US Army Corps
of Engineers
Omaha District

Big Horn Lake
Sediment Management Study

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Presentation Outline

- Omaha COE and Bureau Interagency Agreement
- Study compares sediment management alternatives and provides indication of impacts
- Completed modeling
- Final Draft Report for comment

Study Scope

- Initial appraisal level of detail
- Focus on screening and alternative comparison
- Highlight constraints/issues/impacts of the sediment management challenge
- Technical focus – compare results of alternative model simulations
- Additional factors considered for alternative implementation not a component of this study

Alternatives

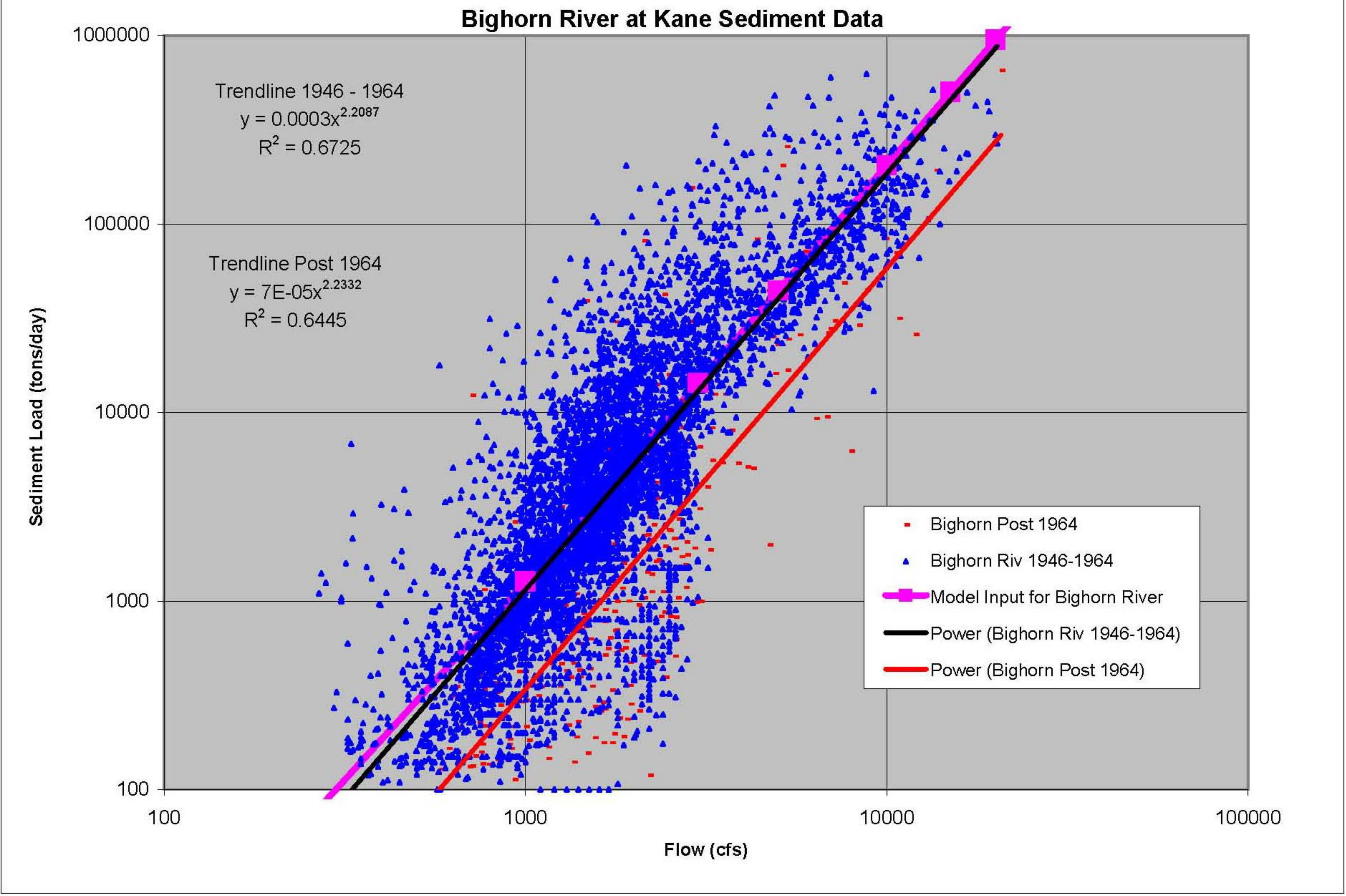
- A) Higher pool level during recreation season
- B) Trap sediments upstream of Lovell Causeway
- C) Flush sediment through HSB with lower pool at high inflow
- D) Dike to manage sediment within HSB
- E) Manage sediments within the watershed (not part of this study)
- F) Dredging of HSB sediments

Evaluation Method

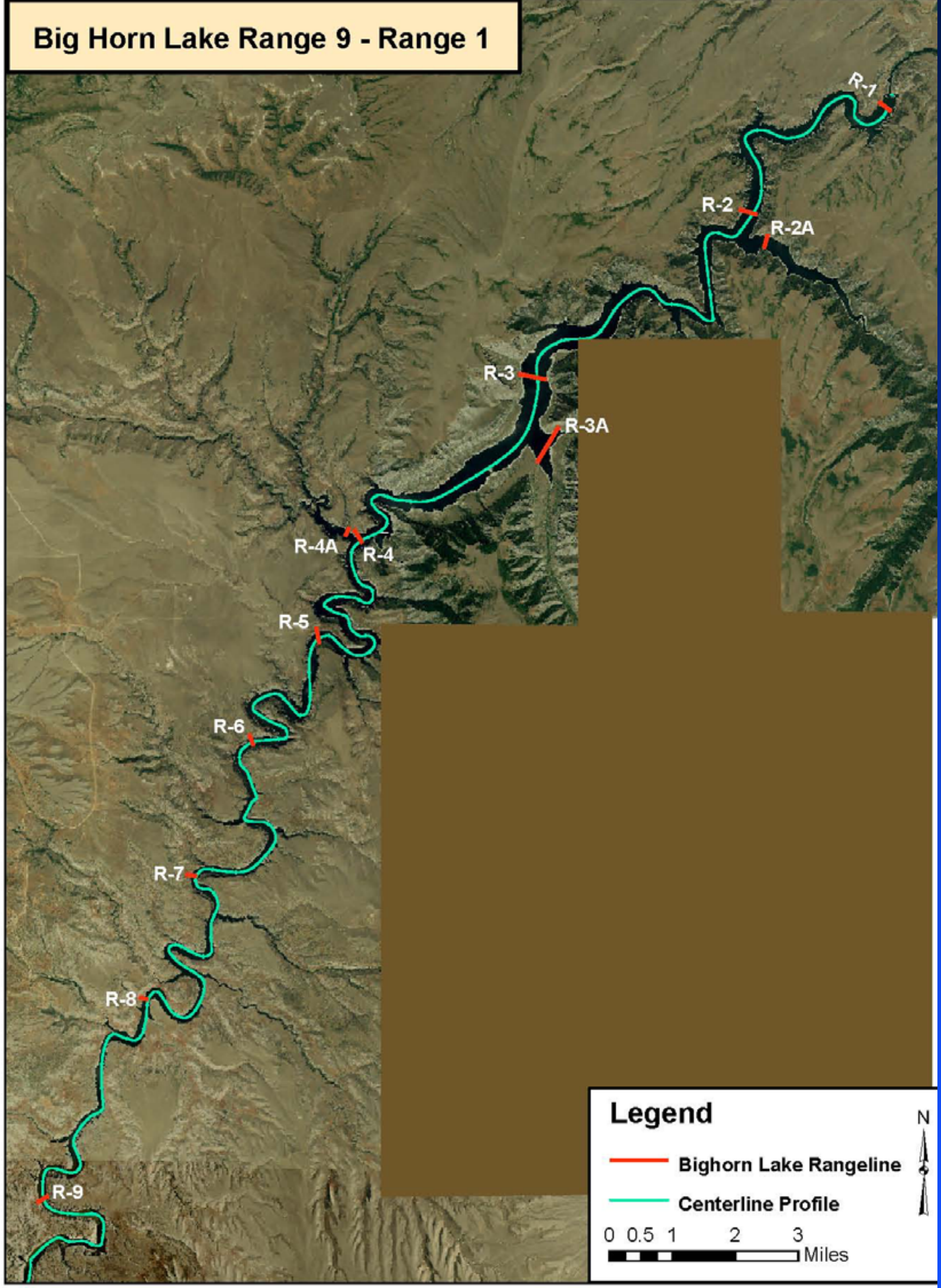
- Collect available data
- Construct hydraulic model, SRH-1D
- Verify model with existing conditions
- Modify model for each alternative
- Simulate future conditions by repeating past historical record
- Simulate with base and alternative condition models
- Compare simulation results

