Final Results of Hydraulic Study – Saratoga AE and Zone A, Carbon County, WY

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01 Introduction

1.1 Study Area

The North Platte River in in Carbon County, Wyoming was studied as a part of this Zone AE flood analysis and study (see Table 1). The study limits are summarized in Table 2.

The North Platte River flows through the town of Saratoga, Wyoming. Approximately 2.8 river miles were analyzed and the reach extends from approximately one mile upstream of Wyoming Way, near the Saratoga Golf Course to less than one mile north of N 1st Street/Highway 130.

The purpose of this study is to develop flood hazard modeling in support of Flood Insurance Study (FIS) revisions for the North Platte River at Saratoga, Wyoming. The Flood Hazard Boundary Map (FHBM) for the community of Saratoga, Wyoming (560012A), dated February 13, 1976, was officially converted to a Flood Insurance Rate Map (FIRM) Zone A by letter on October 1, 1986. Though three letters of map amendment (LOMA) have been submitted in the last few years, no official update has been made to the FIRM since the time of the initial conversion. The original FIRM does not include any detailed information, therefore, this study seeks to provide flood hazard information for Saratoga, Wyoming, using hydraulic models which are based on the latest topographic information supplemented by field survey.

In addition to the Zone AE flood analysis of the North Platte River, Zone A flood analyses of approximately 606 miles of streams in Carbon County were performed. Studied flooding sources include Battle Gulch, Beaver Creek, Big Ditch, Big Ditch Tributaries 1-5, Brush Creek, Cow Creek, Encampment River, Encampment River Tributary 1-4, Foote Creek, Foote Creek Tributaries 1-3, Hadsell Draw, Hadsell Slough, Halleck Creek, Halleck Creek Tributary 1-2, Hugus Draw, Jack Creek, Kinny Creek, Lake Creek, Little Snake River, Martinez Springs Creek, Medicine Bow River, Medicine Bow River Tributaries 1-2, Middle Ditch, Muddy Creek, Muddy Creek Tributary 1, North Fork Encampment River, North Fork Encampment River Tributaries 1-2, North Platte River, North Platte River Tributary 1-4, North Spring Creek, Pass Creek, Pass Creek Tributaries 1-2, Percy Creek, Rattlesnake Creek, Rock Creek, Rock Creek Tributary 1, Sage Creek, Saint Marys Creek, Savery Creek, Savery Creek Tributary 1, Separation Creek, South Spring Creek, Spring Creek, Sugar Creek, Sugar Creek Tributary 1-6, Third Sand Creek, Threemile Creek, Wagonhound Creek, Willow Creek, and Willow Springs.

1.2 Type of Flooding

Riverine flooding is primarily responsible for flood issues in this area.

1.3 Flooding History

Historically, flooding in Carbon County are caused by snowmelt runoff, high-intensity or long duration rainfall events, and dam overtopping or failure. Floods associated with snowmelt tend to occur during the spring and early summer months and have produced some of the more severe and dramatic floods within the watershed.

According to the National Weather Service (NWS), recent historic crests on the North Platte River through Saratoga, Wyoming, have been reached in June 2010, June 2011, and May 2014 with additional crests requiring action in June 2015, 2016, and 2017. Based on video documentary and news reports for the June 2011, May 2014 and May 2016 events, heroic sandbagging efforts were the only action keeping floodwaters from more significantly impacting the town. According to the report Multi-Hazard

Mitigation Plan - Carbon County, Wyoming and the Communities of Baggs, Dixon, Elk Mountain, Encampment, Hanna, Medicine Bow, Rawlins, Riverside, Saratoga, Sinclair (Beck Consulting, et. al. 2015), the following flooding has occurred for the study areas:

- In April 1937, local heavy rains and heavy snowmelt contributed to Sage Creek reaching its highest known stage resulting in washed out bridges and farm buildings.
- In May 1952, rapid snowmelt resulted in flooding of Baggs caused by backwater into the town.
- In May 1984, an upstream dam breach from rainfall and snowmelt resulted in a flow that exceeded a 100-year event in the Little Snake River. The flooding caused damage to rural property in Baggs. The discharge exceeded 13,000 cfs in Dixon. According to the Wilmington Morning Star, flood depths greater than 4-feet (elevation 6,251 ft. NAVD88) occurred within the City and inundated the southern part of Baggs (Associated Press, 1984).
- In June 1986, Pierce Dam failed and emptied its contents into Rock Creek approximately 35 miles north of Laramie along the Albany and Carbon County Line. A bridge along Wyoming Highway 13 was undercut at Rock Creek. Some flooding of buildings and land was reported near the confluence of Rock Creek with the Medicine Bow River.
- In August 1990, a heavy thunderstorm produced 1- to 3-inches of rainfall resulting in flash floods 15 to 20 miles east of the town of Saratoga, Wyoming.
- In May 2008, rapid snowmelt caused the Little Snake River to overflow its banks which resulted in flooding in Baggs.
- In June 2010, heavy snowmelt resulted in flooding of the Medicine Bow River along a portion of the southwest part of Elk Mountain.
- In June 2010, heavy snowmelt resulted in flooding of the North Platte River along the public golf course and Veteran's Island in Saratoga, Wyoming.

