867	1.17	$3,343	$3,437	0.97
RES3A 19067 3455	Wood Frame	2424	$75.50	$183,000	4	$8,909	$6,264	1.42	$8,909	$7,619	1.17
RES1-2SWB 19067 3453	Wood Frame	1020	$75.50	$77,000	4	$2,936	$2,867	1.02	$2,936	$3,437	0.85
RES1-2SWB 19067 2343	Wood Frame	1695	$75.50	$128,000	4	$4,661	$4,511	1.03	$4,661	$5,459	0.85
RES1-2SNB 19067 2222	Wood Frame	1695	$75.50	$128,000	4	$3,070	$4,511	0.68	$3,070	$5,459	0.56
RES1-2SWB 19067 2308	Wood Frame	1695	$75.50	$128,000	4	$4,889	$4,511	1.08	$4,889	$5,459	0.90
RES1-1SNB 19067 2285	Wood Frame	1695	$75.50	$128,000	4	$5,294	$4,511	1.17	$5,294	$5,459	0.97
RES1-2SNB 19067 2640	Wood Frame	1020	$75.50	$77,000	4	$2,041	$2,867	0.71	$2,041	$3,437	0.59
RES1-1SWB 19067 2288	Wood Frame	1695	$75.50	$128,000	4	$4,954	$4,511	1.10	$4,954	$5,459	0.91
RES1-2SWB 19067 1512	Wood Frame	1020	$75.50	$77,000	5	$3,180	$3,140	1.01	$3,180	$3,710	0.86
RES1-1SWB 19067 1509	Wood Frame	1020	$75.50	$77,000	5	$3,592	$3,140	1.14	$3,592	$3,710	0.97
RES1-1SWB 19067 3451	Wood Frame	1020	$75.50	$77,000	5	$3,516	$3,140	1.12	$3,516	$3,710	0.95
RES1-2SWB 19067 1475	Wood Frame	1020	$75.50	$77,000	5	$3,162	$3,140	1.01	$3,162	$3,710	0.85
RES1-1SWB 19067 1478	Wood Frame	1020	$75.50	$77,000	5	$3,404	$3,140	1.08	$3,404	$3,710	0.92
RES1-2SWB 19067 2300	Wood Frame	1695	$75.50	$128,000	5	$6,217	$4,848	1.28	$6,217	$5,796	1.07
RES1-2SWB 19067 2301	Wood Frame	1695	$75.50	$128,000	5	$5,567	$4,848	1.15	$5,567	$5,796	0.96
RES1-2SWB 19067 2309	Wood Frame	1695	$75.50	$128,000	5	$5,927	$4,848	1.22	$5,927	$5,796	1.02
RES5 19067 854	Wood Frame	32411	$75.50	$2,447,000	5	$119,730	$78,449	1.53	$119,730	$96,563	1.24
RES1-1SWB 19067 1472	Wood Frame	1020	$75.50	$77,000	6	$4,357	$3,461	1.26	$4,357	$4,031	1.08
RES1-1SNB 19067 1470	Wood Frame	1020	$75.50	$77,000	6	$3,866	$3,461	1.12	$3,866	$4,031	0.96
RES1-1SNB 19067 3889	Wood Frame	1020	$75.50	$77,000	6	$3,786	$3,461	1.09	$3,786	$4,031	0.94
RES1-1SWB 19067 2286	Wood Frame	1695	$75.50	$128,000	6	$6,833	$5,238	1.30	$6,833	$6,186	1.10
RES1-1SWB 19067 2290	Wood Frame	1695	$75.50	$128,000	6	$7,400	$5,238	1.41	$7,400	$6,186	1.20
RES1-SLNB 19067 2311	Wood Frame	1695	$75.50	$128,000	6	$5,545	$5,238	1.06	$5,545	$6,186	0.90
RES1-1SWB 19067 2671	Wood Frame	1695	$75.50	$128,000	6	$7,116	$5,238	1.36	$7,116	$6,186	1.15

Table 2: Table of Estimated Costs To Elevate or Relocate Structures With Flood Depths Between 3 and 8 Feet

Structure Name	Type of Construction	Estimated ft^2	Estimated Value/ft^2 [1]	Total Estimated Value	Elevation Req'd For 1% ACE Level of Protection (ft)	Avg Annual Damages (Benefits)	Elevation Annual Cost[2]	Elevation BCR	Avg Annual Damages (Benefits)	Relocation Annual Cost[2]	Relocation BCR
RES1-1SNB 19067 4616	Wood Frame	1060	$75.50	$80,000	7	$4,446	$3,946	1.13	$4,446	$4,538	0.98
RES1-2SWB 19067 4634	Wood Frame	1060	$75.50	$80,000	7	$4,744	$3,946	1.20	$4,744	$4,538	1.05
RES4 19067 4599	Wood Frame	8132	$75.50	$614,000	7	$15,635	$22,386	0.70	$15,635	$26,931	0.58
RES1-1SWB 19067 3893	Wood Frame	1020	$75.50	$77,000	7	$4,684	$3,835	1.22	$4,684	$4,405	1.06
RES1-2SNB 19067 2296	Wood Frame	1695	$75.50	$128,000	7	$4,975	$5,685	0.88	$4,975	$6,633	0.75
RES1-2SWB 19067 2305	Wood Frame	1695	$75.50	$128,000	7	$7,410	$5,685	1.30	$7,410	$6,633	1.12
RES1-2SWB 19067 7604	Wood Frame	1020	$75.50	$77,000	7	$4,072	$3,835	1.06	$4,072	$4,405	0.92
RES3B 19067 4639	Masonry	2344	$75.50	$177,000	8	$11,133	$11,405	0.98	$0	N/A	N/A
RES1-2SWB 19067 4595	Wood Frame	1060	$75.50	$80,000	8	$5,000	$4,382	1.14	$5,000	$4,974	1.01
RES1-2SNB 19067 4593	Wood Frame	1060	$75.50	$80,000	8	$3,283	$4,382	0.75	$3,283	$4,974	0.66
RES3B 19067 3456	Wood Frame	2291	$75.50	$173,000	8	$11,317	$7,852	1.44	$11,317	$9,133	1.24
					TOTAL	**$328,806**	**$272,379**	**1.21**	**$317,673**	**$312,820**	**1.02**

[1] Value per square foot is derived from averaging Zillow and Trulia real estate website per square foot data for Charles City and Floyd County, IA.

[2] Cost is based on the FY2015 Federal Discount Rate of 3.375 and a 30 year period of analysis. 30 years is the assumed life of a floodproofing measure for this document.

Note: This structure information is based on default National Structure Inventory/HAZUS data processed through HEC-FIA 3.0 software and is intended to represent an approximation of what actually exists. A more in-depth study (e.g.-feasibility) should be undertaken if a significant expenditure were being considered. Structures are assumed to be in good to excellent condition for relocation and elevation consideration.

Thirty-five of the 41 structures eligible for elevation and 12 of the 40 structures eligible for relocation were determined to have a BCR greater than 1:1 which is a metric that is often used to determine whether there is a Federal interest in a flood risk management action. Flood risk management actions often look at a systems approach so summing the total average annual damages and annual costs results in a 1.21 BCR to elevate all of the eligible structures and a 1.02 BCR to relocate all of the eligible structures.

This rough order of magnitude evaluation provides some insight to a community that they may wish to seek out state and Federal programs that may support flood mitigation actions that include the elevation and/or relocation of structures. Further information associated with the nonstructural evaluation for Charles City may be viewed in Appendix E.

VII. DISCUSSION AND CONCLUSIONS

The goal of this pilot was to better understand and communicate the effects of non-structural actions on community flooding and associated economic impacts. This pilot improved understanding of how climate and landuse changes may impact watershed hydrology and related flood risk. This pilot improved understanding of where less rigorous and quicker methods for evaluating flood risk may be applied for planning purposes. This included evaluating how less rigorous HEC-RAS and GIS-based hydraulic methods impact the estimated extent of inundation and depth of flow at varying locations along the Cedar River. This also included a related comparative evaluation of the difference in extent of inundation and depth of flow between the methods and whether these differences translate into notable differences in economic damages. The comparison between methods provided understanding on the level of accuracy of an approximate channel HEC-RAS hydraulic model and gave confidence to the Pilot Team to explore the economic impacts of differing flow rates associated with the changes in hydrology resulting from a longer period of record. This information has increased awareness of which communities on the Cedar River main stem may experience large changes in estimated economic damages both in terms of total damages and also the relative change in economic damages. This pilot identified a community that had moderate flood risk based on both total damage and percent change in damages and identified non-structural measures that may be taken by communities in order to improve understanding of the tools they have available for decision making. This report and the forthcoming presentations to various interagency forums will communicate the results of this pilot effort and help communities understand how they may do a meaningful non-structural evaluation with a relatively small budget.

This effort included development of a planning level hydraulic model (approximate channel HEC-RAS model) and non structural measures analysis that a multi-disciplinary team could utilize to rapidly assess flood risk for multiple communities within a watershed or river-shed boundary and identify the types of non-structural actions that may be applicable to these communities. This Pilot Team was successful in developing and applying a planning level hydraulic model in order to evaluate the impacts of changes in hydrology on estimated economic damages. A method to calculate rough order of magnitude of economic benefits for elevating and/or relocating structures was developed for a community determined to have a moderate flood risk based on the change in total damages and the percent change of damages resulting from updated hydrology information. This approach is relevant to every stream in the United States as they will all experience changes in hydrology over time and this change will impact those structures that are located along that stream reach.

A. Hydrology and Hydraulics

Hydrology. The use of the #17B methodology within the HEC-SSP software was used based on input data from USGS without scrutinizing the results in order to facilitate a quick analysis. This approach is an appropriate method for statistically updating the hydrology at designated gauge locations throughout a watershed. Comparison of the #17B data with published FIS data allows for an understanding of how stream flows may have changed since the most recent report was published due to outdated hydrology in the recently published version.

Applying a simplified statistical model in the Cedar River Basin uncovered that landuse changes may be decreasing flow during periods of low precipitation (drought) but during periods of high precipitation the interaction term nears zero so precipitation is driving the change in the flow rate for less probable events such as the 1% probability event (100-yr).

Hydraulics. A planning level hydraulic model, known to practitioners as an approximate channel method hydraulic model, was developed for a large river main stem (338 miles) in a relatively short period of time, at a low cost, and produced reasonable results. This hydraulic modeling approach primarily modified the Manning's 'n' value to compensate for the lack of channel data. This approach compared the rating curves from USGS gauges to computed HEC-RAS rating curves at the same location. The manning 'n' values were modified in HEC-RAS to approximate the USGS rating curves which are based on observed flows. Comparison of the approximate channel hydraulic model with a detailed hydraulic model identified that the approximate channel HEC-RAS hydraulic model is often over or under estimating depths at locations with complex hydraulic conditions such as bridge approaches and areas of split flow. The Pilot Team believes that the results from this model may be improved by taking simple actions such as adding in bridge sections and obtaining limited cross-section data where dams or other complex stream conditions exist.

The approximate channel hydraulic model was appropriate for use in evaluating damages at a community level and provided a comparative analysis of how flood risk may have changed in a given community over the past 30 years and/or how flood risk may change over the next 30 to 50 years. Tools such as the approximate channel hydraulic model that may over-estimate flood depths may be useful in supporting community resiliency activities such as planning and zoning. However, over-estimating depths may be a challenge for structural activities which may require a BCR to support project feasibility. The economic evaluation will discuss further how that methodology could be improved to account for uncertainty in the hydraulic model derived depth grids.

B. Economics. The 2012 Silver Jackets pilot titled *Floodplain Management and Risk Communication in the Iowa Cedar Basin* (Smith et al, 2013) explored a method of using published Flood Insurance Rate Map (FIRM) products along with the FEMA HAZUS software to estimate flood risk throughout the Iowa and Cedar River Basins. This pilot documented the challenges of estimating flood risk because of issues with a sloped water surface and an area weighted average method for calculating damages within census blocks. Due to these limitations, this pilot opted to develop an approximate channel HEC-RAS model to generate depth grids and looked to the HEC-FIA program to estimate damages by the depth of flow on the given structure versus an area weighted average method common to HAZUS.

This methodology has limitation due to the lack of accurate spatial placement of the structure type on the landscape but provides a marked improvement from the census block approach used in the 2012 Silver Jackets pilot. Use of this methodology helped to identify communities that have notable changes in flood risk (structure damage potential) both in terms of total damages and also the percentage change. Future efforts may be improved by taking time to hand digitize each structure point in a community based on plot maps or to obtain this information from the city or county assessor's office if they have digitized structures within their boundaries. This pilot also explored some GIS-based methods to estimate floodplain extent which proved to be fairly accurate when compared to the detailed hydraulic model in the comparison area. However, these GIS-based methods are unable to generate a new inundation based on changes in stream flow which limits their effectiveness in estimating community flood risk due to changes in hydrology.

Results from this pilot identify that flood risk associated with estimated economic damages in the Cedar River Basin are approximately 20% greater than that represented in the latest published flood insurance studies and corresponding flood insurance rate maps for the 1% ACE. Results from this pilot uncover that some communities are more vulnerable to economic damages due to changes in hydrology and corresponding streamflow.

Results support the 2012 Silver Jackets conclusions that some of the smallest communities in the watershed have high flood risk on a percentage or per capita basis although their potential damages are relatively small compared to large urban centers. Use of the information developed in this pilot allows for flood mitigation agencies and entities to utilize a two-pronged approach of addressing large urban centers to reduce overall flood damages and also to engage small communities in an effort to reduce the growing flood risk in these communities.

C. Non-Structural Measures. The 1993 Corps Non-Structural Flood Proofing Report provided a wealth of information for an individual or community to estimate the costs of elevating or relocating homes to reduce flood damages. This Pilot Team utilized this information along with automated economics data and spreadsheet tools to estimate the costs and benefits of elevating and relocating structures in a designated community. This exercise was conducted as a proof of concept for the methodology. This methodology may help communities better understand what non-structural actions they may seek state and/or Federal support and which are a sole local responsibility. This effort did not seek to identify measures that would address flood mitigation for flood depths less than 3 feet. This is due in part to the limited time involved in a pilot effort and also due to the limitations of the accuracy of the structure data which is important when identifying berms and walls which require understanding of the physical conditions in order to estimate quantities. These criteria are also important for elevation and relocation but because the structures are randomly placed with the NLCD "developed" area it is assumed that there will be an equal over and under estimation of the flood depth such that the values are a good estimate of the costs and benefits.

The method demonstrated that a multi-disciplinary team can quickly and effectively evaluate non-structural measures including: landuse planning, zoning, structure elevation, and structure relocation for a community based on information that was generated at a watershed or river shed scale. This builds the case for the value in developing large regional systems based models which may provide value to state and local governments in long-term reductions in flood risk.

VIII. LESSONS LEARNED

This pilot determined that a planning level hydraulic model may be developed at a fraction of the costs of a detailed hydraulic model and may provide a reasonable level of accuracy for estimating economic damages at a community level. The Pilot Team learned that the hydraulic model may be improved with a minor investment related to incorporating bridge cross-section information. The Pilot Team explored use of GIS-based methods to estimate the inundation extent but this technique was limited in effectiveness due to the inability to account for changes in stream flow.

This pilot explored how landuse change may be impacting how hydrology is changing in the basin. The Pilot Team learned that landuse change may be having a larger impact during periods of low precipitation (drought) but landuse has a limited to negligible effect on flow during periods of high precipitation.

The Pilot Team confirmed the 2012 Silver Jackets conclusion that some smaller communities may have equal to or greater flood risk than large communities based on the percent change they are experiencing. Flood risk is increasing in the Cedar River Basin in terms of both total value and also the percent change in a community.

The Pilot Team learned that each of the structures may be evaluated for non-structural measures at a community level. These evaluations may be based on laying out berms and walls for structures experiencing flooding less than 3-foot or may include elevations and relocations for those structures experiencing between 3 and 8 feet of flood depth. The elevation and relocation methods are consistent with the Federal standard for estimating average annual costs and benefits and may serve as a valuable tool for helping communities understand where they may be able to receive state and/or Federal aid to reduce their flood risk in partnership with local planning and zoning activities to keep future structures out of harm’s way.

IX. REFERENCES

Smith, J; M. Dougherty; C. Hawes; H. Millway; B. Romic; B. Kamp. *Floodplain Management and Communication of Risk in the Iowa-Cedar Watershed Basin*. Iowa Silver Jackets Pilot Project Report, 2013.

Villarini, G., and A. Strong. *Roles of climate and agricultural practices in discharge changes in an agricultural watershed in Iowa*. Agriculture, Ecosystems and Environment, 2014 (in press).

U.S. Department of the Army, Army Corps of Engineers, National Flood Proofing Committee. *Flood Proofing - How to Evaluate Your Options.*1993.

Non-Structural Landuse Change Impacts on Structure Losses in Cedar River Communities

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APPENDIX A

HYDROLOGIC ASSESSMENT GAGES

Flow Frequency Update

Scope. Streamflow records from various U.S. Geological Survey stream gages throughout the Cedar River Basin were examined to determine flow frequency values. These values were then compared to the most recently published Flood Insurance Study (FIS) flows to assess how updating the period of record may affect event frequency. The USGS gage locations are shown in Figure 1: Map of the Cedar River Basin.

Procedure. Annual peak flow data for each gage was retrieved from the USGS website. Data was screened for abnormalities and entered into the Hydrologic Engineering Center's Statistical Software Package (HEC-SSP, Version 2.0) for analysis. Statistical analyses were performed within HEC-SSP, applying a Log-Pearson Type III Distribution as recommended by Bulletin #17B guidelines (USDOT, 1981). A weighted skew was adopted utilizing the station skew and regional skews ranging from -0.15 to -0.40 with a 0.145 mean square error (Figure A-1).

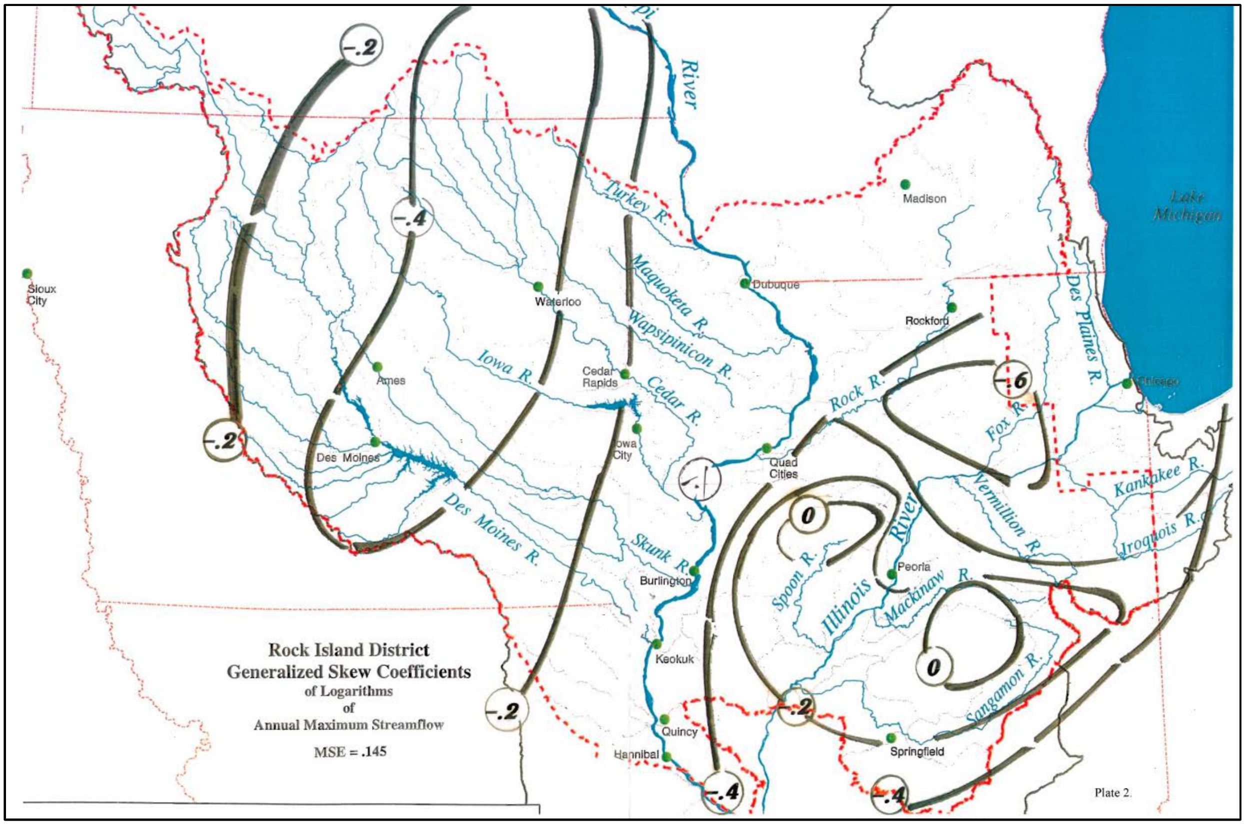

Figure A-1: Rock Island District Generalized Skew Coefficients

Results. A summary of the flow frequencies for the Cedar River main stem and tributary gage stations are shown in Table A-1. For all frequency events and gages the FIS frequency flows are typically lower (by 3 to 42%) than the newly computed frequency flows. This is likely due to a general increase in peak annual flows that have occurred within recent years. By appending the period of record to include these events, an increase in frequency flows is realized.

REFERENCES

The data collection date are shown for the following Iowa counties: Benton 2008, 2010, Blackhawk 2008, 2010, Bremer 2009, Cedar 2009, 2010, Chickasaw 2009, Floyd 2009, Johnson 2009, Linn 2008-2010, Louisa 2010, Mitchell 2008, 2009, Muscatine 2009, 2010.

Hydraulic and Hydrology References and Period of Record

FEMA FIS Studies (various, counties: Mower, MN 2013, Floyd 2008, Chickasaw 2012, Bremer 2008, Blackhawk 2011, Linn 2010, Johnson 2007, Muscatine 2014, Louisa 2015).

Mower, MN FIS 2013	FIS [Bulletin 17B USGS gage near Austin, MN data 1910 thru 1983] **USACE FFA: Austin, MN 1909 thru 2012**
Floyd FIS 2008	FIS [Bulletin 17B USGS Charles City gage data 1964 thru 1976]
FIS 2015	FIS [Bulletin 17B USGS Charles City gage data 1964 thru 2008] **USACE FFA: Charles City 1946 thru 2012**
Chickasaw FIS 2012	FIS [Bulletin 17B USGS Charles City data 1964 thru 1976 and Janesville gage data 1905 thru 1960] **USACE FFA: Janesville 1905 thru 2012**
Bremer FIS 2008	FIS [Bulletin 17B USGS Janesville gage data 1905 thru 1970] **USACE FFA: Janesville 1905 thru 2012**
Blackhawk FIS 2011	FIS [The discharges values for the Cedar River and West Fork Cedar River were taken from the Cedar River study (Reference 18, 1980), which revised the former discharge values in the 1970 flood plain study (Reference 19).] **USACE FFA: Waterloo 1929 thru 2012 & Cedar Rapids 1903 thru 2012**
Linn FIS 2010	FIS [Figure 4 of USGS Bulletin 11 dated 1973] **USACE FFA: Cedar Rapids 1903 thru 2012**
Johnson FIS 2007	FIS [Figure 4 of USGS Bulletin 11 dated 1973]
Muscatine FIS 2014	FIS [Bulletin 17B USGS Conesville gage data 1929 thru 1982] **USACE FFA: Conesville 1940 thru 2012**
Louisa FIS 2015	FIS [Bulletin 17B USGS Conesville gage data 1929 thru 1982] **USACE FFA: Conesville 1940 thru 2012**

Table A-1: Cedar River and Tributaries Period of Record Flow Frequency Analysis. [USGS Gage Station Summary & HEC-SSP (Statistical Software Package) Version 2.0 Results]

											Percent Chance Exceedance Flows (cfs)											
	USGS Gage #	**River Gage**	**Station Name**	**Period of Record (Yrs)**	**Area (sq.mi)**	**Mean**	**Skew**	**Std. Dev.**	**Record Start**	**Record End**	**0.2 (500-yr)**	**0.5 (200-yr)**	**1 (100-yr)**	**2 (50-yr)**	**5 (20-yr)**	**10 (10-yr)**	**20 (5-yr)**	**50 (2-yr)**	**80 (1.25-yr)**	**90 (1.11-yr)**	**95 (1.05-yr)**	**99 (1.01-yr)**
Cedar River Mainstem	05457000	ANSM5	Cedar River near Austin, MN	73	399	4,284	-0.48	0.320	1909	2012	22,162	19,404	17,275	15,110	12,188	9,924	7,593	4,284	2,225	1,527	1,099	566
	05457500	----	Cedar River at Mitchell, IA	11	826	11,084	-0.12	0.145	1934	1962	27,450	25,081	23,260	21,402	18,857	16,820	14,612	11,084	8,330	7,148	6,287	4,917
	05457700	CCYI4	Cedar River at Charles City, IA	58	1,054	9,171	-0.42	0.301	1946	2012	45,461	39,735	35,359	30,944	25,034	20,485	15,816	9,171	4,967	3,504	2,588	1,412
	05458300	WVLI4	Cedar River at Waverly, IA	12	1,547	11,314	-0.26	0.378	2001	2012	101,813	83,061	69,892	57,596	42,672	32,368	22,871	11,314	5,308	3,498	2,450	1,222
	05458500	JANI4	Cedar River at Janesville, IA	93	1,661	10,193	-0.37	0.327	1905	2012	60,644	51,965	45,496	39,115	30,821	24,643	18,507	10,193	5,455	3,617	2,619	1,379
	05464000	ALOI4	Cedar River at Waterloo, IA	74	5,146	24,346	-0.46	0.334	1929	2012	137,290	119,221	105,406	91,483	72,918	58,732	44,332	24,346	12,292	8,305	5,898	2,963
	05464500	CIDI4	Cedar River at Cedar Rapids, IA	110	6,510	24,865	-0.33	0.289	1903	2012	125,277	108,475	95,900	83,436	67,093	54,761	42,307	24,865	13,883	10,024	7,576	4,359
	05465000	CNEI4	Cedar River near Conesville, IA	73	7,787	28,251	-0.36	0.282	1940	2012	133,315	116,389	103,578	90,746	73,704	60,663	47,312	28,251	15,975	11,595	8,795	5,085
Tributaries	05459500	----	Winnebago River at Mason City, Iowa	80	526	3,284	-0.18	0.282	1933	2012	18,126	15,365	13,374	11,463	9,049	7,297	5,587	3,284	1,879	1,388	1,074	656
	05462000	----	Shell Rock River at Shell Rock, IA	59	1,746	8,783	-0.32	0.352	1954	2012	63,198	52,995	45,587	38,457	29,469	22,999	16,789	8,783	4,319	2,906	2,067	1,055
	05458900	----	West Fork Cedar River at Finchford, IA	67	846	5,359	-0.50	0.413	1929	1946	43,364	36,721	31,733	26,804	20,421	15,727	11,174	5,359	2,299	1,410	919	387
	05463000	----	Beaver Creek at New Hartford, IA	67	347	3,863	-0.49	0.415	1946	2012	31,991	27,017	23,296	19,631	14,904	11,445	8,104	3,863	1,648	1,009	656	275
	05463500	----	Black Hawk Creek at Hudson, IA	55	303	2,952	-0.32	0.434	1952	2012	34,009	27,318	22,655	18,341	13,183	9,698	6,570	2,952	1,231	756	497	218
	05464145	----	Twelve Mile Creek near Traer, IA	27	43.8	896	-0.08	0.346	1966	1992	8,122	6,495	5,393	4,395	3,224	2,442	1,737	896	455	318	235	133
	05464220	----	Wolf Creek near Dysart, IA	14	299	3,322	-0.28	0.427	1996	2012	38,747	30,942	25,556	20,614	14,759	10,837	7,342	3,322	1,409	876	584	563
	05464942	----	Hoover Creek, Hoover Nat'l Hist. Site, W. Branch IA	11	2.58	138	0.10	0.439	1967	2011	2,901	2,078	1,582	1,177	759	517	326	138	60	39	27	14

Non-Structural Landuse Change Impacts on Structure Losses in Cedar River Communities

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APPENDIX B

HYDROLOGIC ASSESSMENT
STATISTICAL LANDUSE ASSESSMENT

Detection and Attribution of Changes in Cedar River Streamflow

This effort followed the methodology laid out by Villarini and Strong in their 2014 publication. The following data and information is provided in a bullet format to provide the most minimal context/explanation to the inputs and results from this evaluation.

I. Data

- A. Streamflow
  - 1. Daily streamflow data from USGS gauge sites
  - 2. Analysis of peak discharge considered annual maximum daily average value (not instantaneous peak discharge)
- B. Precipitation. Daily total precipitation from NWS co-op gauges
  - 1. Sourced from Iowa Environmental Mesonet
  - 2. Full period of record was obtained for overall trend analysis, but for modeling the overlapping crop-rainfall record was used.
- C. Land Use. Using row crop harvest acreage as a proxy for land use/land cover
  - 1. Sourced from USDA NASS QuickStats
  - 2. Totals for annual acreage of harvested corn and soybeans by county
    - a. Percent of each county that fell within basin was used to compute weighted total acreage; e.g. 70% of county A is in basin, 1M acres of row crops harvested in 2010, 700k ac added to basin's total
  - 3. Used in the model to estimate the extent of the basin that has cumulatively been converted from natural vegetation to row crop
  - 4. Total acreage is lumped together at the basin level by year
  - 5. Record length varies by county
  - 6. Does not account for conservation practices explicitly
    - a. Resulting sensitivity will report the net impact of agriculture
    - b. Conservation acreage is much smaller than row crop acreage

II. Model

- A. Generalized Additive Models for Location, Scale and Shape
  - 1. Gamma distribution
    - a. Parameterization
      - i. Location
      - ii. Scale
- B. Use In Attributing Changes in Flow

III. Results

- A. Observed Trends
  - 1. Streamflow
    - a. Positive slope in trend line for annual maximum discharge
    - b. 2008 outlier event pulls the line up
  - 2. Precipitation
    - a. Positive slope in trend line for annual total precipitation
      - i. 1993 event is largest but still 20 years from end of record, not necessarily driving the slope
      - ii. Above-average precipitation years occurring more often than below-average
      - iii. Interannual variability is very high (wet years back to back with dry years)
    - b. Positive slope in trend line for rainy season seasonal precipitation (spring/summer)
    - c. Back-to-back wet spring/wet summer becoming more common
      - i. Higher, more positive correlation between spring and summer precipitation totals
  - 3. Land Use
    - a. Agricultural land use is dominated by row crops, primarily corn and soybeans in the Cedar basin
    - b. Row crop intensity has leveled off since the rapid expansion of the 1950s and 1960s (hitting a saturation level, running out of farmable space)
    - c. CRP specifically makes up a relatively small amount of acreage; program only started in the mid/late 1980s
      - i. Total CRP acreage has declined from the peak in the mid-1990s, but remains relatively steady
- B. Peak Streamflow
- C. All Quantiles of Flow at Cedar Rapids, IA
  - 1. Coefficient estimates change for rainfall and interaction with changes in quantile
  - 2. The coefficient indicates the amount of influence of the variable (and offers a test of significance)
  - 3. Coefficients describe the effect of the variable on both the overall trend and the change in variability
  - 4. Largest flow events are driven primarily by changing rainfall
  - 5. Land use has a synergizing effect on flows lower than maximum
    - a. Brings lower flows down
    - b. Increases higher flows

IV. Discussion

- A. Interpretation of Results
- B. Limitations/Caveats
  - 1. Basin-level lumped totals
  - 2. Annual precipitation used to estimate flows
  - 3. Land use described only by acreage
- C. Further Investigation

V. Figures

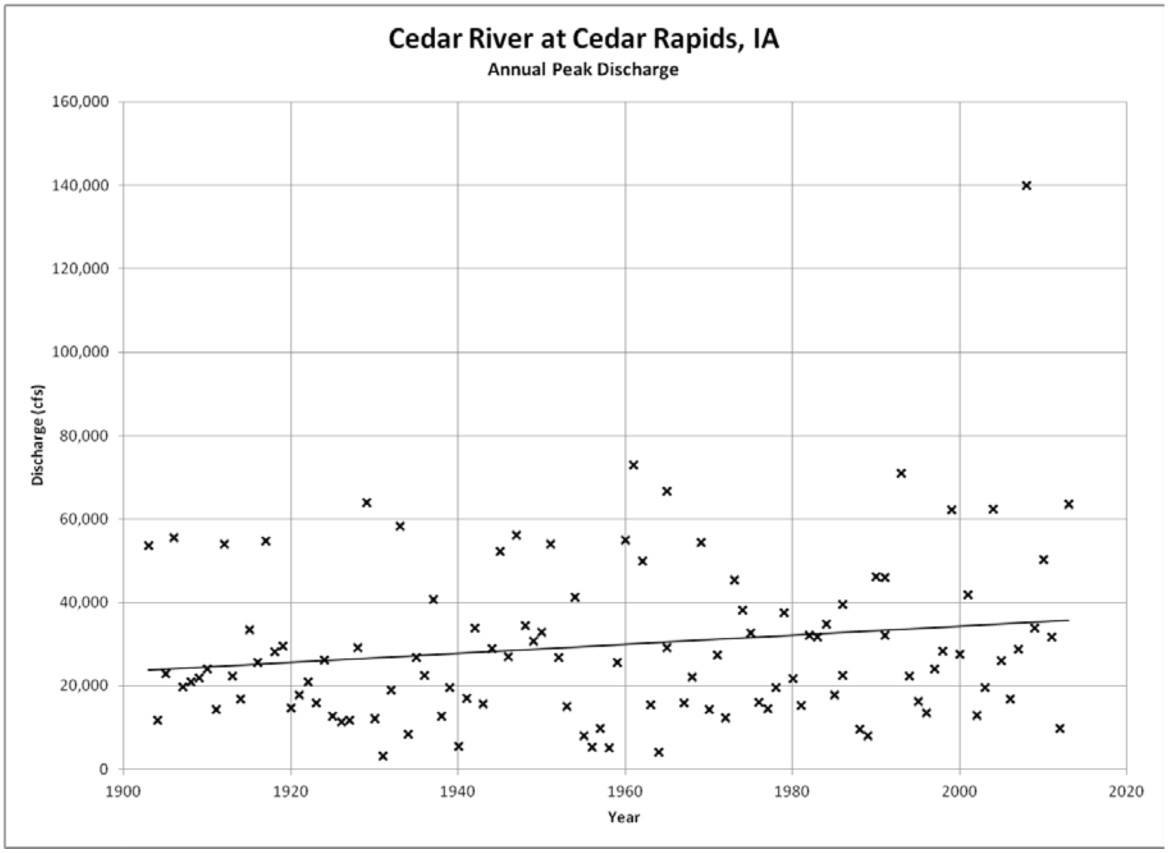

Figure B-1: Multi-decadal Annual Peak Discharge Trend for Cedar Rapids, IA

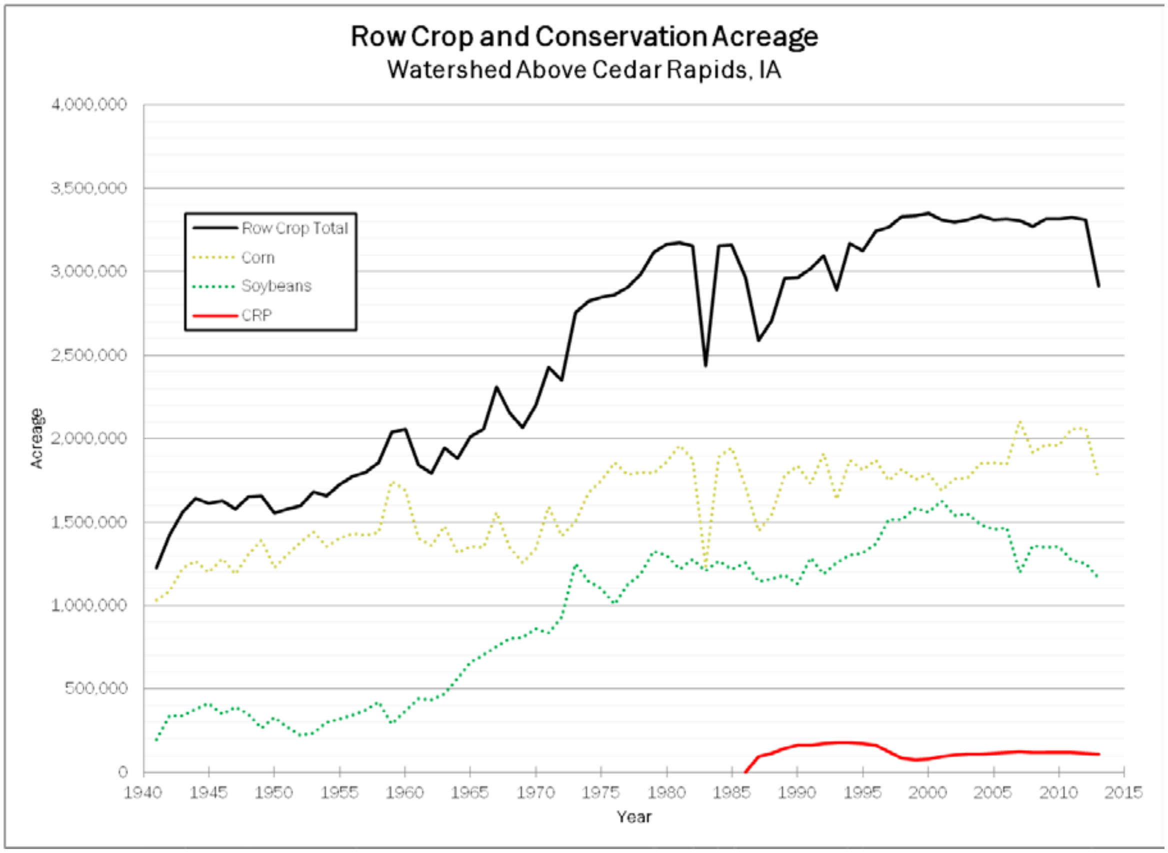

Figure B-2: Multi-decadal Landuse Trends for Portion of Watershed Above Cedar Rapids, IA

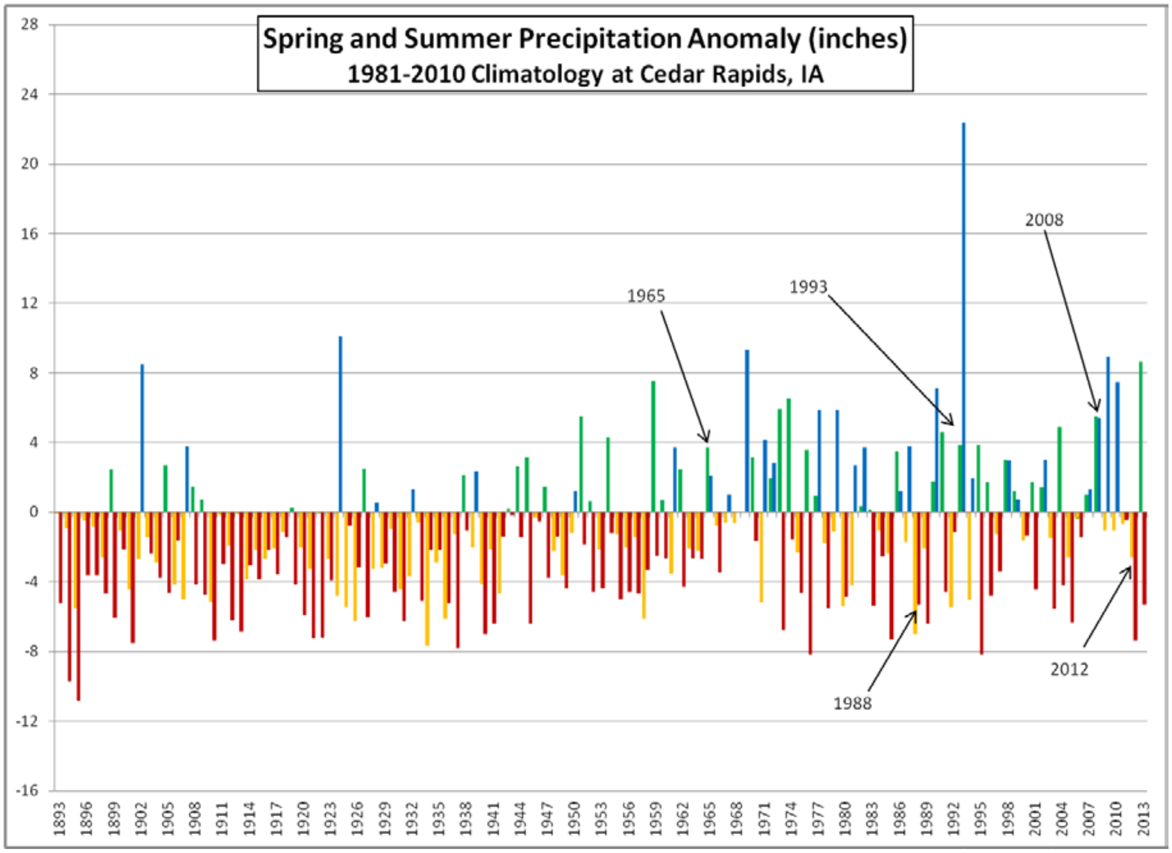

Figure B-3: Spring and Summer Precipitation Anomaly Showing Wet Years Back-to Back With Dry Years

