ERDC/CHL TR/SR/CR-20-??

Coastal and Hydraulics Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

Draft: Nolehoe Creek, DeSoto County, MS: FluvialGeomorph Level I Channel Stability Assessment & Reconnaissance Report

Appendix C. Memphis Metropolitan Stormwater – North DeSoto Count Feasibility Study

Christopher P. Haring and David S. Biedenharn

March 2021

Approved for public release; distribution is unlimited. [[[If distribution limitation is needed, coordinate with sponsoring program office or agency to identify applicable statement and justification per DoDI 5230.24. If not, delete this highlighted text.]]]

The U.S. Army Engineer Research and Development Center (ERDC) solves the nation's toughest engineering and environmental challenges. ERDC develops innovative solutions in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, the Department of Defense, civilian agencies, and our nation's public good. Find out more at www.erdc.usace.army.mil.

To search for other technical reports published by ERDC, visit the ERDC online library at https://erdclibrary.on.worldcat.org/discovery.

ERDC/CHL TR/SR/CR-20-??
March 2021

Nolehoe Creek, DeSoto County, MS: FluvialGeomorph Level I Channel Stability Assessment & Reconnaissance Report

Christopher P. Haring and David S. Biedenharn

Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Prepared for Name of Sponsoring Agency or Program Office [[[not always USACE]]]
City, ST ZIP

Under Project ####, "Project Title"

Monitored by Coastal and Hydraulics Laboratory [for Contract Reports only; for TR/SR, delete this entire item]
U.S. Army Engineer Research and Development Center
Vicksburg, MS 39180-6199

Abstract

DeSoto County in north-central Mississippi requested a study initiative to assess Flood Risk Management and Ecosystem Restoration Alternatives for a series of watersheds including NoleHoe Creek. The USACE-Memphis District is the lead for the study and requested CHL's assistance in developing a rapid geomorphic assessment approach to develop a reconnaissance level of details. With severely limited funding and time constraints, CHL used a newly developed rapid watershed assessment toolkit-FluvialGeomorph, to assess Nolehoe Creek and other watersheds. The analysis uses existing off-the-shelf LiDAR, channel surveys and any other detailed information to provide a basis for restoration and stabilization alternatives. FG is being used in multiple District's as a tool to provide a rapid assessment approach for limited funding and time constrained studies. The results of the analysis are contained in this document.

Contents

Figures and Tables

Figures

Preface

This study was conducted for the Memphis District General Investigation Feasibility Study-Memphis Metropolitan Stormwater-DeSoto County, Mississippi. The Project Lead for coordination with CHL was Andrea Carpenter Crowther.

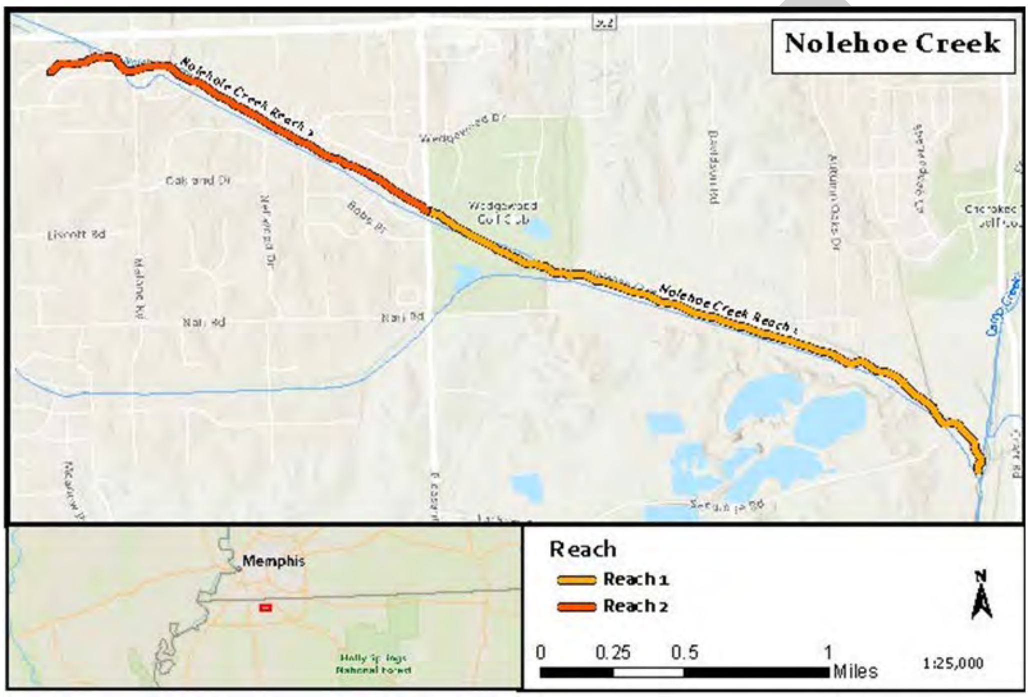
The work was performed by the River and Estuarine Branch of the Flood and Storm Protection Division, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL). At the time of publication, David P. May was Chief; Cary Talbot was Chief; and Julie Rosati was the Technical Director for Flood and Storm Technical Programs. The Acting Deputy Director of ERDC-CHL was Keith Flowers, and the Director was Ty Wamsley.

The Commander of ERDC was COL Teresa A. Schlosser, and the Director was Dr. David W. Pittman.

1 Introduction

The following is an abbreviated FluvialGeomorph (FG) Level I-Channel Stability Assessment for Nolehoe Creek. The FG analysis is based on 2009-2010 LiDAR data, a 2011 thalweg survey provided by the Vicksburg District, and limited field site visits completed on November 5, 2020. The study reaches are defined in Figure 1.

Figure 1. Nolehoe Creek Watershed, De Soto County, MS



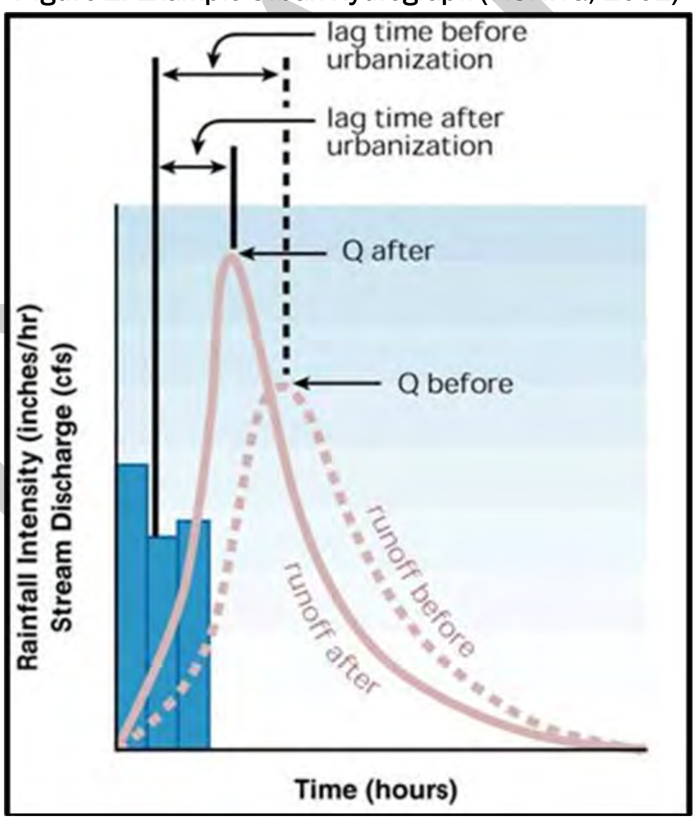
1.1 Background

The Nolehoe Creek is a small mixed rural and urban watershed (< 10 square miles) in De Soto County, north central Mississippi, immediately south of the Memphis, TN (Figure 1). The watershed is approximately 9.3-square miles. Up until recently, the watershed was largely agricultural but is experiencing rapid urbanization. Typical characteristics of agricultural and rapidly urbanizing watersheds include channelization for agricultural and urban land uses, channel degradation due to lower sediment supply from runoff control reservoirs, encroachments to drainage ways, increased channel slopes, reduced access to natural floodplains, and increased runoff rates from non-porous pavement and other urban structures. The primary cause of the historical degradation along Nolehoe Creek is the channelization within the watershed. As illustrated in Figure 1, both Reach 1 and 2 have relatively straight channel alignments that were channelized for agricultural production.

Coupled with past channelization, increased runoff from a rapidly urbanizing watershed will continue to complicate the future stabilization of Nolehoe Creek. Figure 2 illustrates an example hydrograph and the change overtime due to increased urbanization. Changes to the hydrograph impact the channel network by changing thresholds established between the balance of sediment mobilization and transport to channel slope and discharge (Lane, 1955).

