US Army Corps
of Engineers
Omaha District

Big Horn Lake
Sediment Management Study

Dan Pridal
Omaha District Corps of Engineers

Presentation Outline

- Omaha COE and Bureau Interagency Agreement
- Study compares sediment management alternatives and provides indication of impacts
- Study modeling, report 90% complete, pending Bureau review and ITR
- Present study methodology and DRAFT results

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
- 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

SRH 1-D Hydraulic Model

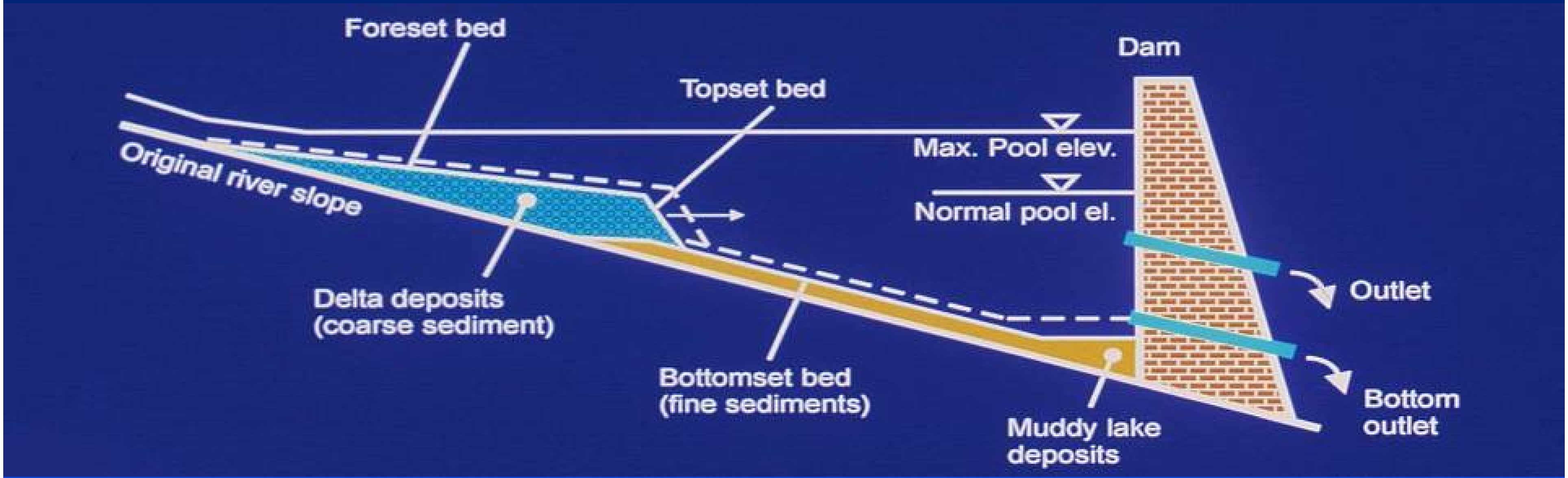
SRH-1D: A numerical model developed to simulate and predict cohesive and non-cohesive sediment transport and related river morphological changes. SRH-1D is an engineering tool for solving fluvial hydraulic problems with the following limitations:
(1) SRH-1D is a one-dimensional model for flow simulation. Phenomena such as secondary currents, lateral diffusion, superelevation, and transverse sediment movement are ignored.
(2) Many of the sediment transport modules and concepts used in SRH-1D are simplified approximations of real phenomena. Those approximations and their limits of validity are embedded in the model.

The latest information about SRH-1D is placed on the Web and can be found by accessing http://www.usbr.gov/pmts/sediment.
Requests may be sent directly to the Bureau of Reclamation's Sedimentation and River Hydraulics Group
(Attention: SRH Support, U.S.Bureau of Reclamation, Sedimentation and River Hydraulics Group, P.O. Box
25007 (86-68540), Denver, CO 80225).
SRH-1D is under continuous development and improvement. A user is encouraged to check the SRH-1D web page regularly for updates.