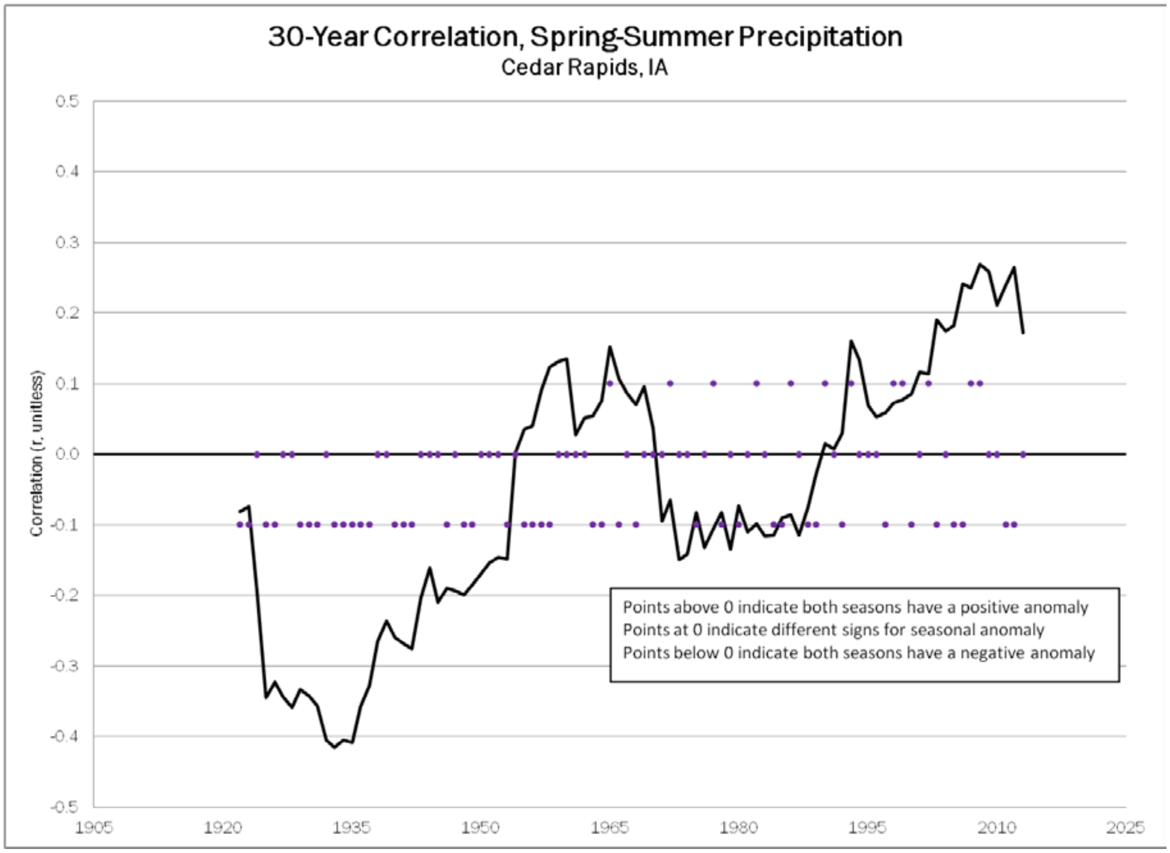

Figure B-4: Spring and Summer Precipitation Correlation

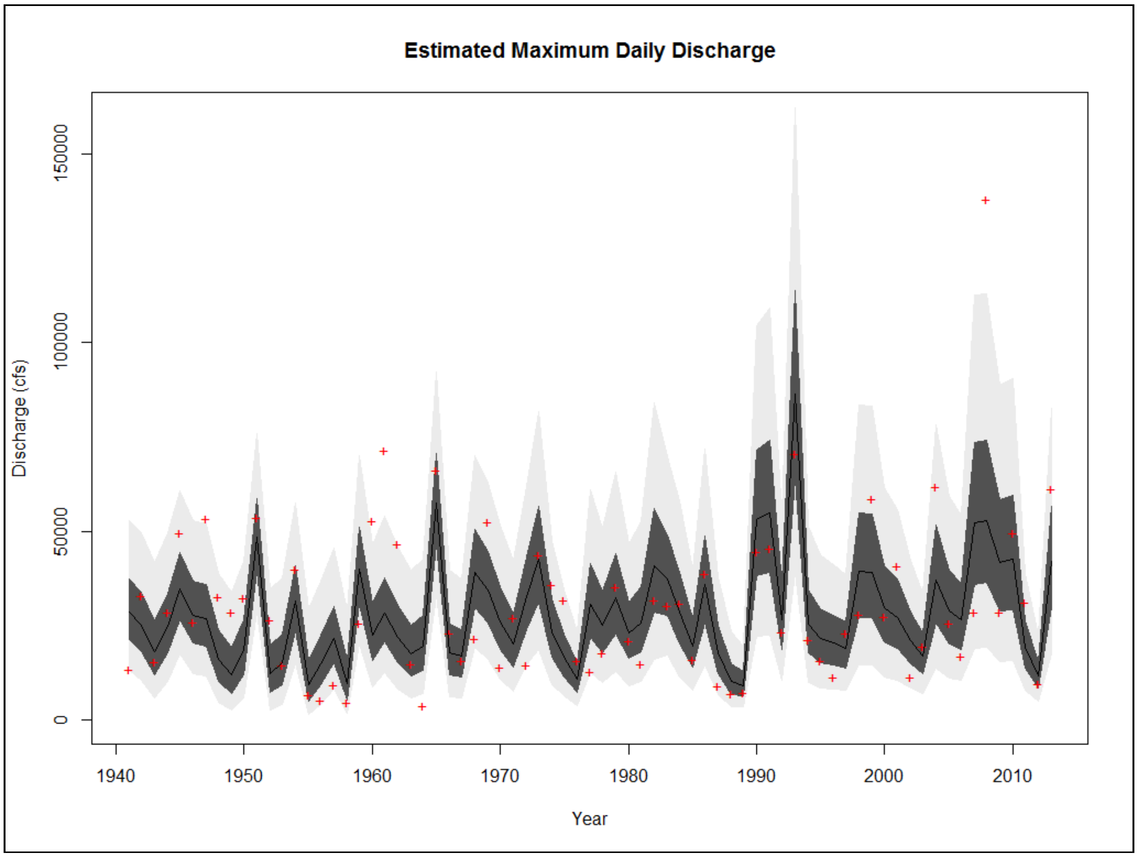

Figure B-5: Estimated Maximum Daily Discharge Along with 10% and 90% Confidence Intervals

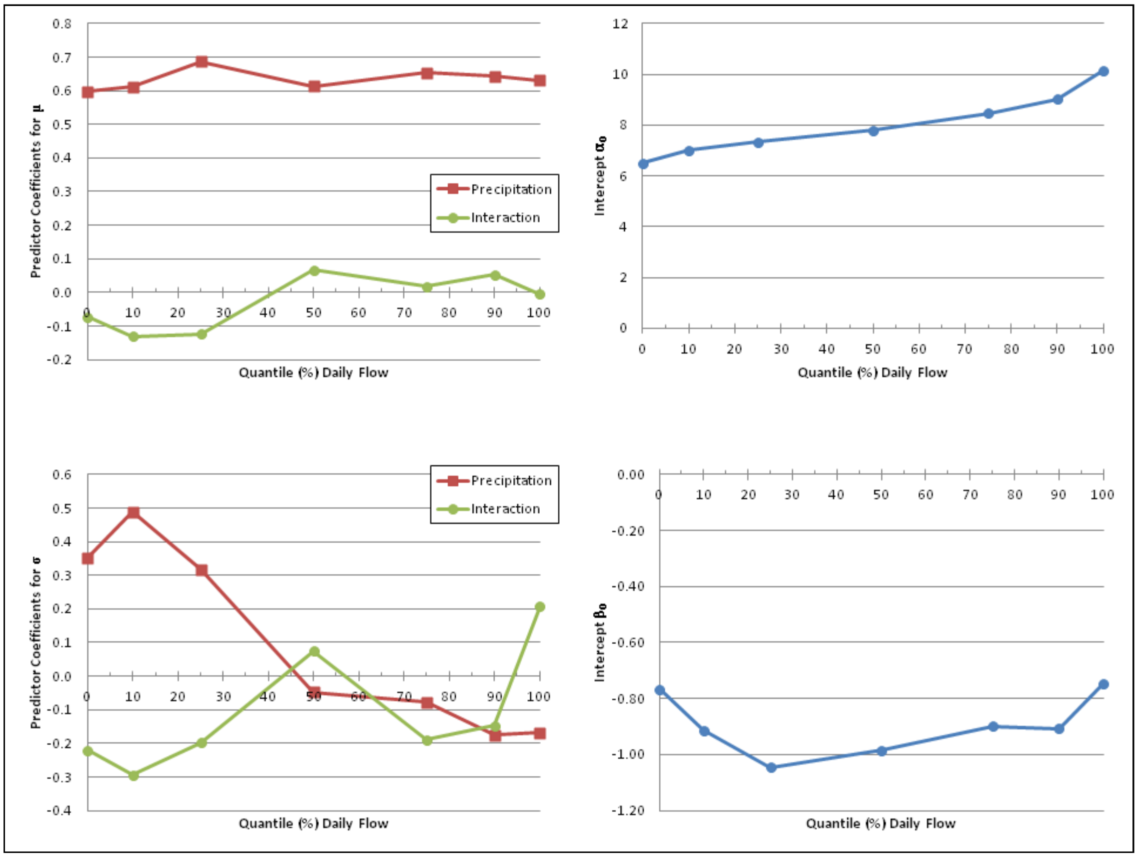

Figure B-6: Coefficient Estimates for Rainfall and Interaction with Changes in Quantile

REFERENCES

Villarini, G., and A. Strong, Roles of climate and agricultural practices in discharge changes in an agricultural watershed in Iowa, Agriculture, Ecosystems and Environment, 2014 (in press).

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https://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css

Non-Structural Landuse Change Impacts on Structure Losses in Cedar River Communities

An Iowa Silver Jackets Non-Structural Flood Risk Management Study

APPENDIX C

HYDRAULICS METHODS

C1 - Flood Insurance Study Flow Profile Methodology
C2 - Comparative Analysis between Floodplain Inundation Methods
C3 - Economic Results of Inundation Comparison

C1 - FLOOD INSURANCE STUDY FLOW PROFILE METHODOLOGY

Scope. Several methods to estimate inundation extents and depths were developed in order to approximate damages during various flood events. Flood Insurance Study (FIS) profiles were utilized to assign water surface elevations throughout the basin and develop depth grids. However, the FIS profiles did not extend continuously throughout the basin, but were focused around municipalities and other areas of interest. To remedy this situation, a method was developed to create continuous profiles from the headwaters to the mouth for the 10%, 2% and 1% chance exceedance events.

Procedure & Results. Published FIS water surface elevation values were compiled, geo-referenced and plotted resulting in approximately 135 total miles of missing data (Figure C-1). The largest gap consisted of a 48 mile reach. To populate these gaps, water surface profiles from the Iowa Highway Research Board were consulted to determine typical slopes throughout these reaches (IHRB, 1963).

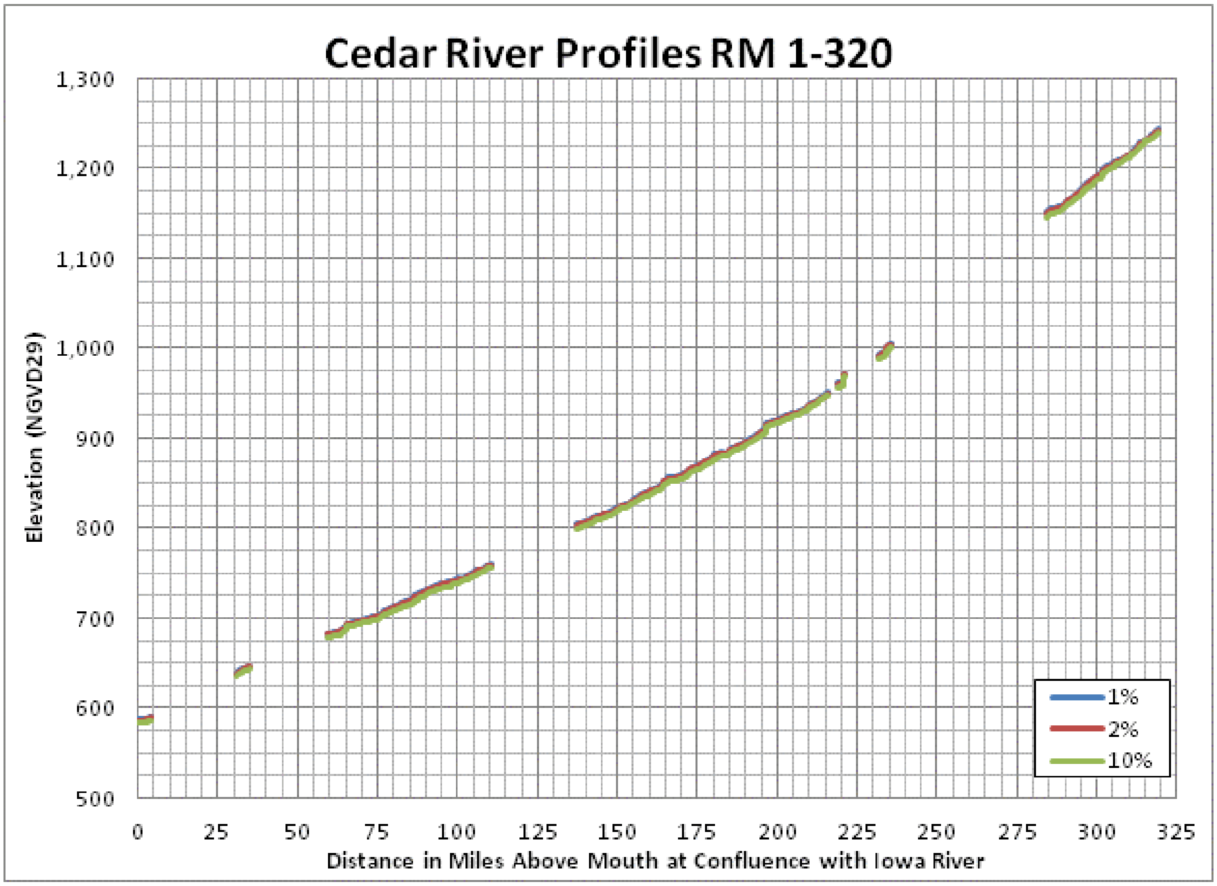

Figure C-1: Available FIS Profile Areas (all items in legends are Annual Chance Exceedance)

Iowa Highway Research Board profiles were then shifted up or down to fill the gaps in the FIS data as illustrated in Figure C-2. Using this method, a continuous profile was generated along the entire Cedar River for the 10%, 2% and 1% chance exceedance events (Figures C-3 through C-9 and Table C-1).

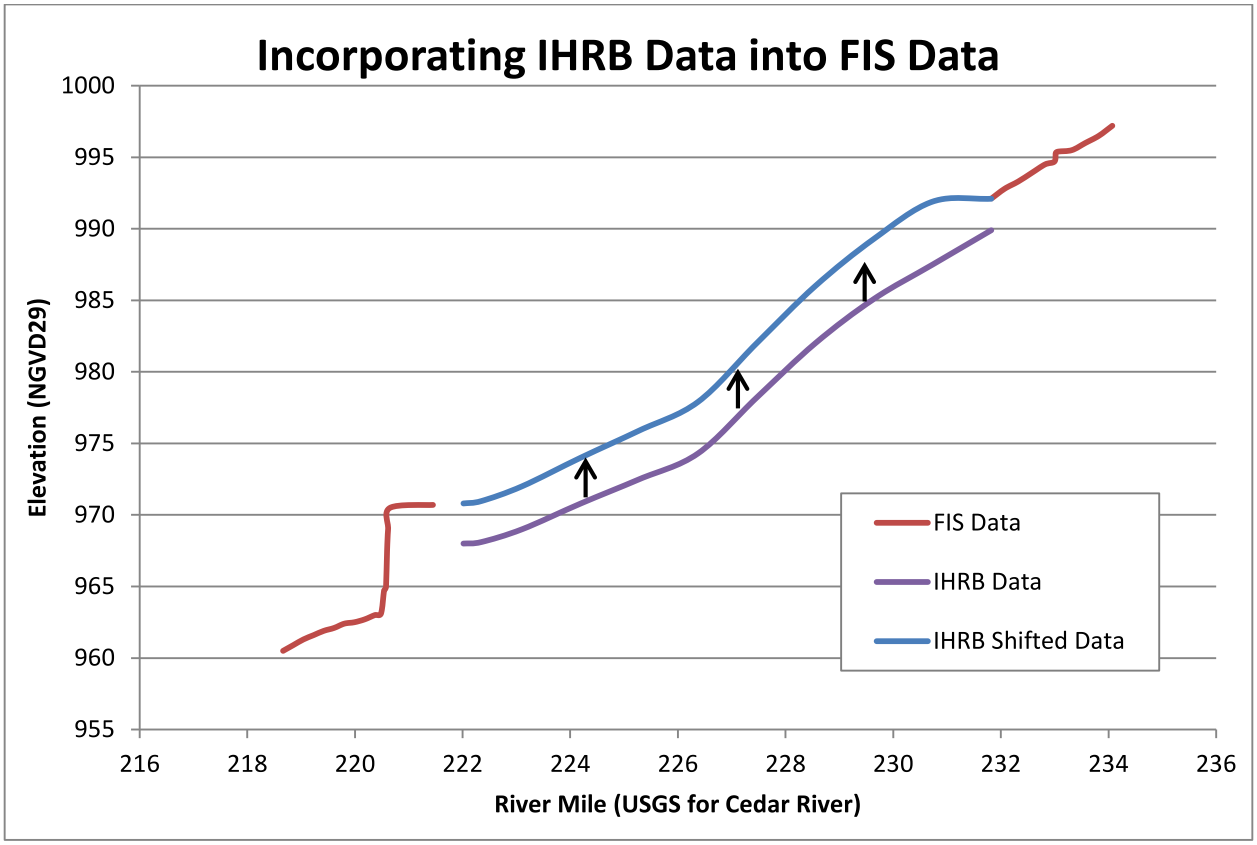

Figure C-2: Incorporating IHRB Data into FIS Data

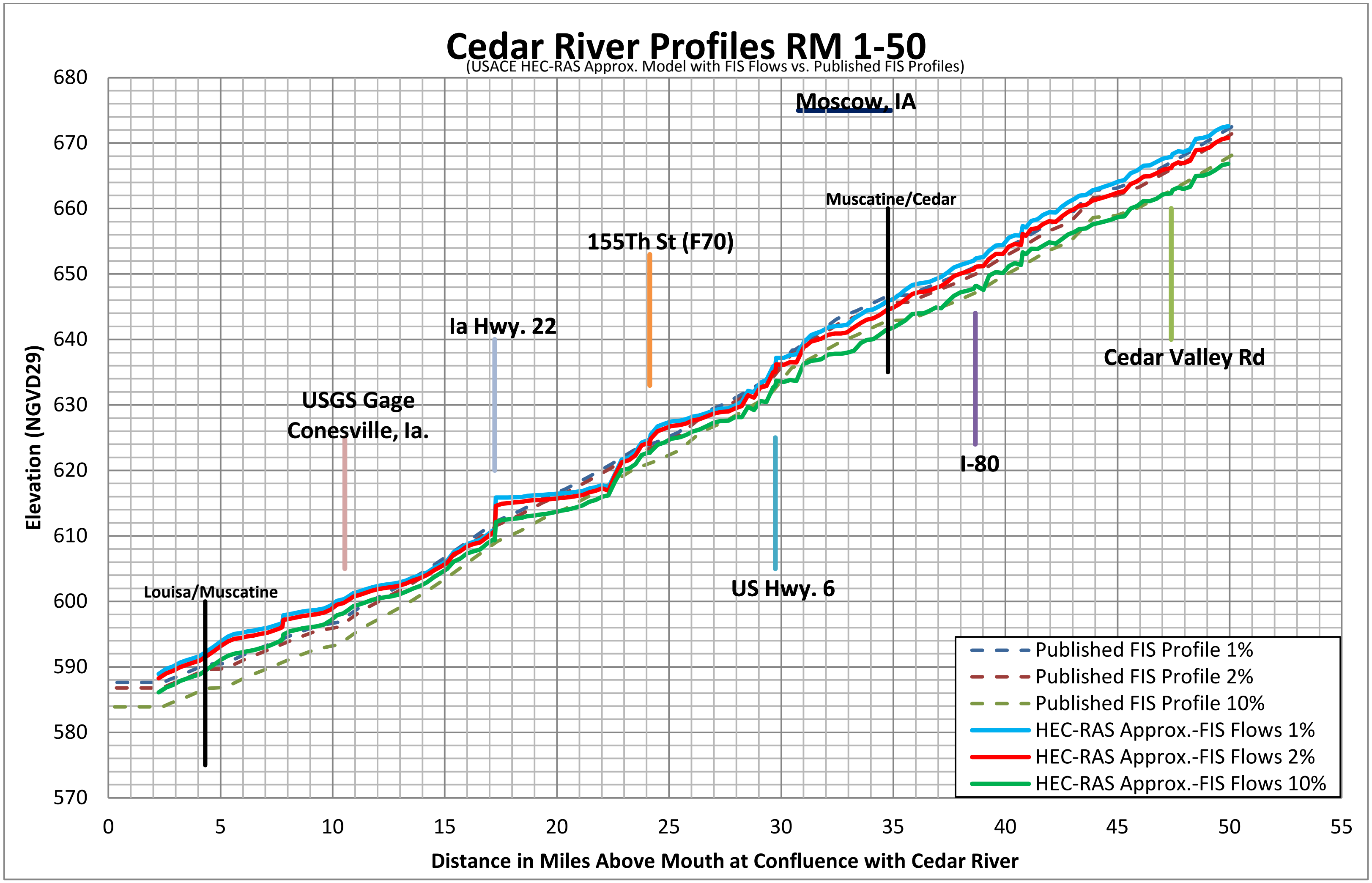

Figure C-3: Cedar River Continuous Profile for HEC-RAS Approx Model with FIS Flows vs. Published FIS Profiles: RM 1-50

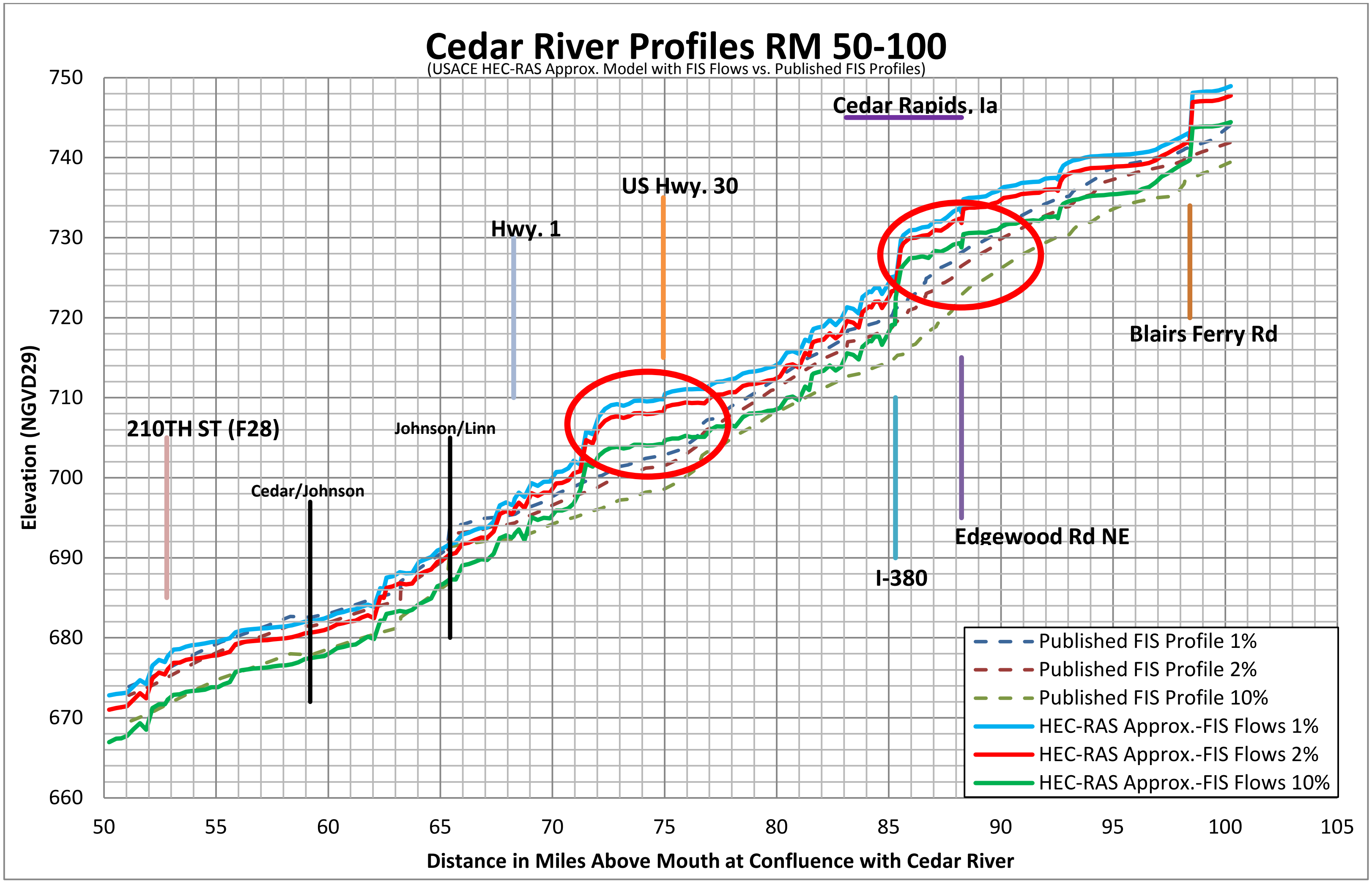

Figure C-4: Cedar River Continuous Profile for HEC-RAS Approx Model with FIS Flows vs. Published FIS Profiles: RM 50-100

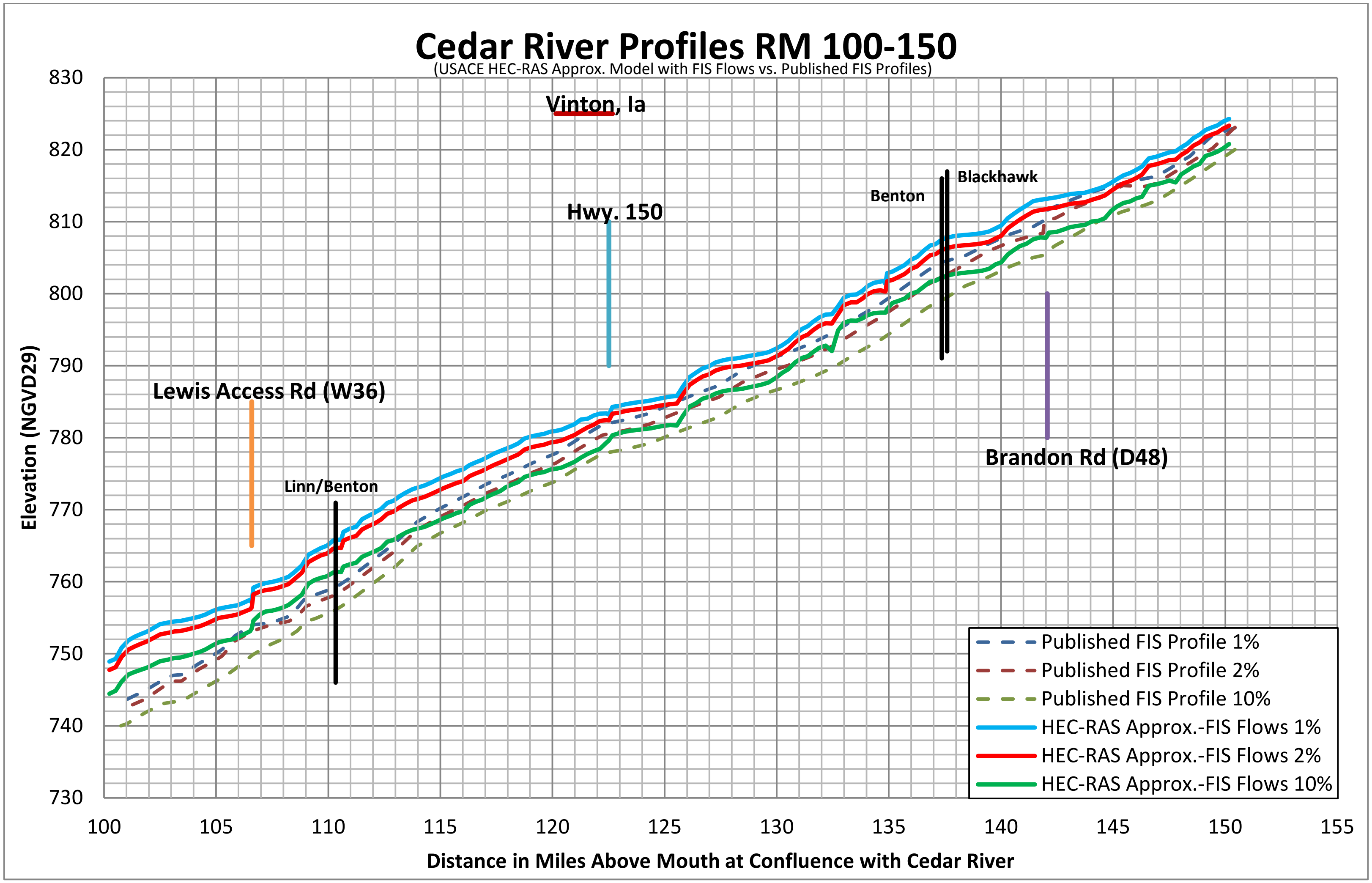

Figure C-5: Cedar River Continuous Profile for HEC-RAS Approx Model with FIS Flows vs. Published FIS Profiles: RM 100-150

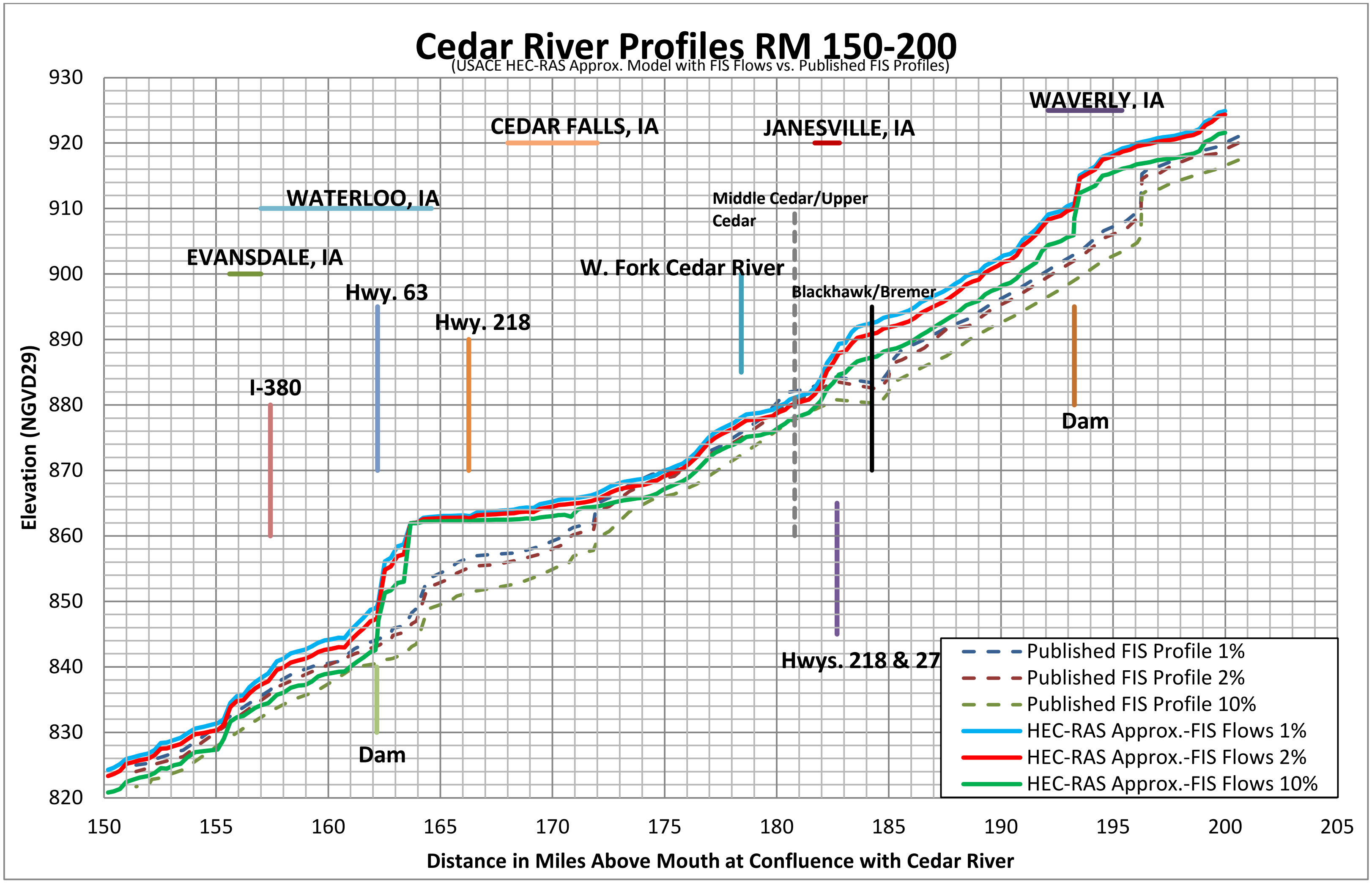

Figure C-6: Cedar River Continuous Profile for HEC-RAS Approx Model with FIS Flows vs. Published FIS Profiles: RM 150-200

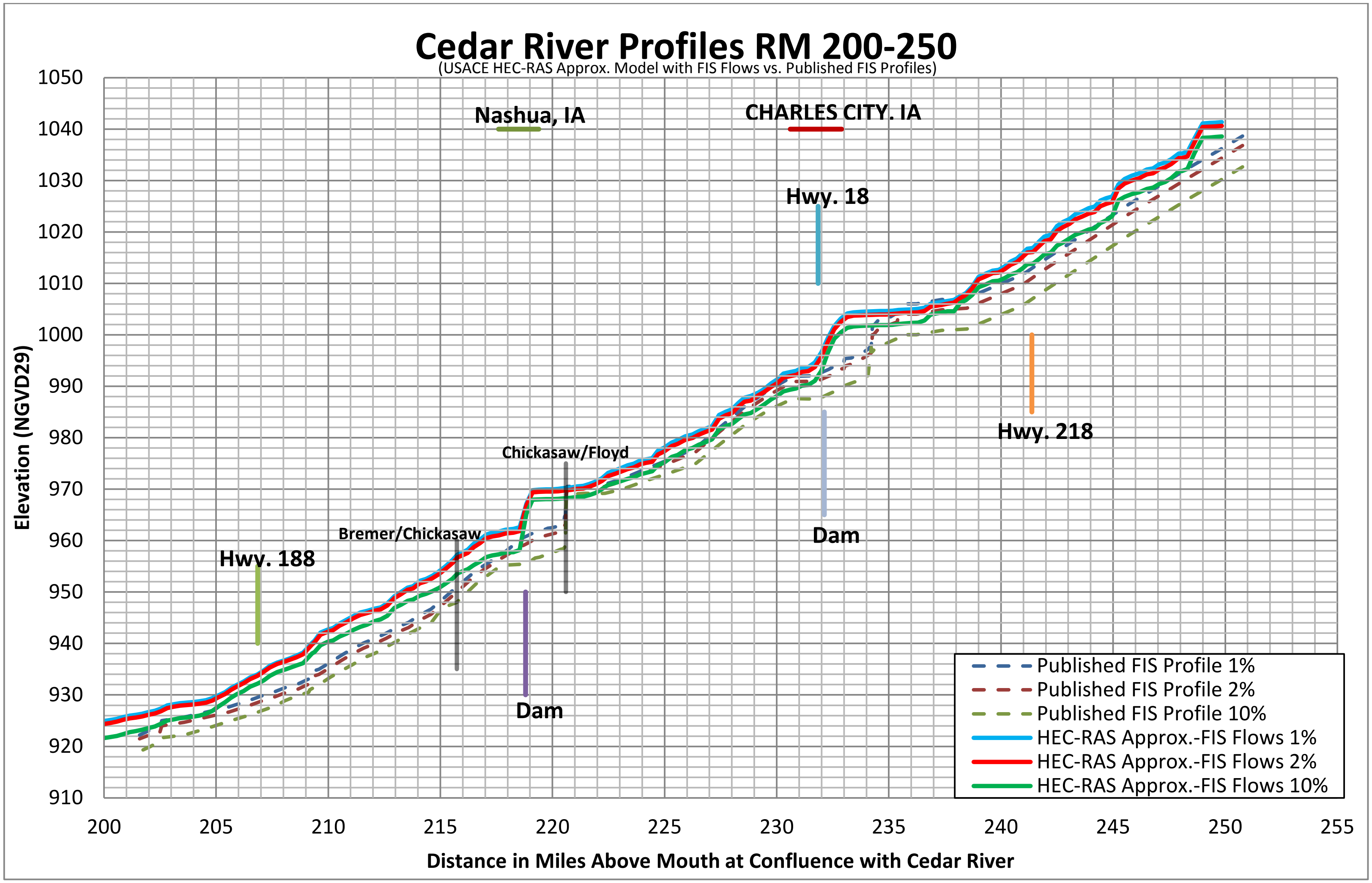

Figure C-7: Cedar River Continuous Profile for HEC-RAS Approx Model with FIS Flows vs. Published FIS Profiles: RM 200-250

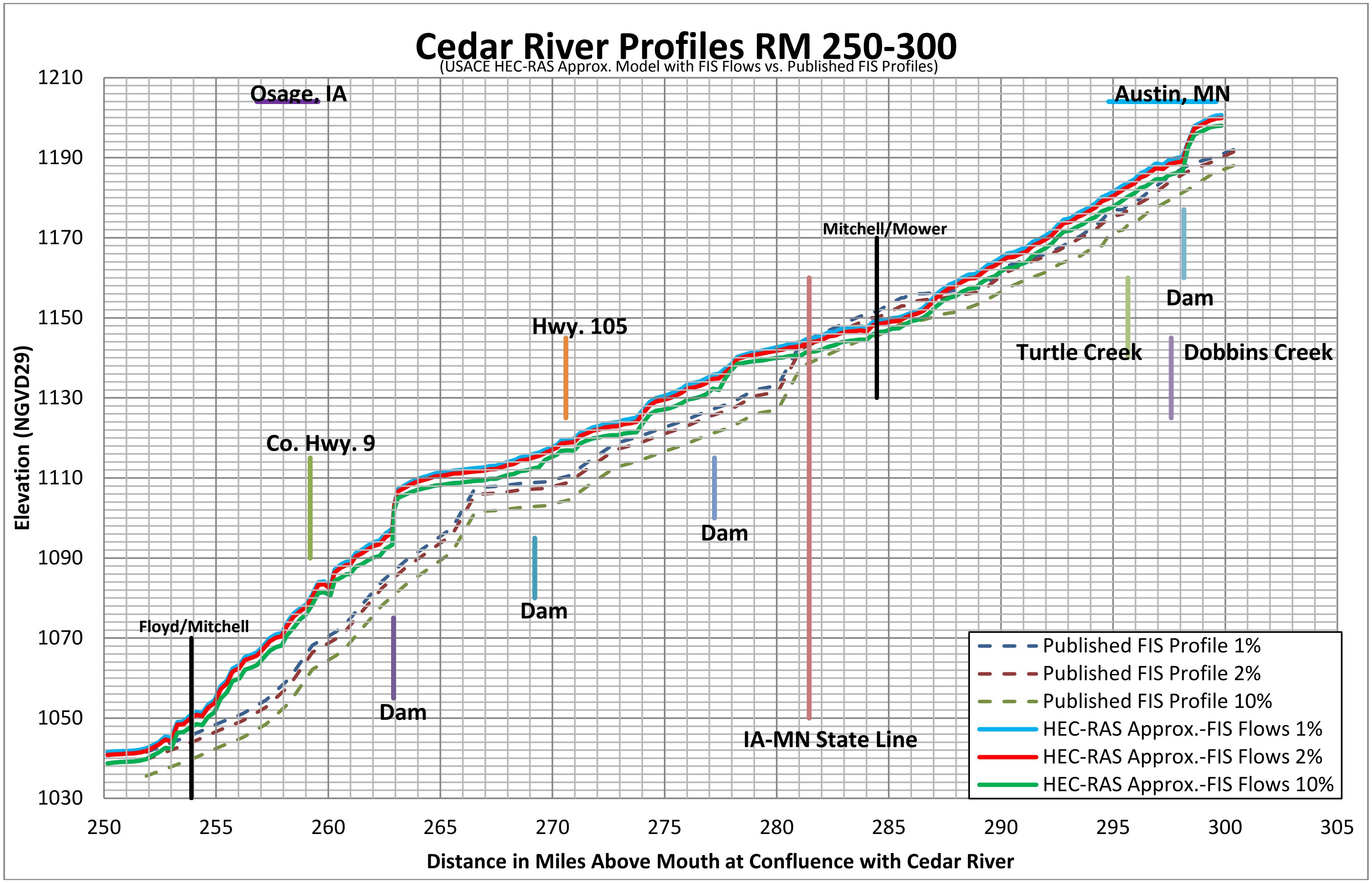

Figure C-8: Cedar River Continuous Profile for HEC-RAS Approx Model with FIS Flows vs. Published FIS Profiles: RM 250-300

