STARR II Strategic Alliance for Risk Reduction

MEMORANDUM

To: File

From: Stephanie Nurre

Nick Mueller

Date: March 20, 2020

Subject: Analysis and Mapping Procedures for Non-Accredited Levees

Initial Data Analysis Technical Memorandum

Village of Bolivar and Town of Bolivar, Allegany County, New York

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Introduction

This memorandum summarizes the initial data analysis performed by Strategic Alliance for Risk Reduction II (STARR II) in support of the Federal Emergency Management Agency (FEMA) Analysis and Mapping Procedures for Non-Accredited Levee Systems. The initial data analysis was performed for levee systems along the Root Creek in the Village and Town of Bolivar in Allegany County, New York.

The Village of Bolivar has a levee system constructed by United States Army Corps of Engineers (USACE). The levee system is known as the Root Creek Right Bank Levee system, located along Root Creek in the Village of Bolivar. It is part of the Root Creek Flood Control System which is located in the Village and Town of Bolivar

Root Creek flows from east to west through the Village and Town of Bolivar to its confluence with Little Genesee Creek. The flood risk due to the 1-percent-annual-chance flood (base flood) of Root Creek is contained within the Root Creek channel on the effective FEMA Flood Insurance Rate Map (FIRM) from 1996.

The locations of the levee systems are shown in Figure 1.

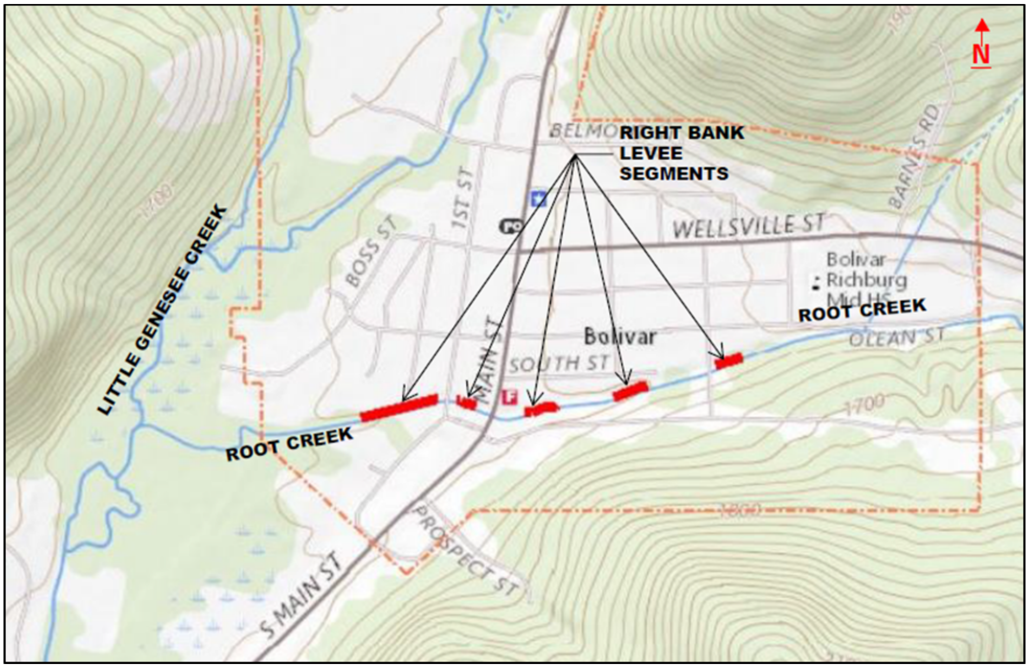


Figure 1: Root Creek Right Bank Levee System in the Village of Bolivar, NY

The effective hydraulic study for Root Creek was developed using HEC-2 hydraulic modeling software. This model is no longer available. The HEC-2 hydraulic modeling program is also not used for new studies. Since this model is not available, the HEC-RAS hydraulic model for Root Creek is leveraged from the *Region II Upper Allegheny Watershed (HUC8 - 05010001) BLE Analysis* prepared by STARR II (furthermore referenced as the Base Level Engineering (BLE) project) to conduct the initial data analysis.

The initial data analysis is performed to provide a first-pass estimate of the potential BFEs and inundation areas associated with the levee systems. Since the first-pass analysis leverages BLE project data that is based on more limited information than a detailed study, it cannot replace a detailed study. A replacement study must produce at least the level of output shown on the current FIRM.

