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Managing Water in the West

Yakima River Geomorphology and Sediment Transport Study:

Gap to Gap Reach, Yakima, WA

U.S. Department of the Interior
Bureau of Reclamation

- **Study performed and report prepared by:**

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- **Bureau of Reclamation, Technical Service Center**
- **Denver, CO**

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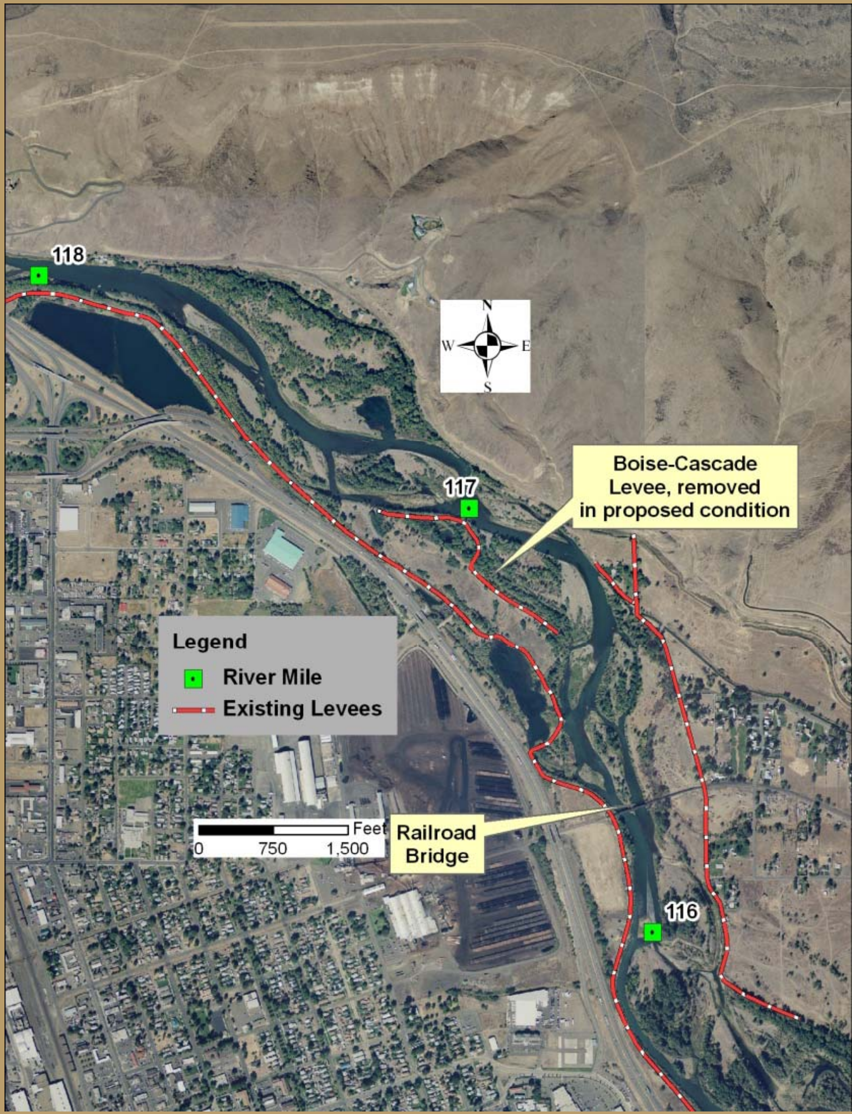
Presentation Outline

- Introduction
- Geomorphic study and results
- Numerical modeling
  - Methodology
  - Results
- Predicted channel condition
- Recommendations
- Conclusions

Study Context

- Levee setback and removal
  - DID #1 Levee
  - Boise Cascade Levee
- Anticipated benefits
  - Reduce flooding impacts to city of Yakima and Union Gap
  - Improve aquatic and riparian habitat in the Gap to Gap reach
- Study approach
  - Combined geomorphic and sediment transport study



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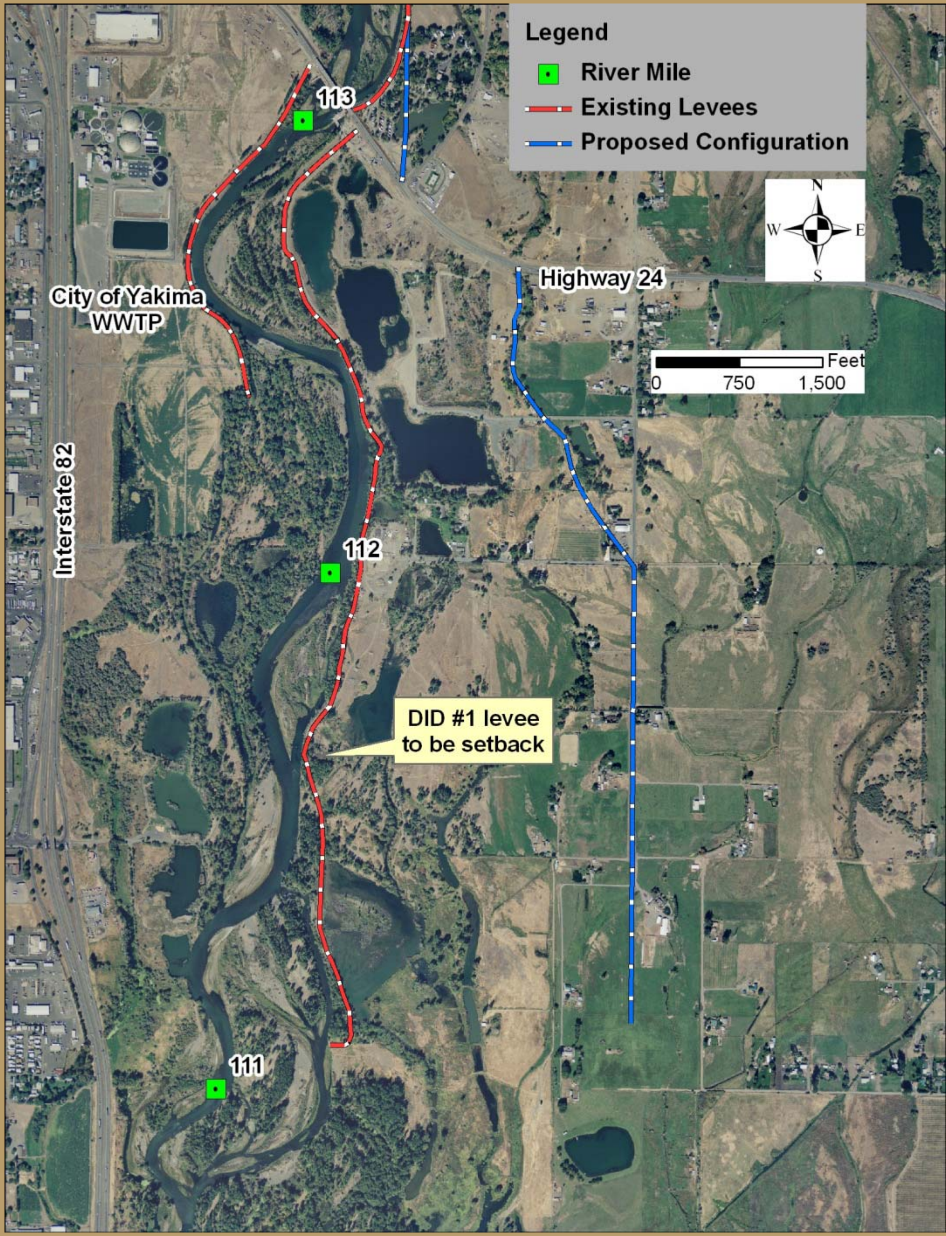
Study Goals

- **Predict future channel conditions over 25 year time frame, including:**
  - **Locations of aggradation and degradation**
  - **Areas of potential erosion and avulsion**
  - **Specifically focus on areas of concern**
    - **Changes in levee configuration**
    - **SR 24 Bridge**
    - **Newland Ponds**
    - **Wastewater Treatment Plant**
    - **Beech Street pit**



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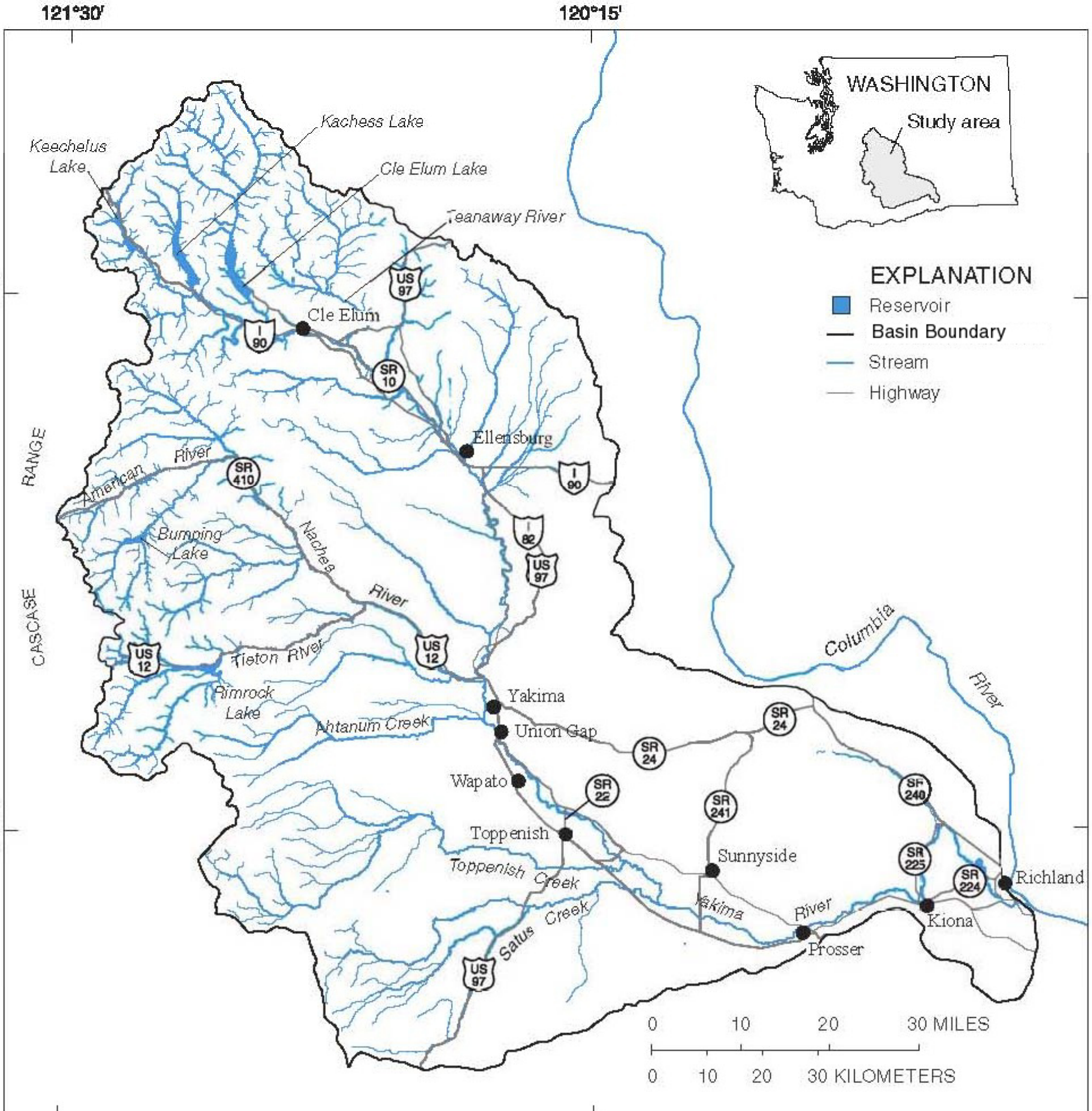


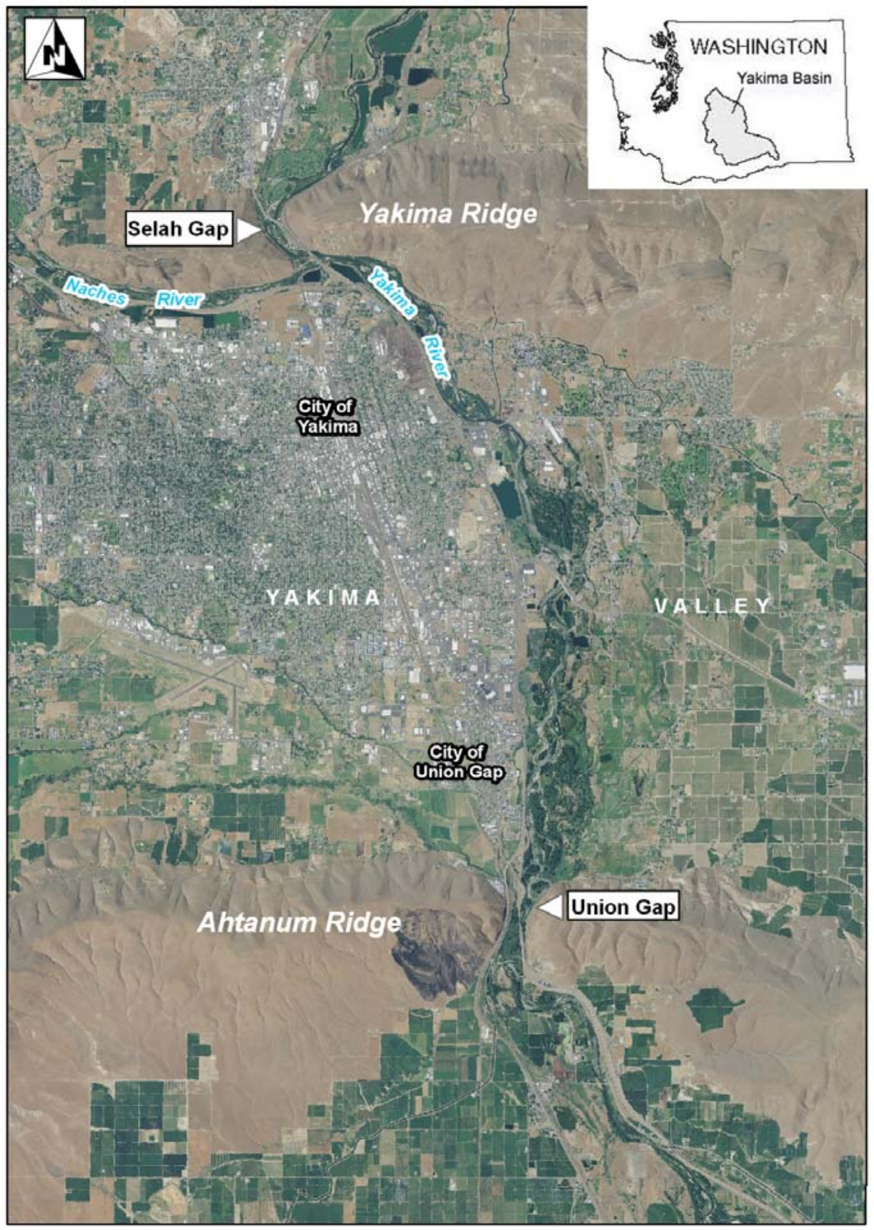
121°30'
120°15'
47°
15'
46°
22'
30"
WASHINGTON
Study area
EXPLANATION
Reservoir
Basin Boundary
Stream
Highway
Kachess Lake
Keechelus Lake
Cle Elum Lake
Teanaway River
Cle Elum
Ellensburg
American River
Bumping Lake
Naches River
Tieton River
Rimrock Lake
Ahtanum Creek
CASCADE RANGE
Yakima
Union Gap
Wapato
Toppenish
Toppenish Creek
Satus Creek
Sunnyside
Yakima River
Prosser
Kiona
Richland
Columbia River
US 97
I 90
SR 10
SR 410
I 82
US 12
SR 24
SR 22
SR 241
SR 240
SR 225
SR 224
0 10 20 30 MILES
0 10 20 30 KILOMETERS

Hydrology

- **Altered hydrograph**
  - Based on reservoir operations for 6 dams (3 in Yakima River watershed, 3 in Naches River watershed)
- **Floods**
  - Largest historical floods: 1933, 1948, 1972, 1996
  - Flood stage exceeded 48 times since circa 1900
  - Sediment transport evaluated for 4 different types of floods
- **60% total water use attributed to agriculture**
  - Return flows account for as much as 80% of mainstem flow in lower river

Setting

- Selah Gap to Union Gap
  - Bounded by anticlinal ridges of Yakima ridge and Ahtanum ridge
    - Evidence for continued growth of ridges
  - Inundated by Missoula floods during late Pleistocene due to backwater behind Wallula gap constriction
  - Human impacts
    - Levees (1947+)
    - Floodplain gravel mining (1945-1973 and continuing)