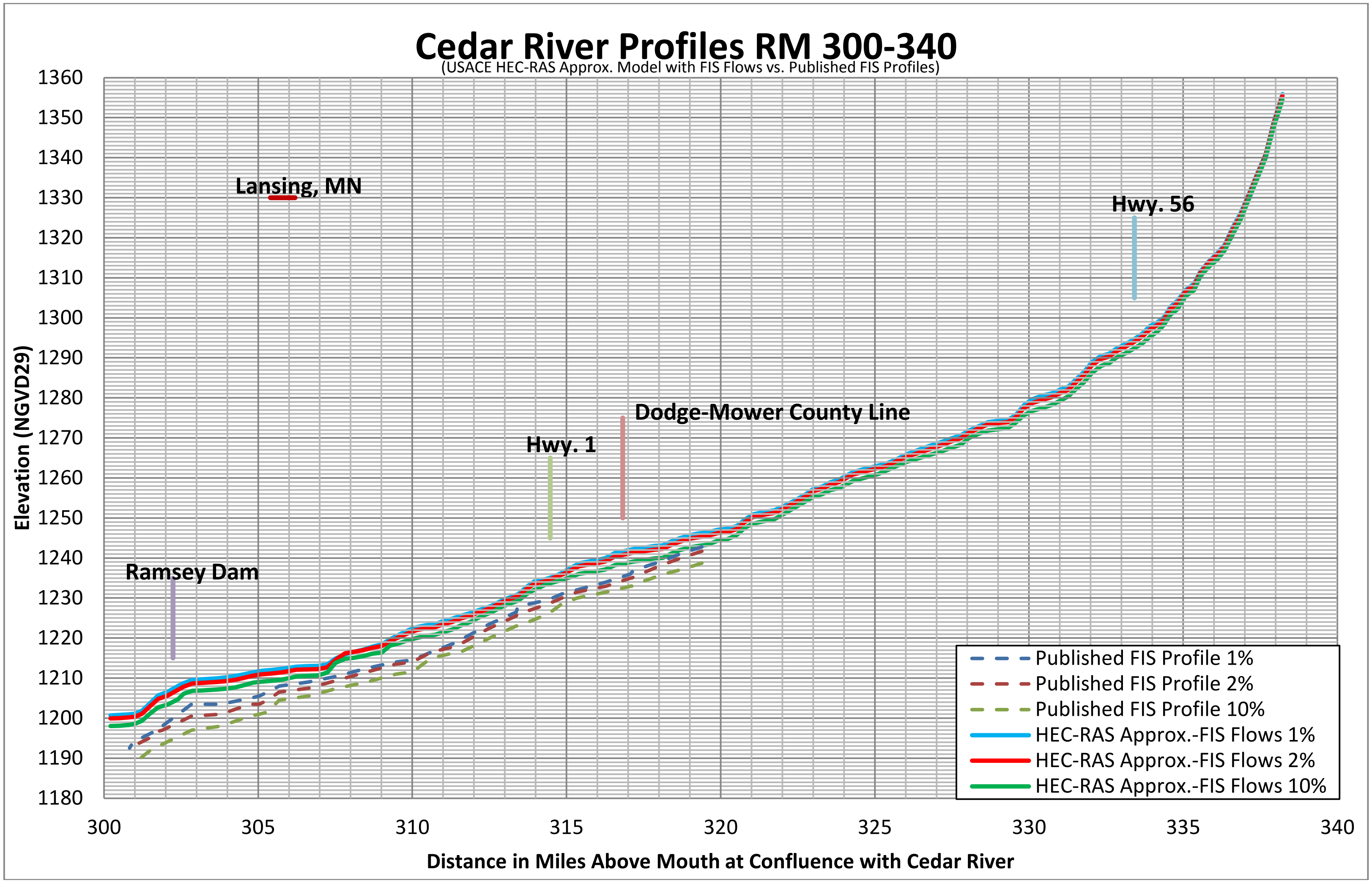

Figure C-9: Cedar River Continuous Profile for HEC-RAS Approx Model with FIS Flows vs. Published FIS Profiles: RM 300-340

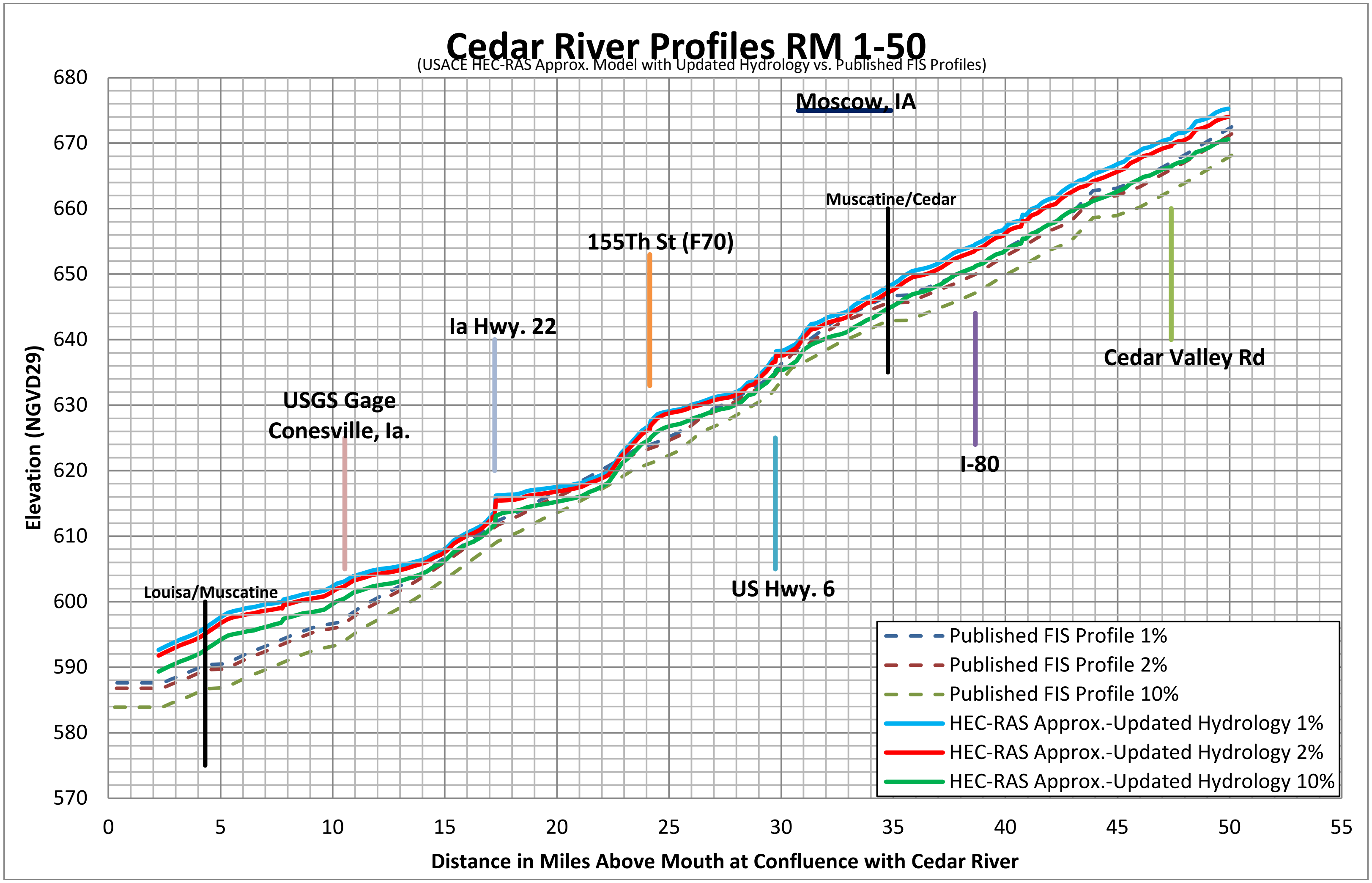

Figure C-10: Cedar River Continuous Profile for HEC-RAS Approx Model with Updated Hydrology vs. Published FIS Profiles: RM 1-50

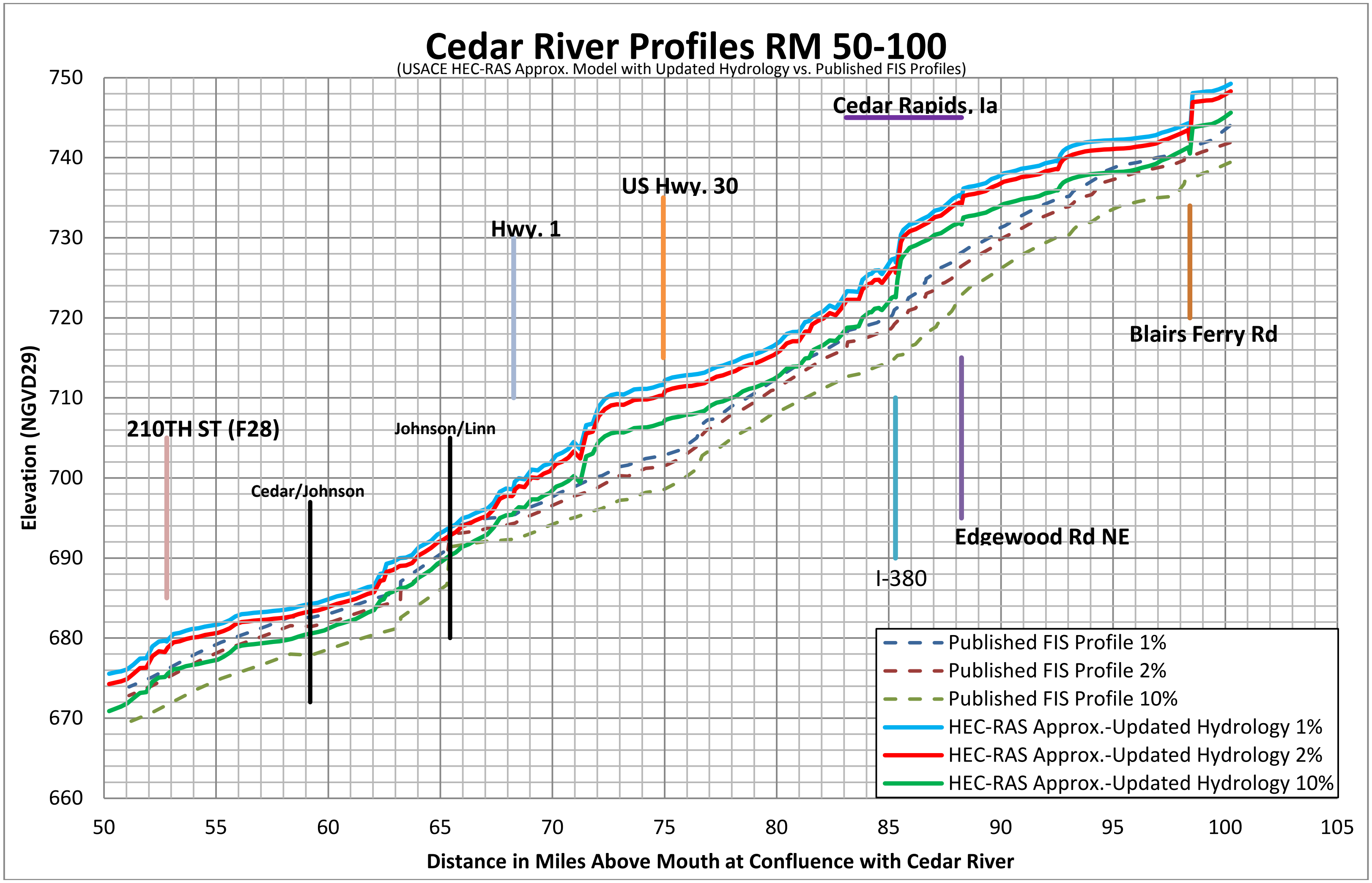

Figure C-11: Cedar River Continuous Profile for HEC-RAS Approx Model with Updated Hydrology vs. Published FIS Profiles: RM 50-100

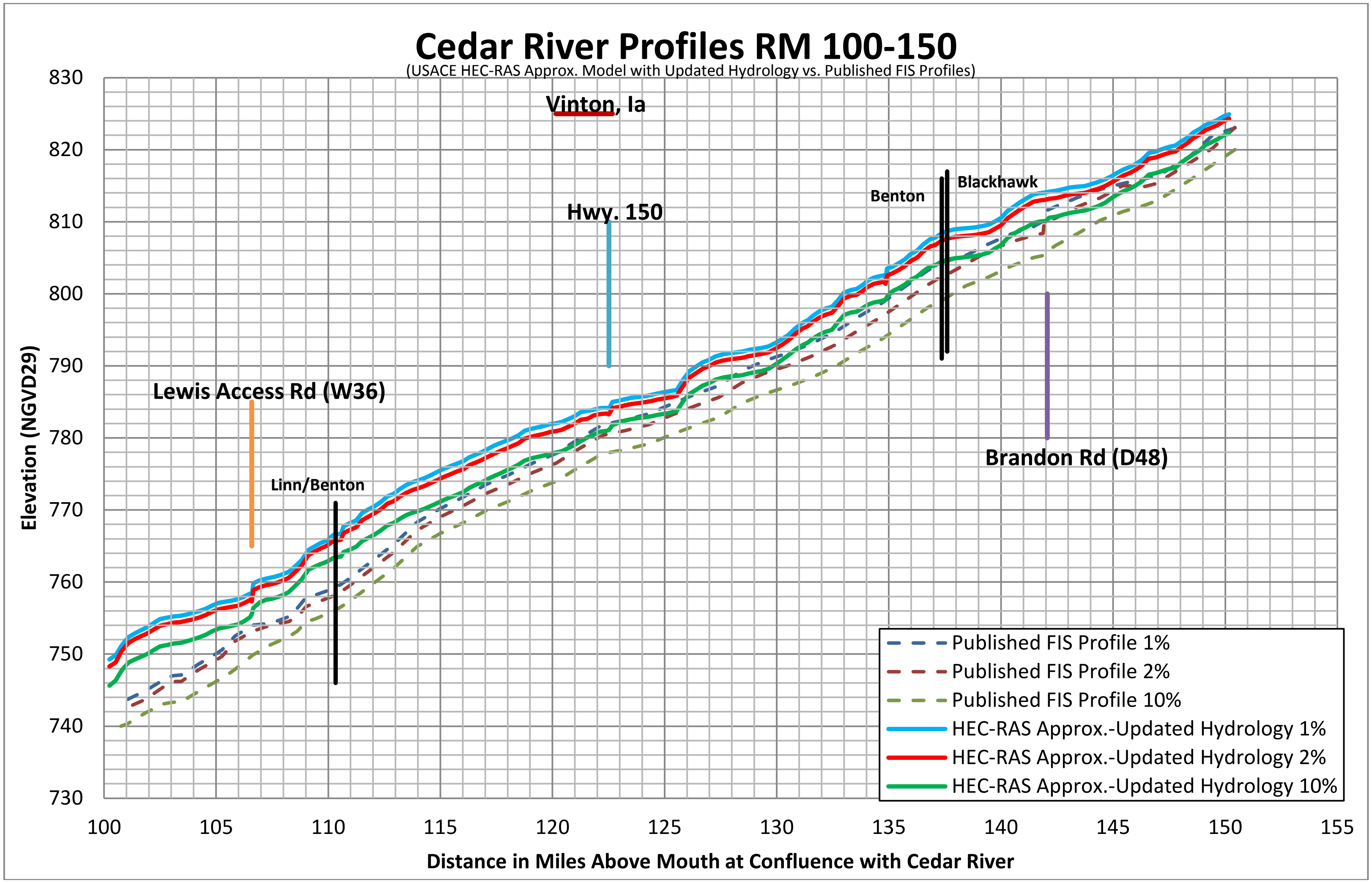

Figure C-12: Cedar River Continuous Profile for HEC-RAS Approx Model with Updated Hydrology vs. Published FIS Profiles: RM 100-150

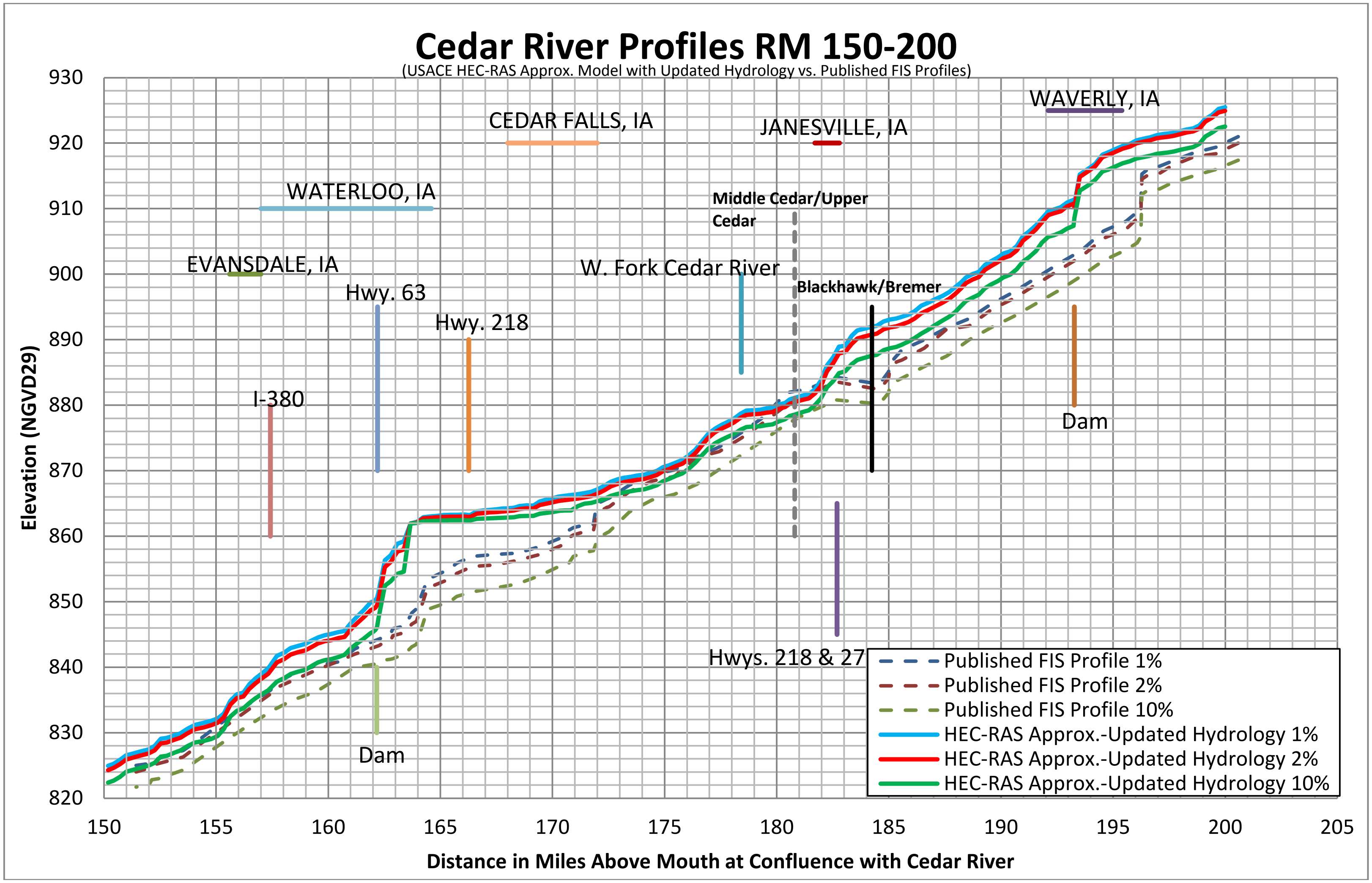

Figure C-13: Cedar River Continuous Profile for HEC-RAS Approx Model with Updated Hydrology vs. Published FIS Profiles: RM 150-200

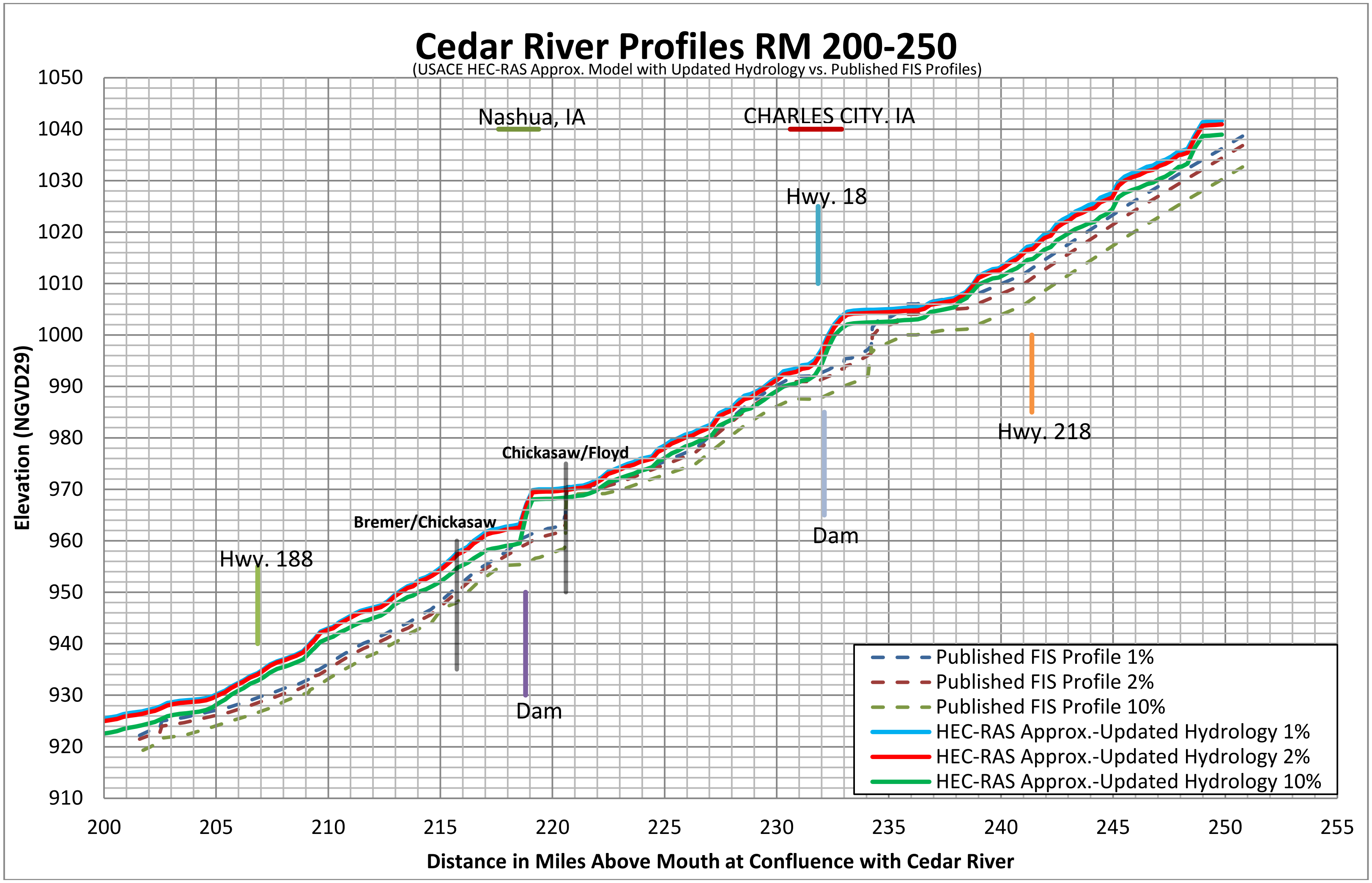

Figure C-14: Cedar River Continuous Profile for HEC-RAS Approx Model with Updated Hydrology vs. Published FIS Profiles: RM 200-250

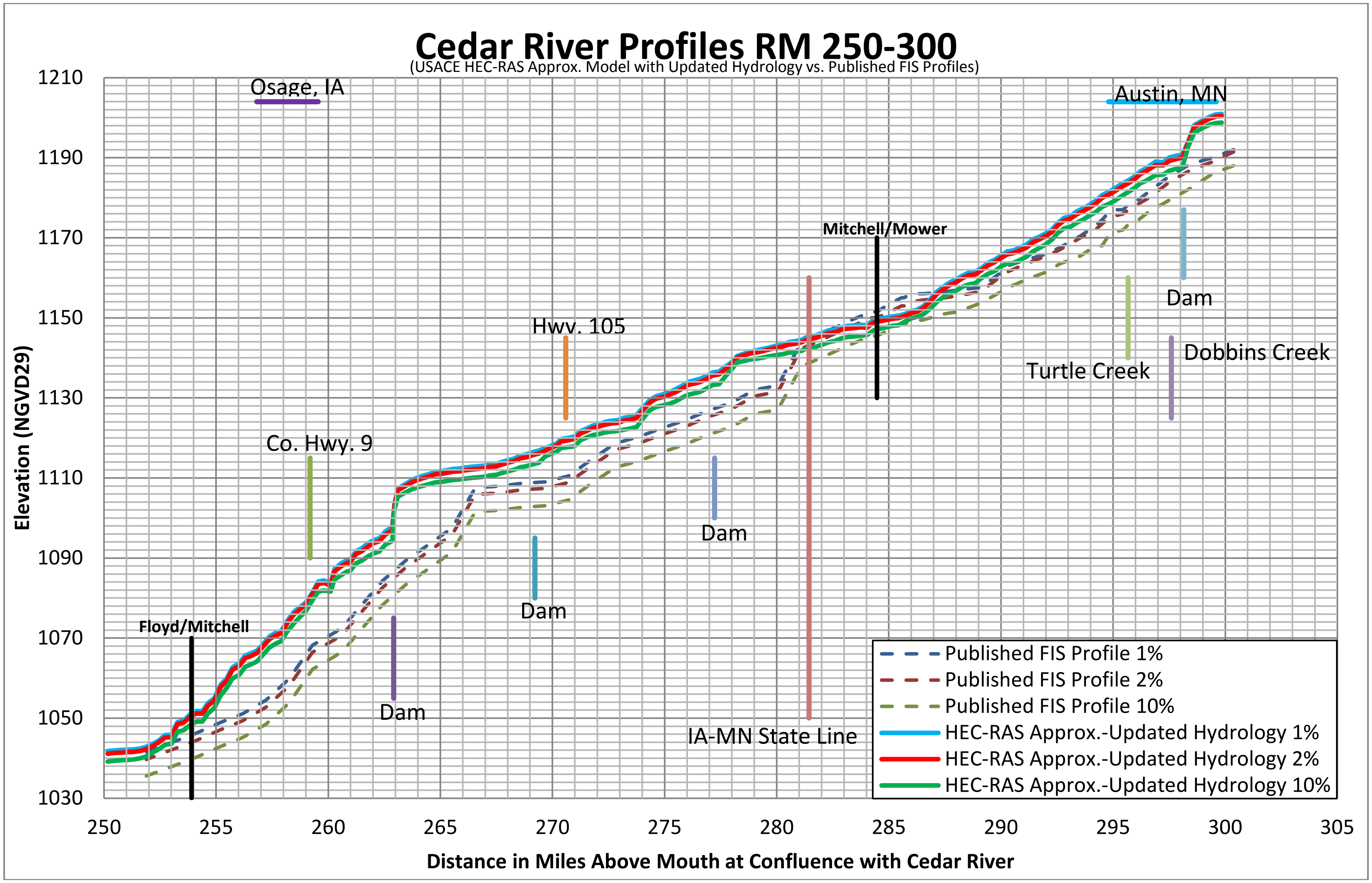

Figure C-15: Cedar River Continuous Profile for HEC-RAS Approx Model with Updated Hydrology vs. Published FIS Profiles: RM 250-300

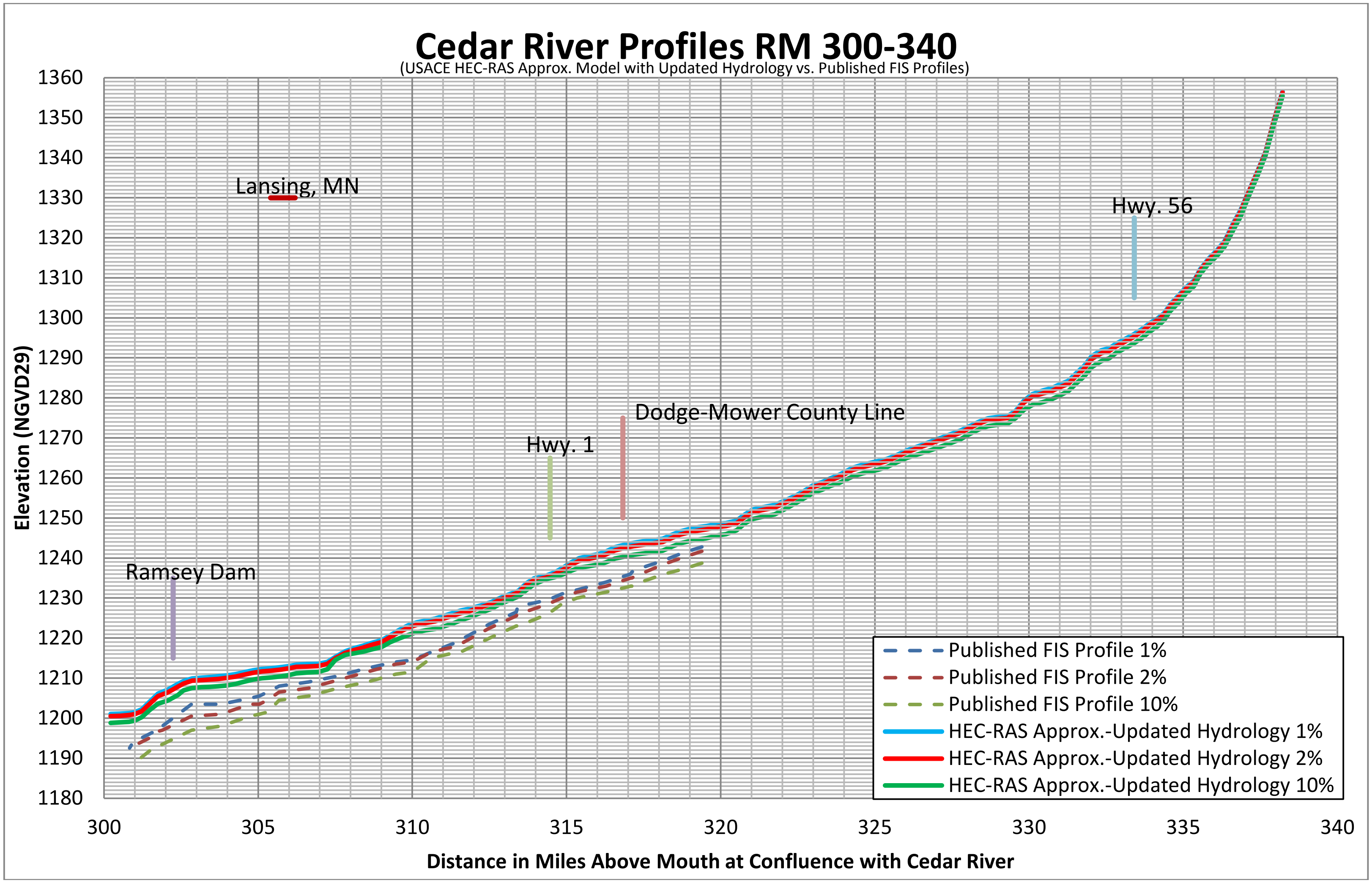

Figure C-16: Cedar River Continuous Profile for HEC-RAS Approx Model with Updated Hydrology vs. Published FIS Profiles: RM 300-340

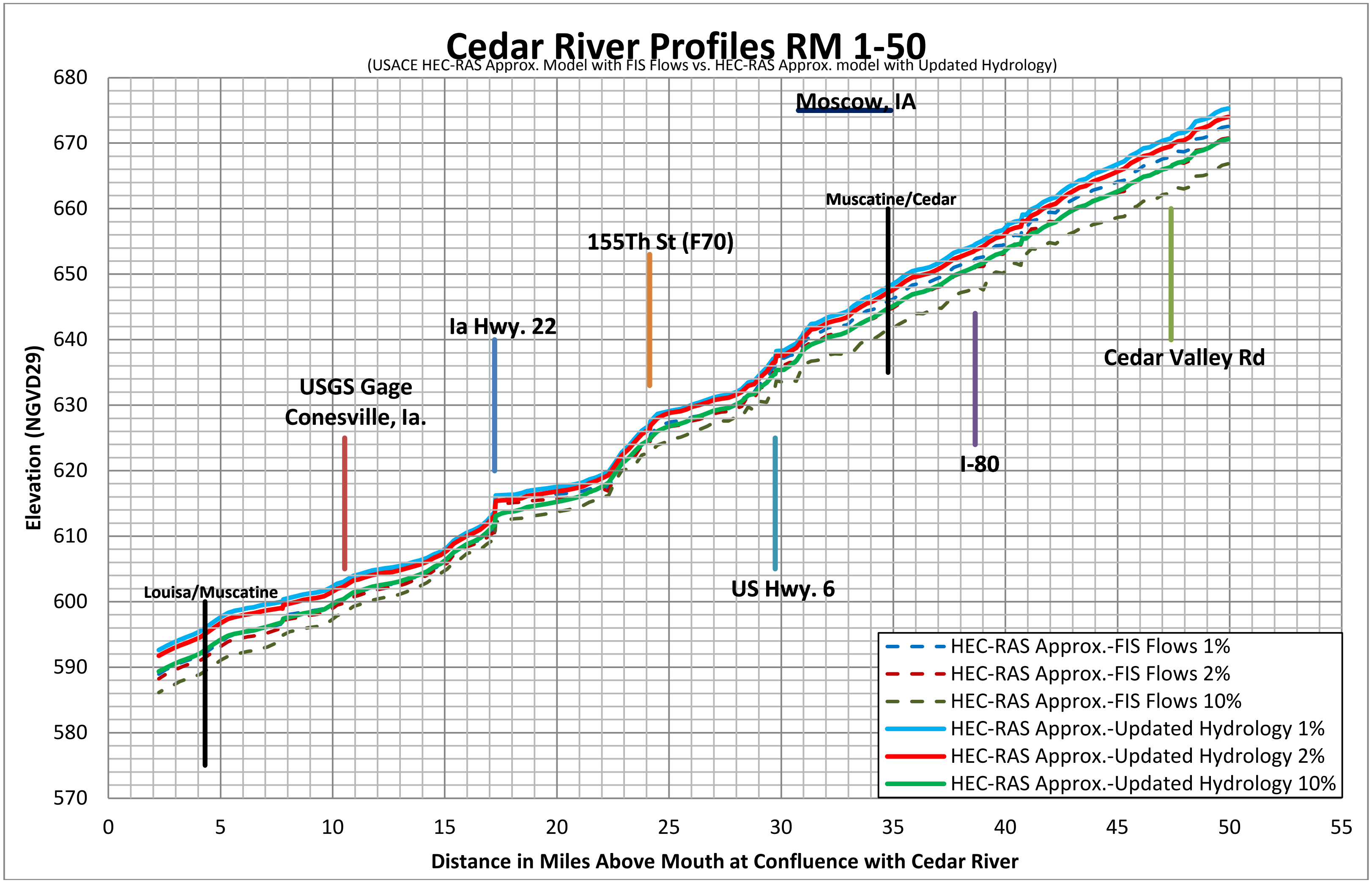

Figure C-17: Cedar River Continuous Profile for HEC-RAS Approx. Model with Updated Hydrology vs. HEC-RAS Approx. Model with FIS Flows: RM 1-50

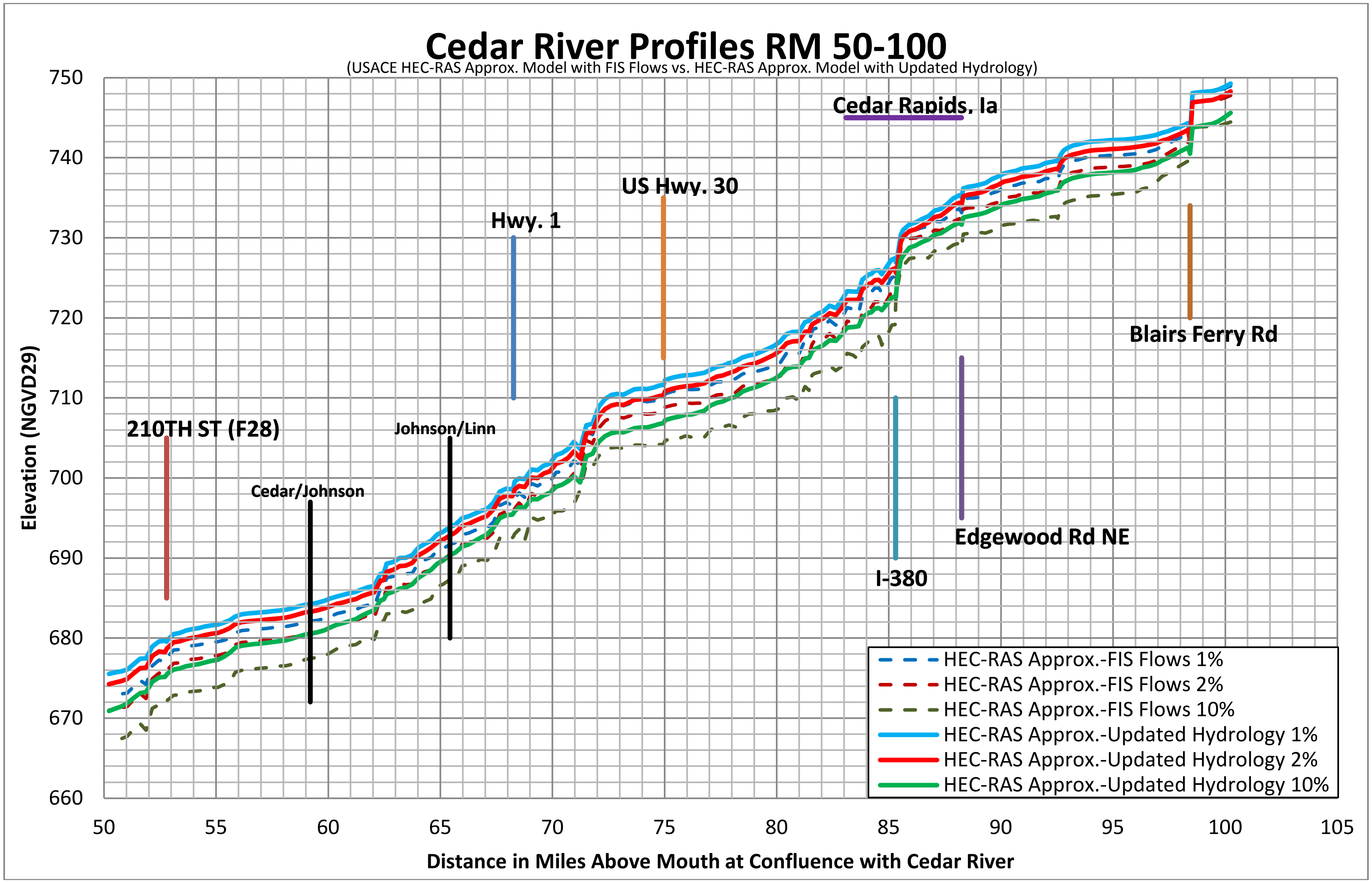

Figure C-18: Cedar River Continuous Profile for HEC-RAS Approx. Model w/ Updated Hydrology vs. HEC-RAS Approx. Model w/ FIS Flows: RM 50-100

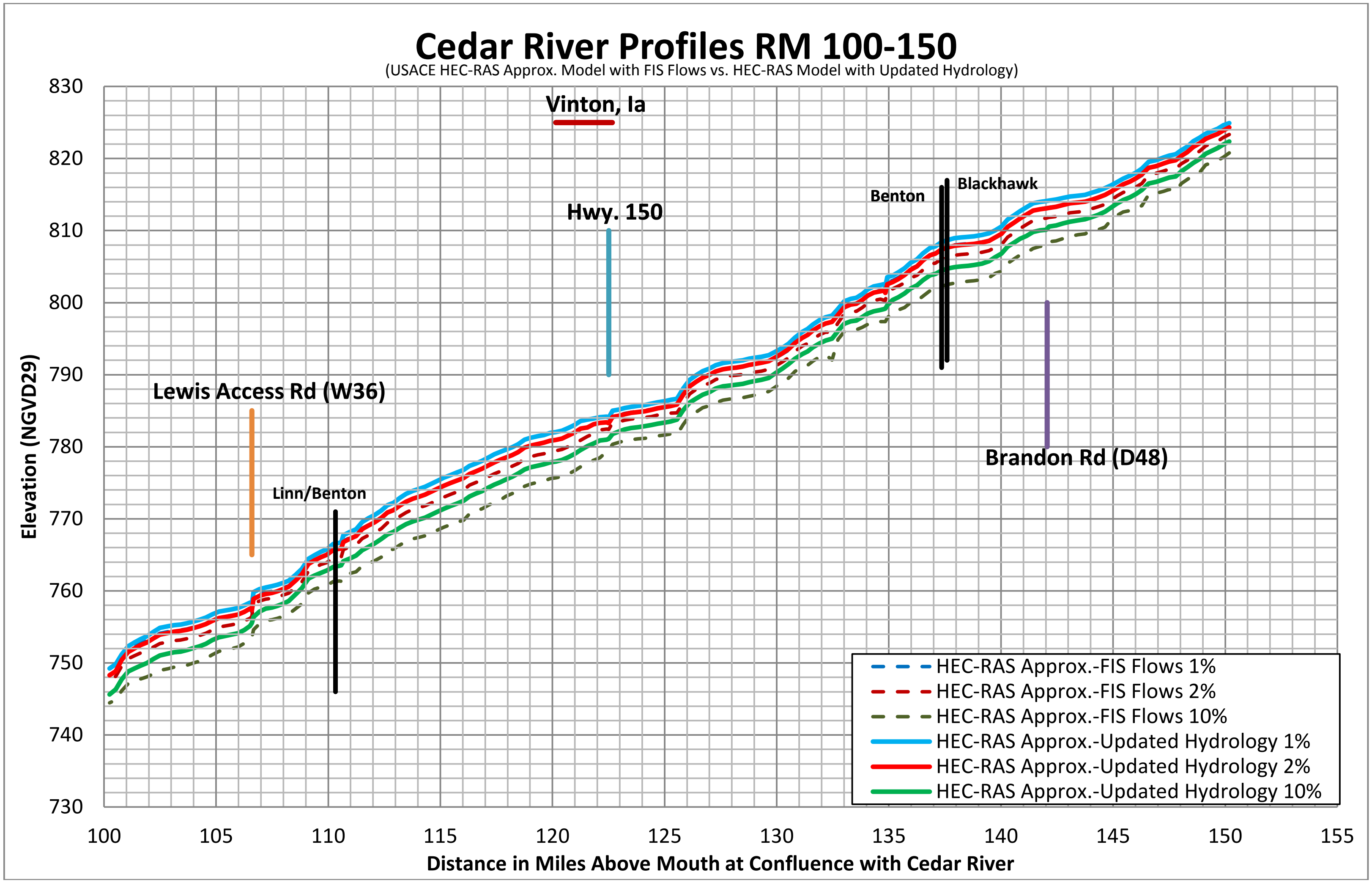

Figure C-19: Cedar River Continuous Profile for HEC-RAS Approx. Model w/ Updated Hydrology vs. HEC-RAS Approx. Model w/ FIS Flows: RM 100-150