Figure 2 illustrates an example hydrograph and the change overtime due to increased urbanization. Changes to the hydrograph impact the channel network by changing thresholds established between the balance of sediment mobilization and transport to channel slope and discharge.

Figure 2. Example Urban Hydrograph (FISRWG, 2001)



As one or more of the components of balance change (Lane, 1955), channel stability is disturbed, and the system adjusts accordingly. To identify potential locations of Nolehoe Creek channel instability, LiDAR water surface profiles and cross-sections were analyzed. The existing LiDAR (2009-2010) can be used to identify locations of channel slope change-identifying potential nick points or existing grade control structures. Nolehoe Creek has very few locations where revetments or grade control structures (GCS) have been applied and have helped to re-establish channel stability. The primary channel stability points are road crossing culverts. For example, during the site visit on November 5, 2020, the channel sections in proximity to the Malone Road culvert were investigated and illustrated in Figures 3 and 4. Figure 3 shows a stable channel upstream of the culvert. The culvert has provided channel bed control in not allowing the upstream portion of this reach to degrade the channel bed as has occurred downstream of the culvert in Figure 4. The section of Reach 2 downstream of the culvert has some of the steepest slopes within the Nolehoe watershed.

Figure 3. Nolehoe Creek-Malone Street culvert-looking upstream at stable channel

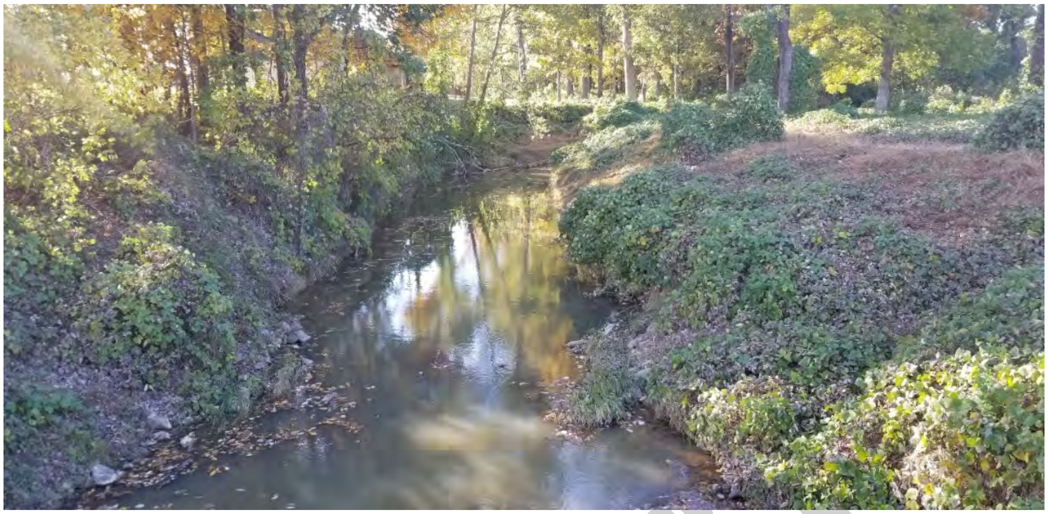


Figure 4. Nolehoe Creek-Malone Street culvert-looking downstream at channel degradation

The culverts at Malone and Pleasant Hill Roads have helped stabilize the stream system in those locations by providing bed control to a trending degradational channel system.

1.1.1 Channel Evolution Model:

The five-stage Channel Evolution Model (CEM) developed by Schumm et al., (1984) in Figure 4 was used to provide qualitative discussion on the condition of the channel reaches. There have been wide-scale changes in land-use in the Nolehoe Creek watershed and they are continuing today. The changes include stream channelization, agricultural and urban development, public infrastructure encroachments in the form of bridges, roadways, utilities. The changes impact soil infiltration and runoff rates changing the characteristic delivery of sediment and hydrologic discharge regimes throughout the watershed. If not mitigated, the changes typically lead to a process of channel bed incision followed by widening and floodplain re-development. The process is outlined in the CEM diagram in Figure 5 and the multiple floodplain terraces defined in Figure 6 provide evidence for the process.

Figure 5. The 5-stage Channel Evolution Model (Schumm et al., 1984)

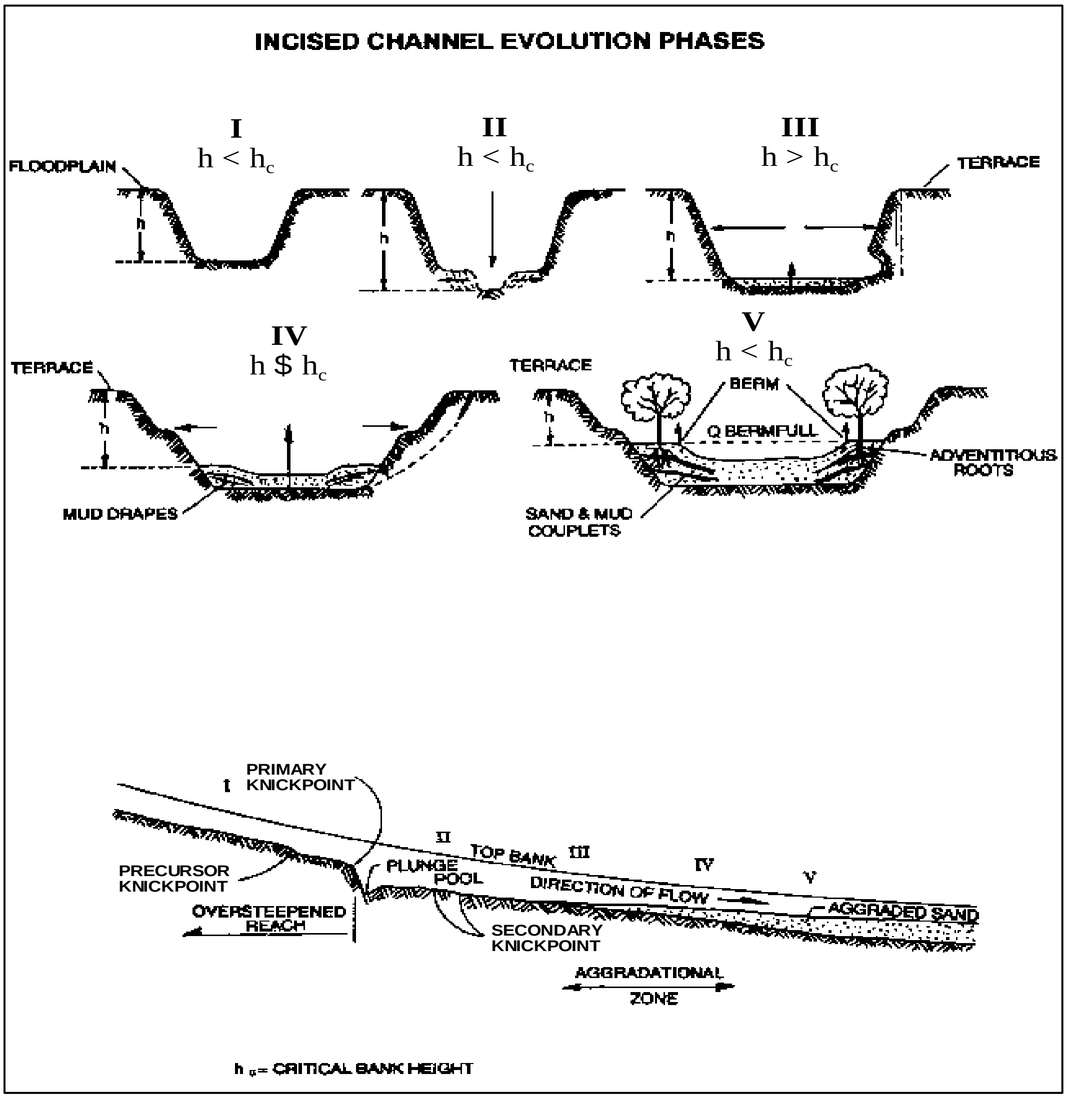
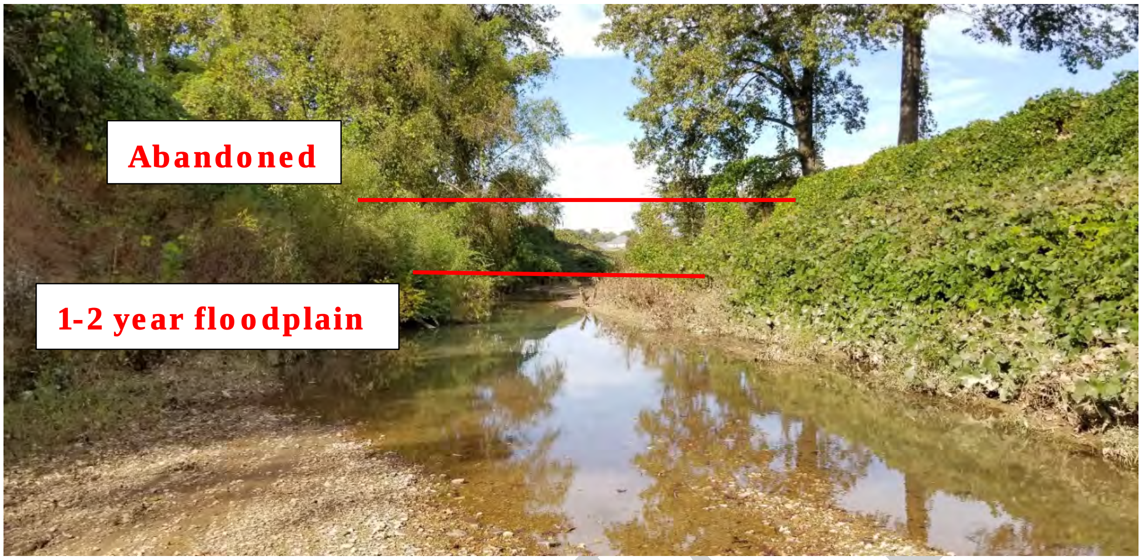