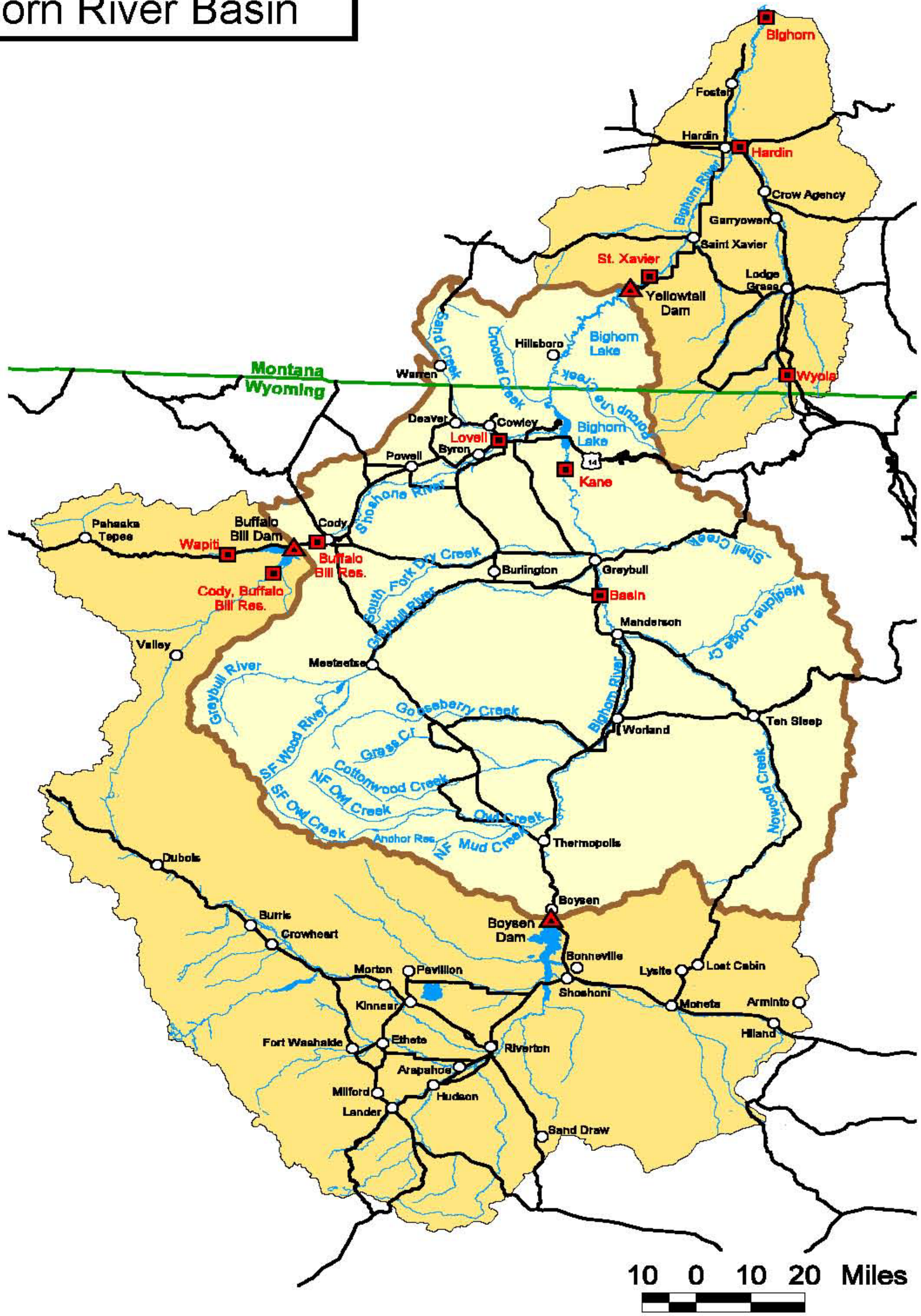
Model Input

- 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

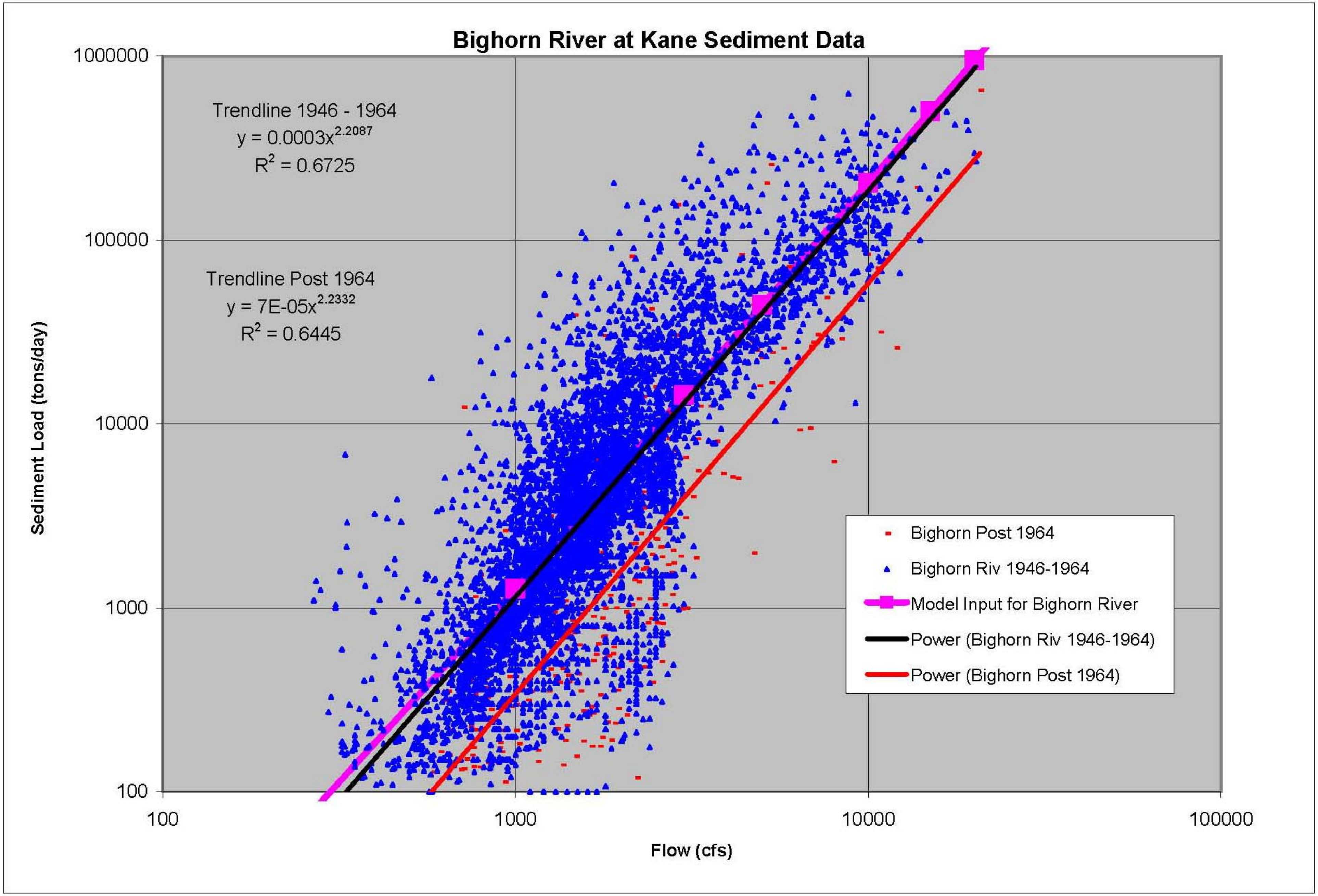
Delta Formation Overview



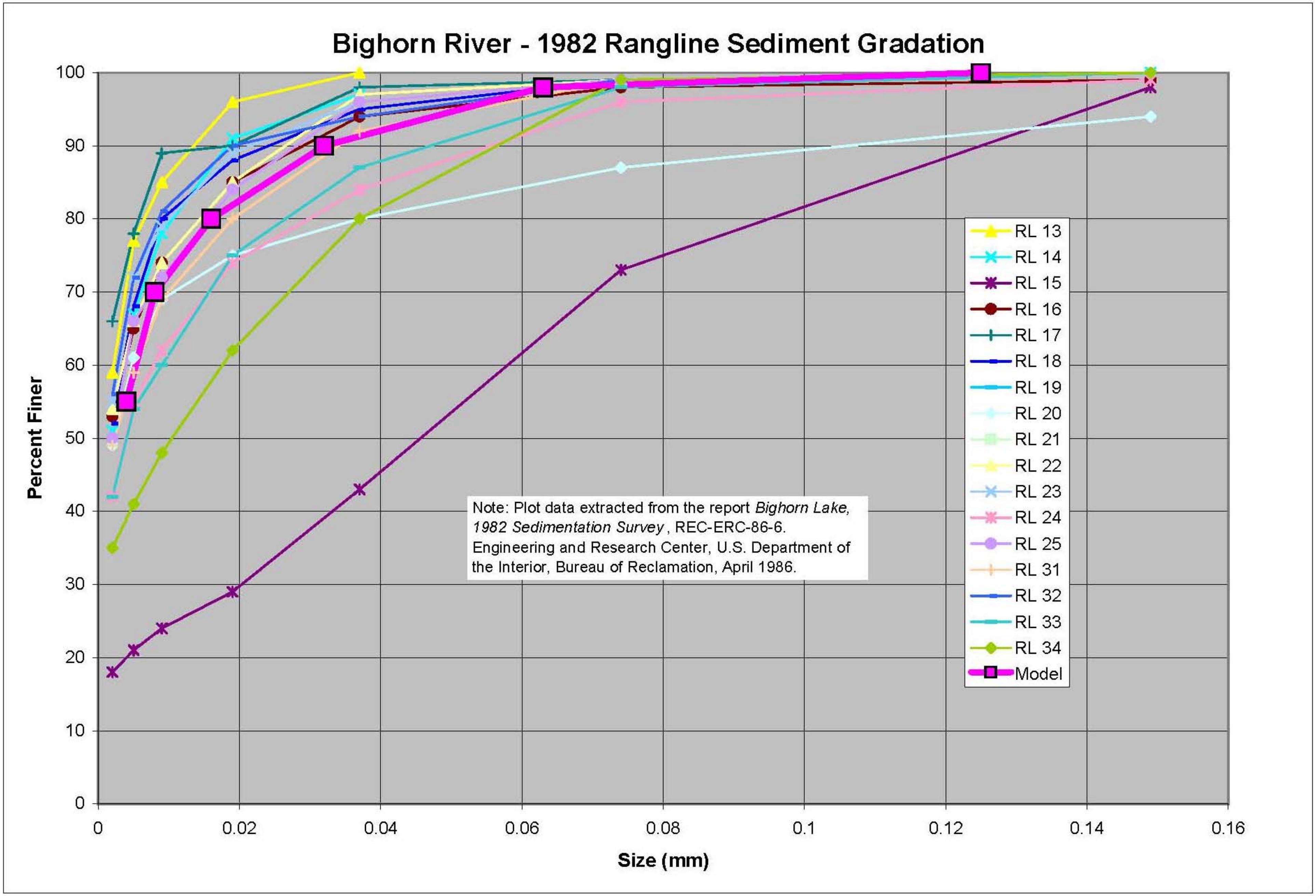
Bighorn River Basin



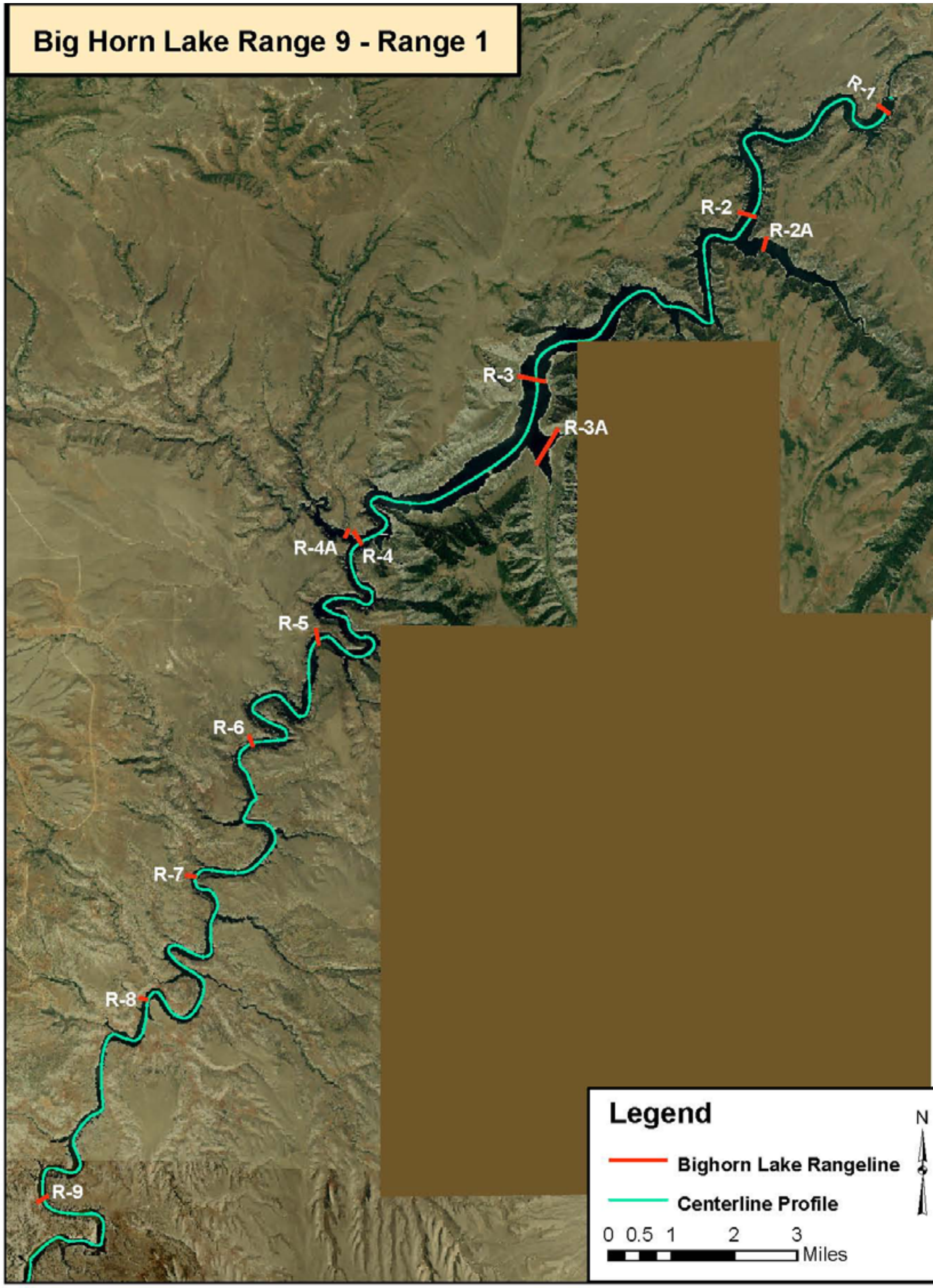
- Stream Gaging Stations
- Dams
- Cities
- State Highways
- State Boundaries
- Yellowtail Drainage Area
- Bighorn River Basin



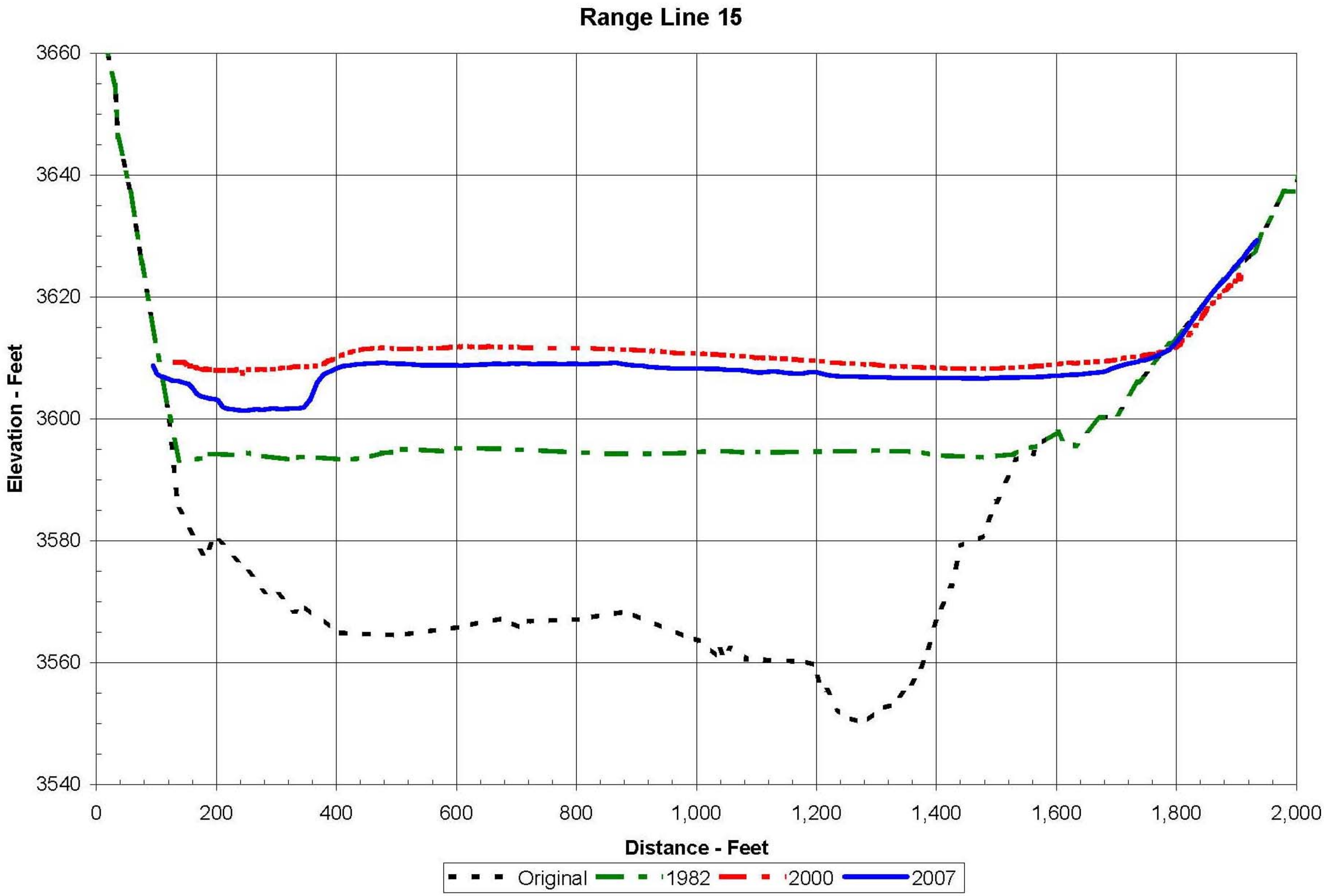
Bighorn River at Kane Sediment Data
Trendline 1946 - 1964
y = 0.0003x^2.2087
R^2 = 0.6725
Trendline Post 1964
y = 7E-05x^2.2332
R^2 = 0.6445
Bighorn Post 1964
Bighorn Riv 1946-1964
Model Input for Bighorn River
Power (Bighorn Riv 1946-1964)
Power (Bighorn Post 1964)
Sediment Load (tons/day)
Flow (cfs)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