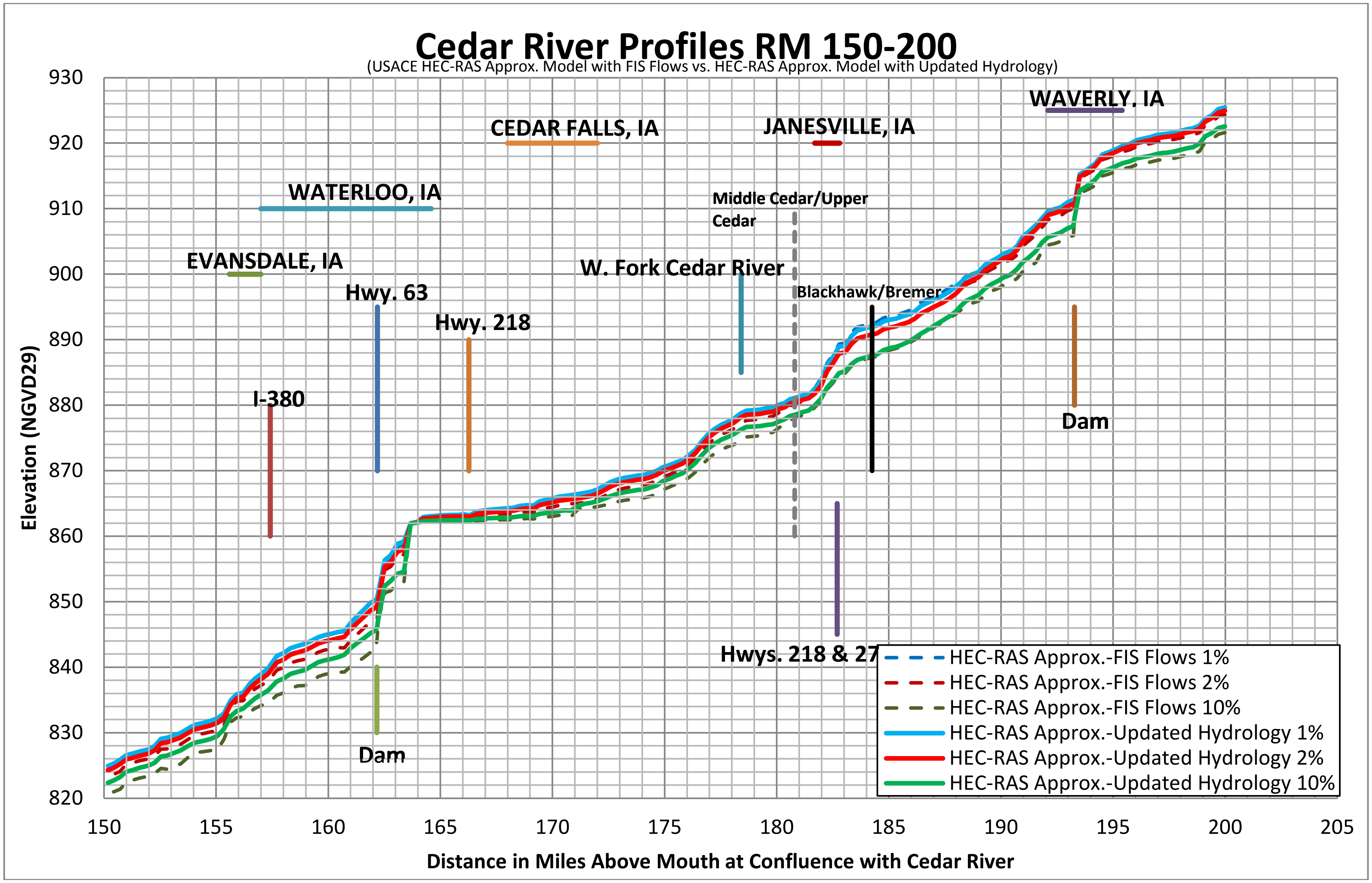

Figure C-20: Cedar River Continuous Profile for HEC-RAS Approx. Model w/ Updated Hydrology vs. HEC-RAS Approx. Model w/ FIS Flows: RM 150-200

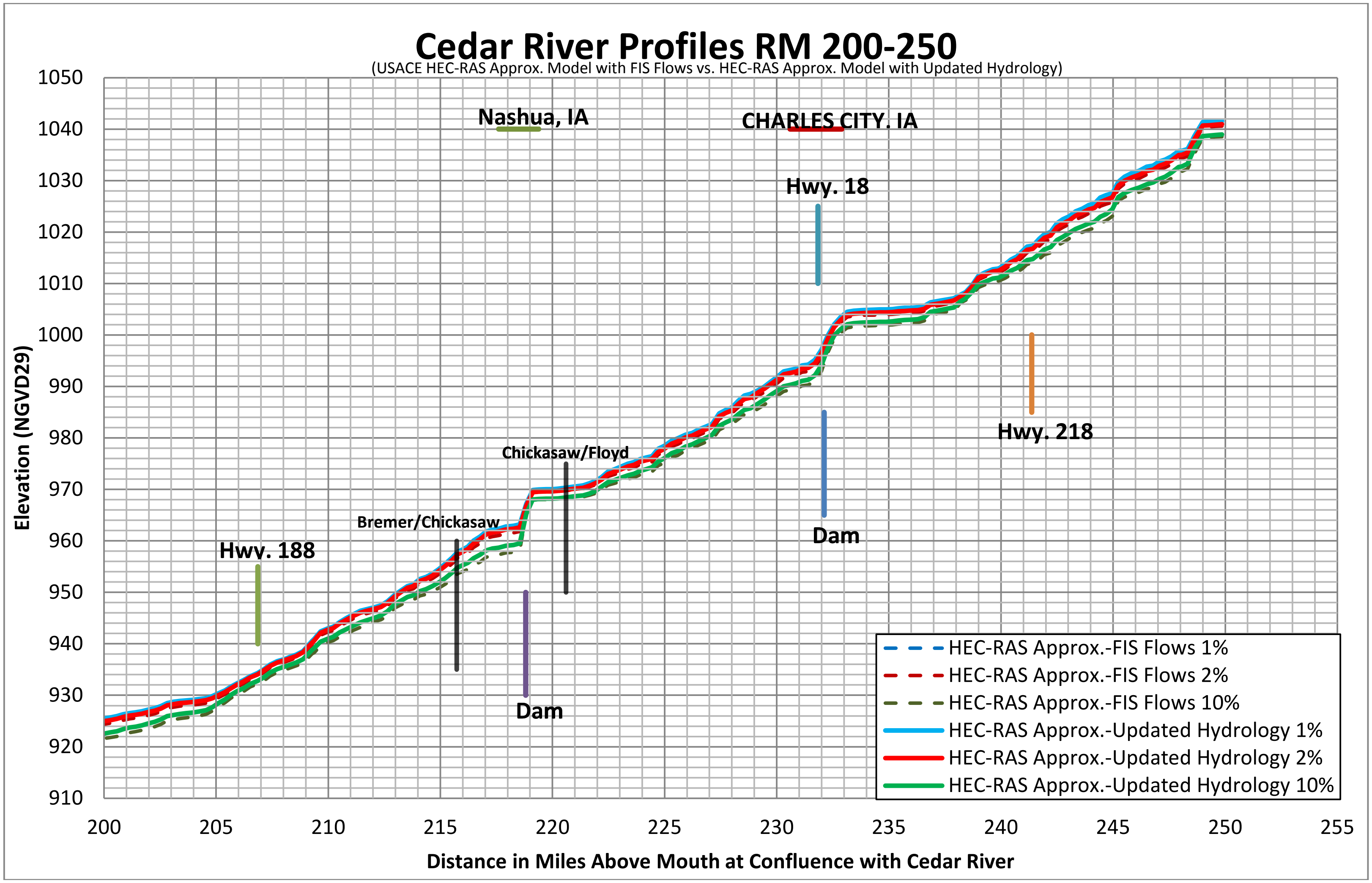

Figure C-21: Cedar River Continuous Profile for HEC-RAS Approx. Model w/ Updated Hydrology vs. HEC-RAS Approx. Model w/ FIS Flows: RM 200-250

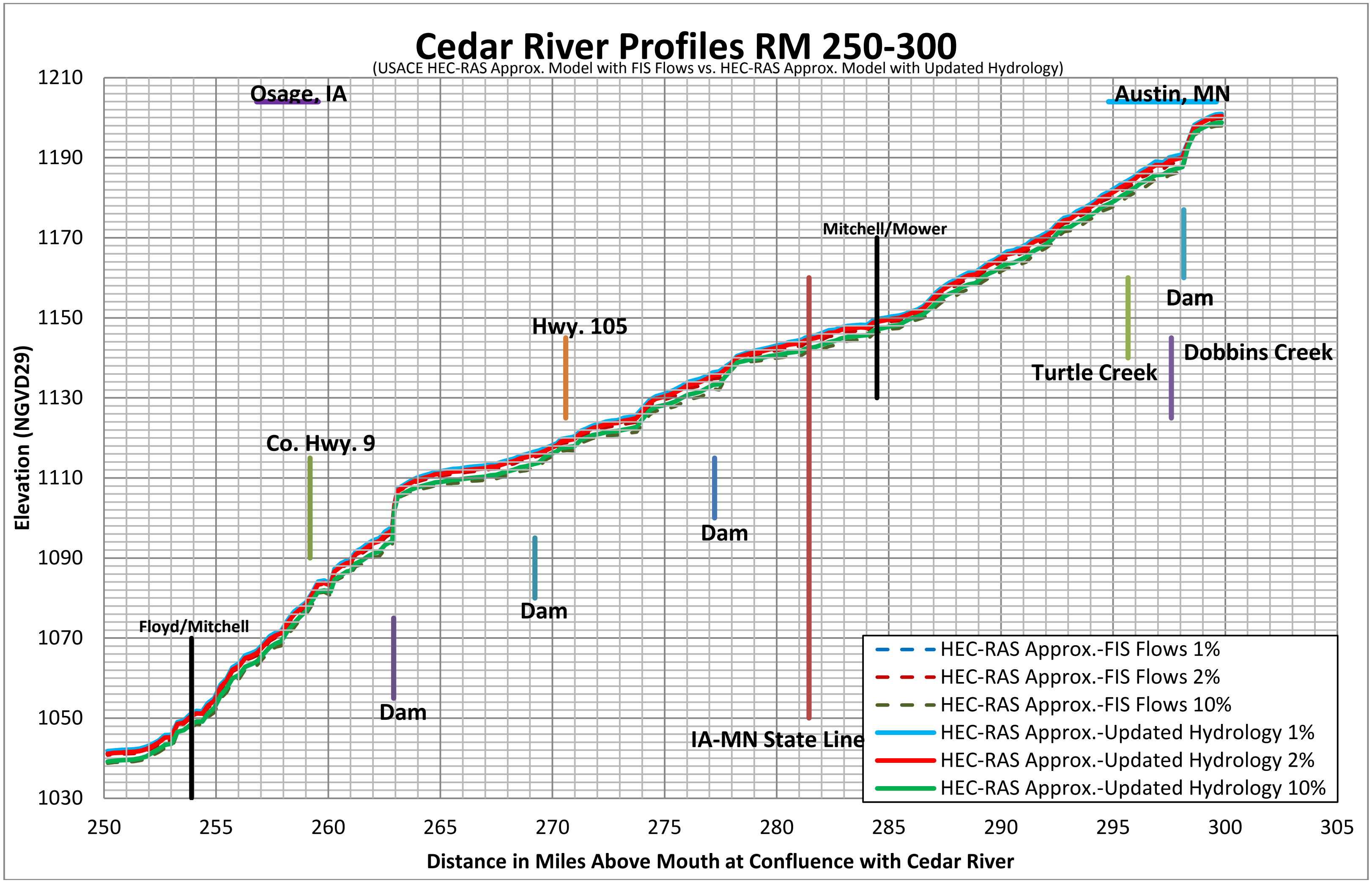

Figure C-22: Cedar River Continuous Profile for HEC-RAS Approx. Model w/ Updated Hydrology vs. HEC-RAS Approx. Model w/ FIS Flows: RM 250-300

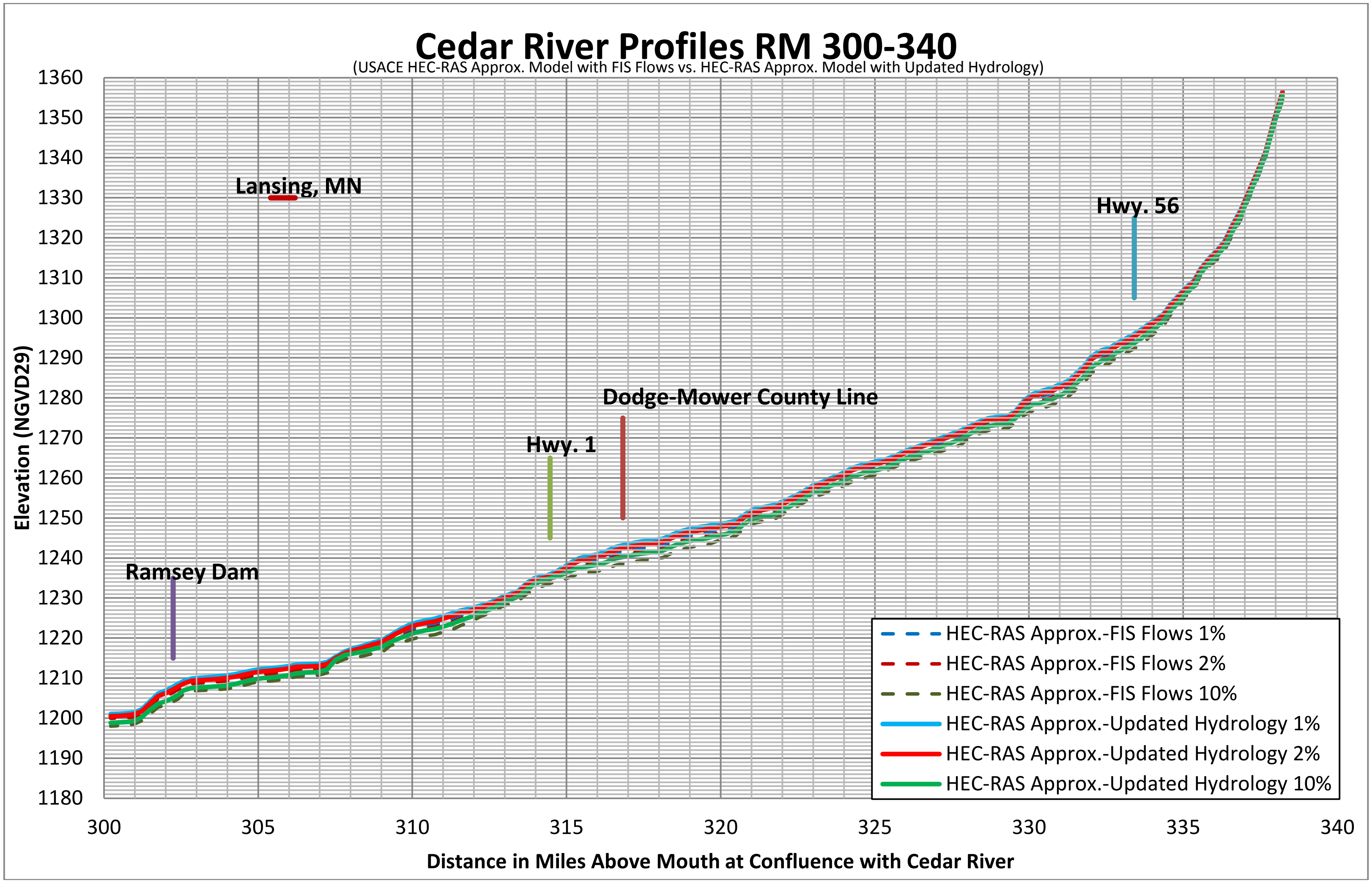

Figure C-23: Cedar River Continuous Profile for HEC-RAS Approx. Model w/ Updated Hydrology vs. HEC-RAS Approx. Model w/ FIS Flows: RM 300-340

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Upper	MN	Mower	319.39	1,242.8	1,241.7	1,238.7	Mower Cty FIS 2013
Upper	MN	Mower	318.75	1,241.2	1,240.1	1,237.2	Mower Cty FIS 2013
Upper	MN	Mower	318.18	1,239.5	1,238.5	1,236.0	Mower Cty FIS 2013
Upper	MN	Mower	317.24	1,237.0	1,235.5	1,233.5	Mower Cty FIS 2013
Upper	MN	Mower	317.12	1,236.5	1,235.0	1,233.0	Mower Cty FIS 2013
Upper	MN	Mower	317.08	1,236.0	1,235.0	1,233.0	Mower Cty FIS 2013
Upper	MN	Mower	316.29	1,234.0	1,233.0	1,231.5	Mower Cty FIS 2013
Upper	MN	Mower	315.34	1,232.0	1,231.5	1,230.0	Mower Cty FIS 2013
Upper	MN	Mower	314.85	1,231.0	1,230.0	1,228.5	Mower Cty FIS 2013
Upper	MN	Mower	314.39	1,229.5	1,228.5	1,226.0	Mower Cty FIS 2013
Upper	MN	Mower	313.45	1,228.0	1,226.0	1,223.0	Mower Cty FIS 2013
Upper	MN	Mower	313.41	1,227.5	1,226.0	1,223.0	Mower Cty FIS 2013
Upper	MN	Mower	313.37	1,226.5	1,225.5	1,223.0	Mower Cty FIS 2013
Upper	MN	Mower	312.50	1,223.5	1,222.5	1,220.0	Mower Cty FIS 2013
Upper	MN	Mower	311.55	1,219.5	1,218.5	1,216.5	Mower Cty FIS 2013
Upper	MN	Mower	311.44	1,219.0	1,218.0	1,216.5	Mower Cty FIS 2013
Upper	MN	Mower	310.61	1,216.5	1,216.5	1,215.0	Mower Cty FIS 2013
Upper	MN	Mower	310.00	1,214.5	1,214.0	1,211.5	Mower Cty FIS 2013
Upper	MN	Mower	309.47	1,214.0	1,213.5	1,211.0	Mower Cty FIS 2013
Upper	MN	Mower	308.52	1,212.5	1,211.5	1,209.0	Mower Cty FIS 2013
Upper	MN	Mower	307.58	1,210.5	1,209.5	1,207.5	Mower Cty FIS 2013
Upper	MN	Mower	306.63	1,209.0	1,207.5	1,205.5	Mower Cty FIS 2013
Upper	MN	Mower	305.68	1,208.0	1,206.5	1,204.5	Mower Cty FIS 2013
Upper	MN	Mower	305.30	1,206.5	1,204.5	1,201.5	Mower Cty FIS 2013
Upper	MN	Mower	305.04	1,205.5	1,203.5	1,201.0	Mower Cty FIS 2013
Upper	MN	Mower	304.74	1,205.0	1,203.5	1,200.5	Mower Cty FIS 2013
Upper	MN	Mower	303.79	1,203.5	1,201.0	1,198.0	Mower Cty FIS 2013
Upper	MN	Mower	302.84	1,203.5	1,200.5	1,197.0	Mower Cty FIS 2013
Upper	MN	Mower	301.89	1,198.0	1,197.0	1,193.5	Mower Cty FIS 2013
Upper	MN	Mower	301.67	1,197.5	1,196.5	1,192.5	Mower Cty FIS 2013
Upper	MN	Mower	301.59	1,196.5	1,195.5	1,192.5	Mower Cty FIS 2013
Upper	MN	Mower	300.95	1,194.0	1,193.0	1,188.5	Mower Cty FIS 2013
Upper	MN	Mower	300.83	1,192.5	1,192.0	1,188.5	Mower Cty FIS 2013
Upper	MN	Mower	300.38	1,192.0	1,191.5	1,188.0	Mower Cty FIS 2013
Upper	MN	Mower	299.43	1,190.0	1,189.0	1,186.0	Mower Cty FIS 2013
Upper	MN	Mower	298.49	1,188.5	1,187.0	1,182.5	Mower Cty FIS 2013
Upper	MN	Mower	297.54	1,185.5	1,184.0	1,179.5	Mower Cty FIS 2013
Upper	MN	Mower	296.59	1,181.5	1,180.0	1,176.5	Mower Cty FIS 2013
Upper	MN	Mower	296.14	1,179.5	1,178.5	1,174.5	Mower Cty FIS 2013
Upper	MN	Mower	295.80	1,179.0	1,177.5	1,174.0	Mower Cty FIS 2013
Upper	MN	Mower	295.45	1,177.0	1,176.0	1,172.0	Mower Cty FIS 2013
Upper	MN	Mower	295.11	1,177.0	1,175.5	1,171.5	Mower Cty FIS 2013
Upper	MN	Mower	294.85	1,176.5	1,175.0	1,171.0	Mower Cty FIS 2013
Upper	MN	Mower	294.51	1,174.5	1,173.5	1,168.0	Mower Cty FIS 2013
Upper	MN	Mower	294.20	1,173.0	1,172.0	1,168.0	Mower Cty FIS 2013
Upper	MN	Mower	293.56	1,170.5	1,170.0	1,165.5	Mower Cty FIS 2013
Upper	MN	Mower	292.61	1,167.5	1,167.0	1,163.5	Mower Cty FIS 2013
Upper	MN	Mower	292.05	1,166.0	1,165.5	1,161.5	Mower Cty FIS 2013
Upper	MN	Mower	291.10	1,164.5	1,163.5	1,159.5	Mower Cty FIS 2013
Upper	MN	Mower	290.30	1,163.0	1,161.5	1,157.5	Mower Cty FIS 2013
Upper	MN	Mower	290.15	1,162.0	1,161.0	1,157.0	Mower Cty FIS 2013
Upper	MN	Mower	289.20	1,158.0	1,157.0	1,154.0	Mower Cty FIS 2013

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Upper	MN	Mower	289.02	1,157.5	1,156.5	1,153.5	Mower Cty FIS 2013
Upper	MN	Mower	288.07	1,157.0	1,155.5	1,151.5	Mower Cty FIS 2013
Upper	MN	Mower	287.50	1,156.5	1,155.0	1,151.0	Mower Cty FIS 2013
Upper	MN	Mower	286.55	1,156.0	1,154.5	1,149.5	Mower Cty FIS 2013
Upper	MN	Mower	285.99	1,156.0	1,154.0	1,149.0	Mower Cty FIS 2013
Upper	MN	Mower	285.68	1,155.0	1,153.0	1,148.5	Mower Cty FIS 2013
Upper	MN	Mower	285.57	1,155.0	1,153.0	1,148.5	Mower Cty FIS 2013
Upper	MN	Mower	285.04	1,153.5	1,151.5	1,147.0	Mower Cty FIS 2013
Upper	MN	Mower	284.47	1,151.5	1,150.0	1,145.5	Mower Cty FIS 2013
Upper	IA	Mitchell	284.2	1,151.5	1,150.0	1,145.5	IA Highway Research
Upper	IA	Mitchell	283.2	1,149.0	1,147.5	1,143.0	IA Highway Research
Upper	IA	Mitchell	282.1	1,146.4	1,144.9	1,140.4	IA Highway Research
Upper	IA	Mitchell	281.1	1,143.8	1,142.3	1,137.8	IA Highway Research
Upper	IA	Mitchell	280.0	1,133.1	1,131.5	1,127.1	IA Highway Research
Upper	IA	Mitchell	279.0	1,132.0	1,130.5	1,126.0	IA Highway Research
Upper	IA	Mitchell	278.0	1,128.8	1,127.2	1,122.8	IA Highway Research
Upper	IA	Mitchell	276.9	1,126.8	1,125.2	1,120.8	IA Highway Research
Upper	IA	Mitchell	275.9	1,124.4	1,122.8	1,118.4	IA Highway Research
Upper	IA	Mitchell	274.9	1,122.4	1,120.8	1,116.4	IA Highway Research
Upper	IA	Mitchell	273.8	1,120.3	1,118.6	1,114.3	IA Highway Research
Upper	IA	Mitchell	272.8	1,118.6	1,117.0	1,112.6	IA Highway Research
Upper	IA	Mitchell	271.7	1,114.6	1,113.0	1,108.6	IA Highway Research
Upper	IA	Mitchell	270.7	1,110.5	1,108.9	1,104.5	IA Highway Research
Upper	IA	Mitchell	269.7	1,109.0	1,107.4	1,103.0	IA Highway Research
Upper	IA	Mitchell	268.6	1,108.7	1,107.0	1,102.7	IA Highway Research
Upper	IA	Mitchell	267.6	1,107.9	1,106.3	1,101.9	IA Highway Research
Upper	IA	Mitchell	266.6	1,107.6	1,105.9	1,101.6	IA Highway Research
Upper	IA	Mitchell	265.5	1,097.5	1,095.8	1,091.5	IA Highway Research
Upper	IA	Mitchell	264.5	1,093.4	1,091.7	1,087.4	IA Highway Research
Upper	IA	Mitchell	263.4	1,089.3	1,087.6	1,083.3	IA Highway Research
Upper	IA	Mitchell	262.4	1,084.3	1,082.5	1,078.3	IA Highway Research
Upper	IA	Mitchell	261.4	1,077.5	1,075.8	1,071.5	IA Highway Research
Upper	IA	Mitchell	260.7	1,073.4	1,071.6	1,067.4	IA Highway Research
Upper	IA	Mitchell	260.3	1,071.6	1,069.8	1,065.6	IA Highway Research
Upper	IA	Mitchell	259.3	1,068.2	1,066.4	1,062.2	IA Highway Research
Upper	IA	Mitchell	258.3	1,059.9	1,058.1	1,053.9	IA Highway Research
Upper	IA	Mitchell	257.2	1,054.5	1,052.7	1,048.5	IA Highway Research
Upper	IA	Mitchell	256.2	1,051.1	1,049.4	1,045.1	IA Highway Research
Upper	IA	Mitchell	255.1	1,048.8	1,047.0	1,042.8	IA Highway Research
Upper	IA	Mitchell	254.1	1,046.2	1,044.4	1,040.2	IA Highway Research
Upper	IA	Floyd	253.0	1,043.9	1,042.1	1,037.9	IA Highway Research
Upper	IA	Floyd	251.9	1,041.5	1,039.7	1,035.5	IA Highway Research
Upper	IA	Floyd	250.8	1,038.7	1,036.8	1,032.7	IA Highway Research
Upper	IA	Floyd	249.7	1,035.7	1,033.8	1,029.7	IA Highway Research
Upper	IA	Floyd	248.5	1,032.8	1,031.0	1,026.8	IA Highway Research
Upper	IA	Floyd	247.4	1,029.9	1,028.0	1,023.9	IA Highway Research
Upper	IA	Floyd	245.7	1,025.5	1,023.6	1,019.5	IA Highway Research
Upper	IA	Floyd	243.6	1,019.4	1,017.5	1,013.4	IA Highway Research
Upper	IA	Floyd	241.8	1,014.3	1,012.4	1,008.3	IA Highway Research
Upper	IA	Floyd	241.0	1,011.8	1,009.8	1,005.8	IA Highway Research
Upper	IA	Floyd	240.7	1,011.2	1,009.3	1,005.2	IA Highway Research
Upper	IA	Floyd	238.5	1,007.1	1,005.2	1,001.1	IA Highway Research

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Upper	IA	Floyd	237.4	1,006.9	1,004.9	1,000.9	IA Highway Research
Upper	IA	Floyd	236.2	1,006.0	1,004.0	1,000.0	IA Highway Research
Upper	IA	Floyd	235.9	1,006.0	1,004.0	1,000.0	Floyd County FIS 2008
Upper	IA	Floyd	235.8	1,006.0	1,004.0	1,000.0	Floyd County FIS 2008
Upper	IA	Floyd	235.4	1,005.6	1,003.7	999.8	Floyd County FIS 2008
Upper	IA	Floyd	235.4	1,004.3	1,002.5	999.3	Floyd County FIS 2008
Upper	IA	Floyd	235.1	1,003.5	1,002.0	998.7	Floyd County FIS 2008
Upper	IA	Floyd	234.8	1,003.6	1,002.0	998.2	Floyd County FIS 2008
Upper	IA	Floyd	234.6	1,003.0	1,001.3	997.6	Floyd County FIS 2008
Upper	IA	Floyd	234.3	1,001.8	1,000.1	997.0	Floyd County FIS 2008
Upper	IA	Floyd	234.3	1,001.5	1,000.0	996.7	Floyd County FIS 2008
Upper	IA	Floyd	234.2	997.9	996.5	997.5	Floyd County FIS 2008
Upper	IA	Floyd	234.1	997.2	996.0	992.1	Floyd County FIS 2008
Upper	IA	Floyd	233.8	996.5	995.4	991.7	Floyd County FIS 2008
Upper	IA	Floyd	233.6	996.0	994.9	991.0	Floyd County FIS 2008
Upper	IA	Floyd	233.3	995.5	994.3	990.6	Floyd County FIS 2008
Upper	IA	Floyd	233.1	995.4	994.0	990.2	Floyd County FIS 2008
Upper	IA	Floyd	233.0	995.3	993.8	990.1	Floyd County FIS 2008
Upper	IA	Floyd	233.0	994.7	993.4	990.0	Floyd County FIS 2008
Upper	IA	Floyd	232.8	994.5	993.4	989.5	Floyd County FIS 2008
Upper	IA	Floyd	232.6	993.9	992.4	989.0	Floyd County FIS 2008
Upper	IA	Floyd	232.3	993.3	992.0	988.5	Floyd County FIS 2008
Upper	IA	Floyd	232.1	992.8	991.5	988.0	Floyd County FIS 2008
Upper	IA	Floyd	231.8	992.1	991.0	987.5	Floyd County FIS 2008
Upper	IA	Floyd	231.8	992.1	991.0	987.5	IA Highway Research
Upper	IA	Floyd	230.7	991.9	990.9	987.6	IA Highway Research
Upper	IA	Floyd	229.6	989.3	988.3	985.4	IA Highway Research
Upper	IA	Floyd	228.6	986.0	985.1	982.4	IA Highway Research
Upper	IA	Floyd	227.5	982.0	981.2	978.7	IA Highway Research
Upper	IA	Floyd	226.4	977.9	977.2	974.9	IA Highway Research
Upper	IA	Floyd	225.3	975.9	975.2	973.3	IA Highway Research
Upper	IA	Floyd	224.2	974.0	973.4	971.7	IA Highway Research
Upper	IA	Floyd	223.1	972.0	971.5	970.0	IA Highway Research
Upper	IA	Floyd	222.3	971.0	970.5	969.2	IA Highway Research
Upper	IA	Floyd	222.0	970.8	970.4	969.1	IA Highway Research
Upper	IA	Chickasaw	221.4	970.7	970.3	969.2	Chickasaw County FIS
Upper	IA	Chickasaw	220.7	970.5	970.0	969.0	Chickasaw County FIS
Upper	IA	Chickasaw	220.6	969.0	968.8	968.3	Chickasaw County FIS
Upper	IA	Chickasaw	220.6	967.5	966.8	965.5	Chickasaw County FIS
Upper	IA	Chickasaw	220.6	965.0	963.0	959.9	Chickasaw County FIS
Upper	IA	Chickasaw	220.6	964.8	963.0	959.0	Chickasaw County FIS
Upper	IA	Chickasaw	220.5	964.7	963.0	958.7	Chickasaw County FIS
Upper	IA	Chickasaw	220.5	963.1	961.9	958.4	Chickasaw County FIS
Upper	IA	Chickasaw	220.4	963.0	961.7	958.3	Chickasaw County FIS
Upper	IA	Chickasaw	220.2	962.7	961.5	958.0	Chickasaw County FIS
Upper	IA	Chickasaw	220.0	962.5	961.3	957.6	Chickasaw County FIS
Upper	IA	Chickasaw	219.8	962.4	961.1	957.4	Chickasaw County FIS
Upper	IA	Chickasaw	219.6	962.1	960.9	957.1	Chickasaw County FIS
Upper	IA	Chickasaw	219.4	961.9	960.6	956.8	Chickasaw County FIS
Upper	IA	Chickasaw	219.2	961.6	960.4	956.6	Chickasaw County FIS
Upper	IA	Chickasaw	219.0	961.3	959.9	956.1	Chickasaw County FIS
Upper	IA	Chickasaw	218.9	960.9	959.4	955.7	Chickasaw County FIS

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Upper	IA	Chickasaw	218.7	960.5	959.0	955.4	Chickasaw County FIS
Upper	IA	Chickasaw	217.7	957.3	956.6	955.2	IA Highway Research
Upper	IA	Chickasaw	216.6	954.3	953.4	951.7	IA Highway Research
Upper	IA	Chickasaw	215.7	951.0	950.0	948.0	IA Highway Research
Upper	IA	Bremer	215.7	951.0	950.0	948.0	Bremer County FIS
Upper	IA	Bremer	215.1	948.5	947.5	946.9	Bremer County FIS
Upper	IA	Bremer	214.6	946.7	945.7	944.0	Bremer County FIS
Upper	IA	Bremer	214.1	945.5	944.5	943.0	Bremer County FIS
Upper	IA	Bremer	213.6	944.1	943.1	941.9	Bremer County FIS
Upper	IA	Bremer	213.1	943.2	942.2	940.5	Bremer County FIS
Upper	IA	Bremer	212.6	942.0	941.0	939.3	Bremer County FIS
Upper	IA	Bremer	212.1	941.0	940.0	938.1	Bremer County FIS
Upper	IA	Bremer	211.6	940.1	939.1	937.2	Bremer County FIS
Upper	IA	Bremer	211.1	939.0	938.0	935.9	Bremer County FIS
Upper	IA	Bremer	210.6	937.7	936.7	934.7	Bremer County FIS
Upper	IA	Bremer	210.1	936.3	935.3	933.4	Bremer County FIS
Upper	IA	Bremer	209.6	935.0	934.0	932.0	Bremer County FIS
Upper	IA	Bremer	209.2	934.4	933.4	931.0	Bremer County FIS
Upper	IA	Bremer	209.1	933.1	932.1	930.5	Bremer County FIS
Upper	IA	Bremer	208.6	932.0	931.0	929.8	Bremer County FIS
Upper	IA	Bremer	208.1	931.4	930.4	928.9	Bremer County FIS
Upper	IA	Bremer	207.6	930.6	929.6	927.8	Bremer County FIS
Upper	IA	Bremer	207.1	929.9	928.9	927.0	Bremer County FIS
Upper	IA	Bremer	206.6	929.1	928.1	926.2	Bremer County FIS
Upper	IA	Bremer	205.6	927.7	926.7	924.9	Bremer County FIS
Upper	IA	Bremer	204.6	926.7	925.7	923.5	Bremer County FIS
Upper	IA	Bremer	203.6	925.7	924.7	922.2	Bremer County FIS
Upper	IA	Bremer	202.6	925.0	924.0	921.7	Bremer County FIS
Upper	IA	Bremer	202.5	923.4	922.6	921.0	Bremer County FIS
Upper	IA	Bremer	202.1	923.2	922.3	920.0	Bremer County FIS
Upper	IA	Bremer	201.6	922.2	921.5	919.0	Bremer County FIS
Upper	IA	Bremer	200.6	921.0	920.0	917.4	Bremer County FIS
Upper	IA	Bremer	199.6	919.4	918.4	916.0	Bremer County FIS
Upper	IA	Bremer	198.6	918.5	917.9	915.0	Bremer County FIS
Upper	IA	Bremer	197.6	917.2	916.5	913.9	Bremer County FIS
Upper	IA	Bremer	197.1	916.5	915.4	913.0	Bremer County FIS
Upper	IA	Bremer	196.6	916.1	915.2	912.9	Bremer County FIS
Upper	IA	Bremer	196.3	915.3	914.5	912.2	Bremer County FIS
Upper	IA	Bremer	196.2	910.5	909.0	905.7	Bremer County FIS
Upper	IA	Bremer	196.1	909.5	908.5	904.8	Bremer County FIS
Upper	IA	Bremer	195.6	908.1	906.9	903.7	Bremer County FIS
Upper	IA	Bremer	194.6	906.6	905.5	902.1	Bremer County FIS
Upper	IA	Bremer	193.6	903.6	902.7	899.7	Bremer County FIS
Upper	IA	Bremer	192.6	901.6	900.6	897.5	Bremer County FIS
Upper	IA	Bremer	190.6	897.3	896.3	893.6	Bremer County FIS
Upper	IA	Bremer	189.6	895.5	894.6	891.9	Bremer County FIS
Upper	IA	Bremer	188.6	893.2	892.1	890.0	Bremer County FIS
Upper	IA	Bremer	187.6	891.8	891.6	887.5	Bremer County FIS
Upper	IA	Bremer	186.6	890.0	888.7	885.9	Bremer County FIS
Upper	IA	Bremer	185.6	888.4	886.9	884.1	Bremer County FIS
Upper	IA	Bremer	185.3	887.5	886.6	883.7	Bremer County FIS
Upper	IA	Bremer	185.2	886.9	885.9	883.1	Bremer County FIS

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Upper	IA	Bremer	185.0	886.4	885.3	882.8	Bremer County FIS
Upper	IA	Bremer	185.0	885.1	884.1	881.9	Bremer County FIS
Upper	IA	Bremer	184.6	883.2	882.4	880.2	Bremer County FIS
Lower	IA	Blackhawk	182.6	884.3	883.6	880.8	Blackhawk County FIS
Lower	IA	Blackhawk	182.4	884.0	883.3	880.4	Blackhawk County FIS
Lower	IA	Blackhawk	181.4	882.5	881.5	878.9	Blackhawk County FIS
Lower	IA	Blackhawk	180.4	881.9	880.0	877.1	Blackhawk County FIS
Lower	IA	Blackhawk	179.4	878.2	877.4	874.7	Blackhawk County FIS
Lower	IA	Blackhawk	178.4	875.8	875.0	872.4	Blackhawk County FIS
Lower	IA	Blackhawk	177.4	873.6	872.9	870.2	Blackhawk County FIS
Lower	IA	Blackhawk	176.4	872.1	872.0	867.9	Blackhawk County FIS
Lower	IA	Blackhawk	175.4	870.1	869.1	866.4	Blackhawk County FIS
Lower	IA	Blackhawk	174.4	869.4	868.4	865.5	Blackhawk County FIS
Lower	IA	Blackhawk	173.4	867.8	866.8	863.7	Blackhawk County FIS
Lower	IA	Blackhawk	172.5	865.8	864.5	860.7	Blackhawk County FIS
Lower	IA	Blackhawk	172.4	865.7	864.4	860.5	Blackhawk County FIS
Lower	IA	Blackhawk	172.1	865.1	863.7	859.8	Blackhawk County FIS
Lower	IA	Blackhawk	171.9	864.1	862.6	858.8	Blackhawk County FIS
Lower	IA	Blackhawk	171.8	861.8	860.8	857.8	Blackhawk County FIS
Lower	IA	Blackhawk	171.4	861.7	860.7	857.5	Blackhawk County FIS
Lower	IA	Blackhawk	170.9	861.3	860.2	856.9	Blackhawk County FIS
Lower	IA	Blackhawk	170.7	860.8	859.7	855.6	Blackhawk County FIS
Lower	IA	Blackhawk	170.4	859.8	858.6	855.6	Blackhawk County FIS
Lower	IA	Blackhawk	169.4	858.4	857.2	854.0	Blackhawk County FIS
Lower	IA	Blackhawk	168.4	857.4	856.3	852.7	Blackhawk County FIS
Lower	IA	Blackhawk	167.4	857.2	855.6	852.1	Blackhawk County FIS
Lower	IA	Blackhawk	166.4	856.9	855.4	851.5	Blackhawk County FIS
Lower	IA	Blackhawk	165.7	855.9	854.3	850.8	Blackhawk County FIS
Lower	IA	Blackhawk	165.4	855.0	853.5	850.0	Blackhawk County FIS
Lower	IA	Blackhawk	164.4	853.4	852.1	848.8	Blackhawk County FIS
Lower	IA	Blackhawk	163.9	848.9	847.0	843.5	Blackhawk County FIS
Lower	IA	Blackhawk	163.7	848.3	846.6	843.1	Blackhawk County FIS
Lower	IA	Blackhawk	163.4	846.3	845.3	842.1	Blackhawk County FIS
Lower	IA	Blackhawk	162.9	845.9	844.8	841.3	Blackhawk County FIS
Lower	IA	Blackhawk	162.8	845.0	844.0	841.2	Blackhawk County FIS
Lower	IA	Blackhawk	162.5	844.6	843.8	841.1	Blackhawk County FIS
Lower	IA	Blackhawk	162.3	844.3	843.3	840.6	Blackhawk County FIS
Lower	IA	Blackhawk	161.4	843.2	842.3	840.1	Blackhawk County FIS
Lower	IA	Blackhawk	161.2	842.8	842.0	840.0	Blackhawk County FIS
Lower	IA	Blackhawk	160.4	840.8	840.9	838.3	Blackhawk County FIS
Lower	IA	Blackhawk	159.4	840.2	839.5	836.2	Blackhawk County FIS
Lower	IA	Blackhawk	158.4	839.0	838.0	835.0	Blackhawk County FIS
Lower	IA	Blackhawk	157.6	837.5	836.8	833.6	Blackhawk County FIS
Lower	IA	Blackhawk	157.4	836.5	835.9	833.2	Blackhawk County FIS
Lower	IA	Blackhawk	156.4	834.3	833.5	831.1	Blackhawk County FIS
Lower	IA	Blackhawk	155.4	832.0	831.0	828.8	Blackhawk County FIS
Lower	IA	Blackhawk	154.4	829.4	828.6	826.4	Blackhawk County FIS
Lower	IA	Blackhawk	153.5	827.3	826.3	824.3	Blackhawk County FIS
Lower	IA	Blackhawk	153.4	827.2	826.2	824.2	Blackhawk County FIS
Lower	IA	Blackhawk	152.4	826.1	825.3	823.0	Blackhawk County FIS
Lower	IA	Blackhawk	152.1	825.8	825.0	822.8	Blackhawk County FIS
Lower	IA	Blackhawk	152.0	825.3	824.6	822.2	Blackhawk County FIS

