Study of Alternatives to Reduce Flooding of Cumberland Road and 106th Street from Mud Creek

Hamilton County, Indiana

Prepared for

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CBBEL Project No. 12-0231

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CHAPTER 1 INTRODUCTION

This report documents the Christopher B. Burke Engineering, LLC (CBBEL) detailed hydrologic and hydraulic analysis of a portion of Mud Creek for the purpose of investigating flood mitigation alternatives for the Hamilton County Surveyor Office and the Town of Fishers. This study was prompted by chronic road flooding near the intersection of Cumberland Road and 106th Street. The study reach is shown below in Figure 1-1.

Figure 1-1: Study Location

Hydrologic and hydraulic modeling of the existing conditions and potential alternatives to reduce flooding are described in this report along with the results and recommendations.

CHAPTER 2 DESCRIPTION OF EXISTING CONDITIONS MODELING

The first step in determining solutions to a flooding issue is the development of an existing conditions model. Hydrologic and hydraulic models were developed to reflect the present conditions as described below.

2.1 HYDROLOGIC MODEL

A hydrologic model of the Mud Creek watershed was developed by CBBEL in 1998 that was eventually approved as the Coordinated Discharge Curve for Sand Creek and Mud Creek. This curve was then used to determine the discharges for the effective FIS model developed by the Indiana Department of Natural Resources (IDNR) in 1999. At the time of its production, it was calibrated to all available data and was considered to be an accurate representation of the hydrologic conditions in the Mud Creek watershed.

In 2003 and 2011, after the previous studies were completed, significant rainfalls occurred that produced flooding with documented flood levels. When the observed rainfall data for these storms was included in the previous hydrologic model, resulting discharges produced water surface elevations in the hydraulic model that were significantly higher than observed elevations. Therefore, the hydrologic model was recalibrated in conjunction with a revised hydraulic model (described in section 2.2) to the June 2003 and June 2011 storm events using available rainfall data and photos of floods to get approximate flood elevations. This method of calibration is non-standard. When measured discharge information such as provided by a USGS stream gage or miscellaneous measurement is available, the hydrologic model is calibrated to the measured discharge using observed rainfall data. The measured discharge is also entered into the hydraulic model to calibrate the hydraulic model. In this instance, the hydraulic model was used as the test of calibration of the hydrologic model since no other way of estimating a discharge for the calibration storms was available. This method is approximate and provides a rough calibration model only.

For this rough calibration model, June 2003 rainfall data and distribution was obtained from previous studies in the area. The June 2011 rainfall was obtained from the National Weather Service hourly radar data adjusted to 3 inches in a 3 hour time period as recorded at a Fishers' park along Sand Creek. Calibration of the model was achieved by using the computed Times of Concentration along with the Clark Unit hydrograph method. The watershed ratio for computing the R value for the Clark Unit hydrograph method was varied over the watershed based on steeper, medium, or flatter slopes in the subbasins. A ratio of 0.5 was used for the steeper areas, 0.8 for

the medium areas, and 0.9 for the flat areas. Computed Times of Concentration were multiplied by 1.4 for the "medium" and "flat" subbasins. These adjustments provided the discharges necessary to calculate the high water mark elevations in the respective hydraulic models. Once the model was calibrated to the two floods noted above, the various frequency rainfalls were entered in the model and run. The resulting discharges are approximately three quarters of the discharges shown in the Mud Creek Coordinated Discharge Curve but do provide frequency discharges that suggest frequencies that generally match with other data. Despite the calibration, the revised discharge associated with a given frequency may still be in error. This is because of the non-standard calibration efforts required in this instance and a potential upstream diversion that may have occurred in the 2003 flooding but has been blocked by development since then. Therefore, the new peak discharges developed as part of this study for calibration purposes to determine the frequency of flooding should not be used as new regulatory values until the model is calibrated to directly measured/observed discharges.

Until corrections are made in the Mud Creek hydraulic model upstream to the diversion point near Brookschool Road and direct calibration of modeled discharges to measured discharges are made possible through installation of a new gaging station on Mud Creek, the likelihood and impact of that diversion on current discharges is unknown. For the purposes of this investigation, it was assumed that no diversion happened in the 2003 flood and no diversion happens for any of the frequency floods.

Table 2-1 shows various peak discharges on Mud Creek through the study area; the discharges are based on results from the calibrated hydrologic model; the 100-year coordinated discharge is also shown.

Table 2-1: Peak Discharges on Mud Creek through Study Area

Recurrence Interval Peak Discharge (cfs)						
2-year	5-year	10-year	25-year	50-year	100-year	100-year[1]
740	1107	1435	1899	2289	2686	3800

[1] Coordinated Discharge 100-year peak flow rate

2.2 HYDRAULIC MODEL

The existing condition hydraulic model used was taken from a recent CBBEL study of the Marion County portion of Mud Creek (including the former USGS stream gage location); the model is a steady-state HEC-RAS (Version 4.1.0) hydraulic model. The model made use of bridge information from the existing FIS model. For this study, the model was updated to include surveyed road profiles of the Cumberland Road Bridge and the 106th Street Bridge. This update was necessary to accurately predict the level of protection provided by each alternative. It should be noted that all

elevations within the model or otherwise part of the analysis are all are referenced to the 1988 North American Vertical Datum (NAVD88).

The existing condition model was modified for each of the proposed alternatives to reflect the changes that would be necessary, if the alternative were implemented. Manning roughness values for the channel were allowed to remain at the calibrated level, rather than lowered values which would be representative of a rigorously maintained channel.

Peak discharges from the revised hydrologic model described in Section 2.1 were used as input for the revised existing condition model and each alternative's hydraulic model. The same model, using Coordinated Discharges instead of calibrated discharges, was also simulated for each alternative to establish a preliminary determination concerning the ability of each alternative to be permitted under an IDNR Construction in a Floodway Permit that is expected to be based on the current IDNR-approved model with flow values that are based on current Coordinated Discharges.

Table 2-2 and Table 2-3 contain summaries of existing-condition hydraulic simulation results along Mud Creek for both the model with calibrated discharges and the model with Coordinated Discharges.

Table 2-2: Modeled Existing Condition Water Surface Elevations at Bridge Crossings

Bridge Crossing	Water Surface Elevation (ft, NAVD88)						
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	100-yr[1]
Cumberland Road	781.5	782.28	783.13	783.91	783.24	783.81	784.39
106th Street	782.3	783.0	783.6	784.2	784.2	784.4	785.1

[1] Coordinated Discharge 100-year peak flow rate

Table 2-3: Existing Condition Flooding Depths over Roadways

Bridge Crossing	Maximum Depth of Flooding over Roadway (ft)						
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	100-yr[1]
Cumberland Road	-	-	0.4	1.2	0.5	1.1	1.7
106th Street	-	0.3	0.9	1.5	1.5	1.7	2.3

[1] Coordinated Discharge 100-year peak flow rate

Depth maps associated with the existing-condition hydraulic simulation results for the "calibrated model" for 2-, 5, 10, 50, and 100-year events are shown in Figure 2-1 through Figure 2-5.

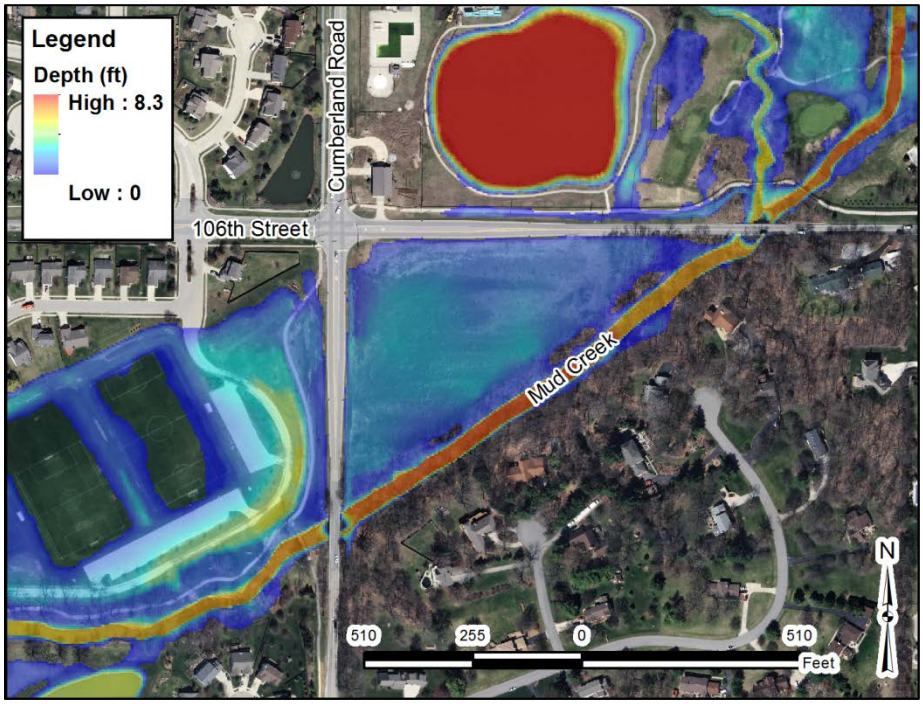

Figure 2-1: 2-year Event Flooding Depths

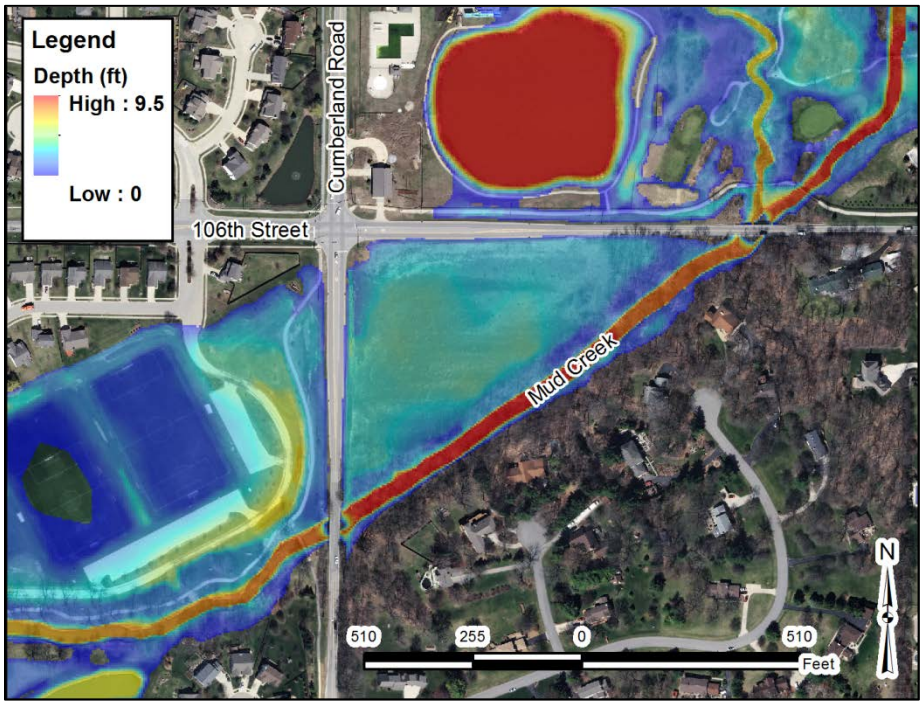

Figure 2-2: 5-year Event Flooding Depths

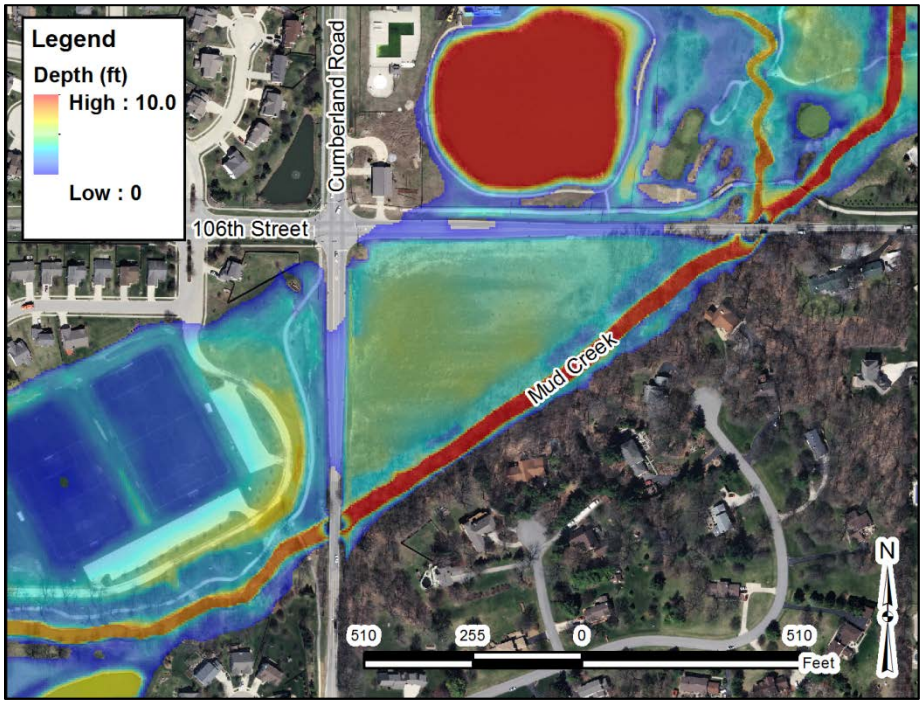

Figure 2-3: 10-year Event Flooding Depths

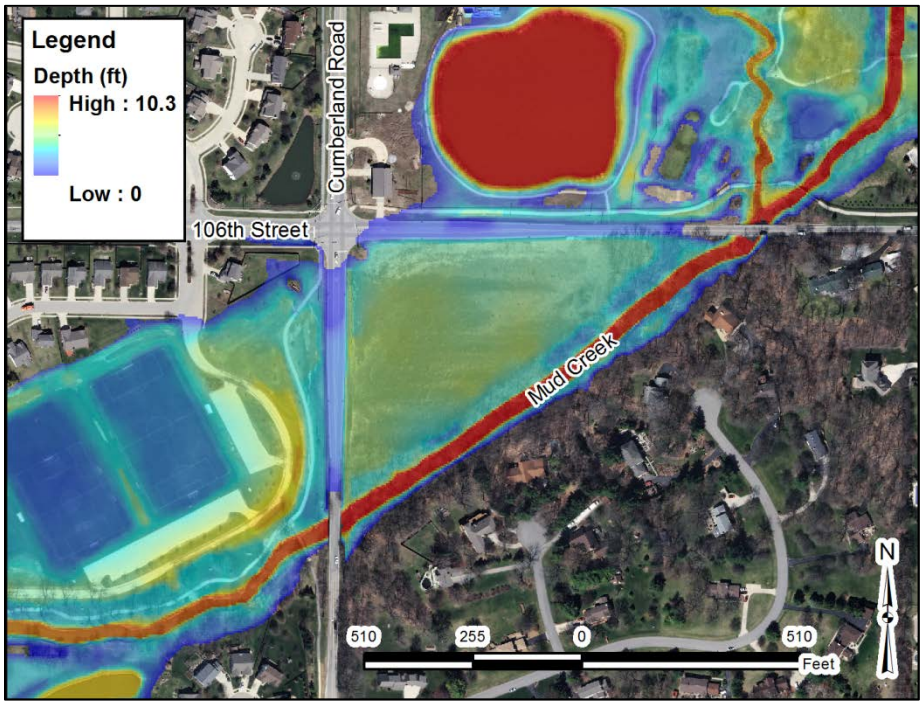

Figure 2-4: 50-year Event Flooding Depths

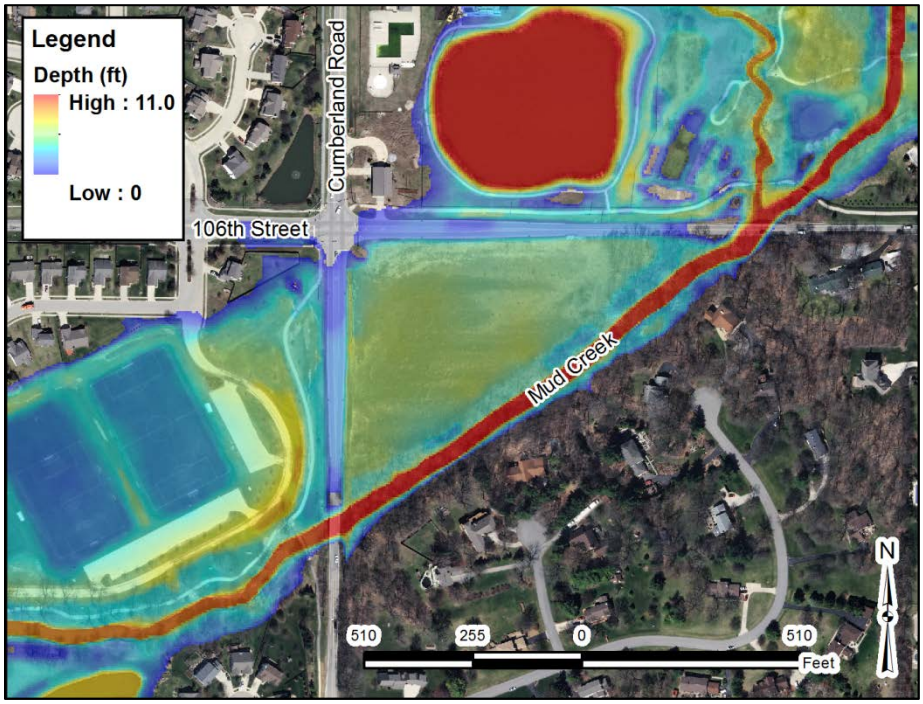

Figure 2-5: 100-year Event Flooding Depths

As can be seen from the figures, flood water from Mud Creek spills out onto attached floodplain areas prior to the 2-year event. The athletic fields to the west of Cumberland Road appear to be inundated by as low as the 5-year event. It should be noted that the inundation areas shown in Figure 2-1 through Figure 2-5 consider the road crest elevation of Cumberland road and 106th Street to be elevation 783.0; a recent survey of the road crest reveals that the true crest elevation is 782.7 for both crossings. This reduces the level of flood-free access from what appears to be the 7-year level to just above a 5-year level of flood-free access along Cumberland Road and the 2-year level along 106th Street.

CHAPTER 3 DETAILED EVALUATION OF ALTERNATIVES

In order to reduce the frequency of flooding along Mud Creek along 106th Street and south on Cumberland Road, several alternatives were investigated. A list of the alternatives investigated is provided in Table 3-1 below.

Table 3-1: Summary and General Description of Alternatives

Alternative #	Description
0	Do nothing (Existing Condition)
1	Raise Cumberland Road and 106th Street
2	Upstream off-line storage
3	2-Stage ditch from 96th Street to 106th Street
4	Increase opening size for Cumberland Road & 106th Street bridges
5	Replace Cumberland Road Bridge & add a high-flow shelf
6	Raise 106th St. & Add Bridge Opening
7	Alternative 5 + Alternative 6
8	Alternative 5 + Alternative 3

The existing condition hydraulic computer modeling was revised to reflect each alternative and its associated effectiveness in reducing roadway flooding near the intersection of Cumberland Road and 106th Street. Detailed information for the analyses, including computer model input data, cost estimate computations, and other calculations for the analyses are summarized in the following sections. It should be noted that all elevations stated in the descriptions and exhibits are referenced to NAVD88.

The analyses of each alternative were performed at a conceptual rather than design level. In addition, the conceptual opinion of probable cost presented for each alternative in this report is based on limited information and a conceptual layout of the alternative and, therefore, is subject to modification during more detailed feasibility or design phases.

3.1 ALTERNATIVE 0 – DO NOTHING (EXISTING CONDITION)

This alternative was included as the base-condition scenario for evaluating the other alternatives. The modeling for this condition is described in Chapter 2 of this document. Figure 2-5 shows the 100-year flooding depths near the intersection.

3.2 ALTERNATIVE 1 – RAISE CUMBERLAND ROAD & 106TH STREET

The first alternative considered was raising Cumberland Road and 106th Street enough to prevent overtopping of the roads. The elevation of each of the roads was raised until the water surface during the 100-year event under that condition was below the road surface. In order to prevent flooding over

the roads, Cumberland Road would need to be raised an average of 2.0 feet over a 600-foot long stretch of the road. Similarly, 106th Street would need to be raised an average of 2.9 feet over a 770-foot long segment plus additional lengths for transitioning to existing grades. The elimination of the flow paths over the roads will cause upstream areas to experience higher flood levels. The 100-year flood elevation just upstream of 106th Street was increased by approximately 1.5 feet as a result of the removal of the road overflow area. The extent of the increased flood elevations further upstream was not determined during this analysis as the resulting changes in the flood profile would not allow for permitting of the project through government agencies. The location of Alternative 1 is highlighted in Figure 3-1; Exhibit 1 provides a more detailed schematic of the changes.