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Geomorphic Analysis tasks

- Surficial geologic mapping of floodplain areas
- Physical observations of geomorphic processes
- Historical Trends analysis
  - Channel complexity (1927-2008)
  - Bar area (1927-2009)
  - Main channel sinuosity (1927-2009)
  - Historical cross section analysis (1969-2005)
- Channel shift maps
  - Predictive areas of erosion, avulsion and instability

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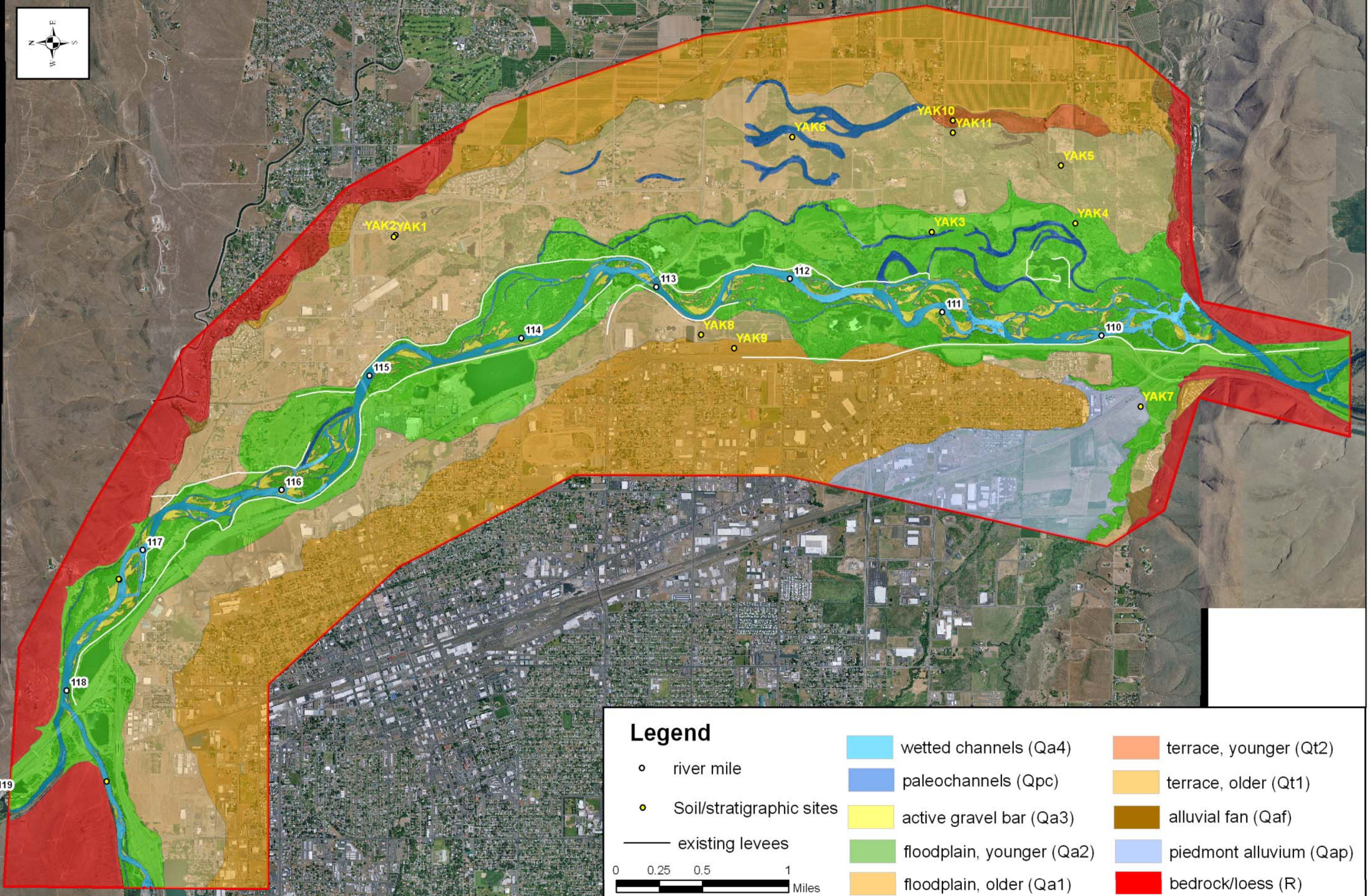

YAK10
YAK11
YAK6
YAK5
YAK2YAK1
YAK3
YAK4
113
112
111
110
114
YAK8
YAK9
115
YAK7
116
117
118
Legend
river mile
Soil/stratigraphic sites
existing levees
wetted channels (Qa4)
paleochannels (Qpc)
active gravel bar (Qa3)
floodplain, younger (Qa2)
floodplain, older (Qa1)
terrace, younger (Qt2)
terrace, older (Qt1)
alluvial fan (Qaf)
piedmont alluvium (Qap)
bedrock/loess (R)
0 0.25 0.5 1
Miles

Younger floodplain deposits

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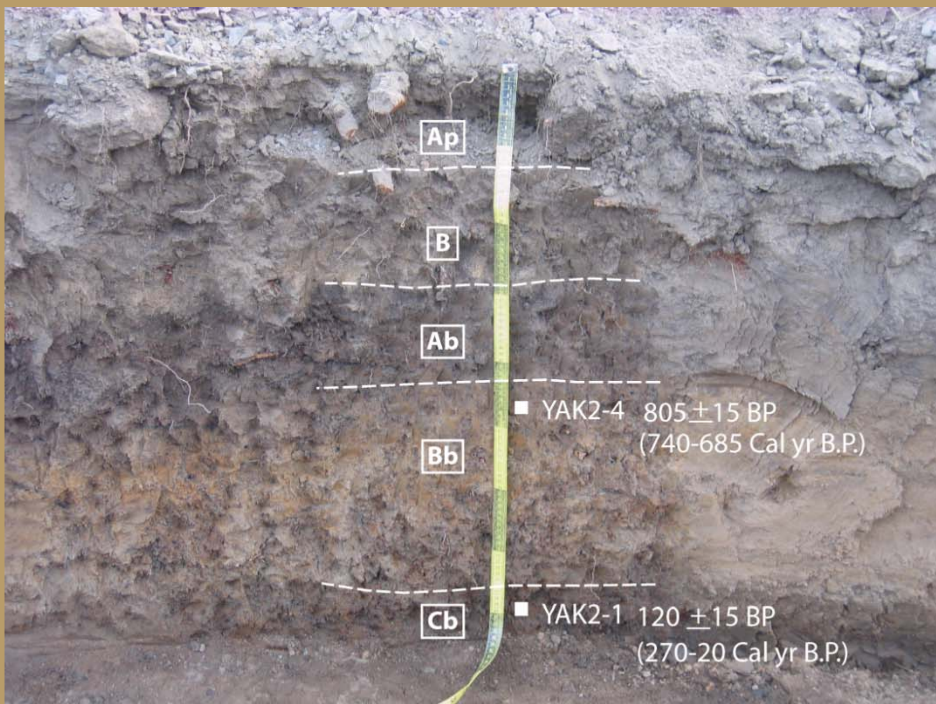
Older floodplain deposits



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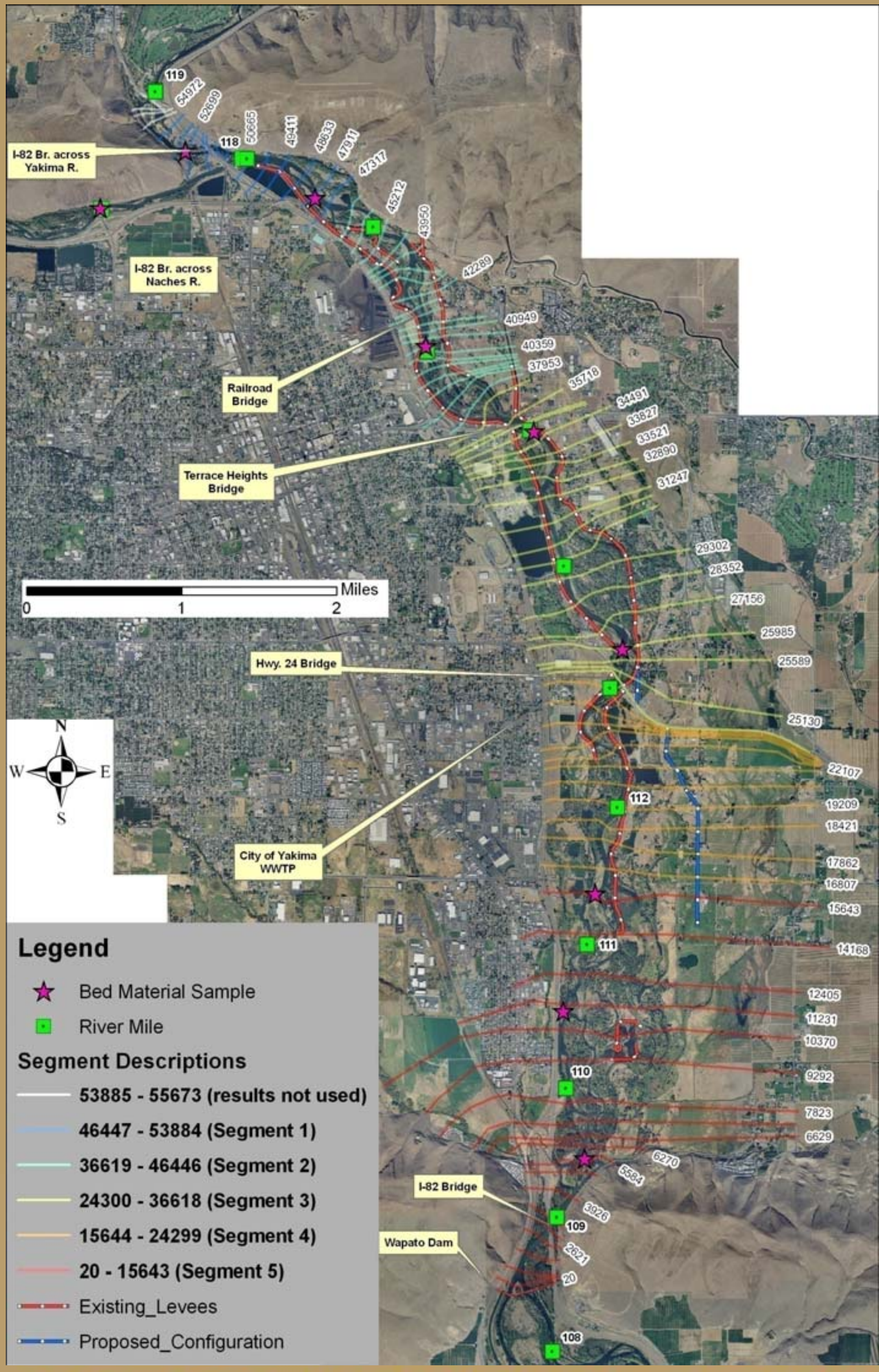
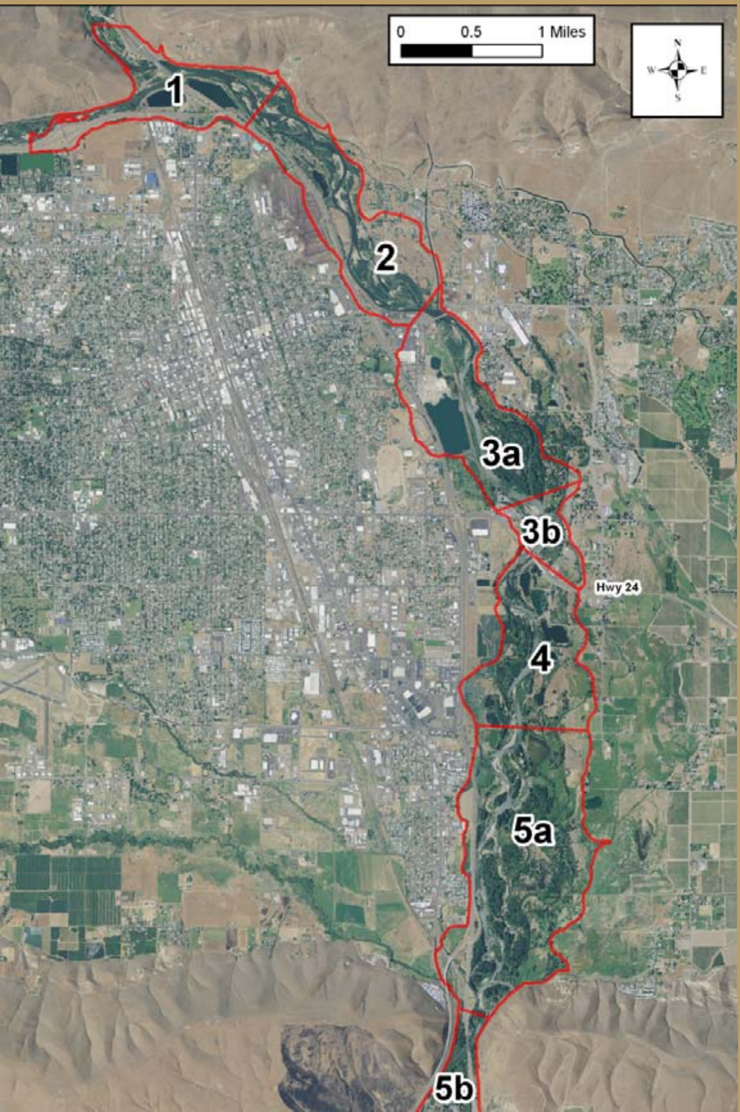
Study segments

- **Based on physical observations of channel dynamics, 2005-2009**
  - **Eroding banks or revetments**
  - **Channel splays or areas of active sedimentation**
  - **Recent channel avulsions**
  - **Channel abandonment or infilling**
- **Classified as stable or dynamic**
- **Defined on the basis of geomorphic observations, then combined with results of sediment model**



Segment geomorphic characteristics



Segment	Lateral channel movement (2005-2009)	Morphology	Channel gradient (ft/ft)	Main channel Sinuosity (ft/ft)	Main channel length (mi)
1	STABLE	anabranching	0.0023	1.15	1.5
2	DYNAMIC	anabranching	0.0031	1.23	2.2
3a	STABLE	single thread to split flow	0.0025	1.13	1.8
3b	DYNAMIC	anabranching	0.0046	1.21	0.5
4	STABLE	split flow to anabranching	0.0019	1.25	1.5
5a	DYNAMIC	anabranching	0.0026	1.20	2.5
5b	STABLE	single thread to split flow	0.0009	1.13	0.9

Segment 1

Yakima R. above Naches to triangular pit

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Segment 2

triangular pit to Terrace Heights pit

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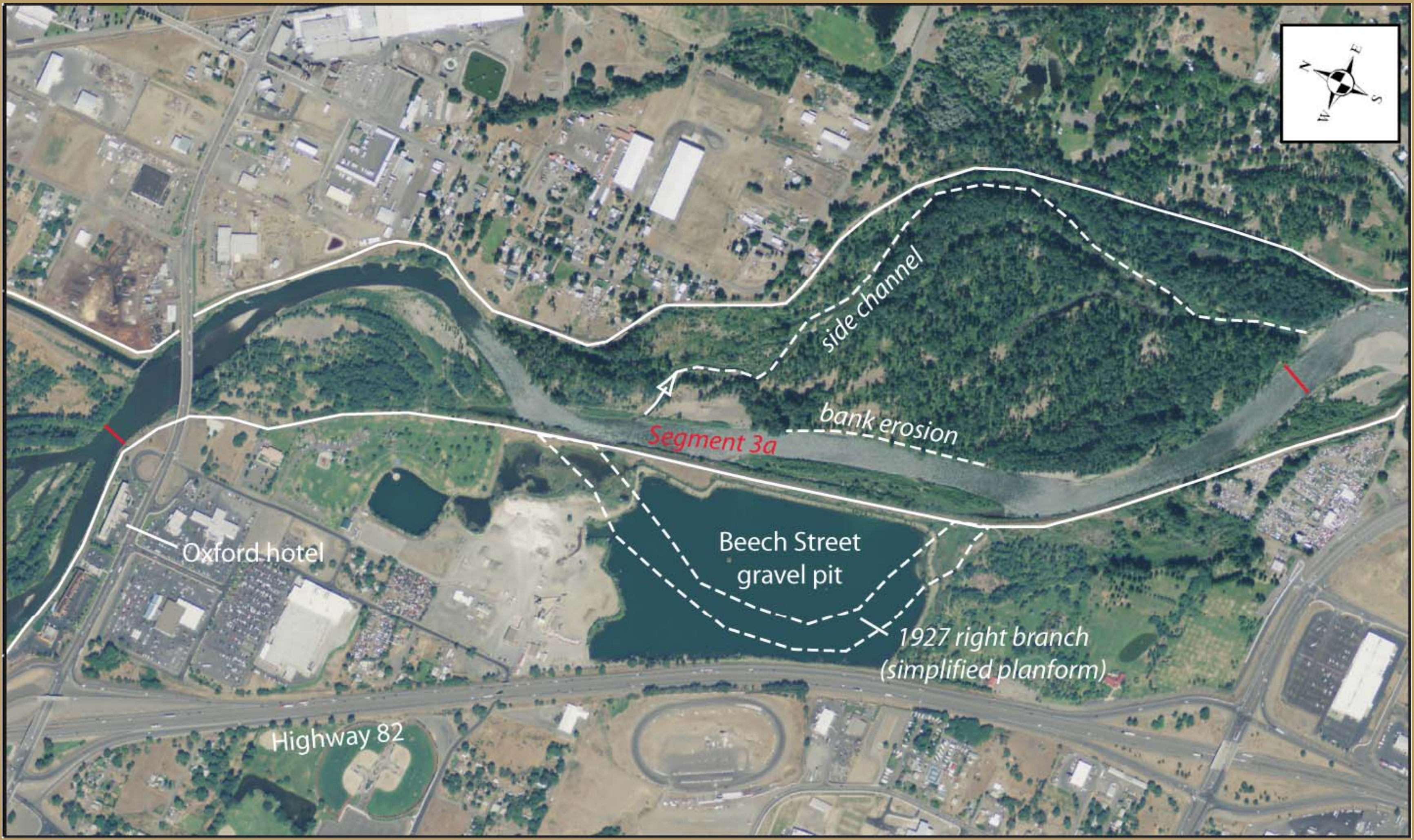
Segment 3a