Figure 6. Nolehoe Creek Cross-section facing upstream approximately 1,800 ft from Camp Creek confluence



1.1.2 Local Geology.

The local surficial geology of the study area is mapped as Eocene age deposits from the Claiborne Group and Kosciusko formation. The Kosciusko formation is classified as irregularly bedded sand, clay, and some quartzite deposits (Bicker, 1969). Field observations of the surficial geologic materials are presented in Figures 7 through 10.

Figure 7. Nolehoe Nolehoe Creek Cross-section facing downstream approximately 1,800 ft from Camp Creek confluence

Figure 8. Nolehoe Nolehoe Creek left bank approximately 700 ft from Camp Creek confluence

Figure 9. Nolehoe Nolehoe Creek left bank approximately 1,000 ft upstream of Pleasant Hill Road

Figure 10. Nolehoe Nolehoe Creek right bank tributary outlet approximately 1,000 ft upstream of Pleasant Hill Road

Figures 7, 9, and 10 had largely interbedded gravel deposits with a compact hard clay matrix. The deposits were especially erosion resistant (Figures 9 and 10) located in Reach 2 where there was a blacktop looking unit directly over a hard-red clay.

1.2 Objective(s)

Nolehoe Creek (Figure 11) as well as other watersheds within the greater De Soto County area have issues with channel erosion that threaten private and public properties. The objective of this study is to use the FG geomorphic watershed assessment approach to assess and identify locations that are susceptible to further channel erosion and determine what areas would benefit greatest from restoration and stabilization measures. Once the areas are identified and mapped then further field validation will occur to define the stabilization and restoration needs within the watershed. This allows for limited funding resources to be targeted to treat the most severe prioritized areas.

This report provides a preliminary assessment for Nolehoe Creek based on limited field investigations and FG analysis of the 2009-2010 Lidar and 2011 thalweg surveys. Comparison of the Lidar survey with the 2011 thalweg showed that these two surveys were in close agreement. Figure 12 shows the 2011 thalweg profile for Nolehoe Creek. One of the primary goals of this project is to minimize channel degradation, channel erosion, and sedimentation to support aquatic ecosystem form and function. This assessment addresses the channel stabilization, erosion control and sedimentation aspects of these goals. Two equilibrium slope curves were available to assess the vertical stability of the channel. The first was developed early in the DHP program in the late 1980s for watersheds that were mostly south of Nolehoe Creek. There was also an equilibrium slope curve that had been developed specifically for the Coldwater streams in the mid-1990s. Comparing these two curves against streams in this area suggested that the Coldwater curve might be overly steep while the older DHP curve was viewed as being more conservative.

For this preliminary assessment, Nolehoe Creek was divided into two broad reaches: (1) Reach 1 extends from the confluence with Camp Creek up to the Pleasant Hill Drive Culvert; and (2) Reach 2 extends from the Pleasant Hill Drive culvert upstream to the Tanner's Way Cove (Figure 1).

Figure 11. Nolehoe Creek Study Reaches (1-2)

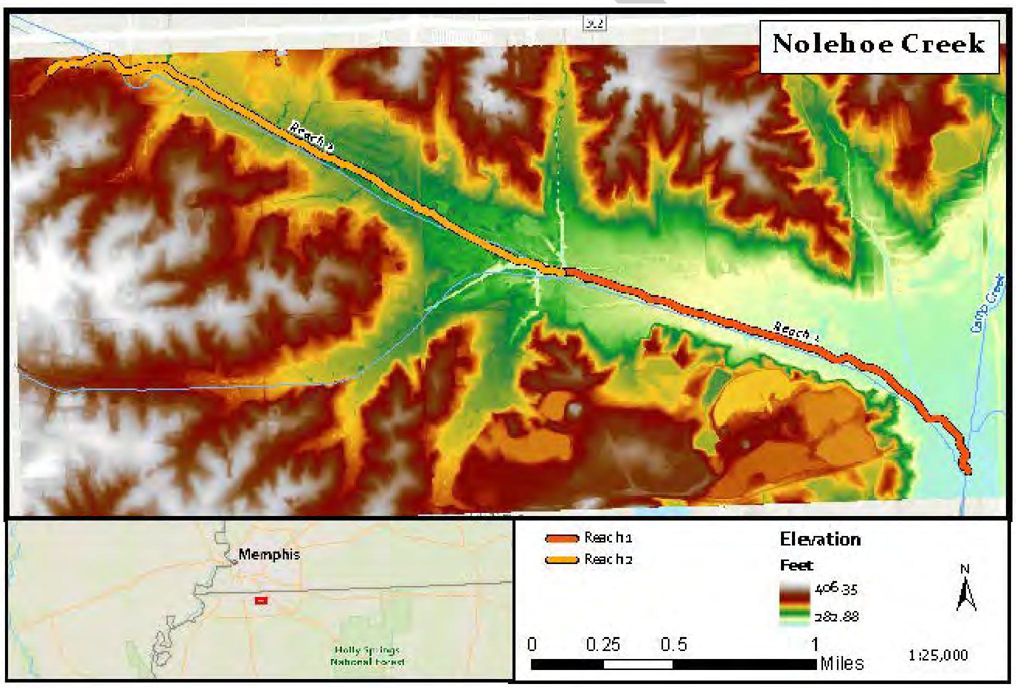
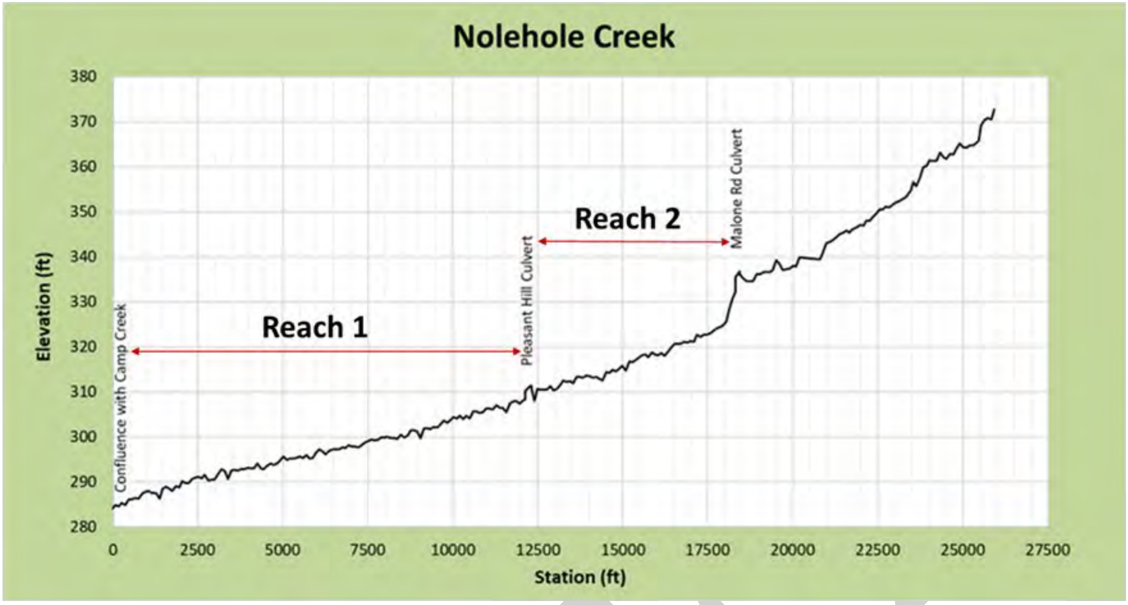


