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GRDA
Grand River Dam Authority

October 28, 2022

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

RE: Pensacola Project (1494-438)
Summary of Updated Study Report Meeting

Dear Secretary Bose:

The Grand River Dam Authority (GRDA) is relicensing the Pensacola Hydroelectric Project (FERC No. 1494) using the Federal Energy Regulatory Commission's (Commission or FERC) Integrated Licensing Process (ILP). In accordance with the Commission's ILP regulations, 18 C.F.R. § 5.15(f), GRDA filed its Updated Study Report (USR) on September 30, 2022. Following its filing of the USR, GRDA held USR meetings with federal and state resource agencies, Native American tribes, local governmental entities, and other interested stakeholders on October 12-13, 2022. The USR meetings were conducted virtually; however, GRDA estimates that approximately 65 individuals participated in the USR meetings. GRDA appreciates the commitment to this process by all relicensing participants and the productive technical dialogue that occurred in the USR meetings.

With this letter, and as required by the Commission's ILP regulations, 18 C.F.R. §§ 5.15(c)(3), 5.15(f), GRDA is filing its summary of the USR meetings. GRDA's meeting summary consists of the agenda for each day of the meeting (Attachment A),[1] an attendee registration list (Attachment B), and the PowerPoint presentation for each study (Attachment C). With regard to the presentation materials for the Cultural Resources Working Group meeting held on October 13, 2022 (Attachment D), this material contains sensitive information regarding cultural resources, and therefore is being filed as privileged information that is exempt from public disclosure. In accordance with FERC regulations, GRDA respectfully requests the Commission to place this information in the non-public file. *See* 18 C.F.R. § 388.112.

[1] Although GRDA had planned to conduct a public summary for the cultural resources study (item P on the agenda), discussions on other studies ran longer than expected, causing GRDA to cancel this portion of the meeting. However, GRDA conducted a Cultural Resources Working Group meeting in conjunction with the USR meetings (items R through U on the agenda).

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Following GRDA's filing of the meeting summary today, relicensing participants have until November 29, 2022, to file any disagreements with the summary or any proposed modified or new studies, in accordance with the Commission's process plan and schedule and the Commission's ILP regulations. *See* 18 C.F.R. §§ 5.15(c)(4), 5.15(f).

If there are any questions or comments regarding this submittal, please contact Jacklyn Smittle (formerly Jacklyn Jaggars,) by phone at (918) 981-8473 or by email at jacklyn.smittle@grda.com.

Sincerely,

Darrell E. Townsend II, Ph.D.
Vice President
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cc: Stakeholder Distribution List (via email)

Attachment A: Agenda
Attachment B: Attendee List
Attachment C: Study Report Presentations
Attachment D: Cultural Resources Information (Privileged)

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September 2022

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Attachment A
Agenda

Agenda for Updated Study Report Meeting

Meeting Date / Time:	Wednesday, October 12 (9:00 AM to 4:30 PM CDT) Thursday, October 13 (9:00 AM to 3:00 PM CDT) Thursday, October 13 (3:00 PM to 5:00 PM CDT)- *Non-Public Cultural Resources Working Group Meeting* Note: Meeting will be conducted virtually.

Wednesday, October 12, 2022: 9:00 AM to 4:30 PM CDT

A. 9:00 to 9:15 AM: Welcome and Introductions – GRDA

B. 9:15 to 9:30 AM: Meeting Purpose 18 C.F.R. § 5.15(c)(2) – GRDA

C. 9:30 to 10:00 AM: Hydrologic and Hydraulic Modeling Study – Mead & Hunt

- Review of Operations Model

D. 10:00 to 10:15 AM: Break

E. 10:15 to 12:30 PM: Hydrologic and Hydraulic Modeling Study – Mead & Hunt

- Review of Upstream Model Results

F. 12:30 to 1:30 PM: Lunch

G. 1:30 to 3:00 PM: Hydrologic and Hydraulic Modeling Study – Mead & Hunt

- Review of Downstream Hydraulic Model

H. 3:00 to 3:15 PM: Break

I. 3:15 to 4:15 PM: Infrastructure Study – Mead & Hunt

J. 4:15 to 4:30 PM: Closing and Adjourn

***Note: If topics are discussed in a shorter time frame than listed in the agenda, the meeting will move forward with the next topic listed in the agenda.**

Thursday, October 13, 2022: 9:00 AM to 3:00 PM CDT

K. 9:00 to 9:15 AM: Welcome and Introductions – GRDA

L. 9:15 to 9:30 AM: Meeting Purpose 18 C.F.R. § 5.15(c)(2) – GRDA

M. 9:30 to 12:30 PM: Sedimentation Study – Anchor QEA/Simons and Associates

N. 12:30 to 1:30 PM: Lunch

O. 1:30 to 2:30 PM: Aquatic Species of Concern Study – Horizon Environmental Services

- Rare and Aquatic Species Sub-Study
- Wetland and Terrestrial Sub-Study

P. 2:30 to 3:00 PM: Cultural Resources Study (Public Summary) – Wood

Q. 3:00 PM: Closing and Adjourn

Note: If topics are discussed in a shorter time frame than listed in the agenda, the meeting will move forward with the next topic listed in the agenda.

Thursday, October 13, 2022: 3:00 PM to 5:00 PM CDT

(Non-Public Cultural Resources Working Group Members Only)

R. 3:00 to 3:15 PM: Upstream Model Results-Area of Potential Effect (APE) for Cultural Resources Studies – Mead & Hunt

S. 3:15 to 3:45 PM: Ethnography (TCP Inventory) -- Algonquin

T. 3:45 to 4:30 PM: Cultural Resources Study – Wood

- Historic Properties Management Plan (HPMP)
- Volume III Archaeology Report

U. 4:30 to 5:00 PM: Closing and Adjourn

Note: If topics are discussed in a shorter time frame than listed in the agenda, the meeting will move forward with the next topic listed in the agenda.

Attachment B

Attendee List

Does not include attendee list for October 13, 2022 since it was a non-public meeting with the Cultural Resources Working Group (CRWG)

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October 12, 2022: Pensacola Project (1494)-Updated Study Report Meeting Attendance

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Attachment C

October 12, 2022 (Day 1):
Study Report Presentations

Grand River Dam Authority Updated Study Report Meeting Pensacola Project (P-1494)

October 12-13, 2022

Housekeeping Items

- Meeting is being recorded
- Mute your lines
- We will pause for questions and answers at appropriate times throughout each presentation
- During the Q&A segments, utilize the “raise your hand” feature to indicate you have a question
- If audio issues exist, please use the “chat” feature
- Participant discussion and dialogue are encouraged during the Q&A segments
- Lunch will be from 12:30-1:30 PM
- If an individual study presentation finishes early, we will proceed with the next agenda item

Purpose of Meeting

- Describe GRDA's progress in implementing its relicensing study plan per:
  - FERC's February 24, 2022 Determination on Request for Study Plan Modifications and New Studies
  - FERC's May 27, 2022 Determine on Requests for Study Modifications (for Sedimentation Study)
- Results for each study during the final study season will be presented
- GRDA will file a meeting summary with FERC by October 30, 2022
- The meeting summary will include only the meeting agenda and presentations
- All stakeholder comments must be submitted in writing
- The deadline for filing all written comments or questions is November 29, 2022

Remaining Relicensing Study Schedule

Activity	Responsible Party	Commission Deadline
Filed Updated Study Report (USR)	GRDA	September 30, 2022
Hold USR Meeting	GRDA	No later than October 15, 2022
File USR Meeting Summary	GRDA	October 30, 2022
File Meeting Summary Disagreements	Stakeholders	November 29, 2022
File Responses to Disagreements	GRDA	December 29, 2022
File Draft License Application (DLA)	GRDA	January 1, 2023
Commission Resolution of Disagreements (if necessary)	FERC	January 28, 2023
Comments on GRDA Draft License Application (DLA)	FERC/Stakeholders	April 1, 2023
File Final License Application (FLA)	GRDA	May 31, 2023

Questions?

Hydrologic and Hydraulic Modeling

Pensacola Hydroelectric Project
Project No. 1494

October 12, 2022

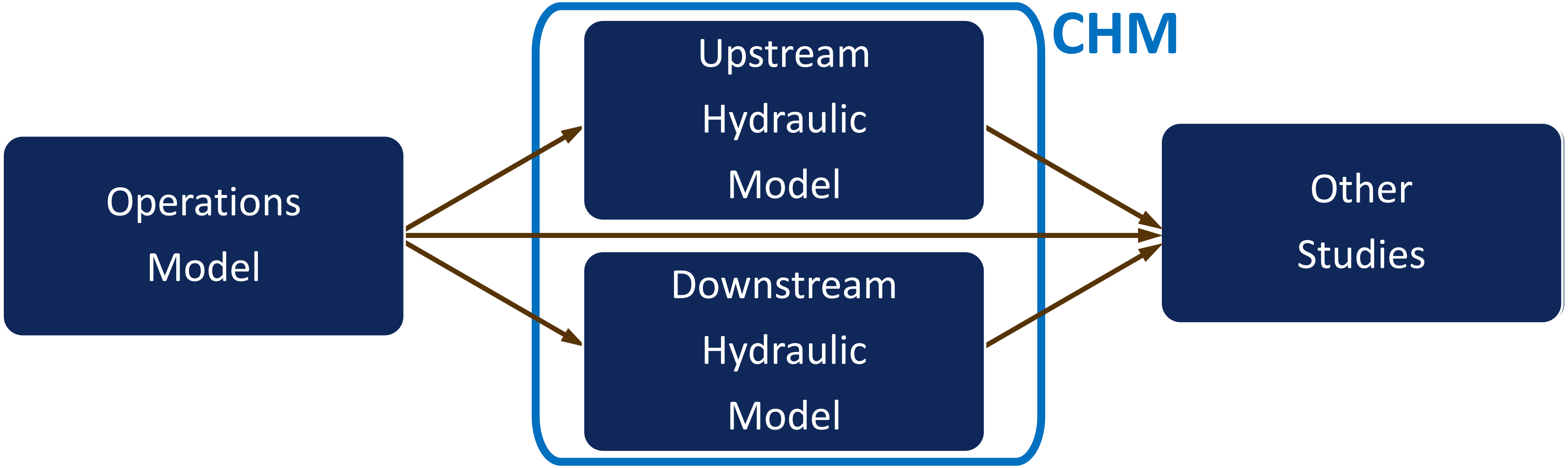
H&H Study Presentation Topics

1. Hydrologic and Hydraulic (H&H) Study Objectives
2. Updated Study Report (USR) Activities
3. Vertical Datums
4. Operations Model (OM) Presentation
5. Upstream Hydraulic Model (UHM) Presentation
6. Downstream Hydraulic Model (DHM) Presentation

H&H Study Objectives

H&H Study Objectives

1. Analyze inundation under current license operations of the Project during several measured inflow events.
2. Provide model results in a format that can inform other analyses.
3. Determine feasibility of implementing anticipated future operations that may be proposed by GRDA as part of relicensing effort.



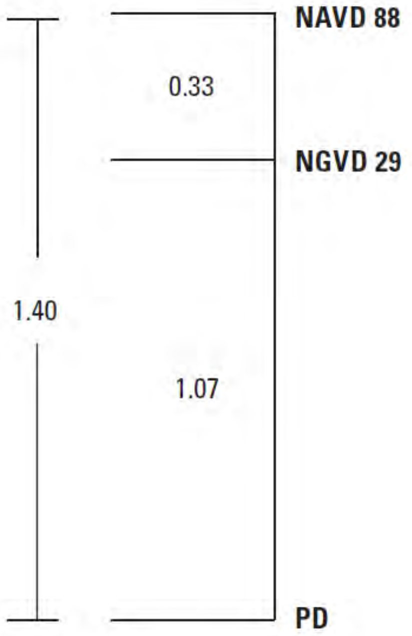
USR Activities

USR Study Activities

1. Update Operations Model (OM), Upstream Hydraulic Model (UHM), and Downstream Hydraulic Model (DHM) based on Federal Energy Regulatory Commission (FERC or Commission) *Discussion and Staff Recommendations*.
   A. Together, the UHM and the DHM form the Comprehensive Hydraulic Model (CHM).
   B. Commission *Discussion and Staff Recommendations* will be discussed during upcoming presentations.
2. Run anticipated operations for upstream and downstream models.
3. Provide lentic and lotic maps for baseline and anticipated operations, as needed, for the Aquatic Species of Concern, the Terrestrial Species of Concern, and the Wetlands and Riparian Habitat Studies.

Vertical Datums

Vertical Datums



	Elevations, in feet		
	NAVD 88	NGVD 29	PD
Conservation pool	743.40	743.07	742.00
Top of the dam	758.40	758.07	757.00

Source: (Hunter, Trevisan, Villa, & Smith, 2020).

Questions?

Next: Operations Model Presentation

Hydrologic and Hydraulic Modeling: Operations Model

Pensacola Hydroelectric Project
Project No. 1494

October 12, 2022

Presentation Outline

1. FERC Determination
2. Operations Model Objectives
3. Final Study Season Improvements
4. Sensitivity Analysis: Stage-Storage Table Update
5. Validation: Historical USGS Gage Data
6. Computed Scenarios

FERC Determination

FERC Determination (Feb 2022)

FERC recommended the following modifications to the OM:

1. Run OM for all inflow events with starting WSELs of 734 to 757 feet PD.
2. Compare WSELs at USGS gage to OM stages for Dec 2015 and Oct 2009 inflow events.
3. Sensitivity analysis for updating to 2019 stage-storage information in the OM.

Also, acknowledged the planned OM improvements proposed by GRDA in the ISR.

GRDA Completion of Approved Study Plan

GRDA completed modifications to the OM

1. Planned improvements from ISR: more consistent matching of OM results to FRM/RWM results.
2. Compared WSELs at USGS gage to OM stages for Dec 2015 and Oct 2009 inflow events.
3. Analyzed sensitivity for updating to 2019 stage-storage information in the OM.
4. Ran OM for all inflow events with starting WSELs of 734 to 757 feet PD.

GRDA simulated several sets of OM cases to support:

1. CHM
2. Sedimentation Study
3. Other Studies

Technical Conference (April 2022)

Technical Conference for Operations Model:

1. Answered relicensing participants' questions regarding the Operations Model
2. Discussed planned improvements to the model
3. Presented the results of the two historical USGS gage data validation cases recommended by the Commission

Operations Model Objectives

Operations Model Objectives

Completed for First Study Season:

1. Validated results with Army Corps of Engineers RiverWare model data
2. Synthesized hypothetical events that informed and set boundary conditions of a Comprehensive Hydraulic Model (CHM)

Completed for Final Study Season:

1. Performed sensitivity analysis for updated stage-area-storage table
2. Validated results with USGS gage data for Oct 2009, Dec 2015 events
3. Added scenarios combining initial reservoir levels and flow events
4. Compared future vs. existing bathymetry, anticipated vs. baseline operations
5. Calculated effects of anticipated operations on seasonal water levels for other studies

Final Study Season Improvements

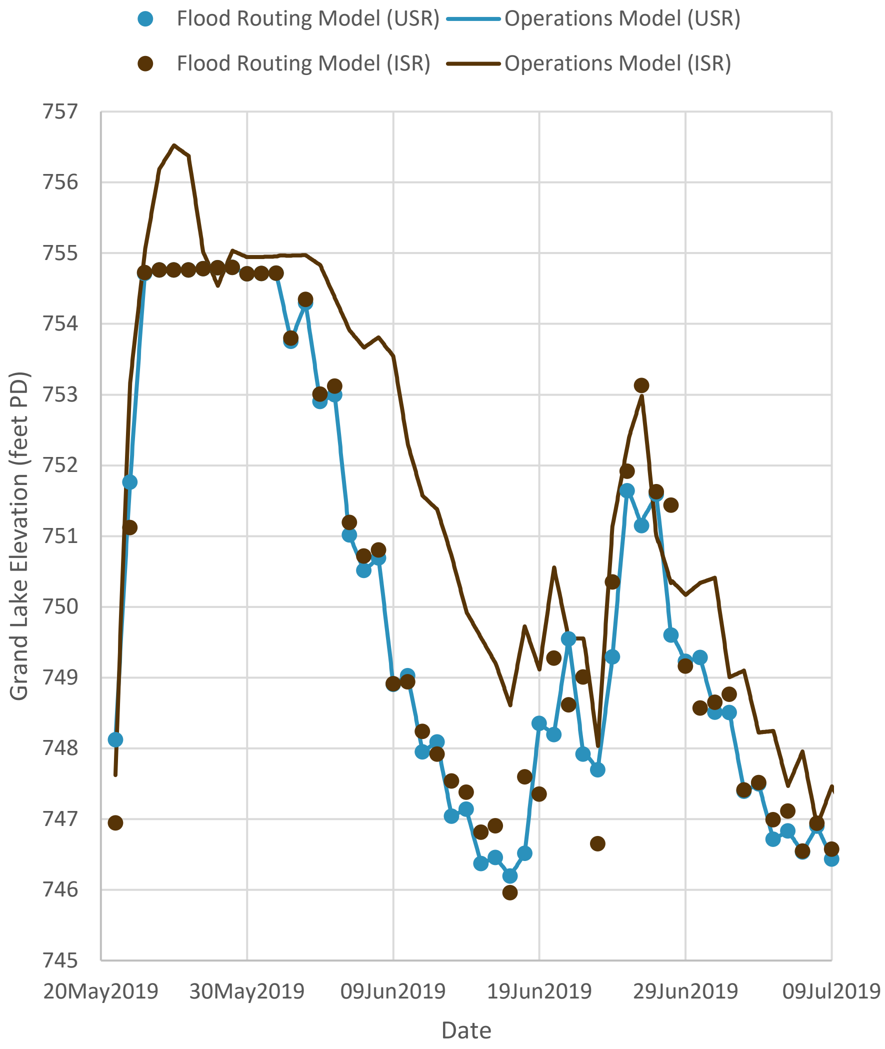
Final Study Season Improvements

Why?

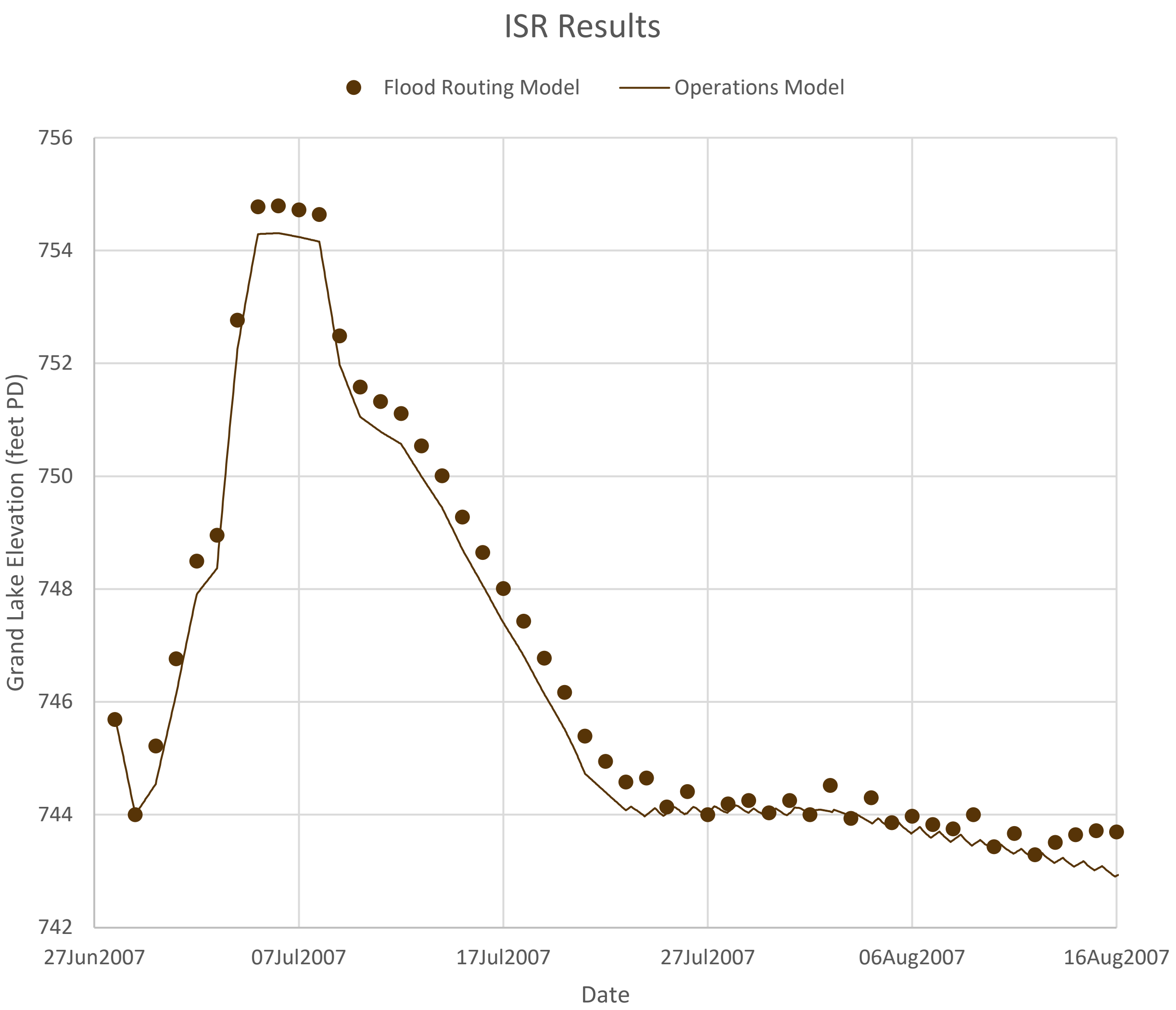
- OM results match FRM/RWM results more consistently, especially for higher peak stages

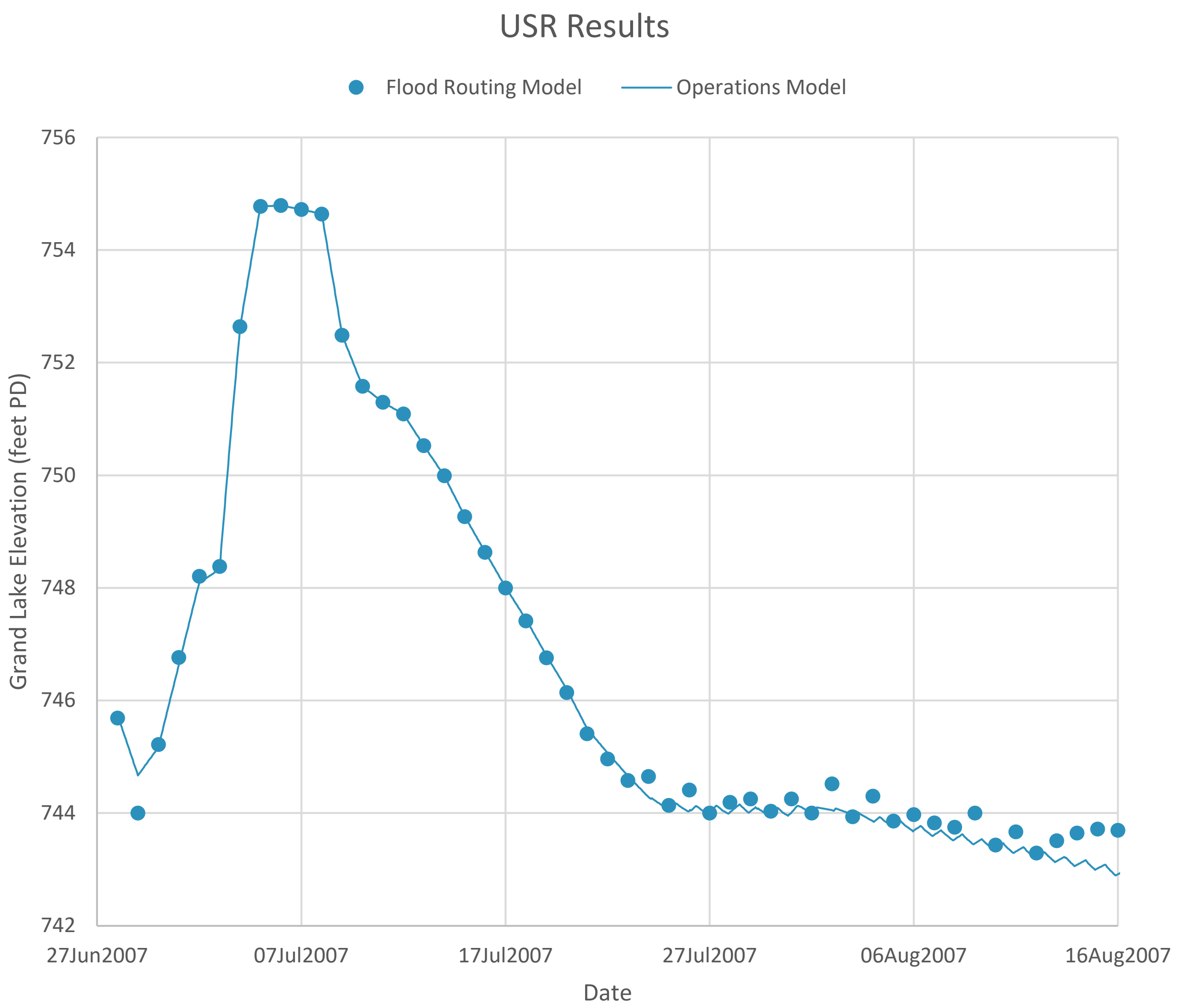
Improvements

- Added logical checks so allowable falling release change (AFRC) does not draw reservoir below target elevation
- Allowed OM spillway discharge to adjust hourly to compensate for power buy-back when real-time market price drops
- Improved matching of OM flow routing to FRM results, with transition between normal operations and spillway operation
- Updated to use 2019 USGS bathymetry (sensitivity analysis)



Final Study Season Improvements





Sensitivity Analysis: Stage-Storage Table

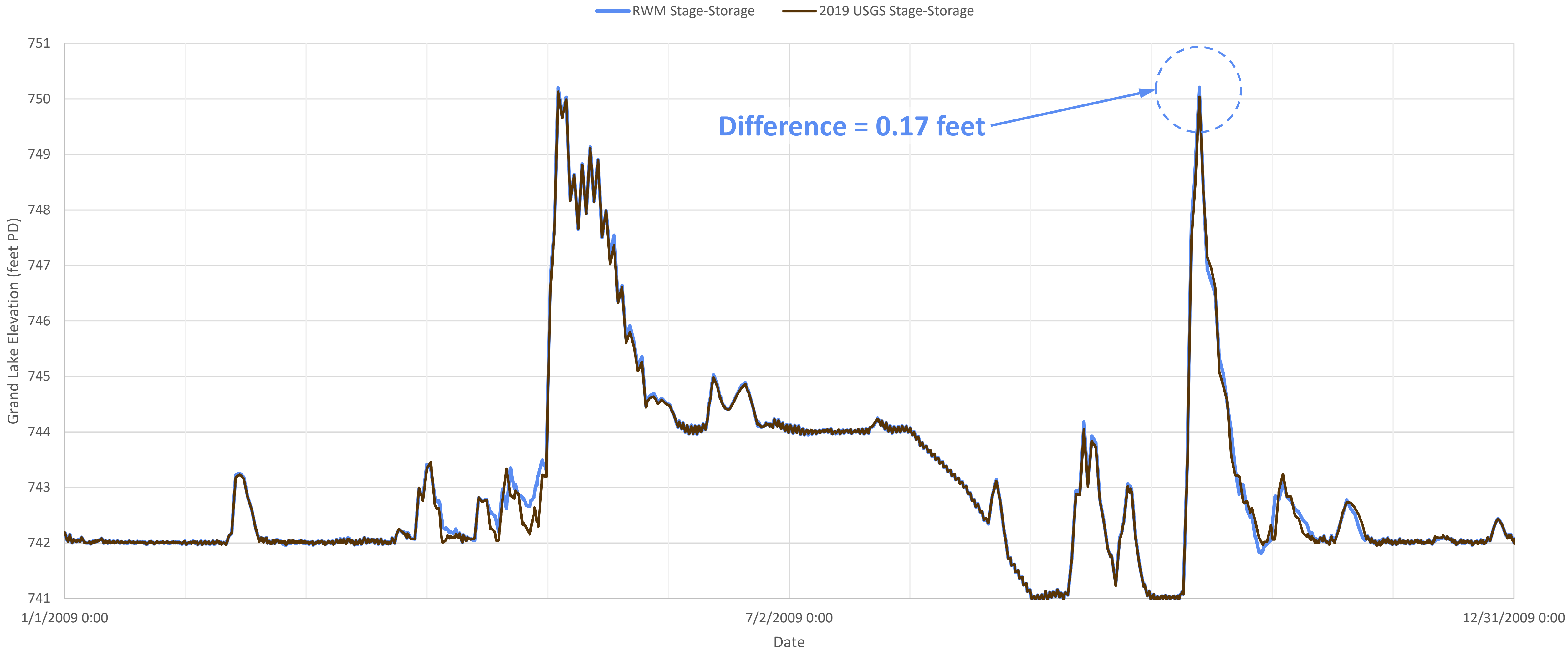
Sensitivity Analysis: Stage-Storage Table

Sensitivity Analysis

- OM simulated for baseline operations using RWM stage-storage table and updated 2019 USGS stage-storage table
- Period-of-record statistics (mean, median, min, max) all within 0.01 feet
- Peak WSEL for inflow events were within 0.17 feet
- USR simulations updated to use 2019 stage-storage table

Sensitivity Parameter	RWM Stage-Storage Table	2019 Stage-Storage Table	Difference (feet)
POR Average (Mean) Grand Lake Elevation (feet PD)	742.87	742.86	0.01
POR Median Grand Lake Elevation (feet PD)	742.05	742.04	0.01
POR Minimum Grand Lake Elevation (feet PD)	740.87	740.88	0.01
POR Maximum Grand Lake Elevation (feet PD)	754.82	754.82	0.00
Peak Grand Lake Elevation (feet PD), June 2004 (1 year)	744.87	744.83	0.04
Peak Grand Lake Elevation (feet PD), July 2007 (4 year)	754.74	754.73	0.01
Peak Grand Lake Elevation (feet PD), Oct 2009 (3 year)	750.21	750.04	0.17
Peak Grand Lake Elevation (feet PD), Dec 2015 (15 year)	754.82	754.82	0.00

Sensitivity Analysis: Stage-Storage Table



Validation: Historical USGS Gage Data

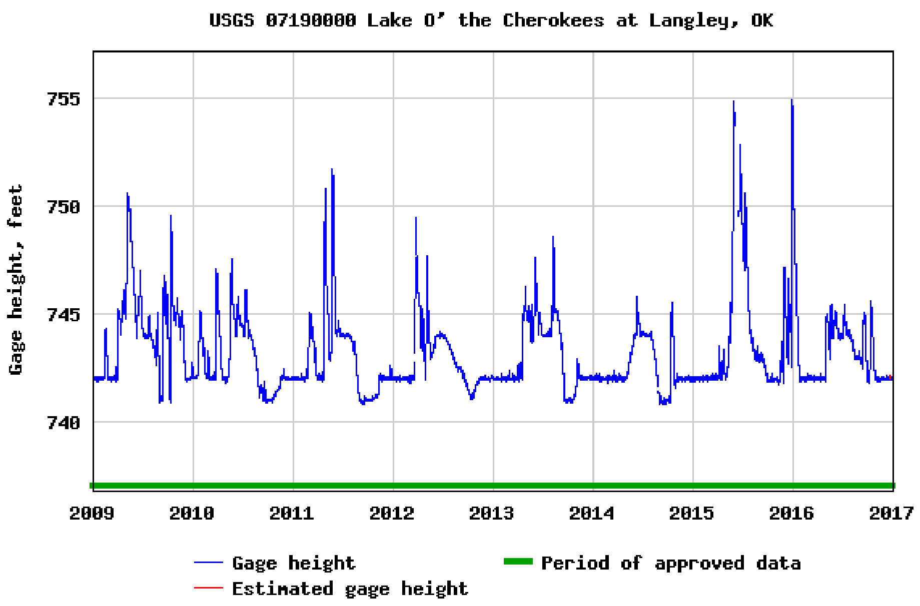
Validation: Historical USGS Gage Data

February 22, 2022 Determination

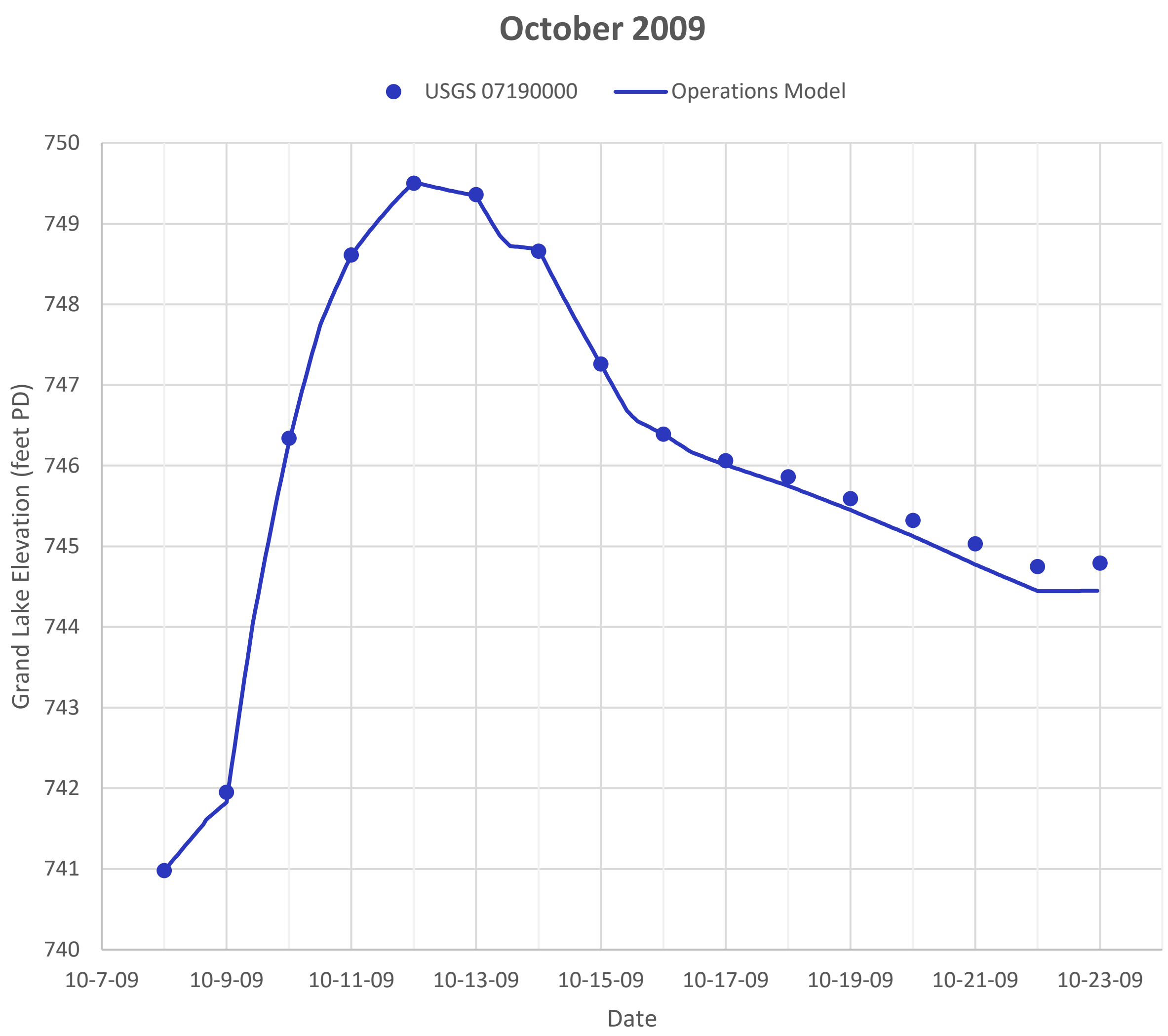
- FERC recommended GRDA compare WSELs at USGS gage to simulated stage hydrographs for the October 2009 and December 2015 events

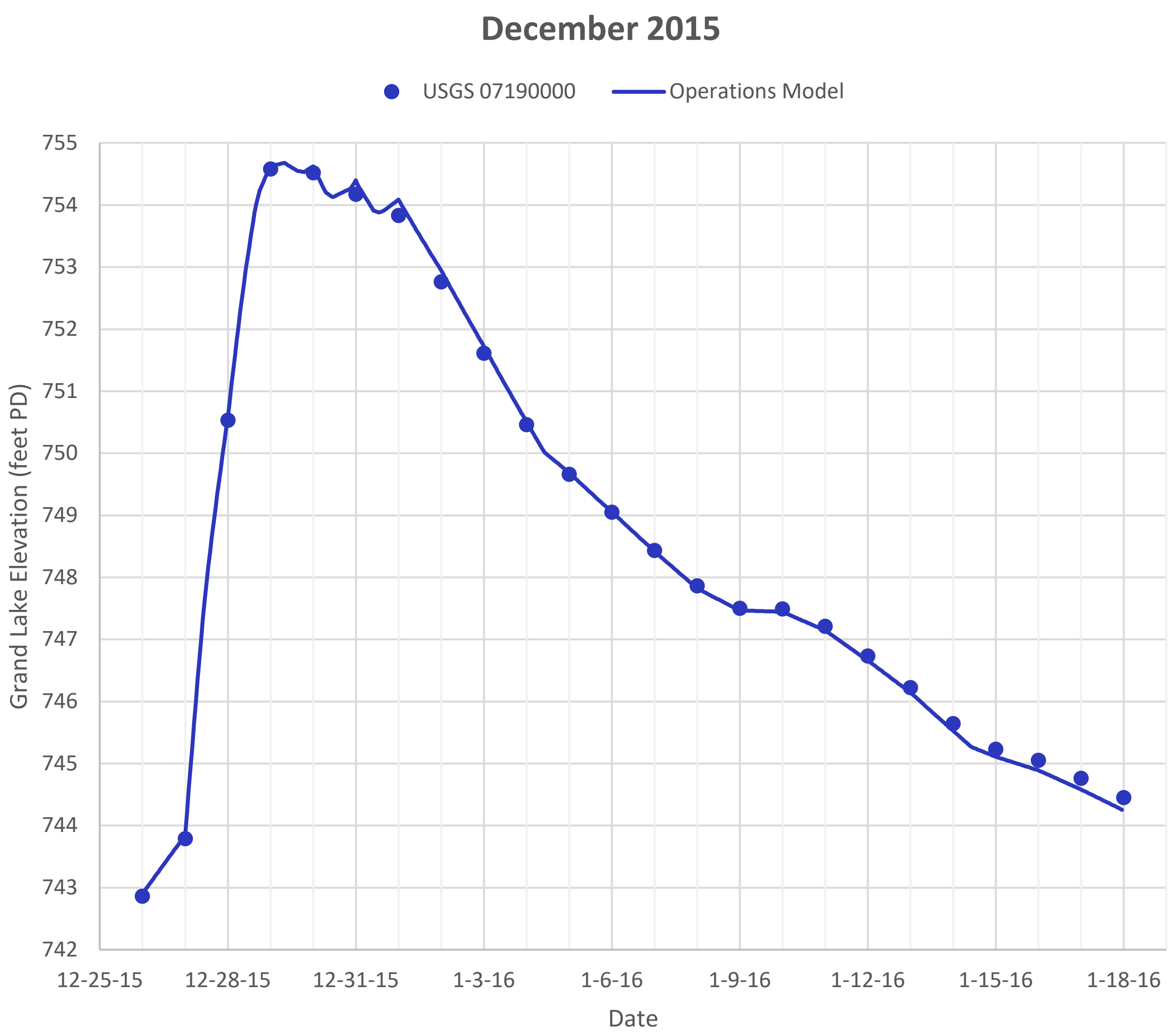
Validation

- USGS gage no. 07190000 (Lake O' the Cherokees at Langley, OK)
- Inflow hydrographs back-calculated from reservoir elevation, discharge, and stage-storage table
- Historical spillway gate openings used to match real operations
- Operations Model simulated stage hydrographs graphically compared to USGS gage data (April 2022 Technical Conference)



Validation: Historical USGS Gage Data



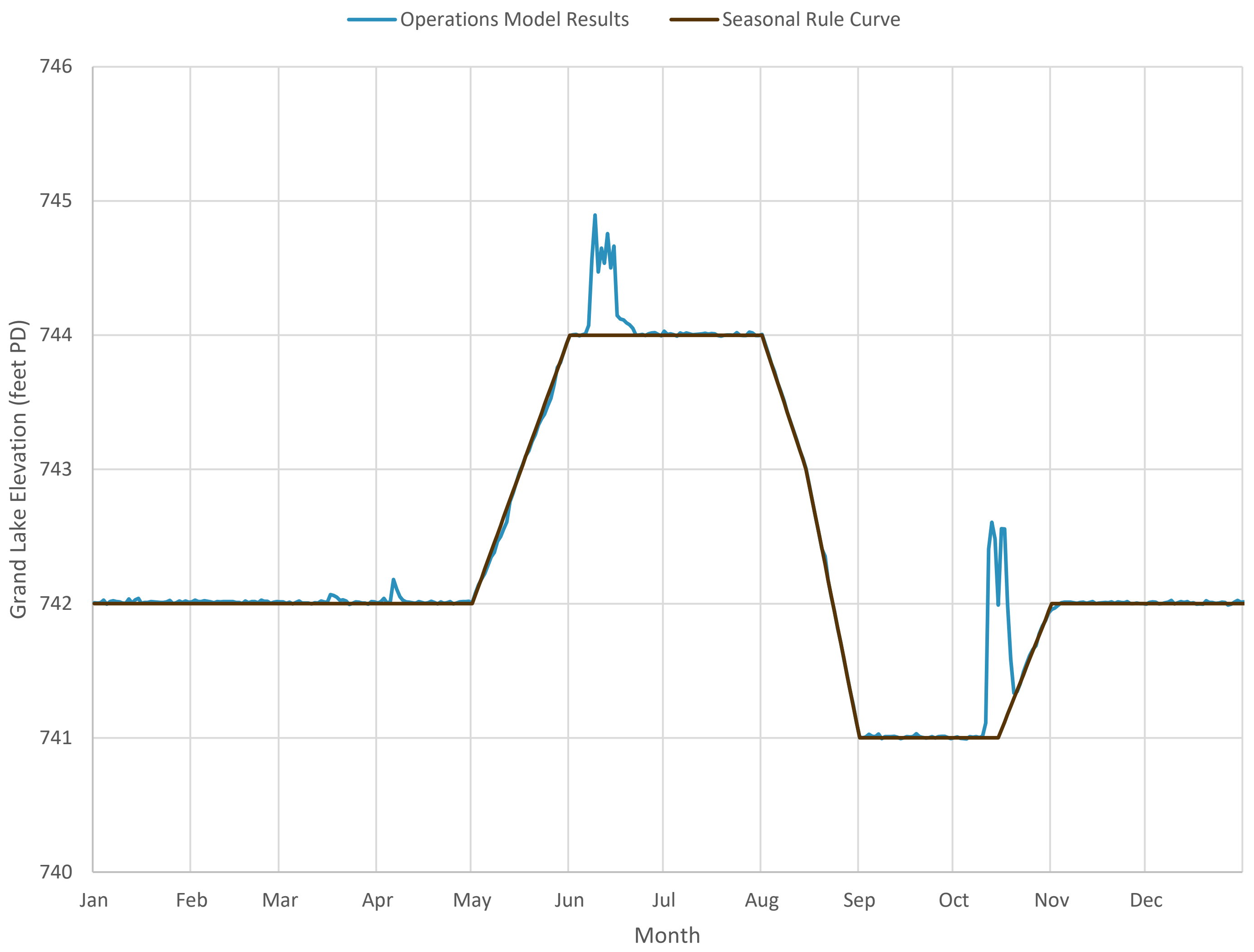


Operations Model Scenarios

Scenarios for CHM, Baseline Operations

Baseline Operations

- Seasonal midnight rule curve, prior to 2015 license amendment
- Same six inflow events, 1-year to 100-year return periods
- Expanded initial reservoir elevations, 734 through 757 feet PD, plus historical
- 71 scenarios total (no historical initial elevation for 100-year)



Scenarios for CHM, Baseline Operations

	Pensacola Initial Elevation (feet PD)	Sep 1993 (21-year)	Jun 2004 (1-year)	Jul 2007 (4-year)	Oct 2009 (3-year)	Dec 2015 (15-year)	100-year
Extreme, Hypothetical Range	757	✓	✓	✓	✓	✓	✓
	753	✓	✓	✓	✓	✓	✓
	749	✓	✓	✓	✓	✓	✓
Anticipated Operational Range	745	✓	✓	✓	✓	✓	✓
	744.5	✓	✓	✓	✓	✓	✓
	744	✓	✓	✓	✓	✓	✓
	743.5	✓	✓	✓	✓	✓	✓
	743	✓	✓	✓	✓	✓	✓
	742.5	✓	✓	✓	✓	✓	✓
	742	✓	✓	✓	✓	✓	✓
Extreme Range	734	✓	✓	✓	✓	✓	✓
Historical (Varies)		✓	✓	✓	✓	✓	N/A

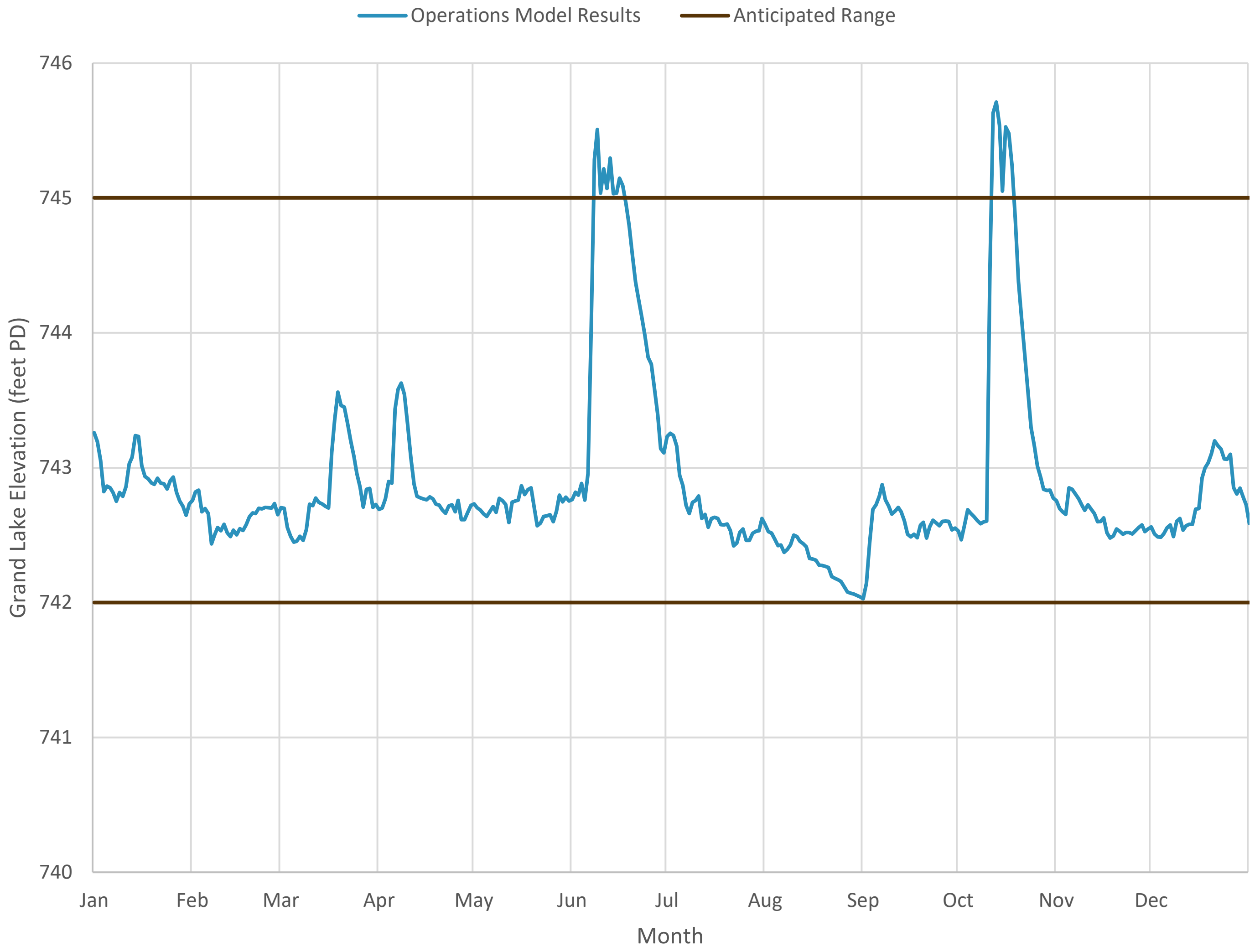
Scenarios for CHM, Anticipated Operations

Anticipated Operations

- Flexible power pool, 742 to 745 feet PD
- Power generated when market price above threshold (standard deviations)
- Average of 743.1 feet PD (when below 745*)
  - Target for Flood Routing Model
- Anticipated vs. Baseline Ops Compared for:

Pensacola Initial Elevation (feet PD)	Jun 2004 (1 year)	Jul 2007 (4 year)	100-year
757 (Extreme Range)	✓		✓
746.5 (Baseline POR) 745.9 (Anticipated POR)		✓	
734 (Extreme Range)	✓		✓

*Army Corps of Engineers may control when below 745



50-year Simulations for Sedimentation Study

OM simulated for 2020-2070

- Data from 1970-2020 randomized
  - Grand Lake inflows from STM
  - Evaporation rates and downstream inflows from RWM
  - Turbine air valve, price factors, units online from OM data
  - No hourly data before 2004: 2008-2020 hourly data repeated
- Stage-storage tables generated from STM
- OM interpolated between existing/future tables over 50 years
- OM stage hydrographs used for STM boundary conditions
- Anticipated vs. Baseline Operations
- Sensitivity to Higher and Lower Sedimentation Rates

Operations	Lower Sediment Rate	Expected Sediment Rate	Higher Sediment Rate
Baseline		✓	
Anticipated	✓	✓	✓

Scenarios for 1D UHM

Single-event simulations for 1D UHM

- Anticipated vs. Baseline Operations and Existing vs. Future Storage (from STM)
- Sensitivity to sedimentation rate
- 30 scenarios combining different initial elevations and inflow events

	July 2007 (4-year)			100-year		
Stage-Storage Condition	740	745	750	740	745	750
Existing, Anticipated Operations	✓	✓	✓	✓	✓	✓
Future, Anticipated Operations, Lower Sediment Rate	✓	✓	✓	✓	✓	✓
Future, Anticipated Operations, Expected Sediment Rate	✓	✓	✓	✓	✓	✓
Future, Anticipated Operations, Higher Sediment Rate	✓	✓	✓	✓	✓	✓
Future, Baseline Operations, Expected Sediment Rate	✓	✓	✓	✓	✓	✓

Scenarios for Other Studies

OM seasonal statistics, inflow event hydrographs

- Aquatic Species Study, Terrestrial Species Study, and Wetlands and Riparian Habitat Study
- Also computed for recreation / boating navigation
- November 1, 2004 to November 1, 2019
- Seasons recommended by each study team
- Anticipated vs. Baseline Operations (USGS 2019 Storage)
    - Median reservoir elevation & inflows by season
    - Percent of time exceeding given elevations within seasons
    - High-flow event stage hydrographs for max inundation

Scenarios for Other Studies

Resources	Season Start	Season End	Median Neosho Inflow (cfs)	Median Tributaries Inflow (cfs)	Median Elevation* (feet PD)
Wetlands and Riparian Habitat	Mar 30	Nov 2	1,992	1,375	742.92 / 743.46
Terrestrial Species	Jan 1	Dec 31	1,133	1,397	742.04 / 743.10
Aquatic Species	May 15	Jul 8	6,697	2,319	744.14 / 744.73
Gray Bats	Apr 1	Jul 31	3,735	2,521	744.01 / 744.11
Recreation	Jun 1	Oct 31	1,319	737	743.14 / 743.07

* Baseline / Anticipated operations results, respectively.

Resources	Percent of time above given reservoir elevation by season*		
	746	751	752
Gray Bats	16.5% / 16.9%	2.9% / 2.7%	1.9% / 1.9%
	742.2		
Recreation	56.9% / 89.2%		

Summary

Operations Model

- Performed sensitivity analysis for USGS 2019 stage-area-storage table
- Validated results with USGS gage data for Oct 2009, Dec 2015 events
- Added scenarios combining initial reservoir levels and flow events
- Compared anticipated vs. baseline operations and future vs. existing bathymetry
- Calculated effects of anticipated operations on seasonal water levels for other studies

Thank you

Mead & Hunt

Hydrologic and Hydraulic Modeling: Upstream Hydraulic Model

Pensacola Hydroelectric Project Project No. 1494

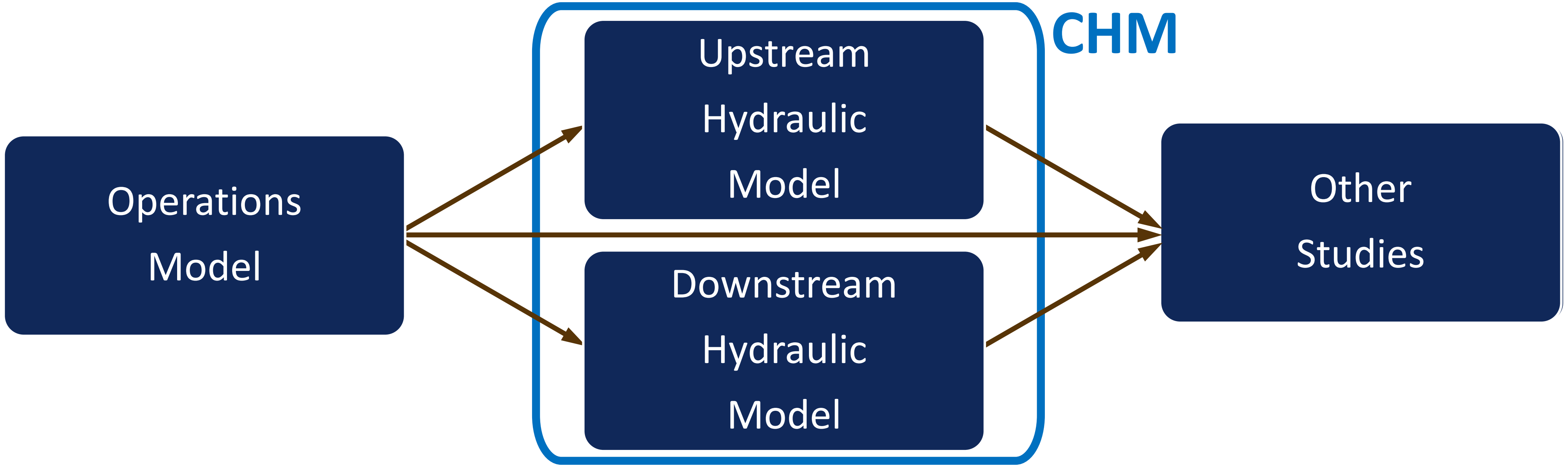
October 12, 2022

Presentation Outline

H&H Study Objectives

H&H Study Objectives

1. Analyze inundation [upstream of Pensacola Dam] under current license operations of the Project during several measured inflow events.
2. Provide model results in a format that can inform other analyses.
3. Determine feasibility of implementing anticipated future operations that may be proposed by GRDA as part of relicensing effort.



FERC Determination

FERC Determination (February 2022)

FERC recommended the following modifications:

1. Run inflow event scenarios at starting reservoir elevations from 734 feet PD up to and including 757 feet PD.

2. Report the frequency, timing, amplitude (i.e., elevation), and duration for each of the simulated inflow events with starting elevations between 734 feet PD and 757 feet PD.

3. Provide the means necessary to complete any additional return frequency analysis that may be deemed necessary following review of the USR.

GRDA Completion of Approved Study Plan

GRDA completed FERC's Approved Study Plan as follows (slide 1 of 3):

1. GRDA simulated inflow event scenarios with starting reservoir elevations ranging from 734 feet PD up to and including 757 feet PD.

GRDA Completion of Approved Study Plan

GRDA completed FERC's Approved Study Plan as follows (slide 2 of 3):

2. GRDA reported the frequency, timing, amplitude, and duration of inflow events:

   A. Frequency of the inflow events (i.e., estimated return period) was reported.

   B. The term "timing" originates in the RSP and refers to seasonality of inflow and inundation. GRDA analyzed timing (or seasonality) of normal operational levels and inflows as it impacts:
      i. The Aquatic Species Study
      ii. The Terrestrial Species Study, and
      iii. The Wetlands and Riparian Habitat Study.

   C. Amplitude (i.e., elevation) is reported as WSEL.

   D. Duration of inundation is reported.

GRDA Completion of Approved Study Plan

GRDA completed FERC's Approved Study Plan as follows (slide 3 of 3):

3. GRDA has included the return frequency analysis (*i.e.*, flood frequency analysis) as an electronic attachment to the USR.

4. As required by the Approved Study Plan, GRDA has developed maps showing areas of potential lentic or lotic conversion.

Upstream Hydraulic Model Objectives

UHM Objectives

Completed for First Study Season:

- ✓UHM Development
- ✓UHM Calibration
- ✓Flood Frequency Analysis
- ✓Inflow Event Analysis
- ✓Definition of Material Difference
- ✓Simulated Scenarios
- ✓Analysis of Results
- ✓Conclusions

Completed/Revised for Final Study Season:

- ✓Simulated Scenarios
- ✓Analysis of Results
- ✓Anticipated Operations Analysis
- ✓Supporting Analyses for Other Studies
- ✓Conclusions

Questions?

Simulated Scenarios

Inflow Events and Historical Pool Elevations

Inflow Event	Type	Estimated Return Period[1]	Pensacola Dam Historical Pool Elevation at Simulation Start (ft, PD)	Simulation Start/End Date
Sept. 1993	Historical	21 years	743.85	9/24/1993 – 10/16/1993
June 2004	Historical	1 year	743.42	6/13/2004 – 6/30/2004
July 2007	Historical	4 years	745.69	6/28/2007 – 7/25/2007
Oct. 2009	Historical	3 years	740.98	10/8/2009 – 10/21/2009
Dec. 2015	Historical	15 years	742.86	12/26/2015 – 1/16/2016
100-year	Synthetic	100 years	N/A[2]	

1 Return period for peak inflow at Pensacola Dam.

2 Because the 100-year event is synthetic, there is no historical pool elevation, or start/end dates. The duration of simulation is 12.5 days.

Additional Pool Elevations Simulated

Inflow Event	Pensacola Dam Pool Elevation at Simulation Start (ft, PD)	
	Anticipated Operational Range	Extreme, Hypothetical Range
Sept. 1993 (21 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
June 2004 (1 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
July 2007 (4 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
Oct. 2009 (3 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
Dec. 2015 (15 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
100-year	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0

Peak Pool Elevations, All Starting Elevations

Event	Pensacola Dam Pool Elevation (ft, PD)		Difference (ft)
	Lowest Peak	Highest Peak	
Sept. 1993 (21 year)	754.1	757.0	2.9
June 2004 (1 year)	744.2	757.0	12.8
July 2007 (4 year)	754.0	757.0	3.0
Oct. 2009 (3 year)	747.5	757.0	9.5
Dec. 2015 (15 year)	754.5	757.0	2.5
100-year	754.9	757.0	2.1

Includes extreme, hypothetical values outside GRDA's anticipated operational range.

Limited Usability of All Starting Elevations

- The highest peak elevation of the pool is unrelated to the magnitude of the inflow event or operations during the inflow event (whether controlled by GRDA or Army Corps of Engineers).
- Rather, the peak elevation is simply the maximum starting pool elevation simulated in accordance with FERC's February 2022 determination.
- The limited usability of the previous table shows the need for presentation of results within GRDA's anticipated operational range, rather than just the extreme, hypothetical range of starting WSELs.
- The extreme, hypothetical range is outside of GRDA's proposed action (anticipated operations).

Peak Pool, Anticipated Operational Range

Event	Pensacola Dam Pool Elevation (ft, PD)		Difference (ft)
	Lowest Peak	Highest Peak	
Sept. 1993 (21 year)	754.8	754.8	0.0
June 2004 (1 year)	744.6	745.0	0.4
July 2007 (4 year)	754.3	754.8	0.5
Oct. 2009 (3 year)	750.1	750.9	0.8
Dec. 2015 (15 year)	754.8	754.8	0.0
100-year	754.9	754.9	0.0

Questions?

Analysis of Results

Study Results

1. Extracted from each simulation:
   - Maximum WSEL
   - Maximum inundation extent
   - Duration of inundation
2. Presentation formats:
   - Tables of maximum WSELs
   - Profile plots of maximum WSELs
   - Maps of maximum inundation extents
   - Tables of duration of inundation
     - Within the boundary of the flowage easement: duration = time of inundation above the flowage easement elevation.
     - Outside the boundary of the flowage easement: duration = time of inundation above the channel bank elevation.
3. Comparisons
   - (A) Impact of starting pool elevations compared to (B) impact of inflow events
   - Impacts of both (A) anticipated operations range and (B) extreme, hypothetical range considered

FERC, February 2022:
Report the frequency, timing, amplitude (i.e., elevation), and duration for each of the simulated inflow events.

Maximum WSEL Differences

Event(s)	Maximum WSEL Differences (ft) for Starting Elevations Within GRDA's Anticipated Operational Range			
	Neosho River[1]	Spring River	Elk River	Tar Creek
Sept. 1993 (21 year)	0.40	0.12	0.06	0.16
June 2004 (1 year)	0.80	0.95	0.44	0.35
July 2007 (4 year)	1.29	1.07	0.53	0.12
Oct. 2009 (3 year)	0.99	0.50	0.87	0.10
Dec. 2015 (15 year)	0.06	0.14	0.06	0.04
100-year	0.04	0.07	0.04	0.01
Impact of inflow events (historical events only)	21.03	36.78	26.75	20.58
Impact of all inflow events (inc. 100-year event)[2]	31.88	36.78	26.75	32.15

1 The max WSEL differences for anticipated operations occur between RM 112.6 and RM 128.8, which is downstream of Miami, OK. For the impact of inflow (impact of nature) simulations, the max WSEL difference occurs at RM 135.9, which is located in Miami, OK.

2 Because the 100-year inflow event is synthetic, there is no historical starting pool elevation. To be conservative, a starting pool elevation of 734 feet PD was used for the 100-year inflow event when calculating the maximum difference in WSEL due to all inflow events.

Maximum WSEL Differences

The maximum simulated WSEL differences due to a change in starting pool elevation within GRDA's anticipated operational range are ***orders of magnitude*** smaller than the maximum WSEL differences that can be caused by nature.

More specifically:

1. **Neosho River:** max impact of nature ranges from 16 to 797 times greater than max simulated impact of GRDA's anticipated operational range.
2. **Spring River:** 34 to 525 times greater.
3. **Elk River:** 31 to 669 times greater.
4. **Tar Creek:** 59 to 2,922 times greater.

Max WSEL: Extreme, Hypothetical Range

Event(s)	Maximum WSEL Differences (ft) for All Starting Elevations, Including Extreme, Hypothetical Values Outside GRDA's Anticipated Operational Range			
	Neosho River[1]	Spring River	Elk River	Tar Creek
Sept. 1993 (21 year)	2.92	0.98	2.97	0.71
June 2004 (1 year)	12.82	12.56	12.81	6.77
July 2007 (4 year)	3.02	2.13	3.00	0.29
Oct. 2009 (3 year)	9.69	6.32	9.65	2.03
Dec. 2015 (15 year)	3.15	3.10	2.59	1.84
100-year	2.05	0.33	1.88	0.06
Impact of inflow events (historical events only)	21.03	36.78	26.75	20.58
Impact of all inflow events (inc. 100-year event)	31.88	36.78	26.75	32.15

1 Along the Neosho River, the maximum WSEL differences for the extreme, hypothetical simulations occur at various locations between RM 77.0 (Pensacola Dam) and RM 122.0, which is downstream of Miami, OK.

For the impact of inflow (impact of nature) simulations, the maximum WSEL difference occurs at RM 135.9, which is located in Miami, OK.

Max WSEL: Extreme, Hypothetical Range

Even using these extreme, hypothetical starting stages, which range from 734 to 757 feet PD, the impact of nature is ***much greater*** than that of a ***23-foot change in starting pool elevation***.

More specifically:

1. **Neosho River:** max impact of nature ranges from 1.6 to 16 times greater than max simulated impact of an extreme, hypothetical starting stage range of 23 feet.
2. **Spring River:** 2.9 to 111 times greater.
3. **Elk River:** 2.1 to 14 times greater.
4. **Tar Creek:** 3.0 to 564 times greater.

Max WSEL: Differences in Miami, OK

Event(s)	Maximum WSEL Differences (ft) Through Miami, OK for Starting Elevations Within GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	0.20	0.16	0.14	0.12
June 2004 (1 year)	0.45	0.35	0.31	0.26
July 2007 (4 year)	0.16	0.12	0.08	0.07
Oct. 2009 (3 year)	0.13	0.10	0.09	0.08
Dec. 2015 (15 year)	0.04	0.04	0.05	0.05
100-year	0.01	0.01	0.01	0.02
Impact of inflow events (historical events only)	20.81	20.51	20.89	20.89
Impact of all inflow events (inc. 100-year event)	31.65	31.67	31.88	31.82

Max WSEL in Miami, OK: Extreme, Hypothetical Range

Event(s)	Maximum WSEL Differences (ft) Through Miami, OK for All Starting Elevations, Including Extreme, Hypothetical Values Outside GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	0.83	0.70	0.61	0.58
June 2004 (1 year)	8.88	6.68	5.65	4.97
July 2007 (4 year)	0.33	0.28	0.23	0.21
Oct. 2009 (3 year)	2.61	2.00	1.71	1.60
Dec. 2015 (15 year)	2.12	1.82	1.65	1.60
100-year	0.06	0.06	0.06	0.06
Impact of inflow events (historical events only)	20.81	20.51	20.89	20.89
Impact of all inflow events (inc. 100-year event)	31.65	31.67	31.88	31.82

Max WSEL Results in Miami, OK

In Miami, any simulated impact of starting stage – whether within GRDA's anticipated operational range or for extreme, hypothetical stages – has little impact on WSELs when compared to nature's impact.

More specifically:

1. The maximum impact of nature ranges from 46 to 3,188 times greater than the maximum simulated impact of GRDA's anticipated operational range.
2. The maximum impact of nature ranges from 2.3 to 531 times greater than the maximum simulated impact of an extreme, hypothetical starting stage range of 23 feet.

Questions?

Inundation Area Differences

Inundation Area Differences

Event	Area of Inundation (acres) for Starting Elevations Within GRDA's Anticipated Operational Range		Difference (%)
	Smallest	Largest	
Sept. 1993 (21 year)	81,954	82,039	0.1%
June 2004 (1 year)	49,778	50,466	1.4%
July 2007 (4 year)	80,328	81,018	0.9%
Oct. 2009 (3 year)	70,506	71,085	0.8%
Dec. 2015 (15 year)	78,499	78,508	0.0%
100-year	92,637	92,649	0.0%
Impact of inflow events (historical events only)	50,102	82,033	48.3%
Impact of all inflow events (inc. 100-year event)	50,102	92,631	59.6%

Inundation Area Differences

The simulated inundation differences due to a change in starting pool elevation within GRDA's anticipated operational range are ***orders of magnitude*** smaller than the inundation area differences that can be caused by nature.

More specifically:

1. If only historical inflow events are considered, the maximum impact of nature ranges from 35 to 4,444 times greater than the maximum simulated impact of GRDA's anticipated operational range.
2. If all inflow events (including the 100-year) are considered, the range is 43 to 5,479 times greater.

Inundation: Extreme, Hypothetical Range

Event	Area of Inundation (acres) for All Starting Elevations, Including Extreme, Hypothetical Values Outside GRDA's Anticipated Operational Range		Difference (%)
	Smallest	Largest	
Sept. 1993 (21 year)	81,277	84,085	3.4%
June 2004 (1 year)	48,943	65,075	28.3%
July 2007 (4 year)	79,989	82,910	3.6%
Oct. 2009 (3 year)	68,613	76,971	11.5%
Dec. 2015 (15 year)	77,482	80,606	4.0%
100-year	92,631	94,192	1.7%
Impact of inflow events (historical events only)	50,102	82,033	48.3%
Impact of all inflow events (inc. 100-year event)	50,102	92,631	59.6%

Inundation: Extreme, Hypothetical Range

Even using these extreme, hypothetical starting stages, which range from 734 to 757 feet PD, the impact of nature is ***much greater*** than that of a ***23-foot change in starting pool elevation***.

More specifically:

1. If only historical inflow events are considered, the maximum impact of nature ranges from 1.7 to 29 times greater than the maximum simulated impact of an extreme, hypothetical starting stage range of 23 feet.
2. If all inflow events (including the 100-year) are considered, the range is 2.1 to 36 times greater.

Inundation: Differences in Miami, OK

Event(s)	Maximum Inundation Area Differences Through Miami, OK for Starting Elevations Within GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	1.1%	0.8%	1.1%	0.9%
June 2004 (1 year)	11.3%	5.3%	6.2%	9.6%
July 2007 (4 year)	0.7%	0.8%	0.4%	0.2%
Oct. 2009 (3 year)	0.7%	0.4%	0.7%	0.7%
Dec. 2015 (15 year)	4.3%	0.2%	0.4%	0.5%
100-year	0.0%	0.1%	0.0%	0.0%
Impact of inflow events (historical events only)	143%	142%	134%	142%
Impact of all inflow events (inc. 100-year event)	162%	164%	147%	151%

Inundation in Miami, OK: Extreme, Hypothetical Range

Event(s)	Maximum Inundation Area Differences Through Miami, OK for All Starting Elevations, Including Extreme, Hypothetical Values Outside GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	4%	3%	4%	5%
June 2004 (1 year)	116%	83%	70%	88%
July 2007 (4 year)	1%	2%	1%	0%
Oct. 2009 (3 year)	16%	8%	16%	15%
Dec. 2015 (15 year)	14%	9%	14%	19%
100-year	0%	0%	0%	0%
Impact of inflow events (historical events only)	143%	142%	134%	142%
Impact of all inflow events (inc. 100-year event)	162%	164%	147%	151%

Inundation Results in Miami, OK

In Miami, any simulated impact of starting stage – whether within GRDA's anticipated operational range or for extreme, hypothetical stages – has little impact on inundation area when compared to nature's impact.

More specifically:

1. The maximum impact of nature ranges from 13 to 8,917 times greater than the maximum simulated impact of GRDA's anticipated operational range.
2. The maximum impact of nature ranges from 1.2 to 1,633 times greater than the maximum simulated impact of an extreme, hypothetical starting stage range of 23 feet.

Questions?

Duration Differences

Duration Differences

Event(s)	Maximum Duration Difference (hours) for Starting Elevations Within GRDA's Anticipated Operational Range			
	Neosho River	Spring River	Elk River	Tar Creek
Sept. 1993 (21 year)	20*	6	0	2
June 2004 (1 year)	1	0	0	0
July 2007 (4 year)	43*	8	0	2
Oct. 2009 (3 year)	4	1	0	1
Dec. 2015 (15 year)	3	2	0	1
100-year	2	2	0	1
Impact of inflow events (historical events only)	239	112	118	158
Impact of all inflow events (inc. 100-year event)	261	115	118	210

* Along the Neosho River, the largest differences in duration for the anticipated operations simulations occur in rural, sparsely populated areas. The largest differences are isolated between RM 124 and 125, which is between Twin Bridges and S. 590 Road Bridge.

Duration Differences

The simulated duration differences due to a change in starting pool elevation within GRDA's anticipated operational range are ***orders of magnitude*** smaller than the duration differences that can be caused by nature.

More specifically:

1. **Neosho River:** max impact of nature ranges from 6 to 261 times greater than max simulated impact of GRDA's anticipated operational range.
2. **Spring River:** 14 to 115 times greater.
3. **Elk River:** 118 times greater.
4. **Tar Creek:** 79 to 210 times greater.

Note: some of the maximum duration differences for a given inflow event on a given reach were zero. In such instances, a value of one hour was used instead of zero to calculate the ratios listed above.

Duration: Extreme, Hypothetical Range

Event(s)	Maximum Duration Difference (hours) for All Starting Elevations, Including Extreme, Hypothetical Values Outside GRDA's Anticipated Operational Range			
	Neosho River	Spring River	Elk River	Tar Creek
Sept. 1993 (21 year)	42	25	1	15
June 2004 (1 year)	41	0	0	0
July 2007 (4 year)	51	41	0	13
Oct. 2009 (3 year)	59	23	1	91
Dec. 2015 (15 year)	52	41	3	59
100-year	25	15	0	7
Impact of inflow events (historical events only)	239	112	118	158
Impact of all inflow events (inc. 100-year event)	261	115	118	210

Duration: Extreme, Hypothetical Range

Even using these extreme, hypothetical starting stages, which range from 734 to 757 feet PD, the impact of nature is ***much greater*** than that of a ***23-foot change in starting pool elevation***.

More specifically:

1. **Neosho River:** max impact of nature ranges from 4 to 10 times greater than max simulated impact of an extreme, hypothetical starting stage range of 23 feet.
2. **Spring River:** 3 to 115 times greater.
3. **Elk River:** 39 to 118 times greater.
4. **Tar Creek:** 2 to 210 times greater.

Note: some of the maximum duration differences for a given inflow event on a given reach were zero. In such instances, a value of one hour was used instead of zero to calculate the ratios listed above.

Duration: Differences in Miami, OK

Event(s)	Maximum Duration Differences (hours) Through Miami, OK for Starting Elevations Within GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	1	1	2	1
June 2004 (1 year)	0	0	0	0
July 2007 (4 year)	2	3	3	2
Oct. 2009 (3 year)	0	4	3	2
Dec. 2015 (15 year)	1	1	1	0
100-year	1	1	1	0
Impact of inflow events (historical events only)	154	166	168	175
Impact of all inflow events (inc. 100-year event)	210	219	220	223

Duration in Miami, OK: Extreme, Hypothetical Range

Event(s)	Maximum Duration Differences (hours) Through Miami, OK for All Starting Elevations, Including Extreme, Hypothetical Values Outside GRDA's Anticipated Operational Range			
	RM 133-134	RM 134-135	RM 135-136	RM 136-137
Sept. 1993 (21 year)	9	10	10	10
June 2004 (1 year)	0	0	0	0
July 2007 (4 year)	13	14	15	16
Oct. 2009 (3 year)	59	59	35	31
Dec. 2015 (15 year)	32	22	18	16
100-year	7	7	7	7
Impact of inflow events (historical events only)	154	166	168	175
Impact of all inflow events (inc. 100-year event)	210	219	220	223

Duration Results in Miami, OK

In Miami, any simulated impact of starting stage – whether within GRDA's anticipated operational range or for extreme, hypothetical stages – has little impact on duration when compared to nature's impact.

