Lewis and Clark Lake Sediment Management Study (LCLSMS)
Preliminary Findings of the Reservoir Flushing Model Using GSTARS4

Hydroscience and Training Center at Colorado State University

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Applying Research to Restoration

- Element IV.B.3 2000 BiOp
  - Habitat Restoration/Creation/Acquisition
    - Suggested management techniques for habitat creation include: (1) replenishment or nourishment of river sandbars and islands;
- Element IV.C 2000 BiOp
  - C. Initiation of Sediment Transport/Habitat Studies
    - The Corps shall research and develop a way to restore the dynamic equilibrium of sediment transport and associated turbidity in river reaches downstream of …. Gavins Point Dams (Segment 10), and stop or reverse bed degradation of the river.
    - Because of the large sediment deposition zone at the upper end of Lewis and Clark Lake and its proximity to Gavins Point Dam, Gavins Point may provide the best opportunity for a pilot study.

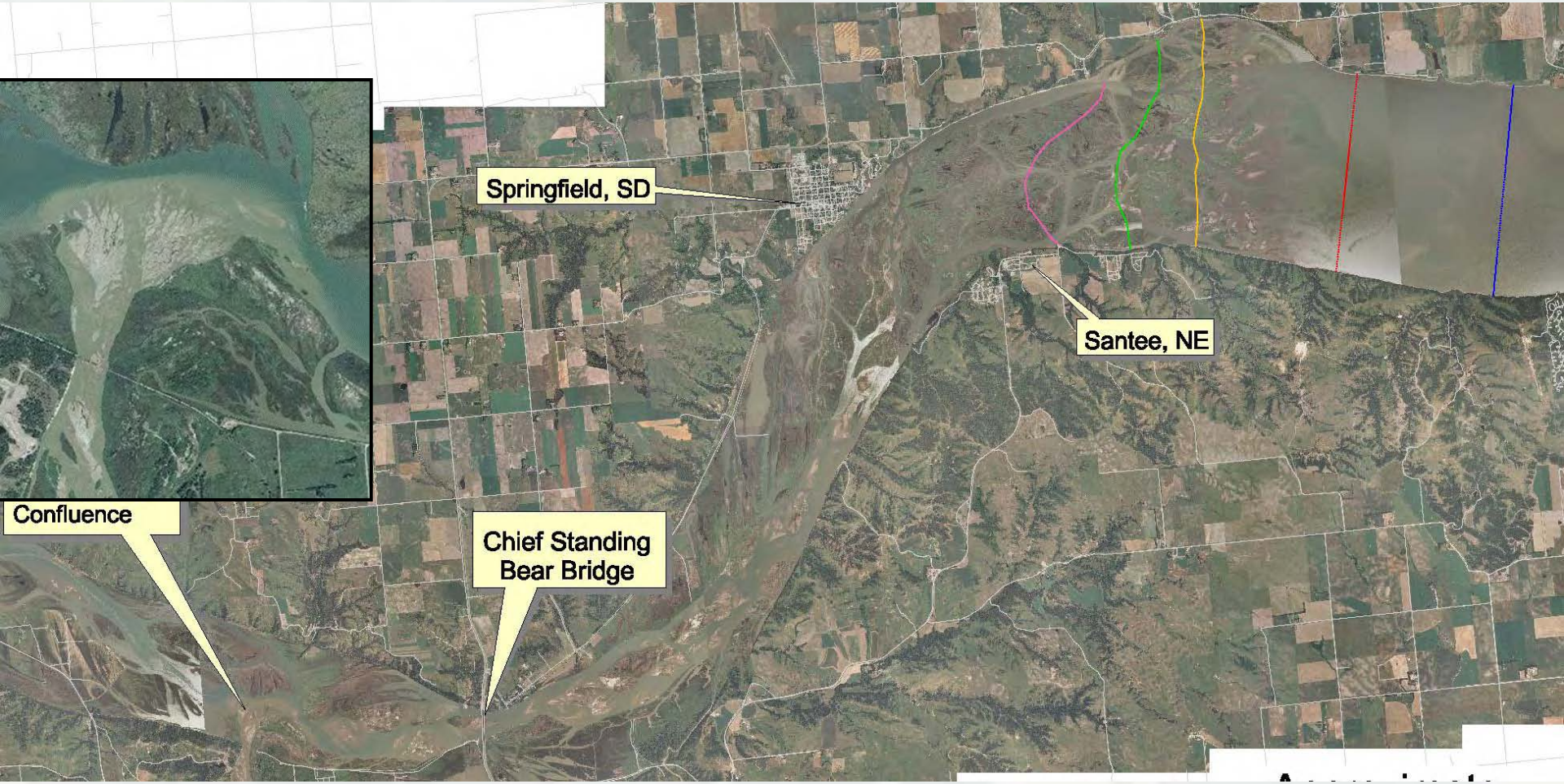
- Conservation Recommendations – Pallid Sturgeon: 2003 Amended BiOp
  - The most significant benefit of increased sediment transport and availability would be expressed in the Lower Missouri River below Gavins Point Dam and in the Middle Mississippi River.
  - Based on the Corps' 2002 Conceptual Analysis of Sedimentation Issues on the Niobrara and Missouri River, there appears to be a feasible alternative to manage reservoir sediment (e.g., reservoir flushing). We strongly encourage the Corps to heed the advice of the contractor that prepared the report and proceed to a Feasibility Study