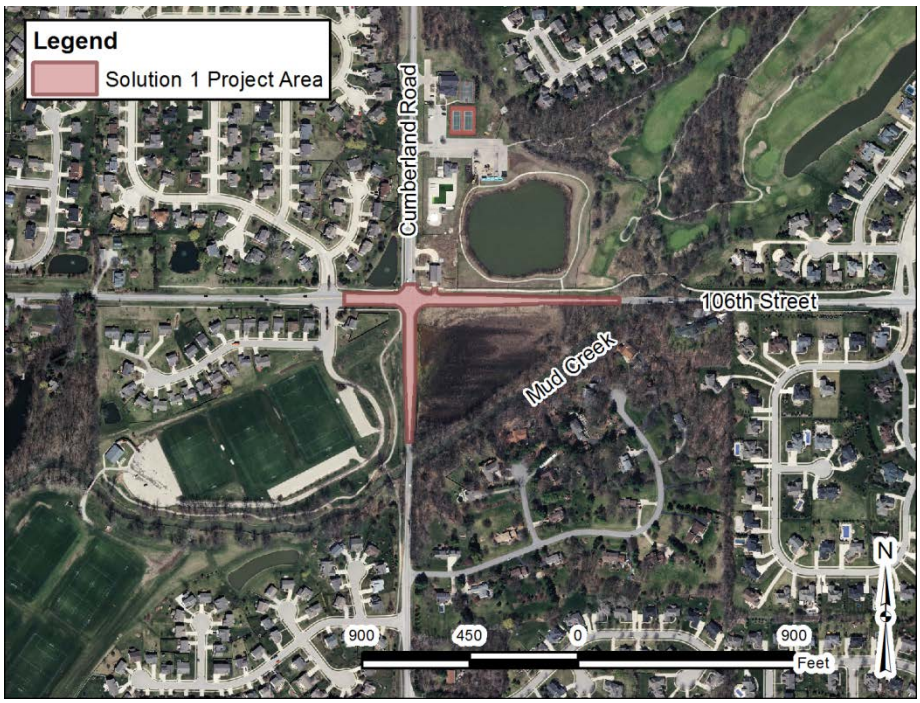

Figure 3-1: Alternative 1 Project Location

The cost associated with raising the roads is estimated to be approximately $1.6 million. This alternative is not recommended due to inability of the project to be permitted in addition to the significant adverse impact to upstream areas.

3.3 ALTERNATIVE 2 – UPSTREAM OFF-LINE STORAGE

Alternative 2 involves the construction of detention ponds in the upstream regions of the Mud Creek watershed. Once the hydrologic model was calibrated to known high water marks, it was possible to determine the volume of runoff that would need to be detained in order to significantly reduce flooding near the intersection. It was determined that a total volume

of approximately 1,950 acre-feet of storage would be required to improve the flood-free level along the study reach of Cumberland Road up to the 100-year level from the 2-year level that currently exists; a total of approximately 400 acre-feet of storage would be required to improve the flood-free level of the roads up to the 25-year level. The corresponding percentage of stored runoff to the total runoff volume for each scenario is 28% and 11%, respectively. Conceptually, the 100-year storage volume could be accommodated in four, 100-acre areas if 5 feet of storage depth were available; the 25-year storage volume could be accommodated in two 40-acre areas 5 feet deep. Exhibit 2 provides an annotated hydrograph of the flow in Mud Creek, and the development and release of flood storage.

An increase in the duration of the peak flow rate is an unavoidable result of storing flood water and allowing it back into the system as channel capacity becomes available. Severe erosion problems may develop as a result of significantly lengthening of the duration of the peak flow rate. Storing and releasing the excess flow during the 100-year event will lengthen the duration of the peak flow from 28 hours to 70 hours; the 25-year peak will be lengthened from 14 hours to 29 hours. The time extension of the peak flow stated should be considered a minimum, as the analysis performed utilized an idealized inflow-outflow scheme. Given that the noted significantly extended duration of flooding would be associated with released discharges that will be on the order of magnitude of the channel forming bankfull discharge, the expected potential channel bank erosion downstream of the pond(s) will be very significant and at unacceptable levels.

The cost associated with these two potential facilities is estimated to be between $14 million and $66 million, depending on the desired level of flood-free access. It should be noted that this cost estimate does not include the cost of acquiring the land on which to construct the detention basins, or the cost of environmental mitigation for tree removal. This alternative is not recommended due to the cost compared to the benefit, as well as the anticipated adverse environmental impacts.

3.4 ALTERNATIVE 3 – 2-STAGE DITCH FROM 96TH STREET TO 106TH STREET

The purpose of this alternative was to increase the flow capacity of the channel downstream of 106th Street with the installation of a 2-stage ditch. An approximately 8,000-foot long stretch of Mud Creek was identified as a possible location of the ditch, extending from 106th Street downstream to 96th Street. Based on site constraints near the athletic fields immediately west of Cumberland Road, the top width of the channel would be limited to approximately 120 feet. Side-slopes of 3H:1V were utilized to promote proper maintenance of the channel banks. For simplicity, the maximum

impact this alternative could have on roadway flooding was determined by modeling a single-stage channel with the same top width and side-slopes. The cross sectional area for a two-stage ditch is expected to be smaller than that assumed here. So, the currently calculated extent of benefits for this alternative is somewhat over-estimated. The existing bridge opening sizes were maintained to isolate the impact of the 2-stage channel from other remedial measures. The general location of the 2-stage ditch is highlighted in Figure 3-2; details of the 2-stage ditch can be seen in Exhibit 3.

Figure 3-2: Alternative 3 Project Location

The results of the modified model showed a 0.9 – 1.4 foot reduction in the 25-year event, a 0 – 0.5 foot reduction for the 50-year event, and a 0.2 – 0.4 foot reduction for the 100-year event. This reduction means that Cumberland Road does not begin to flood until nearly the 25-year event instead of the 2-year event; 106th Street would likely remain flood-free until the 10-year event instead of the 2-year event. The maximum benefit provided by the single-stage ditch still allows the road to be overtopped during the 100-yr event, which makes this solution not viable on its own; it must be paired with other remedial measures to prevent roadway flooding.

Additionally, changes to the cross-section of a channel will result in a response from the channel in terms of sediment transport and channel stability. An assessment of the impact of this alternative has not been performed; however, it is likely that changes of this magnitude will result in significant instability and erosion and sedimentation issues. These issues can be mitigated with additional channel protection and increased maintenance efforts.

Excavation of the 2-stage ditch would cost approximately $5.4 million and not completely solve the issues facing the community. As such, this alternative is not viable by itself. It should be noted that the conceptual cost estimate provided here does not include expenses associated with environmental mitigation for trees to be removed. Given that the reach of the stream being converted is designated as a regulated drain, such mitigation may not be necessary to the degree currently assumed. Should mitigation be required, the total cost of the project could be as much as 30% higher. This alternative is not recommended as a stand-alone project due to cost and environmental factors; however, this alternative may be considered in conjunction with other flood mitigation components.

3.5 ALTERNATIVE 4 – INCREASE CUMBERLAND ROAD & 106TH STREET BRIDGE OPENINGS

Alternative 4 involves increasing the bridge opening sizes for the Cumberland Road and 106th Street bridge crossings. The road crest elevations would also be increased to allow for flood-free access during the 100-year event.

The existing Cumberland Road Bridge would be removed and replaced with a 450-foot long, multiple span bridge. The remaining portion of the road north of the bridge and south of the intersection would be raised to elevation 784.0, resulting in an average road raise of 0.9 feet for another approximately 200 feet. The open area under the bridge would allow for flow in nearly the entire natural floodplain area adjacent to the channel.

The 106th Street Bridge would remain intact; however, a high flow bridge segment would be added just west of the existing bridge to connect an apparent overflow path on the north side of the bridge to the floodplain area located to the west of the channel on the downstream side of the bridge. The new segment of bridge would be approximately 65 feet in length. The remaining portion of the road between the existing bridge and the 106th Street and Cumberland Road intersection would be raised to elevation 784.8, resulting in an average road raise of 1.2 feet over approximately 750 feet.

Additional road modification would be required to the west of the 106th Street and Cumberland Road intersection to tie the elevated road segments into the existing road profiles. Figure 3-3 depicts the location of the proposed changes. A more detailed schematic of the modifications is provided in Exhibit 4.

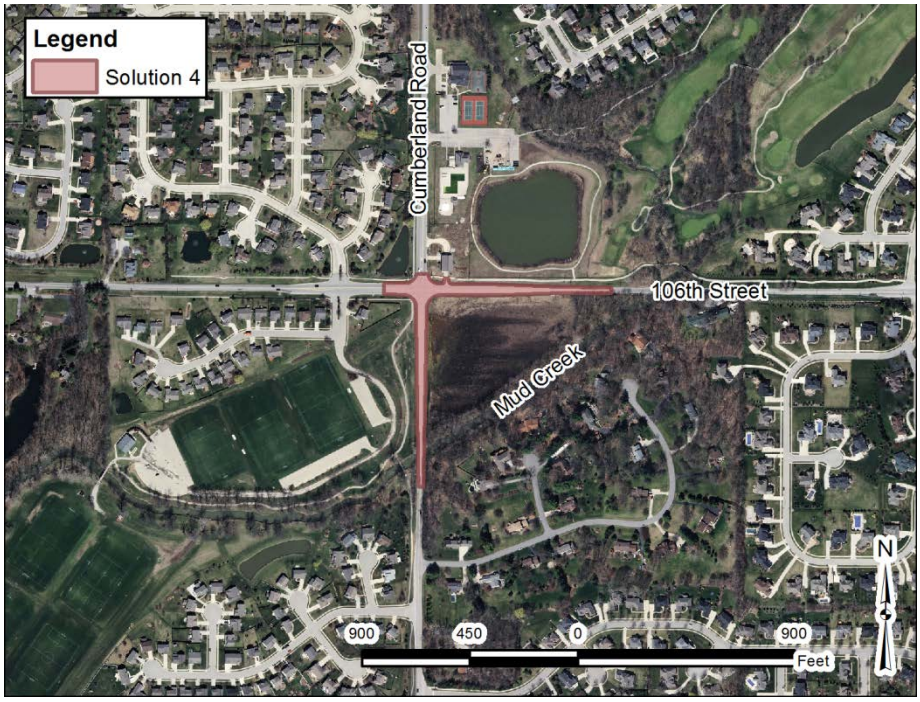

Figure 3-3: Alternative 4 Project Location

While the proposed changes are expected to significantly reduce the risk of roadway flooding and improve the flood-free access of both crossings to 100-year level, the increases in the bridge openings are not sufficient enough to prevent higher regulatory flood elevations upstream of the structures. The regulatory flood elevations would likely increase by approximately 0.6 feet in the vicinity of the 106th Street bridge crossing.

A total project cost of approximately $8.3 million could be expected for the implementation of Alternative 4. This alternative is not recommended based on the cost of the project relative to other alternatives as well as the inability to acquire the necessary permits for the work due to upstream flood stage surcharge.

3.6 ALTERNATIVE 5 – REPLACE CUMBERLAND ROAD BRIDGE & ADD HIGH-FLOW SHELF

This alternative involves the replacement of Cumberland Road Bridge, the removal of the pedestrian bridge immediately downstream of the crossing, and the addition of a high-flow flow shelf on the north side of the channel. This alternative includes no modification of 106th Street, and does not increase the elevation of the Cumberland Road profile.

The existing Cumberland Road Bridge and pedestrian bridge would be replaced by a 230-foot long, multiple-span bridge that would combine the two structures in one, 35-foot wide bridge. The increased opening size of the bridge would be accompanied by the addition of a high-flow shelf on the north side of the channel. The high-flow shelf begins approximately 290 feet

downstream of 106th Street, running in a straight line path to a point approximately 1,000 feet downstream from Cumberland Road, as measured along the channel. The high-flow shelf elevation was set at elevation 778.0 feet, which corresponds to one-half of the average channel depth. Channel modifications would extend for a total distance of approximately 1,900 feet.

The excavation of a high-flow shelf requires slight modification of the existing parking areas adjacent to the athletic fields on the north side of the channel. The parking spaces on the south side of the fields would be relocated to the east parking area; a two-lane access road would be constructed between the east and west parking areas to maintain the current operation of the parking facilities. The general location of the area impacted by the project is shown in Figure 3-4; a more detailed representation of the necessary modifications is shown in Exhibit 5.The size of the high flow shelf could potentially be reduced to minimize the impacts to the athletic fields; however the effectiveness of the solution may be diminished.

Figure 3-4: Alternative 5 Project Location

The results of this alternative were compared to the existing condition model results and showed reduction of the flood elevations upstream of the 106th Street Bridge crossing during the 25, 50, and 100-year events; the corresponding reductions were 0.8 feet, 0.7 feet, and 0.6 feet, respectively. This alternative allows for flood-free access along Cumberland Road during the 100-year event, while the flood-free access along 106th Street is improved from the 2-year level to the 7-year level.

The inclusion of a high-flow shelf will likely require additional maintenance efforts to maintain the condition of the channel. A change in the cross-section of a channel will result in a response from the channel in terms of sediment transport and channel stability. An assessment of the impact of this alternative has not been performed; however, it is likely that the high-flow shelf would induce sediment deposition over the entire area of the shelf. Annual sediment removal would likely be required to prevent a gradual increase in water surface profiles over time.

The overall cost of this alternative was approximately $4.9 million. The cost includes the removal and replacement of the Cumberland Road and pedestrian bridges, the excavation of the high-flow shelf, as well as the modifications to the parking facilities. This alternative should be considered as a stand-alone project, or as the first phase of a multiple phase project due to the effectiveness of the measures as well as the cost relative to the other alternatives.

3.7 ALTERNATIVE 6 – RAISE 106TH STREET & ADD BRIDGE OPENING

Alternative 6 involves raising 106th Street and increasing the open area for flow by adding an additional bridge opening. A high-flow bridge opening will be incorporated to the west of the existing 106th Street bridge opening to connect an apparent high-flow flowpath to the floodplain area on the western overbank area downstream of the bridge. The remaining portion of 106th Street would be raised to an elevation of 785.5 feet. Figure 3-5 provides a project location map. Exhibit 6 provides a schematic of the proposed changes.

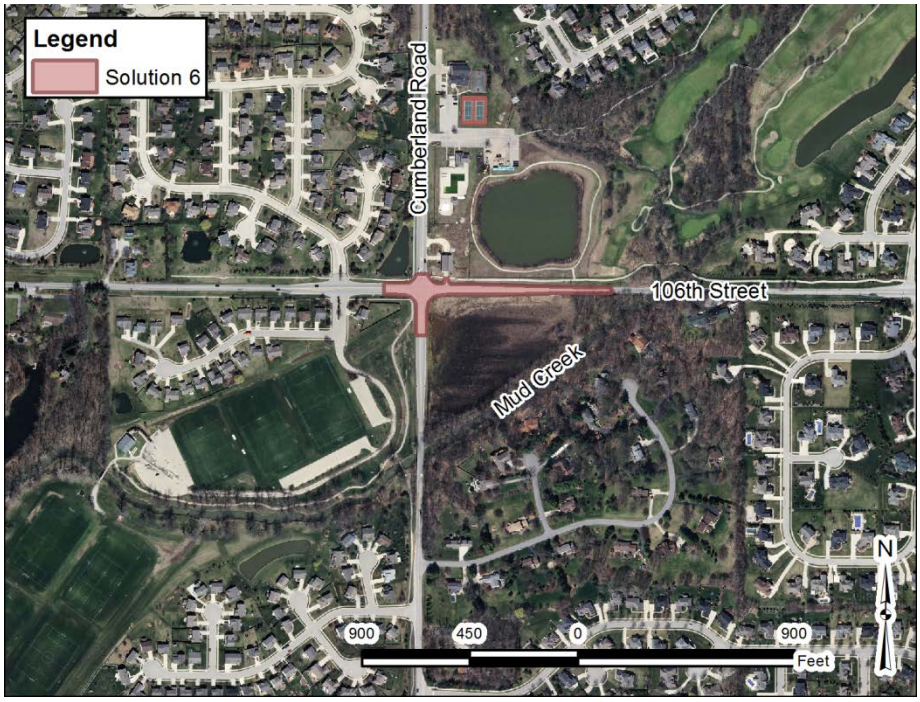

Figure 3-5: Alternative 6 Project Location

The proposed changes result in an increase in the flood elevation upstream the 106th Street Bridge. The flood elevation upstream of the 106th Street Bridge will be increased by 0.3 feet, 0.4 feet, and 0.5 feet for the 25, 50, and 100-year events, respectively.

The overall cost of this alternative is approximately $1.9 million. This alternative does not provide a viable solution to the flooding issues as a standalone project due to the inability to obtain a permit for the project. The inclusion of other remedial measures could allow for the reduced flood elevations overall, as well as increased passage ability over 106th Street.

3.8 ALTERNATIVE 7 – REPLACE CUMBERLAND ROAD BRIDGE, ADD HIGH-FLOW SHELF, & INCREASE 106TH STREET BRIDGE OPENING

Alternative 7 is composed of two phases. The first phase consists of all of the modifications listed in Alternative 5. The second phase is composed of the changes described for 106th Street in Alternative 6. A high-flow bridge opening will be incorporated to the west of the existing 106th Street bridge opening to connect an apparent high-flow flowpath to the floodplain area on the western overbank area downstream of the bridge. The remaining portion of 106th Street would be raised to an elevation of 785.5 feet. Figure 3-5 provides a project location map. Exhibit 7 provides a schematic of the proposed changes.

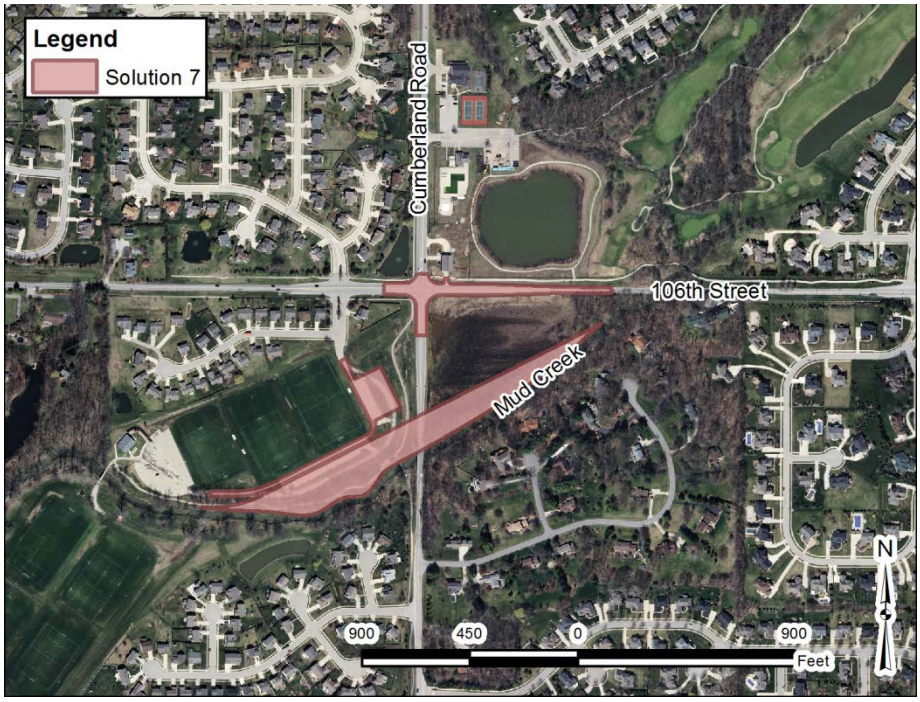

Figure 3-6: Alternative 7 Project Location

The proposed changes result in significant reductions in the flood elevations upstream of both of the bridges, allowing for flood-free access of both roadways during the 100-year event. The flood elevation upstream of the 106th Street Bridge will be lowered by 1.1 feet, 0.6 feet, and 0.4 feet for the 25, 50, and 100-year events, respectively.

The overall cost of this alternative is approximately $6.8 million. As stated in Alternative 5, the inclusion of the high-flow shelf will likely cause sedimentation to occur, resulting in annual maintenance needs to prevent accretion of the shelf; these costs have not been included in the estimate provided. This alternative should be considered as a single, or multi-phase project due to the effectiveness of the measures.

3.9 ALTERNATIVE 8 – REPLACE CUMBERLAND ROAD BRIDGE, ADD HIGH-FLOW SHELF, & 2-STAGE DITCH DOWNSTREAM OF ATHLETIC FIELDS

Alternative 8 is also composed of two phases. The first phase consists of all of the modifications listed in Alternative 5. The second phase is composed of a portion of the changes described for Mud Creek stated in Alternative 3. A large, 2-stage ditch would be incorporated downstream of the pedestrian bridge at the west end of the athletic fields and would extend downstream to 96th Street. The spatial extent of Alternative 8 is shown in Figure 3-6. Exhibit 8 provides additional details concerning the required modifications.

Figure 3-7: Alternative 8 Project Location

The results of this alternative were compared to the existing condition model results and showed reduction of the flood elevations upstream of the 106th Street Bridge crossing during the 25, 50, and 100-year events; the corresponding reductions were 0.8 feet, 0.8 feet, and 0.7 feet, respectively. This alternative allows for flood-free access along Cumberland Road during the 100-year event, while the flood-free access along 106th Street is improved from the 2-year level to the 7-year level.

As stated in Alternative 3 and Alternative 5, the inclusion of significant cross-section changes will result in a response from the channel in terms of sediment transport and channel stability. An assessment of the impact of this alternative has not been performed; however, it is likely that changes of this magnitude will result in significant instability and erosion and sedimentation issues. These issues can be mitigated with additional channel protection and increased maintenance efforts.

The overall cost of this alternative was approximately $8.8 million. It should be noted that the conceptual cost estimate provided here does not include expenses associated with environmental mitigation for trees to be removed. Given that the reach of the stream being converted is designated as a regulated drain, such mitigation may not be necessary to the degree currently assumed. Should mitigation be required, the total cost of the project could be as much as 30% higher. This alternative is not recommended due to cost and environmental factors.

CHAPTER 4 RESULTS & CONCLUSIONS

4.1 HYDRAULIC MODEL RESULTS SUMMARY

The hydraulic model results for each alternative were analyzed to determine if the measures were successful in reducing the flood elevations to allow flood-free access of 106th Street and Cumberland Road; the level of flood-free access was identified for each roadway for all alternatives. The maximum depth of flooding during the 100-year event was noted for 106th Street and Cumberland Road for all modeled solutions. The results are shown for both the "calibrated model" and the "Coordinated Discharges Model", as both models were simulated for all scenarios. However, the conceptual sizing of alternatives and evaluating the success in achieving the target elevations/flooding depths were based on the Calibrated Model results only.

A summary of the hydraulic results for each alternative is shown in Table 4-1. Hydraulic model output for each modeled solution can be seen in Appendix 2.