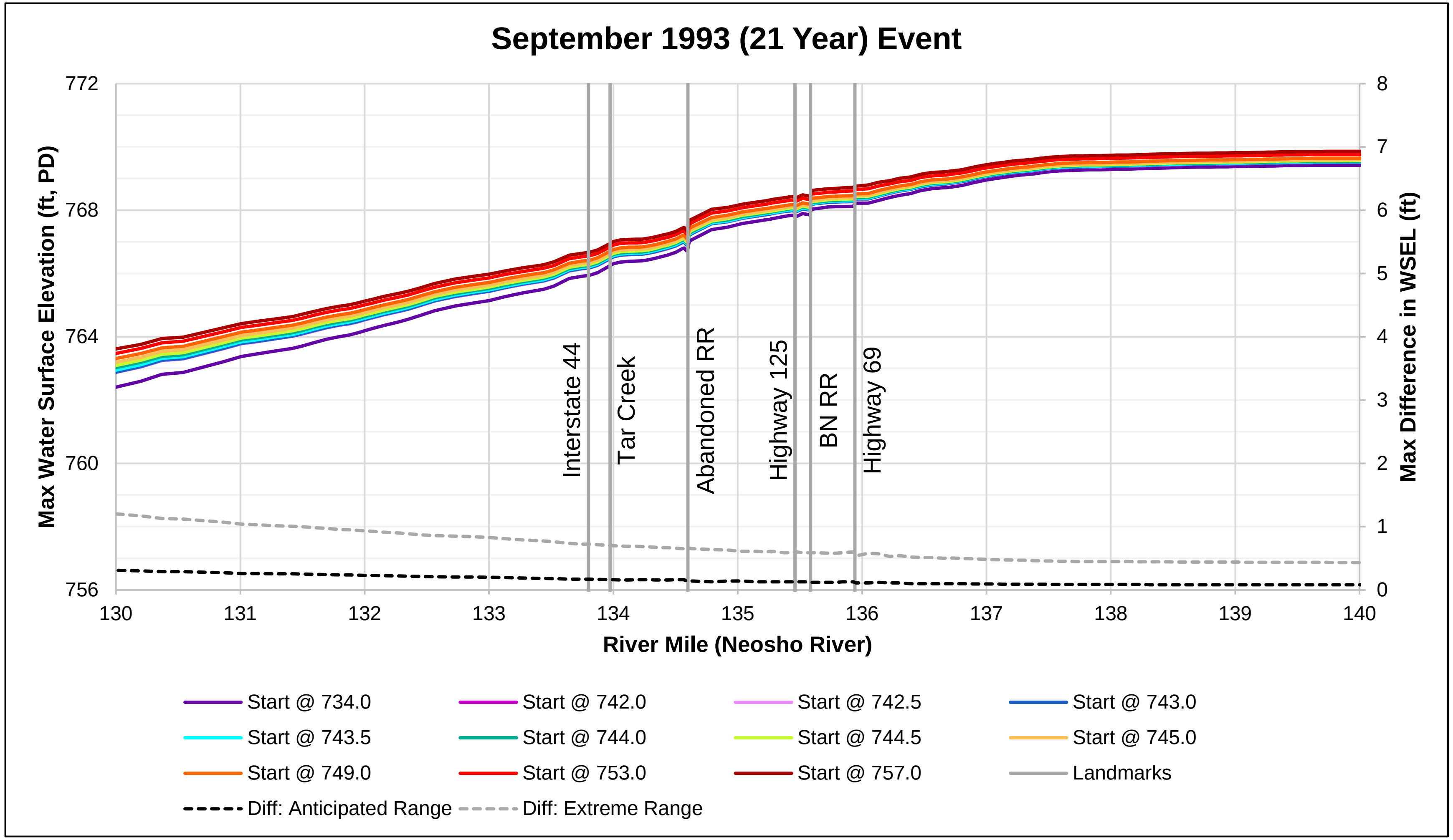
More specifically:

1. The maximum impact of nature ranges from 42 to 223 times greater than the maximum simulated impact of GRDA's anticipated operational range.
2. The maximum impact of nature ranges from 3 to 223 times greater than the maximum simulated impact of an extreme, hypothetical starting stage range of 23 feet.

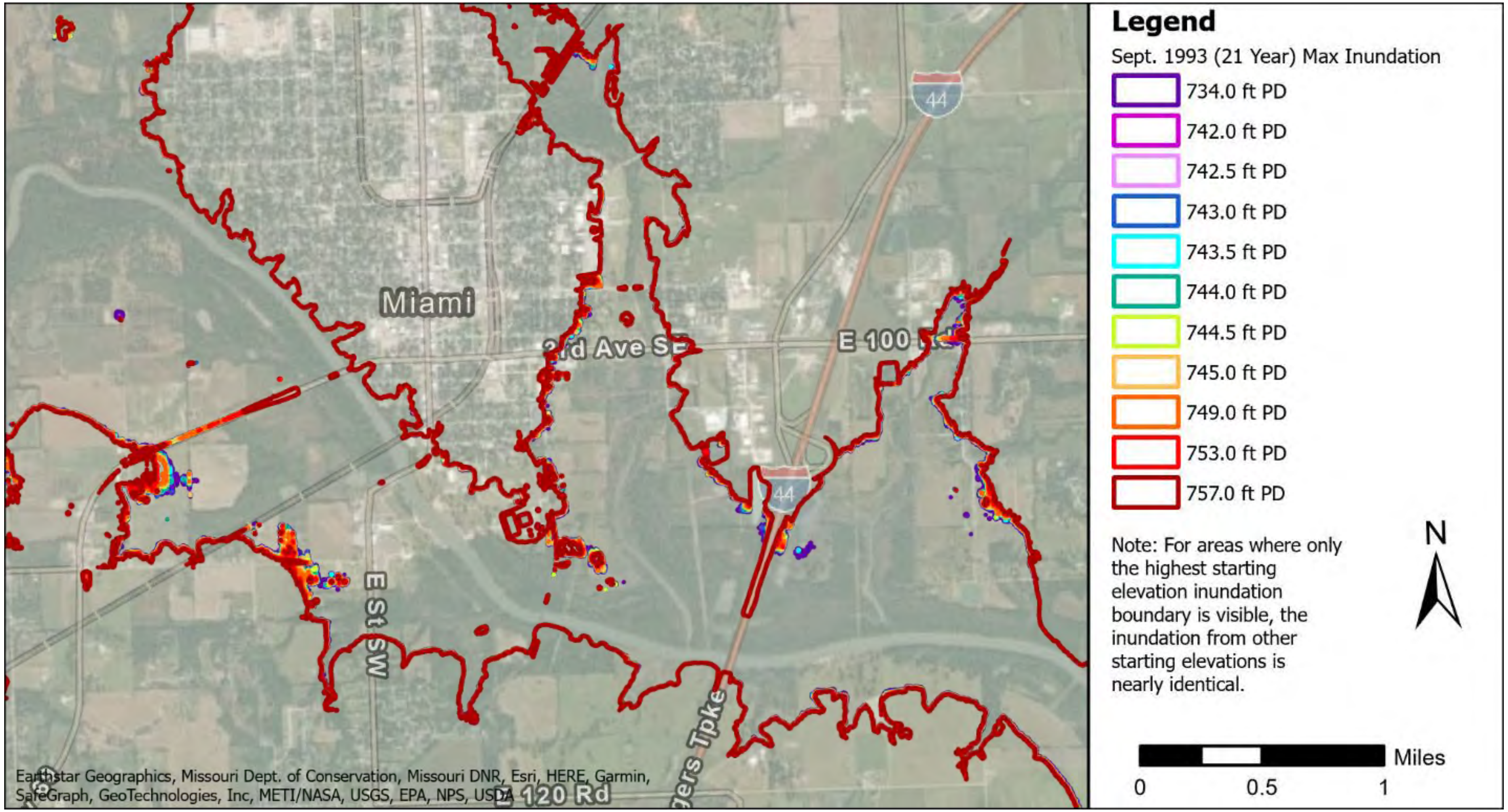
Questions?

Graphical Results

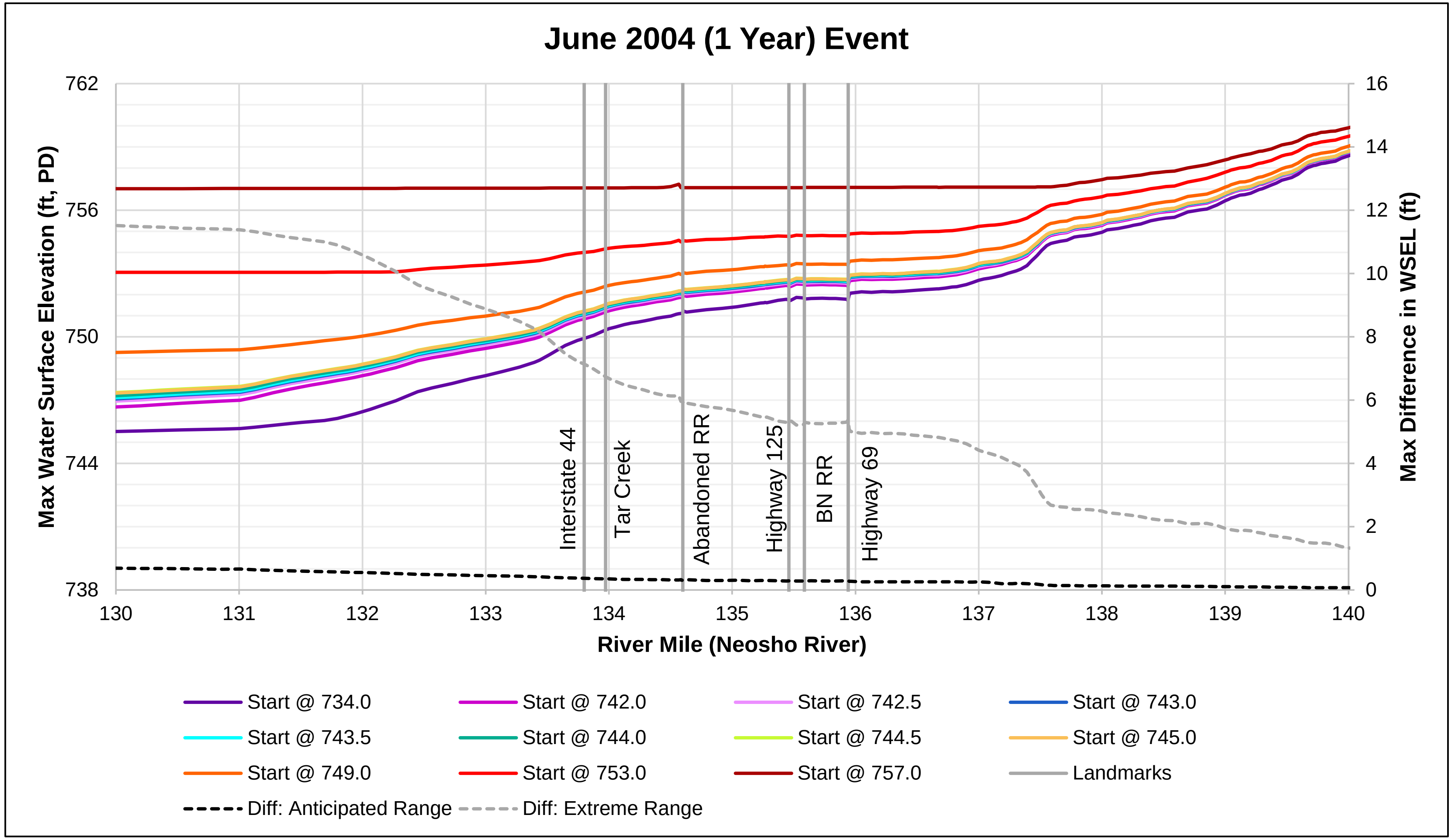
September 1993 WSEL Profiles



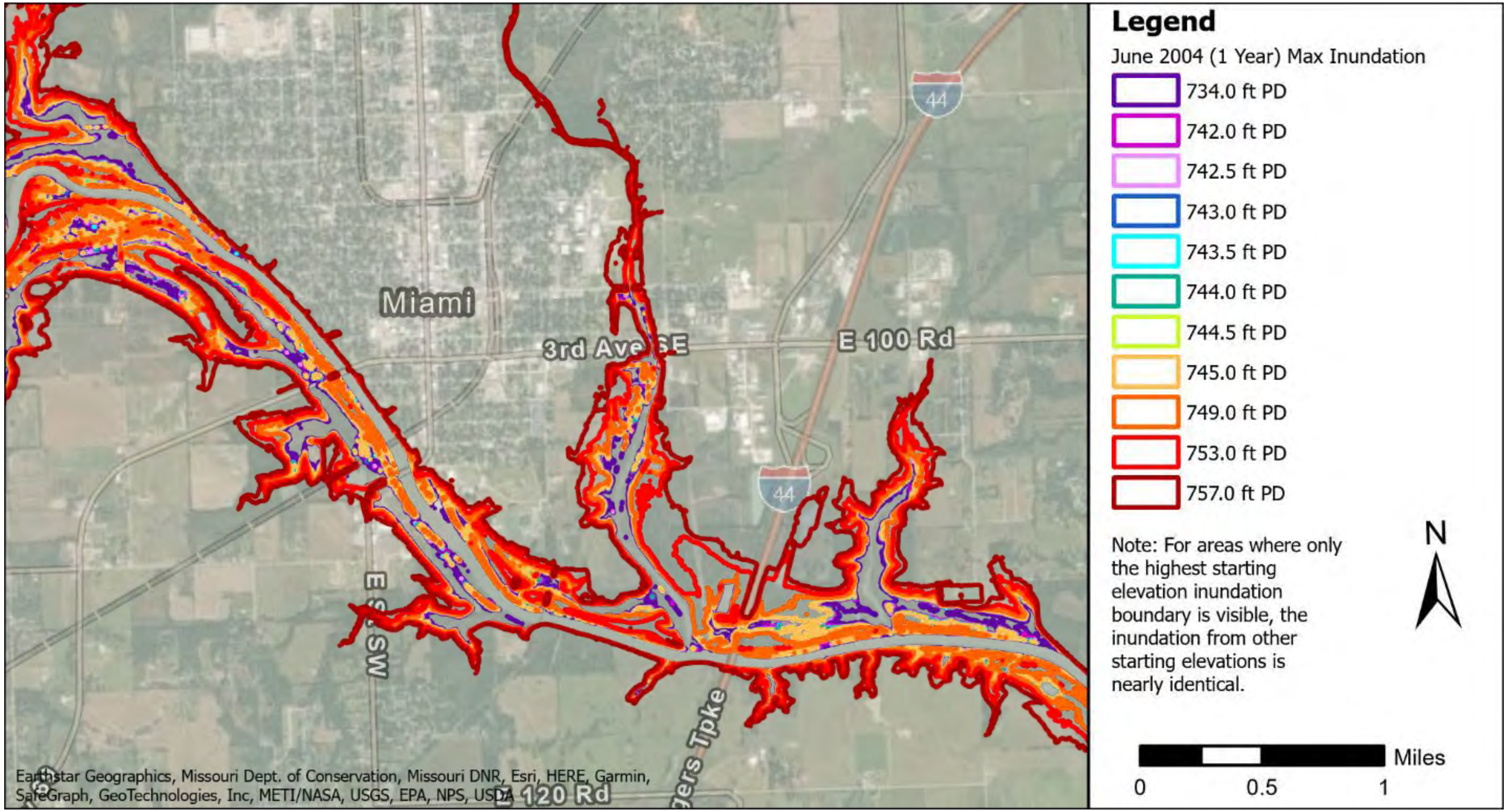
September 1993 Inundation Extent



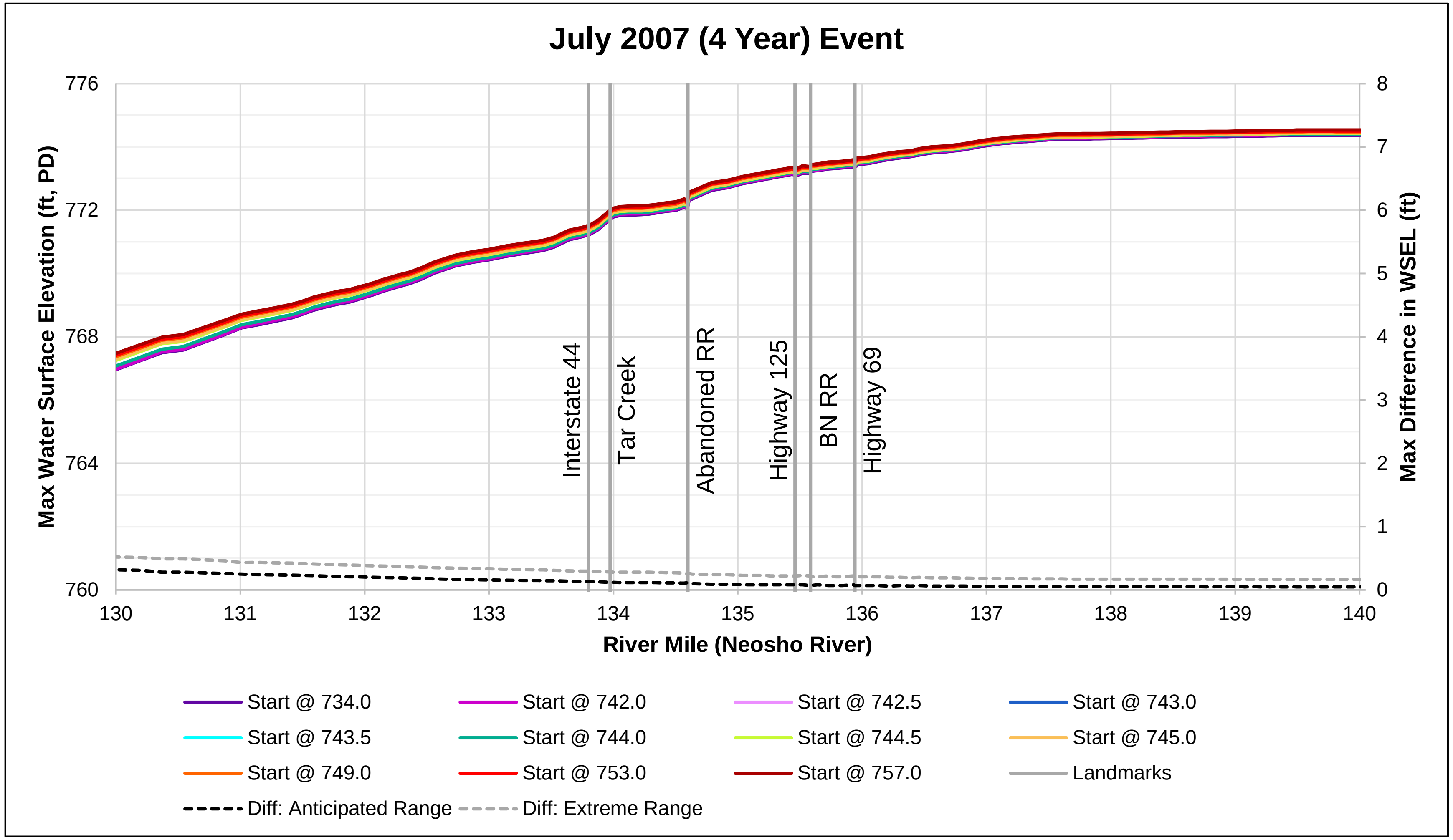
June 2004 WSEL Profiles



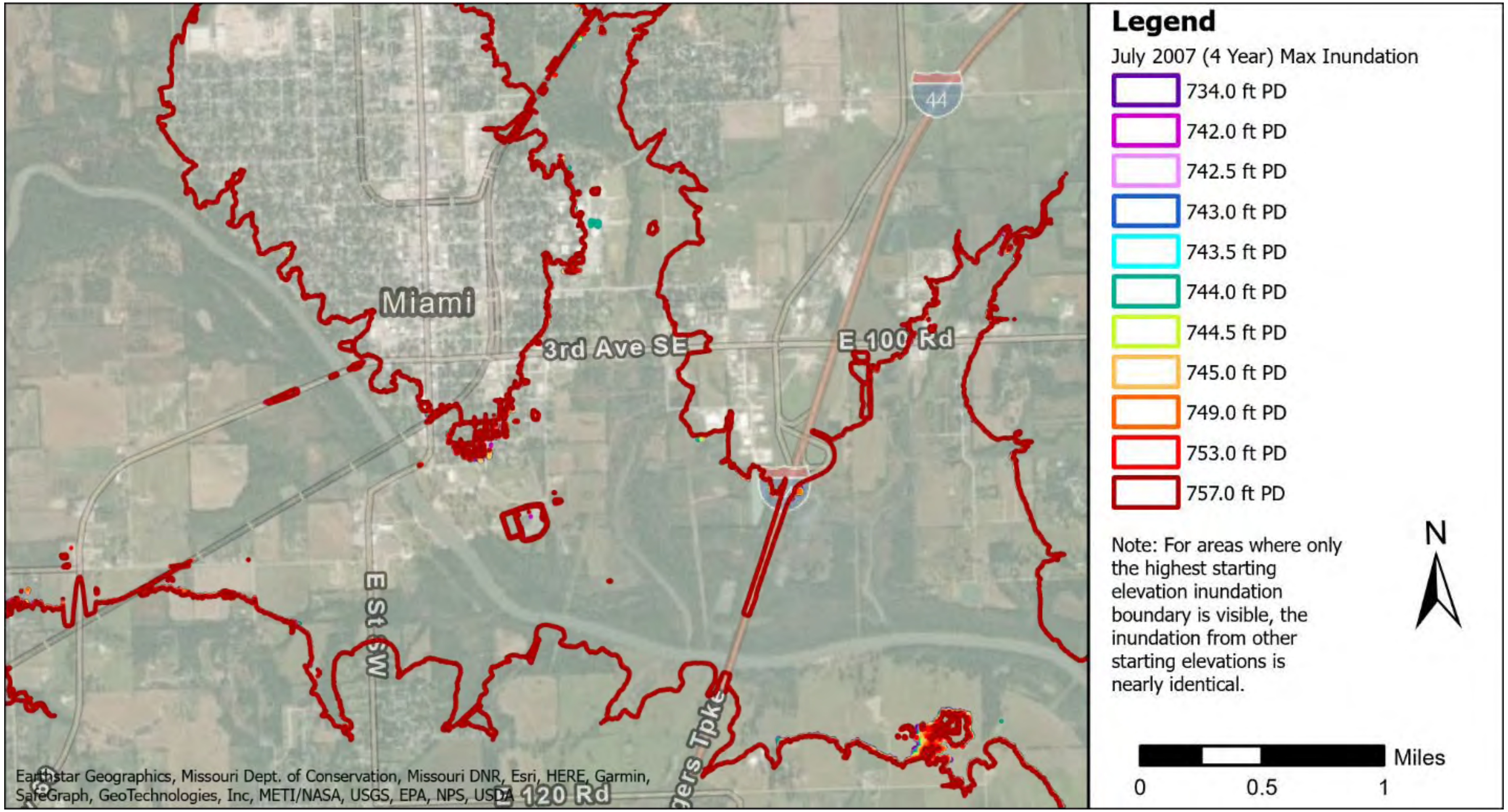
June 2004 Inundation Extent



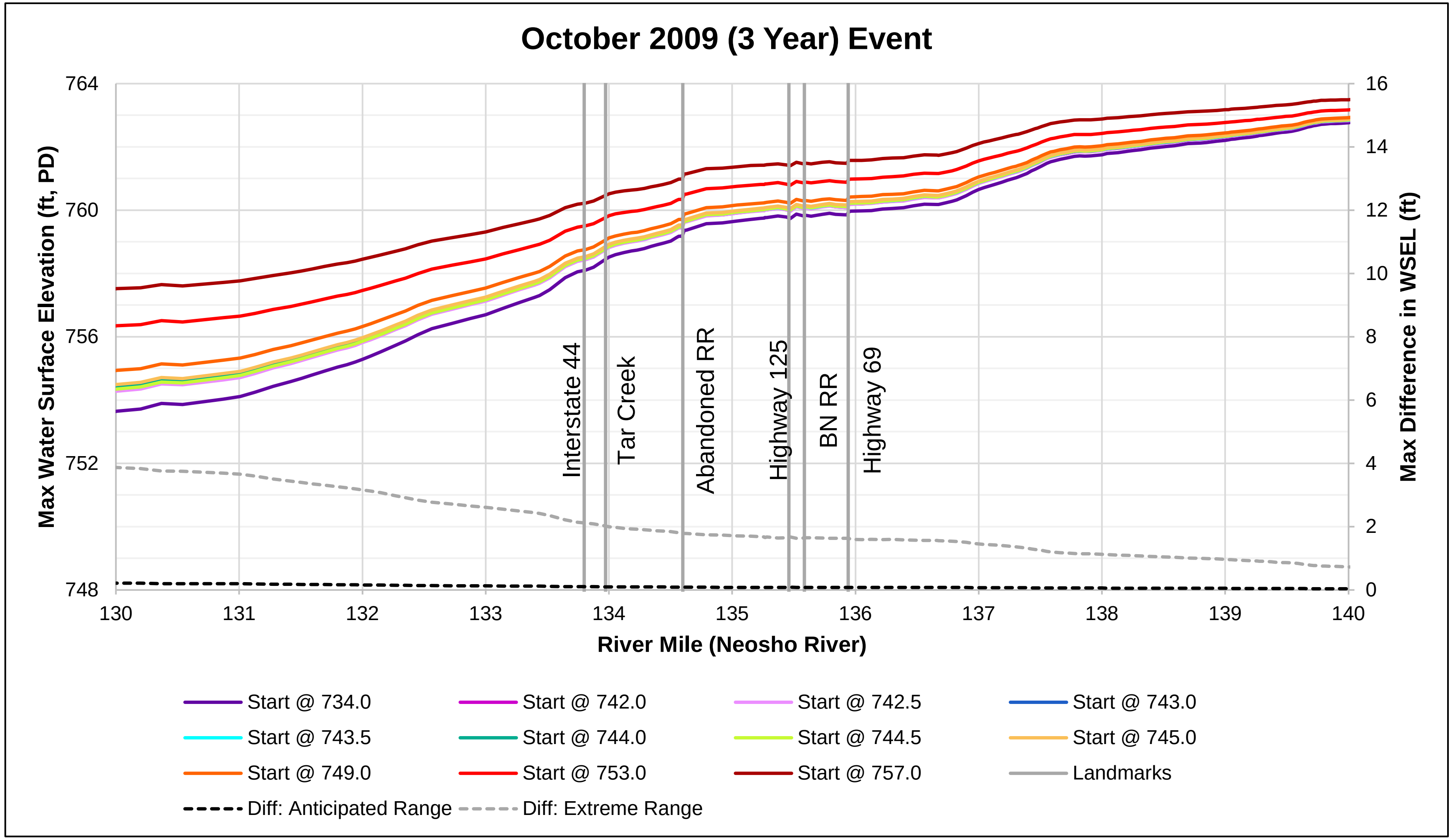
July 2007 WSEL Profiles



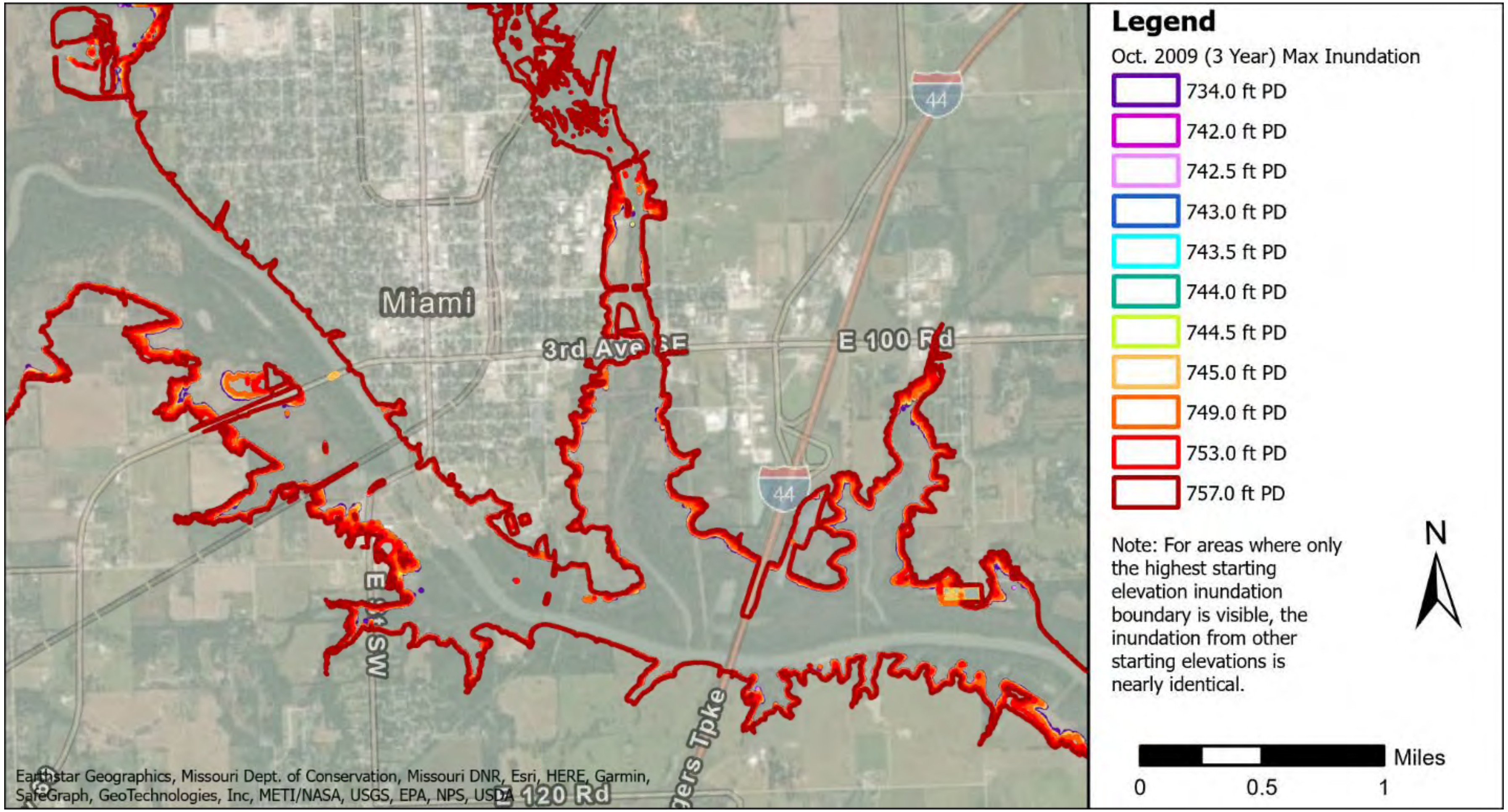
July 2007 Inundation Extent



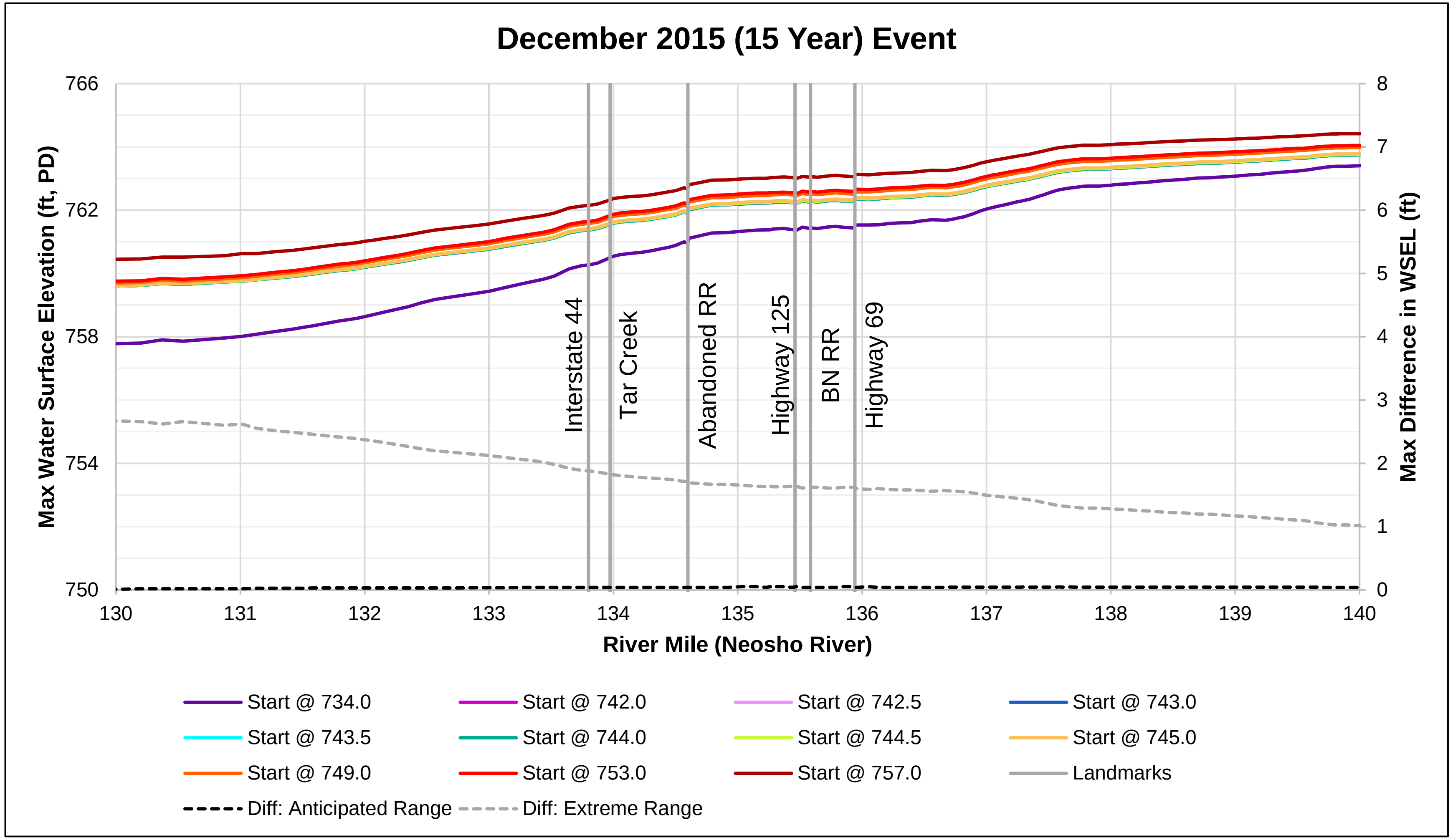
October 2009 WSEL Profiles



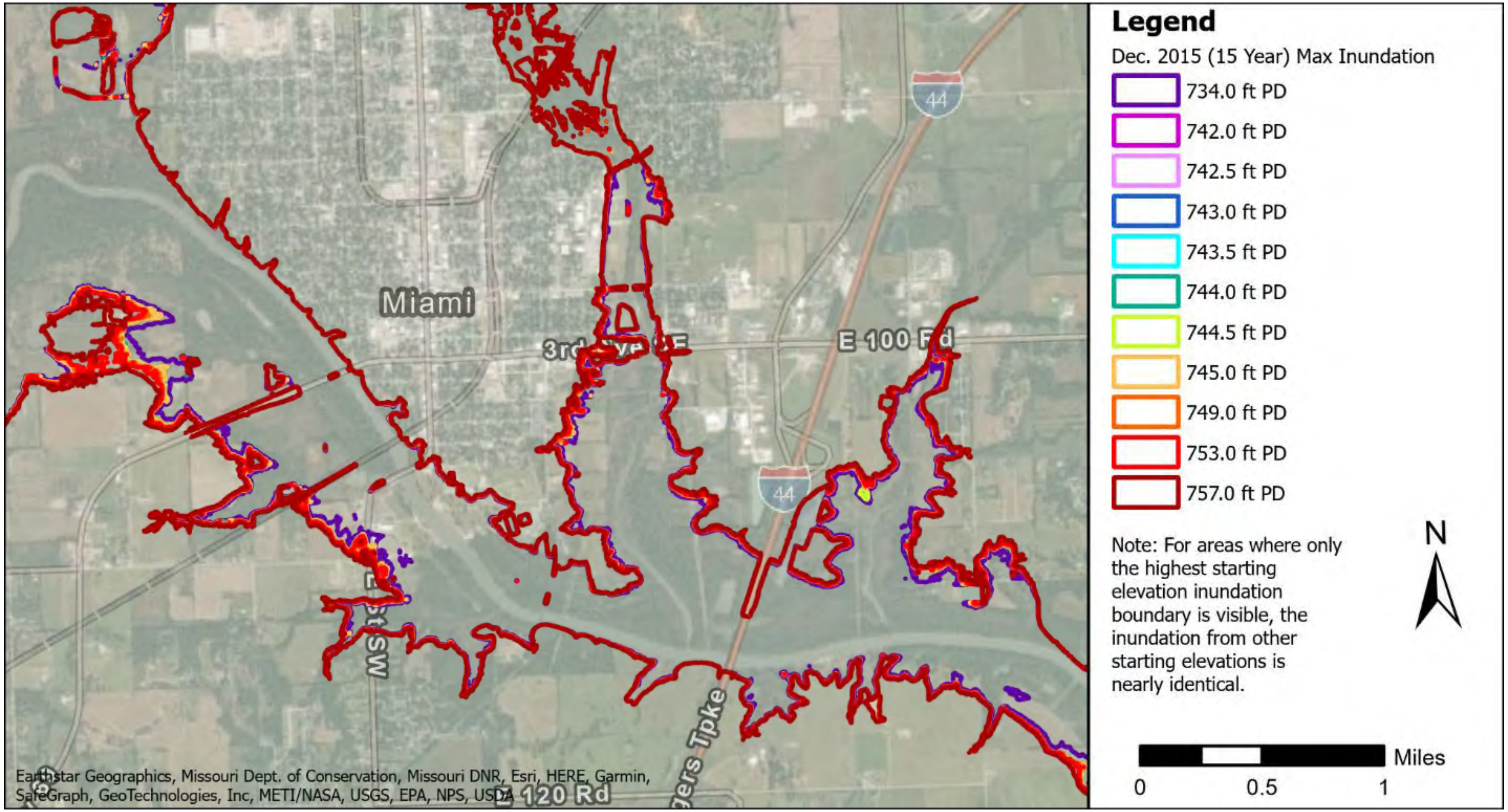
October 2009 Inundation Extent



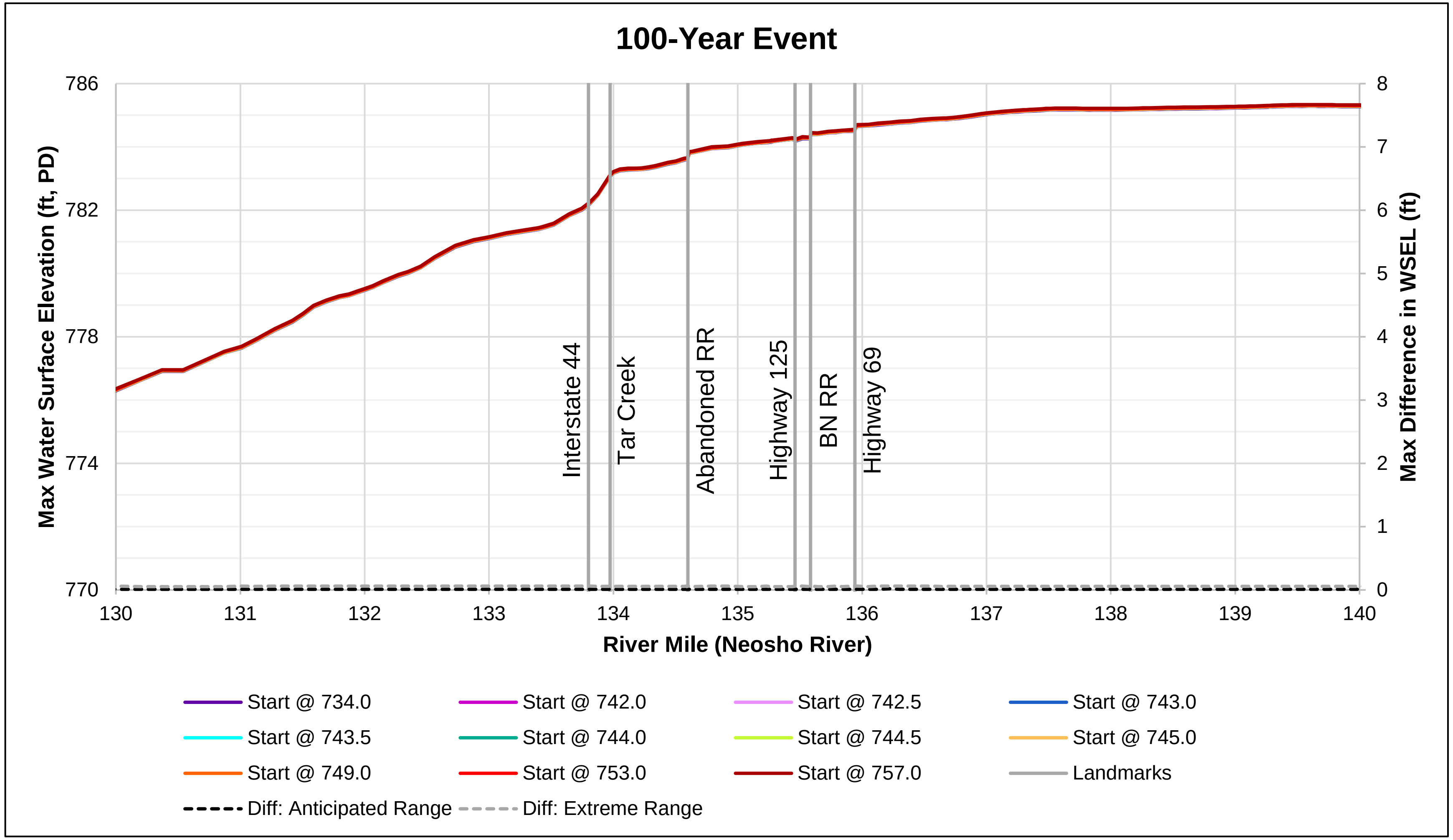
December 2015 WSEL Profiles



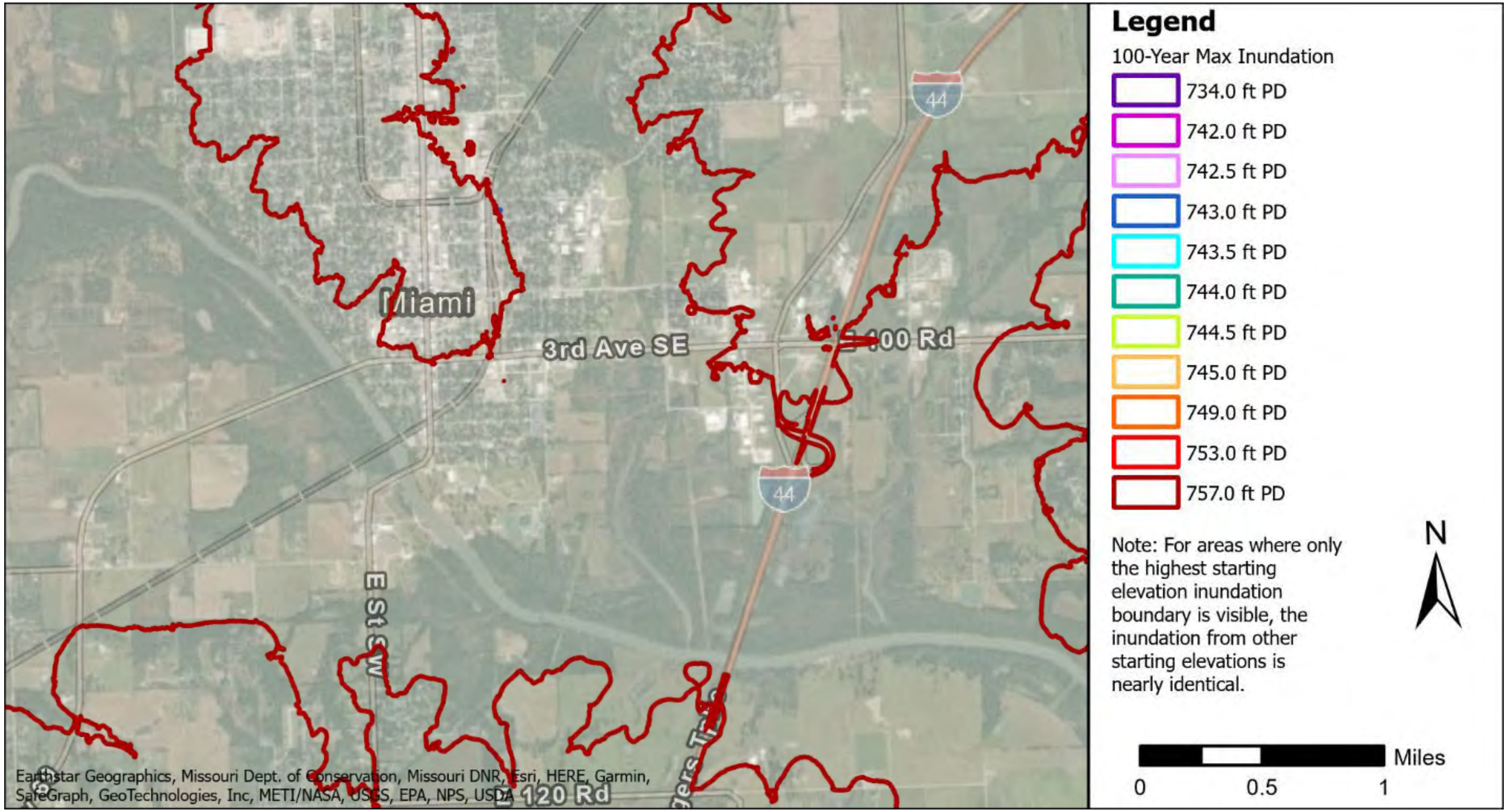
December 2015 Inundation Extent



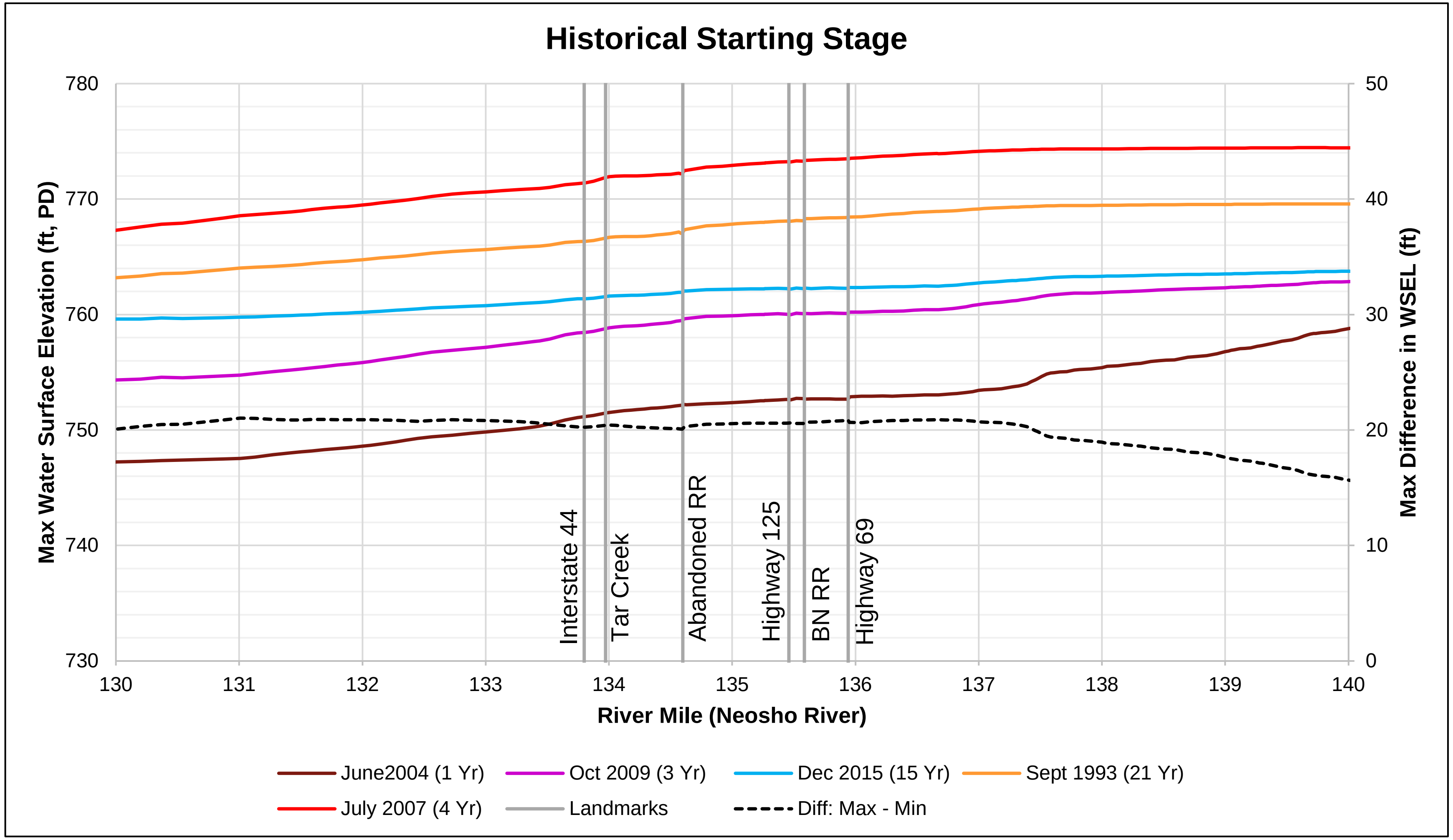
100-Year WSEL Profiles



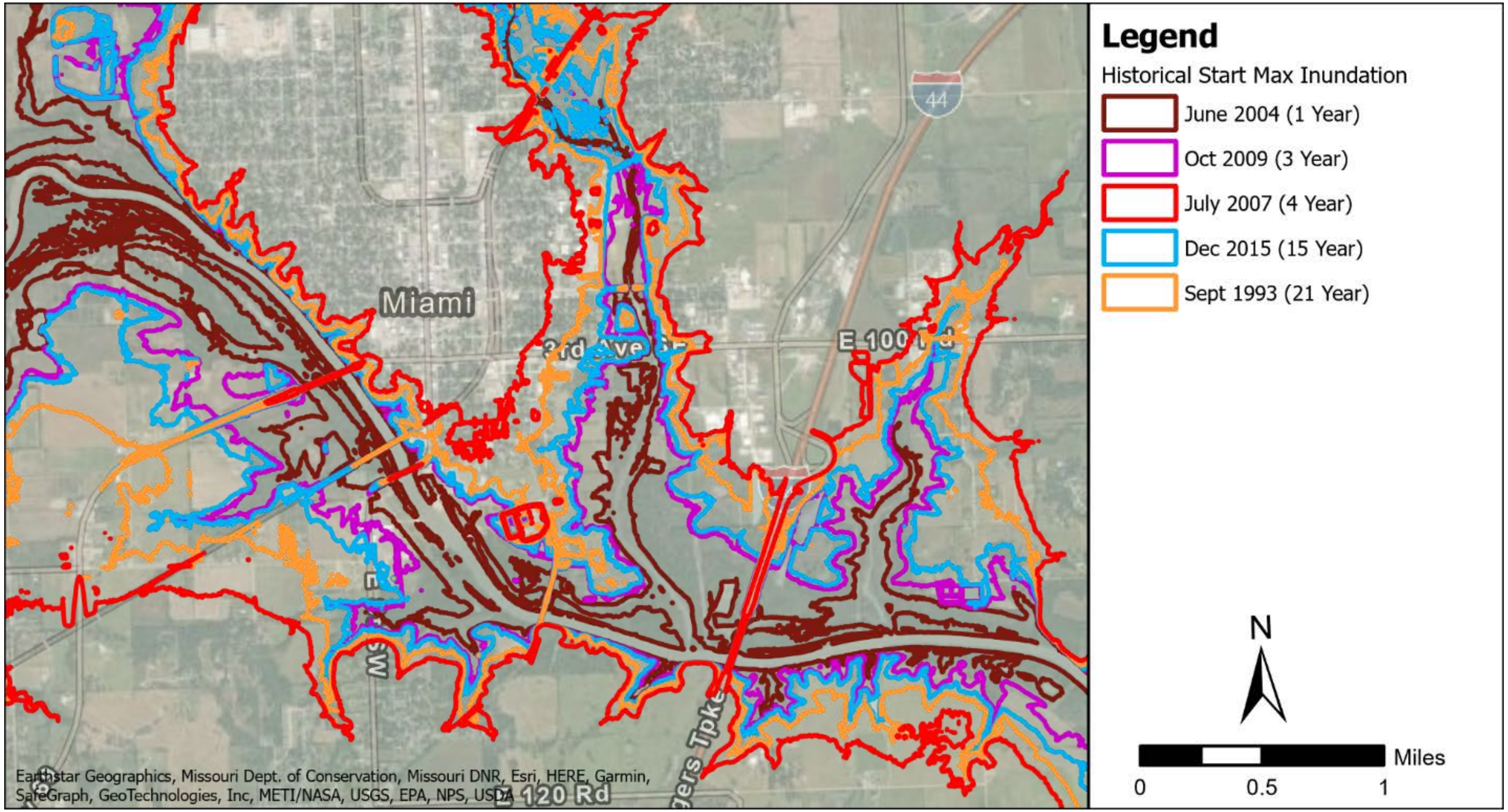
100-Year Inundation Extent



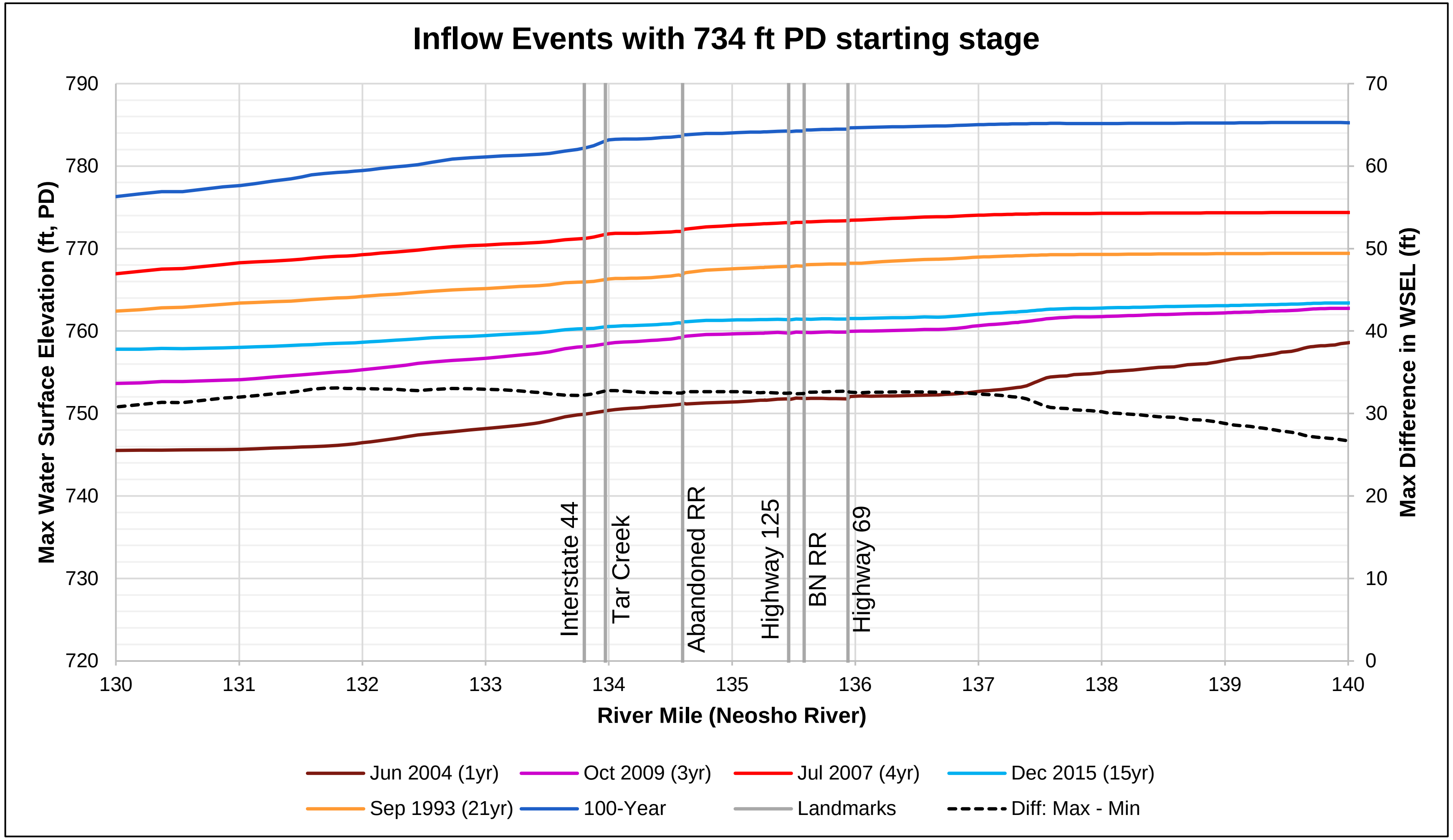
Historical Starting Stage WSEL Profiles



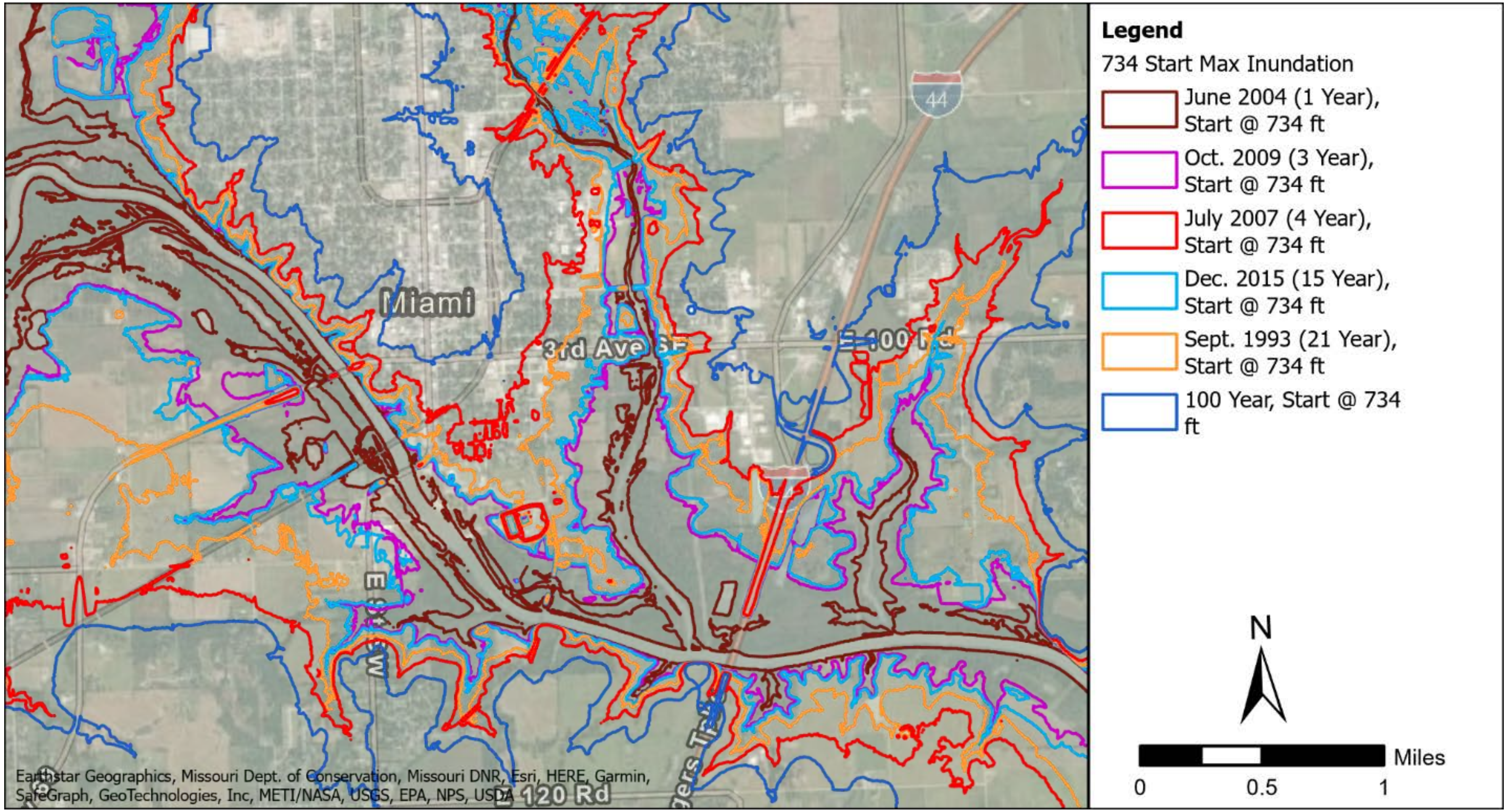
Historical Starting Stage Inundation Extent



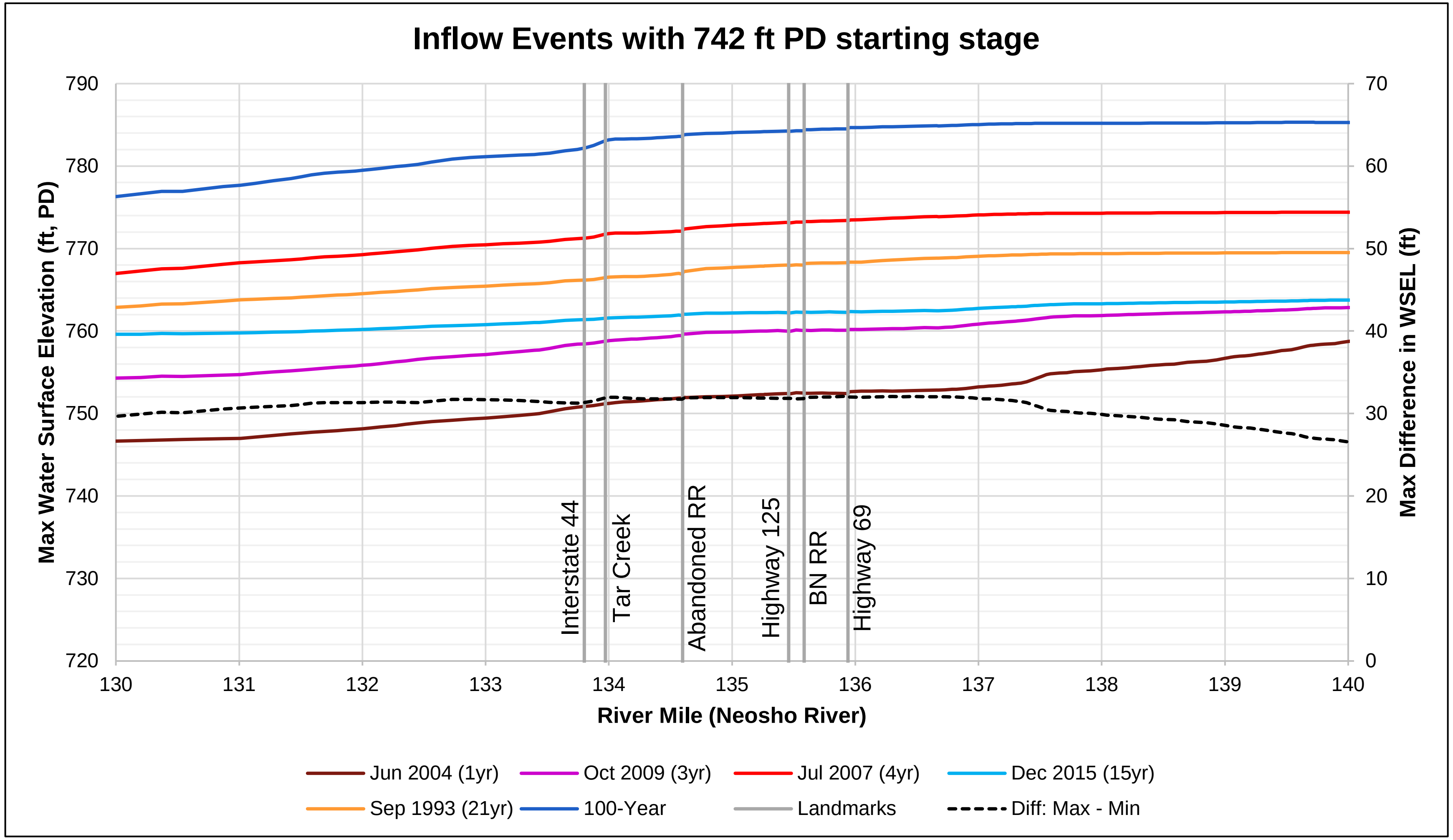
734 ft PD Starting Stage WSEL Profiles



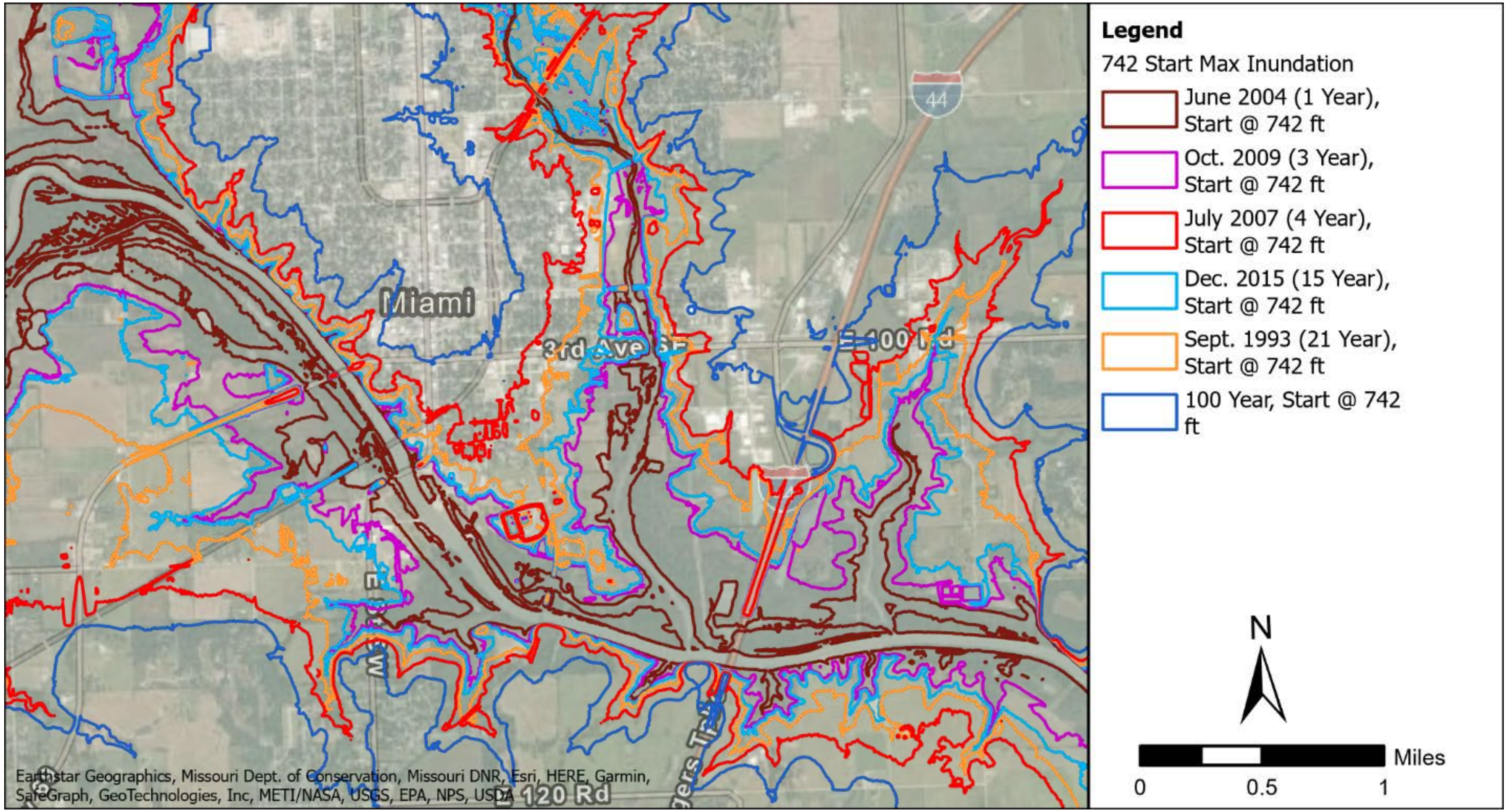
734 ft PD Starting Stage Inundation Extent



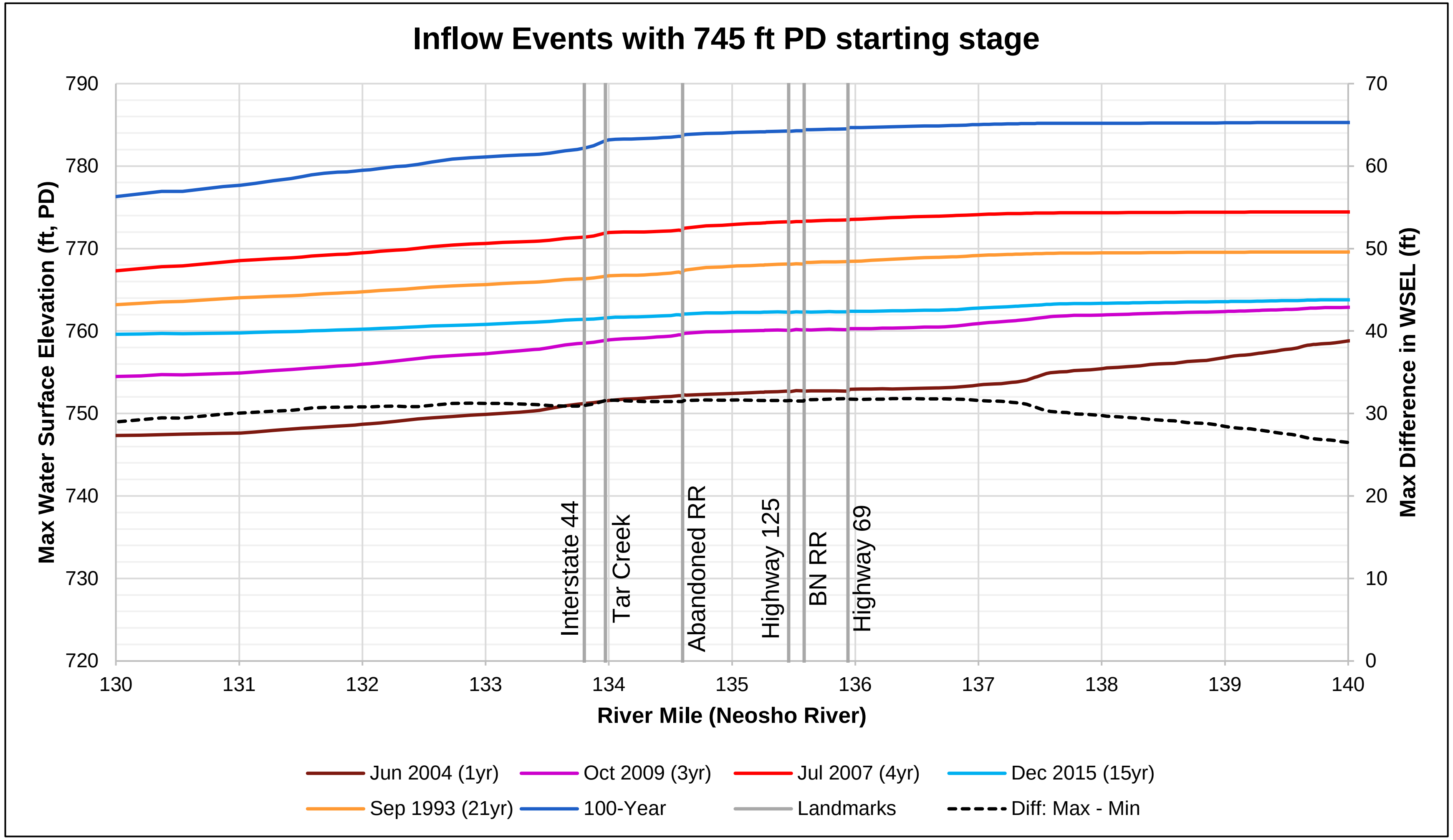
742 ft PD Starting Stage WSEL Profiles



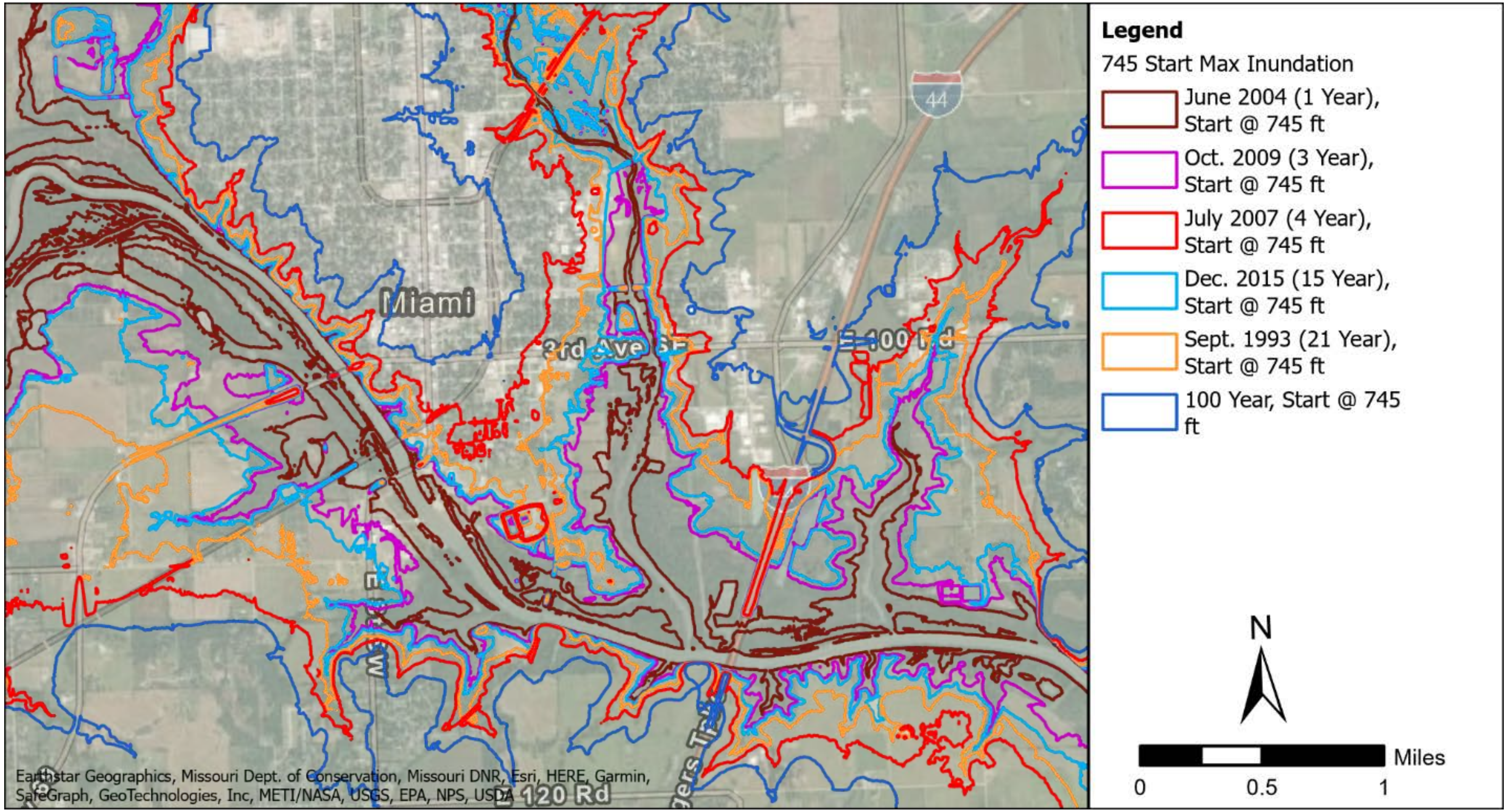
742 ft PD Starting Stage Inundation Extent