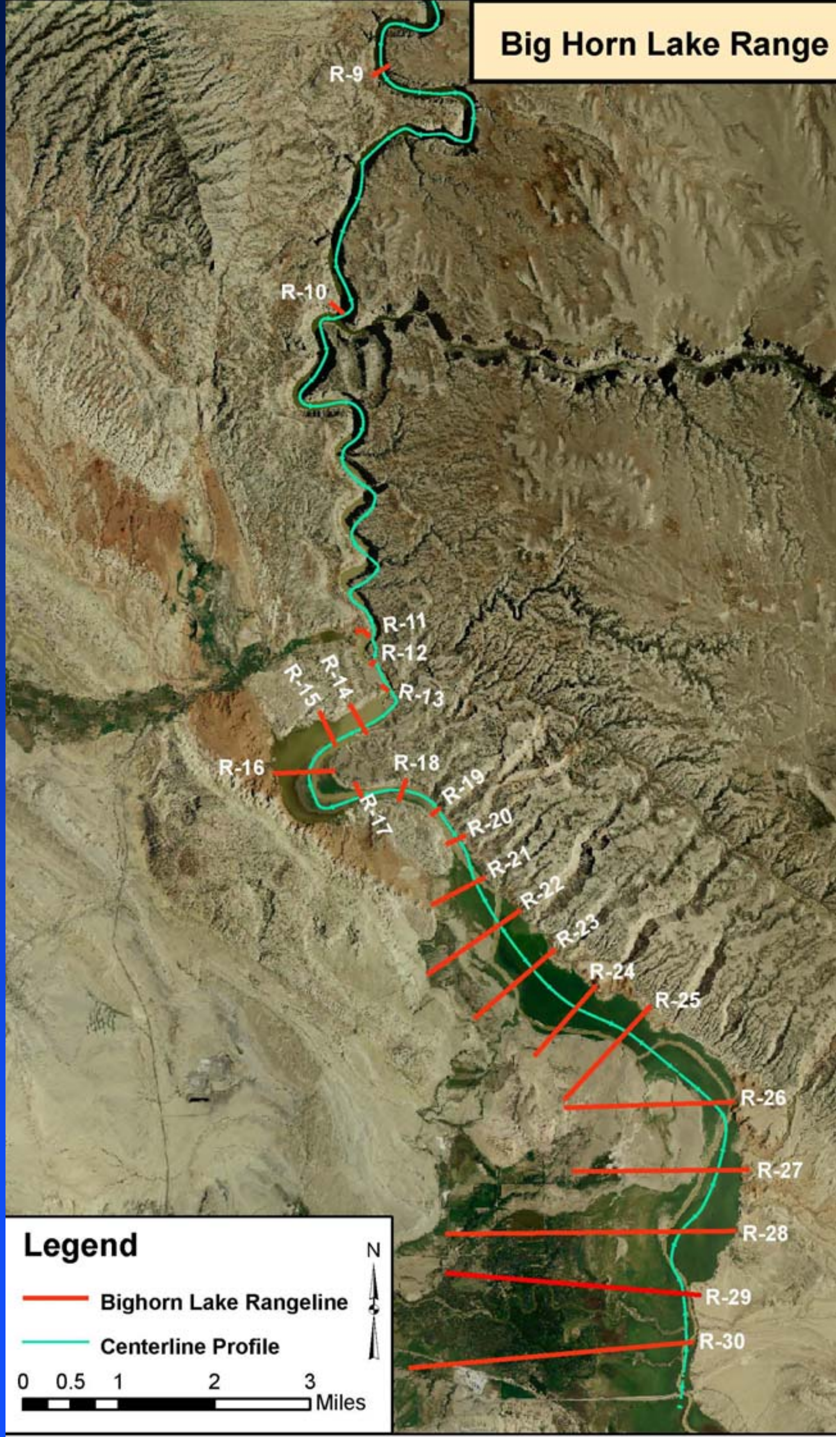
Model Input

- Hydraulic Model Data Requirements
  - Geometry and typical hydraulic parameters
  - Water Inflow for Bighorn River and Shoshone River
  - Sediment inflow and material size that is related to the water inflow
  - Pool Level
- All flow, sediment, and pool data is daily interval



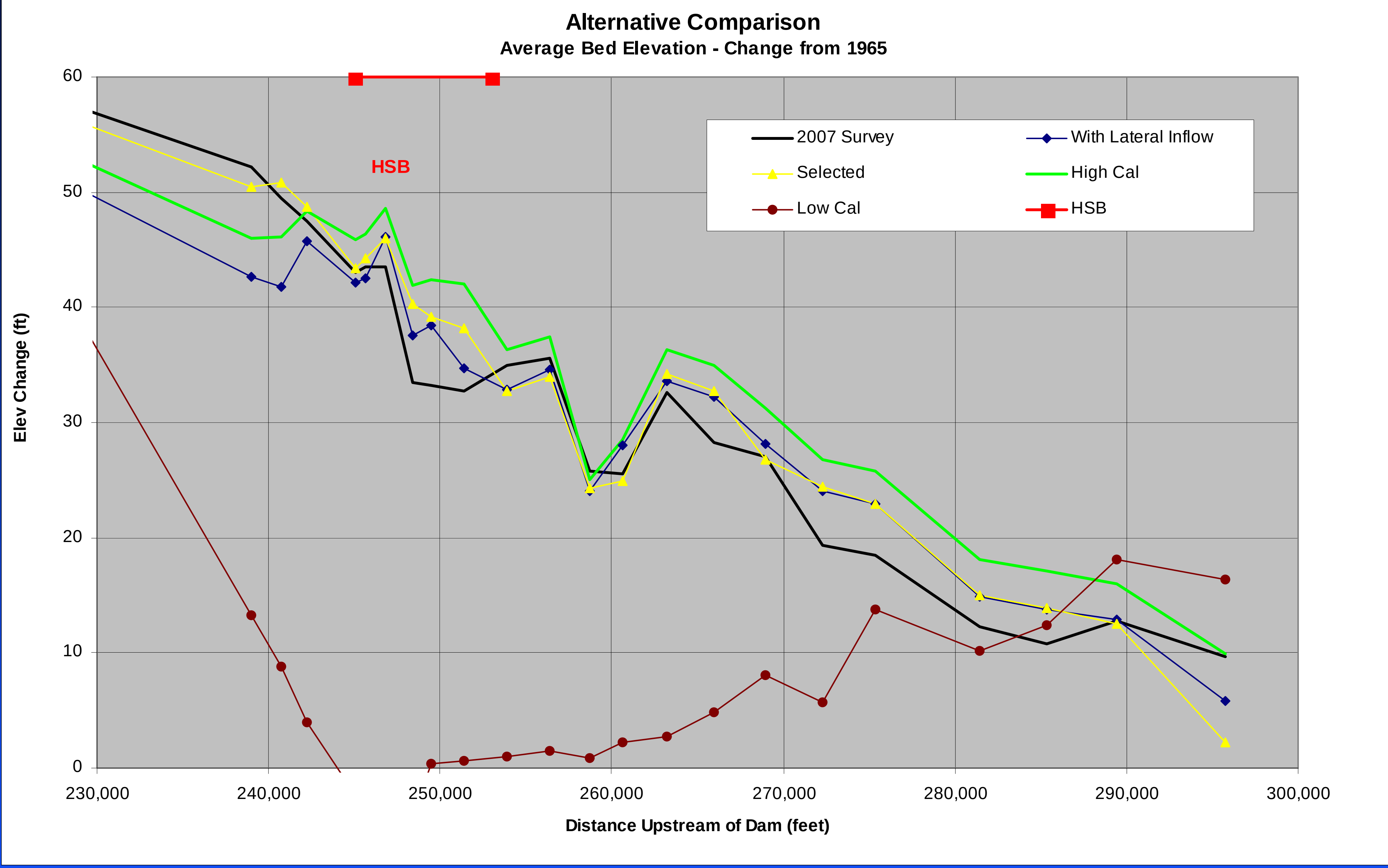
Bighorn River at Kane Sediment Data
Trendline 1946 - 1964
y = 0.0003x^2.2087
R^2 = 0.6725
Trendline Post 1964
y = 7E-05x^2.2332
R^2 = 0.6445
Sediment Load (tons/day)
1000000
100000
10000
1000
100
Flow (cfs)
100
1000
10000
100000
Bighorn Post 1964
Bighorn Riv 1946-1964
Model Input for Bighorn River
Power (Bighorn Riv 1946-1964)
Power (Bighorn Post 1964)

