ATKINS

Lower Hassayampa River Sediment Transport Model Update Summary Final Report

FCD2014C002

WORK ASSIGNMENT #1

Prepared For:

Flood Control District of Maricopa County

Prepared By:

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Phoenix, AZ

June 2015

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Transmittal Memorandum

ATKINS

Date: June 30, 2015

Project: Modeling of Sediment Transport in Hassayampa River

To: Bing Zhao, PhD, PE
Branch Manager
Engineering Application Development and River Mechanics Branch
Flood Control District of Maricopa County

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FLOOD CONTROL DISTRICT

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Subject: FCD2014C002 WA #1 Final Draft Report Submittal

The following items are being submitted to the Flood Control District of Maricopa:

- Lower Hassayampa River Sediment Transport Model Update Summary Final Report
- DVD containing all models, results, plots, data, and tables

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Expires 6/30/17

EXECUTIVE SUMMARY

The Flood Control District of Maricopa County (FCDMC) contracted Atkins under the On-Call Contract FCD2014C002 to perform updates to existing sediment transport models for the Lower Hassayampa River. The work assignment considered 27 miles of the Lower Hassayampa River extending from the Gila River at the downstream end to a location near the CAP siphon at the upstream end. In May 2010, the District obtained new 2-ft accuracy topographic mapping data of a portion of the Lower Hassayampa River ranging from river mile 4.15 to river mile 18.81 to represent post-flood conditions after January 2010 flood event. The focus of this work assignment is the incorporation of this post-flood 2010 topography into existing HEC-6, HEC-6T and FLUVIAL-12 sediment transport models of the Hassayampa River that were developed through previous District-funded projects. The updates performed also included incorporation of 2010 topography and the sediment transport component into an existing HEC-RAS hydraulic model developed by Stantec as part of Lower Hassayampa River Watercourse Masterplan Phase 2.

A few sand and gravel mining pits are located along the Lower Hassayampa River. The model geometry updates performed include development of both the existing conditions and the with-pit condition sediment transport model geometries. The with-pit condition sediment transport models incorporated the mining pit design plan information from five active District-approved Sand and Gravel mining permits.

The model updates used 100-year and long-term hydrographs from the existing conditions HEC-6 sediment transport model developed as part of the Lower Hassayampa River Watercourse Masterplan by JE Fuller Hydrology and Geomorphology.

Model simulations were performed using the updated models for the 100-year, and long-term flood events for the existing and with-pit conditions. The model inputs and results are presented graphically using cross-section and profile plots. In summary, it is noted that the update focus is on the inclusion of post-flood 2010 topography while retaining most of the other parameters from existing models.

1 INTRODUCTION

The Flood Control District of Maricopa County (FCDMC/District) contracted Atkins by issuing a Work Assignment #1 under the On-Call Contract FCD2014C002 to perform updates to existing sediment transport models for the Lower Hassayampa River.

This sediment transport model update considered 27 miles of the Lower Hassayampa River extending from the Gila River at the downstream end to a location near the CAP siphon at the upstream end. Appendix A contains a map of the Lower Hassayampa River including model geometry cross-sections numbered using river mile values starting from 0.35 at downstream end at the Gila River to 27.89 near the CAP siphon.

The Flood Control District of Maricopa County (FCDMC) provided Atkins with the following existing models at the beginning of the work assignment:

- Existing HEC-6 sediment transport model for the Lower Hassayampa River Water Course Master Plan (JE Fuller, April 2006)
- Existing Fluvial-12 sediment transport models (Model 1 and Model 2) for the Lower Hassayampa River (Chang Consultants, May 2009)
- Existing HEC-6T sediment transport model for the Lower Hassayampa River (WEST Consultants, July 2012)
- Existing HEC-RAS hydraulic model for the Lower Hassayampa Water Course Master Plan (Stantec, June 2013)

These models are referred to as "existing" models in this report. The main purpose of the work assignment is to update these existing models using the existing condition cross-section data obtained from the recent HEC-RAS model of the subject reach which was developed as part of Phase 2 Existing Condition for the Lower Hassayampa Watercourse Masterplan (Stantec, 2013). Further details on the model updates are presented in Section 2.

2 IMPLEMENTATION OF THE MODEL UPDATES

This section documents the details of all the model updates. The cross-section geometry update, mining pit implementation, and hydrograph update are discussed in Sections 2.1, 2.2 and 2.3 respectively. Additional model specific implementation details are presented in Sections 2.4, 2.5, 2.6, and 2.7 for the HEC-6, HEC-6T, FLUVIAL-12 and HEC-RAS models respectively.

2.1 Cross-section Geometry Update

One of the key updates performed as part of this work assignment is the cross-section geometry update using the post-flood 2010 topography. In May 2010, the District obtained new 2-ft accuracy topographic data for a portion of the Lower Hassayampa River ranging from river mile 4.15 to river mile 18.81. This new topographic data was obtained as part of Lower Hassayampa River Watercourse Masterplan Phase 2 (LHWCMP Phase2) Study (Stantec, 2013). This topographic data was developed after the flooding event that occurred in January 2010 to provide the post-flood topographic data. Stantec (2013) incorporated this new topography into a HEC-RAS hydraulic model for the District as part of LHWCMP Phase 2. Cross-section data from this HEC-RAS model were used to update the geometry (stations and elevations), channel reach lengths and bank stations of existing HEC-6, HEC-6T and FLUVIAL-12 sediment transport models. These existing sediment models were developed by the District through other previous District projects (See Section 1 for more details). The updates performed for this work assignment also includes incorporation of sediment transport component into the HEC-RAS model developed by Stantec (Stantec, 2013).

The following summarizes a general guidance from the District staff regarding how to use ineffective flow areas for sand and gravel pits in the sediment transport models:

- For Existing Condition Models
  - If Stantec's HEC-RAS model blocked a sand and gravel pit by ineffective flow area approach, then remove the blockage; if Stantec's HEC-RAS model did not block the pit, then do not block it.
  - If Stantec's HEC-RAS model used ineffective flow to block non-pit area, then keep the ineffective flow areas.
- For Ultimate Pit Condition Models
  - If the sand and gravel pit has the approved erosion-protection berms that prevent flow from entering into it, then block the pit. Such erosion-protection berms should have been previously approved by the District as part of a sand and gravel permit.
- For All Models

  - If Stantec's HEC-RAS model does not have ineffective areas in a cross section, please do not add any ineffective areas, except for those pits with erosion-protected berms.

- For Ultimate Pit Condition Models
  - The ultimate pit condition models should be checked against the previously approved sediment transport models that are part of an approved sand and gravel mining permit to make sure the number of cross sections, cross section locations, and cross section geometries are the same as those in the approved models near the pit. If there is an error found in the previous models, then the corrections should be made according to the approved sand and gravel mining plans. If there is no previously approved model, then develop the pit conditions model based on the approved plans. For example, for the pit SG06-005, there is an approved HEC-6 model. It also has a new cross-section added near cross-section 8.22. Therefore, this new cross-section should be added. Other pits such as FA01-113, SG13-002 and SG07-001 also have a previously approved sediment transport model.

The cross-section updates to the HEC-6, HEC-6T and FLUVIAL-12 sediment transport models were performed by using the following procedural details:

- Custom programmatic coding was used to read the geometry data from the Stantec HEC-RAS geometry file (Phase2_existing.g01) and converted to ASCII text files that represents the HEC-6, HEC-6T and FLUVIAL-12. The geometry data included cross-section stations, cross-section elevations, channel reach lengths, and bank stations.
- At cross-sections where the number of geometry points exceeded the maximum allowed in HEC-6, the number of points were reduced using Douglas-Peucker line simplification. Douglas-Peucker simplification method reduces the number of points along a two-dimensional line while retaining the shape as closely as possible.
- The flows exhibit channel overtopping and split flow characteristics at the downstream end of the Lower Hassayampa River. This occurs at locations downstream of river mile 4.00. The Stantec (Stantec, 2013) HEC-RAS hydraulic model replicates these characteristics using lateral weir and split flow options within HEC-RAS. In that mode, the flows are modeled as three separate channels (left overbank channel, main channel, right overbank channel) downstream of river mile 4.00. However, the sediment transport models consider only the main channel since significant sedimentation is anticipated only within the main channel. Based on this assumption, only the main channel is implemented in all the sediment transport model updates for river miles below 4.00 and the overbank split channels are not modeled for sediment transport.
- Additional points were included in the HEC-6, HEC-6T and FLUVIAL-12 models so that a maximum distance of 100 feet is allowed between adjacent points representing the cross-section geometry. Sediment transport models simulate changes in the cross-

section geometry by shifting the elevation of the geometry points up or down and having more points in the geometry results in smoother transition minimizing potential inaccuracies. This step is performed to obtain smoother cross-section geometry shifts due to sedimentation during the course of the model simulation.

- The ineffective areas were modified using the ineffective area locations from the Stantec (Stantec, 2013) HEC-RAS model as the default. It should be noted that HEC-RAS has the capability of defining the ineffective flow areas in a detailed fashion using features such as multiple ineffective flow areas. However, the capabilities of other sediment transport models (HEC-6, HEC-6T and FLUVIAL-12) are more limited and additional simplifying assumptions are sometimes needed to reasonably implement the ineffective flow areas. Sections 2.4, 2.5, and 2.6 contain additional details on model specific ineffective area implementation for the HEC-6, HEC-6T, and FLUVIAL-12 models respectively. The HEC-RAS sediment transport model geometry is based on the Stantec HEC-RAS hydraulic model geometry (Phase2_existing.g01). Therefore, it is not subject to the same limitations as that of HEC-6, HEC-6T and FLUVIAL-12.
- In some cross sections it was necessary to block low-flow channels outside of the bank stations in order to keep flow within the main channel. In HEC-6 and HEC-6T low-flow channels are blocked by defining encroachment stations. In Fluvial-12 and HEC-RAS these channels are blocked using ineffective flow areas.

Additional update details on model specific cross-section conversions are presented in Sections 2.4, 2.5, 2.6, and 2.7. A list of key cross-section related changes performed to the sediment models are presented in a table in Appendix B.

2.2 Mining Pit Geometry Updates

The District provided Atkins with five active mining permits in the area considered during this work assignment. These five active mining permits allow nine pits to be excavated. The permit number, intersecting cross sections from the updated models, and relevant information for each pit is provided in Table 1.

Table 1 District-Approved Active Mining Pits

Pit	Permit Number	Cross Sections	Description
Western Aggregates Phase I & II	SG07-001	5.38-6.05	Approximately 20 feet deep, 3:1 side slopes, within floodway, approximately 2000 feet wide, revised Feb-2013
ABC Sand and Gravel Phase II	SG06-005	7.47-8.21*	Approximately 15 feet deep, 3:1 side slopes, within floodway, approximately 1000 feet wide, revised Sep-2007
ABC Sand and Gravel Phase I	SG06-005	7.84-8.13	Approximately 60 feet deep, 3:1 side slopes, outside floodway with berm, variable width, plans checked May-2007
Hanson Aggregates Instream Pit 2	SG13-002	12.18-12.66	Approximately 10 feet deep, 5:1 side slopes, within floodway, approximately 1500 feet wide, geometry used is from closure plans checked Apr-2015
Hanson Aggregates Overbank Pit 1	SG13-002	12.66-12.85	Approximately 50 feet deep, 3:1 side slopes, within floodway, approximately 800 feet wide, Apr-2015 closure plans used for geometry in "ultimate pit" model
Cemex Parcel 3 Pit	SG03-002	13.23-13.61	Approximately 30 feet deep, variable side slopes, within floodway, approximately 1500 feet wide, plans dated Arp-2005
Pioneer Sand and Gravel Area 3	FA01-113	13.98-14.83	Approximately 30 feet deep, 3:1 side slopes, within floodway, approximately 1500 feet wide, plans stamped Feb-2009
Pioneer Sand and Gravel	FA01-113	14.92-15.78	Approximately 30 feet deep, variable side slopes, within floodway, approximately 1700 feet wide, plans stamped Feb-2009
Pioneer Sand and Gravel	FA01-113	15.59-15.87	Approximately 75 feet deep, variable side slopes, outside floodway with berm, approximately 600 feet wide, plans checked Jun-2006

*Cross section was added to the existing models

The procedure adopted for the cross-section geometry updates at pit locations is as follows:

- The plan details of mining pits were imported in ArcGIS software as scanned images and were georeferenced within ArcGIS. The cross-section alignments were overlaid on top of these images to achieve positional integrity between the geo-referenced mining plan and cross-sectional stationing.
- The cross-section geometry table was altered within HEC-RAS to implement the pit bottom and side slopes (adjusted for non-orthogonal cross section angles). The station locations were measured using the distance tool within GIS. Pit bottom elevations were read off the mining plans. The pit-related cross-sectional geometry updates were first implemented in the HEC-RAS geometry. The updated cross-sections were then transferred from HEC-RAS into the HEC-6, HEC-6T, and FLUVIAL-12 models using the custom programmatic coding discussed in Section 2.1.
- Two additional cross-sections were added to all updated models at river miles 8.21 and 8.54. This was done to match cross sections added to the HEC-6 and HEC-RAS models created by ABC Sand and Gravel. The District provided the ArcGIS TIN Surface used by Stantec for the LHWCMP Phase 2. The cross-section geometry was extracted from this TIN Surface and imported into the HEC-RAS model. The updated cross-section was then transferred from HEC-RAS to HEC-6, HEC-6T and FLUVIAL-12 models using custom programmatic coding discussed in Section 2.1.
- Cross section geometry at Hanson Aggregates Overbank Pit 1 reflects fill required to bring the pit to its closure condition. This was done using the procedure mentioned above.
- Any ineffective flow areas or channel conveyance limits at locations where permits or aerial photographs indicated the presence of mining pits were moved beyond the extent of excavation to allow flow to enter the pits.
- Two pits have bank protection to prevent flow from entering the excavated area (see Table 1). The Levee option in HEC-RAS was used to prevent flow from entering the pits. Similarly, ineffective flow areas were used to block flow in the HEC-6, HEC-6T, and Fluvial-12 models. The height of the levees and ineffective flow areas correspond to the height of the berms shown in the permits.
- Bank station locations were shifted to adequately represent the main channel flowpath under the with-pit conditions. It may be noted that the application of Manning's n distribution within HEC-6 and HEC-6T are dependent on the bank station location. Therefore, any shift in the bank station location also represents a corresponding shift in the Manning's n distribution.

2.3 Hydrograph Updates

The 100-year and long-term hydrographs were obtained from the existing HEC-6 model developed by JE Fuller (JE Fuller, 2006). The JE Fuller model included both hydrographs in a single model with the long-term hydrograph occurring ahead of the 100-year hydrograph. For the model updates, these hydrographs were split into two separate hydrographs resulting in two separate model run simulations for the long-term and 100-year scenarios.

2.4 HEC-6 Model-Specific Implementation Details

The model-specific implementation details for HEC-6 are listed below:

- The cross-section geometry, bank stations and reach lengths for the updated HEC-6 models were generated using custom programmatic coding that converts HEC-RAS geometry to X1 and GR records as needed by HEC-6.
- The ineffective areas and blocked obstructions were implemented using XL and X3 records. In HEC-6, XL records are used to represent conveyance limits while the X3 records are used to represent effective flow areas. HEC-RAS allows detailed specification of ineffective areas and blocked obstructions within the cross-section which may be specified along multiple segments along the cross-section. In comparison, HEC-6 has the limitation of using only these two records to specify with one limit on each side of the channel. Therefore, engineering judgment was used to prioritize the most dominant ineffective areas and/or blocked obstructions for cases where there are more than two ineffective and blocked areas. An appropriate implementation strategy was adopted at these cross-sections using the following conceptual knowledge:
    - The ineffective flow areas implemented using X3 records alter the bottom of the cross section prior to any hydraulic or sediment transport calculations (i.e. elevate the bottom of the cross section in the region of ineffective flow).
    - Deposition is allowed outside of the conveyance limits defined by the XL record.
    - Scour only occurs if it is within the movable bed, within the conveyance limits, within the effective flow limits defined by the X3 record, and below the water surface.
- The cross-section plots provided with the HEC-6 models can be used to view the locations of ineffective areas and blocked obstructions within the cross-section. These plots can be used to make a visual comparison of the ineffective area and blocked obstruction implemented within the HEC-6 model and existing Stantec (Stantec, 2013) HEC-RAS model.
- The sediment transport function used in the HEC-6 models is based on the Tofalleti and Meyer-Peter-Muller Combination.

2.5 HEC-6T Model-Specific Implementation Details

The model-specific implementation details for HEC-6T are as follows:

- The cross-section geometry, bank stations, and reach lengths for the HEC-6T models were generated using custom programmatic coding that converts HEC-RAS geometry to X1 and GR records as required by HEC-6T.
- The ineffective areas and blocked obstructions were implemented using XL and X3 records. In HEC-6T, XL records are used to represent conveyance limits while the X3 records are used to represent encroachment. HEC-RAS allows detailed specification of ineffective areas and blocked obstruction within the cross-section which may be specified along multiple segments along the cross-section. In comparison, HEC-6T has the limitation of using only these two records to specify with one limit on each side of the channel. Therefore, engineering judgment was to prioritize the most dominant ineffective areas and/or blocked obstructions for cases where there are more than two ineffective and blocked areas. The approach adopted is similar to the approach adopted for HEC-6 (See Section 2.4)
- The hydrograph for the HEC-6T models were based on the WEST Consultants HEC-6T model (WEST, 2012). The HEC-6 sediment transport model by JE Fuller, 2006 was converted by WEST Consultants to HEC-6T for the District. Therefore, it was deemed appropriate to use the hydrograph records from WEST Consultants HEC-6T model as the basis for the generation of the 100-year and long-term hydrographs for the HEC-6T models.
- The cross-section plots provided with the HEC-6T models can be used to view the locations of ineffective areas and blocked obstructions within the cross-section. These plots can be used to make a visual comparison of the ineffective area and blocked obstruction implemented within the HEC-6T model and existing Stantec (Stantec, 2013) HEC-RAS model.
- The sediment transport function used in the HEC-6T models is based on the Tofalleti and Meyer-Peter-Muller Combination.

2.6 FLUVIAL-12 Model-Specific Implementation Details

The model-specific implementation details for FLUVIAL-12 are as follows:

- The cross-section geometry and reach lengths for the FLUVIAL-12 model were generated using custom programmatic coding that converts HEC-RAS geometry to X1 and GR records as required by FLUVIAL-12.
- The ineffective areas and blocked obstructions are implemented by increasing the elevations GR records to the elevation needed by the prescribed ineffective areas.
- The hydrograph data was extracted from Q and X records in the JE Fuller HEC-6 model (JE Fuller, 2006) and converted into the format required by FLUVIAL-12 using a spreadsheet. Once converted, the data was copied into the FLUVIAL-12 model and edited using a text editor.
- The cross-section plots provided with the FLUVIAL-12 models can be used to view the locations of ineffective flow areas and blocked obstructions within the cross-section. These plots can be used to make a visual comparison of the ineffective area and blocked obstructions implemented within the FLUVIAL-12 model and existing Stantec (Stantec, 2013) HEC-RAS model.
- The sediment transport function used in the FLUVIAL-12 models is based on the Engelund Hansen Equation.

2.7 HEC-RAS Model-Specific Implementation Details

The model-specific implementation details for HEC-RAS are listed below:

- The data for the sediment transport component was derived from the existing JE Fuller HEC-6 model (JE Fuller, 2006). Key data derived in this manner include sediment inflow at model upstream, sediment gradation data and rating curve at the downstream end.
- Ineffective flow areas were added to block low-flow channels and keep flow within the channel banks where necessary.
- The updated HEC-RAS sediment transport model includes only the main channel for the cross-sections downstream of river mile 4.00 and does not include the lateral weir overtopping and split flows modeled in the existing Stantec HEC-RAS (Stantec, 2013) model.
- Cross section 27.75 had a region of excavation blocked with an ineffective flow area in the existing JE Fuller HEC-6 model. This ineffective flow area was removed in all models except the HEC-RAS model. This cross section is immediately downstream of the upstream boundary condition. Removal of the ineffective flow area caused numerical instability in the model. In addition, it was determined that retaining the ineffective flow area would not significantly alter the results of the model.

- Two profiles are created for the 100-year and long-term hydrograph simulations. The hydrograph information was derived from the existing JE Fuller HEC-6 model (JE Fuller, 2006).
- There is an excavated site at cross section 27.75 which has been blocked using an ineffective flow area for the HEC-RAS Ultimate Pit Condition Model. Cross section 27.75 is just downstream from the upstream boundary condition. This ineffective flow area was added
- The sediment transport function used in the HEC-RAS models is based on the Engelund Hansen Equation.

3 Modeling Simulations and Results

Using the procedures presented in Section 2, the following models were created.

HEC-6 version 4.2 (May 2004):

- Existing condition: long term followed by 100-year simulation
- Existing condition: 100-year simulation
- Existing condition: long term simulation
- Ultimate pit condition: 100-year simulation

HEC-6T version 5.13.22.08t(1010121644):

- Existing condition: long term followed by 100-year simulation
- Existing condition: 100-year simulation
- Existing condition: long term simulation
- Ultimate pit condition: 100-year simulation

Fluvial-12 (Jan 2015):

- Existing condition: 100-year simulation
- Existing condition: long term simulation
- Ultimate pit condition: 100-year simulation

HEC-RAS version 4.1.0:

- Existing condition: 100-year simulation
- Existing condition: long term simulation
- Ultimate pit condition: 100-year simulation

Model simulations for all these scenarios have been performed. Profile plots for each updated model are presented in Appendix C. The plots in Appendix C show the input and output (initial and final) thalweg profiles for each model. The pits with berm protection were blocked prior to plotting the initial thalweg profile. Additional cross section and river profile plots can be found on the DVD accompanying this report for each HEC-6, HEC-6T, and Fluvial-12 model. Appendix D contains maximum scour plots and the corresponding data in tabular format. The maximum scour is the minimum bed elevation recorded in the model minus the minimum initial bed elevation (excluding values within ineffective flow areas or channel conveyance limits) at each cross section. Only positive values, indicating erosion/scour, are reported in the table and figures in Appendix D. The following outlines the procedure used to determine the minimum bed elevation for each of the modeling programs:

- HEC-6: The character B was used in the sixth column of each * record in the 100-year hydrograph. This produced a table of thalweg elevations for each cross section at each 15-minute time step in the output file. Custom programmatic coding was used to determine the minimum bed elevation at each cross section for all time steps.
- HEC-6T: A $MXMN record with values of 3 in the first four fields was inserted at the beginning of the hydrograph records. This produces a table with the minimum bed elevations for each cross section during the model run.
- Fluvial-12: Field seven in the G4 record was set to "1". This causes the TZMIN.DAT to be generated when the model is run. The TZMIN.DAT contains the minimum bed profile.
- HEC-RAS: Profile/time series output was generated at each time step during the model run. The minimum bed elevation for at each cross section for all time steps was determined.

The model results for HEC-6 and HEC-6T are very similar. Increased scour is observed in the Fluvial-12 and HEC-RAS models. Maximum scour in the HEC-RAS model is 20-feet; Fluvial-12 has no such limit. Headcuts migrate further upstream in HEC-RAS and Fluvial-12, which contributes to the increase in scour observed in these models. Differences in the sediment transport functions used in each model may contribute to increased scour and headcut travel. In general, the HEC-6 and HEC-6T models that use Tofalleti-MPM equation seems to predict lower maximum scour depths than the Fluvial-12 and HEC-RAS models that use Engelund-Hansen equation. Overall, the most notable discrepancies between the models occur in the vicinity of mining pits.

4 SUMMARY AND RECOMMENDATIONS

Model simulations were performed using updated models for the 100-year, long-term flood events for the existing and with-pit conditions. The model inputs and results are presented graphically using cross-section and profile plots. These plots are included electronically in the DVD provided with this report. Appendix F contains a description of the contents of the accompanying DVD. The scope of the work performed as part of the work assignment is limited to model updates to incorporate recent 2010 topography and splitting the hydrographs to generate separate 100-year and long-term models. While performing the updates, most of the other modeling input parameters such as sediment gradation, sediment inflow, and Manning's n values were not updated and were retained as-is from existing models. It should be noted that the work assignment did not include any fixed bed model analysis and model sensitivity to parameters such as sediment inflow and manning's n values.

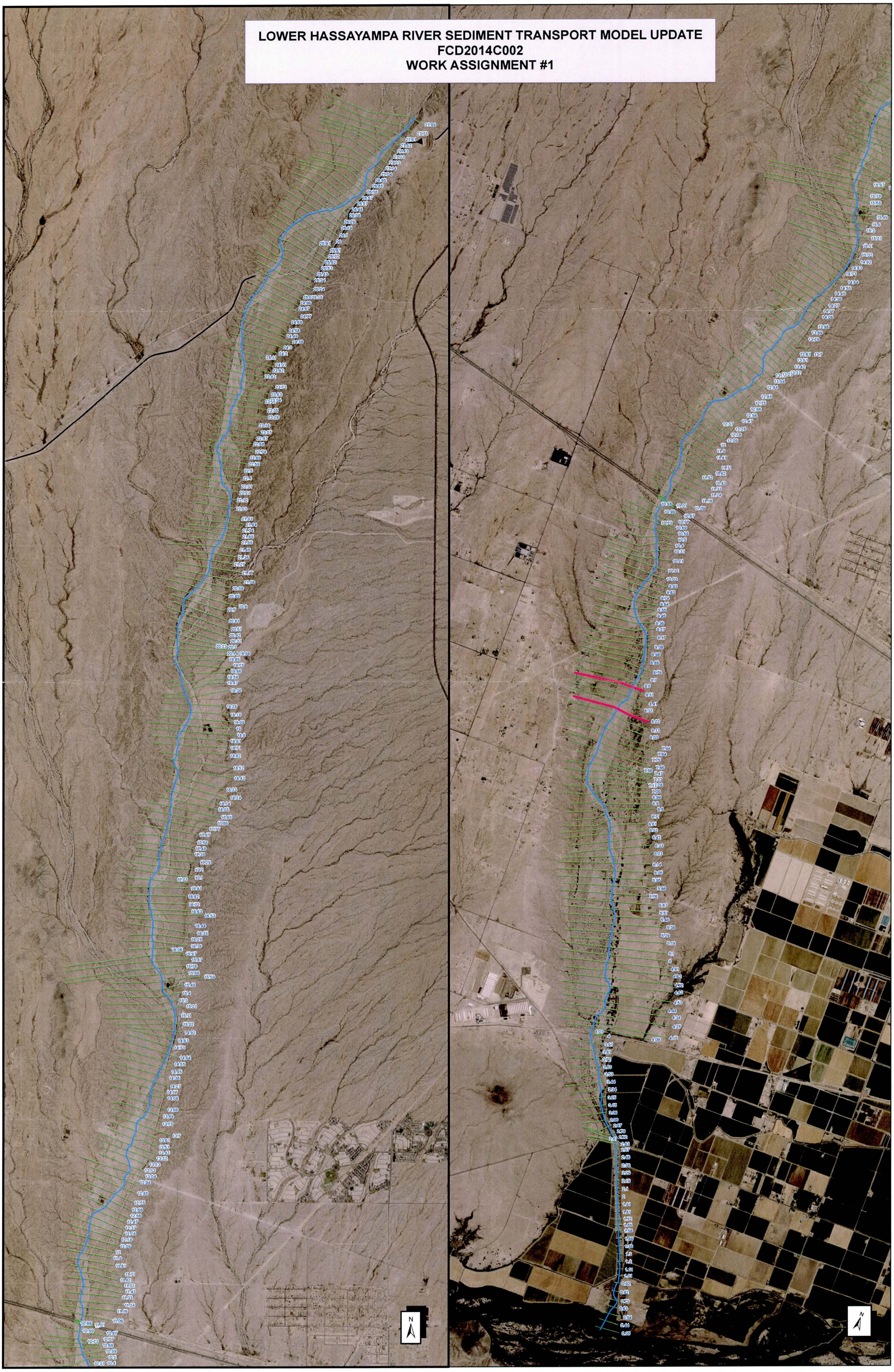
5 REFERENCES

- WEST Consultants, July 2012, Conversion of the Lower Hassayampa HEC-6 Sediment Transport Model to HEC-6T
- Chang Consultants, May 2009, FLUVIAL-12 Modeling of Sand Mining Impacts for Lower Hassayampa River
- JE Fuller, April 2006, Lower Hassayampa River Water Course Master Plan, River Behavior Report
- Stantec, June 2013, Lower Hassayampa Water Course Master Plan, Phase 2, Technical Data Notebook
- R_2D, November 2011, Comparison of Sediment Transport Models for the Lower Hassayampa River
- USACE, 1993, HEC-6 Scour and Deposition in Rivers and Reservoirs, User's Manual, August, 1993.
- Chang Consultants, 2006, FLUVIAL-12 Mathematical Model for Erodible Channels, User's Manual, January 2010.
- MBH Software (2010), Sedimentation in Stream Networks (HEC-6T), User's Manual, March 16, 2010.
- USACE, 2010, HEC-RAS River Analysis System, Version 4.1 User's Manual, January 2010.
- Mining Permit Plans: Received from District via Email on 17-Feb-2015

Appendix A

STUDY REACH AND CROSS-SECTION LOCATION MAP

LOWER HASSAYAMPA RIVER SEDIMENT TRANSPORT MODEL UPDATE
FCD2014C002
WORK ASSIGNMENT #1



Appendix B

MODEL UPDATE DETAILS

Existing Post-Flood 2010 Geometry: Major Changes to Ineffective Flow Area, Channel Conveyance Limits, and Bank Stations			
Cross Section	**Atkins HEC-RAS Existing Conditions**	**HEC-6 and HEC-6T Existing Conditions**	**Fluvial-12 Existing Conditions**
3.91	Right ineffective flow area moved to unblock possible excavation.	Right channel conveyance limit moved to unblock possible excavation.	Right ineffective flow area moved to unblock possible excavation.
5.67	Left bank station and ineffective flow area moved beyond extents of mining.	Left bank station and ineffective flow area moved beyond extents of mining.	Left ineffective flow area moved beyond extents of mining.
5.76	Left bank station and ineffective flow area moved beyond extents of mining.	Left bank station and ineffective flow area moved beyond extents of mining.	Left ineffective flow area moved beyond extents of mining.
6.99	Left overbank moved to block low flow channel.		
10.4	Right ineffective flow area moved to block low flow channel.		
12.18	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
12.28	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
12.37	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
12.47	Right bank station and Channel Conveyance limit moved beyond extents of mining pit.	Right bank station and Channel Conveyance limit moved beyond extents of mining pit.	Right ineffective flow area moved beyond extents of mining pit.
12.56	Right bank and ineffective flow area moved beyond extents of mining activity.	Right bank moved beyond extents of mining activity. Right ineffective flow area removed.	Right ineffective flow area removed due to mining activity.
12.66	Right bank and ineffective flow area moved beyond extents of mining activity.	Right bank and channel conveyance limit moved beyond extents of mining activity.	Right ineffective flow area moved beyond extents of mining activity.
12.75	Right bank and ineffective flow area moved beyond extents of mining activity.	Right bank and channel conveyance limit moved beyond extents of mining activity.	Right ineffective flow area moved beyond extents of mining activity.
12.85	Right bank and ineffective flow area moved beyond extents of mining activity.	Right bank and channel conveyance limit moved beyond extents of mining activity.	Right ineffective flow area moved beyond extents of mining activity.
13.51	Right bank and ineffective flow area moved beyond extents of mining activity.	Right bank and channel conveyance limit moved beyond extents of mining activity.	Right ineffective flow area moved beyond extents of mining activity.
13.7	Left ineffective flow area added on access road	Left channel conveyance limit added on access road	Left inffective flow area added on access road
27.75	Left bank and ineffective flow area were NOT moved beyond excavated region because it caused instability in the model.	Left bank and channel conveyance limit moved beyond excavated region.	Ineffective flow area moved beyond excavated region.