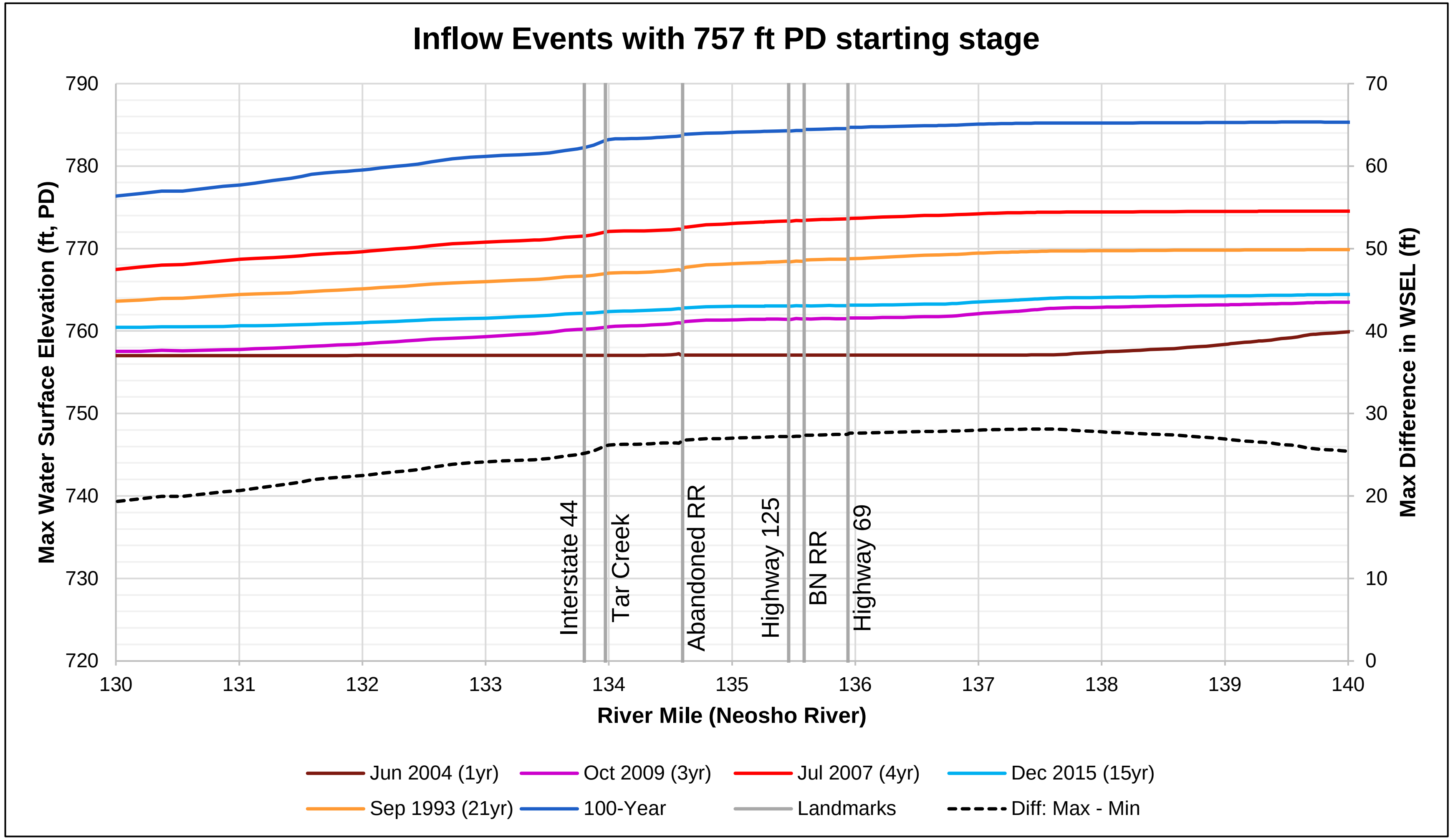
745 ft PD Starting Stage WSEL Profiles



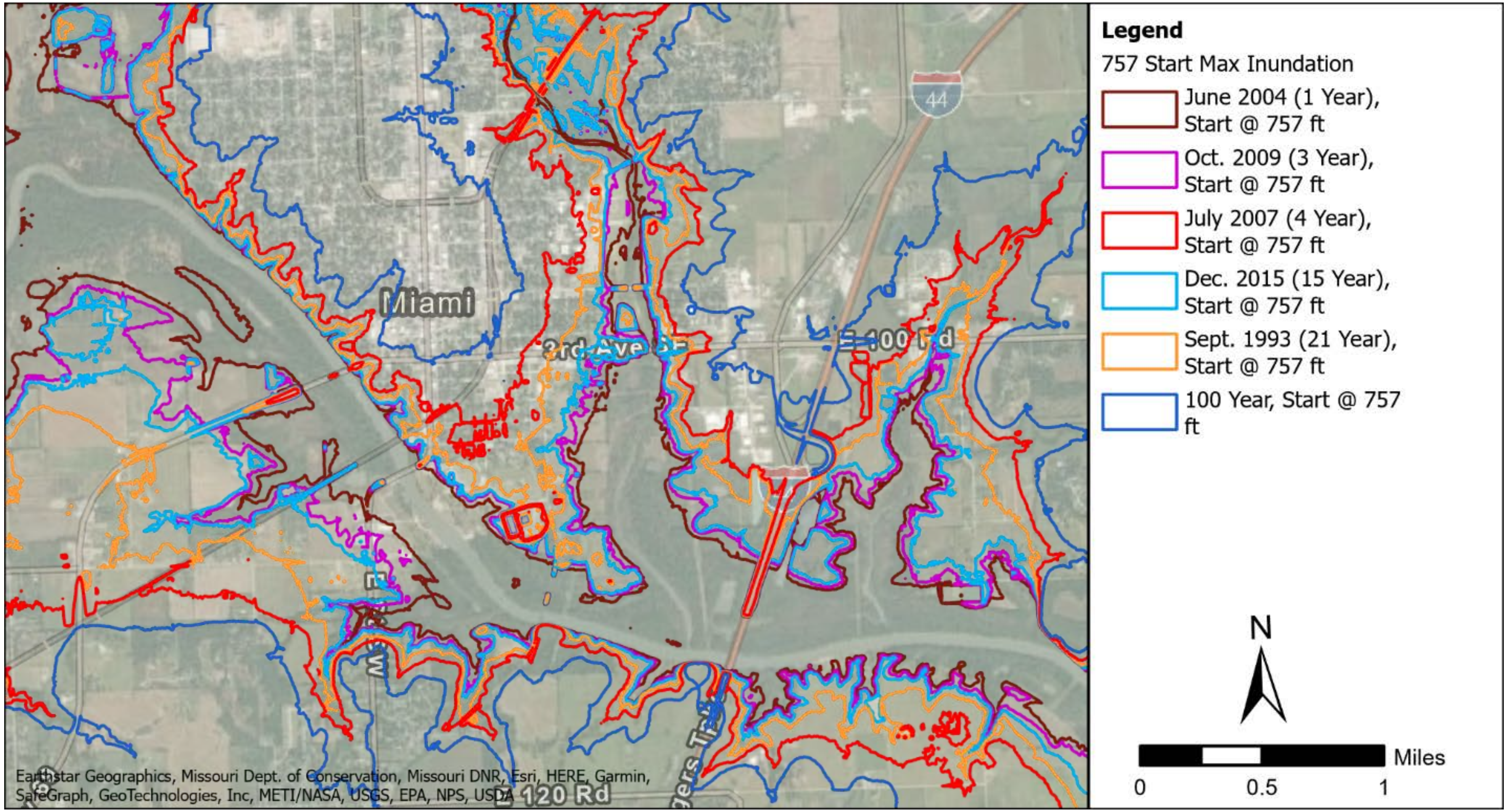
745 ft PD Starting Stage Inundation Extent



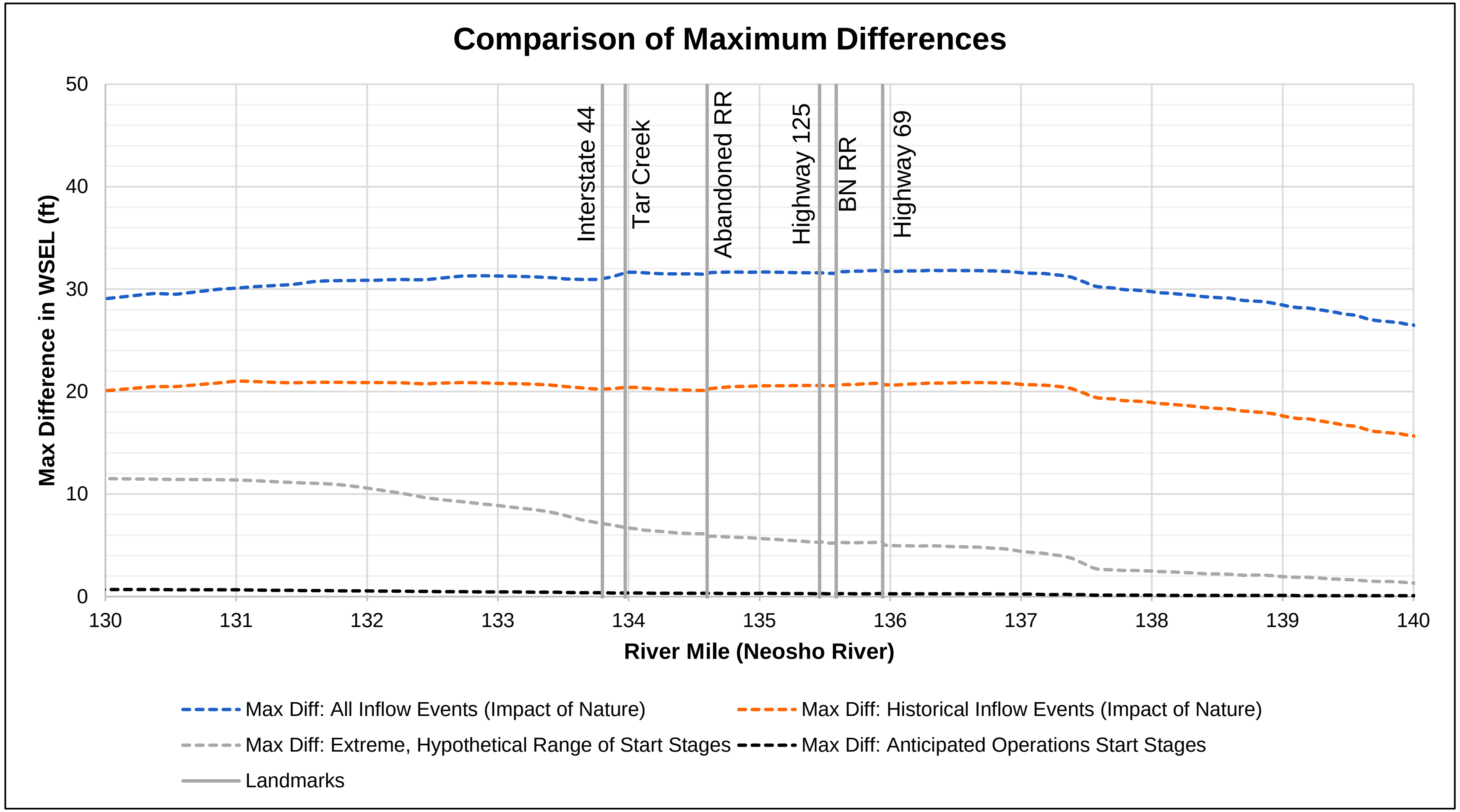
757 ft PD Starting Stage WSEL Profiles



757 ft PD Starting Stage Inundation Extent



Comparison of Maximum WSEL Differences



Discussion of Results

1. The magnitude of the natural inflow event is the ***primary determining factor*** of maximum WSEL.
2. Starting pool elevations within GRDA's anticipated operational range have an ***immaterial impact*** on upstream WSELs.
3. Even if extreme, hypothetical values of starting pool elevations outside GRDA's anticipated operational range are used, the impact of nature is ***much greater*** than that of a ***23-foot change in starting pool elevation***.

Questions?

Anticipated Operations Analysis

Anticipated Operations

As discussed in Section 1.6.2 of GRDA's December 29, 2021 filing with FERC, GRDA anticipates the following operational parameters will apply during the new license term:

1. GRDA will no longer utilize a rule curve with seasonal target elevations.
2. **GRDA will maintain the reservoir between elevations 742 and 745 feet PD for purposes of normal hydropower operations**. While hydropower operations may occur when water surface elevations are outside this range (e.g., maintenance drawdowns and high-flow events), GRDA expects to generally maintain water surface elevations between 742 and 745 feet PD during normal Project operations.
3. Instead of managing the Project to target a specified seasonal elevation, GRDA's anticipated operations may fluctuate reservoir levels within the elevational range of 742 and 745 feet PD, for purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations.
4. **GRDA will continue to adhere to the Army Corps of Engineer's direction on flood control operations in accordance with the Water Control Manual.**

Scenarios Simulated

Pensacola Initial Elevation (feet PD)	Jun 2004 (1 year)	Jul 2007 (4 year)	100-year
757.0 (Extreme Range)	✓		✓
746.5 (Baseline Period of Record) 745.9 (Anticipated Period of Record)		✓	
734.0 (Extreme Range)	✓		✓

Suite of Simulations

All scenarios simulated with:

1. Baseline operations
2. Anticipated operations

The suite represents:

1. The minimum and maximum starting pool elevations requested by FERC
2. The smallest and largest inflow events requested by FERC
3. An event of historical importance to upstream communities
   A. Within studied range of starting pool elevations
   B. Within studied range of inflow magnitudes
   C. Starting pool elevation based on period of record simulation using baseline/anticipated operations. Represents realistic starting elevation based on antecedent conditions and operating rules.
   D. Most integrous comparison of anticipated operations versus baseline operations

Anticipated Operations Results

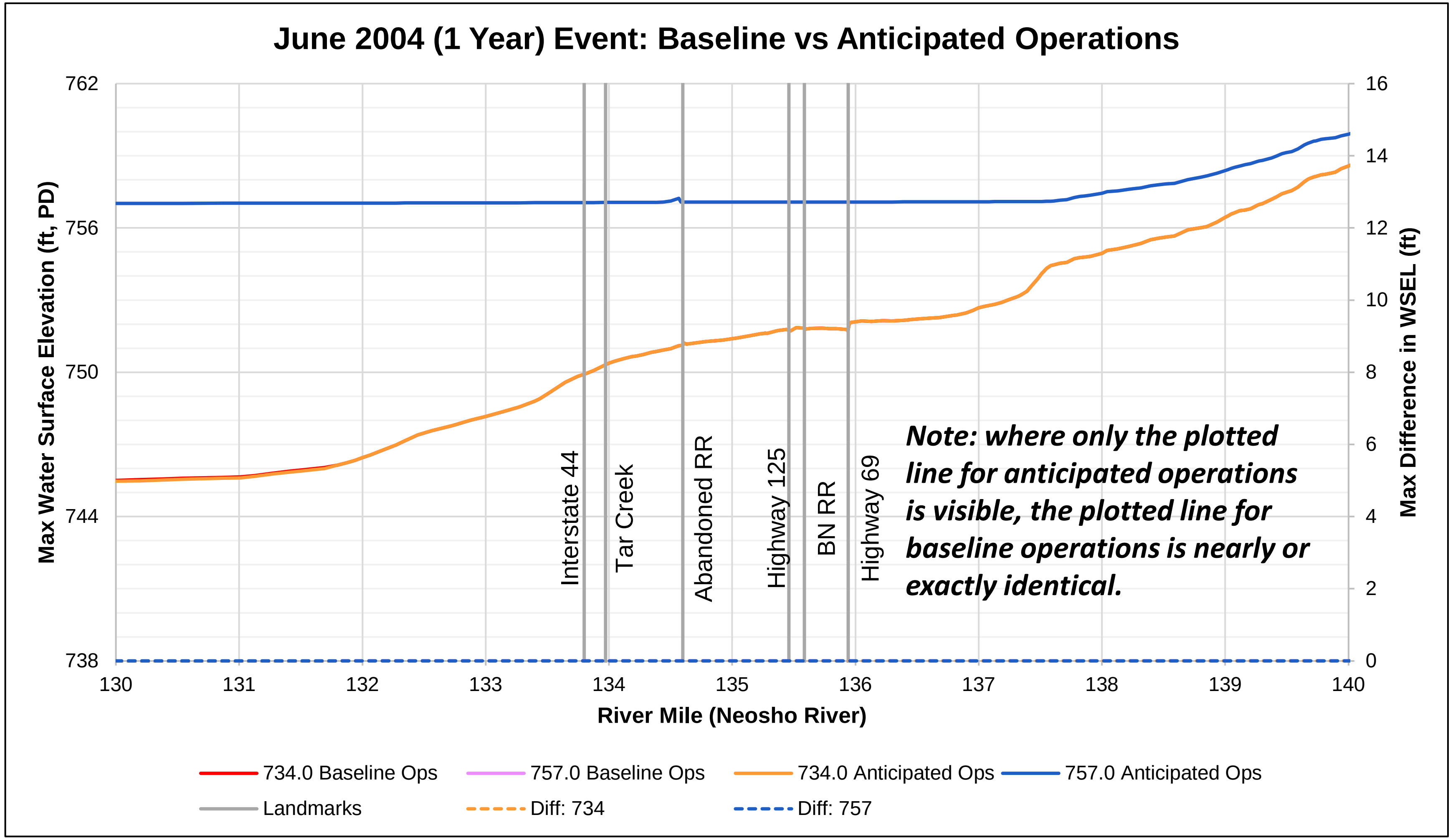
The results show that anticipated operations have an ***immaterial impact*** on upstream WSELs as compared to baseline operations.

Simulation	Maximum Increase in WSEL Due to Anticipated Operations (ft)
June 2004 (1 year) event, starting pool elevation of 734.0 feet PD	0.00
June 2004 (1 year) event, starting pool elevation of 757.0 feet PD	0.00
July 2007 (4 year) event, period of record starting pool elevation	0.02[1]
100-year event, starting pool elevation of 734.0 feet PD	0.05[2]
100-year event, starting pool elevation of 757.0 feet PD	0.00

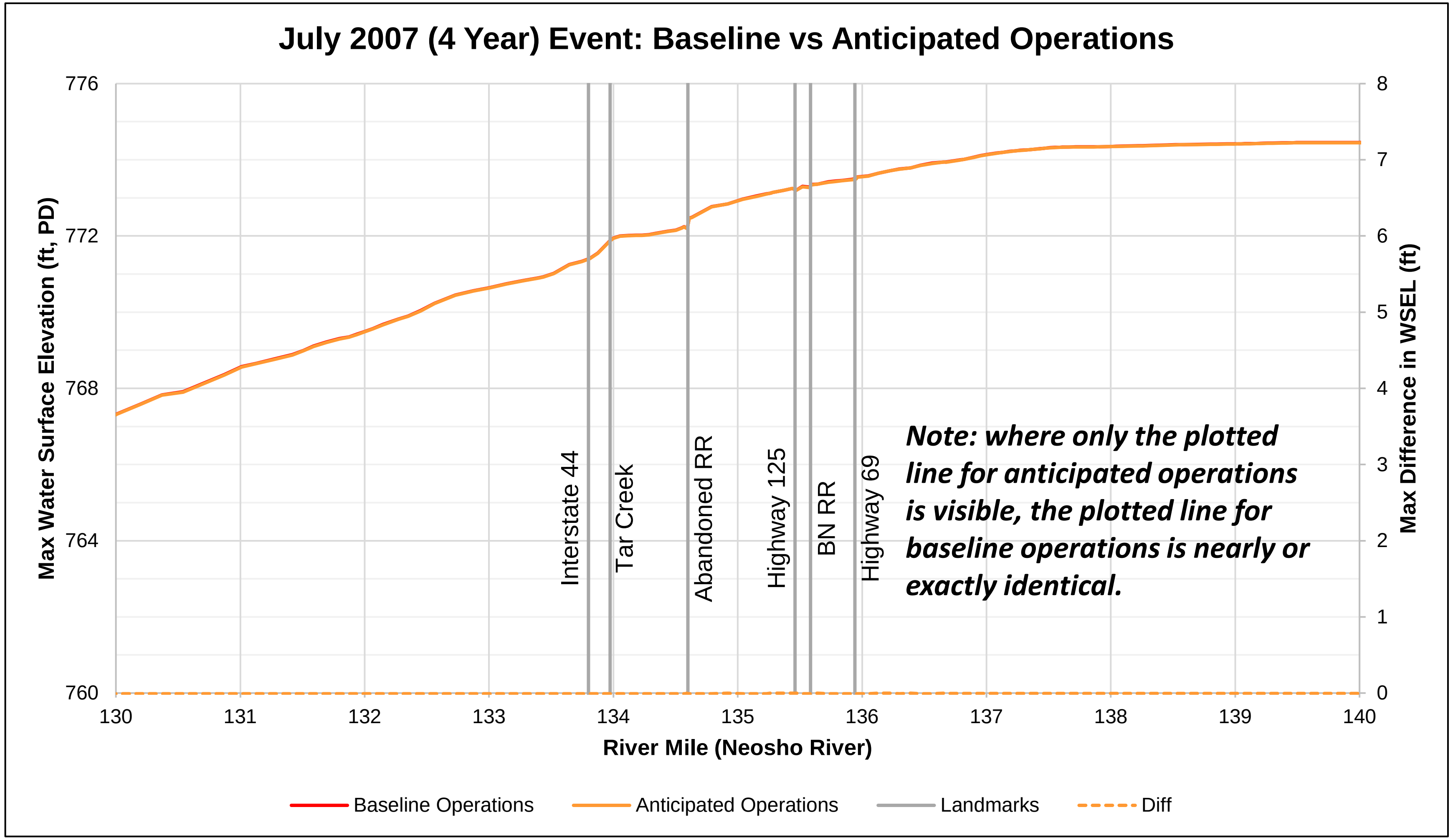
1 Maximum increase occurs on the Elk River. Maximum increase on the Neosho River is 0.01 feet.

2 Maximum increase occurs on the Spring River. Maximum increase on the Neosho River is 0.03 feet.

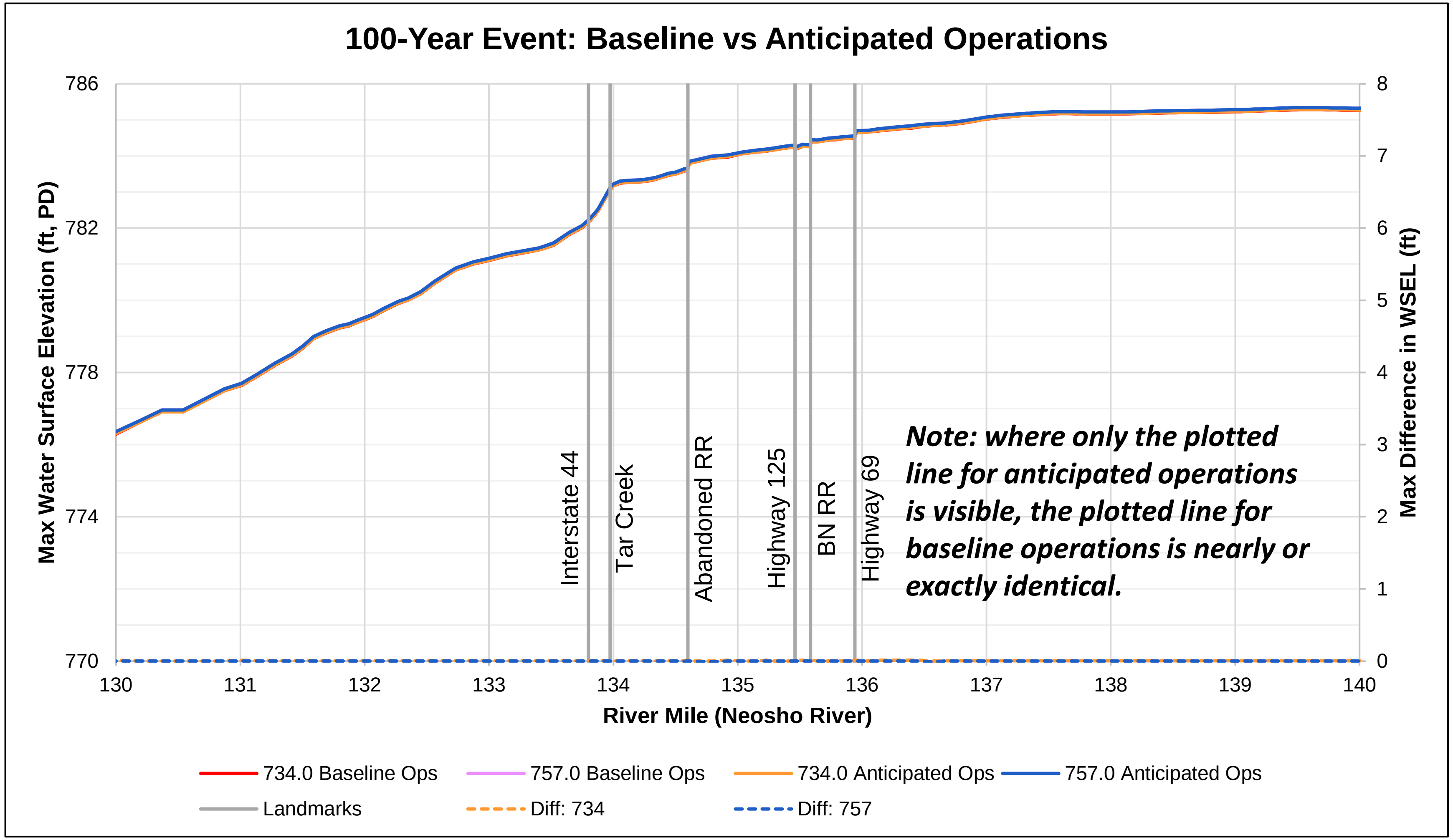
Anticipated Ops Results: June 2004 Event



Anticipated Ops Results: July 2007 Event



Anticipated Ops Results: 100-Year Event



Anticipated Ops Results: Inundation Maps

Based on the maximum WSEL results, no additional maps were created.

- A difference in inundation extent for a differences in WSEL of 0.05 feet or less at a few discrete locations cannot be effectively displayed on a map.
- The extent of inundation for anticipated operations is virtually identical to the extent of inundation for baseline operations.

Anticipated Ops Results: Duration

Simulation	Maximum Increase in Inundation Duration Due to Anticipated Operations (hours)
June 2004 (1 year) event, starting pool elevation of 734.0 feet PD	0
June 2004 (1 year) event, starting pool elevation of 757.0 feet PD	0
July 2007 (4 year) event, period of record starting pool elevation	0
100-year event, starting pool elevation of 734.0 feet PD	2*
100-year event, starting pool elevation of 757.0 feet PD	2*

* Increases in duration occur at RM 129.0, just upstream of the S 590 Road or Connor Bridge (RM 126.7). This area is rural, sparsely populated, and the 2-hour increase in duration is isolated to this location.

Questions?

Supporting Analyses for Other Studies

Supporting Analyses

Analyses conducted in support of four studies:

1. Aquatic Species Study
2. Terrestrial Species Study
3. Wetlands and Riparian Habitat Study
4. Sedimentation Study

Natural Resources Studies

Natural resources teams (Aquatic Species, Terrestrial Species, Wetland and Riparian Habitat) requested comparisons between anticipated and baseline operations during normal operations and inflows. Analysis of normal operations and inflows is necessary for biological assessments.

Aquatic Species Study

1. Simulations to assess impact to specific aquatic species:
   A. Anticipated and baseline operations
   B. 2004 to 2019 period of record simulated
   C. Critical time period (seasonality): **May 15 to July 8 (nursery period for largemouth bass)**
   D. Normal (median) operational level and inflows during critical time period simulated
2. Maximum inundation also identified, per Revised Study Plan:
   A. All major events during period of record simulated: July 2007, Dec. 2015, April 2017, and May 2019
   B. Maximum inundation boundaries merged into single inundation boundary
   C. Maximum inundation for baseline and anticipated operations was virtually identical
3. Maps showing changes to potential lake spawning species habitat were provided to the Aquatic Species Study Team and included in Appendix I.1.

Terrestrial Species Study

1. Simulations to assess impact to specific terrestrial species:
    A. Anticipated and baseline operations
    B. 2004 to 2019 period of record simulated
    C. Critical time period (seasonality): **January 1 to December 31 (active and inactive/hibernation periods)**
    D. Normal (median) operational level and inflows during critical time period simulated
2. Maximum inundation also identified, per Revised Study Plan
3. Maps showing **areas of potential lentic or lotic conversion** were provided to the Terrestrial Species Study Team and included in Appendix I.2.

Wetlands and Riparian Habitat Study

1. Simulations to assess impact to wetland and riparian habitats:
   A. Anticipated and baseline operations
   B. 2004 to 2019 period of record simulated
   C. Critical time period (seasonality): **March 30 to November 2 (growing season)**
   D. Normal (median) operational level and inflows during critical time period simulated
2. Maximum inundation also identified, per Revised Study Plan
3. Maps showing potential wetland and riparian inundation changes were provided to the Wetland and Riparian Habitat Study Team and included in Appendix I.3.

Sedimentation Study

1. Followed the Commission's May 27, 2022 determination regarding the Sedimentation Study.
2. Used 1D version of the UHM (1D UHM) to simulate:
   A. July 2007 (4 year) historical event and 100-year inflow event
   B. Starting reservoir elevations of 740-, 745-, and 750-feet PD.
3. Scenarios were simulated to understand effects of project operation and predicted channel geometry changes on upstream WSELs.
4. OM used to calculate downstream stage hydrographs at Pensacola Dam.
5. Sedimentation Study Team provided geometry files.
6. Results discussed in the Sedimentation report and presentation.

Questions?

Conclusions

Conclusions

1. Starting pool elevations at Pensacola Dam within GRDA's anticipated operational range have an ***immaterial impact*** on upstream WSELs, inundation, and duration.
2. Only natural inflows—***and not Project operation***—caused an appreciable impact on maximum WSELs, inundation extent, or duration of inundation.
3. The differences in WSEL, inundation extent, and duration of inundation due to the size of the inflow event were ***orders of magnitude*** greater than the differences due to the initial stage at Pensacola Dam. The maximum impact of nature typically ranged from over 10 times to over 100 ***or even 1,000 times*** the maximum simulated impact of GRDA's anticipated operations.

Conclusions

4. Even if extreme, hypothetical starting pool elevations outside GRDA's anticipated operational range are used, the maximum impact of nature is ***much greater*** than the maximum simulated impact of an ***extreme, hypothetical starting stage range of 23 feet***. The impact of nature typically ranged from 2 times to 10 ***or even 100 times*** the impact of the extreme, hypothetical starting stage range.
5. Comparing anticipated operations to baseline operations for a suite of simulations that spanned the FERC-requested range of starting pool elevations and inflow event magnitudes, the results of the UHM demonstrate that ***anticipated operations have an immaterial impact on upstream WSELs, inundation, and duration of inundation as compared to baseline operations***.
6. All conclusions on potential lentic or lotic conversion areas are discussed in each of the individual biological assessment reports.

Thank you

Hydrologic and Hydraulic Modeling: Downstream Hydraulic Model

Pensacola Hydroelectric Project
Project No. 1494

October 12, 2022

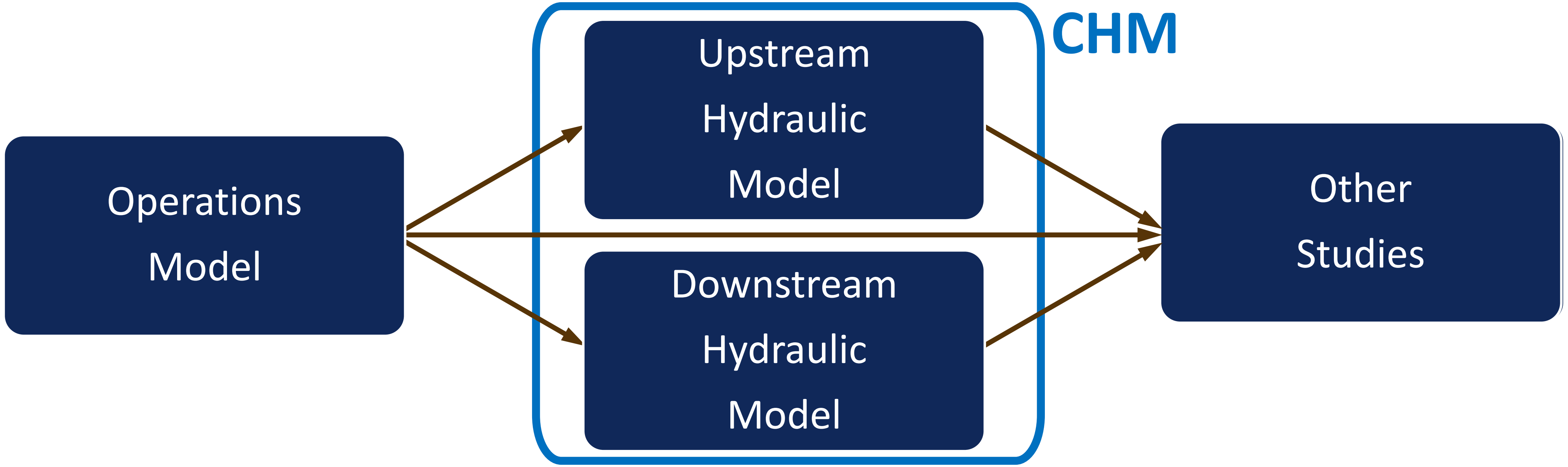
Presentation Outline

1. H&H Study Objectives
2. FERC Determination
3. Downstream Hydraulic Model Objectives
4. Simulated Scenarios
5. Study Results
6. Discussion of Results
7. Conclusions

H&H Study Objectives

H&H Study Objectives

1. Analyze inundation [downstream of Pensacola Dam] under current license operations of the Project during several measured inflow events.
2. Provide model results in a format that can inform other analyses.
3. Determine feasibility of implementing anticipated future operations that may be proposed by GRDA as part of relicensing effort.



FERC Determination

FERC Determination (Feb 2022)

FERC recommended the following modifications for the Downstream Hydraulic Model (DHM):

1. Run inflow event scenarios at starting reservoir elevations for Pensacola Dam from 734 feet PD up to and including 757 feet PD.

2. Report the frequency, timing, amplitude (i.e., elevation), and duration for each of the simulated inflow events with starting elevations for Pensacola Dam between 734 feet PD and 757 feet PD.

GRDA Completion of Approved Study Plan

GRDA completed FERC's Approved Study Plan as follows:

1. GRDA simulated inflow event scenarios with starting reservoir elevations at Pensacola Dam ranging from 734 feet PD up to and including 757 feet PD.

2. GRDA reported the frequency, timing, amplitude, and duration of inflow events:

   A. Frequency of the inflow events (i.e., estimated return period of inflows to Pensacola Dam) was reported.

   B. The term "timing" originates in the RSP and refers to seasonality of inflow to Pensacola Dam and inundation from the Upstream Hydraulic Model (UHM).

   C. Amplitude (i.e., elevation) is reported as WSEL.

   D. Duration of inundation is reported.

Downstream Hydraulic Model Objectives

DHM Objectives

Completed for First Study Season:

✓DHM Development

✓DHM Calibration

✓Initial Simulated Scenarios

Completed/Revised for Final Study Season:

✓Simulated Scenarios

✓Study Results and Discussion

✓Anticipated Operations Analysis

✓Conclusions

Simulated Scenarios

Simulated Scenarios

Inflow Event	Type	Estimated Return Period for Peak Inflow to Pensacola Dam	Pensacola Dam Historical Pool Elevation At Simulation Start (ft, PD)	Simulation Start/End Date
Sept. 1993	Historical	21 years	743.85	Sept. 24, 1993 – Oct. 17, 1993
June 2004	Historical	1 year	743.42	June 13, 2004 – June 26, 2004
July 2007	Historical	4 years	745.69	June 28, 2007 – July 25, 2007
Oct. 2009	Historical	3 years	740.98	Oct. 8, 2009 – Oct. 22, 2009
Dec. 2015	Historical	15 years	742.86	Dec. 26, 2015 – Jan. 17, 2016
100-year	Synthetic	100 years	N/A[1]	N/A[1] (duration of simulation = 14 days)

[1] *Because the 100-year event is synthetic, there is no historical pool elevation, or start/end dates*

Simulated Scenarios

Inflow Event	Pensacola Dam Pool Elevation at Simulation Start (ft, PD)	
	Anticipated Operational Range	Extreme, Hypothetical Range
Sept. 1993 (21 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
June 2004 (1 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
July 2007 (4 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
Oct. 2009 (3 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
Dec. 2015 (15 year)	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0
100-year	742.0, 742.5, 743.0, 743.5, 744.0, 744.5, 745.0	734.0, 749.0, 753.0, 757.0

Study Results

Study Results

- Tabular results
  - Compare max WSELs for each event with varying starting stages at Pensacola Dam
  - Two calculations of maximum differences in peak WSEL:
    - Starting stages at Pensacola Dam within GRDA's anticipated operational range (742 to 745 feet PD)
    - Starting stages at Pensacola Dam at extreme, hypothetical values outside GRDA's anticipated operational range (734 to 757 feet PD)
  - Compare max WSELs using historical starting stages at Pensacola Dam

- Graphical water surface profiles
  - Same comparisons as tabular results

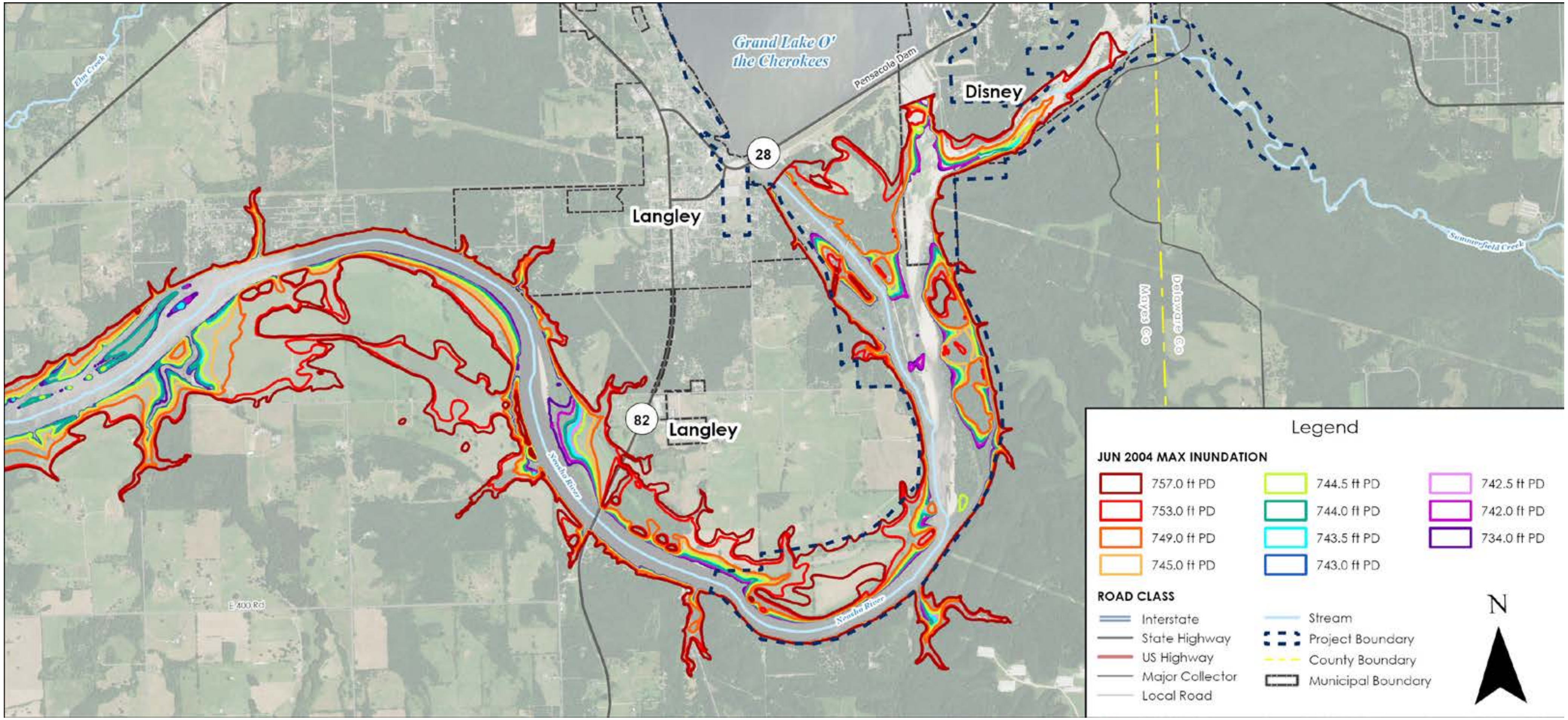
Study Results

- Duration of Inundation
  - Time of inundation above flowage easement for Markham Ferry Hydroelectric Project (Lake Hudson)
  - Flowage easement varies from 637.5 to 658.0 feet NGVD 29
  - Same comparisons as tabular results

- Inundation Maps
  - 10 map sheets to cover study area
  - Maximum inundation extents
  - Same comparisons as tabular results

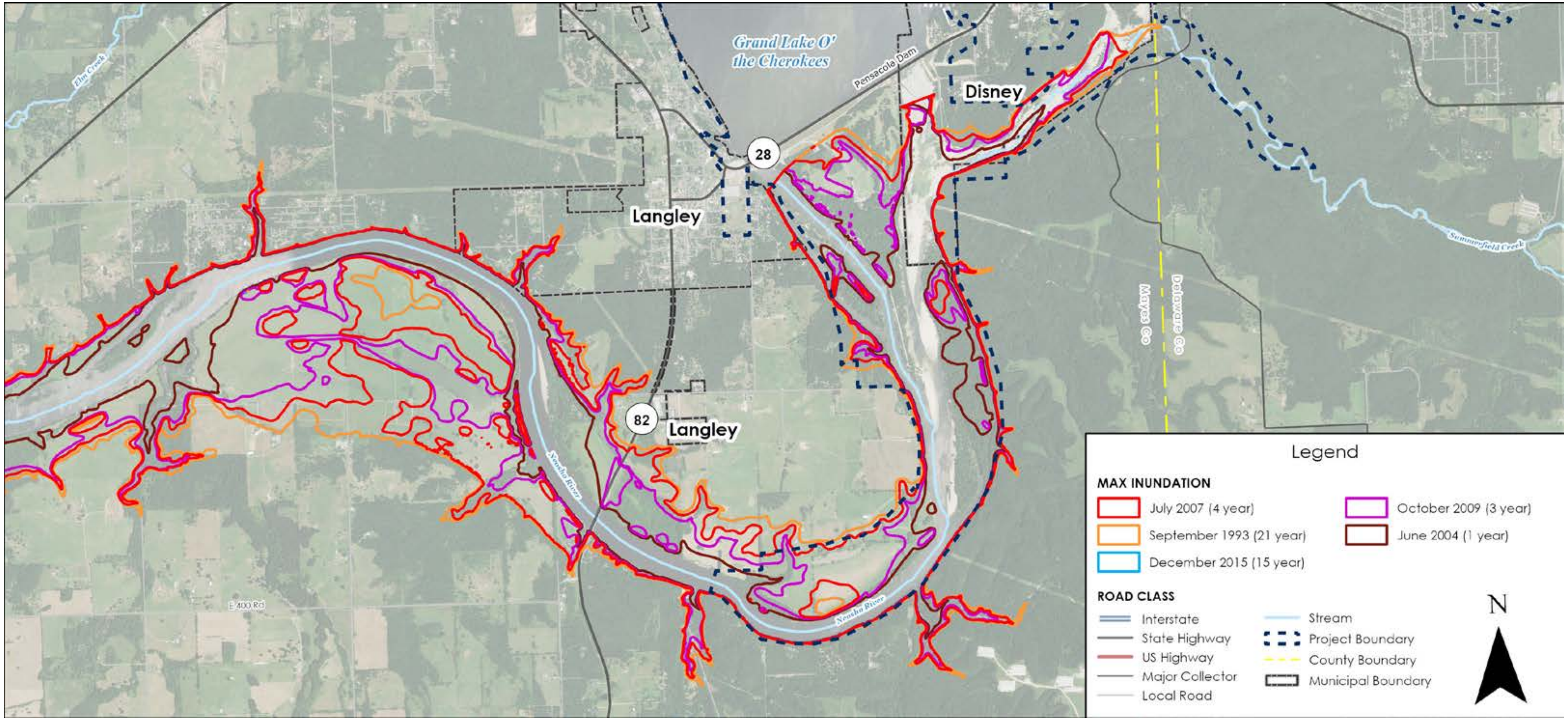
Study Results

Example of Inundation Mapping – June 2004 (1-Year) Event



Study Results

Example of Inundation Mapping – Historical Starting Stages



Study Results

Minimum and Maximum Downstream Inundation Areas
Pensacola Dam Starting Stages Within GRDA's Anticipated Operational Range (742 to 745 ft PD)

Event	Area of Inundation (acres)		Difference (%)
	Smallest	Largest	
September 1993 (21 year)	18,623	19,065	2.3%
June 2004 (1 year)	12,210	12,838	4.9%
July 2007 (4 year)	17,986	18,397	2.2%
October 2009 (3 year)	15,759	17,504	10.0%
December 2015 (15 year)	19,061	19,070	0.0%
100-year	20,721	20,736	0.1%
Historical Starting Stage (Impact of nature)	12,593	19,069	34.0%

Study Results

Minimum and Maximum Downstream Inundation Areas
Pensacola Dam Starting Stages Including **Extreme, Hypothetical** Values (734 to 757 ft PD)

Event	Area of Inundation (acres)		Difference (%)
	Smallest	Largest	
September 1993 (21 year)	16,739	19,560	14.4%
June 2004 (1 year)	12,127	17,263	29.8%
July 2007 (4 year)	17,976	18,605	3.4%
October 2009 (3 year)	15,215	17,994	15.4%
December 2015 (15 year)	18,015	19,507	7.6%
100-year	20,720	20,757	0.2%
Historical Starting Stage (Impact of nature)	12,593	19,069	34.0%

Discussion of Results

September 1993 Event

- Second largest maximum releases from Pensacola Dam of events analyzed

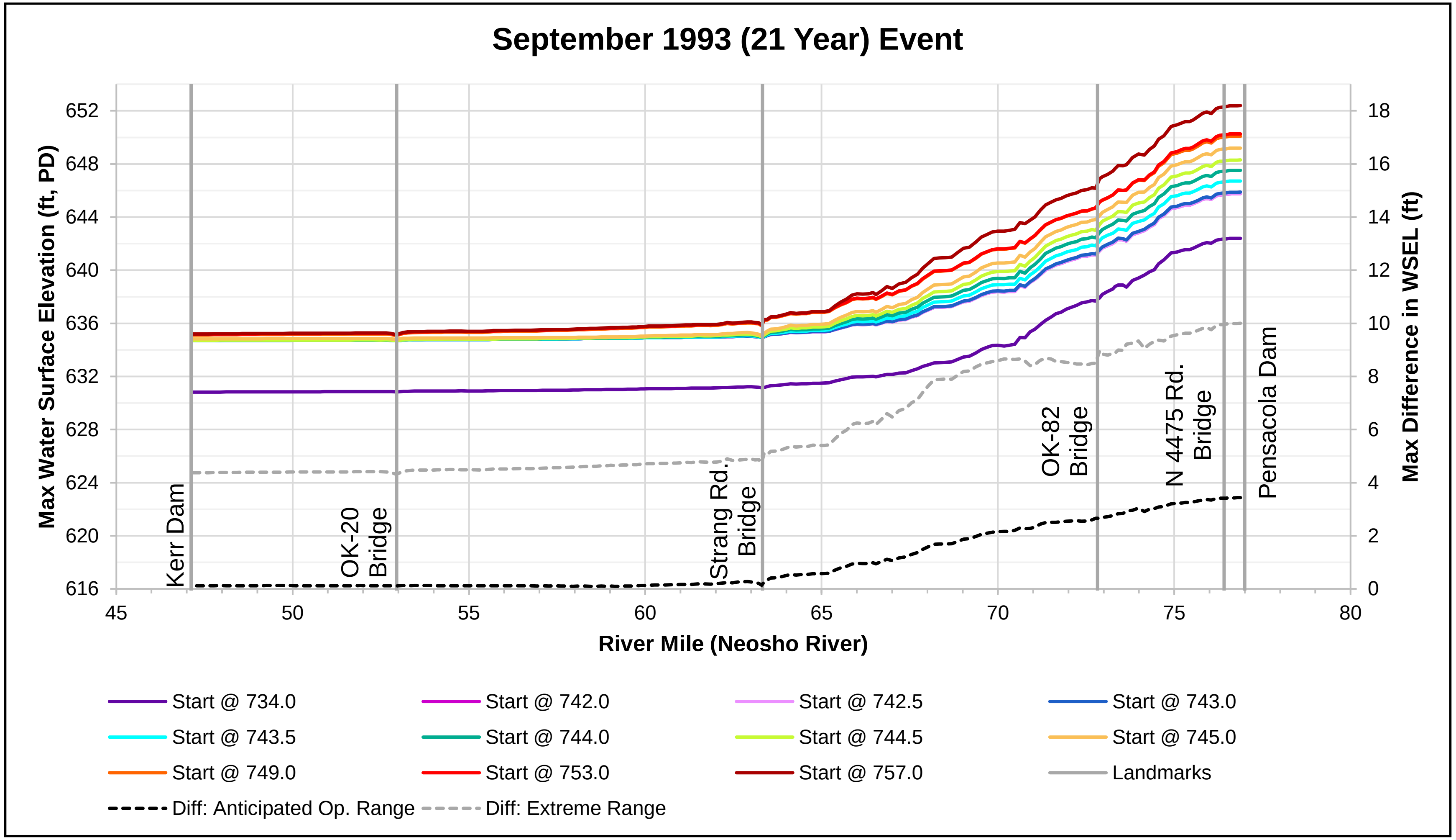
- Peak stages at Kerr Dam:
  - Only differ slightly for starting stages within GRDA's anticipated operational range
  - Differ by maximum of 4.4 feet for extreme, hypothetical starting stages

- Differences in peak WSEL and maximum inundation in upstream portion of DHM:
  - Maximum WSEL differences of 1.1 to 3.4 feet for starting stages within GRDA's anticipated operational range
  - Maximum WSEL differences of 6.6 to 10 feet for starting stages that included extreme, hypothetical values

- Smaller differences in max WSEL and inundation in downstream portion of model
  - No appreciable differences in maximum inundation

- Flowage easement for Lake Hudson not exceeded -> duration of downstream inundation is zero

September 1993 Event



June 2004 Event

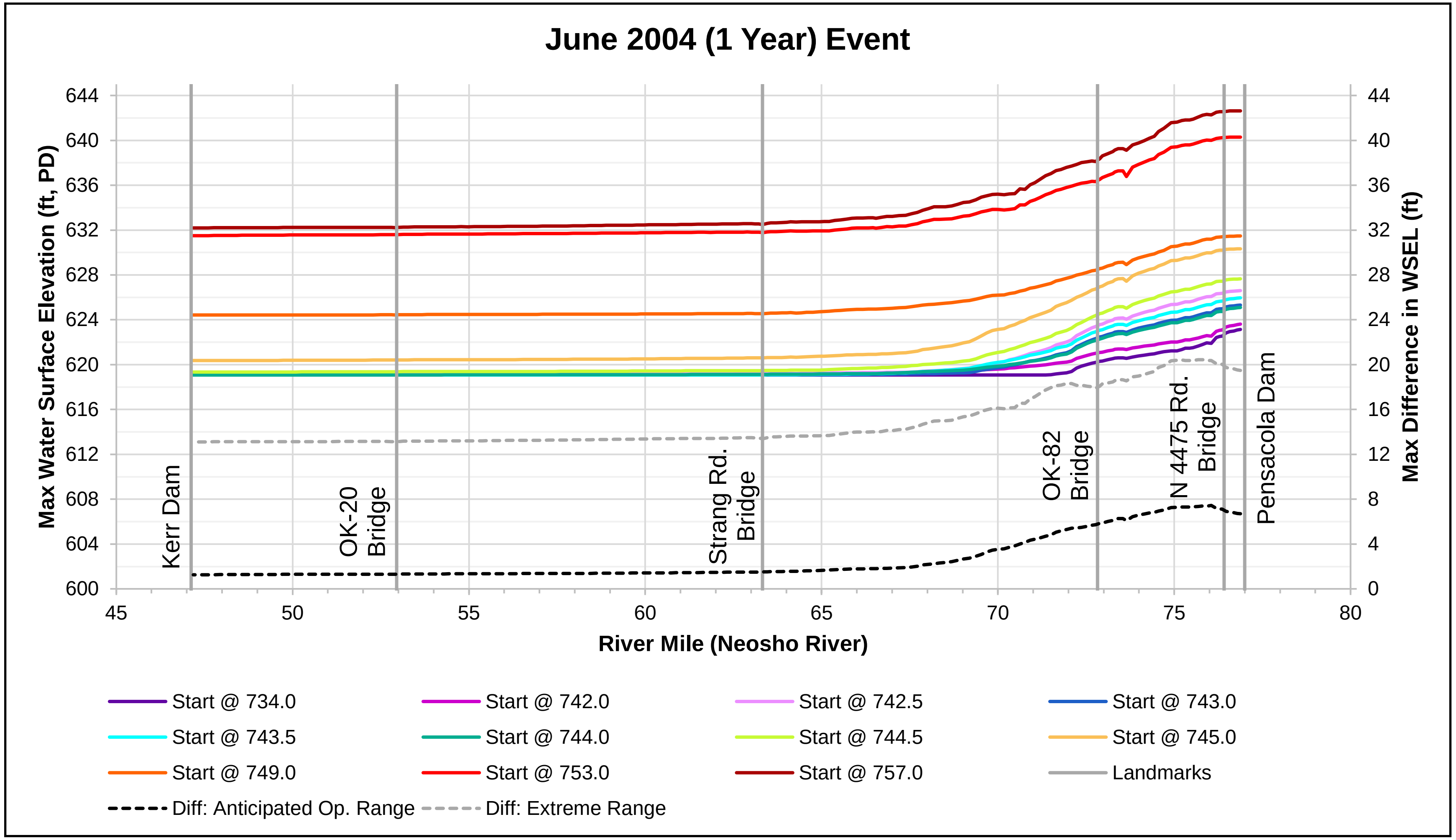
- Smallest releases from Pensacola Dam of events analyzed

- Peak stages at Kerr Dam:
  - Peak stages differ by 1.3 feet for starting stages within GRDA's anticipated operational range
  - Peak stages differ by 13 feet for starting stages that include extreme, hypothetical values

- Differences in maximum WSEL and inundation most pronounced in the upstream portion of the DHM
  - Maximum WSEL differences of 1.8 to 7.3 feet for starting stages within GRDA's anticipated operational range
  - Maximum WSEL differences of 14 to 20 feet for starting stages that include extreme, hypothetical values

- Flowage easement for Lake Hudson not exceeded -> duration of downstream inundation is zero

June 2004 Event



July 2007 Event

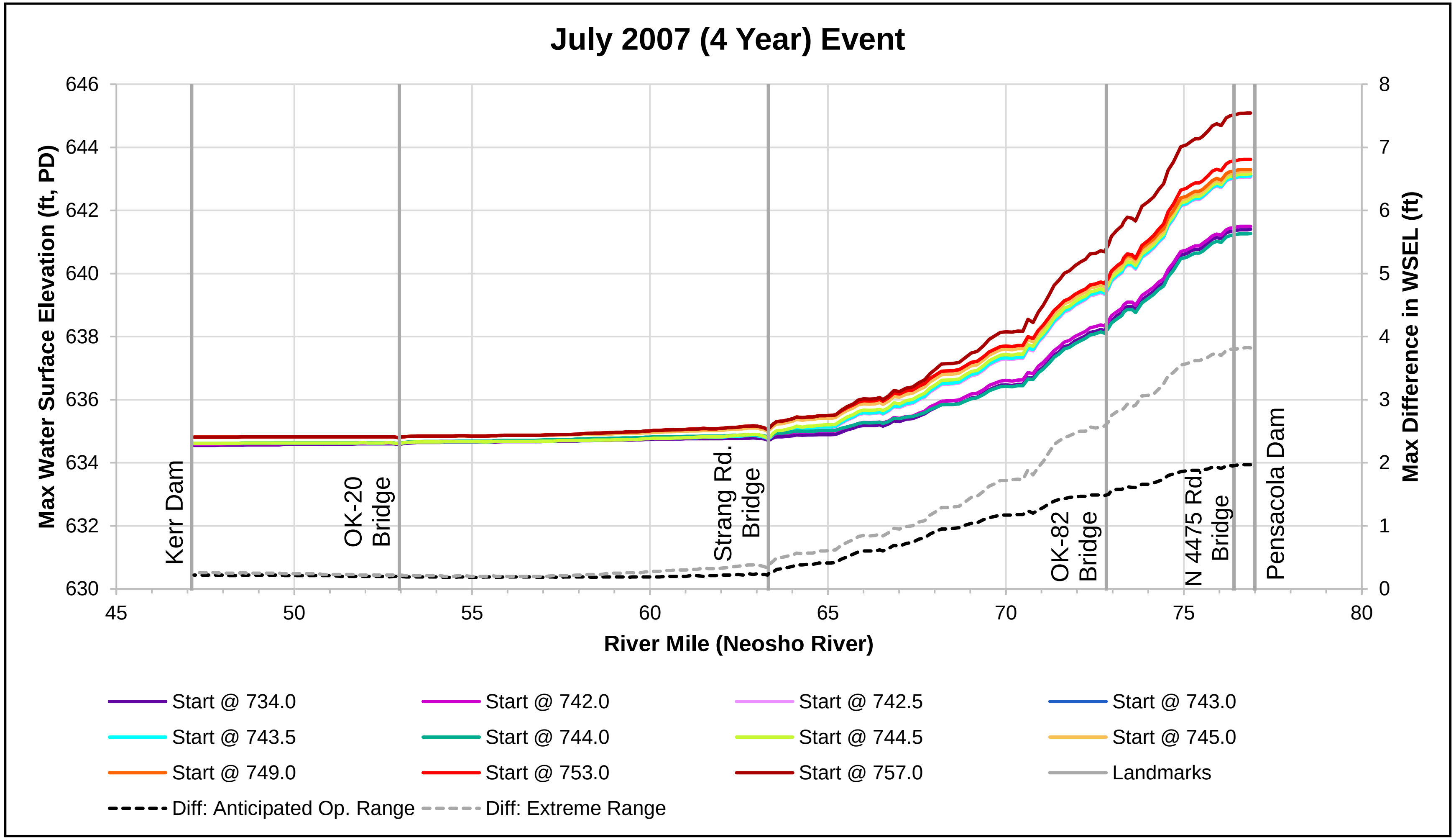
- Third smallest releases from Pensacola Dam of events analyzed

- Peak stages at Kerr Dam only differ slightly for starting stages within GRDA's anticipated operational range and those that include extreme values
  - Differences in maximum inundation not appreciable through Lake Hudson

- Differences in maximum WSEL and inundation more pronounced in the upstream portion of the DHM
  - Maximum WSEL differences of 0.69 to 1.9 feet for starting stages within GRDA's anticipated operational range
  - Maximum WSEL differences of 0.96 to 3.8 feet for starting stages that include extreme, hypothetical values

- Flowage easement for Lake Hudson not exceeded -> duration of downstream inundation is zero

July 2007 Event



October 2009 Event

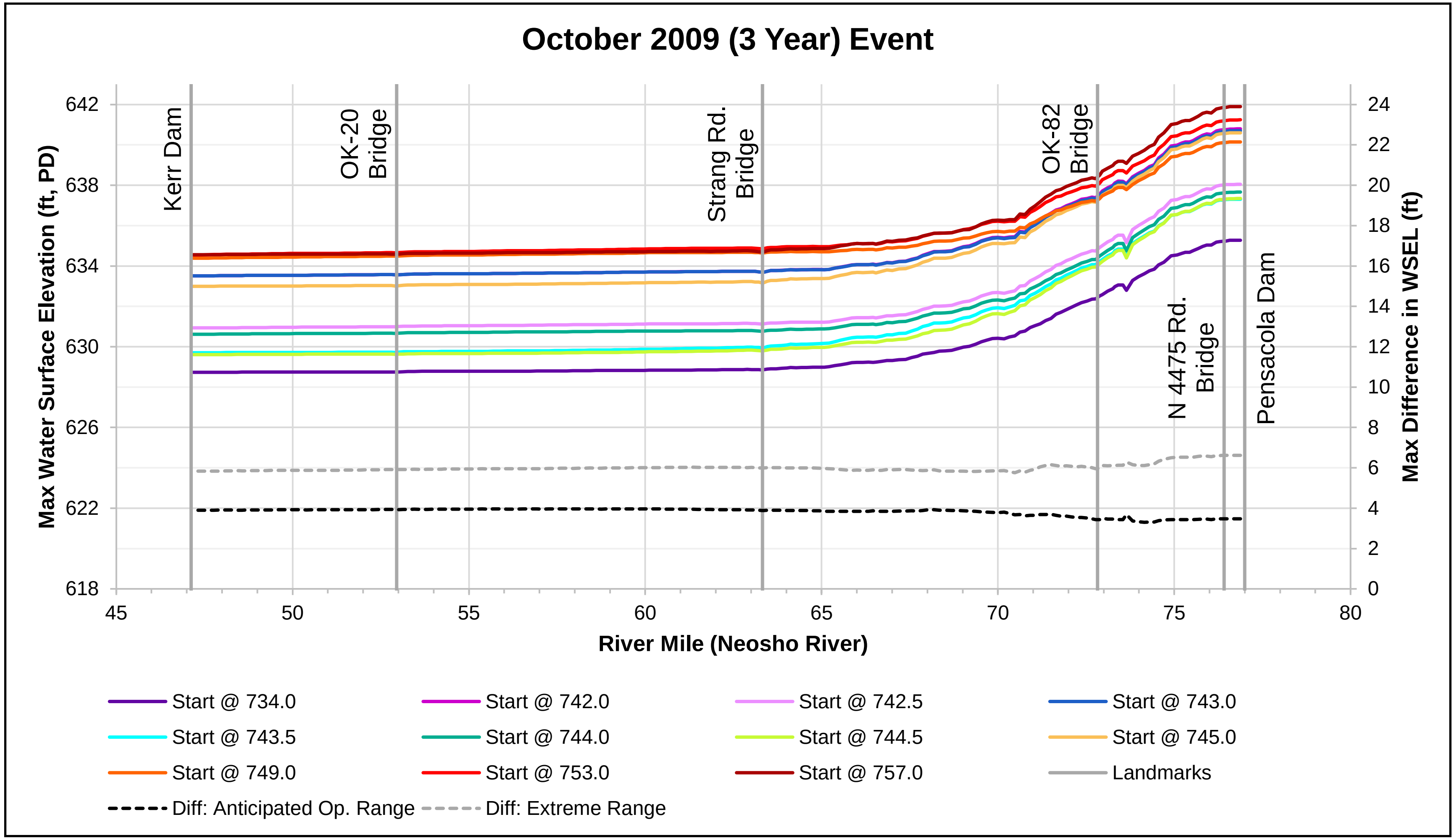
- Second smallest releases from Pensacola Dam of events analyzed

- Peak stages at Kerr Dam:
  - Peak stages differ by 3.9 feet for starting stages within GRDA's anticipated operational range
  - Peak stages differ by 5.8 feet for starting stages that include extreme, hypothetical values

- Nearly uniform differences in max WSELs throughout the model
  - Differences in maximum inundation most pronounced in upstream portion

- Flowage easement for Lake Hudson not exceeded -> duration of downstream inundation is zero

October 2009 Event



December 2015 Event

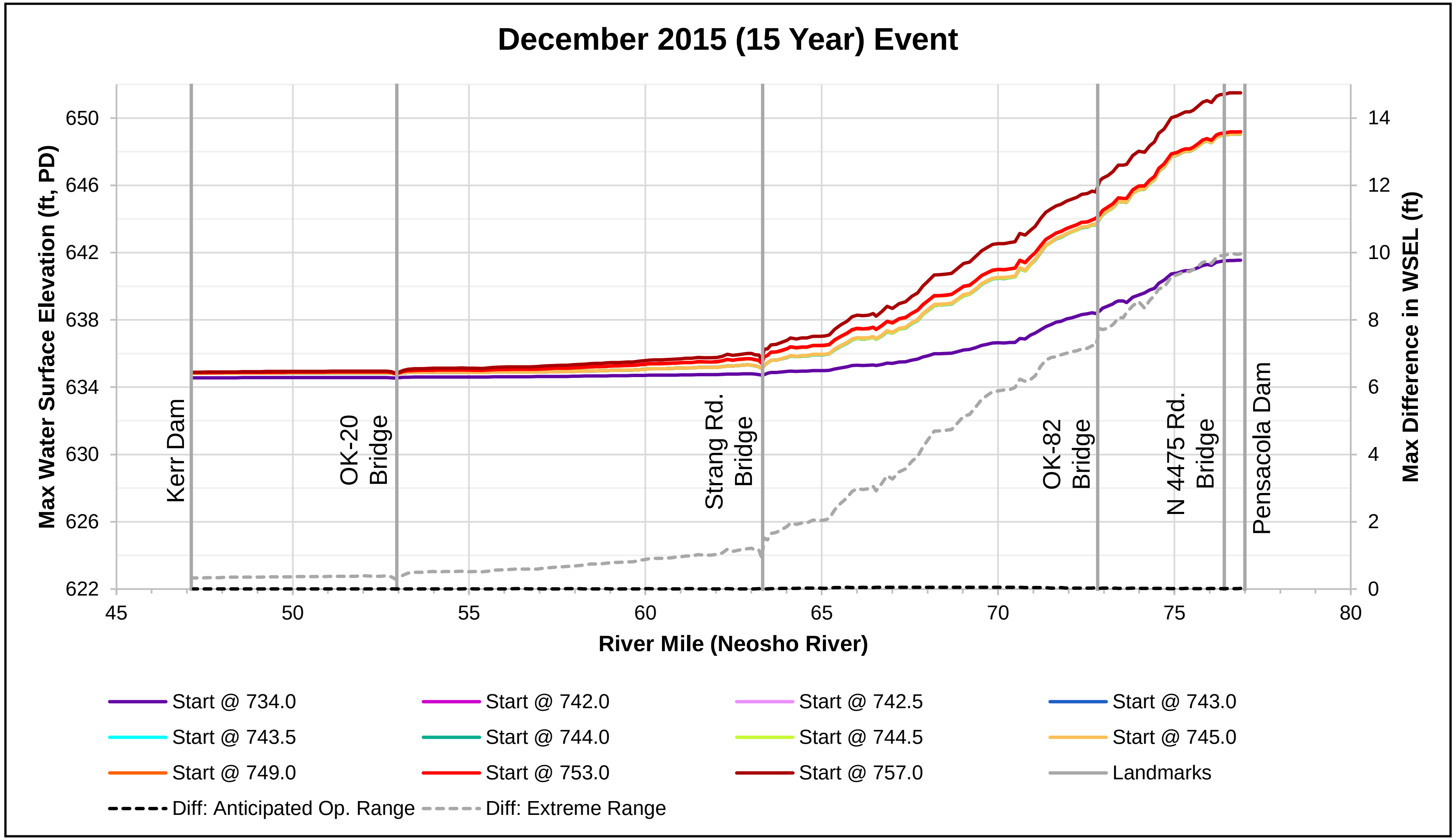
- Third largest releases from Pensacola Dam of events analyzed

- Starting stages at Pensacola Dam within GRDA's anticipated operational range:
  - Releases from Pensacola Dam nearly identical
  - Peak stages at Kerr Dam and differences in maximum WSEL throughout model are nearly identical

- Starting stages at Pensacola Dam that include extreme, hypothetical values:
  - Differences in maximum WSEL and inundation less pronounced through Lake Hudson (WSEL differences 0.33 to 1.2 feet)
  - Differences and maximum WSEL and inundation more pronounced in upper portions of DHM (WSEL differences 1.5 to 9.9 feet)

- Flowage easement for Lake Hudson not exceeded -> duration of downstream inundation is zero

December 2015 Event



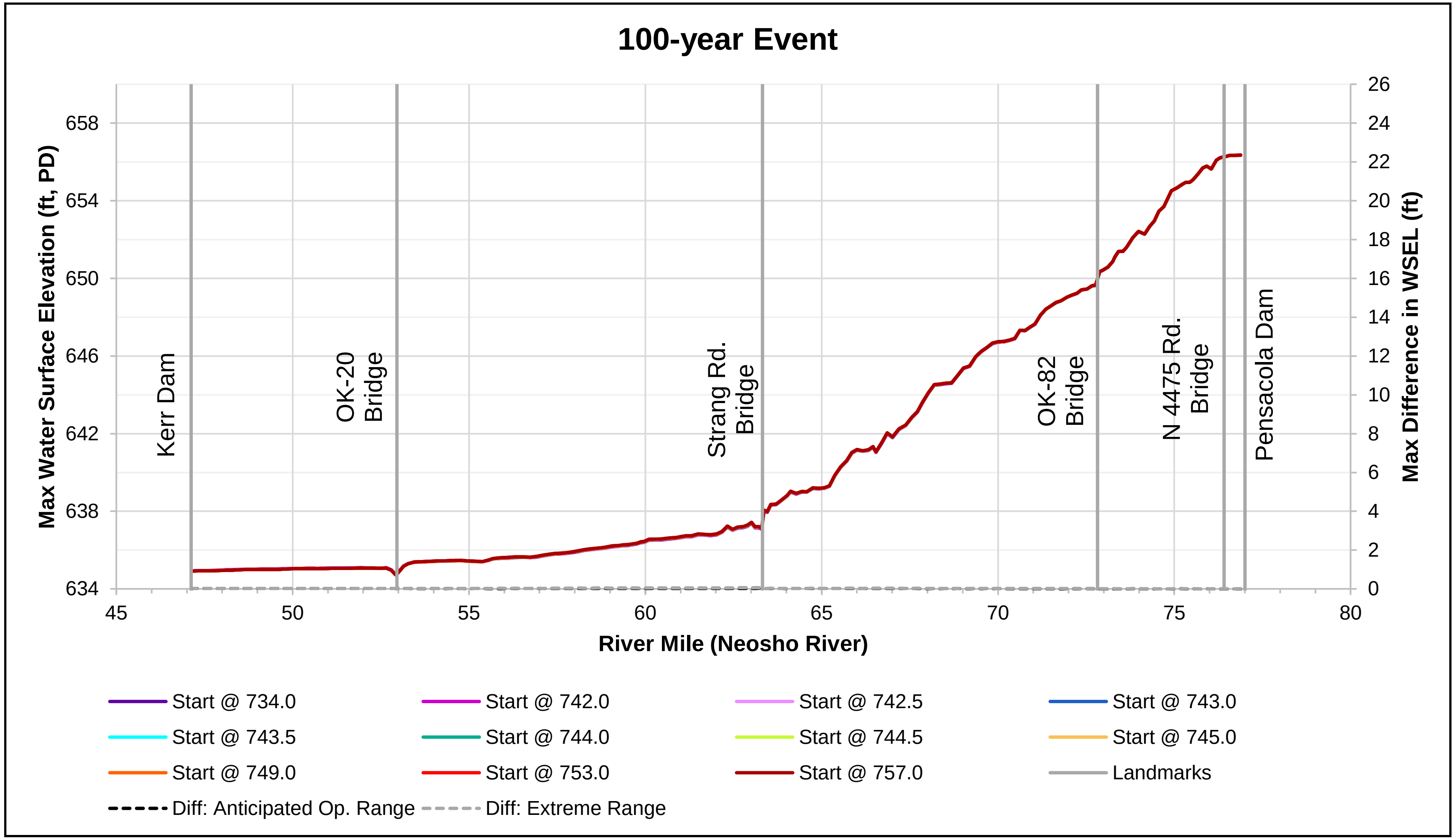
100-year Event

- Largest releases from Pensacola Dam of events analyzed
  - Peak releases identical for all starting stages

- Nearly identical maximum WSELs throughout the DHM for all starting stages analyzed (including extreme, hypothetical starting stages)
  - Maximum inundation extents nearly identical

- 100-year is the only event to exceed Lake Hudson flowage easements
  - Flowage easements only exceeded between RM 69.7 and RM 73.3 (i.e., from 3 miles downstream of OK-82 Bridge to 0.5 miles upstream of OK-82 Bridge)
  - Maximum difference in duration of inundation is 3 hours for starting stages within GRDA's anticipated operational range
  - Maximum difference in duration of inundation is 22 hours for starting stages that include extreme, hypothetical values