The first-pass level results are also intended to help inform the scope of future detailed analyses. In the future, FEMA may fund a detailed study of Root Creek in the Village of Bolivar. Once a detailed study is available, the community will need to be re-engaged, and the potential analysis and mapping options for the levee systems will need to be re-evaluated with respect to the updated BFEs. The detailed study would supersede the effective FIS report and FIRMs when it becomes effective.

The hydrologic and hydraulic assumptions, approaches, and methodology to perform the initial data analysis for the base flood are summarized in this memorandum. FEMA guidance for these procedures are outlined in *Guidance for Flood Risk Analysis and Mapping, Levees* dated February 2019. Details regarding specific attributes of the levee system and available data are in the *Levee Analyses and Mapping Plan, Root Creek Flood Control System*.

BLE Project Hydrology Methods

The BLE project hydrologic analysis calculates peak discharges on a HUC-8 level using gridded input parameters, rural regression equations, and gage analysis, if applicable. Peak flowrates are computed for the 10-percent , 4-percent 2-percent , 1-percent , 1-percent plus, 1-percent minus, and 0.2-percent-annual-chance events at every cross-section of the stream network. The peak discharges were not modified as part of the initial data analysis. Information on the methodologies used to develop the BLE model peak flowrates is in the BLE project report.

BLE Project HEC-RAS Hydraulic Model

The BLE project estimates the flood hazard for Root Creek using HEC-RAS hydraulic modeling software. The methodology for these analyses included the following:

- Peak flowrates developed using regression equations;
- Topographic data processing of publicly available LiDAR;
- Basin-wide hydraulic analysis (HEC-RAS) and generation of approximate floodplain mapping; and
- Structure data based on the National Bridge Inventory.

While the BLE project produced water surface profiles for the flood events listed above, the BLE project produces a lower resolution flood hazard information than the effective studies of Root Creek. Information on the methodologies used to develop the BLE hydraulic models is in the BLE project report.

Modified BLE HEC-RAS Hydraulic Model

As part of the initial data analysis, the Root Creek BLE project model was modified. This analysis is the modified BLE HEC-RAS hydraulic model (modified BLE). The modified BLE model added channel geometry estimates and channel manning's values to the BLE project model for Root Creek. Additionally, in-line channel structures were incorporated based on available plans.

The Root Creek modified BLE model was also truncated at the confluence with Little Genesee Creek to refine the downstream boundary condition. This is because the Root Creek BLE model extended downstream into the Little Genesee Creek.

More information on the updates to the modified BLE model is provided in the *BLE Model Cross Section Geometry Updates* memo in Appendix A of this document.

Natural Valley Procedure

The modified BLE models were used to perform the Natural Valley Procedure to estimate the potential flood hazard of the levee systems.

The Natural Valley Procedure typically allows water to flow freely on either side of the levee system. This procedure is used to estimate the flood hazard on the landside of the levee system known as the levee impacted area. The levee impacted area is also commonly referred to as the levee protected area.

As part of the levee analysis, comparison of the levee crest profile elevations to the BFEs and minimum freeboard estimates are completed. To estimate minimum freeboard requirements, typically the "with levee" condition is modeled. The "with-levee" condition does not allow flow to be conveyed from the riverside to the landside of levee systems that have crest elevations higher than the BFE. The "with levee" condition may produce higher water surface elevations than the traditional Natural Valley Procedure, which allows flow on either side of the levee. Additional details about the "with levee" condition are provided below.

Because the "with levee" condition is used to estimate freeboard and may produce more conservative (higher) BFEs and larger inundation areas than the Natural Valley Procedure, the "with levee" BFEs are the Natural Valley Procedure for this project. The inundation extents of the base flood for the "with levee" condition are delineated by extending the BFEs landward of the levee until high ground is met.

Levee crest profiles and results for the Natural Valley Procedure are provided in the *Levee Analyses and Mapping Plan, Root Creek Flood Control Systems*.

"With Levee" Condition

As noted above, the "with levee" condition models a levee system as blocking flow from the river to the landside of the levee system, if the levee crest elevation is higher than the BFE. To evaluate this, the levee crest profile needs to be evaluated for each levee system.

Levee crest profile data is available for the Root Creek Right Levee System from the available 2-meter Digital Elevation Model (DEM) from the New York State Geographic Information Systems (GIS) Clearinghouse. This levee crest profile was also compared with the levee crest profile estimated from available plans. Profile exhibits comparing the levee crest profiles, base flood profiles, and estimated freeboard profiles for the Root Creek Right Bank Levee system are shown in Appendix B of the *Levee Analyses and Mapping Plan, Root Creek Flood Control System*.