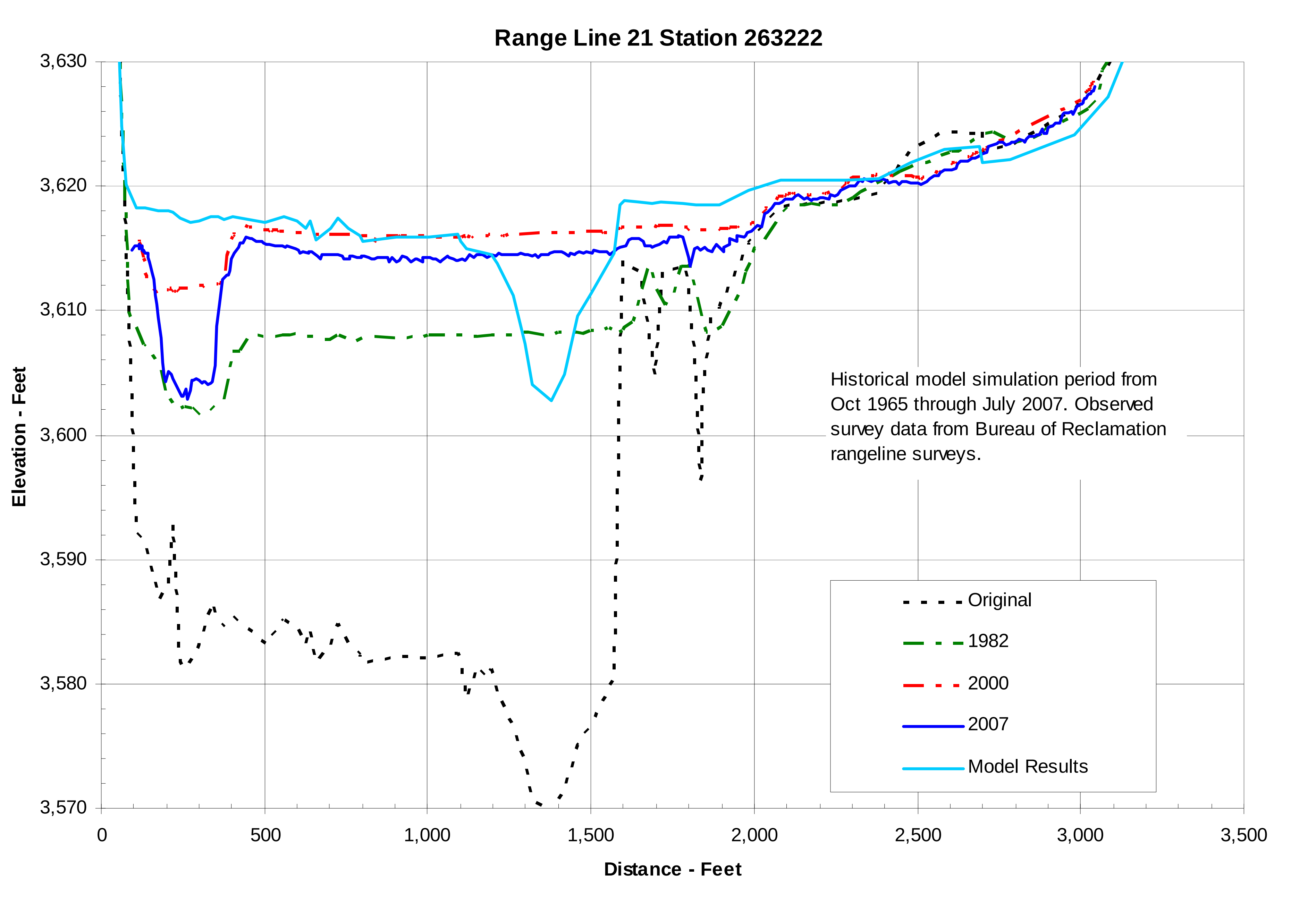

Big Horn Lake Range 9 - Range 1
R-1
R-2
R-2A
R-3
R-3A
R-4A
R-4
R-5
R-6
R-7
R-8
R-9
Legend
Bighorn Lake Rangeline
Centerline Profile
N
0 0.5 1 2 3
Miles


Big Horn Lake Range
R-9
R-10
R-11
R-12
R-13
R-14
R-15
R-16
R-17
R-18
R-19
R-20
R-21
R-22
R-23
R-24
R-25
R-26
R-27
R-28
R-29
R-30
Legend
Bighorn Lake Rangeline
Centerline Profile
N
0 0.5 1 2 3
Miles

Historical Period Simulation

- Start with 1965 era rangeline surveys
- Simulate period from Oct 1966 through July 2007
- Derive flow and sediment model inputs from available data, commonly used values, and results calibration
- Evaluate individual cross sections and average bed elevation between model results and survey
- Accuracy about 5-15% difference from observed, ± 5 ft actual from Causeway past HSB


Alternative Comparison
Average Bed Elevation - Change from 1965
Elev Change (ft)
Distance Upstream of Dam (feet)
60
50
40
30
20
10
0
230,000
240,000
250,000
260,000
270,000
280,000
290,000
300,000
HSB
2007 Survey
With Lateral Inflow
Selected
High Cal
Low Cal
HSB