Bighorn River - 1982 Rangline Sediment Gradation
Percent Finer
Size (mm)
0
10
20
30
40
50
60
70
80
90
100
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
RL 13
RL 14
RL 15
RL 16
RL 17
RL 18
RL 19
RL 20
RL 21
RL 22
RL 23
RL 24
RL 25
RL 31
RL 32
RL 33
RL 34
Model
Note: Plot data extracted from the report Bighorn Lake, 1982 Sedimentation Survey, REC-ERC-86-6. Engineering and Research Center, U.S. Department of the Interior, Bureau of Reclamation, April 1986.


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

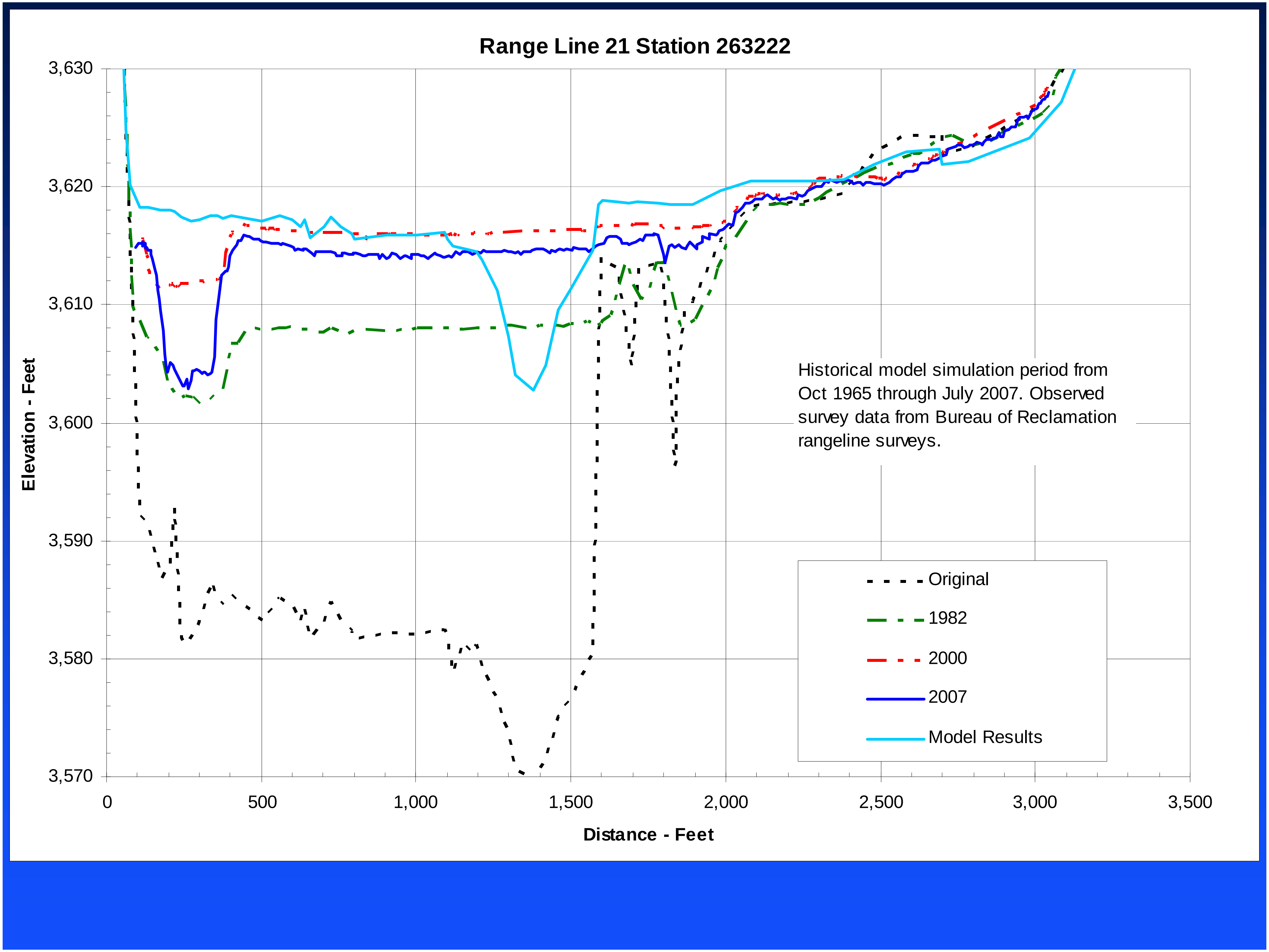

Big Horn Lake Range
R-9
R-10
R-11
R-12
R-13
R-14
R-15
R-16
R-17
R-18
R-19
R-20
R-21
R-22
R-23
R-24
R-25
R-26
R-27
R-28
R-29
R-30
Legend
Bighorn Lake Rangeline
Centerline Profile
N
0 0.5 1 2 3
Miles

