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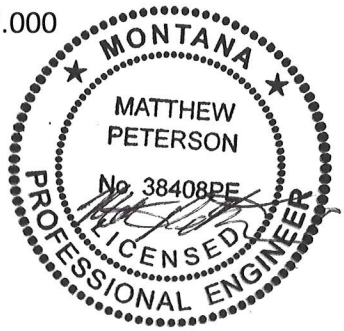
MEMORANDUM

DATE: June 6, 2023 **PROJECT NO.** 350.00737.000

TO: Larry Schock; Montana DNRC

FROM: Matthew Peterson, PE; NewFields

Reviewed By: Dan Hoffman, CFM; NewFields



SUBJECT: **Expressway – Grant Creek Floodplain Analysis, Supplemental Response to DNRC Questions**

INTRODUCTION

This supplement to the November 3, 2022, Expressway – Grant Creek Floodplain Analysis Technical Memorandum, is a response to questions posed by Larry Schock, Montana Department of Natural Resources and Conservation Civil Engineering Specialist, following in his review of the Grant Creek floodplain analysis and hydraulic model developed by NewFields. NewFields staff Matthew Peterson, Emily Smith, and Dan Hoffman met with Mr. Schock on March 28, 2023, to discuss the floodplain analysis and his questions. The following two questions were discussed and are addressed in this memorandum:

1. *Why has the HEC-RAS hydraulic model produced numerous messages about multiple critical depths at cross section 62 through cross section 248? Since the cross section are not complex in nature, can you please discuss/identify why the critical depth messages are appearing in the model (i.e., Is it due to channel steepness, pressurized bridge flows, a combination, or other factors.).*
2. *There is a blocked obstruction at cross station 157. Can you identify what this is and why it is contained in the model?*

Response to Question 1 – Multiple Critical Depths

The Grant Creek HEC-RAS hydraulic model identified multiple critical depths at many of the model cross sections in the reach between River Station 62 and 248. These notifications were listed as notes (not as warnings or errors), which are simply providing information about how the model is performing computations. Critical depth is the flow depth, for a given discharge and cross section, where the specific energy is at a minimum. In simple trapezoidal or rectangular channels, there is only one critical depth for a specific discharge (Petikas, Et al, 2020). Open channels with floodplains or flat overbank areas, are described as compound channels (**Figure 1**) and may have more than one critical depth per discharge (Petikas, Et al, 2020; HEC, 2020).

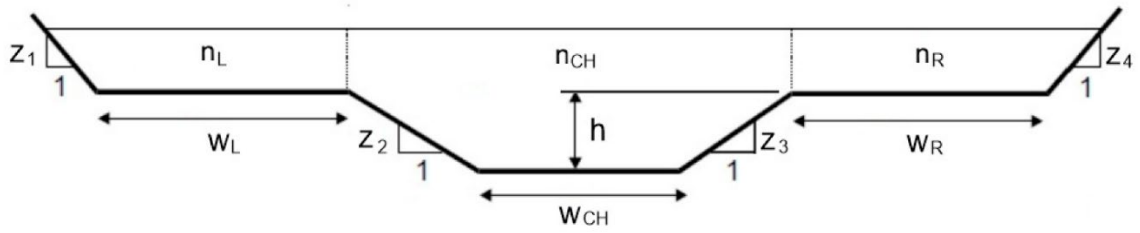


Figure 1. Typical compound channel cross section (taken from Petikas Et al., 2020).

In Question 1 noted above, Mr. Schock states that the cross sections of concern are not complex in nature. While these cross sections appear to be generally uniform and do not contain features such as multiple channels or divided flow, NewFields believes they do fit the definition of a compound channel described in Petikas, Et al, 2020. For example, Cross Section 62 contains a well-defined overbank on both sides of the channel (**Figure 2**). As an experiment, NewFields removed the overbank areas (above the predicted 100-year water surface elevation) from Cross Sections 62 through 94.375 and re-ran the model (see **Figure 3**, for example). The revised model did not produce any multiple critical depth notes associated with the revised cross sections. Predicted water surface elevations remained the same as the original model.