Terrace Heights gravel pit to Old SR24



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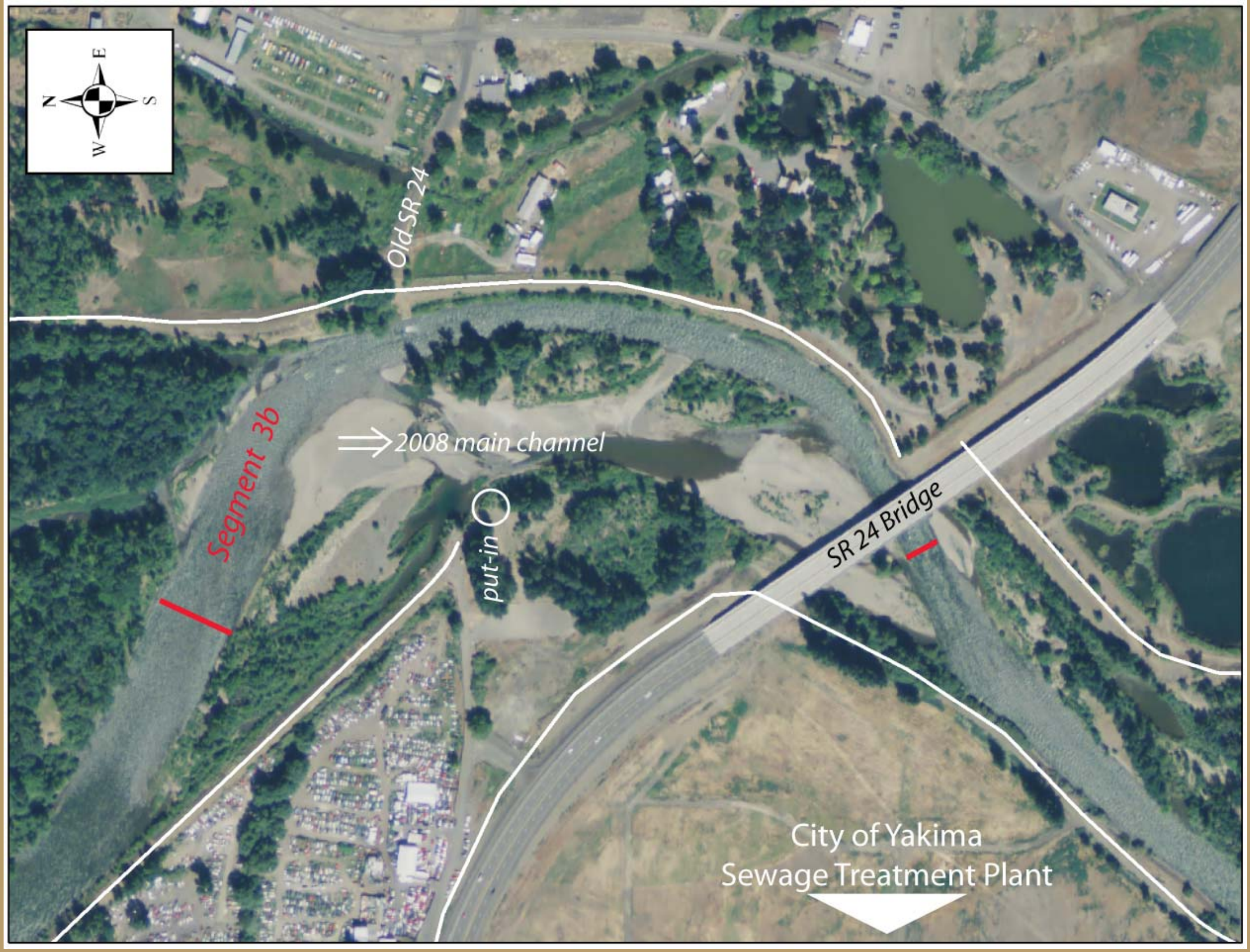
Segment 3b
Old SR24 to SR24 Bridge



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Segment 4
SR24 Bridge to Edler Pond no. 2

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Segment 5a
Edler Pond no. 2 to Union Gap

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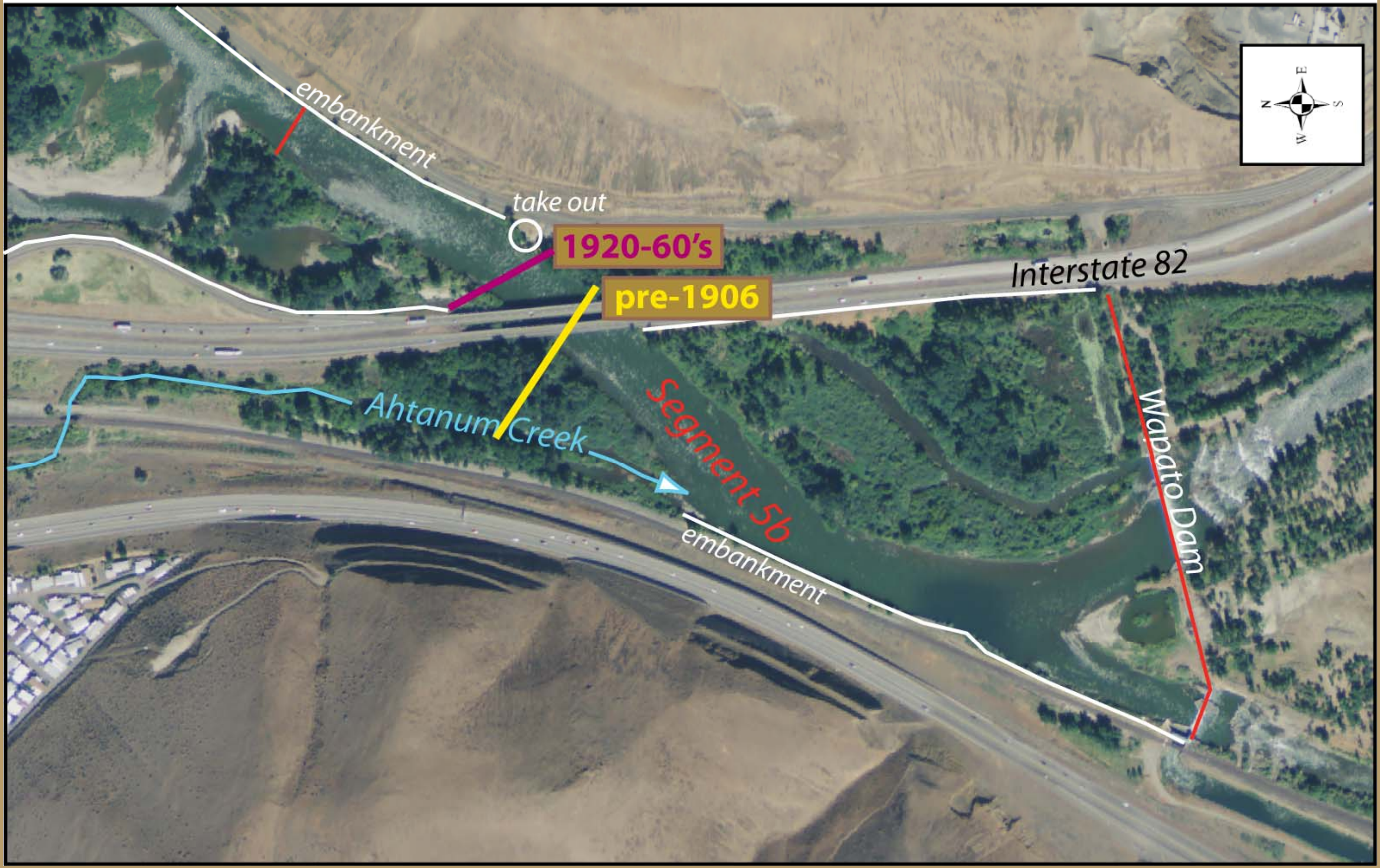
Segment 5b
Union Gap to Wapato Dam



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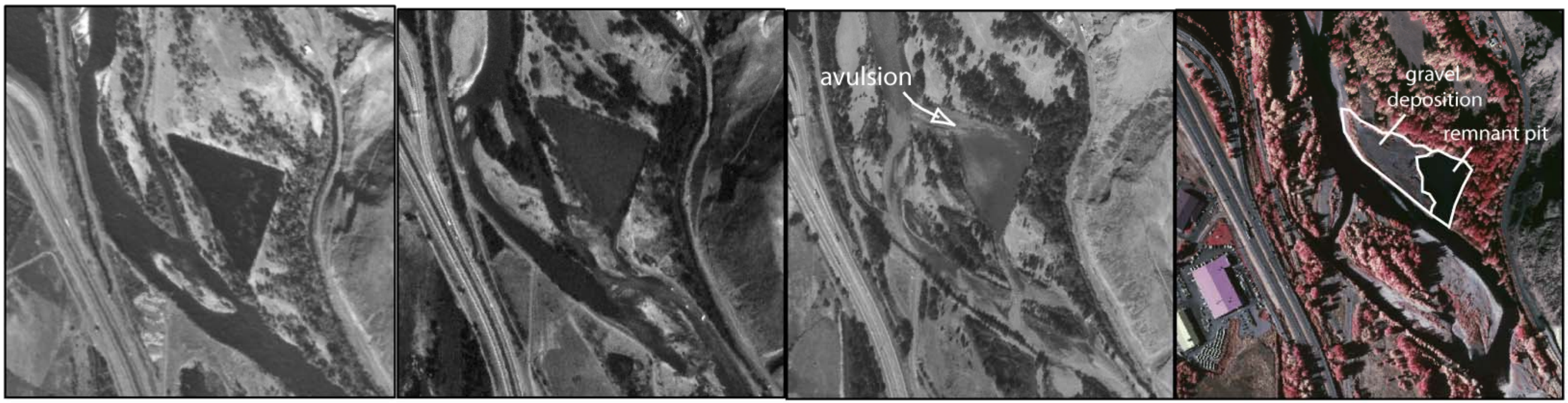
Effects of floods on channel morphology and gravel pit capture

- Reincoporation of gravel pits into floodplain
  - Extreme floods are major catalysts
  - Two processes observed:
    - Lateral migration of channel into pit: rapid filling combined with lateral erosion
    - Channel avulsion into pit: followed by abandonment of original channel or development of split flow channel
- Effects of extreme floods on channel morphology
  - Lateral migration: point bar progradation and bank erosion
  - Channel avulsion
  - Bed scour and deposition
  - Bar formation and erosion

Triangular gravel pit

- *Channel avusion, pit filling and abandonment*
- *Remnant pit*



1966 1979 1992 2000

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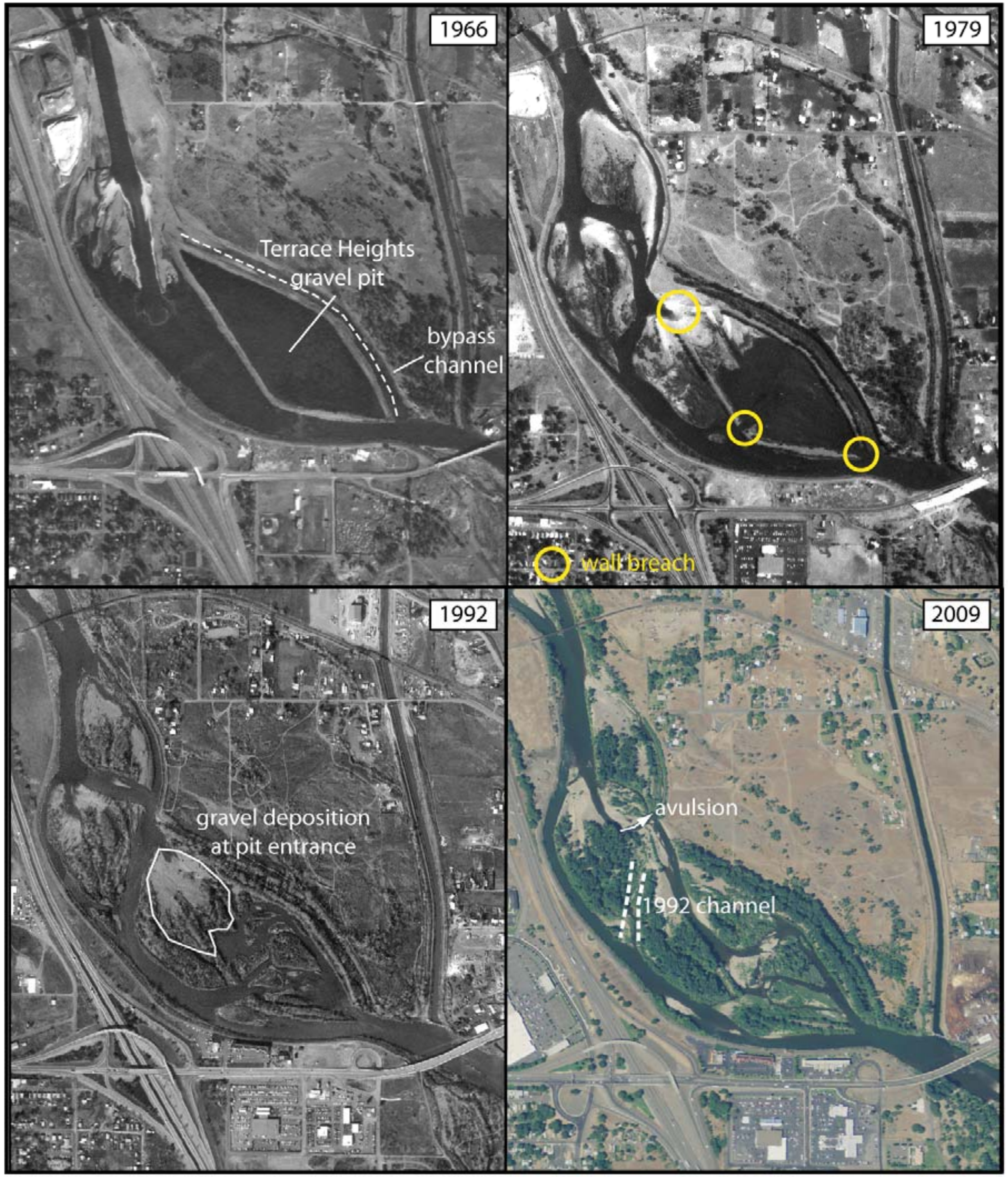
Terrace Heights gravel pit

- Channel excavation through river deposits (1966)
- Multiple wall breaches (1966-1979)
- Gravel deposition at pit Entrance and within pit (1979-1992)
- Channel avulsion at head of pit; formation of complex channel network (1992-2009)