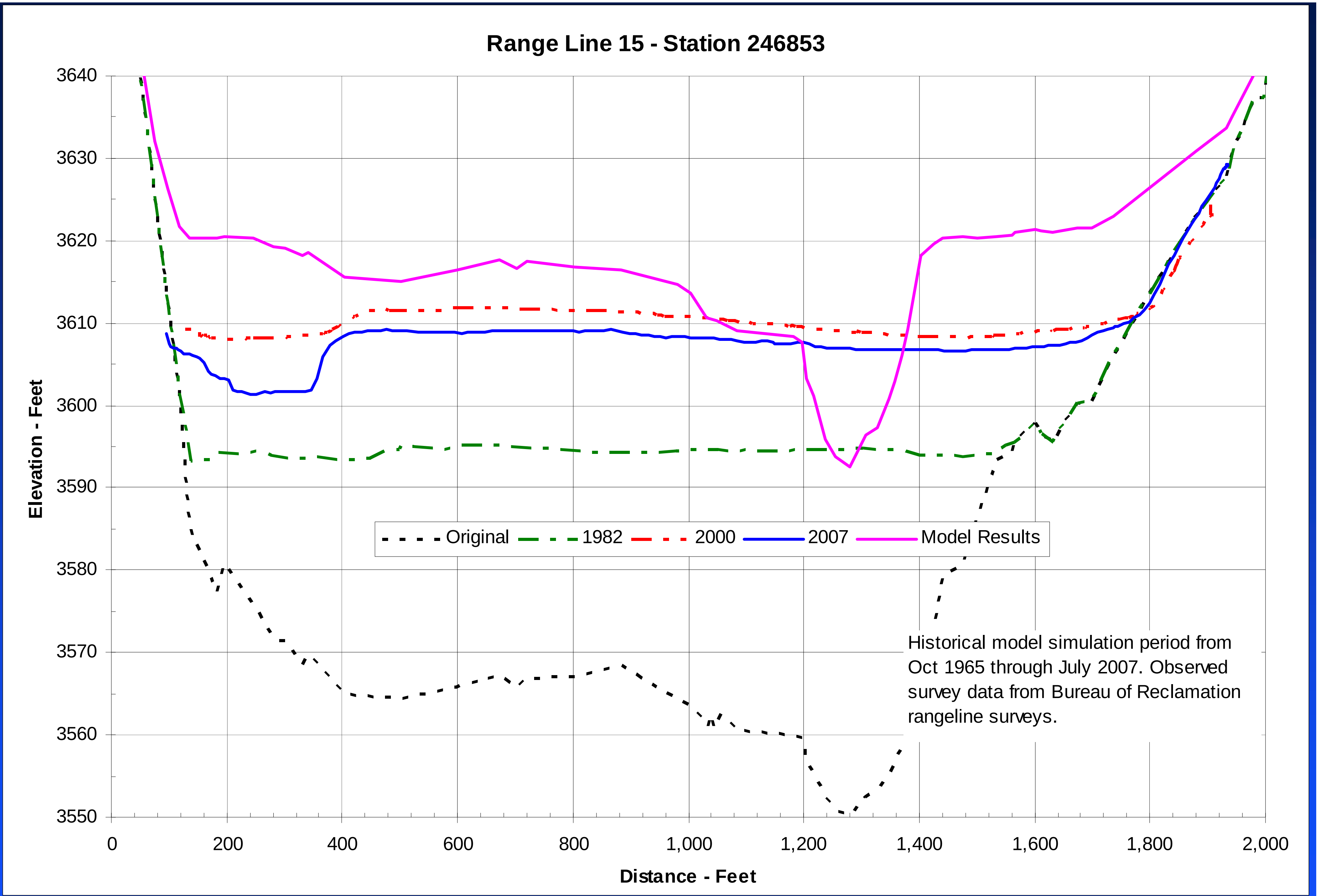


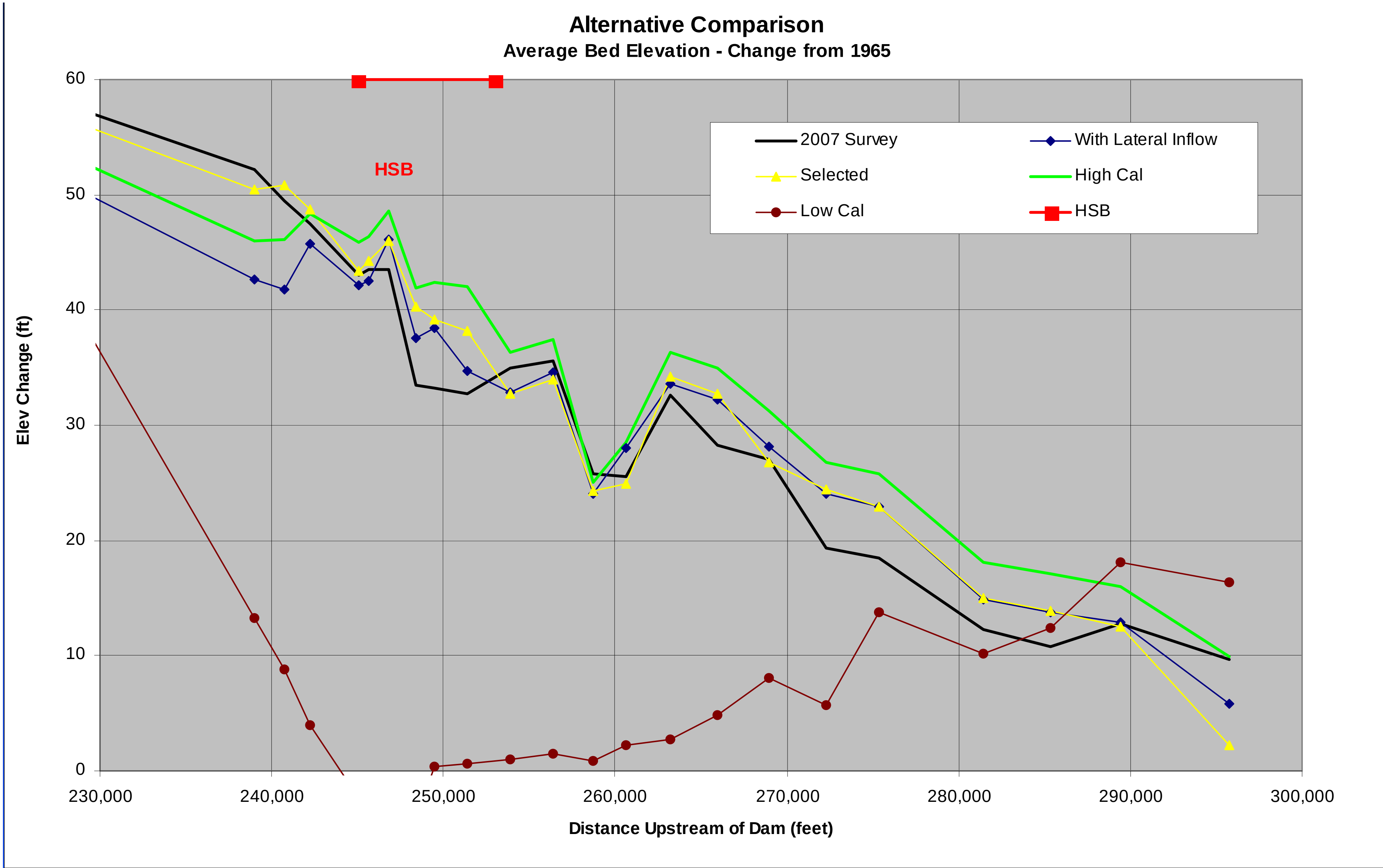
Range Line 15
3660
3640
3620
3600
3580
3560
3540
Elevation - Feet
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
Distance - Feet
Original
1982
2000
2007

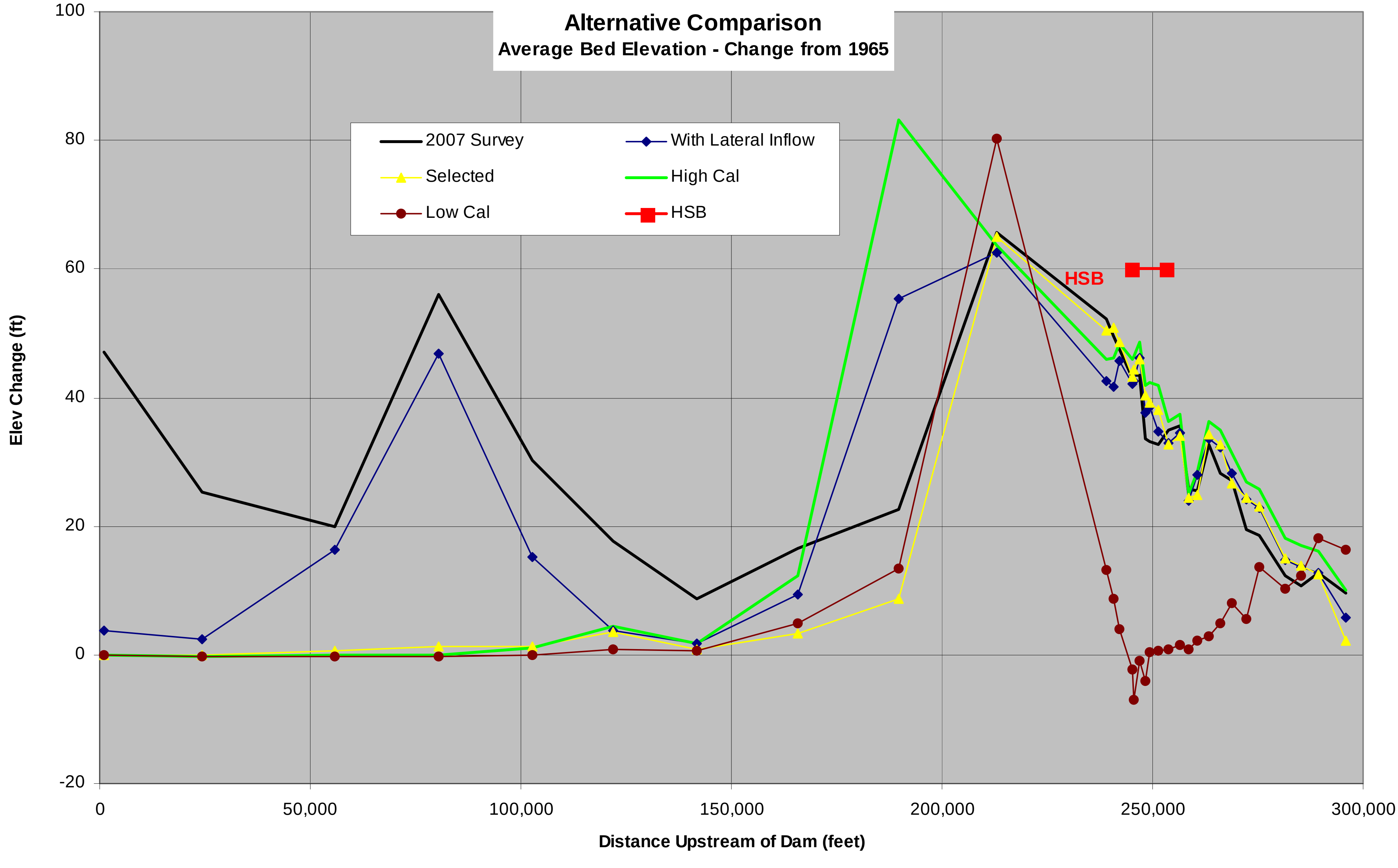
Historical Period Simulation

- 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


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


Range Line 15 - Station 246853
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
Model Results
Historical model simulation period from Oct 1965 through July 2007. Observed survey data from Bureau of Reclamation rangeline surveys.

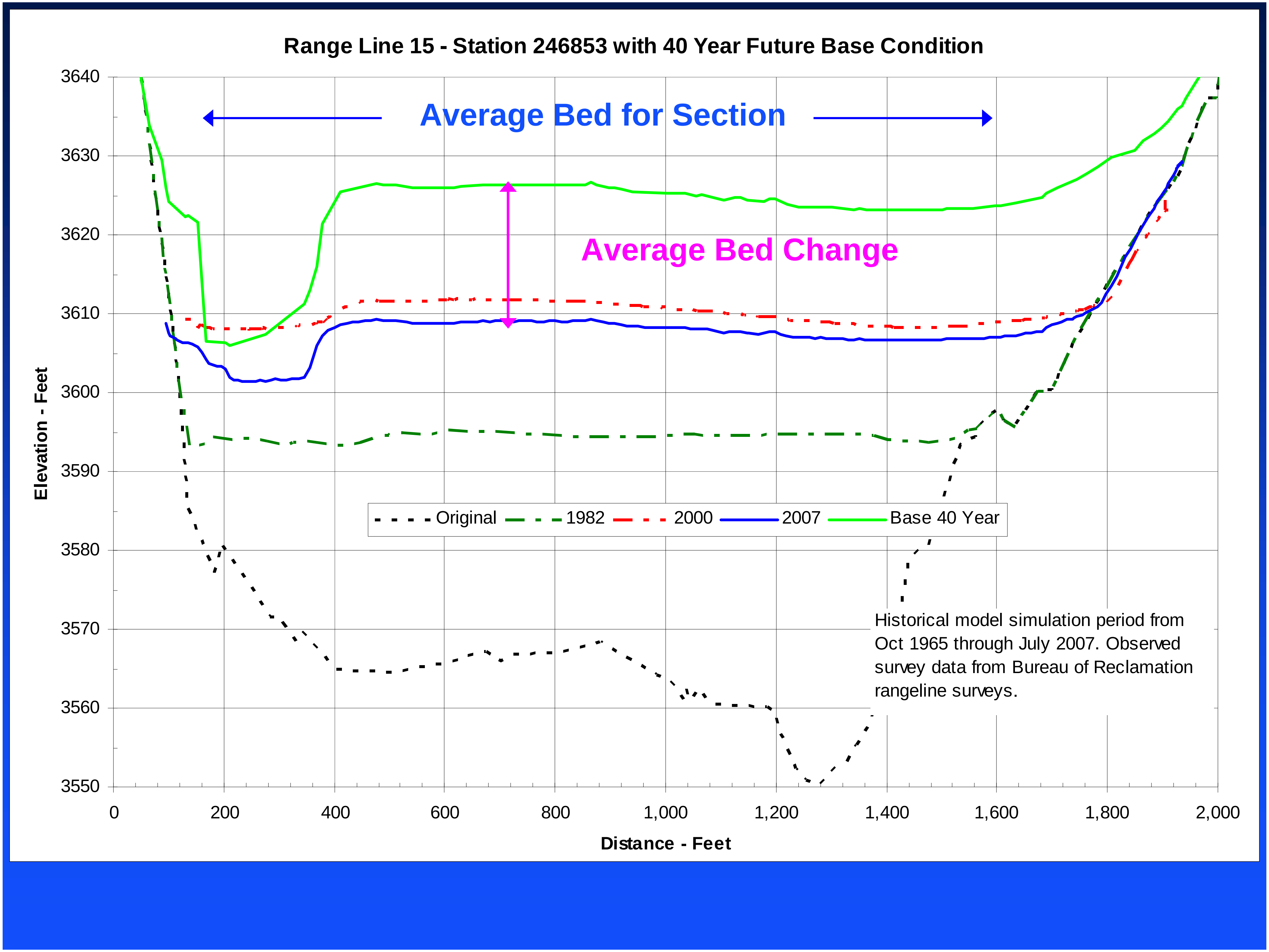

Alternative Comparison
Average Bed Elevation - Change from 1965
Elev Change (ft)
Distance Upstream of Dam (feet)
HSB
2007 Survey
With Lateral Inflow
Selected
High Cal
Low Cal
HSB
0
10
20
30
40
50
60
230,000
240,000
250,000
260,000
270,000
280,000
290,000
300,000



Alternative Comparison
Average Bed Elevation - Change from 1965
2007 Survey
With Lateral Inflow
Selected
High Cal
Low Cal
HSB
HSB
Elev Change (ft)
100
80
60
40
20
0
-20
0
50,000
100,000
150,000
200,000
250,000
300,000
Distance Upstream of Dam (feet)