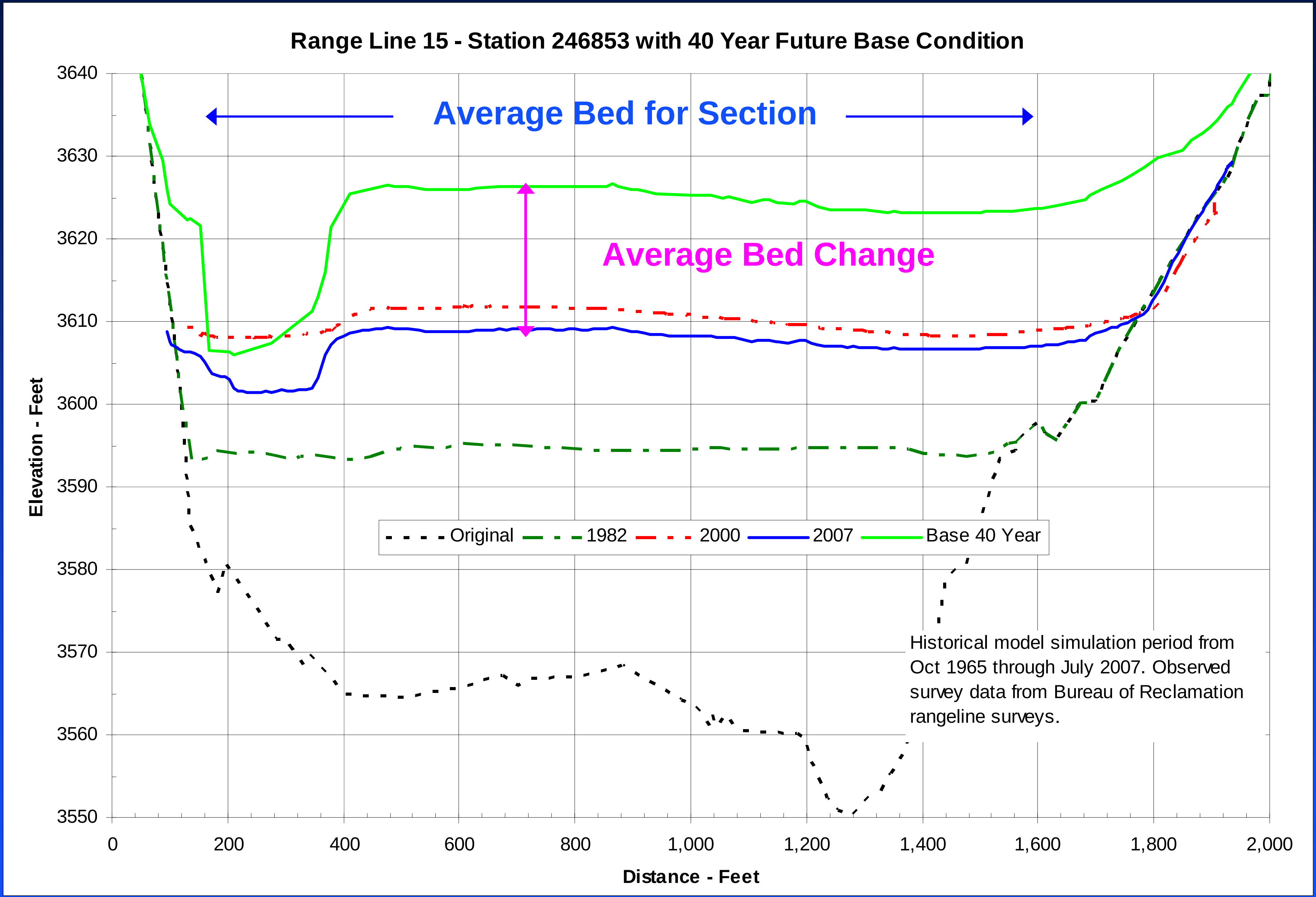
Range Line 21 Station 263222
3,630
3,620
3,610
3,600
3,590
3,580
3,570
Elevation - Feet
0
500
1,000
1,500
2,000
2,500
3,000
3,500
Distance - Feet
Historical model simulation period from Oct 1965 through July 2007. Observed survey data from Bureau of Reclamation rangeline surveys.
Original
1982
2000
2007
Model Results

Base Condition

- Current average bed elevations in HSB vary from 3610 to 3615
- Delta front has moved past HSB
- Previous surveys show sediment accumulates at average rate of 0.8 to 1.1 ft/yr in HSB
- Model shows declining trend, approach ultimate elevation of 3625 to 3630 in 20 years

Evaluate Alternatives

- Use model to simulate future based on historical inflow
- Base condition starts with 2007 survey geometry
- Use “Average Bed Elevation” to compare base to alternatives
- Accuracy limits, future sediment loads, climate, inflow, etc.
- Compare **between model results**, not absolute value


Range Line 15 - Station 246853 with 40 Year Future Base Condition
Average Bed for Section
Average Bed Change
Elevation - Feet
Distance - Feet
3640
3630
3620
3610
3600
3590
3580
3570
3560
3550
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
Original
1982
2000
2007
Base 40 Year
Historical model simulation period from Oct 1965 through July 2007. Observed survey data from Bureau of Reclamation rangeline surveys.

Alternative A- Higher Pool During Recreation Season

Modeled by artificially setting pool level at 3630 or higher from 15 May – 15 Sep

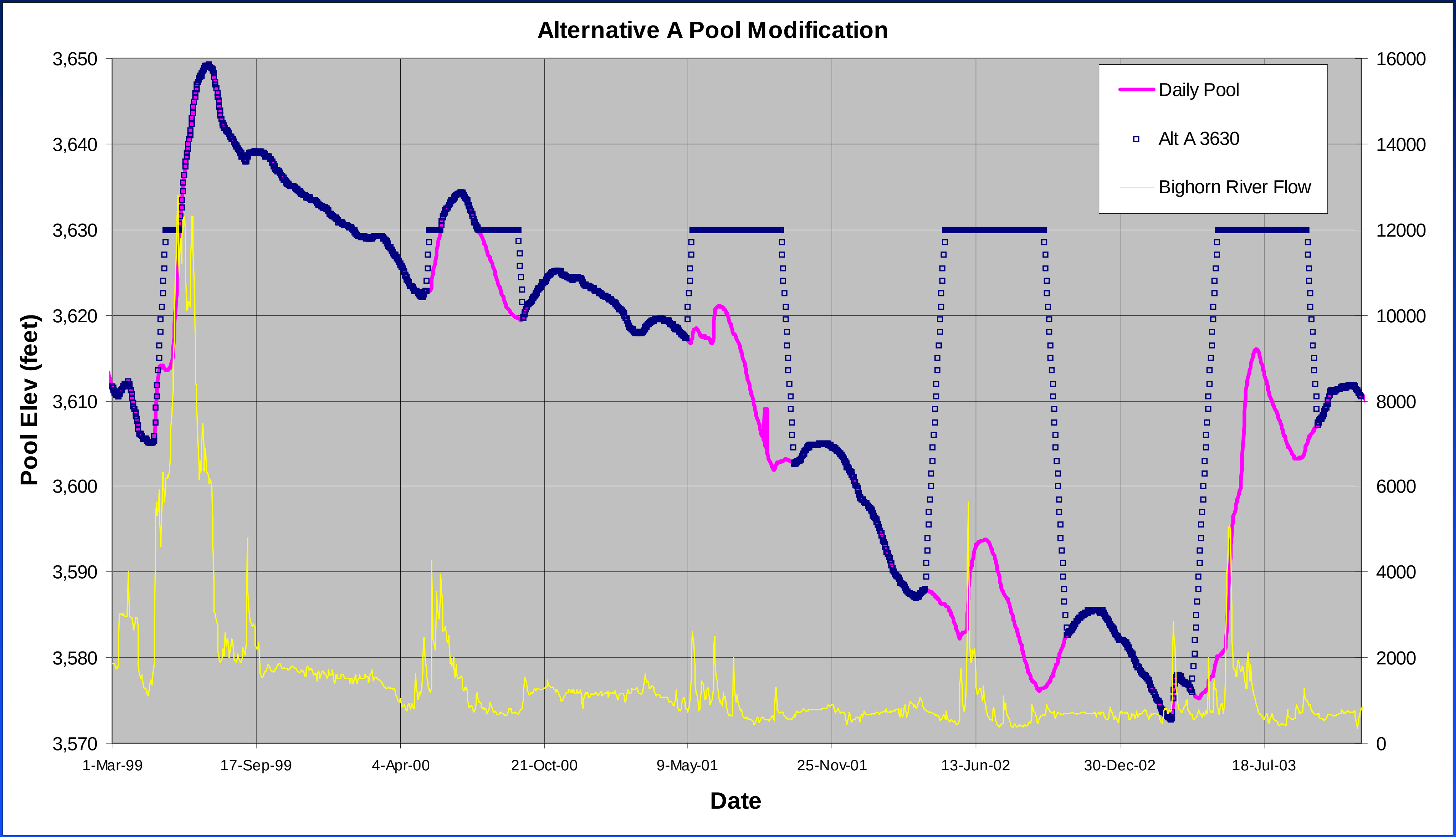
Changes about 60 days per year or roughly 1/6 of the pool levels