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Lower	IA	Blackhawk	151.4	825.0	824.0	821.7	Blackhawk County FIS
Lower	IA	Blackhawk	150.4	823.0	823.1	820.0	Blackhawk County FIS
Lower	IA	Blackhawk	149.4	822.0	820.2	817.9	Blackhawk County FIS
Lower	IA	Blackhawk	148.4	819.1	818.2	815.8	Blackhawk County FIS
Lower	IA	Blackhawk	147.4	817.2	816.3	813.8	Blackhawk County FIS
Lower	IA	Blackhawk	146.9	816.3	815.3	812.9	Blackhawk County FIS
Lower	IA	Blackhawk	146.4	816.0	814.9	812.3	Blackhawk County FIS
Lower	IA	Blackhawk	145.4	815.3	815.0	811.4	Blackhawk County FIS
Lower	IA	Blackhawk	144.4	814.5	813.3	810.2	Blackhawk County FIS
Lower	IA	Blackhawk	143.4	813.4	812.1	808.4	Blackhawk County FIS
Lower	IA	Blackhawk	142.4	812.1	810.5	806.7	Blackhawk County FIS
Lower	IA	Blackhawk	141.9	811.4	810.0	805.6	Blackhawk County FIS
Lower	IA	Blackhawk	141.9	810.1	808.4	805.3	Blackhawk County FIS
Lower	IA	Blackhawk	141.4	809.3	808.1	805.0	Blackhawk County FIS
Lower	IA	Blackhawk	140.4	808.3	807.2	803.8	Blackhawk County FIS
Lower	IA	Blackhawk	139.4	806.9	805.9	802.3	Blackhawk County FIS
Lower	IA	Blackhawk	138.4	805.3	804.1	801.1	Blackhawk County FIS
Lower	IA	Blackhawk	137.4	804.4	802.4	799.2	Blackhawk County FIS
Lower	IA	Benton	137.4	804.4	802.4	799.2	IA Highway Research
Lower	IA	Benton	136.7	803.2	801.3	798.1	IA Highway Research
Lower	IA	Benton	135.7	801.0	799.0	795.9	IA Highway Research
Lower	IA	Benton	134.7	798.7	796.8	793.7	IA Highway Research
Lower	IA	Benton	133.6	796.8	794.9	791.9	IA Highway Research
Lower	IA	Benton	132.6	794.7	792.9	789.9	IA Highway Research
Lower	IA	Benton	131.6	793.1	791.3	788.4	IA Highway Research
Lower	IA	Benton	130.5	791.8	790.1	787.1	IA Highway Research
Lower	IA	Benton	129.5	790.7	789.0	786.1	IA Highway Research
Lower	IA	Benton	128.4	789.3	787.7	784.8	IA Highway Research
Lower	IA	Benton	127.4	787.2	785.6	782.8	IA Highway Research
Lower	IA	Benton	126.4	786.1	784.5	781.7	IA Highway Research
Lower	IA	Benton	125.3	784.8	783.2	780.5	IA Highway Research
Lower	IA	Benton	124.3	783.4	781.9	779.2	IA Highway Research
Lower	IA	Benton	123.3	782.5	781.0	778.4	IA Highway Research
Lower	IA	Benton	122.2	781.8	780.4	777.8	IA Highway Research
Lower	IA	Benton	121.2	779.9	778.5	776.0	IA Highway Research
Lower	IA	Benton	120.2	777.8	776.5	774.0	IA Highway Research
Lower	IA	Benton	119.1	776.5	775.2	772.8	IA Highway Research
Lower	IA	Benton	118.1	775.0	773.7	771.3	IA Highway Research
Lower	IA	Benton	117.1	773.6	772.3	769.9	IA Highway Research
Lower	IA	Benton	116.0	771.8	770.6	768.2	IA Highway Research
Lower	IA	Benton	115.0	770.2	769.0	766.7	IA Highway Research
Lower	IA	Benton	114.0	768.3	767.2	764.9	IA Highway Research
Lower	IA	Benton	112.9	765.2	764.1	761.9	IA Highway Research
Lower	IA	Benton	111.9	762.7	761.7	759.5	IA Highway Research
Lower	IA	Benton	110.8	760.2	759.2	757.1	IA Highway Research
Lower	IA	Benton	110.3	759.2	758.2	756.1	IA Highway Research
Lower	IA	Linn	110.3	759.2	758.2	756.1	Linn County FIS 2010
Lower	IA	Linn	109.4	758.2	757.1	754.9	Linn County FIS 2010
Lower	IA	Linn	109.0	757.9	756.6	754.5	Linn County FIS 2010
Lower	IA	Linn	108.6	756.4	755.2	753.2	Linn County FIS 2010
Lower	IA	Linn	108.6	756.4	755.2	753.1	Linn County FIS 2010
Lower	IA	Linn	108.2	755.2	754.5	752.4	Linn County FIS 2010

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Lower	IA	Linn	107.4	754.3	754.0	751.3	Linn County FIS 2010
Lower	IA	Linn	106.6	754.0	753.2	749.9	Linn County FIS 2010
Lower	IA	Linn	105.9	752.5	751.8	747.9	Linn County FIS 2010
Lower	IA	Linn	105.3	750.6	749.7	746.6	Linn County FIS 2010
Lower	IA	Linn	105.1	750.2	749.3	746.3	Linn County FIS 2010
Lower	IA	Linn	104.3	748.7	747.9	744.9	Linn County FIS 2010
Lower	IA	Linn	103.4	747.1	746.2	743.4	Linn County FIS 2010
Lower	IA	Linn	103.0	747.0	746.2	743.3	Linn County FIS 2010
Lower	IA	Linn	102.6	746.4	745.4	743.1	Linn County FIS 2010
Lower	IA	Linn	101.8	744.9	743.7	741.8	Linn County FIS 2010
Lower	IA	Linn	101.0	743.7	742.6	740.3	Linn County FIS 2010
Lower	IA	Linn	100.8	743.3	742.4	740.0	Linn County FIS 2010
Lower	IA	Linn	100.2	744.0	741.9	739.4	Linn County FIS 2010
Lower	IA	Linn	99.4	742.2	741.1	738.4	Linn County FIS 2010
Lower	IA	Linn	99.0	741.8	740.7	738.0	Linn County FIS 2010
Lower	IA	Linn	98.6	741.4	740.3	737.5	Linn County FIS 2010
Lower	IA	Linn	98.2	741.1	740.2	737.1	Linn County FIS 2010
Lower	IA	Linn	98.2	741.0	739.7	736.7	Linn County FIS 2010
Lower	IA	Linn	97.7	740.4	739.2	735.2	Linn County FIS 2010
Lower	IA	Linn	96.9	740.0	738.7	735.0	Linn County FIS 2010
Lower	IA	Linn	96.1	739.4	738.2	734.5	Linn County FIS 2010
Lower	IA	Linn	95.3	739.0	737.5	733.9	Linn County FIS 2010
Lower	IA	Linn	94.4	738.1	736.8	732.9	Linn County FIS 2010
Lower	IA	Linn	94.4	737.9	736.7	732.7	Linn County FIS 2010
Lower	IA	Linn	94.4	737.6	736.3	732.6	Linn County FIS 2010
Lower	IA	Linn	94.0	737.1	735.4	732.0	Linn County FIS 2010
Lower	IA	Linn	93.4	735.9	734.9	731.4	Linn County FIS 2010
Lower	IA	Linn	93.3	735.9	734.4	731.1	Linn County FIS 2010
Lower	IA	Linn	93.1	735.2	733.9	730.4	Linn County FIS 2010
Lower	IA	Linn	92.9	735.1	733.8	730.3	Linn County FIS 2010
Lower	IA	Linn	92.5	734.9	733.3	730.1	Linn County FIS 2010
Lower	IA	Linn	92.5	734.8	733.3	730.0	Linn County FIS 2010
Lower	IA	Linn	91.7	733.9	732.4	729.0	Linn County FIS 2010
Lower	IA	Linn	90.9	732.8	731.2	727.9	Linn County FIS 2010
Lower	IA	Linn	90.2	731.5	730.1	726.5	Linn County FIS 2010
Lower	IA	Linn	89.8	731.1	729.6	725.9	Linn County FIS 2010
Lower	IA	Linn	89.8	730.6	729.1	725.9	Linn County FIS 2010
Lower	IA	Linn	89.8	730.5	729.1	725.8	Linn County FIS 2010
Lower	IA	Linn	89.0	729.3	727.9	724.4	Linn County FIS 2010
Lower	IA	Linn	88.6	728.9	727.2	723.9	Linn County FIS 2010
Lower	IA	Linn	88.3	728.2	726.5	722.9	Linn County FIS 2010
Lower	IA	Linn	88.1	728.0	726.2	722.4	Linn County FIS 2010
Lower	IA	Linn	87.9	727.1	725.2	721.2	Linn County FIS 2010
Lower	IA	Linn	87.8	726.9	724.9	720.8	Linn County FIS 2010
Lower	IA	Linn	87.5	726.5	724.4	720.0	Linn County FIS 2010
Lower	IA	Linn	87.2	726.1	724.1	719.3	Linn County FIS 2010
Lower	IA	Linn	87.1	725.8	723.7	719.0	Linn County FIS 2010
Lower	IA	Linn	87.1	725.7	723.6	718.9	Linn County FIS 2010
Lower	IA	Linn	86.9	725.3	723.3	718.5	Linn County FIS 2010
Lower	IA	Linn	86.7	725.0	723.1	718.2	Linn County FIS 2010
Lower	IA	Linn	86.7	724.9	723.0	718.2	Linn County FIS 2010
Lower	IA	Linn	86.6	724.4	722.6	718.1	Linn County FIS 2010

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Lower	IA	Linn	86.6	724.4	722.6	718.1	Linn County FIS 2010
Lower	IA	Linn	86.6	724.1	722.3	717.8	Linn County FIS 2010
Lower	IA	Linn	86.4	723.6	721.9	717.3	Linn County FIS 2010
Lower	IA	Linn	86.2	723.0	721.2	716.7	Linn County FIS 2010
Lower	IA	Linn	85.9	722.5	720.9	716.4	Linn County FIS 2010
Lower	IA	Linn	85.7	721.6	720.1	715.7	Linn County FIS 2010
Lower	IA	Linn	85.7	721.6	720.1	715.7	Linn County FIS 2010
Lower	IA	Linn	85.6	721.4	719.9	715.4	Linn County FIS 2010
Lower	IA	Linn	85.4	721.3	719.6	715.3	Linn County FIS 2010
Lower	IA	Linn	85.2	721.0	719.2	714.9	Linn County FIS 2010
Lower	IA	Linn	85.2	720.4	718.9	714.7	Linn County FIS 2010
Lower	IA	Linn	85.1	720.1	718.6	714.4	Linn County FIS 2010
Lower	IA	Linn	84.9	720.0	718.5	714.3	Linn County FIS 2010
Lower	IA	Linn	84.5	719.4	718.0	713.9	Linn County FIS 2010
Lower	IA	Linn	83.7	718.8	717.2	713.0	Linn County FIS 2010
Lower	IA	Linn	83.2	718.4	717.0	712.7	Linn County FIS 2010
Lower	IA	Linn	83.1	718.2	716.7	712.7	Linn County FIS 2010
Lower	IA	Linn	83.1	717.7	716.3	712.6	Linn County FIS 2010
Lower	IA	Linn	82.9	717.4	716.1	712.3	Linn County FIS 2010
Lower	IA	Linn	82.9	717.3	716.1	712.3	Linn County FIS 2010
Lower	IA	Linn	82.8	717.1	715.8	712.2	Linn County FIS 2010
Lower	IA	Linn	82.2	716.0	715.0	711.3	Linn County FIS 2010
Lower	IA	Linn	81.4	715.0	713.7	710.2	Linn County FIS 2010
Lower	IA	Linn	80.7	713.6	712.4	709.1	Linn County FIS 2010
Lower	IA	Linn	79.9	712.2	711.0	708.0	Linn County FIS 2010
Lower	IA	Linn	79.8	712.0	710.9	707.9	Linn County FIS 2010
Lower	IA	Linn	79.1	710.8	709.7	706.7	Linn County FIS 2010
Lower	IA	Linn	78.4	709.5	708.4	705.6	Linn County FIS 2010
Lower	IA	Linn	78.0	709.0	708.0	705.0	Linn County FIS 2010
Lower	IA	Linn	77.3	707.4	706.4	703.4	Linn County FIS 2010
Lower	IA	Linn	77.0	707.3	706.1	703.3	Linn County FIS 2010
Lower	IA	Linn	76.9	707.2	706.0	703.2	Linn County FIS 2010
Lower	IA	Linn	76.7	706.7	705.4	702.8	Linn County FIS 2010
Lower	IA	Linn	76.4	705.1	703.9	701.1	Linn County FIS 2010
Lower	IA	Linn	76.4	705.0	703.9	701.1	Linn County FIS 2010
Lower	IA	Linn	75.7	703.5	702.4	699.6	Linn County FIS 2010
Lower	IA	Linn	74.9	702.8	701.4	698.5	Linn County FIS 2010
Lower	IA	Linn	74.2	702.4	701.2	698.2	Linn County FIS 2010
Lower	IA	Linn	73.4	701.6	700.2	697.3	Linn County FIS 2010
Lower	IA	Linn	73.0	701.4	700.3	697.2	Linn County FIS 2010
Lower	IA	Linn	72.2	700.3	699.1	696.2	Linn County FIS 2010
Lower	IA	Linn	71.8	700.0	698.5	695.9	Linn County FIS 2010
Lower	IA	Linn	71.0	699.0	697.8	695.1	Linn County FIS 2010
Lower	IA	Linn	70.3	698.1	696.9	694.5	Linn County FIS 2010
Lower	IA	Linn	69.6	697.0	696.1	693.8	Linn County FIS 2010
Lower	IA	Linn	69.5	696.9	695.9	693.6	Linn County FIS 2010
Lower	IA	Linn	68.7	696.1	695.0	692.8	Linn County FIS 2010
Lower	IA	Linn	68.6	695.9	694.8	692.5	Linn County FIS 2010
Lower	IA	Linn	68.3	695.5	694.4	692.4	Linn County FIS 2010
Lower	IA	Linn	67.6	695.1	693.9	692.2	Linn County FIS 2010
Lower	IA	Linn	67.3	695.0	693.9	692.2	Linn County FIS 2010
Lower	IA	Linn	66.8	694.9	693.5	692.0	Linn County FIS 2010

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Lower	IA	Linn	66.0	694.2	693.2	691.7	Linn County FIS 2010
Lower	IA	Linn	65.4	694.0	693.0	691.4	Linn County FIS 2010
Lower	IA	Johnson	65.3	691.1	690.0	686.7	Johnson County FIS
Lower	IA	Johnson	63.2	687.1	686.0	682.6	Johnson County FIS
Lower	IA	Johnson	63.2	685.9	684.8	681.4	Johnson County FIS
Lower	IA	Johnson	63.0	685.7	684.6	681.2	Johnson County FIS
Lower	IA	Johnson	62.1	685.0	683.9	680.5	Johnson County FIS
Lower	IA	Johnson	61.1	684.1	683.0	679.7	Johnson County FIS
Lower	IA	Johnson	60.2	683.2	682.1	678.8	Johnson County FIS
Lower	IA	Johnson	59.2	682.6	681.5	677.9	Johnson County FIS
Lower	IA	Cedar	58.3	682.7	681.6	678.0	IA Highway Research
Lower	IA	Cedar	57.3	681.5	680.4	676.9	IA Highway Research
Lower	IA	Cedar	56.3	680.5	679.4	675.9	IA Highway Research
Lower	IA	Cedar	55.2	679.5	678.4	674.9	IA Highway Research
Lower	IA	Cedar	54.2	678.2	677.1	673.7	IA Highway Research
Lower	IA	Cedar	53.2	676.7	675.6	672.2	IA Highway Research
Lower	IA	Cedar	52.1	675.1	674.0	670.7	IA Highway Research
Lower	IA	Cedar	51.1	673.9	672.8	669.5	IA Highway Research
Lower	IA	Cedar	50.1	672.5	671.4	668.1	IA Highway Research
Lower	IA	Cedar	49.1	670.4	669.3	666.0	IA Highway Research
Lower	IA	Cedar	48.0	668.2	667.1	664.0	IA Highway Research
Lower	IA	Cedar	47.0	666.3	665.2	662.1	IA Highway Research
Lower	IA	Cedar	46.0	664.4	663.3	660.2	IA Highway Research
Lower	IA	Cedar	44.9	663.1	662.0	658.9	IA Highway Research
Lower	IA	Cedar	43.9	662.8	661.7	658.6	IA Highway Research
Lower	IA	Cedar	42.9	659.0	657.9	655.0	IA Highway Research
Lower	IA	Cedar	41.9	657.5	656.4	653.5	IA Highway Research
Lower	IA	Cedar	40.8	655.4	654.3	651.4	IA Highway Research
Lower	IA	Cedar	39.8	653.5	652.4	649.5	IA Highway Research
Lower	IA	Cedar	38.8	651.3	650.2	647.3	IA Highway Research
Lower	IA	Cedar	37.7	649.6	648.5	645.7	IA Highway Research
Lower	IA	Cedar	36.7	648.2	647.1	644.4	IA Highway Research
Lower	IA	Cedar	35.7	646.8	645.7	643.0	IA Highway Research
Lower	IA	Muscatine	34.8	646.7	645.6	642.9	Muscatine County FIS
Lower	IA	Muscatine	34.3	645.9	645.0	642.2	Muscatine County FIS
Lower	IA	Muscatine	33.4	644.4	643.6	640.7	Muscatine County FIS
Lower	IA	Muscatine	32.6	643.4	642.6	639.6	Muscatine County FIS
Lower	IA	Muscatine	32.5	643.1	642.2	639.3	Muscatine County FIS
Lower	IA	Muscatine	31.5	640.7	640.1	637.5	Muscatine County FIS
Lower	IA	Muscatine	30.6	638.4	637.9	635.8	Muscatine County FIS
Lower	IA	Muscatine	30.5	638.4	637.9	635.8	IA Highway Research
Lower	IA	Muscatine	29.5	634.1	633.6	631.5	IA Highway Research
Lower	IA	Muscatine	28.5	632.1	631.6	629.4	IA Highway Research
Lower	IA	Muscatine	27.5	630.2	629.6	627.4	IA Highway Research
Lower	IA	Muscatine	26.5	628.7	628.2	625.9	IA Highway Research
Lower	IA	Muscatine	25.4	625.9	625.3	623.1	IA Highway Research
Lower	IA	Muscatine	24.4	624.3	623.8	621.5	IA Highway Research
Lower	IA	Muscatine	23.4	623.1	622.5	620.2	IA Highway Research
Lower	IA	Muscatine	22.4	620.9	620.4	618.0	IA Highway Research
Lower	IA	Muscatine	21.4	619.0	618.4	616.0	IA Highway Research
Lower	IA	Muscatine	20.4	617.2	616.5	614.1	IA Highway Research
Lower	IA	Muscatine	19.4	615.7	615.1	612.6	IA Highway Research

Table C-1: Continuous Chance Exceedance Elevation (NGVD29)

Basin	State	County	USGS RM	1%	2%	10%	Source
Lower	IA	Muscatine	18.4	613.9	613.2	610.8	IA Highway Research
Lower	IA	Muscatine	17.4	612.3	611.7	609.2	IA Highway Research
Lower	IA	Muscatine	16.3	609.9	609.2	606.7	IA Highway Research
Lower	IA	Muscatine	15.3	607.5	606.8	604.2	IA Highway Research
Lower	IA	Muscatine	14.3	605.1	604.4	601.8	IA Highway Research
Lower	IA	Muscatine	13.3	603.0	602.3	599.6	IA Highway Research
Lower	IA	Muscatine	12.3	601.1	600.4	597.8	IA Highway Research
Lower	IA	Muscatine	11.3	599.3	598.6	595.9	IA Highway Research
Lower	IA	Muscatine	10.3	596.8	596.1	593.4	IA Highway Research
Lower	IA	Muscatine	9.3	596.2	595.5	592.7	IA Highway Research
Lower	IA	Muscatine	8.3	595.0	594.2	591.4	IA Highway Research
Lower	IA	Muscatine	7.2	593.5	592.7	589.9	IA Highway Research
Lower	IA	Muscatine	6.2	592.2	591.4	588.6	IA Highway Research
Lower	IA	Muscatine	5.2	590.5	589.7	586.9	IA Highway Research
Lower	IA	Louisa	4.3	590.4	589.6	586.7	Louisa County FIS
Lower	IA	Louisa	4.0	589.9	589.1	586.2	Louisa County FIS
Lower	IA	Louisa	3.6	589.3	588.5	585.6	Louisa County FIS
Lower	IA	Louisa	3.2	588.7	587.9	585.0	Louisa County FIS
Lower	IA	Louisa	2.8	588.2	587.4	584.5	Louisa County FIS
Lower	IA	Louisa	2.5	587.7	586.9	584.0	Louisa County FIS
Lower	IA	Louisa	2.4	587.6	586.8	583.9	Louisa County FIS
Lower	IA	Louisa	2.0	587.6	586.8	583.9	Louisa County FIS
Lower	IA	Louisa	1.6	587.6	586.8	583.9	Louisa County FIS
Lower	IA	Louisa	1.2	587.6	586.8	583.9	Louisa County FIS
Lower	IA	Louisa	0.8	587.6	586.8	583.9	Louisa County FIS
Lower	IA	Louisa	0.4	587.6	586.8	583.9	Louisa County FIS
Lower	IA	Louisa	0.0	587.6	586.8	583.9	Louisa County FIS

C2 - COMPARATIVE ANALYSIS BETWEEN FLOODPLAIN INUNDATION METHODS

A. Centerline Method Inundation Approximation

Scope. The “Centerline” method was developed as a potentially quicker, less costly alternative to detailed hydraulic modeling. The method’s intent is to estimate inundation extents and depths in order to approximate damages during various FIS frequency events.

Procedure. A geo-referenced centerline of the Cedar River was obtained from the Iowa Flood Center (IFC) and checked for accuracy along the test reach from Palo to Cedar Rapids, Iowa. Elevations from the Cedar River continuous FIS frequency profiles were then assigned along the centerline for the 10%, 2% and 1% chance exceedance events. The centerline was then copied laterally outward on either side, far enough to span the entire estimated floodplain (Figure C-10).

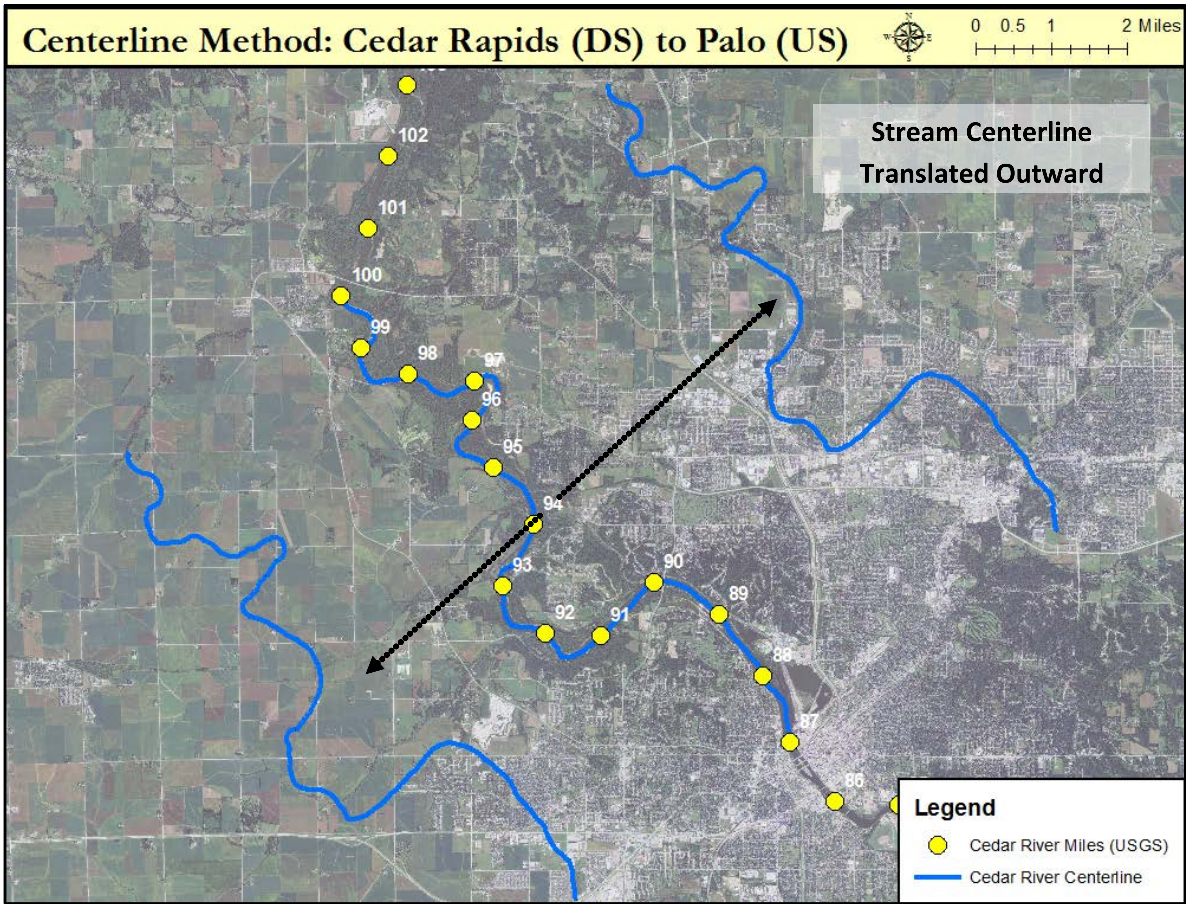

Figure C-10: Centerline Method Translation

Translating the centerline laterally outward represents an effort to preserve slope variance along the centerline. A more traditional method such as drawing widely spaced cross sections and applying water surface elevations to each results in uniform slopes between sections resulting in possible further loss of detail.

Water surface elevation (WSE) grids were then generated for each FIS event (Figure C-11). Elevation data (Iowa LiDAR) was then subtracted from the WSE grids and depth grids were produced. Further analyses took place to compare the resulting depth grids from this procedure with those from detailed HEC-RAS modeling, approximate HEC-RAS modeling and a simplified “Cross Section” method.

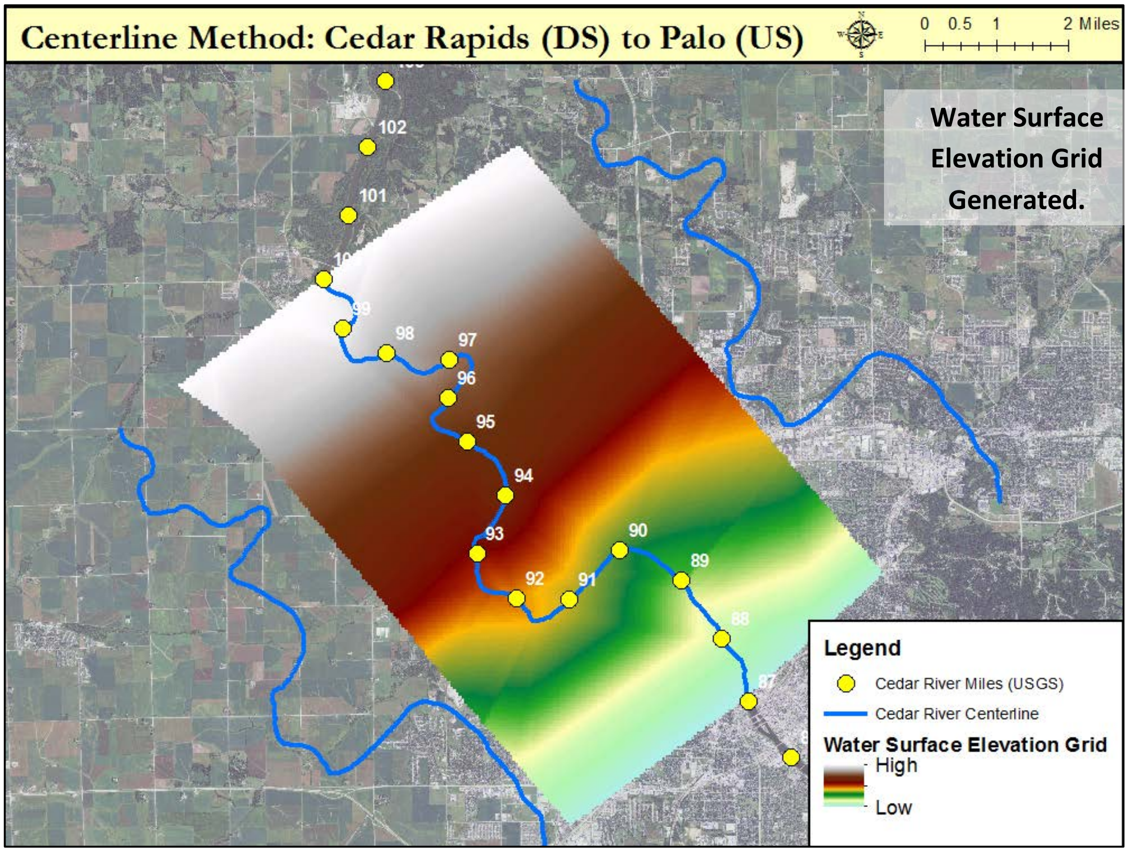

Figure C-11: Centerline Method Water Surface Elevation Grid Generation

B. HEC-RAS Approximate Method. Rock Island District developed an 'approximate method' main stem Cedar River HEC-RAS Model for this pilot effort. The Cedar River study reach was 240 river miles. USACE attempted to follow the Iowa DNR mapping procedure that the Iowa Flood Center and Omaha District developed. USACE used the statewide mosaic of 3 meter DEMs produced from the Iowa LiDAR data (elevation values are in centimeters converted to feet NAVD88) for the model overbank surface. USACE adjusted the steam centerline, banklines, and flowlines that IDNR/IFC provided October 2013. Due to time and funding constraints, USACE generalized model n-values based upon the Tables C-2 and C-3, provided by IDNR/IFC. USACE did not use the shape file provided for the base floodplain Manning's coefficients (2001 NLCD classifications) because the cross-section widths and associated n-values exceeded the limits of HEC-RAS.

Approximate HEC-RAS Modeling Assumptions/Guidelines

- Cross Section Spacing: ~1500 ft
- Bridges: disregard
- Blocked areas: use for:
    - Tributaries to prevent extra conveyance
- Roughness
- Overbank n-values: generalized
- Ineffective flow areas: only permanent ineffective flow areas should be used in modeling

Table C-2: Channel Roughness Coefficients Generalized

Contributing Drainage Area	Manning's Roughness Coefficient
Less than 10 square miles	0.045
Greater than 10 square miles	0.035

Table C-3: Overbank Roughness Coefficients Generalized

NCLD 2001 Classification	Manning's Roughness Coefficient
11 - Open Water	0.02
21 - Developed, Open Space	0.03
22 - Developed, Low Intensity	0.05
23 - Developed, Medium Intensity	0.10
24 - Developed, High Intensity	0.15
31 - Barren Land	0.05
41 - Deciduous Forest	0.12
42 - Evergreen Forest	0.12
43 - Mixed Forest	0.12
52 - Scrub/Shrub	0.08
71 - Grassland/Herbaceous	0.035
81 - Pasture/Hay	0.035
82 - Cultivated Crops	0.07
90 - Woody Wetlands	0.10
95 - Emergent Herbaceous Wetland	0.045

Iowa LiDAR data was used for the overbank surface areas of the approximate HEC-RAS model. The data collection date are shown for the following Iowa counties: Benton 2008, 2010, Blackhawk 2008, 2010, Bremer 2009, Cedar 2009, 2010, Chickasaw 2009, Floyd 2009, Johnson 2009, Linn 2008-2010, Louisa 2010, Mitchell 2008, 2009, Muscatine 2009, 2010.

C3 – ECONOMIC RESULTS OF INUNDATION COMPARISON

Table C-4 displays the total damages and number of structures flooded for each of the respective floodplain inundation methods.

Table C-4: Cedar River Comparison Reach - Method Comparison [1]

Centerline Offset (Annual Chance Exceedance)	**Total Estimated Economic Damages ($K)**	**Structures Flooded**
1% ACE	$116,957	2,177
2% ACE	$51,250	1,262
10% ACE	$14,566	254
GIS Cross Section		
1% ACE	$120,516	2,042
2% ACE	$51,093	1,222
10% ACE	$14,309	273
Detailed RAS		
1% ACE	$147,166	2,020
2% ACE	$58,323	1,235
10% ACE	$12,657	220
Approximate RAS		
1% ACE	$225,430	2,875
2% ACE	$151,402	2,385
10% ACE	$58,215	1,395

[1] This data was produced using USACE HEC-FIA version 3.0 software. Economic damage values originate from stock FEMA HAZUS based National Structure Inventory data and contain an undetermined amount of uncertainty. The main purpose of this data is to compare the various methodologies for depth grid production against a constant inventory of damageable elements.

REFERENCES

FEMA FIS Studies (various, counties: Mower, MN, Floyd, Chickasaw, Bremer, Blackhawk, Linn, Johnson, Muscatine, Louisa).

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U.S. Department of the Interior, Geological Survey, *Floods of May 30 to June 15, 2008 in the Iowa River and Cedar River Basins, Eastern Iowa*, Open File Report 2010-1190.

U.S. Geological Survey, Water Resources Division, in cooperation with The Iowa State Highway Commission, *Cedar River Basin Floods, Bulletin #27*, June 1963.

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Non-Structural Landuse Change Impacts on Structure Losses in Cedar River Communities

An Iowa Silver Jackets Non-Structural Flood Risk Management Study

APPENDIX D

ECONOMIC EVALUATION

Table D-1. Estimated Economic Damages for Cedar River Communities: Approximate HEC-RAS – FIS Flow

	Exceedence Probability			
Community	**0.01**	**0.02**	**0.1**	**Average Annual Damages**
Cedar Falls	$205,639,838	$189,782,657	$159,256,209	$17,995,065
Waterloo	168,448,058	148,522,630	118,230,558	13,939,462
Cedar Rapids	204,166,071	137,079,591	50,160,887	11,237,508
Unassigned	104,024,795	89,236,079	57,479,549	7,875,177
Austin	47,153,321	40,417,120	28,532,260	3,667,361
Waverly	32,738,806	28,286,488	14,776,593	2,355,038
Charles City	15,164,064	12,965,320	8,240,495	1,140,520
Evansdale	12,053,489	9,171,534	4,003,154	753,648
Vinton	8,383,998	7,180,155	4,269,546	619,649
Janesville	4,987,278	3,662,193	2,199,624	327,593
Nashua	2,989,946	2,812,137	2,198,195	259,323
Palo	2,692,625	1,369,662	486,996	121,504
Elk Run Heights	2,101,098	1,321,001	95,327	94,775
Gilbertville	1,250,275	1,027,769	576,729	88,073
Mapleview	613,552	587,367	485,610	55,059
La Porte City	817,810	468,070	84,636	36,716
Mitchell	369,926	346,543	281,097	32,387
Plainfield	300,692	270,073	140,219	22,272
Bertram	35,072	15,962	0	1,244
Total	813,930,715	674,522,351	451,497,682	60,622,374

[1] "Unassigned" includes all areas not located within the mapped boundaries of a community.

Table D-2. Estimated Economic Damages for Cedar River Communities:
Approximate HEC-RAS – Updated Hydrology Flow

	Exceedence Probability			
Community	**0.01**	**0.02**	**0.1**	**Average Annual Damages**
Cedar Falls	$221,076,257	$201,484,115	$164,556,384	$18,965,184
Waterloo	188,580,942	163,653,092	120,839,956	15,026,701
Cedar Rapids	305,893,671	180,194,539	54,561,984	14,879,639
Unassigned	121,470,972	101,559,692	61,384,530	8,847,632
Austin	69,625,652	61,570,513	35,963,766	5,253,609
Waverly	58,194,800	28,319,417	14,769,509	2,738,076
Charles City	21,731,390	17,053,529	9,119,057	1,458,142
Evansdale	14,498,811	11,446,418	4,782,629	923,876
Vinton	10,344,009	8,391,422	4,569,095	715,538
Janesville	4,921,949	3,968,303	2,053,600	334,547
Nashua	3,863,747	3,033,068	2,288,839	285,998
Palo	3,903,182	2,462,823	526,357	190,429
Elk Run Heights	3,944,710	1,852,908	150,170	148,558
Gilbertville	1,438,017	1,191,659	635,288	100,606
La Porte City	2,184,102	690,842	123,118	68,774
Mapleview	695,927	671,819	567,061	63,353
Mitchell	416,153	386,685	297,154	35,529
Plainfield	509,475	270,073	140,219	25,404
Bertram	51,823	27,310	0	2,006
Total	$1,033,345,589	$788,228,226	$477,328,715	$70,063,603

[1] "Unassigned" includes all areas not located within the mapped boundaries of a community.

Table D-3: Loss Ratio – HEC-RAS Approximate Method – FIS flows

	Total Inventory		**1% ACE**		**2% ACE**		**10% ACE**	
Community	**Estimated Value**	**Percent of Total**	**Estimated Economic Damages [1]**	**Loss Ratio**	**Estimated Economic Damages[1]**	**Loss Ratio**	**Estimated Economic Damages [1]**	**Loss Ratio**
Cedar Rapids	$1,485,187,723	35.52%	$204,166,071	13.7%	$137,079,591	9.2%	$50,160,887	3.4%
Waterloo	813,282,192	19.45%	168,448,058	20.7%	148,522,630	18.3%	118,230,558	14.5%
Cedar Falls	507,200,857	12.13%	205,639,838	40.5%	189,782,657	37.4%	159,256,209	31.4%
Unassigned	380,254,441	9.09%	104,024,795	27.4%	89,236,079	23.5%	57,479,549	15.1%
Waverly	330,111,251	7.90%	32,738,806	9.9%	28,286,488	8.6%	14,776,593	4.5%
Austin	289,691,692	6.93%	47,153,321	16.3%	40,417,120	14.0%	28,532,260	9.8%
Charles City	91,686,934	2.19%	15,164,064	16.5%	12,965,320	14.1%	8,240,495	9.0%
Vinton	48,119,386	1.15%	8,383,998	17.4%	7,180,155	14.9%	4,269,546	8.9%
Evansdale	43,091,825	1.03%	12,053,489	28.0%	9,171,534	21.3%	4,003,154	9.3%
Palo	40,073,656	0.96%	2,692,625	6.7%	1,369,662	3.4%	486,996	1.2%
Janesville	39,022,242	0.93%	4,987,278	12.8%	3,662,193	9.4%	2,199,624	5.6%
La Porte City	38,964,075	0.93%	817,810	2.1%	468,070	1.2%	84,636	0.2%
Elk Run Heights	33,435,122	0.80%	2,101,098	6.3%	1,321,001	4.0%	95,327	0.3%
Nashua	27,785,091	0.66%	2,989,946	10.8%	2,812,137	10.1%	2,198,195	7.9%
Plainfield	5,416,910	0.13%	300,692	5.6%	270,073	5.0%	140,219	2.6%
Gilbertville	5,299,547	0.13%	1,250,275	23.6%	1,027,769	19.4%	576,729	10.9%
Mapleview	1,432,511	0.03%	613,552	42.8%	587,367	41.0%	485,610	33.9%
Mitchell	861,700	0.02%	369,926	42.9%	346,543	40.2%	281,097	32.6%
Bertram	269,827	0.01%	35,072	13.0%	15,962	5.9%	0	0.0%
TOTAL	**$4,181,186,982**	**100%**	**$813,930,715**	**19.5%**	**$674,522,351**	**16.1%**	**$451,497,682**	**10.8%**

[1] Estimated Economic Damages = TOTAL (Structure+Content+Vehicle Values)

Table D-4: Percent Change in Estimated Economic Damages by Community
Approximate HEC-RAS: FIS to Updated Hydrology Flows

	Exceedance Probability			
Community	**0.01**	**0.02**	**0.1**	**Average Annual Damages**
Cedar Falls	7.5%	6.2%	3.3%	5.4%
Waterloo	12.0%	10.2%	2.2%	7.8%
Cedar Rapids	49.8%	31.5%	8.8%	32.4%
Unassigned[1]	16.8%	13.8%	6.8%	12.3%
Austin	47.7%	52.3%	26.0%	43.3%
Waverly	77.8%	0.1%	0.0%	16.3%
Charles City	43.3%	31.5%	10.7%	27.8%
Evansdale	20.3%	24.8%	19.5%	22.6%
Vinton	23.4%	16.9%	7.0%	15.5%
Janesville	-1.3%	8.4%	-6.6%	2.1%
Nashua	29.2%	7.9%	4.1%	10.3%
Palo	45.0%	79.8%	8.1%	56.7%
Elk Run Heights	87.7%	40.3%	57.5%	56.7%
Gilbertville	15.0%	15.9%	10.2%	14.2%
Mapleview	13.4%	14.4%	16.8%	15.1%
La Porte City	167.1%	47.6%	45.5%	87.3%
Mitchell	12.5%	11.6%	5.7%	9.7%
Plainfield	69.4%	0.0%	0.0%	14.1%
Bertram	47.8%	71.1%	0.0%	61.2%
Average	**41.3%**	**25.5%**	**11.9%**	**26.9%**

[1] "Unassigned" includes all areas not located within the mapped boundaries of a community.