Based on the available data and comparison profile exhibits, the crest elevations of the Root Creek Right Bank Levee are close, but slightly higher than the base flood profile for Root Creek.

While the levee system may be freeboard deficient, the estimated levee crest elevations are higher than the base flood profile. Therefore, the Natural Valley Procedure reflects the "with-levee" condition where the Root Creek Right Bank Levee system blocks flow from Root Creek from the landside area.

References

Lumia, Richard, Freehafer, D.A., and Smith, M.J., *Magnitude and Frequency of Floods in* New York: U.S. Geological Survey Scientific Investigations Report 2006–5112, 152 p, 2006.

New York Department of Environmental Conservation (2011), *Bolivar Flood Damage Reduction Project*, Region 9 Counties, http://www.dec.ny.gov/docs/water_pdf/fcpprjbolvar.pdf (last access March 11, 2020).

STARR II, *Region II Upper Allegheny Watershed (HUC8 - 05010001), Base Level Engineering Analysis*, draft 2019.

USACE *Hydrologic Engineering Center River Analysis System (HEC-RAS) v5.0.7.* United States Army Corps of Engineers, Hydrologic Engineering Center, 2019.

Appendix A

BLE Model Cross Section Geometry Updates

STARR II Strategic Alliance for Risk Reduction

MEMORANDUM

To: Cattaraugus and Allegany LAMP Project Team

From: Nick Mueller

cc: Stephanie Nurre

Date: December 10, 2019

Subject: BLE Model Modification Approach

Cattaraugus and Allegheny County LAMP Projects

The purpose of this memo is to describe a technical approach that may be used by the modeling team to update the Base Level Engineering (BLE) hydraulic model cross section geometry. The BLE model cross section geometry was generated directly from LiDAR and therefore does not incorporate below water (bathymetric) channel data.

The project team will update the cross-section geometry to incorporate estimated bathymetric data. The intent of incorporating the below water geometry is to more accurately model base flood 100-year water surface elevations for use in the Levee Analysis and Mapping Procedures for Non-accredited Levee systems first-pass level hydraulic analysis. For larger rivers, the below channel updates may be more significant. For smaller creeks and streams, the depth of water when the LiDAR was flown may be less, and therefore, the channel cross-section may need only minor adjustments. For consistency, the following approach should be used for each study area in Cattaraugus and Allegany Counties.

1. Truncate the BLE model

The BLE model should be truncated to the study area prior to making updates to the model geometry. The modeler should identify a location significantly far enough downstream to truncate the model where the downstream boundary condition is not controlling the 100-year water surface elevations through the study area. This can be checked visually in the profile editor. The model can be truncated upstream of the project area at a point where it is estimated the 100-year inundation limits no longer impact the study area.

2. Set Model Bank Stations

The next step should be to set the left and right bank stations in the RAS model. This can be done using RAS Mapper. The BLE models provided use one composite Manning's value across the entire length of the cross section. Bank stations should be set to distinguish the channel Manning's value with the adjacent floodplain Manning's 'n'. Setting bank stations will also provide a reference for setting the channel invert described in Step 3 below.

Channel bank stations should represent the location of the approximate bankfull elevation or roughly 1.2-year discharge. The bank stations can be set based on aerial imagery where there is a change in vegetation along the channel cross section. For larger rivers, the bank station location may be near the location where the normal water surface elevation intersects the ground. For smaller tributaries, the bankfull elevation may not correspond with the water surface limits but should be determined based on topography and changes in roughness. In most cases, the bank stations are typically below the physical 'top of bank' according to the LiDAR.

To set bank stations in RAS Mapper:

I. Create a new Geometry file with 'LAMP' in the name.

II. Begin editing the 'Bank Lines' layer. Draw two polylines representing the location of the left and right bank stations according to the above guidance.