Lewis and Clark Lake behind Gavins Point Dam

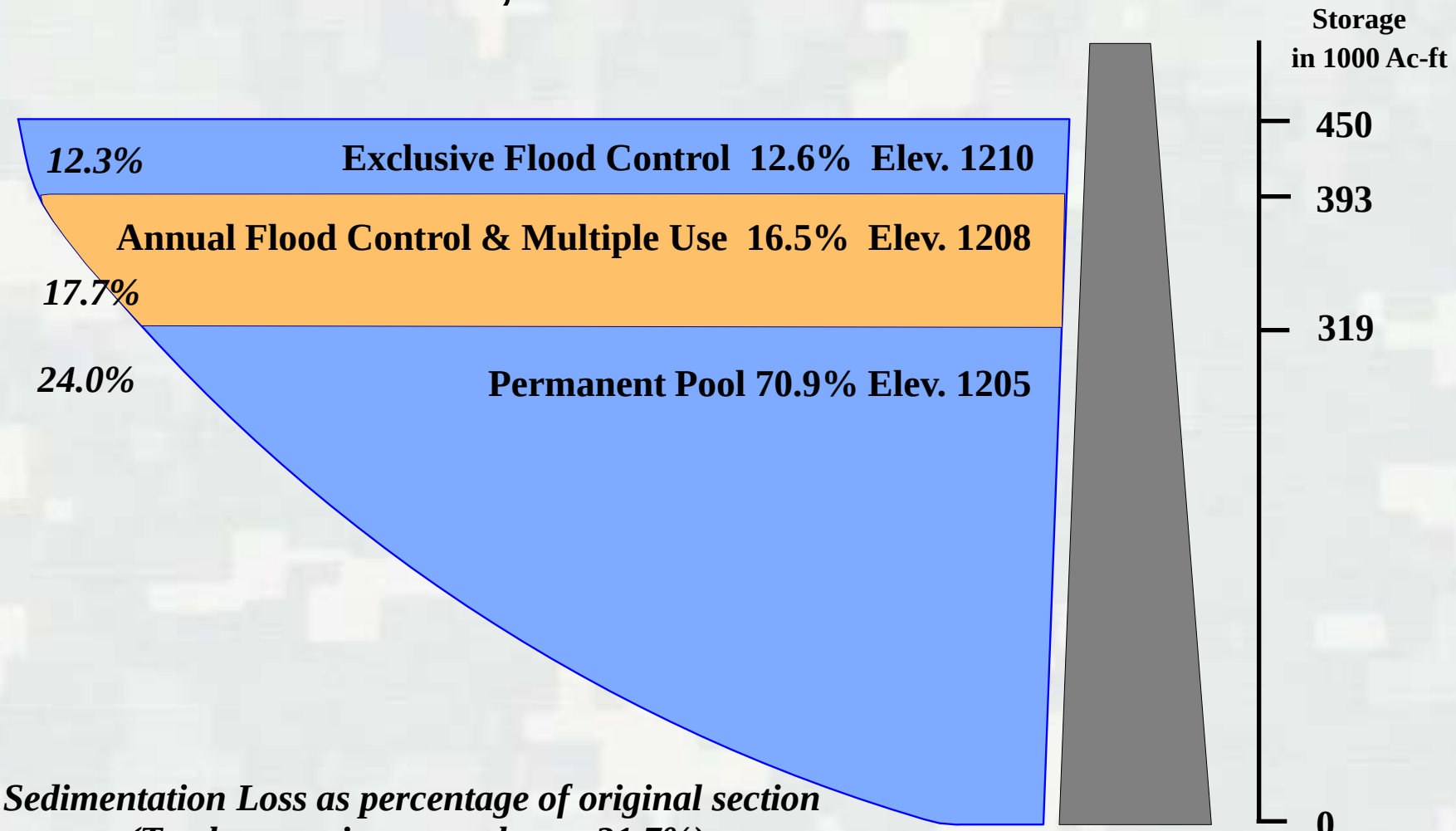
Lewis and Clark Lake Facts

- Authorized Project Purposes:
  - Reregulation of Flows for Navigation
  - Hydropower Generation
  - Flood Control
  - Recreation
  - Water supply
  - Fish and Wildlife (endangered species)
  - Water quality
  - Irrigation
- Original open lake = 25 miles Current open lake = 17 miles
- 2,400 ac-ft of sediment deposited annually below elevation 1210 ft
- 55-60% of sediment load from Niobrara River
- Elevated groundwater due to deposition forced relocation of Niobrara, NE
- Navigation and Hydropower impacted in 125-175 years, other purposes sooner

Delta Locations



Lewis and Clark Lake at Gavins Point Dam, Yankton, SD - River Mile 811



Sedimentation Loss as percentage of original section storage (Total reservoir storage loss = 21.7%)

Volumes based on 2007 survey data

LCLSMS Project Goals

- Evaluate the engineering viability of using varying discharges and stages through/in Lewis and Clark Lake to transport currently deposited sediments in the lake to/through Gavins Point Dam
- Develop modeling tools that will allow for analysis of most upstream and downstream flow and sediment transport scenarios
- Design a test flow that would verify the model (there is no physical test as part of this study)
- Draw conclusions about the viability of the flow alternatives modeled

LCLSMS Project Plan

- ***Phase 1*** – Selection and modification of the GSTARS (General Sediment Transport Model for Alluvial River Systems) for unsteady flow analysis. *(completed 2006)*
  - Under contract by the Colorado State University Hydroscience and Training Center, Ft. Collins, CO.
- ***Phase 2*** – Collection of river and reservoir survey data and initial public meeting *(completed 2007)*
- ***Phase 3*** – GSTARS4 (modified version of GSTARS) model calibration with reservoir data *(completed 2010)*
- ***Phase 4*** – Analysis of flow alternatives within the reservoir model *(completed March 5th, 2011)*
- ***Phase 5*** – Development of a downstream flow model from Gavins Point Dam to Sioux City, IA, by USACE, with HEC-RAS w/sediment *(current)*
- ***Phase 6*** – Analysis of reservoir model output by the downstream flow model *(current)*
- ***Phase 7*** - Completion of study with recommendations of viable alternatives *(Fall 2011)*

GSTARS4 Model Information

- Generalized Sediment Transport model for Alluvial River Simulation v.4
  - Merges GSTARS3 with the fully unsteady SRH-1D code, which gives quasi-2d flow with stream tubes and truly unsteady flow
- 2007 Survey and sediment sample data
- Calibrated with 1975-1995 daily flow data
- Tested with Xiaolangdi Reservoir, China flushing data for verification