Table D-5. Total Change in Estimated Economic Damages by Community
Approximate HEC-RAS: FIS to Updated Hydrology Flows

	Exceedance Probability			
Community	**0.01**	**0.02**	**0.1**	**Estimated Average Annual Damages**
Cedar Falls	$15,436,419	$11,701,458	$5,300,175	$970,119
Waterloo	$20,132,884	$15,130,461	$2,609,398	$1,087,240
Cedar Rapids	$101,727,601	$43,114,949	$4,401,097	$3,642,131
Unassigned[1]	$17,446,177	$12,323,613	$3,904,981	$972,454
Austin	$22,472,331	$21,153,393	$7,431,506	$1,586,248
Waverly	$25,455,993	$32,929	-$7,085	$383,038
Charles City	$6,567,326	$4,088,209	$878,562	$317,622
Evansdale	$2,445,323	$2,274,884	$779,475	$170,229
Vinton	$1,960,010	$1,211,267	$299,549	$95,889
Janesville	-$65,329	$306,110	-$146,024	$6,954
Nashua	$873,801	$220,930	$90,645	$26,675
Palo	$1,210,557	$1,093,161	$39,360	$68,925
Elk Run Heights	$1,843,612	$531,907	$54,843	$53,784
Gilbertville	$187,742	$163,891	$58,559	$12,534
Mapleview	$82,375	$84,453	$81,451	$8,294
La Porte City	$1,366,292	$222,772	$38,483	$32,058
Mitchell	$46,227	$40,142	$16,057	$3,142
Plainfield	$208,783	$0	$0	$3,132
Bertram	$16,751	$11,347	$0	$762
Total	**219,414,874**	**113,705,876**	**25,831,032**	**9,441,229**

[1] "Unassigned" includes all areas not located within the mapped boundaries of a community

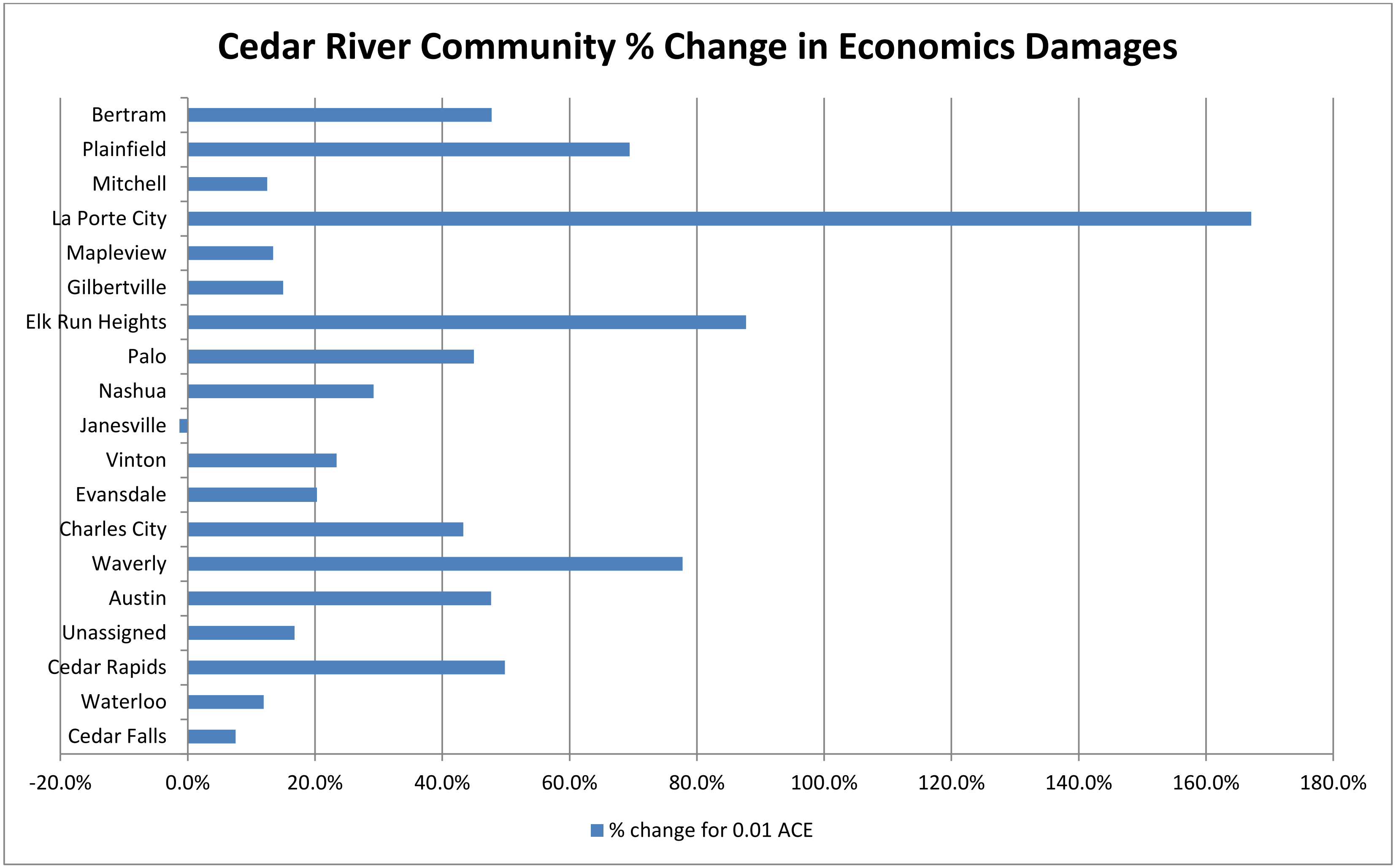

Figure D-1: Percent Change in Estimated Economic Damages for Cedar River Communities for 0.01 Annual Chance Exceedance Event

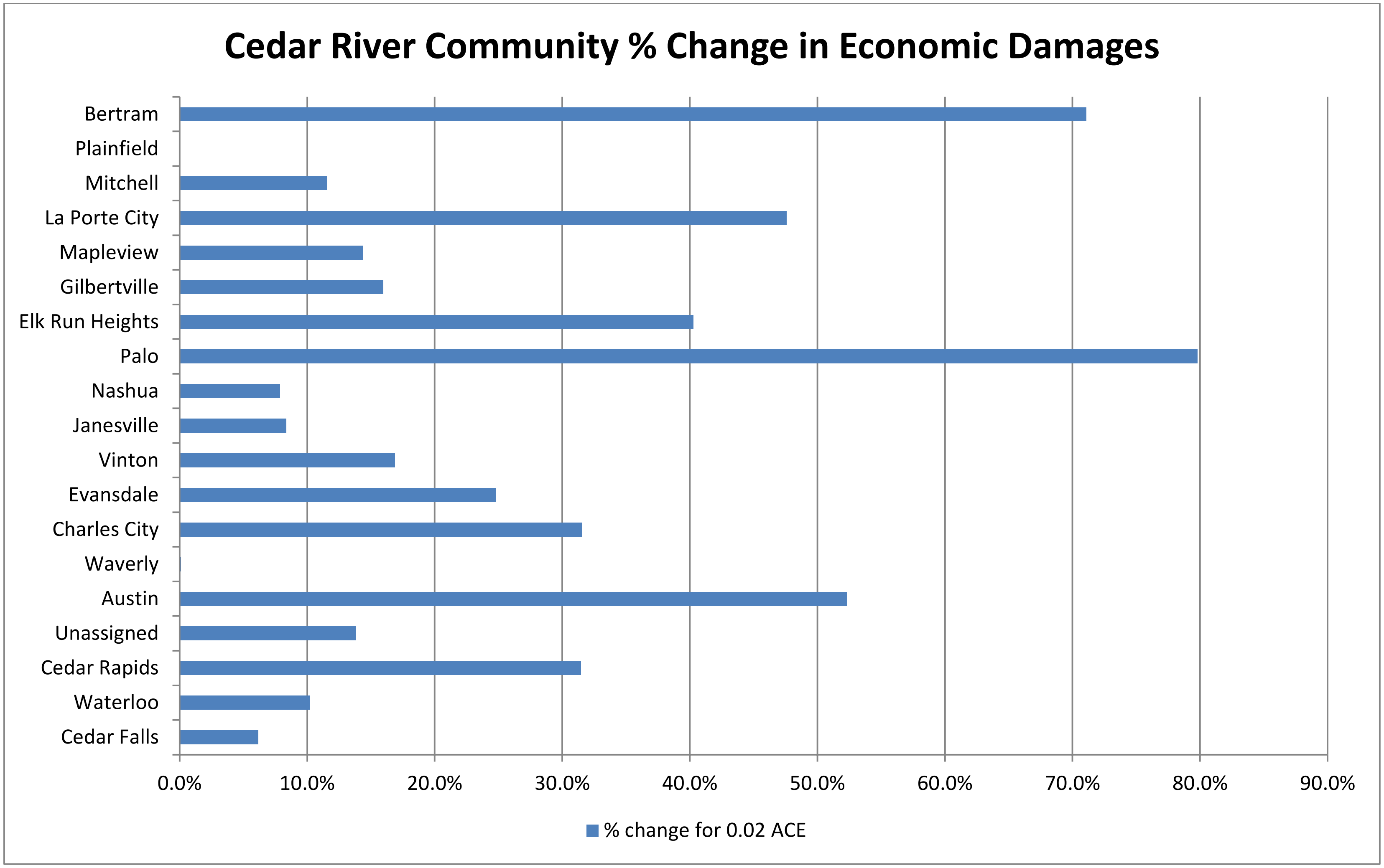

Figure D-2: Percent Change in Estimated Economic Damages for Cedar River Communities for 0.02 Annual Chance Exceedance Event

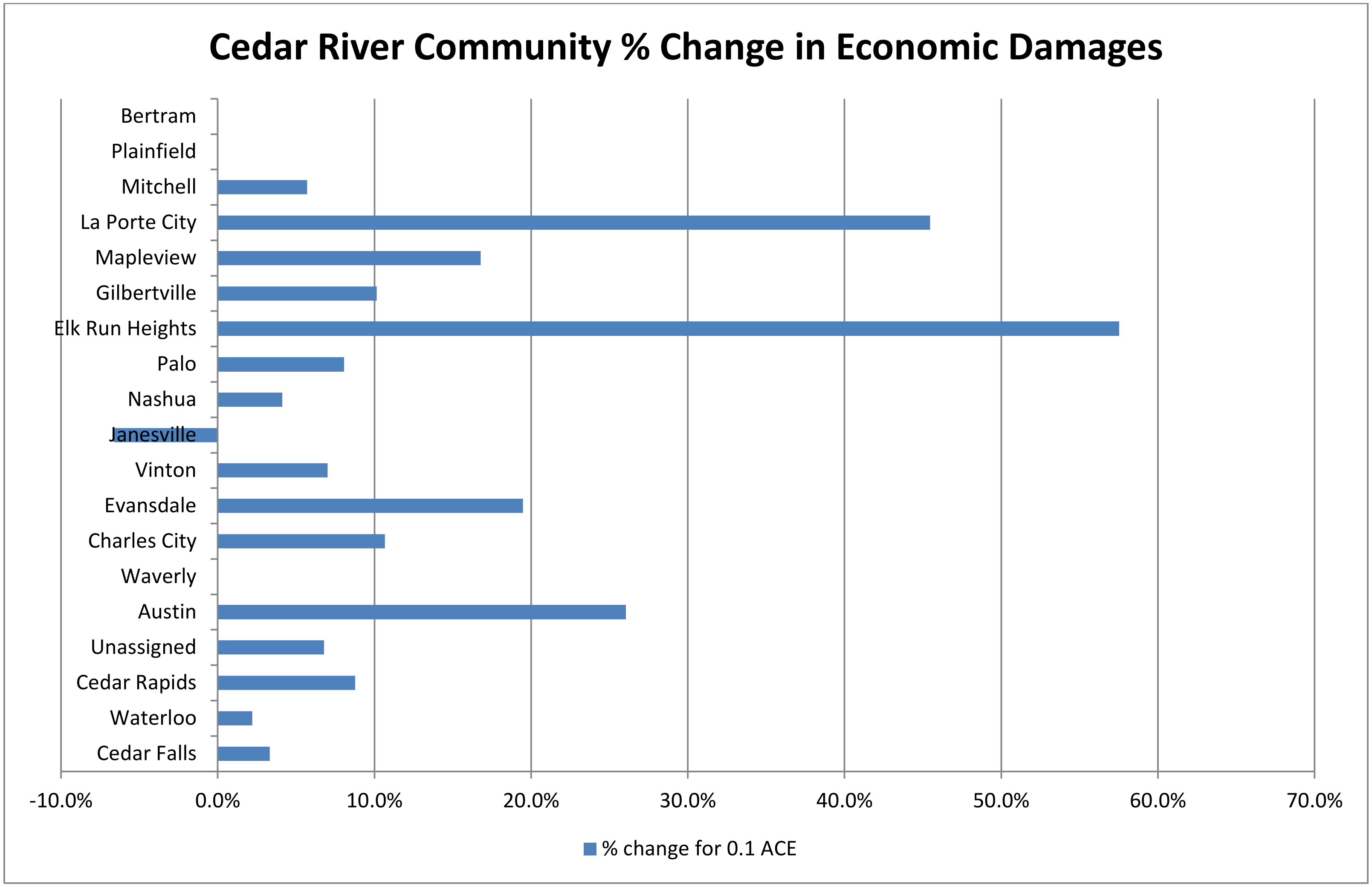

Figure D-3: Percent Change in Estimated Economic Damages for Cedar River Communities for 0.1 Annual Chance Exceedance Event

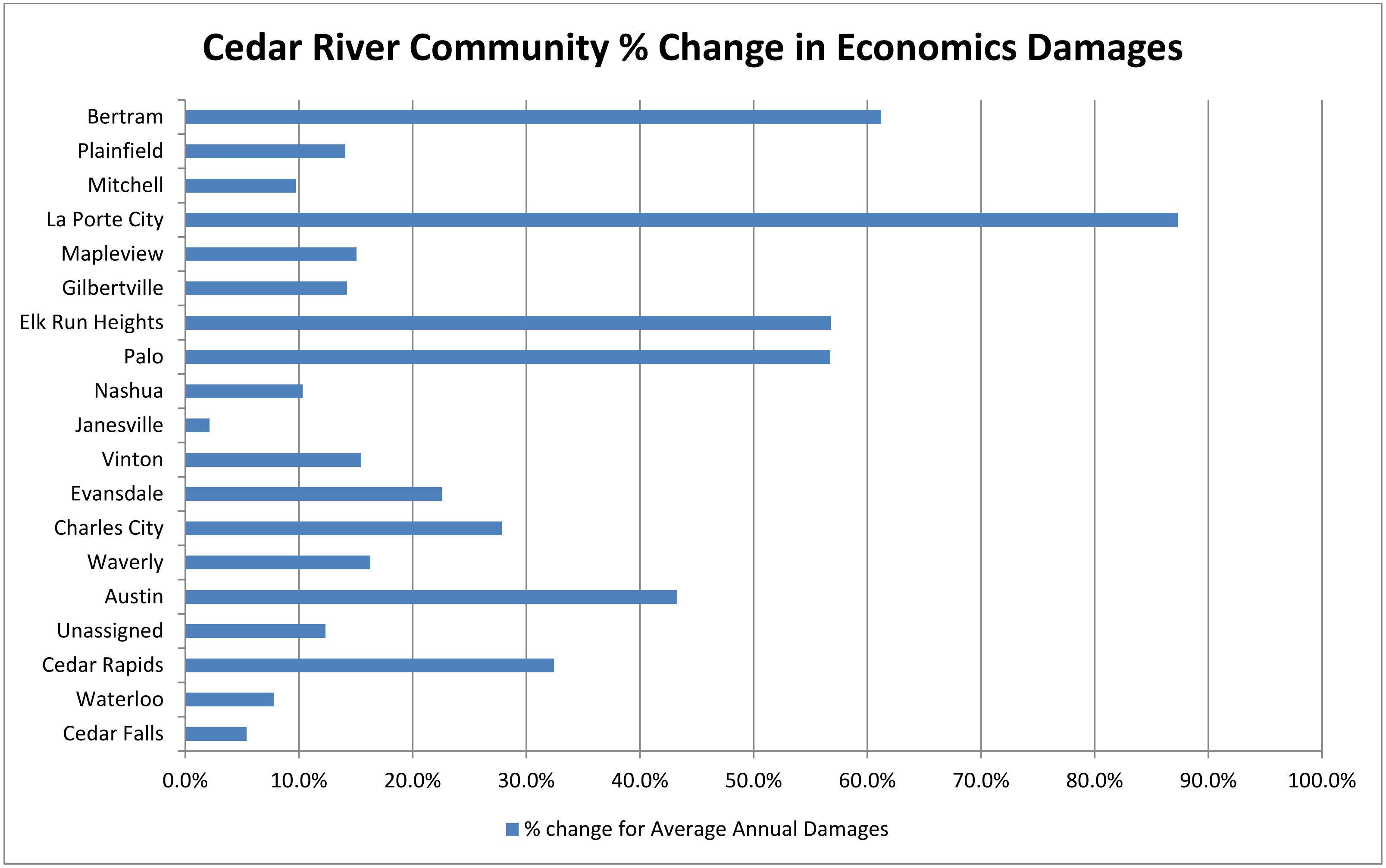

Figure D-4. Percent Change in Estimated Average Annual Damages for Cedar River Communities

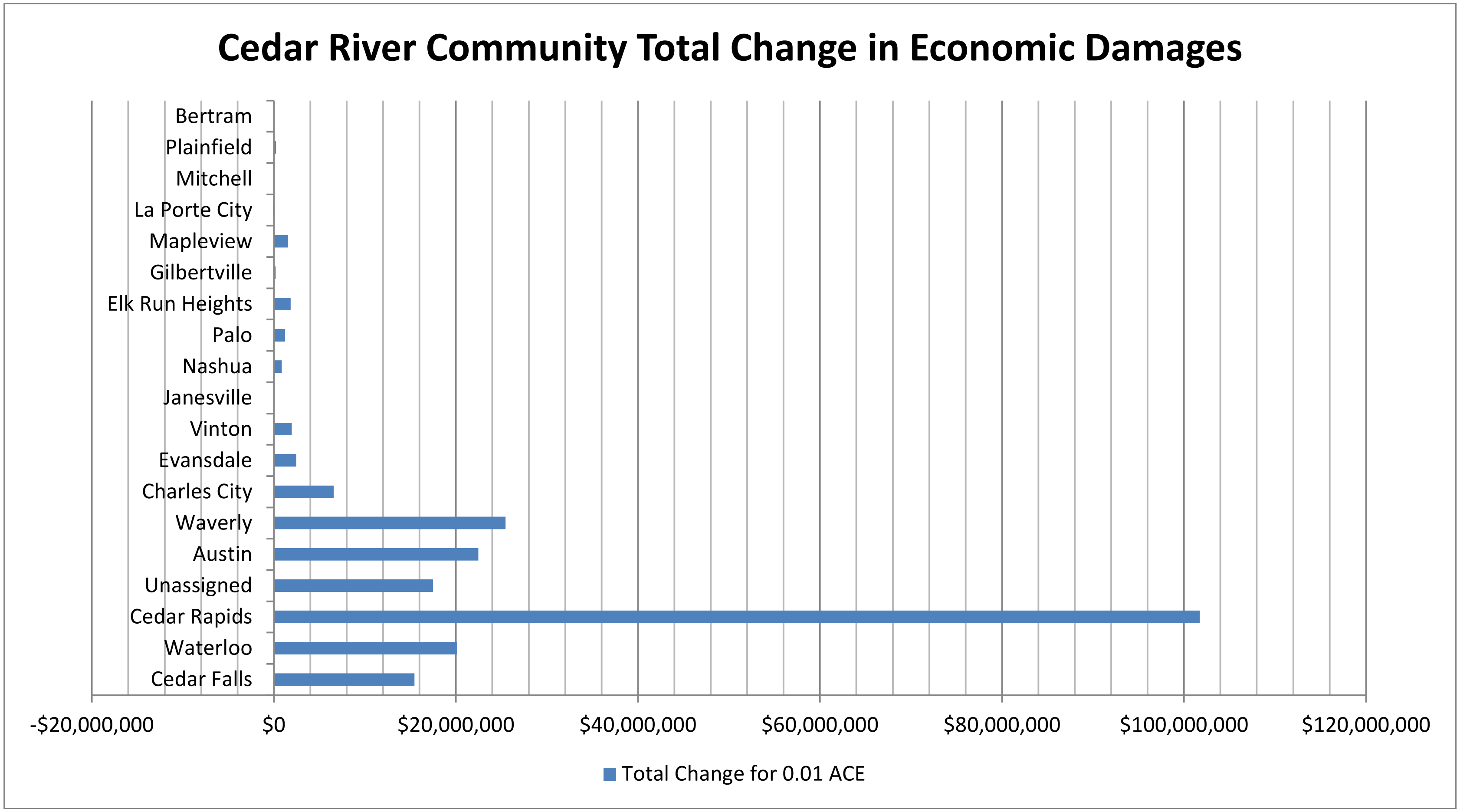

Figure D-5. Total Change in Estimated Economic Damages for Cedar River Communities for 0.01 Annual Chance Exceedance Event

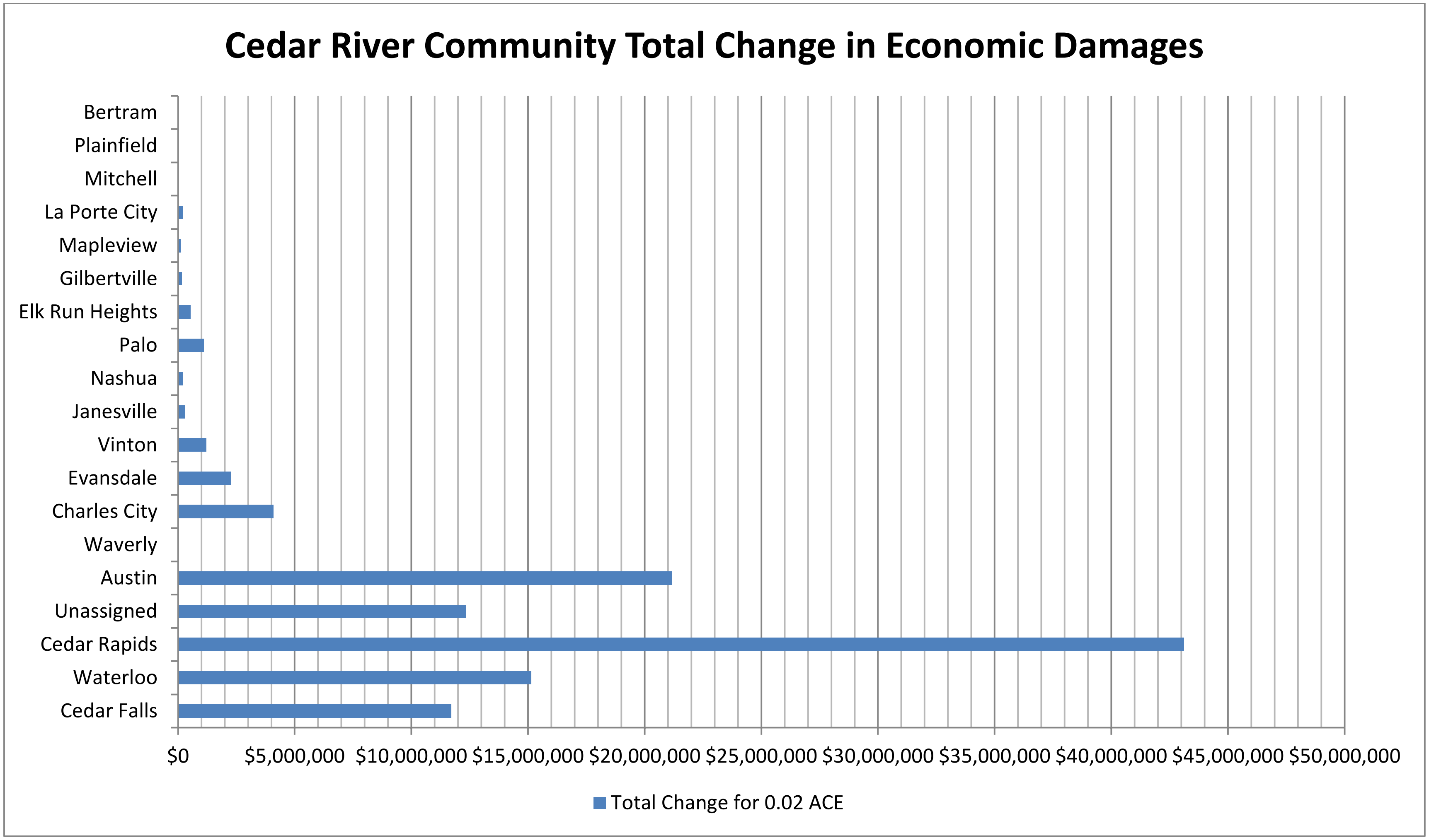

Figure D-6. Total Change in Estimated Economic Damages for Cedar River Communities for 0.02 Annual Chance Exceedance Event

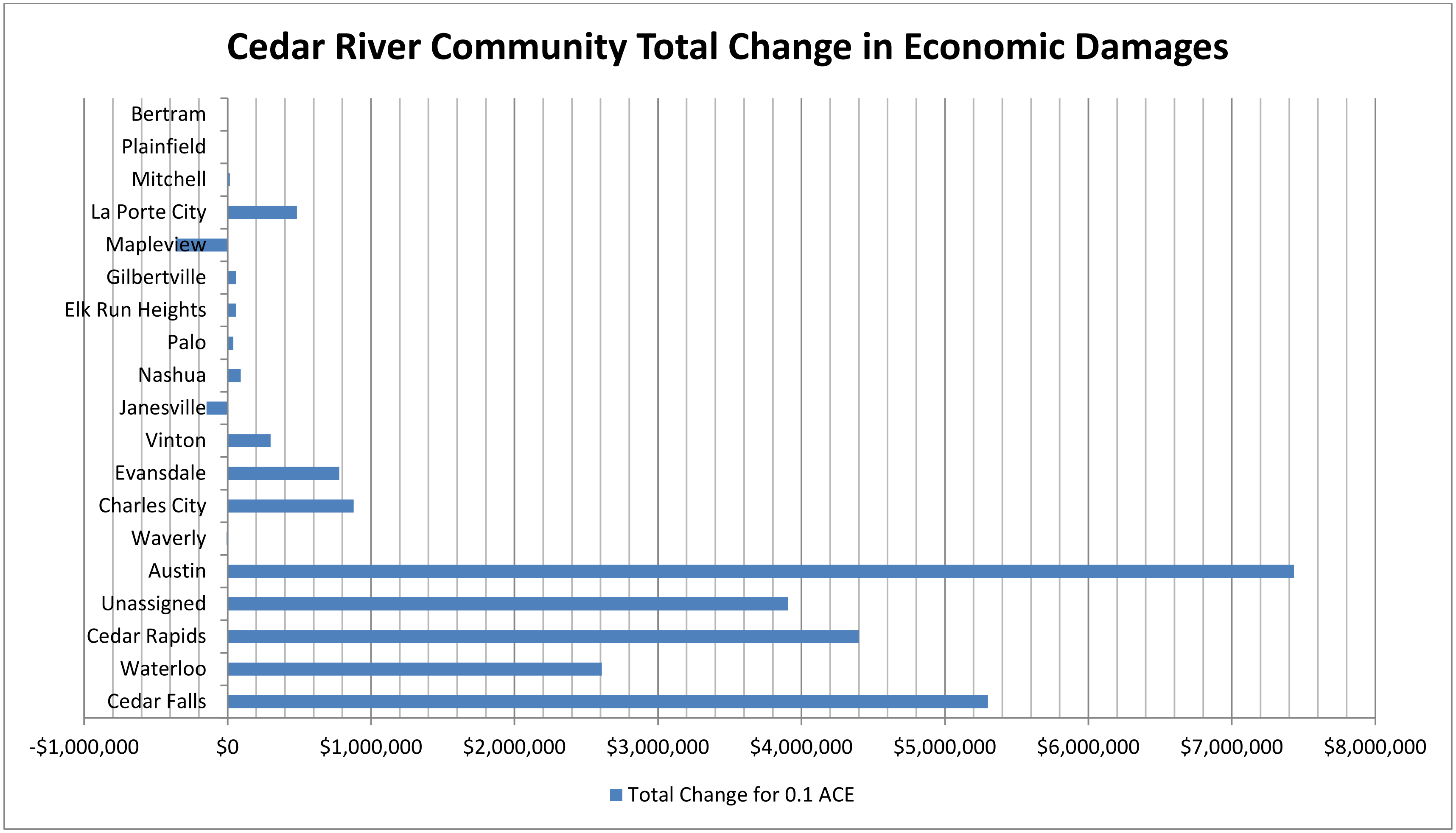

Figure D-7. Total Change in Estimated Economic Damages for Cedar River Communities for 0.1 Annual Chance Exceedance Event

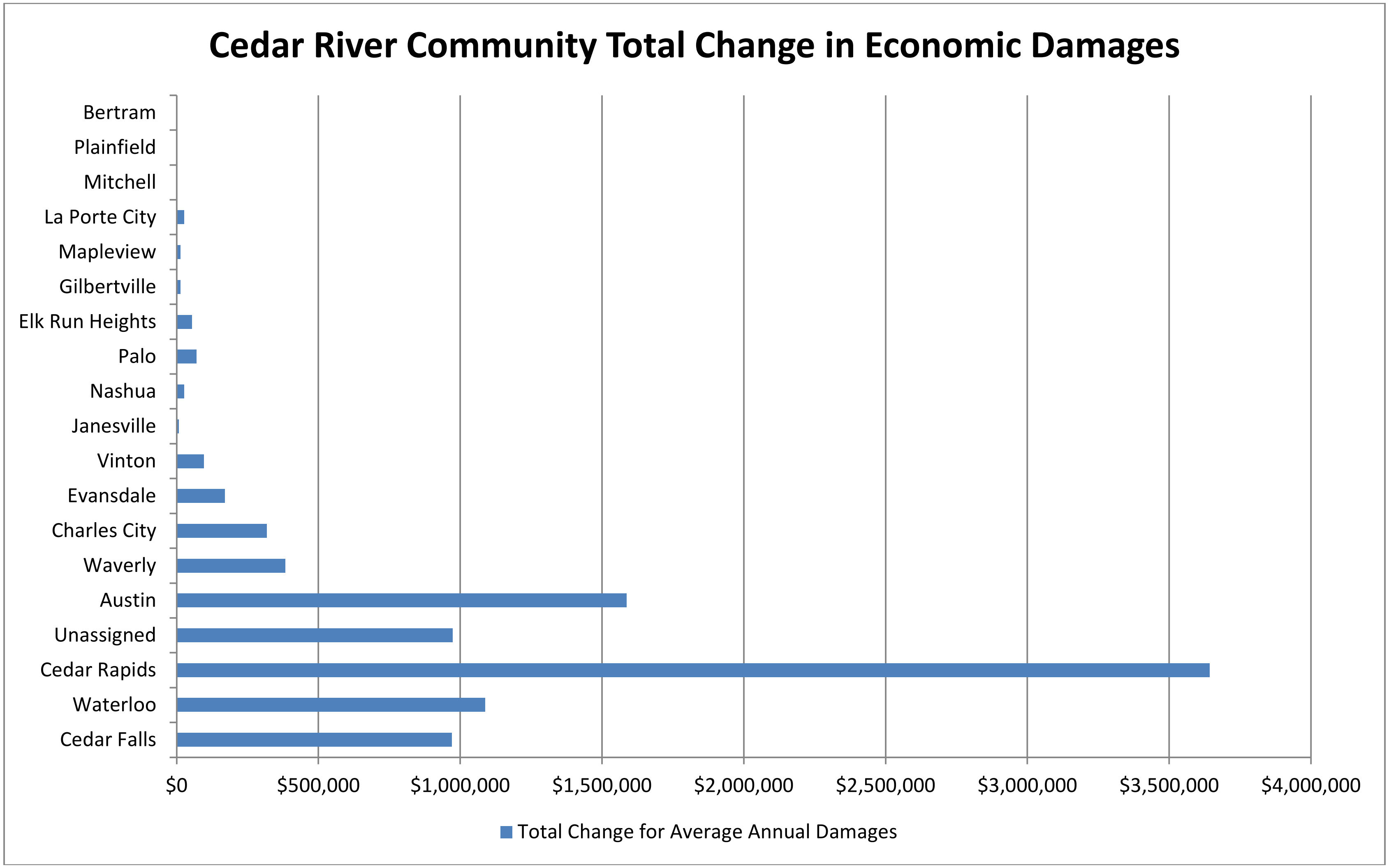

Figure D-8. Total Change in Estimated Average Annual Damages for Cedar River Communities

Non-Structural Landuse Change Impacts on Structure Losses in Cedar River Communities

An Iowa Silver Jackets Non-Structural
Flood Risk Management Study

APPENDIX E

NON-STRUCTURAL MEASURES EVALUATION

Table E-1: Cedar River Non-Structural Measures Silver Jackets - HEC-FIA Results and Subsequent Data for the Community of Charles City, IA

INPUTS							
Return Period	30						
Discount Rate	0.03375						
Non-Structural Costs		**Price Level**		**Home Value (per FT^{2})**		**CWCCIS Price Level Data**	
Elevation		Jul-93	Jan-15	Zillow value per FT^{2}	\$69	Jun-93	429.04
Wood Frame Building on Piles, Posts, or Piers	per FT^{2}	\$26.00	\$49	Trulia value per FT^{2}	<u>\$82</u>	Mar-15	814.54
Wood Frame Foundation Walls	per FT^{2}	\$19.00	\$36	Average	\$75.50	Update Factor	1.899
Brick Building	per FT^{2}	\$32.00	\$61				
Fill	per YD^{3}	\$10.00	\$19				
Relocation							
Moving Building		\$5	\$9.49		**YD^{3} Conversion - FT^{3}/27**		
(simple wood frame being moved a few hundred feet)							
# of Structures Sampled	205						
Average Flood Depth	2.11						
Elevation BCRs above 1.0	39						
Relocation BCRs above 1.0	13						

Table E-2: Charles City Structures Evaluated in Non-Structural Measures Analysis - **ELEVATION**

COMMUNITY	COUNTY	DMGCATNAME	STRUCTNAME	ID_CONSTRU	Estimated FT^2	Estimated Value/FT^2 [1]	VALUE	Elevation Req'd (FT) for 1% ACE Level of Protection	100YR_DMG	50YR_DMG	10YR_DMG	Average Annual Damages (Benefits)	Elevation Eligible	Estimated Elev. Cost	Est. Total Elev. Cost (Est. Cost + 10% Contractor Profit)	Annual Elevation Cost [2]	Elevation Annual Net Benefits	Elevation BCR
Charles City	Floyd	Residential	RES1-1SWB 19067 4621	Wood Frame	1060	$75.50	$80,000	1	$21,503	$15,805	$0	$1,034	YES	$40,398	$44,438	$2,378	($1,345)	0.43
Charles City	Floyd	Residential	RES1-1SWB 19067 4620	Wood Frame	1060	$75.50	$80,000	1	$7,646	$0	$0	$115	YES	$40,398	$44,438	$2,378	($2,264)	0.05
Charles City	Floyd	Residential	RES1-3SWB 19067 4636	Wood Frame	1060	$75.50	$80,000	1	$17,582	$13,867	$0	$888	YES	$40,398	$44,438	$2,378	($1,491)	0.37
Charles City	Floyd	Residential	RES1-2SNB 19067 4627	Wood Frame	1060	$75.50	$80,000	1	$13,008	$7,884	$0	$550	YES	$40,398	$44,438	$2,378	($1,829)	0.23
Charles City	Floyd	Residential	RES1-1SWB 19067 4623	Wood Frame	1060	$75.50	$80,000	1	$22,552	$17,467	$0	$1,124	YES	$40,398	$44,438	$2,378	($1,254)	0.47
Charles City	Floyd	Residential	RES1-2SWB 19067 4631	Wood Frame	1060	$75.50	$80,000	1	$6,095	$0	$0	$91	YES	$40,398	$44,438	$2,378	($2,287)	0.04
Charles City	Floyd	Residential	RES1-1SWB 19067 4618	Wood Frame	1060	$75.50	$80,000	1	$22,932	$18,069	$7,645	$1,463	YES	$40,398	$44,438	$2,378	($916)	0.62
Charles City	Floyd	Residential	RES1-1SNB 19067 4614	Wood Frame	1060	$75.50	$80,000	1	$24,393	$14,699	$0	$1,027	YES	$40,398	$44,438	$2,378	($1,351)	0.43
Charles City	Floyd	Residential	RES1-2SWB 19067 4632	Wood Frame	1060	$75.50	$80,000	1	$6,273	$0	$0	$94	YES	$40,398	$44,438	$2,378	($2,284)	0.04
Charles City	Floyd	Residential	RES1-2SWB 19067 4711	Wood Frame	1060	$75.50	$80,000	1	$23,627	$21,462	$6,246	$1,570	YES	$40,398	$44,438	$2,378	($808)	0.66
Charles City	Floyd	Residential	RES1-2SWB 19067 4712	Wood Frame	1060	$75.50	$80,000	1	$23,785	$21,712	$6,508	$1,594	YES	$40,398	$44,438	$2,378	($784)	0.67
Charles City	Floyd	Residential	RES1-1SNB 19067 4705	Wood Frame	1060	$75.50	$80,000	1	$26,277	$18,792	$0	$1,240	YES	$40,398	$44,438	$2,378	($1,139)	0.52
Charles City	Floyd	Residential	RES1-2SWB 19067 4688	Wood Frame	1060	$75.50	$80,000	1	$8,225	$0	$0	$123	YES	$40,398	$44,438	$2,378	($2,255)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 4956	Wood Frame	1060	$75.50	$80,000	1	$8,319	$7,629	$0	$468	YES	$40,398	$44,438	$2,378	($1,910)	0.20
Charles City	Floyd	Residential	RES1-2SWB 19067 4686	Wood Frame	1060	$75.50	$80,000	1	$8,066	$0	$0	$121	YES	$40,398	$44,438	$2,378	($2,257)	0.05
Charles City	Floyd	Residential	RES1-SLWB 19067 4637	Wood Frame	1060	$75.50	$80,000	1	$24,187	$17,862	$7,297	$1,458	YES	$40,398	$44,438	$2,378	($920)	0.61
Charles City	Floyd	Residential	RES1-3SWB 19067 4680	Masonry	1060	$75.50	$80,000	1	$19,093	$15,303	$5,094	$1,179	YES	$66,550	$73,205	$3,918	($2,739)	0.30
Charles City	Floyd	Residential	RES1-2SWB 19067 4679	Wood Frame	1060	$75.50	$80,000	1	$7,199	$0	$0	$108	YES	$40,398	$44,438	$2,378	($2,270)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 4677	Wood Frame	1060	$75.50	$80,000	1	$7,388	$0	$0	$111	YES	$40,398	$44,438	$2,378	($2,268)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 4671	Wood Frame	1060	$75.50	$80,000	1	$23,646	$19,199	$7,750	$1,529	YES	$40,398	$44,438	$2,378	($850)	0.64
Charles City	Floyd	Residential	RES1-1SWB 19067 5080	Wood Frame	1060	$75.50	$80,000	1	$7,983	$0	$0	$120	YES	$40,398	$44,438	$2,378	($2,259)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 4660	Wood Frame	1060	$75.50	$80,000	1	$23,184	$20,199	$5,599	$1,481	YES	$40,398	$44,438	$2,378	($898)	0.62
Charles City	Floyd	Residential	RES1-1SWB 19067 4647	Wood Frame	1060	$75.50	$80,000	1	$7,842	$0	$0	$118	YES	$40,398	$44,438	$2,378	($2,261)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 5002	Wood Frame	1060	$75.50	$80,000	1	$9,744	$6,169	$0	$424	YES	$40,398	$44,438	$2,378	($1,955)	0.18
Charles City	Floyd	Residential	RES1-2SWB 19067 5004	Wood Frame	1060	$75.50	$80,000	1	$12,692	$8,439	$0	$570	YES	$40,398	$44,438	$2,378	($1,808)	0.24
Charles City	Floyd	Residential	RES1-2SWB 19067 3367	Wood Frame	1020	$75.50	$77,000	1	$14,747	$11,234	$0	$727	YES	$38,917	$42,809	$2,291	($1,565)	0.32
Charles City	Floyd	Residential	RES1-1SWB 19067 6486	Wood Frame	1020	$75.50	$77,000	1	$7,626	$0	$0	$114	YES	$38,917	$42,809	$2,291	($2,177)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 4999	Wood Frame	1060	$75.50	$80,000	1	$10,013	$8,069	$0	$513	YES	$40,398	$44,438	$2,378	($1,865)	0.22
Charles City	Floyd	Residential	RES1-1SWB 19067 4708	Masonry	1060	$75.50	$80,000	1	$10,136	$8,096	$0	$516	YES	$66,550	$73,205	$3,918	($3,402)	0.13
Charles City	Floyd	Residential	RES1-1SWB 19067 4998	Wood Frame	1060	$75.50	$80,000	1	$9,717	$8,003	$0	$506	YES	$40,398	$44,438	$2,378	($1,873)	0.21
Charles City	Floyd	Residential	RES1-1SNB 19067 4589	Wood Frame	1060	$75.50	$80,000	1	$26,543	$19,287	$0	$1,266	YES	$40,398	$44,438	$2,378	($1,112)	0.53
Charles City	Floyd	Residential	RES1-3SWB 19067 4715	Wood Frame	1060	$75.50	$80,000	1	$6,775	$0	$0	$102	YES	$40,398	$44,438	$2,378	($2,277)	0.04
Charles City	Floyd	Residential	RES1-1SWB 19067 4709	Wood Frame	1060	$75.50	$80,000	1	$8,637	$7,762	$0	$479	YES	$40,398	$44,438	$2,378	($1,900)	0.20
Charles City	Floyd	Residential	RES1-2SWB 19067 4687	Wood Frame	1060	$75.50	$80,000	1	$14,115	$9,627	$0	$645	YES	$40,398	$44,438	$2,378	($1,734)	0.27
Charles City	Floyd	Residential	RES1-2SWB 19067 4713	Wood Frame	1060	$75.50	$80,000	1	$7,374	$0	$0	$111	YES	$40,398	$44,438	$2,378	($2,268)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 4684	Wood Frame	1060	$75.50	$80,000	1	$8,396	$7,706	$0	$473	YES	$40,398	$44,438	$2,378	($1,906)	0.20

Table E-2: Charles City Structures Evaluated in Non-Structural Measures Analysis - **ELEVATION**