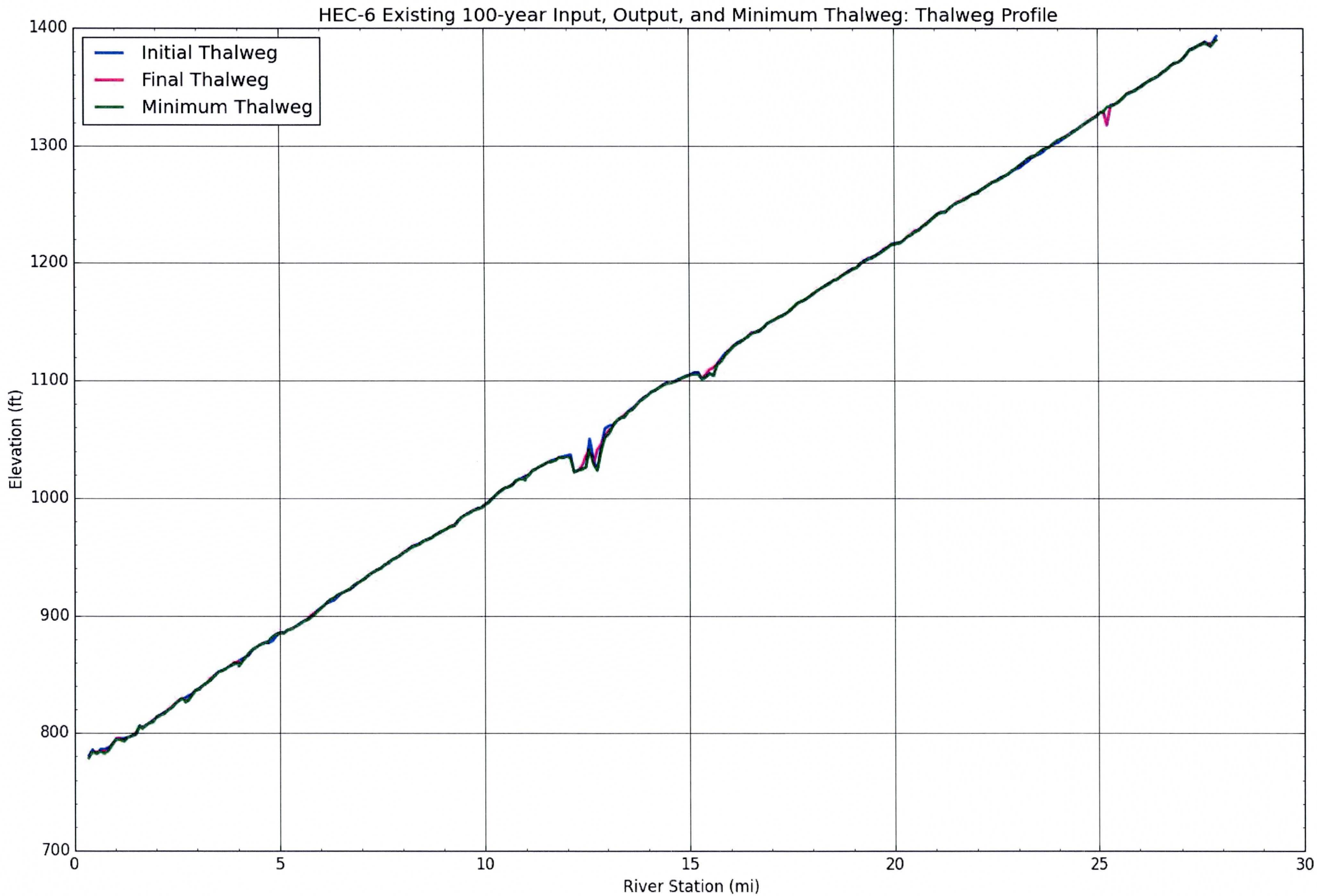
Ultimate Pit Geometry: Major Changes to Ineffective Flow Area, Channel Conveyance Limits, and Bank Stations			
Cross Section	Atkins HEC-RAS Ultimate Pit Conditions	HEC-6 and HEC-6T Ultimate Pit Conditions	Fluvial-12 Ultimate Pit Conditions
3.91	Right ineffective flow area moved to unblock possible excavation.	Right channel conveyance limit moved to unblock possible excavation.	Right ineffective flow area moved to unblock possible excavation.
5.38	Right bank station moved beyond extent of mining pit.	Right bank station moved beyond extent of mining pit.	
5.48	Right bank station moved beyond extent of mining pit.	Right bank station moved beyond extent of mining pit.	
5.57	Right bank station moved beyond extent of mining pit.	Right bank station moved beyond extent of mining pit.	
5.67	Left ineffective flow area moved beyond extent of mining facility. Right bank station moved beyond extents of mining pit.	Left channel conveyance limit moved beyond extent of mining facility.	Left ineffective flow area moved beyond extent of mining facility.
5.76	Left bank station and ineffective flow area moved beyond extents of mining pit. Right bank station moved beyond extents of mining pit.	Left bank station and channel conveyance limit moved beyond extents of mining pit. Right bank station moved beyond extents of mining pit.	Left ineffective flow area moved beyond extent of mining facility.
5.86	Right bank station moved beyond extent of mining pit.	Right bank station moved beyond extent of mining pit.	
5.95	Right bank station moved beyond extent of mining pit.	Right bank station moved beyond extent of mining pit.	
6.05	Right bank station moved beyond extent of mining pit.	Right bank station moved beyond extent of mining pit.	
6.99	Left overbank moved to block low flow channel.		
7.84	Levee added to right side of cross section to prevent flow from entering pit with bank protection.	Right ineffective flow area added to prevent flow in pit with bank protection.	Right ineffective flow area added to prevent flow in pit with bank protection.
7.94	Levee added to right side of cross section to prevent flow from entering pit with bank protection.	Right ineffective flow area added to prevent flow in pit with bank protection.	Right ineffective flow area added to prevent flow in pit with bank protection.
8.03	Levee added to right side of cross section to prevent flow from entering pit with bank protection.	Right ineffective flow area added to prevent flow in pit with bank protection.	Right ineffective flow area added to prevent flow in pit with bank protection.
8.13	Levee added to right side of cross section to prevent flow from entering pit with bank protection.	Right ineffective flow area added to prevent flow in pit with bank protection.	Right ineffective flow area added to prevent flow in pit with bank protection.
12.18	Right bank station and ineffective flow area moved beyond extents of mining.	Right bank station and channel conveyance limit moved beyond extents of mining.	Right channel conveyance limit moved beyond extents of mining.
12.28	Right bank station and ineffective flow area moved beyond extents of mining.	Right bank station and channel conveyance limit moved beyond extents of mining.	Right channel conveyance limit moved beyond extents of mining.

Ultimate Pit Geometry: Major Changes to Ineffective Flow Area, Channel Conveyance Limits, and Bank Stations			
Cross Section	**Atkins HEC-RAS Ultimate Pit Conditions**	**HEC-6 and HEC-6T Ultimate Pit Conditions**	**Fluvial-12 Ultimate Pit Conditions**
12.37	Right bank station and ineffective flow area moved beyond extents of mining.	Right bank station and channel conveyance limit moved beyond extents of mining.	Right channel conveyance limit moved beyond extents of mining.
12.47	Right bank station and ineffective flow area moved beyond extents of mining.	Right bank station and channel conveyance limit moved beyond extents of mining.	Right channel conveyance limit moved beyond extents of mining.
12.56	Right bank station moved beyond extents of mining.	Right bank station moved beyond extents of mining.	
12.66	Right bank station and ineffective flow area moved beyond extents of mining.	Right bank station and channel conveyance limit moved beyond extents of mining.	Right channel conveyance limit moved beyond extents of mining.
12.75	Right bank station and ineffective flow area moved beyond extents of mining.	Right bank station and channel conveyance limit moved beyond extents of mining.	Right channel conveyance limit moved beyond extents of mining.
12.85	Right bank station moved beyond extents of mining.	Right bank station moved beyond extents of mining.	
13.51	Right bank station and ineffective flow area moved beyond extents of mining.	Right bank station and channel conveyance limit moved beyond extents of mining.	Right channel conveyance limit moved beyond extents of mining.
13.61	Right bank station moved beyond mining pit extents. Ineffective flow area moved beyond extents of mining access road.	Right bank station moved beyond extents of mining. Channel conveyance limit moved beyond extents of mining access road.	Right channel conveyance limit moved beyond extents of mining access road.
13.7	Right bank station moved beyond mining pit extents. Ineffective flow area moved beyond extents of mining access road.	Right bank station moved beyond extents of mining. Channel conveyance limit moved beyond extents of mining access road.	Right channel conveyance limit moved beyond extents of mining access road.
14.17	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
14.27	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
14.36	Left and right bank station moved beyond extents of mining pit.	Left and right bank station moved beyond extents of mining pit.	
14.45	Left and right bank station moved beyond extents of mining pit.	Left and right bank station moved beyond extents of mining pit.	
14.55	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
14.64	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
14.73	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
15.21	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
15.3	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	
15.4	Right bank station moved beyond extents of mining pit.	Right bank station moved beyond extents of mining pit.	

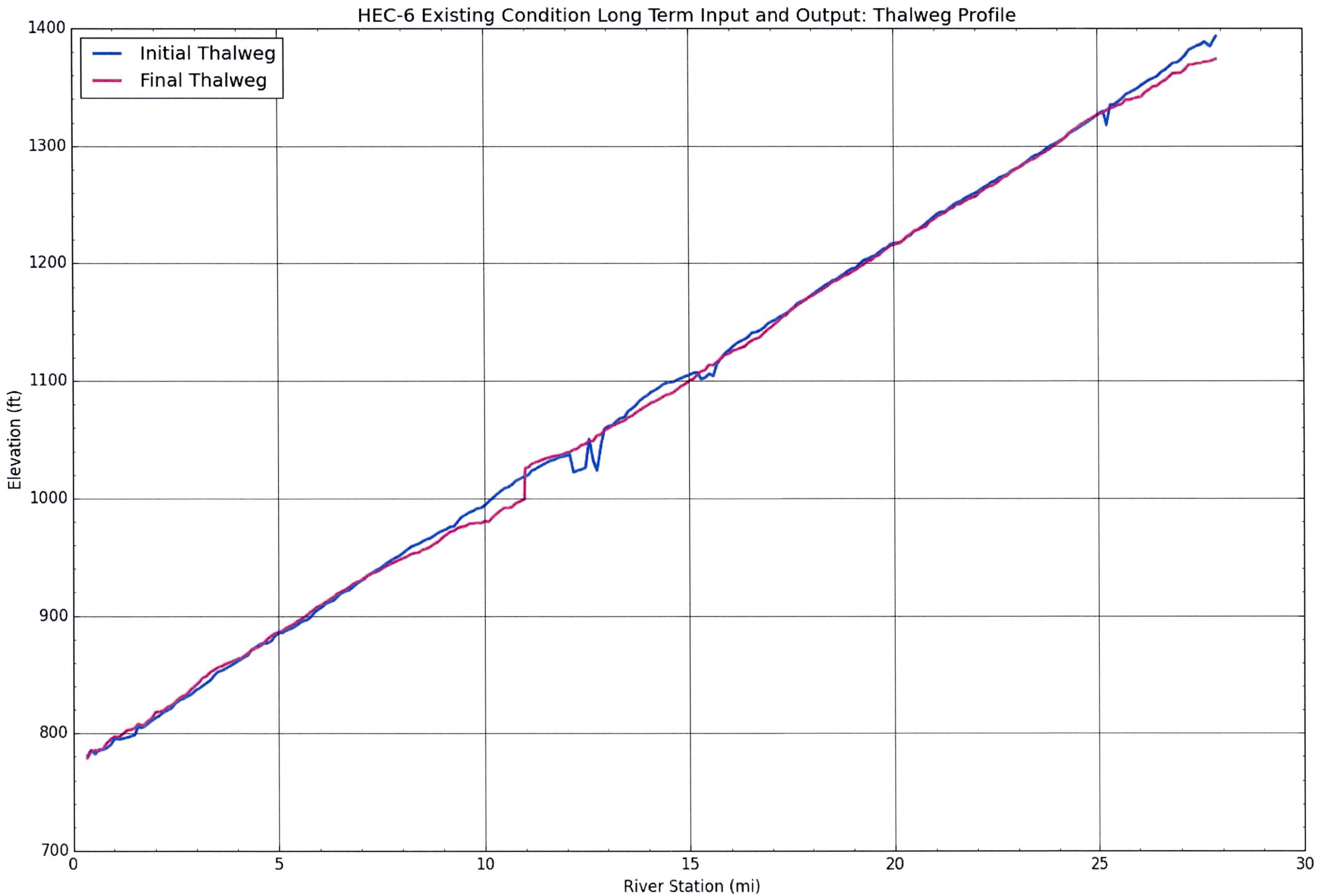
Ultimate Pit Geometry: Major Changes to Ineffective Flow Area, Channel Conveyance Limits, and Bank Stations			
Cross Section	**Atkins HEC-RAS Ultimate Pit Conditions**	**HEC-6 and HEC-6T Ultimate Pit Conditions**	**Fluvial-12 Ultimate Pit Conditions**
15.49	Left and right bank station moved beyond extents of mining pit.	Left and right bank station moved beyond extents of mining pit.	
15.59	Levee added on right bank to prevent flow in pit with berm. Left and right bank stations moved beyond extents of main pit.	Ineffective flow area added on right side to prevent flow in pit with berm. Left and right bank stations moved beyond extents of main pit.	Ineffective flow area added on right side to prevent flow in pit with berm.
15.68	Levee added on right bank to prevent flow in pit with berm.	Ineffective flow area added on right side to prevent flow in pit with berm.	Ineffective flow area added on right side to prevent flow in pit with berm.
15.78	Levee added on right bank to prevent flow in pit with berm.	Ineffective flow area added on right side to prevent flow in pit with berm.	Ineffective flow area added on right side to prevent flow in pit with berm.
15.87	Levee added on right bank to prevent flow in pit with berm.	Ineffective flow area added on right side to prevent flow in pit with berm.	Ineffective flow area added on right side to prevent flow in pit with berm.
27.75	Left bank and ineffective flow area were NOT moved beyond excavated region because it caused instability in the model.	Left bank and channel conveyance limit moved beyond excavated region.	Ineffective flow area moved beyond excavated region.

Appendix C

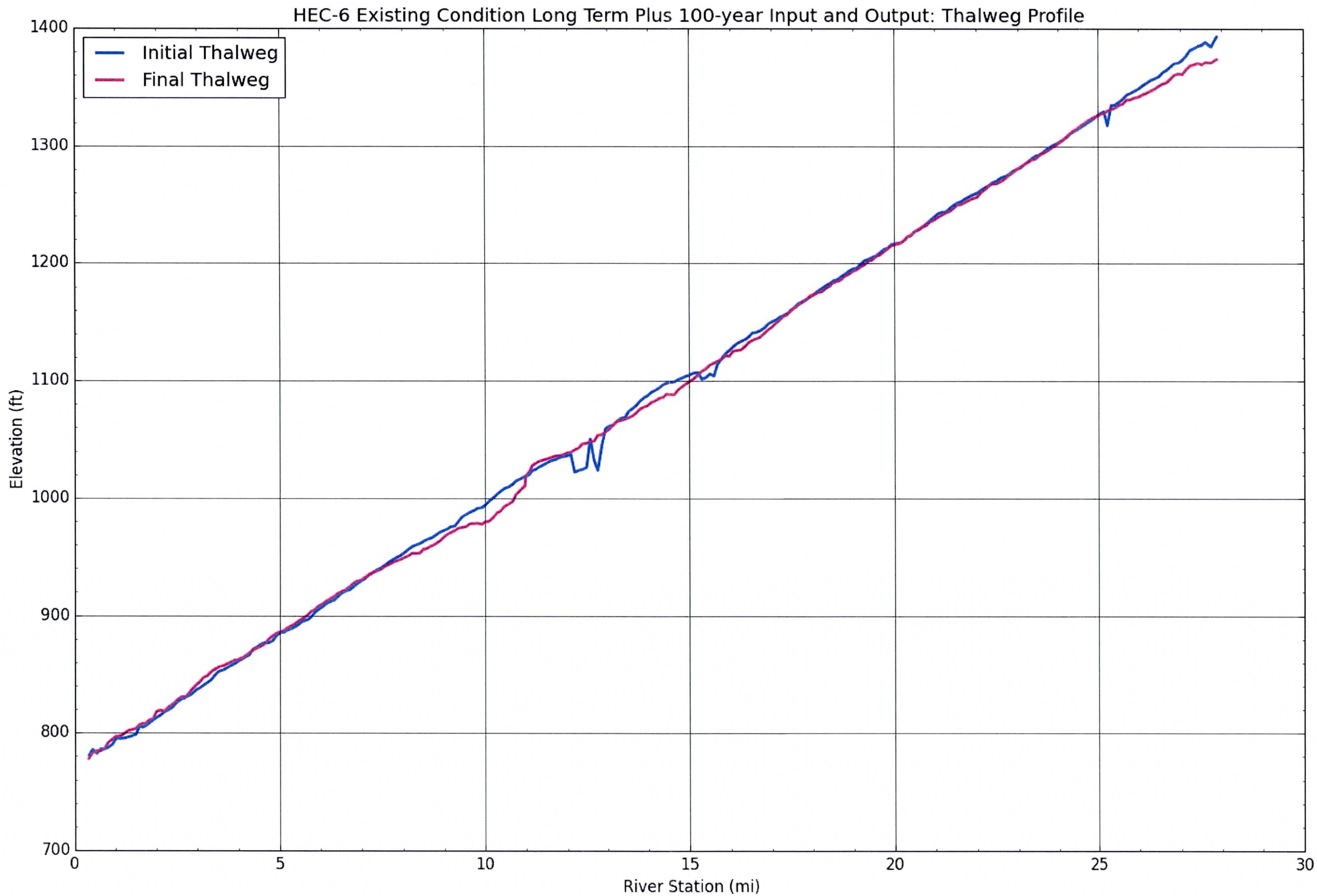
BED CHANGE PROFILE PLOTS

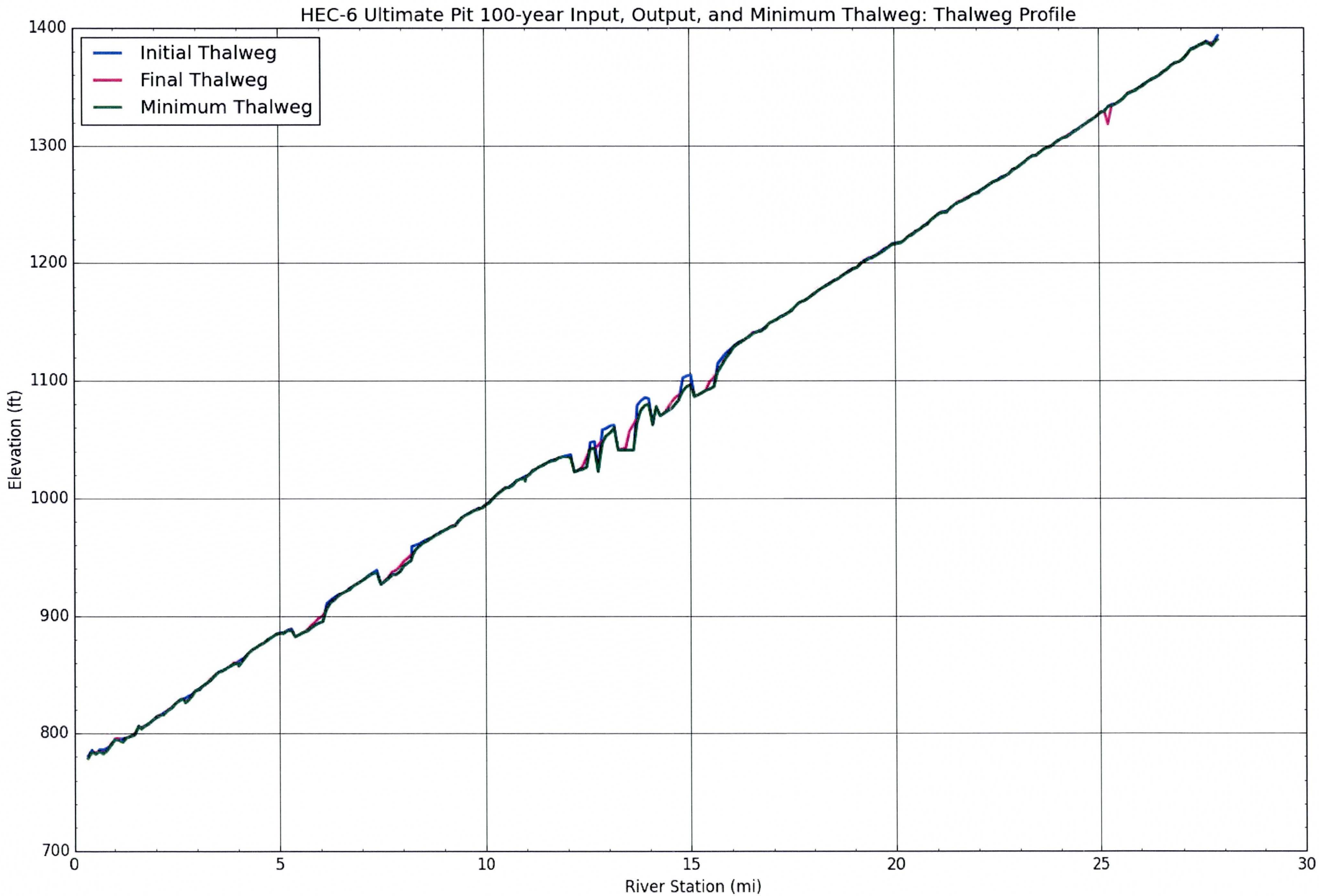


HEC-6 Existing 100-year Input, Output, and Minimum Thalweg: Thalweg Profile
Initial Thalweg
Final Thalweg
Minimum Thalweg
Elevation (ft)
River Station (mi)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30

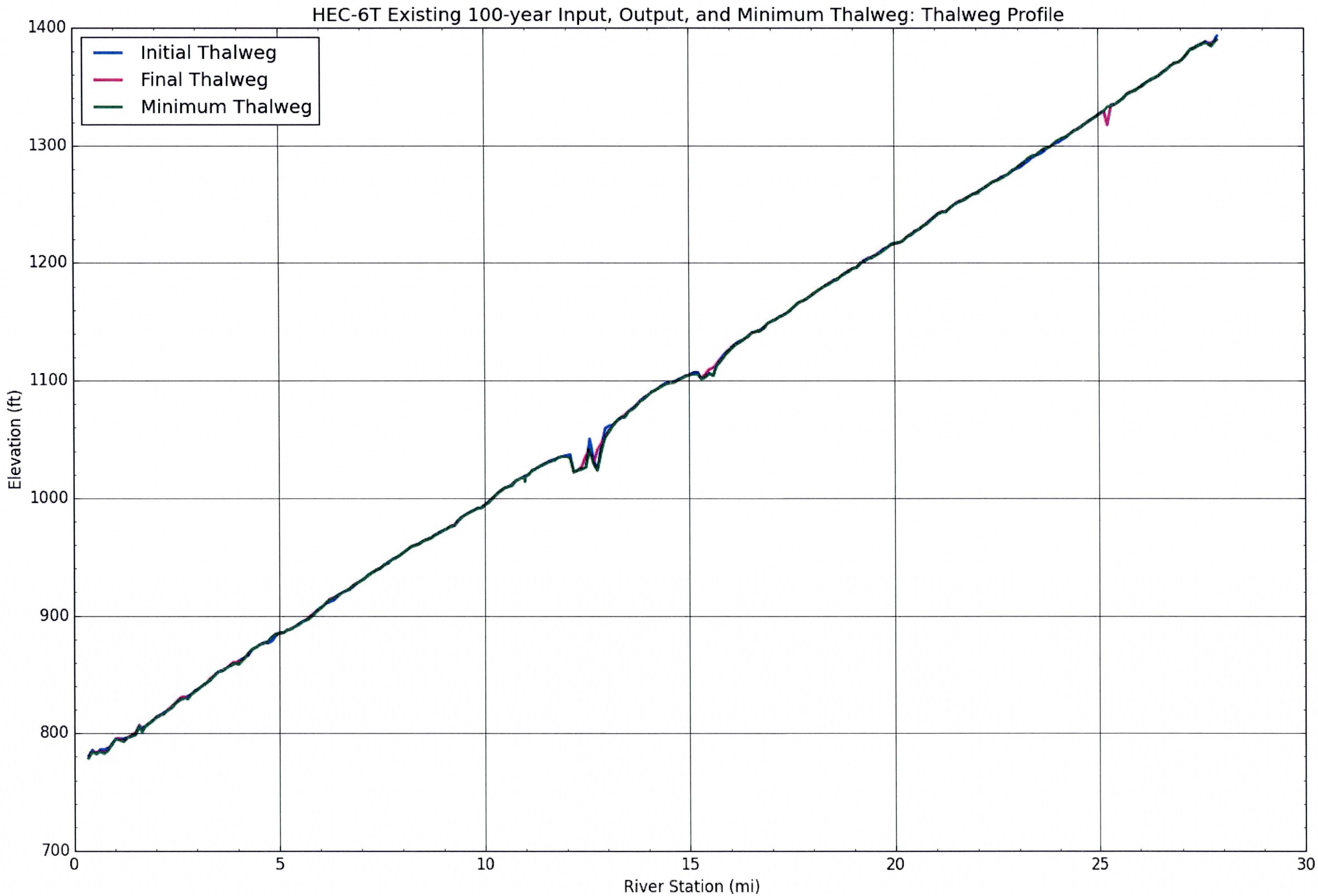


HEC-6 Existing Condition Long Term Input and Output: Thalweg Profile
Initial Thalweg
Final Thalweg
Elevation (ft)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30
River Station (mi)