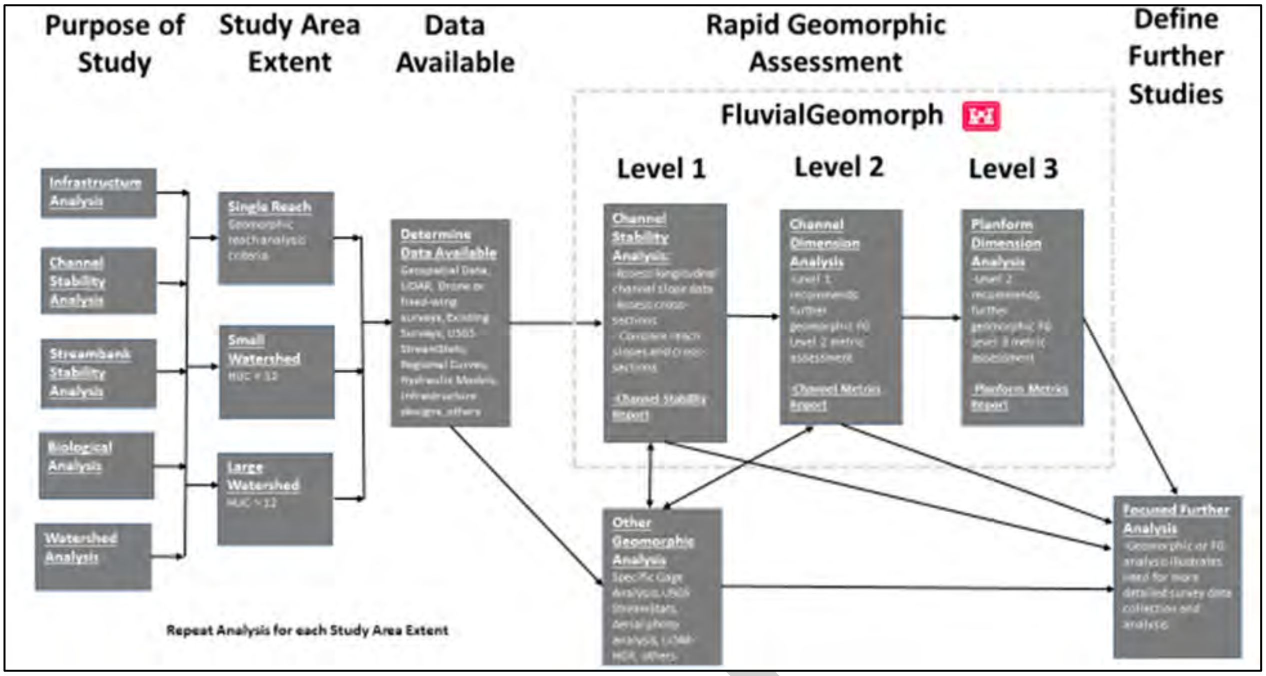
Figure 12. Thalweg Survey of Nolehoe Creek Study Reaches (1-2)



1.3 Approach to Watershed Assessments using FluvialGeomorph (FG)

The FG watershed assessment approach was developed to provide a relatively rapid method for evaluating stream channel stability based on existing LiDAR-high resolution terrain data. There are five categories identified in completing typical geomorphic studies outlined for the FG toolkit analysis and they are illustrated in Figure 13. FG-Level 1 defines the Channel Stability Analysis (CSA) for stream channel reaches or watersheds. The rapid assessment analyzes the longitudinal water surface slope profiles and cross-sectional analysis. This provides a reconnaissance level of detail to identify potential areas of concern based on simple slope and cross-sectional area comparative analysis. The CSA provides a basis for identifying potential areas of interest where channel degradation, aggradation, or widespread channel changes are observed. The first FG workflow is described in more detail in Haring et al. (in-draft 2020).

Figure 13. FluvialGeomorph Watershed Assessment Workflow



1.3.1 LiDAR Data and Resolution:

LiDAR data for Nolehoe Creek in Desoto County, MS was downloaded from the NOAA Data Access Viewer, https://coast.noaa.gov/dataviewer/#/lidar/search/where:projectid=25.

The data set was extracted from a larger classified data set and only includes points classified as Ground within the requested geographic bounds. The best available LiDAR for the area was Mississippi Delta Yazoo Phase 2 data flown between December 17, 2009 and July 9, 2010. The data was collected at 1-meter pulse spacing. The vertical accuracy is 15 cm RMSE or better. The coordinate system is State Plane Mississippi West 1983 in NAVD 88.

The ground classified points were combined into a LAS dataset and then transformed into a DEM. The DEM was hydro-modified to allow flow through areas where bridges crossed the creek.

1.3.2 Analysis Assumptions and Limitations:

FG is not a model, so stating and understanding the limitations of this and other geomorphic and hydraulic data is of utmost importance. Assumptions include:

- The LiDAR data used in the analysis does not penetrate the water surface so true channel depth is not directly measurable. However, if LiDAR is collected during low-water conditions then the least amount of water depth is lost. Riffle cross-over locations in smaller stream systems provide the least amount of depth loss as the water surface to the bottom of the channel can be minimal (Haring et al., 2019).

- Any identified geomorphic metrics for FG Level II analysis are based on the depth captured between the water surface and the bankfull indicators.

- Based on assessing the LiDAR water surface profile, it also appears that LiDAR was collected during low water conditions. Comparison of the 2010 LiDAR profile with the 2011 surveyed thalweg from the Vicksburg District showed that the two surveys matched closely.

- The interpretation of the LiDAR data needs to be completed in an objective consistent manner. Depending on the year of collection there are differing levels of accuracy that can be expected and should be considered when assessing and making recommendations from interpreting the data.

- The LiDAR water surface slope trends are only representing the range of points that the LiDAR collected. Vegetation can affect LiDAR coverage and can have major impacts on the assessment abilities using LiDAR. When assessing the slope trends or cross-sections, aerial photos should be reviewed to determine level of potential vegetation interference.

- The FG program is meant to be used to assess stream channel conditions and provide an assessment of where system instability exists. Field site visits are recommended to validate the information.

2 Interpretation of Geomorphic Data-Level I FG Analysis

The cross-sections for all the reaches were spaced at 50 feet apart. The individual lateral cross-section stationing across the channel cross-sections were spaced at 1-foot increments. The longitudinal water surface profiles were plotted using approximately 3 foot spacing. The Level 1-CSA uses a combination of cross-sections and the longitudinal profile to assess channel stability reach trends.

2.1 Reach 1 -Confluence of Nolehoe and Camp Creeks to Pleasant Hill Road

The Reach 1 site map is illustrated in Figure 14 and the water surface profile from 2009-2010 plotted in Figure 15.

Based on the LiDAR cut cross-sections, channel bank heights vary throughout the reach from 15 to 25 ft to the terrace level to 5-7 ft for actively building the floodplain berms. The channel has actively built floodplain berms within the incised channel margins shown in Figures 16-20. This is typically a sign of the channel adjusting with reduced downcutting and is approaching a new state of dynamic equilibrium (CEM IV). There may still be some localized streambank erosion as the channel continues to adjust. Floodplain berm elevations and associated channel stationing were collected from the LiDAR cross-sections and analyzed to determine the newly forming floodplain slope. The slope is calculated at 0.0022 ft/ft which is flatter than the interpolated LiDAR channel slope in the reach at 0.0033 ft/ft. The flatter slope is likely due less developed floodplain berms on the upstream section of the reach with continued adjustments to the elevation as the channel further develops. The floodplain should continue to build and develop as additional sediment deposition and channel adjustments occur within Reach 1, assuming it continues to trend toward a CEM stage V. However, it must be stated that this is all based on a preliminary assessment, and therefore, definitive conclusions about the future state of the channel are difficult to make. While the channel does appear to be approaching a CEM stage IV at this time, some degradation could occur if future urbanization accelerates, or further incision migrates upstream from Camp Creek.