Note that the remaining cross sections of concern (RS 99 to 248) were not revised because these cross sections do contain compound features below the predicted 100-year water surface elevation (**Figure 4** and **Figure 5**), which may cause the HEC-RAS model to generate the multiple critical depth notes regardless of the overbank areas.

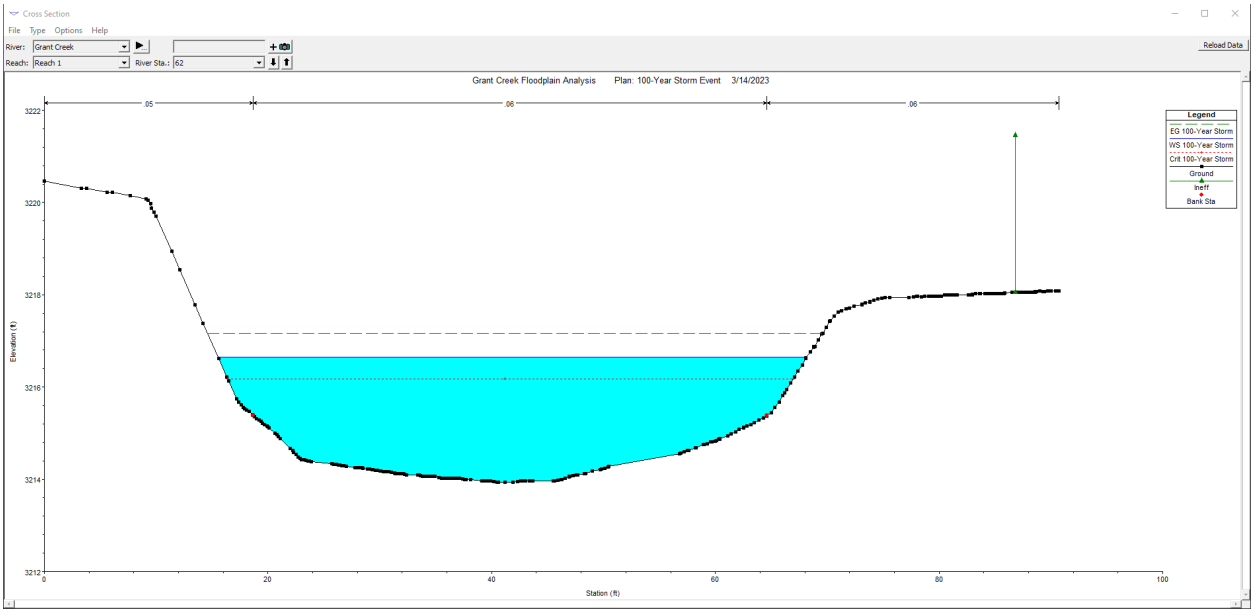


Figure 2. HEC-RAS Cross Section 62 in Original HEC-RAS Model

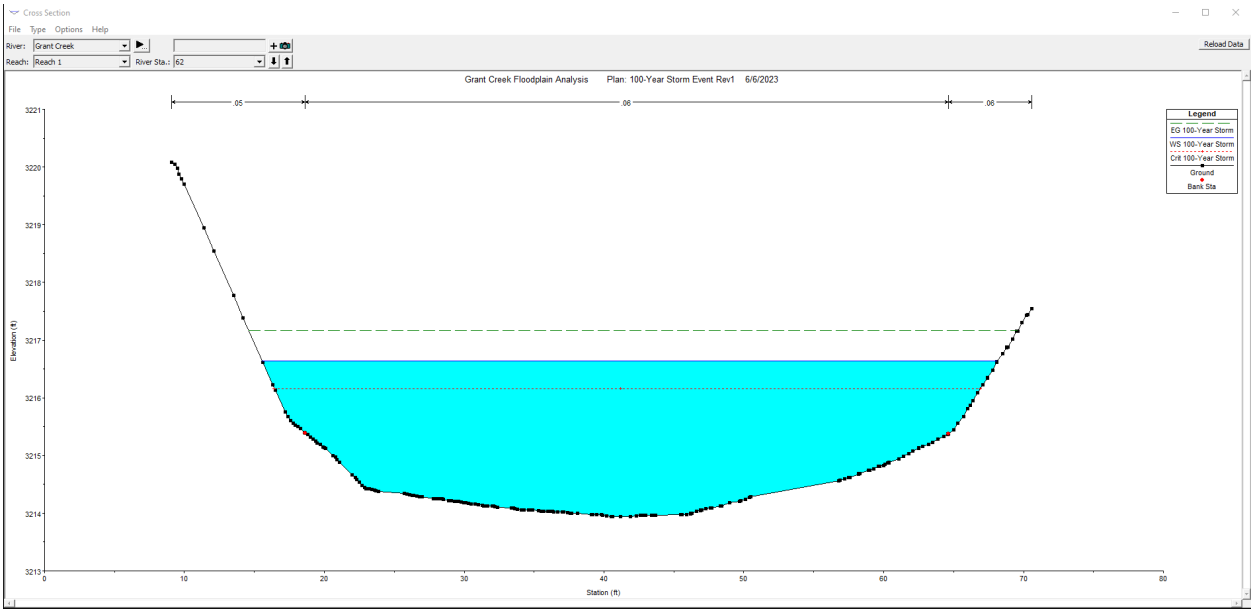


Figure 3. HEC-RAS Cross Section 62 in Revised HEC-RAS Model

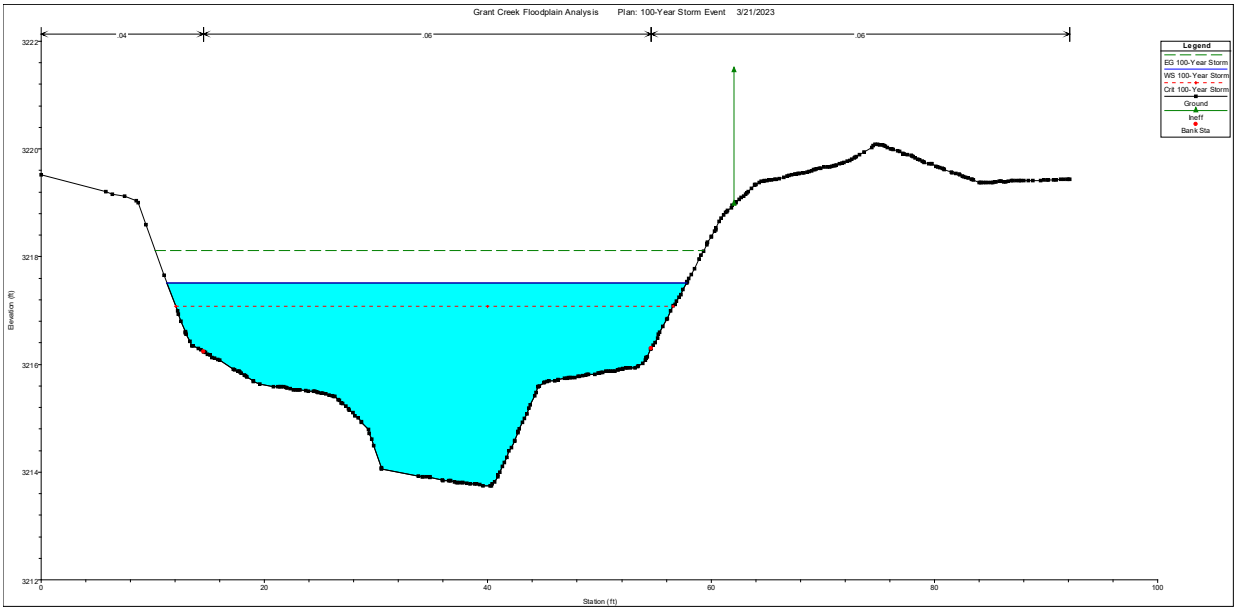


Figure 4. Grant Creek HEC-RAS model cross section 133.