Table 4-1: Hydraulic Model Results Summary

Alt. Number	Description	Min Road Elevation (ft, NAVD88)	100-yr Water Surface Elevation[1] Calibrated Model[2] (ft, NAVD88)	100-yr Water Surface Elevation[1] Coordinated Model[3] (ft, NAVD88)	Change in 100-yr WSE Calibrated Model[2] (ft)	Change in 100-yr WSE Coordinated Model[3] (ft)	Highest Flood-free Access RI (yr)	Max Depth of Flooding (ft)
0	Do Nothing (Existing Condition)	782.7	783.8	784.4	-	-	5	1.1
		782.7	784.4	785.1	-	-	2	1.7
1	Raise Cumberland Rd & 106th St.	785.4	785.4	786.1	1.6	1.7	100	0.0
		786.0	786.3	786.7	1.9	1.7	100	0.3
2	Upstream Storage	782.7	781.8	784.4	-2.0	0.0	100	0.0
		782.7	782.5	784.9	-1.9	-0.2	100	0.0
3	2-Stage Ditch	782.7	783.6	784.1	-0.2	-0.3	25	0.9
		782.7	784.0	784.5	-0.4	-0.5	10	1.3
4	Increase Bridge Openings	784.0	783.1	784.0	-0.8	-0.4	100	0.0
		784.8	785.0	785.8	0.6	0.8	100	0.2
5	Cumberland Rd Bridge & High-flow Shelf	782.7	782.8	783.7	-1.0	-0.7	100	0.1
		782.7	783.8	784.3	-0.6	-0.8	7	1.1
6	Raise 106th Street & Add Bridge Opening	782.7	783.8	784.4	0.0	0.0	5	1.1
		785.5	784.9	785.7	0.5	0.6	100	0.0
7	Alternative 5 + 106th St. Bridge	782.7	782.8	783.7	-1.0	-0.7	100	0.1
		785.5	784.0	785.1	-0.4	0.1	100	0.0
8	Alternative 5 + 2-Stage Ditch	782.7	782.7	783.4	-1.2	-1.0	100	0.0
		782.7	783.7	784.2	-0.6	-0.8	7	1.0

[1] Water surface elevation at upstream face of Cumberland Rd / 106th St bridge
[2] 100-yr Event determined using calibrated HEC-HMS model
[3] Coordinated Discharge 100-yr Event

= Cumberland Road Information & Results

= 106th Street Information & Results

4.2 CONCEPTUAL OPINION OF PROBABLE COST SUMMARY

Conceptual opinions of the probable cost for each solution were developed using industry standard production rates and observed unit costs for similar work in the same area as the project sites. A detailed breakdown of the cost estimates can be found in Appendix 2.

Table 4-2: Summary of Opinions of Probable Cost

Alt. Number	Description	Construction Cost ($ in Millions)	Professional Services Cost ($ in Millions)	Total Project Cost ($ in Millions)
0	Do Nothing (Existing Condition)	-	-	-
1	Raise Cumberland Rd & 106th St.	$1.3	$0.3	$1.6
2	Upstream Storage	$57.7	$8.1	$65.8
3	2-Stage Ditch	$4.7	$0.7	$5.4
4	Increase Bridge Openings	$7.4	$1.0	$8.3
5	Cumberland Rd Bridge & High-flow Shelf	$4.3	$0.6	$4.9
6	Raise 106th St. & Add Bridge Section	$1.6	$0.2	$1.9
7	Alternative 5 + Alternative 6	$5.9	$0.8	$6.7
8	Alternative 5 + Alternative 3	$7.7	$1.1	$8.8

4.3 EVALUATION OF ALTERNATIVE PERFORMANCE

As briefly described in Chapter 3, each of the alternatives modeled provided some flooding relief near the intersection of Cumberland Road and 106th Street. The degree of improvement, the level of upstream impact, the permitting effort anticipated, and the ability to acquire a Construction in a Floodway permit varied for each alternative. A summary of the findings is shown in Table 4-3.

Table 4-3: Summary of Alternative Performance

Alt. Number	Description	Highest Flood-free Access RI (yr)	Max Depth of Flooding (ft)	Average Road Raise (ft)	Length of Revised Bridge / Road (ft)	Length of Channel Modification (ft)	Permittable (Y / N)	Total Project Cost ($, in Millions)
0	Do Nothing (Existing Condition)	5	1.1	-	-	-	-	-
		2	1.7	-	-			
1	Raise Cumberland Rd & 106th St.	100	0.0	2.0	671	0	N	$1.6
		100	0.3	2.9	767			
2	Upstream Storage	100	0.0	-	-	0	Y	$65.8
		100	0.0	-	-			
3	2-Stage Ditch	25	0.9	-	-	8000	Y	$5.4
		10	1.3	-	-			
4	Increase Bridge Openings	100	0.0	0.9	651	0	N	$8.3
		100	0.2	1.2	813			
5	Cumberland Rd Bridge & High-flow Shelf	100	0.1	-	230	1900	Y	$4.9
		7	1.1	-	-			
6	Raise 106th St. & Add Bridge Opening	5	1.1	-	-	0	N	$1.9
		100	0.0	0.7	813			
7	Alternative 5 + 106th St. Bridge	100	0.1	-	230	1900	Y	$6.7
		100	0.0	0.7	813			
8	Alternative 5 + 2-Stage Ditch	100	0.0	-	230	6950	Y	$8.8
		7	1.0	-	-			

[1] Water surface elevation at upstream face of Cumberland Rd / 106th St bridge

[2] 100-yr Event determined using calibrated HEC-HMS model

[3] Coordinated Discharge 100-yr Event

= Cumberland Road Information & Results

= 106th Street Information & Results

CHAPTER 5 RECOMMENDATIONS

The various alternatives discussed above were compared based on cost and the communities' overall needs. Based on this comparison and general observations, a series of recommendations were developed. These recommendations are discussed below.

1. Acquire Property at Southeast Quadrant of Intersection

The parcel of land to the southeast of the 106th Street and Cumberland Road intersection should be purchased to prevent the potential for development of the area. The property is completely within the delineated floodway and should be protected to prevent additional surcharges.

2. Pursue Standard Calibration of Hydrologic & Hydraulic Models Using USGS Gage Data & Unsteady-state Hydraulic Modeling

As discussed in Chapter 2, there is some uncertainty regarding the model calibration and resulting existing peak frequency discharges along both Sand and Mud Creek. The model used as a part of this project was based on available data and reasonably matches all currently available high water marks, but, due to lack of gage data, calibration parameters were determined by hydraulic model results instead of real data.

A gage on Sand Creek, a gage on Mud Creek upstream of Sand Creek, and the Mud Creek gage in Marion County have recently been reestablished. Information gathered by these gages over time will allow for a more standard method of model calibration to be done. A clearer understanding of the stream's response to rainfall will allow for more certainty in developing adequate solutions to flooding problems within the entire Mud Creek and Sand Creek watersheds. Though a more standardized calibration does not change the physical history of the stream, it does help to characterize the true risk of flooding more accurately. This allows designs to be tailored to a particular level of risk without gross over-design or under-design.

By increasing the conveyance capacity of the 106th Street and Cumberland Road bridges, it is likely that the peak flow rate experienced in downstream channel segments will increase. Significant changes in flow rates may result in channel migration, or other adverse erosion related issues. Steady-state modeling is not able to provide information concerning the changes to flow regime, thus an unsteady-state model would need to be developed in order to accurately quantify the impacts to both upstream and downstream channel segments.

3. Pursue a Phased Implementation of Alternative 7

Based on the results of the modeling, the best alternative to fully achieve the desired results for the community is Alternative 7. This alternative provides

100-year flood-free access along both Cumberland Road and 106th Street. Alternative 5 could also be constructed as the first phase of a two-phase project, followed by work on the 106th Street and its bridge (Alternative 6) as the second phase of the project. The summary of the two project phases are as follows:

1) Implement Alternative 5: Replace Cumberland Road Bridge with a new 230-foot long bridge with a significantly larger opening. Excavate a high-flow shelf along the north bank of the stream to allow for increased capacity under the bridge. Finally, reestablish the sports complex parking area to the east of the athletic fields. This will make the Cumberland Road flood free access for the 100-year event and will improve the flood-free access of the 106th Street from a 2-year event to 7-year event. The estimated cost for this portion of the project is approximately $4.9 million.
2) Implement Alternative 6: Raise approximately 813 feet of 106th Street, including the intersection at 106th Street and Cumberland Road. A 65-foot section of bridge would be added to the west of the existing bridge crossing on 106th Street to help accommodate larger flow events, increasing the level of flood-free access along 106th Street to the 100-year level. The additional cost of this phase is estimated at nearly $1.8 million.

EXHIBITS

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CERTIFIED:
PRELIMINARY
NOT FOR CONSTRUCTION

TITLE:
ALTERNATIVE 1

PROJECT:
MUD CREEK
FLOOD STUDY

PROJECT NO. 12-0231

SHEET 2 OF 8

DRAWING NO. EX1

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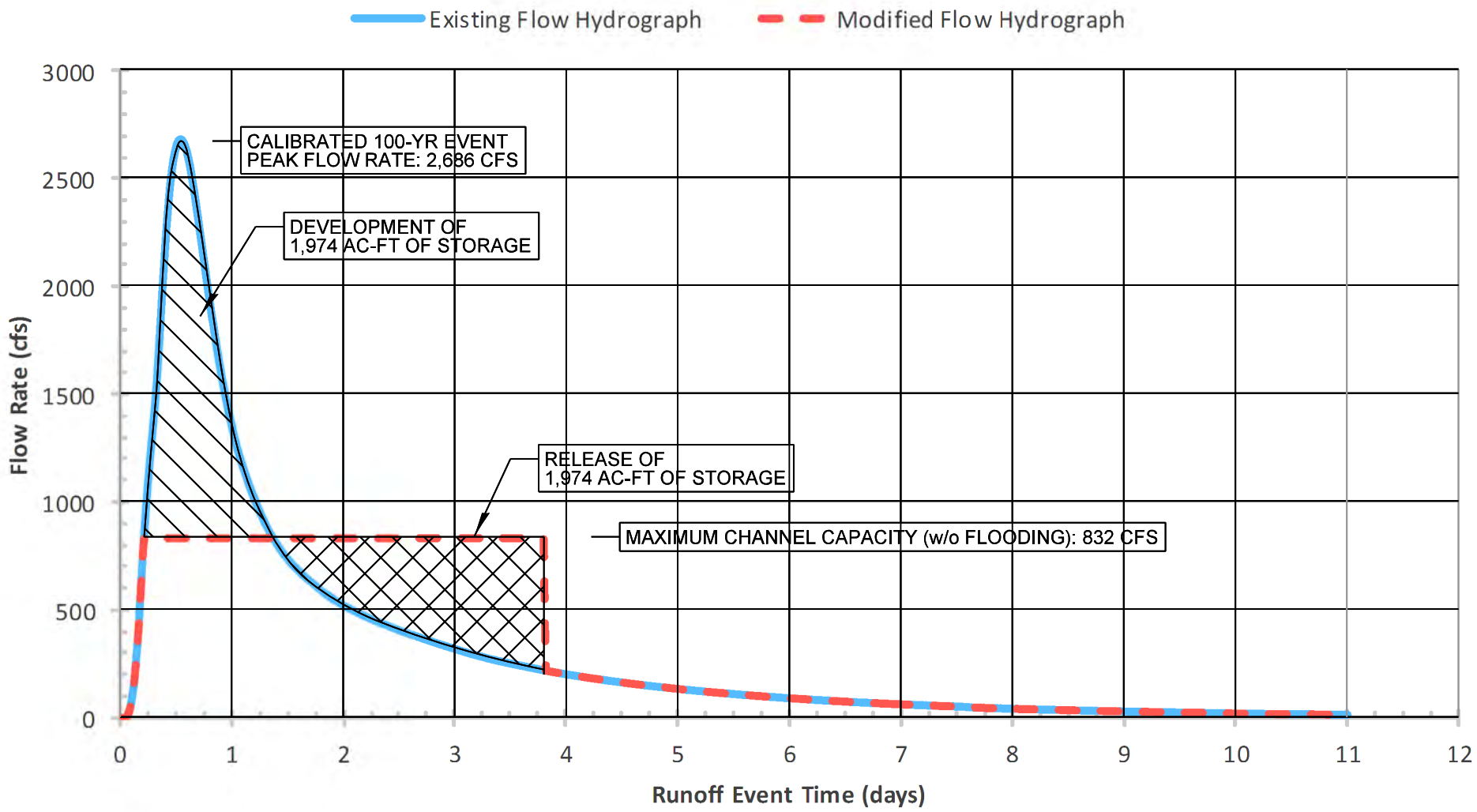
11/14/2012



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TITLE: SOLUTION #2

PROJECT: MUD CREEK FLOOD STUDY

PROJECT NO. 12-0231

SHEET 2 OF 8

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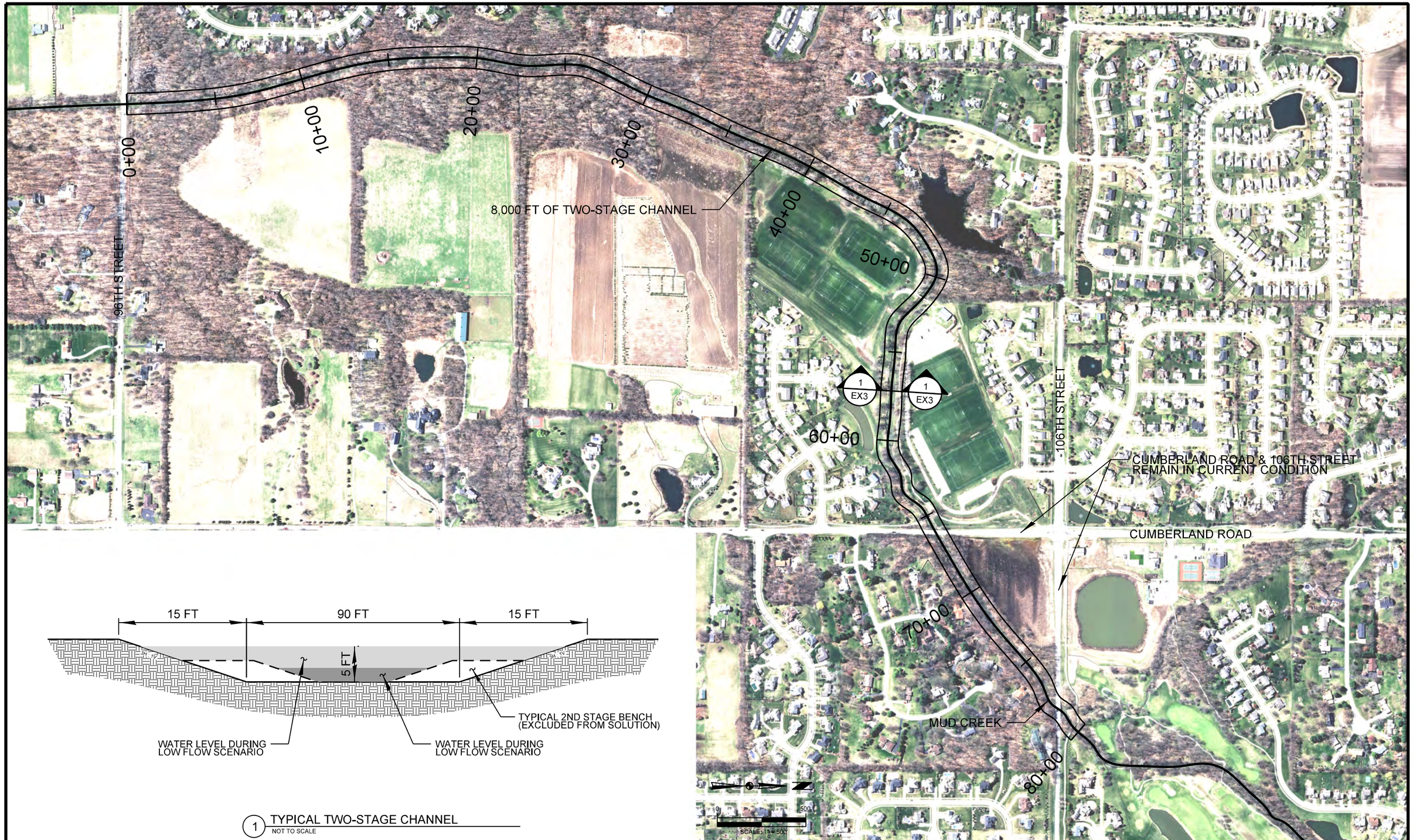

1 TYPICAL TWO-STAGE CHANNEL
NOT TO SCALE

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PRELIMINARY
NOT FOR CONSTRUCTION

TITLE:
ALTERNATIVE 3

PROJECT:
MUD CREEK
FLOOD STUDY

PROJECT NO. 12-0231
SHEET 4 OF 8
DRAWING NO. EX3

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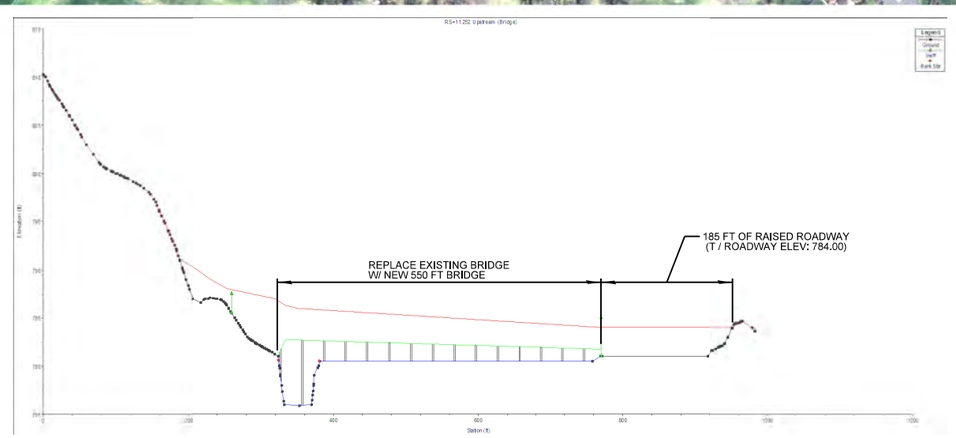

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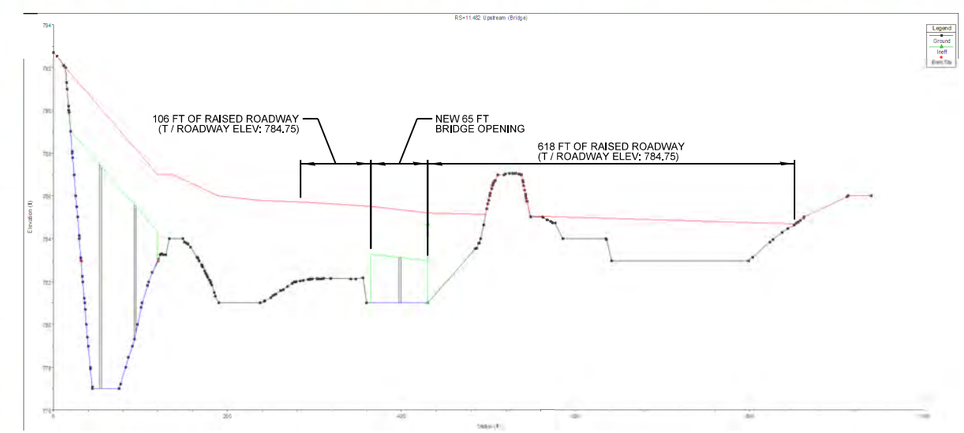

2 106TH STREET BRIDGE PROFILE
NOT TO SCALE

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SCALE: 1" = 200'

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TITLE: ALTERNATIVE 4

PROJECT: MUD CREEK FLOOD STUDY

PROJECT NO. 12-0231

SHEET 5 OF 8

DRAWING NO. EX4

106TH STREET

INCREASED PARKING LOT SIZE
TO ACCOMODATE LOST SPACES

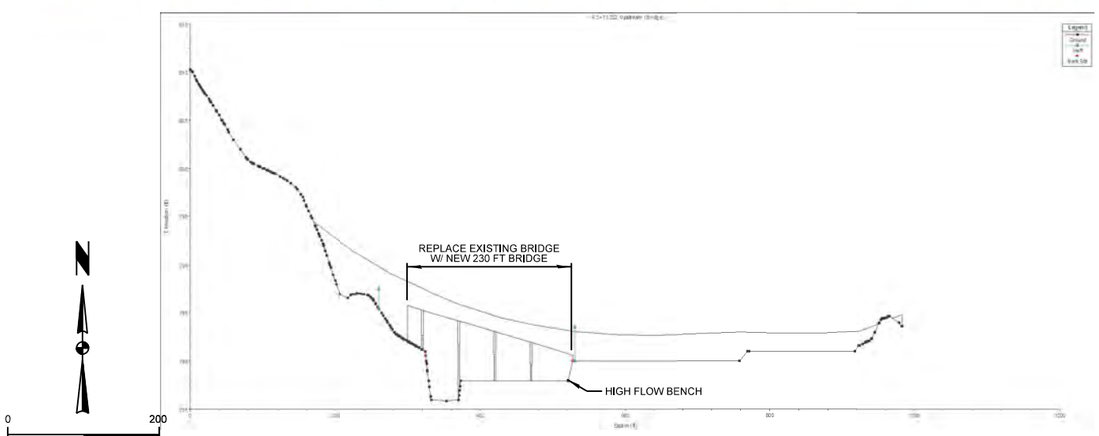
HIGH FLOW BENCH
(T / BENCH ELEV: 778.00)
(T / BANK ELEV: 780.00)