02 Zone AE Methodology and Modeling

2.1 Methodology

Pre-Processing

The Zone AE methodology incorporates the Watershed Information System (WISE) software as a preprocessor to HEC-RAS. WISE uses the georeferenced data from the terrain model and miscellaneous shapefiles (including streams, cross sections, etc…) and with user input creates the input data files for HEC-RAS.

Processing

The hydraulic model used for this flood study was the U. S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System, version 5.0.4 (HEC-RAS). The HEC-RAS models for the North Platte River were developed for the 10-, 4-, 2-, 1-, and 0.2-percent-annual-chance flood events as well as the 1-percent-plus. The one-dimensional steady flow using normal depth boundary conditions was the model method chosen for this analysis.

The scope for the North Platte River through Saratoga, Wyoming, does not include development of a floodway.

2.2 Hydrology

The North Platte River falls into three hydrologic regions: Rocky Mountain, Eastern Basin and Eastern Plain and High Desert. Additional details on the hydrologic methodology and peak discharges for all flood events can be found in Final Results of Hydrology Study Carbon County, WY *(August 2019)*. A summary of the discharges are provided in Table 3.

2.3 Boundary Conditions and Tie-ins

This study uses normal depth boundary conditions for the reach analyzed (see Table 4). A normal depth boundary condition was used for the North Platte River at the downstream end of the study area while no boundary condition was used at the upstream end. Normal depths were calculated based on measurement near the mouth of each study reach.

2.4 Topography and Cross Sections

The topographic data for the models were developed using the digital elevation model (DEM) obtained from 2016 USGS 3DEP LiDAR, 2011 Natural Resources Conservation Services LiDAR,2016 Compass LiDAR and 2012 City of Rawlins LiDAR. The DEM data area referenced in horizontal datum NAD 83 (Wyoming East Central State Plane Coordinates, feet) and vertical datum NAVD 88 (feet). The main channel and floodplain cross sections were placed at representative locations along the model reaches. Cross sections were further refined utilizing the data collected from field survey.

2.5 Survey and Structures

A total of five bridges located along the modeled reach were field surveyed for this study.

A summary of the field surveyed structures are provided in Table 5. All surveyed structures were modeled in HEC-RAS by incorporating the field measurements recorded supplemented by best engineering judgments.

Contraction and expansion (C/E) coefficients were increased to 0.3 and 0.5 at the upstream and downstream face sections. In some cases, good engineering judgment was used to increase C/E coefficients at the approach sections. All other contraction and expansion values were kept at 0.1 and 0.3, respectively.

The bridge modeling approach chosen for low flow for all structures was the “Highest Energy Answer” between Energy and Momentum Equations. The high flow method was set to “Pressure and/or Weir” for structures where the water surface reached the bridge low chord.

2.6 Ineffective Areas and Blocked Obstruction

Ineffective flow areas were modeled in HEC-RAS by using the ineffective flow area option. Aerial imagery was used to determine areas of ineffective flow caused by development. Ineffective flow areas were also added in areas of sheet flow or areas where the flow is not channelized.

Review of these ineffective flow areas revealed that the water surface elevations are sensitive to elevation of the ineffective flow area. The elevations of the ineffective flow areas in areas of sheet flow or areas where the flow is not channelized were refined over several iterations to develop a reasonable solution.

Additionally, ineffective flow areas were added down- and upstream of hydraulic structures to account for low-velocity flow caused by the structure's geometry.

2.7 Channel Roughness Values

Manning's n-values are summarized in Table 6. For the main channel of the North Platte River, n-values were determined based on field photos and aerials. The channel n-value used were 0.035. For areas outside the channel, aerial imagery was used to determine the Manning's n-values. Remaining values generally follow guidance as provided in the HEC-RAS guidance and consistent with Chow. Overbank n-values range from 0.035 to 0.075.

2.8 Split Flow

The North Platte River, especially upstream and downstream of Saratoga, Wyoming, is braided, which means that the river splits and rejoins frequently. For this reason, the apparent flow split at Veterans Island Park was not modeled formally as a split flow occurrence in HEC-RAS. In this instance, the cross section topography determined the direction of flow.

2.9 Floodway

As scoped, no floodway analysis is required for this reach of the North Platte River through Saratoga, Wyoming.

2.10 Floodplain Boundaries

The 1-percent-annual-chance floodplain boundaries were delineated using an automated process. This process compares a ground surface DEM to a water surface DEM using standard ESRI ArcGIS functionality to determine where the 1-percent-annual-chance and 0.2-percent-annual-chance floodplains lie. The digital terrain data provided for the study area was used in this calculation.

Input data for the water surface model consisted of newly created cross sections developed during the hydraulic analysis task using HEC-RAS and HEC-GeoRAS. This data provided the water surface elevation from which a water surface TIN and DEM was generated. This process was performed to provide the 1-percent-annual-chance and 0.2-percent-annual-chance event flood hazard TINs and DEMs.

Standard ArcGIS "Map Algebra" calculations were then performed to compare the ground surface DEM to the water surface DEM to find the location where the two DEMs intersect. The location of the resulting flood boundary lines was then visually verified for accuracy using the contours generated from the terrain data.