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

Change Yellowtail operation to alter pool level

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

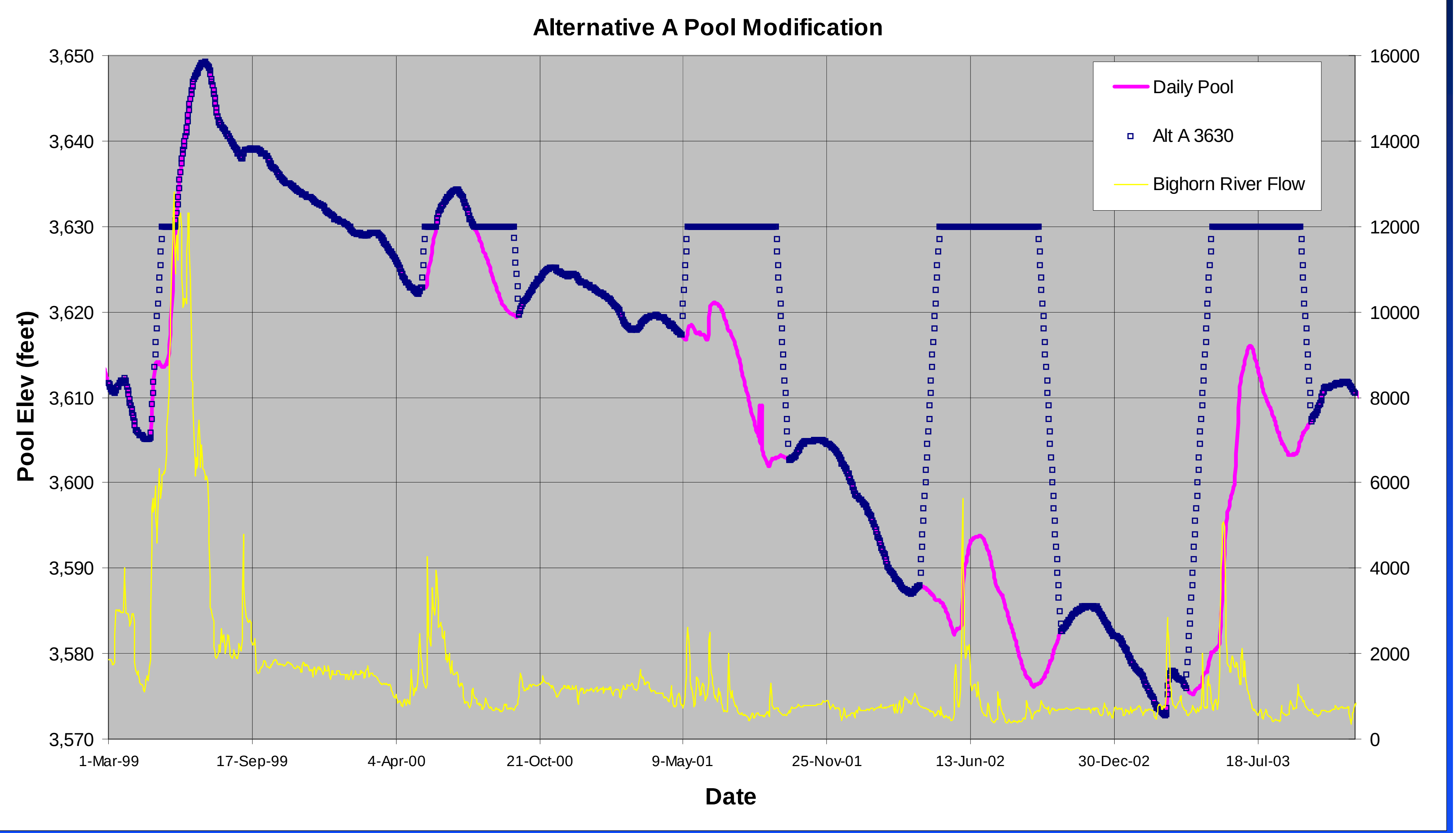
Changes about 60 days per year or roughly 1/6 of the pool levels

May not be sufficient inflow to reach desired pool levels in drought periods

As sediment levels within HSB rise with time, the positive impact of a higher pool is compromised

Refine with a reservoir routing model that tracks actual pool levels

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

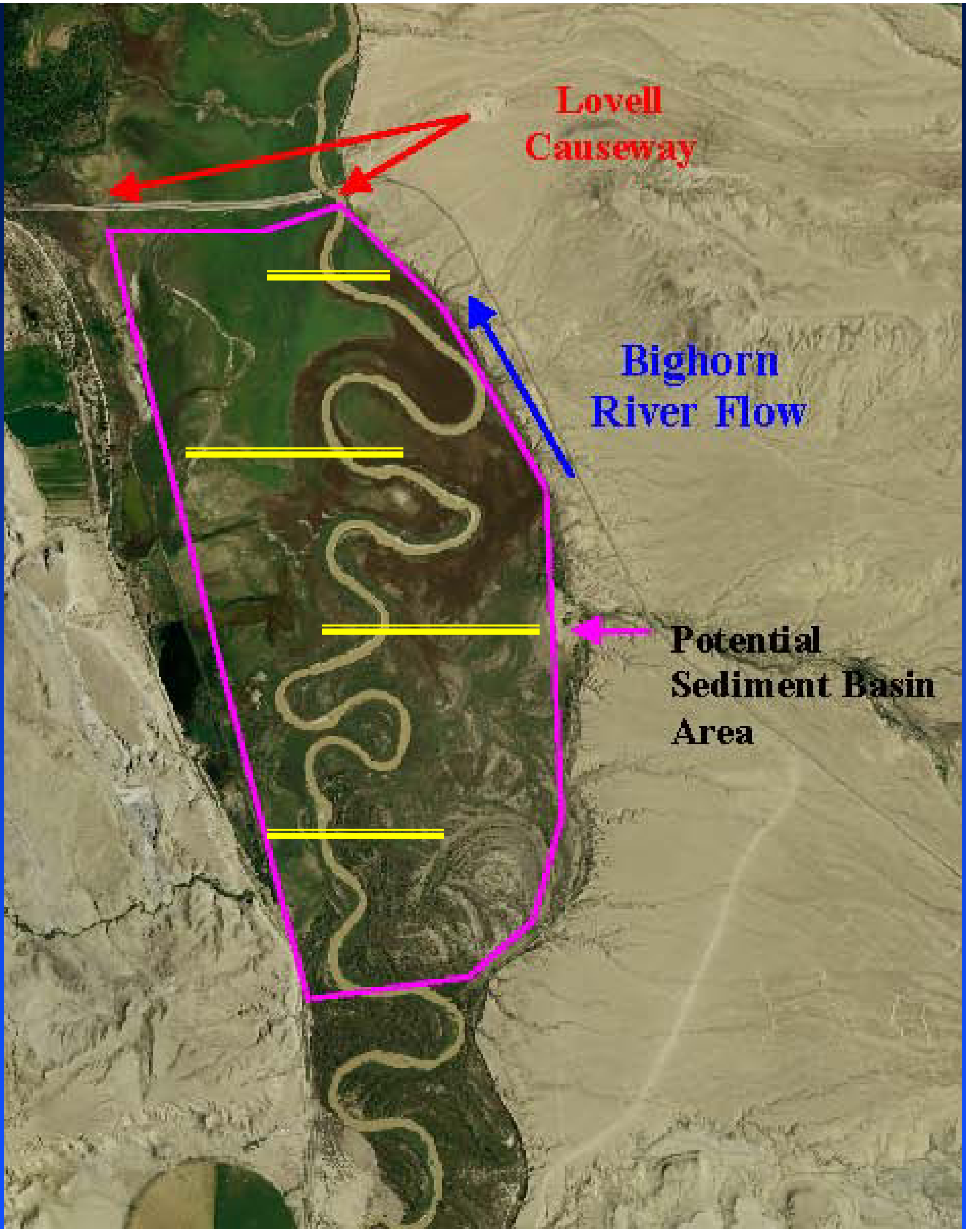
Basin Area – 2300 acres, Average Depth 10 ft

Max Basin Sediment Storage about 8 – 10,000 ac-ft, 14,000,000 cubic yards

Assume Bighorn River sediment trap efficiency of 70% (Model with maximum efficiency that is likely possible to evaluate potential)

- Requires periodic sediment removal to maintain trap efficiency over time
- Requires real estate purchase for storage basin and easement for impacted upstream lands
- High cost to implement and operate (10's of millions)

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.



Alternative C – Flush Sediment Through HSB

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

High inflow correlated with high sediment inflow

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

Lower pool during fill period will increase risk to incur lower summer pool levels in drought periods

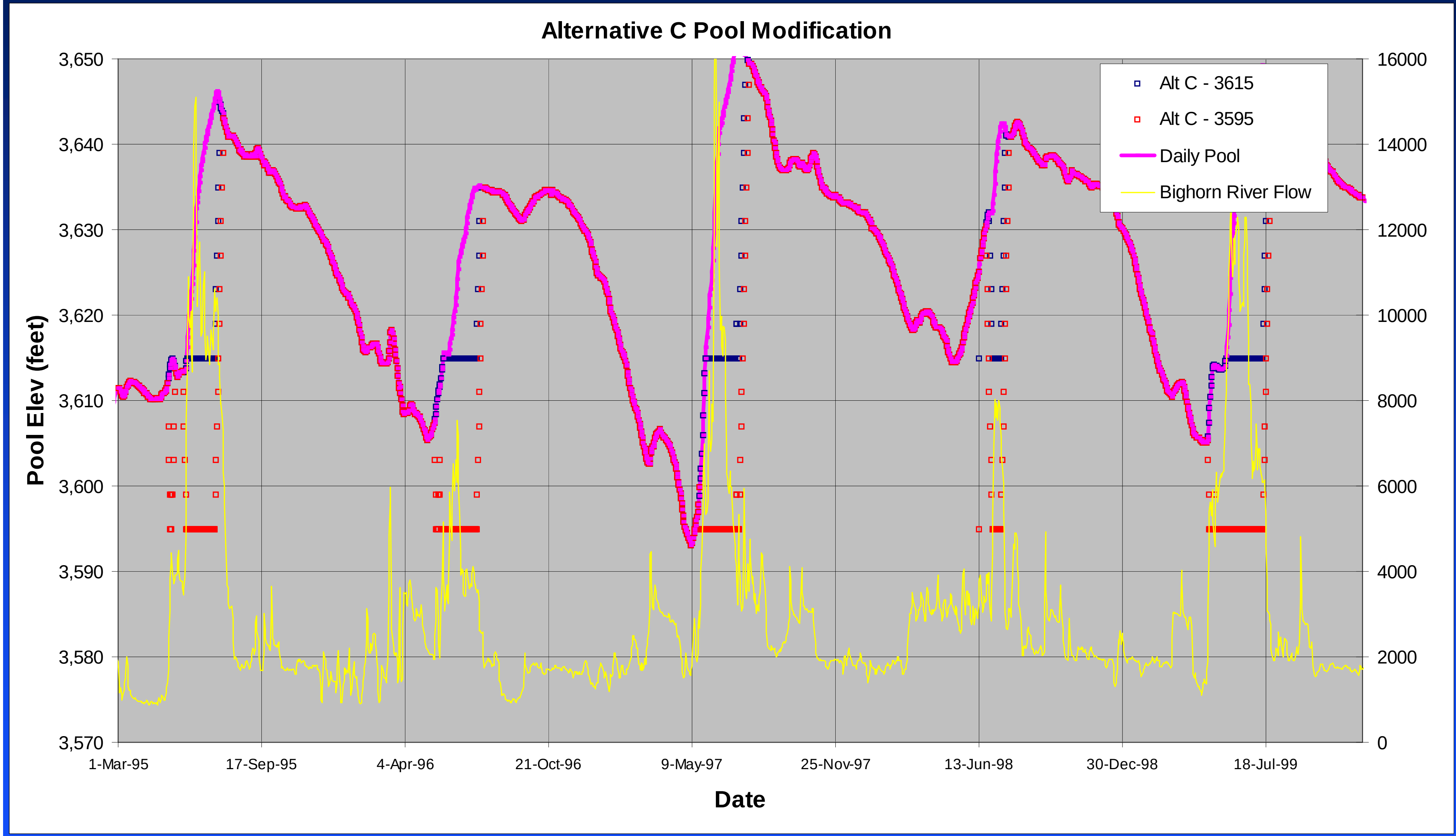
Low pool period/high inflow period includes the recreation season