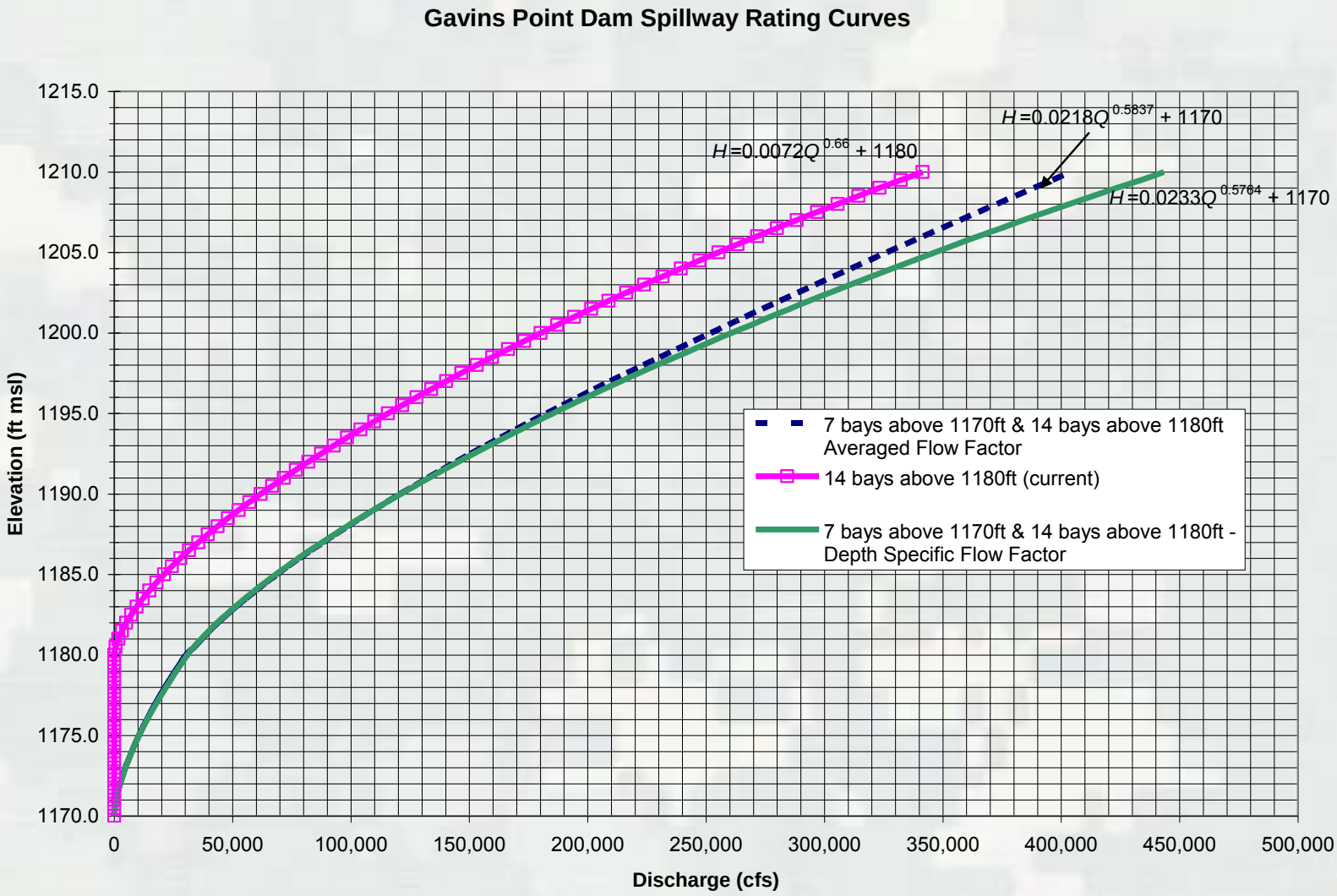
Flow Scenarios Modeled

(guidance from 2002 Conceptual Analysis Report)

Scenario no.	spillway	Days of main flushing	Discharge (cfs)					
			For initial lake drain*		For main flushing*		For reservoir refilling*	
			Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
1	Existing	8	55,000	80,000	171,000	176,000	75,000	60,000
2	Existing	10	15,000	40,000	83,000	88,000	35,000	20,000
3	Existing	Until 2,600 ac-ft of sediment flushed	15,000	40,000	83,000	88,000	35,000	20,000
4	Modified	8	55,000	80,000	171,000	176,000	75,000	60,000
5	Modified	Until 2,600 ac-ft of sediment flushed	15,000	40,000	83,000	88,000	35,000	20,000

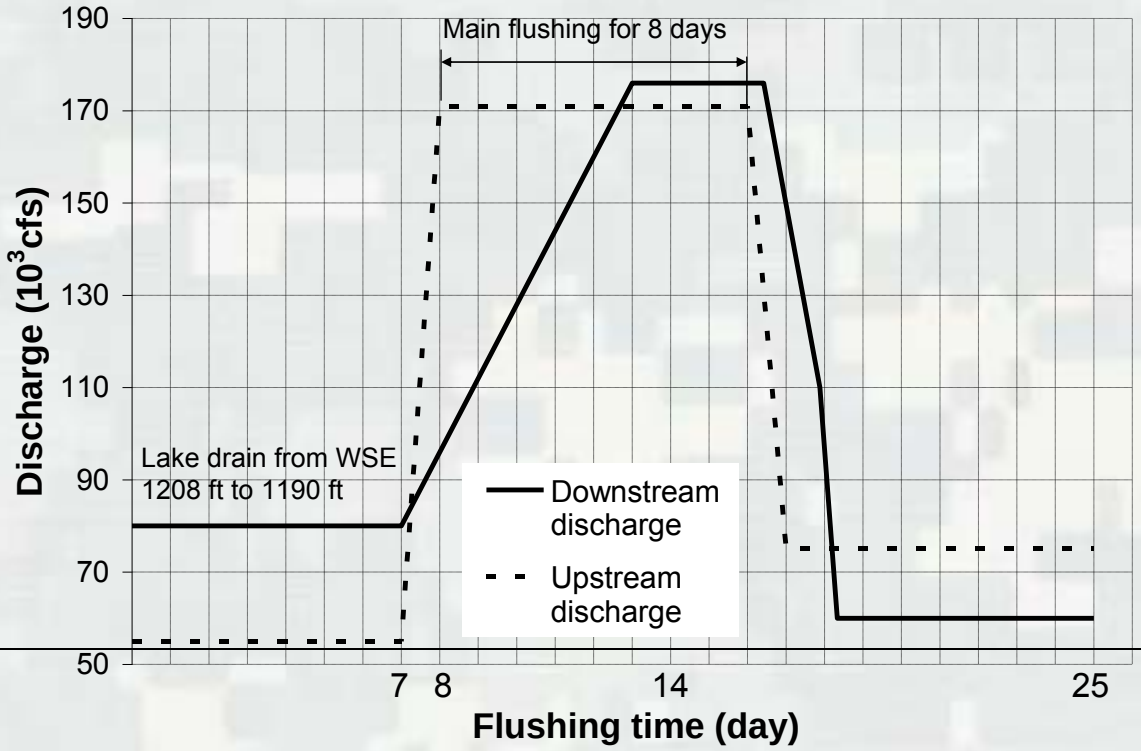
*tributary inflows set for a combined 5,000 cfs