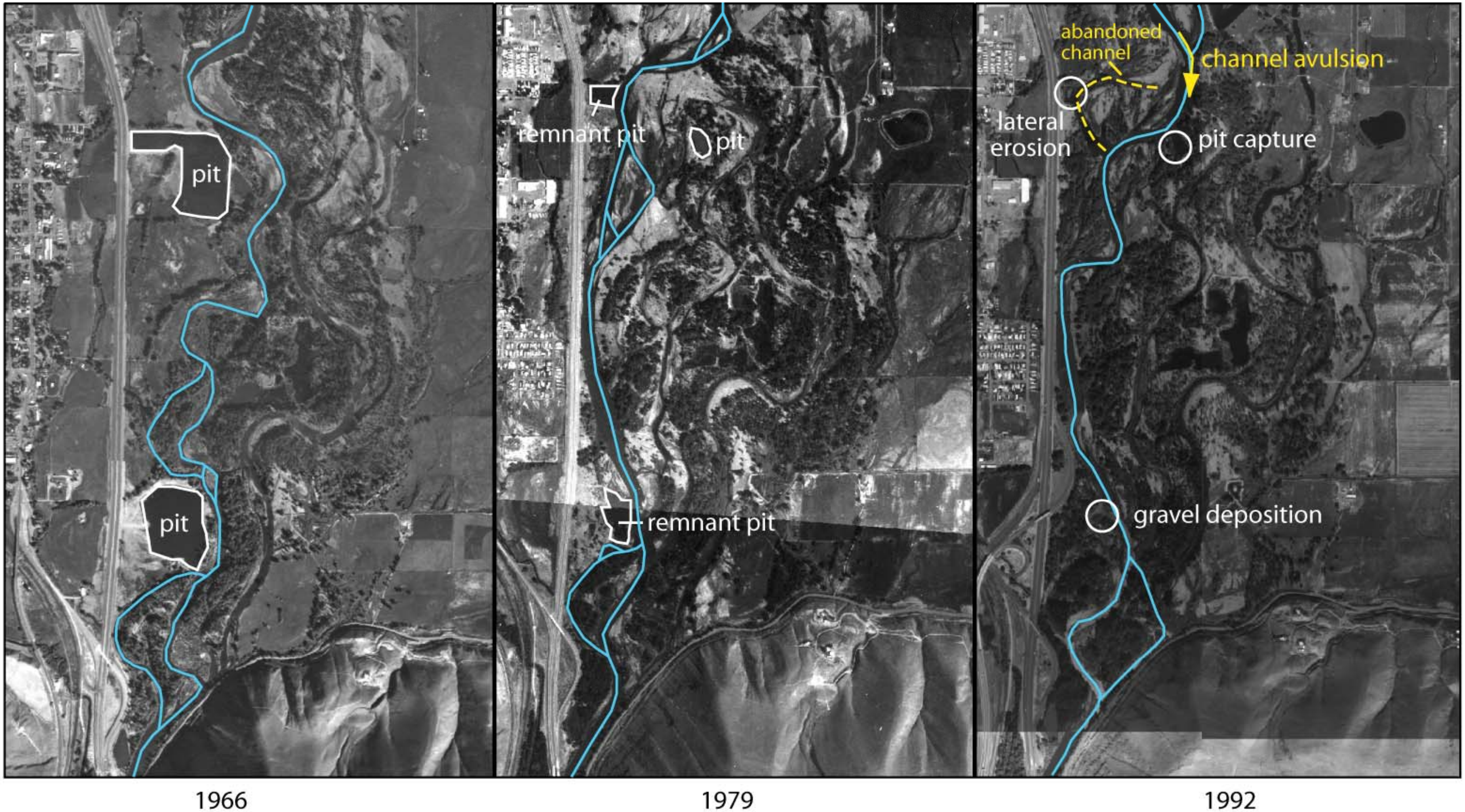


SR 24 gravel pit
--wall breach, pit filling

1966

1979

Reach 5b gravel pit captures
--channel avulsion, headcutting



Edler Ponds

--wall breach in April 2002
--lateral erosion, pit filling
--point bar progradation

2000 2005 2009

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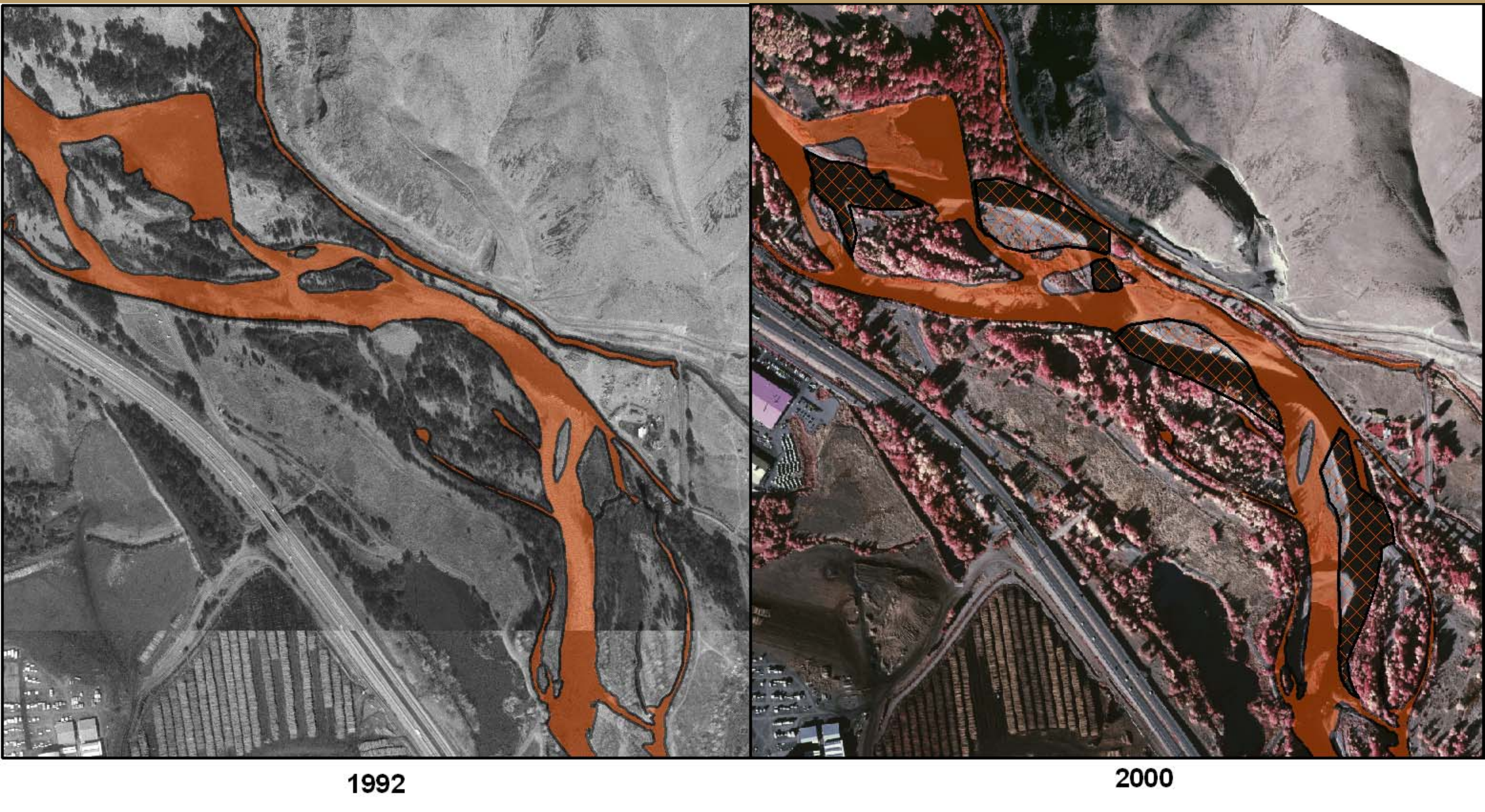
1996 flood effects in segment 2

--multiple channel avulsions

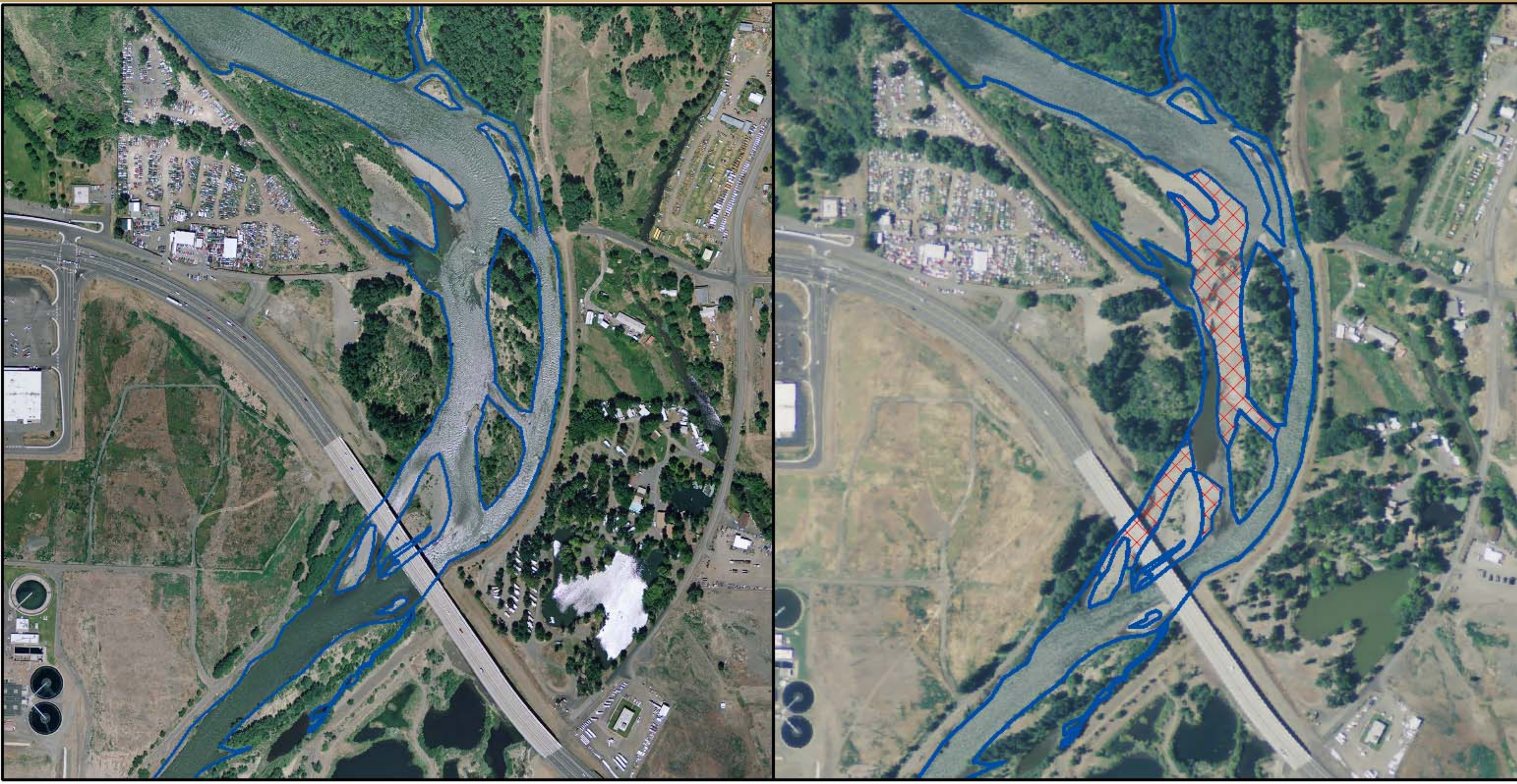
--bar formation and erosion

--increase in main channel sinuosity



2009 flood effects at SR24 Bridge

--channel avulsion and filling



2008 2009

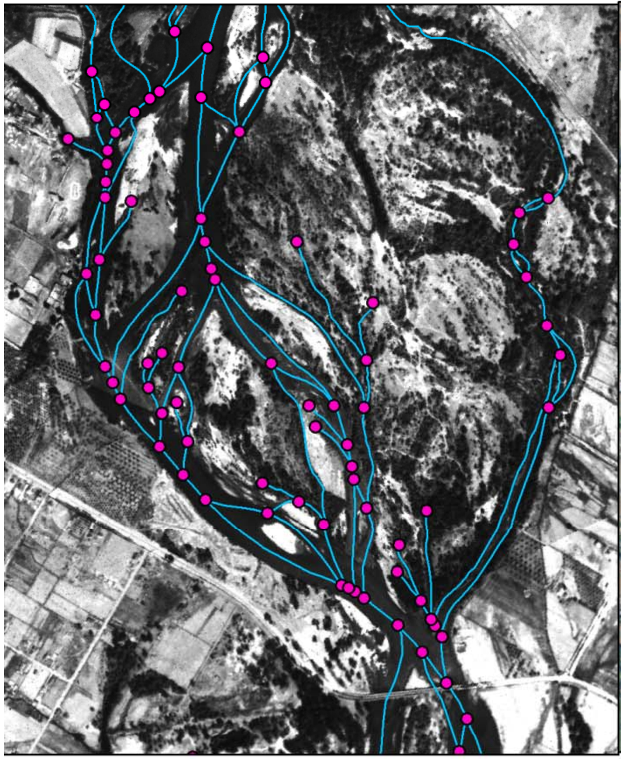
Historical Trends

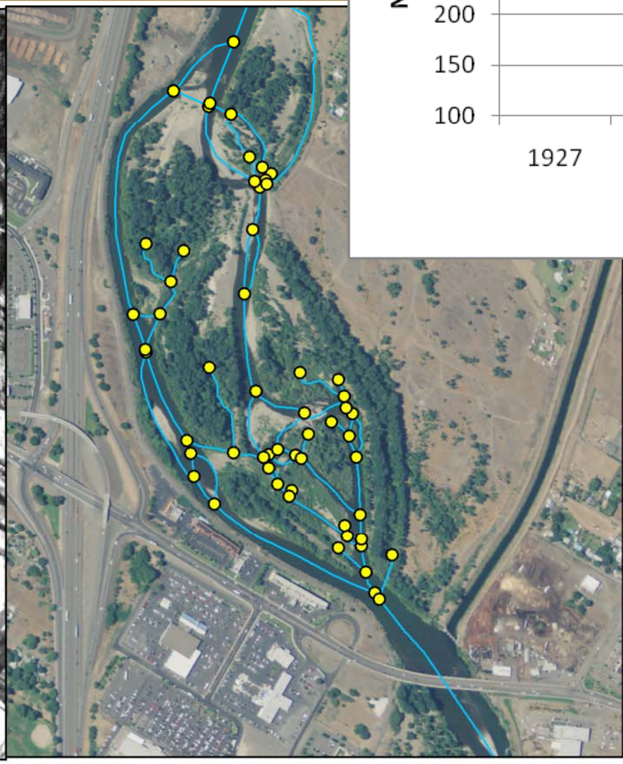
Historical conditions → present channel morphology