Refine with a reservoir routing model that tracks actual pool levels

Annual Maximum Inflow Summary

Flow	Date	Flow	Date	Flow	Date
29,776	1-Jul-67	8,830	27-Jun-80	11,020	16-Jun-92
14,764	10-Jun-68	19,005	10-Jun-81	13,873	4-Jul-93
18,607	26-Jun-69	10,891	17-Jun-82	6,207	30-Mar-94
16,850	29-Jun-70	12,928	8-Jul-83	18,073	15-Jul-95
15,649	28-Jun-71	11,200	17-Jun-84	11,909	17-Jun-96
13,926	10-Jun-72	4,416	12-May-85	21,006	11-Jun-97
10,255	21-May-73	17,180	21-Jun-86	13,999	6-Jul-98
17,285	23-Jun-74	11,670	28-May-87	16,854	31-May-99
15,680	12-Jul-75	17,217	8-May-88	6,554	18-May-00
11,837	23-Jun-76	5,286	21-Jun-89	10,117	14-Jun-01
5,131	11-May-77	7,117	12-Jun-90	6,116	2-Jun-02
23,215	19-May-78	18,264	15-Jun-91	7,515	20-Jun-03
9,371	30-May-79	11,020	16-Jun-92	2,858	22-Sep-04

Alt. C - Modified Pool Levels

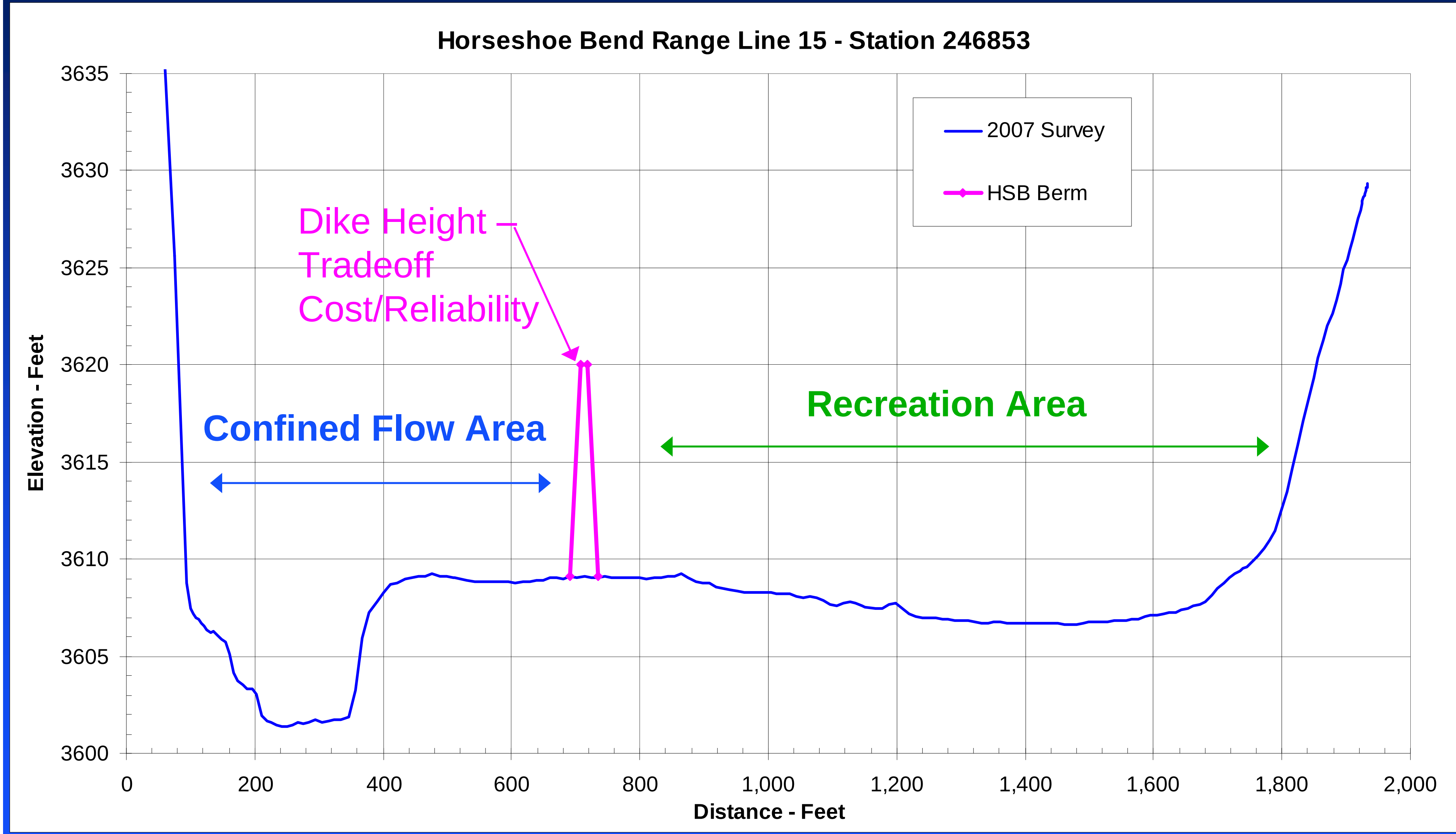


Alternative D – Dike Within Horseshoe Bend

- Implement local features to control and alter sediment deposition and transport through Horseshoe Bend
- Propose berm construction to separate flowing river from recreation area
- Sediments move past Horseshoe Bend with minimal impact to recreation area
- Alternative is most independent of other actives, least impacted by hydrology
- 9000 foot length, 15 ft average height, built from all rock or earth core
- 250,000 tons rock

- Will need periodic maintenance of structure
- Does not impact fine sediments that are in the water column and will deposit in the recreation area
- May be safety issues with dike
- Likely need to raise structure over time as sediments accumulate
- Implementation cost multi-million

Alternative D Typical Cross Section



Alternative F - Dredge sediment within Horseshoe Bend

Dredge sediments over the length of Horseshoe Bend

Assume disposal of sediments below HSB within pool

Assumed dredge to elevation of 3590

For HSB, dredge area about 500 acres, average depth of 20 feet

Initial dredge volume is 16 Million cubic yards

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

Will require periodic maintenance dredging (5-8 yrs)

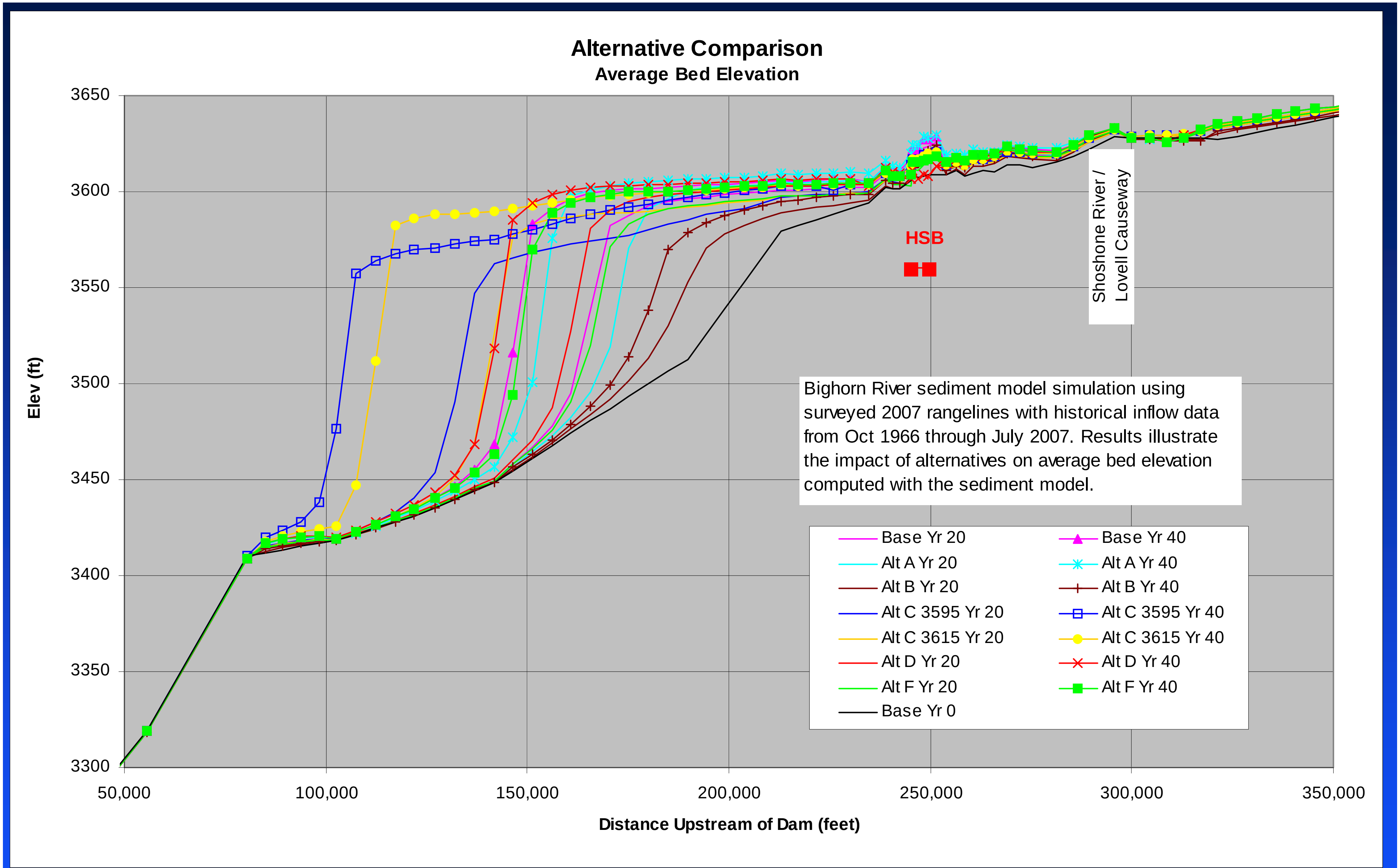
Permit issues with dredging and discharge