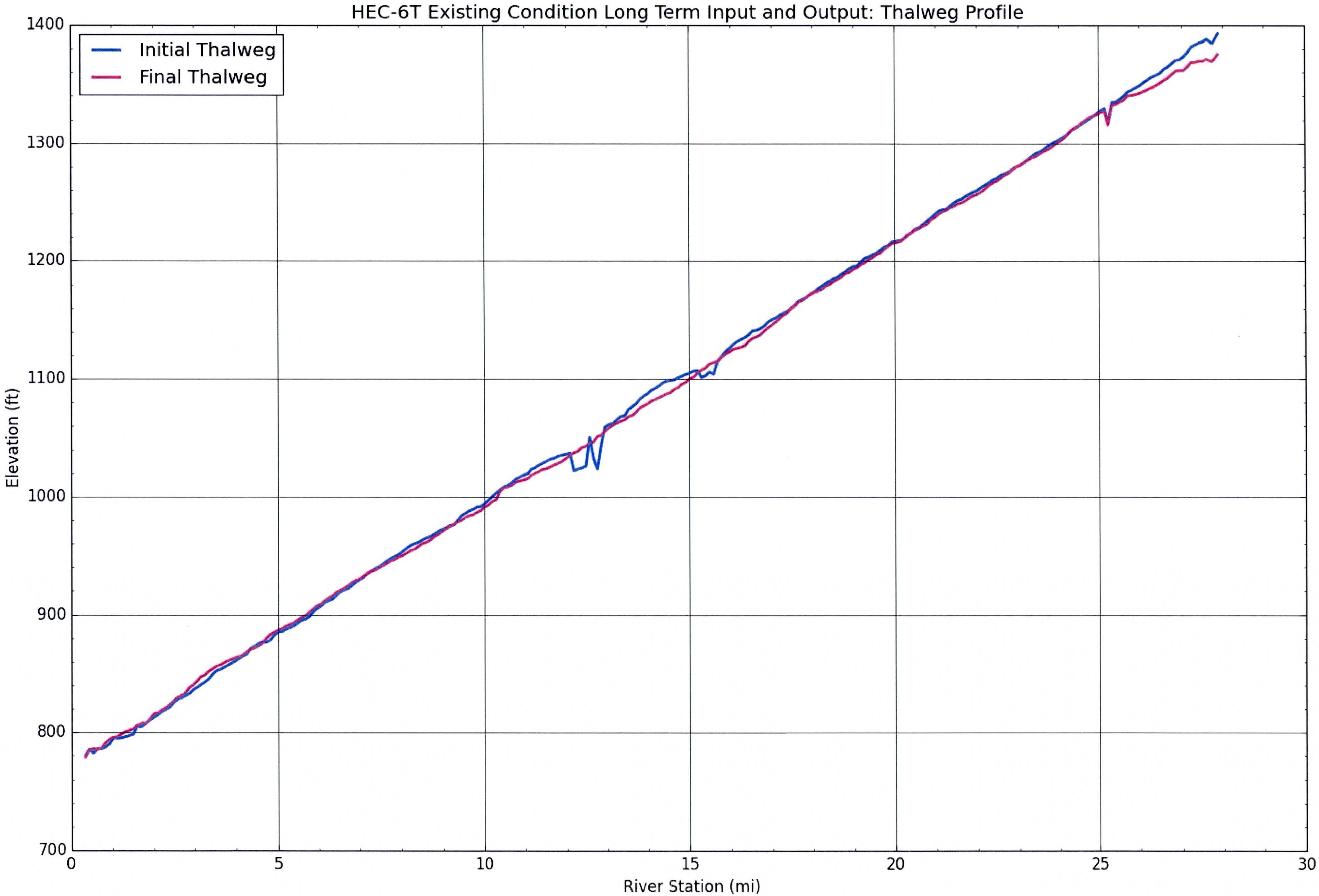

HEC-6 Existing Condition Long Term Plus 100-year Input and Output: Thalweg Profile
Initial Thalweg
Final Thalweg
Elevation (ft)
River Station (mi)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30

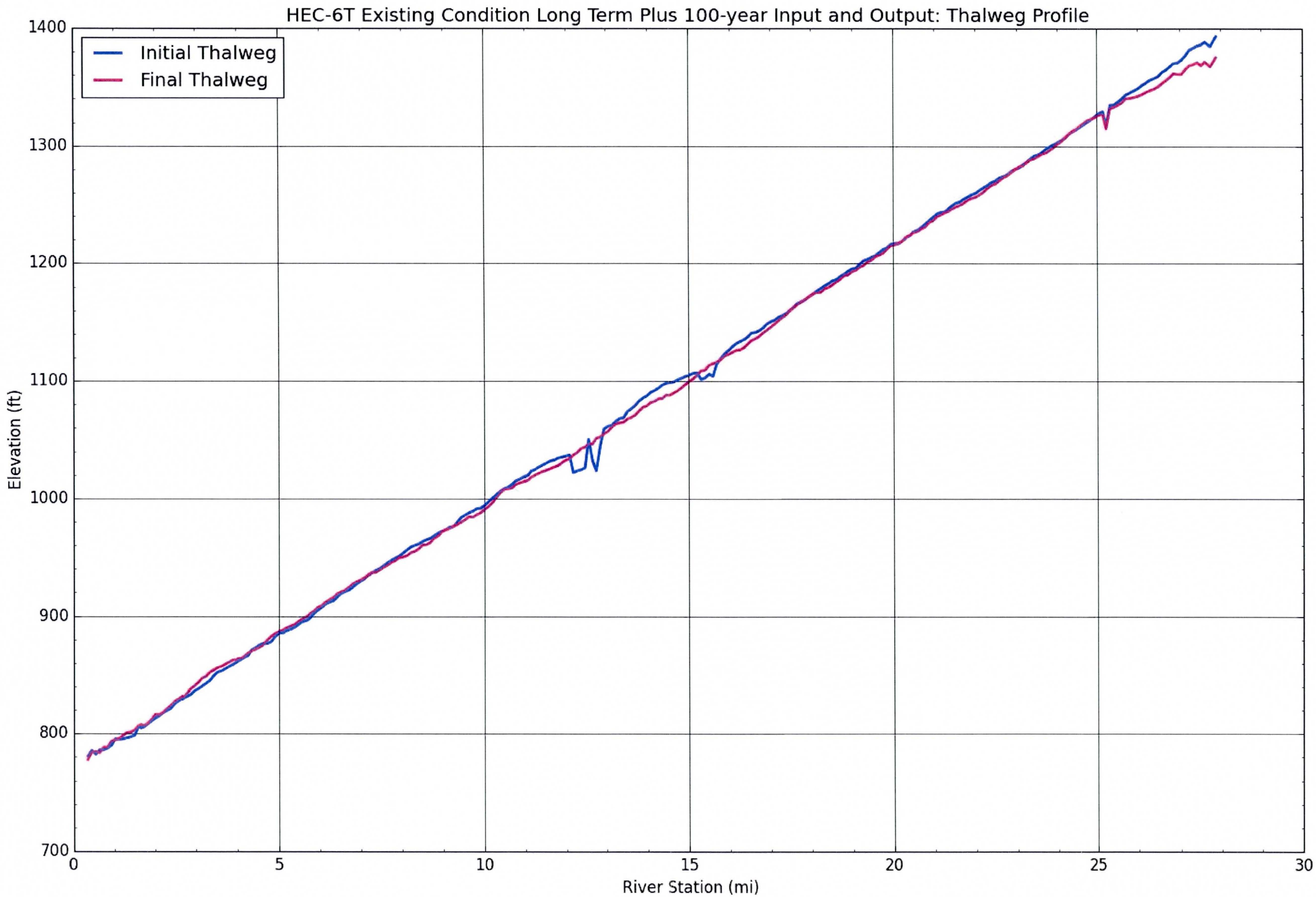


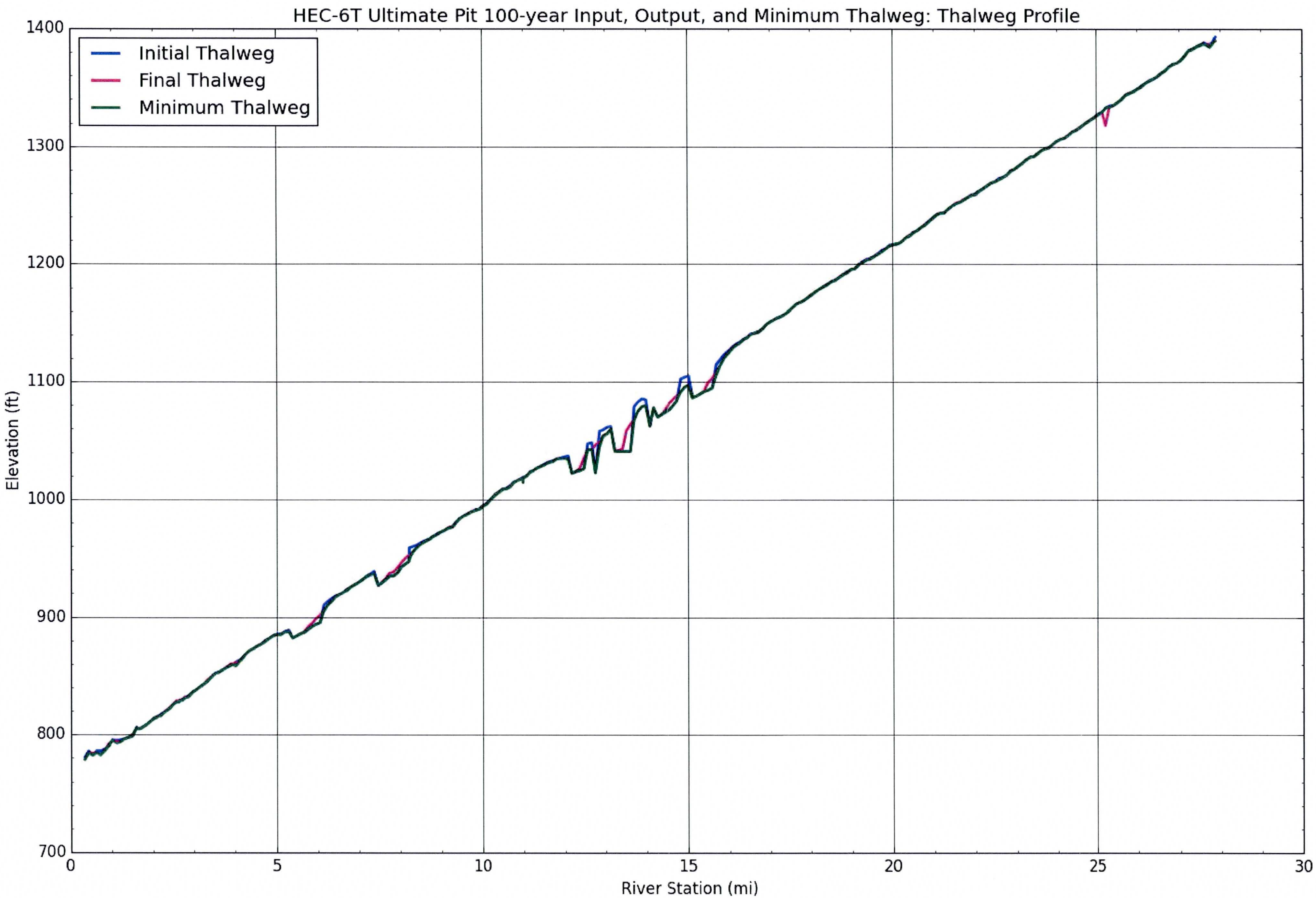
HEC-6 Ultimate Pit 100-year Input, Output, and Minimum Thalweg: Thalweg Profile
Initial Thalweg
Final Thalweg
Minimum Thalweg
Elevation (ft)
River Station (mi)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30

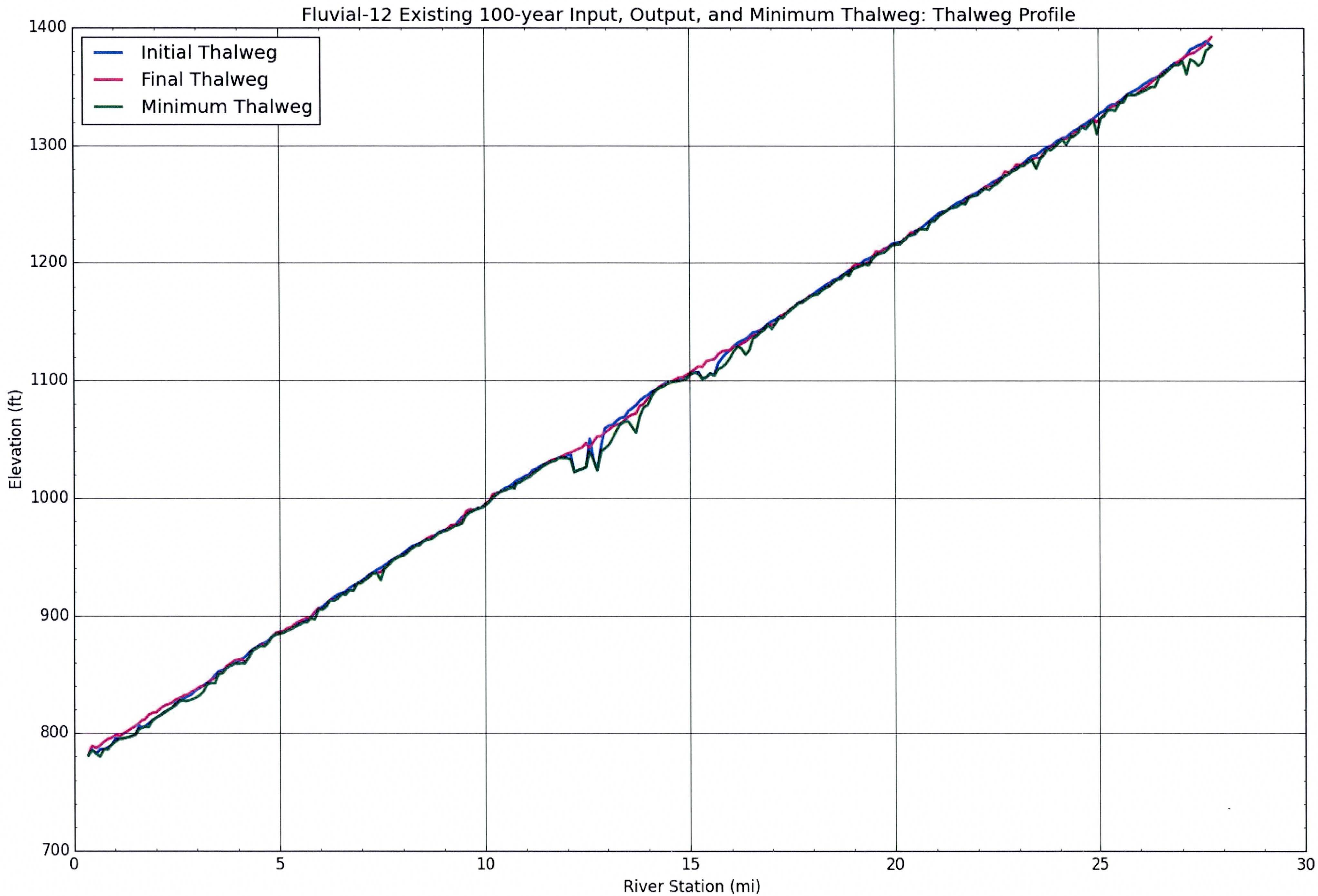


HEC-6T Existing 100-year Input, Output, and Minimum Thalweg: Thalweg Profile
Initial Thalweg
Final Thalweg
Minimum Thalweg
Elevation (ft)
River Station (mi)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30

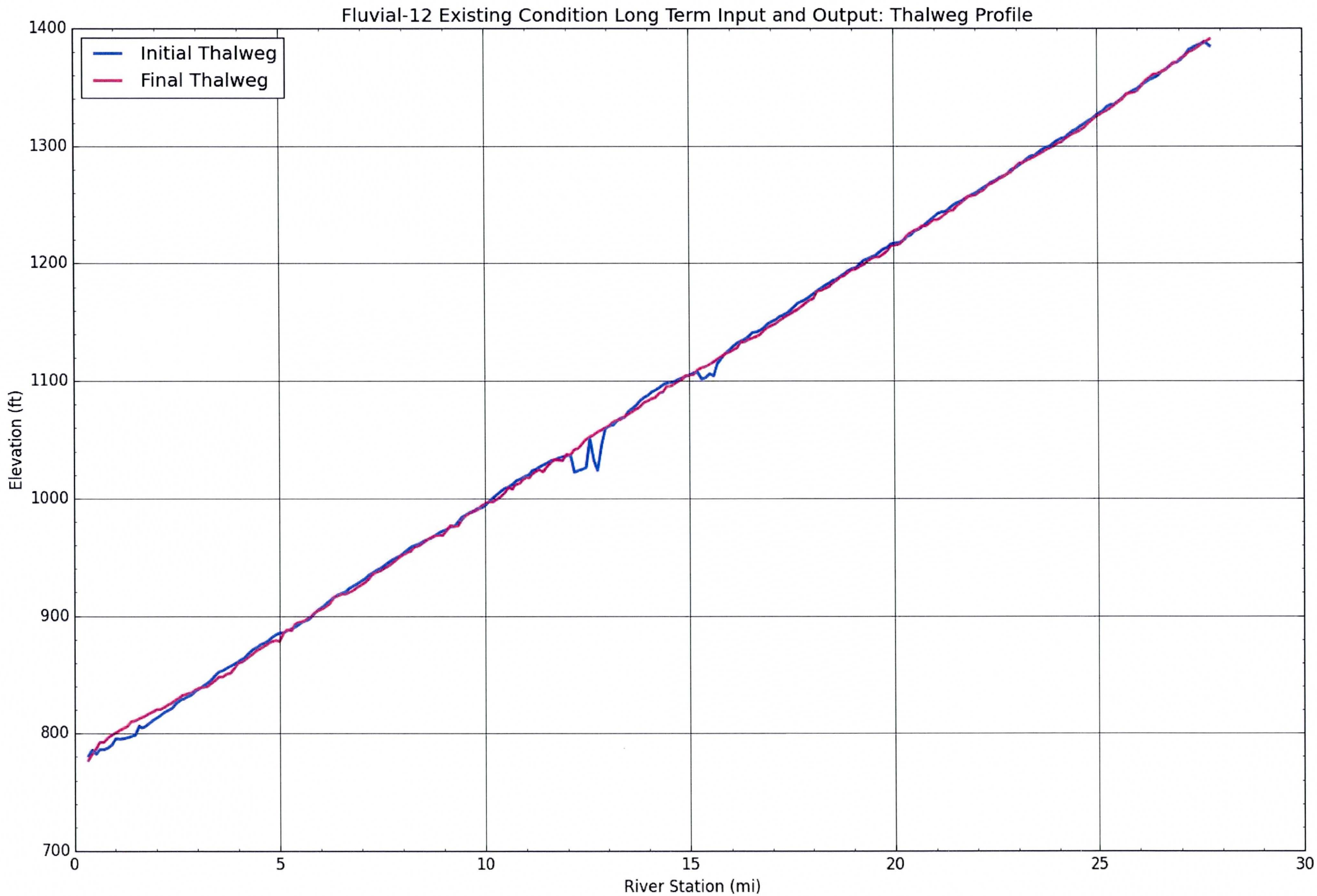

HEC-6T Existing Condition Long Term Input and Output: Thalweg Profile
Initial Thalweg
Final Thalweg
Elevation (ft)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30
River Station (mi)

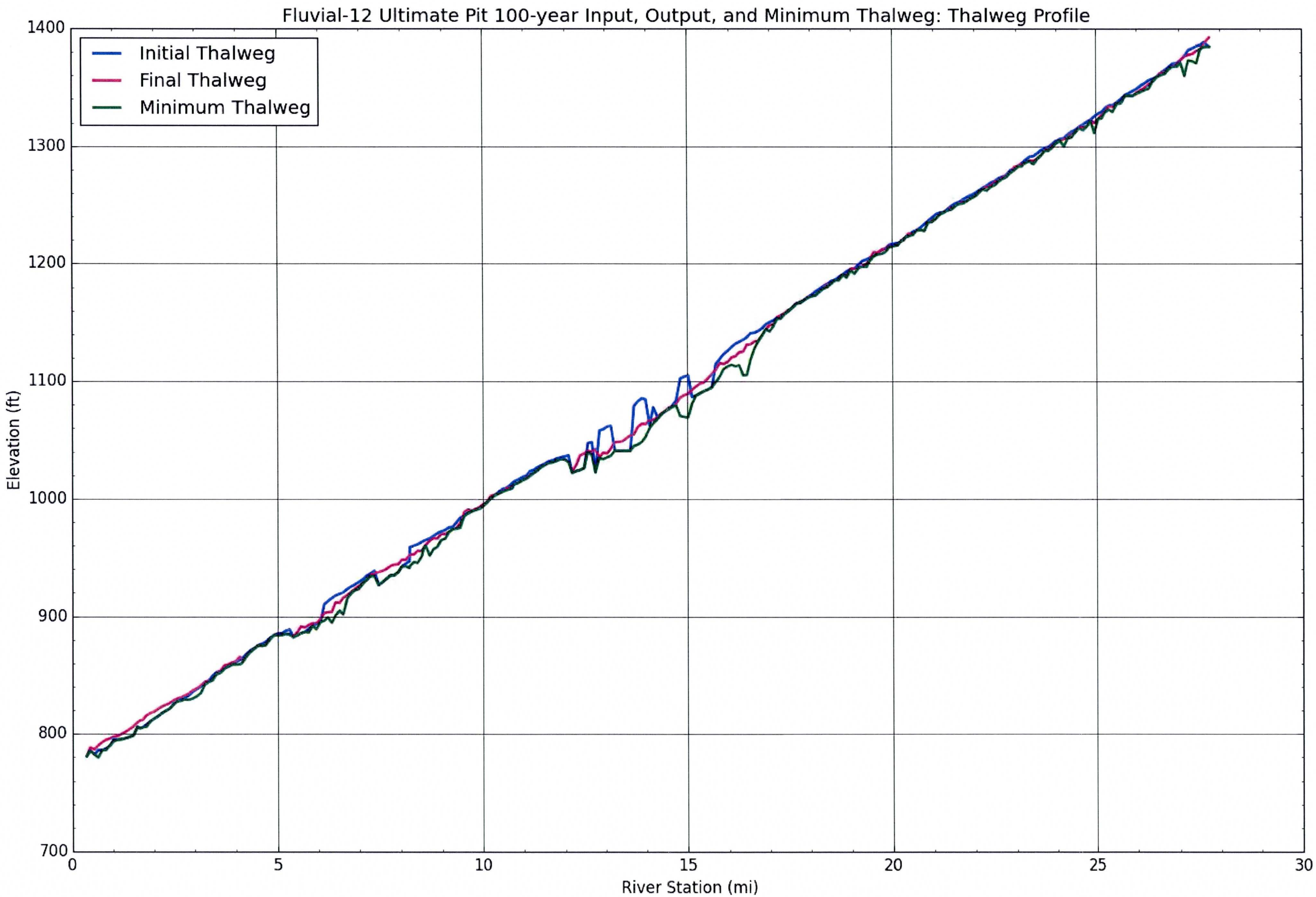

HEC-6T Existing Condition Long Term Plus 100-year Input and Output: Thalweg Profile
Initial Thalweg
Final Thalweg
Elevation (ft)
River Station (mi)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30


HEC-6T Ultimate Pit 100-year Input, Output, and Minimum Thalweg: Thalweg Profile
Initial Thalweg
Final Thalweg
Minimum Thalweg
Elevation (ft)
River Station (mi)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30

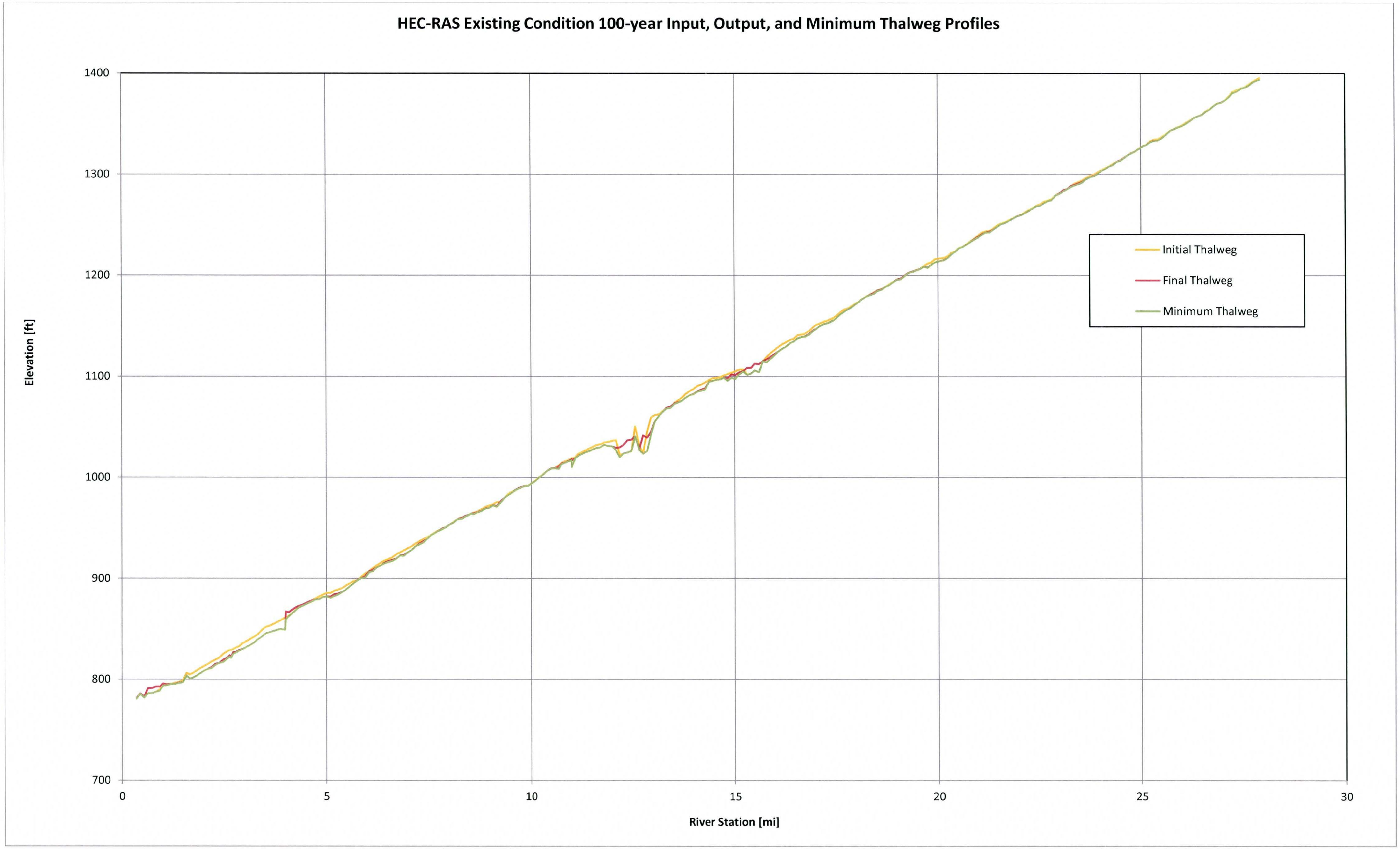


Fluvial-12 Existing 100-year Input, Output, and Minimum Thalweg: Thalweg Profile
Initial Thalweg
Final Thalweg
Minimum Thalweg
Elevation (ft)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30
River Station (mi)