MUD CREEK

ACCESS ROAD TO
EAST PARKING AREA

REPLACE EXISTING BRIDGE
W/ NEW 230 FT BRIDGE

CUMBERLAND ROAD



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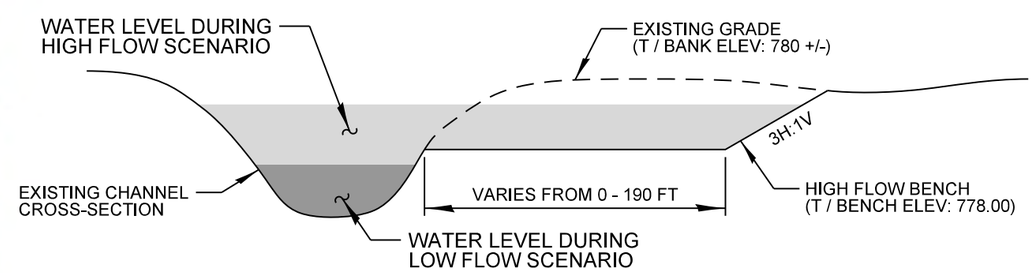

2 TYPICAL HIGH FLOW BENCH DETAIL
NOT TO SCALE

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TITLE: ALTERNATIVE 5

PROJECT: MUD CREEK FLOOD STUDY

PROJECT NO. 12-0231

SHEET 6 OF 8

DRAWING NO. EX5

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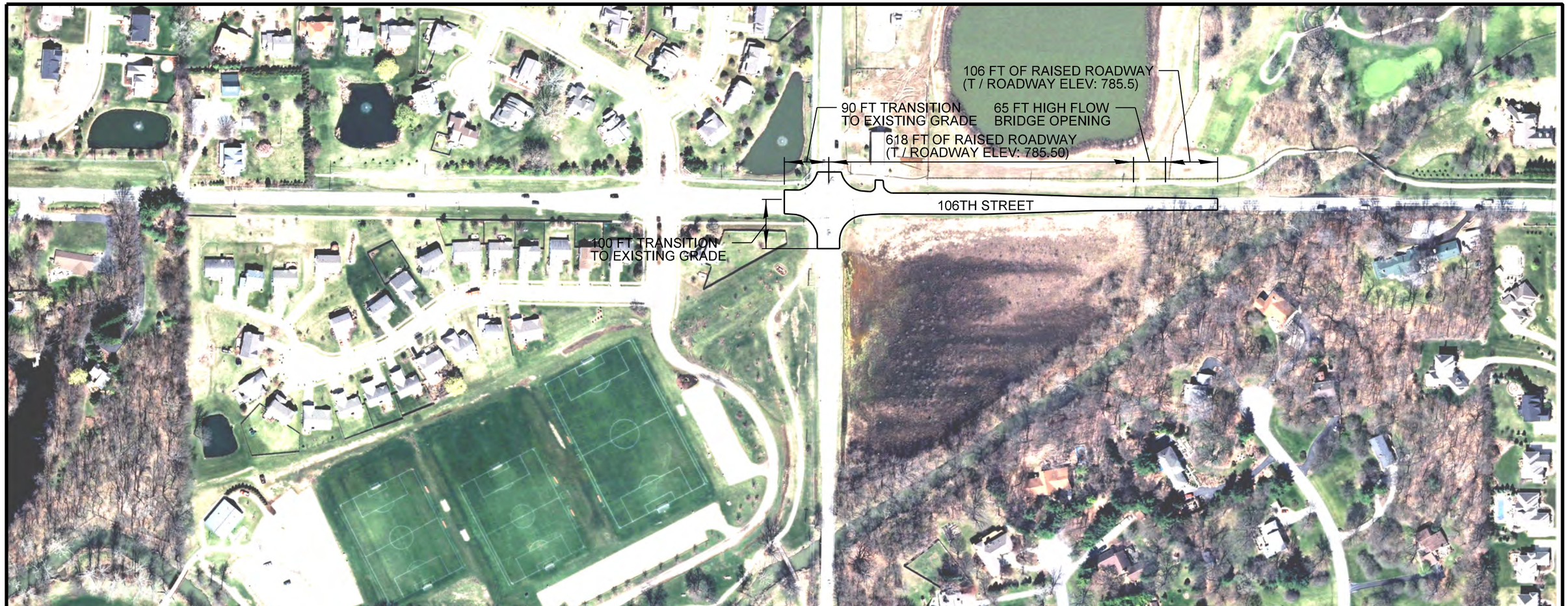

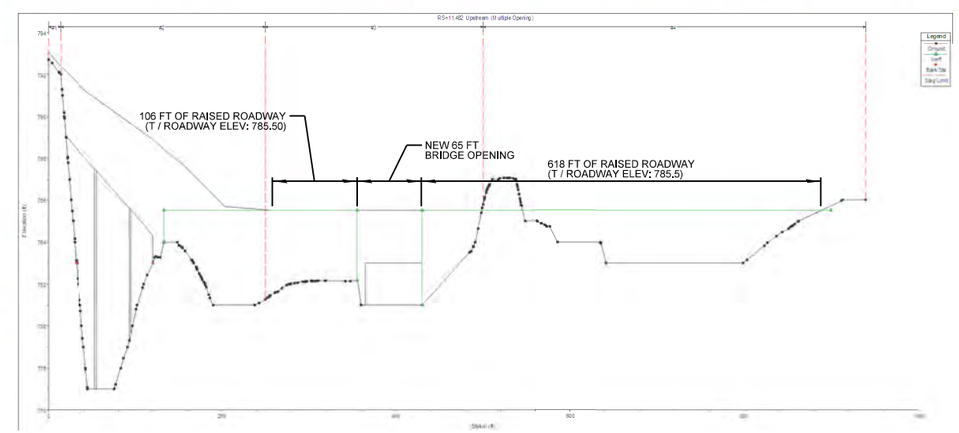

3 106TH STREET BRIDGE PROFILE
NOT TO SCALE

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TITLE: ALTERNATIVE 6

PROJECT: MUD CREEK FLOOD STUDY

PROJECT NO. 12-0231

SHEET 6 OF 8

DRAWING NO. EX6

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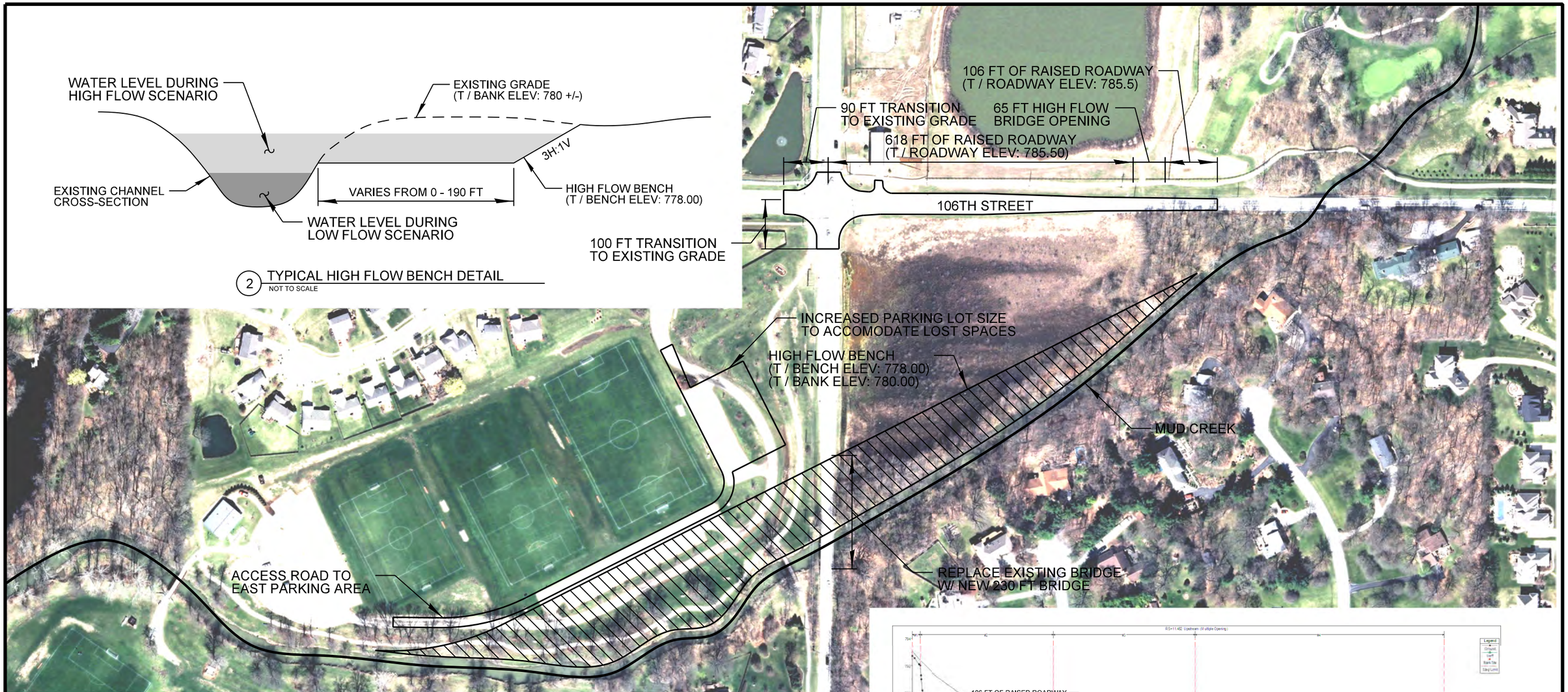

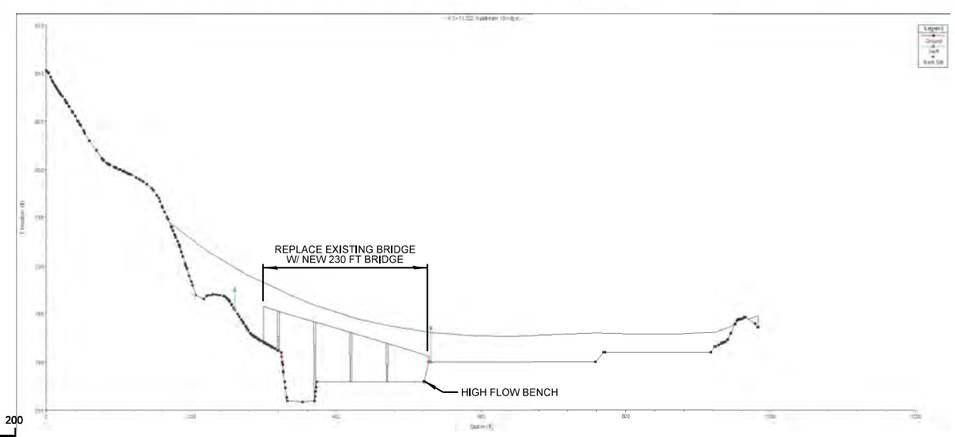

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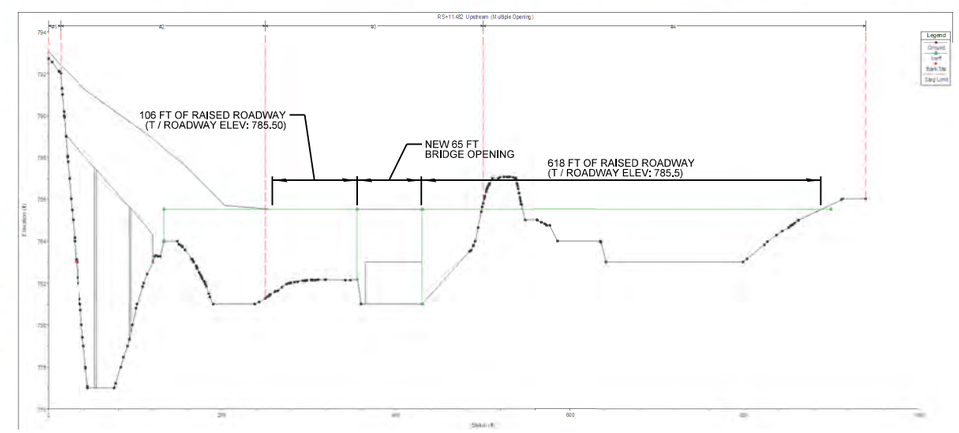

3 106TH STREET BRIDGE PROFILE
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TITLE: ALTERNATIVE 7

PROJECT: MUD CREEK FLOOD STUDY

PROJECT NO. 12-0231

SHEET 7 OF 8

DRAWING NO. EX7

1 TYPICAL TWO-STAGE CHANNEL
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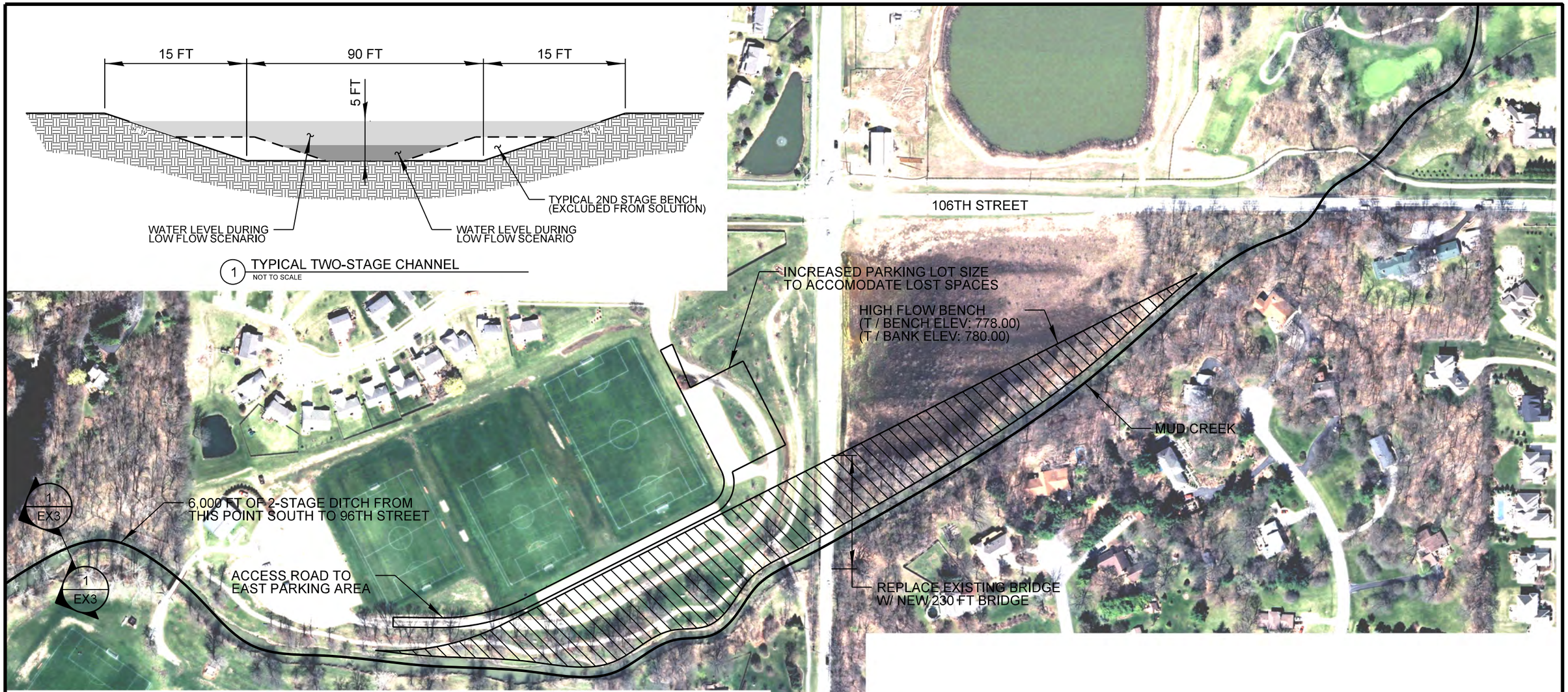

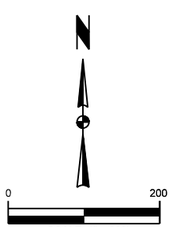

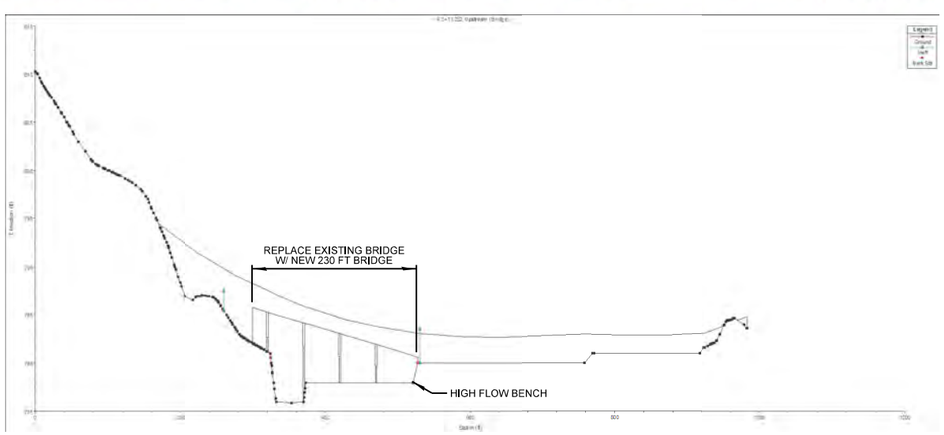

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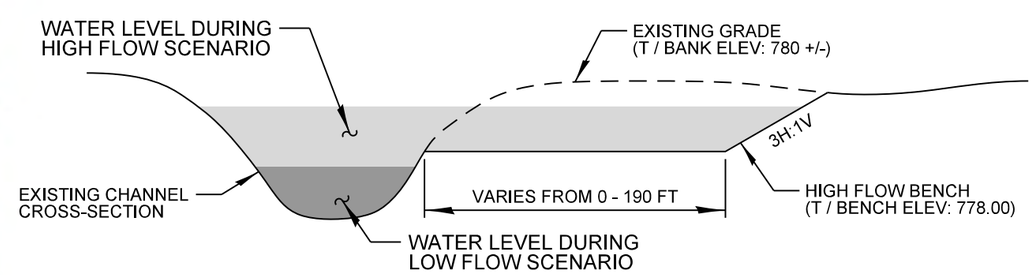

3 TYPICAL HIGH FLOW BENCH DETAIL
NOT TO SCALE

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PROJECT: MUD CREEK FLOOD STUDY

PROJECT NO. 12-0231

SHEET 8 OF 8

DRAWING NO. EX8

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APPENDIX 1 HYDROLOGIC AND HYDRAULIC COMPUTER MODELS CD

APPENDIX 2 HYDRAULIC MODEL RESULTS

HEC-RAS Plan: Existing 2012 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	783.08		783.13	0.000874	2.32	649.63	487.22	0.21
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.86		783.90	0.000617	2.20	1065.71	576.53	0.18
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	784.17		784.21	0.000716	2.48	1246.01	602.38	0.20
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	784.58		784.63	0.000754	2.68	1496.67	616.42	0.20
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	784.90		784.95	0.000769	2.81	1695.97	627.29	0.21
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.20		785.26	0.000777	2.93	1890.98	649.02	0.21
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	785.90		785.97	0.000832	3.26	2357.38	685.67	0.22
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	782.28	779.29	782.39	0.001060	2.53	291.93	275.20	0.23
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	783.02	779.90	783.18	0.001451	3.13	353.97	535.15	0.28
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	783.46	780.33	783.56	0.000975	2.75	887.50	596.17	0.23
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	783.78	780.93	783.90	0.001149	3.12	1082.03	621.39	0.25
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	784.04	781.37	784.17	0.001272	3.41	1249.61	705.70	0.27
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	784.38	781.80	784.49	0.001180	3.43	1490.03	723.74	0.26
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	785.05	783.24	785.18	0.001186	3.72	1989.83	785.96	0.27
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	782.06	779.20	782.17	0.001225	2.69	297.24	875.89	0.25
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	782.79	779.81	782.94	0.001309	3.14	432.66	888.56	0.26
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	783.31	780.28	783.33	0.000223	1.40	2124.19	902.01	0.11
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	783.60	780.87	783.62	0.000277	1.62	2385.14	903.91	0.13
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	783.84	781.35	783.86	0.000310	1.76	2602.76	905.52	0.13
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	784.19	782.21	784.21	0.000301	1.81	2917.63	907.28	0.13
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	784.86	783.04	784.89	0.000336	2.06	3525.71	910.29	0.14
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	781.87		781.90	0.000394	1.89	881.62	595.89	0.15
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	782.66		782.68	0.000308	1.84	1377.48	644.42	0.13
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	783.23		783.25	0.000273	1.84	1747.34	657.71	0.13
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	783.49		783.52	0.000365	2.18	1920.30	658.49	0.15
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	783.71		783.75	0.000427	2.41	2067.56	659.13	0.16
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	784.06		784.10	0.000431	2.50	2297.41	660.13	0.16
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	784.71		784.76	0.000515	2.89	2725.19	661.78	0.18
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	781.71		781.74	0.000375	1.84	878.57	511.68	0.14
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	782.54		782.56	0.000300	1.81	1312.69	530.56	0.13
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	783.12		783.14	0.000278	1.86	1622.71	540.01	0.13
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	783.34		783.38	0.000397	2.27	1742.78	545.68	0.15
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	783.53		783.58	0.000488	2.56	1848.35	551.18	0.17
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	783.88		783.92	0.000508	2.69	2038.30	553.69	0.17
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	784.48		784.54	0.000641	3.19	2373.04	555.59	0.20
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	781.50	778.17	781.60	0.000886	2.66	326.89	608.55	0.22
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	782.28	778.83	782.42	0.001052	3.21	434.35	645.62	0.24
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	783.08	779.38	783.10	0.000204	1.55	1902.40	665.43	0.11
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	783.29	780.09	783.31	0.000293	1.90	2038.80	668.33	0.13
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	783.47	780.86	783.50	0.000361	2.15	2159.46	671.02	0.15
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	783.81	781.32	783.84	0.000370	2.25	2390.30	678.42	0.15
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	784.39	782.31	784.44	0.000471	2.68	2793.11	697.57	0.17
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	781.20	778.35	781.37	0.001439	3.36	243.98	646.88	0.28
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.75	779.06	782.02	0.002049	4.32	299.83	664.41	0.34
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	782.04	779.63	782.42	0.002745	5.18	330.02	671.33	0.39
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	782.37	780.37	782.93	0.003758	6.31	364.98	676.44	0.46
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.60	781.24	783.32	0.004614	7.18	390.44	680.43	0.52
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.90	781.70	782.94	0.000598	2.67	1951.71	685.53	0.19
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.60	782.70	783.65	0.000616	2.91	2445.15	725.53	0.19
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.93	778.72	780.98	0.000798	2.32	558.33	368.11	0.20
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.38	779.37	781.46	0.001087	2.90	862.53	721.34	0.24
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.69	779.79	781.75	0.001036	2.95	1081.76	724.64	0.23
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	782.06	779.98	782.12	0.000992	3.03	1351.51	728.76	0.23
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	782.35	779.98	782.41	0.000952	3.08	1564.06	744.34	0.23
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.63	779.98	782.69	0.000915	3.12	1769.35	766.09	0.23
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	783.34	780.93	783.40	0.000840	3.22	2294.76	812.72	0.22
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.50	778.15	780.57	0.000949	2.48	595.40	644.51	0.22
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.92	778.82	780.98	0.000927	2.62	870.59	661.81	0.22
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.24	779.76	781.30	0.000906	2.72	1093.79	710.84	0.22
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.63	779.98	781.69	0.000870	2.81	1378.13	735.02	0.22
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.95	780.65	782.00	0.000828	2.86	1610.24	752.77	0.22
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	782.24	780.78	782.30	0.000798	2.91	1840.54	786.46	0.22
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	782.99	781.08	783.05	0.000709	2.98	2439.60	807.42	0.21
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	780.05	777.59	780.10	0.000850	2.20	669.12	659.95	0.20
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.50	778.68	780.55	0.000787	2.29	965.58	703.75	0.20
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.85	779.54	780.89	0.000749	2.35	1195.98	729.14	0.20
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	781.24	779.71	781.29	0.000755	2.50	1475.58	830.13	0.20
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.58	779.96	781.62	0.000706	2.53	1717.30	851.80	0.20
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.89	780.16	781.94	0.000673	2.57	1945.60	878.50	0.19
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.68	780.44	782.73	0.000610	2.68	2531.71	909.90	0.19