Modified Spillway Scenarios



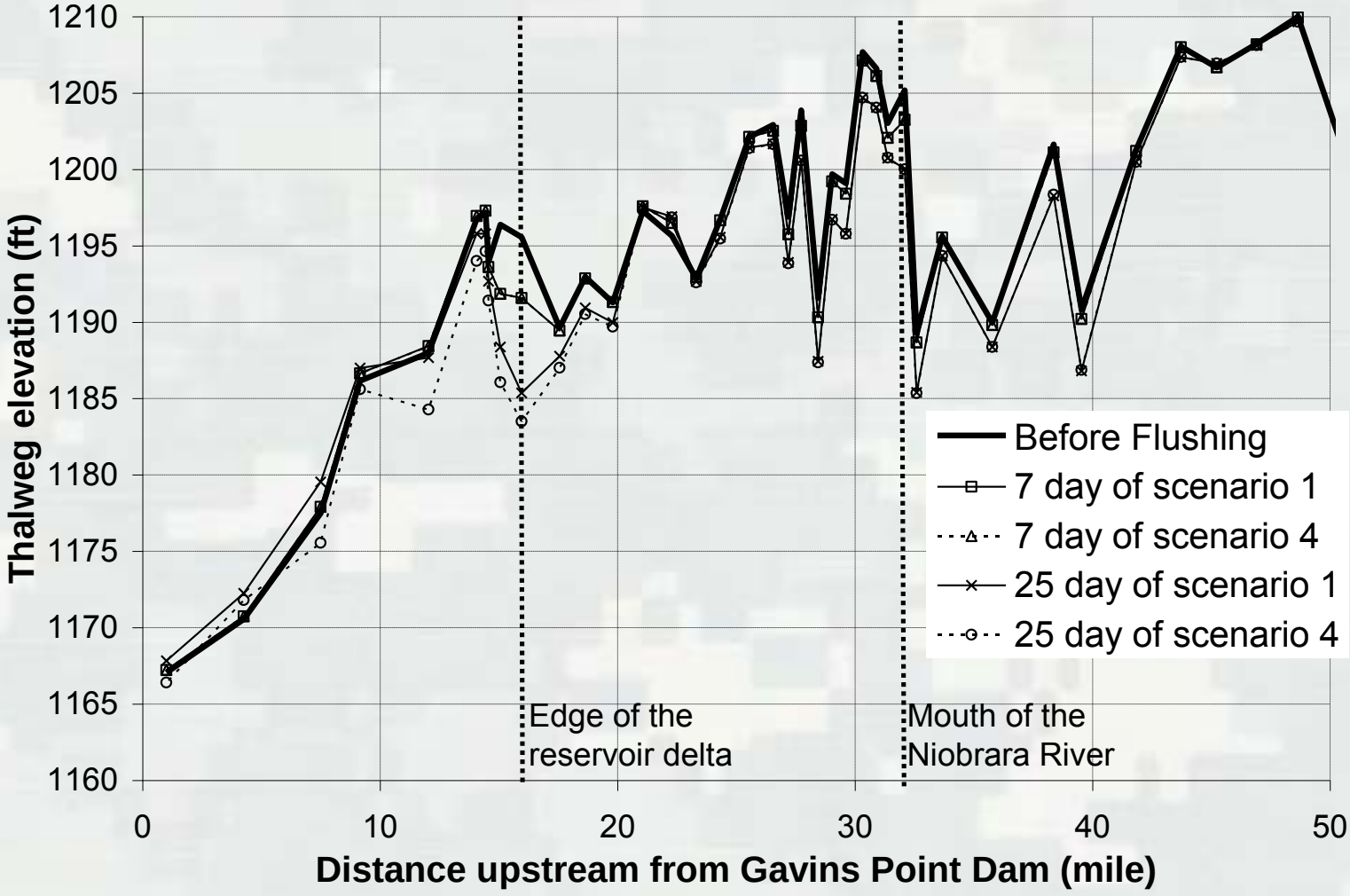
Discharge Staging

- Each scenario requires:
  - Reservoir drawdown (gate controlled discharge)
  - Spillway gate opening
  - Peak flushing flow (stage controlled discharge)
  - Reservoir refilling (gate controlled discharge)
- Timing by T&E due to varying peak travel time

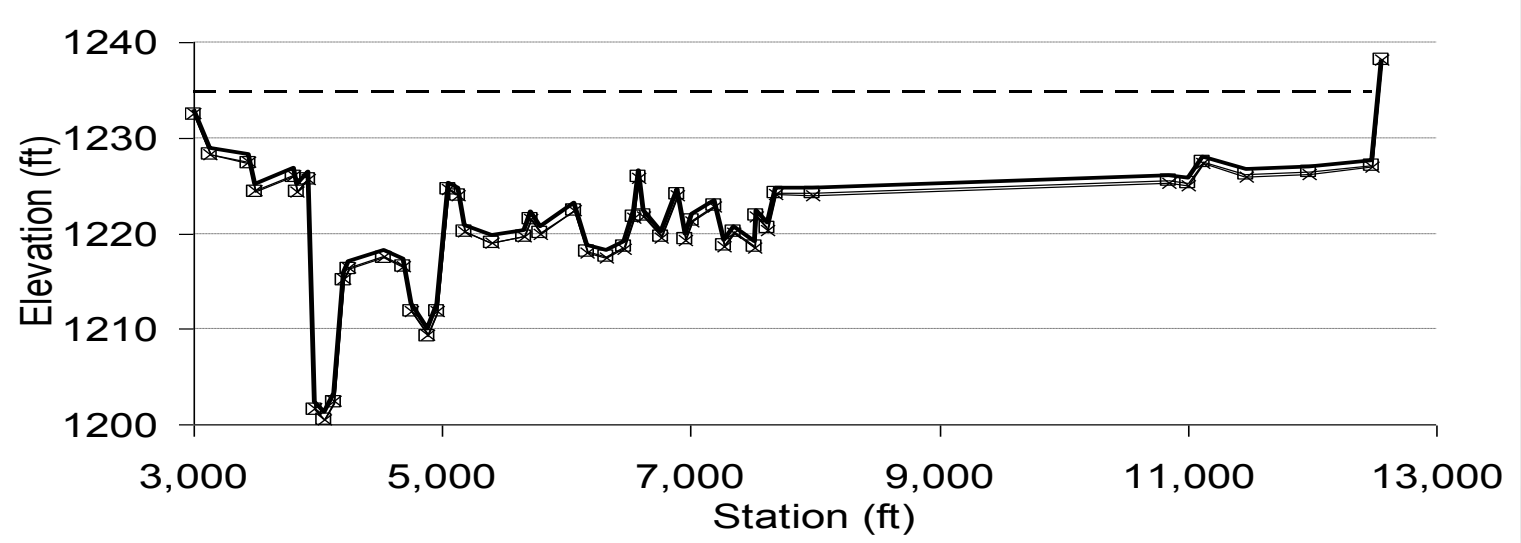


Model Output

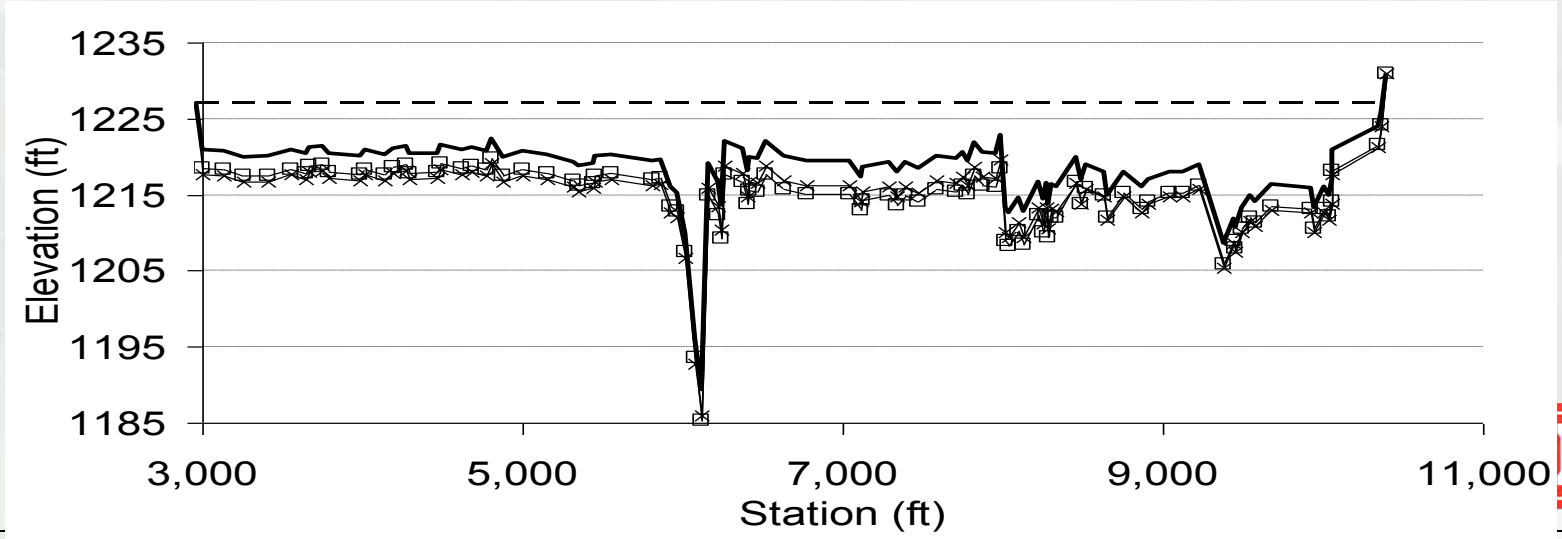
- Scenario 1 & 4 (same discharge, modified spillway)