Pool did not reach El. 3630 in 7 Years from 1970 to 2006

Probable recreation benefit for 15 – 25 years

+ Higher pool for recreation season
+ Increases sediment deposition rate upstream
+ Reduce rate of delta migration toward dam
- Likely to require system operation modification to implement, achieve higher pool by 15 May
- Increases sediment deposition rate within HSB, heighten drought impact, drawdown for extreme event
- Achieving pool level likely to impact other reservoir operations

Alt. A - Modified Pool Levels



Alternative B – Trap Sediment Upstream of Lovell

Alter Causeway east of Lovell to serve as impoundment

Area is wide and shallow, more effective for coarse material than fine

Basin Area – 2300 acres, Average Depth 10 ft, 23,000 ac-ft storage

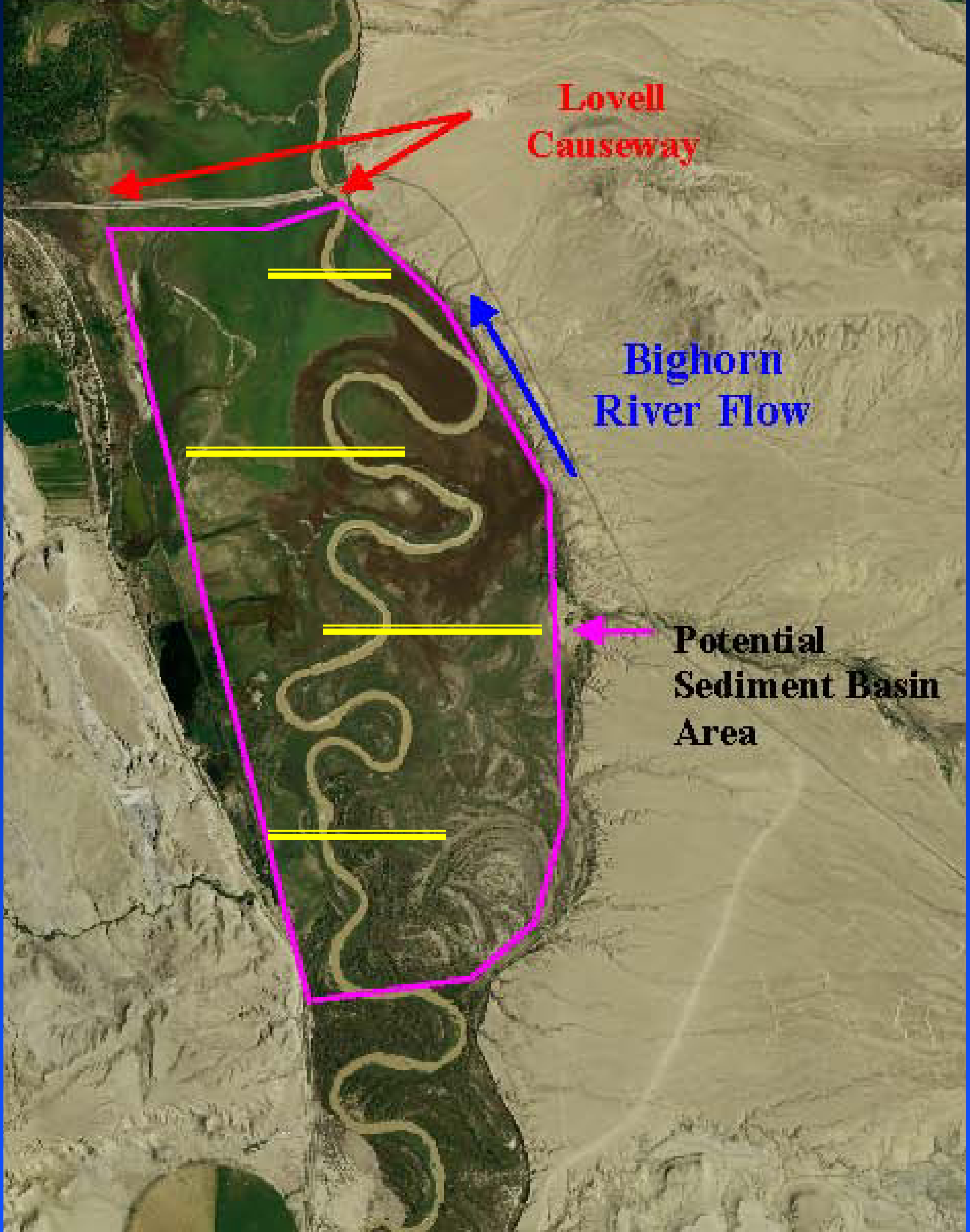
Assume maximum sediment trap efficiency of 70%

Build with dikes or restricting Causeway

+ Trapped sediments benefit all downstream areas
- High initial and periodic sediment removal cost to maintain trap efficiency over time
- No impact on current HSB sediment levels
- Disposal area impact / cost (real estate, permit, loss of use)
- Possible impact to Causeway, upstream lands

Construct spaced berms to increase travel time and sediment retention within basin. Size and extent to be determined in next design phase. Sediment trap efficiency decreases for higher flow as travel time reduces.

Second option to restrict Causeway opening and use as dam. May be WY DOT issues with unequal water elevation for embankment.



Alternative C – Flush Sediment Through HSB

Maintain lower pool level during high sediment runoff period to flush sediment past Horseshoe Bend

Model does not route flow within the pool, only examining impact of pool level on sediment deposition