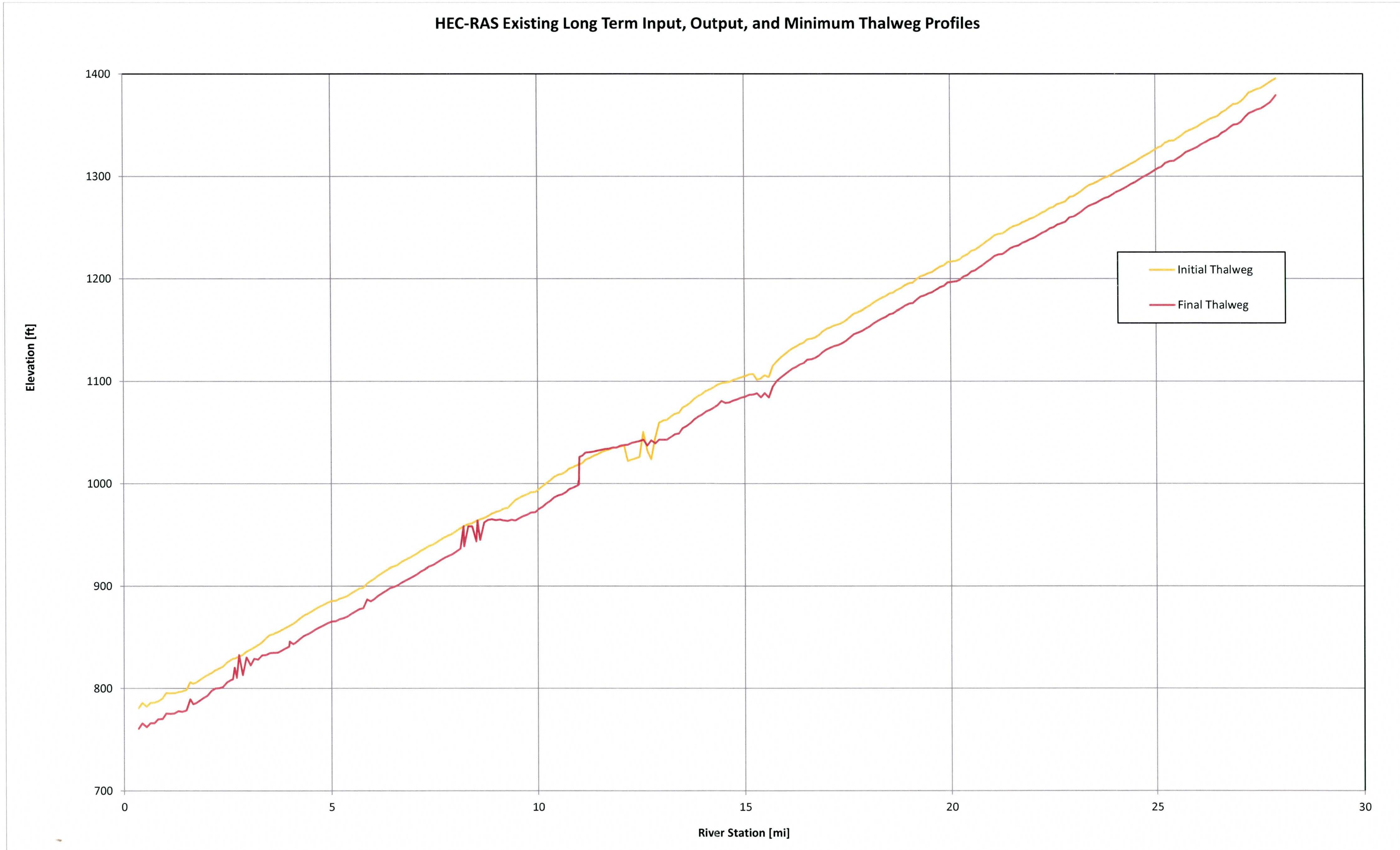

Fluvial-12 Existing Condition Long Term Input and Output: Thalweg Profile
Initial Thalweg
Final Thalweg
Elevation (ft)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30
River Station (mi)

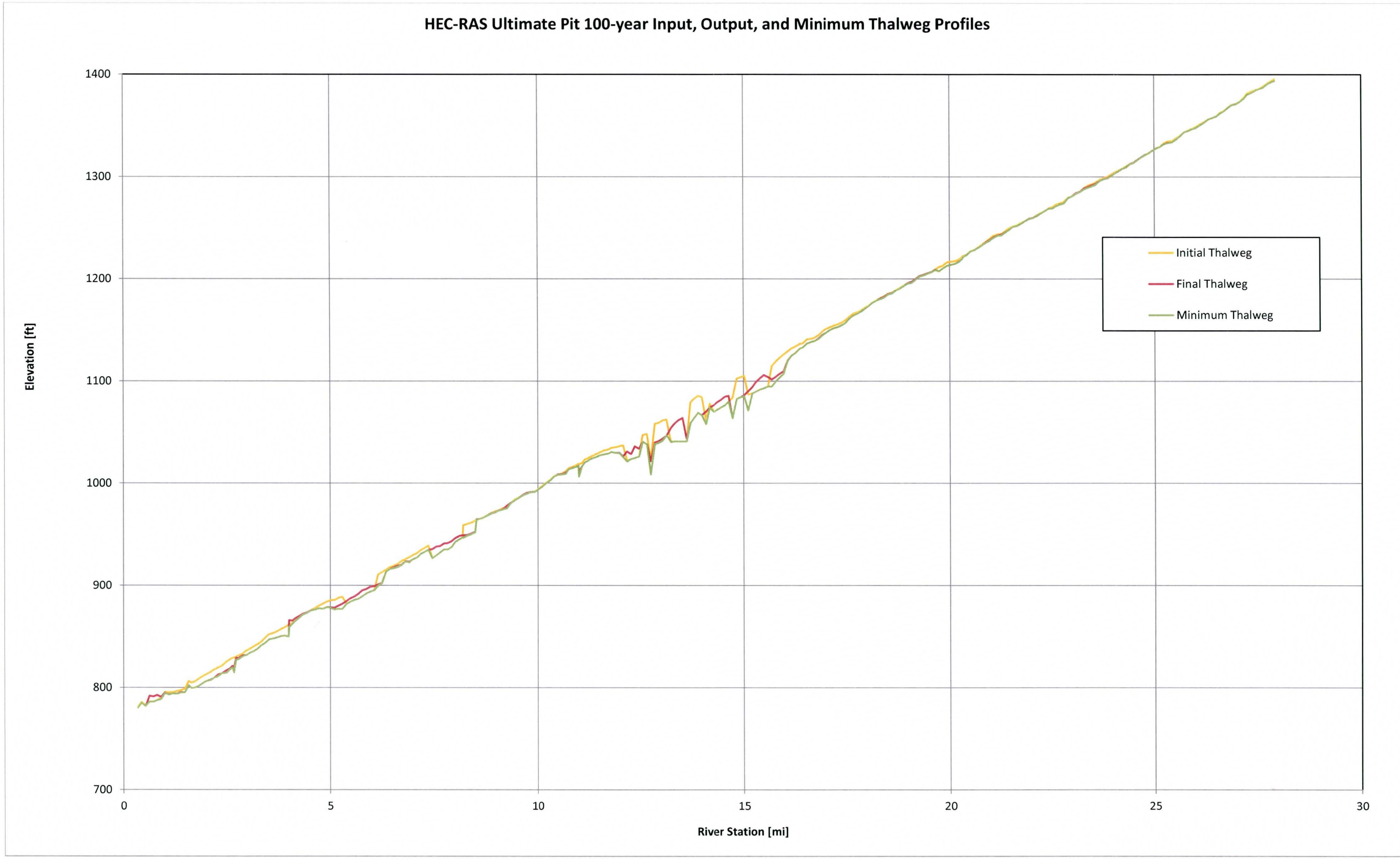


Fluvial-12 Ultimate Pit 100-year Input, Output, and Minimum Thalweg: Thalweg Profile
Initial Thalweg
Final Thalweg
Minimum Thalweg
Elevation (ft)
River Station (mi)
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30



HEC-RAS Existing Condition 100-year Input, Output, and Minimum Thalweg Profiles
Elevation [ft]
River Station [mi]
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30
Initial Thalweg
Final Thalweg
Minimum Thalweg


HEC-RAS Existing Long Term Input, Output, and Minimum Thalweg Profiles
Elevation [ft]
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30
River Station [mi]
Initial Thalweg
Final Thalweg


HEC-RAS Ultimate Pit 100-year Input, Output, and Minimum Thalweg Profiles
Elevation [ft]
River Station [mi]
Initial Thalweg
Final Thalweg
Minimum Thalweg
1400
1300
1200
1100
1000
900
800
700
0
5
10
15
20
25
30

Appendix D

MAXIMUM SCOUR PLOT

	Minimum Bed Elevation Change (Maximum Scour)							
	Fluvial-12		HEC-6		HEC-6T		HEC-RAS	
Station	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit
0.35	0.00	0.00	2.33	2.31	2.31	2.29	0.04	0.77
0.44	0.10	0.20	1.67	1.63	1.65	1.46	0.13	0.76
0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.70
0.63	6.50	6.20	1.67	1.61	1.81	1.54	0.20	0.20
0.73	0.00	0.00	3.66	3.78	3.62	3.80	0.00	0.00
0.82	1.70	1.90	2.71	2.27	2.38	1.80	0.03	0.03
0.92	0.00	0.00	0.00	0.00	0.00	0.00	1.49	1.52
1.01	2.80	3.20	0.92	0.92	0.36	0.37	1.95	0.89
1.11	0.00	0.00	1.05	1.20	1.34	2.68	1.37	2.13
1.2	0.10	0.20	2.74	3.25	2.90	2.00	0.26	1.48
1.3	0.00	0.00	0.00	0.00	0.00	0.00	1.29	2.68
1.39	0.30	0.00	0.04	0.04	0.04	0.04	1.10	2.32
1.49	0.00	0.00	0.00	0.00	0.00	0.00	1.84	3.32
1.58	2.80	3.60	0.50	0.59	0.27	1.15	2.67	4.11
1.65	0.60	0.80	1.10	1.09	3.96	0.04	3.91	5.44
1.72	0.20	0.10	0.00	0.00	0.45	0.00	4.30	5.86
1.81	3.10	3.10	0.04	0.75	0.50	0.50	5.22	7.04
1.91	0.40	0.50	1.95	0.15	0.78	0.28	5.02	7.03
2	0.00	0.00	0.00	0.00	0.00	0.00	4.72	6.78
2.1	0.10	0.00	0.02	0.02	0.02	0.02	4.99	7.87
2.19	0.90	0.90	1.55	2.06	1.69	1.62	6.76	7.97
2.29	0.00	0.00	0.01	0.22	0.05	0.01	5.26	8.56
2.38	0.00	0.00	0.00	0.00	0.00	0.00	5.12	7.61
2.48	1.60	1.80	0.00	0.00	0.00	0.00	8.06	11.16
2.57	0.70	1.00	0.04	0.04	0.04	0.04	7.55	10.01
2.63	1.50	1.90	0.00	0.00	0.00	1.68	6.83	9.48
2.67	1.50	1.80	0.00	0.00	0.00	0.00	7.85	14.53
2.72	3.30	3.60	4.37	4.66	0.32	1.57	5.12	3.20
2.78	3.90	4.20	4.29	3.82	2.56	0.33	5.38	3.87
2.87	4.50	5.20	1.76	1.99	0.31	1.16	4.85	2.66
2.96	6.40	6.80	0.00	0.00	0.81	0.35	5.88	4.45
3.06	6.40	6.90	1.16	1.22	0.36	0.34	5.66	3.87
3.15	5.40	5.60	0.00	0.00	0.00	0.00	5.95	4.60
3.25	1.40	0.60	0.03	0.03	0.03	0.03	5.88	4.48
3.34	2.80	0.80	0.00	0.00	0.00	0.00	4.94	3.53
3.44	7.10	4.60	0.65	0.32	0.45	0.44	6.63	5.16
3.53	2.30	1.10	0.33	0.38	0.27	0.37	6.52	5.14
3.63	2.50	1.60	0.64	0.64	0.89	0.84	6.76	5.48
3.72	0.30	0.30	0.03	0.03	0.03	0.03	7.33	6.03
3.81	0.00	0.00	0.01	0.01	0.01	0.01	7.95	6.83

	Minimum Bed Elevation Change (Maximum Scour)							
	Fluvial-12		HEC-6		HEC-6T		HEC-RAS	
Station	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit
3.91	0.00	0.00	0.01	0.01	0.01	0.01	9.35	8.27
4	2.00	2.00	1.84	1.76	2.04	1.55	11.90	11.11
4.01	2.40	2.40	4.71	4.51	3.24	3.42	2.50	2.47
4.09	3.60	3.60	2.51	2.58	2.01	1.87	0.82	0.91
4.15	5.50	4.20	1.12	1.06	0.88	0.88	0.00	0.00
4.25	4.30	2.50	0.28	0.27	0.05	0.21	0.10	0.06
4.34	1.20	1.90	0.27	0.27	0.00	0.00	0.07	0.02
4.44	1.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00
4.53	1.20	0.50	0.05	0.17	0.06	0.03	0.13	0.09
4.63	3.20	2.20	0.47	0.29	0.56	0.17	0.48	0.66
4.72	2.10	2.90	0.72	0.00	0.75	0.00	0.00	1.28
4.82	0.00	1.00	0.00	0.00	0.00	0.14	2.59	4.98
4.91	0.00	0.10	0.01	0.00	0.00	0.00	2.64	5.24
5	0.90	1.50	0.53	0.41	0.47	0.58	3.55	7.36
5.1	0.30	1.50	0.78	0.76	0.38	0.65	5.23	9.42
5.19	0.60	2.20	0.02	0.50	0.02	0.51	5.34	10.85
5.29	0.50	4.20	0.46	1.34	0.47	1.39	4.98	12.15
5.38	0.00	0.00	0.00	0.03	0.00	0.03	4.07	0.60
5.48	1.20	0.00	0.71	0.00	0.72	0.00	3.99	0.00
5.57	1.20	0.00	0.32	0.04	0.34	0.04	3.24	0.04
5.67	2.00	0.00	0.01	0.01	0.01	0.01	1.20	0.01
5.76	0.70	3.50	0.00	0.00	0.00	0.00	0.00	0.00
5.86	5.80	0.00	1.66	0.01	1.52	0.01	1.96	0.06
5.95	0.20	4.70	0.83	0.00	0.69	0.00	4.65	0.00
6.05	2.60	0.00	0.21	0.04	0.11	0.04	1.12	0.04
6.14	2.80	14.20	0.00	5.05	0.00	5.66	3.00	10.91
6.23	0.30	13.80	0.00	2.19	0.00	3.27	2.06	11.26
6.33	3.10	20.90	0.82	2.24	1.01	2.46	2.54	2.05
6.42	3.70	18.30	0.27	1.21	0.90	1.00	2.75	1.72
6.52	1.20	12.30	0.02	0.15	0.02	0.16	3.12	2.34
6.61	3.10	21.80	0.00	0.00	0.00	0.00	3.40	2.61
6.71	1.90	7.70	1.27	1.35	1.13	1.13	4.35	3.87
6.8	4.60	6.40	0.01	0.01	0.01	0.01	3.10	2.08
6.9	0.20	5.40	0.00	0.00	0.00	0.00	5.29	5.28
6.99	2.10	6.20	0.02	0.02	0.02	0.02	4.14	4.24
7.09	1.20	3.40	0.00	0.00	0.00	0.00	3.69	4.45
7.18	2.00	3.20	0.17	0.42	0.10	0.21	3.17	3.71
7.28	1.00	2.20	0.00	0.76	0.00	0.67	3.10	3.94
7.37	2.60	4.10	0.64	2.04	0.59	1.99	3.74	4.22
7.47	10.20	0.00	0.52	0.00	0.56	0.00	1.40	0.46

	Minimum Bed Elevation Change (Maximum Scour)							
	Fluvial-12		HEC-6		HEC-6T		HEC-RAS	
Station	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit
7.56	3.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00
7.66	2.50	0.00	1.10	0.04	1.10	0.04	0.78	0.04
7.75	1.10	0.30	0.00	0.01	0.00	0.01	0.60	0.01
7.84	0.70	0.10	0.53	0.00	0.53	0.00	0.71	0.00
7.94	0.70	0.00	0.03	0.00	0.03	0.00	0.44	0.00
8.03	2.50	0.40	0.05	0.35	0.05	0.31	0.17	0.00
8.13	2.50	0.00	0.82	0.00	0.12	0.00	0.96	0.00
8.21	1.60	2.30	0.50	0.00	0.01	0.00	0.02	0.00
8.22	1.90	14.20	0.75	10.11	0.16	9.96	0.37	12.48
8.32	1.00	13.30	0.76	3.85	0.67	4.31	1.50	11.61
8.41	1.60	15.00	0.97	2.22	0.81	2.20	0.00	11.44
8.51	0.00	13.00	0.00	1.33	0.00	1.24	0.48	11.59
8.54	0.60	10.40	0.21	1.56	0.17	1.34	0.00	0.00
8.6	0.70	13.70	0.89	1.42	0.89	1.03	1.60	0.23
8.7	1.40	13.40	0.48	0.24	0.58	0.66	1.22	0.47
8.79	1.00	10.30	0.00	0.00	0.00	0.00	1.64	0.23
8.89	0.60	16.70	0.86	0.93	0.80	0.83	1.76	0.68
8.98	0.80	6.60	0.20	0.28	0.12	0.13	2.50	0.97
9.08	1.40	5.20	0.00	0.00	0.00	0.00	1.38	0.28
9.17	1.60	4.50	0.02	0.02	0.02	0.02	5.15	1.69
9.27	0.10	1.10	0.00	0.00	0.00	0.00	0.61	0.70
9.36	3.40	4.10	0.00	0.00	0.00	0.00	0.11	0.00
9.45	5.80	8.20	0.42	0.44	0.39	0.35	1.49	0.97
9.55	1.00	0.90	0.27	0.16	0.08	0.08	0.95	0.54
9.64	0.40	0.50	0.95	0.70	0.73	0.79	0.19	0.20
9.74	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00
9.83	0.90	1.10	0.97	1.03	0.44	0.98	0.32	0.48
9.93	0.20	0.10	0.29	0.27	0.51	0.26	0.28	0.37
10.02	0.50	0.20	0.02	0.02	0.02	0.02	0.17	0.26
10.12	1.00	1.00	1.39	1.41	1.50	1.57	0.73	0.90
10.21	0.00	0.00	0.37	0.47	0.55	0.41	0.32	0.54
10.31	0.20	0.30	0.00	0.00	0.00	0.00	0.41	0.59
10.4	0.50	0.50	0.03	0.03	0.03	0.03	0.00	0.00
10.5	2.10	1.70	0.03	0.03	0.02	0.09	0.02	0.25
10.59	1.70	2.10	0.13	0.72	0.04	0.78	0.57	1.19
10.69	3.00	3.40	1.02	1.13	1.45	1.28	3.49	2.80
10.73	5.40	6.20	0.63	0.87	0.86	0.91	1.77	1.64
10.77	2.60	2.00	0.02	0.12	0.39	0.41	1.33	1.09
10.87	3.10	2.80	0.00	0.00	0.00	0.00	1.24	1.66
10.98	2.30	2.60	2.66	1.95	0.99	1.15	1.54	1.52

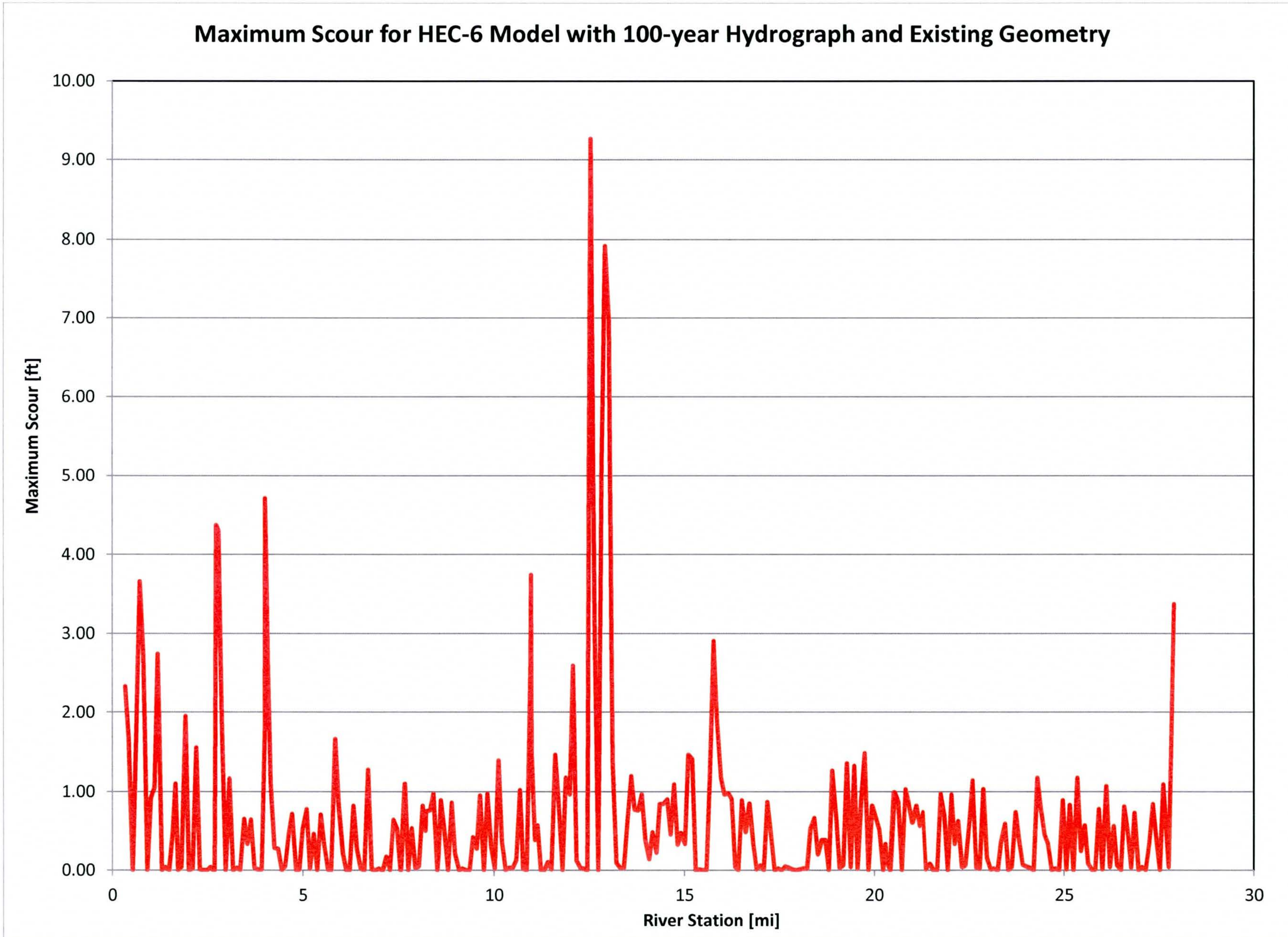
	Minimum Bed Elevation Change (Maximum Scour)							
	Fluvial-12		HEC-6		HEC-6T		HEC-RAS	
Station	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit
10.99	1.90	2.40	3.74	4.40	3.12	1.79	2.38	3.11
11	2.20	2.60	1.29	1.57	5.27	4.83	2.13	1.63
11.01	2.10	2.50	1.43	0.82	0.67	0.74	8.42	12.16
11.09	2.50	2.90	0.38	0.24	0.03	0.07	1.28	3.30
11.16	3.60	4.10	0.57	1.04	0.55	0.78	2.29	3.05
11.24	2.30	3.00	0.00	0.00	0.00	0.11	1.58	2.29
11.33	2.10	2.80	0.00	0.00	0.07	0.00	2.04	2.30
11.43	1.10	1.30	0.10	0.50	0.39	0.43	2.31	2.77
11.52	1.20	1.60	0.01	0.19	0.46	0.71	2.68	2.91
11.62	1.20	1.60	1.46	0.77	1.08	0.91	3.10	3.91
11.71	1.30	1.80	0.88	0.91	0.74	0.76	3.00	4.02
11.81	0.40	1.90	0.00	0.21	0.00	0.00	2.25	3.89
11.9	1.30	1.50	1.17	0.19	0.07	0.54	4.28	5.49
12	2.30	2.80	0.96	1.17	1.02	1.28	5.59	7.02
12.09	4.00	5.20	2.59	2.27	2.53	2.47	9.98	11.57
12.18	0.00	0.00	0.12	0.00	0.17	0.00	2.02	0.74
12.28	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.03
12.37	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02
12.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.56	11.00	7.90	9.27	5.66	9.63	5.61	9.89	6.79
12.66	0.00	10.80	3.19	5.97	3.27	5.67	4.83	10.25
12.75	0.00	0.00	0.00	0.02	0.00	0.02	0.00	14.04
12.85	5.80	23.30	5.20	12.57	5.57	14.05	19.33	20.04
12.94	17.30	25.30	7.92	6.46	8.00	5.70	17.12	19.92
13.04	16.50	25.40	6.96	6.16	5.41	5.83	6.03	19.99
13.13	11.60	25.00	1.40	2.55	0.87	2.31	1.73	15.37
13.23	8.20	0.00	0.09	0.00	0.09	0.00	0.85	0.67
13.32	5.50	0.00	0.03	0.00	0.03	0.00	0.03	0.00
13.42	3.90	0.00	0.03	0.00	0.03	0.00	0.03	0.00
13.51	8.70	0.00	0.63	0.00	0.61	0.00	1.26	0.00
13.61	16.30	0.00	1.19	0.00	1.02	0.00	1.99	0.03
13.7	23.50	35.10	0.77	15.38	1.18	11.87	3.29	20.02
13.79	13.30	36.20	0.76	8.09	0.80	7.96	3.76	19.04
13.89	8.30	34.10	0.96	6.81	1.26	6.78	4.25	16.51
13.98	8.50	31.20	0.38	4.71	0.30	4.79	5.06	18.11
14.08	4.30	2.50	0.14	0.26	0.29	0.36	5.44	4.85
14.17	0.80	12.90	0.48	0.05	0.27	0.06	6.08	3.79
14.27	0.60	1.30	0.22	0.00	0.43	0.00	7.06	0.00
14.36	1.90	1.50	0.84	0.00	1.00	0.00	2.05	0.00
14.45	1.40	0.80	0.84	0.00	0.92	0.00	2.72	0.00