Changes in channel geometry



41.8 mi above GPD (just above Lazy River Acres)



32.6 mi above GPD (Niobrara, NE)

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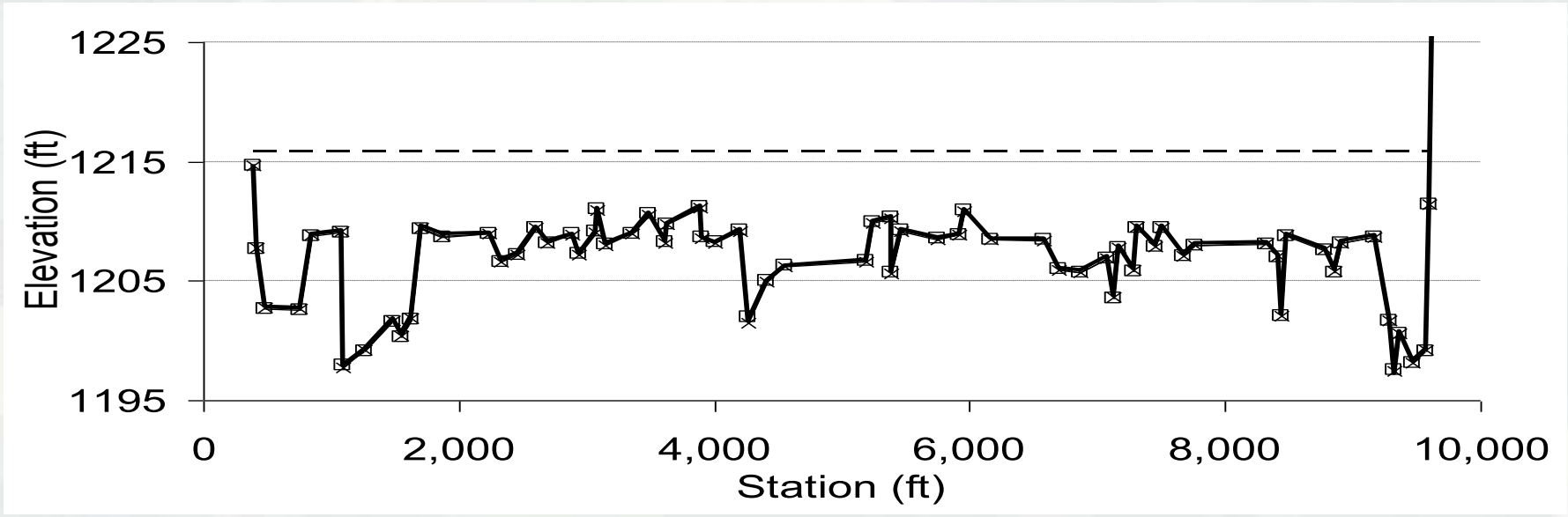
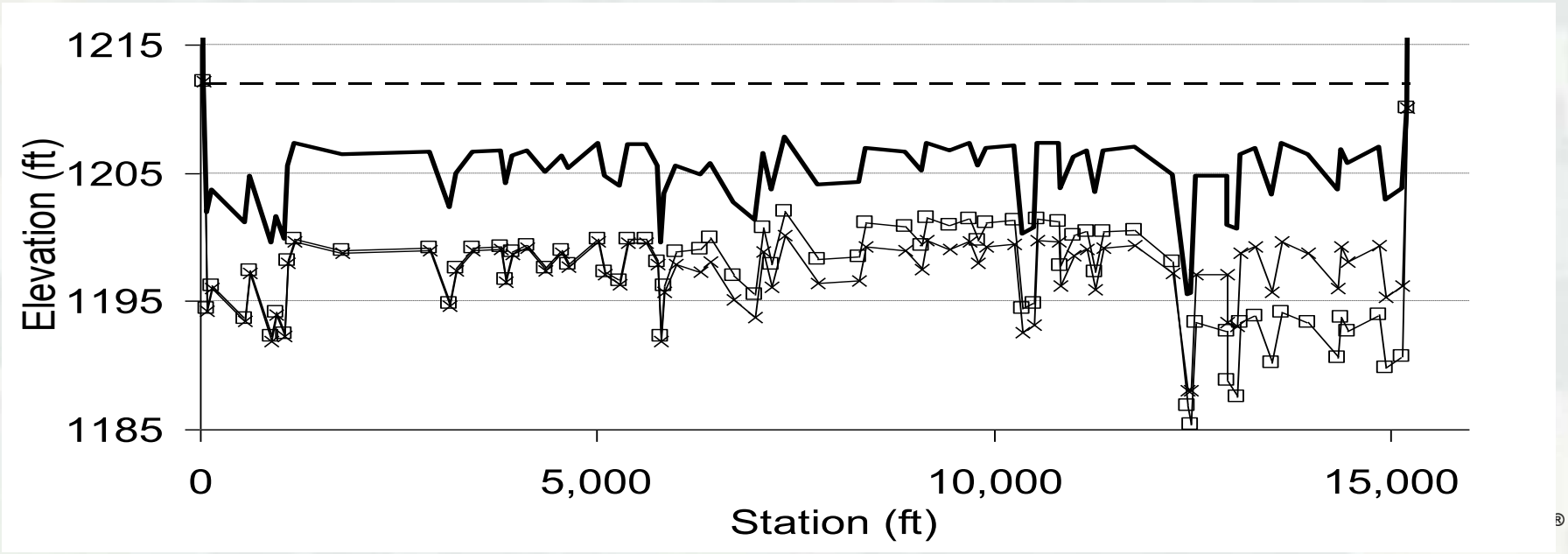
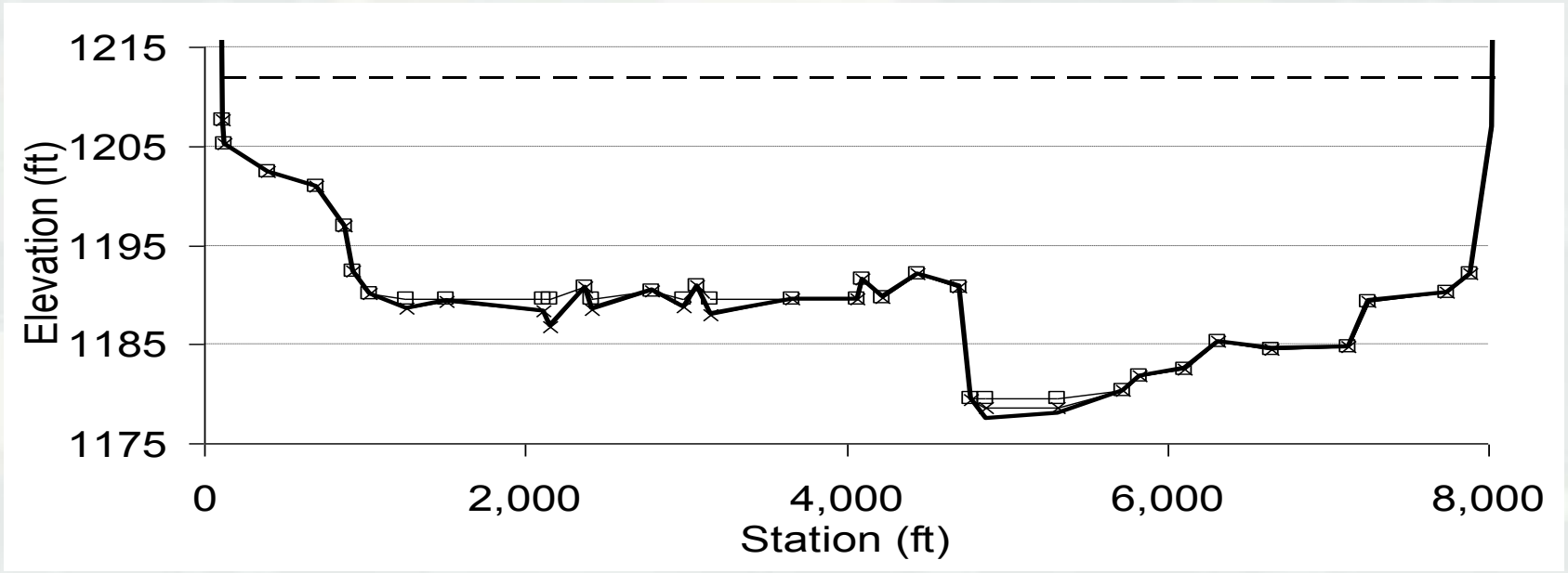