High cost to implement (10’s of millions)

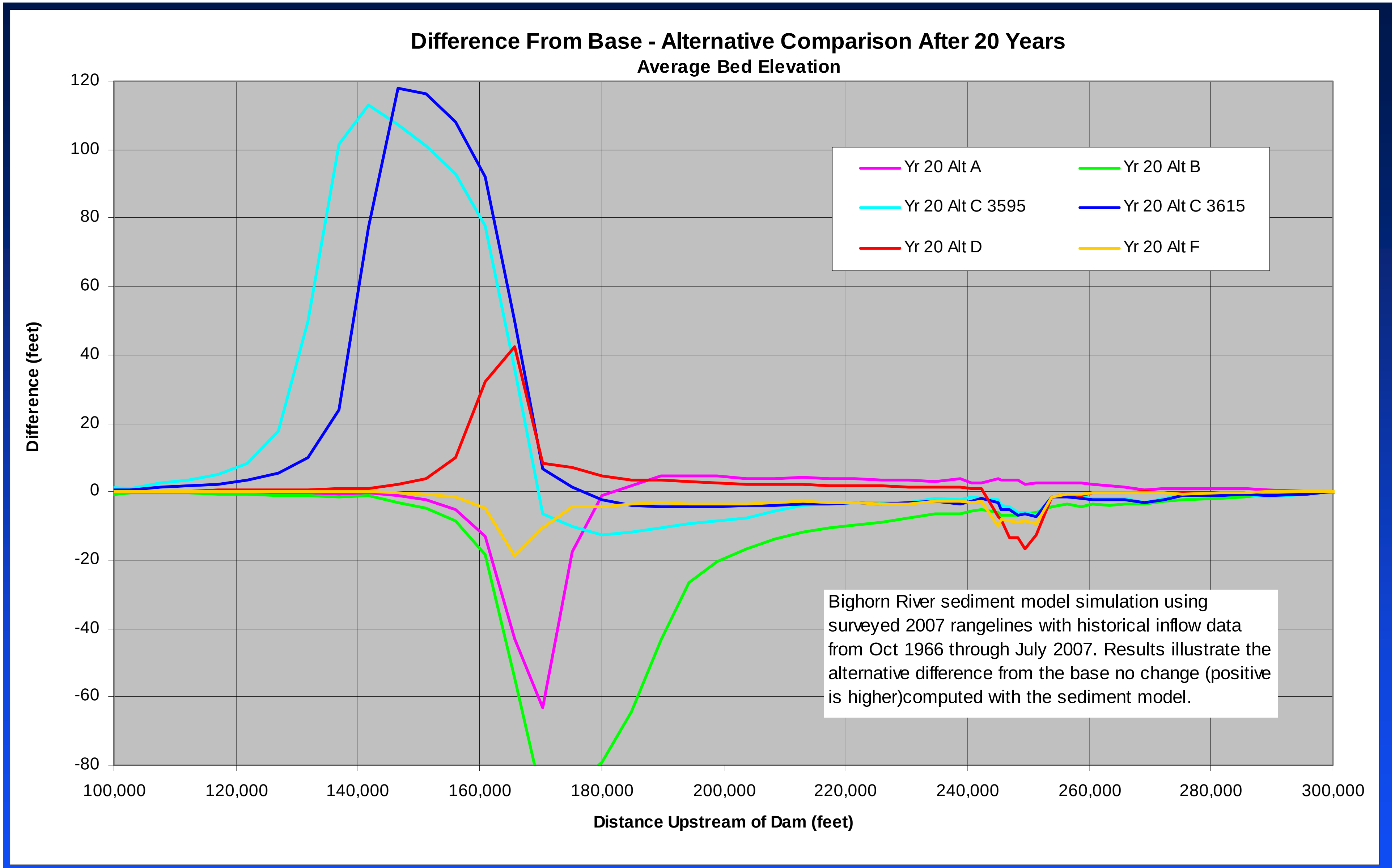
High volume will result in a nearly perpetual dredge

Results Summary

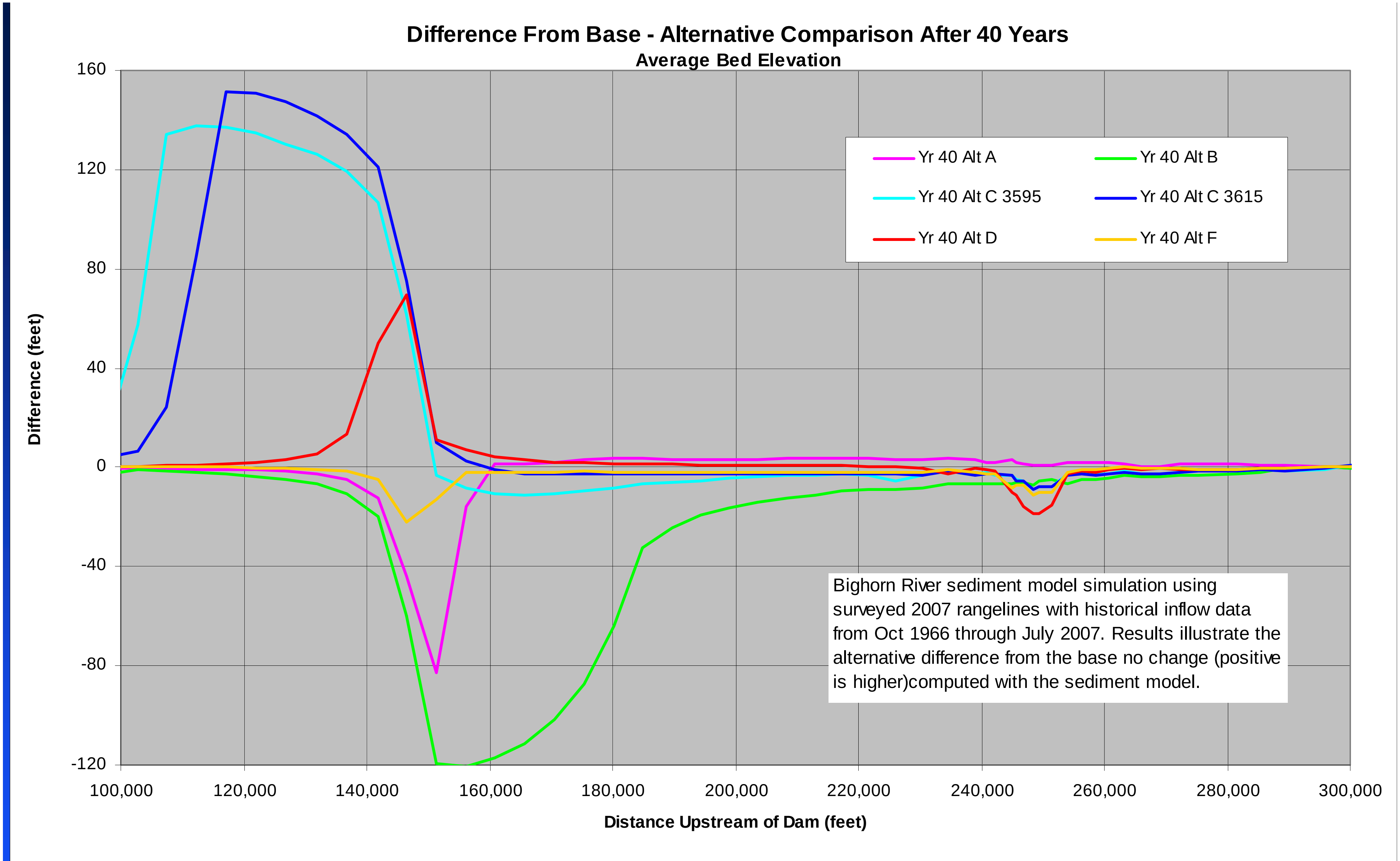
- Tool to compare between model results of sediment management alternatives
- Initial assessment level of detail
- **ALL** alternatives affect sediment and evaluation should consider short and long term impacts\tradeoffs
- Value of model demonstrated to evaluate sediment response to a number of actions