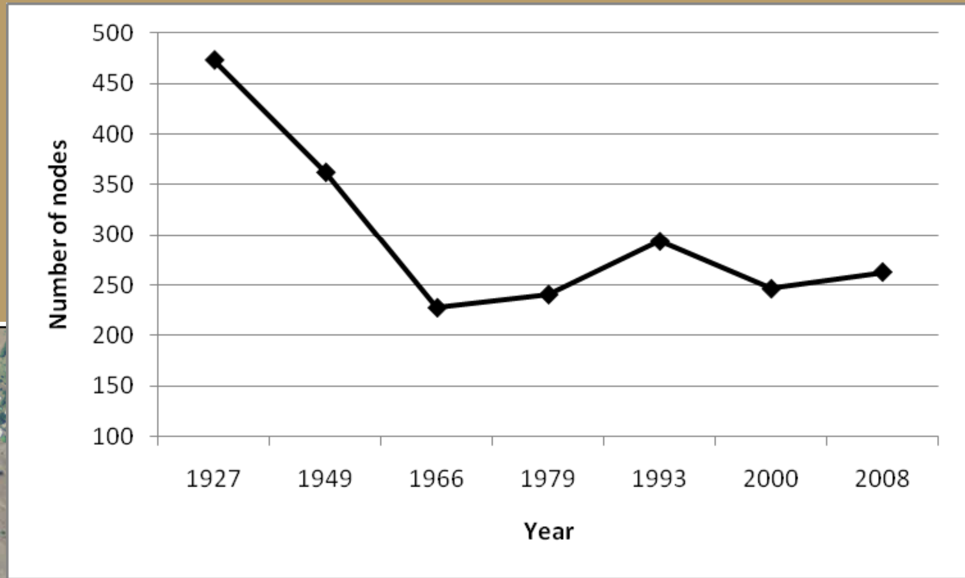
Channel complexity

nodal analysis

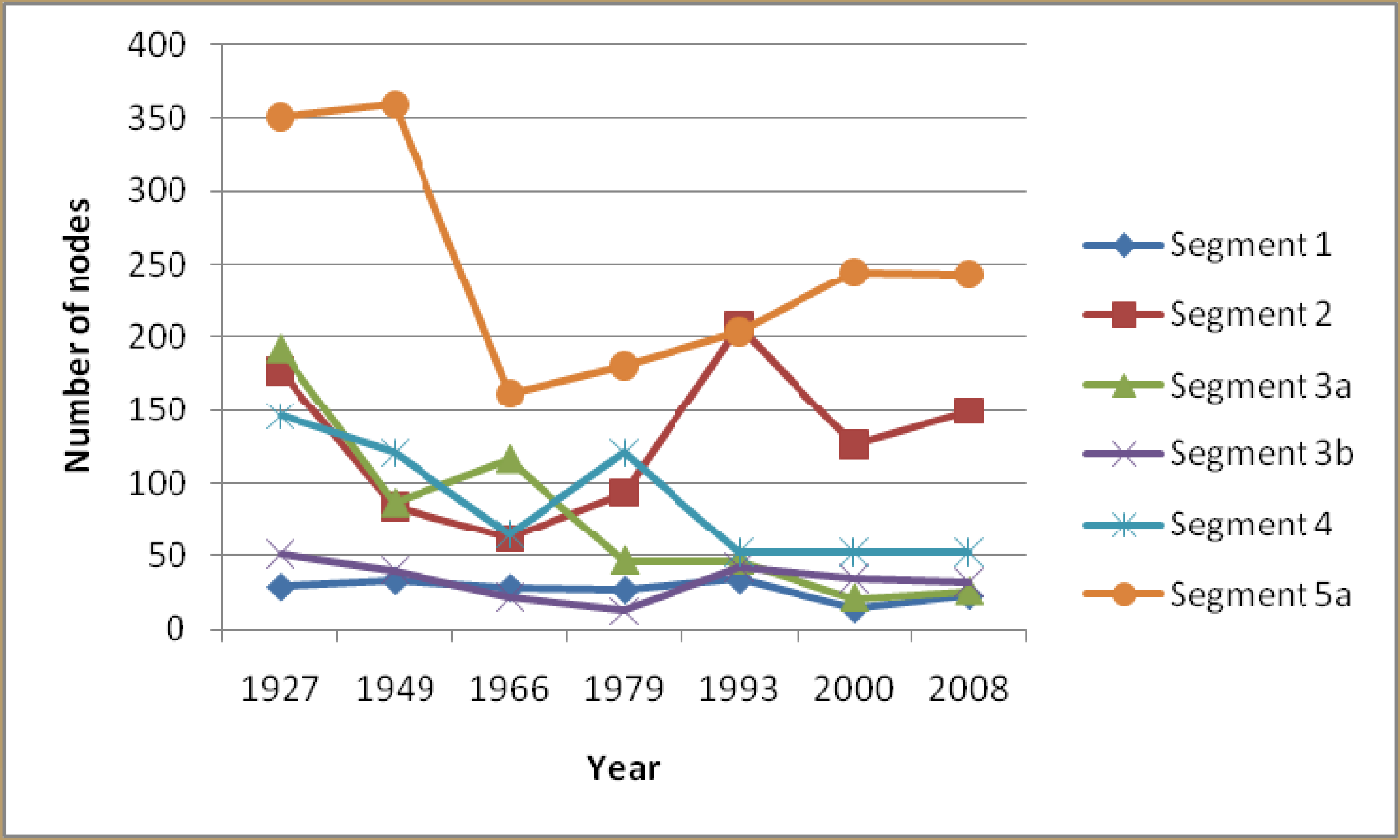
total channel length







Nodal analysis by segment



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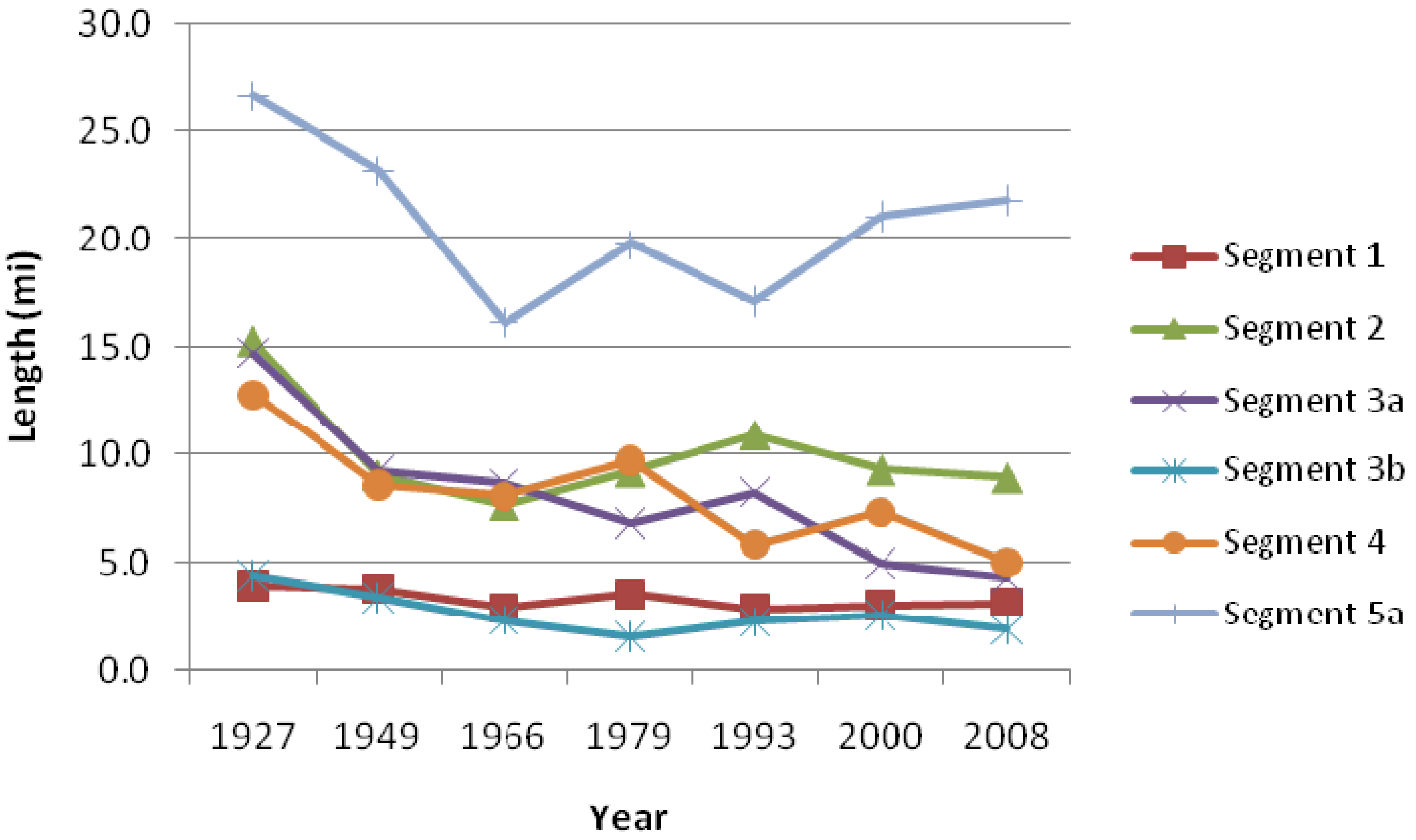
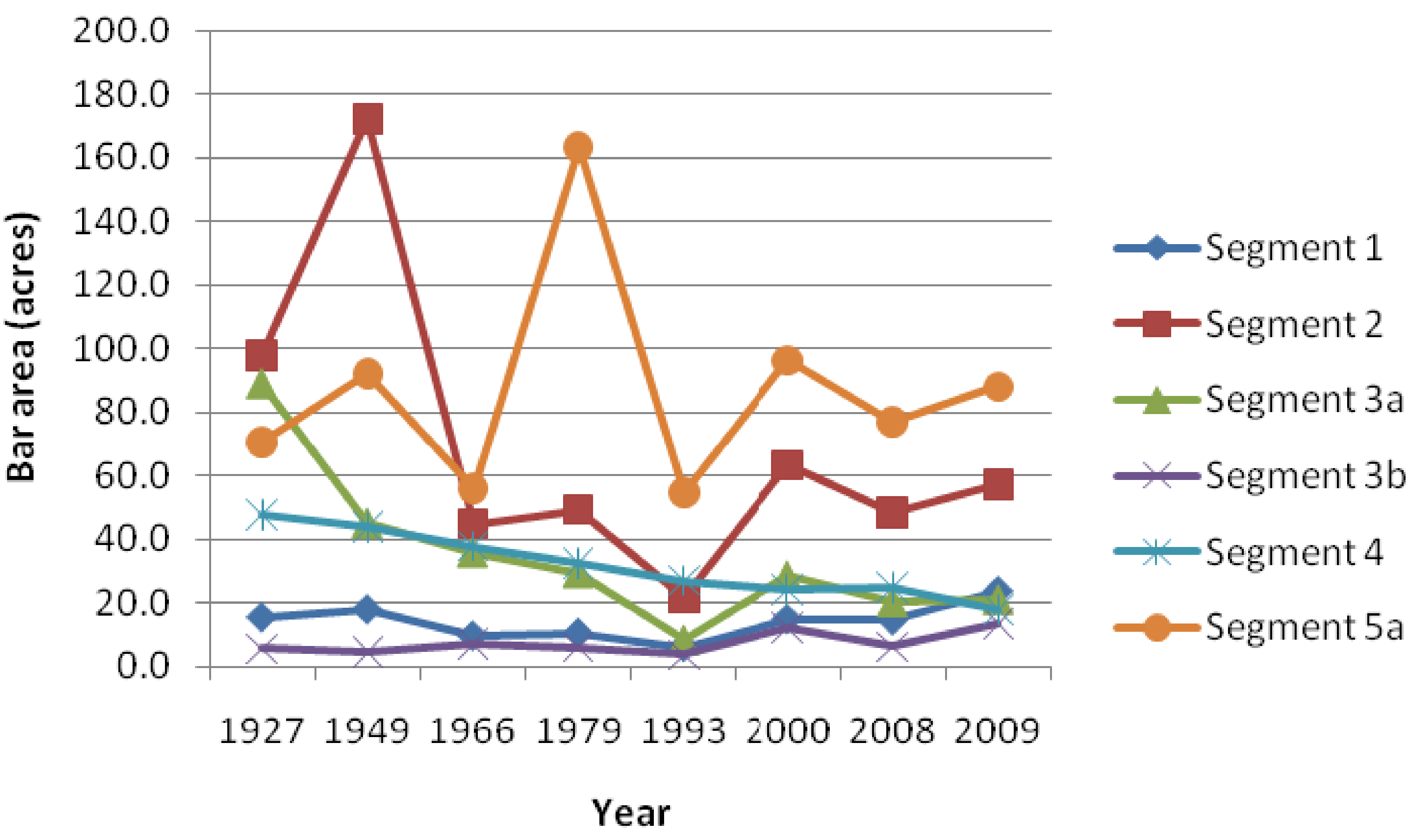
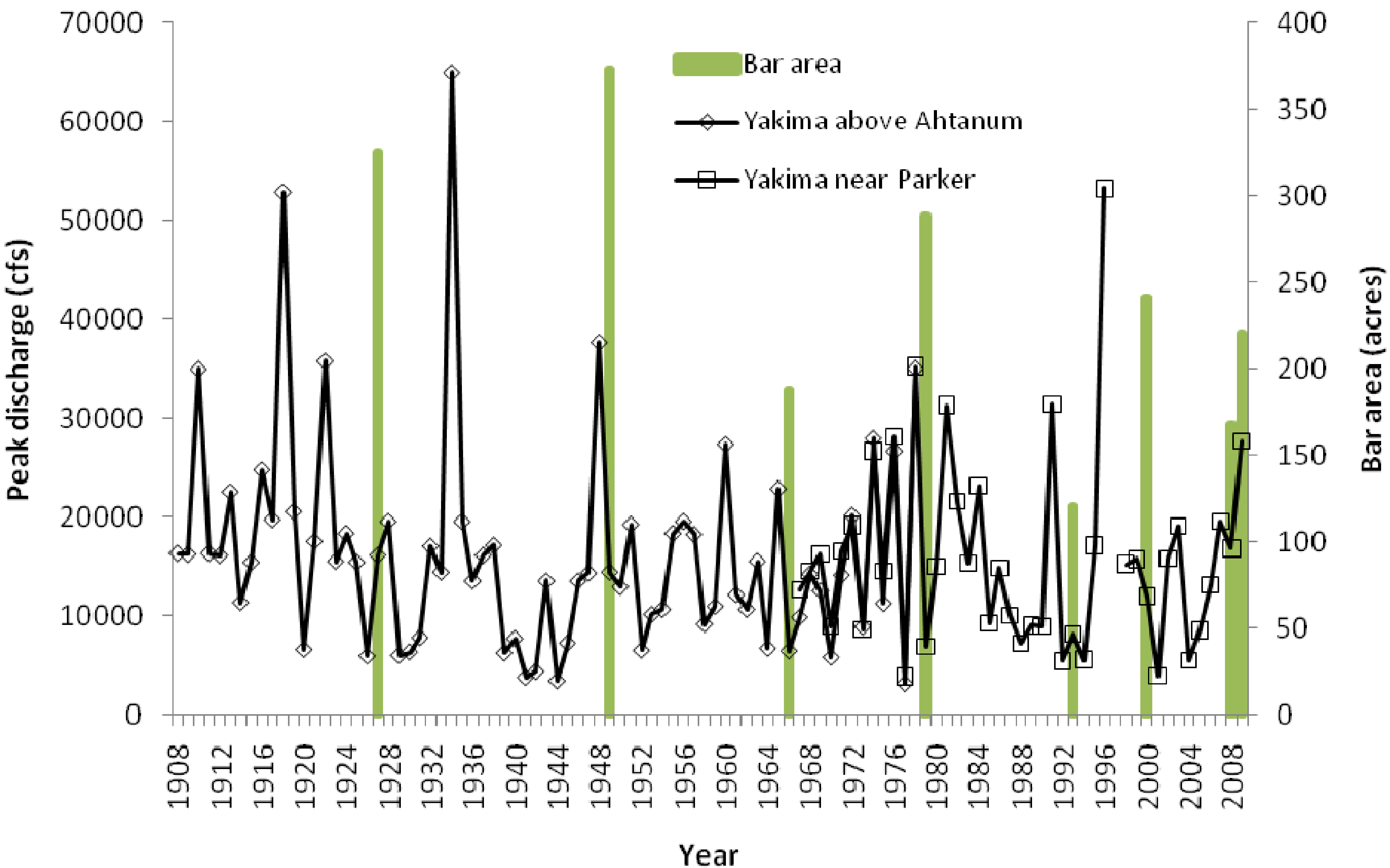
Channel complexity
Total channel length