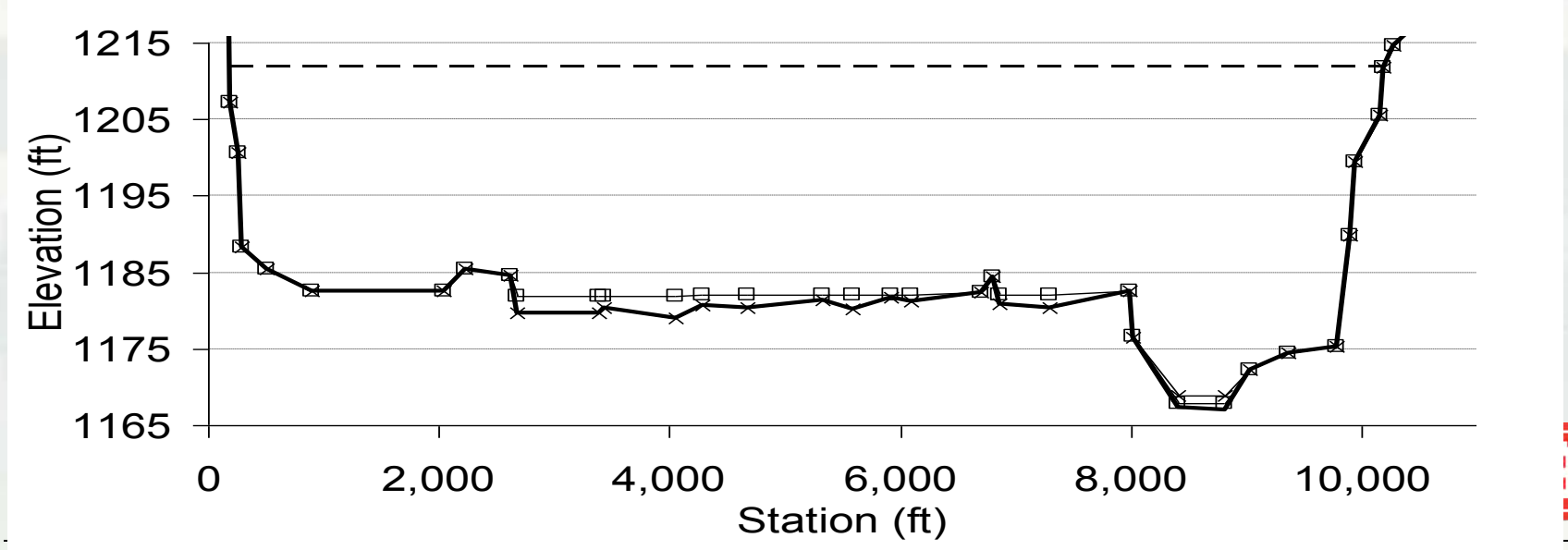
21.1 mi above GPD (near Springfield, SD)



16 mil above GPD (just below visible delta face)