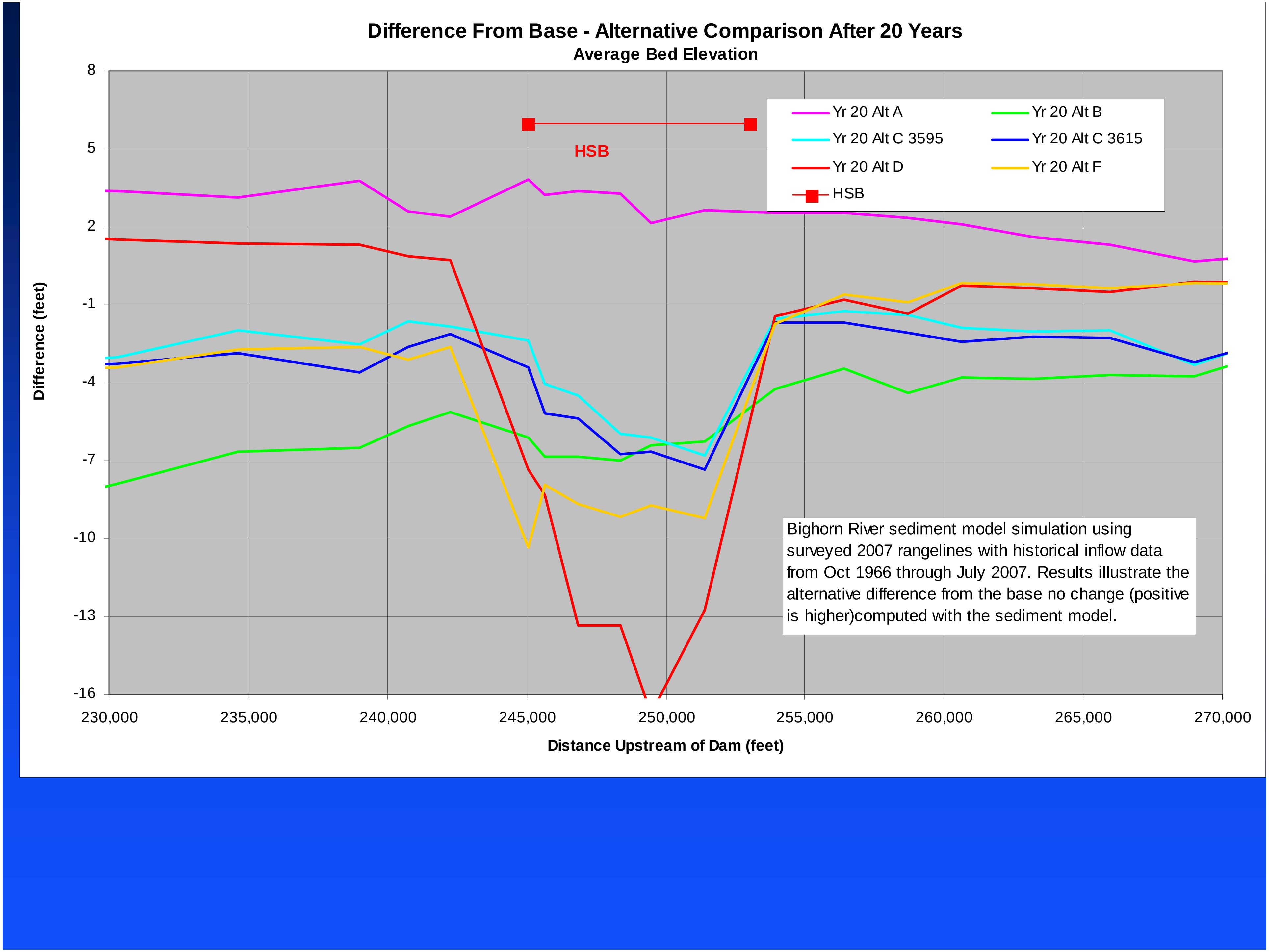


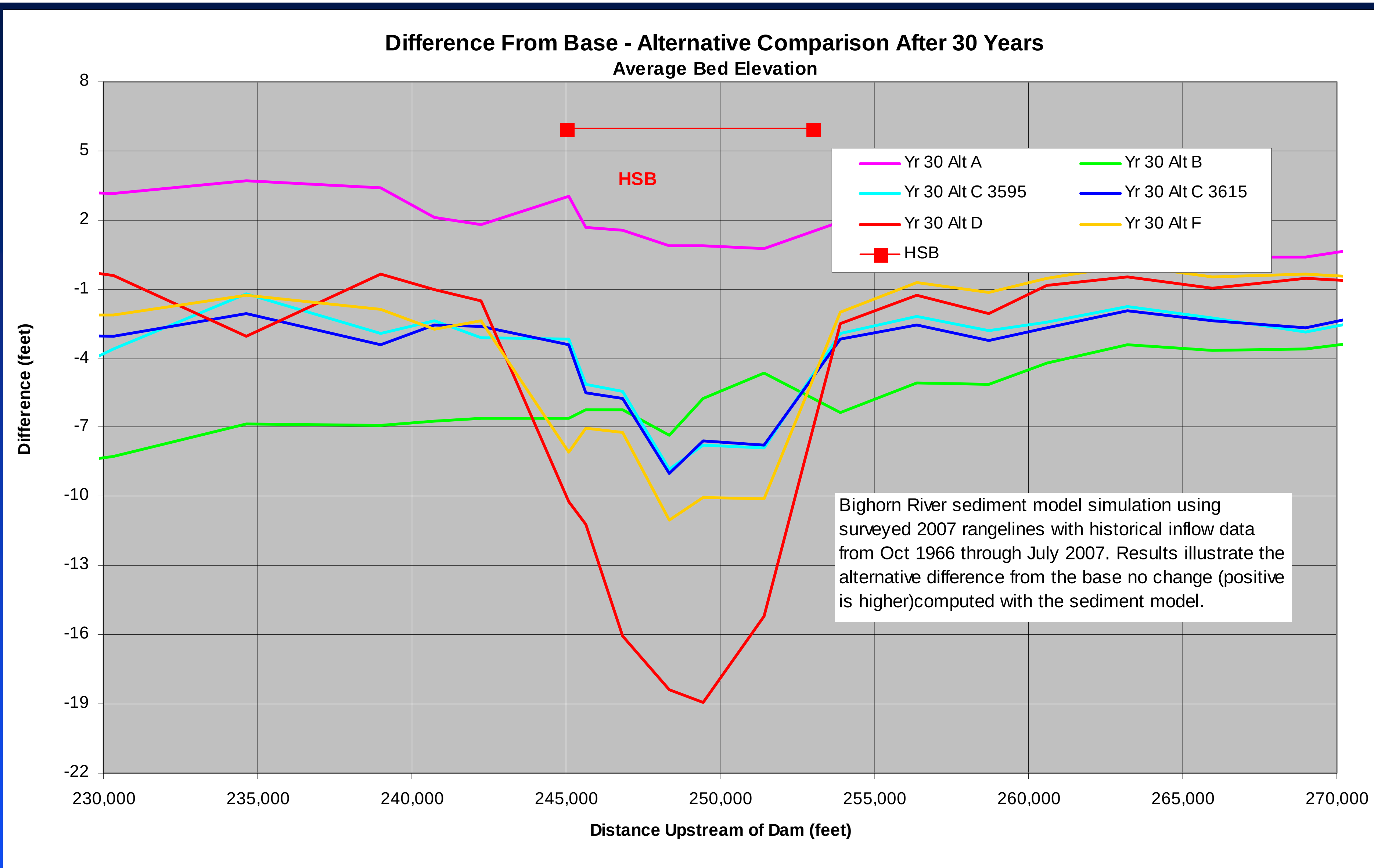
Alternative Comparison
Average Bed Elevation
Elev (ft)
3650
3600
3550
3500
3450
3400
3350
3300
50,000
100,000
150,000
200,000
250,000
300,000
350,000
Distance Upstream of Dam (feet)
HSB
Shoshone River / Lovell Causeway
Bighorn River sediment model simulation using surveyed 2007 rangelines with historical 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



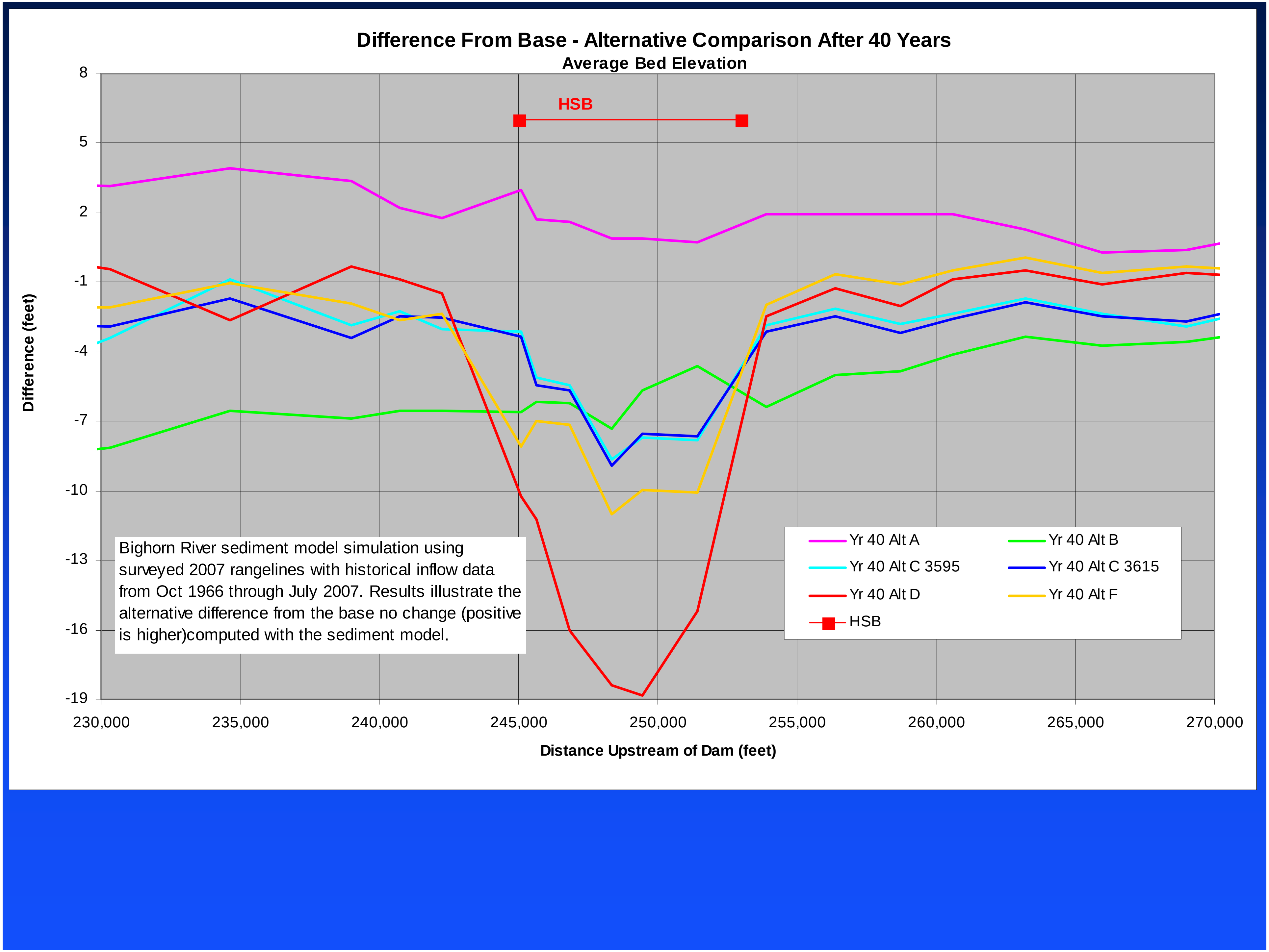
Difference From Base - Alternative Comparison After 20 Years
Average Bed Elevation
Yr 20 Alt A
Yr 20 Alt B
Yr 20 Alt C 3595
Yr 20 Alt C 3615
Yr 20 Alt D
Yr 20 Alt F
Bighorn River sediment model simulation using surveyed 2007 rangelines with historical inflow data from Oct 1966 through July 2007. Results illustrate the alternative difference from the base no change (positive is higher)computed with the sediment model.
Difference (feet)
120
100
80
60
40
20
0
-20
-40
-60
-80
100,000
120,000
140,000
160,000
180,000
200,000
220,000
240,000
260,000
280,000
300,000
Distance Upstream of Dam (feet)


Difference From Base - Alternative Comparison After 40 Years
Average Bed Elevation
160
120
80
40
0
-40
-80
-120
Difference (feet)
100,000
120,000
140,000
160,000
180,000
200,000
220,000
240,000
260,000
280,000
300,000
Distance Upstream of Dam (feet)
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
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.


Difference From Base - Alternative Comparison After 20 Years
Average Bed Elevation
Yr 20 Alt A
Yr 20 Alt B
Yr 20 Alt C 3595
Yr 20 Alt C 3615
Yr 20 Alt D
Yr 20 Alt F
HSB
HSB
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.
Difference (feet)
8
5
2
-1
-4
-7
-10
-13
-16
230,000
235,000
240,000
245,000
250,000
255,000
260,000
265,000
270,000
Distance Upstream of Dam (feet)



Difference From Base - Alternative Comparison After 30 Years
Average Bed Elevation
Difference (feet)
8
5
2
-1
-4
-7
-10
-13
-16
-19
-22
230,000
235,000
240,000
245,000
250,000
255,000
260,000
265,000
270,000
Distance Upstream of Dam (feet)
HSB
Yr 30 Alt A
Yr 30 Alt B
Yr 30 Alt C 3595
Yr 30 Alt C 3615
Yr 30 Alt D
Yr 30 Alt F
HSB
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.



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


Questions ?

EMPLACEMENT OF COARSE-GRAINED TOPSET AND FORESET AND FINE-GRAINED BOTTOMSET IN A LABORATORY FLUME (Kostic and Parker, 2003a,b)