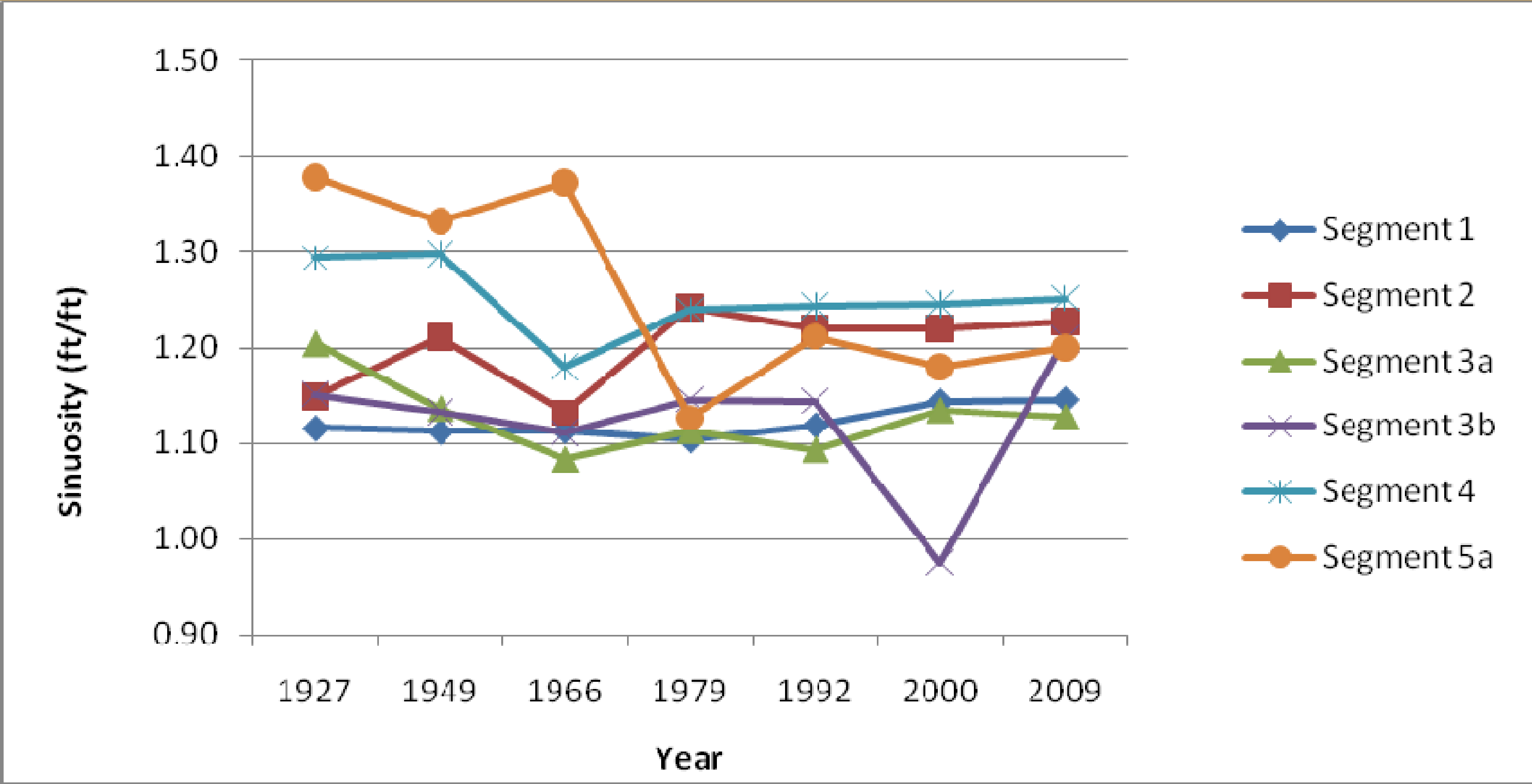
Unvegetated bar area by segment



Unvegetated bar area & hydrology



Main channel sinuosity



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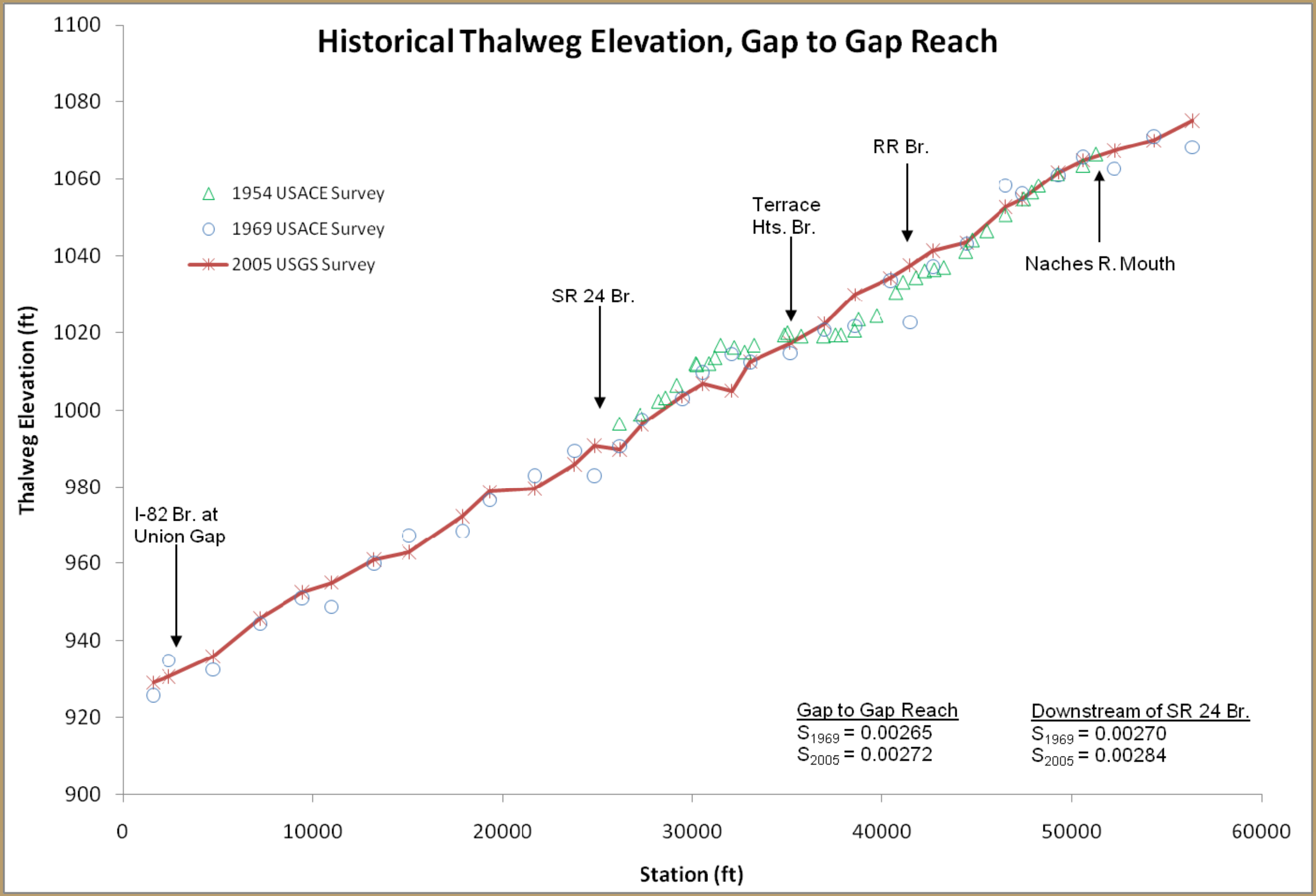
Channel survey comparison *1969-2005*

- **1969 channel survey**
  - USACE survey
  - Alignments and vertical corrections provided by Yakima County
- **2005 channel survey**
  - LiDAR data
  - Data extracted for 1969 alignments
- **Only floodplain area within levees included in analysis**

Longitudinal profile 1969-2005



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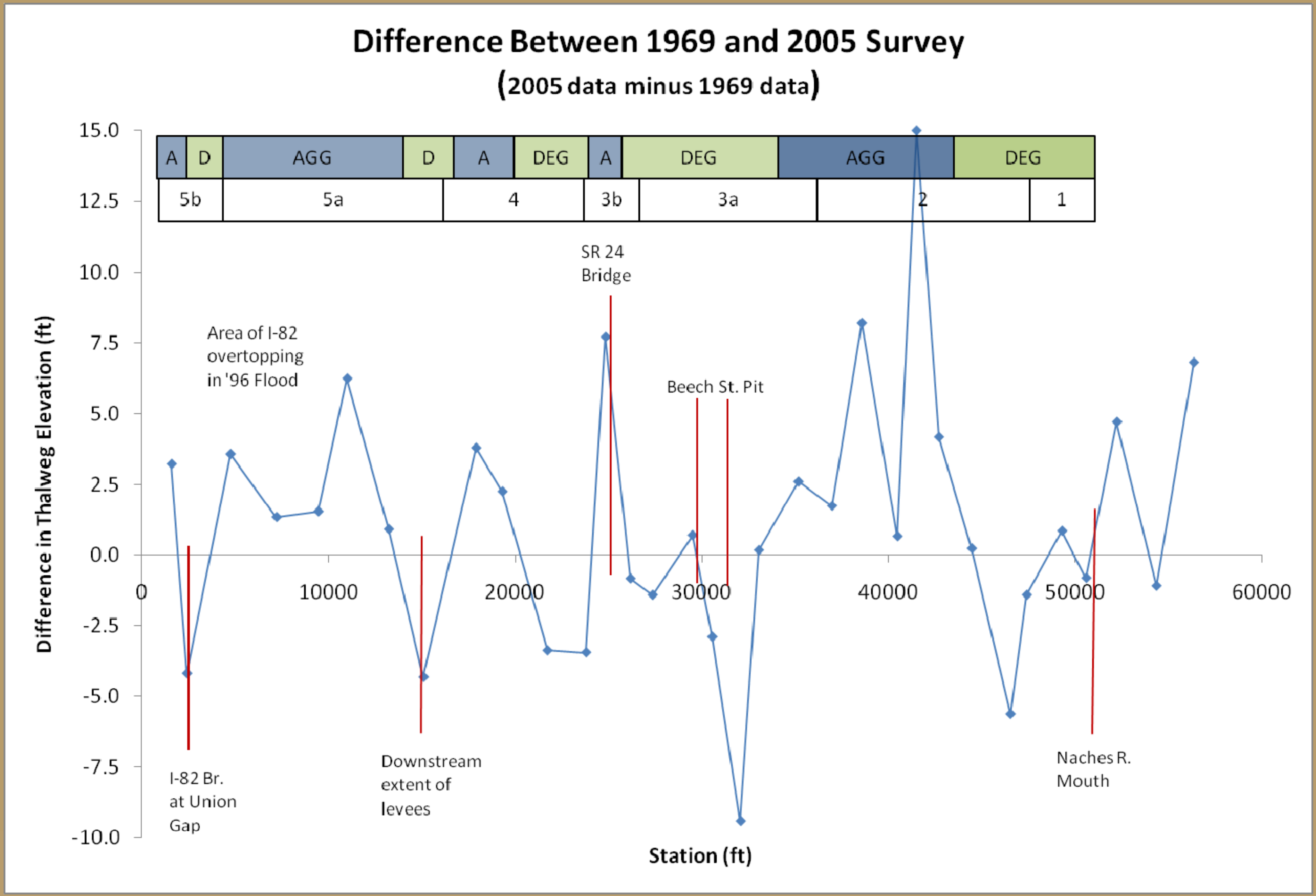
Thalweg difference plot



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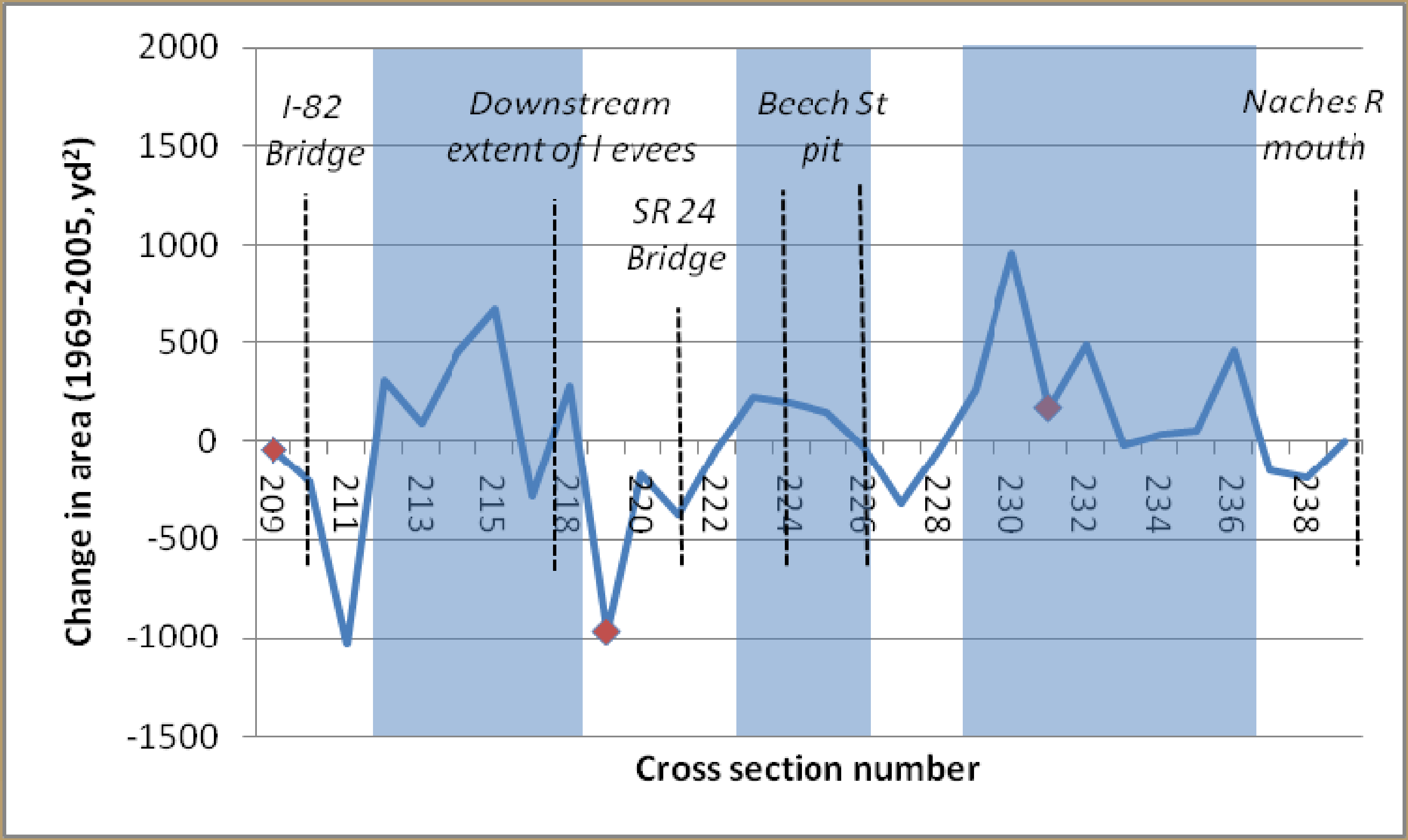
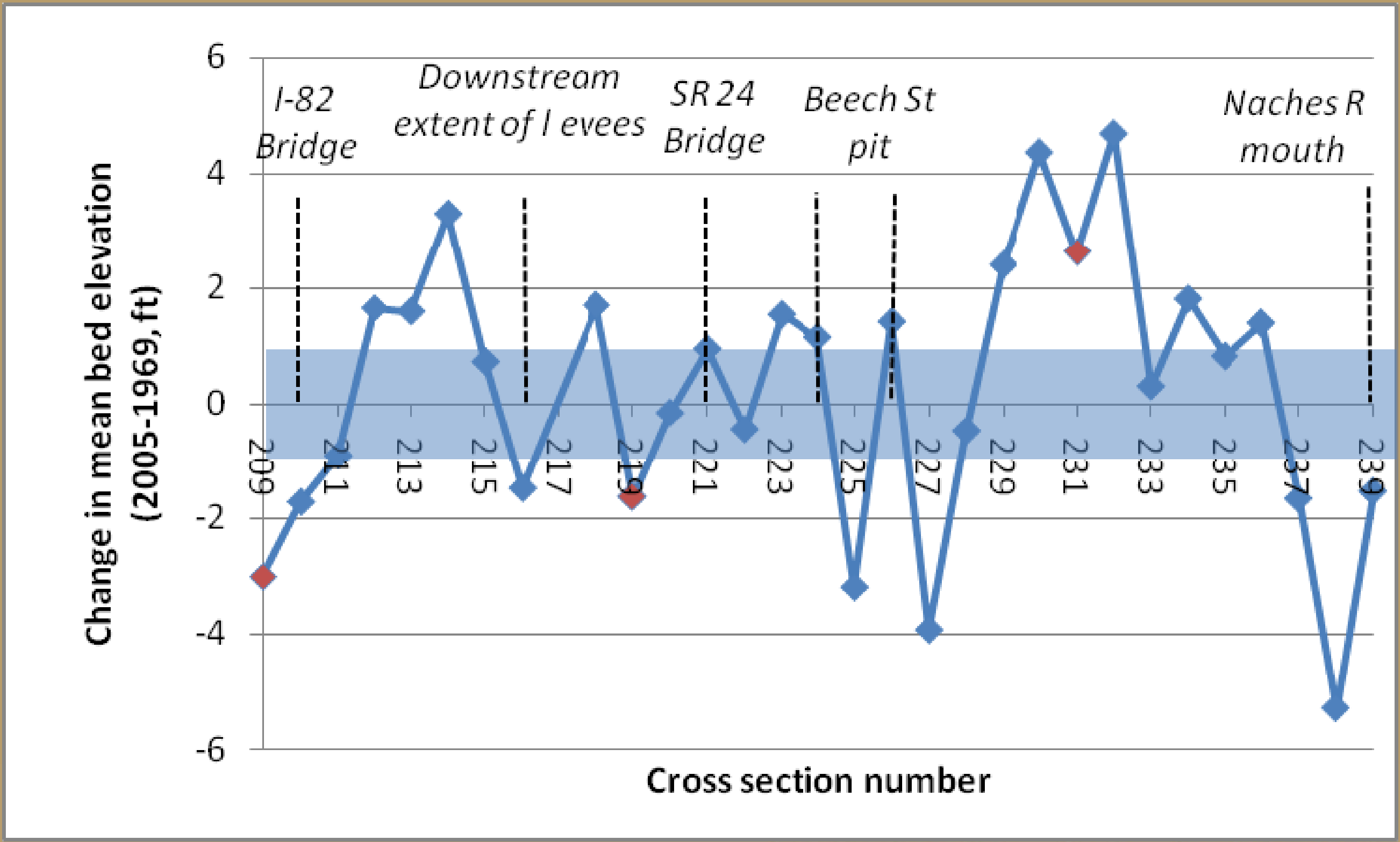
Cross sectional area changes