HEC-RAS Plan: Solution 2 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	783.08		783.13	0.000874	2.32	649.63	487.22	0.21
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.86		783.90	0.000617	2.20	1065.71	576.53	0.18
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	784.17		784.21	0.000716	2.48	1246.01	602.38	0.20
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	784.58		784.63	0.000754	2.68	1496.67	616.42	0.20
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	784.90		784.95	0.000769	2.81	1695.97	627.29	0.21
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.20		785.26	0.000777	2.93	1890.98	649.02	0.21
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	785.90		785.97	0.000832	3.26	2357.38	685.67	0.22
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	782.28	779.29	782.39	0.001060	2.53	291.93	275.20	0.23
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	783.02	779.90	783.18	0.001451	3.13	353.97	535.15	0.28
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	783.46	780.33	783.56	0.000975	2.75	887.50	596.17	0.23
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	783.78	780.93	783.90	0.001149	3.12	1082.03	621.39	0.25
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	784.04	781.37	784.17	0.001272	3.41	1249.61	705.70	0.27
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	784.38	781.80	784.49	0.001180	3.43	1490.03	723.74	0.26
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	785.05	783.24	785.18	0.001186	3.72	1989.83	785.96	0.27
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	782.06	779.20	782.17	0.001225	2.69	297.24	875.89	0.25
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	782.79	779.81	782.94	0.001309	3.14	432.66	888.56	0.26
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	783.31	780.28	783.33	0.000223	1.40	2124.19	902.01	0.11
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	783.60	780.87	783.62	0.000277	1.62	2385.14	903.91	0.13
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	783.84	781.35	783.86	0.000310	1.76	2602.76	905.52	0.13
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	784.19	782.21	784.21	0.000301	1.81	2917.63	907.28	0.13
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	784.86	783.04	784.89	0.000336	2.06	3525.71	910.29	0.14
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	781.87		781.90	0.000394	1.89	881.62	595.89	0.15
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	782.66		782.68	0.000308	1.84	1377.48	644.42	0.13
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	783.23		783.25	0.000273	1.84	1747.34	657.71	0.13
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	783.49		783.52	0.000365	2.18	1920.30	658.49	0.15
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	783.71		783.75	0.000427	2.41	2067.56	659.13	0.16
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	784.06		784.10	0.000431	2.50	2297.41	660.13	0.16
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	784.71		784.76	0.000515	2.89	2725.19	661.78	0.18
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	781.71		781.74	0.000375	1.84	878.57	511.68	0.14
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	782.54		782.56	0.000300	1.81	1312.69	530.56	0.13
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	783.12		783.14	0.000278	1.86	1622.71	540.01	0.13
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	783.34		783.38	0.000397	2.27	1742.78	545.68	0.15
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	783.53		783.58	0.000488	2.56	1848.35	551.18	0.17
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	783.88		783.92	0.000508	2.69	2038.30	553.69	0.17
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	784.48		784.54	0.000641	3.19	2373.04	555.59	0.20
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	781.50	778.17	781.60	0.000886	2.66	326.89	608.55	0.22
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	782.28	778.83	782.42	0.001052	3.21	434.35	645.62	0.24
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	783.08	779.38	783.10	0.000204	1.55	1902.40	665.43	0.11
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	783.29	780.09	783.31	0.000293	1.90	2038.80	668.33	0.13
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	783.47	780.86	783.50	0.000361	2.15	2159.46	671.02	0.15
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	783.81	781.32	783.84	0.000370	2.25	2390.30	678.42	0.15
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	784.39	782.31	784.44	0.000471	2.68	2793.11	697.57	0.17
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	781.20	778.35	781.37	0.001439	3.36	243.98	646.88	0.28
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.75	779.06	782.02	0.002049	4.32	299.83	664.41	0.34
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	782.04	779.63	782.42	0.002745	5.18	330.02	671.33	0.39
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	782.37	780.37	782.93	0.003758	6.31	364.98	676.44	0.46
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.60	781.24	783.32	0.004614	7.18	390.44	680.43	0.52
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.90	781.70	782.94	0.000598	2.67	1951.71	685.53	0.19
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.60	782.70	783.65	0.000616	2.91	2445.15	725.53	0.19
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.93	778.72	780.98	0.000798	2.32	558.33	368.11	0.20
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.38	779.37	781.46	0.001087	2.90	862.53	721.34	0.24
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.69	779.79	781.75	0.001036	2.95	1081.76	724.64	0.23
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	782.06	779.98	782.12	0.000992	3.03	1351.51	728.76	0.23
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	782.35	779.98	782.41	0.000952	3.08	1564.06	744.34	0.23
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.63	779.98	782.69	0.000915	3.12	1769.35	766.09	0.23
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	783.34	780.93	783.40	0.000840	3.22	2294.76	812.72	0.22
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.50	778.15	780.57	0.000949	2.48	595.40	644.51	0.22
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.92	778.82	780.98	0.000927	2.62	870.59	661.81	0.22
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.24	779.76	781.30	0.000906	2.72	1093.79	710.84	0.22
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.63	779.98	781.69	0.000870	2.81	1378.13	735.02	0.22
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.95	780.65	782.00	0.000828	2.86	1610.24	752.77	0.22
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	782.24	780.78	782.30	0.000798	2.91	1840.54	786.46	0.22
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	782.99	781.08	783.05	0.000709	2.98	2439.60	807.42	0.21
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	780.05	777.59	780.10	0.000850	2.20	669.12	659.95	0.20
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.50	778.68	780.55	0.000787	2.29	965.58	703.75	0.20
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.85	779.54	780.89	0.000749	2.35	1195.98	729.14	0.20
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	781.24	779.71	781.29	0.000755	2.50	1475.58	830.13	0.20
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.58	779.96	781.62	0.000706	2.53	1717.30	851.80	0.20
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.89	780.16	781.94	0.000673	2.57	1945.60	878.50	0.19
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.68	780.44	782.73	0.000610	2.68	2531.71	909.90	0.19

HEC-RAS Plan: Solution 3 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	781.69	780.84	782.21	0.008946	6.01	162.68	185.77	0.63
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	782.63		782.86	0.004088	4.65	455.38	398.68	0.44
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	783.27		783.41	0.002415	3.98	745.67	510.02	0.35
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	783.95		784.05	0.001623	3.62	1115.73	585.90	0.29
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	784.35		784.44	0.001435	3.59	1358.52	608.73	0.28
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	784.63		784.73	0.001415	3.70	1530.92	618.31	0.28
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	785.32		785.42	0.001391	3.97	1966.72	655.66	0.28
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	780.84	778.22	780.89	0.000570	1.79	412.58	119.03	0.17
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	781.80	778.58	781.87	0.000566	2.10	529.22	208.78	0.18
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	782.50	778.88	782.59	0.000581	2.34	615.50	333.55	0.18
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	783.33	779.24	783.41	0.000488	2.37	1147.13	612.48	0.17
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	783.74	779.53	783.82	0.000503	2.52	1405.02	641.03	0.18
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	783.96	779.80	784.06	0.000579	2.76	1545.84	651.46	0.19
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	784.50	780.50	784.63	0.000756	3.33	1929.28	730.52	0.22
Mud Creek	Hamilton County	11.482		Bridge									
Mud Creek	Hamilton County	11.466	2-yr	740.00	777.00	780.58	778.22	780.63	0.000726	1.94	381.72	117.46	0.19
Mud Creek	Hamilton County	11.466	5-yr	1107.00	777.00	781.49	778.58	781.57	0.000724	2.26	491.97	781.09	0.20
Mud Creek	Hamilton County	11.466	10-yr	1435.00	777.00	782.14	778.88	782.24	0.000740	2.52	587.85	877.27	0.20
Mud Creek	Hamilton County	11.466	25-yr	1899.00	777.00	782.98	779.24	783.10	0.000721	2.77	744.05	891.79	0.21
Mud Creek	Hamilton County	11.466	50-yr	2289.00	777.00	783.57	779.53	783.59	0.000221	1.64	2630.60	903.69	0.12
Mud Creek	Hamilton County	11.466	100-yr	2686.00	777.00	783.80	779.80	783.83	0.000247	1.77	2841.53	905.23	0.12
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	777.00	784.41	780.50	784.45	0.000299	2.08	3393.38	908.25	0.14
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	780.40	777.20	780.44	0.000345	1.53	506.77	251.40	0.14
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	781.32	777.58	781.37	0.000335	1.74	806.65	612.46	0.14
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	781.98	777.86	782.03	0.000324	1.86	1036.28	629.16	0.14
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	782.85	778.24	782.90	0.000301	1.97	1340.07	646.62	0.14
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	783.49	778.52	783.52	0.000188	1.66	2367.93	658.51	0.11
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	783.72	778.82	783.75	0.000221	1.83	2513.57	659.15	0.12
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	784.30	779.52	784.34	0.000299	2.25	2896.04	660.74	0.14
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	780.23	777.20	780.27	0.000394	1.59	508.03	425.22	0.14
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	781.17	777.58	781.21	0.000359	1.76	791.17	517.12	0.14
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	781.84	777.86	781.88	0.000347	1.89	992.33	522.88	0.14
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	782.71	778.24	782.76	0.000324	2.02	1257.36	532.62	0.14
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	783.41	778.52	783.44	0.000198	1.69	2185.30	547.62	0.11
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	783.62	778.82	783.66	0.000239	1.89	2297.97	552.87	0.12
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	784.16	779.52	784.22	0.000339	2.37	2596.97	554.57	0.15
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	780.13	777.13	780.17	0.000417	1.63	454.65	435.27	0.15
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	781.06	777.51	781.12	0.000451	1.96	566.11	594.44	0.16
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	781.71	777.80	781.78	0.000492	2.23	649.44	617.53	0.17
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	782.56	778.17	782.66	0.000522	2.53	774.30	653.72	0.18
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	783.24	778.47	783.35	0.000527	2.73	884.51	667.68	0.18
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	783.57	778.75	783.61	0.000222	1.83	2523.63	672.62	0.12
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	784.10	779.46	784.15	0.000311	2.26	2879.20	686.22	0.14
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	779.73	777.13	779.79	0.000703	2.08	356.60	198.88	0.19
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	780.49	777.53	780.59	0.000844	2.57	431.70	566.70	0.22
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	780.94	777.84	781.08	0.001026	3.02	476.44	579.61	0.24
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	781.46	778.26	781.66	0.001281	3.61	528.79	657.20	0.27
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	781.78	778.59	782.05	0.001526	4.10	562.51	665.40	0.30
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.09	778.89	782.41	0.001764	4.56	594.30	672.09	0.33
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	782.89	779.68	782.96	0.000546	2.70	2287.45	685.36	0.18
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.50	779.58	776.74	779.61	0.000431	1.61	522.20	210.91	0.15
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.50	780.33	777.11	780.38	0.000475	1.89	709.65	295.23	0.16
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.50	780.76	777.41	780.82	0.000540	2.15	842.65	325.59	0.17
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.50	781.23	777.79	781.32	0.000705	2.62	1091.11	719.64	0.20
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.50	781.56	778.14	781.65	0.000709	2.74	1330.34	723.24	0.20
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.50	781.88	778.47	781.97	0.000697	2.81	1562.30	726.72	0.20
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.50	782.67	779.19	782.76	0.000659	2.98	2140.05	769.70	0.20
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.50	779.30	776.74	779.36	0.000614	1.85	421.71	207.53	0.18
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.50	780.01	777.11	780.08	0.000729	2.23	595.72	557.26	0.20
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.50	780.43	777.41	780.51	0.000736	2.39	874.54	697.82	0.20
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.50	780.88	777.79	780.96	0.000721	2.53	1195.05	706.38	0.20
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.50	781.22	778.08	781.30	0.000706	2.62	1443.23	748.75	0.20
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.50	781.56	778.37	781.64	0.000668	2.65	1697.78	763.43	0.20
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.50	782.38	779.28	782.46	0.000594	2.75	2338.75	790.52	0.19
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	779.02	776.22	779.07	0.000474	1.70	489.83	371.18	0.16
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	779.71	776.58	779.76	0.000492	1.91	807.53	533.29	0.16
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.12	776.88	780.17	0.000523	2.07	1067.36	717.09	0.17
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	780.58	777.25	780.64	0.000524	2.21	1388.78	739.69	0.17
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	780.93	777.55	780.99	0.000518	2.30	1632.80	763.94	0.17
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.28	777.83	781.34	0.000499	2.35	1883.30	832.09	0.17
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.13	778.71	782.19	0.000468	2.49	2501.85	894.51	0.17

HEC-RAS Plan: Solution 4 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	782.98		783.04	0.001012	2.45	602.94	445.85	0.22
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.64		783.69	0.000838	2.48	939.29	551.72	0.21
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	784.10		784.15	0.000785	2.57	1204.51	599.95	0.21
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	784.67		784.72	0.000677	2.57	1555.25	619.65	0.19
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	785.07		785.12	0.000642	2.62	1807.30	640.69	0.19
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.42		785.47	0.000634	2.71	2032.24	660.76	0.19
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	786.27		786.32	0.000653	3.00	2641.41	829.31	0.20
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	782.31	779.29	782.37	0.000756	2.14	505.93	361.42	0.20
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	782.99	779.90	783.05	0.000795	2.30	737.10	393.30	0.20
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	783.46	780.36	783.53	0.000785	2.46	907.57	595.66	0.21
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	784.06	781.39	784.14	0.000793	2.69	1134.06	706.51	0.21
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	784.47	781.81	784.55	0.000788	2.83	1299.01	728.83	0.21
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	784.96	782.00	785.01	0.000524	2.45	2082.78	765.45	0.18
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	785.82	782.82	785.87	0.000503	2.62	2775.77	836.19	0.18
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	782.09	779.20	782.15	0.000822	2.22	533.74	876.44	0.20
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	782.71	779.81	782.77	0.000768	2.38	793.38	887.14	0.20
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	783.12	780.28	783.19	0.000786	2.56	965.46	900.72	0.21
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	783.59	781.53	783.67	0.000830	2.80	1166.47	903.85	0.22
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	783.87	781.85	783.96	0.000925	3.06	1283.11	905.68	0.23
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	784.22	781.97	784.31	0.000932	3.20	1432.66	907.39	0.23
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	785.03	782.63	785.06	0.000293	1.96	3682.40	911.04	0.13
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	781.82	778.48	781.89	0.000658	2.43	543.49	593.17	0.19
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	782.42	779.21	782.50	0.000770	2.83	745.37	638.05	0.21
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	782.81	779.79	782.90	0.000859	3.12	882.62	646.15	0.22
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	783.25	781.35	783.36	0.000985	3.50	1039.62	657.78	0.24
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	783.46	781.62	783.60	0.001184	3.91	1115.81	658.41	0.26
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	783.80	781.85	783.95	0.001225	4.11	1237.85	659.40	0.27
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	784.68	782.47	784.85	0.001282	4.54	1553.95	661.73	0.28
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	781.55	778.48	781.61	0.000642	2.36	592.99	503.61	0.18
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	782.12	779.22	782.19	0.000748	2.73	788.83	525.66	0.20
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	782.47	780.56	782.55	0.000858	3.05	913.54	529.67	0.22
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	782.85	780.99	782.96	0.001027	3.47	1050.66	534.43	0.24
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	782.96	781.32	783.10	0.001353	4.03	1088.38	536.08	0.28
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	783.29	781.52	783.43	0.001394	4.23	1205.75	544.32	0.28
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	784.16	782.06	784.33	0.001423	4.62	1518.50	554.59	0.29
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	781.42	778.17	781.48	0.000607	2.18	616.69	605.67	0.18
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	781.98	778.82	782.04	0.000643	2.43	874.99	630.96	0.19
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	782.32	779.38	782.39	0.000721	2.68	1035.25	646.98	0.20
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	782.69	781.04	782.77	0.000849	3.04	1209.93	656.98	0.22
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	782.73	781.29	782.85	0.001178	3.59	1231.52	658.09	0.26
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	783.06	781.48	783.19	0.001166	3.71	1394.07	665.21	0.26
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	784.03	781.89	784.09	0.000741	3.25	2379.30	683.78	0.21
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	781.21	778.34	781.26	0.000665	2.27	609.61	647.46	0.19
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.74	779.06	781.80	0.000675	2.46	846.71	664.26	0.19
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	782.04	780.15	782.10	0.000768	2.73	980.64	671.37	0.21
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	782.41	780.98	782.49	0.000868	3.03	1148.23	677.22	0.22
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.70	781.15	782.78	0.000928	3.24	1278.71	681.96	0.23
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.98	781.31	783.07	0.000972	3.42	1404.73	687.48	0.24
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.68	781.67	783.79	0.001055	3.82	1726.13	729.82	0.25
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.97		781.03	0.000813	2.36	525.03	395.90	0.20
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.43		781.51	0.001125	2.97	844.68	721.86	0.24
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.73		781.80	0.001074	3.02	1062.52	725.13	0.24
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	782.10		782.17	0.001031	3.11	1329.74	729.26	0.24
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	782.39		782.45	0.000992	3.15	1539.26	746.73	0.23
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.67		782.73	0.000948	3.19	1745.71	769.63	0.23
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	783.37		783.44	0.000867	3.28	2269.64	814.24	0.22
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.51		780.59	0.001025	2.58	564.04	645.15	0.23
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.94		781.01	0.000989	2.72	842.46	662.67	0.23
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.26		781.33	0.000959	2.81	1067.44	712.19	0.23
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.65		781.72	0.000916	2.89	1351.51	737.78	0.23
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.96		782.03	0.000870	2.93	1581.84	753.65	0.22
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	782.27		782.33	0.000828	2.97	1817.54	787.15	0.22
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	783.02		783.08	0.000727	3.02	2419.51	856.07	0.21
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	780.04	777.59	780.09	0.000873	2.22	652.33	658.63	0.21
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.50	778.68	780.55	0.000815	2.33	932.24	703.64	0.20
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.84	779.54	780.89	0.000787	2.41	1144.67	728.79	0.20
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	781.24	779.71	781.29	0.000806	2.59	1401.06	829.91	0.21
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.57	780.03	781.62	0.000767	2.64	1617.85	850.97	0.21
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.89	780.16	781.94	0.000728	2.67	1832.24	878.40	0.20
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.68	780.44	782.73	0.000688	2.84	2395.14	909.84	0.20