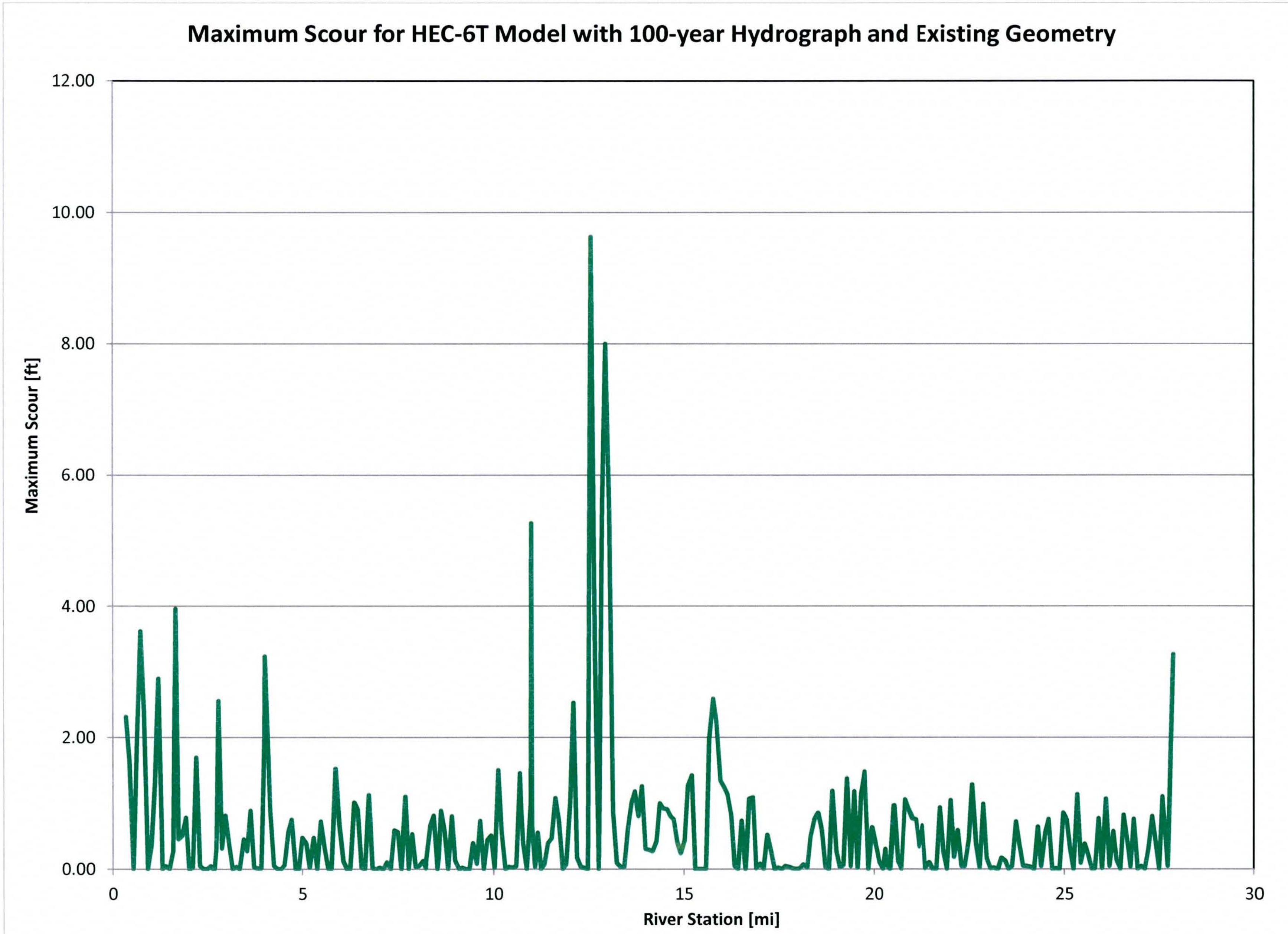
	Minimum Bed Elevation Change (Maximum Scour)							
	Fluvial-12		HEC-6		HEC-6T		HEC-RAS	
Station	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit
14.55	0.50	0.00	0.90	0.04	0.91	0.04	2.10	0.04
14.64	0.30	0.00	0.45	0.00	0.80	0.00	2.40	0.00
14.73	1.70	5.30	1.09	0.00	0.75	0.00	2.41	19.87
14.83	2.30	32.70	0.32	11.38	0.40	11.07	6.86	19.95
14.92	2.90	35.50	0.47	9.20	0.24	8.65	5.17	19.76
15.02	0.00	37.40	0.33	8.46	0.44	7.84	7.81	20.00
15.11	0.00	6.70	1.46	0.56	1.27	0.56	4.77	15.71
15.21	1.40	0.00	1.40	0.05	1.42	0.05	2.34	0.05
15.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.4	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
15.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.68	5.20	16.40	1.17	7.19	1.96	9.26	0.12	20.02
15.78	8.30	14.60	2.90	6.54	2.59	5.50	5.40	19.65
15.87	8.80	12.90	1.88	4.77	2.23	3.33	5.99	19.67
15.97	6.90	13.30	1.16	3.03	1.34	2.35	5.18	19.13
16.06	4.30	16.80	0.96	0.87	1.25	1.53	4.61	9.42
16.16	3.00	16.40	0.98	1.21	1.13	1.16	4.54	6.95
16.25	6.40	22.40	0.90	0.68	0.83	1.09	4.10	6.09
16.35	13.50	33.00	0.04	0.04	0.04	0.00	2.31	3.86
16.44	11.90	29.20	0.00	0.00	0.00	0.00	2.79	4.22
16.53	5.40	17.00	0.89	1.04	0.73	0.82	3.04	4.18
16.63	3.60	16.60	0.48	0.02	0.00	0.26	2.51	3.10
16.72	1.90	8.50	0.85	1.05	1.07	1.05	3.23	3.40
16.82	2.20	6.00	0.33	0.96	1.09	0.58	3.74	3.75
16.91	1.10	3.30	0.01	0.01	0.01	0.01	3.85	4.00
17.01	6.80	6.80	0.06	0.06	0.08	0.00	3.13	3.13
17.1	3.30	3.60	0.00	0.00	0.00	0.00	1.74	1.94
17.2	1.40	1.30	0.87	0.62	0.52	0.43	2.69	2.81
17.29	2.40	1.60	0.46	0.37	0.28	0.19	2.68	2.71
17.39	0.00	0.00	0.00	0.00	0.00	0.00	2.61	2.65
17.48	0.00	0.00	0.02	0.02	0.02	0.02	2.76	2.78
17.58	0.70	0.60	0.00	0.00	0.00	0.00	1.86	1.64
17.67	0.30	0.30	0.05	0.05	0.05	0.05	2.28	1.85
17.77	1.30	1.20	0.03	0.03	0.03	0.03	1.16	1.47
17.86	0.60	0.50	0.01	0.01	0.01	0.01	1.00	0.83
17.95	0.60	0.60	0.00	0.00	0.00	0.00	0.76	0.73
18.05	1.20	1.40	0.01	0.01	0.01	0.01	0.42	0.40
18.14	3.40	3.20	0.02	0.01	0.07	0.07	0.17	0.12
18.24	2.90	4.00	0.02	0.02	0.02	0.01	0.10	0.07

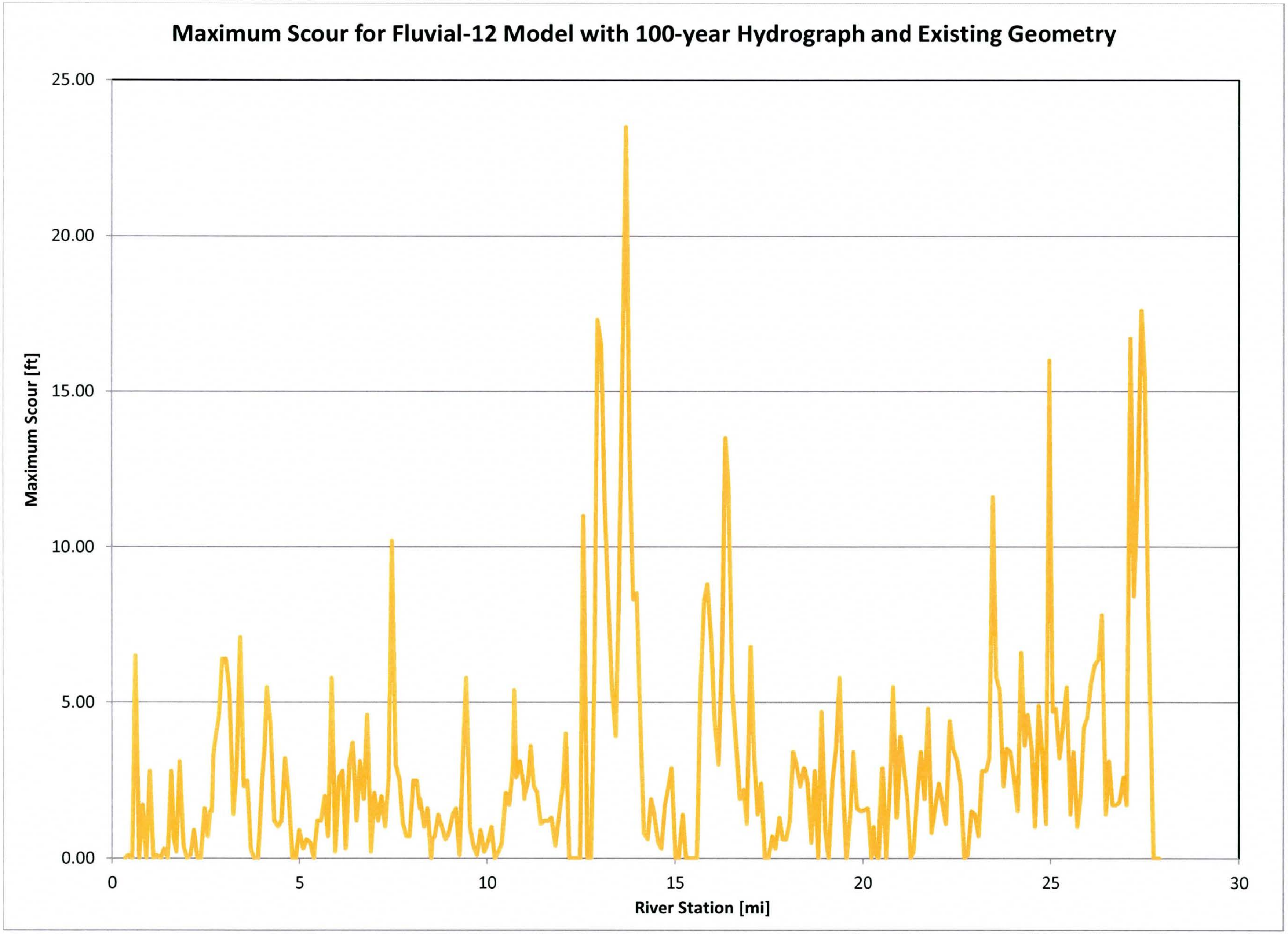
	Minimum Bed Elevation Change (Maximum Scour)							
	Fluvial-12		HEC-6		HEC-6T		HEC-RAS	
Station	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit
18.33	2.30	2.70	0.53	0.53	0.51	0.46	0.90	0.86
18.43	2.90	2.80	0.66	0.73	0.76	0.58	1.38	1.30
18.52	2.40	2.40	0.20	0.69	0.86	0.31	0.75	0.69
18.62	0.50	1.00	0.38	0.25	0.58	0.39	0.92	0.85
18.71	2.80	1.20	0.38	0.45	0.03	0.48	0.32	0.33
18.81	0.00	0.20	0.00	0.00	0.00	0.00	0.59	0.54
18.9	4.70	5.90	1.26	1.22	1.19	1.23	0.48	0.47
19	0.80	0.80	0.66	0.61	0.26	0.02	0.00	0.00
19.09	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.03
19.19	2.50	3.50	0.06	0.06	0.06	0.06	0.36	0.36
19.28	3.50	3.40	1.35	1.35	1.38	1.35	0.08	0.08
19.38	5.80	6.40	0.04	0.04	0.04	0.04	0.22	0.22
19.47	2.10	2.20	1.32	1.18	1.18	1.16	0.32	0.32
19.56	0.00	0.00	0.02	0.02	0.02	0.02	0.08	0.05
19.66	1.30	1.50	0.88	1.10	1.15	0.86	0.63	0.51
19.75	3.40	3.70	1.48	1.54	1.48	1.47	4.30	4.35
19.85	1.60	2.30	0.00	0.00	0.00	0.00	2.55	2.82
19.94	1.50	1.90	0.82	0.82	0.63	0.80	3.12	3.36
20.14	1.60	1.50	0.50	0.41	0.10	0.20	2.59	2.68
20.23	0.00	0.00	0.00	0.00	0.00	0.00	1.92	2.13
20.3	1.00	1.60	0.33	0.30	0.30	0.30	1.65	2.18
20.32	0.20	0.20	0.12	0.07	0.07	0.07	1.37	1.19
20.42	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.22
20.51	2.90	3.10	0.99	0.93	0.97	0.93	0.44	0.34
20.61	0.00	0.10	0.86	0.12	0.11	0.11	0.16	0.16
20.7	2.10	2.30	0.00	0.00	0.00	0.00	0.35	0.35
20.8	5.50	6.10	1.03	1.26	1.06	1.05	0.78	0.79
20.89	1.30	1.10	0.85	0.03	0.91	0.81	1.01	1.01
20.98	3.90	3.70	0.60	0.36	0.77	0.78	1.79	1.79
21.08	2.80	3.30	0.82	0.94	0.75	0.74	1.93	1.93
21.17	1.90	1.90	0.56	0.58	0.34	0.32	1.41	1.41
21.27	0.00	0.20	0.74	1.05	0.66	0.61	1.53	1.53
21.36	0.20	0.10	0.01	0.05	0.01	0.01	1.32	1.36
21.46	2.20	2.40	0.08	0.12	0.10	0.13	1.32	1.45
21.55	3.40	3.60	0.00	0.00	0.00	0.00	0.48	0.43
21.65	1.90	2.50	0.00	0.00	0.00	0.00	0.59	0.59
21.74	4.80	4.60	0.97	0.74	0.94	0.81	0.84	0.76
21.84	0.80	3.10	0.70	0.82	0.24	0.20	0.21	0.12
21.93	1.60	2.00	0.00	0.00	0.00	0.00	0.00	0.00
22.03	2.40	2.50	0.96	0.88	1.05	1.13	0.59	0.57

	Minimum Bed Elevation Change (Maximum Scour)							
	Fluvial-12		HEC-6		HEC-6T		HEC-RAS	
Station	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit
22.12	1.80	1.90	0.33	0.44	0.18	0.48	0.67	0.66
22.21	1.10	1.20	0.62	0.46	0.59	0.60	0.86	0.45
22.31	4.40	4.00	0.04	0.04	0.04	0.04	0.23	0.22
22.4	3.50	3.80	0.06	0.06	0.04	0.04	0.62	0.26
22.5	3.10	3.50	0.61	0.47	0.45	0.45	1.37	1.50
22.59	2.40	2.70	1.14	1.19	1.29	1.25	1.33	1.45
22.69	0.00	1.70	0.03	0.32	0.37	0.39	0.68	1.16
22.78	0.10	2.10	0.02	0.02	0.02	0.02	1.28	1.79
22.88	1.50	2.50	1.03	1.02	0.99	0.97	0.50	0.62
22.97	1.40	1.30	0.15	0.15	0.16	0.15	0.00	0.00
23.07	0.70	0.80	0.01	0.01	0.01	0.01	0.01	0.01
23.16	2.80	2.70	0.02	0.02	0.02	0.02	0.15	0.28
23.26	2.80	2.50	0.00	0.00	0.00	0.00	1.05	1.05
23.35	3.20	2.80	0.37	0.37	0.17	0.14	2.05	2.04
23.45	11.60	10.90	0.59	0.56	0.12	0.26	1.15	1.14
23.54	5.80	6.40	0.00	0.00	0.00	0.00	2.13	2.12
23.63	5.40	5.50	0.04	0.04	0.04	0.04	1.12	0.96
23.73	2.30	2.40	0.74	0.75	0.72	0.72	1.17	1.16
23.82	3.50	3.40	0.39	0.38	0.38	0.42	1.14	1.15
23.92	3.40	2.50	0.07	0.37	0.05	0.05	1.40	1.51
24.01	2.60	2.20	0.05	0.24	0.05	0.06	1.14	1.20
24.11	1.50	1.50	0.03	0.03	0.03	0.03	0.59	0.66
24.2	6.60	5.60	0.00	0.00	0.00	0.00	0.00	0.00
24.3	3.60	4.40	1.17	1.16	0.64	0.64	0.93	0.93
24.39	4.60	2.60	0.80	0.76	0.04	0.04	0.23	0.23
24.49	3.50	1.80	0.44	0.45	0.56	0.65	0.48	0.48
24.58	1.00	1.00	0.33	0.32	0.76	0.79	0.52	0.52
24.68	4.90	2.90	0.00	0.00	0.00	0.00	0.00	0.00
24.77	3.30	2.00	0.02	0.02	0.01	0.01	0.01	0.01
24.87	1.10	1.20	0.00	0.00	0.00	0.00	0.13	0.13
24.96	16.00	7.90	0.89	0.50	0.86	0.91	0.12	0.12
25.06	4.70	1.50	0.01	0.01	0.74	0.73	0.17	0.17
25.15	4.80	2.60	0.83	0.83	0.32	0.33	0.12	0.13
25.24	3.20	2.90	0.00	0.00	0.00	0.00	1.10	1.10
25.34	4.30	3.40	1.17	1.26	1.14	1.17	1.51	1.51
25.43	5.50	4.20	0.24	0.05	0.09	0.09	1.29	1.29
25.53	1.40	0.70	0.57	0.57	0.38	0.37	1.10	1.10
25.62	3.40	3.00	0.08	0.40	0.22	0.27	0.48	0.48
25.72	1.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
25.81	2.00	2.00	0.01	0.01	0.01	0.01	0.31	0.30

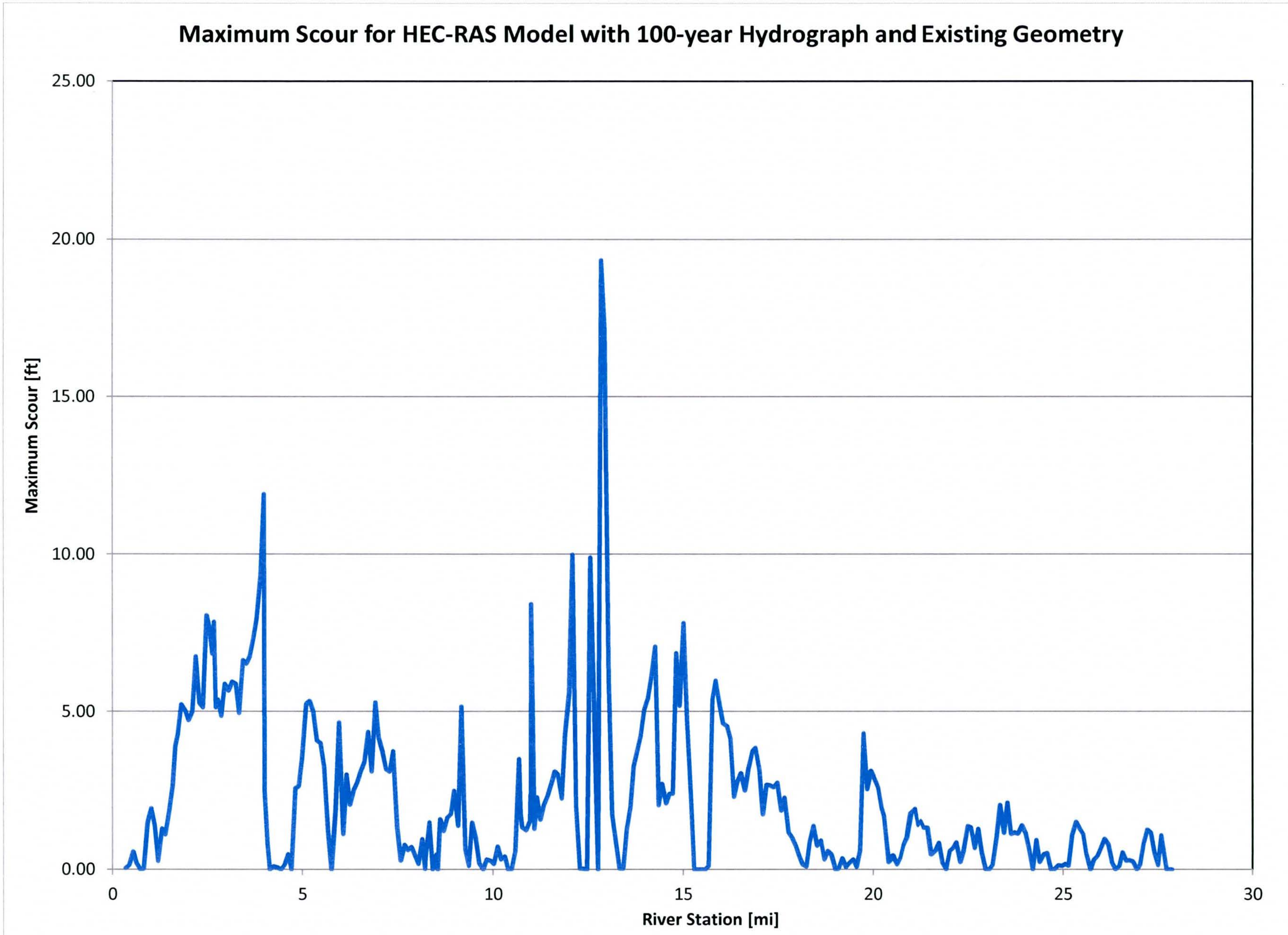
	Minimum Bed Elevation Change (Maximum Scour)							
	Fluvial-12		HEC-6		HEC-6T		HEC-RAS	
Station	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit	Existing	Ultimate Pit
25.91	4.20	4.10	0.78	0.84	0.77	0.81	0.42	0.42
26	4.50	4.30	0.01	0.01	0.01	0.01	0.68	0.68
26.1	5.60	5.60	1.07	1.08	1.07	1.09	0.96	0.96
26.19	6.20	6.10	0.04	0.04	0.04	0.04	0.79	0.79
26.29	6.40	6.70	0.56	0.57	0.57	0.56	0.21	0.21
26.38	7.80	1.60	0.06	0.06	0.13	0.10	0.00	0.00
26.48	1.40	0.10	0.00	0.00	0.00	0.00	0.11	0.11
26.57	3.10	2.10	0.81	0.82	0.82	0.82	0.54	0.54
26.67	1.70	2.80	0.49	0.48	0.45	0.45	0.28	0.28
26.76	1.70	1.30	0.03	0.03	0.03	0.03	0.29	0.29
26.85	1.80	1.40	0.73	0.73	0.76	0.75	0.26	0.26
26.95	2.60	3.80	0.00	0.00	0.00	0.00	0.00	0.00
27.04	1.70	1.90	0.04	0.04	0.04	0.04	0.16	0.16
27.14	16.70	16.30	0.00	0.00	0.00	0.00	0.86	0.86
27.23	8.40	9.70	0.33	0.35	0.31	0.30	1.26	1.26
27.33	11.80	10.50	0.84	0.84	0.80	0.81	1.15	1.15
27.43	17.60	17.20	0.39	0.39	0.40	0.39	0.51	0.51
27.52	15.40	14.10	0.00	0.00	0.00	0.00	0.14	0.14
27.61	7.80	7.50	1.09	1.09	1.10	1.10	1.08	1.08
27.75	0.00	1.70	0.04	0.04	0.04	0.04	0.00	0.00
27.89	-	-	3.37	3.43	3.27	3.29	0.00	0.00

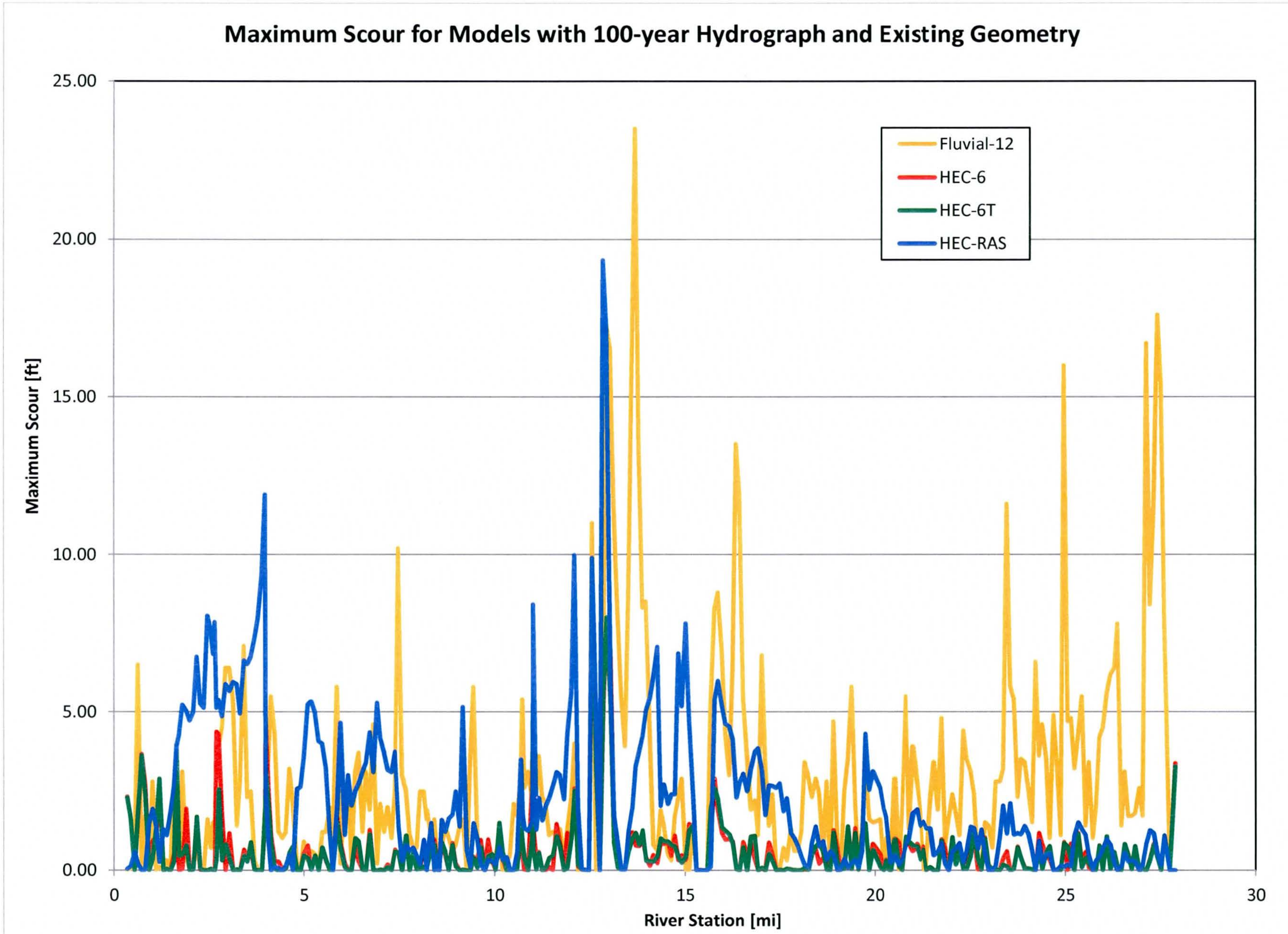

Maximum Scour for HEC-6 Model with 100-year Hydrograph and Existing Geometry
Maximum Scour [ft]
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
5
10
15
20
25
30
River Station [mi]

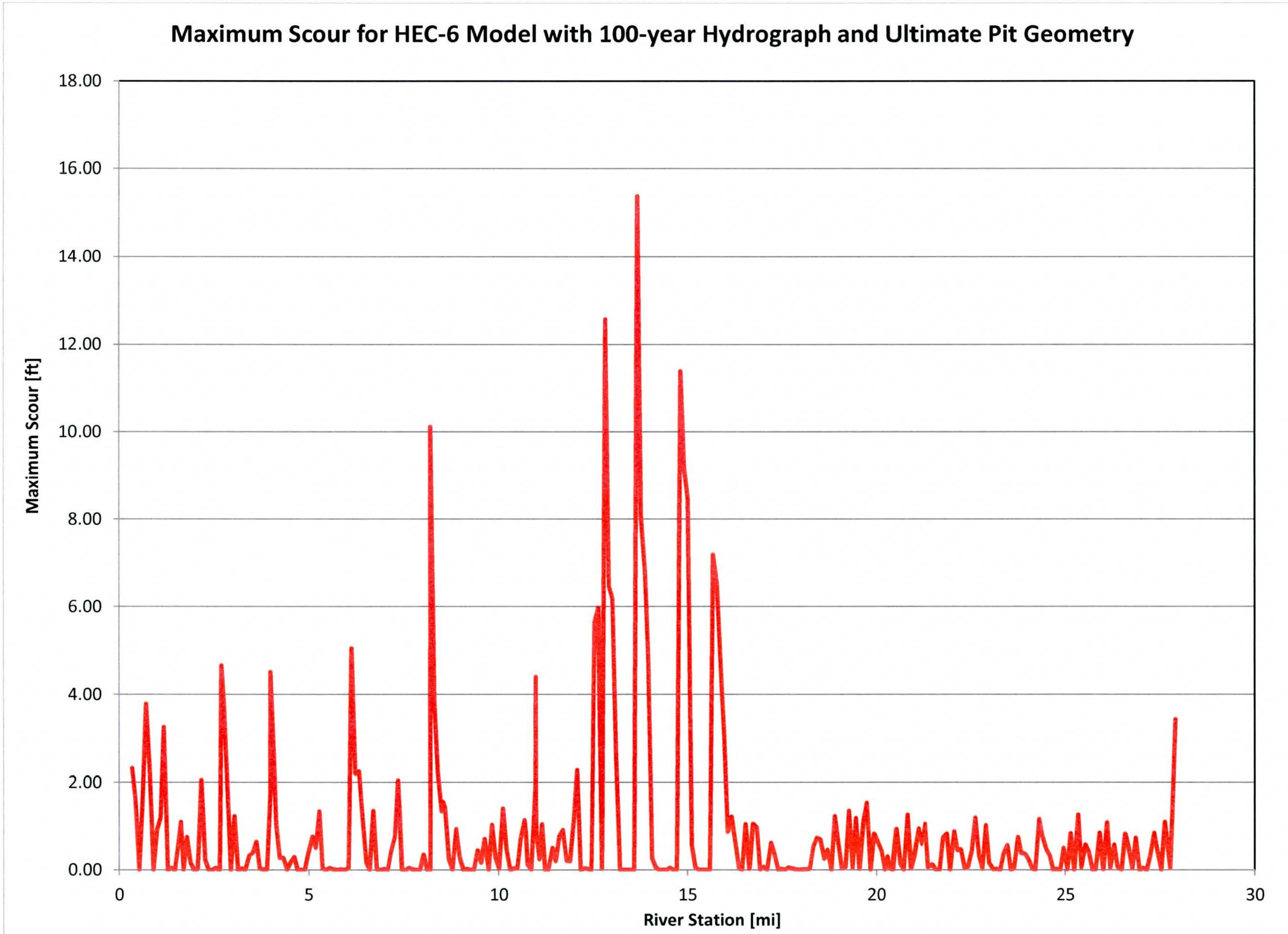

Maximum Scour for HEC-6T Model with 100-year Hydrograph and Existing Geometry
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Maximum Scour [ft]
0
5
10
15
20
25
30
River Station [mi]