Figure 14. Nolehoe Creek Reach 1: Cross-section Location Map

Figure 15. FG level 1-Nolehoe Creek Reach 1: LiDAR water-surface profile with cross-section locations

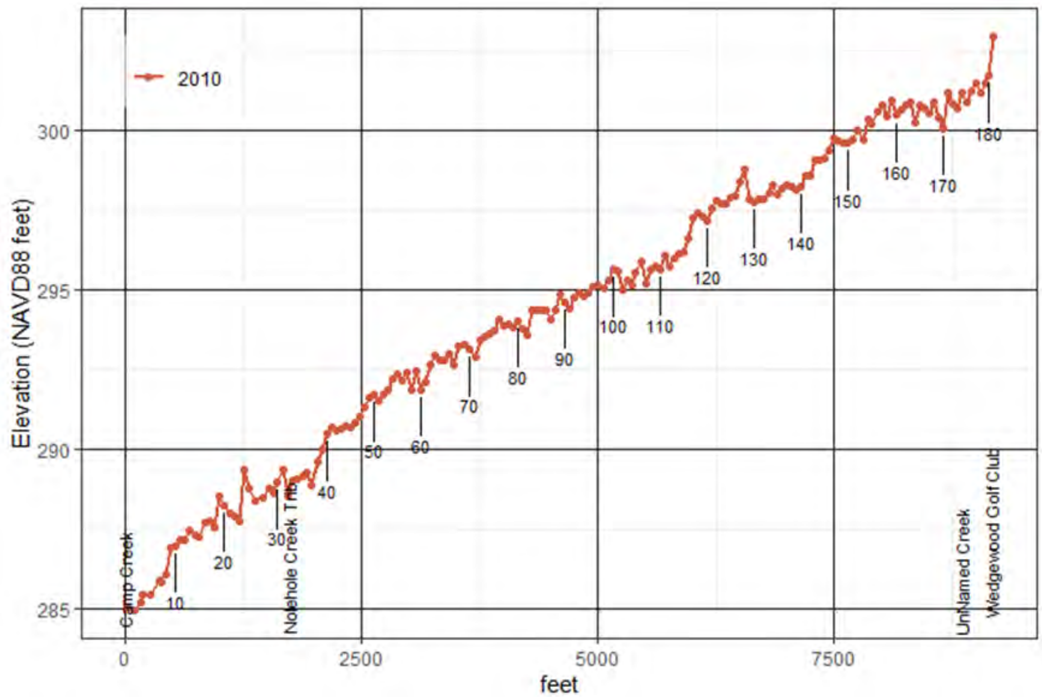


Figure 16. Cross-section 13, illustrating right-bank floodplain berm building in lower Reach 1.

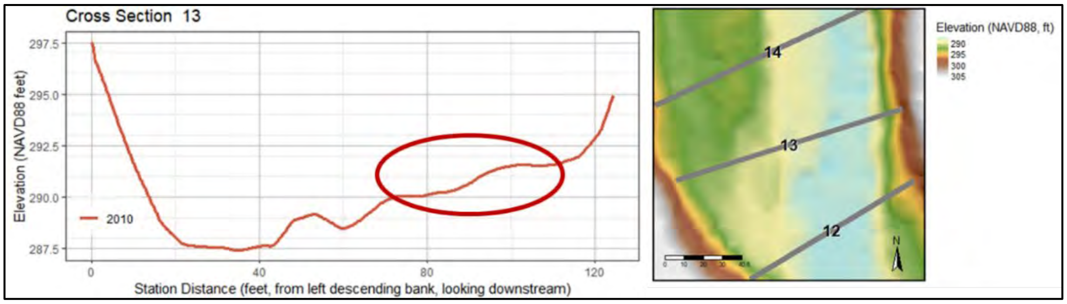


Figure 17. Cross-section 30, illustrating left-bank floodplain berm building.

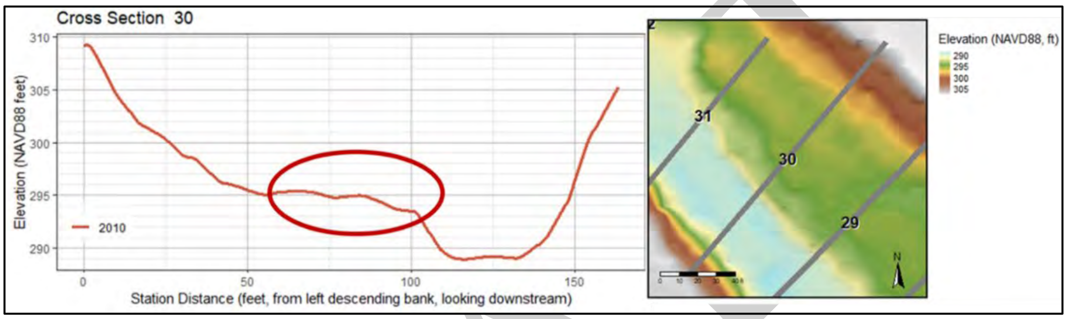


Figure 18. Cross-section 43, illustrating left-bank floodplain berm building.

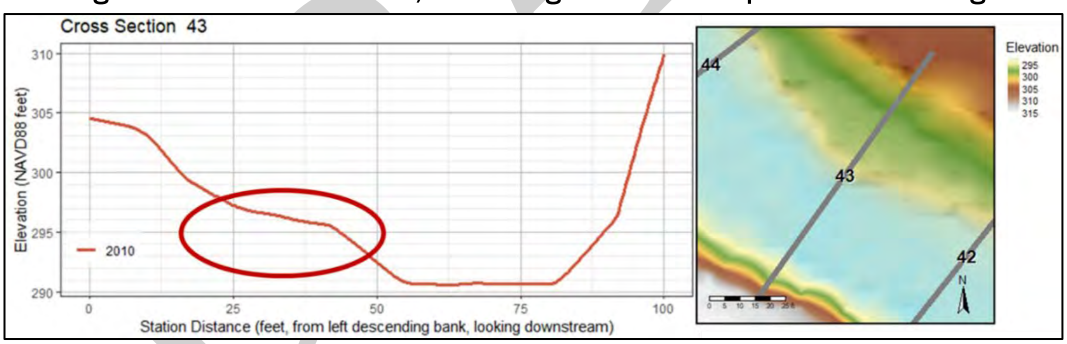


Figure 19. Cross-section 129, illustrating left and right floodplain berm development.

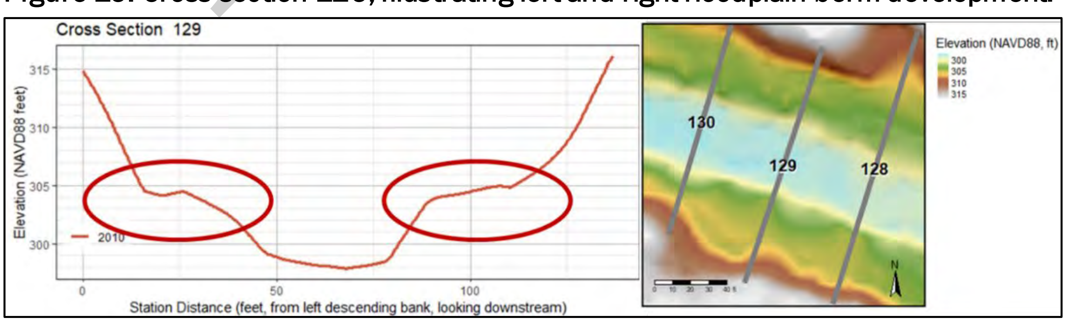
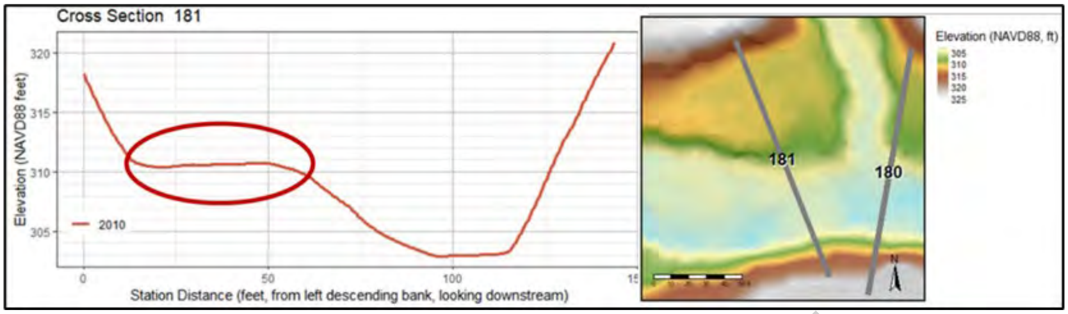


Figure 20. Cross-section 181, illustrating left bank floodplain berm upstream of tributary