HEC-RAS Plan: Solution 5 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	782.85		782.92	0.001266	2.68	544.24	427.54	0.25
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.60		783.65	0.000889	2.54	916.52	547.02	0.21
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	784.13		784.18	0.000746	2.52	1227.24	601.28	0.20
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	784.64		784.69	0.000700	2.60	1536.92	618.64	0.20
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	784.95		785.00	0.000730	2.76	1726.91	628.94	0.20
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.23		785.28	0.000757	2.90	1908.35	650.67	0.21
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	785.89		785.96	0.000839	3.28	2350.10	685.09	0.22
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	781.65	779.30	781.80	0.001705	3.03	244.09	153.00	0.29
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	782.36	779.90	782.58	0.002248	3.71	298.11	280.85	0.34
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	782.85	780.36	783.13	0.002738	4.24	338.68	323.26	0.38
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	783.42	780.93	783.69	0.002530	4.40	653.05	593.17	0.37
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	783.52	781.38	783.87	0.003234	5.05	712.84	600.71	0.42
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	783.78	781.80	784.13	0.003204	5.22	871.96	621.48	0.42
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	784.29	783.66	784.68	0.003536	5.86	1212.78	718.58	0.45
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	781.27	779.19	781.45	0.002289	3.43	215.77	707.56	0.33
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	781.86	779.80	782.14	0.003353	4.30	264.82	819.66	0.41
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	782.28	780.28	782.63	0.003678	4.85	336.95	879.69	0.43
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	782.79	780.87	783.21	0.003883	5.41	431.06	888.41	0.46
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	783.16	781.35	783.20	0.000694	2.41	1981.68	900.96	0.20
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	783.41	782.21	783.45	0.000696	2.50	2208.45	902.62	0.20
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	784.12	783.00	784.17	0.000643	2.63	2856.22	906.98	0.19
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	781.02	778.48	781.06	0.000418	1.51	579.97	605.16	0.14
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	781.58	778.79	781.62	0.000498	1.82	772.26	618.97	0.16
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	781.99	779.05	782.05	0.000551	2.05	916.59	629.31	0.17
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	782.49	779.37	782.56	0.000610	2.32	1092.95	640.42	0.18
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	782.88	779.62	782.96	0.000644	2.51	1229.75	647.02	0.19
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	783.23	779.86	783.28	0.000427	2.13	2069.95	657.72	0.16
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	783.93	780.79	783.99	0.000484	2.45	2531.24	659.76	0.17
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	780.86	778.44	780.89	0.000322	1.27	666.65	501.30	0.13
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	781.39	778.71	781.42	0.000405	1.58	824.08	518.90	0.14
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	781.78	778.93	781.82	0.000465	1.81	941.81	522.32	0.16
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	782.25	779.21	782.31	0.000539	2.10	1085.49	527.03	0.17
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	782.62	779.42	782.69	0.000584	2.30	1197.86	531.54	0.18
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	782.97	779.62	783.06	0.000622	2.48	1305.46	536.38	0.19
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	783.73	780.31	783.79	0.000476	2.37	2326.11	553.22	0.17
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	780.80	778.34	780.82	0.000269	1.16	641.17	443.07	0.11
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	781.30	778.59	781.33	0.000369	1.49	744.91	601.89	0.14
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	781.67	778.76	781.72	0.000448	1.76	825.04	615.91	0.15
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	782.12	779.02	782.19	0.000549	2.09	926.34	638.91	0.17
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	782.47	779.20	782.55	0.000618	2.33	1009.03	651.53	0.19
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	782.81	779.39	782.91	0.000676	2.54	1090.46	659.95	0.20
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	783.65	779.85	783.70	0.000386	2.13	2610.48	674.82	0.15
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	780.76	778.39	780.78	0.000288	1.18	632.39	573.80	0.12
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.24	778.62	781.27	0.000397	1.52	733.79	649.28	0.14
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	781.59	778.81	781.63	0.000487	1.80	808.34	660.36	0.16
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	782.00	779.06	782.07	0.000609	2.15	897.12	670.73	0.18
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.31	779.25	782.40	0.000697	2.41	965.88	675.50	0.20
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.61	779.43	782.72	0.000778	2.65	1030.93	680.52	0.21
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.35	779.90	783.51	0.000948	3.21	1366.41	712.83	0.24
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.68	778.41	780.69	0.000272	1.10	682.65	318.88	0.11
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.12	778.62	781.15	0.000360	1.39	916.70	718.52	0.13
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.46	778.79	781.49	0.000397	1.55	1156.71	722.16	0.14
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	781.85	779.02	781.90	0.000433	1.74	1444.07	726.47	0.15
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	782.17	779.21	782.21	0.000446	1.85	1670.26	730.08	0.16
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.46	779.37	782.51	0.000453	1.95	1885.31	751.50	0.16
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	783.21	779.79	783.26	0.000458	2.16	2436.32	807.17	0.16
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.45	778.34	780.49	0.000677	1.89	666.90	698.16	0.18
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.87	778.76	780.92	0.000675	2.04	966.95	706.15	0.19
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.20	779.19	781.24	0.000669	2.15	1205.98	747.75	0.19
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.59	779.64	781.64	0.000657	2.27	1504.15	764.55	0.19
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.91	780.08	781.96	0.000633	2.33	1747.66	776.40	0.19
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	782.21	780.12	782.26	0.000612	2.39	1980.78	785.49	0.19
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	782.97	780.82	783.02	0.000565	2.52	2585.50	806.75	0.18
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	780.05	777.59	780.10	0.000850	2.20	669.12	659.95	0.20
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.50	778.68	780.55	0.000787	2.29	965.54	703.75	0.20
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.85	779.54	780.89	0.000749	2.35	1195.98	729.14	0.20
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	781.24	779.71	781.29	0.000755	2.50	1475.58	830.13	0.20
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.58	779.96	781.62	0.000706	2.53	1717.34	851.80	0.20
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.89	780.16	781.94	0.000673	2.57	1945.60	878.50	0.19
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.68	780.44	782.73	0.000610	2.68	2531.75	909.90	0.19

HEC-RAS Plan: Solution 6 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	783.05		783.10	0.000915	2.36	636.15	483.76	0.21
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.78		783.82	0.000687	2.30	1020.07	567.81	0.19
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	784.44		784.47	0.000507	2.16	1411.25	611.67	0.17
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	785.08		785.11	0.000439	2.17	1810.35	641.09	0.16
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	785.37		785.41	0.000481	2.35	2000.04	658.25	0.17
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.71		785.75	0.000488	2.45	2229.09	676.24	0.17
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	786.45		786.50	0.000567	2.84	2794.53	853.01	0.19
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	782.37	779.29	782.45	0.000810	2.23	398.92	364.40	0.20
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	783.08	779.89	783.17	0.001005	2.63	511.41	557.62	0.23
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	783.84	780.35	783.95	0.000871	2.74	643.70	627.91	0.22
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	784.46	780.93	784.59	0.000983	3.16	753.09	728.16	0.24
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	784.61	781.67	784.79	0.001283	3.68	780.64	737.39	0.27
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	784.87	782.01	785.09	0.001486	4.08	827.09	758.01	0.30
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	785.65	782.78	785.82	0.001268	4.09	1865.67	825.09	0.28
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	782.21	779.20	782.28	0.000834	2.28	468.07	878.54	0.21
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	782.99	779.81	783.06	0.000722	2.40	720.88	891.95	0.20
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	783.73	780.28	783.79	0.000574	2.37	965.20	904.74	0.18
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	784.31	780.86	784.38	0.000608	2.61	1159.83	907.82	0.19
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	784.40	781.82	784.50	0.000825	3.07	1188.58	908.20	0.22
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	784.58	781.96	784.70	0.000986	3.43	1249.78	909.00	0.24
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	784.90	782.80	785.10	0.001564	4.47	1356.00	910.46	0.31
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	781.97	778.48	782.03	0.000551	2.27	592.39	601.45	0.17
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	782.78	779.21	782.84	0.000525	2.43	873.58	645.86	0.17
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	783.57	779.79	783.62	0.000424	2.37	1154.58	658.72	0.16
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	784.14	781.35	784.20	0.000470	2.63	1359.68	660.34	0.17
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	784.16	781.62	784.24	0.000675	3.15	1365.63	660.39	0.20
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	784.29	781.85	784.39	0.000845	3.57	1411.57	660.72	0.23
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	784.71	782.47	784.76	0.000515	2.89	2725.44	661.78	0.18
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	781.71	778.48	781.78	0.000639	2.40	553.90	511.76	0.18
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	782.55	779.22	782.61	0.000591	2.55	806.16	530.66	0.18
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	783.39	779.81	783.44	0.000469	2.47	1062.83	546.93	0.17
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	783.94	781.15	784.00	0.000539	2.79	1231.83	553.88	0.18
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	783.85	781.43	783.95	0.000837	3.45	1203.75	553.59	0.22
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	783.87	781.65	784.01	0.001131	4.02	1211.90	553.67	0.26
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	784.48	782.24	784.54	0.000641	3.19	2373.24	555.59	0.20
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	781.50	778.17	781.60	0.000886	2.66	326.89	608.55	0.22
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	782.28	778.83	782.42	0.001052	3.21	434.35	645.62	0.24
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	783.13	779.39	783.28	0.000954	3.37	566.26	666.11	0.24
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	783.91	780.08	783.93	0.000170	1.54	2460.69	680.79	0.10
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	783.24	780.87	783.61	0.002244	5.23	584.92	667.75	0.36
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	783.81	781.31	783.84	0.000368	2.24	2395.06	678.58	0.15
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	784.39	782.29	784.44	0.000470	2.68	2793.36	697.59	0.17
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	781.20	778.34	781.37	0.001439	3.36	243.98	646.88	0.28
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.75	779.06	782.02	0.002049	4.32	299.83	664.41	0.34
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	782.04	779.65	782.42	0.002745	5.18	330.02	671.33	0.39
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	782.37	780.36	782.93	0.003758	6.31	364.98	676.44	0.46
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.62	781.22	782.67	0.000585	2.56	1763.59	680.70	0.18
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.90	781.71	782.94	0.000598	2.67	1951.71	685.53	0.19
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.60	782.40	783.65	0.000616	2.91	2445.19	725.53	0.19
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.93	778.72	780.98	0.000798	2.32	558.33	368.11	0.20
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.38	779.37	781.46	0.001087	2.90	862.53	721.34	0.24
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.69	779.79	781.75	0.001036	2.95	1081.76	724.64	0.23
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	782.06	779.98	782.12	0.000992	3.03	1351.51	728.76	0.23
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	782.35	779.98	782.41	0.000952	3.08	1564.02	744.33	0.23
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.63	779.98	782.69	0.000915	3.12	1769.35	766.09	0.23
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	783.34	780.93	783.40	0.000840	3.22	2294.80	812.72	0.22
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.50	778.15	780.57	0.000949	2.48	595.40	644.51	0.22
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.92	778.82	780.98	0.000927	2.62	870.59	661.81	0.22
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.24	779.76	781.30	0.000906	2.72	1093.79	710.84	0.22
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.63	779.98	781.69	0.000870	2.81	1378.13	735.02	0.22
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.95	780.65	782.00	0.000829	2.86	1610.14	752.77	0.22
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	782.24	780.78	782.30	0.000798	2.91	1840.54	786.46	0.22
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	782.99	781.08	783.05	0.000709	2.98	2439.65	807.43	0.21
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	780.05	777.59	780.10	0.000850	2.20	669.12	659.95	0.20
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.50	778.68	780.55	0.000787	2.29	965.58	703.75	0.20
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.85	779.54	780.89	0.000749	2.35	1195.98	729.14	0.20
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	781.24	779.71	781.29	0.000755	2.50	1475.58	830.13	0.20
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.58	779.96	781.62	0.000706	2.53	1717.21	851.79	0.20
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.89	780.16	781.94	0.000673	2.57	1945.60	878.50	0.19
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.68	780.44	782.73	0.000610	2.68	2531.75	909.90	0.19

HEC-RAS Plan: Solution 7 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	782.81		782.89	0.001342	2.74	529.50	422.90	0.26
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.49		783.55	0.001034	2.70	859.49	535.08	0.23
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	783.97		784.02	0.000902	2.71	1128.06	588.32	0.22
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	784.49		784.54	0.000836	2.79	1442.58	613.42	0.21
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	784.91		784.96	0.000757	2.80	1705.51	627.80	0.21
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.33		785.38	0.000690	2.80	1972.08	656.08	0.20
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	786.39		786.44	0.000593	2.89	2745.84	846.19	0.19
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	781.62	779.29	781.76	0.001617	2.94	286.48	236.48	0.28
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	782.28	779.89	782.46	0.001963	3.45	384.74	360.23	0.32
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	782.74	780.35	782.94	0.002248	3.81	455.99	381.42	0.34
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	783.14	780.93	783.40	0.002794	4.42	521.43	562.84	0.38
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	783.60	781.67	783.89	0.002709	4.67	600.25	607.50	0.39
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	784.02	782.01	784.34	0.002719	4.97	675.05	704.59	0.39
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	785.12	782.78	785.51	0.002531	5.47	872.55	790.75	0.39
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	781.27	779.21	781.44	0.002222	3.38	242.69	707.58	0.33
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	781.86	779.81	782.08	0.002800	3.93	363.00	822.39	0.37
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	782.29	780.29	782.54	0.002810	4.25	494.94	879.96	0.38
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	782.81	780.88	783.05	0.002598	4.44	662.97	888.85	0.37
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	783.20	781.83	783.44	0.002449	4.56	791.52	901.27	0.37
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	783.57	781.96	783.82	0.002330	4.68	913.37	903.72	0.36
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	784.41	782.79	784.68	0.002259	5.09	1191.57	908.24	0.37
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	781.02	778.48	781.06	0.000418	1.51	579.97	605.16	0.14
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	781.58	778.79	781.62	0.000498	1.82	772.26	618.97	0.16
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	781.99	779.03	782.05	0.000551	2.05	916.59	629.31	0.17
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	782.49	779.38	782.56	0.000610	2.32	1092.95	640.42	0.18
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	782.88	779.62	782.96	0.000644	2.51	1229.75	647.02	0.19
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	783.25	779.86	783.34	0.000670	2.67	1360.03	657.78	0.20
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	784.05	780.68	784.17	0.000774	3.14	1648.04	660.11	0.22
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	780.86	778.44	780.89	0.000322	1.27	666.65	501.30	0.13
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	781.39	778.71	781.42	0.000405	1.58	824.08	518.90	0.14
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	781.78	778.93	781.82	0.000465	1.81	941.81	522.32	0.16
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	782.25	779.20	782.31	0.000539	2.10	1085.49	527.03	0.17
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	782.62	779.42	782.69	0.000584	2.30	1197.86	531.54	0.18
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	782.97	779.62	783.06	0.000622	2.48	1305.46	536.38	0.19
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	783.72	780.31	783.84	0.000759	3.00	1536.14	553.21	0.21
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	780.80	778.34	780.82	0.000269	1.16	641.17	443.07	0.11
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	781.30	778.59	781.33	0.000369	1.49	744.91	601.89	0.14
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	781.67	778.76	781.72	0.000448	1.76	825.04	615.91	0.15
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	782.12	779.02	782.19	0.000549	2.09	926.34	638.91	0.17
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	782.47	779.20	782.55	0.000618	2.33	1009.03	651.53	0.19
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	782.81	779.39	782.91	0.000676	2.54	1090.46	659.95	0.20
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	783.65	779.85	783.70	0.000386	2.13	2610.48	674.82	0.15
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	780.76	778.39	780.78	0.000288	1.18	632.39	573.80	0.12
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.24	778.62	781.27	0.000397	1.52	733.79	649.28	0.14
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	781.59	778.81	781.63	0.000487	1.80	808.34	660.36	0.16
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	782.00	779.06	782.07	0.000609	2.15	897.12	670.73	0.18
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.31	779.25	782.40	0.000697	2.41	965.88	675.50	0.20
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.61	779.43	782.72	0.000778	2.65	1030.92	680.52	0.21
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.35	779.90	783.51	0.000948	3.21	1366.45	712.83	0.24
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.68	778.41	780.69	0.000272	1.10	682.65	318.88	0.11
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.12	778.62	781.15	0.000360	1.39	916.70	718.52	0.13
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.46	778.79	781.49	0.000397	1.55	1156.71	722.16	0.14
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	781.85	779.02	781.90	0.000433	1.74	1444.07	726.47	0.15
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	782.17	779.21	782.21	0.000446	1.85	1670.26	730.08	0.16
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.46	779.37	782.51	0.000453	1.95	1885.26	751.49	0.16
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	783.21	779.79	783.26	0.000458	2.16	2436.36	807.17	0.16
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.45	778.34	780.49	0.000677	1.89	666.90	698.16	0.18
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.87	778.76	780.92	0.000675	2.04	966.95	706.15	0.19
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.20	779.19	781.24	0.000669	2.15	1205.98	747.75	0.19
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.59	779.64	781.64	0.000657	2.27	1504.15	764.55	0.19
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.91	780.08	781.96	0.000633	2.33	1747.66	776.40	0.19
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	782.21	780.12	782.26	0.000612	2.39	1980.74	785.49	0.19
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	782.97	780.82	783.02	0.000565	2.52	2585.55	806.75	0.18
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	780.05	777.59	780.10	0.000850	2.20	669.12	659.95	0.20
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.50	778.68	780.55	0.000787	2.29	965.58	703.75	0.20
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.85	779.54	780.89	0.000749	2.35	1195.98	729.14	0.20
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	781.24	779.71	781.29	0.000755	2.50	1475.58	830.13	0.20
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.58	779.96	781.62	0.000706	2.53	1717.34	851.80	0.20
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.89	780.16	781.94	0.000673	2.57	1945.56	878.50	0.19
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.68	780.44	782.73	0.000610	2.68	2531.80	909.90	0.19

HEC-RAS Plan: Solution 8 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	782.84		782.91	0.001285	2.69	540.49	426.36	0.25
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.59		783.64	0.000897	2.55	912.85	546.26	0.22
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	784.12		784.17	0.000756	2.53	1220.82	600.90	0.20
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	784.64		784.69	0.000702	2.61	1535.18	618.54	0.20
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	784.95		785.00	0.000730	2.76	1727.37	628.97	0.20
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.23		785.28	0.000758	2.90	1907.43	650.52	0.21
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	785.90		785.96	0.000835	3.27	2354.70	685.46	0.22
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	781.62	779.30	781.77	0.001751	3.06	241.74	150.18	0.29
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	782.34	779.90	782.57	0.002281	3.73	296.45	279.30	0.34
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	782.82	780.36	783.10	0.002792	4.27	336.07	320.44	0.38
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	783.39	780.93	783.67	0.002628	4.46	635.45	590.95	0.38
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	783.49	781.38	783.85	0.003367	5.13	693.92	598.30	0.43
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	783.73	781.80	784.10	0.003439	5.36	836.95	617.28	0.44
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	784.23	783.66	784.65	0.003771	6.01	1174.78	715.77	0.46
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	781.22	779.19	781.41	0.002367	3.48	212.92	704.60	0.34
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	781.82	779.80	782.12	0.003462	4.34	260.28	808.60	0.41
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	782.23	780.28	782.60	0.003845	4.92	329.03	878.95	0.44
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	782.73	780.87	783.17	0.004098	5.51	420.60	887.44	0.47
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	783.08	781.35	783.13	0.000766	2.51	1914.79	899.47	0.20
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	783.31	782.21	783.36	0.000781	2.62	2123.64	902.00	0.21
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	784.06	783.00	784.11	0.000683	2.69	2800.21	906.71	0.20
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	780.96	778.48	780.99	0.000451	1.55	558.16	586.31	0.15
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	781.53	778.79	781.58	0.000526	1.86	754.55	617.66	0.17
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	781.93	779.05	781.99	0.000587	2.09	893.67	627.99	0.18
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	782.41	779.37	782.48	0.000655	2.37	1064.01	637.92	0.19
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	782.78	779.62	782.87	0.000696	2.57	1195.39	645.89	0.20
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	783.11	779.86	783.17	0.000473	2.21	1995.02	657.38	0.17
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	783.86	780.79	783.92	0.000512	2.50	2483.01	659.55	0.18
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	780.79	778.44	780.81	0.000353	1.31	643.09	493.19	0.13
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	781.32	778.71	781.36	0.000432	1.61	804.97	518.38	0.15
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	781.69	778.93	781.74	0.000502	1.86	917.09	521.54	0.16
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	782.15	779.21	782.21	0.000587	2.15	1054.38	525.99	0.18
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	782.50	779.42	782.58	0.000641	2.37	1161.03	530.05	0.19
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	782.83	779.62	782.92	0.000687	2.56	1262.96	534.17	0.20
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	783.64	780.31	783.71	0.000505	2.42	2279.09	552.95	0.17
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	780.71	778.34	780.74	0.000295	1.19	623.78	442.03	0.12
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	781.23	778.58	781.27	0.000393	1.52	730.33	599.80	0.14
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	781.58	778.77	781.63	0.000483	1.80	805.36	611.44	0.16
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	782.01	779.01	782.08	0.000599	2.14	900.21	632.33	0.18
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	782.33	779.21	782.42	0.000680	2.40	976.86	647.46	0.19
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	782.65	779.39	782.76	0.000750	2.63	1052.34	656.01	0.21
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	783.38	779.86	783.53	0.000942	3.22	1232.58	669.68	0.24
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	780.67	778.39	780.69	0.000318	1.21	613.84	571.07	0.12
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.16	778.62	781.20	0.000426	1.56	718.43	644.52	0.15
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	781.49	778.81	781.54	0.000529	1.84	788.09	658.02	0.17
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	781.88	779.06	781.95	0.000670	2.21	870.86	667.67	0.19
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.17	779.25	782.26	0.000775	2.49	934.50	673.21	0.21
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.44	779.43	782.56	0.000875	2.75	994.14	677.76	0.22
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.14	779.90	783.32	0.001112	3.39	1214.71	701.46	0.26
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.58	778.41	780.60	0.000306	1.14	657.23	312.43	0.12
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.04	778.62	781.07	0.000399	1.44	857.10	717.58	0.14
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.35	778.79	781.39	0.000456	1.63	1076.69	720.95	0.15
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	781.71	779.02	781.76	0.000512	1.85	1339.01	724.89	0.16
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	781.99	779.21	782.05	0.000538	1.98	1544.96	727.98	0.17
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.26	779.37	782.32	0.000556	2.10	1739.12	738.53	0.17
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	782.95	779.79	783.02	0.000569	2.34	2250.29	796.13	0.18
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.29	778.34	780.35	0.000939	2.15	555.50	695.11	0.21
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.74	778.76	780.79	0.000862	2.25	871.11	703.47	0.21
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.02	779.19	781.08	0.000894	2.41	1073.09	739.98	0.22
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.37	779.64	781.43	0.000903	2.57	1334.32	755.19	0.22
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.66	780.08	781.72	0.000879	2.65	1551.55	768.27	0.22
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	781.93	780.12	781.99	0.000855	2.71	1759.93	776.89	0.22
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	782.64	780.82	782.71	0.000773	2.83	2323.21	797.74	0.21
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	779.48	777.59	779.62	0.002210	3.42	379.77	400.61	0.32
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.02	778.68	780.13	0.002050	3.39	646.60	654.36	0.32
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.38	779.54	780.48	0.001647	3.24	885.74	696.17	0.29
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	780.79	779.71	780.87	0.001443	3.24	1154.81	721.50	0.27
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.10	779.96	781.18	0.001349	3.28	1371.81	812.22	0.27
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.41	780.16	781.48	0.001207	3.24	1594.72	840.04	0.26
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.22	780.44	782.28	0.000957	3.19	2183.84	902.88	0.23