7.5 mi above GPD

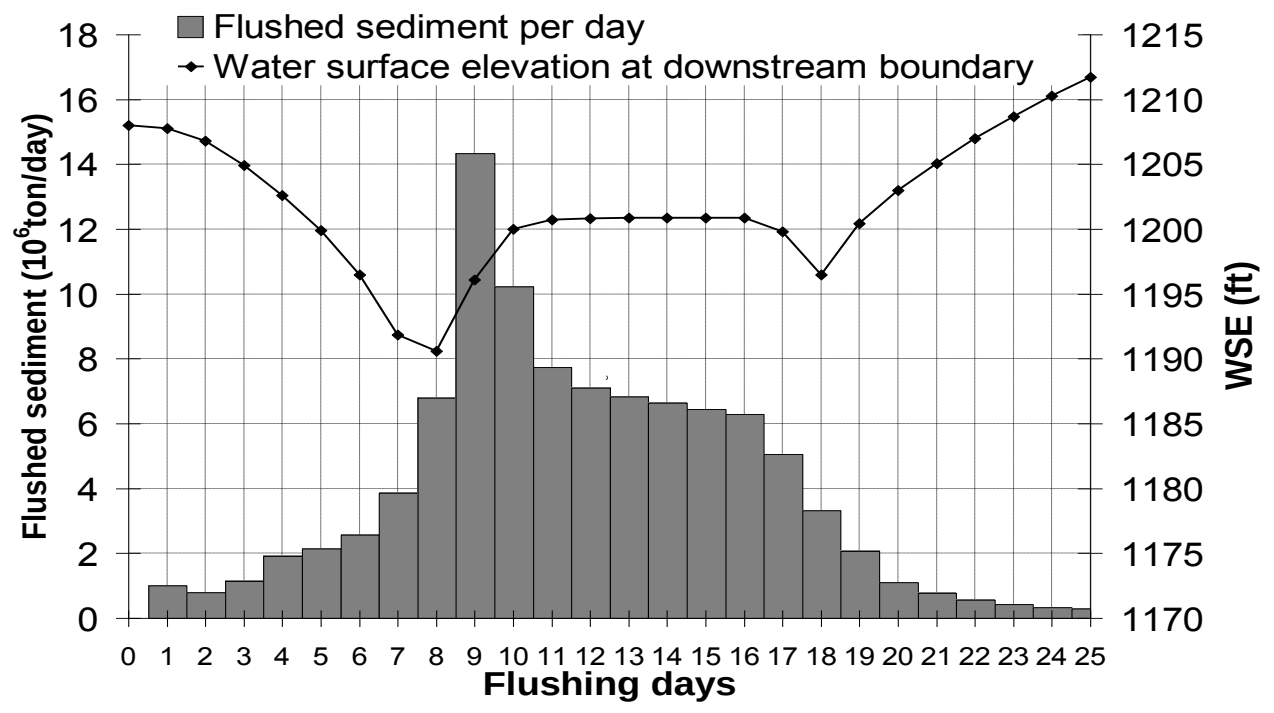


1.0 mi above GPD

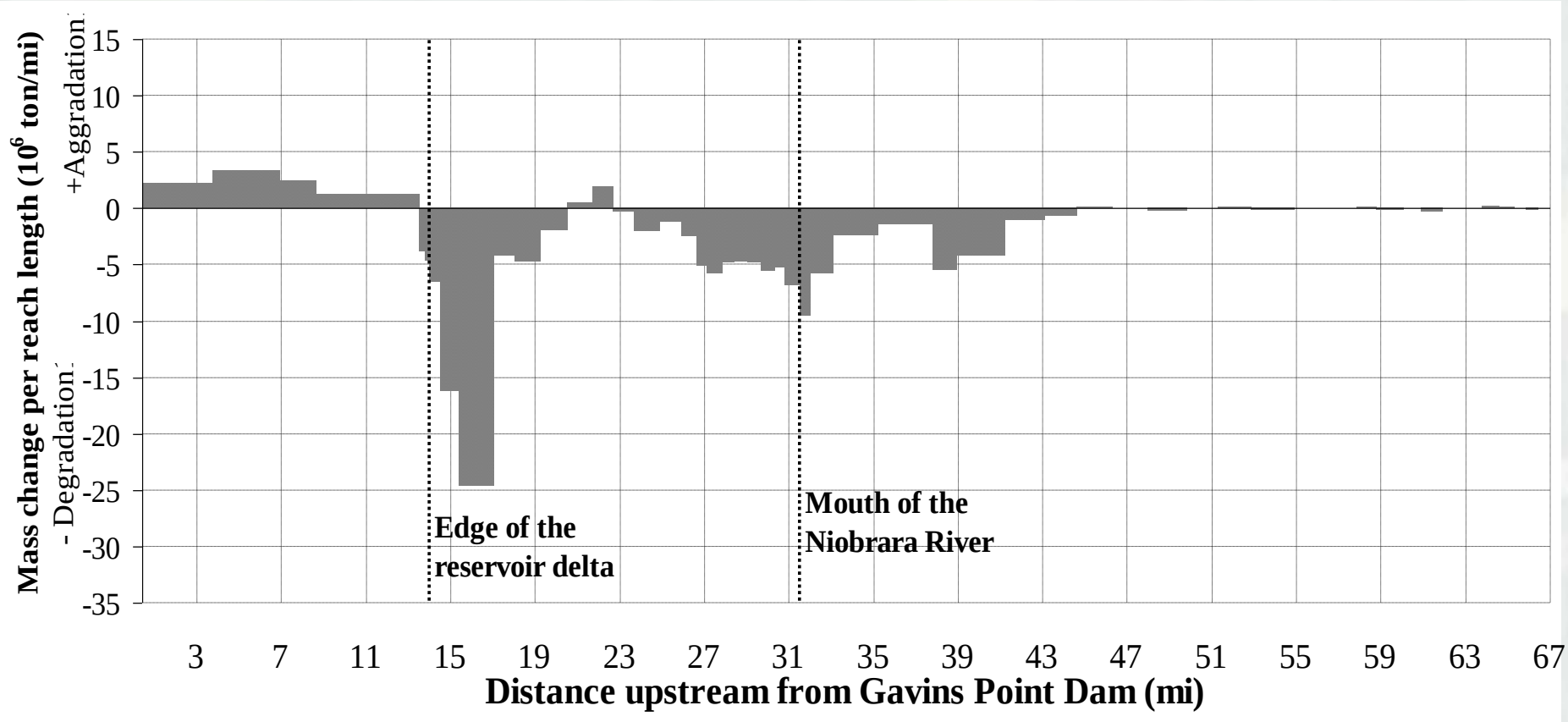
Summary of Sediment Transport

Scenario no.	Total operation days	Cumulative water past Gavins Point Dam		Cumulative sediment transport past		Ratio of discharged sediment / water
		(10^{10}ft^3)	(10^5ac-ft)*	(10^6ton)	(10^3ac-ft)*	
1	25	22.9	52.6	99.7	95.4	$1.8\ 10^{-2}$
2	25	11.6	26.6	72.0	68.8	$2.6\ 10^{-2}$
3 & 5	8	2.7	6.2	3.9	3.8	$6.2\ 10^{-3}$
4	25	23.0	52.8	178.4	170.6	$3.2\ 10^{-2}$