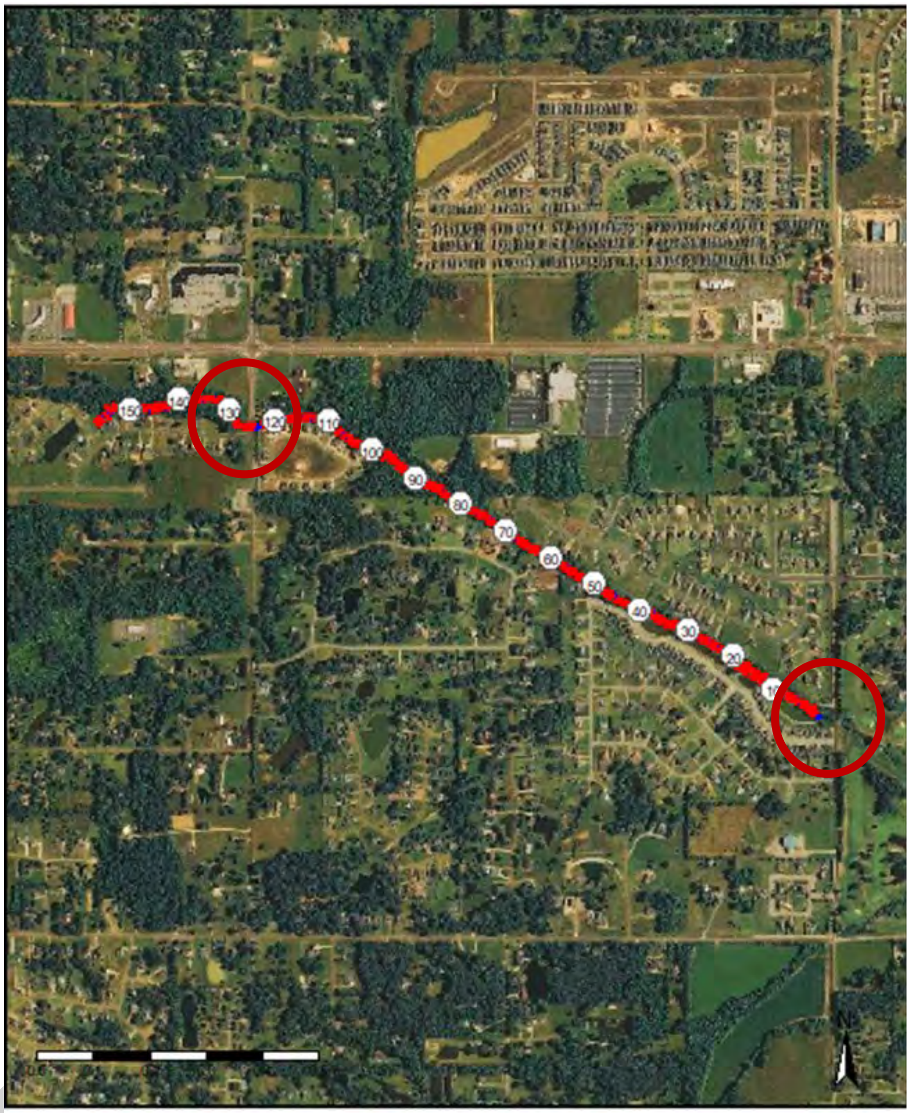


Limited field investigations revealed that this is a sand and gravel bed stream, but sediment depths were generally less than 2 feet. While there were no active signs of channel degradation (knickpoints, overwidening, etc.) observed at the Sandridge Road area, comparison of the 2011 thalweg survey with the DHP equilibrium slope curve suggested that some portions of the channel could be slightly degradational. However, comparisons with the Coldwater equilibrium slope curve suggest that the channel should be relatively stable. The lack of a comprehensive field investigation, coupled with the survey being 10 years old, makes it difficult to make definitive conclusions about the present–day vertical stability of this reach. Therefore, a conservative approach was adopted, which assumes that although Reach 1 appears to be approaching vertical stability (possibly CEM stage IV), some additional degradation could occur, particularly if the future flow regime changes as the watershed becomes more urbanized, or additional incision migrates up from Camp Creek. Inspection of Google Earth imagery reveals that this a straight reach with alternate bars and numerous areas of local bank instability. There are also numerous gullies occurring in this reach. The LiDAR profile within the lower 2,500 feet of the reach has a relatively steep slope of 0.0045 ft/ft compared to the rest of the reach. This may indicate new bed degradation from Camp Creek adjustments that maybe working upstream into Noehoe Creek.

2.2 Reach 2 – Pleasant Hill Road to Tanner's Way Covehill Road

The Reach 2 site map is illustrated in Figure 21 and the water surface profile from 2009-2010 plotted in Figure 22. There are two main road crossing within this reach that are functioning as GCS's. They are outlined in Figures 21 and 22 with red circles. Also, within the reach is a zone of erosion resistant materials in the channel bed and banks (orange circle). The material was identified during the site visit (Figures 9 and 10).

Figure 21. Nolehoe Creek Reach 2: Cross-section Location Map



Based on the LiDAR cut cross-sections, a similar range of average channel bank heights were found in Reach 2. The terrace level was approximately 15 to 20 ft, while the actively building floodplain berms are about 5-7 ft. One major difference between the reaches is the Reach 2 channel has not built floodplain berms extensively within the incised channel margins of the lower section of the reach (Figures 23-27). This is the section that has erosion resistant materials (Figure 23) and is acting more like a threshold channel than an alluvial channel. There is a noticeable change in bank heights (channel type) from downstream of the Malone Street culvert that is over-steepened and degrading to upstream of the culvert that has stabilized and built active floodplain berms on each side of the channel. The farthest upstream section transitions back to a more incised channel before it terminates at a water retention pond at Tanner's Way Cove. The channel slopes based on the LiDAR range from 0.0037 ft/ft downstream of the Malone Street Culvert to 0.0052 ft/ft upstream. There are more channel breaks within the reach especially immediately downstream of the culvert and at the far upstream end of the reach. These areas were not well documented during the field site visit and should be further investigated.

Figure 22. FG level 1-Nolehoe Creek Reach 2: LiDAR water-surface profile with cross-section locations

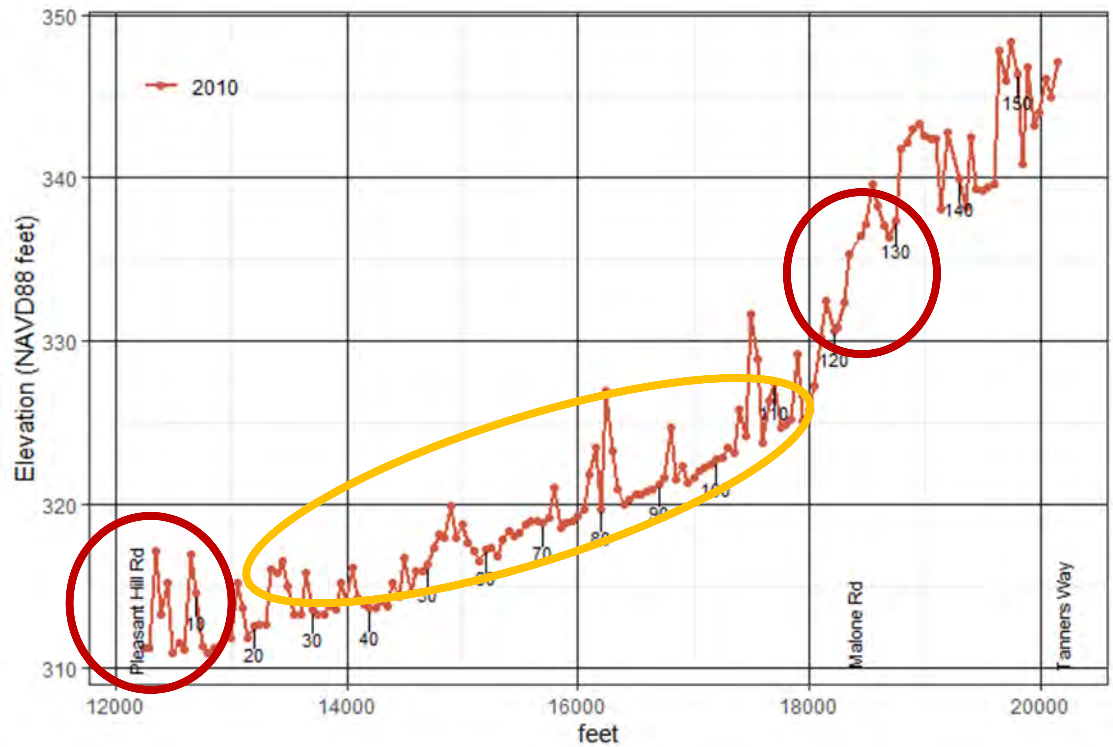


Figure 23. Cross-section 8, illustrating lack of floodplain berm building in lower Reach 2.