APPENDIX 3 CONCEPTUAL OPINIONS OF PROBABLE COST

Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 1 - Raise Cumberland Road & 106th Street

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Demolition**				
2	Remove Asphalt	7,800	SY	$ 8	$ 62,000
3	Strip & Stockpile Topsoil	600	CY	$ 8	$ 5,000
4	Utility Relocation	1	LS	$ 50,000	$ 50,000
5		Estimated Demolition Cost			$ 117,000
6	**Road Construction**				
7	Place & Compact Road Fill Material	10,700	CY	$ 10	$ 107,000
8	Obtain Fill Material	10,700	CY	$ 20	$ 214,000
9	Install Road Subbase	3,000	TN	$ 35	$ 105,000
10	Asphalt Pavement	3,400	TN	$ 60	$ 204,000
11	Pavement Markings	1	LS	$ 5,000	$ 5,000
12		Estimated Road Construction Cost			$ 635,000
13	**Site Restoration**				
14	Finish Grading	5,200	SY	$ 2	$ 10,000
15	Topsoil Placement	900	CY	$ 5	$ 5,000
16	Obtain Topsoil Material	300	CY	$ 10	$ 3,000
17	Seeding, Mulch, & Erosion Control Blankets	5,200	SY	$ 3	$ 16,000
18		Estimated Site Restoration Cost			$ 34,000
19	**Miscellaneous**				
20	Erosion and Sediment Control (1%)	1	LS	$ 10,000	$ 10,000
21	Construction Surveying (1%)	1	LS	$ 10,000	$ 10,000
22	Construction Mobilization/Demobilization (5%)	1	LS	$ 40,000	$ 40,000
23	Maintenance of Traffic (5%)	1	LS	$ 40,000	$ 40,000
24	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 400,000	$ 400,000
25		Estimated Miscellaneous Cost			$ 500,000
26					
27		**Estimated Total Construction Cost**			**$ 1,286,000**
28					
29	**Professional Services**				
30	Topographic Site Survey (1%)	1	LS	$ 20,000	$ 20,000
31	Geotechnical Engineering Investigation (1%)	1	LS	$ 20,000	$ 20,000
32	Engineering Design (8%)	1	LS	$ 160,000	$ 160,000
33	Construction Observation (4%)	1	LS	$ 80,000	$ 80,000
34		Estimated Professional Services Cost			$ 280,000
35					
36					
37		**Estimated Total Cost for Project**			**$ 1,566,000**

Notes and Assumptions

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Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 2 - Offline Storage Upstream of 106th Street

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Upstream Storage Basin Construction**				
2	Remove Trees and Stumps	40	AC	$ 25,000	$ 1,000,000
3	Topsoil Stripping	211,000	CY	$ 10	$ 2,110,000
5	Dewatering	1	LS	$ 250,000	$ 250,000
4	Storage Basin Excavation	3,200,000	CY	$ 5	$ 16,000,000
6	Basin Inlet & Outlet Structures	1	LS	$ 500,000	$ 500,000
5	Finish Grading	2,000,000	SY	$ 2	$ 4,000,000
7	Topsoil Placement	334,000	CY	$ 5	$ 1,670,000
8	Obtain Topsoil Material	123,000	CY	$ 10	$ 1,230,000
9	Seeding and Mulch	2,000,000	SY	$ 2	$ 4,000,000
10	Erosion Control Blankets	2,000,000	SY	$ 3	$ 6,000,000
11		Estimated Upstream Storage Basin Construction Cost			$ 36,760,000
12	**Miscellaneous**				
13	Erosion and Sediment Control (1%)	1	LS	$ 370,000	$ 370,000
14	Construction Surveying (1%)	1	LS	$ 370,000	$ 370,000
15	Construction Mobilization/Demobilization (5%)	1	LS	$ 1,840,000	$ 1,840,000
16	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 18,380,000	$ 18,380,000
17		Estimated Miscellaneous Cost			$ 20,960,000
18					
19		**Estimated Total Construction Cost**			**$ 57,720,000**
20					
21	**Professional Services**				
22	Topographic Site Survey (1%)	1	LS	$ 580,000	$ 580,000
23	Geotechnical Engineering Investigation (1%)	1	LS	$ 580,000	$ 580,000
24	Engineering Design (8%)	1	LS	$ 4,620,000	$ 4,620,000
25	Construction Observation (4%)	1	LS	$ 2,310,000	$ 2,310,000
26		Estimated Professional Services Cost			$ 8,090,000
27					
28					
29		**Estimated Total Cost for Project**			**$ 65,810,000**

Notes and Assumptions

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Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 2a - Offline Storage Upstream of 106th Street

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Upstream Storage Basin Construction**				
2	Remove Trees and Stumps	10	AC	$ 25,000	$ 250,000
3	Topsoil Stripping	44,000	CY	$ 10	$ 440,000
5	Dewatering	1	LS	$ 250,000	$ 250,000
4	Storage Basin Excavation	700,000	CY	$ 5	$ 3,500,000
6	Basin Inlet & Outlet Structures	1	LS	$ 160,000	$ 160,000
5	Finish Grading	400,000	SY	$ 2	$ 800,000
7	Topsoil Placement	67,000	CY	$ 5	$ 335,000
8	Obtain Topsoil Material	23,000	CY	$ 10	$ 230,000
9	Seeding and Mulch	400,000	SY	$ 2	$ 800,000
10	Erosion Control Blankets	400,000	SY	$ 3	$ 1,200,000
11		Estimated Upstream Storage Basin Construction Cost			$ 7,965,000
12	**Miscellaneous**				
13	Erosion and Sediment Control (1%)	1	LS	$ 80,000	$ 80,000
14	Construction Surveying (1%)	1	LS	$ 80,000	$ 80,000
15	Construction Mobilization/Demobilization (5%)	1	LS	$ 400,000	$ 400,000
16	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 3,990,000	$ 3,990,000
17		Estimated Miscellaneous Cost			$ 4,550,000
18					
19		**Estimated Total Construction Cost**			**$ 12,515,000**
20					
21	**Professional Services**				
22	Topographic Site Survey (1%)	1	LS	$ 130,000	$ 130,000
23	Geotechnical Engineering Investigation (1%)	1	LS	$ 130,000	$ 130,000
24	Engineering Design (8%)	1	LS	$ 1,000,000	$ 1,000,000
25	Construction Observation (4%)	1	LS	$ 500,000	$ 500,000
26		Estimated Professional Services Cost			$ 1,760,000
27					
28					
29		**Estimated Total Cost for Project**			**$ 14,275,000**

Notes and Assumptions

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Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 3 - Two-Stage Ditch from 96th Street to 106th Street

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Demolition / Utility Relocation**				
2	Relocate Existing Utilities	1	LS	$ 200,000	$ 200,000
3	Clear & Grub Trees	13	AC	$ 25,000	$ 328,000
4		Estimated Demolition / Utility Relocation Cost			$ 528,000
5	**Channel Construction**				
6	Topsoil Stripping	7,800	CY	$ 10	$ 78,000
7	Channel Excavation	100,000	CY	$ 10	$ 1,000,000
8	Finish Grading	107,600	SY	$ 5	$ 538,000
9	Topsoil Placement	18,000	CY	$ 5	$ 90,000
10	Obtain Topsoil Material	10,200	CY	$ 10	$ 102,000
11	Seeding and Mulch	107,600	SY	$ 3	$ 323,000
12	Erosion Control Blankets	107,600	SY	$ 3	$ 323,000
13		Estimated Channel Construction Cost			$ 2,454,000
14	**Miscellaneous**				
15	Erosion and Sediment Control (1%)	1	LS	$ 30,000	$ 30,000
16	Construction Surveying (1%)	1	LS	$ 30,000	$ 30,000
17	Construction Mobilization/Demobilization (5%)	1	LS	$ 150,000	$ 150,000
18	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 1,500,000	$ 1,500,000
19		Estimated Miscellaneous Cost			$ 1,710,000
20					
21		**Estimated Total Construction Cost**			**$ 4,692,000**
22					
23	**Professional Services**				
24	Topographic Site Survey (1%)	1	LS	$ 50,000	$ 50,000
25	Geotechnical Engineering Investigation (1%)	1	LS	$ 50,000	$ 50,000
26	Engineering Design (8%)	1	LS	$ 380,000	$ 380,000
27	Construction Observation (4%)	1	LS	$ 190,000	$ 190,000
28		Estimated Professional Services Cost			$ 670,000
29					
30					
31		**Estimated Total Cost for Project**			**$ 5,362,000**

Notes and Assumptions

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Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 4 - Raise Cumberland Road & 106th Street & Increase Bridge Openings

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Demolition**				
2	Remove Asphalt	5,200	SY	$ 8	$ 42,000
3	Strip & Stockpile Topsoil	100	CY	$ 8	$ 1,000
4	Utility Relocation	1	LS	$ 50,000	$ 50,000
	Remove Existing Cumberland Rd Bridge	1	LS	$ 50,000	$ 50,000
5		Estimated Demolition Cost			$ 143,000
6	**Bridge Construction**				
7	Cumberland Road Bridge	1	LS	$ 3,600,000	$ 3,600,000
8	106th Street Bridge	1	LS	$ 600,000	$ 600,000
9		Estimated Bridge Construction Cost			$ 4,200,000
10	**Road Construction**				
11	Place & Compact Road Fill Material	3,400	CY	$ 10	$ 34,000
12	Obtain Fill Material	3,400	CY	$ 20	$ 68,000
13	Install Road Subbase	2,000	TN	$ 35	$ 70,000
14	Asphalt Pavement	2,300	TN	$ 60	$ 138,000
15	Pavement Markings	1	LS	$ 3,000	$ 3,000
16		Estimated Road Construction Cost			$ 313,000
17	**Site Restoration**				
18	Finish Grading	2,100	SY	$ 2	$ 4,000
19	Topsoil Placement	400	CY	$ 5	$ 2,000
20	Seeding, Mulch, & Erosion Control Blankets	2,100	SY	$ 3	$ 6,000
21		Estimated Site Restoration Cost			$ 12,000
22	**Miscellaneous**				
23	Erosion and Sediment Control (1%)	1	LS	$ 50,000	$ 50,000
24	Construction Surveying (1%)	1	LS	$ 50,000	$ 50,000
25	Construction Mobilization/Demobilization (5%)	1	LS	$ 240,000	$ 240,000
26	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 2,340,000	$ 2,340,000
27		Estimated Miscellaneous Cost			$ 2,680,000
28					
29		**Estimated Total Construction Cost**			**$ 7,348,000**
30					
31	**Professional Services**				
32	Topographic Site Survey (1%)	1	LS	$ 70,000	$ 70,000
33	Geotechnical Engineering Investigation (1%)	1	LS	$ 70,000	$ 70,000
34	Engineering Design (8%)	1	LS	$ 590,000	$ 590,000
35	Construction Observation (4%)	1	LS	$ 290,000	$ 290,000
36		Estimated Professional Services Cost			$ 1,020,000
37					
38					
39		**Estimated Total Cost for Project**			**$ 8,368,000**

Notes and Assumptions

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Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 5 - Replace Cumberland Road Bridge & Add High Flow Bench

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Demolition / Utility Relocation**				
2	Relocate Existing Utilities	1	LS	$ 50,000	$ 50,000
3	Remove Existing Cumberland Rd Bridge	1	LS	$ 50,000	$ 50,000
4	Remove Parking Lot Asphalt	4,900	SY	$ 8	$ 39,000
5		Estimated Demolition / Utility Relocation Cost			$ 139,000
6	**Channel Construction**				
7	Topsoil Stripping	2,400	CY	$ 10	$ 24,000
8	Channel Excavation	9,000	CY	$ 10	$ 90,000
9	Finish Grading	21,700	SY	$ 5	$ 109,000
10	Topsoil Placement	4,000	CY	$ 5	$ 20,000
11	Obtain Topsoil Material	1,600	CY	$ 10	$ 16,000
12	Seeding and Mulch	21,700	SY	$ 3	$ 65,000
13	Erosion Control Blankets	21,700	SY	$ 3	$ 65,000
14		Estimated Channel Construction Cost			$ 389,000
15	**Bridge Construction**				
16	Cumberland Road Bridge	1	LS	$ 1,900,000	$ 1,900,000
17		Estimated Bridge Construction Cost			$ 1,900,000
18	**Site Restoration**				
19	Parking Lot Subbase	1,400	TN	$ 35	$ 49,000
20	Parking Lot Asphalt	1,700	TN	$ 60	$ 102,000
21	Finish Grading	21,700	SY	$ 2	$ 43,000
22	Topsoil Placement	3,700	CY	$ 5	$ 19,000
23	Seeding, Mulch, & Erosion Control Blankets	21,700	SY	$ 3	$ 65,000
24		Estimated Site Restoration Cost			$ 278,000
25	**Miscellaneous**				
26	Erosion and Sediment Control (1%)	1	LS	$ 30,000	$ 30,000
27	Construction Surveying (1%)	1	LS	$ 30,000	$ 30,000
28	Construction Mobilization/Demobilization (5%)	1	LS	$ 140,000	$ 140,000
29	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 1,360,000	$ 1,360,000
30		Estimated Miscellaneous Cost			$ 1,560,000
31					
32		**Estimated Total Construction Cost**			**$ 4,266,000**
33					
34	**Professional Services**				
35	Topographic Site Survey (1%)	1	LS	$ 40,000	$ 40,000
36	Geotechnical Engineering Investigation (1%)	1	LS	$ 40,000	$ 40,000
37	Engineering Design (8%)	1	LS	$ 340,000	$ 340,000
38	Construction Observation (4%)	1	LS	$ 170,000	$ 170,000
39		Estimated Professional Services Cost			$ 590,000
40					
41					
42		**Estimated Total Cost for Project**			**$ 4,856,000**

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Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 5A - Replace Cumberland Rd & 106th St Bridge & Add High Flow Bench

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Demolition / Utility Relocation**				
2	Relocate Existing Utilities	1	LS	$ 75,000	$ 75,000
3	Remove Asphalt	4,500	SY	$ 8	$ 36,000
4	Strip & Stockpile Topsoil	300	CY	$ 8	$ 2,000
5		Estimated Demolition / Utility Relocation Cost			$ 113,000
6	**Bridge Construction**				
7	106th Street Bridge	1	LS	$ 600,000	$ 600,000
8		Estimated Bridge Construction Cost			$ 600,000
9	**Road Construction**				
10	Place & Compact Road Fill Material	3,400	CY	$ 10	$ 34,000
11	Obtain Fill Material	3,400	CY	$ 20	$ 68,000
12	Install Road Subbase	1,700	TN	$ 35	$ 60,000
13	Asphalt Pavement for Road	2,000	TN	$ 60	$ 120,000
14	Pavement Markings	1	LS	$ 3,000	$ 3,000
15	Finish Grading (Road Embankment Slopes)	2,000	SY	$ 2	$ 4,000
16	Topsoil Placement	400	CY	$ 5	$ 2,000
17	Seeding, Mulch, & Erosion Control Blankets	2,000	SY	$ 3	$ 6,000
18		Estimated Road Construction Cost			$ 297,000
19	**Miscellaneous**				
20	Erosion and Sediment Control (1%)	1	LS	$ 20,000	$ 20,000
21	Construction Surveying (1%)	1	LS	$ 20,000	$ 20,000
22	Construction Mobilization/Demobilization (5%)	1	LS	$ 60,000	$ 60,000
23	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 510,000	$ 510,000
24		Estimated Miscellaneous Cost			$ 610,000
25					
26		**Estimated Total Construction Cost**			**$ 1,620,000**
27					
28	**Professional Services**				
29	Topographic Site Survey (1%)	1	LS	$ 20,000	$ 20,000
30	Geotechnical Engineering Investigation (1%)	1	LS	$ 20,000	$ 20,000
31	Engineering Design (8%)	1	LS	$ 130,000	$ 130,000
32	Construction Observation (4%)	1	LS	$ 60,000	$ 60,000
33		Estimated Professional Services Cost			$ 230,000
34					
35					
36		**Estimated Total Cost for Project**			**$ 1,850,000**

Notes and Assumptions

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Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 7 - Replace Cumberland Rd & 106th St Bridge & Add High Flow Bench

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Demolition / Utility Relocation**				
2	Relocate Existing Utilities	1	LS	$ 75,000	$ 75,000
3	Remove Existing Cumberland Rd Bridge	1	LS	$ 50,000	$ 50,000
4	Remove Asphalt	9,400	SY	$ 8	$ 75,000
5	Strip & Stockpile Topsoil	2,600	CY	$ 8	$ 21,000
6		Estimated Demolition / Utility Relocation Cost			$ 221,000
7	**Channel Construction**				
8	Channel Excavation	9,000	CY	$ 10	$ 90,000
9	Finish Grading	21,700	SY	$ 5	$ 109,000
10	Topsoil Placement	4,000	CY	$ 5	$ 20,000
11	Obtain Topsoil Material	1,400	CY	$ 10	$ 14,000
12	Seeding and Mulch	21,700	SY	$ 3	$ 65,000
13	Seeding, Mulch, & Erosion Control Blankets	21,700	SY	$ 3	$ 65,000
14		Estimated Channel Construction Cost			$ 363,000
15	**Bridge Construction**				
16	Cumberland Road Bridge	1	LS	$ 1,900,000	$ 1,900,000
17	106th Street Bridge	1	LS	$ 600,000	$ 600,000
18		Estimated Bridge Construction Cost			$ 2,500,000
19	**Road Construction**				
20	Place & Compact Road Fill Material	3,400	CY	$ 10	$ 34,000
21	Obtain Fill Material	3,400	CY	$ 20	$ 68,000
22	Parking Lot Subbase	1,400	TN	$ 35	$ 49,000
23	Asphalt for Parking Lot	1,700	TN	$ 60	$ 102,000
24	Install Road Subbase	3,500	TN	$ 35	$ 123,000
25	Asphalt Pavement for Road	4,100	TN	$ 60	$ 246,000
26	Pavement Markings	1	LS	$ 3,000	$ 3,000
27	Finish Grading (Road Embankment Slopes)	2,000	SY	$ 2	$ 4,000
28	Topsoil Placement	400	CY	$ 5	$ 2,000
29	Seeding, Mulch, & Erosion Control Blankets	2,000	SY	$ 3	$ 6,000
30		Estimated Road Construction Cost			$ 637,000
31	**Miscellaneous**				
32	Erosion and Sediment Control (1%)	1	LS	$ 40,000	$ 40,000
33	Construction Surveying (1%)	1	LS	$ 40,000	$ 40,000
34	Construction Mobilization/Demobilization (5%)	1	LS	$ 190,000	$ 190,000
35	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 1,870,000	$ 1,870,000
36		Estimated Miscellaneous Cost			$ 2,140,000
37					
38		**Estimated Total Construction Cost**			**$ 5,861,000**
39					
40	**Professional Services**				
41	Topographic Site Survey (1%)	1	LS	$ 60,000	$ 60,000
42	Geotechnical Engineering Investigation (1%)	1	LS	$ 60,000	$ 60,000
43	Engineering Design (8%)	1	LS	$ 470,000	$ 470,000
44	Construction Observation (4%)	1	LS	$ 230,000	$ 230,000
45		Estimated Professional Services Cost			$ 820,000
46					
47					
48		**Estimated Total Cost for Project**			**$ 6,681,000**

Notes and Assumptions

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Gen. Costs have been estimated without the benefit of survey data, utility coordination, or design. This estimate is intended for planning level consideration, and should only be used for such purposes only.

Opinion of Probable Cost for Mud Creek Flood Risk Reduction

Alternate 8 - Replace Cumberland Road Bridge & 2-Stage Ditch

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Demolition / Utility Relocation**				
2	Relocate Existing Utilities	1	LS	$ 200,000	$ 200,000
3	Clear & Grub Trees	10	AC	$ 25,000	$ 245,000
4	Remove Existing Cumberland Rd Bridge	1	LS	$ 50,000	$ 50,000
5	Remove Parking Lot Asphalt	4,900	SY	$ 8	$ 39,000
6	Strip & Stockpile Topsoil	8,200	CY	$ 8	$ 66,000
7		Estimated Demolition / Utility Relocation Cost			$ 600,000
8	**Channel Construction**				
9	Channel Excavation	86,000	CY	$ 10	$ 860,000
10	Finish Grading	103,700	SY	$ 5	$ 519,000
11	Topsoil Placement	18,000	CY	$ 5	$ 90,000
12	Obtain Topsoil Material	9,800	CY	$ 10	$ 98,000
13	Seeding and Mulch	103,700	SY	$ 3	$ 311,000
14	Erosion Control Blankets	103,700	SY	$ 3	$ 311,000
15		Estimated Channel Construction Cost			$ 2,189,000
16	**Bridge Construction**				
17	Cumberland Road Bridge	1	LS	$ 1,900,000	$ 1,900,000
18		Estimated Bridge Construction Cost			$ 1,900,000
19	**Parking Lot Restoration**				
20	Parking Lot Subbase	1,400	TN	$ 35	$ 49,000
21	Asphalt for Parking Lot	1,700	TN	$ 60	$ 102,000
22		Estimated Parking Lot Restoration Cost			$ 151,000
23	**Miscellaneous**				
24	Erosion and Sediment Control (1%)	1	LS	$ 100,000	$ 100,000
25	Construction Surveying (1%)	1	LS	$ 100,000	$ 100,000
26	Construction Mobilization/Demobilization (5%)	1	LS	$ 300,000	$ 300,000
27	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 2,400,000	$ 2,400,000
28		Estimated Miscellaneous Cost			$ 2,900,000
29					
30		**Estimated Total Construction Cost**			**$ 7,740,000**
31					
32	**Professional Services**				
33	Topographic Site Survey (1%)	1	LS	$ 80,000	$ 80,000
34	Geotechnical Engineering Investigation (1%)	1	LS	$ 80,000	$ 80,000
35	Engineering Design (8%)	1	LS	$ 620,000	$ 620,000
36	Construction Observation (4%)	1	LS	$ 310,000	$ 310,000
37		Estimated Professional Services Cost			$ 1,090,000
38					
39					
40		**Estimated Total Cost for Project**			**$ 8,830,000**

Notes and Assumptions

Gen. All costs are estimates based on the engineer's knowledge of common construction methods and materials. Christopher B. Burke Engineering does not guarantee that the actual bid price will not vary from the costs used with this estimate.