Mean bed elevation changes



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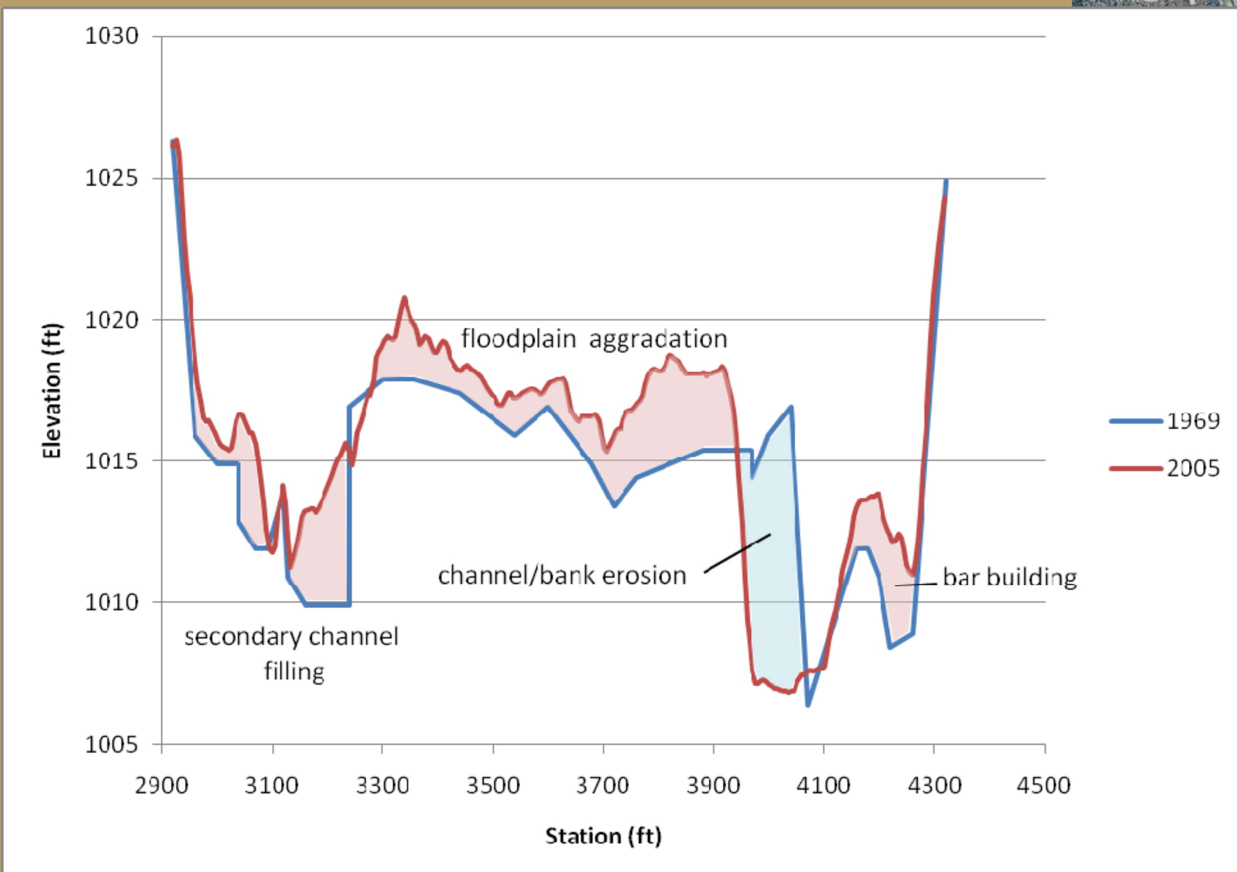
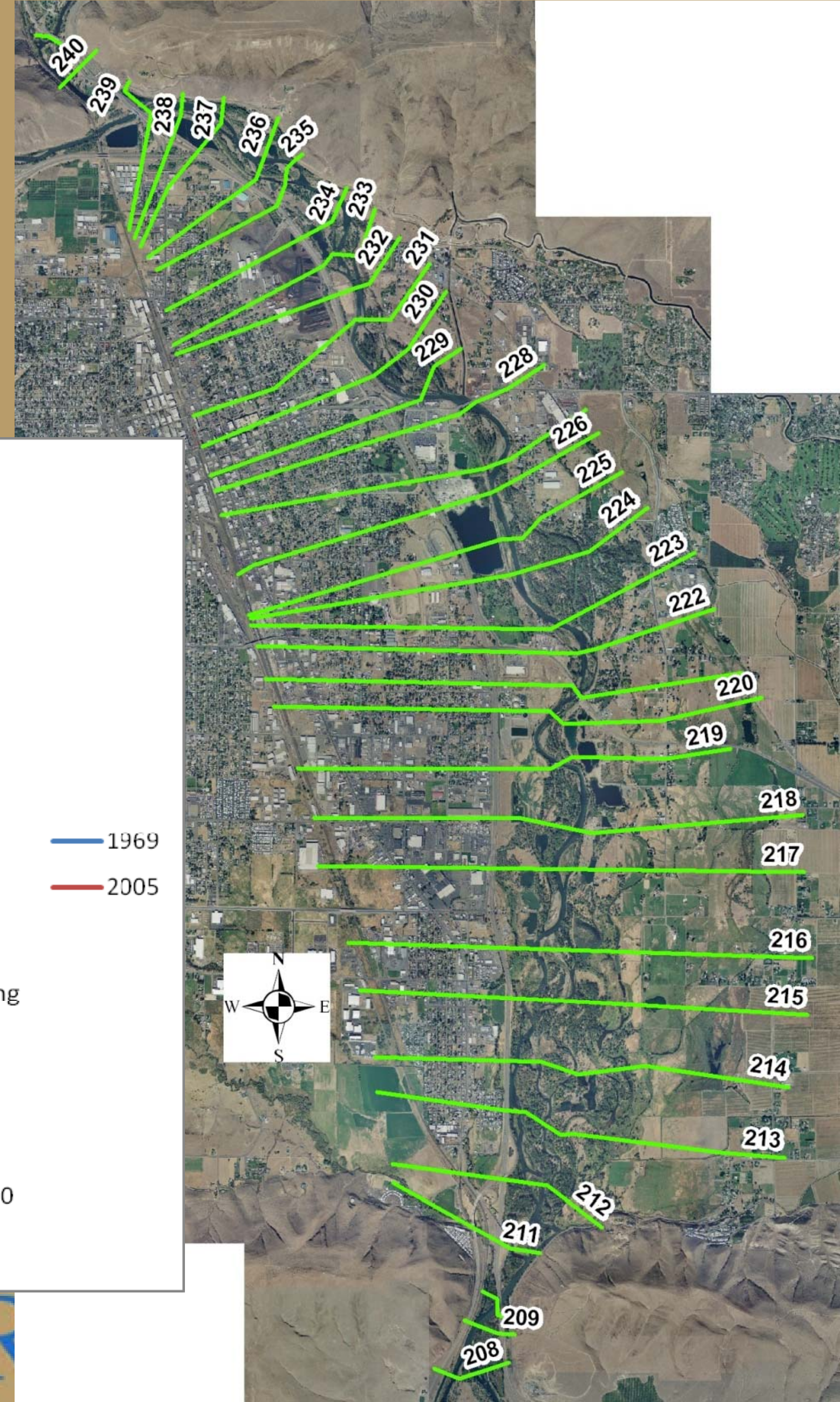
Areas of aggradation and degradation

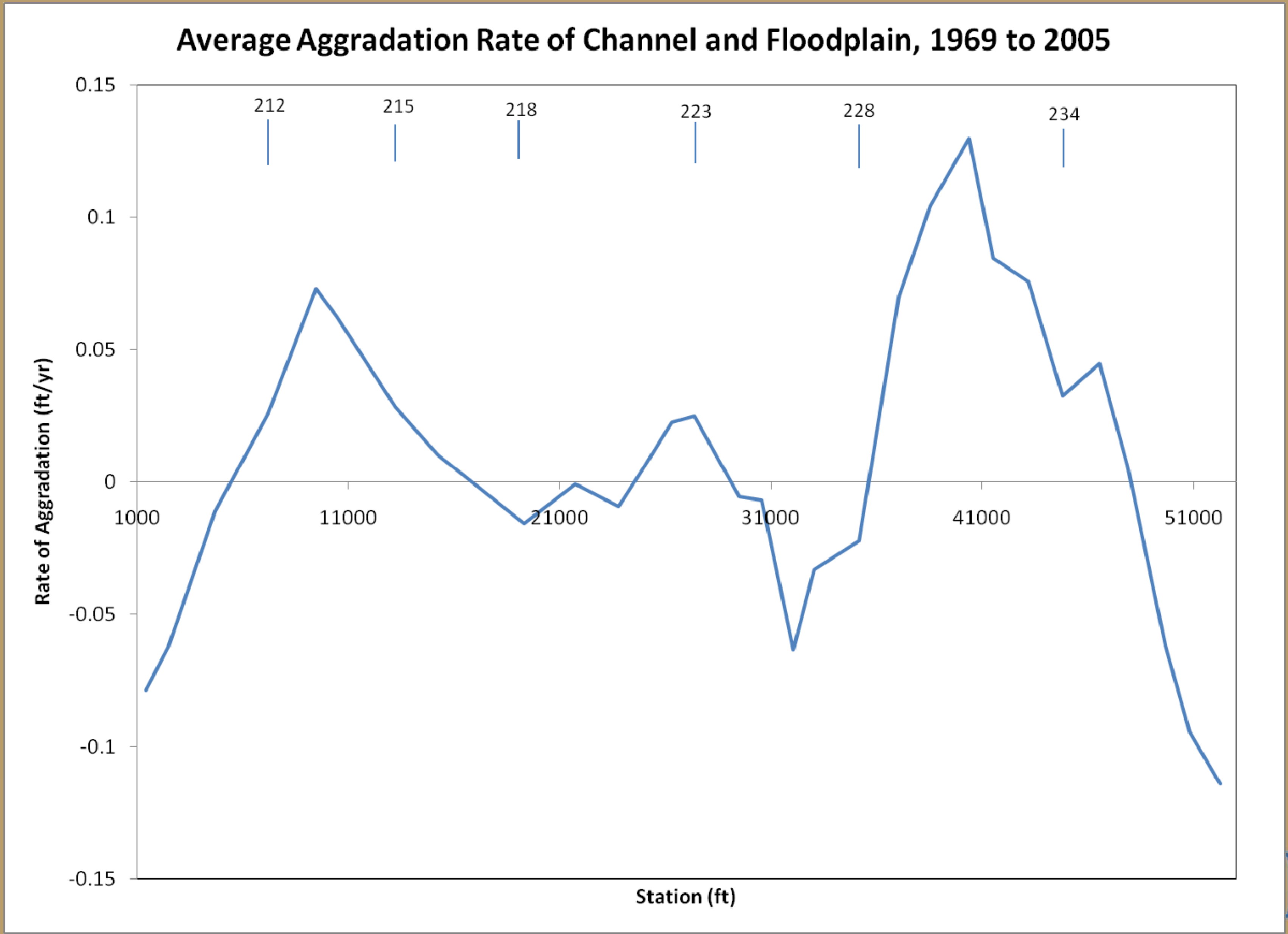
- **Areas of aggradation**
  - Triangular pit to Terrace Heights Bridge (Segment 2)
  - Beech Street pit to Old SR24 (part of segment 3a)
  - Edler Ponds to Union Gap (segment 5a)
- **Areas of degradation**
  - Naches River mouth to triangular gravel pit (segment 1)
  - Terrace Heights Bridge to Beech Street pit (part of segment 3a)
  - Old SR24 to Edler Ponds (segment 3b; segment 4)
  - Union Gap vicinity to I-82 Bridge (segment 5b)

Cross section 225





Historical aggradation rates



Aggradation rates by segment

Segment	Aggradation/degradation rate (ft/yr)	Lateral change
1	-0.094	STABLE
2	0.077	DYNAMIC
3a	-0.018	STABLE
3b	0.013	DYNAMIC
4	-0.001	STABLE
5a	0.032	DYNAMIC
5b	-0.079	STABLE

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Summary of geomorphic tasks

- Geomorphic surfaces
  - older and younger floodplain units, bound by older terraces. Late Holocene channel migration from east to west
- Historical Trends
  - Lateral change: Channel complexity, sinuosity, unvegetated bar area (1927-2009)
  - Vary by study segment
    - Few changes: S1
    - Major changes: S2, S5a
  - Vertical changes: cross section surveys (1969-2005)
    - Specific areas of aggradation and degradation are noted; areas with largest changes located in relict gravel pits
- Observations of channel dynamics
  - Stable reaches (1, 3a, 4, 5b) and dynamic reaches (2, 3b, 5a)
  - Effects of gravel pit captures and extreme floods

Numerical Modeling - Geometry

- **Model surface used a combination of LiDAR and bathymetric survey to create a 5’ x 5’ raster in Arc GIS (Inverse Distance Weighted interpolation)**
  - **LiDAR and aerial photography collected in 2005**
  - **Bathymetric survey collected by USGS**
    - **Most of the reach surveyed in the summers of 2004 and 2005**
    - **Selah and Union Gaps surveys performed in 2008**
- **HEC-GeoRAS used to extract cross section geometry**
  - **Levees, bank points, and surface roughness (Manning’s *n*)**
  - **Ineffective flow areas and blocked obstructions**