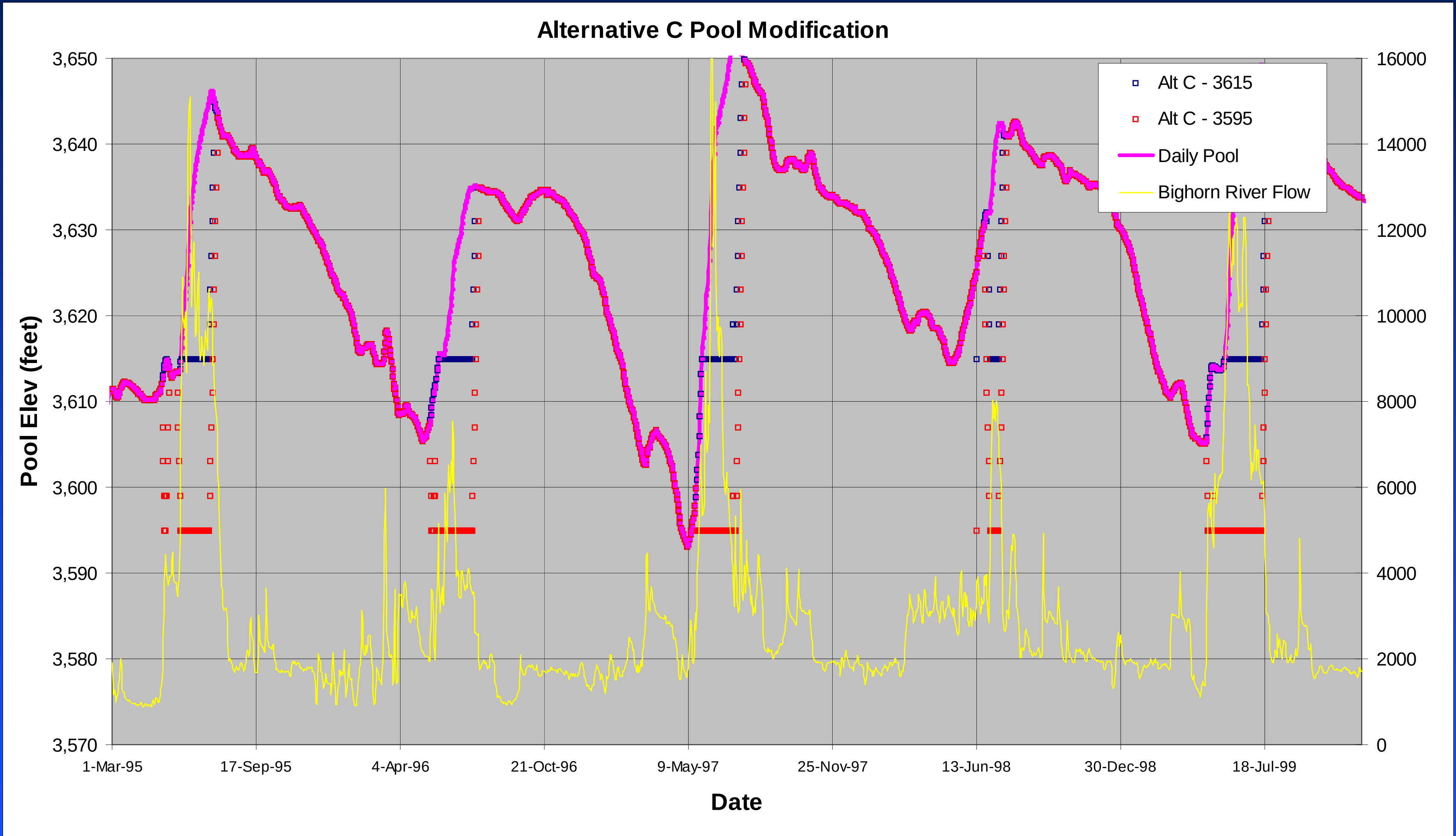
Altered pool during typical high flow period selected as 1 May through 30 July

Examined two pool levels, 3595 and 3615

Pool changes about 20 – 25 days/year

+ Maintains lower sediment levels at HSB
- Lower pool during fill period will increase risk to incur lower summer pool levels in drought periods
- Low pool period/high inflow period includes the recreation season
- Refine with a reservoir routing model that tracks actual pool levels
- Increases delta migration rate toward dam
- Implementation likely to impact reservoir operation and releases

Alt. C - Modified Pool Levels



Alternative D – Dike Within Horseshoe Bend

Construct dike to separate flowing river from recreation area

Sediments move past Horseshoe Bend

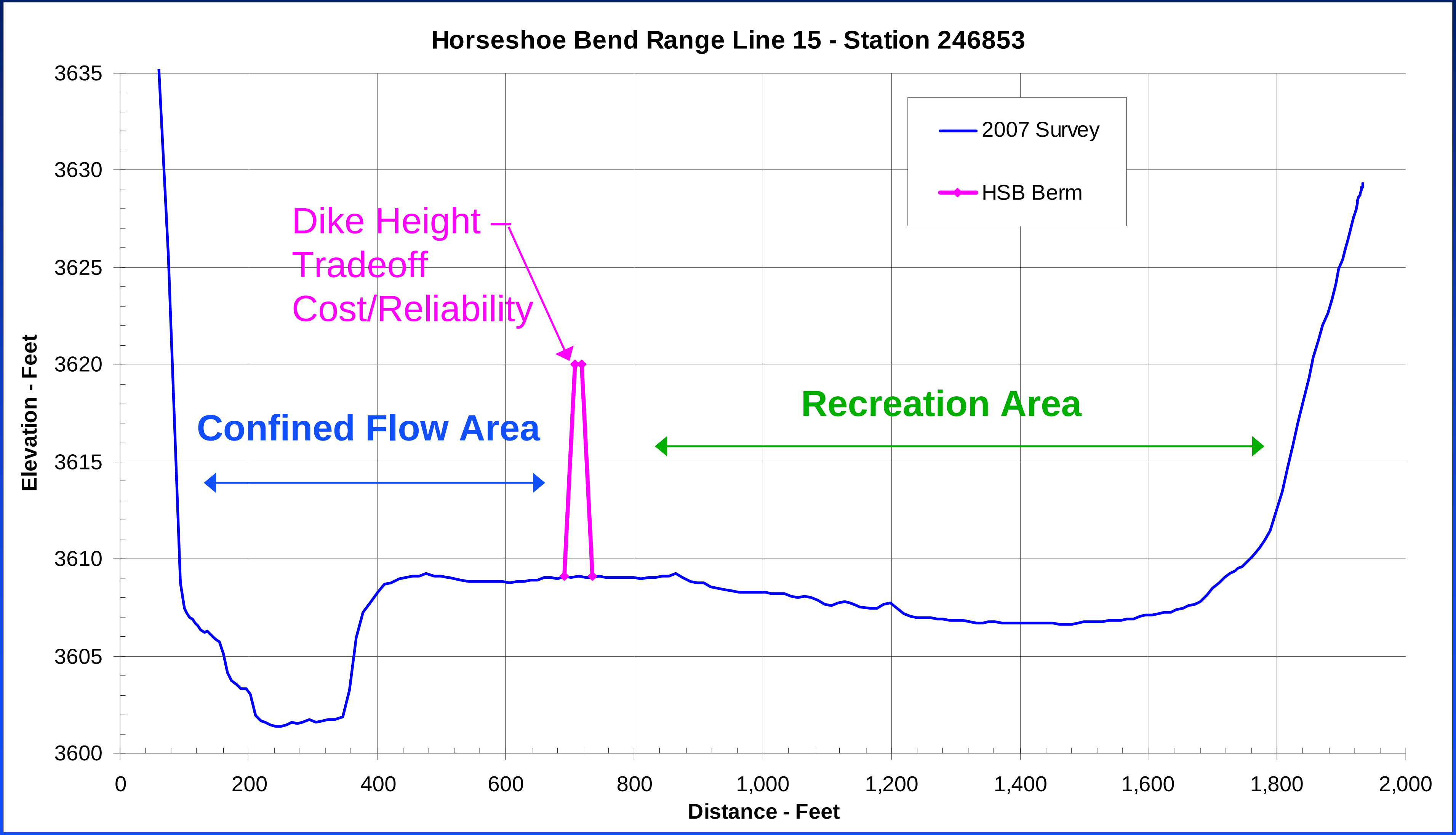
9000 foot length, 15 ft average height, built from all rock or earth core

250,000 tons rock

+ Maintains lower sediment levels within HSB
+ Minimal impact to sediment beyond HSB boundaries
+ Independent of other activities

- High initial and maintenance cost
- Does not impact turbidity, fine sediments in the water column and will deposit in the recreation area
- Public safety, access from HSB to pool
- Likely need to raise structure over time as sediments accumulate

Alternative D Typical Cross Section



Alternative F - Dredge sediment within Horseshoe Bend

Dredge sediments over the length of Horseshoe Bend

Dredge sediment disposal below HSB within pool or land area

Assumed dredge to elevation of 3590 (20 feet)

For HSB, dredge area about 500 acres, average depth of 20 feet, return conditions to about 20 years ago