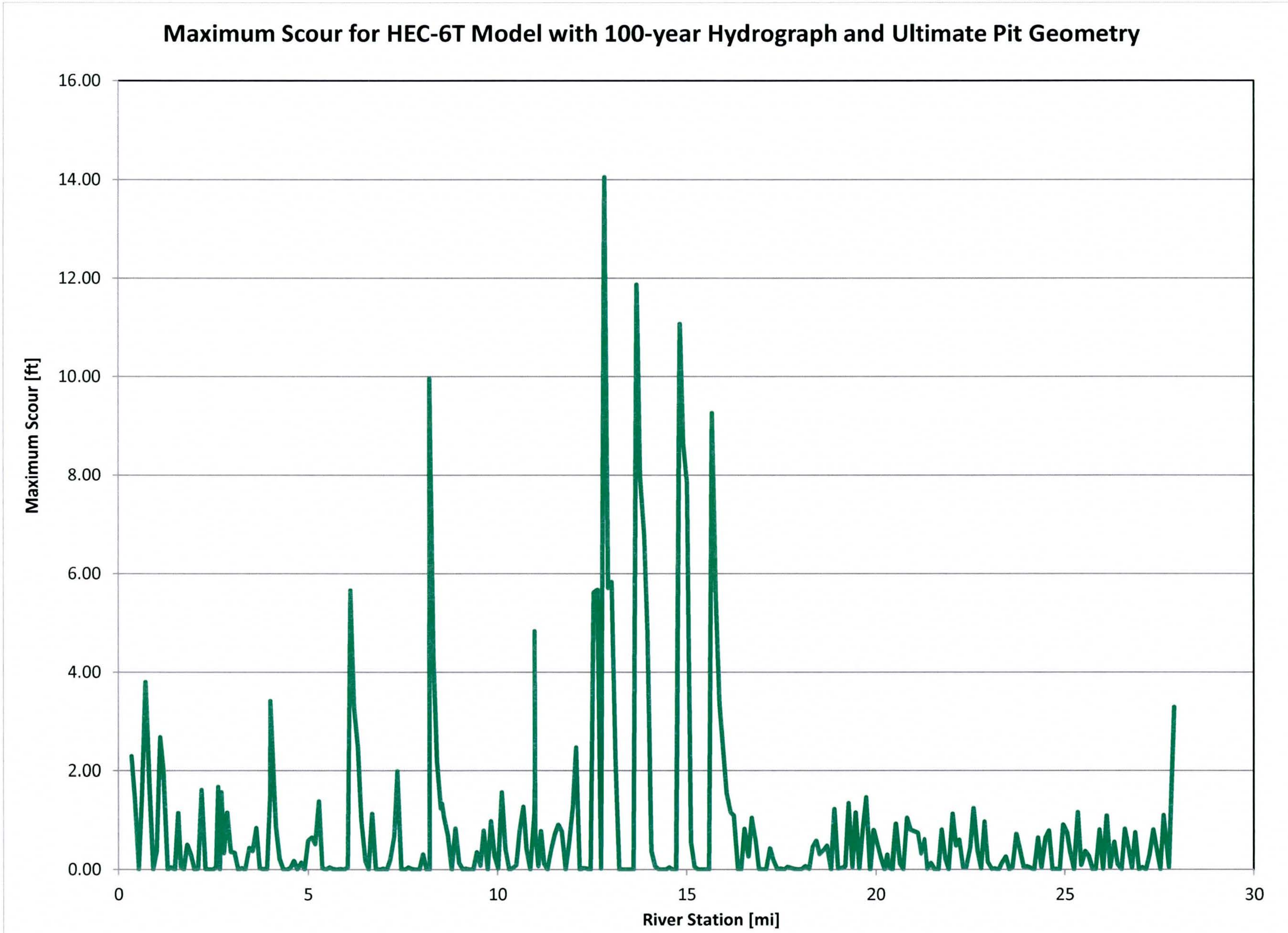
Maximum Scour for Fluvial-12 Model with 100-year Hydrograph and Existing Geometry
25.00
20.00
15.00
10.00
5.00
0.00
Maximum Scour [ft]
0
5
10
15
20
25
30
River Station [mi]

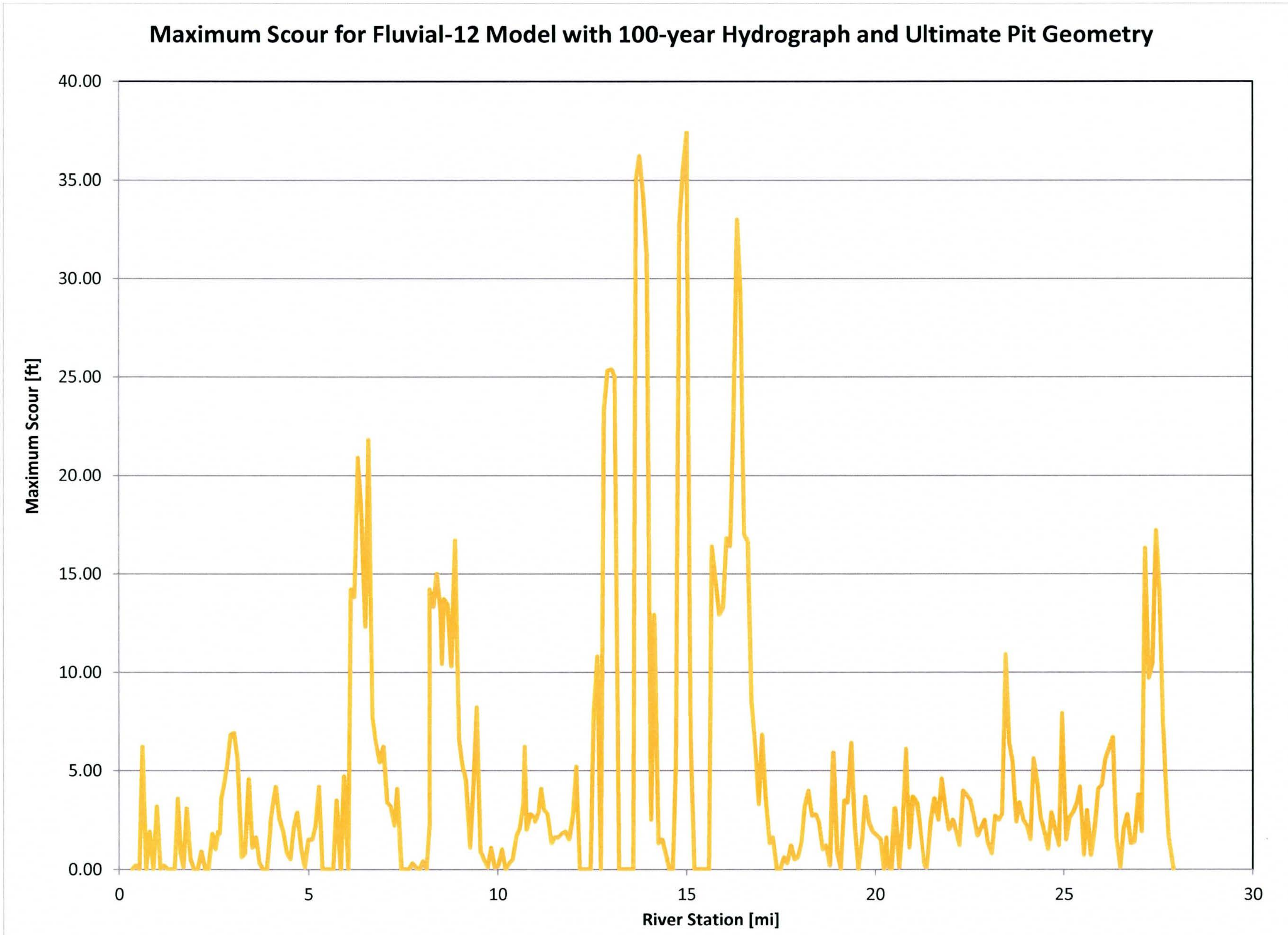

Maximum Scour for HEC-RAS Model with 100-year Hydrograph and Existing Geometry
Maximum Scour [ft]
25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
20
25
30
River Station [mi]


Maximum Scour for Models with 100-year Hydrograph and Existing Geometry
Maximum Scour [ft]
25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
20
25
30
River Station [mi]
Fluvial-12
HEC-6
HEC-6T
HEC-RAS

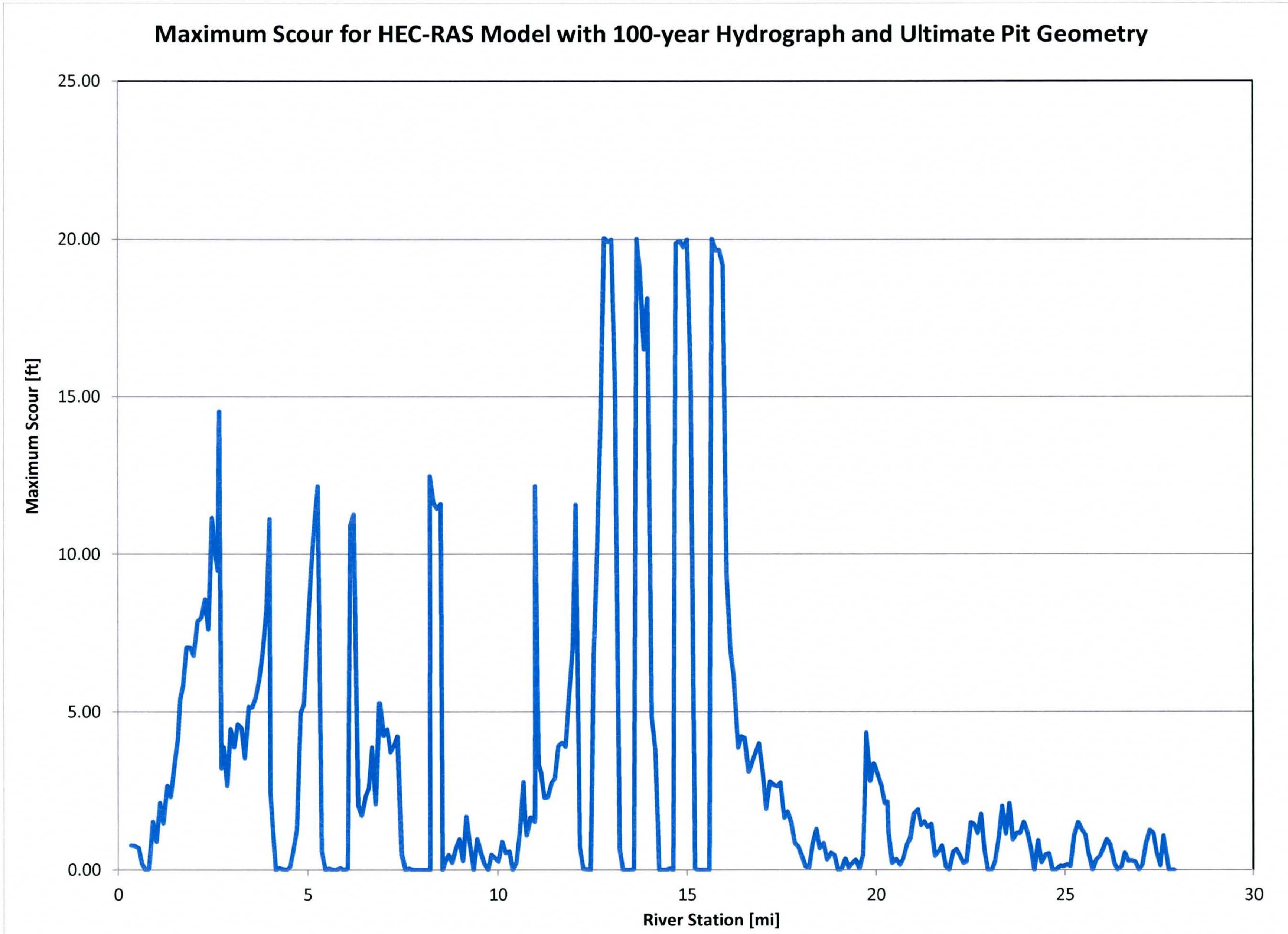


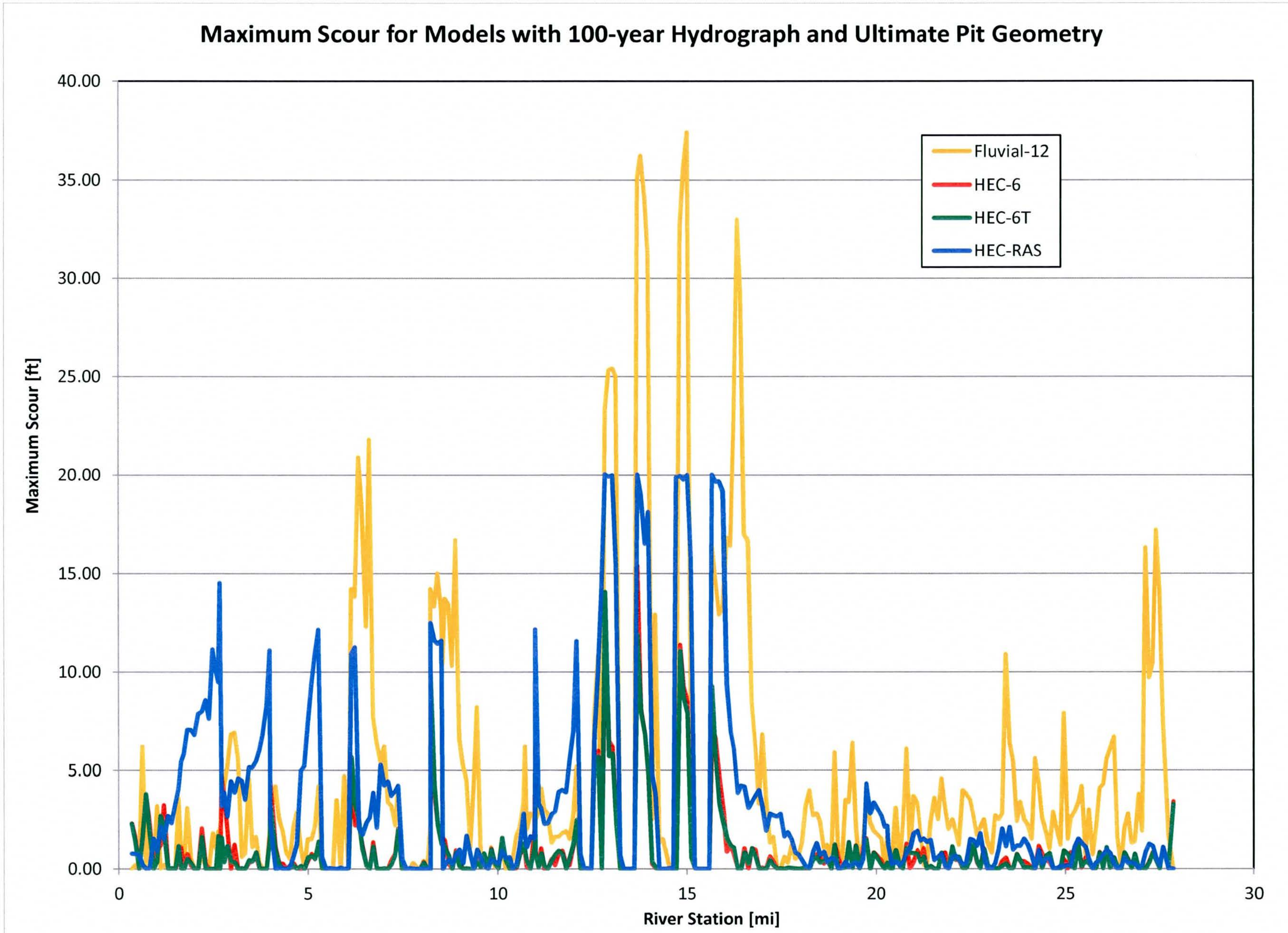
Maximum Scour for HEC-6 Model with 100-year Hydrograph and Ultimate Pit Geometry
Maximum Scour [ft]
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
5
10
15
20
25
30
River Station [mi]


Maximum Scour for HEC-6T Model with 100-year Hydrograph and Ultimate Pit Geometry
Maximum Scour [ft]
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
5
10
15
20
25
30
River Station [mi]



Maximum Scour for Fluvial-12 Model with 100-year Hydrograph and Ultimate Pit Geometry
Maximum Scour [ft]
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
20
25
30
River Station [mi]


Maximum Scour for HEC-RAS Model with 100-year Hydrograph and Ultimate Pit Geometry
25.00
20.00
15.00
10.00
5.00
0.00
Maximum Scour [ft]
0
5
10
15
20
25
30
River Station [mi]


Maximum Scour for Models with 100-year Hydrograph and Ultimate Pit Geometry
Fluvial-12
HEC-6
HEC-6T
HEC-RAS
Maximum Scour [ft]
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
20
25
30
River Station [mi]

Appendix E

RESPONSES TO FLOOD CONTROL DISTRICT COMMENTS

Flood Control District
of Maricopa County

MEMORANDUM

Date: June 30, 2015

To: Brian Schalk, P.E., CFM, Atkins Project Manager, Atkins North America, Inc.

From: Shimin Li, PhD, P.E., Senior Civil Engineer, Engineering Application Development and River Mechanics Branch, Engineering Division

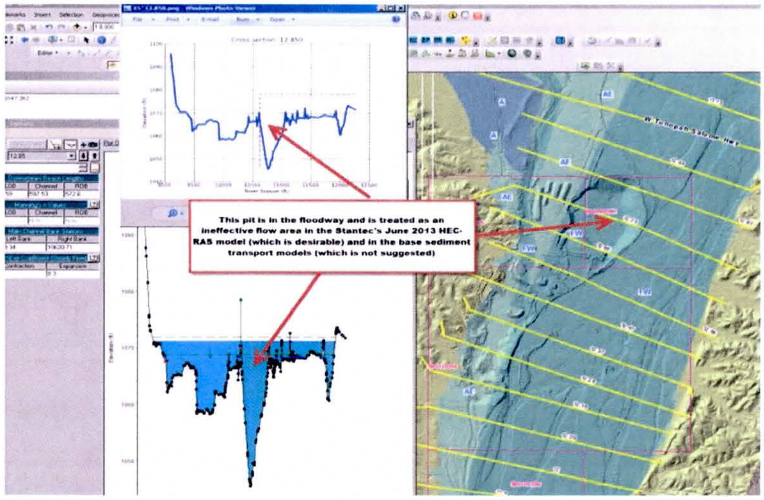
Pramita Chitraka, EIT, CFM, Hydrologist, Engineering Application Development and River Mechanics Branch, Engineering Division

Cc: Bing Zhao, PhD, P.E., Engineering Application Development and River Mechanics Branch Manager, Engineering Division

Subject: Hassayampa River Sediment Transport Models Update Contract #2014C002/ Summary Final Report (draft) dated May 2015, updated HEC-6, HEC-6T, HEC-RAS, and Fluvial-12 models, and Atkins' updated comment responses dated 6/16/2015 but submitted on 6/25/2015

The Summary Final Report (draft) dated May 2015, updated models, and the updated comment responses dated 6/16/2015 were received on 6/25/2015. Below are the comments and updated comments. Resolved comments are grayed out.

1. **(FCD 2/27/2015)** For the base sediment transport models (HEC-6, HEC-6T, HEC-RAS and Fluvial-12), please disregard/remove Stantec's 2013 HEC-RAS ineffective areas (in both floodway and fringe) caused by sand and gravel pits (see the picture below for an example). Please keep the ineffective areas in the base sediment transport models that are caused by non-sand-gravel-pits. The table in next page lists the Stantec's HEC-RAS model's river station numbers whose ineffective areas are recommended to be disregarded in the base sediment transported models. Please verify that these river stations truly represent sand and gravel pits.



Line number	Ineffective areas from Stantec's 2013 HEC-RAS model are recommended to be removed from all base sediment transport models for the following river stations. These ineffective flow areas represent sand and gravel pits. Please verify that these river stations truly represent sand and gravel pits based on aerials and topographic data.
1	27.75
2	12.85
3	12.75
4	12.66
5	12.56
6	12.47
7	12.37
8	12.28
9	12.18
10	5.76
11	5.67

(Atkins 3-3-2015) Action Taken: Ineffective flow areas and channel conveyance limits for all cross sections verified to contain sand and gravel pits have been moved beyond the pit contained in the cross section. Bank stations were also moved to include sand and gravel pits within the main channel.

(FCD 3/20/2015):

Below are our principle concepts concerning using ineffective areas in the updated models and making sure that the updated ultimate pit models be consistent with existing approved ultimate pit condition sediment transport models. Please check the models to make sure these concepts are applied.

a. For Existing Condition Models

a) If Stantec's HEC-RAS model blocked a sand and gravel pit by ineffective flow area approach, then remove the blockage; if Stantec's HEC-RAS model did not block the pit, then do not block it.

b) If Stantec's HEC-RAS model used ineffective flow to block non-pit area, then keep the ineffective flow areas.

b. For Ultimate Pit Condition Models

a) If the sand and gravel pit has the approved erosion-protection berms that prevent flow from entering into it, then block the pit. Please make sure that the berms have the erosion protection approved by the District and water does not enter into the pit.

c. For All Models

a) If Stantec's HEC-RAS model does not have ineffective areas in a cross section, please do not add any ineffective areas, except for those pits with erosion-protected berms.

d. For Ultimate Pit Condition Models

- Please double check the ultimate pit condition models against the approved sediment transport models that are part of an approved sand and gravel mining permit to make sure the number of cross sections, cross section locations, and cross section geometries are the same as those in the approved models near the pit. If there is an error found in the previous models, then do not use the wrong cross-section data. If there is no previously approved model, then develop the pit conditions. Based on our review, for the pit SG06-005, there is an approved HEC-6 model. It also has a new cross-section added near cross-section 8.22.

Please consider adding this cross-section to your model. We also found for this pit that the cross-section geometry in your submitted model does not match the cross-section geometry in the geometry of the approved model. Please check. Pit FA01-113, SG13-002 and SG07-001 also have a sediment transport model. Please review. We suggest you to come to the District to review the permit files and models with the District staff.

(Atkins 5-27-2015) Action Taken: All models have been checked to ensure that ineffective flow areas for all sand/gravel pits without bank protection have been removed. Two pits (SG06-005 Phase 1 and FA01-113 Area 2) with bank protection have been modeled using ineffective flow areas in HEC-6, HEC-6T, and Fluvial-12. The pits with bank protection have been modeled using obstructions in HEC-RAS. All ineffective flow areas from the Stantec model not associated with sand and gravel pits have been retained.

Some of the approved models for the pit permits have generalized geometry or have pit locations that are offset from the permit plans. The updated cross section geometry in the Atkins "Ultimate Pit" model consistently matches the construction plans and is used for all pit locations.

We have added 2 cross sections from the approved pit model for SG06-005 in all the updated models.

(FCD 6/9/2015) Please add above principle concepts (FCD 3/20/2015) concerning using ineffective areas to the beginning of section 2.1 in the report as a general guidance for the use of ineffective flows. The following are the suggested text for your consideration.

"The following summarizes a general guidance from the District staff regarding how to use ineffective flow areas for sand and gravel pits in the sediment transport models:

- For Existing Condition Models
  - If Stantec's HEC-RAS model blocked a sand and gravel pit by ineffective flow area approach, then remove the blockage; if Stantec's HEC-RAS model did not block the pit, then do not block it.
  - If Stantec's HEC-RAS model used ineffective flow to block non-pit area, then keep the ineffective flow areas.
- For Ultimate Pit Condition Models
  - If the sand and gravel pit has the approved erosion-protection berms that prevent flow from entering into it, then block the pit. Such erosion-protection berms should have been previously approved by the District as part of a sand and gravel permit.

- For All Models

  - If Stantec's HEC-RAS model does not have ineffective areas in a cross section, please do not add any ineffective areas, except for those pits with erosion-protected berms.

- For Ultimate Pit Condition Models

  - The ultimate pit condition models should be checked against the previously approved sediment transport models that are part of an approved sand and gravel mining permit to make sure the number of cross sections, cross section locations, and cross section geometries are the same as those in the approved models near the pit. If there is an error found in the previous models, then the corrections should be made according to the approved sand and gravel mining plans. If there is no previously approved model, then develop the pit conditions model based on the approved plans. For example, for the pit SG06-005, there is an approved HEC-6 model. It also has a new cross-section added near cross-section 8.22. Therefore, this new cross-section should be added. Other pits such as FA01-113, SG13-002 and SG07-001 also have a previously approved sediment transport model."

In the HEC-RAS ultimate pit condition model, an ineffective flow area (IFA) is still shown in the cross section RS 27.75 (this IFA is not shown in HEC-6, HEC-6T and Fluvial-12 models).

(Atkins 6-25-2015) We have added the suggested text to the final report. Cross section 27.75 is near the upstream boundary. The ineffective flow area present in cross section 27.75 of the Ultimate Pit Model is required for model stability. We have addressed the need for this ineffective flow area in Appendix B of the final report.

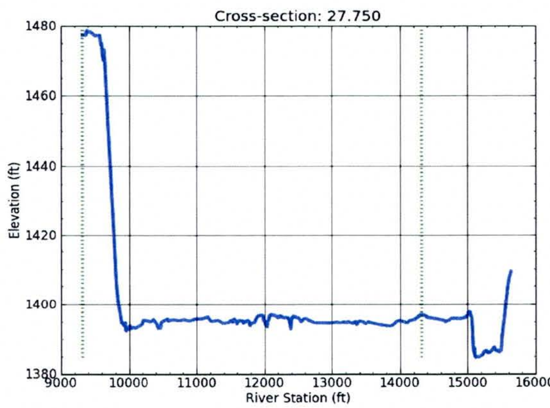
(FCD 6/30/2015) Suggested text has been added to the final report. Explanation of the ineffective area RS 27.75 in HEC-RAS is added in Appendix B. Comment resolved.

2. **(FCD 2/27/2015)** For the "ultimate pit" models, ineffective or blocked areas should be needed if the proposed berms (with riprap) are supposed to block flow from entering into the pit. Please carefully examine the approved permits and plans.

(Atkins 3-3-2015) Action Taken: This comment will be addressed in the "ultimate pit" model.

(FCD 3/20/2015) Two pits have riprap protected berms: FA01113 area 2/pit 2 and SG06-005 phase 1 pit. These two pits are treated as ineffective flow areas in the corresponding river cross section profiles of the updated HEC-RAS ultimate pit model, and in the updated Fluvial-12 ultimate pit model, the corresponding ineffective areas are eliminated. Comment resolved.

3. **(FCD 2/27/2015)** What do the two vertical dashed green lines in below screen capture represent (photo XS_27.750.png of the Plot/Update HEC-6 folder)? Please note that in the June 2013 HEC-RAS model this cross section has only one ineffe ft.



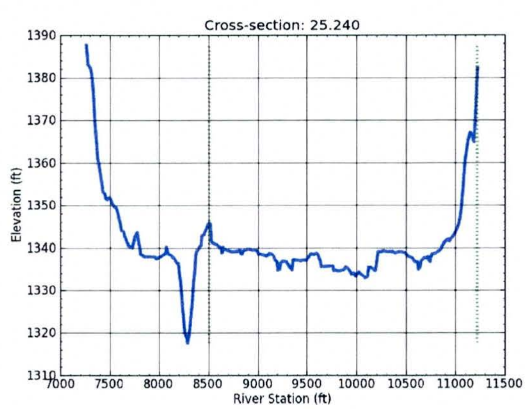
(Atkins 3-3-2015) Action Taken: The vertical dashed green lines represent channel conveyance limits in the HEC-6 and HEC-6T models. When only one side of the channel requires a conveyance limit, the conveyance limit for the side which does not require a conveyance limit is placed at outer-most station of the cross section. In cross section 27.750 the conveyance limit was moved beyond the limit of a sand and gravel pit to an approximate location of station 15600. A legend has been added to all plots in response to this comment.

(FCD 3/20/2015) FCD's updating comments to be made later.

(Atkins 5-26-2015) Submittal of Summary Final Report (draft) and newly updated models.

(FCD 6/9/2015) Comment resolved.