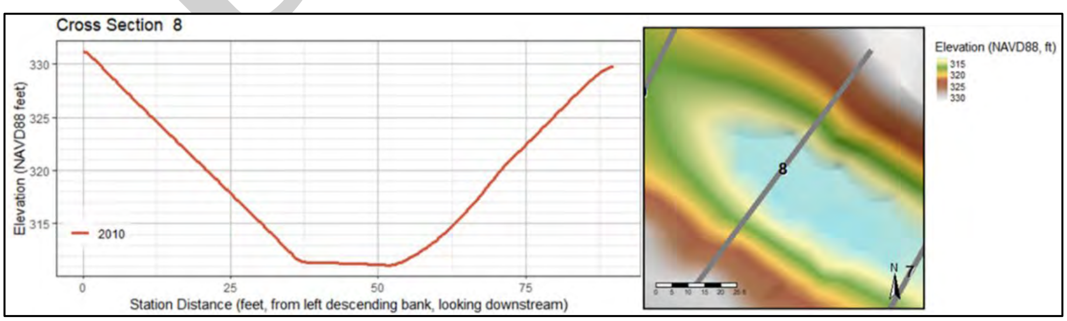


Figure 24. Cross-section 68, illustrating minor left-bank floodplain berm building.

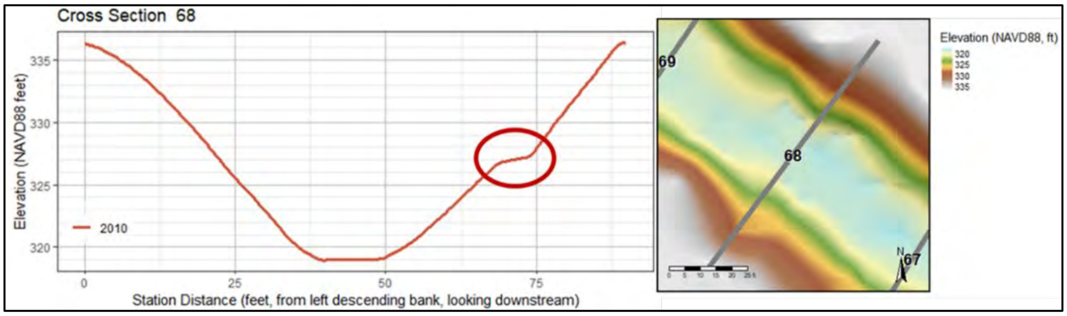


Figure 25. Cross-section 105, illustrating lack of floodplain berm building in lower Reach 2.

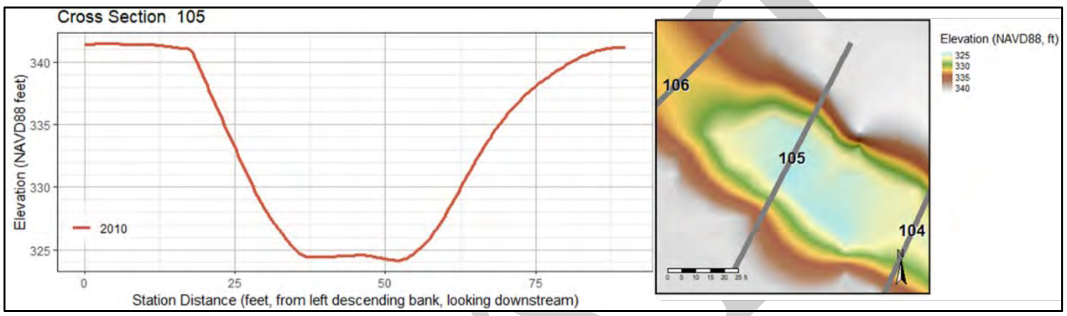


Figure 26. Cross-section 126, illustrating left and right floodplain berm development immediately upstream of Malone Road Culvert.

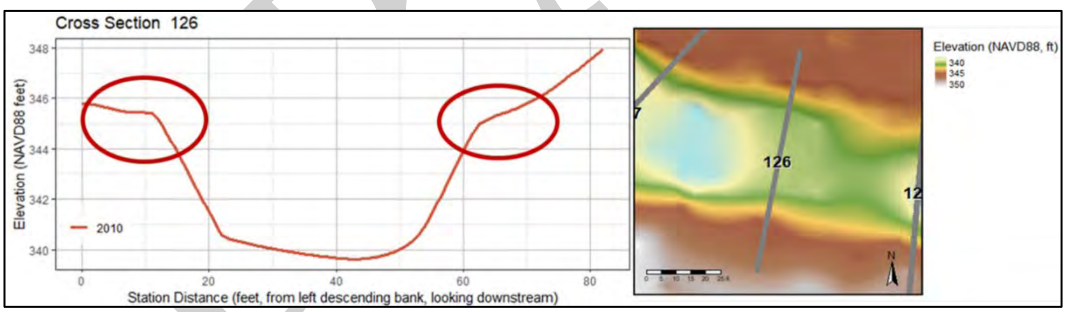
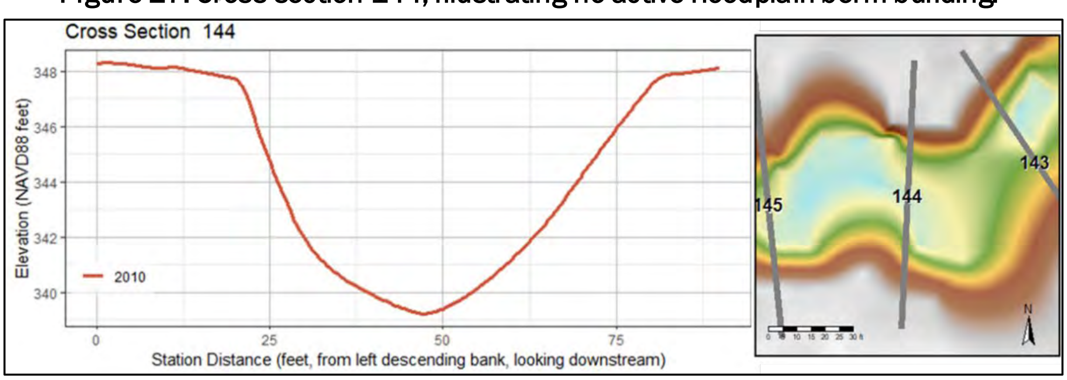


Figure 27. Cross-section 144, illustrating no active floodplain berm building.



The character of this reach changes dramatically from Reach 1. Upstream of Pleasant Hill Rd, the channel bed is comprised of very resistant clay that is limiting the degradation of this reach. It appears that the channel in Reach 2 has incised into this very resistant material and has essentially become locked in placed. In fact, Reach 2 has the characteristics of a throughput reach, where any sediment coming into the reach is transported through it with little to no change in the overall channel dimensions. Cluer and Thorne (2013) referred to this as “arrested degradation” where they argue that the channel is essentially non-alluvial and has limited value with respect to environmental quality. This reach does have a well-established woody riparian vegetation zone, and there does not appear to be the same degree of alternate bar development as observed in Reach 1. There does appear to be a few areas of localized bank instability, but the banks appear to be more stable, likely due to the resistant clay and cemented gravel strata that is controlling the bank toe. There are a few gullies present in this reach, but not as ubiquitous as in Reach 1.

Comparison of the DHP equilibrium slope curve suggest that Reach 2 is degradational. However, according to the Coldwater curve, only the upper 2,000 feet of the reach is degradational. The limited field investigations indicated that the channel bed was comprised predominantly of a hard clay material, with little to no sediment accumulation in the bed. As in Reach 1, we have adopted a conservative approach and have assumed that the channel may have degradational tendencies, albeit, at a very extremely slow rate due to the presence of the resistant bed material.

3 Summary of Findings

Based on the FG analysis and the limited field assessments the following reconnaissance level geomorphic information is provided as summaries of each reach.

3.1 Reach 1 Summary

Based on the FG Level 1 and field site analysis:

- Reach 1 appears to be stabilizing from a trend of degradation. Based on the field site visit, there is conclusive evidence of past bed degradation at the Sandridge Road Bridge (Figure 28) with localized areas of bank erosion (Figure 29) where the channel is still adjusting, or possible planform issues are causing accelerated erosion. The section is likely in a late CEM Stage IV.