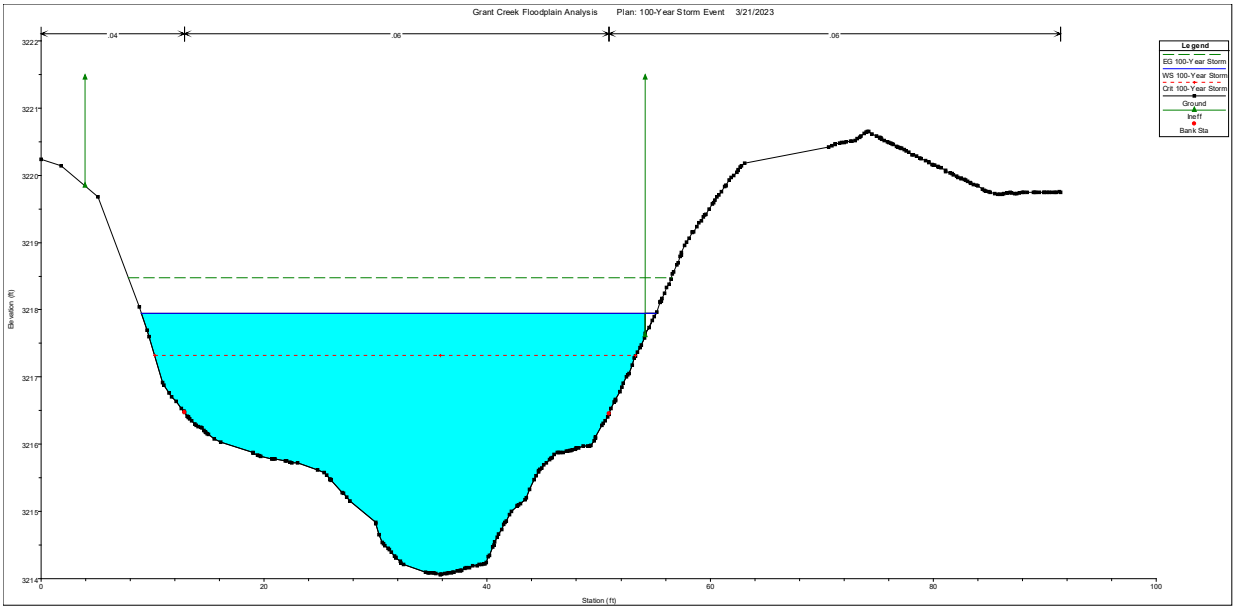


Figure 5. Grant Creek HEC-RAS model cross section 152

For the reasons discussed above, NewFields believes the HEC-RAS Grant Creek hydraulic model identified and noted multiple critical depths for cross sections between River Station 62 and 248 because they are compound channels.

Response to Question 2 – Blocked Obstruction

The blocked obstruction downstream of the Expressway Boulevard Bridge at model cross section 157 represents a large cottonwood tree encroaching on the channel, immediately downstream of the bridge. A photograph of the tree and the bridge is included below as **Photo 1**. The tree obstructs a portion of the flow under and downstream of the Expressway Boulevard Bridge and increases the channel roughness. This obstruction was included in the hydraulic model to more accurately predict water surface elevations and hydraulic conditions.

Photo 1. Looking upstream at the Expressway Boulevard Bridge. A large cottonwood tree is visible just downstream of the bridge next to the broken stump.

Conclusion

This memorandum addressed the questions posed by DNRC in March 2023. NewFields believes the hydraulic model results information presented in the November 3, 2022, Expressway – Grant Creek Floodplain Analysis Technical Memorandum are accurate and do not require any modifications.

Please contact me at mpeterson@newfields.com if you have any questions.

Sincerely,
NewFields

Matthew Peterson, PE
Civil Engineer

References

Petikas, I., Keramaris, E., and Kanakoudis, V., 2020. Calculation of Multiple Critical Depths in Open Channels Using an Adaptive Cubic Polynomials Algorithm. Water, 12(3), 799.

Hydraulic Engineering Center, 2020. HEC-RAS River Analysis System Hydraulic Reference Manual, Version 6.0, CPD-69. December.