4. **(FCD 2/27/2015)** What does the right-side vertical dashed green line in below screen capture represent (photo XS_25.24.png of the Plot/Update HEC-6 folder)? Please note that in the HEC-RAS cross section there is only one left-side ineffective flow area with starting station at 8507.4 ft.



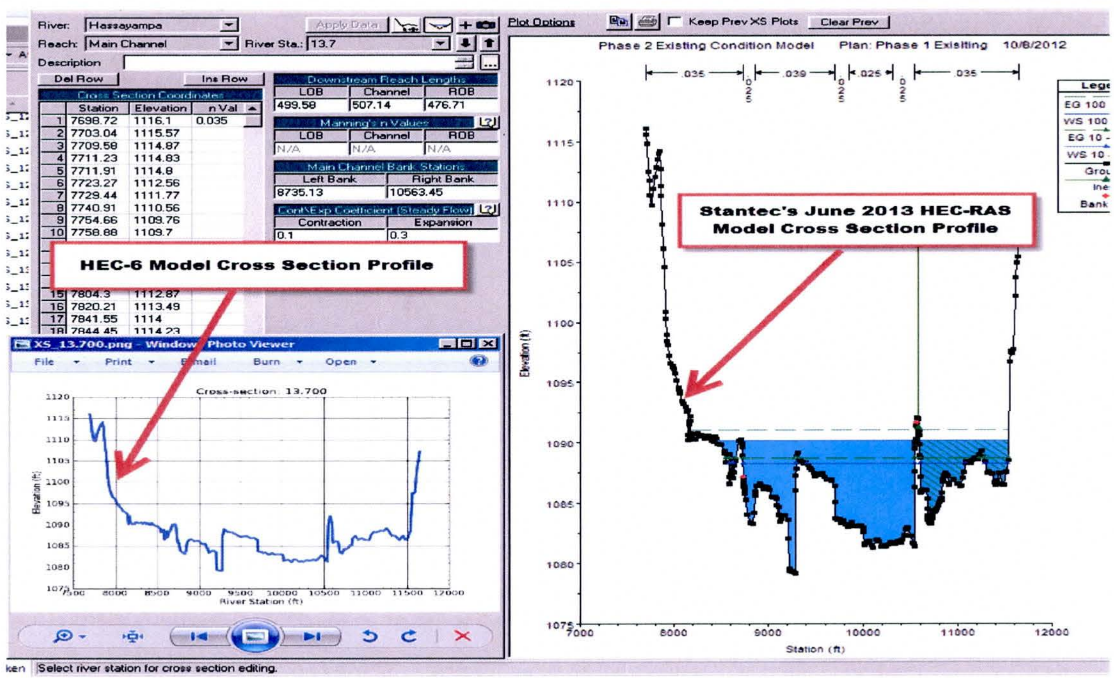
(Atkins 3-3-2015) Action Taken: The vertical dashed green lines represent channel conveyance limits in the HEC-6 and HEC-6T models. The left-side ineffective flow area in the Stantec HEC-RAS model is modeled in the updated HEC-6 and HEC-6T models using channel conveyance limits since there does not appear to be a berm preventing inundation. The right channel conveyance limit resides at the right-most point in the cross section so that is does not interfere with channel hydraulics of sediment transport. A legend has been added to all plots in response to this comment.

(FCD 3/20/2015) FCD's updating comments to be made later.

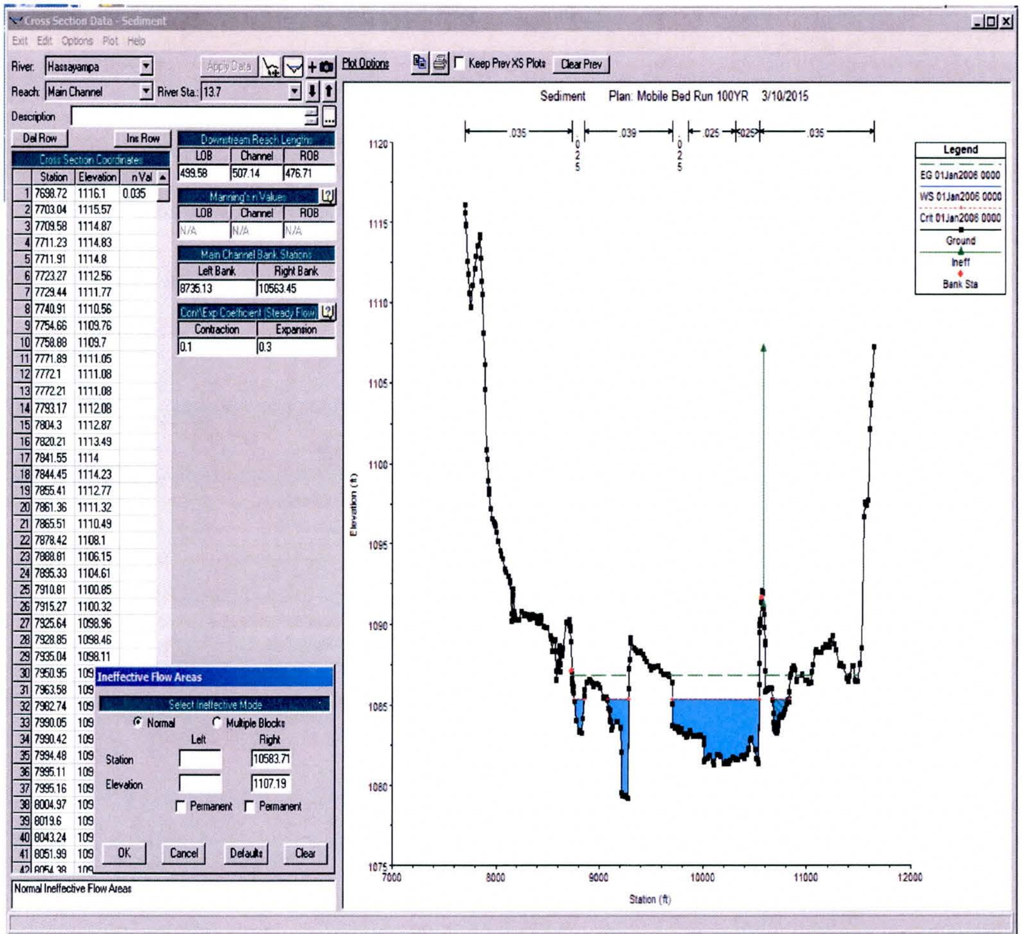
(Atkins 5-26-2015) Submittal of Summary Final Report (draft) and newly updated models.

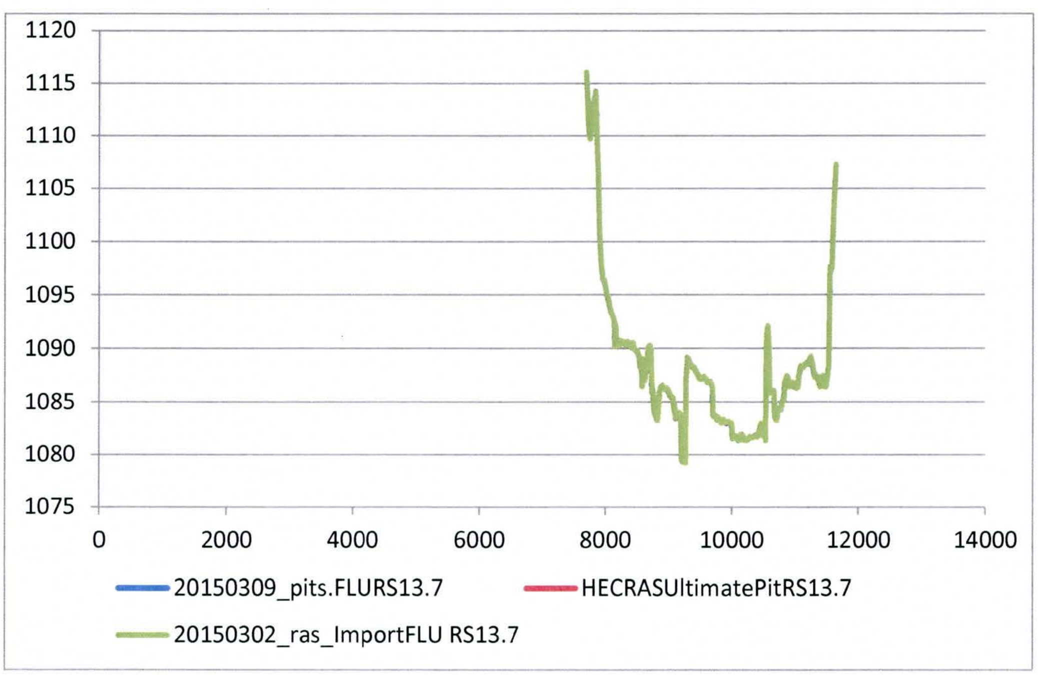
(FCD 6/9/2015) Comment resolved.

5. **(FCD 2/27/2015)** I did not see an ineffective area vertical line in the HEC-6 model for three cross-sections. But HEC-RAS has ineffective flow lines. It seems that these are not sand and gravel pits. The three cross-sections are XS_13.7, XS_13.610, and XS_13.51. The screen capture below is an illustration of the issue. We assume this is not a pit and the ineffective flow area should be retained in the base HEC-6 model.



(FCD 3/20/2015) Below screen capture shows the HEC-RAS ultimate pit sediment transport model includes an ineffective flow area in cross section RS 13.7 as the Stantec's 2013 HEC-RAS hydraulics model did (which is good). However, as shown in another screen capture that follows the below screen capture, the updated Fluvial-12 base and ultimate pit models do not reflect this ineffective area in their cross section RS 13.7 (which may not be good because the Fluvial-12 and HEC-RAS models become inconsistent in their cross section profiles).

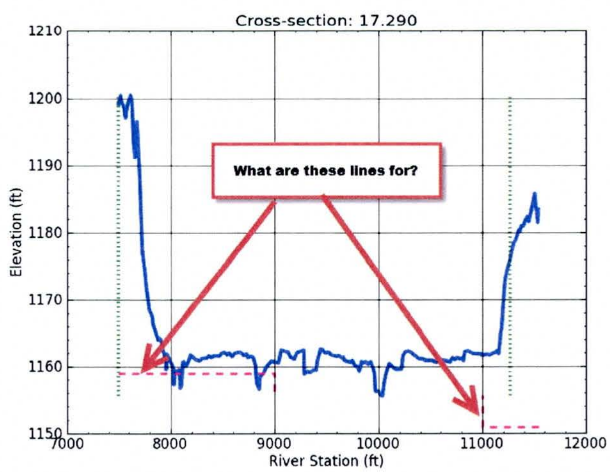




(Atkins 5-27-2015) Action Taken: Previously, only ineffective flow areas (not channel conveyance limits) from the HEC-6 model were reflected in the Fluvial-12 cross sections. The Fluvial-12 model has been updated so that the cross section geometry now reflects both the ineffective flow area and channel conveyance limits present in the HEC-6 model.

FCD (6/9/2015) Okay, Comment resolved.

6. **(FCD 2/27/2015)** What are those purple lines in the HEC-6 cross section profile photos? An example of these cross section profile photos is shown below.



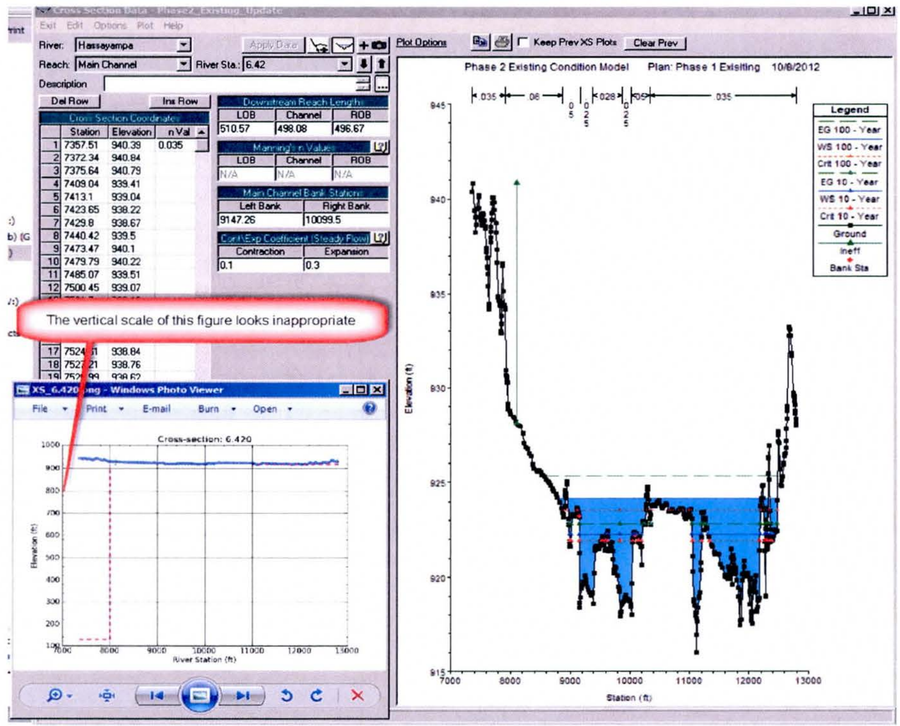
(Atkins 3-3-2015) Action Taken: The dashed purple lines represent ineffective flow areas in the HEC-6 and HEC-6T models. A legend has been added to all plots in response to this comment.

(FCD 3/20/2015) FCD's updating comments to be made later.

(Atkins 5-27-2015) NOTE: If one ineffective flow area is needed in the model, an ineffective flow area for both the left and right sides of the channel must be present for HEC-6 to run, therefore any unused ineffective flow areas (ones which are below the cross section and never intersect the cross section) have been moved to the extreme edge of the cross section.

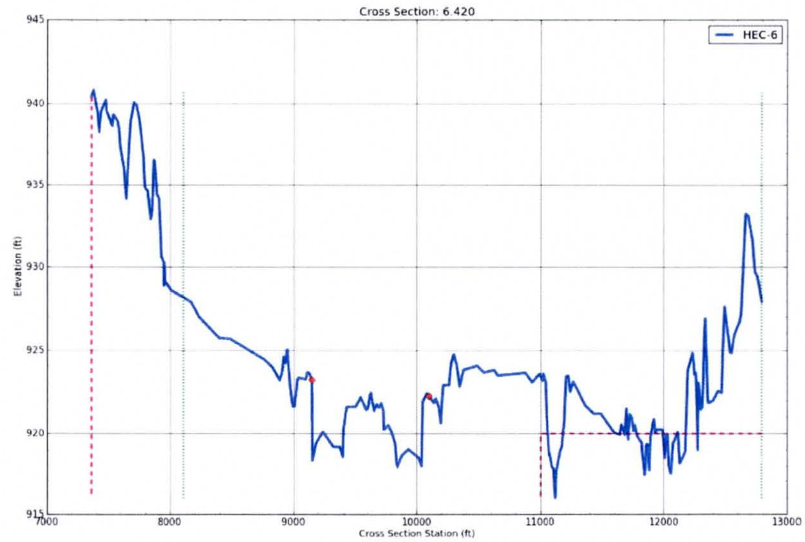
(FCD 6/9/2015) Okay. Comment resolved.

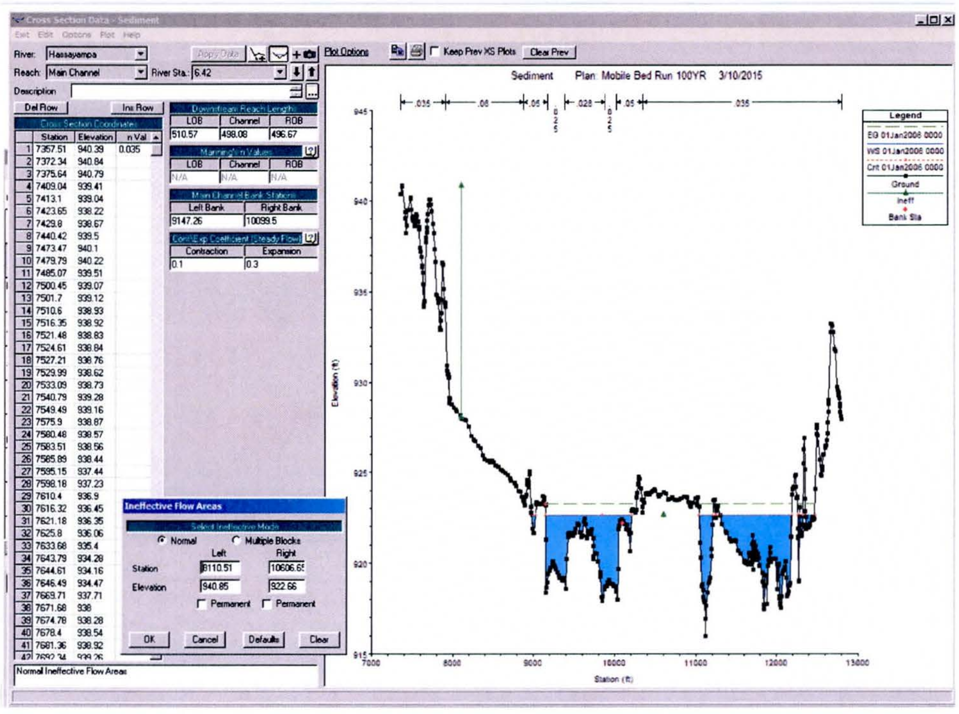
7. **(FCD 2/27/2015)** The vertical/horizontal scale in following cross section profile photos (HEC-6 base model) appears inappropriate: XS_23.920.png, XS_23.630.png, XS_23.540.png, XS_22.880.png, XS_6.420.png, XS_6.230.png. An example of these photos is shown below.

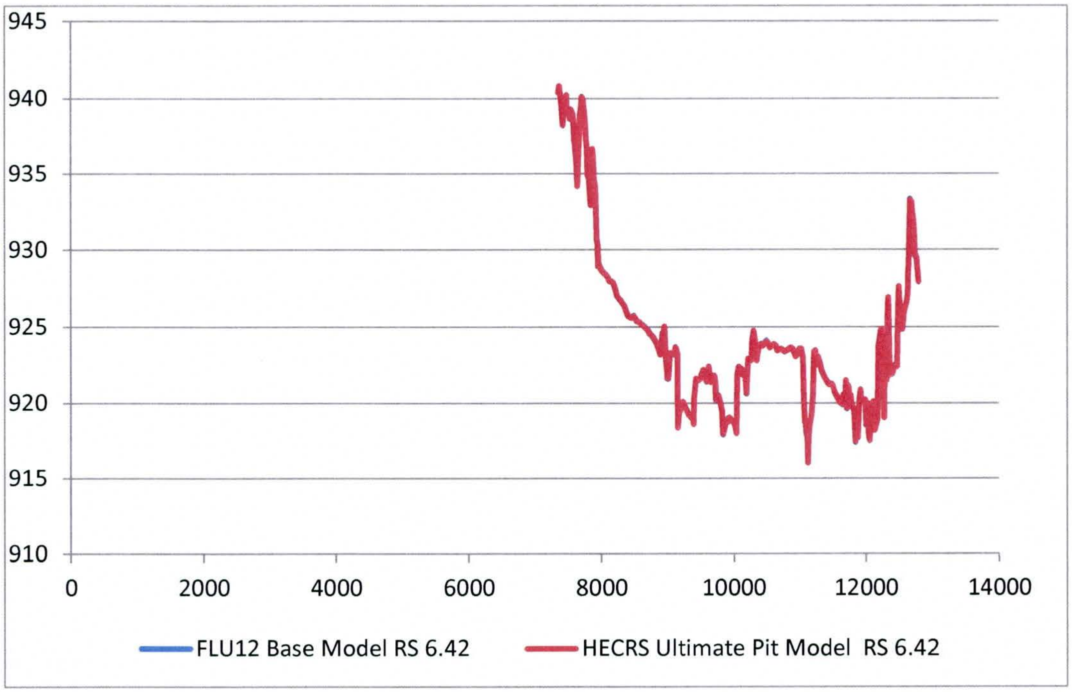


(Atkins 3-3-2015) Action Taken: The vertical and horizontal scale of these plots is determined by the location of the cross section points, the two points dictating ineffective flow areas, and channel conveyance limits. To avoid errors, the left and right points determining the location of ineffective flow must be included in the HEC-6 model. When only one point of the ineffective flow was necessary in the JE Fuller HEC-6 model, the other was place below the cross section. In the case of the aforementioned cross sections they were placed hundreds of feet below the cross section. The plots generated are scaled to show all relevant data. To resolve this problem, a point representing an ineffective flow area which is present, but not in use, is moved to the station and elevation of the outermost point on the corresponding side of the cross section.

(FCD 3/20/2015) The figures/figure scales have been changed as shown in below screen capture, which is good. However, some discrepancies in ineffective flow area, conveyance limit, and encroachment between the models are shown in the two screen captures that follow the below screen capture. The two screen captures show that HEC-RAS model includes left and right ineffective areas, HEC-6 model includes conveyance limits and encroachment, and Fluvial-12 model does not reflect the ineffective flow areas. Please discuss how these discrepancies will impact the modeling results.


Cross Section: 6.420
HEC-6
Elevation (ft)
Cross Section Station (ft)
945
940
935
930
925
920
915
7000
8000
9000
10000
11000
12000
13000

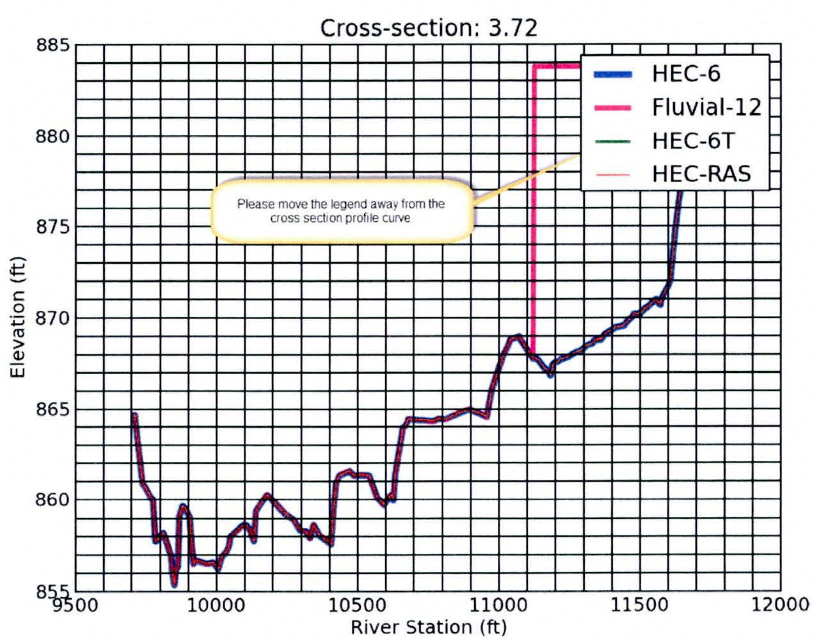

Cross Section Data - Sediment
River: Hassayampa
Reach: Main Channel
River Sta.: 6.42
Description
Del Row
Ins Row
Cross Section Coordinates
Station
Elevation
n Val
Downstream Reach Lengths
LOB
Channel
ROB
510.57
498.08
496.67
Manning's n Values
N/A
Main Channel Bank Stations
Left Bank
Right Bank
9147.26
10099.5
Cont\Exp Coefficient (Steady Flow)
Contraction
Expansion
0.1
0.3
Ineffective Flow Areas
Select Ineffective Mode
Normal
Multiple Blocks
Left
Right
Station
8110.51
10606.65
Elevation
940.85
922.66
Permanent
OK
Cancel
Defaults
Clear
Normal Ineffective Flow Areas
Plot Options
Keep Prev XS Plots
Clear Prev
Sediment Plan: Mobile Bed Run 100YR 3/10/2015
Legend
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



(Atkins 5-27-2015) Action Taken: In HEC-6 and HEC-6T, ineffective flow areas are used to alter the cross section geometry prior to performing any hydraulic and sediment transport modeling (similar to editing the cross section in Fluvial-12), whereas conveyance limits define the limits of erosion. Erosion may not occur outside of the conveyance limits, however, deposition may still occur outside the conveyance limits. Conveyance limits and ineffective flow areas were using in accordance with what had been used in the original 2006 JE Fuller HEC-6 model.

FCD (6/9/2015) Okay, comment resolved.

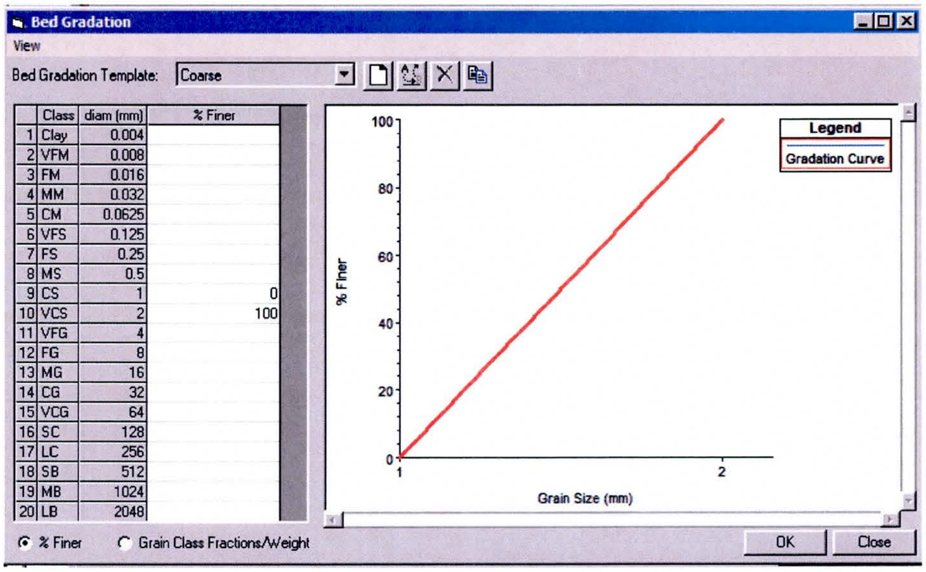
8. **(FCD 2/27/2015)** For the photos in the "Updated Models –HEC-RAS, HEC-6, HEC-6T, Fluvial-12" folder, please move the legend away from the cross section profiles curves (see the screen capture below for an example).

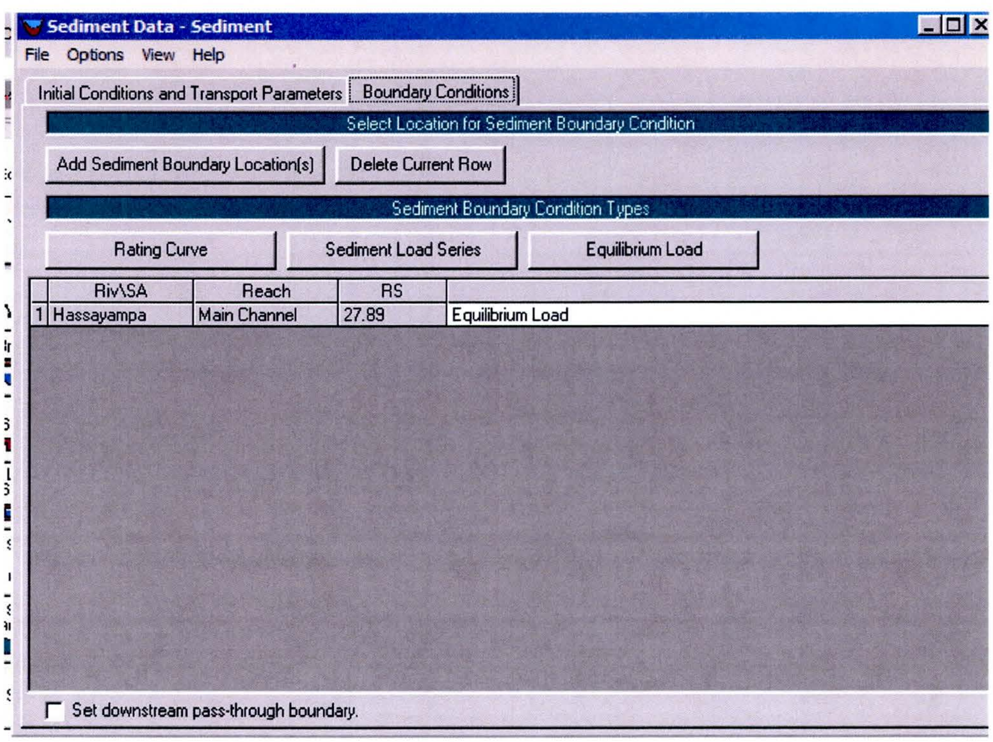


(Atkins 3-3-2015) Action Taken: Previously the legends appeared at the top right corner of each plot. Now all legends have been placed in the most suitable location.