Initial dredge volume is 16 Million cubic yards

Annual inflow sediment load is about 3220 ac-ft or 5 Million cubic yards

+ Land disposal removes sediment and benefits project

- High initial and maintenance dredging cost

- Permit issues with dredging, contaminants, discharge\disposal of material

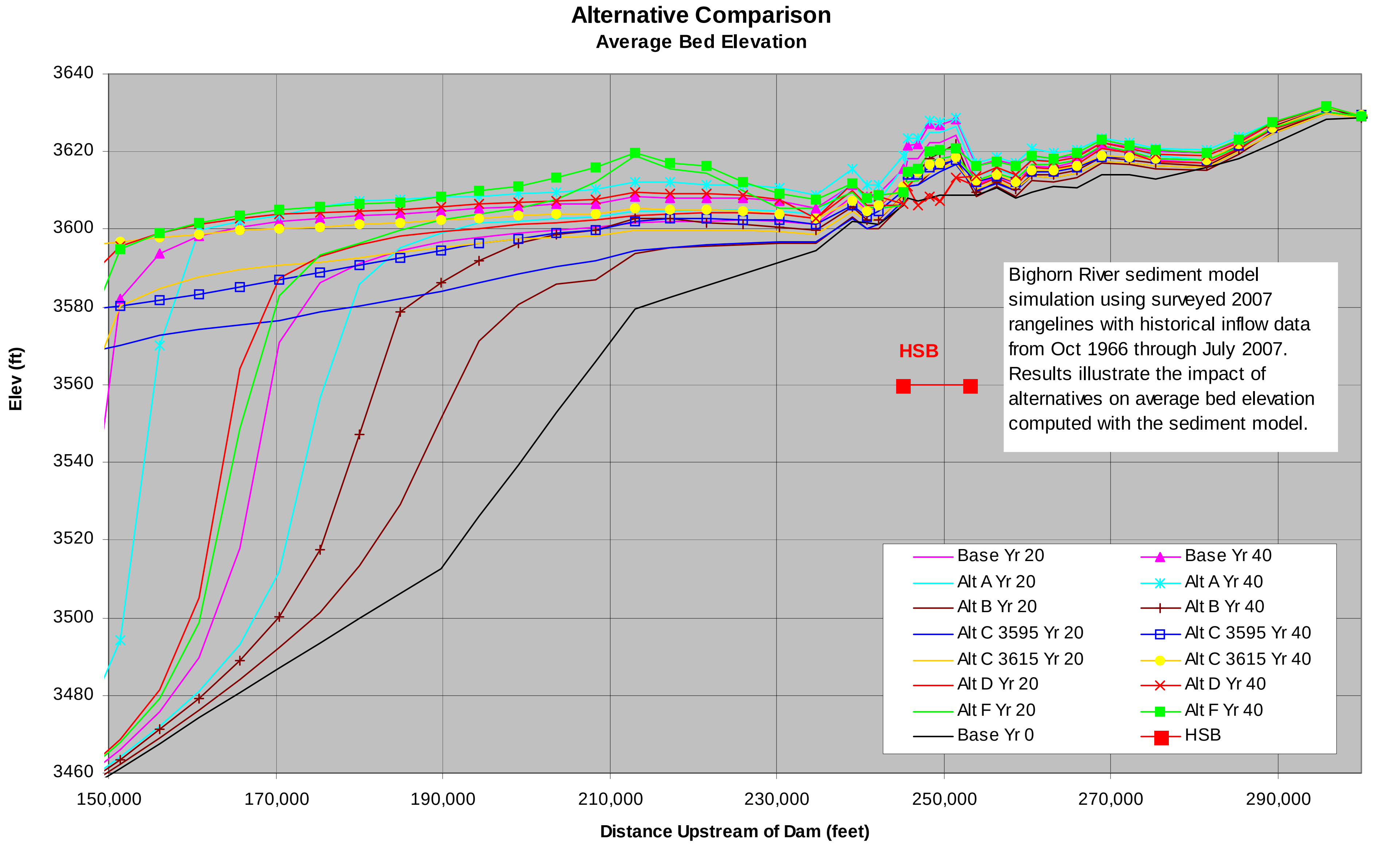
- Pool disposal advances delta migration rate

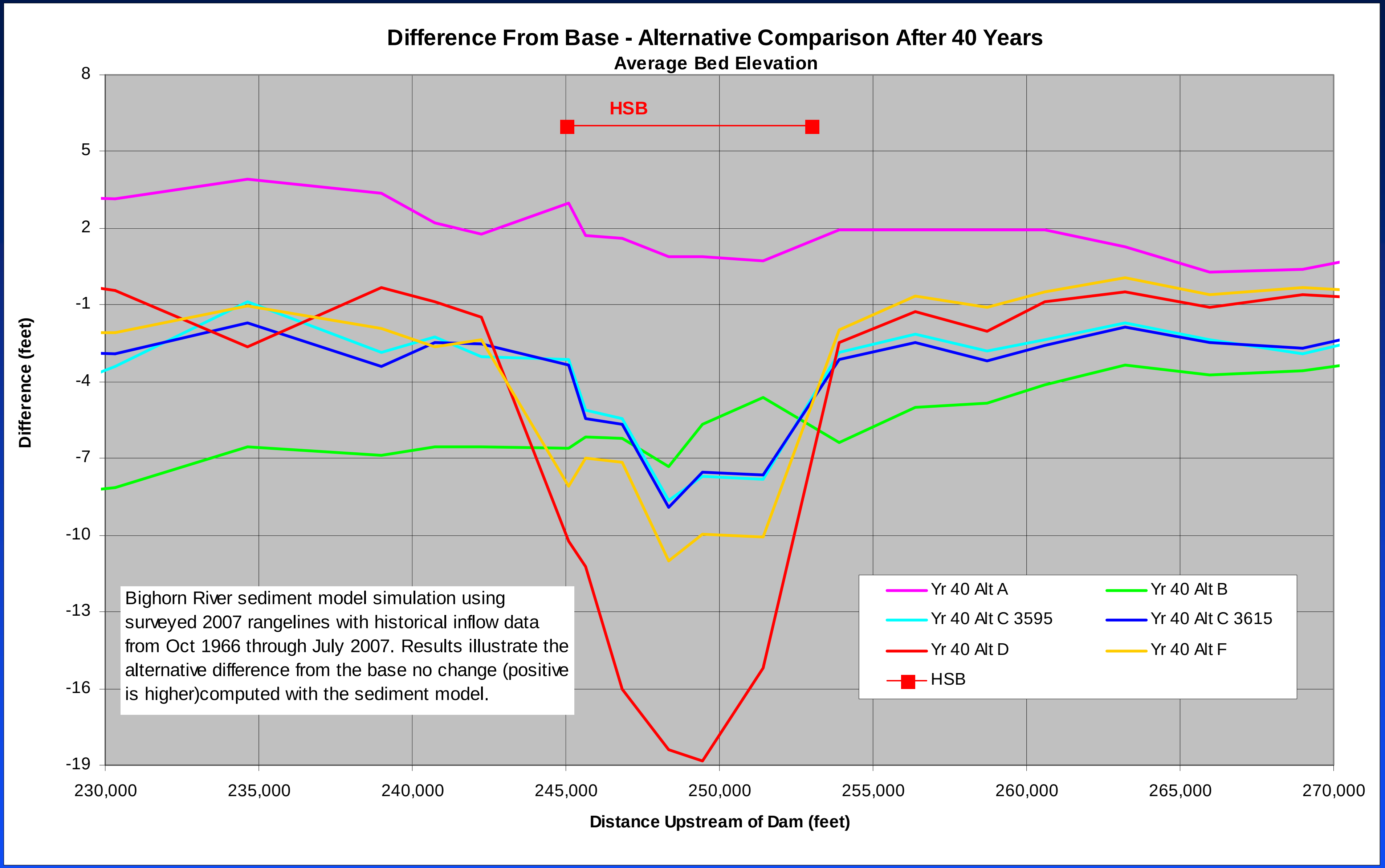
- High volume will result in a nearly perpetual dredge

Cost Summary

Alternative	Cost / Notes
A – Higher Rec. Season Pool	Construction Cost – NA Likely to include indirect costs as modified pool levels alter project benefits.
B – Sediment Trap Upstream	Construction Cost - $34,000,000 Cost estimate includes initial construction cost plus a one-time excavation cost for 2 million cubic yards. Will incur additional significant O&M cost due to removal of deposited materials to maintain sediment trap.
C – Lower Pool During Peak Inflow	Construction Cost – NA Likely to include indirect costs as modified pool levels alter project benefits.
D – HSB Dike	Construction Cost - $24,000,000 (All rock dike) Costs may be lower by using an earth core rock dike, geotubes, or similar product. Will incur significant O&M cost to maintain structure, also dredging will be required at connection locations, possibly throughout area due to general turbidity.
F – Dredge HSB	Construction Cost - $145,000,000 (Dredge and remove sediments to disposal area) Construction Cost - $73,000,000 (Dredge and discharge in pool downstream of HSB) Will incur significant O&M cost to dredge repetitively.