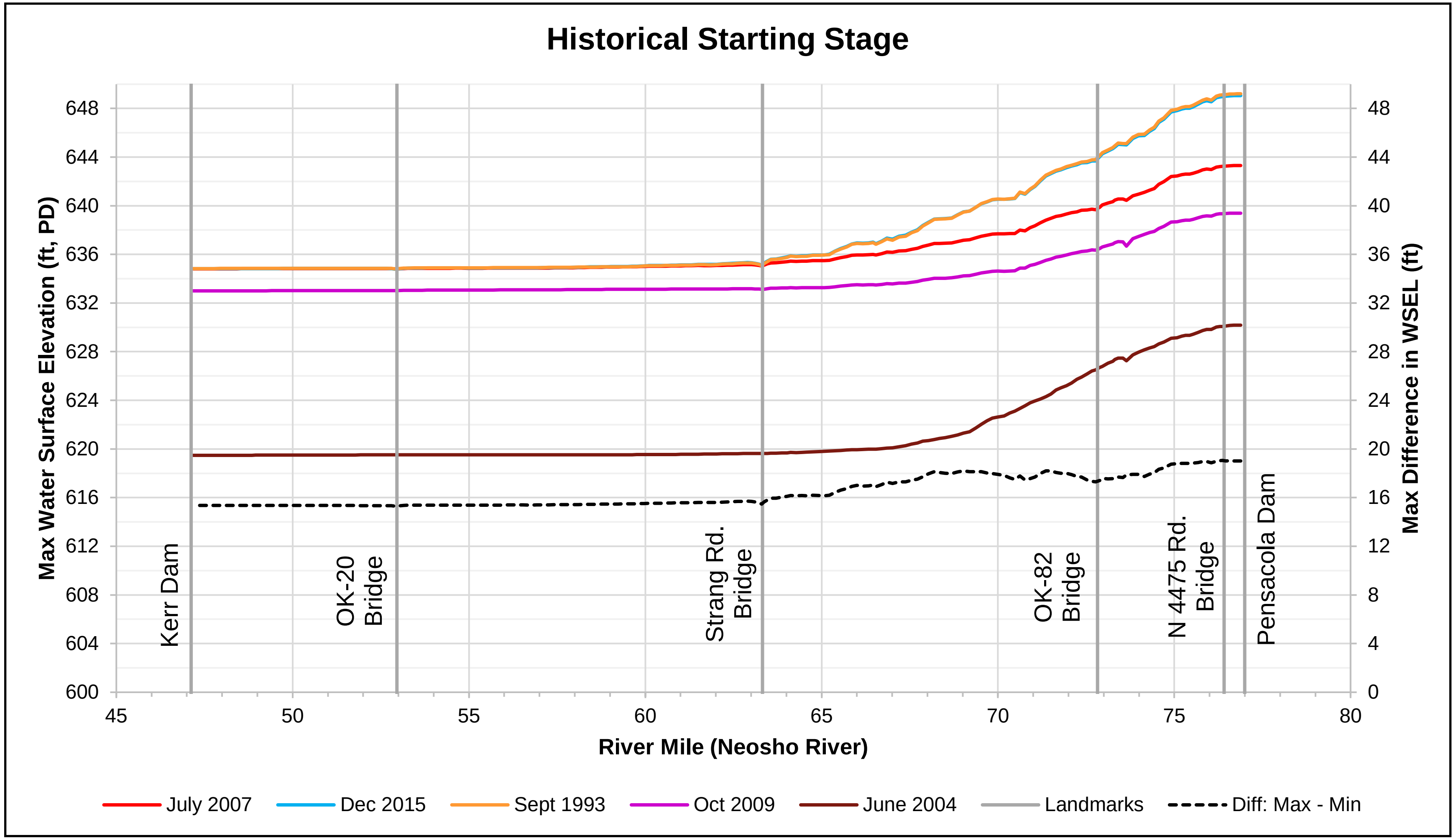
100-year Event



Compare Historical Starting Stages

- Releases from Pensacola Dam vary significantly between all the flow events using historical starting stages
- Peak stages at Kerr Dam differ by maximum of approximately 15 feet
- Differences in maximum WSELs and maximum inundation extents throughout the model
  - Most pronounced through the upper portion of the model
- Flowage easement for Lake Hudson not exceeded for any of the events with historical starting stage
  - Duration of inundation is zero

Compare Historical Starting Stages



Anticipated Operations Analysis

Anticipated Operations Analysis

- GRDA anticipates operating Pensacola Dam with a fluctuating reservoir between 742 and 745 feet PD
  - Will no longer use rule curve

- Anticipated vs. Baseline operations compared for:

<table>
<tr><th>Pensacola Initial Elevation (feet PD)</th><th>Jun 2004 (1 year)</th><th>Jul 2007 (4 year)</th><th>100-year</th></tr>
<tr><td>757.0 (Extreme Range)</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>746.5 (Baseline POR)
745.9 (Anticipated POR)</td><td colspan="3">✓</td></tr>
<tr><td>734.0 (Extreme Range)</td><td>✓</td><td></td><td>✓</td></tr>
</table>

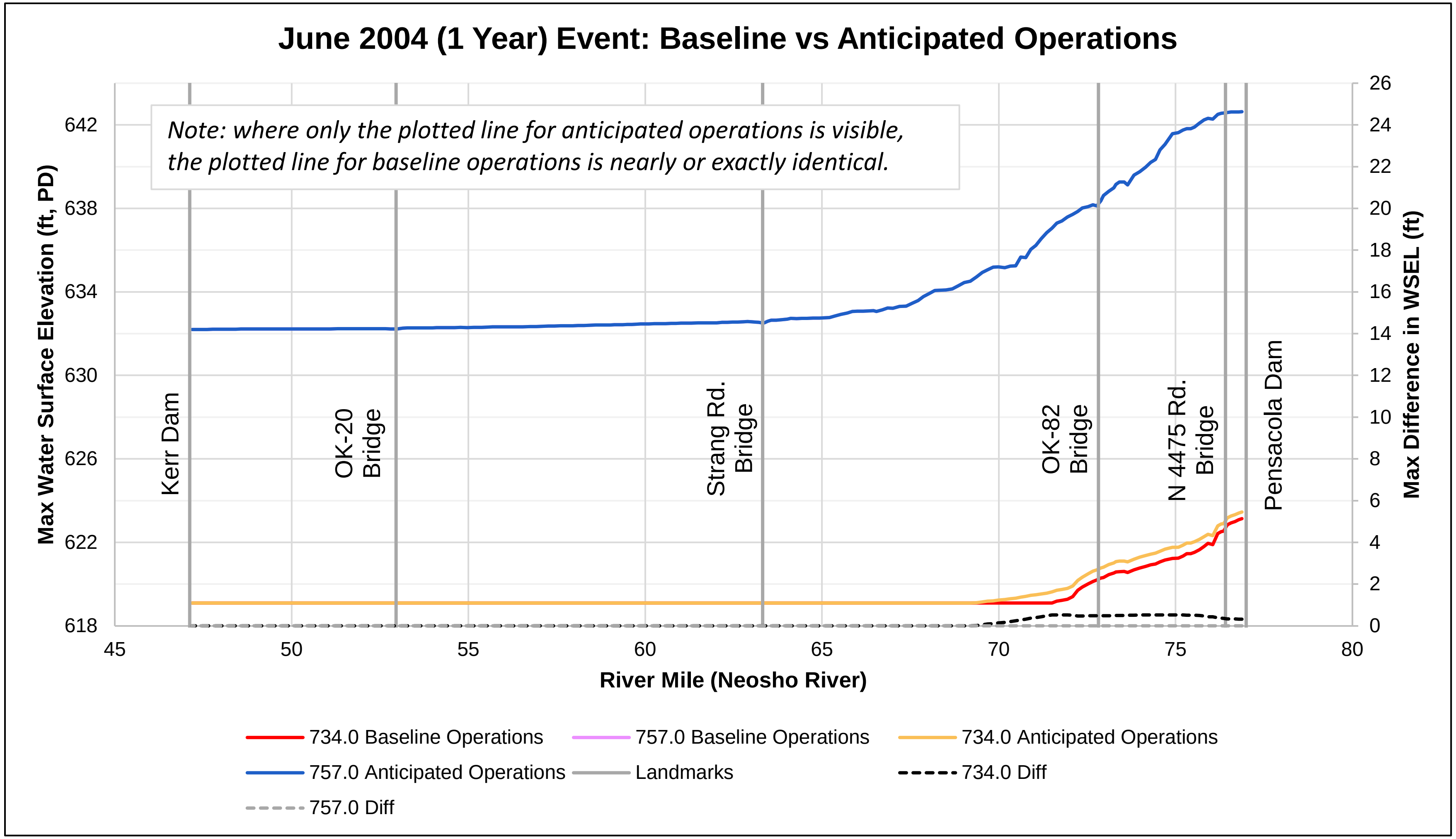
Anticipated Operations Analysis

Simulation	Maximum Increase in Peak WSEL Due to Anticipated Operations (ft)
June 2004 (1 year) event, starting pool elev. of 734.0 ft PD	0.53*
June 2004 (1 year) event, starting pool elev. of 757.0 ft PD	0.00
July 2007 (4 year) event, period of record starting pool elev.	0.00
100-year event, starting pool elev. of 734.0 ft PD	0.01
100-year event, starting pool elev. of 757.0 ft PD	0.00

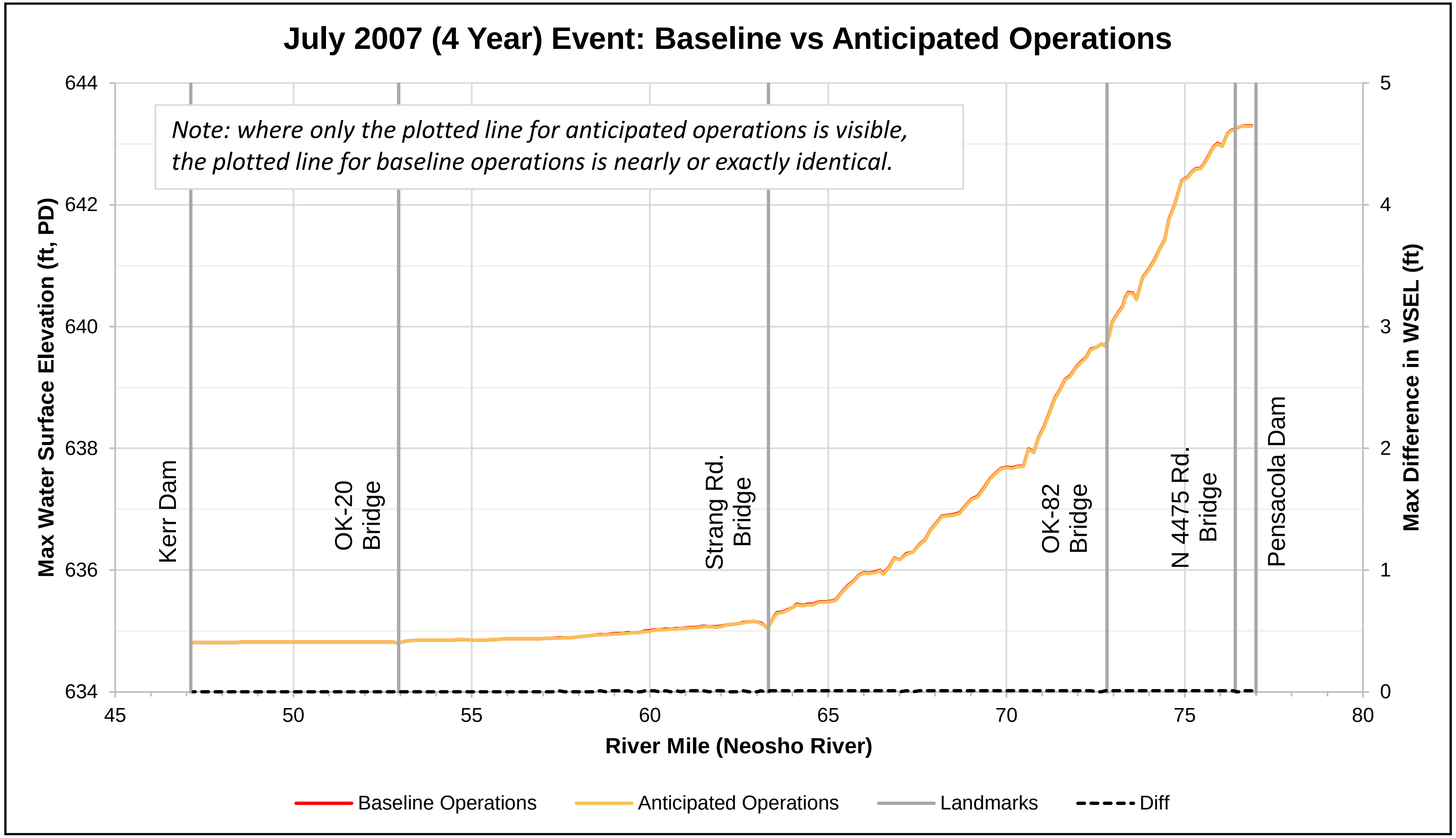
** Flows contained within riverbanks, no spillway releases from Pensacola Dam*

- Anticipated operations have an immaterial impact on downstream WSELs compared to baseline operations.
- No additional inundation maps were created because the differences can not be effectively displayed on a map.
  - The extent of inundation for anticipated operations is virtually identical to the extent of inundation for baseline operations.
- Maximum difference in duration of inundation is 1 hour when comparing baseline to anticipated operations.
  - Occurs only for the 100-year event at 734-foot PD starting stage.

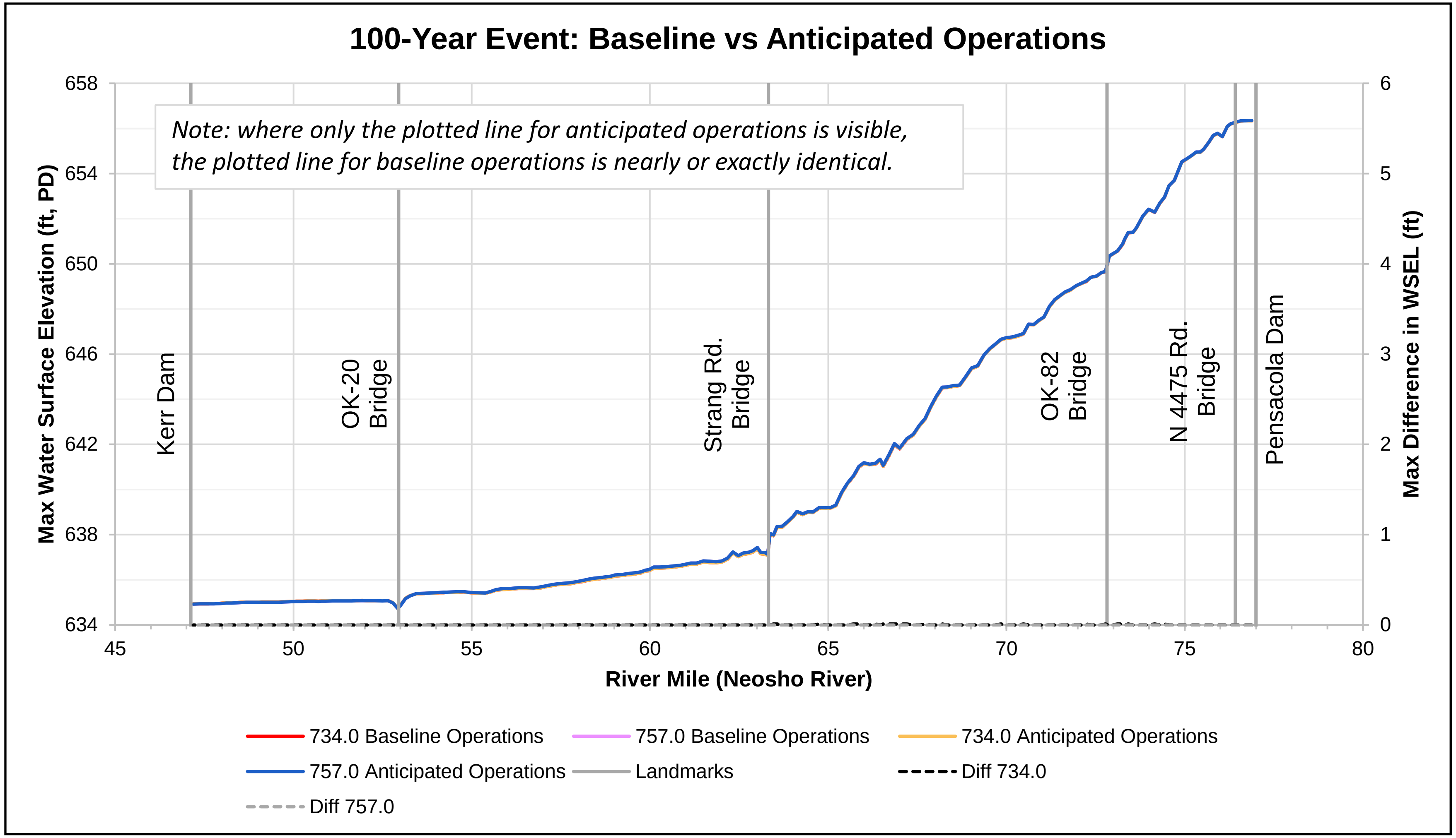
Anticipated Operations Analysis



Anticipated Operations Analysis



Anticipated Operations Analysis



Conclusions

Conclusions

- Initial stages at Pensacola Dam within GRDA's anticipated and extreme, hypothetical operational ranges have an influence on downstream WSELs and out-of-bank inundation

- Out-of-bank inundation is result of spillway releases directed by the Army Corps of Engineers
  - Section 7 of 1944 Flood Control Act: Army Corps of Engineers is responsible for flood control operations
  - Arkansas River Basin Water Control Master Manual: System balancing of flood storage
  - Section 7612 (c) of National Defense Authorization Act of Fiscal Year 2020: "The Secretary [of the Army] shall have exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees"

- **Anticipated operations have an immaterial impact compared to baseline operations**

Thank you

Mead & Hunt

Infrastructure Study

Pensacola Hydroelectric Project
Project No. 1494

October 12, 2022

Presentation Outline

1. Infrastructure Study Objectives
2. FERC Determination
3. Study Results
4. Discussion of Results
5. Conclusions

Infrastructure Study Objectives

Infrastructure Study Objectives

1. In consultation with the stakeholders, determine list of infrastructure types to be included in the study. Include infrastructure types that have the potential to be flooded under Army Corps of Engineers-directed flood control operations and GRDA's Project operations.

2. Determine range of inflow conditions for which model results show Project operations (hydropower or Army Corps of Engineers-directed flood control) are likely to have an effect on flooding. Provide maps and tables identifying frequency and depth of flooding for each item of infrastructure under baseline operations and for the range of inflow conditions where operations may have an effect on flooding.

3. If needed based on H&H study results, provide additional maps and tabular information for anticipated operations.

FERC Determination

FERC Determination (February 2022)

FERC recommended the following modifications:

1. On maps and in tabular format, for each affected infrastructure location, show the change in depth and frequency for the same starting elevations required in the H&H Study (*i.e.*, 734 feet PD through 757 feet PD).

2. Include maps and tabular data for the June 2004 (1-year) and October 2009 (3-year) inflow events. These maps and tabular data will be in addition to the September 1993 (21-year), July 2007 (4-year), and December 2015 (15-year) inflow events.

3. On the tables and maps, clearly show the frequency of flooding (*i.e.*, return period) for each modeled event.

GRDA Completion of Approved Study Plan

GRDA completed FERC's Approved Study Plan as follows:

1. The same starting elevations required in the H&H Study (*i.e.*, 734 feet PD through 757 feet PD) are presented on maps and in tables for each infrastructure location.
2. Maps and tables now present:
   A. September 1993 (21-year event)
   B. June 2004 (1-year event) ***(new to Infrastructure Study)***
   C. July 2007 (4-year event)
   D. October 2009 (3-year event) ***(new to Infrastructure Study)***
   E. December 2015 (15-year event).
3. On tables and maps (and throughout the report), return period for each modeled event is clearly displayed.

Study Results

Starting Reservoir Elevations

1. All starting elevations recommended by FERC (734 feet PD through 757 feet PD) analyzed. Results are tabulated and mapped.

2. Discussion focused on GRDA's anticipated operational range of 742 feet PD to 745 feet PD.

3. Starting reservoir elevation of 734 feet PD, ***a hypothetical operational condition considered extreme and well outside of GRDA's anticipated operational range***, also reviewed to determine whether a reduction in reservoir elevation would decrease loss of infrastructure use.

Starting Reservoir Elevations

4. Starting elevation of 757 feet PD also analyzed. Results can be summarized as follows:

   If GRDA operated at 757 feet PD, ***a reservoir elevation that is 12 feet higher than the top of GRDA's anticipated operational range and an elevation equal to the top of dam***, infrastructure locations would be inundated by depths similar to or greater than those depths for operational levels within GRDA's anticipated operational range.

   Practically speaking, increasing the top of the operational range to 757 feet PD is simply not possible.

Classification of Difference in Depth

Infrastructure locations with differences in depth greater than 0.1 feet were divided into three classes:

1. Class 1: greater than 0.1 feet up to 0.3 feet.
2. Class 2: greater than or equal to 0.3 feet up to 0.5 feet.
3. Class 3: greater than or equal to 0.5 feet.

Infrastructure locations meeting these criteria were placed in a class based on the greatest difference in depth for the inflow events.

15 out of 228 infrastructure locations (7% of locations) met the criteria.

Class 1 Differences (>0.1 ft, <0.3 ft)

Infra-structure ID	Map Panel	Location	Difference in Depth (ft)				
			Sep. 1993 (21 year)	June 2004 (1 year)	July 2007 (4 year)	Oct. 2009 (3 year)	Dec. 2015 (15 year)
57	B4, B4-3	Rockdale Blvd Bridge over Tar Creek	0.2	0.0	0.1	0.0	0.0
86	B4, B4-4	SH 10 Bridge over Little Elm Creek	0.0	0.0	0.2	0.0	0.0
88	B4, B4-3	SH 10 Bridge over Tar Creek	0.2	0.0	0.1	0.0	0.0
94	B4, B4-3	Lion Taylor Park	0.2	0.0	0.1	0.0	0.0
97	B4, B4-4	S 580 Rd Bridge over Little Elm Creek	0.2	0.0	0.2	0.2	0.1

Notes on Class 1 Differences

- Infrastructure ID 103, Riverview Park, was included as a Class 1 difference in the Initial Study Report (ISR). With FERC-required modifications to the Operations Model, the differences in depth are now less than or equal to 0.1 feet at that location.
- Infrastructure IDs 86 and 88 were not included as Class 1 differences in the ISR. With FERC-required modifications to the Operations Model, depth differences at Infrastructure IDs 86 and 88 now exceed 0.1 feet and are thus included in the USR.

Class 2 Differences (≥0.3 ft, <0.5 ft)

There were no infrastructure locations with Class 2 differences.

- Infrastructure ID 127, Hudson Creek Bridge, and ID 150, Wyandotte High School, were classified as Class 2 differences in the ISR.
- With FERC-required modifications to the Operations Model, these two infrastructure locations were reclassified as Class 3 differences in the USR.

Class 3 Differences (≥ 0.5 ft)

Infra-structure ID	Map Panel	Location	Difference in Depth (ft)				
			Sep. 1993 (21 year)	June 2004 (1 year)	July 2007 (4 year)	Oct. 2009 (3 year)	Dec. 2015 (15 year)
127	C4	Hudson Creek Bridge	0.1	0.0	0.5	0.4	0.0
139	C5	Twin Bridges State Park	0.1	0.0	1.1	0.5	0.0
140	C6	Shawnee Branch Bridge	0.1	0.0	1.1	0.0	0.0
150	C6	Wyandotte High School	0.1	0.0	0.8	0.0	0.0
166	E3	Fly Creek Bridge	0.0	0.0	0.6	0.0	0.0

Class 3 table continues on the next slide.

Class 3 Differences (≥ 0.5 ft)

Infra-structure ID	Map Panel	Location	Difference in Depth (ft)				
			Sep. 1993 (21 year)	June 2004 (1 year)	July 2007 (4 year)	Oct. 2009 (3 year)	Dec. 2015 (15 year)
167	E3	Bernice State Park	0.0	0.0	0.6	0.0	0.0
175	F3	Cherokee Seaplane Base	0.0	0.0	0.6	0.0	0.0
181	F5	Wolf Creek Park	0.0	0.0	0.5	0.8	0.1
185	F5	Grove Springs Park	0.0	0.0	0.5	0.8	0.1
206	G3	Bacon’s Heliport	0.0	0.4	0.6	0.8	0.0

End of Class 3 table.

Questions?

Discussion of Results

Results Discussed

1. Only selected results are presented because the results are so similar at nearly all the locations with Class 1, Class 2, or Class 3 differences.
2. Report contains full descriptions of each location with Class 1, Class 2, or Class 3 differences.
3. In report, the inflow event that causes the largest difference in depth is discussed first, followed by discussion of difference in depth for the other inflow events.
4. **For all locations, any increased depth resulting from a different starting reservoir elevation within GRDA's operational range did not result in any additional loss of infrastructure use.**
5. **Under a hypothetical, extreme operational level of 734 feet PD, only two parks would experience a minor decrease in the loss of infrastructure use.**

Class 1 Example

Rockdale Boulevard Bridge Over Tar Creek (ID 57)

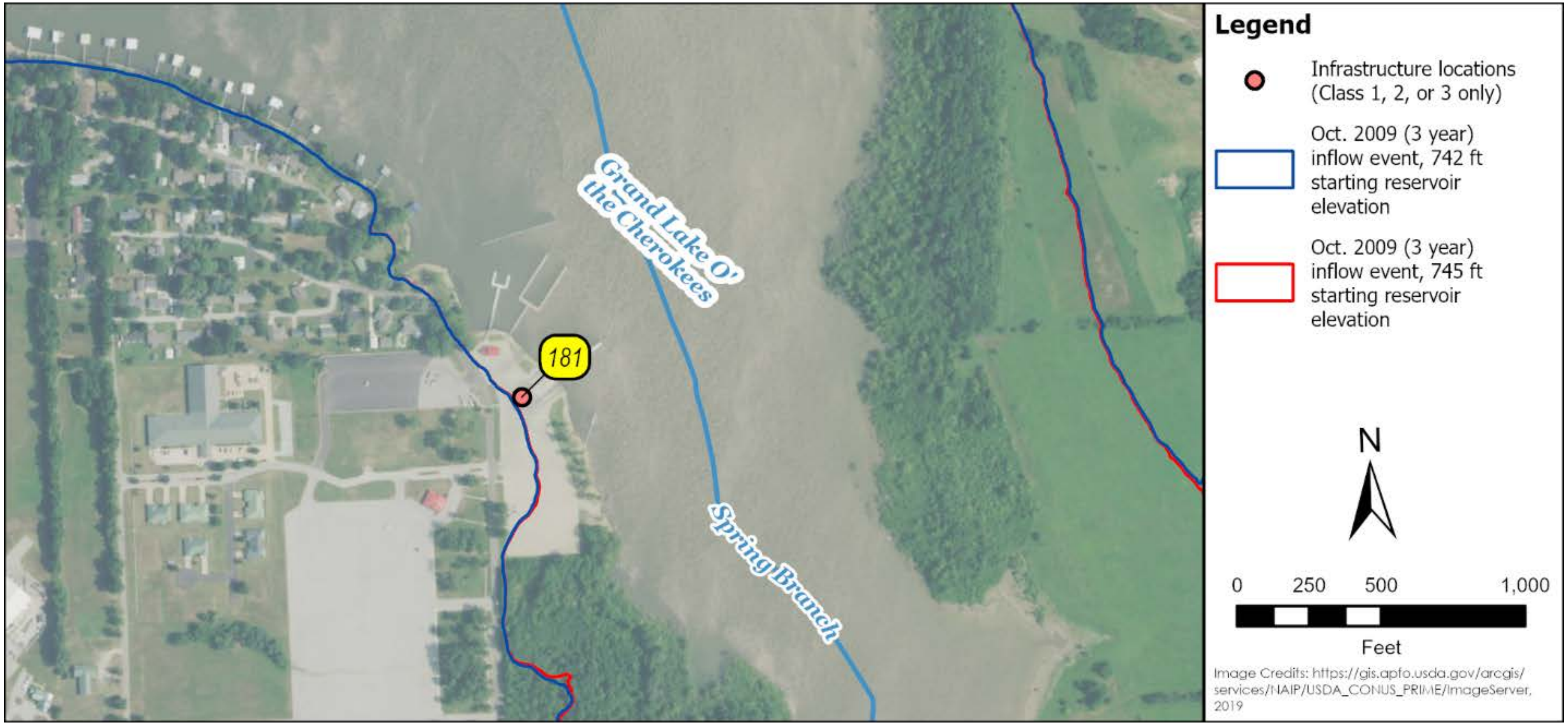
Class 1 Example

Rockdale Boulevard Bridge Over Tar Creek (ID 57)

- September 1993 (21 year) event:
  - Inundated by 1.3 to 1.5 feet of water for starting reservoir elevations within GRDA's anticipated operational range.
  - Infrastructure location is inundated regardless of starting reservoir elevation within GRDA's anticipated operational range.
- July 2007 (4 year) event:
  - Inundated by 6.8 to 6.9 feet of water for starting reservoir elevations within GRDA's anticipated operational range.
  - Infrastructure location is inundated regardless of starting reservoir elevation within GRDA's anticipated operational range.
- June 2004 (1 year) event, October 2009 (3 year) event, and December 2015 (15 year) event:
  - Not inundated, regardless of starting reservoir elevation within GRDA's anticipated operational range.
- **For all events, starting reservoir elevations within the anticipated operational range do not result in additional loss of infrastructure use at this location.**
- If GRDA operated at 734 feet PD, this infrastructure location would still be inundated by the same inflow events and would be inundated by depths similar to those depths for operational levels within GRDA's anticipated operational range.

Class 3 Example: Wolf Creek Park

Wolf Creek Park (ID 181)



Wolf Creek Park

Wolf Creek Park (ID 181)

- October 2009 (3 year) inflow event:
  - Inundated by 0.8 to 1.6 feet of water for starting reservoir elevations within GRDA's anticipated operational range.
  - Only low-lying areas are unusable regardless of starting reservoir elevation within GRDA's anticipated operational range.
  - Structures subject to flooding are outside the inundation for all studied events.
  - Site was designed (and funded) by GRDA to not be impacted by inflow events.
- September 1993 (21 year) event:
  - Inundated by 5.5 feet of water for all starting reservoir elevations within GRDA's anticipated operational range.
  - Infrastructure location is inundated regardless of starting reservoir elevation within GRDA's anticipated operational range.
- July 2007 (4 year) event:
  - Inundated by 5.0 to 5.5 feet of water for starting reservoir elevations within GRDA's anticipated operational range.
  - Infrastructure location is inundated regardless of starting reservoir elevation within GRDA's anticipated operational range.

Wolf Creek Park (Continued)

Wolf Creek Park (ID 181)

- December 2015 (15 year) event:
  - Inundated by 5.5 to 5.6 feet of water for starting reservoir elevations within GRDA’s anticipated operational range.
  - Infrastructure location is inundated regardless of starting reservoir elevation within GRDA’s anticipated operational range.
- June 2004 (1 year) event:
  - Not inundated, regardless of starting reservoir elevation within GRDA’s anticipated operational range.

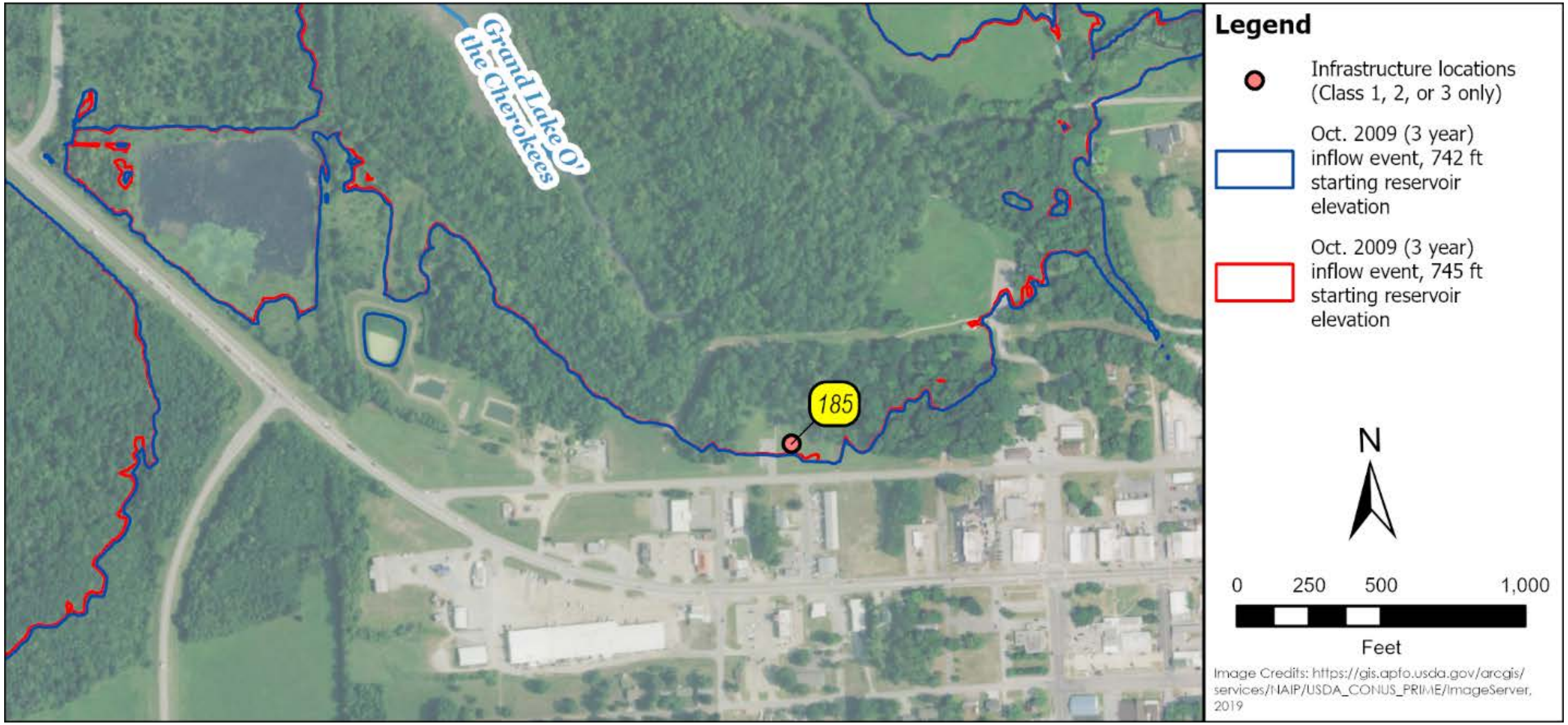
Wolf Creek Park (Continued)

Wolf Creek Park (ID 181)

- **For all events, starting reservoir elevations within the anticipated operational range do not result in additional loss of infrastructure use at this location.**
- If GRDA operated at 734 feet PD, this infrastructure location would still be inundated by the same inflow events and would be inundated by depths similar to those depths for operational levels within GRDA's anticipated operational range, except for the October 2009 (3 year) inflow event, for which no inundation would occur.
- Because the site was designed (and funded) by GRDA to not be impacted by inflow events, only the low-lying areas near Grand Lake are inundated. Reducing the operational range to 734 feet PD would still result in the same impact to infrastructure use at this location.

Class 3 Example: Grove Springs Park

Grove Springs Park (ID 185)



Grove Springs Park

Grove Springs Park (ID 185)

- October 2009 (3 year) inflow event:
  - Inundated by 0.8 to 1.6 feet of water for starting reservoir elevations within GRDA's anticipated operational range.
  - Most of park will be unusable regardless of starting reservoir elevation within GRDA's anticipated operational range.
  - Park does not contain structures that can be damaged if exposed to periodic flooding.
- September 1993 (21 year) event:
  - Inundated by 5.5 feet of water for all starting reservoir elevations within GRDA's anticipated operational range.
  - Infrastructure location is inundated regardless of starting reservoir elevation within GRDA's anticipated operational range.
- July 2007 (4 year) event:
  - Inundated by 5.0 to 5.5 feet of water for starting reservoir elevations within GRDA's anticipated operational range.
  - Infrastructure location is inundated regardless of starting reservoir elevation within GRDA's anticipated operational range.

Grove Springs Park (Continued)

Grove Springs Park (ID 185)

- December 2015 (15 year) event:
  - Inundated by 5.5 to 5.6 feet of water for starting reservoir elevations within GRDA's anticipated operational range.
  - Infrastructure location is inundated regardless of starting reservoir elevation within GRDA's anticipated operational range.
- June 2004 (1 year) event:
  - Not inundated, regardless of starting reservoir elevation within GRDA's anticipated operational range.
- **For all events, starting reservoir elevations within the anticipated operational range do not result in additional loss of infrastructure use at this location.**
- If GRDA operated at 734 feet PD, this infrastructure location would still be inundated by the same inflow events and would be inundated by depths similar to those depths for operational levels within GRDA's anticipated operational range, except for the October 2009 (3 year) inflow event, for which no inundation would occur.

Conclusions

Conclusions

1. Only 7% of infrastructure locations experience an appreciable increase in maximum inundation depth for different starting reservoir elevations within GRDA's anticipated operational range of 742 feet PD to 745 feet PD.

2. All appreciable increases in maximum inundation depth occur during high-flow conditions when the Army Corps of Engineers controls the flood control operations under federal law, except when the time of maximum inundation depth is solely a function of inflow event arrival time and not reservoir elevation, meaning that the time of maximum depth at the infrastructure location was completely independent of the Project reservoir elevation. ***Therefore, infrastructure locations are not adversely affected by GRDA's anticipated operations.***

Conclusions

4. Except for two parks, a reduction in reservoir operational elevation to 734 feet PD would not decrease the loss of infrastructure use for any of the inflow events studied.

   A. Wolf Creek Park was designed (and partially funded) by GRDA to avoid being impacted by inflow events. Only a low-lying portion of the park near Grand Lake would experience a difference in inundation for the October 2009 (3 year) inflow event. Therefore, any potential adverse impacts have already been mitigated by GRDA during their assistance in the design and funding of the improvements to the park.

   B. At Grove Springs Park, low-lying portions of the park would experience a difference in inundation for the October 2009 (3 year) inflow event. Decreasing the low end of the anticipated operation range from 742 to 734 feet PD, a difference of 8 feet in operational elevation, would only change infrastructure adverse impacts slightly at Grove Springs Park.

Conclusions

5. If GRDA operated at 757 feet PD, ***a reservoir elevation that is 12 feet higher than the top of GRDA's anticipated operational range and an elevation equal to the top of dam***, infrastructure locations would be inundated by depths similar to or greater than those depths for operational levels within GRDA's anticipated operational range. Practically speaking, increasing the top of the operational range to 757 feet PD is simply not possible.

6. ***In summary, infrastructure locations are not adversely affected by GRDA's baseline or anticipated operations of the Project***, which consist of reservoir levels within an operational range of 742 feet PD to 745 feet PD. Even under the hypothetical and extreme operational level of 734 feet PD, only two parks would experience a minor decrease in the loss of infrastructure use.

Questions?

Thank you

Attachment C

October 13, 2022 (Day 2): Study Report Presentations

Grand River Dam Authority
Updated Study Report Meeting
Pensacola Project (P-1494)

October 12-13, 2022

GRDA

Housekeeping Items

- Meeting is being recorded
- Mute your lines
- We will pause for questions and answers at appropriate times throughout each presentation
- During the Q&A segments, utilize the “raise your hand” feature to indicate you have a question
- If audio issues exist, please use the “chat” feature
- Participant discussion and dialogue are encouraged during the Q&A segments
- Lunch will be from 12:30-1:30 PM
- If an individual study presentation finishes early, we will proceed with the next agenda item

Purpose of Meeting

- Describe GRDA's progress in implementing its relicensing study plan per:
  - FERC's February 24, 2022 Determination on Request for Study Plan Modifications and New Studies
  - FERC's May 27, 2022 Determine on Requests for Study Modifications (for Sedimentation Study)
- Results for each study during the final study season will be presented
- GRDA will file a meeting summary with FERC by October 30, 2022
- The meeting summary will include only the meeting agenda and presentations
- All stakeholder comments must be submitted in writing
- The deadline for filing all written comments or questions is November 29, 2022

Remaining Relicensing Study Schedule

Activity	Responsible Party	Commission Deadline
Filed Updated Study Report (USR)	GRDA	September 30, 2022
Hold USR Meeting	GRDA	No later than October 15, 2022
File USR Meeting Summary	GRDA	October 30, 2022
File Meeting Summary Disagreements	Stakeholders	November 29, 2022
File Responses to Disagreements	GRDA	December 29, 2022
File Draft License Application (DLA)	GRDA	January 1, 2023
Commission Resolution of Disagreements (if necessary)	FERC	January 28, 2023
Comments on GRDA Draft License Application (DLA)	FERC/Stakeholders	April 1, 2023
File Final License Application (FLA)	GRDA	May 31, 2023

Questions?

Sedimentation Study

Pensacola Hydroelectric Project
Project No. 1494

October 13, 2022

Anchor QEA
Simons & Associates

Presentation Outline

1. Sedimentation Study Objectives
2. FERC Determination
3. Sedimentation Study Tasks
   I. Subsurface Investigations
   II. Analysis of Historical Bathymetry
   III. Qualitative Analysis
   IV. Quantitative Analysis
   V. Sediment Transport Model Objectives
   VI. Calibration and Validation
   VII. Future Simulations
      a) Sediment Loading Analysis
      b) Operations Analysis
4. Conclusions

Sedimentation Study Objectives

Sedimentation Study Objectives

1. Determine potential effect of Project operations on sediment transport, erosion, and deposition in the lower reaches of tributaries to Grand Lake upstream of Pensacola Dam

2. Provide an understanding of sediment transport processes and patterns upstream of Grand Lake on the Neosho, Spring, and Elk rivers, as well as on Tar Creek

FERC Determination

FERC Determination (May 2022)

FERC recommended the following modifications:

1. Develop Sediment Transport Model (STM) down to river mile (RM) 100
2. Evaluate impacts to upstream water levels after 50-year STM predictions using 1D Upstream Hydraulic Model (1D UHM) during the July 2007 and synthetic 100-year flow events for starting WSEs of 740-, 745-, and 750-feet Pensacola Datum (PD)

Also acknowledged planned fieldwork and STM improvements proposed by GRDA in the Updated Study Plan (USP; submitted April 2022)

GRDA Completion of Modifications

GRDA completed FERC's requested modifications as follows

1. GRDA developed the STM down to RM 100
2. Future predicted geometries were evaluated using the 1D UHM for the specified events and starting reservoir WSEs

Sedimentation Study Tasks

Sedimentation Study Tasks

Completed for First Study Season:

- ✓Fieldwork
  - ✓Water Level Monitoring
  - ✓Sediment Grab & Core Sampling
  - ✓Sediment Transport Measurements
- ✓STM *Hydraulic* Calibration

Completed/Revised for Final Study Season:

- ✓Subsurface Investigation of Delta Feature
- ✓Analysis of Historical Bathymetry
- ✓Qualitative Analysis
- ✓Quantitative Analysis
- ✓STM Refinement & *Sediment* Calibration
- ✓50-Year Future Simulations
  - ✓Sensitivity Analysis
- ✓Analysis of Future Sedimentation Impacts
- ✓Conclusions

Subsurface Investigations

Subsurface Investigations

Sub-Bottom Profiling

- Sub-bottom profiler (SBP)
  - Similar to bathymetric surveying sonar systems
  - Higher power allows pulses to penetrate soft bed materials
  - Provides information on sediment layer thicknesses

Subsurface Investigations

Sub-Bottom Profiling

- Sub-bottom profiler (SBP)
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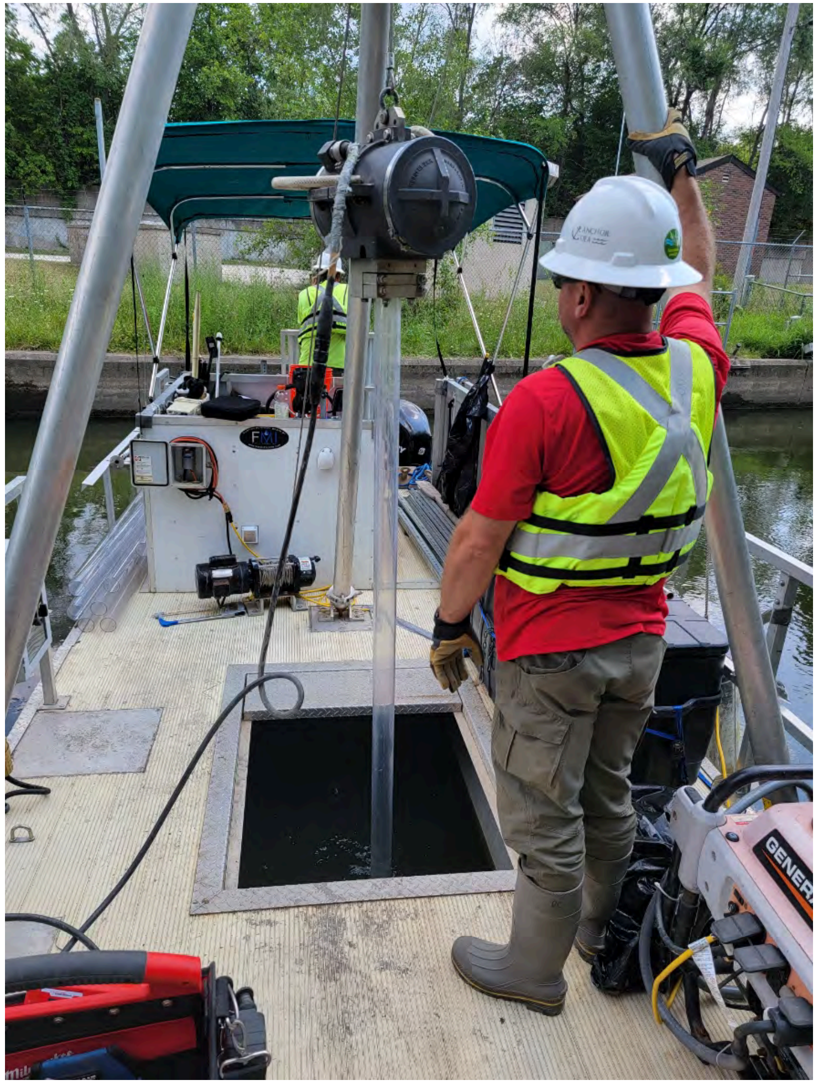
  - Provides information on sediment layer thicknesses

Vibracore Sampling

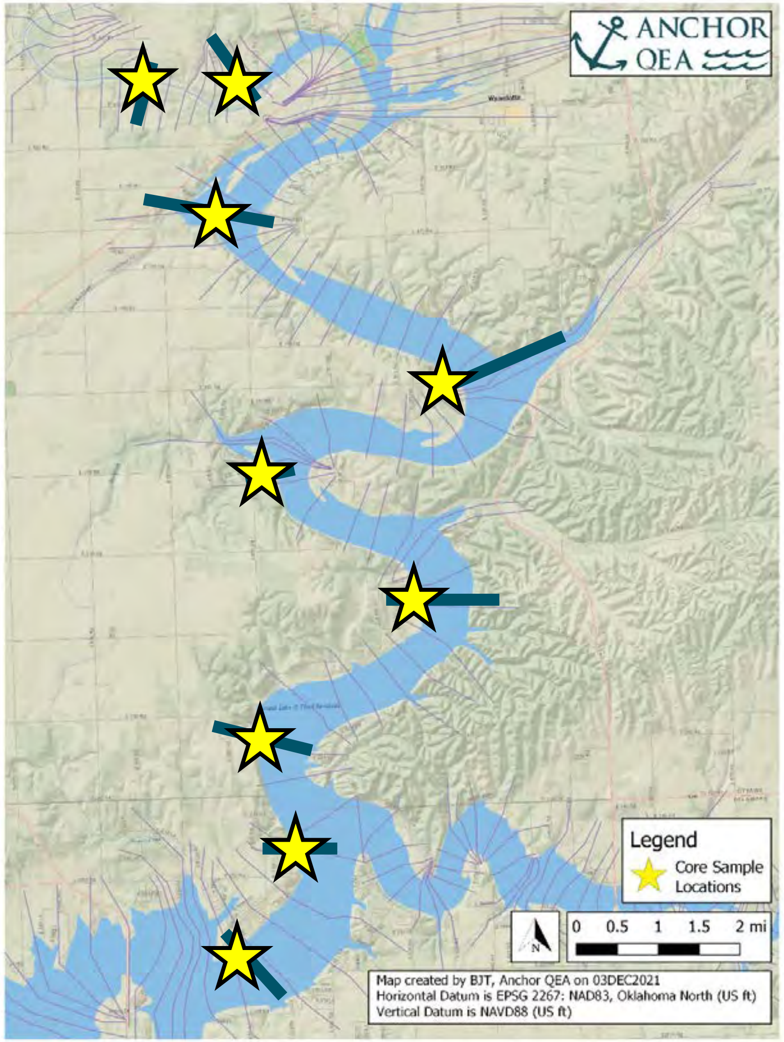
- Sample tubes vibrated into sediment bed
- Provides
  - Layer thickness measurements
  - Grain size distribution



Subsurface Investigations

Target areas of reported deposition

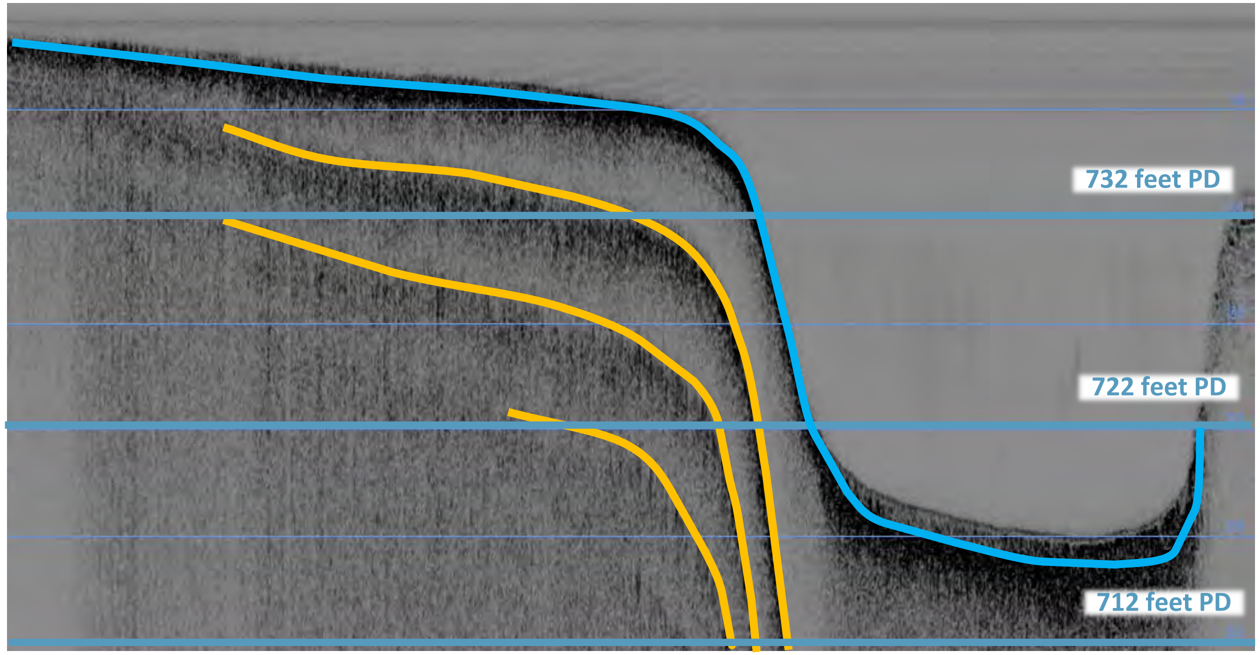
- SBP data verified by vibracoring
- Field crew collected 9 SBP transects along Neosho River
  - RM 103.72 (Hickory Point)
  - RM 125.56 (~1 mi downstream of Connors Bridge)



SBP Survey

Cross section at **RM 112.34**

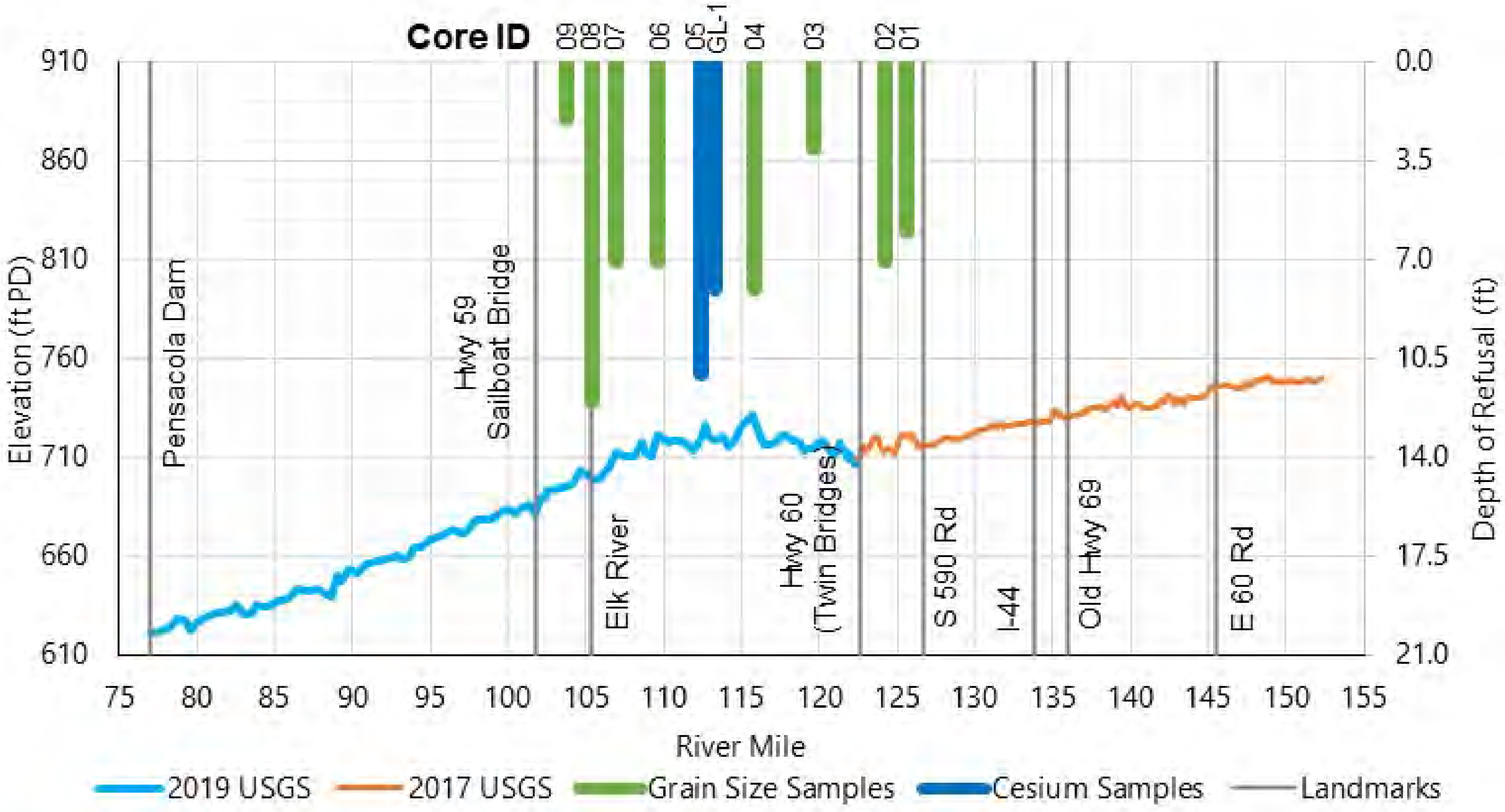
- SBP shows small layer of soft material deposition (~2-3 ft)
  - **Layer transition**
  - **Multiples**



Vibracore Sampling

Collected 24 cores

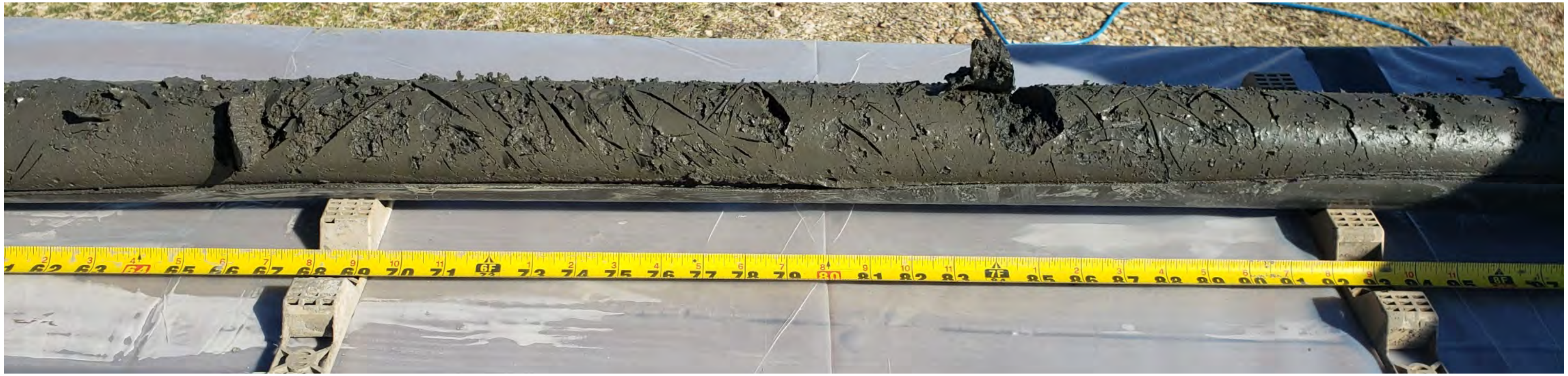
- Range from 1.5 to 11 feet in delta feature



Vibracore Sampling

Collected 24 cores

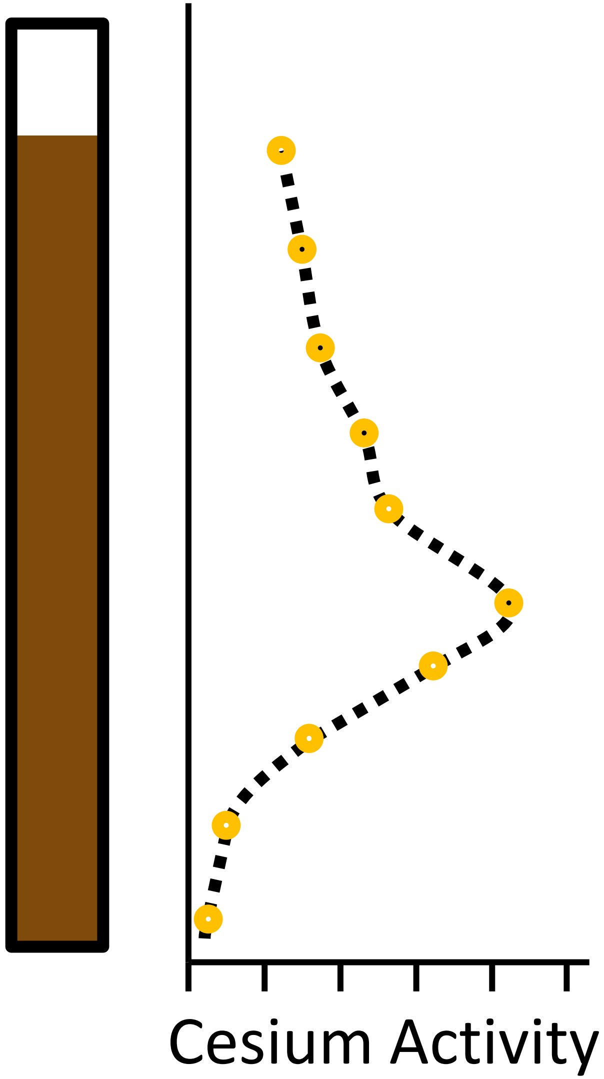
- Range from 1.5 to 11 feet in delta feature
- Grain size analysis indicated 89% silt and clay
- Firmer material lower in cores
- Limited air bubbles/biota near surface



Cesium 137 Dating

2 cores taken for cesium 137 (Cs-137) dating

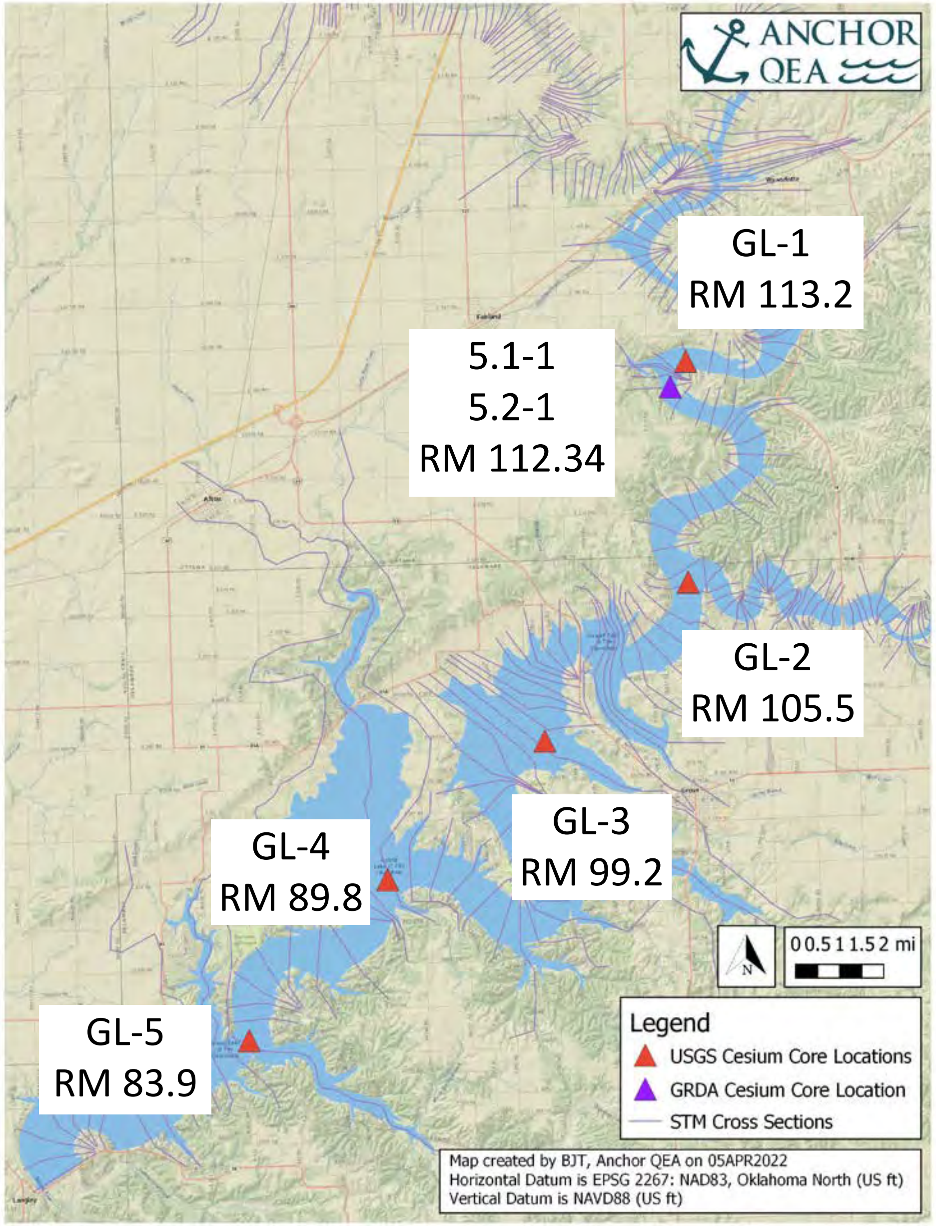
- Cs-137 is not naturally-occurring isotope
- Product of nuclear fission
  - First appeared in ~1945
  - Atmospheric nuclear testing increased until ~1963/64
- Dating uses relative concentration of Cs-137
  - Sediment deposited before 1945 has no detectable Cs-137
  - Peak concentration at 1963/64 layer
  - Tests determine depth to 1963/64, can estimate rate of deposition
- Must be area of continual deposition



Cesium 137 Dating

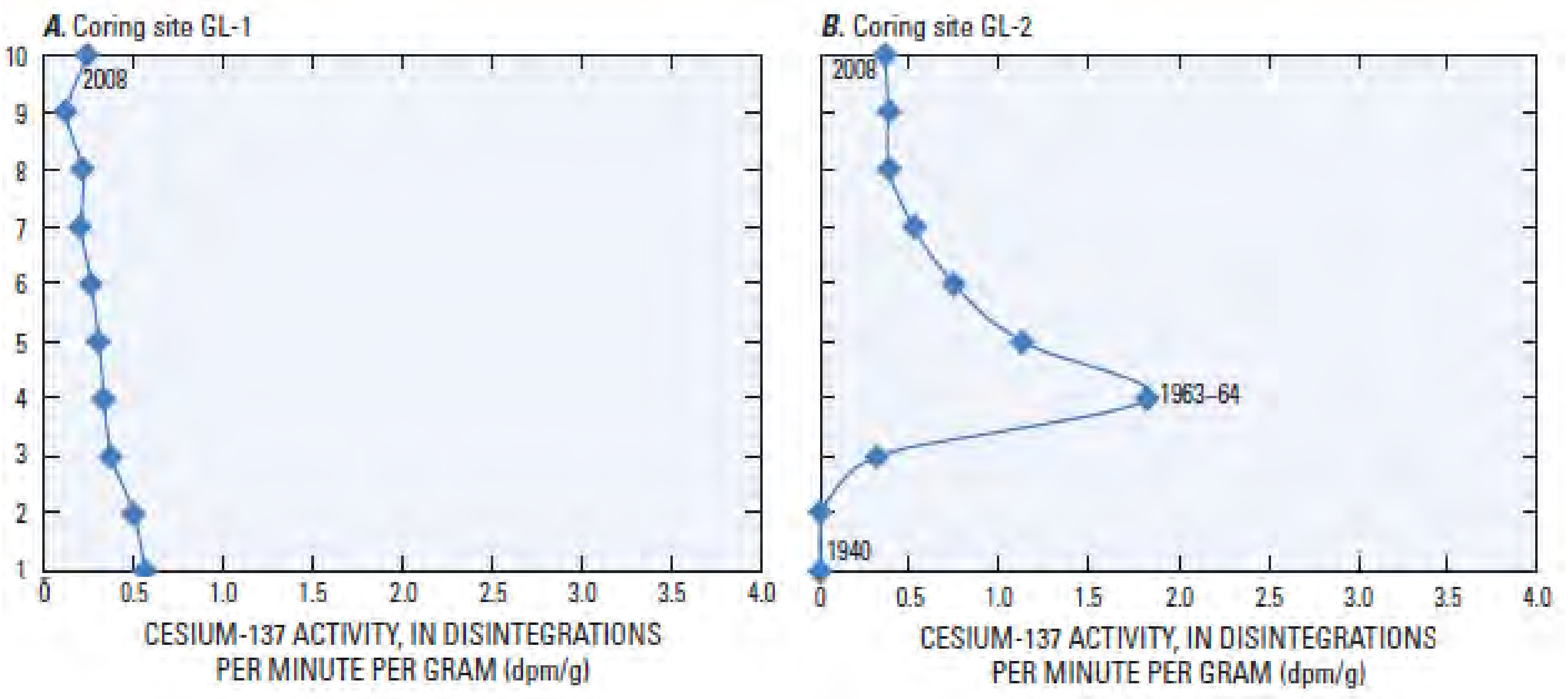
USGS (Juracek and Becker 2009) collected 5 cores in Grand Lake

- 2 in delta feature
  - GL-1: 5.4 ft
  - GL-2: 7.5 ft



Cesium 137 Dating

- Peak found in GL-2, but not in GL-1 (Juracek and Becker 2009)



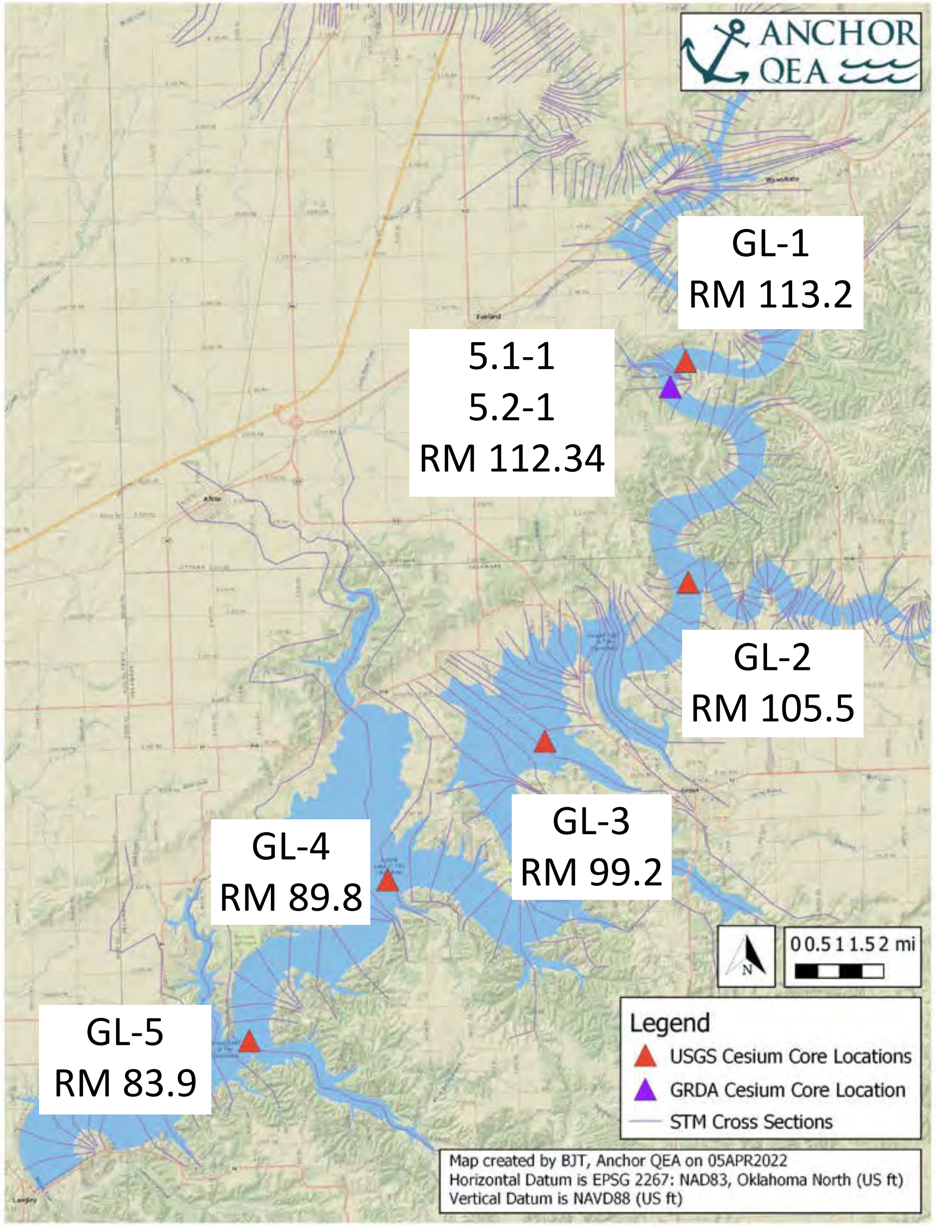
Cesium 137 Dating

- Peak found in GL-2, but not in GL-1 (Juracek and Becker 2009)
  - "Substantial postdepositional disturbance, including possible removal, of the bottom sediment was indicated for [GL-1] and any trends in constituent deposition may not be meaningful."
  - Representative of only post 1963/64 deposition
  - Shallow, may be disturbed by lake level fluctuations, wind-induced turbulence
- Indicated a non-continuously depositional environment
  - May also have been result of insufficient coring depth

Cesium 137 Dating

GRDA repeated sampling efforts near GL-1 (RM 113.2) with vibracore

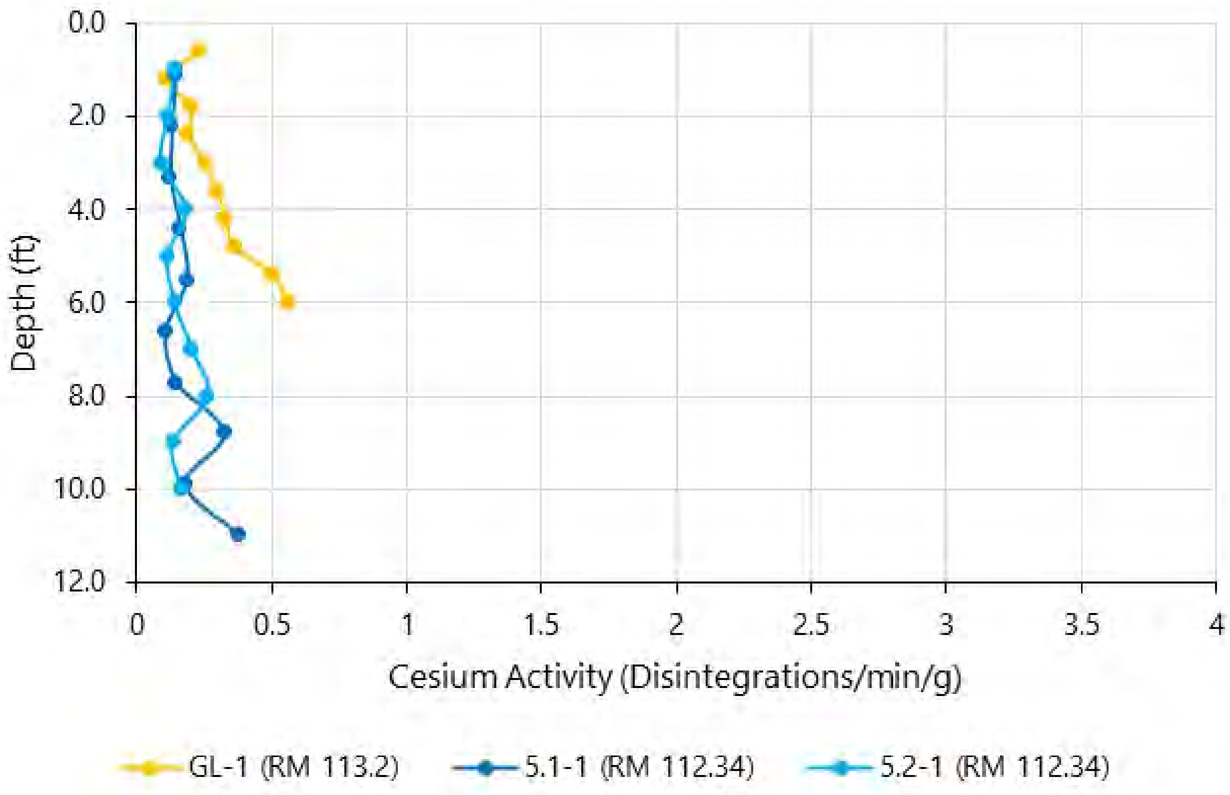
- Cores 5.1-1 and 5.2-1 (RM 112.34) approximately 10 feet



Cesium 137 Dating

GRDA repeated sampling efforts near GL-1 (RM 113.2) with vibracore

- Cores 5.1-1 and 5.2-1 (RM 112.34) approximately 10 feet
- Cs-137 activity shows no peak
- Confirms area is regularly disturbed (non-continuously depositional)
  - Consistent with typical delta feature evolution patterns (Vanoni 2006)