COMMUNITY	COUNTY	DMGCATNAME	STRUCTNAME	ID_CONSTRU	Estimated FT^2	Estimated Value/FT^2 ^{1}	VALUE	Elevation Req'd (FT) for 1% ACE Level of Protection	100YR_DMG	50YR_DMG	10YR_DMG	Average Annual Damages (Benefits)	Elevation Eligible	Estimated Elev. Cost	Est. Total Elev. Cost (Est. Cost + 10% Contractor Profit)	Annual Elevation Cost ^{2}	Elevation Annual Net Benefits	Elevation BCR
Charles City	Floyd	Residential	RES1-2SWB 19067 4714	Masonry	1060	$75.50	$80,000	1	$7,342	$0	$0	$110	YES	$66,550	$73,205	$3,918	($3,808)	0.03
Charles City	Floyd	Residential	RES3A 19067 4638	Wood Frame	2384	$75.50	$180,000	1	$56,320	$11,057	$0	$1,342	YES	$89,633	$98,596	$5,277	($3,935)	0.25
Charles City	Floyd	Residential	RES1-1SWB 19067 4683	Wood Frame	1060	$75.50	$80,000	1	$8,263	$0	$0	$124	YES	$40,398	$44,438	$2,378	($2,255)	0.05
Charles City	Floyd	Residential	RES1-SLWB 19067 4716	Wood Frame	1060	$75.50	$80,000	1	$15,278	$11,569	$0	$750	YES	$40,398	$44,438	$2,378	($1,629)	0.32
Charles City	Floyd	Residential	RES1-1SWB 19067 4707	Wood Frame	1060	$75.50	$80,000	1	$24,048	$19,835	$7,808	$1,566	YES	$40,398	$44,438	$2,378	($813)	0.66
Charles City	Floyd	Residential	RES1-1SWB 19067 6503	Wood Frame	1020	$75.50	$77,000	1	$7,549	$0	$0	$113	YES	$38,917	$42,809	$2,291	($2,178)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 6783	Wood Frame	1020	$75.50	$77,000	1	$7,420	$0	$0	$111	YES	$38,917	$42,809	$2,291	($2,180)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 6786	Wood Frame	1020	$75.50	$77,000	1	$5,496	$0	$0	$82	YES	$38,917	$42,809	$2,291	($2,209)	0.04
Charles City	Floyd	Residential	RES1-1SWB 19067 6791	Wood Frame	1020	$75.50	$77,000	1	$7,361	$0	$0	$110	YES	$38,917	$42,809	$2,291	($2,181)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 1508	Wood Frame	1020	$75.50	$77,000	1	$22,497	$19,405	$8,036	$1,532	YES	$38,917	$42,809	$2,291	($759)	0.67
Charles City	Floyd	Residential	RES1-2SWB 19067 1511	Wood Frame	1020	$75.50	$77,000	1	$10,349	$7,430	$0	$490	YES	$38,917	$42,809	$2,291	($1,802)	0.21
Charles City	Floyd	Residential	RES1-2SWB 19067 1539	Wood Frame	1020	$75.50	$77,000	1	$6,716	$0	$0	$101	YES	$38,917	$42,809	$2,291	($2,191)	0.04
Charles City	Floyd	Residential	RES1-SLWB 19067 3340	Wood Frame	1020	$75.50	$77,000	1	$22,005	$17,296	$8,992	$1,468	YES	$38,917	$42,809	$2,291	($823)	0.64
Charles City	Floyd	Residential	RES1-2SNB 19067 3335	Wood Frame	1020	$75.50	$77,000	1	$11,951	$6,285	$0	$462	YES	$38,917	$42,809	$2,291	($1,829)	0.20
Charles City	Floyd	Residential	RES1-1SNB 19067 3331	Wood Frame	1020	$75.50	$77,000	1	$20,768	$11,435	$0	$826	YES	$38,917	$42,809	$2,291	($1,465)	0.36
Charles City	Floyd	Residential	RES1-2SWB 19067 3338	Wood Frame	1020	$75.50	$77,000	1	$20,679	$16,082	$6,005	$1,274	YES	$38,917	$42,809	$2,291	($1,017)	0.56
Charles City	Floyd	Residential	RES1-2SNB 19067 3366	Wood Frame	1020	$75.50	$77,000	1	$5,079	$0	$0	$76	YES	$38,917	$42,809	$2,291	($2,215)	0.03
Charles City	Floyd	Residential	RES1-2SWB 19067 3368	Wood Frame	1020	$75.50	$77,000	1	$16,172	$12,241	$0	$793	YES	$38,917	$42,809	$2,291	($1,498)	0.35
Charles City	Floyd	Residential	RES1-1SWB 19067 3365	Wood Frame	1020	$75.50	$77,000	1	$14,090	$10,417	$0	$680	YES	$38,917	$42,809	$2,291	($1,611)	0.30
Charles City	Floyd	Residential	RES1-1SWB 19067 3364	Wood Frame	1020	$75.50	$77,000	1	$12,955	$9,917	$0	$641	YES	$38,917	$42,809	$2,291	($1,651)	0.28
Charles City	Floyd	Residential	RES1-1SWB 19067 3332	Wood Frame	1020	$75.50	$77,000	1	$15,538	$11,054	$0	$731	YES	$38,917	$42,809	$2,291	($1,561)	0.32
Charles City	Floyd	Residential	RES1-2SWB 19067 3289	Wood Frame	1020	$75.50	$77,000	1	$5,037	$0	$0	$76	YES	$38,917	$42,809	$2,291	($2,216)	0.03
Charles City	Floyd	Residential	RES1-3SWB 19067 3339	Wood Frame	1020	$75.50	$77,000	1	$9,064	$6,833	$0	$443	YES	$38,917	$42,809	$2,291	($1,848)	0.19
Charles City	Floyd	Residential	RES1-2SWB 19067 1479	Wood Frame	1020	$75.50	$77,000	1	$22,605	$21,055	$8,951	$1,645	YES	$38,917	$42,809	$2,291	($647)	0.72
Charles City	Floyd	Residential	RES1-2SNB 19067 1473	Wood Frame	1020	$75.50	$77,000	1	$12,762	$11,116	$0	$692	YES	$38,917	$42,809	$2,291	($1,600)	0.30
Charles City	Floyd	Residential	RES1-2SWB 19067 2226	Wood Frame	1695	$75.50	$128,000	1	$31,771	$24,138	$8,636	$1,908	YES	$64,057	$70,463	$3,771	($1,863)	0.51
Charles City	Floyd	Residential	RES1-2SNB 19067 2297	Wood Frame	1695	$75.50	$128,000	1	$9,844	$0	$0	$148	YES	$64,057	$70,463	$3,771	($3,624)	0.04
Charles City	Floyd	Residential	RES1-2SWB 19067 2307	Wood Frame	1695	$75.50	$128,000	1	$35,335	$29,533	$12,843	$2,373	YES	$64,057	$70,463	$3,771	($1,399)	0.63
Charles City	Floyd	Residential	RES1-2SWB 19067 2344	Wood Frame	1695	$75.50	$128,000	1	$33,218	$25,584	$9,432	$2,027	YES	$64,057	$70,463	$3,771	($1,745)	0.54
Charles City	Floyd	Residential	RES1-2SWB 19067 3896	Wood Frame	1020	$75.50	$77,000	1	$8,319	$5,793	$0	$385	YES	$38,917	$42,809	$2,291	($1,906)	0.17
Charles City	Floyd	Residential	RES1-1SNB 19067 847	Wood Frame	1695	$75.50	$128,000	1	$35,730	$21,197	$0	$1,490	YES	$64,057	$70,463	$3,771	($2,282)	0.40
Charles City	Floyd	Residential	RES1-2SWB 19067 2634	Wood Frame	1020	$75.50	$77,000	1	$21,772	$19,023	$8,190	$1,510	YES	$38,917	$42,809	$2,291	($781)	0.66
Charles City	Floyd	Residential	RES1-2SWB 19067 852	Wood Frame	1695	$75.50	$128,000	1	$36,544	$32,733	$14,306	$2,593	YES	$64,057	$70,463	$3,771	($1,178)	0.69
Charles City	Floyd	Residential	RES1-1SWB 19067 2216	Wood Frame	1695	$75.50	$128,000	1	$12,691	$0	$0	$190	YES	$64,057	$70,463	$3,771	($3,581)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 2639	Wood Frame	1020	$75.50	$77,000	1	$22,558	$19,487	$8,675	$1,562	YES	$38,917	$42,809	$2,291	($729)	0.68
Charles City	Floyd	Residential	RES1-1SWB 19067 3133	Wood Frame	1020	$75.50	$77,000	1	$7,350	$0	$0	$110	YES	$38,917	$42,809	$2,291	($2,181)	0.05

Table E-2: Charles City Structures Evaluated in Non-Structural Measures Analysis - **ELEVATION**

													Elevation Eligible	**Estimated Elev. Cost**	**Est. Total Elev. Cost (Est. Cost + 10% Contractor Profit)**	**Annual Elevation Cost ^{2}**	**Elevation Annual Net Benefits**	**Elevation BCR**
Charles City	Floyd	Residential	RES1-2SWB 19067 2641	Wood Frame	1020	$75.50	$77,000	1	$7,139	$0	$0	$107	YES	$38,917	$42,809	$2,291	($2,184)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 3122	Wood Frame	1020	$75.50	$77,000	1	$7,844	$7,342	$0	$448	YES	$38,917	$42,809	$2,291	($1,843)	0.20
Charles City	Floyd	Residential	RES1-2SNB 19067 850	Wood Frame	1695	$75.50	$128,000	1	$21,275	$18,820	$0	$1,166	YES	$64,057	$70,463	$3,771	($2,605)	0.31
Charles City	Floyd	Residential	RES1-1SWB 19067 3123	Wood Frame	1020	$75.50	$77,000	1	$7,813	$0	$0	$117	YES	$38,917	$42,809	$2,291	($2,174)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 849	Wood Frame	1695	$75.50	$128,000	1	$12,793	$0	$0	$192	YES	$64,057	$70,463	$3,771	($3,580)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 3127	Wood Frame	1020	$75.50	$77,000	1	$21,400	$18,123	$7,976	$1,456	YES	$38,917	$42,809	$2,291	($836)	0.64
Charles City	Floyd	Residential	RES1-3SWB 19067 3900	Wood Frame	1020	$75.50	$77,000	1	$6,990	$5,017	$0	$331	YES	$38,917	$42,809	$2,291	($1,961)	0.14
Charles City	Floyd	Residential	RES1-1SWB 19067 2340	Wood Frame	1695	$75.50	$128,000	1	$13,083	$12,252	$0	$748	YES	$64,057	$70,463	$3,771	($3,024)	0.20
Charles City	Floyd	Residential	RES1-1SWB 19067 2341	Wood Frame	1695	$75.50	$128,000	1	$13,654	$12,677	$0	$775	YES	$64,057	$70,463	$3,771	($2,996)	0.21
Charles City	Floyd	Residential	RES1-1SNB 19067 2339	Wood Frame	1695	$75.50	$128,000	1	$8,576	$0	$0	$129	YES	$64,057	$70,463	$3,771	($3,643)	0.03
Charles City	Floyd	Residential	RES1-1SWB 19067 2631	Wood Frame	1020	$75.50	$77,000	1	$13,294	$9,760	$0	$639	YES	$38,917	$42,809	$2,291	($1,653)	0.28
Charles City	Floyd	Residential	RES1-2SWB 19067 3107	Wood Frame	1020	$75.50	$77,000	1	$12,525	$8,772	$0	$583	YES	$38,917	$42,809	$2,291	($1,709)	0.25
Charles City	Floyd	Residential	RES1-2SWB 19067 2624	Wood Frame	1020	$75.50	$77,000	1	$13,517	$9,729	$0	$641	YES	$38,917	$42,809	$2,291	($1,651)	0.28
Charles City	Floyd	Residential	RES1-1SWB 19067 2621	Wood Frame	1020	$75.50	$77,000	1	$10,128	$7,946	$0	$509	YES	$38,917	$42,809	$2,291	($1,782)	0.22
Charles City	Floyd	Residential	RES1-2SWB 19067 2623	Wood Frame	1020	$75.50	$77,000	1	$7,596	$0	$0	$114	YES	$38,917	$42,809	$2,291	($2,177)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 2619	Wood Frame	1020	$75.50	$77,000	1	$10,455	$8,022	$0	$518	YES	$38,917	$42,809	$2,291	($1,773)	0.23
Charles City	Floyd	Residential	RES1-SLWB 19067 2229	Wood Frame	1695	$75.50	$128,000	1	$20,183	$15,643	$0	$1,007	YES	$64,057	$70,463	$3,771	($2,765)	0.27
Charles City	Floyd	Residential	RES1-1SWB 19067 2217	Wood Frame	1695	$75.50	$128,000	1	$26,571	$18,704	$0	$1,240	YES	$64,057	$70,463	$3,771	($2,531)	0.33
Charles City	Floyd	Residential	RES1-1SWB 19067 2291	Wood Frame	1695	$75.50	$128,000	1	$13,313	$12,294	$0	$753	YES	$64,057	$70,463	$3,771	($3,018)	0.20
Charles City	Floyd	Residential	RES1-1SWB 19067 2600	Wood Frame	1020	$75.50	$77,000	1	$9,068	$7,702	$0	$483	YES	$38,917	$42,809	$2,291	($1,809)	0.21
Charles City	Floyd	Residential	RES1-1SNB 19067 2670	Wood Frame	1695	$75.50	$128,000	1	$14,822	$0	$0	$222	YES	$64,057	$70,463	$3,771	($3,549)	0.06
Charles City	Floyd	Residential	RES1-1SWB 19067 848	Wood Frame	1695	$75.50	$128,000	1	$12,179	$0	$0	$183	YES	$64,057	$70,463	$3,771	($3,589)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 851	Wood Frame	1695	$75.50	$128,000	1	$30,480	$22,660	$8,378	$1,812	YES	$64,057	$70,463	$3,771	($1,959)	0.48
Charles City	Floyd	Residential	RES1-2SWB 19067 2968	Wood Frame	1695	$75.50	$128,000	1	$32,434	$24,230	$9,015	$1,937	YES	$64,057	$70,463	$3,771	($1,834)	0.51
Charles City	Floyd	Residential	RES1-2SWB 19067 2306	Wood Frame	1695	$75.50	$128,000	1	$37,533	$34,808	$15,345	$2,743	YES	$64,057	$70,463	$3,771	($1,028)	0.73
Charles City	Floyd	Residential	RES1-1SWB 19067 2998	Wood Frame	1695	$75.50	$128,000	1	$12,587	$0	$0	$189	YES	$64,057	$70,463	$3,771	($3,583)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 2997	Wood Frame	1695	$75.50	$128,000	1	$26,429	$18,275	$0	$1,219	YES	$64,057	$70,463	$3,771	($2,553)	0.32
Charles City	Floyd	Residential	RES1-2SWB 19067 3008	Wood Frame	1695	$75.50	$128,000	1	$28,794	$21,132	$0	$1,383	YES	$64,057	$70,463	$3,771	($2,389)	0.37
Charles City	Floyd	Residential	RES3B 19067 2314	Wood Frame	2503	$75.50	$189,000	1	$6,110	$0	$0	$92	YES	$94,056	$103,461	$5,538	($5,446)	0.02
Charles City	Floyd	Residential	RES1-1SWB 19067 2289	Wood Frame	1695	$75.50	$128,000	1	$20,213	$15,331	$0	$993	YES	$64,057	$70,463	$3,771	($2,778)	0.26
Charles City	Floyd	Residential	RES1-2SWB 19067 2304	Masonry	1695	$75.50	$128,000	1	$22,708	$16,420	$0	$1,080	YES	$105,900	$116,490	$6,235	($5,155)	0.17
Charles City	Floyd	Residential	RES1-1SWB 19067 2632	Wood Frame	1020	$75.50	$77,000	1	$19,573	$14,408	$7,630	$1,247	YES	$38,917	$42,809	$2,291	($1,044)	0.54
Charles City	Floyd	Residential	RES1-2SWB 19067 2635	Wood Frame	1020	$75.50	$77,000	1	$18,468	$13,584	$0	$888	YES	$38,917	$42,809	$2,291	($1,403)	0.39
Charles City	Floyd	Residential	RES1-3SWB 19067 2310	Wood Frame	1695	$75.50	$128,000	1	$15,044	$10,764	$0	$710	YES	$64,057	$70,463	$3,771	($3,061)	0.19
Charles City	Floyd	Residential	RES1-1SWB 19067 2292	Masonry	1695	$75.50	$128,000	1	$16,090	$13,037	$0	$828	YES	$105,900	$116,490	$6,235	($5,407)	0.13
Charles City	Floyd	Residential	RES1-2SWB 19067 7607	Wood Frame	1020	$75.50	$77,000	1	$13,590	$9,279	$0	$621	YES	$38,917	$42,809	$2,291	($1,670)	0.27

Table E-2: Charles City Structures Evaluated in Non-Structural Measures Analysis - **ELEVATION**

														Elevation Eligible	Estimated Elev. Cost	Est. Total Elev. Cost (Est. Cost + 10% Contractor Profit)	Annual Elevation Cost ^{2}	Elevation Annual Net Benefits	Elevation BCR
Charles City	Floyd	Residential	RES1-1SWB 19067 7573	Wood Frame	1020	$75.50	$77,000	1	$11,431	$8,447	$0	$552		YES	$38,917	$42,809	$2,291	($1,740)	0.24
Charles City	Floyd	Residential	RES1-SLWB 19067 7620	Wood Frame	1020	$75.50	$77,000	1	$14,233	$10,624	$0	$692		YES	$38,917	$42,809	$2,291	($1,600)	0.30
Charles City	Floyd	Residential	RES1-SLNB 19067 7619	Wood Frame	1020	$75.50	$77,000	1	$925	$0	$0	$14		YES	$38,917	$42,809	$2,291	($2,277)	0.01
Charles City	Floyd	Residential	RES1-2SWB 19067 7599	Wood Frame	1020	$75.50	$77,000	1	$15,614	$10,820	$0	$721		YES	$38,917	$42,809	$2,291	($1,570)	0.31
Charles City	Floyd	Residential	RES1-1SNB 19067 7550	Wood Frame	1020	$75.50	$77,000	1	$4,152	$0	$0	$62		YES	$38,917	$42,809	$2,291	($2,229)	0.03
Charles City	Floyd	Residential	RES1-2SWB 19067 7591	Wood Frame	1020	$75.50	$77,000	1	$21,159	$15,934	$0	$1,034		YES	$38,917	$42,809	$2,291	($1,257)	0.45
Charles City	Floyd	Residential	RES1-1SNB 19067 7553	Wood Frame	1020	$75.50	$77,000	1	$6,430	$0	$0	$96		YES	$38,917	$42,809	$2,291	($2,195)	0.04
Charles City	Floyd	Residential	RES1-3SWB 19067 7616	Wood Frame	1020	$75.50	$77,000	1	$9,294	$6,419	$0	$428		YES	$38,917	$42,809	$2,291	($1,863)	0.19
Charles City	Floyd	Residential	RES1-1SWB 19067 7577	Wood Frame	1020	$75.50	$77,000	1	$11,267	$8,283	$0	$542		YES	$38,917	$42,809	$2,291	($1,749)	0.24
Charles City	Floyd	Residential	RES1-1SWB 19067 2681	Wood Frame	1695	$75.50	$128,000	1	$22,562	$16,443	$0	$1,078		YES	$64,057	$70,463	$3,771	($2,693)	0.29
Charles City	Floyd	Residential	RES1-1SWB 19067 4590	Wood Frame	1060	$75.50	$80,000	2	$30,026	$24,145	$8,902	$1,893		YES	$43,094	$47,403	$2,537	($644)	0.75
Charles City	Floyd	Residential	RES1-1SWB 19067 4706	Wood Frame	1060	$75.50	$80,000	2	$29,251	$23,628	$8,516	$1,843		YES	$43,094	$47,403	$2,537	($695)	0.73
Charles City	Floyd	Residential	RES1-1SWB 19067 2287	Wood Frame	1695	$75.50	$128,000	2	$43,576	$37,380	$18,318	$3,068		YES	$67,551	$74,307	$3,977	($909)	0.77
Charles City	Floyd	Residential	RES1-2SWB 19067 2317	Wood Frame	1695	$75.50	$128,000	2	$43,052	$37,618	$22,966	$3,257		YES	$67,551	$74,307	$3,977	($720)	0.82
Charles City	Floyd	Residential	RES1-2SWB 19067 2625	Wood Frame	1020	$75.50	$77,000	2	$29,518	$24,506	$14,162	$2,112		YES	$41,559	$45,715	$2,447	($335)	0.86
Charles City	Floyd	Residential	RES5 19067 853	Masonry	32411	$75.50	$2,447,000	2	$809,392	$520,191	$0	$35,549		YES	$2,028,773	$2,231,650	$119,445	($83,895)	0.30
Charles City	Floyd	Residential	RES1-2SWB 19067 7614	Wood Frame	1020	$75.50	$77,000	2	$24,921	$21,753	$7,663	$1,659		YES	$41,559	$45,715	$2,447	($788)	0.68
Charles City	Floyd	Residential	RES1-2SWB 19067 3336	Wood Frame	1020	$75.50	$77,000	3	$30,772	$27,306	$18,700	$2,438		YES	$44,792	$49,271	$2,637	($199)	0.92
Charles City	Floyd	Residential	RES1-1SWB 19067 3333	Masonry	1020	$75.50	$77,000	3	$31,721	$27,354	$16,027	$2,348		YES	$69,963	$76,959	$4,119	($1,771)	0.57
Charles City	Floyd	Residential	RES1-1SWB 19067 4592	Wood Frame	1060	$75.50	$80,000	3	$33,070	$26,996	$10,489	$2,130		YES	$46,385	$51,023	$2,731	($600)	0.78
Charles City	Floyd	Residential	RES1-1SNB 19067 1507	Wood Frame	1020	$75.50	$77,000	3	$35,241	$33,434	$19,830	$2,826		YES	$44,792	$49,271	$2,637	$189	1.07
Charles City	Floyd	Residential	RES1-2SNB 19067 3452	Wood Frame	1020	$75.50	$77,000	3	$21,422	$18,376	$11,642	$1,614		YES	$44,792	$49,271	$2,637	($1,023)	0.61
Charles City	Floyd	Residential	RES3A 19067 3341	Wood Frame	2424	$75.50	$183,000	3	$89,961	$83,899	$12,498	$5,625		YES	$100,514	$110,565	$5,918	($293)	0.95
Charles City	Floyd	Residential	RES1-2SWB 19067 3454	Masonry	1020	$75.50	$77,000	3	$31,133	$27,907	$19,232	$2,492		YES	$69,963	$76,959	$4,119	($1,627)	0.61
Charles City	Floyd	Residential	RES1-2SNB 19067 2342	Wood Frame	1695	$75.50	$128,000	3	$30,626	$25,535	$6,878	$1,884		YES	$71,714	$78,885	$4,222	($2,339)	0.45
Charles City	Floyd	Residential	RES1-2SWB 19067 2302	Wood Frame	1695	$75.50	$128,000	3	$55,036	$50,798	$35,329	$4,525		YES	$71,714	$78,885	$4,222	$302	1.07
Charles City	Floyd	Residential	RES1-2SWB 19067 2303	Wood Frame	1695	$75.50	$128,000	3	$52,707	$47,977	$33,369	$4,284		YES	$71,714	$78,885	$4,222	$62	1.01
Charles City	Floyd	Residential	RES1-2SNB 19067 2299	Wood Frame	1695	$75.50	$128,000	3	$35,023	$29,972	$18,911	$2,631		YES	$71,714	$78,885	$4,222	($1,592)	0.62
Charles City	Floyd	Residential	RES1-1SWB 19067 2294	Wood Frame	1695	$75.50	$128,000	3	$60,306	$53,526	$33,467	$4,652		YES	$71,714	$78,885	$4,222	$430	1.10
Charles City	Floyd	Residential	RES2 19067 2313	Manufactured Housing	750	$20.00	$15,000	3	$15,750	$14,011	$3,860	$1,021		YES	$33,932	$37,325	$1,998	($977)	0.51
Charles City	Floyd	Residential	RES1-1SWB 19067 2316	Wood Frame	1695	$75.50	$128,000	3	$51,283	$43,876	$25,158	$3,750		YES	$71,714	$78,885	$4,222	($472)	0.89
Charles City	Floyd	Residential	RES1-1SNB 19067 2669	Wood Frame	1695	$75.50	$128,000	3	$55,338	$49,357	$16,508	$3,711		YES	$71,714	$78,885	$4,222	($511)	0.88
											TOTALS	**$183,220**				**TOTALS**	**$524,622**	**($341,402)**	**0.35**

Table E-2: Charles City Structures Evaluated in Non-Structural Measures Analysis - **ELEVATION**

													Elevation Eligible	Estimated Elev. Cost	Est. Total Elev. Cost (Est. Cost + 10% Contractor Profit)	Annual Elevation Cost [2]	Elevation Annual Net Benefits	Elevation BCR
Charles City	Floyd	Residential	RES1-2SWB 19067 4635	Wood Frame	1060	$75.50	$80,000	4	$39,471	$34,738	$22,288	$3,047	YES	$50,347	$55,381	$2,964	$83	1.03
Charles City	Floyd	Residential	RES1-1SWB 19067 4622	Wood Frame	1060	$75.50	$80,000	4	$42,798	$38,373	$21,427	$3,226	YES	$50,347	$55,381	$2,964	$262	1.09
Charles City	Floyd	Residential	RES1-1SWB 19067 4619	Wood Frame	1060	$75.50	$80,000	4	$43,137	$38,701	$21,701	$3,257	YES	$50,347	$55,381	$2,964	$292	1.10
Charles City	Floyd	Residential	RES1-1SWB 19067 4602	Wood Frame	1060	$75.50	$80,000	4	$39,452	$34,454	$17,764	$2,853	YES	$50,347	$55,381	$2,964	($111)	0.96
Charles City	Floyd	Residential	RES1-2SWB 19067 1513	Wood Frame	1020	$75.50	$77,000	4	$38,854	$35,245	$24,594	$3,153	YES	$48,691	$53,560	$2,867	$286	1.10
Charles City	Floyd	Residential	RES1-1SNB 19067 3449	Wood Frame	1020	$75.50	$77,000	4	$37,498	$35,957	$27,399	$3,276	YES	$48,691	$53,560	$2,867	$410	1.14
Charles City	Floyd	Residential	RES1-1SWB 19067 3450	Wood Frame	1020	$75.50	$77,000	4	$41,580	$38,239	$24,968	$3,343	YES	$48,691	$53,560	$2,867	$476	1.17
Charles City	Floyd	Residential	RES3A 19067 3455	Wood Frame	2424	$75.50	$183,000	4	$106,729	$96,370	$74,274	$8,909	YES	$106,397	$117,037	$6,264	$2,644	1.42
Charles City	Floyd	Residential	RES1-2SWB 19067 3453	Wood Frame	1020	$75.50	$77,000	4	$36,177	$32,899	$22,833	$2,936	YES	$48,691	$53,560	$2,867	$70	1.02
Charles City	Floyd	Residential	RES1-2SWB 19067 2343	Wood Frame	1695	$75.50	$128,000	4	$57,012	$52,389	$36,220	$4,661	YES	$76,620	$84,282	$4,511	$150	1.03
Charles City	Floyd	Residential	RES1-2SNB 19067 2222	Wood Frame	1695	$75.50	$128,000	4	$40,144	$35,840	$21,373	$3,070	YES	$76,620	$84,282	$4,511	($1,441)	0.68
Charles City	Floyd	Residential	RES1-2SWB 19067 2308	Wood Frame	1695	$75.50	$128,000	4	$60,458	$54,682	$38,033	$4,889	YES	$76,620	$84,282	$4,511	$378	1.08
Charles City	Floyd	Residential	RES1-1SNB 19067 2285	Wood Frame	1695	$75.50	$128,000	4	$61,128	$58,428	$43,705	$5,294	YES	$76,620	$84,282	$4,511	$783	1.17
Charles City	Floyd	Residential	RES1-2SNB 19067 2640	Wood Frame	1020	$75.50	$77,000	4	$25,794	$23,467	$14,952	$2,041	YES	$48,691	$53,560	$2,867	($826)	0.71
Charles City	Floyd	Residential	RES1-1SWB 19067 2288	Wood Frame	1695	$75.50	$128,000	4	$63,436	$56,681	$36,290	$4,954	YES	$76,620	$84,282	$4,511	$443	1.10
Charles City	Floyd	Residential	RES1-2SWB 19067 1512	Wood Frame	1020	$75.50	$77,000	5	$39,114	$35,498	$24,904	$3,180	YES	$53,331	$58,665	$3,140	$40	1.01
Charles City	Floyd	Residential	RES1-1SWB 19067 1509	Wood Frame	1020	$75.50	$77,000	5	$44,094	$40,339	$27,883	$3,592	YES	$53,331	$58,665	$3,140	$452	1.14
Charles City	Floyd	Residential	RES1-1SWB 19067 3451	Wood Frame	1020	$75.50	$77,000	5	$43,289	$39,701	$26,992	$3,516	YES	$53,331	$58,665	$3,140	$376	1.12
Charles City	Floyd	Residential	RES1-2SWB 19067 1475	Wood Frame	1020	$75.50	$77,000	5	$38,944	$35,333	$24,701	$3,162	YES	$53,331	$58,665	$3,140	$22	1.01
Charles City	Floyd	Residential	RES1-1SWB 19067 1478	Wood Frame	1020	$75.50	$77,000	5	$42,144	$38,755	$25,689	$3,404	YES	$53,331	$58,665	$3,140	$264	1.08
Charles City	Floyd	Residential	RES1-2SWB 19067 2300	Wood Frame	1695	$75.50	$128,000	5	$73,073	$67,373	$52,238	$6,217	YES	$82,347	$90,581	$4,848	$1,369	1.28
Charles City	Floyd	Residential	RES1-2SWB 19067 2301	Wood Frame	1695	$75.50	$128,000	5	$66,503	$60,646	$46,016	$5,567	YES	$82,347	$90,581	$4,848	$719	1.15
Charles City	Floyd	Residential	RES1-2SWB 19067 2309	Wood Frame	1695	$75.50	$128,000	5	$69,692	$64,003	$50,046	$5,927	YES	$82,347	$90,581	$4,848	$1,079	1.22
Charles City	Floyd	Residential	RES5 19067 854	Wood Frame	32411	$75.50	$2,447,000	5	$1,407,865	$1,343,919	$953,395	$119,730	YES	$1,332,462	$1,465,708	$78,449	$41,281	1.53
Charles City	Floyd	Residential	RES1-1SWB 19067 1472	Wood Frame	1020	$75.50	$77,000	6	$52,346	$47,555	$35,796	$4,357	YES	$58,790	$64,669	$3,461	$896	1.26
Charles City	Floyd	Residential	RES1-1SNB 19067 1470	Wood Frame	1020	$75.50	$77,000	6	$45,192	$39,626	$35,118	$3,866	YES	$58,790	$64,669	$3,461	$404	1.12
Charles City	Floyd	Residential	RES1-1SNB 19067 3889	Wood Frame	1020	$75.50	$77,000	6	$42,413	$39,041	$34,817	$3,786	YES	$58,790	$64,669	$3,461	$324	1.09
Charles City	Floyd	Residential	RES1-1SWB 19067 2286	Wood Frame	1695	$75.50	$128,000	6	$81,080	$74,321	$56,819	$6,833	YES	$88,969	$97,866	$5,238	$1,595	1.30
Charles City	Floyd	Residential	RES1-1SWB 19067 2290	Wood Frame	1695	$75.50	$128,000	6	$88,439	$80,387	$61,388	$7,400	YES	$88,969	$97,866	$5,238	$2,161	1.41
Charles City	Floyd	Residential	RES1-SLNB 19067 2311	Wood Frame	1695	$75.50	$128,000	6	$65,897	$58,706	$47,869	$5,545	YES	$88,969	$97,866	$5,238	$307	1.06
Charles City	Floyd	Residential	RES1-1SWB 19067 2671	Wood Frame	1695	$75.50	$128,000	6	$86,476	$77,718	$58,036	$7,116	YES	$88,969	$97,866	$5,238	$1,878	1.36
Charles City	Floyd	Residential	RES1-1SNB 19067 4616	Wood Frame	1060	$75.50	$80,000	7	$52,815	$48,234	$37,076	$4,446	YES	$67,020	$73,722	$3,946	$500	1.13
Charles City	Floyd	Residential	RES1-2SWB 19067 4634	Wood Frame	1060	$75.50	$80,000	7	$58,250	$52,859	$37,301	$4,744	YES	$67,020	$73,722	$3,946	$799	1.20
Charles City	Floyd	Residential	RES4 19067 4599	Wood Frame	8132	$75.50	$614,000	7	$206,410	$180,144	$110,799	$15,635	YES	$380,223	$418,246	$22,386	($6,751)	0.70
Charles City	Floyd	Residential	RES1-1SWB 19067 3893	Wood Frame	1020	$75.50	$77,000	7	$55,445	$50,740	$39,214	$4,684	YES	$65,142	$71,657	$3,835	$848	1.22
Charles City	Floyd	Residential	RES1-2SNB 19067 2296	Wood Frame	1695	$75.50	$128,000	7	$58,140	$53,872	$41,959	$4,975	YES	$96,563	$106,219	$5,685	($710)	0.88

Table E-2: Charles City Structures Evaluated in Non-Structural Measures Analysis - **ELEVATION**

													Elevation Eligible	**Estimated Elev. Cost**	**Est. Total Elev. Cost (Est. Cost + 10% Contractor Profit)**	**Annual Elevation Cost [2]**	**Elevation Annual Net Benefits**	**Elevation BCR**
Charles City	Floyd	Residential	RES1-2SWB 19067 2305	Wood Frame	1695	$75.50	$128,000	7	$87,438	$80,355	$62,073	$7,410	YES	$96,563	$106,219	$5,685	$1,725	1.30
Charles City	Floyd	Residential	RES1-2SWB 19067 7604	Wood Frame	1020	$75.50	$77,000	7	$50,572	$45,574	$31,554	$4,072	YES	$65,142	$71,657	$3,835	$236	1.06
Charles City	Floyd	Residential	RES3B 19067 4639	Masonry	2344	$75.50	$177,000	8	$122,250	$119,372	$98,194	$11,133	YES	$193,713	$213,084	$11,405	($272)	0.98
Charles City	Floyd	Residential	RES1-2SWB 19067 4595	Wood Frame	1060	$75.50	$80,000	8	$61,136	$55,607	$39,528	$5,000	YES	$74,427	$81,869	$4,382	$619	1.14
Charles City	Floyd	Residential	RES1-2SNB 19067 4593	Wood Frame	1060	$75.50	$80,000	8	$40,013	$36,348	$26,190	$3,283	YES	$74,427	$81,869	$4,382	($1,098)	0.75
Charles City	Floyd	Residential	RES3B 19067 3456	Wood Frame	2291	$75.50	$173,000	8	$119,656	$117,636	$105,712	$11,317	YES	$133,371	$146,708	$7,852	$3,465	1.44
											TOTALS	**$328,806**			**TOTALS**	**$272,379**	**$56,427**	**1.21**
Charles City	Floyd	Residential	RES1-2SWB 19067 4629	Wood Frame	1060	$75.50	$80,000	N/A	$80,285	$79,074	$76,133	$7,808	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SNB 19067 4600	Wood Frame	1060	$75.50	$80,000	N/A	$61,322	$60,666	$54,745	$5,840	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 6606	Wood Frame	1629	$75.50	$123,000	N/A	$107,101	$103,578	$82,417	$9,564	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 6602	Wood Frame	1629	$75.50	$123,000	N/A	$115,275	$113,827	$108,085	$11,175	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 6633	Wood Frame	1629	$75.50	$123,000	N/A	$102,499	$97,999	$77,730	$9,057	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SNB 19067 7587	Wood Frame	1020	$75.50	$77,000	N/A	$60,433	$59,770	$56,900	$5,872	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-3SWB 19067 4597	Masonry	1060	$75.50	$80,000	N/A	$76,359	$74,469	$68,330	$7,230	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 4594	Wood Frame	1060	$75.50	$80,000	N/A	$82,031	$81,126	$77,892	$7,997	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 4596	Wood Frame	1060	$75.50	$80,000	N/A	$80,290	$79,055	$76,077	$7,805	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 4591	Wood Frame	1060	$75.50	$80,000	N/A	$76,527	$75,146	$71,592	$7,393	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-SLWB 19067 4598	Wood Frame	1060	$75.50	$80,000	N/A	$76,492	$75,123	$70,187	$7,335	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 4628	Wood Frame	1060	$75.50	$80,000	N/A	$71,388	$69,172	$57,520	$6,484	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 4633	Wood Frame	1060	$75.50	$80,000	N/A	$74,651	$73,297	$66,531	$7,079	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SNB 19067 3894	Wood Frame	1020	$75.50	$77,000	N/A	$53,526	$52,941	$47,122	$5,070	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SNB 19067 3895	Wood Frame	1020	$75.50	$77,000	N/A	$53,631	$53,139	$47,640	$5,101	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 3891	Masonry	1020	$75.50	$77,000	N/A	$64,299	$62,400	$55,509	$5,993	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES3A 19067 3902	Wood Frame	2424	$75.50	$183,000	N/A	$129,330	$128,148	$123,016	$12,627	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 3892	Wood Frame	1020	$75.50	$77,000	N/A	$65,450	$63,791	$56,387	$6,108	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-SLWB 19067 3901	Wood Frame	1020	$75.50	$77,000	N/A	$69,793	$68,579	$63,763	$6,683	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SNB 19067 7583	Wood Frame	1020	$75.50	$77,000	N/A	$55,693	$54,662	$51,224	$5,344	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-SLWB 19067 2312	Wood Frame	1695	$75.50	$128,000	N/A	$102,331	$94,876	$79,572	$8,987	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 7568	Wood Frame	1020	$75.50	$77,000	N/A	$72,453	$71,369	$67,728	$7,008	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-SLWB 19067 7622	Masonry	1020	$75.50	$77,000	N/A	$71,800	$70,475	$64,384	$6,824	NO	N/A	N/A	N/A	N/A	N/A

[1] Value per square foot is derived from averaging Zillow and Trulia real estate website per square foot data for Charles City and Floyd County, IA.
[2] Cost is based on the FY2015 Federal Discount Rate of 3.375 and a 30 year period of analysis. 30 years is the assumed life of a floodproofing measure for this document.

Note: This structure information is based on default National Structure Inventory/HAZUS data processed through HEC-FIA 3.0 software and is intended to represent an approximation of what actually exists. A more in-depth study (e.g.-feasibility) should be undertaken if a significant expenditure were being considered. Structures are assumed to be in good to excellent condition for relocation and elevation consideration.