Estimates include 5% mobilization and preparation, 15% unlisted, 25% contingency and 20% non-contract costs. All costs are present-value, and the maintenance and dredging costs would be subject to fund indexing due to the multi-year nature of the work.


Alternative Comparison
Average Bed Elevation
Elev (ft)
3640
3620
3600
3580
3560
3540
3520
3500
3480
3460
150,000
170,000
190,000
210,000
230,000
250,000
270,000
290,000
Distance Upstream of Dam (feet)
HSB
Bighorn River sediment model simulation using surveyed 2007 rangelines with historical inflow data from Oct 1966 through July 2007. Results illustrate the impact of alternatives on average bed elevation computed with the sediment model.
Base Yr 20
Base Yr 40
Alt A Yr 20
Alt A Yr 40
Alt B Yr 20
Alt B Yr 40
Alt C 3595 Yr 20
Alt C 3595 Yr 40
Alt C 3615 Yr 20
Alt C 3615 Yr 40
Alt D Yr 20
Alt D Yr 40
Alt F Yr 20
Alt F Yr 40
Base Yr 0
HSB



Difference From Base - Alternative Comparison After 40 Years
Average Bed Elevation
HSB
Difference (feet)
8
5
2
-1
-4
-7
-10
-13
-16
-19
230,000
235,000
240,000
245,000
250,000
255,000
260,000
265,000
270,000
Distance Upstream of Dam (feet)
Bighorn River sediment model simulation using surveyed 2007 rangelines with historical inflow data from Oct 1966 through July 2007. Results illustrate the alternative difference from the base no change (positive is higher)computed with the sediment model.
Yr 40 Alt A
Yr 40 Alt B
Yr 40 Alt C 3595
Yr 40 Alt C 3615
Yr 40 Alt D
Yr 40 Alt F
HSB

Summary

- Accuracy of 5-15 % bed change, tool best used to compare alternatives, not actual elevation
- Initial assessment level of detail
- Less than adequate sediment data set
- **ALL** alternatives affect sediment, consider short and long term impacts\tradeoffs
- Value of model demonstrated to evaluate sediment response to operations change
- Since using historic record, 1967 event near start of simulation has big influence
- Sediment is episodic, focus on long term

Results Summary

Alternative Results Difference Comparison
Alt. Computed Elev - Base Condition Elev. (feet)

	Alternative A - Higher Rec Season Pool Change From Base for All Alternatives					Alternative B - Upstream Sed Trap Change From Base for All Alternatives				
	Year 5	Year 10	Year 20	Year 30	Year 40	Year 5	Year 10	Year 20	Year 30	Year 40
Min	-34.1	-56.5	-59.1	-70.7	-88.0	-41.0	-67.5	-84.8	-107.8	-122.8
Max	4.3	5.5	3.8	4.0	4.1	0.0	0.0	0.1	0.1	0.0
Avg. HSB-Causeway	1.4	1.8	1.8	1.2	1.2	-1.8	-2.7	-4.1	-5.0	-5.0
Avg. HSB	3.2	3.2	3.0	1.7	1.6	-4.7	-5.7	-6.7	-8.3	-7.5

	Alternative C - Lower Pool to 3595					Alternative C - Lower Pool to 3615				
	Year 5	Year 10	Year 20	Year 30	Year 40	Year 5	Year 10	Year 20	Year 30	Year 40
Min	-8.5	-8.7	-12.9	-15.9	-15.5	-7.6	-7.2	-7.8	-11.1	-10.6
Max	56.9	81.9	114.2	129.3	143.7	60.4	85.7	114.2	136.7	153.3
Avg. HSB-Causeway	-2.1	-2.7	-3.6	-4.7	-4.7	-1.8	-2.3	-3.1	-4.2	-4.3
Avg. HSB	-5.2	-5.9	-7.0	-9.2	-8.5	-4.7	-5.3	-6.0	-8.2	-7.7

	Alternative D - HSB Berm					Alternative F - Initial Dredge HSB				
	Year 5	Year 10	Year 20	Year 30	Year 40	Year 5	Year 10	Year 20	Year 30	Year 40
Min	-12.4	-13.4	-15.4	-19.4	-19.5	-14.2	-7.2	-6.1	-7.7	-7.7
Max	19.6	33.0	46.2	75.1	85.8	30.9	25.8	30.6	59.9	69.1
Avg. HSB-Causeway	-1.5	-2.1	-3.1	-4.5	-4.8	-1.3	-0.9	-1.2	-1.9	-1.9
Avg. HSB	-5.5	-7.8	-10.7	-14.2	-14.7	-6.7	-5.2	-5.3	-7.0	-6.6

Caution on absolute time, better to use long term average difference

Summary of Alternative Evaluations			
Alternative	Cost	O&M Notes	Pros / Cons
A – Higher Rec. Season Pool	NA[1]	NA[1]	+ Higher pool for recreation season + Increases sediment deposition rate upstream + Reduce rate of delta migration toward dam - Likely to require system operation modification to implement, achieve higher pool by 15 May - Increases sediment deposition rate within HSB, heighten drought impact - Achieving pool level likely to impact other reservoir operations
B – Sediment Trap Upstream	$34,000,000	Removal deposited material on 3 to 5 year interval	+ Trapped sediments benefit all downstream areas - High initial and periodic sediment removal cost to maintain trap efficiency over time - No impact on current HSB sediment levels - Disposal area impact / cost (real estate, permit, loss of use) - Possible impacted upstream lands
C – Lower Pool During Peak Inflow	NA[1]	NA[1]	+ Maintains lower sediment levels at HSB - Low pool for portion of recreation season +Reduces sediment deposition rate within HSB and upstream - Increase rate of delta migration toward dam, lessens project life - Achieving pool level likely to impact other reservoir operations and releases
D – HSB Dike	$24,000,000 (All rock dike)	Maintain structure Some dredging at connection locations	+ Maintains lower sediment levels within HSB + Minimal impact to sediment beyond HSB boundaries - High initial and maintenance cost - Does not impact fine sediments that are in the water column and will deposit in the recreation area - Public safety, access from HSB to pool - Likely need to raise structure over time as sediments accumulate
F – Dredge HSB	$145 mil (land disposal) $73 mil (pool)	Repetitively dredge on a 5 to 10 year interval	+ Land disposal removes sediment and benefits project - High initial and maintenance dredging cost - Permit issues with dredging and discharge - Pool disposal advances delta migration rate - High volume will result in a nearly perpetual dredge

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Recommendations

- Alt. A is a minimal cost alternative that provides benefit for 15 – 20 years or more
- Alt. B provides benefit but needs maintenance, $34 mil to implement, does remove sed. from system, possible issues with wetland, upstream impact, embankment
- Alt. C not recommended
- Alt. D provides a long term benefit although at a substantial cost - $24 mil
- Alt. F provides a long term benefit but appears cost prohibitive, still have 5-10 yr maintenance cost

Questions ?