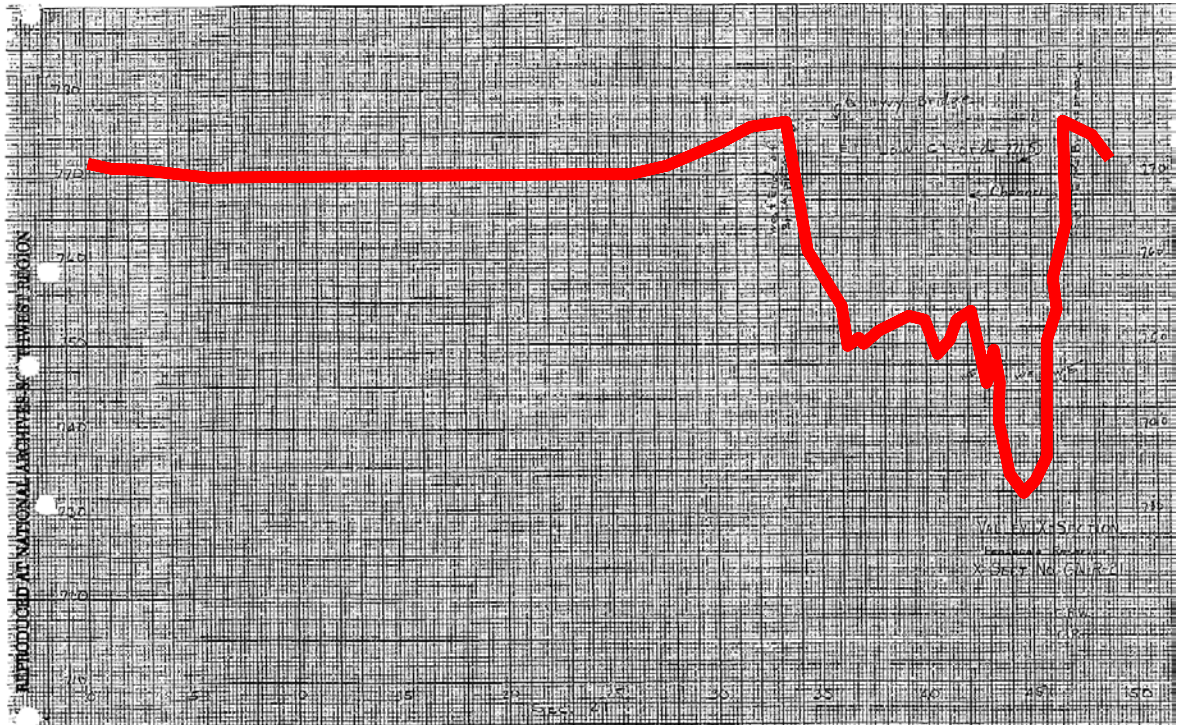


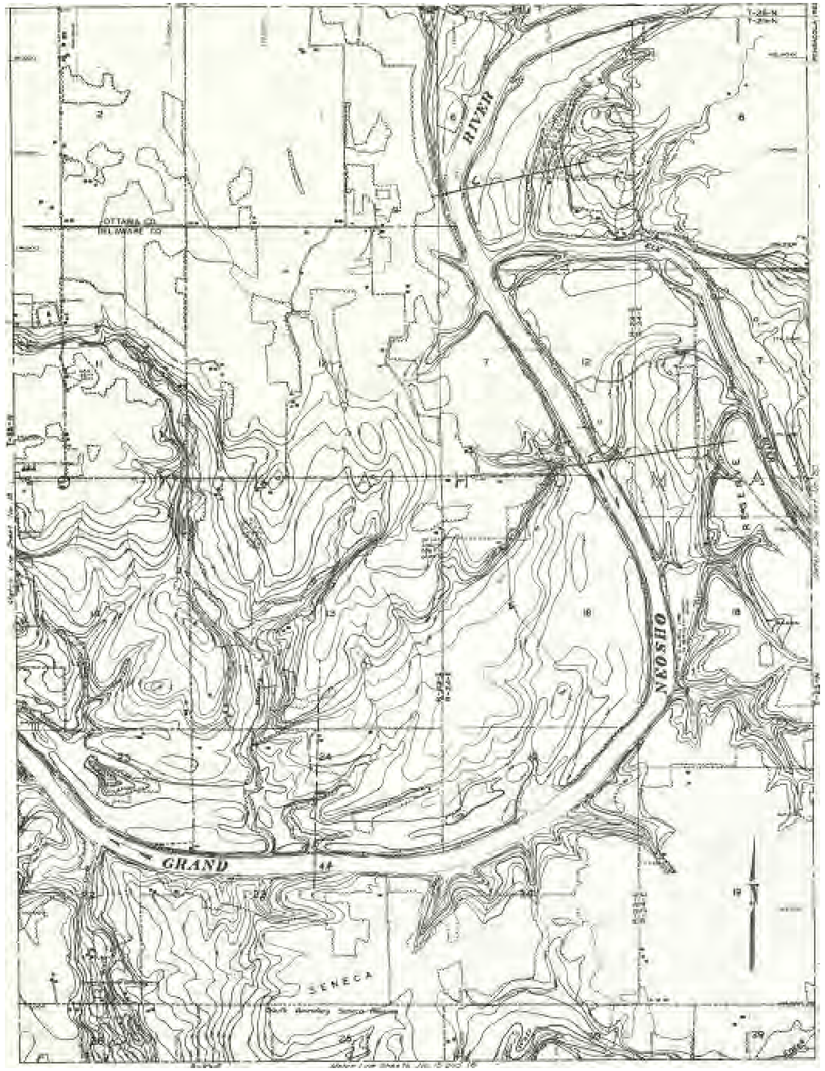
Analysis of Historical Bathymetry

Analysis of Historical Bathymetry

Based on several datasets

- Circa-1940 topographic maps & cross section surveys

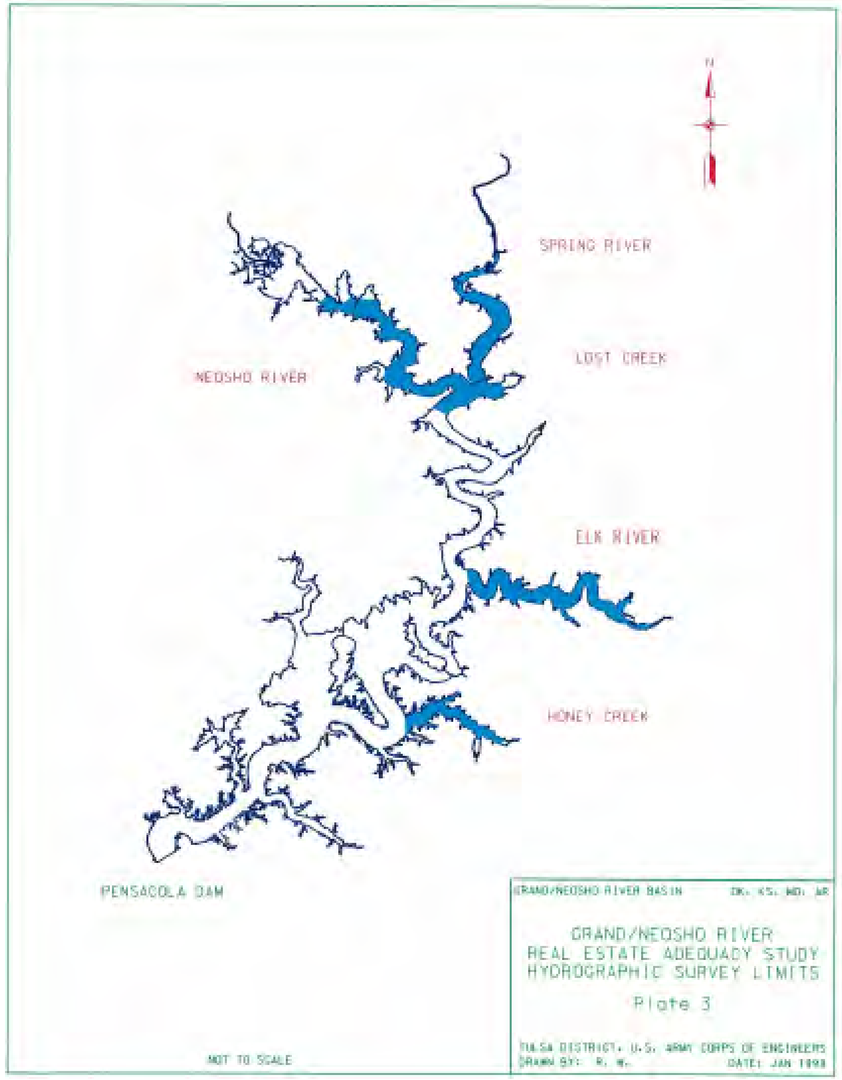




Analysis of Historical Bathymetry

Based on several datasets

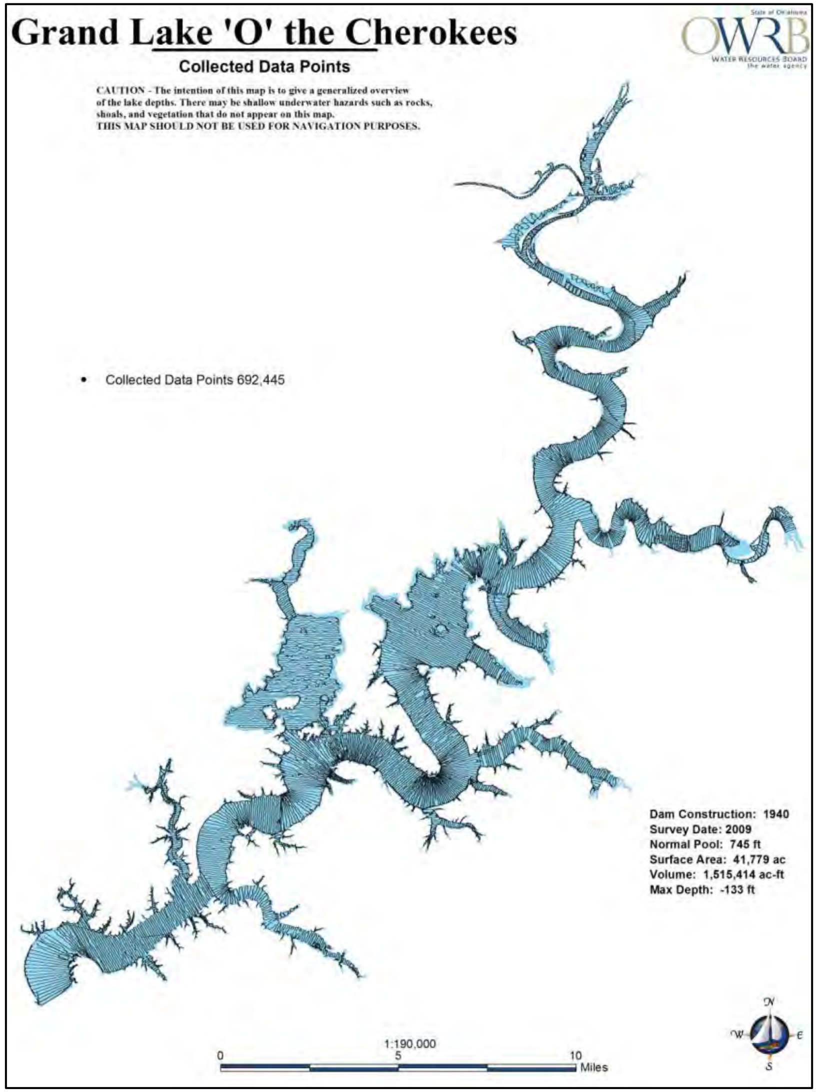
- Circa-1940 topographic maps & cross section surveys
- 1998 REAS surveys



Analysis of Historical Bathymetry

Based on several datasets

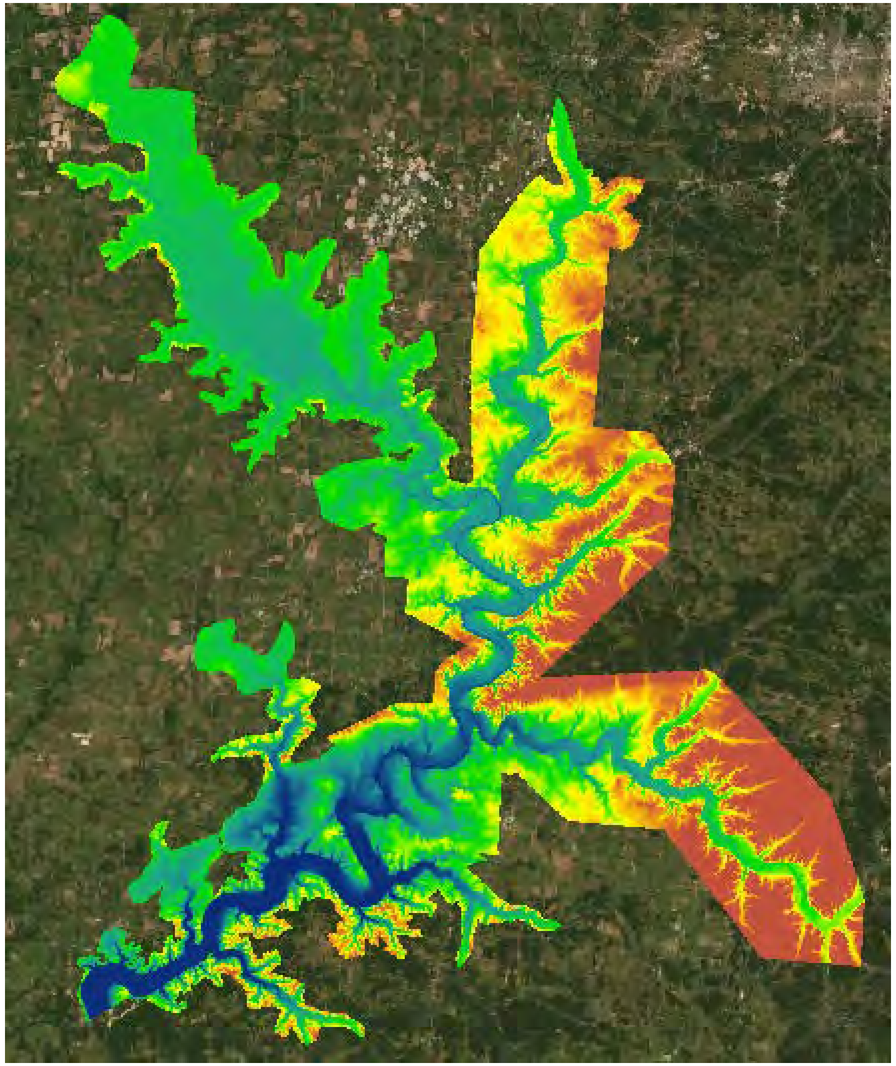
- Circa-1940 topographic maps & cross section surveys
- 1998 REAS surveys
- 2009 OWRB Grand Lake survey



Analysis of Historical Bathymetry

Based on several datasets

- Circa-1940 topographic maps & cross section surveys
- 1998 REAS surveys
- 2009 OWRB Grand Lake survey
- 2017 USGS tributary survey
- 2019 USGS Grand Lake survey



Circa-1940 Terrain Development

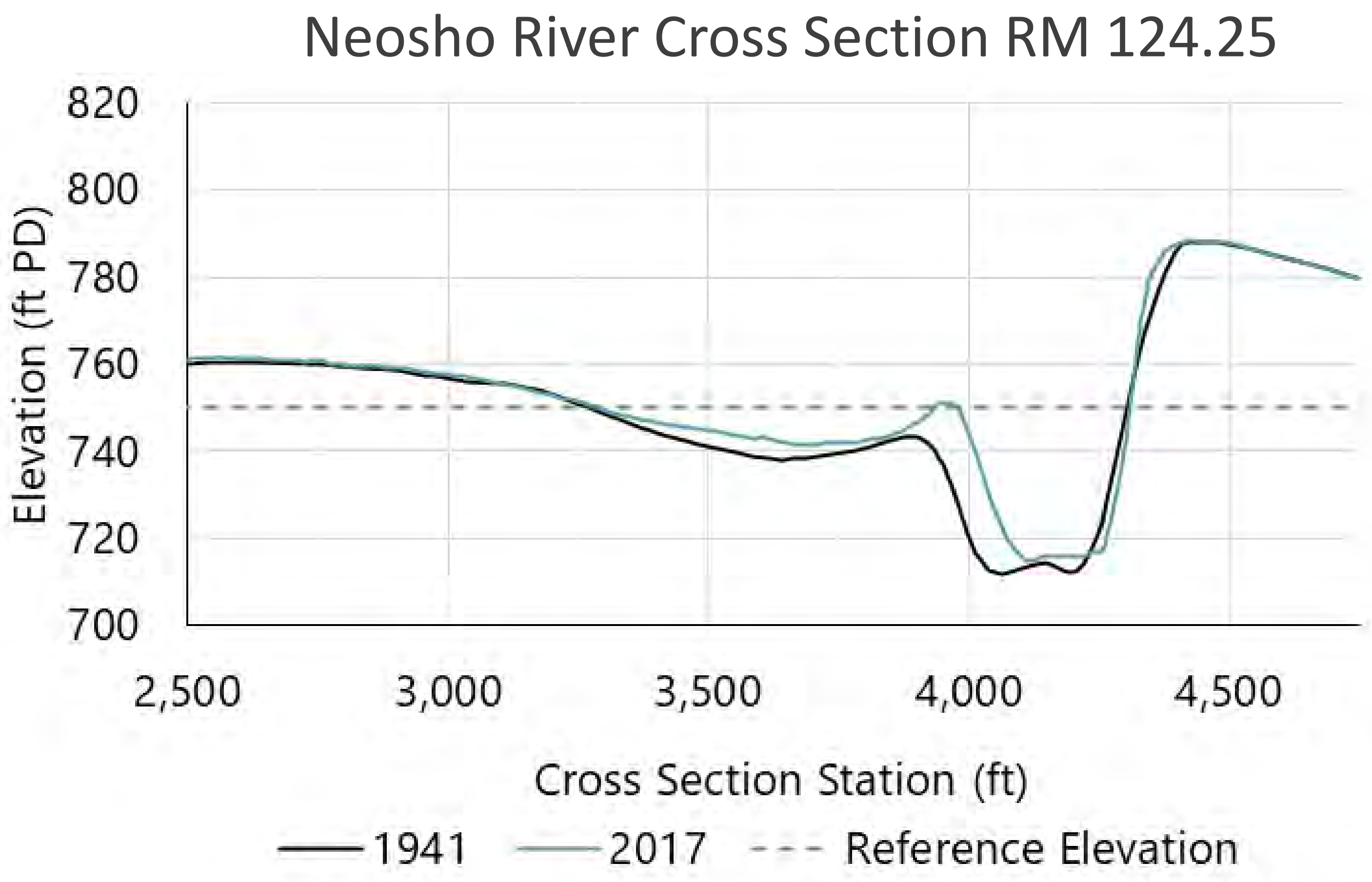
Digitization of available data

- Trace contour lines from topographic map
- Create raster surface
- Locate cross section information
  - Reported river mile
  - Raster elevations
- Burn cross section information into raster

Analysis of Historical Bathymetry

Upstream Areas

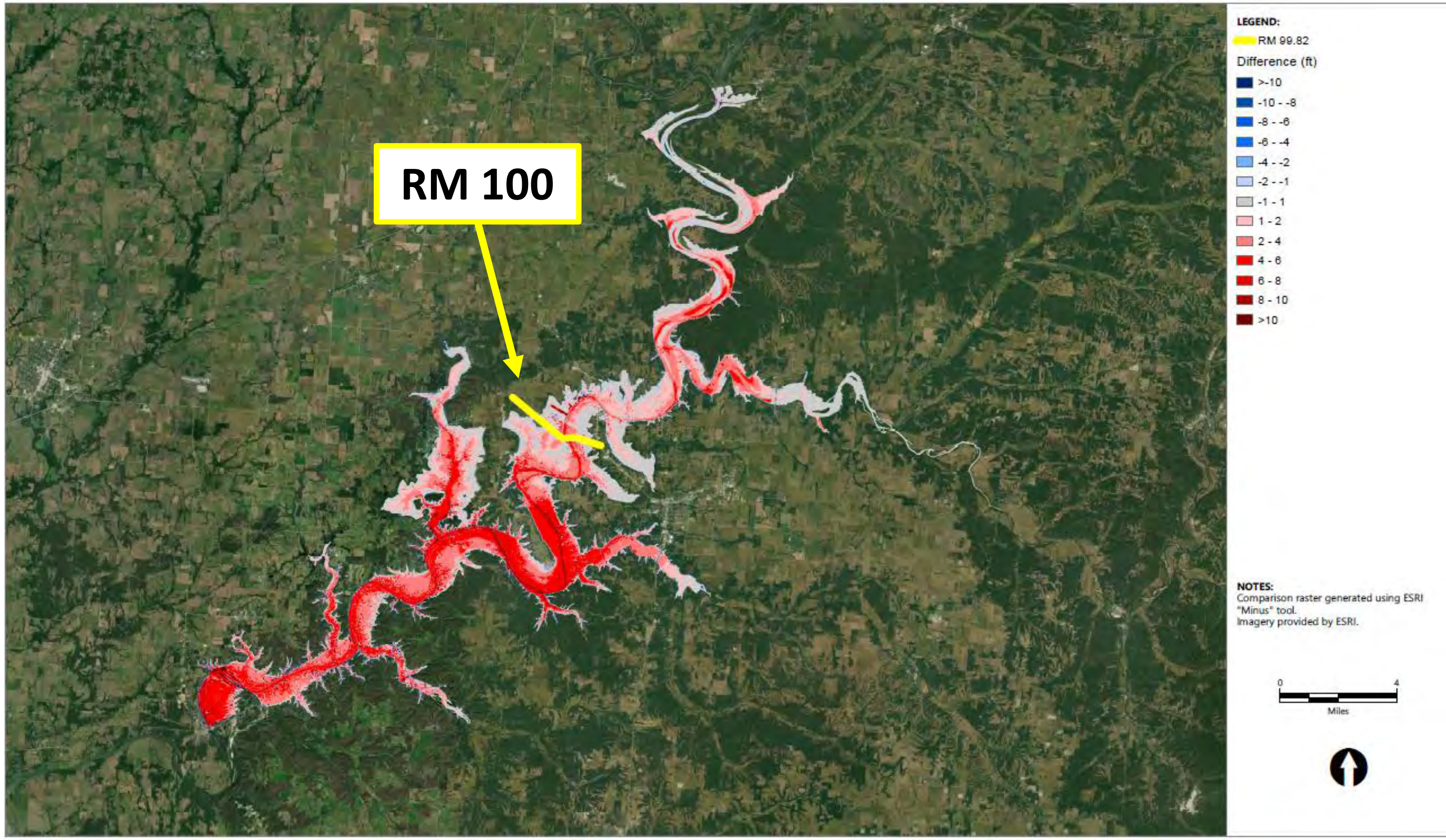
- Compare circa-1940 cross sections with modern geometry
  - Select reference elevation
  - Change in area
  - Calculate volume change



Analysis of Historical Bathymetry

Downstream Areas

- Raster comparisons
  - 2009 – 2019
    - 92,000 acre-feet
    - 81,000 acre-feet below RM 100



Analysis of Historical Bathymetry

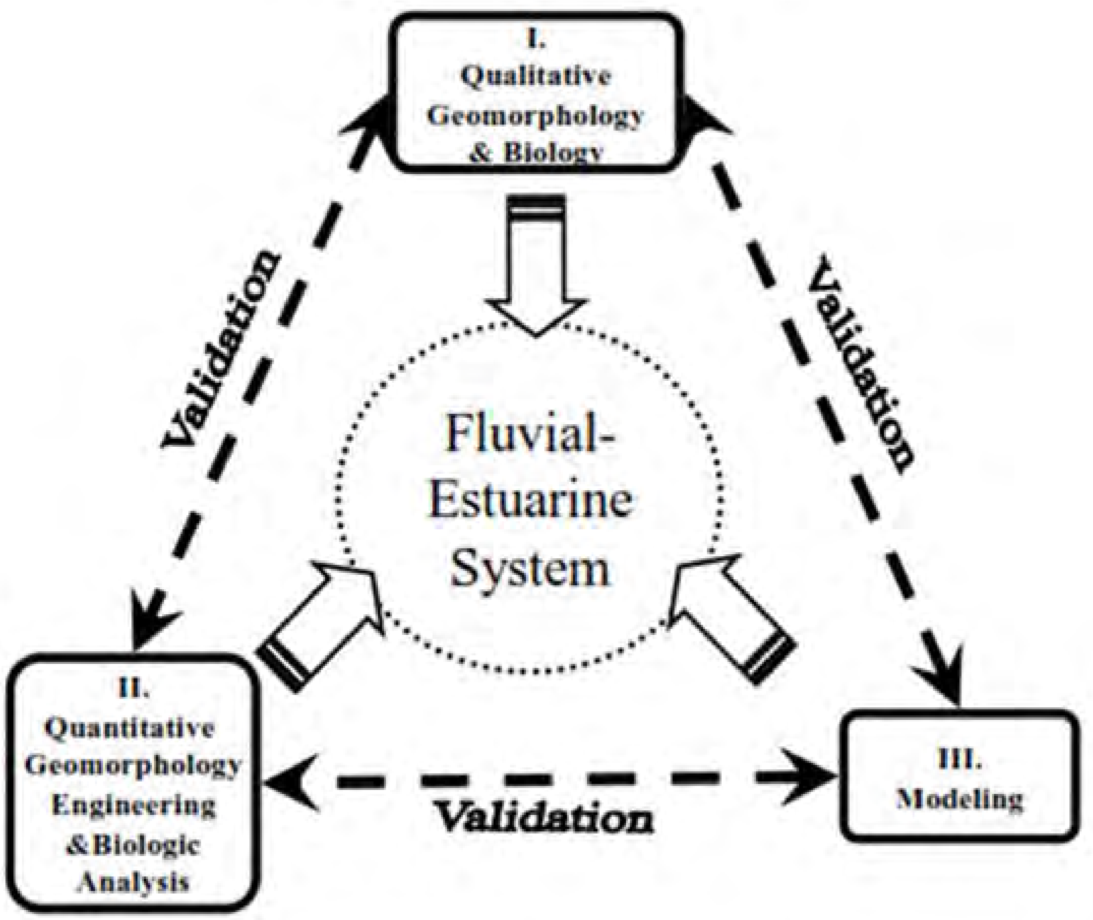
Upstream Areas showed relatively little change

Larger changes below Spring River and in reservoir

- Circa-1940 dataset poor quality for raster comparisons

Three-Level Approach

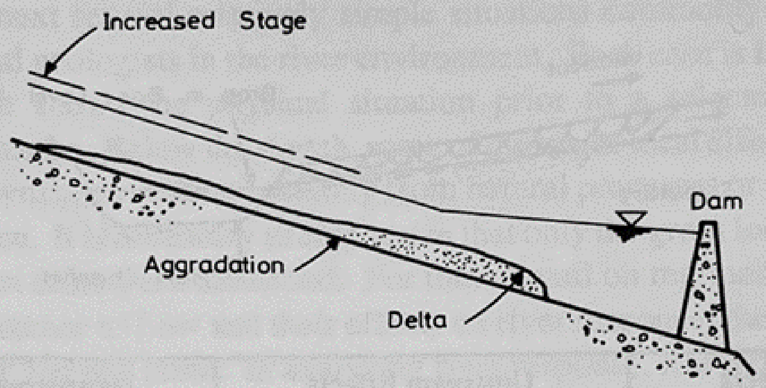
Conceptual Schematic of the three-level approach for analyzing geomorphology, sediment transport, and sedimentation processes



Note: Validation must occur between all three levels to ensure that reasonable results have been achieved.

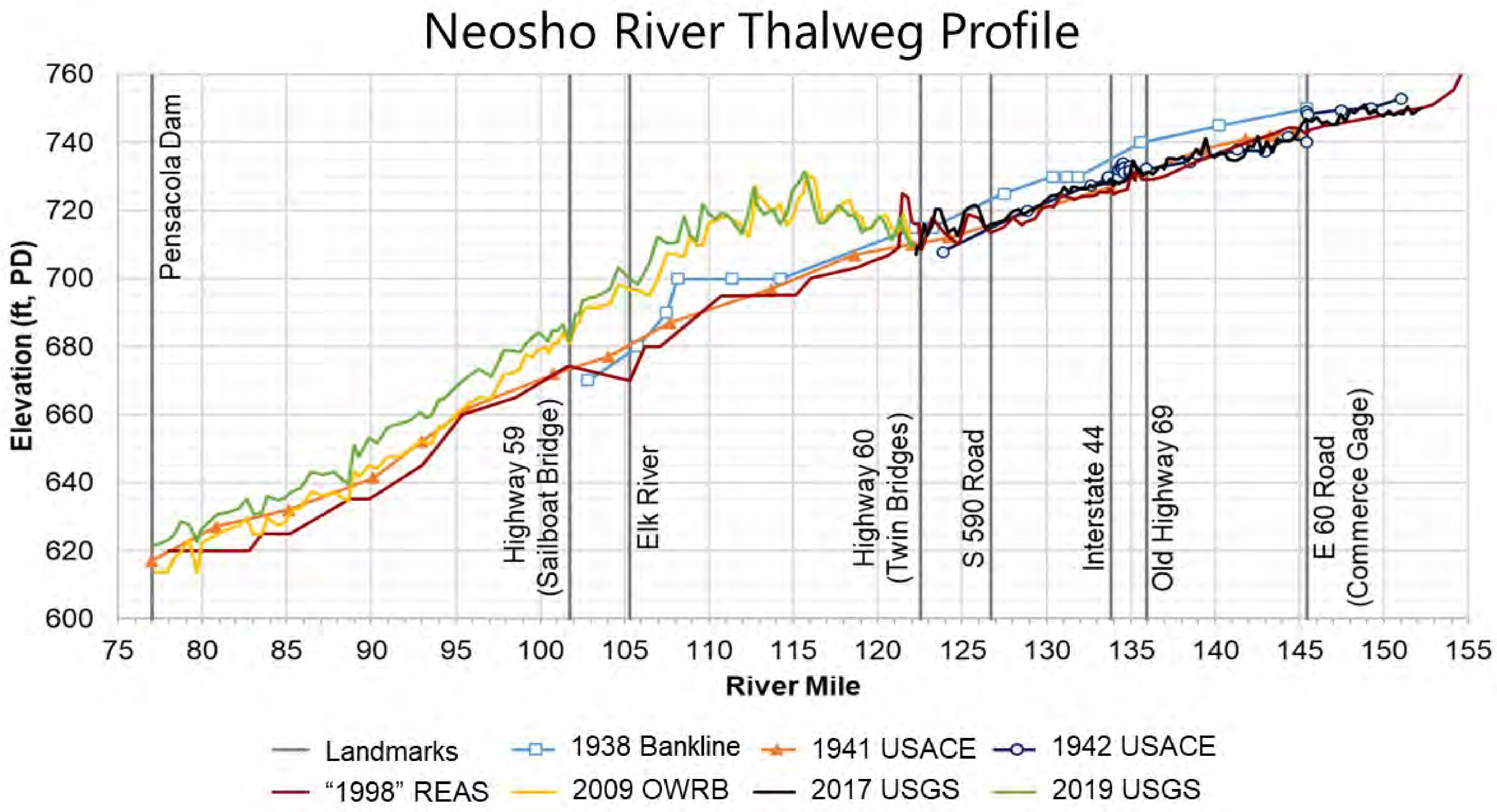
Qualitative Analysis

Typical Geomorphic Response to Dam Construction

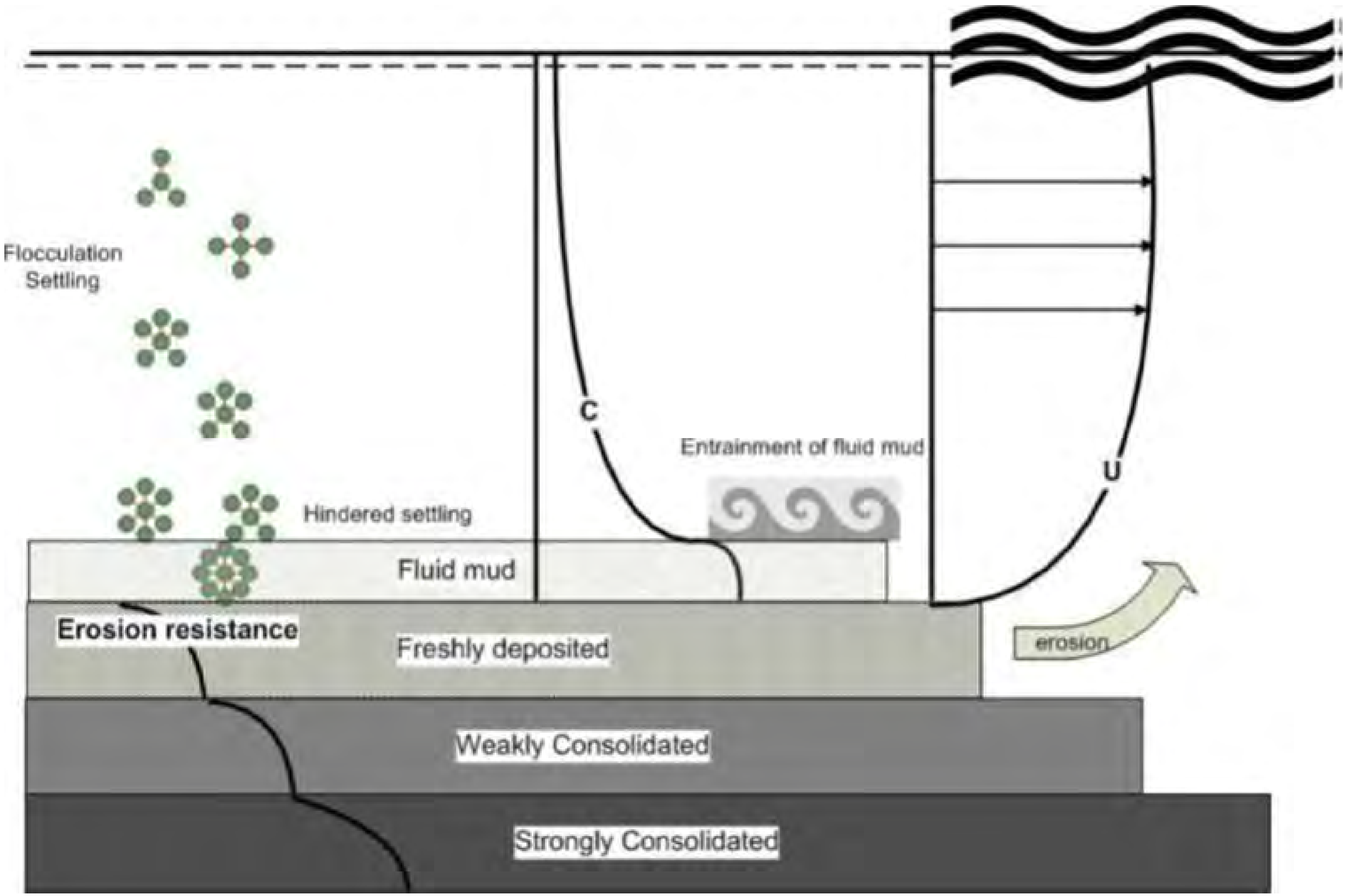


Local Effects	Upstream Effects	Downstream Effects
Aggradation of bed	See local effects	See downstream effects, Fig. 2.18
Loss of waterway capacity	Change in base level for tributaries	
Change in river geometry	Deposition in tributaries near confluences	
Increased flood stage	Aggradation causing a perched river channel to develop a change in the alignment of the main channel	

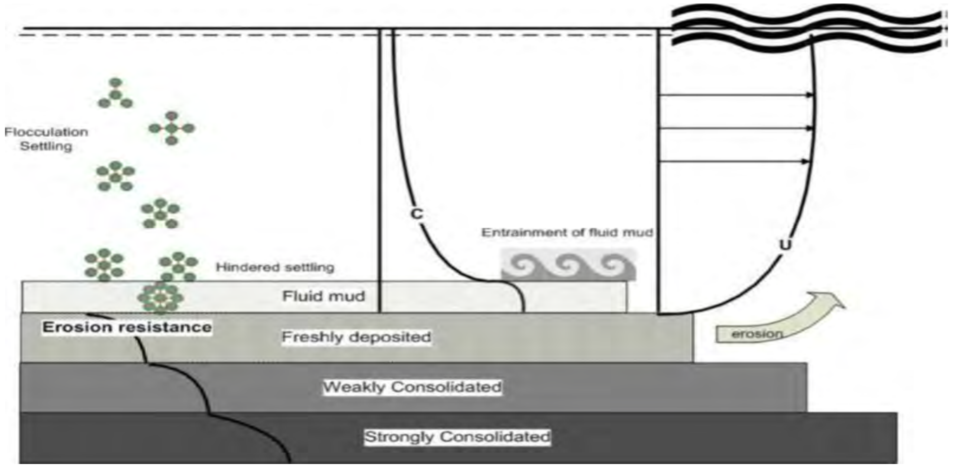
Historical Neosho River Thalweg Comparison



Typical Reservoir Sedimentation Processes



Typical Reservoir Sedimentation Processes



SEDflume sediment mostly silt and clay

- Surface layer of unconsolidated, mobile material
- Integral Consulting (2020) described layer of "fluff" that erodes "in clouds" of sediment
- Density currents move sediment

Lumborg and Vested (2008)

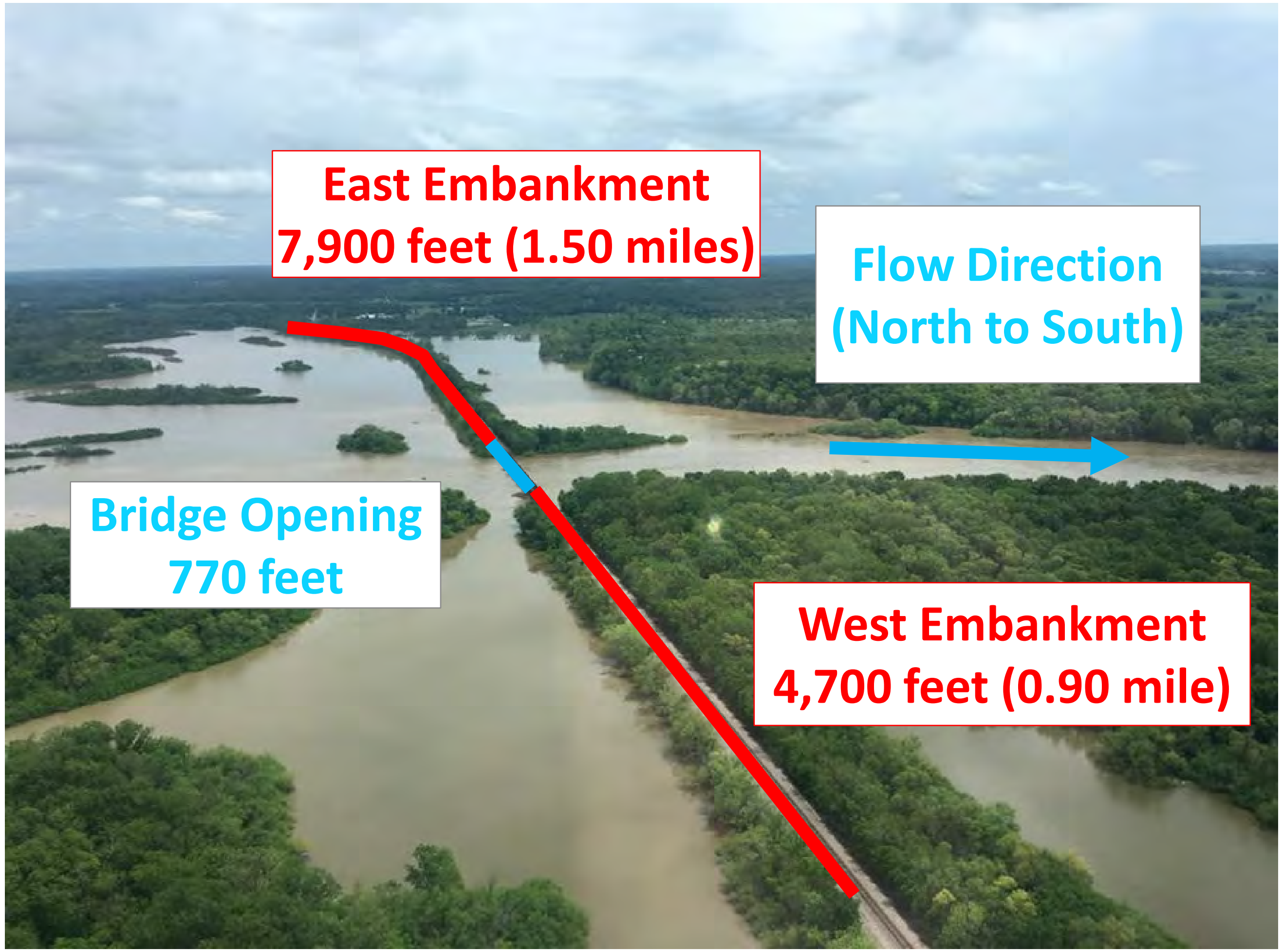
- "hindered settling…may lead to high concentration suspensions or fluid mud layers"
- "The layer…moves as a gel rather than as a Newtonian fluid."
- "Fluid mud layers accomplish a significant challenge for fine-grain sediment modelling…make it difficult to predict cohesive sediment dynamics."

Bridges

Burlington Northern Railroad Bridge and embankment near Twin Bridges

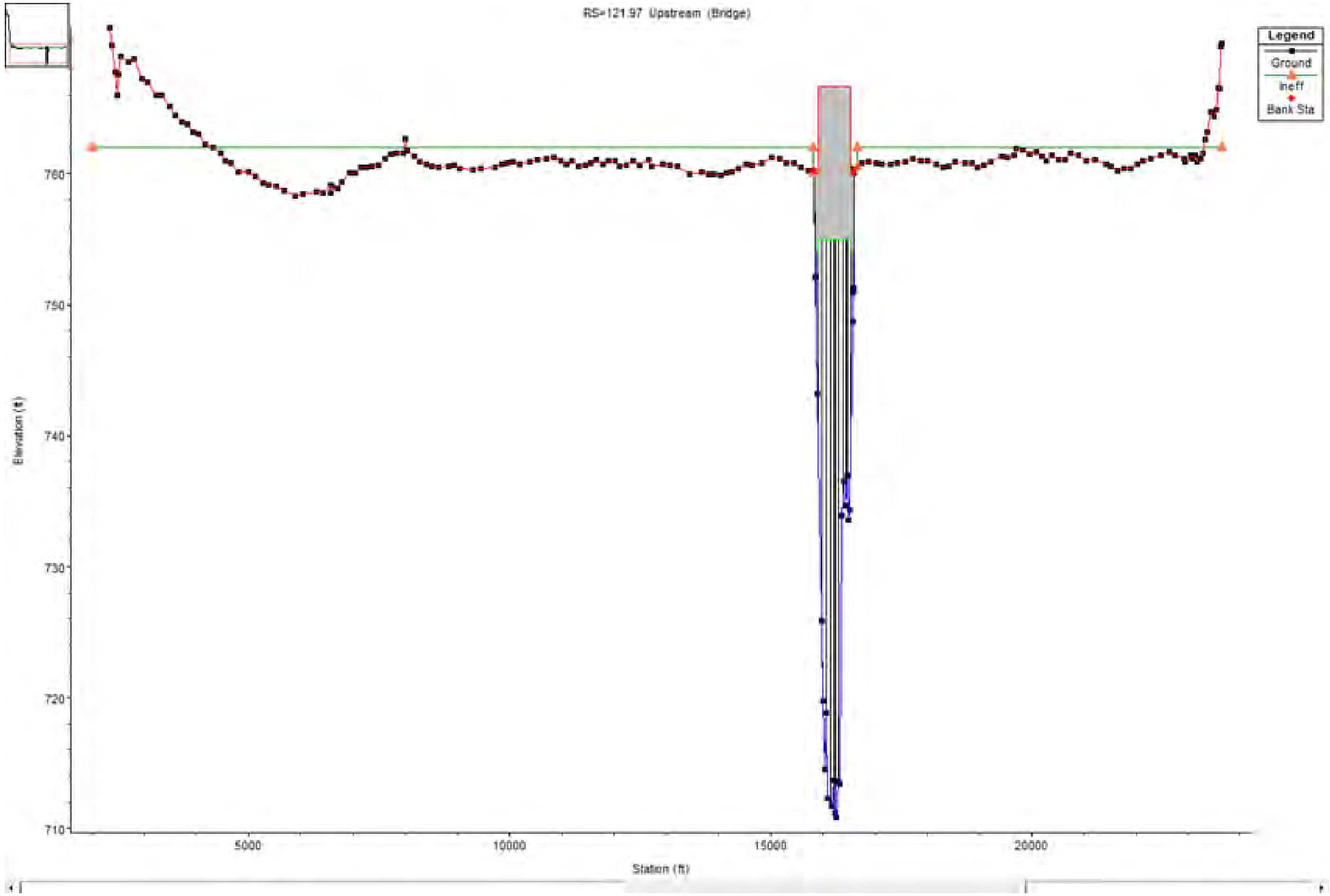
Bridges

Burlington Northern Railroad Bridge and embankment near Twin Bridges



Bridges

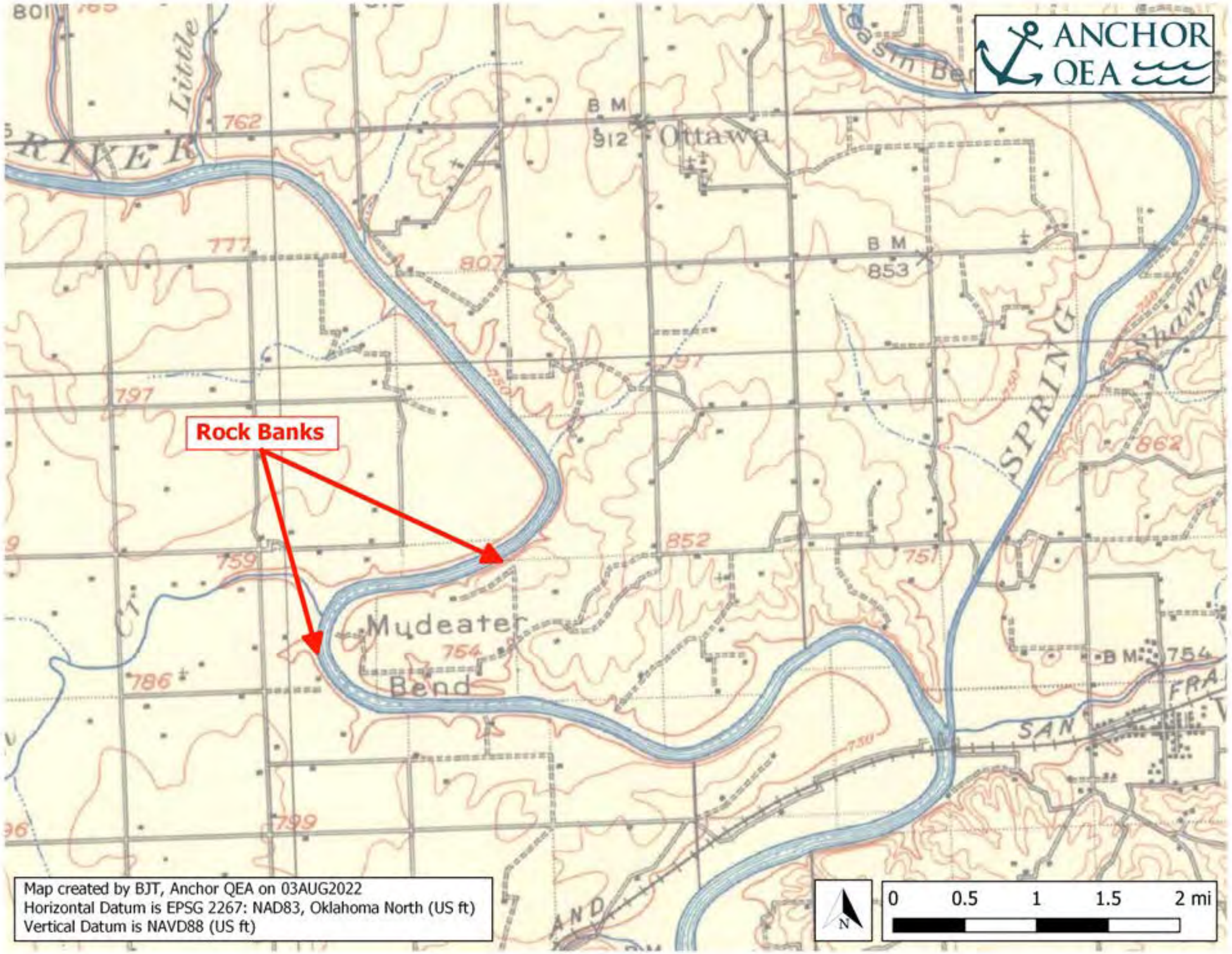
Burlington Northern Railroad Bridge Cross Section



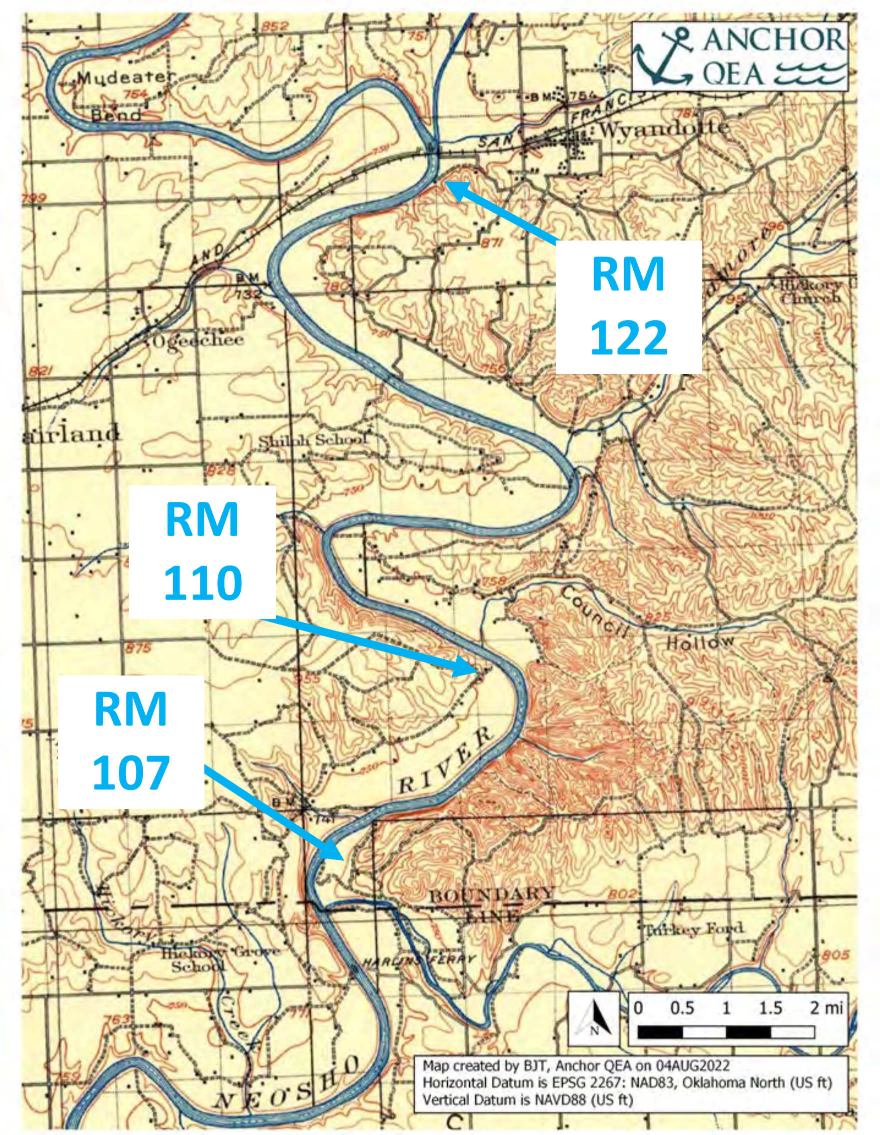
Debris Trapped on Bridge Piers

Vertical Rocky Banks Along the Neosho River

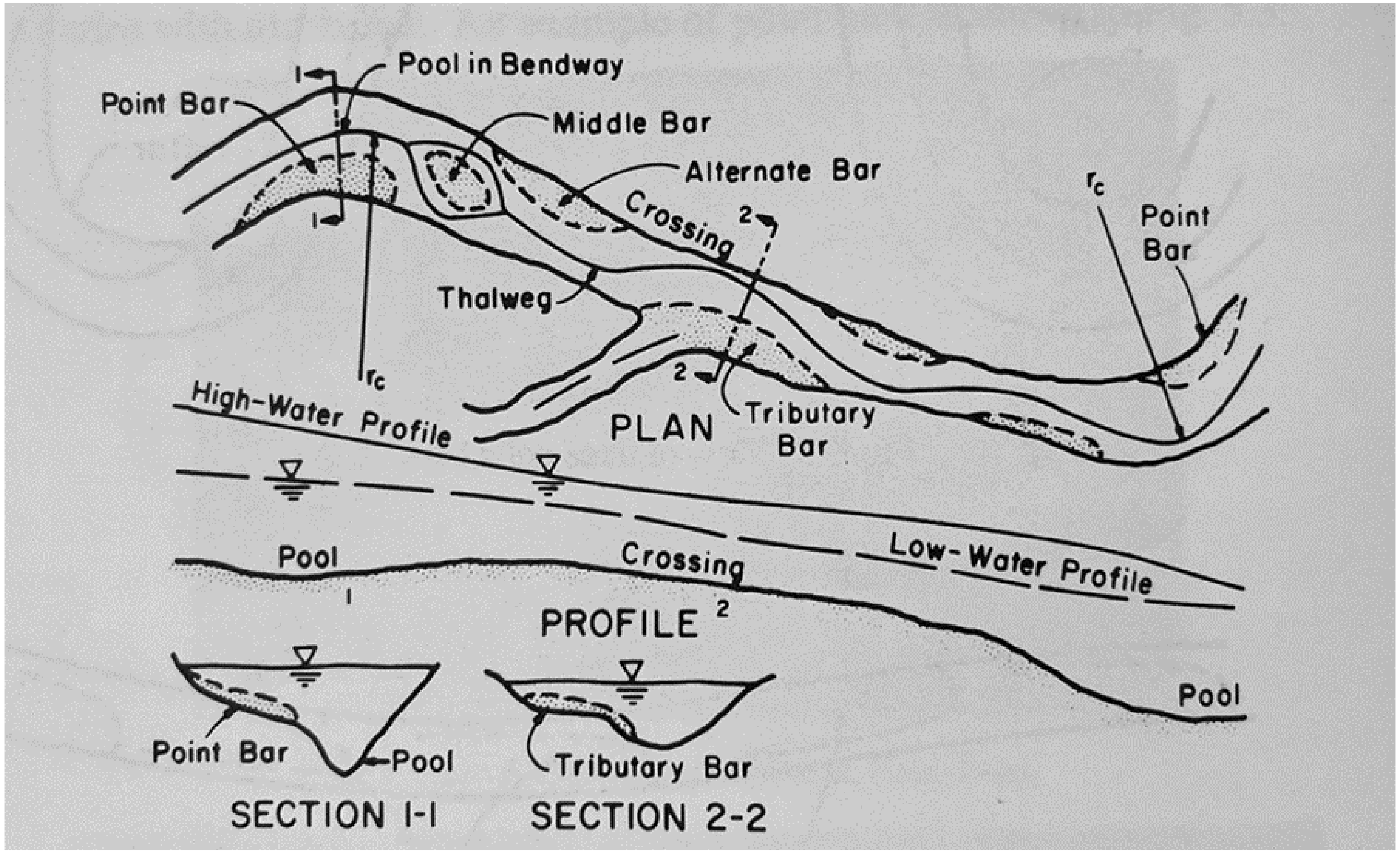
Vertical Rocky Bank Locations



Geologic Constrictions



Alluvial Bars



Tributary bar

- Natural geomorphic process
- Typically forms when a steeper tributary joins river

Stream Slopes

- Elk River: 56% steeper
- Spring River: 7% steeper

Quantitative Analysis

Quantitative Analysis

US Society on Dams (USSD 2015):

- “Detailed analysis [of sediment transport conditions associated with reservoirs]…lies beyond present knowledge, and only qualitative or rough quantitative estimates can be provided.

HEC-RAS Sediment Transport Routines

- Do not account for:
  - Density currents
  - Mud flows
- Most effective in upper portions of study area

Sediment Transport Rating Curves

Sediment Rating Curve Analysis Tool

- Built into HEC-RAS
- Two primary components
  - Bias correction
  - Stationarity analysis

Sediment Transport Rating Curves

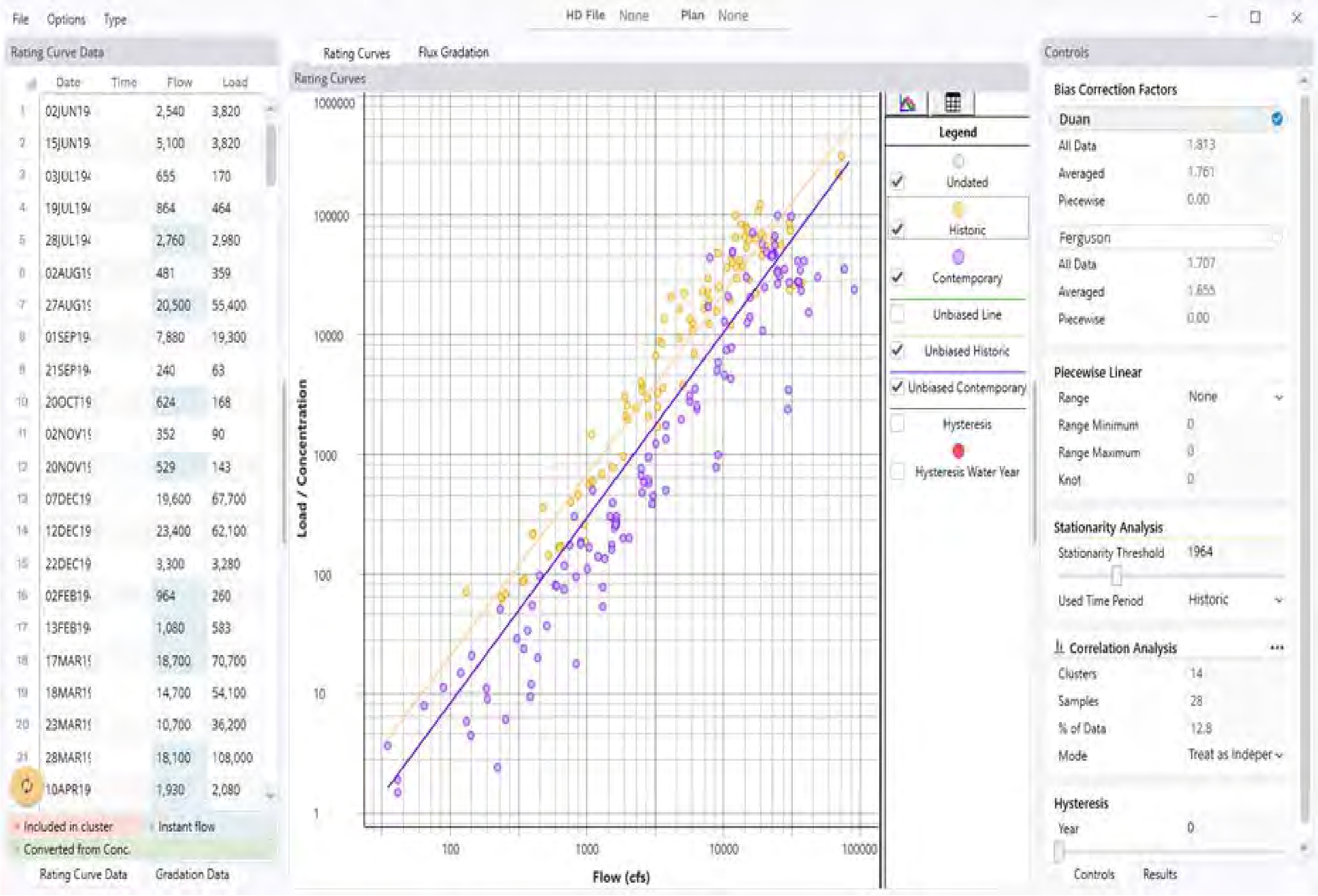
Sediment Rating Curve Analysis Tool

- Bias correction:
  - Log-transforming regression allows fit of power function
  - Typically results in under-prediction of sediment loading without bias correction

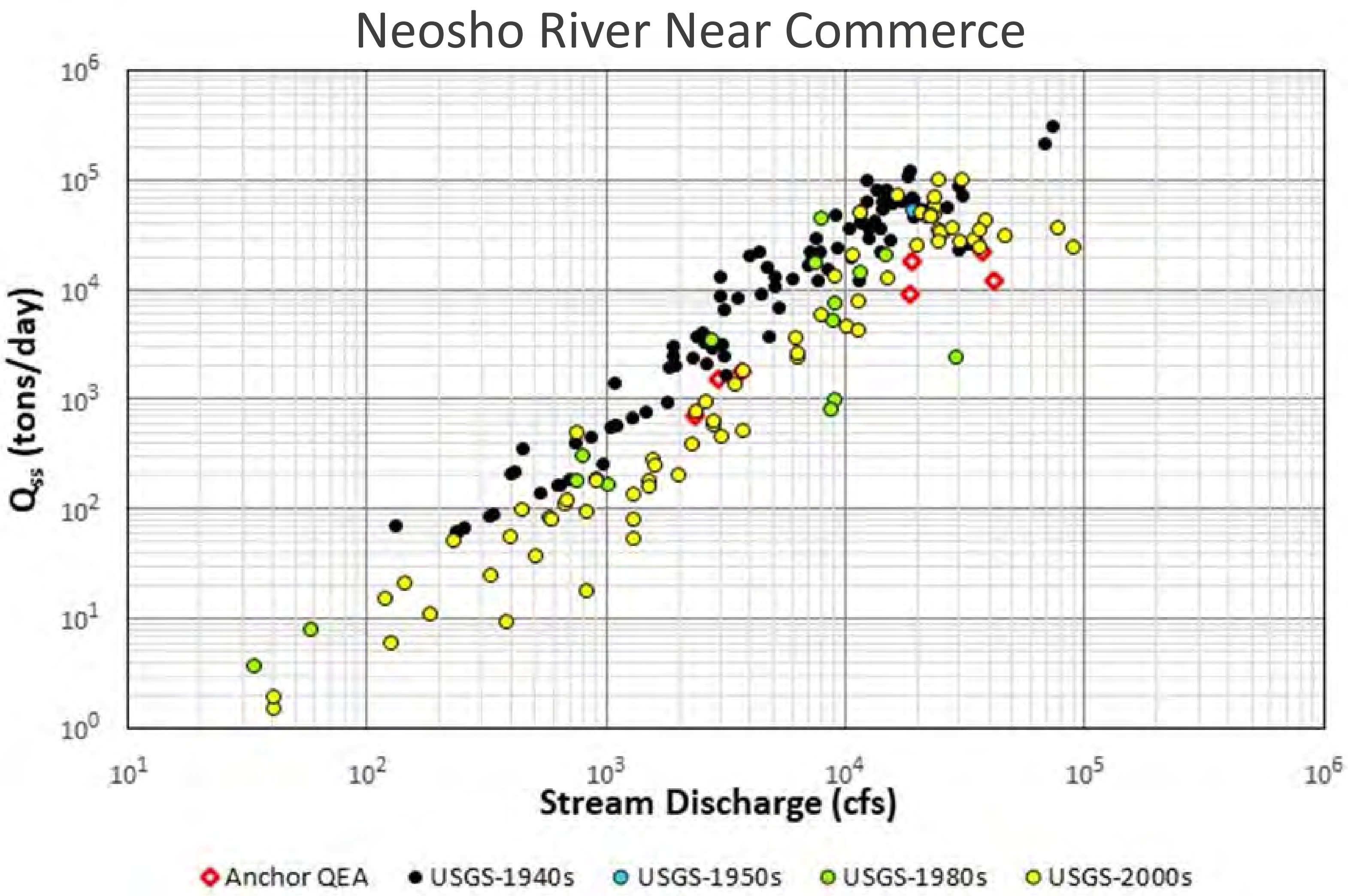
Sediment Transport Rating Curves

Sediment Rating Curve Analysis Tool

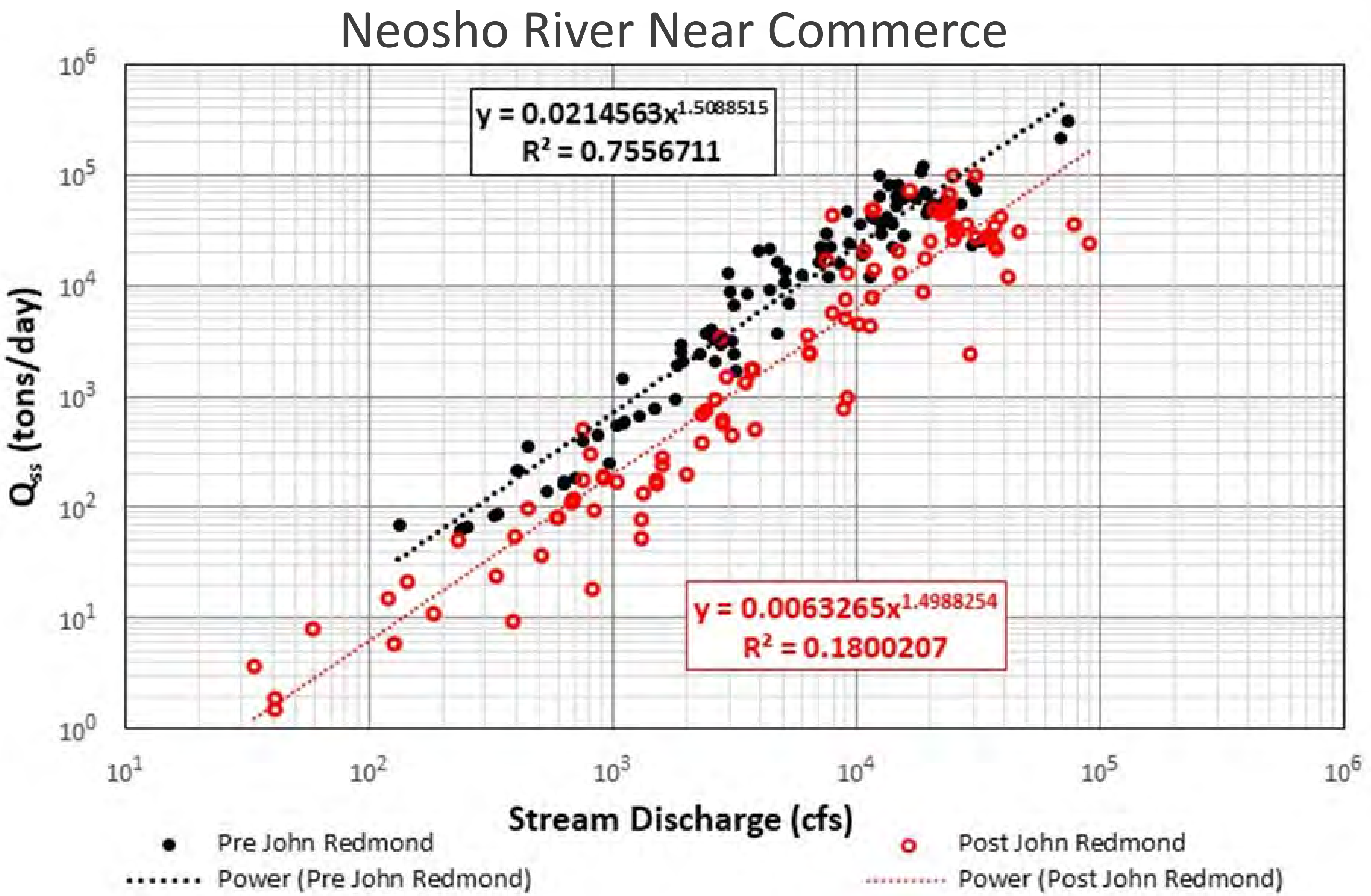
- Stationarity analysis:
  - Sediment loads change over time
    - Agricultural impacts
    - Land use changes
    - Fires
    - Mass wasting events
    - Dams/removals
    - Pavement installations



Sediment Transport Stationarity Analysis

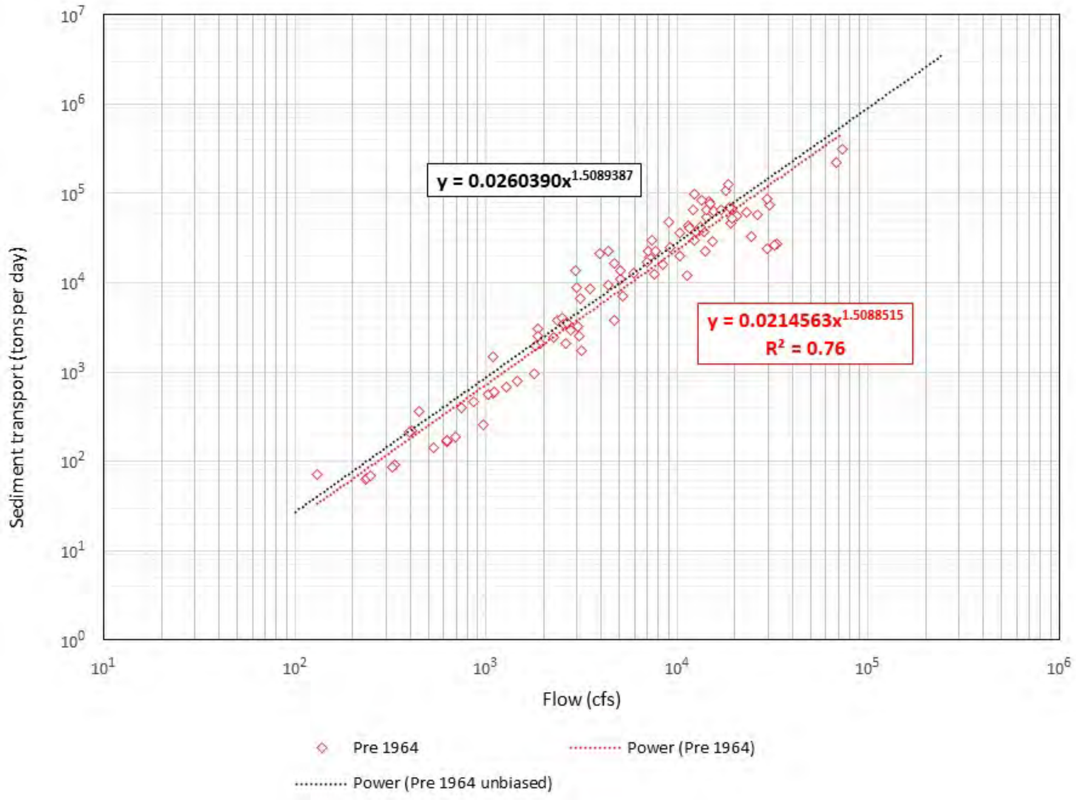


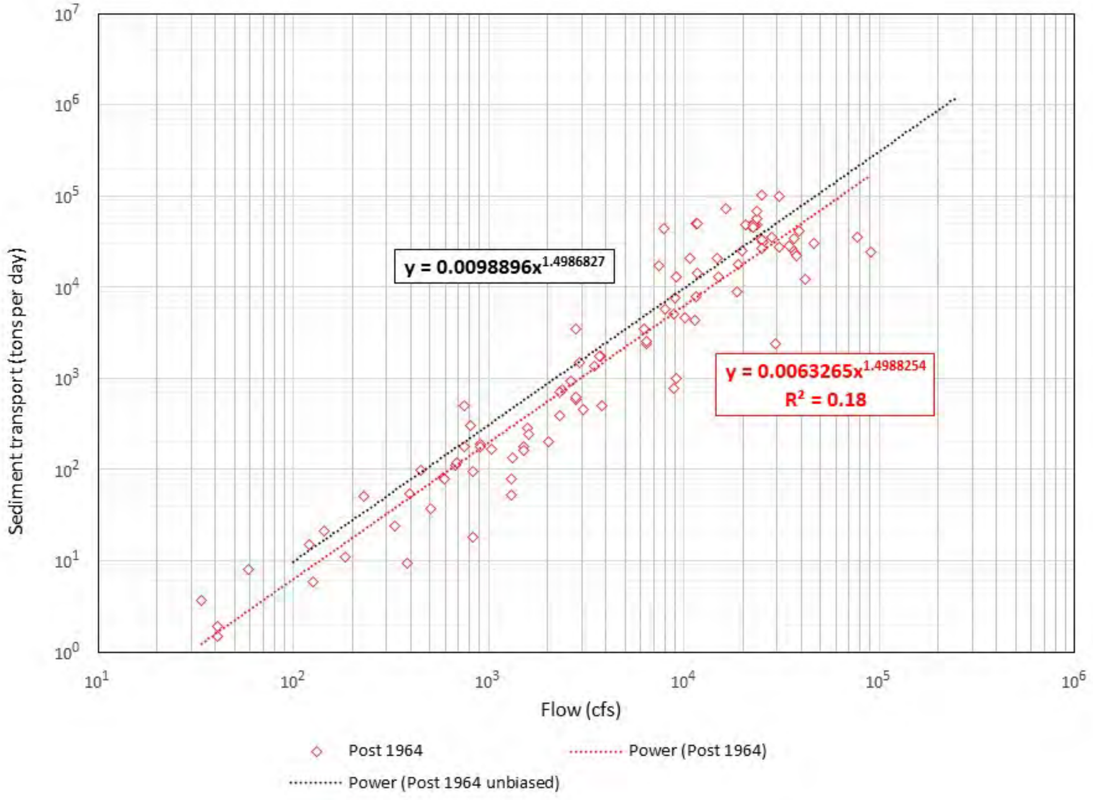
Neosho River Pre- and Post-John Redmond



Neosho River Pre- and Post-John Redmond

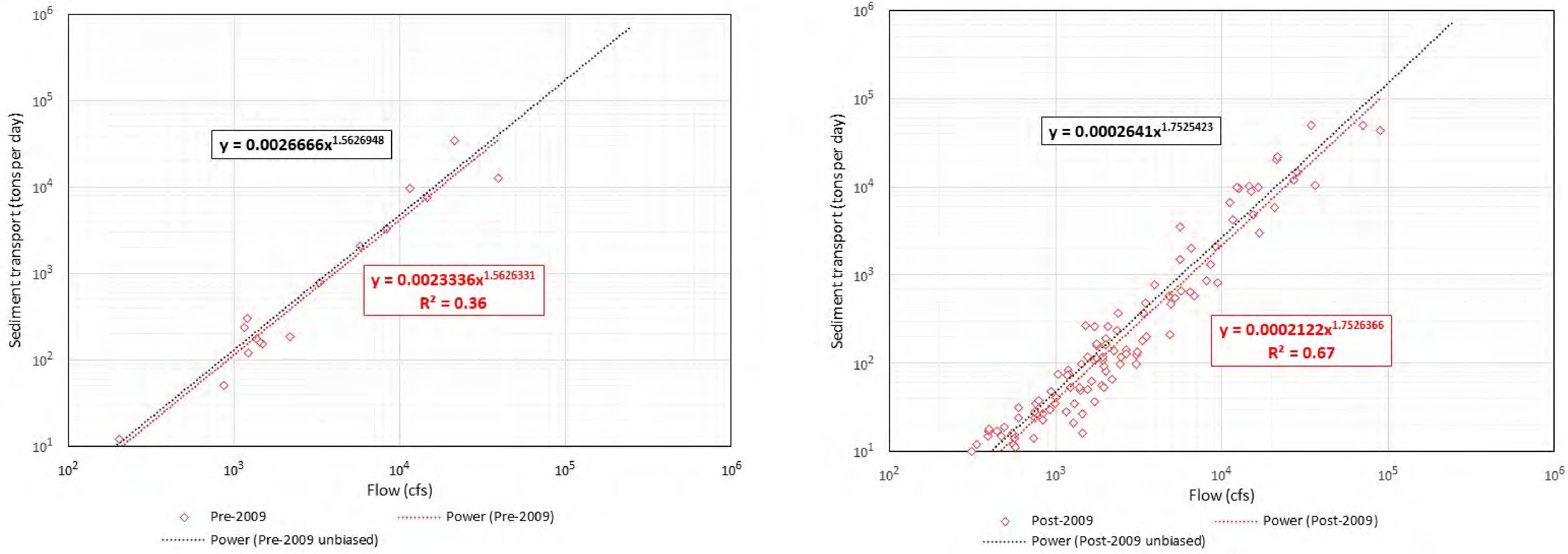
Neosho River Near Commerce





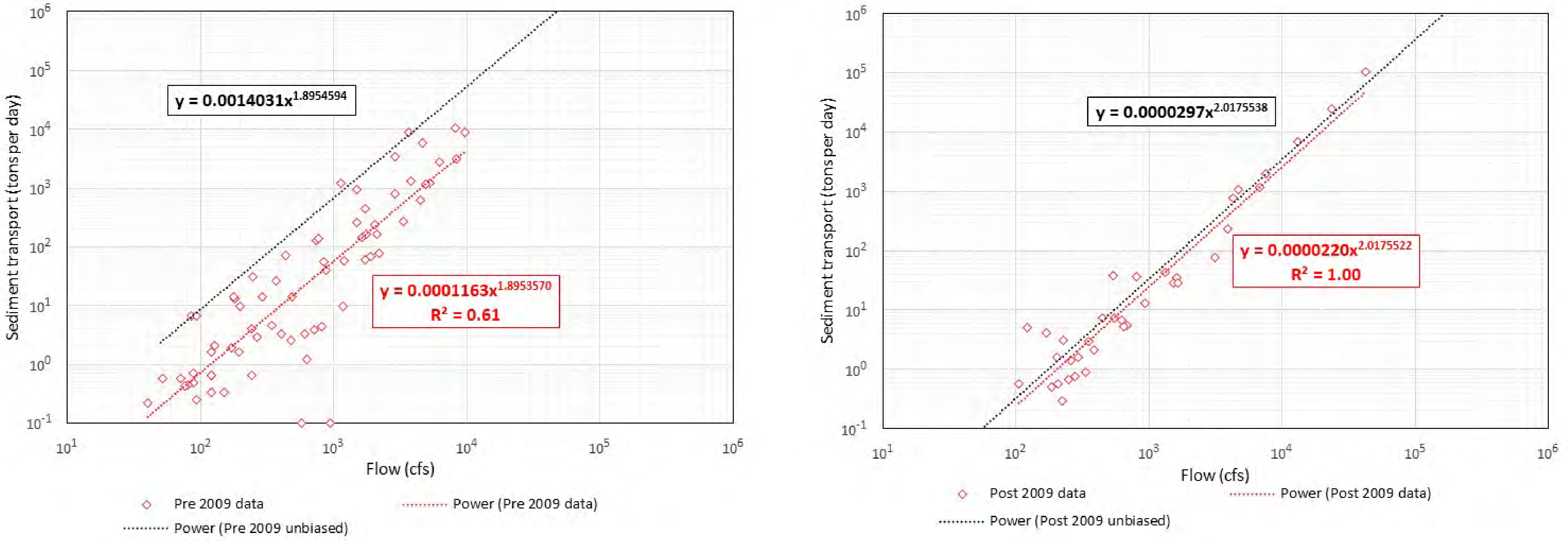
Spring River Pre- and Post-2009

Spring River near Quapaw



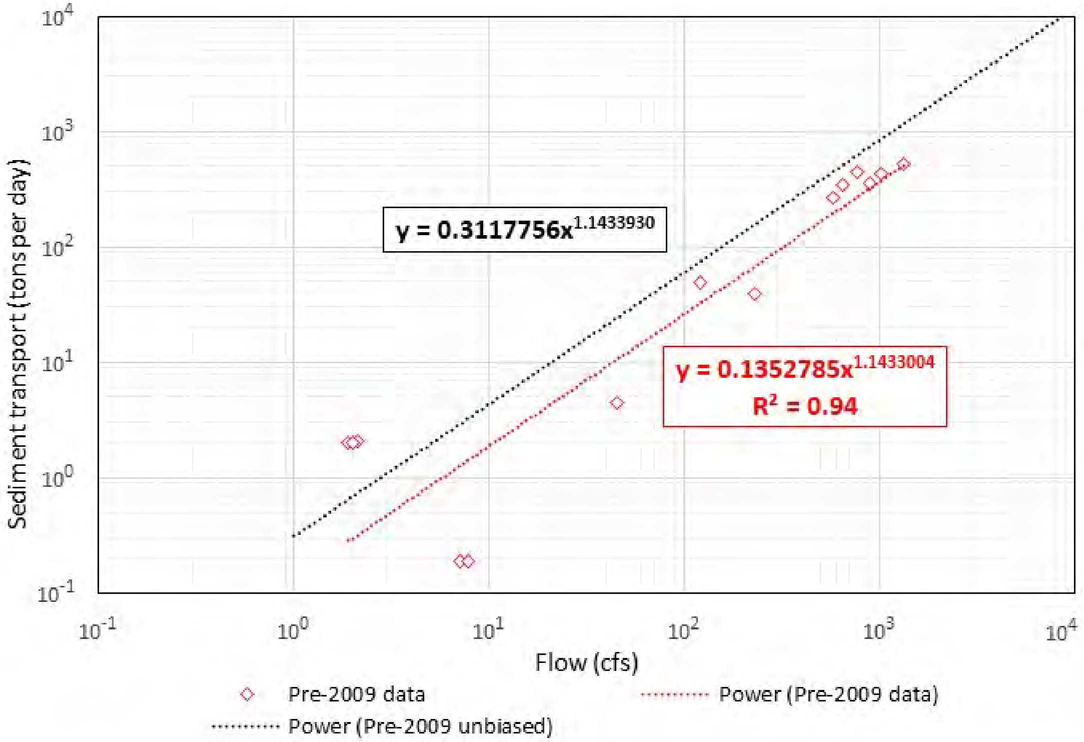
Elk River Pre- and Post-2009

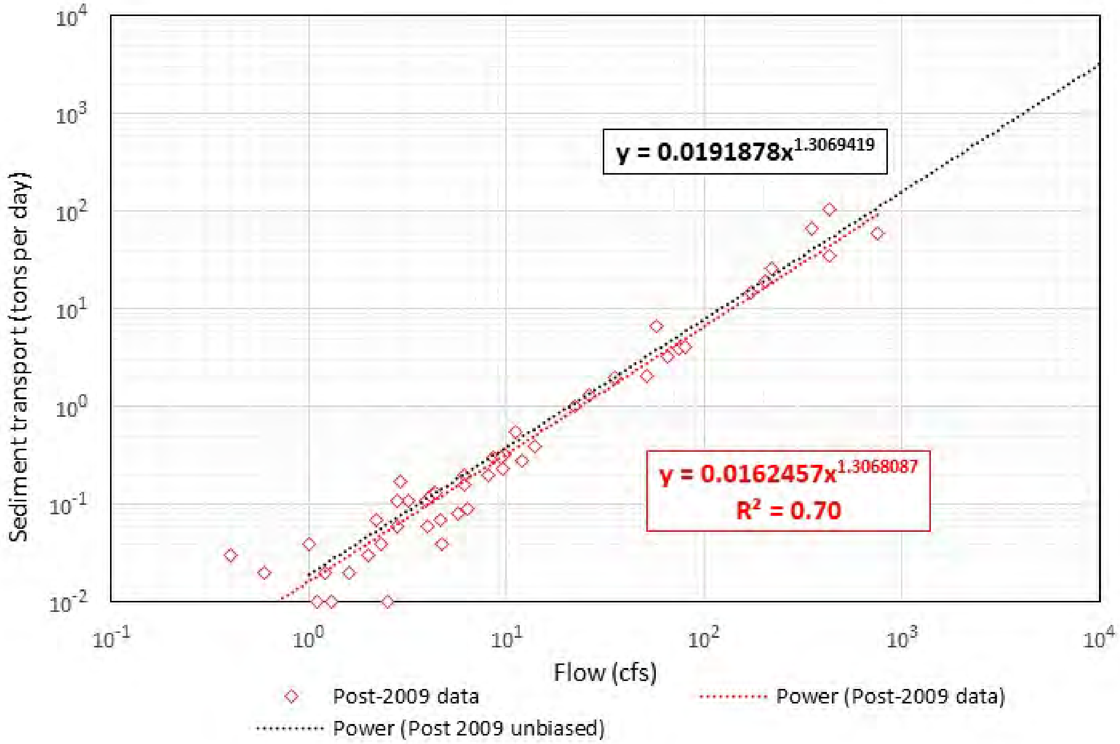
Elk River near Tiff City



Tar Creek Pre- and Post-2009

Tar Creek near Commerce





Sediment Transport Rating Curves

River	Pre-2009	Post-2009
Neosho*	$Q_{ss} = 0.0260390\ Q^{1.5089387}$	$Q_{ss} = 0.0098896\ Q^{1.4986827}$
Tar	$Q_{ss} = 0.3117756\ Q^{1.1433930}$	$Q_{ss} = 0.0191878\ Q^{1.3069419}$
Spring	$Q_{ss} = 0.0026666\ Q^{1.5626948}$	$Q_{ss} = 0.0002641\ Q^{1.7525423}$
Elk	$Q_{ss} = 0.0014031\ Q^{1.8954594}$	$Q_{ss} = 0.0000297\ Q^{2.0175538}$

Note: *Neosho values are pre- and post-1964.