Gen. All costs are in 2012 dollars.

Gen. Estimated costs have been rounded.

Gen. This estimate does not include unforeseen cost increases that may result from shortages in fuel and materials as a result of natural or man made disasters.

Gen. Costs have been estimated without the benefit of survey data, utility coordination, or design. This estimate is intended for planning level consideration, and should only be used for such purposes only.

To:	Jason Armor – Town of Fishers
From:	Brian Meunier, Peggy Shepherd – CBBEL
Subject:	106th St & Cumberland Rd Roundabout Modeling Results
Date:	Friday, July 19, 2013
Project Name:	Mud Creek Flood Study
Project No.:	12-0231
Cc:	Jeromy Richardson, Jon Clodfelter – United Consulting
	Lenny Noens - CBBEL

Christopher B. Burke Engineering, LLC (CBBEL) was hired by the Town of Fishers and Hamilton County in 2012 to complete a flood risk reduction study focused on the 106th Street and Cumberland Road crossings over Mud Creek. CBBEL submitted a draft report in October 2012 which contained the findings of the study and potential solutions to the issues with flood-free access near the 106th Street and Cumberland Road intersection. Following the submittal of the draft report, CBBEL was informed that a new roundabout would be designed for the intersection and that slight road profile modifications might be made. CBBEL's project scope was increased to assess the permitability of the roundabout project based on the potential profile changes. A preliminary road profile for the roundabout was provided to CBBEL on July 15, 2013; this memorandum summarizes the impact of the roundabout profile on the flooding near the intersection.

Impact of Adding 106th St – Cumberland Rd Roundabout without Mitigation of Surcharges

The increased elevation of the 106th St – Cumberland Rd intersection reduces the area available for flow over 106th Street and Cumberland Road. This is largely due to the length of the vertical transition curves for each roadway. CBBEL's hydraulic modeling of the intersection indicates that the revised roadway profiles decrease the flow area during the 100-year [Coordinated Discharge] runoff event for 106th Street and Cumberland Road by 198 sf and 182 sf, respectively. This reduction in flow area results in a base flood surcharge of 0.13 – 0.32 feet in the vicinity of the two road crossings. Therefore, the elevated roundabout is not a permittable project without mitigation efforts to reduce the base flood surcharges.

Potential Surcharge Mitigation Option and Impacts to Adjacent Structures

CBBEL modeled the addition of a large box culvert structure to the immediate north of the existing Cumberland Road Bridge. Three (3) 12-foot x 4-foot reinforced concrete box structures would be placed side-by-side with a bottom elevation about 2 feet above the existing channel invert to provide the additional flow area necessary to reduce the surcharge created by the road profile increase. The inclusion of the stated box structures should be considered the minimum level of mitigation required. A residual surcharge of 0.02 feet exists upstream of the 106th Street Bridge, even with the additional structure in place. This assumes that there is no impact to regulatory water surface elevations by any IDNR approved projects downstream. The addition of the box structures would not be capable of increasing the flood-free access of the either roadway. The structures would only serve as mitigation of the roundabout road profile changes.

The inclusion of the box structures would require a shelf to be excavated into the north bank of Mud Creek. An expansion and contraction zone would need to be added to the upstream and downstream side of the structure to transition flow out-of and back-to Mud Creek. The transition zones will likely require erosion protection measures to combat turbulent flow and scour. The pedestrian bridge downstream of Cumberland Road would need to be relocated further to the west to allow for an adequately sized contraction to be constructed. The bridge structure could likely be reused on new foundations. Minor pathway realignment would be necessary to reincorporate the bridge into the trail system.

Implications on Future Plans for Flood-free Access

The addition of the box culvert structures mirrors the original improvement recommendations by CBBEL in October 2012. It is not anticipated that the box structures would need to be removed to construct improvements aimed at increasing the flood-free access to 106th Street and Cumberland Road. Additional flow area could be added below the roadway in the form of box structures or bridge openings to the north of the box structures used as roundabout mitigation. The excavated shelf would need to be increased in size to transition the flow to the new structures; relocation of existing park features would likely be required to include a significant amount of additional flow area under Cumberland Road.

HEC-RAS Plan: United Round Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	783.08		783.13	0.000869	2.31	651.21	487.62	0.21
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.87		783.90	0.000613	2.20	1068.91	577.13	0.18
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	784.23		784.27	0.000658	2.40	1284.50	604.56	0.19
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	784.61		784.66	0.000727	2.64	1515.76	617.47	0.20
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	784.97		785.01	0.000717	2.74	1738.24	629.57	0.20
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.27		785.33	0.000726	2.85	1936.92	653.27	0.20
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	786.03		786.09	0.000795	3.23	2445.32	784.22	0.22
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	782.29	779.31	782.39	0.001055	2.53	292.51	275.69	0.23
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	783.04	779.88	783.19	0.001435	3.12	355.16	536.70	0.27
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	783.62	780.36	783.70	0.000795	2.54	985.90	609.54	0.21
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	783.87	780.93	783.97	0.001038	3.00	1136.30	629.34	0.24
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	784.24	781.36	784.34	0.001007	3.11	1388.71	716.02	0.24
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	784.56	781.77	784.66	0.000968	3.17	1620.73	734.18	0.24
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	785.30	782.84	785.40	0.000934	3.39	2189.27	802.21	0.24
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	782.07	779.20	782.18	0.001214	2.68	298.82	876.04	0.25
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	782.81	779.81	782.95	0.001289	3.13	435.72	888.84	0.26
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	783.47	780.28	783.49	0.000184	1.30	2268.68	903.06	0.10
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	783.65	780.87	783.67	0.000262	1.58	2431.00	904.24	0.12
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	784.04	781.35	784.06	0.000253	1.63	2781.78	906.62	0.12
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	784.37	782.21	784.38	0.000256	1.71	3076.68	908.05	0.12
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	785.09	783.04	785.12	0.000280	1.93	3737.73	911.20	0.13
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	781.88		781.91	0.000387	1.88	888.90	596.58	0.14
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	782.68		782.70	0.000300	1.82	1390.50	644.66	0.13
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	783.40		783.42	0.000227	1.70	1862.84	658.23	0.12
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	783.55		783.58	0.000345	2.13	1957.97	658.65	0.14
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	783.93		783.96	0.000349	2.22	2213.95	659.78	0.14
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	784.26		784.29	0.000366	2.34	2426.27	660.63	0.15
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	784.97		785.01	0.000428	2.69	2896.33	662.40	0.16
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	781.73		781.76	0.000367	1.82	886.44	512.53	0.14
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	782.56		782.59	0.000292	1.80	1325.06	530.84	0.13
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	783.31		783.33	0.000233	1.73	1727.40	544.93	0.12
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	783.41		783.44	0.000375	2.22	1778.57	547.42	0.15
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	783.79		783.83	0.000396	2.36	1989.65	553.41	0.15
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	784.10		784.14	0.000425	2.51	2162.81	554.39	0.16
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	784.78		784.83	0.000520	2.94	2539.71	556.53	0.18
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	781.52	778.16	781.62	0.000872	2.65	329.26	609.23	0.22
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	782.31	778.83	782.45	0.001029	3.19	438.51	646.46	0.24
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	783.05	779.38	783.21	0.001007	3.44	553.56	665.00	0.24
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	783.35	780.09	783.38	0.000275	1.85	2085.01	669.35	0.13
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	783.74	780.87	783.76	0.000286	1.96	2341.33	676.77	0.13
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	784.04	781.33	784.07	0.000306	2.09	2551.82	684.34	0.14
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	784.71	782.30	784.75	0.000389	2.50	3016.61	716.43	0.16
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	781.22	778.35	781.39	0.001413	3.34	246.19	648.33	0.27
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.78	779.05	782.05	0.001992	4.28	303.52	665.30	0.33
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	782.12	779.64	782.49	0.002576	5.07	338.81	672.51	0.38
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	782.51	780.36	782.55	0.000456	2.23	1690.64	678.97	0.16
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.73	781.24	782.77	0.000518	2.44	1838.47	682.45	0.17
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	783.02	781.71	783.06	0.000527	2.54	2037.21	694.98	0.18
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.75	782.50	783.80	0.000539	2.76	2557.32	733.63	0.18
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.94	778.72	780.99	0.000851	2.40	513.01	377.83	0.21
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.40	779.37	781.48	0.001177	3.02	715.69	721.48	0.25
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.71	779.79	781.80	0.001225	3.22	863.68	724.91	0.25
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	782.09	779.98	782.19	0.001283	3.46	1043.57	729.21	0.26
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	782.39	779.98	782.49	0.001309	3.62	1182.66	746.92	0.27
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.67	779.98	782.78	0.001320	3.76	1316.99	770.09	0.27
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	783.38	780.93	783.50	0.001334	4.07	1656.50	814.59	0.28
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.50	778.15	780.57	0.000949	2.48	595.40	644.51	0.22
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.92	778.82	780.98	0.000927	2.62	870.59	661.81	0.22
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.24	779.76	781.30	0.000906	2.72	1093.79	710.84	0.22
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.63	779.98	781.69	0.000870	2.81	1378.13	735.02	0.22
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.95	780.65	782.00	0.000829	2.86	1610.19	752.77	0.22
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	782.24	780.78	782.30	0.000798	2.91	1840.54	786.46	0.22
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	782.99	781.08	783.05	0.000709	2.98	2439.60	807.42	0.21
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	780.05	777.59	780.10	0.000850	2.20	669.12	659.95	0.20
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.50	778.68	780.55	0.000787	2.29	965.58	703.75	0.20
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.85	779.54	780.89	0.000749	2.35	1195.98	729.14	0.20
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	781.24	779.71	781.29	0.000755	2.50	1475.58	830.13	0.20
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.58	779.96	781.62	0.000706	2.53	1717.26	851.79	0.20
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.89	780.16	781.94	0.000673	2.57	1945.60	878.50	0.19
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.68	780.44	782.73	0.000610	2.68	2531.71	909.90	0.19

HEC-RAS Plan: Rounabout w Box Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Mud Creek	Hamilton County	11.628	2-yr	740.00	777.90	783.02		783.08	0.000960	2.41	622.05	480.50	0.22
Mud Creek	Hamilton County	11.628	5-yr	1107.00	777.90	783.76		783.80	0.000710	2.33	1006.03	565.11	0.19
Mud Creek	Hamilton County	11.628	10-yr	1435.00	777.90	784.26		784.30	0.000630	2.35	1305.18	605.73	0.19
Mud Creek	Hamilton County	11.628	25-yr	1899.00	777.90	784.57		784.62	0.000759	2.69	1492.79	616.20	0.21
Mud Creek	Hamilton County	11.628	50-yr	2289.00	777.90	784.86		784.91	0.000803	2.86	1670.50	625.92	0.21
Mud Creek	Hamilton County	11.628	100-yr	2686.00	777.90	785.19		785.24	0.000789	2.95	1880.72	648.08	0.21
Mud Creek	Hamilton County	11.628	100 yr Coor	3800.00	777.90	785.92		785.98	0.000820	3.25	2369.44	686.63	0.22
Mud Creek	Hamilton County	11.487	2-yr	740.00	777.00	782.15	779.31	782.26	0.001164	2.63	281.63	229.63	0.24
Mud Creek	Hamilton County	11.487	5-yr	1107.00	777.00	782.79	779.88	782.97	0.001693	3.32	333.60	317.84	0.30
Mud Creek	Hamilton County	11.487	10-yr	1435.00	777.00	783.20	780.36	783.44	0.002103	3.88	370.25	565.97	0.33
Mud Creek	Hamilton County	11.487	25-yr	1899.00	777.00	783.76	780.93	783.88	0.001176	3.15	1070.06	619.96	0.26
Mud Creek	Hamilton County	11.487	50-yr	2289.00	777.00	783.95	781.36	784.08	0.001363	3.48	1189.99	634.64	0.28
Mud Creek	Hamilton County	11.487	100-yr	2686.00	777.00	784.33	781.77	784.45	0.001251	3.50	1452.78	720.86	0.27
Mud Creek	Hamilton County	11.487	100 yr Coor	3800.00	777.00	785.10	782.84	785.21	0.001131	3.65	2028.53	789.14	0.26
Mud Creek	Hamilton County	11.482		Mult Open									
Mud Creek	Hamilton County	11.466	2-yr	740.00	776.80	781.90	779.20	782.02	0.001436	2.83	271.21	827.45	0.27
Mud Creek	Hamilton County	11.466	5-yr	1107.00	776.80	782.49	779.81	782.67	0.001767	3.48	375.67	883.26	0.30
Mud Creek	Hamilton County	11.466	10-yr	1435.00	776.80	782.94	780.28	783.15	0.001925	3.89	459.17	890.96	0.32
Mud Creek	Hamilton County	11.466	25-yr	1899.00	776.80	783.51	780.87	783.53	0.000309	1.69	2298.56	903.28	0.13
Mud Creek	Hamilton County	11.466	50-yr	2289.00	776.80	783.62	781.35	783.64	0.000396	1.94	2397.12	904.00	0.15
Mud Creek	Hamilton County	11.466	100-yr	2686.00	776.80	784.04	782.21	784.07	0.000347	1.91	2785.16	906.64	0.14
Mud Creek	Hamilton County	11.466	100 yr Coor	3800.00	776.80	784.84	783.04	784.87	0.000341	2.07	3507.82	910.20	0.14
Mud Creek	Hamilton County	11.392	2-yr	740.00	776.00	781.62		781.67	0.000578	2.22	735.81	582.75	0.17
Mud Creek	Hamilton County	11.392	5-yr	1107.00	776.00	782.24		782.28	0.000532	2.30	1110.00	634.31	0.17
Mud Creek	Hamilton County	11.392	10-yr	1435.00	776.00	782.73		782.77	0.000474	2.30	1423.88	645.26	0.16
Mud Creek	Hamilton County	11.392	25-yr	1899.00	776.00	783.38		783.41	0.000407	2.28	1848.14	658.17	0.15
Mud Creek	Hamilton County	11.392	50-yr	2289.00	776.00	783.44		783.49	0.000553	2.67	1891.85	658.36	0.18
Mud Creek	Hamilton County	11.392	100-yr	2686.00	776.00	783.89		783.94	0.000498	2.65	2187.37	659.66	0.17
Mud Creek	Hamilton County	11.392	100 yr Coor	3800.00	776.00	784.69		784.74	0.000524	2.90	2710.53	661.73	0.18
Mud Creek	Hamilton County	11.306	2-yr	740.00	776.00	781.37		781.42	0.000615	2.26	707.16	495.28	0.18
Mud Creek	Hamilton County	11.306	5-yr	1107.00	776.00	782.02		782.07	0.000559	2.34	1040.34	524.71	0.17
Mud Creek	Hamilton County	11.306	10-yr	1435.00	776.00	782.54		782.58	0.000505	2.35	1311.59	530.53	0.17
Mud Creek	Hamilton County	11.306	25-yr	1899.00	776.00	783.21		783.25	0.000446	2.37	1673.18	542.31	0.16
Mud Creek	Hamilton County	11.306	50-yr	2289.00	776.00	783.21		783.26	0.000651	2.86	1670.34	542.17	0.19
Mud Creek	Hamilton County	11.306	100-yr	2686.00	776.00	783.68		783.73	0.000600	2.87	1927.86	553.06	0.19
Mud Creek	Hamilton County	11.306	100 yr Coor	3800.00	776.00	784.45		784.52	0.000653	3.21	2357.98	555.50	0.20
Mud Creek	Hamilton County	11.262	2-yr	740.00	775.90	781.27	778.36	781.31	0.000404	1.62	465.20	601.03	0.14
Mud Creek	Hamilton County	11.262	5-yr	1107.00	775.90	781.88	778.71	781.95	0.000551	2.09	549.20	626.20	0.17
Mud Creek	Hamilton County	11.262	10-yr	1435.00	775.90	782.36	779.01	782.45	0.000653	2.43	621.45	648.35	0.19
Mud Creek	Hamilton County	11.262	25-yr	1899.00	775.90	782.99	779.37	783.11	0.000750	2.82	724.99	664.10	0.21
Mud Creek	Hamilton County	11.262	50-yr	2289.00	775.90	783.14	779.65	783.17	0.000319	1.87	2096.90	666.23	0.14
Mud Creek	Hamilton County	11.262	100-yr	2686.00	775.90	783.61	779.92	783.65	0.000295	1.90	2415.72	673.16	0.13
Mud Creek	Hamilton County	11.262	100 yr Coor	3800.00	775.90	784.38	780.61	784.42	0.000337	2.19	2941.84	697.09	0.15
Mud Creek	Hamilton County	11.252		Bridge									
Mud Creek	Hamilton County	11.240	2-yr	740.00	775.80	781.15	778.45	781.20	0.000499	1.74	429.25	643.65	0.16
Mud Creek	Hamilton County	11.240	5-yr	1107.00	775.80	781.68	778.81	781.76	0.000708	2.27	495.30	662.81	0.19
Mud Creek	Hamilton County	11.240	10-yr	1435.00	775.80	782.03	779.10	782.15	0.000910	2.71	539.17	671.28	0.22
Mud Creek	Hamilton County	11.240	25-yr	1899.00	775.80	782.45	779.47	782.62	0.001183	3.28	592.86	677.93	0.26
Mud Creek	Hamilton County	11.240	50-yr	2289.00	775.80	782.68	779.75	782.71	0.000356	1.85	1986.19	681.66	0.14
Mud Creek	Hamilton County	11.240	100-yr	2686.00	775.80	782.97	780.03	783.01	0.000370	1.96	2186.11	687.35	0.15
Mud Creek	Hamilton County	11.240	100 yr Coor	3800.00	775.80	783.71	780.70	783.75	0.000398	2.21	2707.81	731.38	0.16
Mud Creek	Hamilton County	11.182	2-yr	740.00	775.59	780.94	778.72	780.99	0.000851	2.40	513.01	377.83	0.21
Mud Creek	Hamilton County	11.182	5-yr	1107.00	775.59	781.40	779.37	781.48	0.001178	3.02	715.66	721.48	0.25
Mud Creek	Hamilton County	11.182	10-yr	1435.00	775.59	781.71	779.79	781.80	0.001225	3.22	863.68	724.91	0.25
Mud Creek	Hamilton County	11.182	25-yr	1899.00	775.59	782.09	779.98	782.19	0.001283	3.46	1043.57	729.21	0.26
Mud Creek	Hamilton County	11.182	50-yr	2289.00	775.59	782.39	779.98	782.49	0.001309	3.62	1182.69	746.92	0.27
Mud Creek	Hamilton County	11.182	100-yr	2686.00	775.59	782.67	779.98	782.78	0.001320	3.76	1316.99	770.09	0.27
Mud Creek	Hamilton County	11.182	100 yr Coor	3800.00	775.59	783.38	780.93	783.50	0.001334	4.07	1656.50	814.59	0.28
Mud Creek	Hamilton County	11.086	2-yr	740.00	775.46	780.50	778.15	780.57	0.000949	2.48	595.40	644.51	0.22
Mud Creek	Hamilton County	11.086	5-yr	1107.00	775.46	780.92	778.82	780.98	0.000927	2.62	870.55	661.81	0.22
Mud Creek	Hamilton County	11.086	10-yr	1435.00	775.46	781.24	779.76	781.30	0.000906	2.72	1093.79	710.84	0.22
Mud Creek	Hamilton County	11.086	25-yr	1899.00	775.46	781.63	779.98	781.69	0.000870	2.81	1378.13	735.02	0.22
Mud Creek	Hamilton County	11.086	50-yr	2289.00	775.46	781.95	780.65	782.00	0.000828	2.86	1610.28	752.78	0.22
Mud Creek	Hamilton County	11.086	100-yr	2686.00	775.46	782.24	780.78	782.30	0.000798	2.91	1840.54	786.46	0.22
Mud Creek	Hamilton County	11.086	100 yr Coor	3800.00	775.46	782.99	781.08	783.05	0.000709	2.98	2439.60	807.42	0.21
Mud Creek	Hamilton County	10.987	2-yr	740.00	775.00	780.05	777.59	780.10	0.000850	2.20	669.12	659.95	0.20
Mud Creek	Hamilton County	10.987	5-yr	1107.00	775.00	780.50	778.68	780.55	0.000787	2.29	965.54	703.75	0.20
Mud Creek	Hamilton County	10.987	10-yr	1435.00	775.00	780.85	779.54	780.89	0.000749	2.35	1195.98	729.14	0.20
Mud Creek	Hamilton County	10.987	25-yr	1899.00	775.00	781.24	779.71	781.29	0.000755	2.50	1475.58	830.13	0.20
Mud Creek	Hamilton County	10.987	50-yr	2289.00	775.00	781.58	779.96	781.62	0.000706	2.53	1717.43	851.81	0.20
Mud Creek	Hamilton County	10.987	100-yr	2686.00	775.00	781.89	780.16	781.94	0.000673	2.57	1945.60	878.50	0.19
Mud Creek	Hamilton County	10.987	100 yr Coor	3800.00	775.00	782.68	780.44	782.73	0.000610	2.68	2531.71	909.90	0.19