Figure 28.Nolehoe Creek-Sand Ridge Road Bridge failure site (left bank)

Figure 29. Nolehoe Creek right bank erosion site with large point bar

- Other than the road culverts at Malone and Pleasant Hill, there were no identified GCS's in the reach. However, there is a presence of new floodplain berms forming in some areas within the channel especially in Reach 1 and upstream of the Malone Road Culvert.

- There is widespread tributary and small drainage channel instability along the margins, adjacent to the stream channel. As part of the Nolehoe Creek restoration and stabilization plan, additional analysis is required to treat the areas throughout the watershed.

3.2 Reach 2 Summary

Based on the FG Level 1 and field site analysis:

- The lower section of Reach 2 has non-alluvial channel characteristics. Based on the field site visit, there is conclusive evidence of past bed degradation and (Figure 30) localized bank erosion. The section has a very slow degradational trend (CEM II & III) because of the presence of a cohesive, erosion resistant clay bed and lower banks that have effectively locked the channel in place.

- Grade control is provided in the reach by the Pleasant Hill (Figure 31) and Malone Road Culverts. There is a marked channel change from relatively unstable conditions downstream to stable immediately upstream of the Malone Street Culvert.

- There is widespread tributary and small drainage channel instability along the margins, adjacent to the stream channel. As part of the Nolehoe Creek restoration and stabilization plan, additional analysis is required to treat the areas throughout the watershed.

Figure 30. Nolehoe Creek section approximately 1200 ft upstream of Pleasant Hill Road

Figure 31. Nolehoe Creek riprap structure immediately upstream of Pleasant Hill Road Culvert

- Grade control is provided in the reach by the Pleasant Hill (Figure 31) and Malone Road Culverts. There is a marked channel change from relatively unstable conditions downstream to stable immediately upstream of the Malone Street Culvert.

- There is widespread tributary and small drainage channel instability along the margins, adjacent to the stream channel. As part of the Nolehoe Creek restoration and stabilization plan, additional analysis is required to treat the areas throughout the watershed.

4 Recommendations: Nolehoe Creek Stabilization Plan

A rigorous assessment of the stability of Nolehoe Creek was not conducted. Therefore, there is considerable uncertainty in the findings of this study.

4.1.1 Reach 1 Plan

Reach 1 appears to have widespread local bank instability along the entire reach. It is difficult to state with certainty whether this is systematic instability associated with a degradational regime, or if it is local instability associated with alternate bars and locally shifting alignments. For Reach 1, we feel that the most effective way to achieve the project goals to minimize channel degradation, channel erosion, and sedimentation is through the construction of a series of grade control structures. The location of the proposed six grade control structures for Reach 1 are shown in Figures 32 and 33. It must be emphasized that the locations of these structures is preliminary and that final locations, and structure grades may change based on more detailed investigations. These structures would not only stabilize the channel grade against any future degradation but would also improve the local bank stability in this reach.

While the grade control structures will improve the bank stability in this reach, we feel that there is an opportunity to take advantage of the stabilizing effects of these structures to enhance the stability by applying bio-engineering techniques at localized areas of bank instability. As a rule, bio-engineering techniques without some structural element (riprap) in these highly unstable streams is not effective. However, in these straight reaches which would be hydraulically controlled by the grade control structures, we feel that these types of features could be successful. It should also be recognized that even if some of these features did fail, the consequences of failure and replacement costs would be minimal. These structures would also improve the aquatic habitat for macro-invertebrates, fisheries, and provide a more naturalized ecological environment. If stable habitat can be designed and implemented, then reaches will be re-established with the appropriate ecological functions. There is a noticeable lack of any woody vegetation zones along top bank in Reach 1. Therefore, consideration should be given to the construction of a woody vegetation riparian zone throughout Reach 1. There are also numerous gullies (about 10) in the reach that would benefit from the construction of riser pipes.

Figure 32.Grade Control Plan for Nolehoe Creek

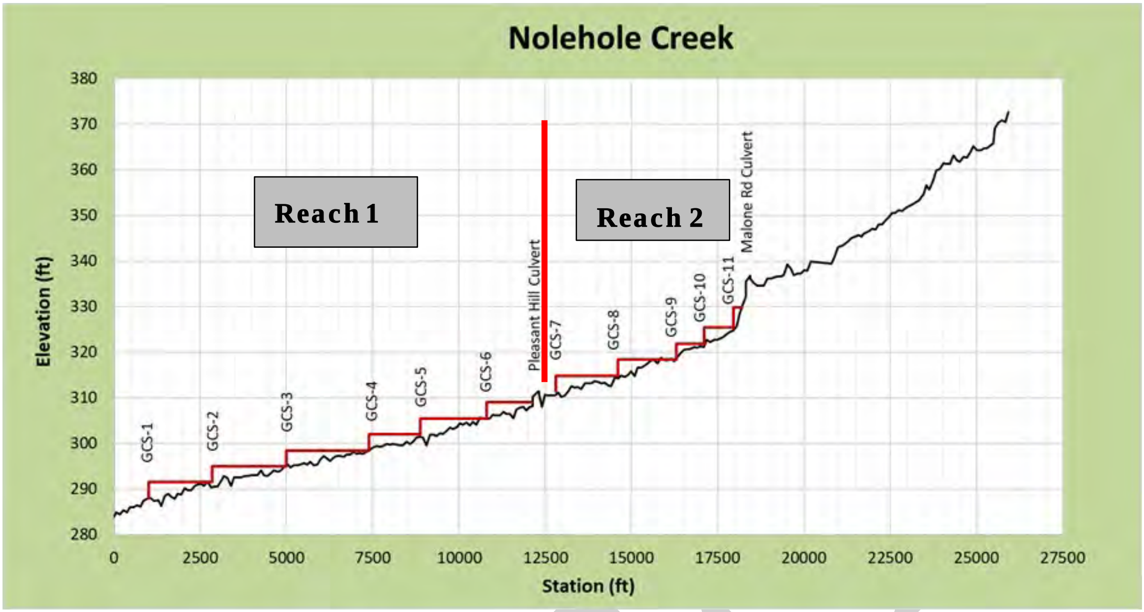


Figure 33.Grade Control Plan for Reach 1

4.1.2 Reach 2 Plan

As discussed previously, it appears that Reach 2 has essentially become locked in place and has limited environmental quality. For this reason, we feel that there is an opportunity to enhance the habitat conditions in this reach with a series of sloping rock riffle type of grade control structures.

The location of five proposed grade control structures in Reach 2 are shown in Figures 31 and 33. It should be emphasized that while these structures will add to the stability of the channel bed, their primary goal is to improve the aquatic habitat for macro-invertebrates, fisheries, and provide a more naturalized ecological environment. Although bank instabilities are not as widespread as in Reach 1, there are a few locations that could benefit from stabilization with bio-engineering techniques as described for Reach 1. There are a few (5-10) gullies that may also warrant the construction of riser pipes.

Figure 33. Grade Control Plan for Reach 1

5 Conclusions

Based on the limited amount of time and funding available to complete the geomorphic assessments, using existing tools such as the FG Level I Channel Stability Assessment are extremely important to provide the best available information. Continued refinement and development of rapid watershed assessment tools is of utmost importance.

A restoration toolkit based on Engineering With Nature (EWN) principles was developed for the DeSoto County Watershed Study and provides a basic information on possible restoration plans. It could be included for each to the watershed reports but was compiled and summarized as it generally relates to all watersheds in the study.

References

Cluer, B., & Thorne, C., 2013. A Stream Evolution Model Integrating Habitat and Ecosystem Benefits. River Research and Applications, DOI: 10.1002/rra.2631

Haring, C.H., and Dougherty, M.P. 2021. Geomorphic Metrics used on FluvialGeomorph. ERDC-CHL Technical Report (in-draft)

Haring, C. H., F. H. Weirich, B. D. Cramer, J. A. Dorale, T. C. Foster, and L. J. Weber. 2019. *An Assessment of a LiDAR-based Approach for Estimating Hydraulic Geometry Regional and Regime Relationship Curves for the Southern Driftless Area of the Midwest.*

Lane, E.W., 1955. The Importance of Fluvial Morphology in Hydraulic Engineering. Proceedings, American Society of Civil Engineers, Vol. 81, Paper 745, July.

Federal Interagency Stream Restoration Working Group (FISRWG), 1998. Stream Corridor Restoration: Principles, Processes and Practices. National Technical Information Service. U.S. Department of Commerce, Springfield, VA.

Schumm, S.A., Harvey, M.D., and Watson, C.C., 1984. Incised Channels: Morphology, Dynamics and Control. Water Resources Publications, LLC.

EDITOR WILL INSERT SF298 REPORT DOCUMENTATION FORM BEFORE FINAL REVIEW.