Flow and Water Level Summary

Tributary	1940–2009	2009–2019	2020–2069 Anticipated Operation	2020–2069 Baseline Operation
Neosho River (cfs)	3,818	4,312	4,183	4,183
Tar Creek (cfs)	48	40	55	55
Spring River (cfs)	2,212	2,664	2,526	2,526
Elk River (cfs)	822	953	887	887
Grand Lake Average WSE (feet)	740.95	743.49	742.57	741.65

Sediment Transport Summary

Tributary	Total Sediment Transport (tons) 1940–2009	Total Sediment Transport (tons) 2009–2019	Total Sediment Transport (tons) 2020–2069
Neosho River	214,264,051	21,144,118	89,616,776
Tar Creek	864,297	19,702	122,593
Spring River	27,464,343	4,088,037	15,866,424
Elk River	57,766,979	1,432,848	3,535,827
Total	300,359,670	26,684,705	109,141,619
No. of years	69	11	50

Sediment Transport to Grand Lake

Pursuant to federal law, including the Flood Control Act of 1944 and Section 7612 of the National Defense Authorization Act for 2020, flood control operations at the Project are regulated exclusively by US Army Corps of Engineers **when the reservoir elevation is above 745 feet PD or expected to rise beyond that level.**

River	Percentage of Sediment Delivered ≥ 745 feet PD	Percentage of Sediment Delivered < 745 feet PD
Neosho River	75	25
Tar Creek	63	37
Spring River	80	20
Elk River	75	25
Total	76	24

Sediment Density

Vanoni (2006)

- Unit weight is complicated, depends on:
  - Reservoir operations
  - Sediment particle size
  - Compaction rate
  - Others

Sediment Density

Lane and Koelzer (1943)

- Texas reservoirs: 31 – 82 lb/ft³
- Missouri Basin reservoirs: 25.2 – 116 lb/ft³
- European reservoir: 13.7 – 87.2 lb/ft³
- Soil Conservation Service: 20.1 – 101.7 lb/ft³

Vanoni (2006)

- Average density for 210 samples: 44 lb/ft³

Grand Lake deposit surface layer: 21.2 – 103.0 lb/ft³

- Average: 52.7 lb/ft³
- Used 58 lb/ft³ & 70 lb/ft³

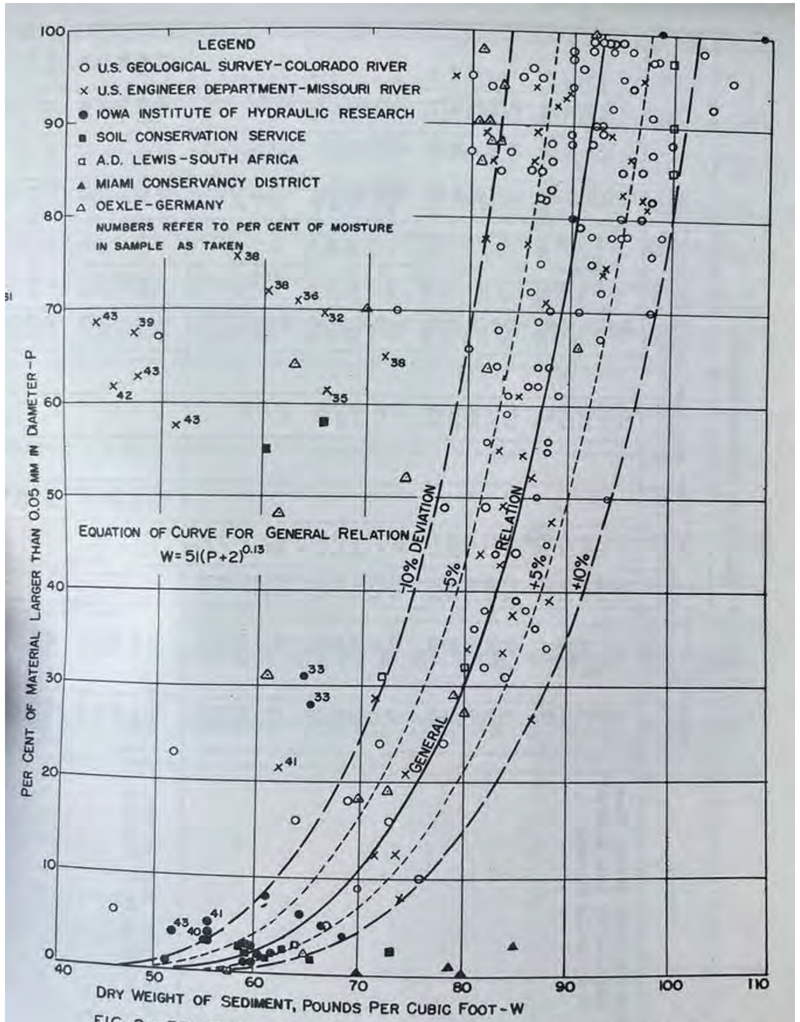


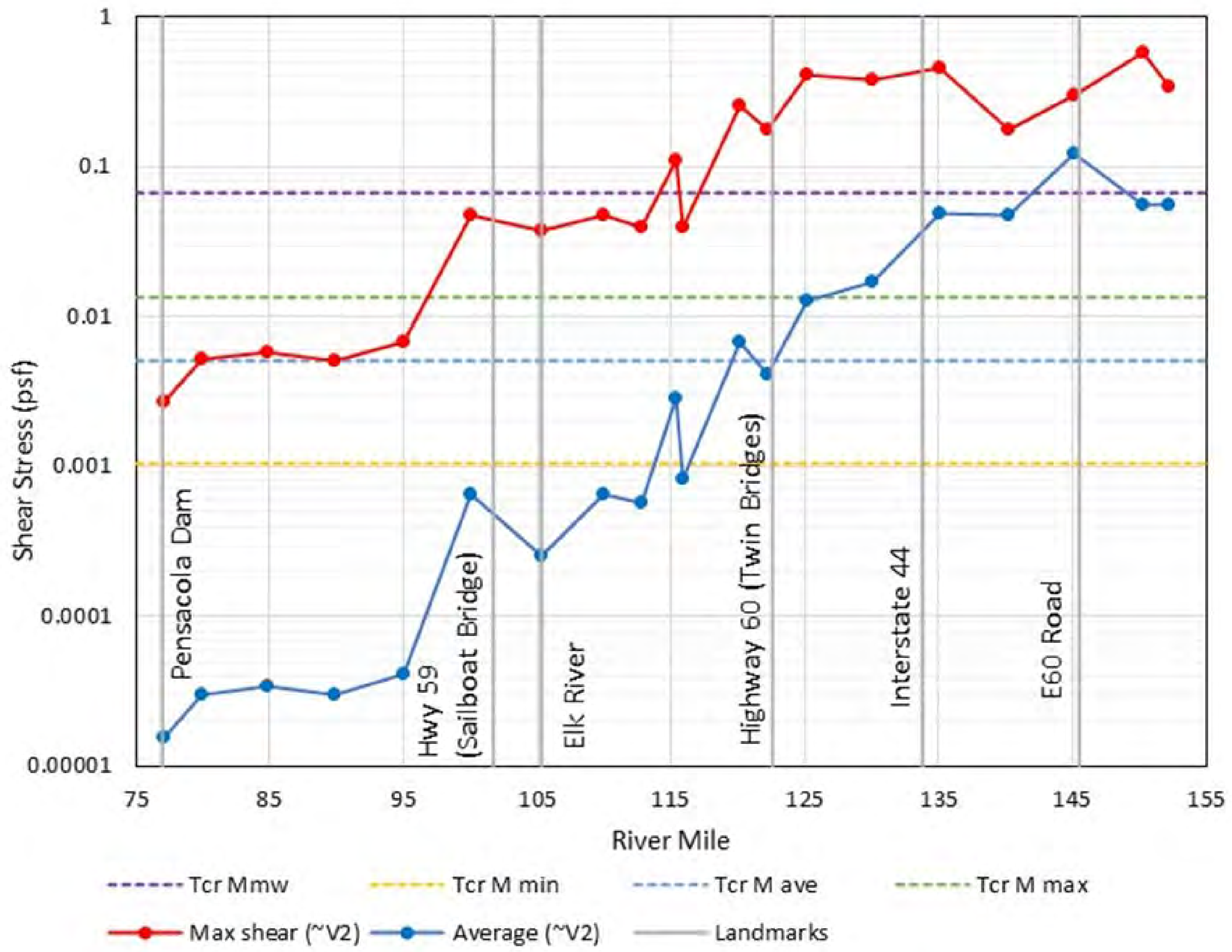
FIG. 2 - RELATION OF UNIT WEIGHT OF DEPOSITED SEDIMENTS TO PER CENT OF SAND

Bathymetric Change & Shear Stress

Quantitative Analysis

- Hydraulic shear stress determination
  - Hydraulic modeling

Neosho River Shear Stress Profile

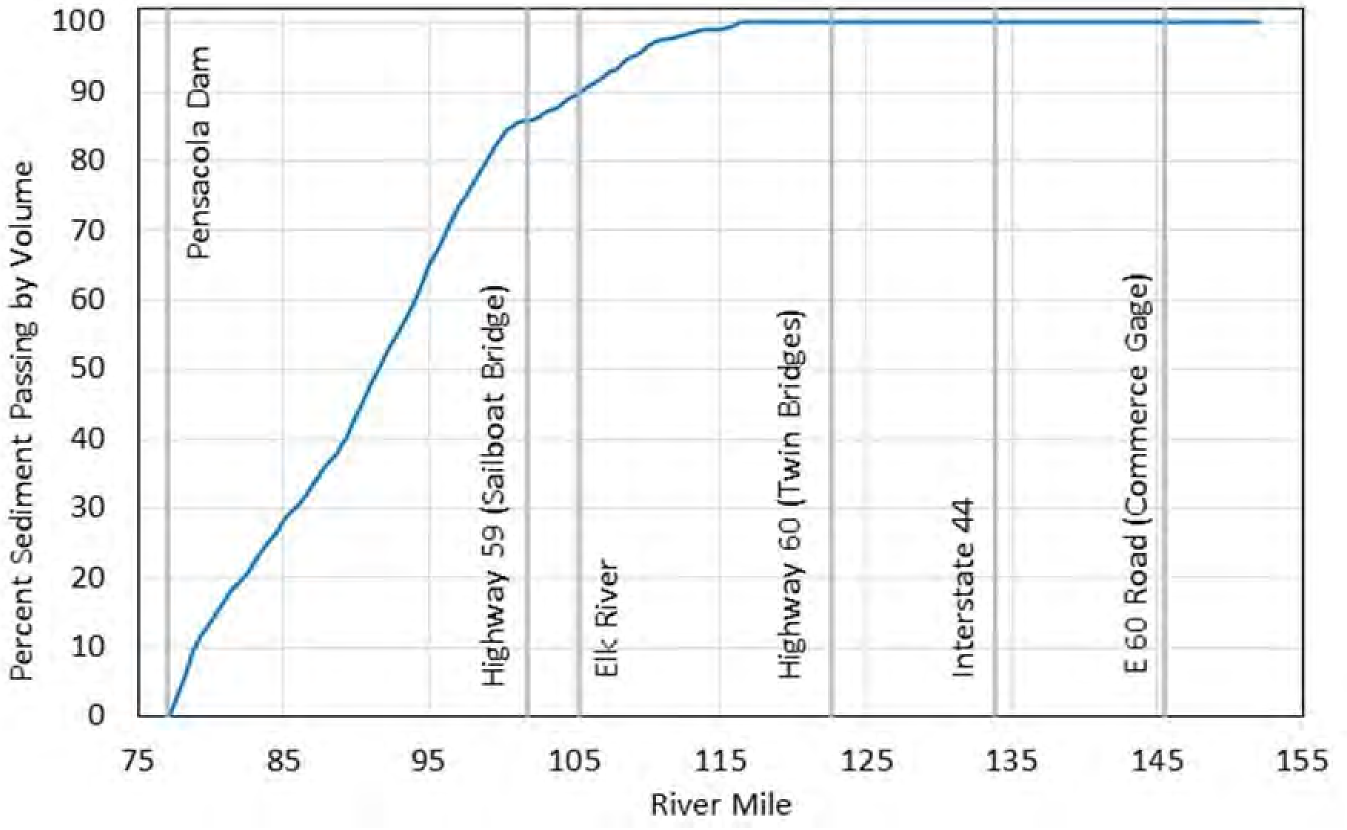


Bathymetric Change & Shear Stress

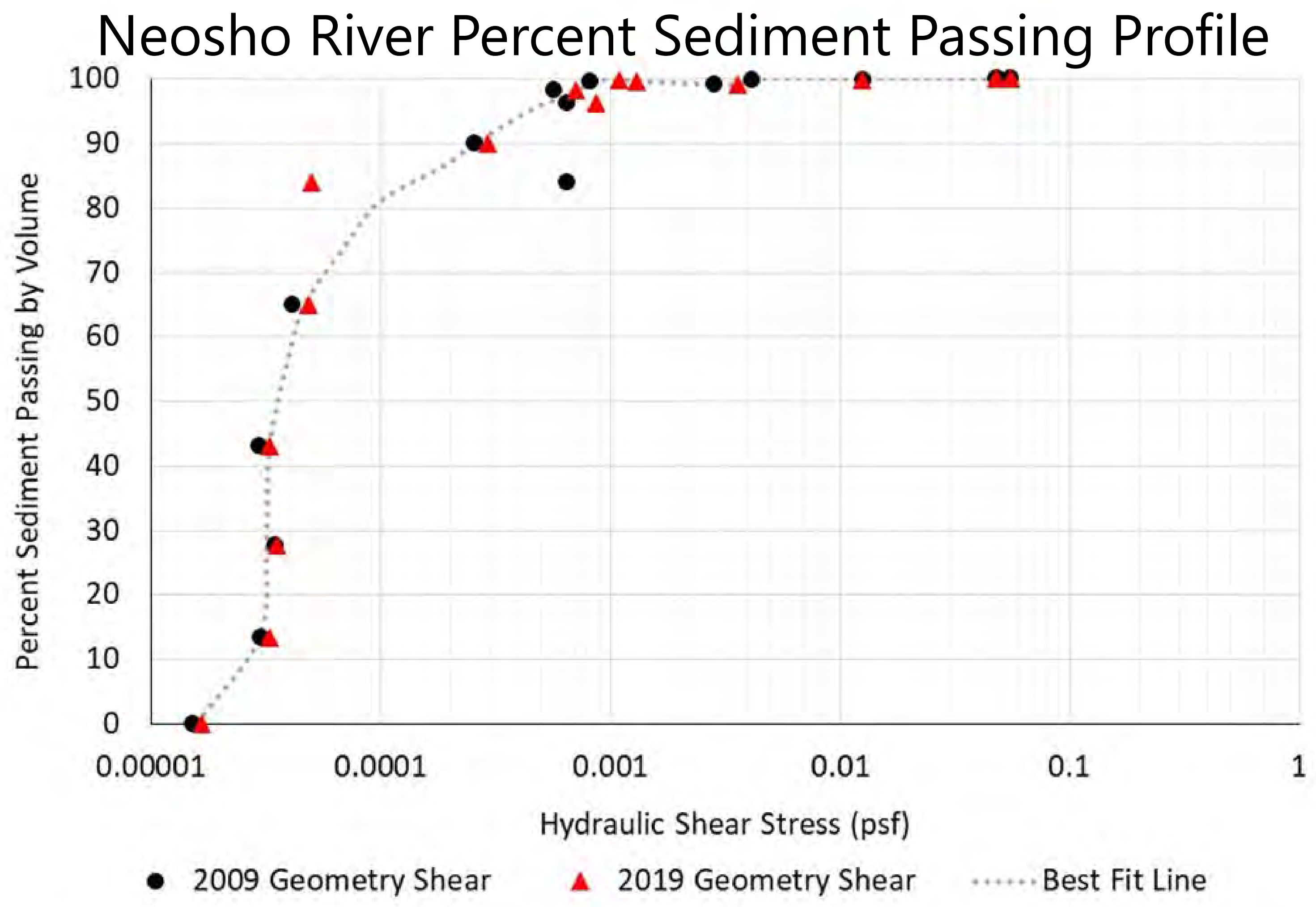
Quantitative Analysis

- Sediment passing evaluation
  - Drops below 100% at RM 116
  - Average hydraulic shear stress approximately equal to minimum surface critical shear stress

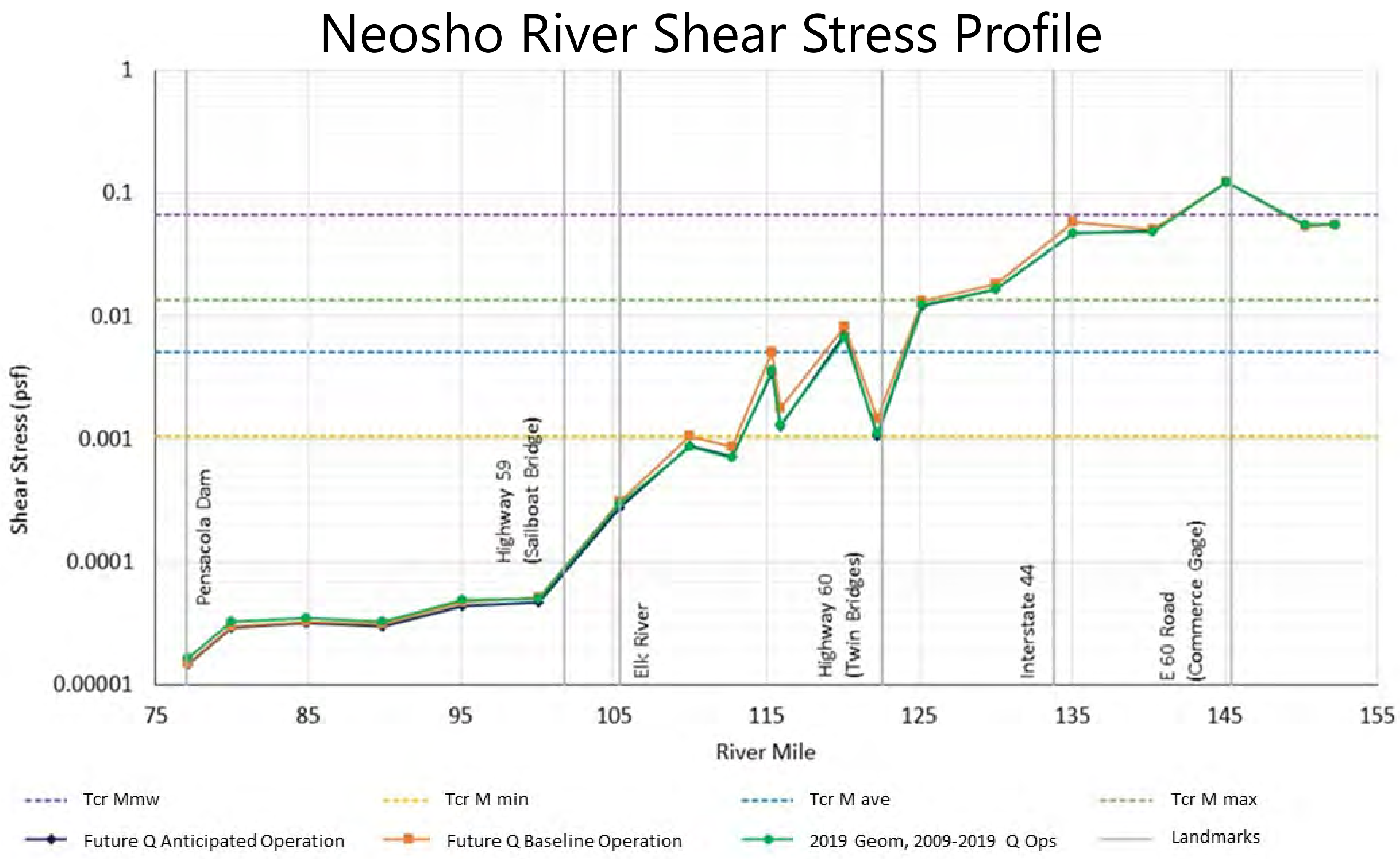
Neosho River Percent Sediment Passing Profile



Percentage of Volume Passing

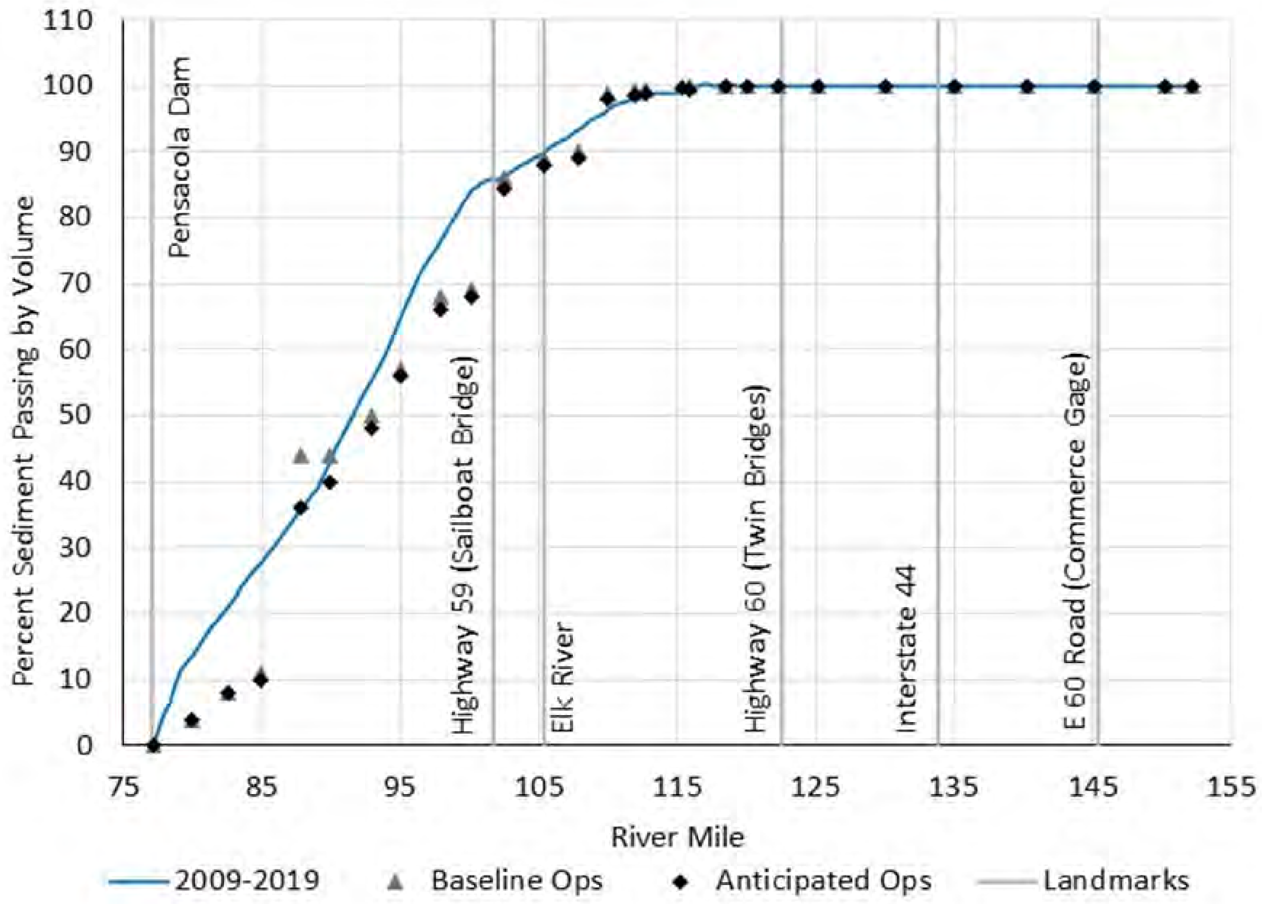


Hydraulic Shear Stress – Future Scenarios

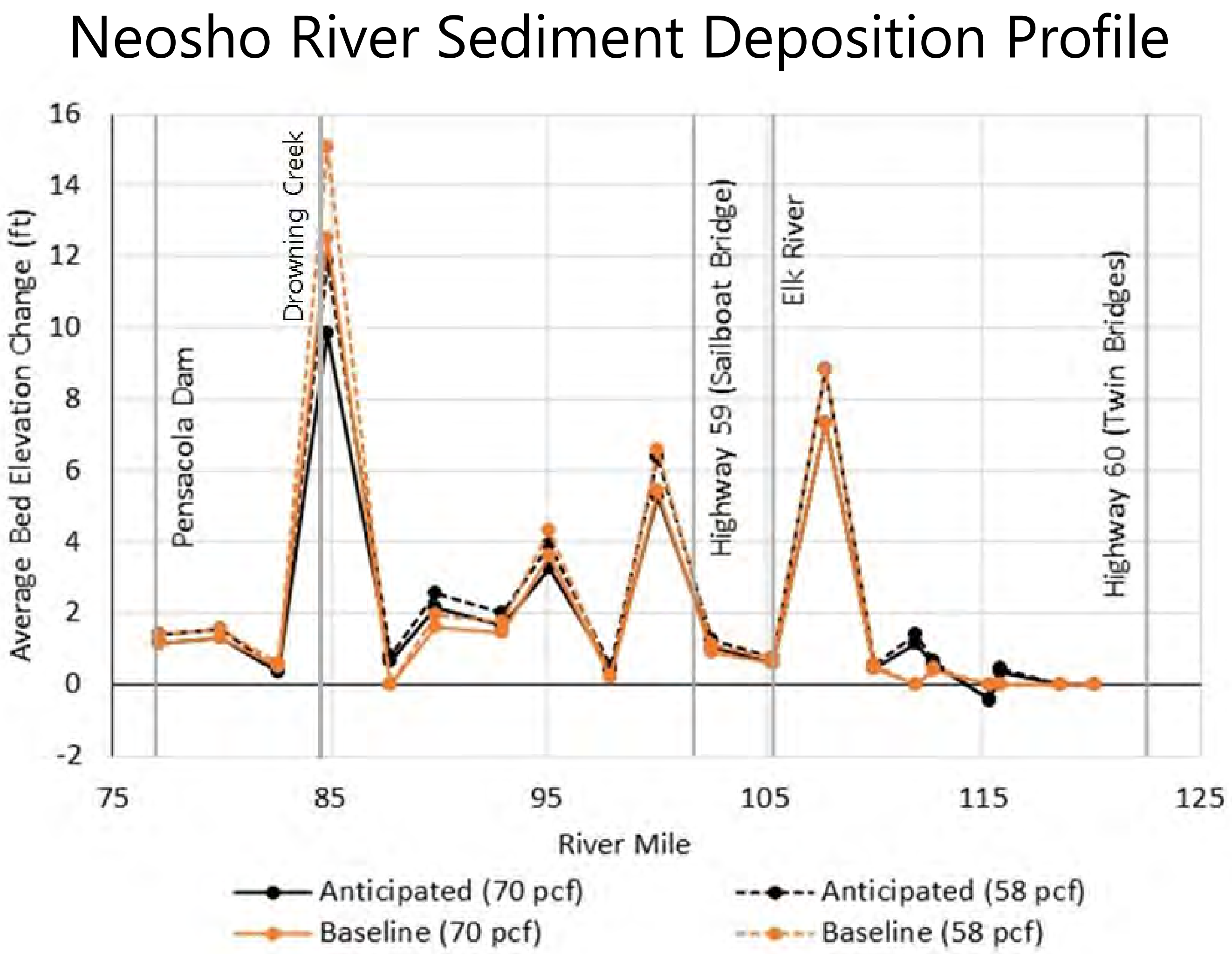


Percentage of Volume Passing – Future

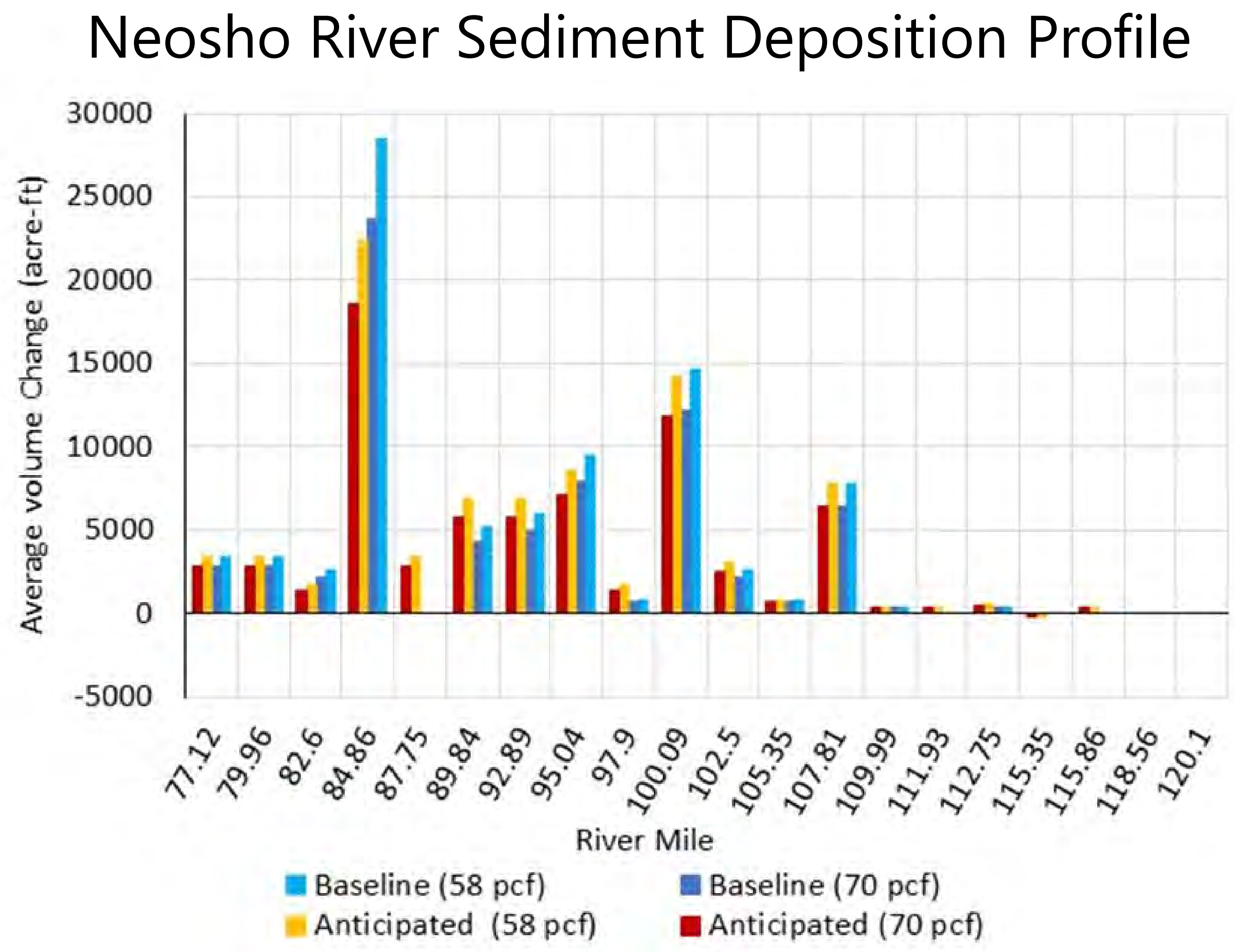
Neosho River Percent Sediment Passing Profile



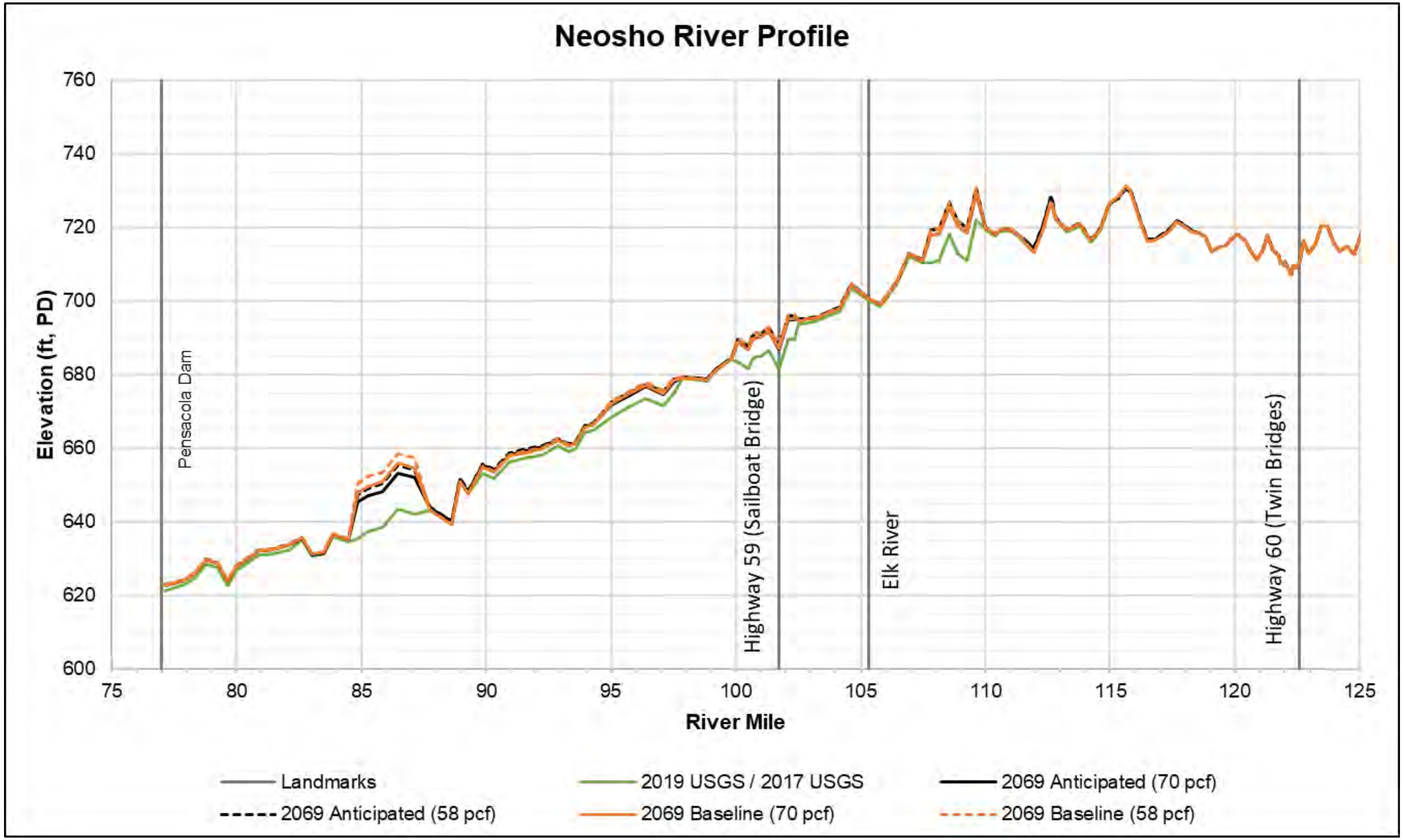
Average Bed Elevation Change



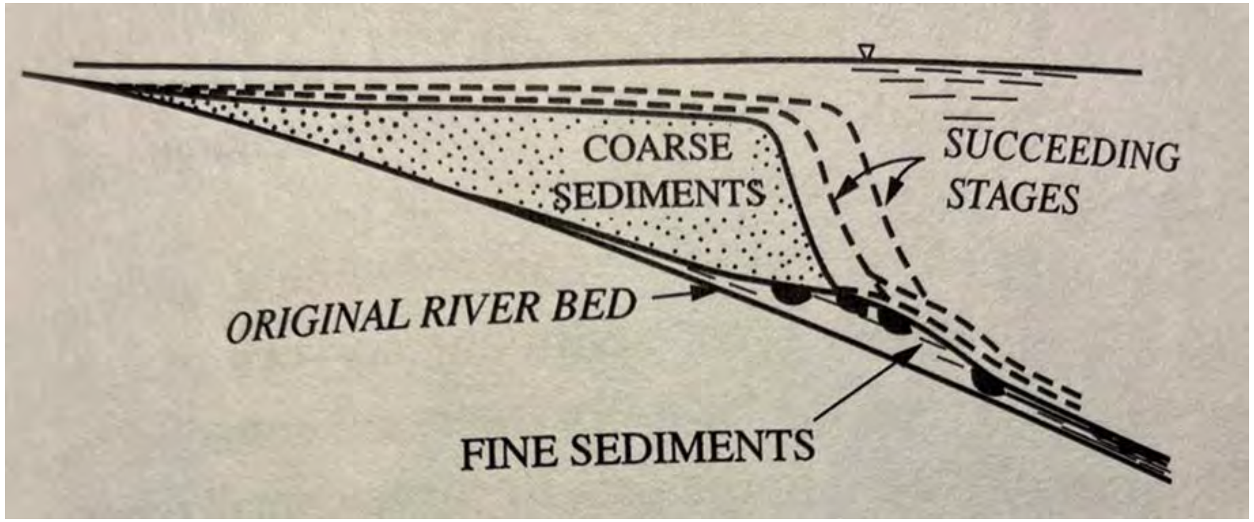
Average Bed Volume Change



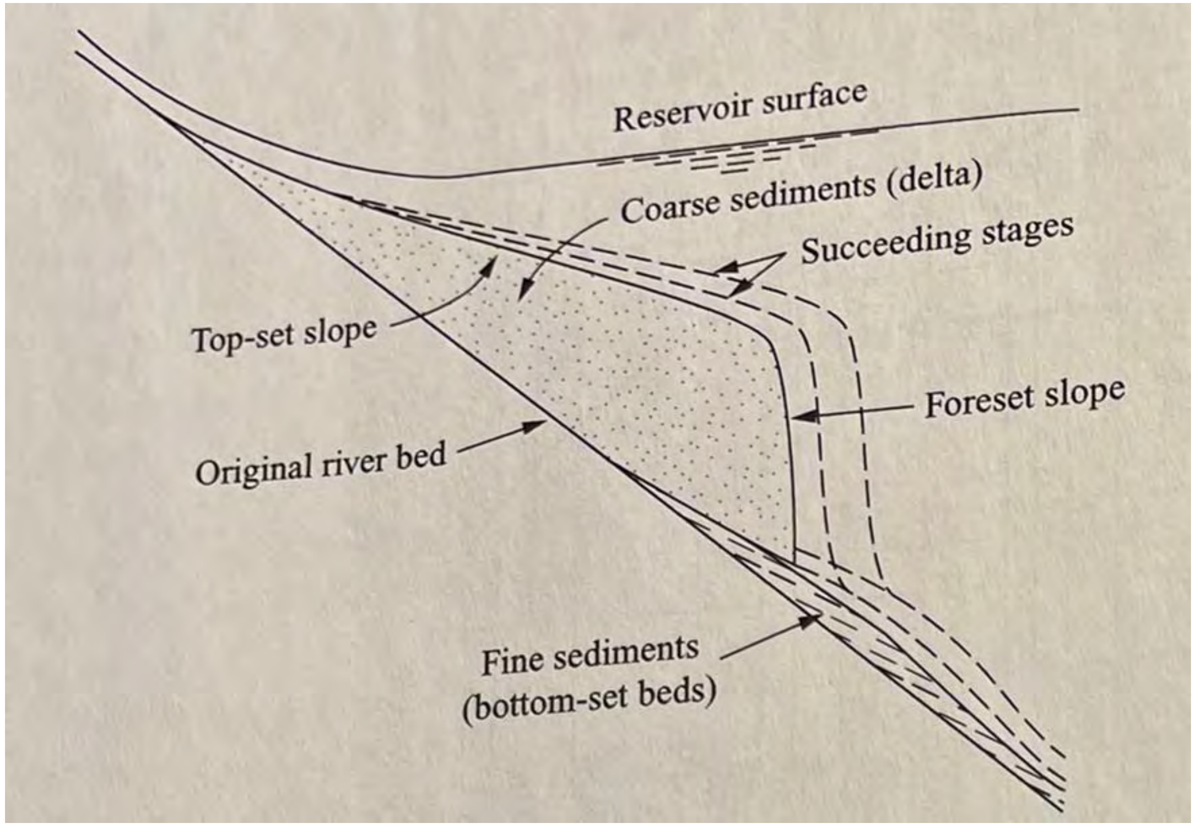
Thalweg Bed Elevation Profile



Delta Feature Evolution



Figures from Vanoni (2006)



Sediment Trapping Efficiency

John Redmond Reservoir

- Drainage area: 3,015 mi^2
- Years with complete records (2010, 2014 – 2019):
  - Trapping efficiency 82-94%; mean 89%
- Operations on sediment flushing (USGS study):
  - Operating at 1,039 ft NGVD29 led to 3% more effective reducing storage loss
  - Baseline was "higher flood pool" – top of pool is 1,068 ft NGVD29
  - Reducing WSE up to 29 ft resulted in 3% improvement

Sediment Trapping Efficiency

Grand Lake

- 68 miles long, capacity of 1.44M acre-ft (745 ft PD)
- Likely *higher* sediment trapping efficiency than John Redmond
  - John Redmond average of 89%
  - Grand Lake well above 90%

Quantitative Analysis - Conclusions

Summary

- 50 years of operation shows no significant deposition on top of delta feature
- Most of incoming load deposited on downstream face of feature
  - More than 98% of sediment transported past RM 110
  - Peak of delta feature at approximately RM 116 – near Sycamore Creek
- Top surface of delta feature in dynamic equilibrium
  - Matches scientific literature expectations
- No significant difference between *Baseline* and *Anticipated Operations*
- Approximately 76% of incoming sediment flows into reservoir during US Army Corps of Engineers control (WSE at or expected to rise above 745 ft PD)

STM Refinement and Calibration

STM Refinement & Calibration

Process Outline

- Hydraulic calibration
- Sediment calibration
- Validate sediment deposition results

Hydraulic Calibration

Circa-1940 Terrain

- USGS has discharge, but no stage records
- USGS no longer has gage station rating curves
- Manning's *n* values based on land use

Land Cover	n Value
Field crops	0.040
Pasture	0.080
Urban	0.070
Urban, dense	0.090
Water	0.040
Woody vegetation	0.100
Woody vegetation, dense	0.150

Hydraulic Calibration

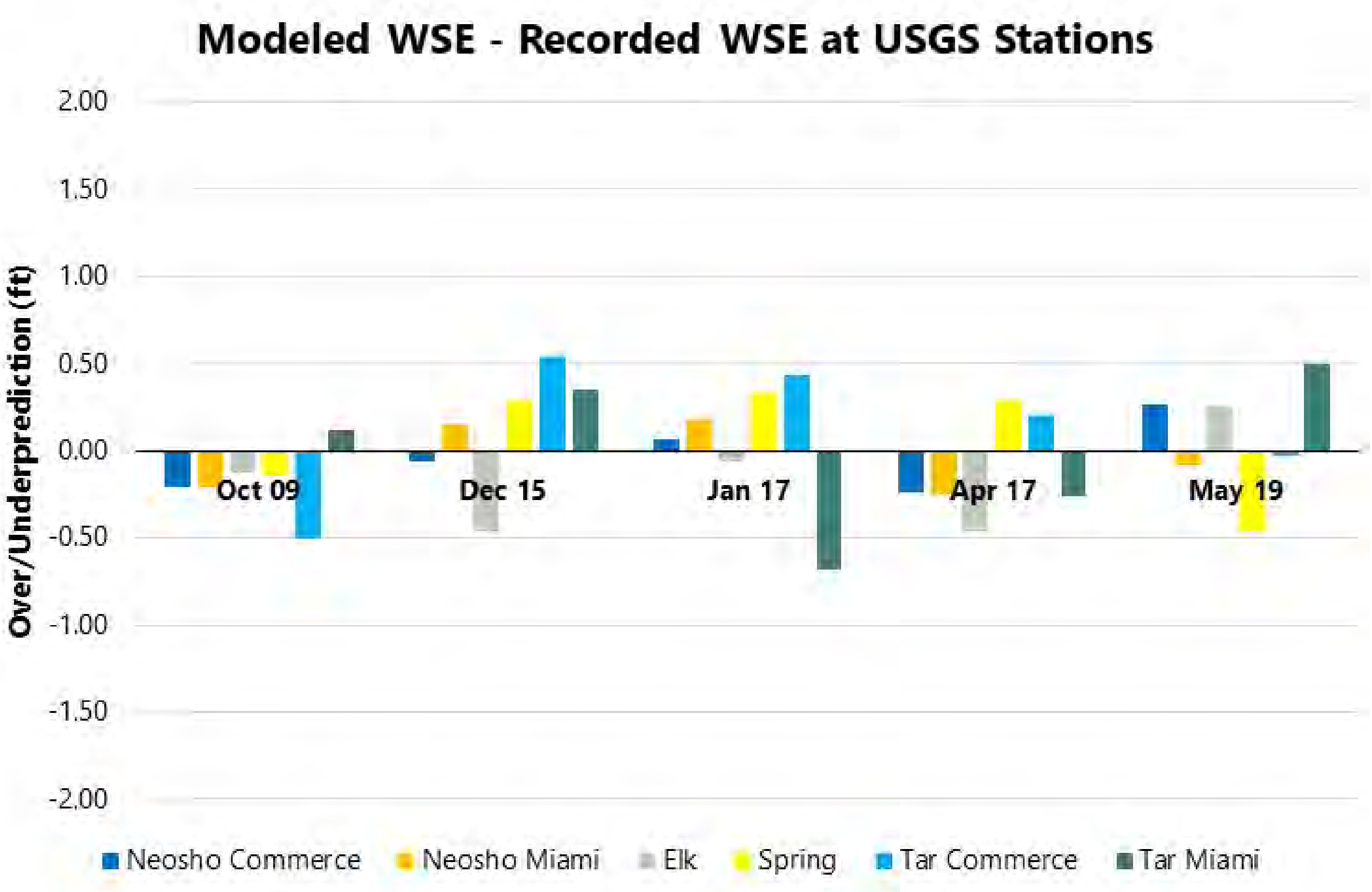
2019 Terrain

- Simulated with hard (non-erodible) bed for historical events
  - July 2007
  - October 2009
  - December 2015
  - January 2017
  - April 2017
  - May 2019
- Flow roughness factors adjusted to match peak WSE records

Hydraulic Calibration

2019 Terrain

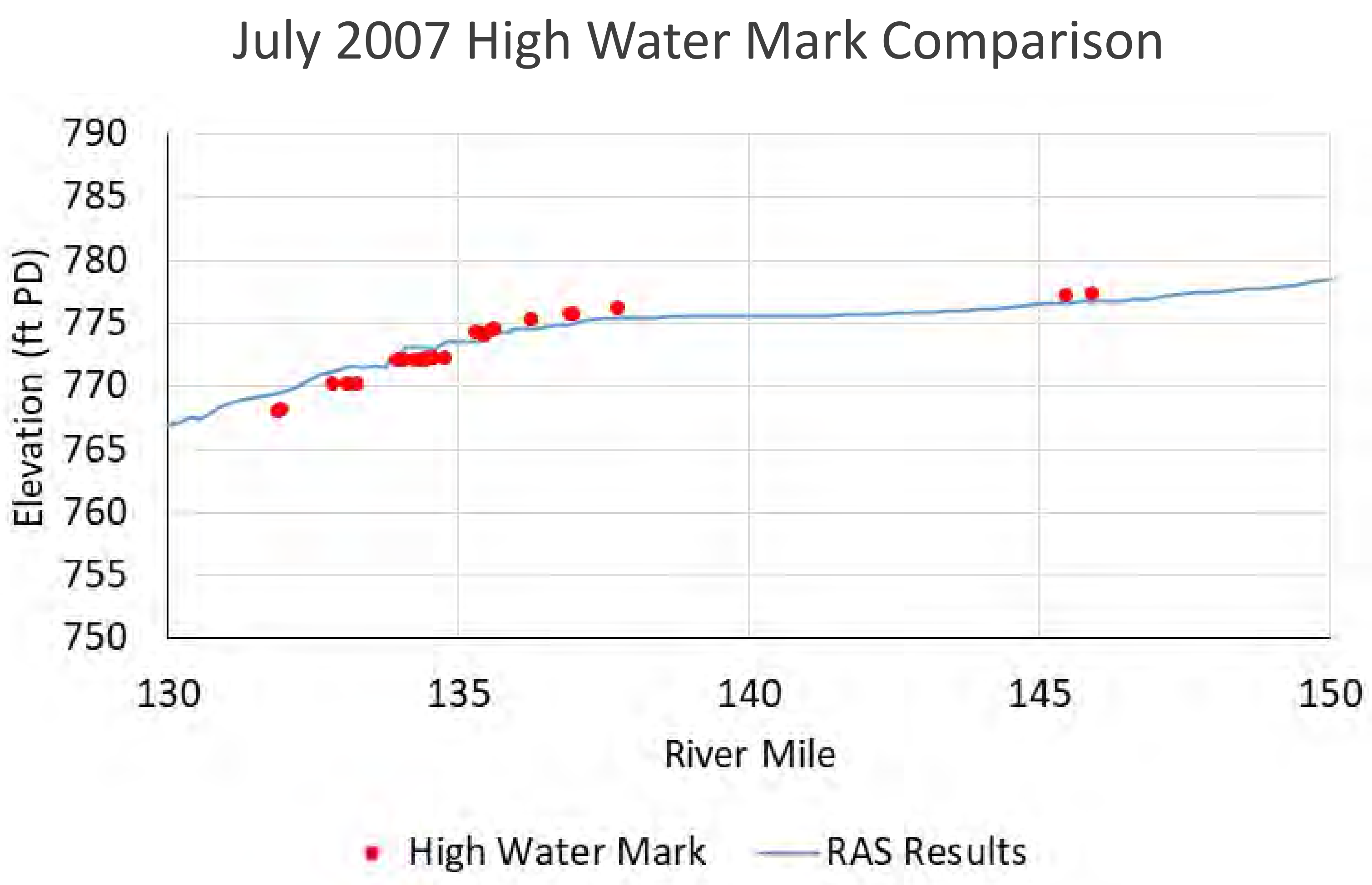
- USGS Gage comparison



Hydraulic Calibration

2019 Terrain

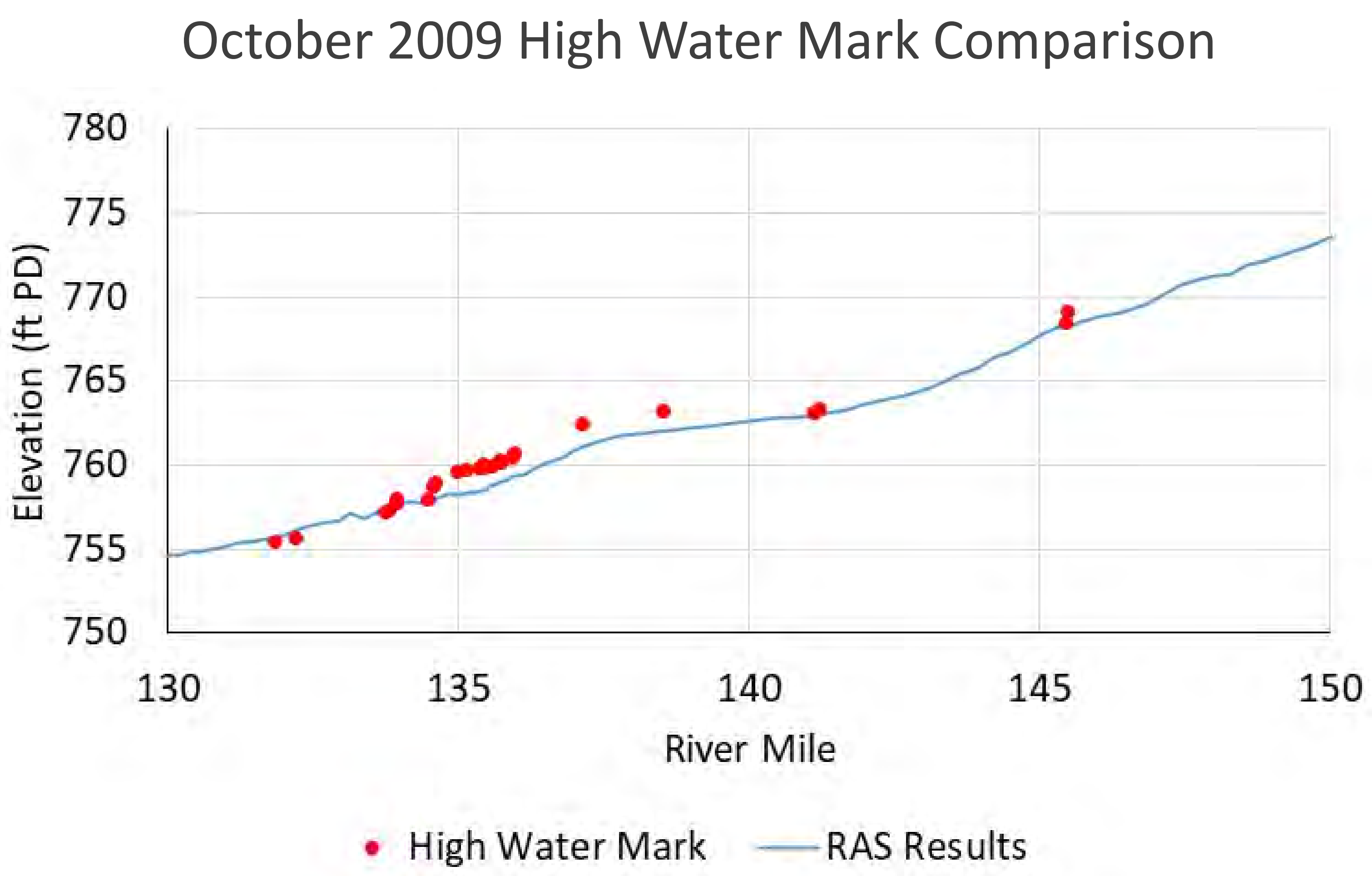
- High Water Marks



Hydraulic Calibration

2019 Terrain

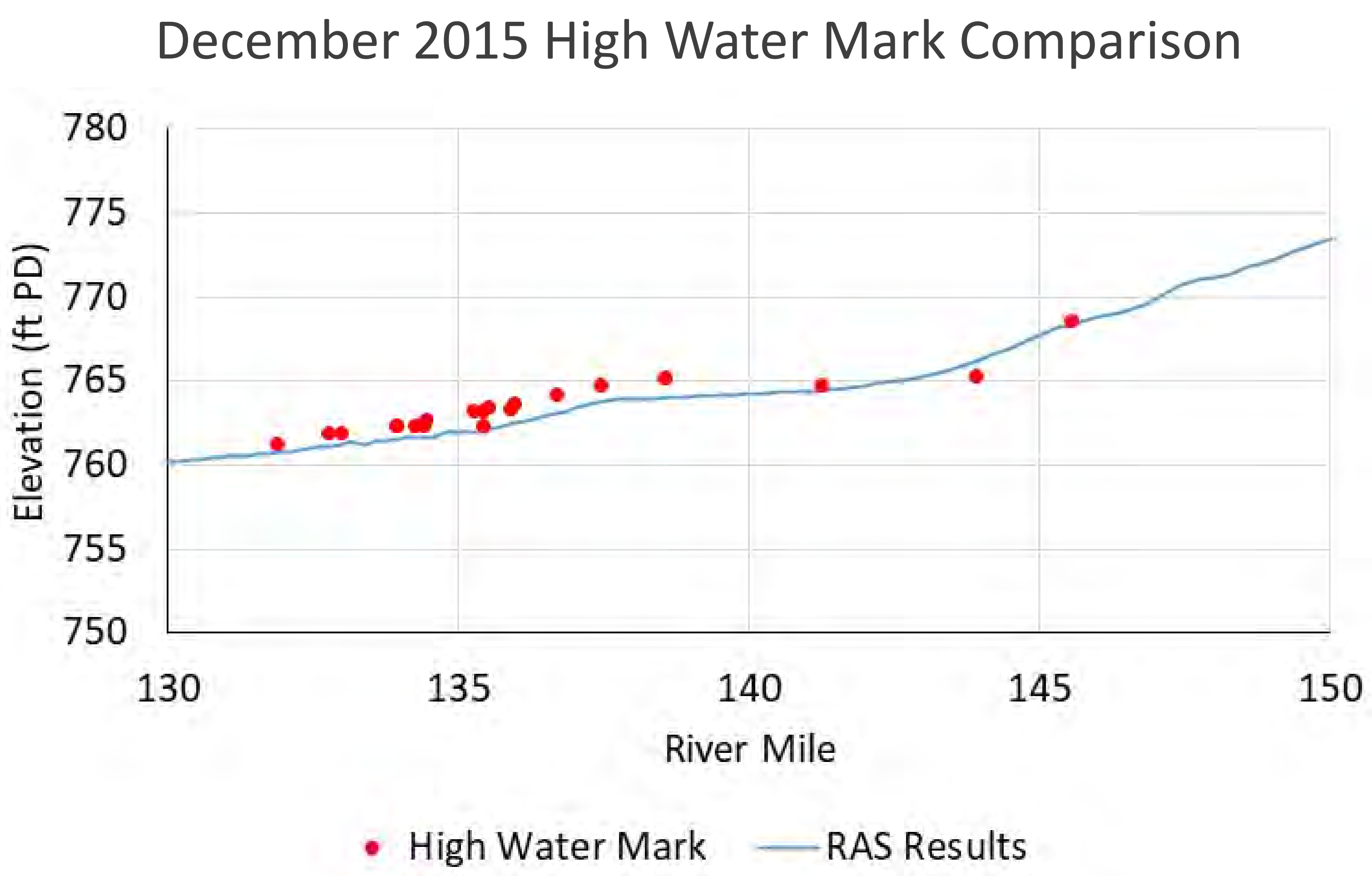
- High Water Marks



Hydraulic Calibration

2019 Terrain

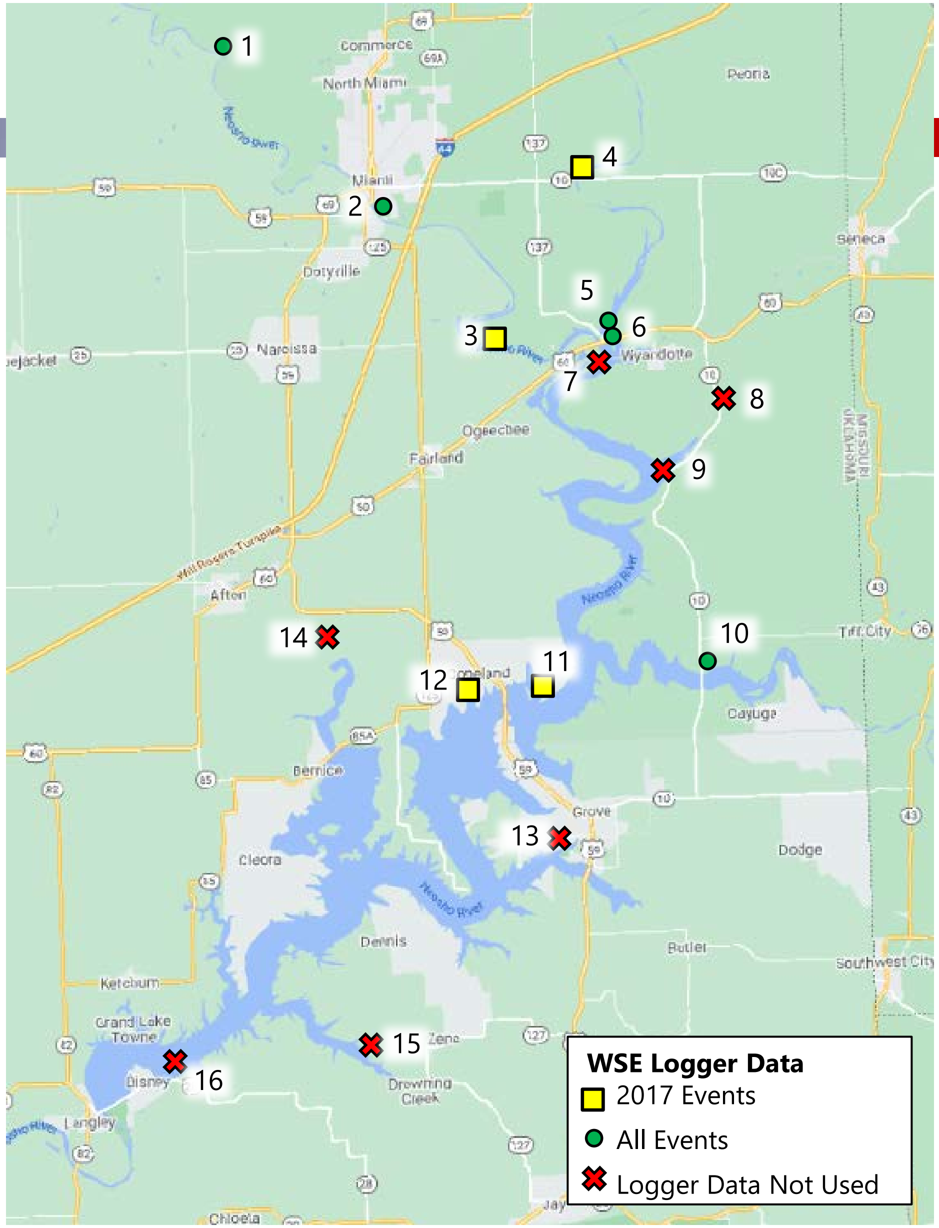
- High Water Marks



Hydraulic Calibration

2019 Terrain

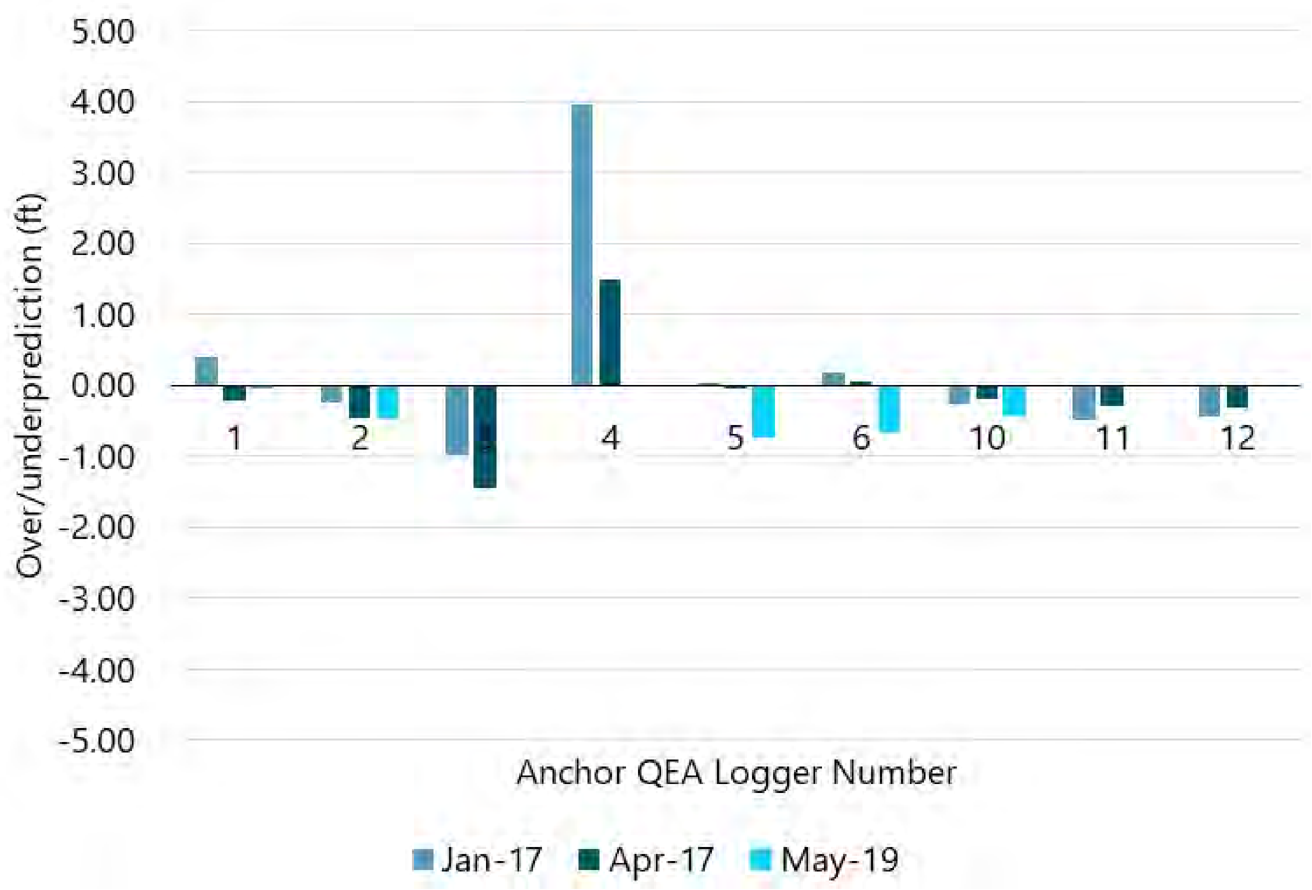
- Anchor QEA Loggers
  - Placed throughout study area