III. Delete the bank lines (red lines) which are currently at the ends of the model cross sections. 'Stop Editing'

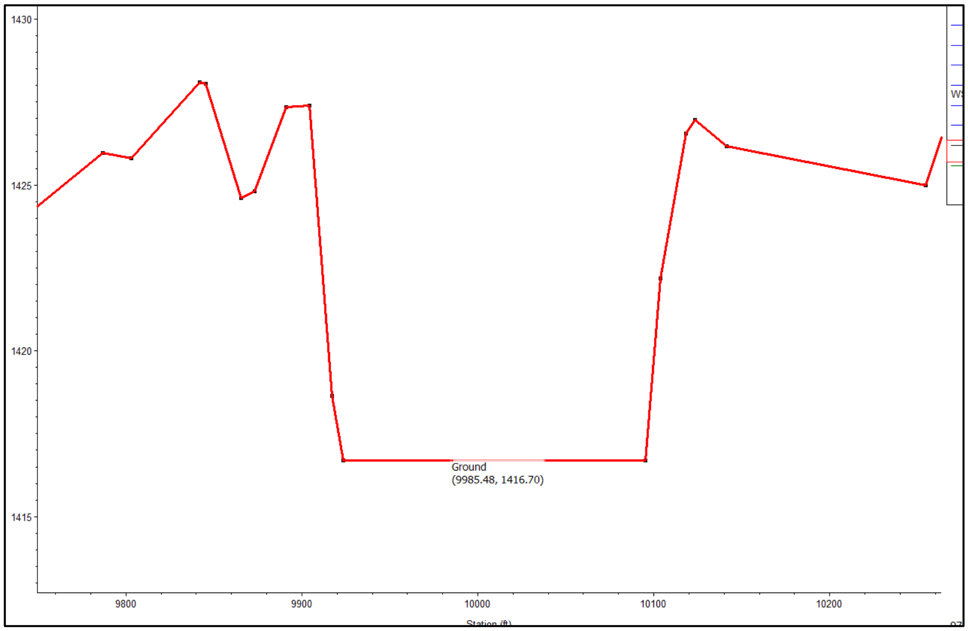
IV. Begin Editing 'Cross Sections'. Right Click 'Cross Sections' and 'Compute' → 'Bank Stations'. The Bank stations should snap to the intersection of the new bank line and model cross section. Done.

3. Channel Bathymetry and Invert Elevations

The below water surface topography needs to be estimated. The intent is to assume additional capacity for conveyance, but not to overestimate available channel conveyance. A channel invert elevation also needs to be estimated. With limited data available to the project team, this may be done with the following information:

The steps to assume a channel invert elevation are described in section 4. The steps to do this are as follows:

a) Identify location of study channel in BLE section. Typically, the 'flat' location in the geometry.



b) Incorporate an assumed below water surface geometry. *Note this approach may need modified on a case-by-case basis.

   a. Use the RAS 'Channel Design/Modification' Tool (Tools/Channel Design Mod)

b. Create a 'Template Design'

   i. First save a 'New Template'
   ii. Type – Simple Trapezoid
   iii. Channel Depth = ½ Bankfull Depth (Streamstats, described in Section 4)
   iv. Bottom Width = ¼ the Bankfull Width (Streamstats)
   v. Side Slope = Based on existing stream, assume between 15H:1V and 25H:1V
   vi. Manning's 'n' = 0.030 (main stem) or 0.035 (tributaries)
   vii. Daylight Slope = 5 (this will be somewhat arbitrary)

c. Create New Channel Geometry

   i. In Channel Design Main Window – apply the Template just created (drop-down)
   ii. Confirm Channel is centered between bank stations
   iii. Assign Channel invert 'Fixed Elevation according to section 4 below

4. Assign Channel Invert Elevations

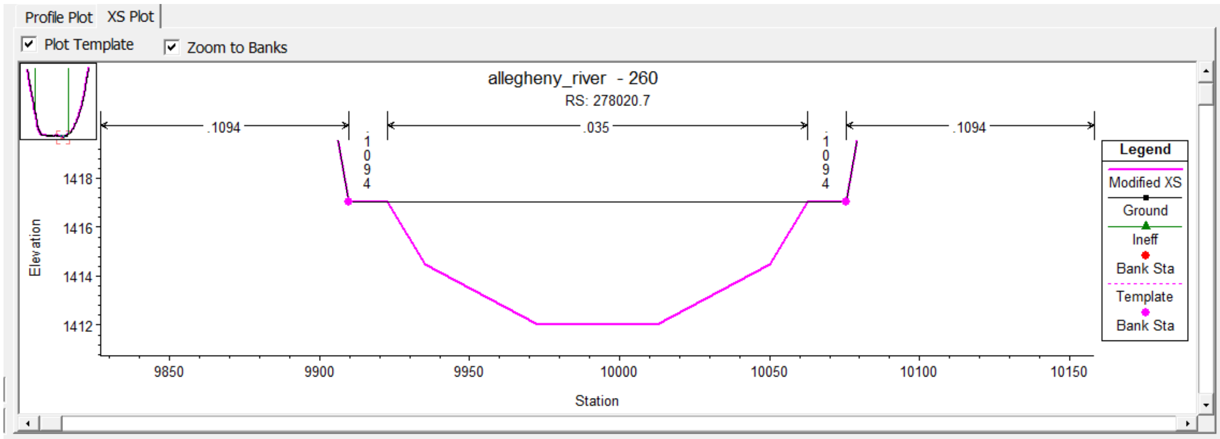
Channel Inverts can be assigned using either:

1. The Effective Flood Insurance Study (FIS) profile
2. Streamstats bankfull depth parameter

It is recommended to use option 2 above and compare with the effective FIS profile for reasonableness. Option 2 should be more efficient than pulling invert elevations and georeferencing effective FIS profile information.