(FCD 3/20/2015) Okay. Comment resolved.

9.**(FCD 3/20/2015)** In the HEC-RAS sediment transport models the initial sediment gradations and the upstream sediment inflow load (shown in below screen captures) are not the same as those in the JE Fuller's 2006 HEC-6 model. Please revise these to be consistent with the JE Fuller's 2006 HEC-6 model.





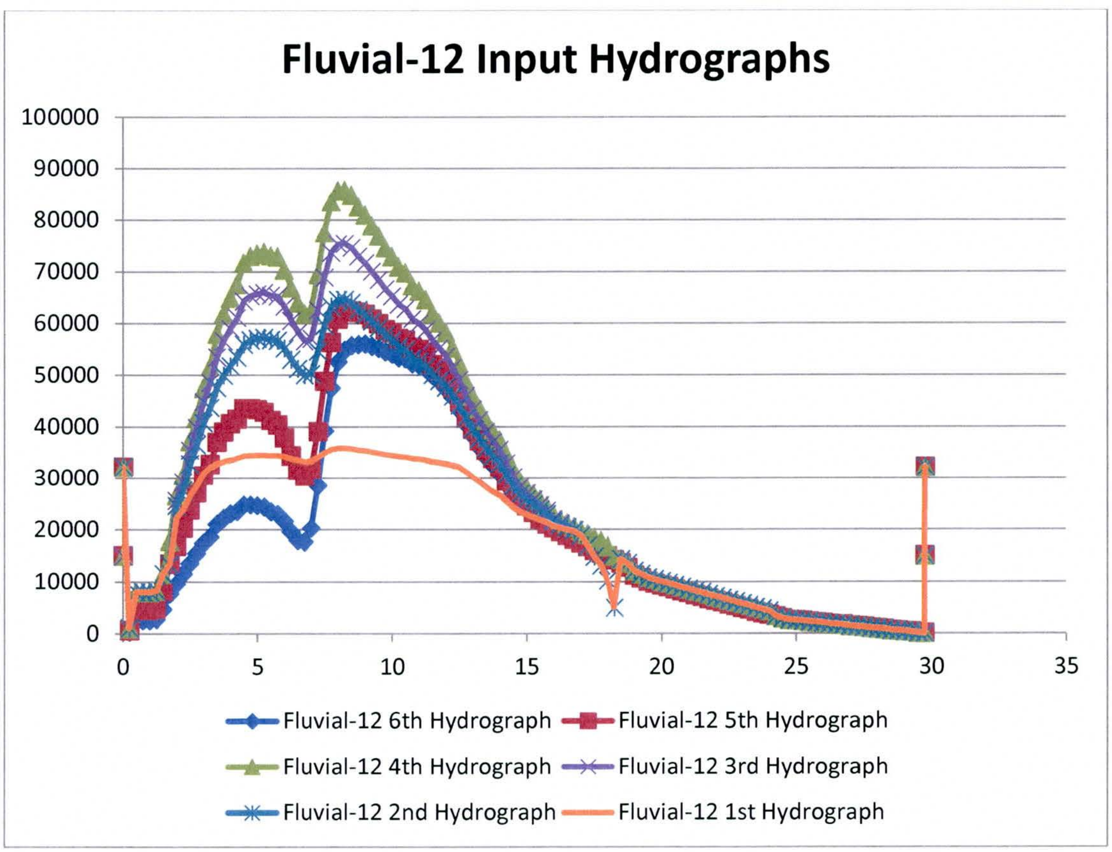
(Atkins 5-27-2015) Action Taken: Sediment load at the upstream boundary has been was set to match the 2006 JE Fuller HEC-6 model. The HEC-RAS gradation has been changed to match the 2006 JE Fuller HEC-6 model.

FCD (6/9/2015) Okay, Comment resolved.

10. **(FCD 3/25/2015)** In Atkins Fluvial-12 sediment transport models, it seems that the flow hydrograph at the lower reach of the river after the splits, the total Q is still used. In the meeting of February 17, 2015, Atkins mentioned that they would revise the Q based on the original JE Fuller's HEC-6 model's Q. Please revise it to be consistent with the JE Fuller's 2006 HEC-6 model.

(Atkins 5-27-2015) Action Taken: We have replaced the hydrograph from the original 2009 Chang model with the hydrograph from the 2006 HEC-6 model by JE Fuller.

(FCD 6/9/2015) Below figure shows the six input hydrographs for the Fluvial-12. Please explain why the hydrographs have sharp spikes at time 0 hour and time 30 hour (see figure below) (we did not see these two spikes in the 100-year hydrograph of JE Fuller's HEC-6 model).



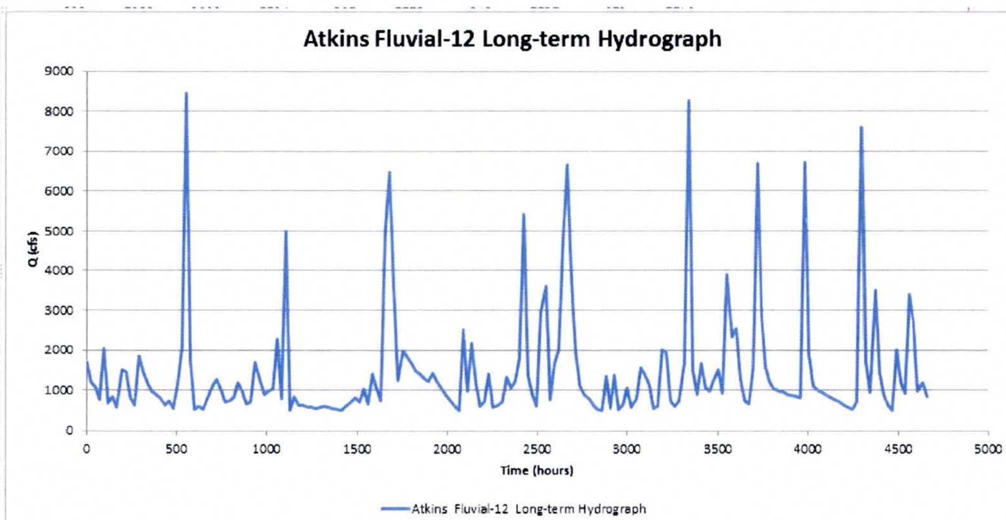
(Atkins 6-25-2015) We have removed these spikes. They are artifacts of near instantaneous 10-year events used for output recording purposes in JE Fuller's HEC-6 model. We have also used linear interpolation to eliminate the dip in the first hydrograph in the image below.

(FCD 6/30/2015) Please eliminate the dip in other hydrographs in the Fluvial-12.

(Atkins 6-30-2015) The spikes and dips have been removed in all affected hydrographs.

(FCD 6/30/2015) The spikes and dips have been removed in all affected hydrographs. Comment resolved.

11. **(FCD 3/25/2015)** In the JE Fuller's long term HEC-6 model, the hydrograph is different in these three reaches: from RS 27.89 to RS 21.08, from RS 21.08 to RS 15.21 and from RS 15.21 to RS 0.35 (there are local inflows at RS 21.08 and RS 15.21). However, in Atkins long term Fluvial-12 model, one hydrograph appears to cover the entire river reach from RS 27.89 to RS 0.35 (which is shown in below screen capture). Please revise these to be consistent with the JE Fuller's 2006 HEC-6 model.

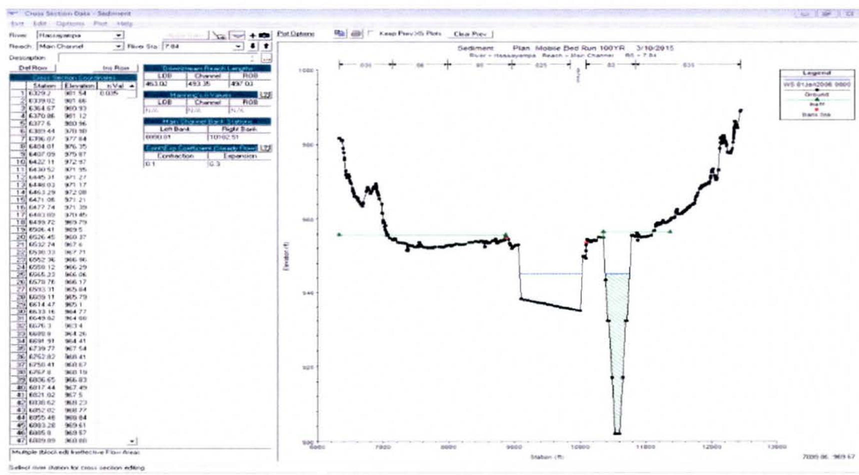


(Atkins 5-27-2015) Action Taken: We have replaced the hydrograph from the original 2009 Chang model with the hydrograph from the 2006 HEC-6 model by JE Fuller.

(FCD 6/9/2015) Okay. Comment resolved.

12. **(FCD 4/1/2015)** In the ultimate HEC-RAS sediment transport model, the pit with the berm with protection (XS 7.84-8.13 and XS 15.59-15.87) is blocked

using ineffective flow approach. Since flow never gets into the pit, the pit should be blocked completely either by using levee or obstruction.



(Atkins 5-27-2015) Action Taken: Pits with bank protection in the "Ultimate Pit Model" have been blocked using levees instead of ineffective flow areas.

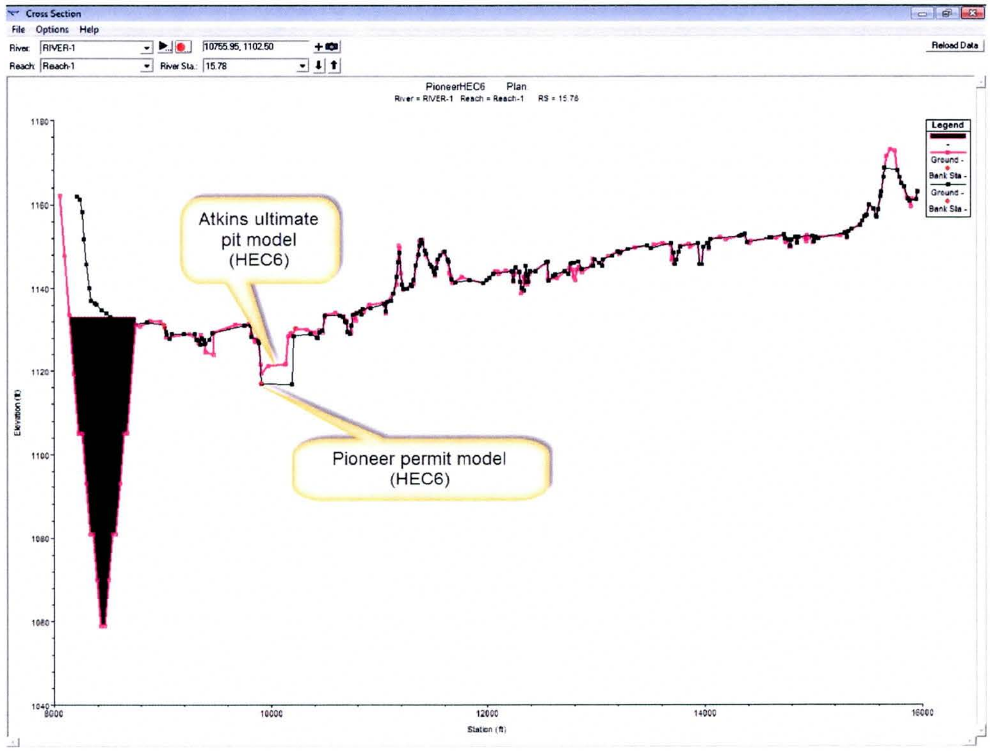
(FCD 6/9/2015) Okay. The ultimate pit condition model is updated. Comment resolved.

13. **(FCD 4/1/2015)** The ultimate pit condition for HEC-6 and HEC-6T are submitted for long term flow condition only which contradicts with the scope of work (SOW). According to SOW, the ultimate pit condition should be modeled for 100 year flood event.

(Atkins 5-27-2015) Action Taken: The historic flow hydrograph has been replaced with the 100yr hydrograph.

(FCD 6/9/2015) Comment resolved.

14. **(FCD 4/7/2015)** The channel in the XS15.68, XS 15.78, XS 15.02 and XS 14.92 should be modeled according the permit in ultimate pit condition. Below is the screenshot showing the difference in Pioneer permit model and Atkins ultimate pit model. Please verify the depth of the channel from the permit.



(Atkins 5-27-2015) Action Taken: It was determined that the geometry in the Atkins "Ultimate Pit Model" matches the approved plans for the pit.

(FCD 6/9/2015) Okay. Comment resolved.

15. **(FCD 6/9/2015)** Last line on page 4 of the draft Summary Final Report: "Section 0" should be "Section 2.0."

    (Atkins 6-25-2015) This has been updated in the final report

    (FCD 6/30/2015) Comment resolved.

16. **(FCD 6/9/2015)** Line 9 on page 9 of the draft Summary Final Report: "HEC-6T" should be "HEC-6" and in last line of bullet # 4, page 10 "HEC-6" should be "HEC-6T".

    (Atkins 6-25-2015) This has been updated in the final report

    (FCD 6/30/2015) Comment resolved.

17. **(FCD 6/9/2015)** Line 23 on page 9 of the draft Summary Final Report: The word "move" may be deleted.

    (Atkins 6-25-2015) The word "move" has been removed.

    (FCD 6/30/2015) Comment resolved.

18. **(FCD 6/9/2015)** Line 2 on page 12 of the draft Summary Final Report: "Section 0" should be "Section 2.0."

    (Atkins 6-25-2015) This has been updated in the final report

    (FCD 6/30/2015) Comment resolved.

19. **(FCD 6/9/2015)** Lines 18 and 19 on page 12 of the draft Summary Final Report: These two lines should be revised to be consistent with the Scope of Work, where three models are required: existing condition with 100-year hydrograph, existing condition with long term hydrograph, and ultimate pit with 100-year hydrograph.

    (Atkins 6-25-2015) These lines have been changed to be consistent with the scope of work.

    (FCD 6/30/2015) Comment resolved.

20. **(FCD 6/9/2015)** Appendix C to the draft Summary Final Report: The titles and legends of the thalweg profile figures are for "Input" and "Output". Are the "Input" and "Output" for the initial thalweg and thalweg at the end of the simulation? If yes, please use "Initial Thalweg" and "Thalweg at the End" instead of "Input" and "Output". An alternative way is to define "Input" and "Output" as a footnote on each figure.

    (Atkins 6-25-2015) We will change the legends from "Input" and "Output" to "Initial Thalweg" and "Final Thalweg" respectively.

    (FCD 6/30/2015) Legends have been revised per suggestion. Comment resolved.

21. **(FCD 6/9/2015)** Based on the fourth bullet point on page 3 of the scope of work, "For each river cross-section the maximum scour depth during the 100-year flood hydrograph period will be compared in both graphical and tabular format for each of the four computer programs. Any discrepancy should be discussed."

    However, in Appendix D "Maximum Scour Plot", the maximum scour results listed in the table "Minimum Bed Elevation Change (Maximum Scour)" are not the maximum scour depth during the 100-year flood hydrograph period. In addition, no discussion was made about the comparison and possible discrepancy between the four computer programs.

    Here are some modeling tips to obtain the maximum scour depth during the 100-year flood hydrograph period. For HEC-6T, $MXMN command can be used to automatically obtain the maximum scour. For Fluvial-12, G4 card should be used with a value of 1 for field 7, which will create an additional output file called TZMIN. For HEC-RAS, Sediment Transport Analysis ➔

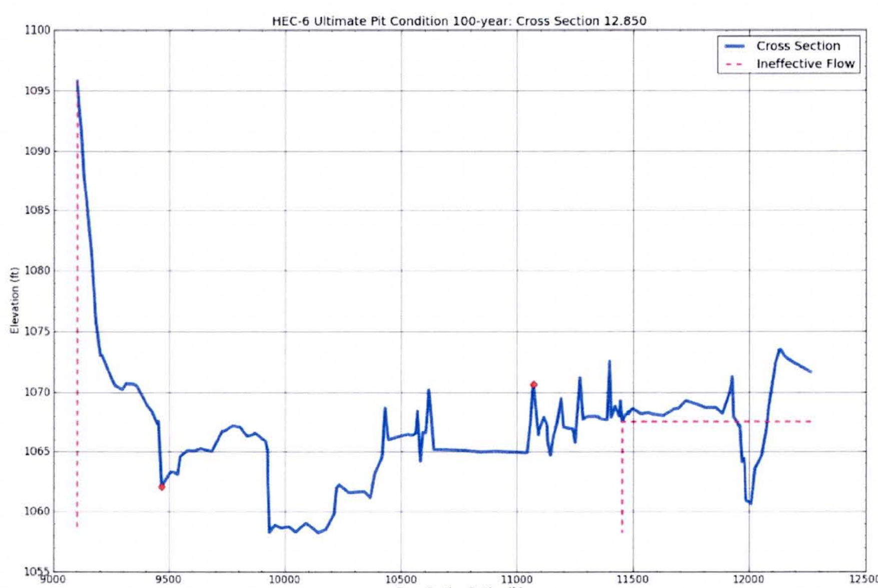
Options ➔ Sediment Output Options ➔ Enter 1 as the Number of Increments Between Profile/Time Series Output. Then the maximum scour depth can be obtained from the Sediment Spatial Plot table under View menu. For HEC-6, use B in column 6 of * card to obtain bed profile table in a 15-min interval or reasonably larger interval in the 100-year hydrograph. The reasonably larger interval may be 30-min.

Please list and compare the maximum scour depth as indicated in the scope of work and discuss discrepancy if there is any differences between computer programs.

(Atkins 6-25-2015) We have utilized the * record in HEC-6, the $MXMN command in HEC-6T, the G4 record in Fluvial-12, and the appropriate procedure in HEC-RAS to obtain the maximum scour. We discuss the differences between the models in our final report.

(FCD 6/30/2015) Recommended methods/ways for determining the maximum scour have been followed. Comment resolved.

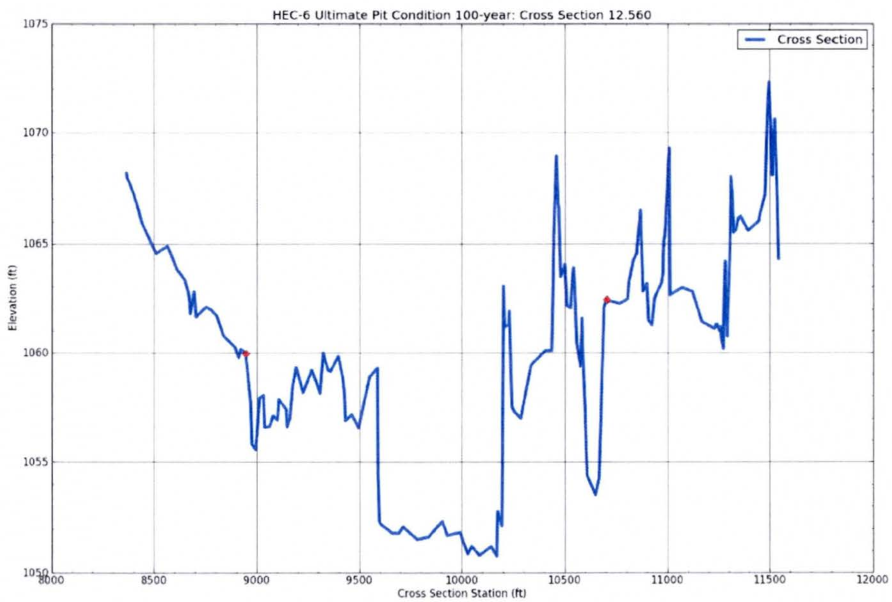
22. **(FCD 6/9/2015)** According to Hanson Aggregate Closure Plan, the filling on the North side of the Pit 1 is at elevation 1068, but in the models the elevation shown at XS 12.85 is around 1065 for the ultimate pit condition. Please verify.



(Atkins 6-25-2015) The Closure plans for Hanson Aggregate Pit 1 indicate a fill elevation of 1068. The geometry for all four Ultimate pit models have been updated.

(FCD 6/30/2015) Comment resolved.

23. **(FCD 6/9/2015)** Attached below is the plot of HEC 6 input data at XS 12.56. The lowest elevation is about at 1051 ft. However, Hanson Aggregate Closure Plan has the bottom elevation of Pit 2 (floodway pit) of 1048 ft which does not match with the plot below. Please verify this for all sediment transport models (HEC-6, HEC-6T, HEC-RAS, and Fluvial-12).



(Atkins 6-25-2015) We have confirmed that the bottom of cross section 12.56 should be between 1048.26 and 1047.5. Cross section 12.56 for all four Ultimate Pit Models have been edited to be in accordance with the closure plans for Hanson Aggregate Pit 2.

(FCD 6/30/2015) Comment resolved.

24. **(FCD 6/9/2015)** The permit number for Hanson Aggregate is SG13-002 (not SG-13-02). Please verify and correct in Table 1, page # 7 of the draft report.

(Atkins 6-25-2015) We have corrected the permit number in Table 1.

(FCD 6/30/2015) Comment resolved.

25. **(FCD 6/9/2015)** On page 12, please indicate the time stamp for HEC-6 and Fluvial-12 executables.

(Atkins 6-25-2015) We have indicated the date associated with the HEC-6 and Fluvial-12 executable files in Section 3 of the report.

(FCD 6/30/2015) Comment resolved.

26. **(FCD 6/9/2015)** The 5-26-2015-submitted HEC 6 and HEC 6T output files for Existing 100yr_hydro, Existing full_hydro and Existing Long_term_hydro are not the same as the output files we generated by running the executables for the submitted input files. Please verify and update the output files.

    (Atkins (6-25-2015) We have re-run each model before our final submission.

    (FCD 6/30/2015) Comment resolved.

27. **(FCD 6/9/2015)** On page 8, bullet No. 6 indicates that ineffective flow areas are used for erosion-protection berm for HEC-6, HEC-6T, Fluvial-12. However, in the actual HEC-6 and HEC-6T models, X3 card Method 3 of Encroachment is used. It is confusing to use the word of "Ineffective flow areas" because X3 card Method 1 is called "Ineffective flow area option" in HEC-6 and HEC-6T modeling. Maybe the phrase of "Ineffective flow area" should be avoided in this paragraph.

    (Atkins 6-25-2015) This bullet point was rephrased to be more specific about how low-flow channels are blocked.

    (FCD 6/30/2015) Comment resolved.

28. **(FCD 6/9/2015)** On page 8, bullet No. 6 indicates that levee option in HEC-RAS was used to prevent flow from entering pits with berms that are erosion protected. The locations of these levees in HEC-RAS or the locations of "ineffective flow areas" in HEC-6, HEC-6T and Fluvial-12 do not represent the locations of the berms, but represent the top edges of the pits. The difference is about 60-ft at Pioneer pit (FA01-113). This misplacement of the berms in the computer programs need to be corrected.

    (Atkins 6-25-2015) We have gone through each cross section and compared the placement and elevation of these levees and "ineffective flow areas" against the georeferenced pit plans and have made all necessary corrections.

    (FCD 6/30/2015) The location of the berms has been updated. Comment resolved.

29. **(FCD 6/9/2015)** On page 8, bullet No. 6 indicates that two pits have bank protection and that "ineffective flow areas" are used for erosion-protection berm in HEC-6, HEC-6T, and Fluvial-12 programs. The bullet No.6 also indicates that the height of the "ineffective flow areas" in the HEC-6, HEC-6T and Fluvial-12 correspond to the height of the berms shown in the permits. This description of how "ineffective flow areas" height was set in the HEC-6, HEC-6T and Fluvial-12 programs is not correct. For example, at RS 7.49, the permit plan sheet 3 (seal dated 6/27/2007) shows that the top of berm elevation at this location is 958.20. However, the elevation of the "ineffective flow areas" in HEC-6, HEC-6T and Fluvial-12 is 961.00 at this cross section location. Please check all "ineffective flow areas" elevations that represent top of protected berm

elevations in HEC-6, HEC-6T and Fluvial-12 programs, and revise the elevations in these programs according to the pit permits.

(Atkins 6-25-2015) We have gone through each cross section and compared the placement and elevation of these levees and "ineffective flow areas" against the georeferenced pit plans and have made all necessary corrections.

(FCD 6/30/2015) The corrections have been made. Comment resolved.

30. **(FCD 6/9/2015)** The final printed report should attach a DVD in the back of the report. The report should have one small section that lists and briefly describes each item on the DVD. Please make sure the DVD will contain all files that were used to generate the results and the report.

    (Atkins 6-25-2015) We have added an Appendix in the report that outlines the contents of the included DVD.

    (FCD 6/30/2015) The said appendix has been added. Comment resolved.

31. **(FCD 6/9/2015)** Please attach this comment/response file at the back of the report.

    (Atkins 6-25-2015) We have included this comment response document as an Appendix to the final report.

    (FCD 6/30/2015) The comment response document as an Appendix has been added to the final report. Comment resolved.

Appendix F

CONTENTS OF ATTACHED DVD

This Appendix contains a brief description of the files contained on the DVD that accompanies this report. Notable item on the DVD are: the original models provided to Atkins by the Flood Control District of Maricopa County, the model updates performed by Atkins, plots of the thalweg and cross section profiles for HEC-6, HEC-6T, and Fluvial-12, and all documents used to compile this report. Included for each HEC-6, HEC-6T, and Fluvial-12 model is a "Plots" folder; within this folder are two subfolders: (1) "Input" which contains the river and cross section profiles for the input file, and (2) "Input_Output" which contains the river and cross section profiles for the input (initial conditions) and output (final conditions), including two profile plots including the minimum bed elevation. The following list outlines the contents of the DVD based on folder locations:

- Fluvial-12
    - Existing
        - 100yr_Hydro: Contains the input and output files for the updated Fluvial-12 model with post-2010 topographic data with the 100-year hydrograph from the 2006 JE Fuller HEC-6 model.
        - Long_Term_Hydro: Contains the input and output files for the updated Fluvial-12 model with post-2010 topographic data with the long term hydrograph from the 2009 Chang Consultants Fluvial-12 model.
    - Pit
        - 100yr_Hydro: Contains the input and output files for the updated Fluvial-12 model with post-2010 topographic data altered to reflect the full permit conditions of the active mining permits on this reach as of May 2015 with the 100-year hydrograph from the 2006 JE Fuller HEC-6 model.
- GIS
    - Georeferenced Images: Contains georeferenced TIFF images of the mining plans used to create the "ultimate pit" geometries. The images are arranged by permit number.
    - Shapefiles: Contains shapefiles representing HEC-RAS model centerline and cutlines. Also included is the Feb 2015 Parcel information obtained from the FCD.
    - Stantec LHRWMP Phase II TIN (2010): Contains the TIN used by Stantec to create the 2013 HEC-RAS model
- HEC-6
    - Existing
        - 100yr_Hydro: Contains the input and output files for the updated HEC-6 model with post-2010 topographic data with the 100-year hydrograph.
        - Full_Hydro: Contains the input and output files for the updated HEC-6 model with post-2010 topographic data with the long term hydrograph directly followed by the 100-year hydrograph.
        - Long_Term_Hydro: Contains the input and output files for the updated HEC-6 model with post-2010 topographic data with the long term hydrograph.
    - Pit
        - 100yr_Hydro: Contains the input and output files for the updated HEC-6 model with post-2010 topographic data altered to reflect the full permit conditions of the active mining permits on this reach as of May 2015 with the 100-year hydrograph.

- HEC-6T
  - Existing
    - 100yr_Hydro: Contains the input and output files for the updated HEC-6T model with post-2010 topographic data with the 100-year hydrograph.
    - Full_Hydro: Contains the input and output files for the updated HEC-6T model with post-2010 topographic data with the long term hydrograph directly followed by the 100-year hydrograph.
    - Long_Term_Hydro: Contains the input and output files for the updated HEC-6T model with post-2010 topographic data with the long term hydrograph.
  - Pit
    - 100yr_Hydro: Contains the input and output files for the updated HEC-6T model with post-2010 topographic data altered to reflect the full permit conditions of the active mining permits on this reach as of May 2015 with the 100-year hydrograph.
- HEC-RAS: Contains the HEC-RAS model containing both existing condition (post-flood 2010) and ultimate pit condition geometries, 100-year and long term hydrographs from the 2006 JE Fuller HEC-RAS model, and sediment gradation data from the 2006 JE Fuller HEC-6 model.
- Mine Permits: Contains the original data obtained from the FCD for each active permit in the study reach
- Original Models: This folder contains the original sediment transport models obtained from the FCD.
- Report: Contains the final report and the MS Word, MS Excel, and PDF documents used to compile final report.