Hydraulic Calibration

2019 Terrain

- Anchor QEA Loggers



STM Refinement & Calibration

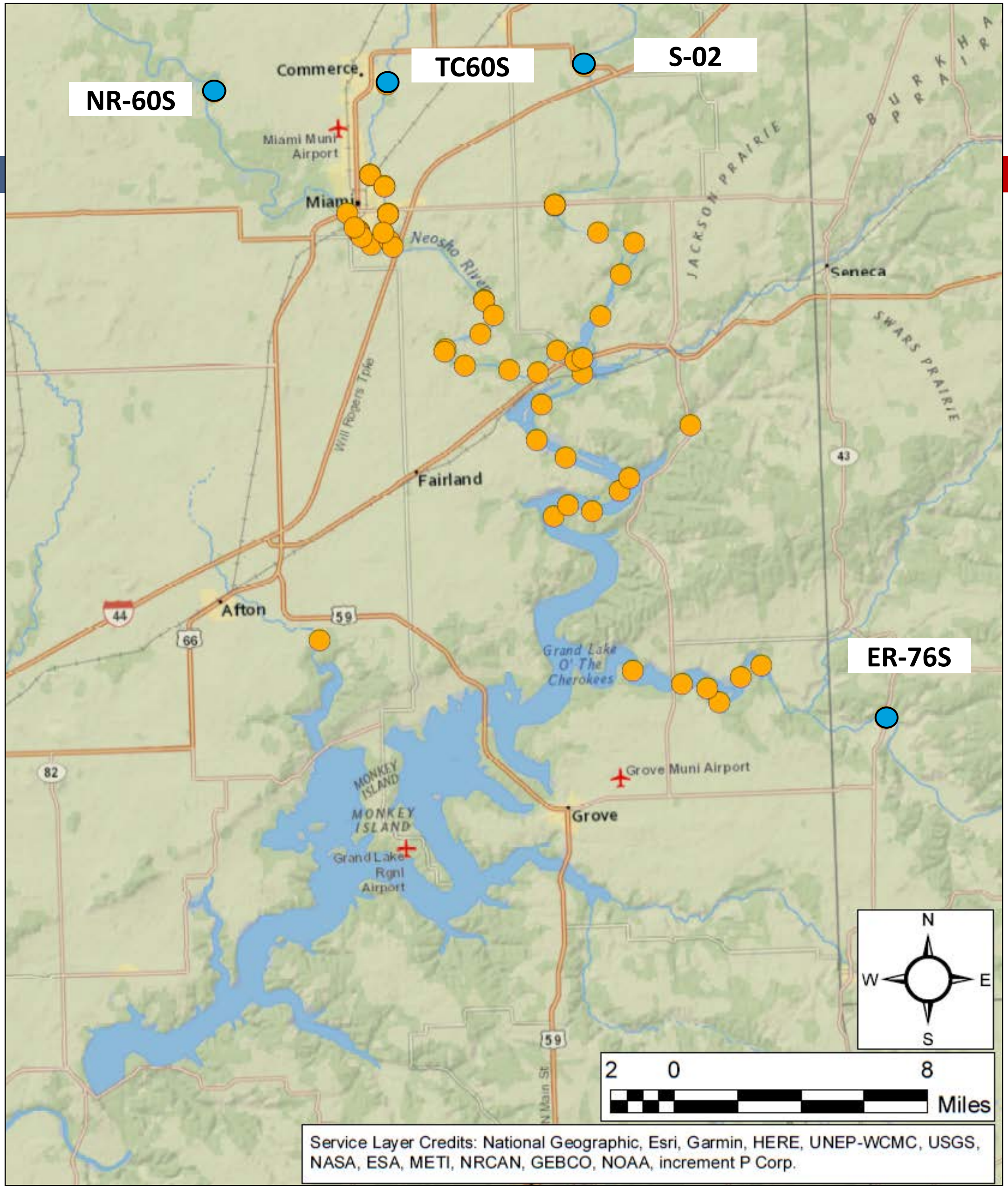
Process Outline

- Hydraulic calibration
- Sediment calibration
- Validate sediment deposition results

Sediment Calibration

Model Inputs

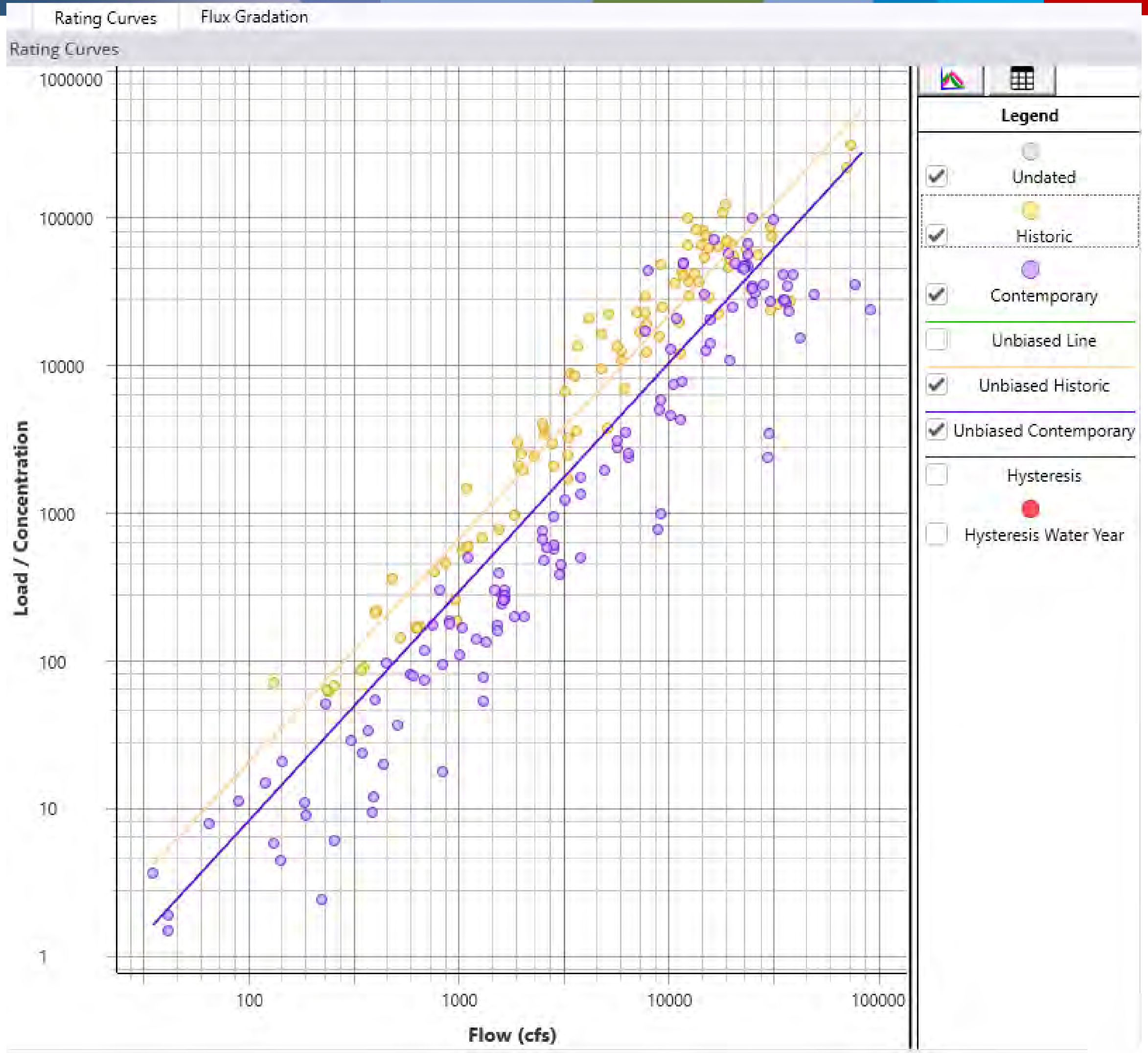
- USGS flow/storage data available from October 1942
  - Reservoir storage data converted to WSE through USGS curves
- Temperatures set to daily averages from Anchor QEA WSE monitoring
- Bed sediment set to most upstream sample



Sediment Calibration

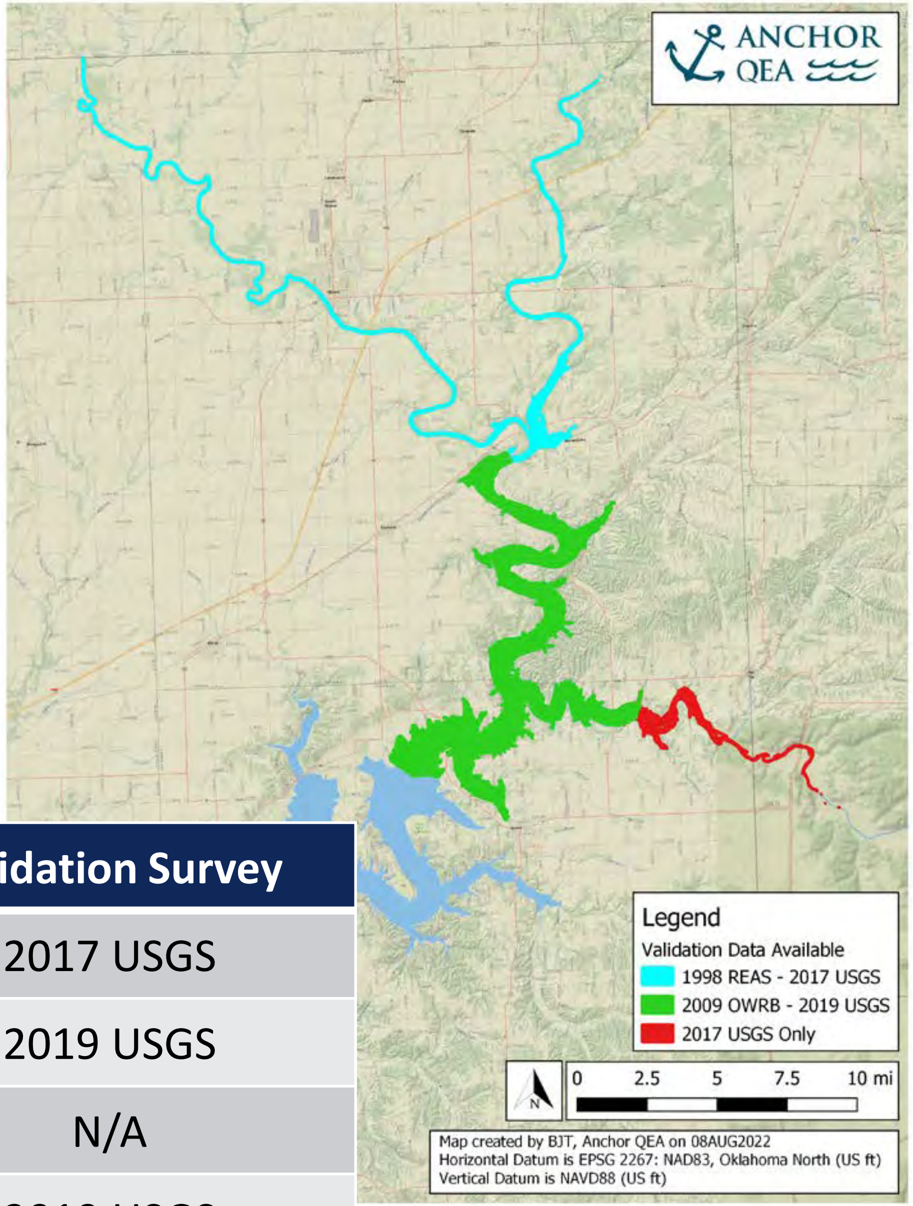
Model Inputs

- Inflowing sediment rating curves
  - Typically presented in form of $Q_{ss} = aQ^b$
  - Introduces bias
  - HEC-RAS Sediment Rating Curve Analysis Tool to remove bias using Duan (1983) method
- Grain size distributions adapted from transport sampling results



Calibration Parameters

- Start with circa-1940 data
- Calibrate to first reliable survey
- Validate with most recent reliable survey



Reach	Starting Survey	Calibration Survey	Validation Survey
Upper (Above RM 120.1)	Circa-1940 USACE	Circa-1998 REAS	2017 USGS
Lower (RM 120.1–RM 100)	Circa-1940 USACE	2009 OWRB	2019 USGS
Elk River (Above RM 5.47)	Circa-1940 USACE	2017 USGS	N/A
Reservoir (Below RM 100)	Circa-1940 USACE	2009 OWRB*	2019 USGS

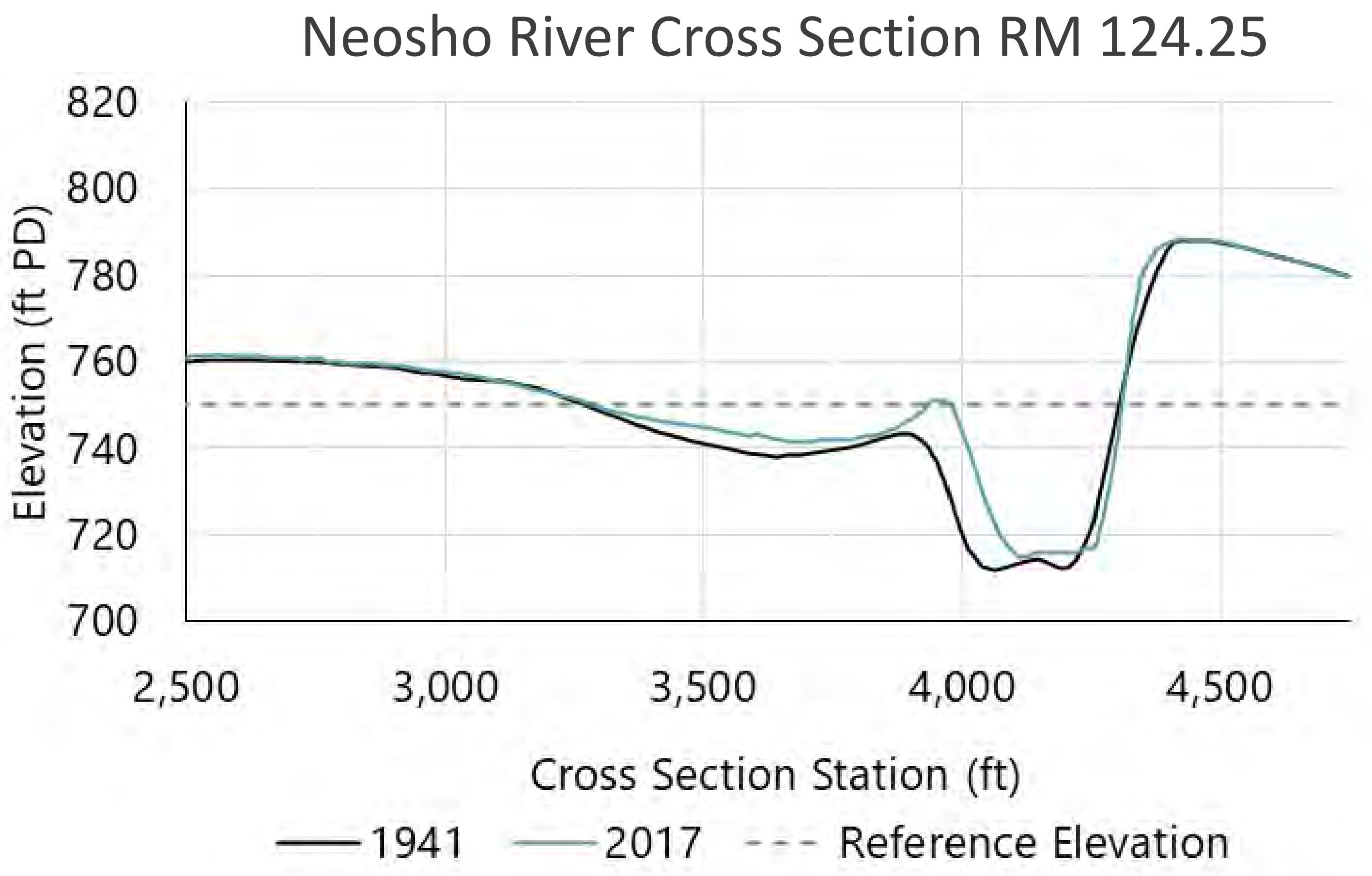
Calibration Parameters

- Planned to use 2009 data for analysis below RM 100
- Sedimentation rates from 1940 to 2009 were implausibly different than 2009 to 2019
- Deposition assessment from circa-1940 to 2019 instead

Deposition Measurements

Measured Changes

- Compare circa-1940 cross sections with modern geometry
  - Select reference elevation
  - Change in area
  - Calculate volume change



Calibration Metrics

Modeled Deposition

- Converted from mass to volume using specific weight of 58 lb/ft^3
- Compared volume change between surveys to model outputs
  - Nash-Sutcliffe Efficiency (NSE)
  - Percent Bias (PBIAS)
  - RMSE-Observations Standard Deviation Ratio (RSR)

Calibration Metrics

Calibration Evaluation

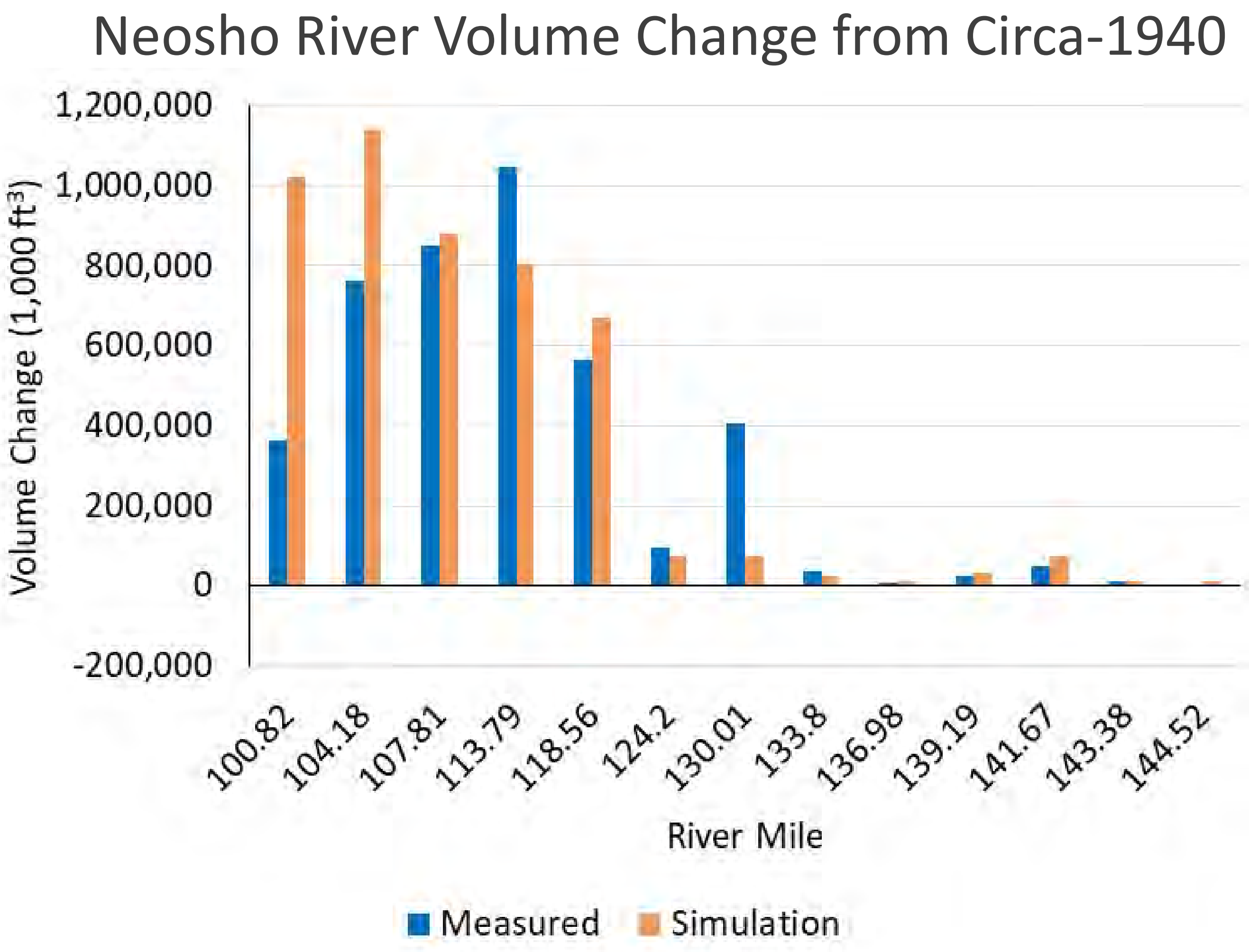
- Moriasi et al. (2007) provides guidance for sediment transport evaluations

Model Performance	NSE	PBIAS	RSR
Very Good	0.75 < NSE ≤ 1.00	|PBIAS| < 15	0.00 ≤ NSE ≤ 0.50
Good	0.65 < NSE ≤ 0.75	15 ≤ |PBIAS| < 30	0.50 ≤ NSE ≤ 0.60
Satisfactory	0.50 < NSE ≤ 0.65	30 ≤ |PBIAS| < 55	0.60 ≤ NSE ≤ 0.70
Unsatisfactory	NSE ≤ 0.50	|PBIAS| ≥ 55	RSR > 0.70

Calibration Results

Simulated Deposition

- Overpredicts deposition on downstream face of delta feature
  - Model results above RM 120.1 are compared to 1998 REAS data
  - Model results below RM 120.1 are compared to 2009 OWRB data



Calibration Results

Simulated Deposition

- Evaluation of model results shows good agreement with measured results

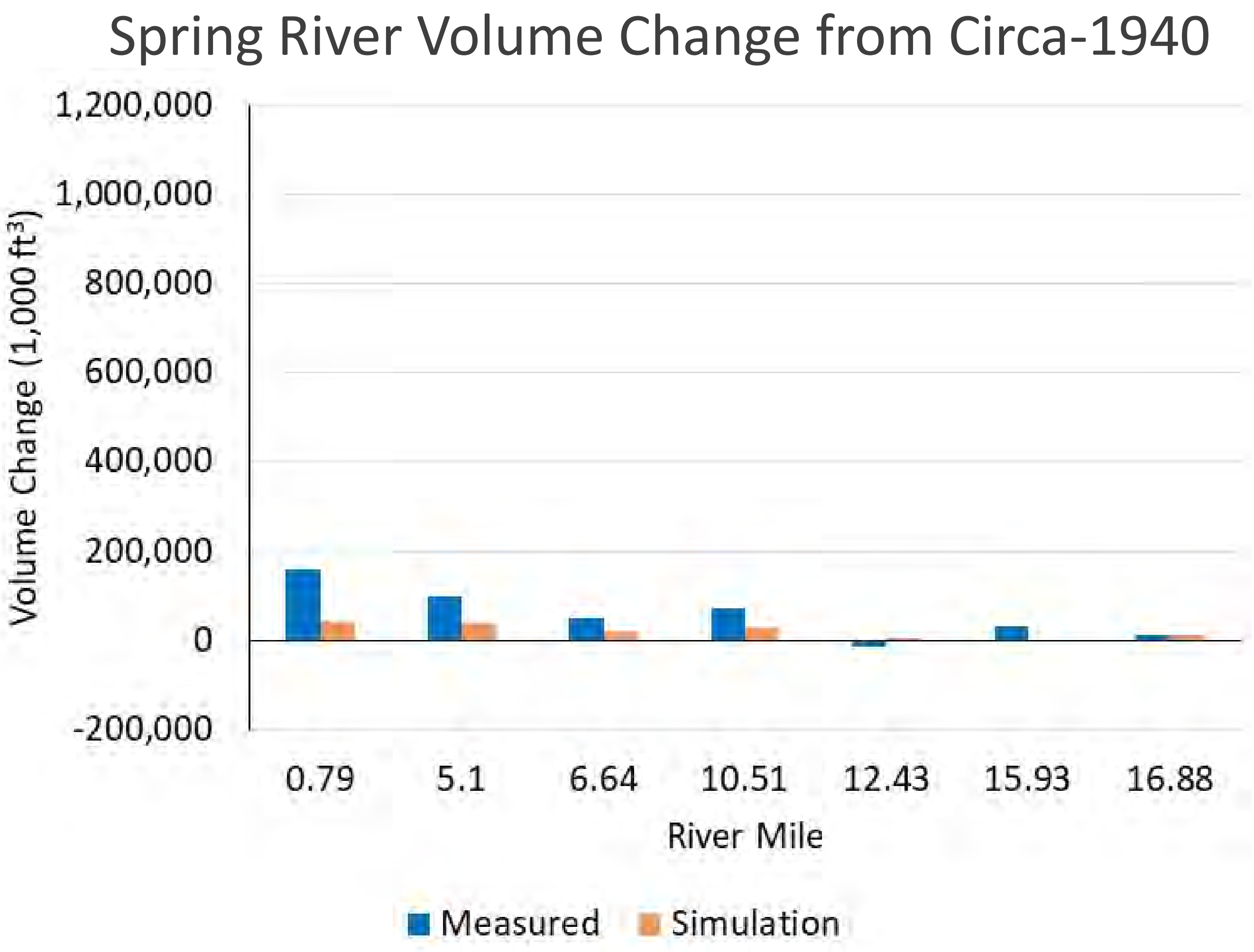
Neosho River Volume Change from Circa-1940

Reach	NSE (Target: > 0.5)	PBIAS (|Target|: < 0.55)	RSR (Target: < 0.70)
All Locations	-0.94	0.19	0.69
Excluding RM 130.01, 104.18, 100.82	0.95	0.01	0.22

Calibration Results

Simulated Deposition

- Spring River

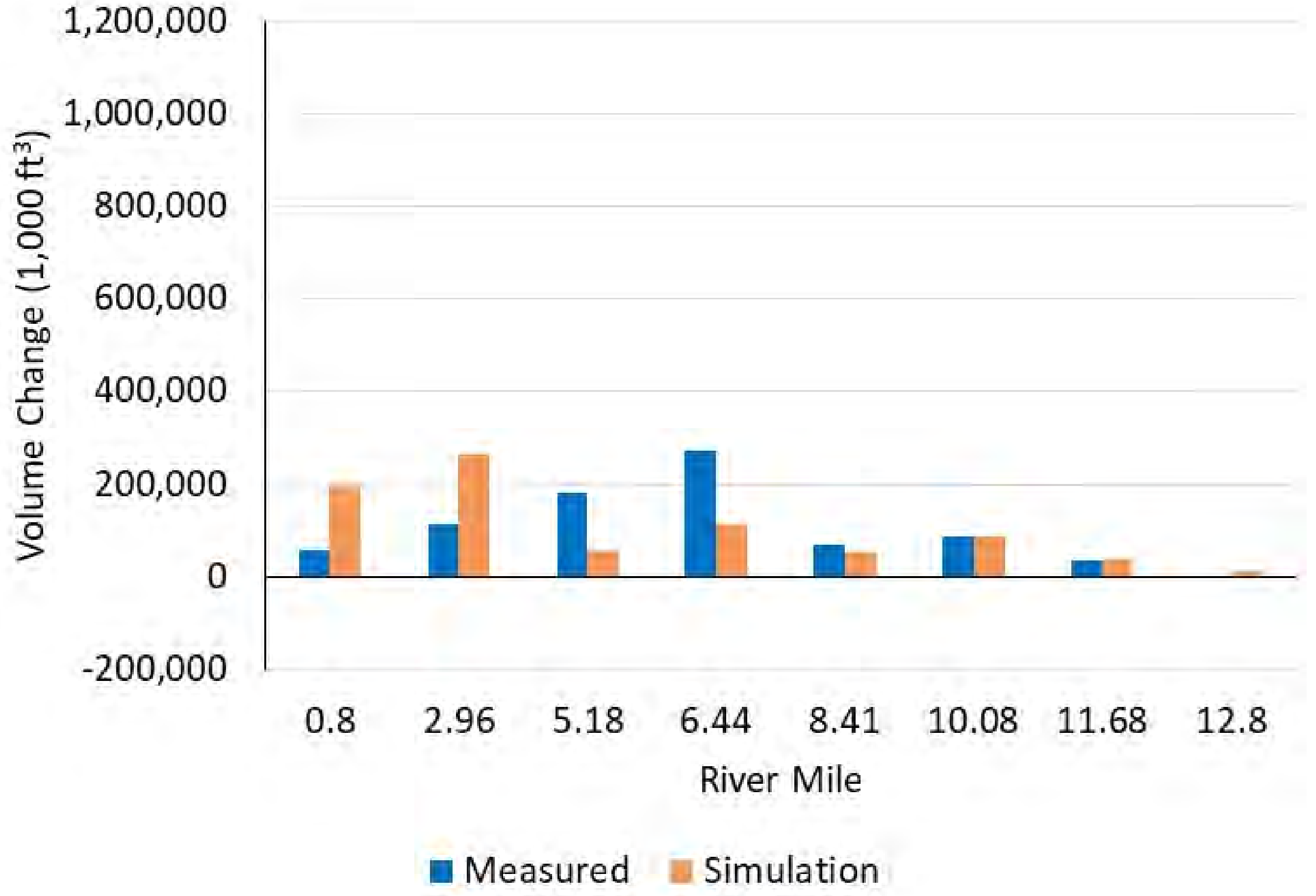


Calibration Results

Simulated Deposition

- Spring River
- Elk River

Elk River Volume Change from Circa-1940



Calibration Results

Simulated Deposition

- These rivers have least reliable cross section survey placement
  - Neosho cross sections placed with bridges as reference points
  - No bridges to locate Spring or Elk River cross section survey data

Spring and Elk River Volume Change from Circa-1940

Reach	NSE (Target: > 0.5)	PBIAS (|Target|: < 0.55)	RSR (Target: < 0.70)
Spring River	0.04	-0.62	0.98
Elk River	-0.55	0.03	1.24

STM Refinement & Calibration

Process Outline

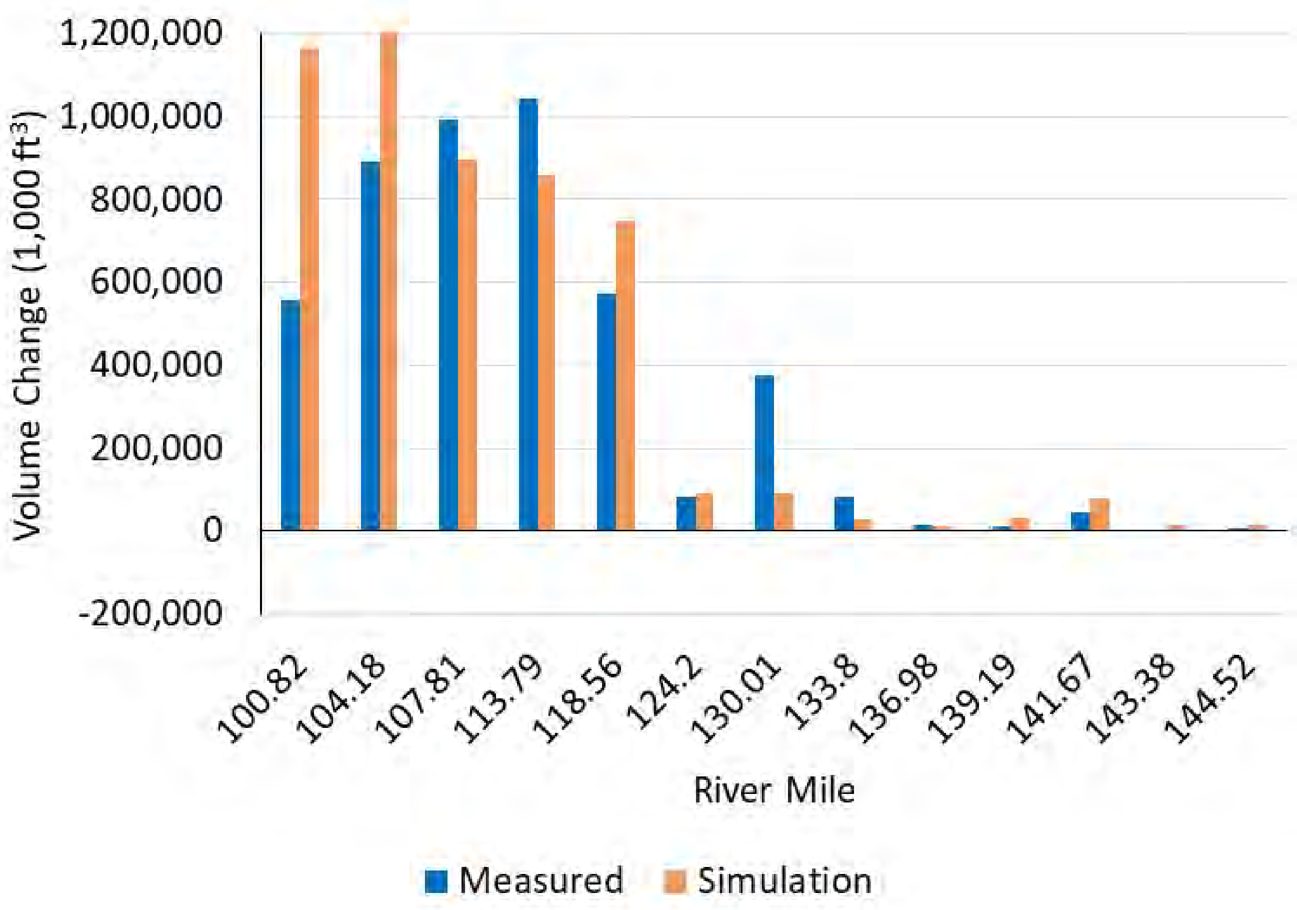
- Hydraulic calibration
- Sediment calibration
- Validate sediment deposition results

Validation Results

Simulated Deposition

- Overpredicts deposition on downstream face of delta feature
  - Model results above RM 120.1 are compared to 2017 USGS data
  - Model results below REM 120.1 are compared to 2019 USGS data

Neosho River Volume Change from Circa-1940



Validation Results

Simulated Deposition

- Evaluation of model results shows good agreement with measured results

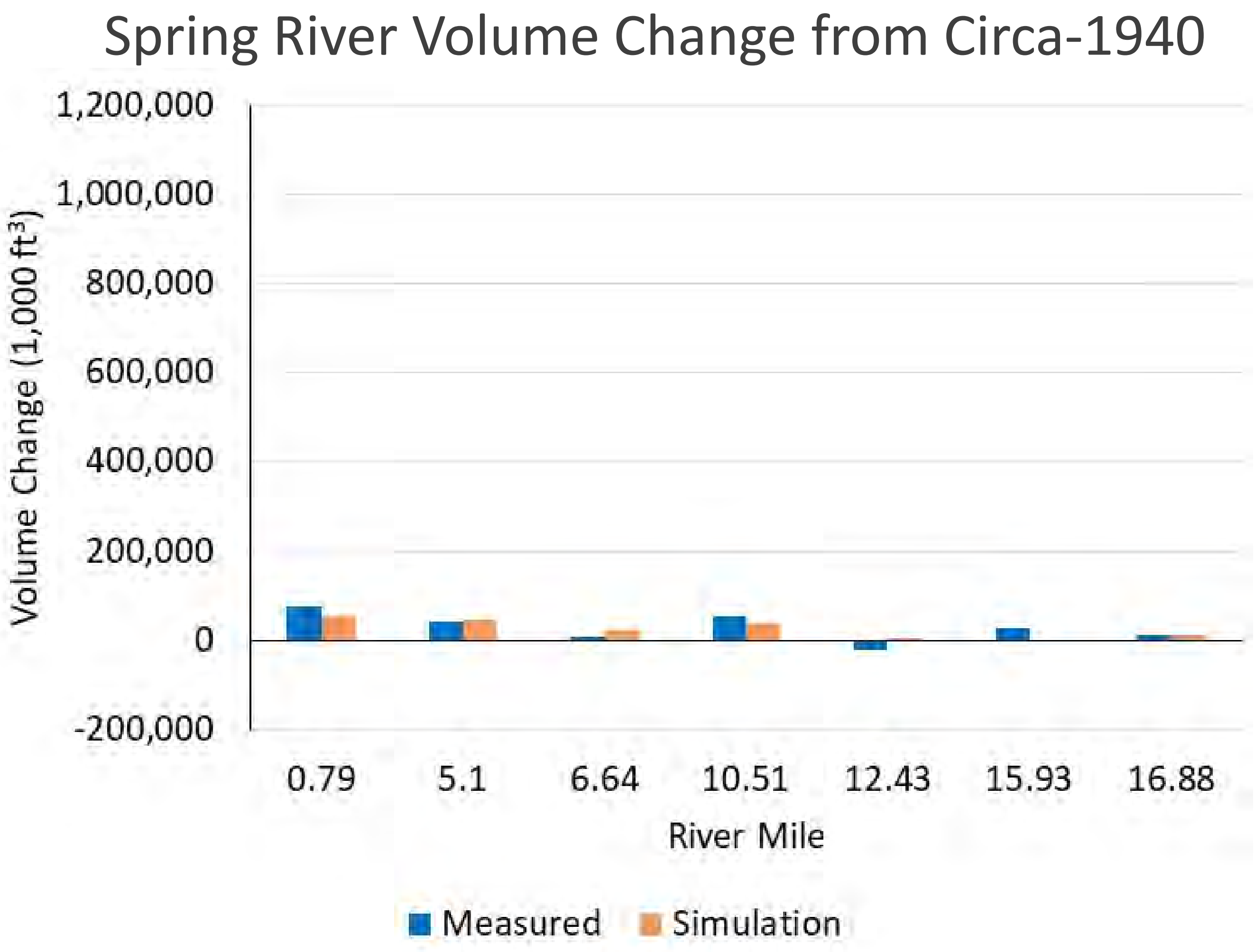
Neosho River Volume Change from Circa-1940

Reach	NSE (Target: > 0.5)	PBIAS (|Target|: < 0.55)	RSR (Target: < 0.70)
All Locations	-0.64	0.25	0.69
Excluding RM 130.01, 104.18, 100.82	0.80	0.13	0.44

Validation Results

Simulated Deposition

- Spring River

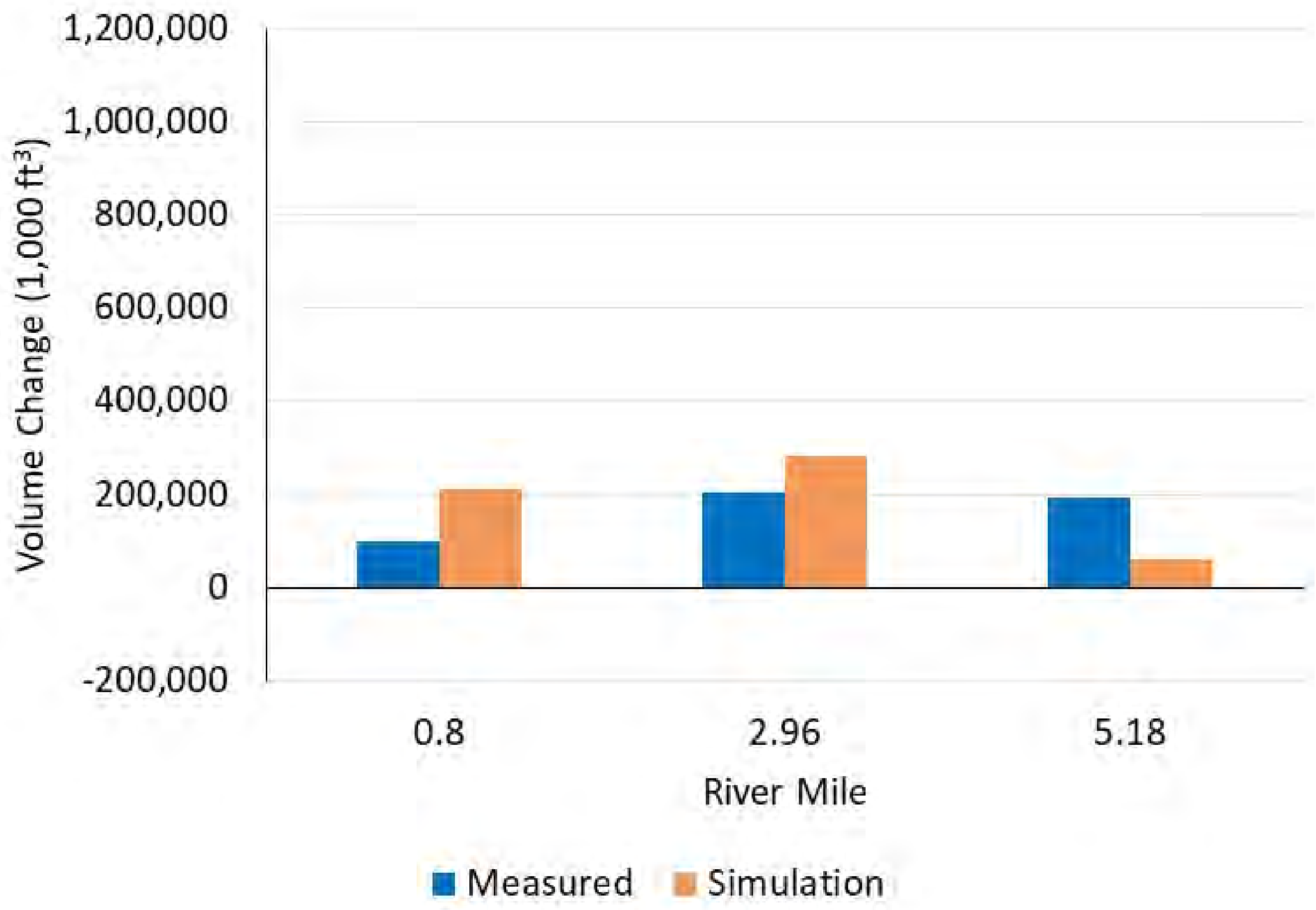


Validation Results

Simulated Deposition

- Spring River
- Elk River
  - No validation survey available above RM 5.46

Elk River Volume Change from Circa-1940



Validation Results

Simulated Deposition

- Similar results to calibration

Spring and Elk River Volume Change from Circa-1940

Reach	NSE (Target: > 0.5)	PBIAS (|Target|: < 0.55)	RSR (Target: < 0.70)
Spring River	0.62	-0.09	0.62
Elk River	0.08	-0.04	0.98

Validation Results

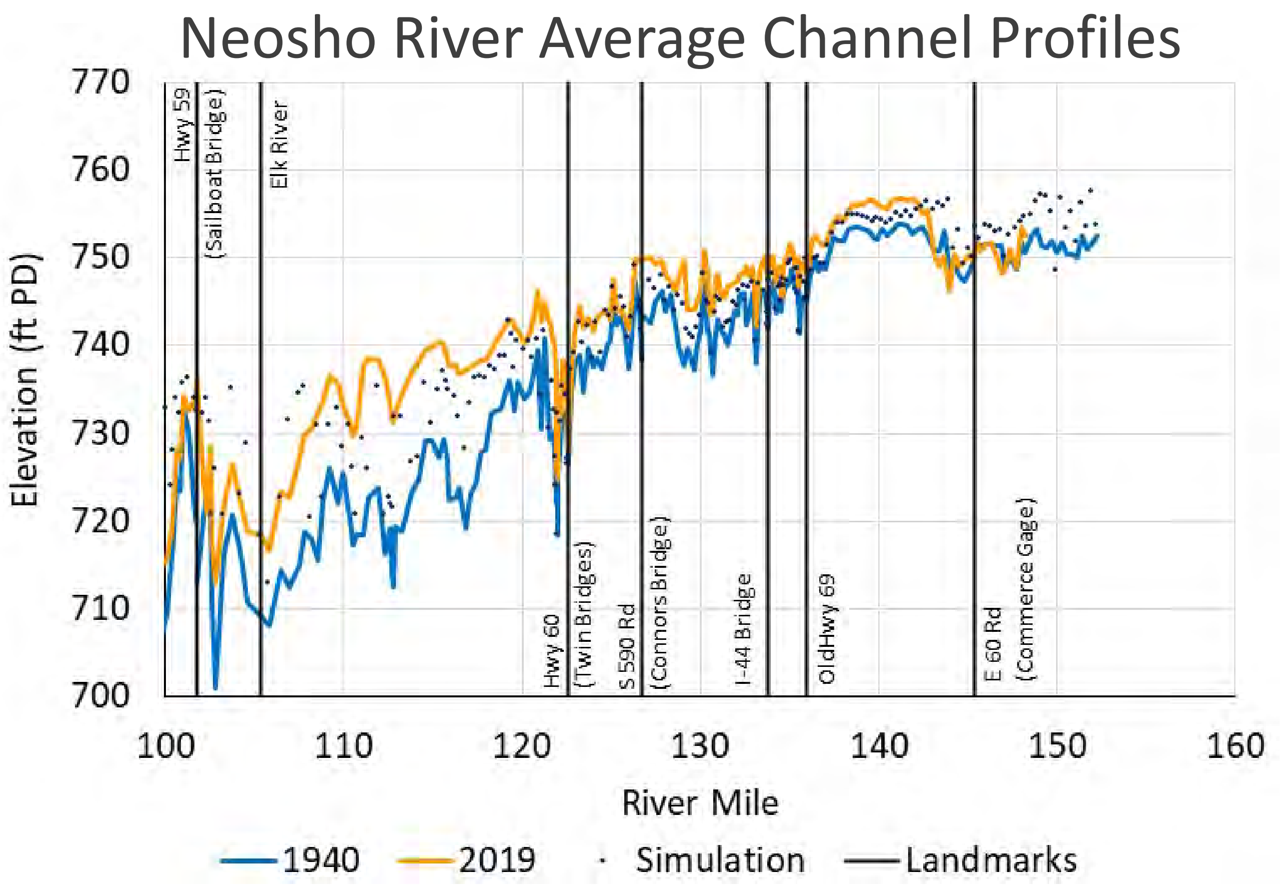
Average Channel & Section

- Other metrics to evaluate model accuracy
  - Provides more information than simple thalweg profiles

Validation Results

Average Channel & Section

- Neosho River average channel: -1.2 ft
- Neosho River average section: -1.8 ft
- Largely impacted by quality of circa-1940 data
  - Poorly-scanned topographic maps, 5 ft contours
  - Limited cross-section survey data



Calibration/Validation Discussion

HEC-RAS Results

- HEC-RAS can provide volume changes at ***all*** cross sections (1940 and 2019)
  - Indicates ~53,700 acre-feet of deposition from RM 145.4 to Spring River
- At locations of ***measured*** cross sections, model shows better agreement
  - Indicates ~18,500 acre-feet of deposition from RM 145.4 to Spring River
  - Approximately 1/3 HEC-RAS volume
  - Model predicts ~ 15,300 acre-feet in this reach
- Largely impacted by quality of circa-1940 data
  - Unsurveyed portions of channels far wider than shown in 2019 data
  - Data in unsurveyed locations is far less reliable

50-Year Future Simulations

Predictive Simulations

Analyses

- Future *Anticipated Operations* vs existing conditions
- Sediment Sensitivity Evaluation
  - Available datasets from 1940 have high levels of uncertainty, but best available
  - Calibration/validation only as good as those data points
  - Sediment sensitivity analysis done to bound potential range of deposition
- Future *Anticipated Operations* vs Future *Baseline Operations*

Future Conditions Analysis

Evaluate Effects of Sedimentation

- Start with 2019 terrain
- Simulate 50 years of flow & sediment input in STM
- Export resulting geometry to 1D Upstream Hydraulic Model (1D UHM)
  - Distinct from both UHM discussed during H&H presentation and the STM
- Run fully unsteady July 2007 and synthetic 100-year event in 1D UHM
  - Starting reservoir pool at 740, 745, and 750 feet PD
- Evaluate water level impacts

Inflow Inputs

Inflow Analysis

- Use last 50 years of flow data from relevant tributaries
- Evaluate whether there is trend
  - No significant temporal trend identified
- Randomize annual flows for future timeframe
- Water temperature set to daily mean

Inflow Inputs

Reservoir Operations

- Pass data through Operations Model (OM)
  - Reservoir WSE outputs used for STM boundary conditions
- Run STM for 50-year simulation
  - Update stage-storage tables, compare to previous
- Pass data back through OM
  - Update outputs, compare to previous
- Iterate above process as needed

Sediment Inputs

Bed Sediment

- Parameterized based on field samples
  - Grab & core sampling
  - SEDflume erosion analysis

Inflowing Sediment

- Used same rating curves as calibration
  - These are conservative
  - Stationarity analyses suggest future loads will be smaller
    - John Redmond Dam
    - Land use
    - Sediment erosion best management practices (no-till, cover crops, etc.)

Stage-Storage Calculations

Modeled Reaches

- HEC-RAS stage-storage outputs

Stage-Storage Calculations

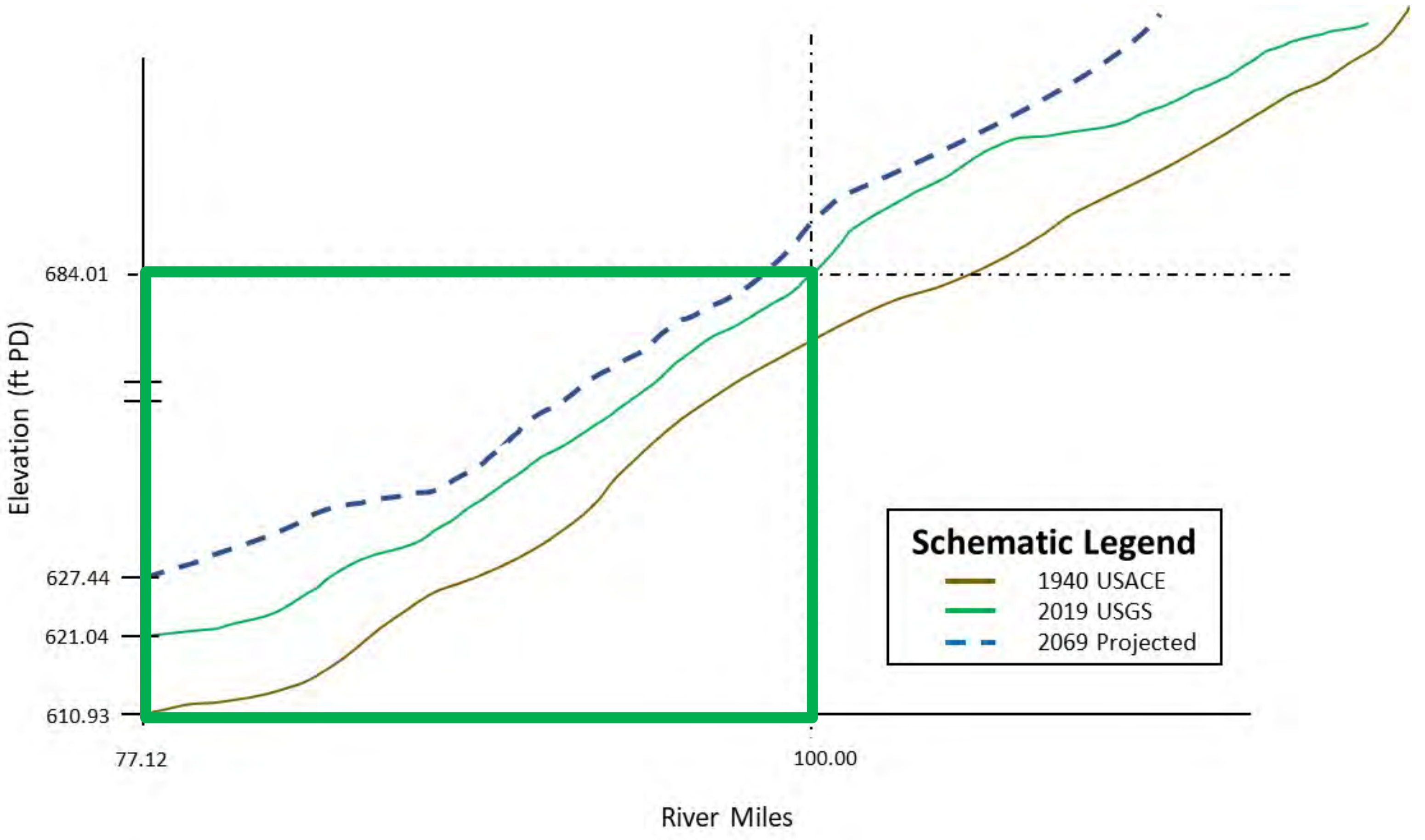
Below RM 100

- Historical information
  - Long-term deposition 1940-2019 at base of Pensacola dam: 0.13 feet/year
    - Assume similar rate for future scenarios
  - Total change in storage of 319,473 acre-feet
- Calibration model outputs
  - Total sediment inflow of 402,733 acre-feet
    - Trap efficiency of ~0.8
  - 166,500 acre-feet deposited in modeled reach
    - 152,982 acre-feet deposited below RM 100

Stage-Storage Calculations

Below RM 100

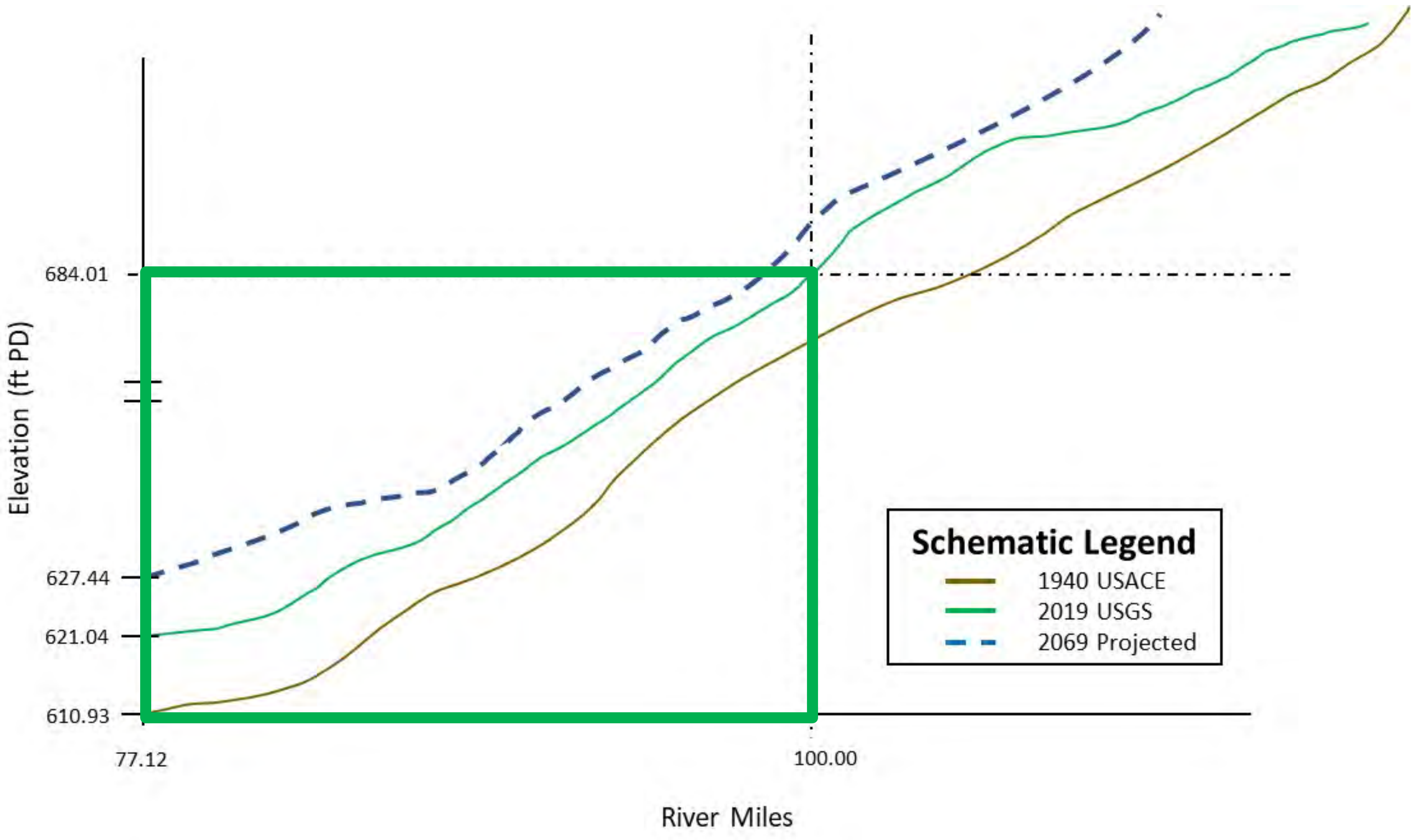
- 2019 elevation of 684.01 ft PD
  - Everything below that deposited downstream of RM 100
  - Measured 1940-2019 deposition 69,926 acre-feet



Stage-Storage Calculations

Below RM 100

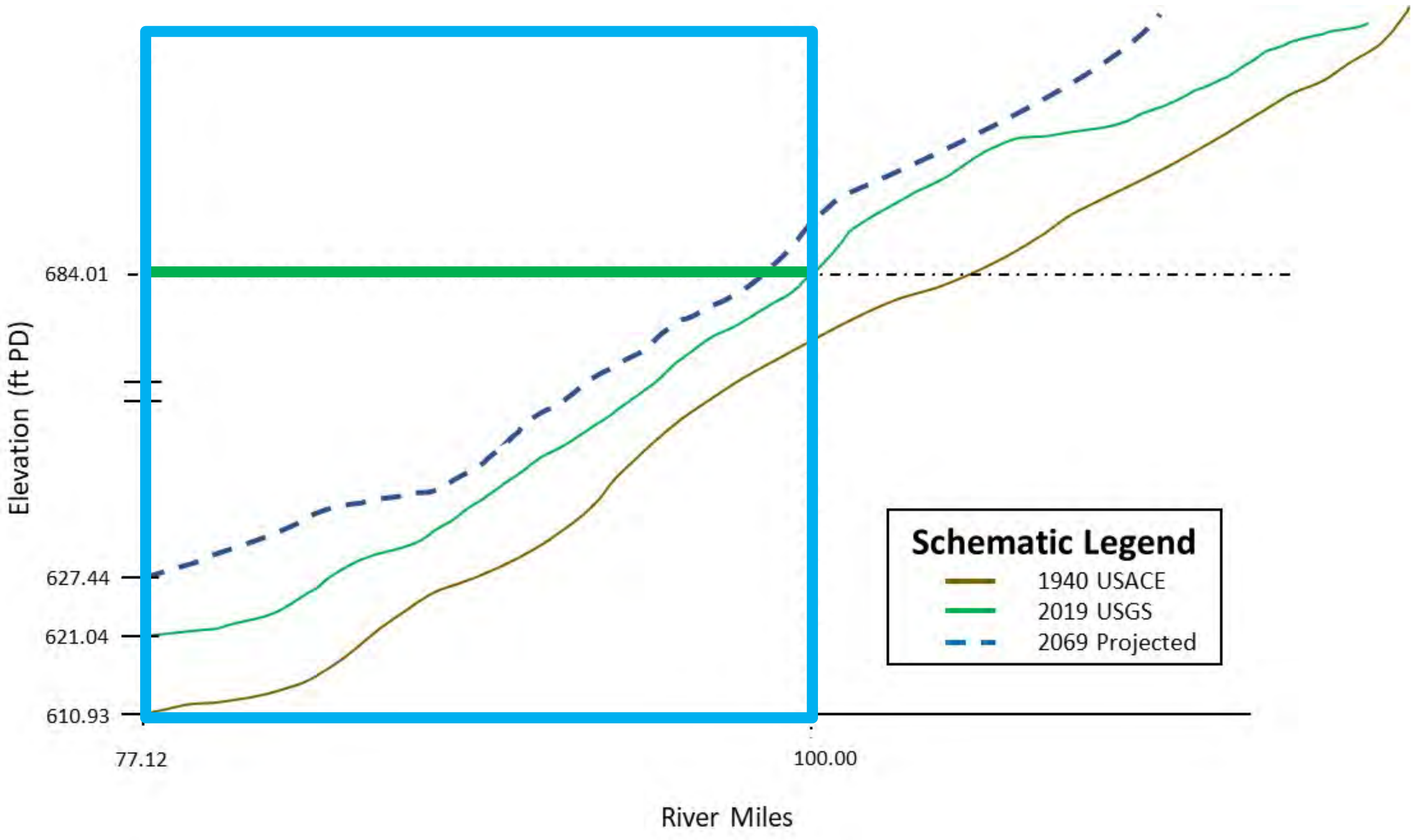
- Measured 69,926 acre-feet in **green box**



Stage-Storage Calculations

Below RM 100

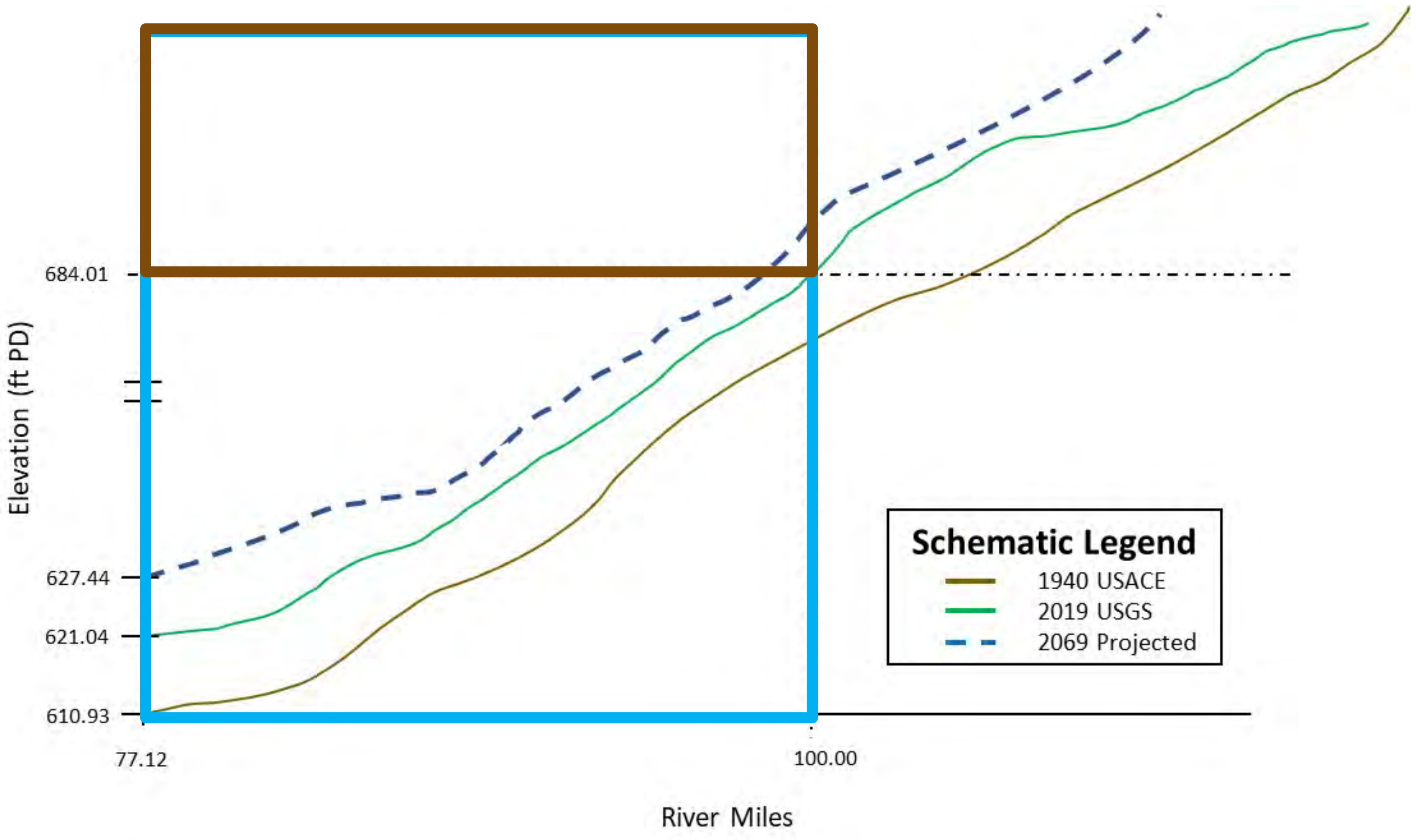
- Measured 69,926 acre-feet in **green box**
- Modeled 152,982 acre-feet in **blue box**



Stage-Storage Calculations

Below RM 100

- Measured 69,926 acre-feet in **green box**
- Modeled 152,982 acre-feet in **blue box**
- 83,056 acre-feet in **brown box**



Stage-Storage Calculations

Below RM 100

- Volume of deposition assumed proportional to increase in storage volume increment at each elevation step
- Added to HEC-RAS stage-storage outputs to create total curve
- Pass back to OM

STM Comparisons

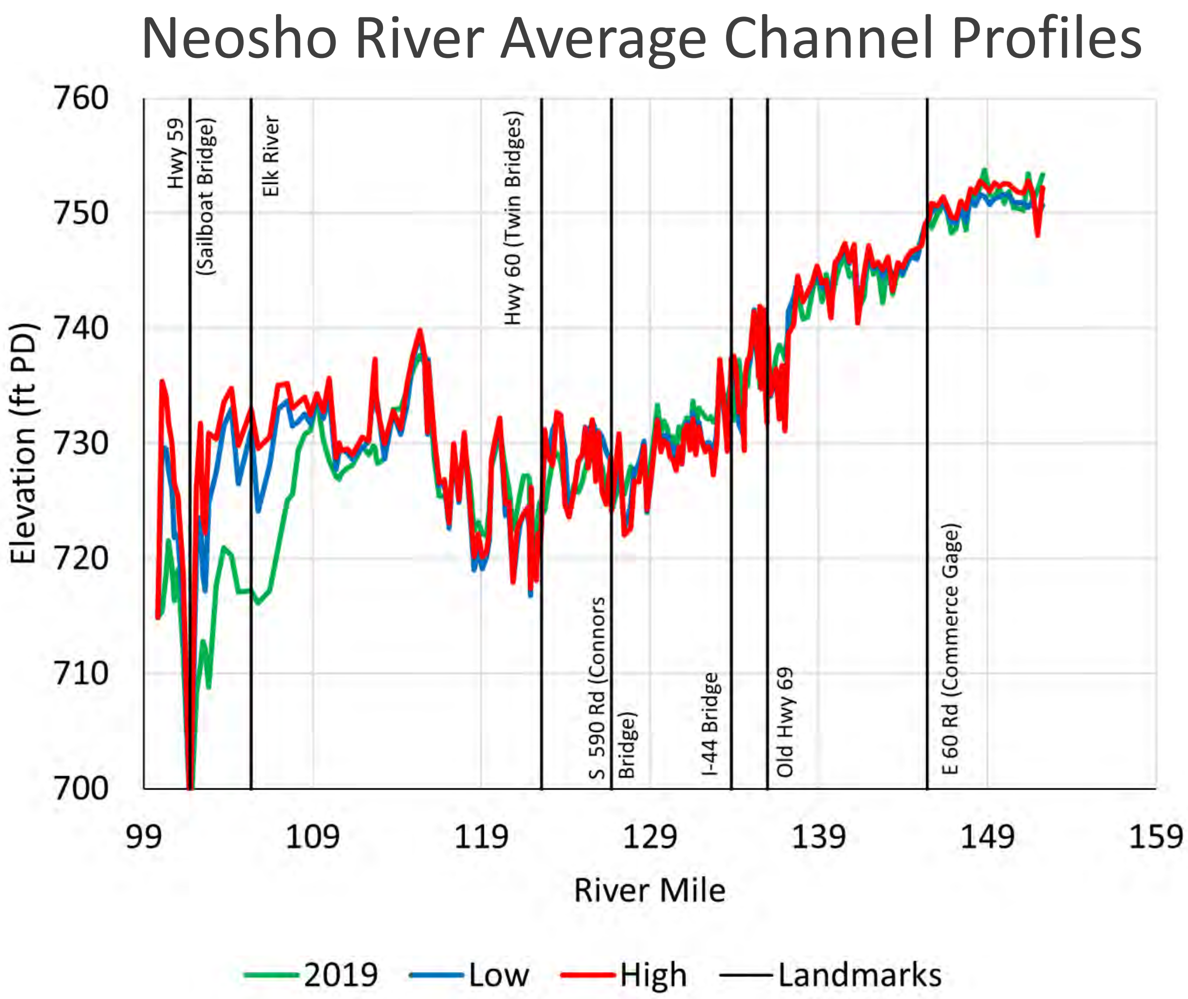
Future Geometries

- Evaluate differences between sediment loading
  - *High* vs *Low Sedimentation*
- Evaluate differences between Project operations scenarios
  - *Anticipated* vs *Baseline Operations*

STM Results

Sediment Loading Evaluation

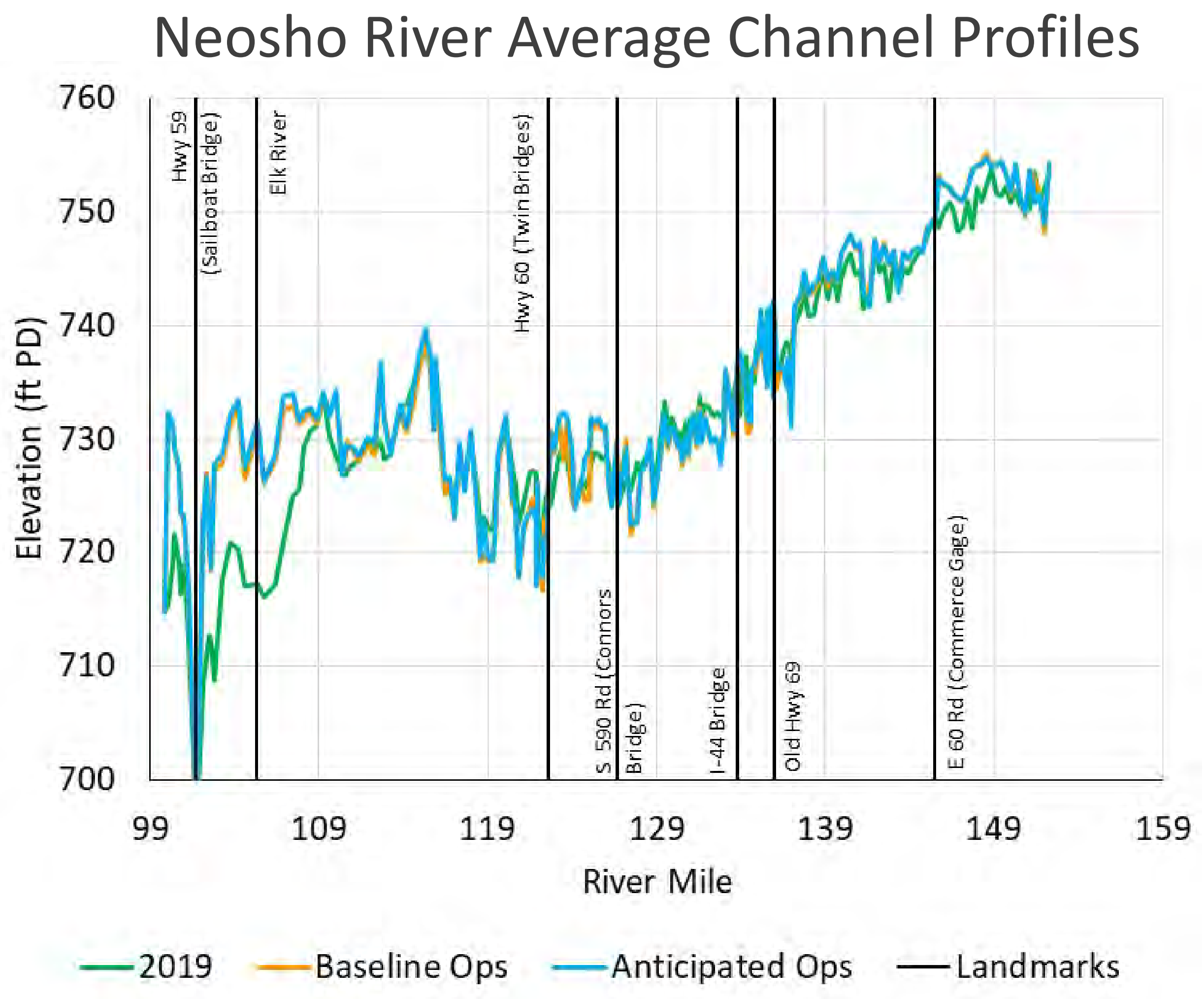
- Comparison between *High* and *Low Sedimentation* over 50-year future time period
  - Increased/decreased expected sediment loading by 20%
  - Adjusted water temperatures
  - Changed fall velocity methods
- Deposition almost entirely on downstream face of delta feature, as expected (Vanoni 2006)



STM Results

Operations Evaluation

- Comparison between *Baseline* and *Anticipated Operations* over 50-year future time period
- Deposition almost entirely on downstream face of delta feature, as expected (Vanoni 2006)
- Operations have limited impact on sediment deposition patterns



STM Results

Average Channel Changes

- Largest differences due to differences in sediment loading – ***not*** Project operations
- Most deposition occurs in lower portion of the model
  - Downstream face of the delta feature (Vanoni 2006)

Comparison	Mean Change in Average Channel (feet)	Mean Change in Average Channel Below RM 122 (feet)	Mean Change in Average Channel Below RM 115.35 (feet)
High Sediment – Low Sediment	0.47	1.45	2.09
Anticipated Ops – Baseline Ops	0.24	0.38	0.45

Analysis of Future Sedimentation Impacts

1D UHM Results

1D UHM

- Used STM output geometry

Inflow Event and Starting WSE (feet PD)	Existing Stage-Storage	Future Stage-Storage			
	Anticipated Ops				Baseline Ops
	Sediment Rate N/A	Expected Sediment	Low Sediment	High Sediment	Expected Sediment
July 2007, 740	✓	✓	✓	✓	✓
July 2007, 745	✓	✓	✓	✓	✓
July 2007, 750	✓	✓	✓	✓	✓
100-Year, 740	✓	✓	✓	✓	✓
100-Year, 745	✓	✓	✓	✓	✓
100-Year, 750	✓	✓	✓	✓	✓

1D UHM Results

Boundary Effects

- STM is impacted by boundary effects
  - Common with any numerical simulation
  - Produces unreliable data near upstream extents of model
  - Measured changes show that simulated changes are not real
- Evaluations excluded upstream portions of tributaries

Stream	Analyzed Region
Neosho River	99.8–145.4
Tar Creek	1.6–7.0
Spring River	0.0–17.0
Elk River	0.0–15.0