In Streamstats, the modeler should find the study location and select a representative location for bankfull computations. This will likely be the 'middle' of the study reach since we will apply the values upstream and downstream.

   i. Using Streamstats Bankfull Depth, assign the 'Fixed Elevation' the Channel Design/Mod editor
   ii. The Fixed Elevation at each cross section can be calculated as
      1. Fixed Elevation = Bank Station Elevation – Bankfull Depth
      2. If the left and right bank station elevations are different, use the average elevation, or the one that appears most correct
   iii. The Editor should now look like this example:

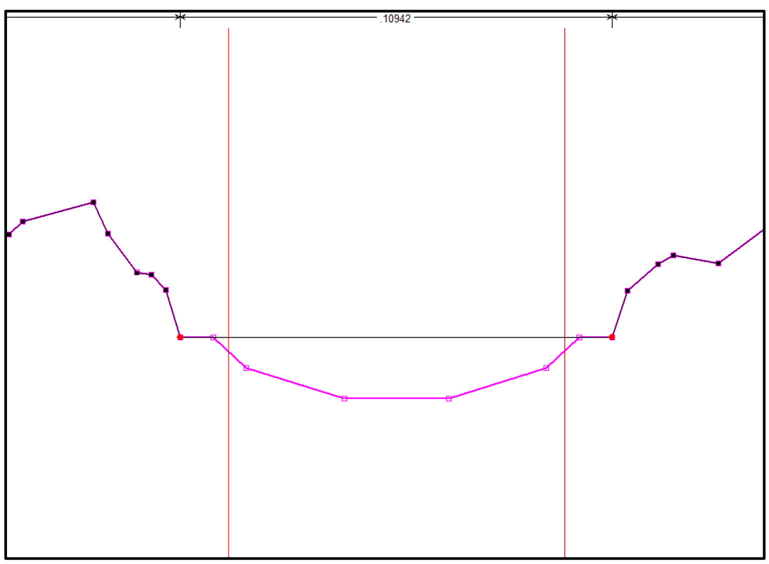


a. Ensure the template XS channel geometry is contained within the bank stations.

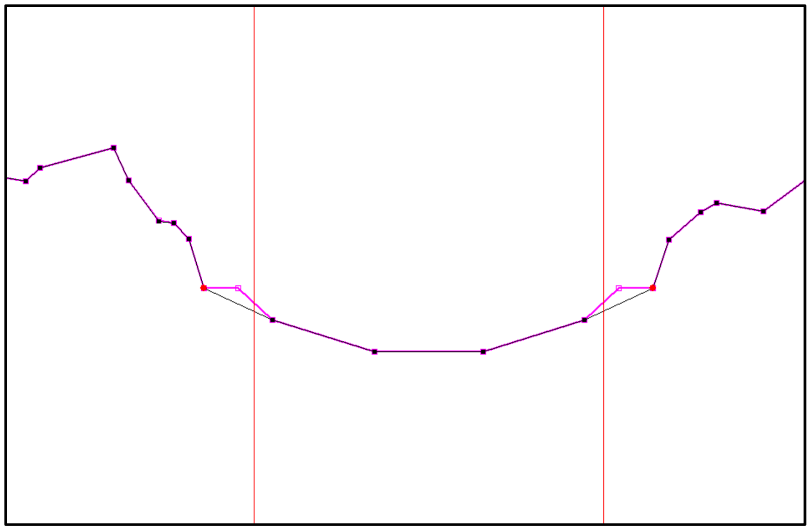
b. 'Click' – "Create a Geometry File with these Modifications" and save this file with 'Merge' in the name. Say 'Yes' when prompted to save the design edits.

c. Merge Channel data into 'LAMP' Geometry

iv. Merge only the channel data below the 'daylight' slope. Set the merge lines in the middle of the 'daylight' slope.



i. The result should be a 'smooth' transition between the template cross section and LiDAR geometry. Final channel is represented by the black line.



5. Other geometry updates

a. Consider revising expansion/contraction coefficients around structures

   i. One cross section downstream, two cross section upstream