Table E-3: Charles City Structures Evaluated in Non-Structural Measures Analysis - **RELOCATION**

COMMUNITY	COUNTY	DMGCATNAME	STRUCTNAME	ID_CONSTRU	Estimated FT^2	Estimated Value/FT^2 [1]	VALUE	Elevation Req'd (FT) for 1% ACE Level of Protection	100YR_DMG	50YR_DMG	10YR_DMG	Average Annual Damages (Benefits)	Relocation Eligible	Estimated Relocation Cost	Estimated Total Relocation Cost (Est. Cost + 10% Contractor Profit)	Annual Relocation Cost[2]	Relocation Annual Net Benefits	Relocation BCR
Charles City	Floyd	Residential	RES1-1SWB 19067 4621	Wood Frame	1060	$75.50	$80,000	1	$21,503	$15,805	$0	$1,034	YES	$40,398	$44,438	$2,378	($1,345)	0.43
Charles City	Floyd	Residential	RES1-1SWB 19067 4620	Wood Frame	1060	$75.50	$80,000	1	$7,646	$0	$0	$115	YES	$40,398	$44,438	$2,378	($2,264)	0.05
Charles City	Floyd	Residential	RES1-3SWB 19067 4636	Wood Frame	1060	$75.50	$80,000	1	$17,582	$13,867	$0	$888	YES	$40,398	$44,438	$2,378	($1,491)	0.37
Charles City	Floyd	Residential	RES1-2SNB 19067 4627	Wood Frame	1060	$75.50	$80,000	1	$13,008	$7,884	$0	$550	YES	$40,398	$44,438	$2,378	($1,829)	0.23
Charles City	Floyd	Residential	RES1-1SWB 19067 4623	Wood Frame	1060	$75.50	$80,000	1	$22,552	$17,467	$0	$1,124	YES	$40,398	$44,438	$2,378	($1,254)	0.47
Charles City	Floyd	Residential	RES1-2SWB 19067 4631	Wood Frame	1060	$75.50	$80,000	1	$6,095	$0	$0	$91	YES	$40,398	$44,438	$2,378	($2,287)	0.04
Charles City	Floyd	Residential	RES1-1SWB 19067 4618	Wood Frame	1060	$75.50	$80,000	1	$22,932	$18,069	$7,645	$1,463	YES	$40,398	$44,438	$2,378	($916)	0.62
Charles City	Floyd	Residential	RES1-1SNB 19067 4614	Wood Frame	1060	$75.50	$80,000	1	$24,393	$14,699	$0	$1,027	YES	$40,398	$44,438	$2,378	($1,351)	0.43
Charles City	Floyd	Residential	RES1-2SWB 19067 4632	Wood Frame	1060	$75.50	$80,000	1	$6,273	$0	$0	$94	YES	$40,398	$44,438	$2,378	($2,284)	0.04
Charles City	Floyd	Residential	RES1-2SWB 19067 4711	Wood Frame	1060	$75.50	$80,000	1	$23,627	$21,462	$6,246	$1,570	YES	$40,398	$44,438	$2,378	($808)	0.66
Charles City	Floyd	Residential	RES1-2SWB 19067 4712	Wood Frame	1060	$75.50	$80,000	1	$23,785	$21,712	$6,508	$1,594	YES	$40,398	$44,438	$2,378	($784)	0.67
Charles City	Floyd	Residential	RES1-1SNB 19067 4705	Wood Frame	1060	$75.50	$80,000	1	$26,277	$18,792	$0	$1,240	YES	$40,398	$44,438	$2,378	($1,139)	0.52
Charles City	Floyd	Residential	RES1-2SWB 19067 4688	Wood Frame	1060	$75.50	$80,000	1	$8,225	$0	$0	$123	YES	$40,398	$44,438	$2,378	($2,255)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 4956	Wood Frame	1060	$75.50	$80,000	1	$8,319	$7,629	$0	$468	YES	$40,398	$44,438	$2,378	($1,910)	0.20
Charles City	Floyd	Residential	RES1-2SWB 19067 4686	Wood Frame	1060	$75.50	$80,000	1	$8,066	$0	$0	$121	YES	$40,398	$44,438	$2,378	($2,257)	0.05
Charles City	Floyd	Residential	RES1-SLWB 19067 4637	Wood Frame	1060	$75.50	$80,000	1	$24,187	$17,862	$7,297	$1,458	YES	$40,398	$44,438	$2,378	($920)	0.61
Charles City	Floyd	Residential	RES1-3SWB 19067 4680	Masonry	1060	$75.50	$80,000	1	$19,093	$15,303	$5,094	$1,179	YES	$66,550	$73,205	$3,918	($2,739)	0.30
Charles City	Floyd	Residential	RES1-2SWB 19067 4679	Wood Frame	1060	$75.50	$80,000	1	$7,199	$0	$0	$108	YES	$40,398	$44,438	$2,378	($2,270)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 4677	Wood Frame	1060	$75.50	$80,000	1	$7,388	$0	$0	$111	YES	$40,398	$44,438	$2,378	($2,268)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 4671	Wood Frame	1060	$75.50	$80,000	1	$23,646	$19,199	$7,750	$1,529	YES	$40,398	$44,438	$2,378	($850)	0.64
Charles City	Floyd	Residential	RES1-1SWB 19067 5080	Wood Frame	1060	$75.50	$80,000	1	$7,983	$0	$0	$120	YES	$40,398	$44,438	$2,378	($2,259)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 4660	Wood Frame	1060	$75.50	$80,000	1	$23,184	$20,199	$5,599	$1,481	YES	$40,398	$44,438	$2,378	($898)	0.62
Charles City	Floyd	Residential	RES1-1SWB 19067 4647	Wood Frame	1060	$75.50	$80,000	1	$7,842	$0	$0	$118	YES	$40,398	$44,438	$2,378	($2,261)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 5002	Wood Frame	1060	$75.50	$80,000	1	$9,744	$6,169	$0	$424	YES	$40,398	$44,438	$2,378	($1,955)	0.18
Charles City	Floyd	Residential	RES1-2SWB 19067 5004	Wood Frame	1060	$75.50	$80,000	1	$12,692	$8,439	$0	$570	YES	$40,398	$44,438	$2,378	($1,808)	0.24
Charles City	Floyd	Residential	RES1-2SWB 19067 3367	Wood Frame	1020	$75.50	$77,000	1	$14,747	$11,234	$0	$727	YES	$38,917	$42,809	$2,291	($1,565)	0.32
Charles City	Floyd	Residential	RES1-1SWB 19067 6486	Wood Frame	1020	$75.50	$77,000	1	$7,626	$0	$0	$114	YES	$38,917	$42,809	$2,291	($2,177)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 4999	Wood Frame	1060	$75.50	$80,000	1	$10,013	$8,069	$0	$513	YES	$40,398	$44,438	$2,378	($1,865)	0.22
Charles City	Floyd	Residential	RES1-1SWB 19067 4708	Masonry	1060	$75.50	$80,000	1	$10,136	$8,096	$0	$516	YES	$66,550	$73,205	$3,918	($3,402)	0.13
Charles City	Floyd	Residential	RES1-1SWB 19067 4998	Wood Frame	1060	$75.50	$80,000	1	$9,717	$8,003	$0	$506	YES	$40,398	$44,438	$2,378	($1,873)	0.21
Charles City	Floyd	Residential	RES1-1SNB 19067 4589	Wood Frame	1060	$75.50	$80,000	1	$26,543	$19,287	$0	$1,266	YES	$40,398	$44,438	$2,378	($1,112)	0.53
Charles City	Floyd	Residential	RES1-3SWB 19067 4715	Wood Frame	1060	$75.50	$80,000	1	$6,775	$0	$0	$102	YES	$40,398	$44,438	$2,378	($2,277)	0.04
Charles City	Floyd	Residential	RES1-1SWB 19067 4709	Wood Frame	1060	$75.50	$80,000	1	$8,637	$7,762	$0	$479	YES	$40,398	$44,438	$2,378	($1,900)	0.20
Charles City	Floyd	Residential	RES1-2SWB 19067 4687	Wood Frame	1060	$75.50	$80,000	1	$14,115	$9,627	$0	$645	YES	$40,398	$44,438	$2,378	($1,734)	0.27
Charles City	Floyd	Residential	RES1-2SWB 19067 4713	Wood Frame	1060	$75.50	$80,000	1	$7,374	$0	$0	$111	YES	$40,398	$44,438	$2,378	($2,268)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 4684	Wood Frame	1060	$75.50	$80,000	1	$8,396	$7,706	$0	$473	YES	$40,398	$44,438	$2,378	($1,906)	0.20

Table E-3: Charles City Structures Evaluated in Non-Structural Measures Analysis - **RELOCATION**

COMMUNITY	COUNTY	DMGCATNAME	STRUCTNAME	ID_CONSTRU	Estimated FT^2	Estimated Value/FT^2 [1]	VALUE	Elevation Req'd (FT) for 1% ACE Level of Protection	100YR_DMG	50YR_DMG	10YR_DMG	Average Annual Damages (Benefits)	Relocation Eligible	Estimated Relocation Cost	Estimated Total Relocation Cost (Est. Cost + 10% Contractor Profit)	Annual Relocation Cost[2]	Relocation Annual Net Benefits	Relocation BCR
Charles City	Floyd	Residential	RES1-2SWB 19067 4714	Masonry	1060	$75.50	$80,000	1	$7,342	$0	$0	$110	YES	$66,550	$73,205	$3,918	($3,808)	0.03
Charles City	Floyd	Residential	RES3A 19067 4638	Wood Frame	2384	$75.50	$180,000	1	$56,320	$11,057	$0	$1,342	YES	$89,633	$98,596	$5,277	($3,935)	0.25
Charles City	Floyd	Residential	RES1-1SWB 19067 4683	Wood Frame	1060	$75.50	$80,000	1	$8,263	$0	$0	$124	YES	$40,398	$44,438	$2,378	($2,255)	0.05
Charles City	Floyd	Residential	RES1-SLWB 19067 4716	Wood Frame	1060	$75.50	$80,000	1	$15,278	$11,569	$0	$750	YES	$40,398	$44,438	$2,378	($1,629)	0.32
Charles City	Floyd	Residential	RES1-1SWB 19067 4707	Wood Frame	1060	$75.50	$80,000	1	$24,048	$19,835	$7,808	$1,566	YES	$40,398	$44,438	$2,378	($813)	0.66
Charles City	Floyd	Residential	RES1-1SWB 19067 6503	Wood Frame	1020	$75.50	$77,000	1	$7,549	$0	$0	$113	YES	$38,917	$42,809	$2,291	($2,178)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 6783	Wood Frame	1020	$75.50	$77,000	1	$7,420	$0	$0	$111	YES	$38,917	$42,809	$2,291	($2,180)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 6786	Wood Frame	1020	$75.50	$77,000	1	$5,496	$0	$0	$82	YES	$38,917	$42,809	$2,291	($2,209)	0.04
Charles City	Floyd	Residential	RES1-1SWB 19067 6791	Wood Frame	1020	$75.50	$77,000	1	$7,361	$0	$0	$110	YES	$38,917	$42,809	$2,291	($2,181)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 1508	Wood Frame	1020	$75.50	$77,000	1	$22,497	$19,405	$8,036	$1,532	YES	$38,917	$42,809	$2,291	($759)	0.67
Charles City	Floyd	Residential	RES1-2SWB 19067 1511	Wood Frame	1020	$75.50	$77,000	1	$10,349	$7,430	$0	$490	YES	$38,917	$42,809	$2,291	($1,802)	0.21
Charles City	Floyd	Residential	RES1-2SWB 19067 1539	Wood Frame	1020	$75.50	$77,000	1	$6,716	$0	$0	$101	YES	$38,917	$42,809	$2,291	($2,191)	0.04
Charles City	Floyd	Residential	RES1-SLWB 19067 3340	Wood Frame	1020	$75.50	$77,000	1	$22,005	$17,296	$8,992	$1,468	YES	$38,917	$42,809	$2,291	($823)	0.64
Charles City	Floyd	Residential	RES1-2SNB 19067 3335	Wood Frame	1020	$75.50	$77,000	1	$11,951	$6,285	$0	$462	YES	$38,917	$42,809	$2,291	($1,829)	0.20
Charles City	Floyd	Residential	RES1-1SNB 19067 3331	Wood Frame	1020	$75.50	$77,000	1	$20,768	$11,435	$0	$826	YES	$38,917	$42,809	$2,291	($1,465)	0.36
Charles City	Floyd	Residential	RES1-2SWB 19067 3338	Wood Frame	1020	$75.50	$77,000	1	$20,679	$16,082	$6,005	$1,274	YES	$38,917	$42,809	$2,291	($1,017)	0.56
Charles City	Floyd	Residential	RES1-2SNB 19067 3366	Wood Frame	1020	$75.50	$77,000	1	$5,079	$0	$0	$76	YES	$38,917	$42,809	$2,291	($2,215)	0.03
Charles City	Floyd	Residential	RES1-2SWB 19067 3368	Wood Frame	1020	$75.50	$77,000	1	$16,172	$12,241	$0	$793	YES	$38,917	$42,809	$2,291	($1,498)	0.35
Charles City	Floyd	Residential	RES1-1SWB 19067 3365	Wood Frame	1020	$75.50	$77,000	1	$14,090	$10,417	$0	$680	YES	$38,917	$42,809	$2,291	($1,611)	0.30
Charles City	Floyd	Residential	RES1-1SWB 19067 3364	Wood Frame	1020	$75.50	$77,000	1	$12,955	$9,917	$0	$641	YES	$38,917	$42,809	$2,291	($1,651)	0.28
Charles City	Floyd	Residential	RES1-1SWB 19067 3332	Wood Frame	1020	$75.50	$77,000	1	$15,538	$11,054	$0	$731	YES	$38,917	$42,809	$2,291	($1,561)	0.32
Charles City	Floyd	Residential	RES1-2SWB 19067 3289	Wood Frame	1020	$75.50	$77,000	1	$5,037	$0	$0	$76	YES	$38,917	$42,809	$2,291	($2,216)	0.03
Charles City	Floyd	Residential	RES1-3SWB 19067 3339	Wood Frame	1020	$75.50	$77,000	1	$9,064	$6,833	$0	$443	YES	$38,917	$42,809	$2,291	($1,848)	0.19
Charles City	Floyd	Residential	RES1-2SWB 19067 1479	Wood Frame	1020	$75.50	$77,000	1	$22,605	$21,055	$8,951	$1,645	YES	$38,917	$42,809	$2,291	($647)	0.72
Charles City	Floyd	Residential	RES1-2SNB 19067 1473	Wood Frame	1020	$75.50	$77,000	1	$12,762	$11,116	$0	$692	YES	$38,917	$42,809	$2,291	($1,600)	0.30
Charles City	Floyd	Residential	RES1-2SWB 19067 2226	Wood Frame	1695	$75.50	$128,000	1	$31,771	$24,138	$8,636	$1,908	YES	$64,057	$70,463	$3,771	($1,863)	0.51
Charles City	Floyd	Residential	RES1-2SNB 19067 2297	Wood Frame	1695	$75.50	$128,000	1	$9,844	$0	$0	$148	YES	$64,057	$70,463	$3,771	($3,624)	0.04
Charles City	Floyd	Residential	RES1-2SWB 19067 2307	Wood Frame	1695	$75.50	$128,000	1	$35,335	$29,533	$12,843	$2,373	YES	$64,057	$70,463	$3,771	($1,399)	0.63
Charles City	Floyd	Residential	RES1-2SWB 19067 2344	Wood Frame	1695	$75.50	$128,000	1	$33,218	$25,584	$9,432	$2,027	YES	$64,057	$70,463	$3,771	($1,745)	0.54
Charles City	Floyd	Residential	RES1-2SWB 19067 3896	Wood Frame	1020	$75.50	$77,000	1	$8,319	$5,793	$0	$385	YES	$38,917	$42,809	$2,291	($1,906)	0.17
Charles City	Floyd	Residential	RES1-1SNB 19067 847	Wood Frame	1695	$75.50	$128,000	1	$35,730	$21,197	$0	$1,490	YES	$64,057	$70,463	$3,771	($2,282)	0.40
Charles City	Floyd	Residential	RES1-2SWB 19067 2634	Wood Frame	1020	$75.50	$77,000	1	$21,772	$19,023	$8,190	$1,510	YES	$38,917	$42,809	$2,291	($781)	0.66
Charles City	Floyd	Residential	RES1-2SWB 19067 852	Wood Frame	1695	$75.50	$128,000	1	$36,544	$32,733	$14,306	$2,593	YES	$64,057	$70,463	$3,771	($1,178)	0.69
Charles City	Floyd	Residential	RES1-1SWB 19067 2216	Wood Frame	1695	$75.50	$128,000	1	$12,691	$0	$0	$190	YES	$64,057	$70,463	$3,771	($3,581)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 2639	Wood Frame	1020	$75.50	$77,000	1	$22,558	$19,487	$8,675	$1,562	YES	$38,917	$42,809	$2,291	($729)	0.68
Charles City	Floyd	Residential	RES1-1SWB 19067 3133	Wood Frame	1020	$75.50	$77,000	1	$7,350	$0	$0	$110	YES	$38,917	$42,809	$2,291	($2,181)	0.05

Table E-3: Charles City Structures Evaluated in Non-Structural Measures Analysis - **RELOCATION**

													Relocation Eligible	Estimated Relocation Cost	Estimated Total Relocation Cost (Est. Cost + 10% Contractor Profit)	Annual Relocation Cost[2]	Relocation Annual Net Benefits	Relocation BCR
Charles City	Floyd	Residential	RES1-2SWB 19067 2641	Wood Frame	1020	$75.50	$77,000	1	$7,139	$0	$0	$107	YES	$38,917	$42,809	$2,291	($2,184)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 3122	Wood Frame	1020	$75.50	$77,000	1	$7,844	$7,342	$0	$448	YES	$38,917	$42,809	$2,291	($1,843)	0.20
Charles City	Floyd	Residential	RES1-2SNB 19067 850	Wood Frame	1695	$75.50	$128,000	1	$21,275	$18,820	$0	$1,166	YES	$64,057	$70,463	$3,771	($2,605)	0.31
Charles City	Floyd	Residential	RES1-1SWB 19067 3123	Wood Frame	1020	$75.50	$77,000	1	$7,813	$0	$0	$117	YES	$38,917	$42,809	$2,291	($2,174)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 849	Wood Frame	1695	$75.50	$128,000	1	$12,793	$0	$0	$192	YES	$64,057	$70,463	$3,771	($3,580)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 3127	Wood Frame	1020	$75.50	$77,000	1	$21,400	$18,123	$7,976	$1,456	YES	$38,917	$42,809	$2,291	($836)	0.64
Charles City	Floyd	Residential	RES1-3SWB 19067 3900	Wood Frame	1020	$75.50	$77,000	1	$6,990	$5,017	$0	$331	YES	$38,917	$42,809	$2,291	($1,961)	0.14
Charles City	Floyd	Residential	RES1-1SWB 19067 2340	Wood Frame	1695	$75.50	$128,000	1	$13,083	$12,252	$0	$748	YES	$64,057	$70,463	$3,771	($3,024)	0.20
Charles City	Floyd	Residential	RES1-1SWB 19067 2341	Wood Frame	1695	$75.50	$128,000	1	$13,654	$12,677	$0	$775	YES	$64,057	$70,463	$3,771	($2,996)	0.21
Charles City	Floyd	Residential	RES1-1SNB 19067 2339	Wood Frame	1695	$75.50	$128,000	1	$8,576	$0	$0	$129	YES	$64,057	$70,463	$3,771	($3,643)	0.03
Charles City	Floyd	Residential	RES1-1SWB 19067 2631	Wood Frame	1020	$75.50	$77,000	1	$13,294	$9,760	$0	$639	YES	$38,917	$42,809	$2,291	($1,653)	0.28
Charles City	Floyd	Residential	RES1-2SWB 19067 3107	Wood Frame	1020	$75.50	$77,000	1	$12,525	$8,772	$0	$583	YES	$38,917	$42,809	$2,291	($1,709)	0.25
Charles City	Floyd	Residential	RES1-2SWB 19067 2624	Wood Frame	1020	$75.50	$77,000	1	$13,517	$9,729	$0	$641	YES	$38,917	$42,809	$2,291	($1,651)	0.28
Charles City	Floyd	Residential	RES1-1SWB 19067 2621	Wood Frame	1020	$75.50	$77,000	1	$10,128	$7,946	$0	$509	YES	$38,917	$42,809	$2,291	($1,782)	0.22
Charles City	Floyd	Residential	RES1-2SWB 19067 2623	Wood Frame	1020	$75.50	$77,000	1	$7,596	$0	$0	$114	YES	$38,917	$42,809	$2,291	($2,177)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 2619	Wood Frame	1020	$75.50	$77,000	1	$10,455	$8,022	$0	$518	YES	$38,917	$42,809	$2,291	($1,773)	0.23
Charles City	Floyd	Residential	RES1-SLWB 19067 2229	Wood Frame	1695	$75.50	$128,000	1	$20,183	$15,643	$0	$1,007	YES	$64,057	$70,463	$3,771	($2,765)	0.27
Charles City	Floyd	Residential	RES1-1SWB 19067 2217	Wood Frame	1695	$75.50	$128,000	1	$26,571	$18,704	$0	$1,240	YES	$64,057	$70,463	$3,771	($2,531)	0.33
Charles City	Floyd	Residential	RES1-1SWB 19067 2291	Wood Frame	1695	$75.50	$128,000	1	$13,313	$12,294	$0	$753	YES	$64,057	$70,463	$3,771	($3,018)	0.20
Charles City	Floyd	Residential	RES1-1SWB 19067 2600	Wood Frame	1020	$75.50	$77,000	1	$9,068	$7,702	$0	$483	YES	$38,917	$42,809	$2,291	($1,809)	0.21
Charles City	Floyd	Residential	RES1-1SNB 19067 2670	Wood Frame	1695	$75.50	$128,000	1	$14,822	$0	$0	$222	YES	$64,057	$70,463	$3,771	($3,549)	0.06
Charles City	Floyd	Residential	RES1-1SWB 19067 848	Wood Frame	1695	$75.50	$128,000	1	$12,179	$0	$0	$183	YES	$64,057	$70,463	$3,771	($3,589)	0.05
Charles City	Floyd	Residential	RES1-2SWB 19067 851	Wood Frame	1695	$75.50	$128,000	1	$30,480	$22,660	$8,378	$1,812	YES	$64,057	$70,463	$3,771	($1,959)	0.48
Charles City	Floyd	Residential	RES1-2SWB 19067 2968	Wood Frame	1695	$75.50	$128,000	1	$32,434	$24,230	$9,015	$1,937	YES	$64,057	$70,463	$3,771	($1,834)	0.51
Charles City	Floyd	Residential	RES1-2SWB 19067 2306	Wood Frame	1695	$75.50	$128,000	1	$37,533	$34,808	$15,345	$2,743	YES	$64,057	$70,463	$3,771	($1,028)	0.73
Charles City	Floyd	Residential	RES1-1SWB 19067 2998	Wood Frame	1695	$75.50	$128,000	1	$12,587	$0	$0	$189	YES	$64,057	$70,463	$3,771	($3,583)	0.05
Charles City	Floyd	Residential	RES1-1SWB 19067 2997	Wood Frame	1695	$75.50	$128,000	1	$26,429	$18,275	$0	$1,219	YES	$64,057	$70,463	$3,771	($2,553)	0.32
Charles City	Floyd	Residential	RES1-2SWB 19067 3008	Wood Frame	1695	$75.50	$128,000	1	$28,794	$21,132	$0	$1,383	YES	$64,057	$70,463	$3,771	($2,389)	0.37
Charles City	Floyd	Residential	RES3B 19067 2314	Wood Frame	2503	$75.50	$189,000	1	$6,110	$0	$0	$92	YES	$94,056	$103,461	$5,538	($5,446)	0.02
Charles City	Floyd	Residential	RES1-1SWB 19067 2289	Wood Frame	1695	$75.50	$128,000	1	$20,213	$15,331	$0	$993	YES	$64,057	$70,463	$3,771	($2,778)	0.26
Charles City	Floyd	Residential	RES1-2SWB 19067 2304	Masonry	1695	$75.50	$128,000	1	$22,708	$16,420	$0	$1,080	YES	$105,900	$116,490	$6,235	($5,155)	0.17
Charles City	Floyd	Residential	RES1-1SWB 19067 2632	Wood Frame	1020	$75.50	$77,000	1	$19,573	$14,408	$7,630	$1,247	YES	$38,917	$42,809	$2,291	($1,044)	0.54
Charles City	Floyd	Residential	RES1-2SWB 19067 2635	Wood Frame	1020	$75.50	$77,000	1	$18,468	$13,584	$0	$888	YES	$38,917	$42,809	$2,291	($1,403)	0.39
Charles City	Floyd	Residential	RES1-3SWB 19067 2310	Wood Frame	1695	$75.50	$128,000	1	$15,044	$10,764	$0	$710	YES	$64,057	$70,463	$3,771	($3,061)	0.19
Charles City	Floyd	Residential	RES1-1SWB 19067 2292	Masonry	1695	$75.50	$128,000	1	$16,090	$13,037	$0	$828	YES	$105,900	$116,490	$6,235	($5,407)	0.13
Charles City	Floyd	Residential	RES1-2SWB 19067 7607	Wood Frame	1020	$75.50	$77,000	1	$13,590	$9,279	$0	$621	YES	$38,917	$42,809	$2,291	($1,670)	0.27

Table E-3: Charles City Structures Evaluated in Non-Structural Measures Analysis - **RELOCATION**

														Relocation Eligible	Estimated Relocation Cost	Estimated Total Relocation Cost (Est. Cost + 10% Contractor Profit)	Annual Relocation Cost[2]	Relocation Annual Net Benefits	Relocation BCR
Charles City	Floyd	Residential	RES1-1SWB 19067 7573	Wood Frame	1020	$75.50	$77,000	1	$11,431	$8,447	$0	$552		YES	$38,917	$42,809	$2,291	($1,740)	0.24
Charles City	Floyd	Residential	RES1-SLWB 19067 7620	Wood Frame	1020	$75.50	$77,000	1	$14,233	$10,624	$0	$692		YES	$38,917	$42,809	$2,291	($1,600)	0.30
Charles City	Floyd	Residential	RES1-SLNB 19067 7619	Wood Frame	1020	$75.50	$77,000	1	$925	$0	$0	$14		YES	$38,917	$42,809	$2,291	($2,277)	0.01
Charles City	Floyd	Residential	RES1-2SWB 19067 7599	Wood Frame	1020	$75.50	$77,000	1	$15,614	$10,820	$0	$721		YES	$38,917	$42,809	$2,291	($1,570)	0.31
Charles City	Floyd	Residential	RES1-1SNB 19067 7550	Wood Frame	1020	$75.50	$77,000	1	$4,152	$0	$0	$62		YES	$38,917	$42,809	$2,291	($2,229)	0.03
Charles City	Floyd	Residential	RES1-2SWB 19067 7591	Wood Frame	1020	$75.50	$77,000	1	$21,159	$15,934	$0	$1,034		YES	$38,917	$42,809	$2,291	($1,257)	0.45
Charles City	Floyd	Residential	RES1-1SNB 19067 7553	Wood Frame	1020	$75.50	$77,000	1	$6,430	$0	$0	$96		YES	$38,917	$42,809	$2,291	($2,195)	0.04
Charles City	Floyd	Residential	RES1-3SWB 19067 7616	Wood Frame	1020	$75.50	$77,000	1	$9,294	$6,419	$0	$428		YES	$38,917	$42,809	$2,291	($1,863)	0.19
Charles City	Floyd	Residential	RES1-1SWB 19067 7577	Wood Frame	1020	$75.50	$77,000	1	$11,267	$8,283	$0	$542		YES	$38,917	$42,809	$2,291	($1,749)	0.24
Charles City	Floyd	Residential	RES1-1SWB 19067 2681	Wood Frame	1695	$75.50	$128,000	1	$22,562	$16,443	$0	$1,078		YES	$64,057	$70,463	$3,771	($2,693)	0.29
Charles City	Floyd	Residential	RES1-1SWB 19067 4590	Wood Frame	1060	$75.50	$80,000	2	$30,026	$24,145	$8,902	$1,893		YES	$43,094	$47,403	$2,537	($644)	0.75
Charles City	Floyd	Residential	RES1-1SWB 19067 4706	Wood Frame	1060	$75.50	$80,000	2	$29,251	$23,628	$8,516	$1,843		YES	$43,094	$47,403	$2,537	($695)	0.73
Charles City	Floyd	Residential	RES1-1SWB 19067 2287	Wood Frame	1695	$75.50	$128,000	2	$43,576	$37,380	$18,318	$3,068		YES	$67,551	$74,307	$3,977	($909)	0.77
Charles City	Floyd	Residential	RES1-2SWB 19067 2317	Wood Frame	1695	$75.50	$128,000	2	$43,052	$37,618	$22,966	$3,257		YES	$67,551	$74,307	$3,977	($720)	0.82
Charles City	Floyd	Residential	RES1-2SWB 19067 2625	Wood Frame	1020	$75.50	$77,000	2	$29,518	$24,506	$14,162	$2,112		YES	$41,559	$45,715	$2,447	($335)	0.86
Charles City	Floyd	Residential	RES5 19067 853	Masonry	32411	$75.50	$2,447,000	2	$809,392	$520,191	$0	$35,549		YES	$2,028,773	$2,231,650	$119,445	($83,895)	0.30
Charles City	Floyd	Residential	RES1-2SWB 19067 7614	Wood Frame	1020	$75.50	$77,000	2	$24,921	$21,753	$7,663	$1,659		YES	$41,559	$45,715	$2,447	($788)	0.68
Charles City	Floyd	Residential	RES1-2SWB 19067 3336	Wood Frame	1020	$75.50	$77,000	3	$30,772	$27,306	$18,700	$2,438		YES	$44,792	$49,271	$2,637	($199)	0.92
Charles City	Floyd	Residential	RES1-1SWB 19067 3333	Masonry	1020	$75.50	$77,000	3	$31,721	$27,354	$16,027	$2,348		YES	$69,963	$76,959	$4,119	($1,771)	0.57
Charles City	Floyd	Residential	RES1-1SWB 19067 4592	Wood Frame	1060	$75.50	$80,000	3	$33,070	$26,996	$10,489	$2,130		YES	$46,385	$51,023	$2,731	($600)	0.78
Charles City	Floyd	Residential	RES1-1SNB 19067 1507	Wood Frame	1020	$75.50	$77,000	3	$35,241	$33,434	$19,830	$2,826		YES	$44,792	$49,271	$2,637	$189	1.07
Charles City	Floyd	Residential	RES1-2SNB 19067 3452	Wood Frame	1020	$75.50	$77,000	3	$21,422	$18,376	$11,642	$1,614		YES	$44,792	$49,271	$2,637	($1,023)	0.61
Charles City	Floyd	Residential	RES3A 19067 3341	Wood Frame	2424	$75.50	$183,000	3	$89,961	$83,899	$12,498	$5,625		YES	$100,514	$110,565	$5,918	($293)	0.95
Charles City	Floyd	Residential	RES1-2SWB 19067 3454	Masonry	1020	$75.50	$77,000	3	$31,133	$27,907	$19,232	$2,492		YES	$69,963	$76,959	$4,119	($1,627)	0.61
Charles City	Floyd	Residential	RES1-2SNB 19067 2342	Wood Frame	1695	$75.50	$128,000	3	$30,626	$25,535	$6,878	$1,884		YES	$71,714	$78,885	$4,222	($2,339)	0.45
Charles City	Floyd	Residential	RES1-2SWB 19067 2302	Wood Frame	1695	$75.50	$128,000	3	$55,036	$50,798	$35,329	$4,525		YES	$71,714	$78,885	$4,222	$302	1.07
Charles City	Floyd	Residential	RES1-2SWB 19067 2303	Wood Frame	1695	$75.50	$128,000	3	$52,707	$47,977	$33,369	$4,284		YES	$71,714	$78,885	$4,222	$62	1.01
Charles City	Floyd	Residential	RES1-2SNB 19067 2299	Wood Frame	1695	$75.50	$128,000	3	$35,023	$29,972	$18,911	$2,631		YES	$71,714	$78,885	$4,222	($1,592)	0.62
Charles City	Floyd	Residential	RES1-1SWB 19067 2294	Wood Frame	1695	$75.50	$128,000	3	$60,306	$53,526	$33,467	$4,652		YES	$71,714	$78,885	$4,222	$430	1.10
Charles City	Floyd	Residential	RES2 19067 2313	Manufactured Housing	750	$20.00	$15,000	3	$15,750	$14,011	$3,860	$1,021		YES	$33,932	$37,325	$1,998	($977)	0.51
Charles City	Floyd	Residential	RES1-1SWB 19067 2316	Wood Frame	1695	$75.50	$128,000	3	$51,283	$43,876	$25,158	$3,750		YES	$71,714	$78,885	$4,222	($472)	0.89
Charles City	Floyd	Residential	RES1-1SNB 19067 2669	Wood Frame	1695	$75.50	$128,000	3	$55,338	$49,357	$16,508	$3,711		YES	$71,714	$78,885	$4,222	($511)	0.88
											TOTALS	**$183,220**				**TOTALS**	$524,622	($341,402)	0.35

Table E-3: Charles City Structures Evaluated in Non-Structural Measures Analysis - **RELOCATION**

													Relocation Eligible	**Estimated Relocation Cost**	**Estimated Total Relocation Cost (Est. Cost + 10% Contractor Profit)**	**Annual Relocation Cost[2]**	**Relocation Annual Net Benefits**	**Relocation BCR**
Charles City	Floyd	Residential	RES1-2SWB 19067 4635	Wood Frame	1060	$75.50	$80,000	4	$39,471	$34,738	$22,288	$3,047	YES	$50,347	$55,381	$2,964	$83	1.03
Charles City	Floyd	Residential	RES1-1SWB 19067 4622	Wood Frame	1060	$75.50	$80,000	4	$42,798	$38,373	$21,427	$3,226	YES	$50,347	$55,381	$2,964	$262	1.09
Charles City	Floyd	Residential	RES1-1SWB 19067 4619	Wood Frame	1060	$75.50	$80,000	4	$43,137	$38,701	$21,701	$3,257	YES	$50,347	$55,381	$2,964	$292	1.10
Charles City	Floyd	Residential	RES1-1SWB 19067 4602	Wood Frame	1060	$75.50	$80,000	4	$39,452	$34,454	$17,764	$2,853	YES	$50,347	$55,381	$2,964	($111)	0.96
Charles City	Floyd	Residential	RES1-2SWB 19067 1513	Wood Frame	1020	$75.50	$77,000	4	$38,854	$35,245	$24,594	$3,153	YES	$48,691	$53,560	$2,867	$286	1.10
Charles City	Floyd	Residential	RES1-1SNB 19067 3449	Wood Frame	1020	$75.50	$77,000	4	$37,498	$35,957	$27,399	$3,276	YES	$48,691	$53,560	$2,867	$410	1.14
Charles City	Floyd	Residential	RES1-1SWB 19067 3450	Wood Frame	1020	$75.50	$77,000	4	$41,580	$38,239	$24,968	$3,343	YES	$48,691	$53,560	$2,867	$476	1.17
Charles City	Floyd	Residential	RES3A 19067 3455	Wood Frame	2424	$75.50	$183,000	4	$106,729	$96,370	$74,274	$8,909	YES	$106,397	$117,037	$6,264	$2,644	1.42
Charles City	Floyd	Residential	RES1-2SWB 19067 3453	Wood Frame	1020	$75.50	$77,000	4	$36,177	$32,899	$22,833	$2,936	YES	$48,691	$53,560	$2,867	$70	1.02
Charles City	Floyd	Residential	RES1-2SWB 19067 2343	Wood Frame	1695	$75.50	$128,000	4	$57,012	$52,389	$36,220	$4,661	YES	$76,620	$84,282	$4,511	$150	1.03
Charles City	Floyd	Residential	RES1-2SNB 19067 2222	Wood Frame	1695	$75.50	$128,000	4	$40,144	$35,840	$21,373	$3,070	YES	$76,620	$84,282	$4,511	($1,441)	0.68
Charles City	Floyd	Residential	RES1-2SWB 19067 2308	Wood Frame	1695	$75.50	$128,000	4	$60,458	$54,682	$38,033	$4,889	YES	$76,620	$84,282	$4,511	$378	1.08
Charles City	Floyd	Residential	RES1-1SNB 19067 2285	Wood Frame	1695	$75.50	$128,000	4	$61,128	$58,428	$43,705	$5,294	YES	$76,620	$84,282	$4,511	$783	1.17
Charles City	Floyd	Residential	RES1-2SNB 19067 2640	Wood Frame	1020	$75.50	$77,000	4	$25,794	$23,467	$14,952	$2,041	YES	$48,691	$53,560	$2,867	($826)	0.71
Charles City	Floyd	Residential	RES1-1SWB 19067 2288	Wood Frame	1695	$75.50	$128,000	4	$63,436	$56,681	$36,290	$4,954	YES	$76,620	$84,282	$4,511	$443	1.10
Charles City	Floyd	Residential	RES1-2SWB 19067 1512	Wood Frame	1020	$75.50	$77,000	5	$39,114	$35,498	$24,904	$3,180	YES	$53,331	$58,665	$3,140	$40	1.01
Charles City	Floyd	Residential	RES1-1SWB 19067 1509	Wood Frame	1020	$75.50	$77,000	5	$44,094	$40,339	$27,883	$3,592	YES	$53,331	$58,665	$3,140	$452	1.14
Charles City	Floyd	Residential	RES1-1SWB 19067 3451	Wood Frame	1020	$75.50	$77,000	5	$43,289	$39,701	$26,992	$3,516	YES	$53,331	$58,665	$3,140	$376	1.12
Charles City	Floyd	Residential	RES1-2SWB 19067 1475	Wood Frame	1020	$75.50	$77,000	5	$38,944	$35,333	$24,701	$3,162	YES	$53,331	$58,665	$3,140	$22	1.01
Charles City	Floyd	Residential	RES1-1SWB 19067 1478	Wood Frame	1020	$75.50	$77,000	5	$42,144	$38,755	$25,689	$3,404	YES	$53,331	$58,665	$3,140	$264	1.08
Charles City	Floyd	Residential	RES1-2SWB 19067 2300	Wood Frame	1695	$75.50	$128,000	5	$73,073	$67,373	$52,238	$6,217	YES	$82,347	$90,581	$4,848	$1,369	1.28
Charles City	Floyd	Residential	RES1-2SWB 19067 2301	Wood Frame	1695	$75.50	$128,000	5	$66,503	$60,646	$46,016	$5,567	YES	$82,347	$90,581	$4,848	$719	1.15
Charles City	Floyd	Residential	RES1-2SWB 19067 2309	Wood Frame	1695	$75.50	$128,000	5	$69,692	$64,003	$50,046	$5,927	YES	$82,347	$90,581	$4,848	$1,079	1.22
Charles City	Floyd	Residential	RES5 19067 854	Wood Frame	32411	$75.50	$2,447,000	5	$1,407,865	$1,343,919	$953,395	$119,730	YES	$1,332,462	$1,465,708	$78,449	$41,281	1.53
Charles City	Floyd	Residential	RES1-1SWB 19067 1472	Wood Frame	1020	$75.50	$77,000	6	$52,346	$47,555	$35,796	$4,357	YES	$58,790	$64,669	$3,461	$896	1.26
Charles City	Floyd	Residential	RES1-1SNB 19067 1470	Wood Frame	1020	$75.50	$77,000	6	$45,192	$39,626	$35,118	$3,866	YES	$58,790	$64,669	$3,461	$404	1.12
Charles City	Floyd	Residential	RES1-1SNB 19067 3889	Wood Frame	1020	$75.50	$77,000	6	$42,413	$39,041	$34,817	$3,786	YES	$58,790	$64,669	$3,461	$324	1.09
Charles City	Floyd	Residential	RES1-1SWB 19067 2286	Wood Frame	1695	$75.50	$128,000	6	$81,080	$74,321	$56,819	$6,833	YES	$88,969	$97,866	$5,238	$1,595	1.30
Charles City	Floyd	Residential	RES1-1SWB 19067 2290	Wood Frame	1695	$75.50	$128,000	6	$88,439	$80,387	$61,388	$7,400	YES	$88,969	$97,866	$5,238	$2,161	1.41
Charles City	Floyd	Residential	RES1-SLNB 19067 2311	Wood Frame	1695	$75.50	$128,000	6	$65,897	$58,706	$47,869	$5,545	YES	$88,969	$97,866	$5,238	$307	1.06
Charles City	Floyd	Residential	RES1-1SWB 19067 2671	Wood Frame	1695	$75.50	$128,000	6	$86,476	$77,718	$58,036	$7,116	YES	$88,969	$97,866	$5,238	$1,878	1.36
Charles City	Floyd	Residential	RES1-1SNB 19067 4616	Wood Frame	1060	$75.50	$80,000	7	$52,815	$48,234	$37,076	$4,446	YES	$67,020	$73,722	$3,946	$500	1.13
Charles City	Floyd	Residential	RES1-2SWB 19067 4634	Wood Frame	1060	$75.50	$80,000	7	$58,250	$52,859	$37,301	$4,744	YES	$67,020	$73,722	$3,946	$799	1.20
Charles City	Floyd	Residential	RES4 19067 4599	Wood Frame	8132	$75.50	$614,000	7	$206,410	$180,144	$110,799	$15,635	YES	$380,223	$418,246	$22,386	($6,751)	0.70
Charles City	Floyd	Residential	RES1-1SWB 19067 3893	Wood Frame	1020	$75.50	$77,000	7	$55,445	$50,740	$39,214	$4,684	YES	$65,142	$71,657	$3,835	$848	1.22
Charles City	Floyd	Residential	RES1-2SNB 19067 2296	Wood Frame	1695	$75.50	$128,000	7	$58,140	$53,872	$41,959	$4,975	YES	$96,563	$106,219	$5,685	($710)	0.88

Table E-3: Charles City Structures Evaluated in Non-Structural Measures Analysis - **RELOCATION**

													Relocation Eligible	Estimated Relocation Cost	Estimated Total Relocation Cost (Est. Cost + 10% Contractor Profit)	Annual Relocation Cost[2]	Relocation Annual Net Benefits	Relocation BCR
Charles City	Floyd	Residential	RES1-2SWB 19067 2305	Wood Frame	1695	$75.50	$128,000	7	$87,438	$80,355	$62,073	$7,410	YES	$96,563	$106,219	$5,685	$1,725	1.30
Charles City	Floyd	Residential	RES1-2SWB 19067 7604	Wood Frame	1020	$75.50	$77,000	7	$50,572	$45,574	$31,554	$4,072	YES	$65,142	$71,657	$3,835	$236	1.06
Charles City	Floyd	Residential	RES3B 19067 4639	Masonry	2344	$75.50	$177,000	8	$122,250	$119,372	$98,194	$11,133	YES	$193,713	$213,084	$11,405	($272)	0.98
Charles City	Floyd	Residential	RES1-2SWB 19067 4595	Wood Frame	1060	$75.50	$80,000	8	$61,136	$55,607	$39,528	$5,000	YES	$74,427	$81,869	$4,382	$619	1.14
Charles City	Floyd	Residential	RES1-2SNB 19067 4593	Wood Frame	1060	$75.50	$80,000	8	$40,013	$36,348	$26,190	$3,283	YES	$74,427	$81,869	$4,382	($1,098)	0.75
Charles City	Floyd	Residential	RES3B 19067 3456	Wood Frame	2291	$75.50	$173,000	8	$119,656	$117,636	$105,712	$11,317	YES	$133,371	$146,708	$7,852	$3,465	1.44
											TOTALS	**$328,806**			**TOTALS**	**$272,379**	**$56,427**	**1.21**
Charles City	Floyd	Residential	RES1-2SWB 19067 4629	Wood Frame	1060	$75.50	$80,000	N/A	$80,285	$79,074	$76,133	$7,808	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SNB 19067 4600	Wood Frame	1060	$75.50	$80,000	N/A	$61,322	$60,666	$54,745	$5,840	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 6606	Wood Frame	1629	$75.50	$123,000	N/A	$107,101	$103,578	$82,417	$9,564	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 6602	Wood Frame	1629	$75.50	$123,000	N/A	$115,275	$113,827	$108,085	$11,175	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 6633	Wood Frame	1629	$75.50	$123,000	N/A	$102,499	$97,999	$77,730	$9,057	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SNB 19067 7587	Wood Frame	1020	$75.50	$77,000	N/A	$60,433	$59,770	$56,900	$5,872	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-3SWB 19067 4597	Masonry	1060	$75.50	$80,000	N/A	$76,359	$74,469	$68,330	$7,230	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 4594	Wood Frame	1060	$75.50	$80,000	N/A	$82,031	$81,126	$77,892	$7,997	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 4596	Wood Frame	1060	$75.50	$80,000	N/A	$80,290	$79,055	$76,077	$7,805	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 4591	Wood Frame	1060	$75.50	$80,000	N/A	$76,527	$75,146	$71,592	$7,393	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-SLWB 19067 4598	Wood Frame	1060	$75.50	$80,000	N/A	$76,492	$75,123	$70,187	$7,335	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 4628	Wood Frame	1060	$75.50	$80,000	N/A	$71,388	$69,172	$57,520	$6,484	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SWB 19067 4633	Wood Frame	1060	$75.50	$80,000	N/A	$74,651	$73,297	$66,531	$7,079	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SNB 19067 3894	Wood Frame	1020	$75.50	$77,000	N/A	$53,526	$52,941	$47,122	$5,070	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SNB 19067 3895	Wood Frame	1020	$75.50	$77,000	N/A	$53,631	$53,139	$47,640	$5,101	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 3891	Masonry	1020	$75.50	$77,000	N/A	$64,299	$62,400	$55,509	$5,993	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES3A 19067 3902	Wood Frame	2424	$75.50	$183,000	N/A	$129,330	$128,148	$123,016	$12,627	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 3892	Wood Frame	1020	$75.50	$77,000	N/A	$65,450	$63,791	$56,387	$6,108	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-SLWB 19067 3901	Wood Frame	1020	$75.50	$77,000	N/A	$69,793	$68,579	$63,763	$6,683	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-2SNB 19067 7583	Wood Frame	1020	$75.50	$77,000	N/A	$55,693	$54,662	$51,224	$5,344	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-SLWB 19067 2312	Wood Frame	1695	$75.50	$128,000	N/A	$102,331	$94,876	$79,572	$8,987	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-1SWB 19067 7568	Wood Frame	1020	$75.50	$77,000	N/A	$72,453	$71,369	$67,728	$7,008	NO	N/A	N/A	N/A	N/A	N/A
Charles City	Floyd	Residential	RES1-SLWB 19067 7622	Masonry	1020	$75.50	$77,000	N/A	$71,800	$70,475	$64,384	$6,824	NO	N/A	N/A	N/A	N/A	N/A

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