1D UHM Results

Future *Anticipated Operations* vs Existing Conditions

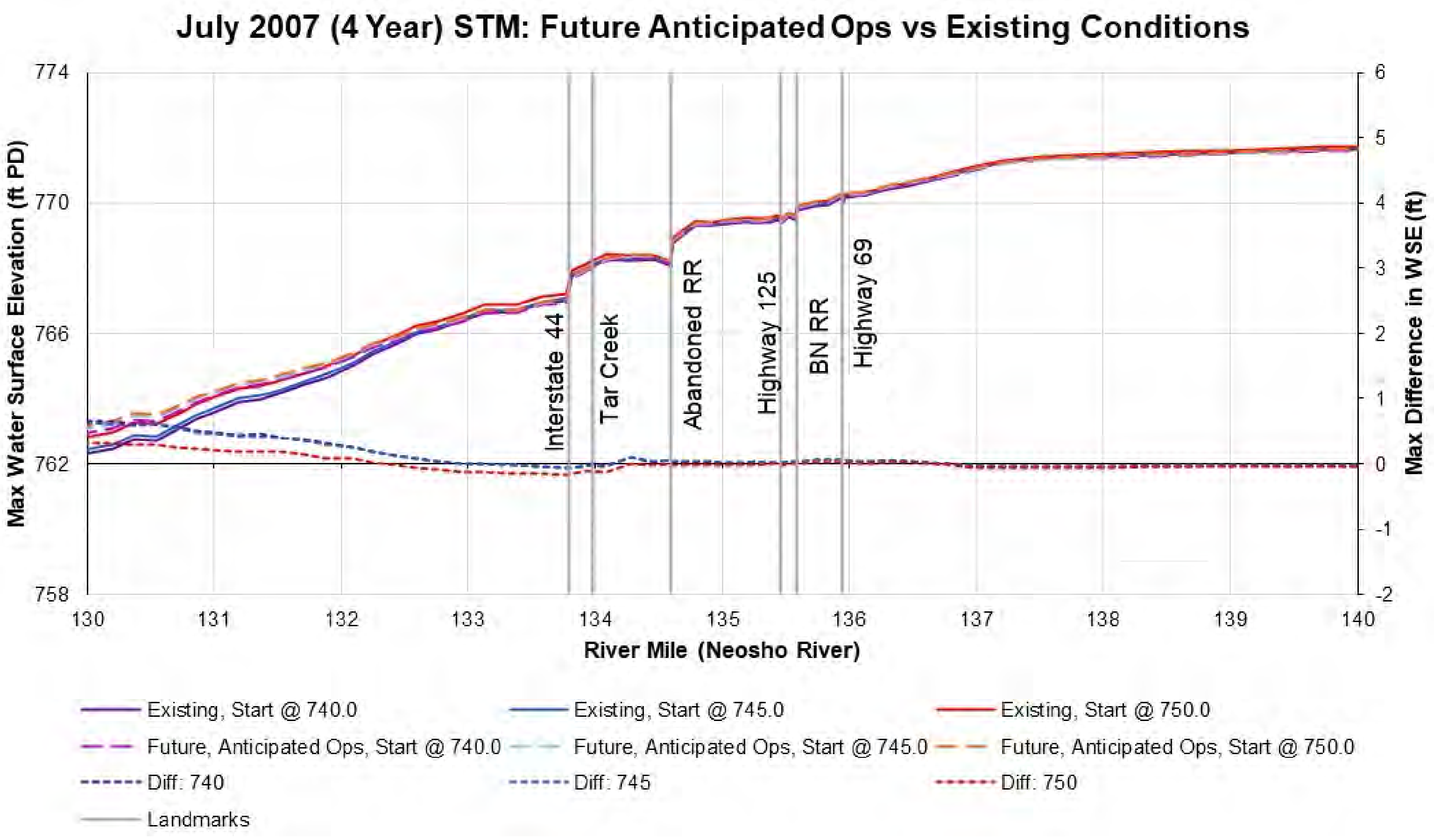
- Focusing on Neosho River, but other tributary information is provided in USR
- Positive values indicate increases under future conditions
- Impact of 50 years of sedimentation
  - Increases with lower starting pool for July 2007
  - Decreases with lower starting pool for 100-year

Starting Stage (feet PD)	July 2007 (4-Year) Event	100-Year Event
	Neosho River	Neosho River
Maximum Increase in WSE		
Max	**1.28**	**1.25**
Maximum Decrease in WSE		
Max	**-0.68**	**-0.01**
Average Change in WSE (feet)		
740	0.27	0.40
745	0.23	0.40
750	-0.04	0.41

Anticipated Ops vs Existing

July 2007

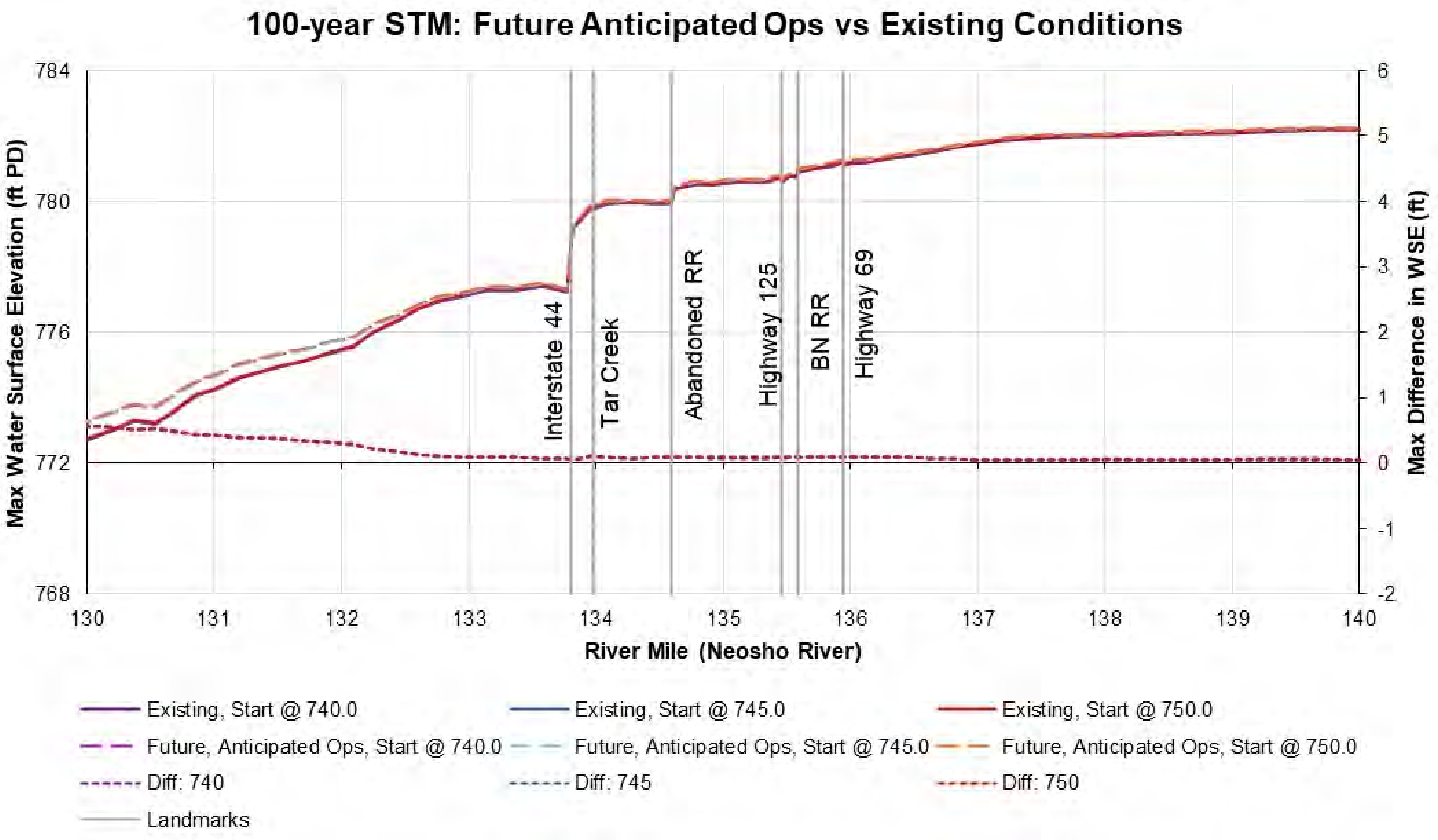
- Largest impact near Miami is +0.11 ft
  - Upstream of Tar Creek confluence



Anticipated Ops vs Existing

100-Year Event

- Largest impact near Miami is +0.11 ft
  - Near Tar Creek confluence



Anticipated Ops vs Existing

Takeaways

- Water levels are expected to remain similar despite 50 years of sedimentation
- Largest impacts are downstream of urbanized areas
- Impacts in urbanized areas are immaterial

1D UHM Results

Future *High* vs *Low Sedimentation*

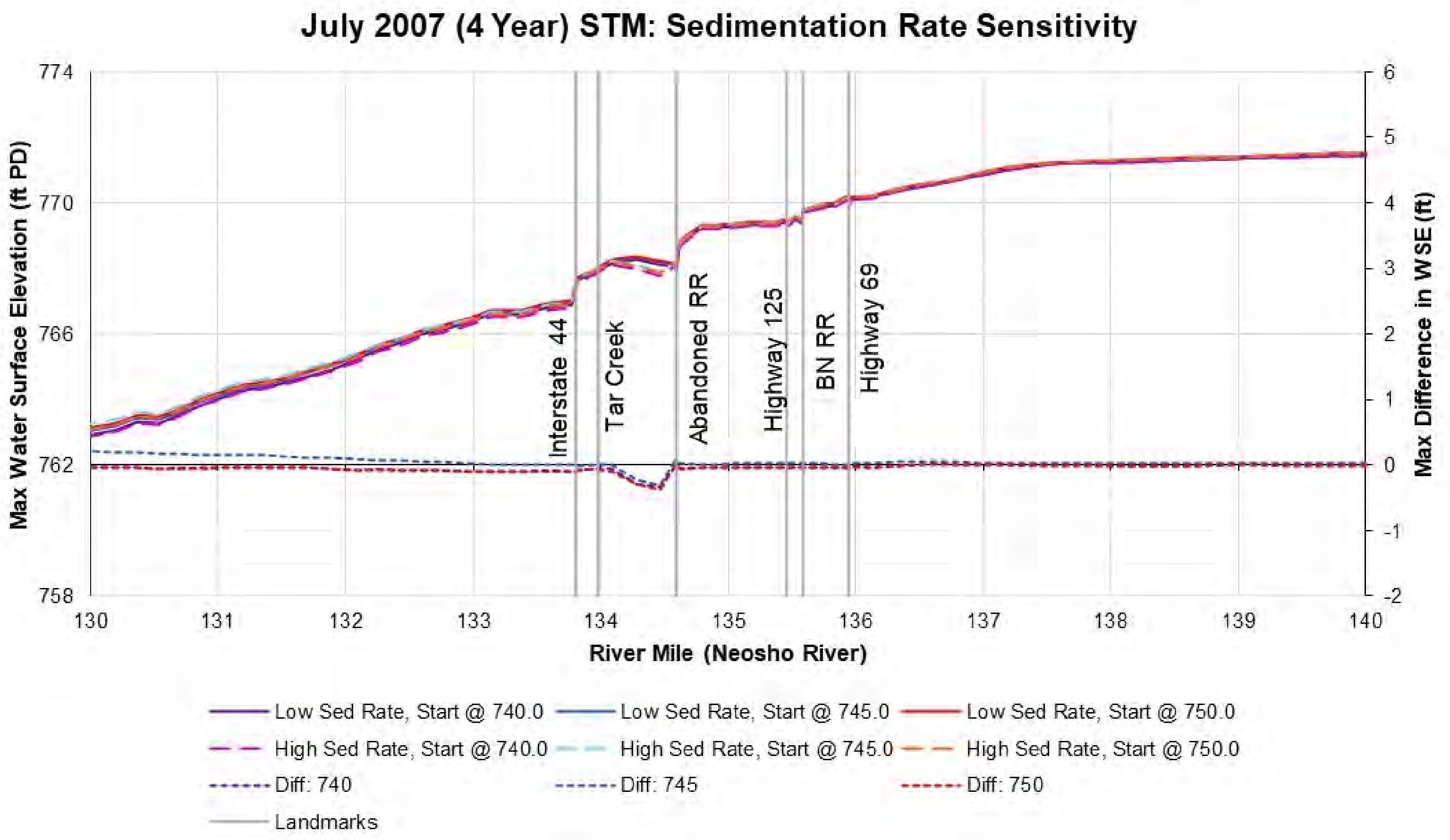
- Positive values indicate increases under *High Sedimentation*
- Used as sensitivity analysis due to data quality
  - Stationarity evaluation suggests both *High* and *Low Sedimentation* are conservative
    - Sediment loading has decreased over time
      - John Redmond Reservoir
      - Different land use
      - Better cropland management (no-till, cover crops)

Starting Stage (feet PD)	July 2007 (4-Year) Event	100-Year Event
	Neosho River	Neosho River
Maximum Increase in WSE		
Max	**1.38**	**1.21**
Maximum Decrease in WSE		
Max	**-0.38**	**-0.03**
Average Change in WSE (feet)		
740	0.06	0.22
745	0.30	0.22
750	0.02	0.20

High vs Low Sedimentation

July 2007

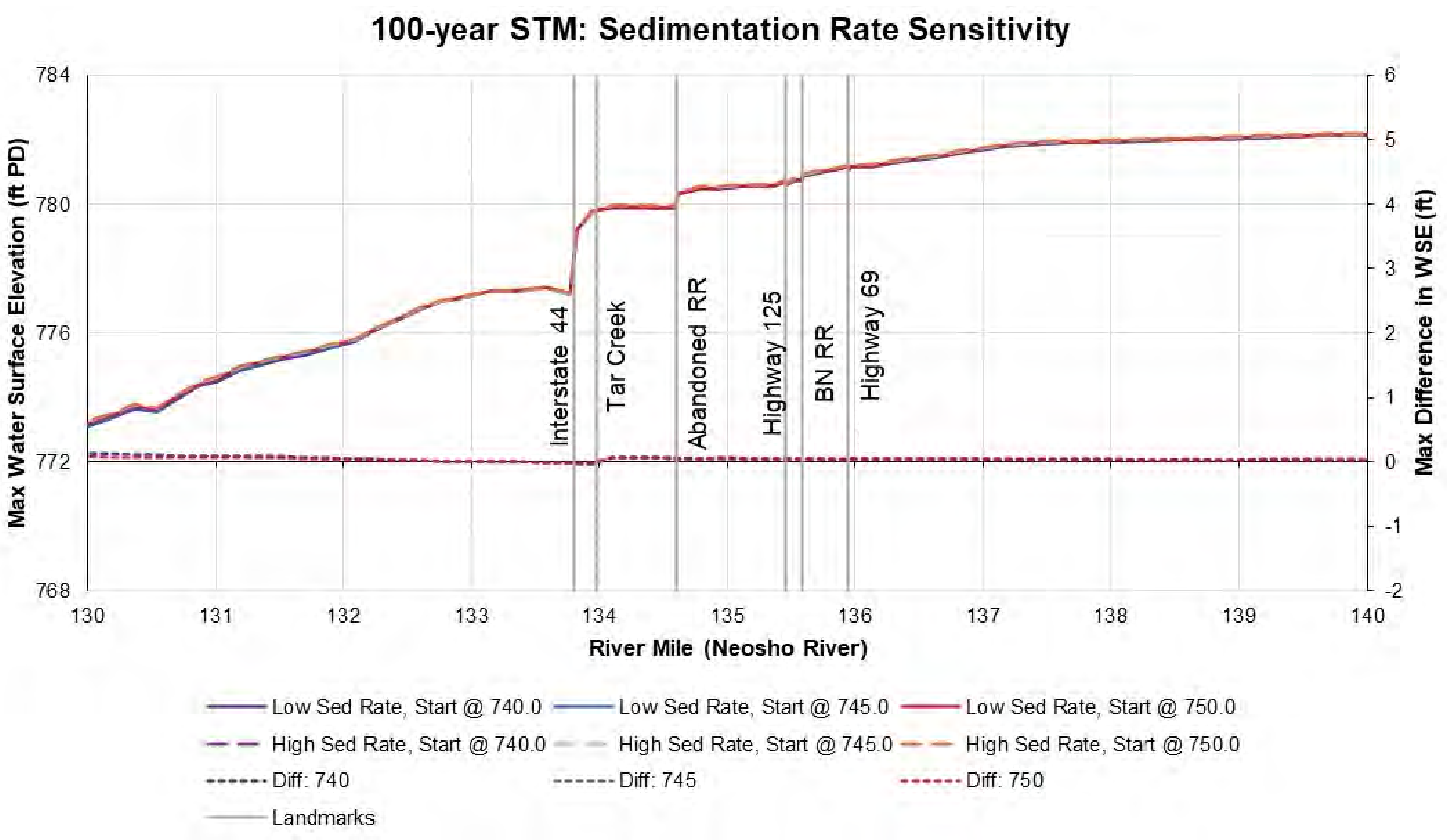
- Largest impact near Miami is +0.06 ft
  - Near abandoned RR bridge



High vs Low Sedimentation

100-Year Event

- Largest impact near Miami is +0.07 ft
  - Near Tar Creek confluence



High vs Low Sedimentation

Takeaways

- Sediment loading accounts for as much as 1.38 ft of WSE variability
- Largest impacts are downstream of urbanized areas
  - Near Twin Bridges
- Potential range of incoming sediment load – ***not*** controlled by GRDA – has similar impact to 50 years of ongoing sedimentation
- Impacts in urbanized areas are immaterial

1D UHM Results

Future *Anticipated* vs *Baseline Operations*

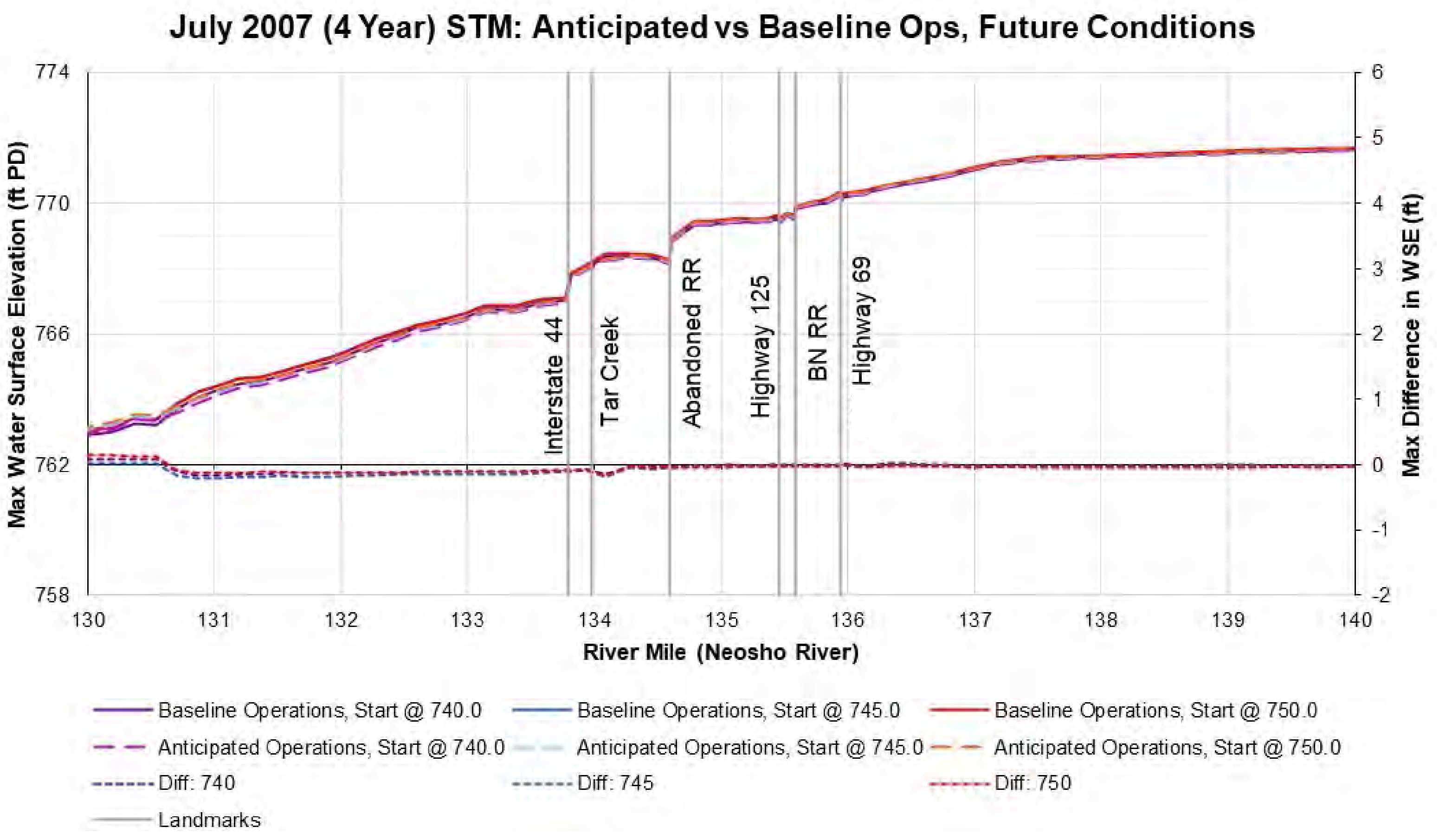
- Positive values indicate increases under *Anticipated Operations*
- Used as sensitivity analysis for operations impacts

Starting Stage (feet PD)	July 2007 (4-Year) Event	100-Year Event
	Neosho River	Neosho River
Maximum Increase in WSE		
Max	**0.26**	**1.14**
Maximum Decrease in WSE		
Min	**-1.39**	**0.00**
Average Change in WSE (feet)		
740	-0.48	0.22
745	-0.19	0.22
750	-0.03	0.22

Anticipated Ops vs Baseline Ops

July 2007

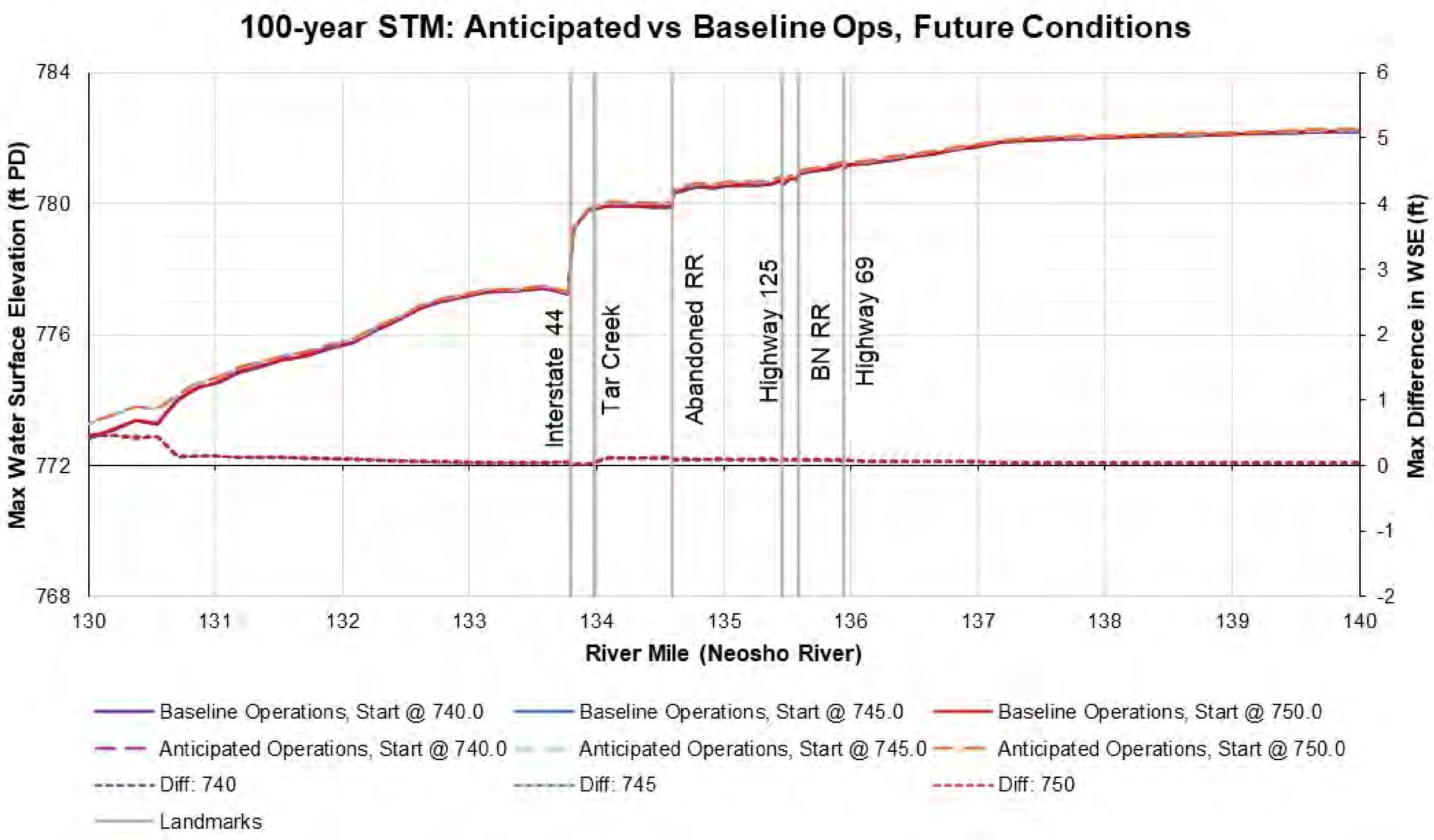
- Generally negative changes
  - Anticipated Ops ***reduce*** WSE
- Largest impact near Miami is +0.03 ft
  - Near Hwy 69 bridge



Anticipated Ops vs Baseline Ops

100-Year Event

- Largest impact near Miami is +0.12 ft
  - Upstream of Tar Creek confluence



Anticipated Ops vs *Baseline Ops*

Takeaways

- More typical flow events (July 2007) expected to have *decreased* WSE under *Anticipated Operations*
- 100-year event expected to increase 0.12 ft
- Largest impacts are downstream of urbanized areas
  - Near Twin Bridges
- Impacts in urbanized areas are immaterial

Conclusions

Conclusions

1. Sediment deposition in the region of the delta feature is influenced by a variety of factors including incoming sediment loads, tributary confluences, the exposed bedrock, and upstream constrictions
2. Sedimentation rates in Grand Lake and associated tributaries are dictated primarily by incoming sediment loads rather than Project operations
3. Impacts to water levels due to sediment loading, a natural phenomenon outside GRDA's control, are generally larger than impacts due to Project operations
4. Impacts to water levels due to Project operations are immaterial in urbanized areas

Thank you

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Aquatic Species of Concern Study

Pensacola Hydroelectric Project
Project No. 1494

October 13, 2022

Presentation Outline

1. Aquatic Species of Concern Study Objectives
2. Process and Timeline
3. Phase 2 Survey Methods
4. Phase 2 Survey Results
5. Comprehensive Hydraulic Model Results
6. Discussion and Conclusions

Aquatics Species of Concern Study Objectives

Aquatic Species of Concern Study Objectives

1. Assess potential impacts of Project operations on Paddlefish recruitment based on an analysis of available spawning substrate during the Paddlefish spawning period.
2. Use a three-phased approach to gather information and assess potential impacts of Project operations on Neosho Madtom, Neosho Smallmouth Bass, Neosho Mucket, Rabbitsfoot, and Winged Mapleleaf.

Phase 1: Review of Existing Information (2021)

Phase 2: Surveys to Document Distribution of Species of Concern (2022)

Phase 3: Assessment of Potential Impacts for Relevant Species (2022)

Aquatic Species Evaluated
Paddlefish (*Polyodon spathula*)
Neosho Smallmouth Bass (*Micropterus dolomieu velox*)
Neosho Madtom (*Noturus placidus*)
Neosho Mucket (*Lampsilis rafinesqueana*)
Rabbitsfoot (*Theliderma cylindrica*)
Winged Mapleleaf (*Quadrula fragosa*)

Process and Timeline

Timeline – Initial Study Report

- Sep.- Oct. 2021: GRDA files Initial Study Report (ISR) and hosts ISR Meeting summarizing results of Phase 1/Year 1 studies

  - **Paddlefish** – Presented results of analysis and determined no additional Year 2 studies necessary.
  - **Neosho Smallmouth Bass –** Presented results of analysis and determined no additional Phase 2 studies necessary.
  - **Neosho Madtom** – Presented literature review and proposed Phase 2 surveys in Neosho River.
  - **Neosho Mucket** – Presented literature review and proposed Phase 2 surveys in Elk River.
  - **Rabbitsfoot** – Presented literature review and proposed no Phase 2 surveys targeted at this species.
  - **Winged Mapleleaf** – Presented literature review and proposed no targeted Phase 2 surveys.

Timeline – FERC Determination

- Dec. 2021 – GRDA responds to ISR comments
- Feb. 2022 – FERC issues Year 2 Study Plan Determination (Year 2 SPD)
  - FERC recommended that GRDA add surveys for Neosho Mucket in additional reaches identified by USFWS
    - Spring River between Warren Branch and the confluence with the Neosho River
    - Neosho River between the City of Miami and the confluence with the Spring River
  - FERC recommended consultation with USFWS, EcoAnalysts, and Tar Creek Trustee Council on mussel survey design
  - FERC recommended adding surveys for Neosho Madtom in portions of the Spring River

Timeline – GRDA Completion of Modifications

- Spring 2022 – GRDA prepared proposed mussel survey methodology and shared with USFWS, EcoAnalysts, and TCTC
  - Each agency/reviewer provided comments on this survey design
  - Comments were reviewed and addressed in final survey design
- Summer 2022 - GRDA conducted Phase 2 surveys and Phase 3 analysis
- Sep./Oct. 2022 – GRDA filed Updated Study Report (USR) and hosts USR Meeting summarizing results of final study season

Phase 2 Survey Methods

Aquatic Study Methods – Neosho Mucket

- Survey Areas:
  - Elk River from OK/MO state line to Buffalo Creek confluence
  - Spring River from Warren Branch to confluence with Neosho River
  - Neosho River from Riverside Park in Miami to confluence with Spring River

- Three-phased survey methodology implemented in July 2022
  - Phase 1 – Identify any potential Neosho Mucket Habitat
    - Habitat assessment by trained malacologist based on descriptions of Neosho Mucket habitat in the literature
  - Phase 2 – Qualitative Timed Searches
    - Best approach for detecting rare species
    - Minimum of 3 person-hours per site, 5 person-hours if mussels detected
    - Dive gear used to access deeper areas
    - Immediately transition to Phase 3 Quantitative Surveys if listed mussels detected
  - Phase 3 – Quantitative Quadrat Surveys
    - Excavation of multiple 0.25 m^2 quadrats per site
    - Used to assess density of listed species (if present)

Aquatic Study Methods – Neosho Madtom

- Survey Areas:
  - Spring River from I-44 bridge downstream to Hwy. 10 bridge
  - Neosho River from Craig/Ottawa County border downstream to Hwy. 60 bridge
  - Within these reaches, sampling focused on riffles and gravel bars with gravel and cobble
- Collection Methods:
  - Kick-seining - Kicking, splashing, disturbing the substrate upstream of a stationary seine
  - Effective in capturing madtoms and other benthic fishes in swift riffles and runs
  - Surveys in Spring River conducted in July 2022 (605 cfs at time of sampling, 725 cfs median)
  - Surveys in Neosho postponed due to high flows (2,190 cfs at time, 1,100 cfs median)
  - Neosho River surveys completed in August 2022 (171 cfs)
  - All fishes identified to species, measured (mm), and enumerated
  - Substrate composition and current velocity quantified at each sampling location

Questions

Phase 2 Survey Results

Results – Neosho Mucket Surveys

- Elk River:
  - Approximately 1-mile study area
  - Sampled 3 riffle/run complexes identified as potential Neosho Mucket habitat
  - Sampled 2 deeper pool areas in between
  - 17 person-hours of total effort at 5 locations
  - 1 Plain Pocketbook (*Lampsilis cardium*)

Results – Neosho Mucket Surveys

- Spring River:
  - Approximately 10.5-river mile study area
  - Sampled 2 riffle/run complexes with gravel/cobble substrates identified as potential Neosho Mucket habitat
  - Sampled 2 deeper silt-dominated reservoir-influenced areas downstream
  - 20 person-hours of total effort at 4 locations
  - 38 individual mussels of 8 species
    - Plain Pocketbook – 4
    - Threehorn Wartyback – 5
    - Fragile Papershell – 2
    - Pink Papershell – 9
    - Bleufer – 11
    - Mapleleaf – 1
    - Pistolgrip – 1
    - Flat Floater - 5

Results – Neosho Mucket Surveys

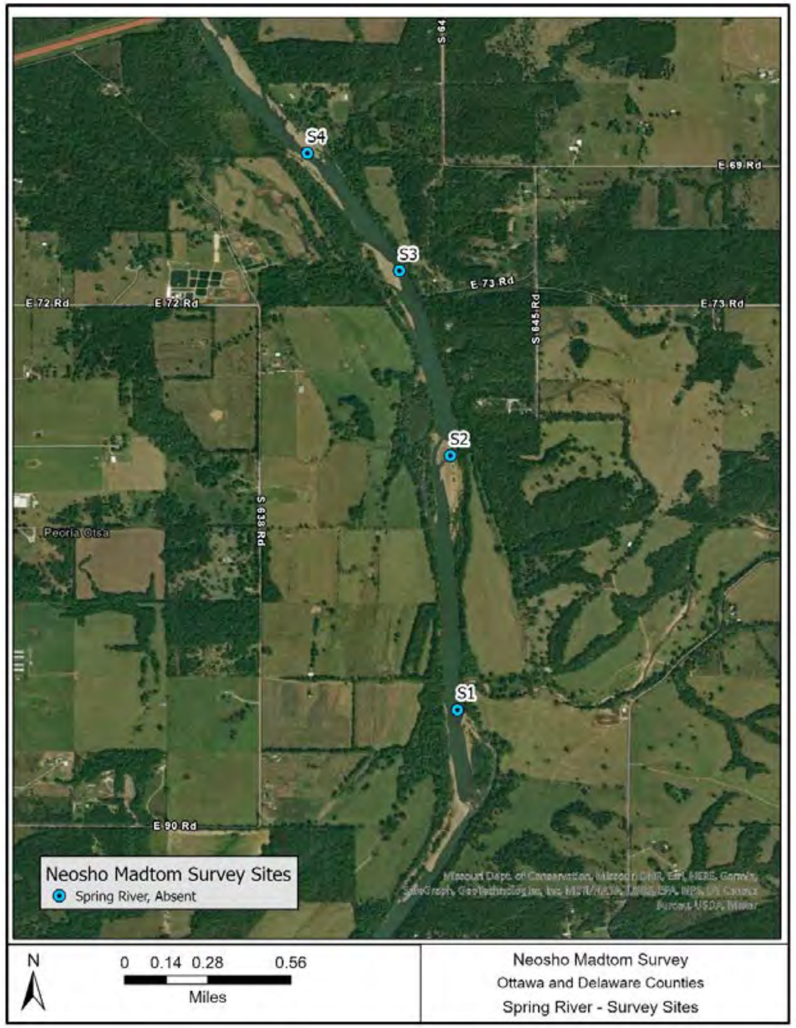
- Neosho River:
  - Approximately 13-river mile study area
  - No potential Neosho Mucket habitat identified
  - Sampled 4 deeper lentic areas to document the community present
  - 20 person-hours of total effort at 4 locations
  - 149 individual mussels of 10 species
    - Bleufer – 91
    - Fragile Papershell – 21
    - Threehorn Wartyback – 14
    - Pistolgrip – 4
    - Pink Papershell – 8
    - Flat Floater - 5
    - Yellow Sandshell – 3
    - White Heelsplitter – 1
    - Lilliput – 1
    - Paper Pondshell - 1

Results – Neosho Mucket Surveys

- Overall:
  - Habitat Assessment
    - No potential Neosho Mucket habitat identified in Neosho River study area
    - Potential Neosho Mucket habitat limited to upper portions of Spring River study area and the Elk River study area
  - Survey Results
    - 57 person-hours of survey effort at 13 sites
    - 188 individual mussels from 12 species
    - No listed mussels collected
    - Most common species included generalist or lentic-adapted species:
      - Bleufer
      - Fragile Papershell
      - Threehorn Wartyback
      - Pink Papershell
      - Flat Floater

Results – Neosho Madtom Surveys

- Spring River:
  - Four riffle/run complexes sampled from Warren Branch to I-44
  - 5 kick-seine stations per riffle complex
  - 343 fishes representing 18 species
  - Neosho Madtoms were not observed

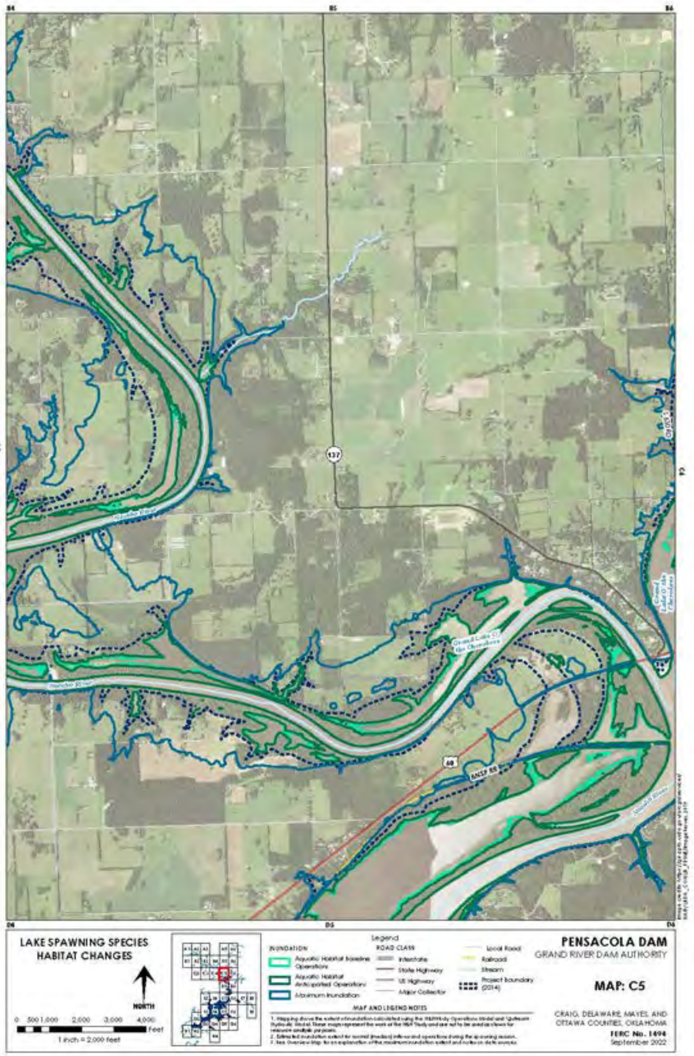


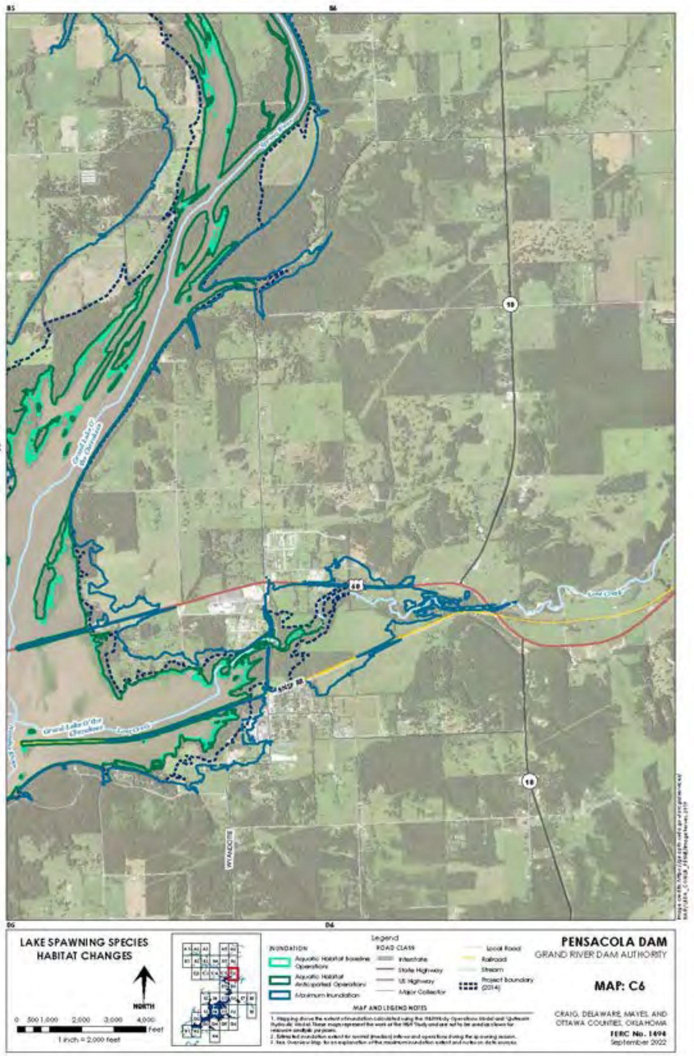
Results – Neosho Madtom Surveys

- Neosho River:
  - Seven riffle/run complexes sampled from county line to near Miami
  - 5 kick-seine stations per riffle complex
  - 575 fishes representing 21 species
  - 13 Neosho Madtoms were observed at 5/7 sites

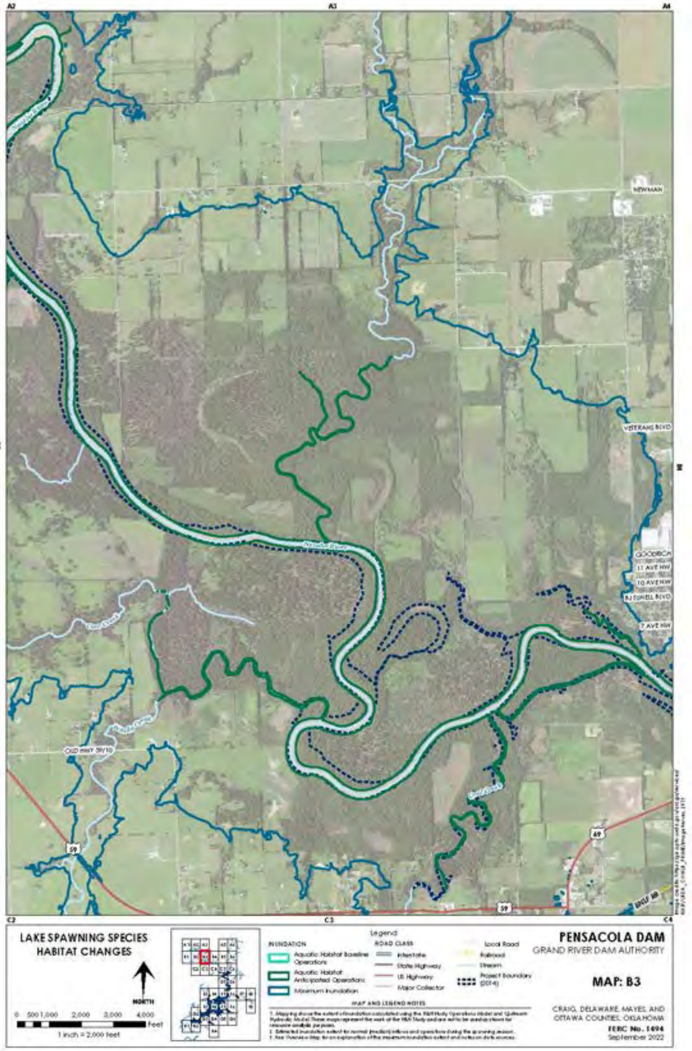
Comprehensive Hydraulic Model (CHM) Results

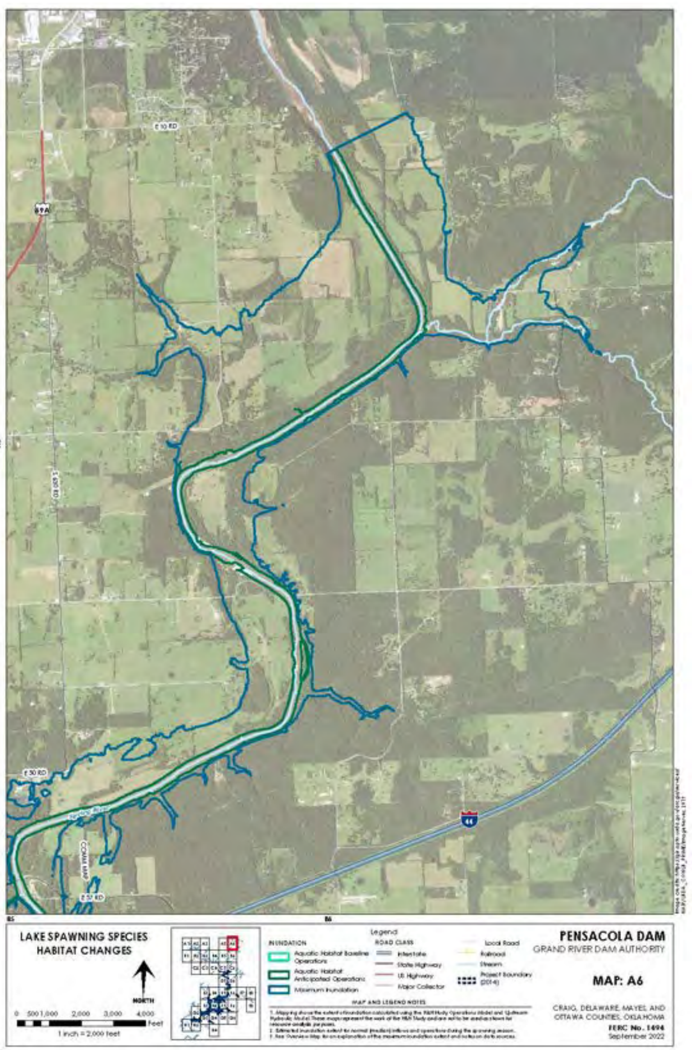
Results – CHM near Twin Bridges Area





Results – CHM Neosho and Spring Rivers





Results – CHM

Table 13. Previous and Anticipated Velocities at Neosho Madtom Sampling Locations

Site	Latitude	Longitude	RM	1D or 2D	Section-averaged velocity (ft/s)		Difference in velocity (ft/s)
					Previous Operations	Proposed Operations	
Spring 1	36.891539	-94.729085	10.94	1D	1.65	1.43	-0.22
Spring 2	36.903907	-94.72943	11.83	1D	1.46	1.40	-0.06
Spring 3	36.912914	-94.731908	12.43	1D	2.98	2.91	-0.07
Spring 4	36.891539	-94.729085	10.94	1D	1.65	1.43	-0.22
Neosho 1	36.93597	-94.99258	148.72	2D	3.87	3.86	-0.01
Neosho 2	36.93336	-94.95569	145.79	2D	4.47	4.46	-0.01
Neosho 3	36.92761	-94.96014	145.26	2D	3.65	3.63	-0.02
Neosho 4	36.91657	-94.96173	144.45	2D	3.65	3.63	-0.02
Neosho 5	36.90761	-94.95527	143.69	2D	3.43	3.41	-0.02
Neosho 6	36.90008	-94.953251	143.13	2D	3.02	2.99	-0.04
Neosho 7	36.87222	-94.93223	139.47	2D	3.92	3.81	-0.10

Discussion and Conclusions

Discussion of Results by Species

- Neosho Smallmouth Bass
  - Based on the literature review and agency coordination, Neosho Smallmouth Bass are not known to occur within Grand Lake or within the Project area.
  - No Neosho Smallmouth Bass were observed during in GRDA’s 2022 surveys.
  - Changes to inundation and velocity are minimal within study area.
  - No impacts to Neosho Smallmouth Bass are expected from Project operations.

Discussion of Results by Species

- Neosho Madtom
  - Neosho Madtoms were not documented within the Spring River study area but were found at 5 of 7 sites within the Neosho River study area.
  - Neosho Madtoms were most common in upstream portions of the study area near the Craig/Ottawa County line and occurrence decreased in downstream areas near Miami.
  - CHM results suggest negligible change to inundation in this channelized upstream portion of the project area.
  - Similarly, CHM results suggest minimal change to current velocity (-0.01 to -0.22 ft/s) in these areas due to anticipated Project operations.
  - Any impact of the proposed action on Neosho Madtom populations is expected to be negligible.

Discussion of Results by Species

- Neosho Mucket
  - Habitat assessments by trained malacologist identified limited amounts of potential Neosho Mucket habitat within the Elk and Spring River study areas, and none within the Neosho River study area.
  - Despite over 57 person-hours of effort at 13 sites within the selected portions of the Elk, Spring, and Neosho Rivers, which resulted in collection of 188 individual mussels, no Neosho Mucket were detected.
  - Given that no Neosho Mucket were observed in the study areas, and the fact that CHM results suggest negligible changes to inundation and current velocity in these areas, no impacts to Neosho Mucket are expected due to anticipated project operations.

Credit: B. Ray

Discussion of Results by Species

- Winged Mapleleaf
  - Based on the literature review, the only known Oklahoma population of Winged Mapleleaf is in the Little River of southeastern Oklahoma.
  - The species is not known to occur in the Project area.
  - No Winged Mapleleaf were observed during previous surveys in the area, nor in GRDA's 2022 surveys described here.
  - Therefore, no impacts to Winged Mapleleaf are expected from Project operations.

Discussion of Results by Species

- Rabbitsfoot
  - The literature review identified that Rabbitsfoot are known from upstream sections of the Spring and Neosho Rivers but are considered extirpated from the Oklahoma portions of these rivers.
  - USFWS's most recent five-year review of the species acknowledges the Oklahoma segment of the Spring River as historic range with no extant population.
  - Rabbitsfoot have not been documented in the Spring or Neosho within Oklahoma, including 2022 surveys within the Project area.
  - Therefore, no impacts to Rabbitsfoot are expected due to Project operations.

Credit: B Ray

Terrestrial Species of Concern Study for the Pensacola Hydroelectric Project (FERC Project No. 1494) Craig, Delaware, Mayes, and Ottawa Counties, Oklahoma

Prepared For:

GRDA Grand River Dam Authority

Prepared By:

Horizon Environmental Services, Inc.

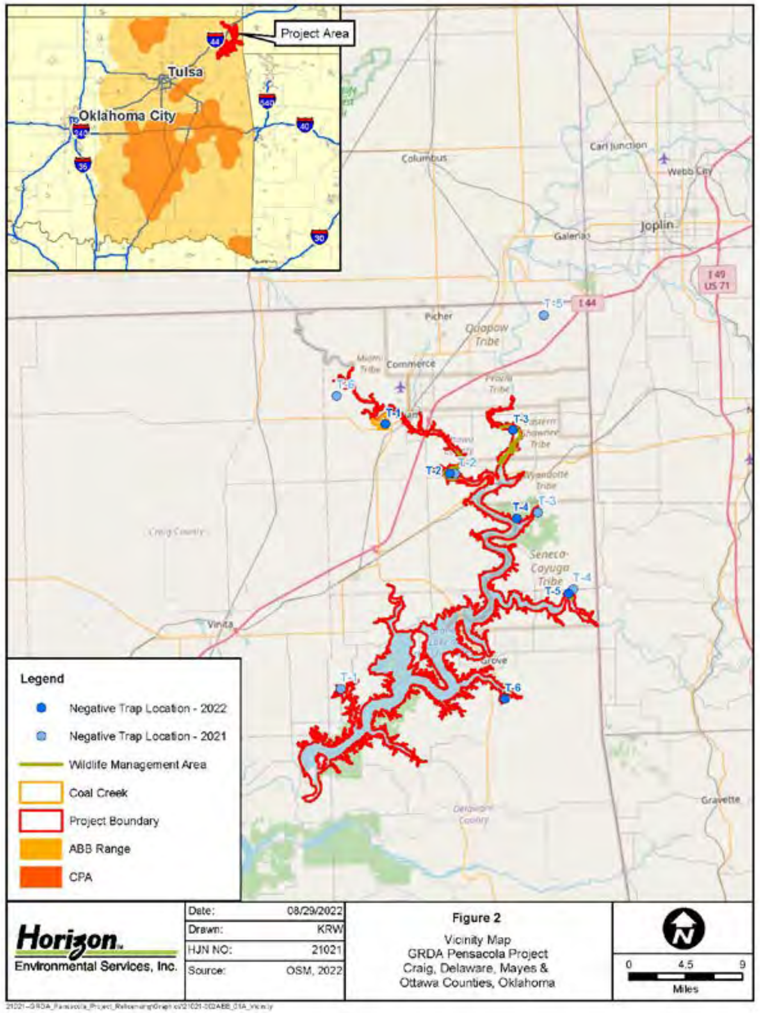
American Burying Beetles, Final Study Season

According to the revised study plan, GRDA has completed the following:

❖ GRDA conducted American burying beetle (ABB) surveys at six locations covering the Coal Creek mitigation site, the designated Wildlife Management Areas (WMA) and coordinated with the United States Fish and Wildlife Service (USFWS).

❖ The presence/absence surveys ran from July 18, 2022, to July 23, 2022, following USFWS survey protocols. Weather parameters were valid, and no ABBs were captured.

❖2022 ABB survey results mirror the 2021 ABB survey results.



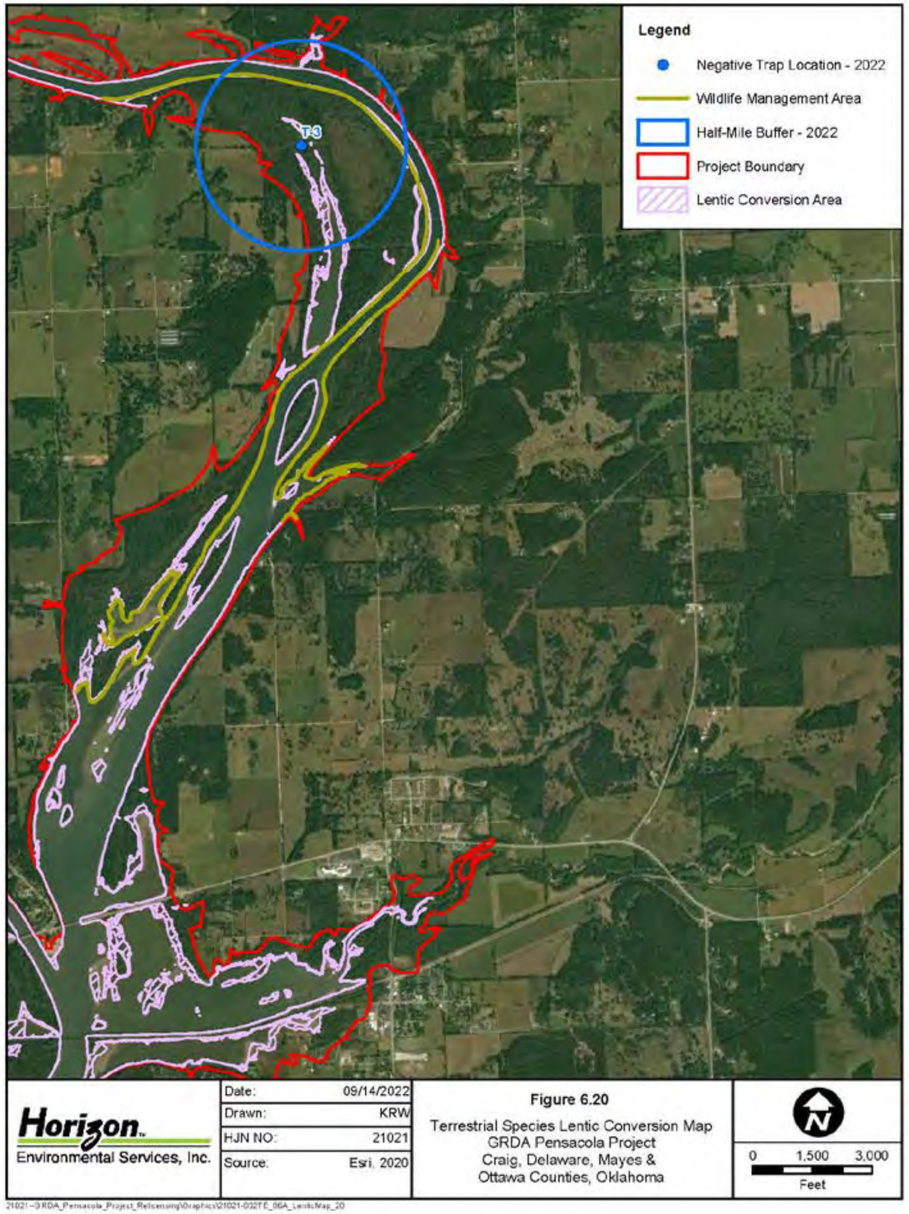
Anticipated Effects Analysis

Purpose: compare distribution of beetles to inundation maps generated by the Comprehensive Hydraulic Model (CHM) to characterize the effects of anticipated operations of the Pensacola Hydroelectric Project (Project) operations.

- ❖ Development of maps showing areas of potential lentic or lotic conversion which could impact the habits of the ABB.
- ❖ Seasonal period review included the full calendar year. For both anticipated operations and baseline operations, the seasonal median operational level and inflows were simulated in the CHM.
- ❖ The maximum inundation was virtually identical for anticipated and baseline operations because the maximum inundation boundary occurs when the USACE is in flood control operations, and it is not an effect of GRDA baseline or anticipated operations. Therefore, to analyze the impacts of the baseline versus the anticipated Project operations, the normal (median) inundations are used because they occur on such a regular basis that a habitat conversion can occur versus just a regular inundation.

Findings

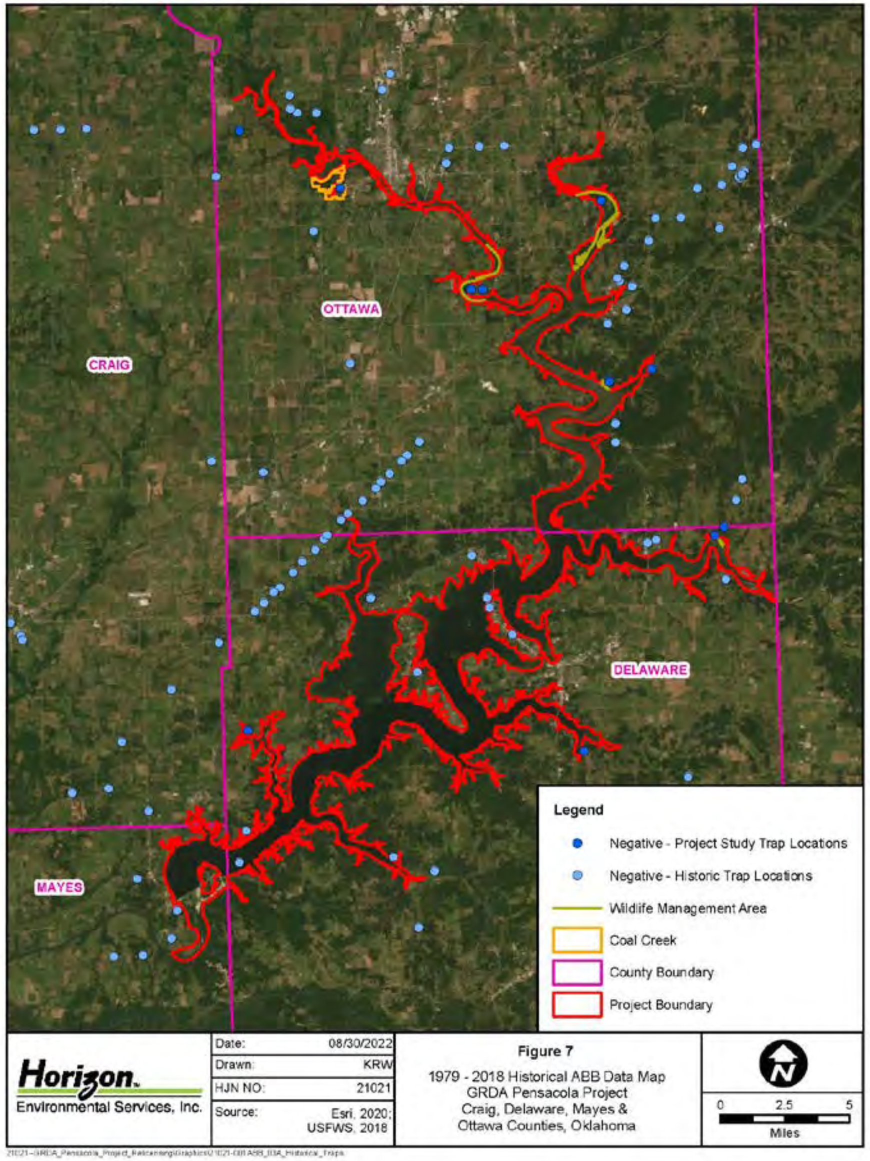
- ❖ The comparison of the baseline and anticipated Project operations yielded a total of 2.79% terrestrial habitat that may become aquatic habitat as a result of the anticipated operations.
- ❖ Shoreline habitat (rocky/sandy substrate) is not suitable for ABB overwintering and is poor foraging habitat.



Findings Continued

- ❖According to USFWS comprehensive survey data from 1979 – 2018, no ABBs have been found in Delaware or Ottawa Counties, nor within the vicinity of the Project in Mayes or Craig Counties.

- ❖Despite the expectation that some suitable ABB habitat may be converted to aquatic habitat, there is no reasonable expectation that ABBs are or have been using the habitat. Thus, it is GRDA's opinion that the ABB will not be affected by anticipated operations.



Gray Bats, Final Study Season

Purpose: assess the degree to which anticipated Project operations under the new license would inundate the main entrance to Beaver Dam Cave and compare the frequency of inundation with that associated with baseline operations.

- ❖ Cave DL-2 (Beaver Dam Cave) in Delaware County is adjacent to Drowning Creek, a tributary of Grand Lake, and is within the maximum inundation area on the lentic conversion maps.
- ❖Cave DL-91 (Twin Cave) is also located in Delaware County about 1 kilometer (km) from Grand Lake with an elevation (840 feet) precluding any threat of inundation. It is also outside of the maximum inundation area on the lentic conversion maps.

Background

Purpose: assess the degree to which anticipated Project operations under the new license would inundate the main entrance to Beaver Dam Cave and compare the frequency of inundation with that associated with baseline operations.

- ❖ Complete inundation of the cave passage of DL-2 occurs at about elevation 752 feet Pensacola Datum (PD)
- ❖In October 2008 a small, high passage within cave DL-2 was identified and minimally excavated and enlarged.
- ❖Additional excavation and enlargement of this second high passage was completed in October 2013.
- ❖An inspection of the passage following a flood event in summer 2015, and again during this project period in 2022, revealed scattered guano in the enlarged passage indicating use by bats. The post-inundation monitoring visit to the cave on 27 June 2022 failed to give any indication that take had occurred as a result of inundation in early May 2022.

Anticipated Effects Analysis

- ❖ The size and status of the DL-2 colony remains relatively constant for the past 25 years.
- ❖ For both anticipated operations and baseline operations, the seasonal median operational level and inflows were simulated in the CHM. Seasonal period review spanned April 1st to July 31st.

Anticipated Effects Analysis, Continued

Purpose: The second product of the CHM for the Terrestrial Species Study was specific to the gray bat analysis and provided the percentage of time the reservoir would be above the key reservoir elevations of 746 feet PD, 751 feet PD, and 752 feet PD for both the baseline and anticipated Project operations during the key season for gray bats of April 1 to July 31 each year.

The percentages and their significance are displayed in the table below:

Percentage of Time Above Reservoir Elevation	Baseline Operations	Anticipated Operations	Percentage Increase	Significance
746 feet PD	16.5%	16.9%	0.4%	The elevation at which water flows into the entrance of Beaver Dam Cave
751 feet PD	2.9%	2.7%	-0.2%	Evacuation of cave
752 feet PD	1.9%	1.9%	0%	Complete inundation of cave entrance

Discussion and Conclusion

ABB

- ❖Poor habitat
- ❖No ABB captures
- ❖No historic ABB captures
- ❖Anticipated operations will not affect the ABB

Bats

- ❖The secondary exit suffices to provide an alternative access by gray bats in cave DL-2.
- ❖Regardless of the efficacy of the alternative access, the entrance to cave DL-2 does not become completely inundated to elevations 751 feet PD and greater (complete inundation is 752 feet PD) any more frequently under the anticipated Project operations than it becomes inundated under the baseline Project operations. Therefore, there is no impact to gray bats.

Wetlands and Riparian Habitat Study for the Pensacola Hydroelectric Project (FERC Project No. 1494)
Craig, Delaware, Mayes, and Ottawa Counties, Oklahoma

Prepared For:

Grand River Dam Authority

Prepared By:

Horizon Environmental Services, Inc.

Final Study Season

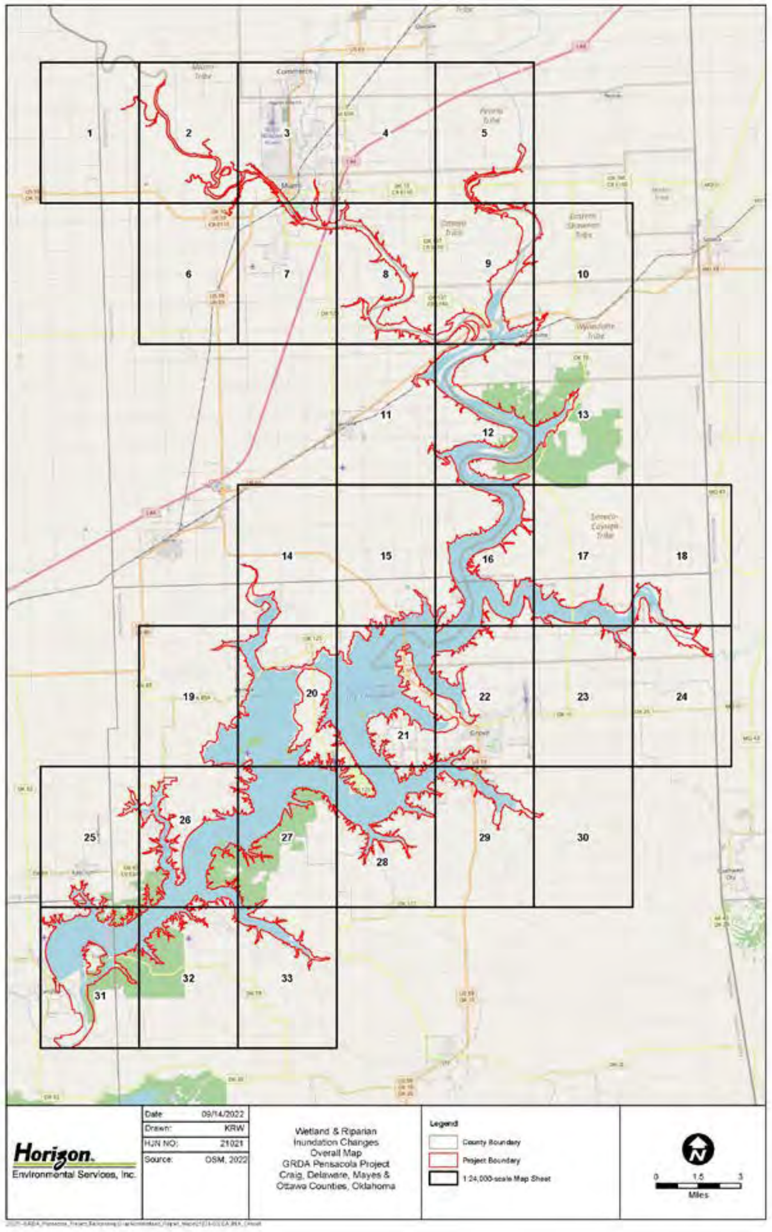
According to the revised study plan, the following was completed:

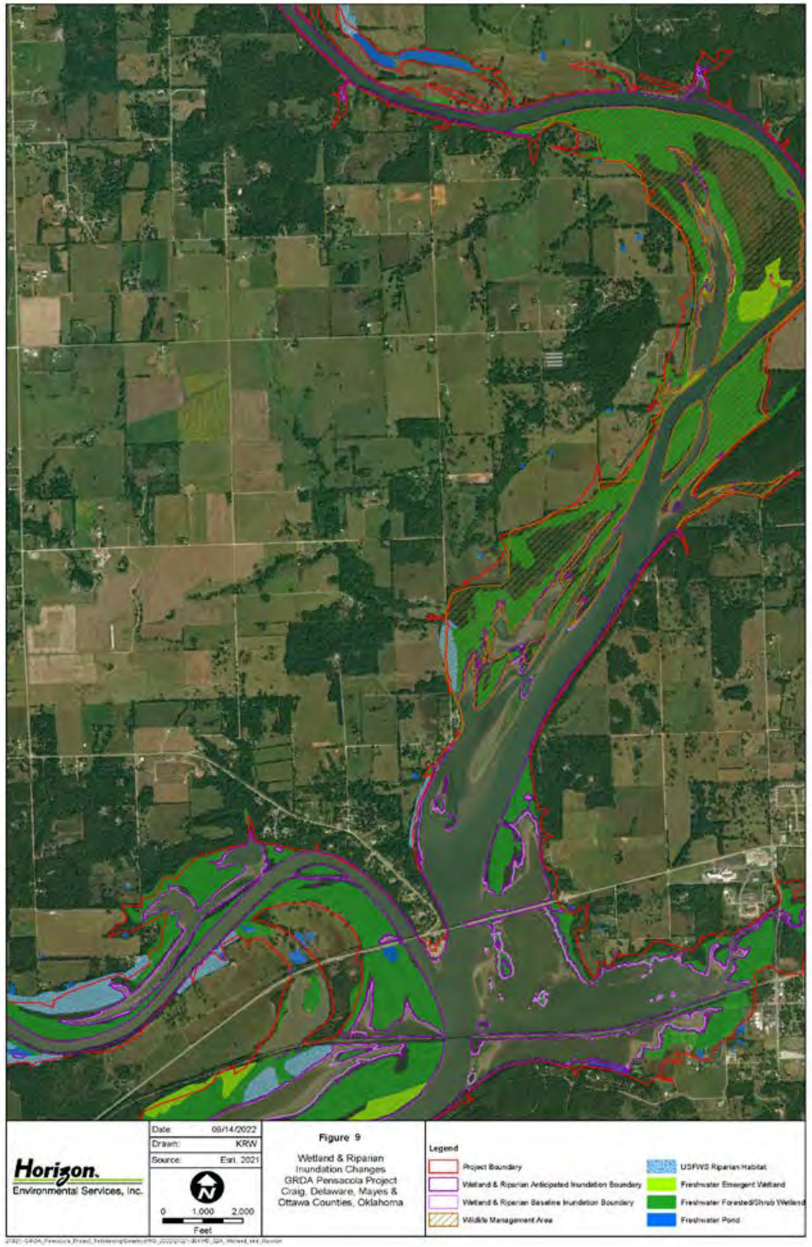
- Used the US Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI), GRDA's Wildlife Management Areas (WMAs), and GRDA's Comprehensive Hydraulic Model (CHM) data to identify, display, and describe the current composition of wetland and riparian communities within the study area.
- Used that data to develop a Geographic Information System (GIS) database on the extent, classification, and estimate the total acres of wetland, riparian habitats, and WMAs within the study area.
- For the purpose of this study plan, Horizon used the Wetland & Riparian Baseline and Anticipated Inundation Boundary extents provided by Mead & Hunt to clip wetland, riparian, and WMA polygons to produce the data set for analysis.
- Horizon utilized this data to assess the potential impact to wetlands, riparian habitats, and WMAs from the potential change in inundation occurring in the study area.

Database Analysis Results

The database displayed 160.78 acres of wetland types, 2.70 acres of riparian habitat, and 28.54 acres of WMAs within the study area. The breakdown of the wetland habitat types are provided below:

- ❖ 5.88 acres of Palustrine Emergent Wetlands
- ❖ 33.69 acres of Palustrine Scrub-Shrub Wetlands
- ❖ 119.24 acres of Palustrine Forested Wetlands
- ❖ 1.97 acres of Open Water

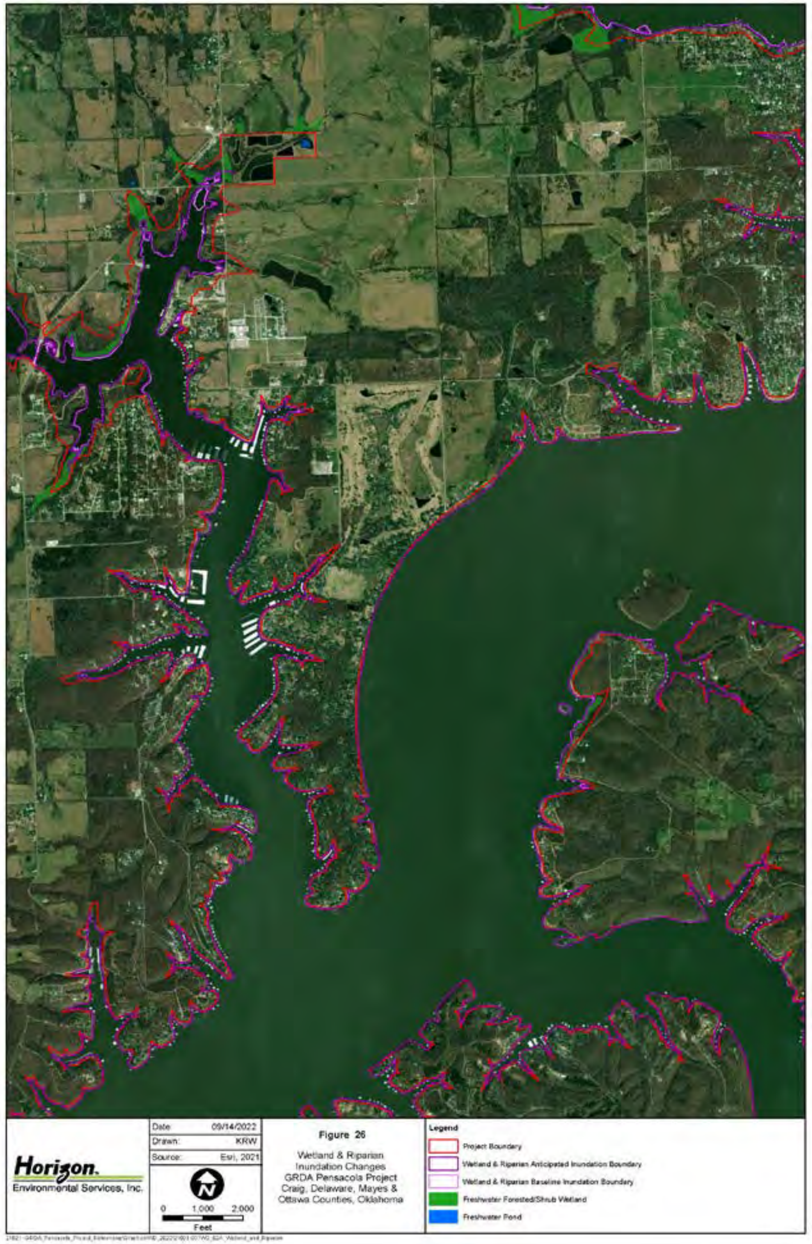




This slide provides examples of the figures from the GIS database analysis indicating that the difference between the median water elevation of baseline operations and anticipated operations is very narrow.

Figure 9 (to the left) is a representative view of the upper reaches of the lake that are riverine in nature.

Figure 26 (to the right) is a representative view of the lower portion of the lake that is lacustrine habitat.



Discussion and Conclusion

The anticipated operations (during the wetland/growing season from March 3rd to November 2nd) under the new license will result in water level fluctuations ranging from 742 to 745 feet Pensacola Datum (PD) (or 3 feet), whereas baseline operations have resulted in frequent water level fluctuations ranging from 741 to 745 feet PD (or 4 feet).

After reviewing the CHM model and conducting the desktop review, no major deviations in water elevation/inundation were observed for the wetlands, riparian areas, and the WMAs from baseline operations to the anticipated operations. Therefore, it was determined that field verification would not be warranted.

Based on the results of the CHM model, GIS database analysis, and desktop review, it was determined that anticipated operations of the GRDA Pensacola Hydroelectric Project will not have a significant effect on wetlands, riparian areas, and WMAs within the study area.