*Density of 48 lb/ft3 due to silt and clay



Re-deposition of Sediments above Gavins Point Dam



Scenario 1 @ 25 days

Particle Size Distribution of Flushed Sediments

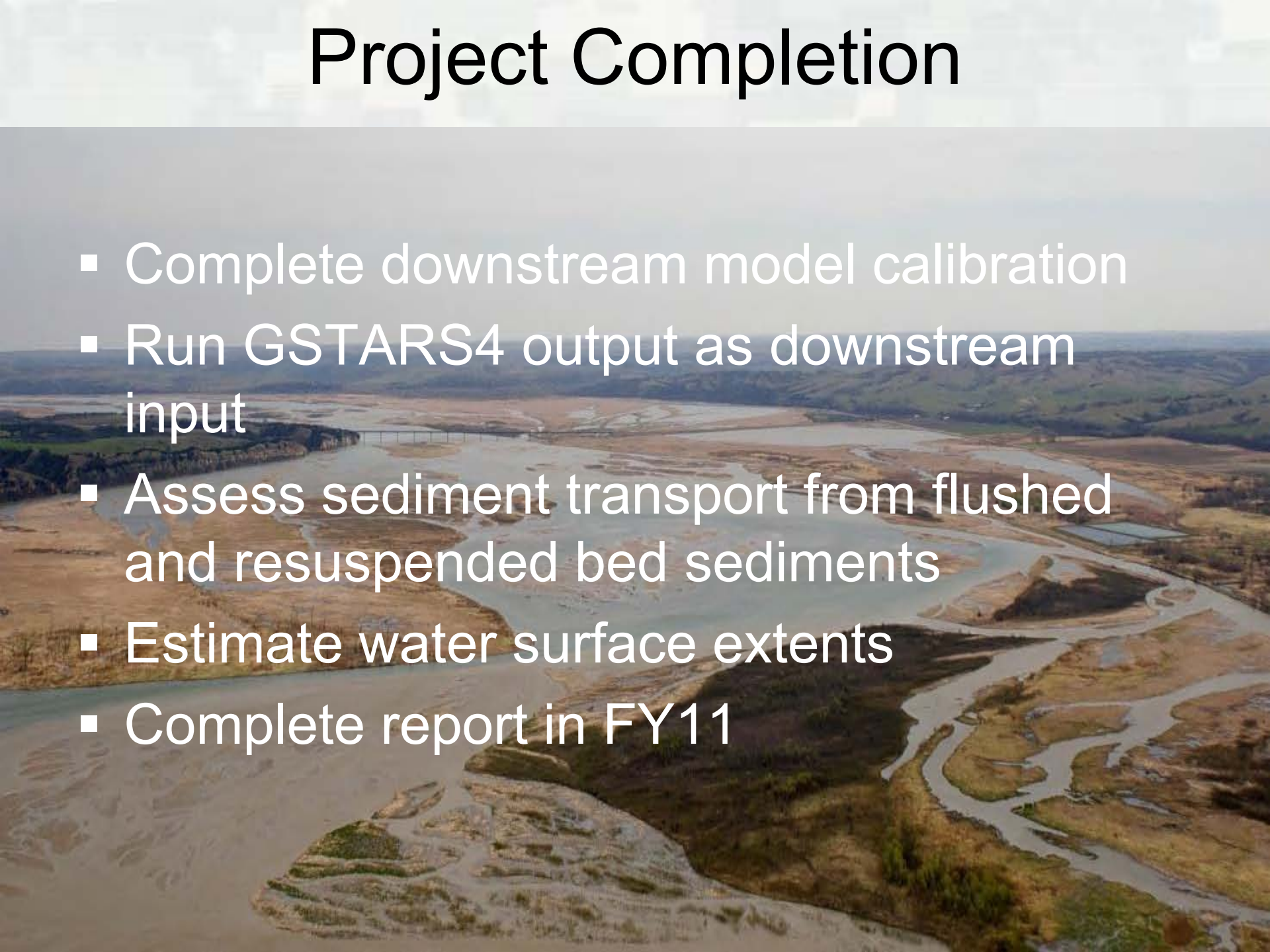
Time (hour)	Water discharge (cfs)	Sediment discharge (ton/hour)	Gradation (%)				
			Silt and Finer	Very Fine and Fine Sand	Medium Sand	Coarse and Very Coarse Sand	Gravels and Larger
			0.001 - 0.0625 mm	0.0625 - 0.250 mm	0.250 - 0.500 mm	0.500 - 2.00 mm	2.00 + mm
1	78756	41475	100.00	0.00	0.00	0.00	0.00
86	77704	82882	100.00	0.00	0.00	0.00	0.00
120	77120	94530	100.00	0.00	0.00	0.00	0.00
136	76662	107617	100.00	0.00	0.00	0.00	0.00
168	74445	214347	100.00	0.00	0.00	0.00	0.00
192	63137	360596	100.00	0.00	0.00	0.00	0.00
250	171072	326398	100.00	0.00	0.00	0.00	0.00
300	175935	284977	100.00	0.00	0.00	0.00	0.00
380	176010	260571	100.00	0.00	0.00	0.00	0.00
400	171851	199779	100.00	0.00	0.00	0.00	0.00
429	117812	138968	100.00	0.00	0.00	0.00	0.00
440	66086	101127	100.00	0.00	0.00	0.00	0.00
600	61501	10818	100.00	0.00	0.00	0.00	0.00

Discharge PSD for Scenario 1

Time (hour)	Water discharge (cfs)	Sediment discharge (ton/hour)	Gradation (%)				
			Silt and Finer	Very Fine and Fine Sand	Medium Sand	Coarse and Very Coarse Sand	Gravels and Larger
			0.001 - 0.0625 mm	0.0625 - 0.250 mm	0.250 - 0.500 mm	0.500 - 2.00 mm	2.00 + mm
1	78756	41475	100.00	0.00	0.00	0.00	0.00
80	77800	76049	100.00	0.00	0.00	0.00	0.00
135	76697	106567	100.00	0.00	0.00	0.00	0.00
188	68919	518533	99.95	0.05	0.00	0.00	0.00
212	62265	776438	99.93	0.06	0.00	0.00	0.00
265	172765	571188	99.99	0.01	0.00	0.00	0.00
330	175753	490813	99.99	0.01	0.00	0.00	0.00
400	175715	454700	99.99	0.01	0.00	0.00	0.00
420	171110	371526	99.99	0.01	0.00	0.00	0.00
450	110449	303626	99.99	0.01	0.00	0.00	0.00
460	69662	209722	100.00	0.00	0.00	0.00	0.00
500	62658	79171	100.00	0.00	0.00	0.00	0.00
600	61740	18188	100.00	0.00	0.00	0.00	0.00

Discharge PSD for Scenario 4 (mod spillway)

Project Completion



- Complete downstream model calibration
- Run GSTARS4 output as downstream input
- Assess sediment transport from flushed and resuspended bed sediments
- Estimate water surface extents
- Complete report in FY11

Preliminary Results Takeaways

- It is possible to undertake hydraulic flushing of delta sediments
- Dewatering of Lewis and Clark Lake is necessary for effective flushing
- Physical limitations of the infrastructure reduce effectiveness
- Higher discharge flushes = higher sediment transport
- With the deep lake area right behind the dam, most if not all the sand re-deposits and only silts and clays are transported below the dam
- Continued flushes would be expected to increase efficiency (although this was not modeled)
- Flushed sediment is not highly suitable to ESH needs: silts and clays
- Discharges will also redistribute sediments currently below Gavins Point
- Varying discharges would likely cause mild to major flooding depending on location
- Environmental, social, political, economic impacts WERE NOT considered in this study

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