Review of the delineated flood boundaries involved a visual inspection of floodplain boundaries, as well an automated check that verified that the 1-percent-annual-chance flood boundaries were in compliance with the Floodplain Boundary Standard (FBS) outlined in FEMA Procedure Memorandum 38.

03 Zone A Methodology and Modeling

The process of the hydraulic evaluation of a Zone A study stream is similar to that of a Zone AE study. All evaluations use WISE as a preprocessor for creating a HEC-RAS model to route flood discharges. In addition, the same terrain data set is utilized for generating the geometric characteristics of the channel cross sections. The cross section locations are either manually placed or are placed using an automated routine within WISE and then manually adjusted. Where this process differs from the Zone AE study methodologies is in how structures (bridges, dams, culverts, etc.) are handled. No information is entered into the Zone A model to represent any structures; however, in areas where a hydraulic structure (i.e. bridge) was processed out of the terrain data (e.g. the bridge deck was removed, so that the underlying channel is visible), a cross section is placed along the road centerline to account for the hydraulic impact of the embankment. A cross section is only placed along a roadway embankment in cases where a hydraulic structure was clearly removed from the terrain. In instances where a hydraulic structure was not processed out of the terrain, a cross section is not placed along the road centerline, as this would cause improper water surface elevation [WSEL] increases due to the embankment. In the case of dams, a cross section is placed along crest of the dam embankment.

Channel roughness coefficients for the Zone A streams used the National Land Cover Database (NLCD) from 2011 to serve as the source data for deriving roughness coefficients that are associated with land characteristics. The information is then used to create a HEC-RAS computer model of the study stream. In all cases the starting water surface elevations are based on assumed normal depth at the downstream end of the modeled segment. Further model refinements (ineffective flow areas, blocked obstructions, contraction/expansion coefficients, etc.) are not implemented except in cases where crossing flood profiles or other model inconsistencies were evident in the raw WISE output. Ineffective flow areas and other minor model adjustments are added in those areas to eliminate modeling inconsistencies. Since the streams being studied typically have no historical data, no calibration is performed on the models. However, the results are compared against the effective floodplain data for the project area.

04 Results

Model files with simulated results are provided in Appendix A.

05 Effective Elevation Comparison

No effective study has been published for the North Platte River at Saratoga, Wyoming. The only existing information is a hard copy flood map, which is difficult to read and has no supporting data or documentation, therefore, no effective comparison can be completed.

06 Conclusions

The purpose of this study was to update the flood hazard information for the North Platte River near Saratoga, Wyoming, using the latest survey data and topographic information, and to provide approximate (Zone A) flood boundaries for additional flooding sources throughout Carbon County. The data and information was incorporated into hydraulic models that were utilized to develop floodplain boundaries.

The floodplain delineation presented to representatives of the City of Saratoga in a form prior to the presentation of preliminary maps was not out of line with what they expected. Also, in support of the information provided in Section 1.3, the representatives reported that sandbagging had been the solution, which kept flooding from becoming widespread during high stage events on the North Platte River in the past several years.

07 References

1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System v5.0.3, Davis, California, February 2016.

2) Federal Emergency Management Agency, August 1988, Flood Insurance Study, Town of Baggs, Wyoming, Carbon County.

3) Federal Emergency Management Agency, July 2015, Discovery Report Carbon County, Wyoming and the Upper North Platte Watershed, HUC 10180002.

08 Tables

Table 1: AE Study Streams

Stream	Study Type	Hydraulic Model
North Platte River	AE-Study: 1D Steady	HEC-RAS 5.0.5

Table 2: Study Stream Limits

Stream	Downstream Limit	Upstream Limit	Miles Studied	Study Type
North Platte River	Approximately 1.0-mile downstream of N 1st Street/Highway 130 (Saratoga, WY)	Approximately 1-mile upstream of Wyoming Way near the Saratoga Golf Course (Saratoga, WY)	2.8	AE-Study: 1D Steady

Table 3: Summary of Peak Discharges

Flooding Source and Location	Drainage Area (sq. miles)	10% Annual Chance cfs	4% Annual Chance cfs	2% Annual Chance cfs	1% Annual Chance cfs	1% Plus Event cfs	0.2% Annual Chance cfs
North Platte River	2,823	11,604	13,709	15,195	16,610	18,655	19,720

Table 4: Boundary Conditions

Stream	Reach	Downstream Boundary Condition	Upstream Boundary Condition
North Platte River	NP2	Normal Depth = 0.005	N/A

Table 5: Field Survey

Stream	Survey ID	Description
North Platte River	CA_NPR_04	Bridge
North Platte River	CA_NPR_03A	Bridge
North Platte River	CA_NPR_03	Bridge
North Platte River	CA_NPR_02	Bridge
North Platte River	CA_NPR_01	Bridge

Table 6: Channel Roughness Values

Stream	Channel N-Values	Overbank N-Values	Description
North Platte River	0.035	0.035 – 0.075	scattered brush and trees, open field, medium density residential

09 Appendix

[Digital Only]