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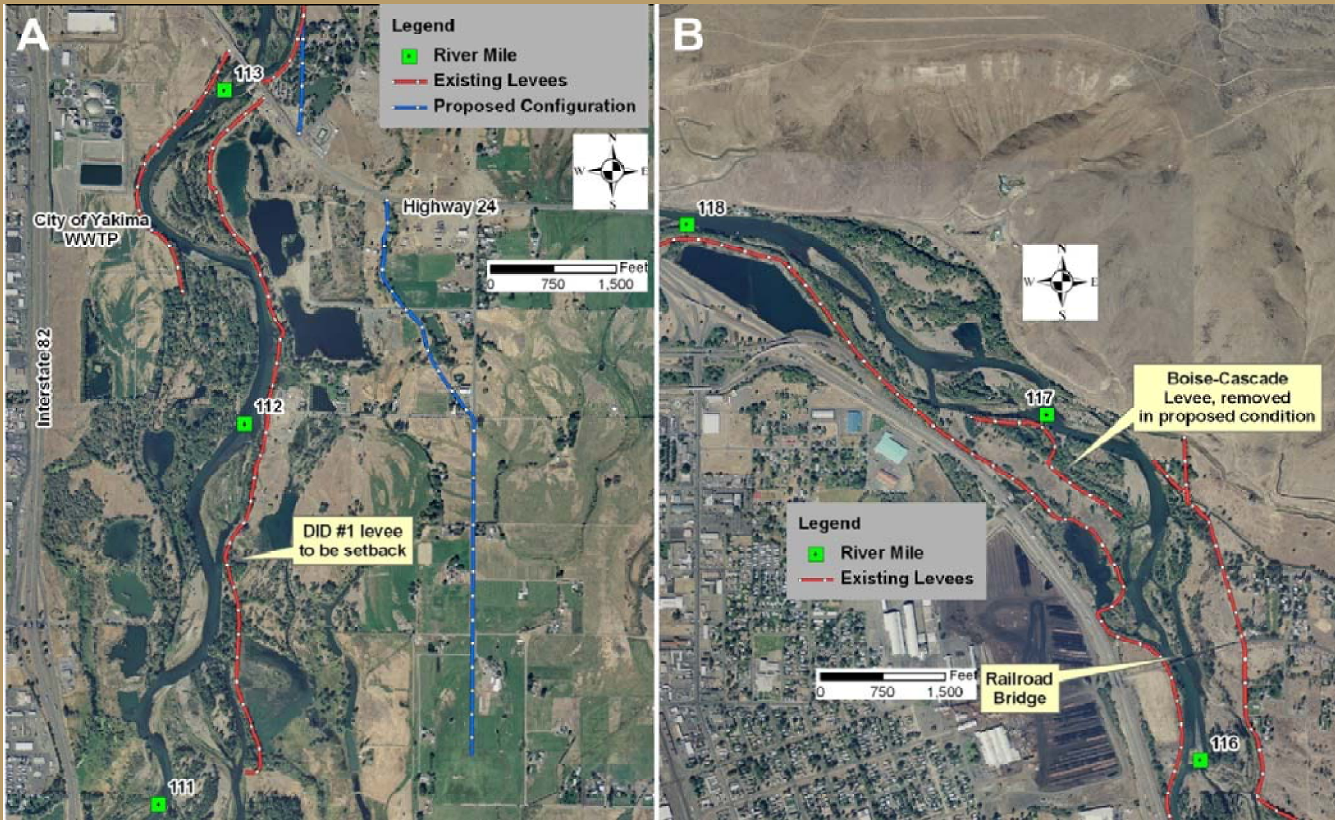
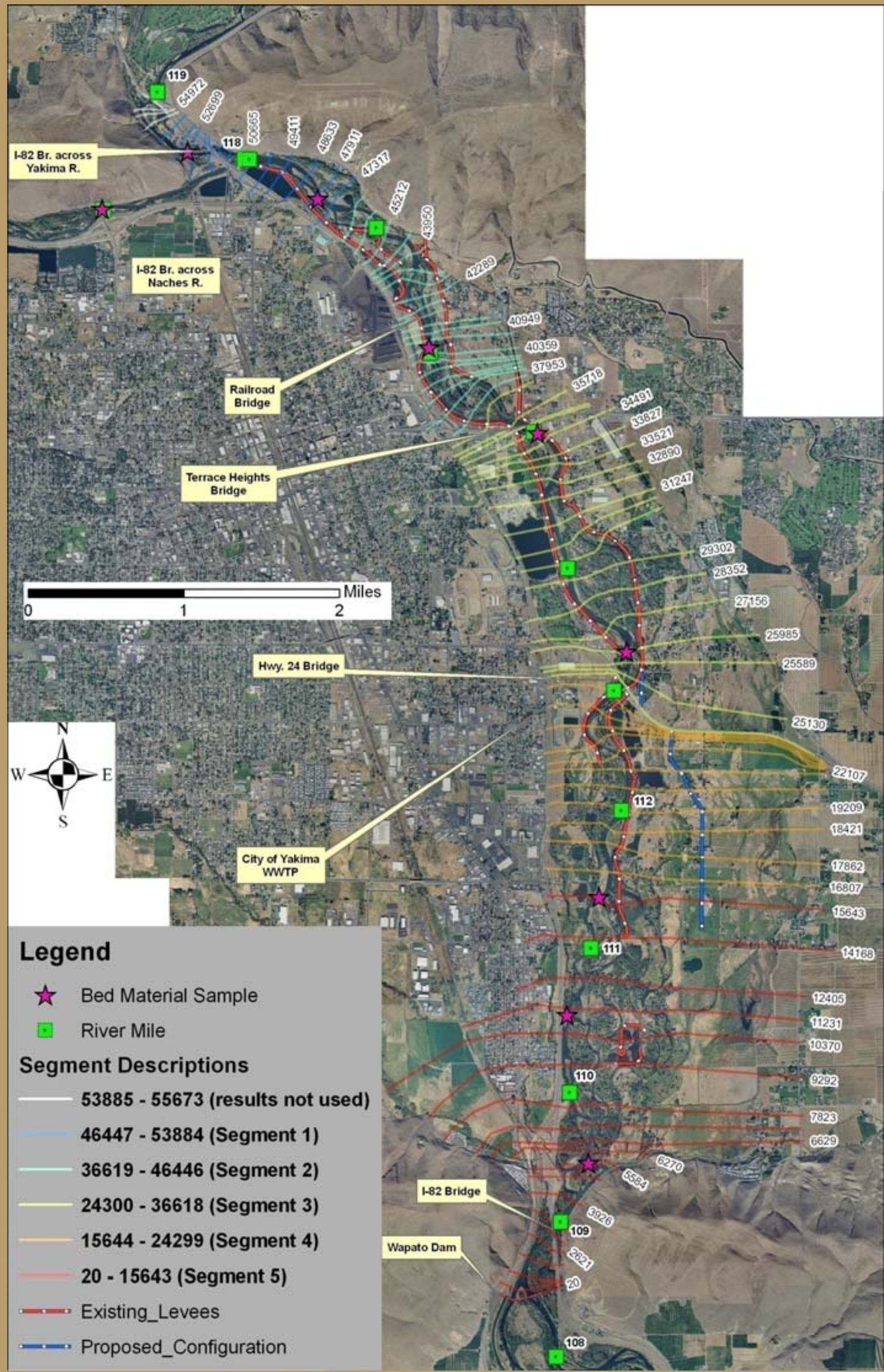
Numerical Modeling - Geometry

- **Proposed geometry includes**
  - Setting back KOA levee (Fig. A)
  - Setting back DID #1 levee (Fig. A)
  - Remove Boise Cascade levee (Fig. B)



Numerical Modeling - Geometry

- Cross section layout



Numerical Modeling - Hydrology

- Upstream boundary conditions determined with a combination of gages (USGS and Reclamation)
  - Yakima R. at Umtanum (USGS gage #12484500)
  - Naches R. blw. Tieton R. (USGS gage #12494000)
    - Corrected using Reclamation gage records to account for diversions and returns to develop an input hydrograph at
      - Yakima River at Selah Gap
      - Naches River at mouth
  - When applicable, combined discharges matched well with measured discharge at
    - Yakima River abv. Ahtanum Cr. (USGS gage #12500450)
    - Yakima River at Terrace Heights (Reclamation gage YRTW)

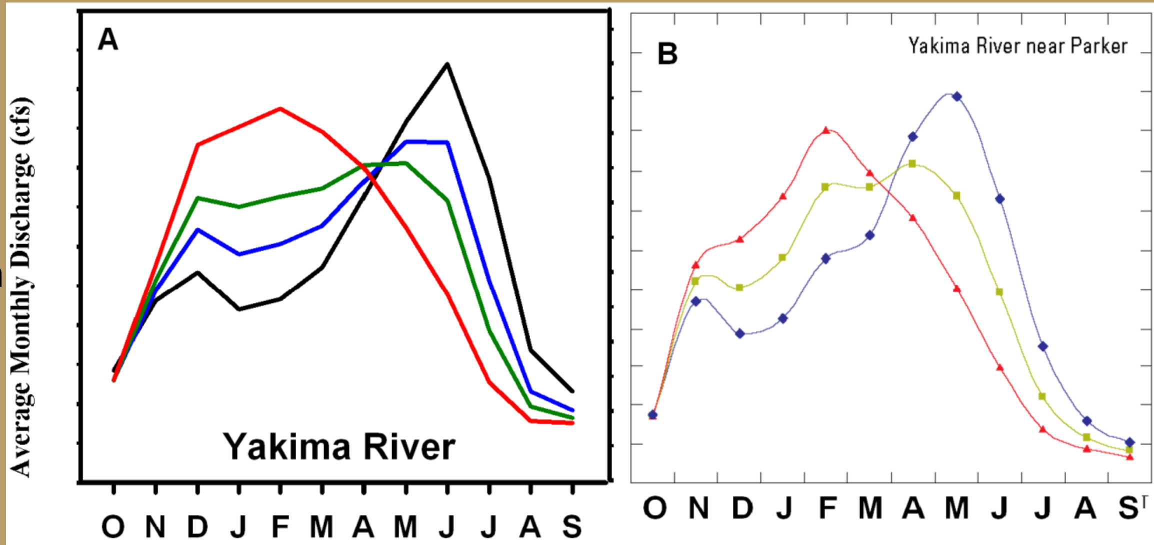
Numerical Modeling - Hydrology

- Several Hydrologic scenarios used for analysis
  - Average hydrograph, 1985 – 2009 representative of most probable future scenario
    - 1960 – 1984, similar sediment transport results to average hydrograph
    - 1935 – 1959 , wet period with not representative of future scenarios due to changes in climate, precipitation, reservoir operations
  - Wet and dry periods evaluated with annual peaks from Yakima R. at Umtanum and Naches R. blw. Tieton R.
    - Wet hydrograph: 1909 – 1912, 1931 – 1938, 1945 – 1952, 1974 – 1982
    - Dry hydrograph: 1960 – 1972, 1982 – 1990, 1999 – 2004
    - Provided bounds on sediment transport results

Numerical Modeling - Hydrology

- **Consideration of climate change**
  - **Decrease in snowmelt by 10% - 23 % (Mastin, 2008)**
  - **Increase in precipitation by 1.3% (range of -9% to +12% for the decade of the 2020s (Littell et al., 2009)**
  - **Large uncertainty in basin specific changes with respect to in-stream flows, particularly for near future scenarios**
    - **No accounting for climate change in future hydrology for sediment modeling – insufficient resolution**

A – Historical (black) and projected hydrograph taken from Littell et al., (2009). Blue line = 2020’s, Green line = 2040’s, and red line = 2080’s.
B – Historical (Blue) and projected hydrograph taken from Mastin (2008). Green = an increase in average annual temperature in the Pacific Northwest by 1° C (early 21st century), Red = an increase in average annual temperature in the Pacific Northwest by 2° C (mid 21st century).



Numerical Modeling - Hydrology

- Four flood types from the historical record were examined for event based sediment transport
- Flood – A: very large peak with long duration (73 days)
- Flood – B: Relatively low peak, very long duration (16,400 cfs, 122 days – several peaks > 14,000 cfs)
- Flood – C: High peak on the Naches R. with low peak on the Yakima (only one on the record)
- Flood – D: High peak and short duration (44,000 cfs, 30 days)

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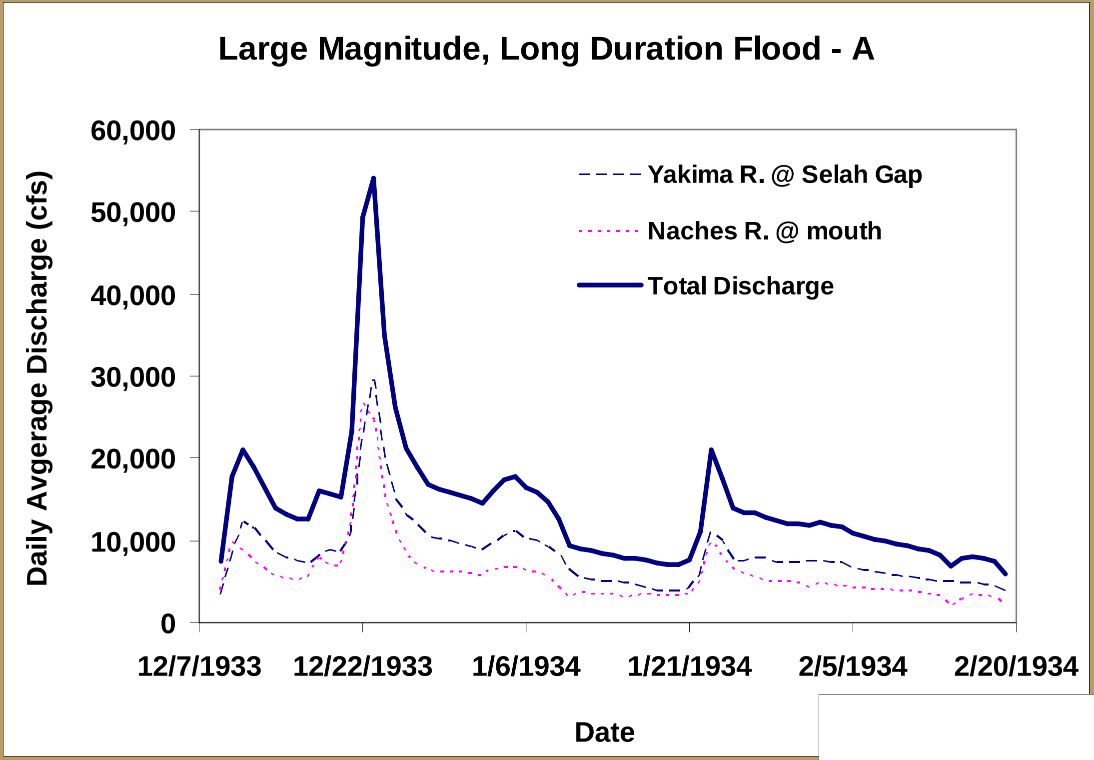
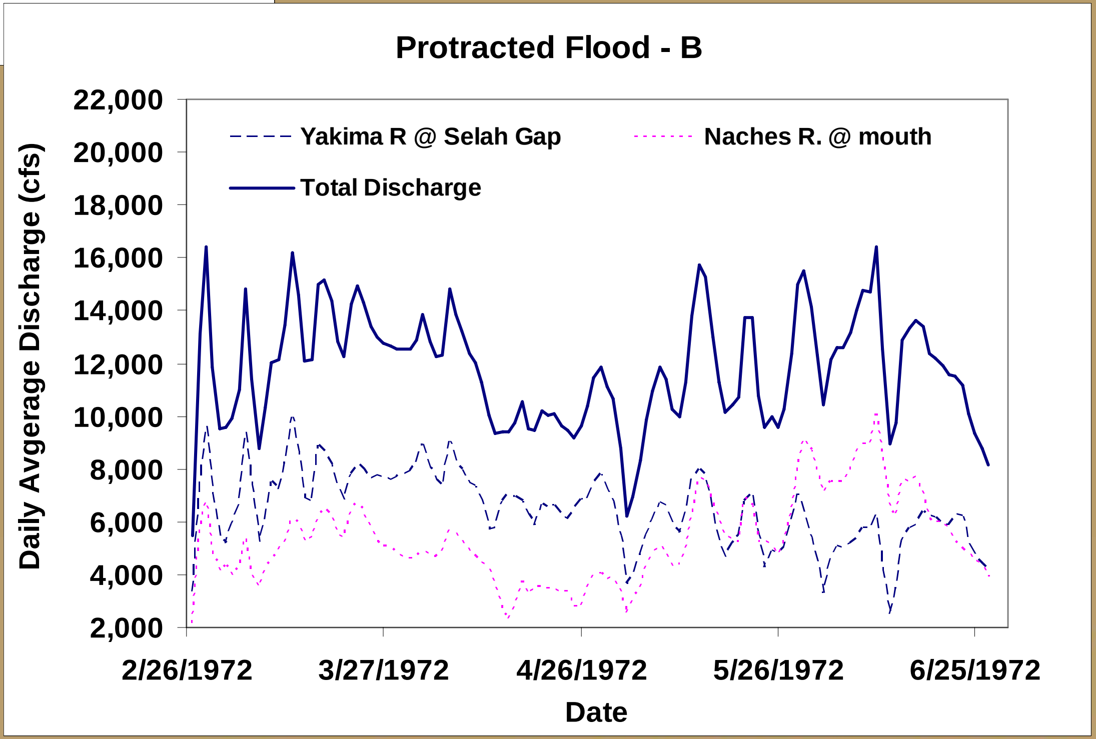
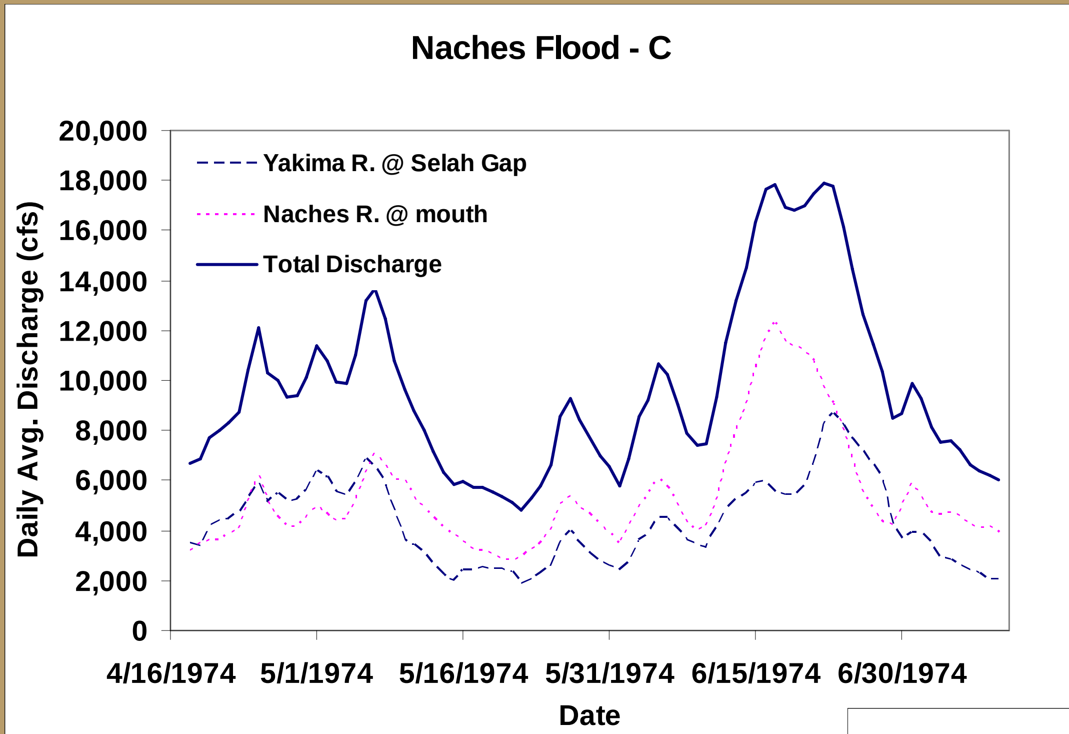
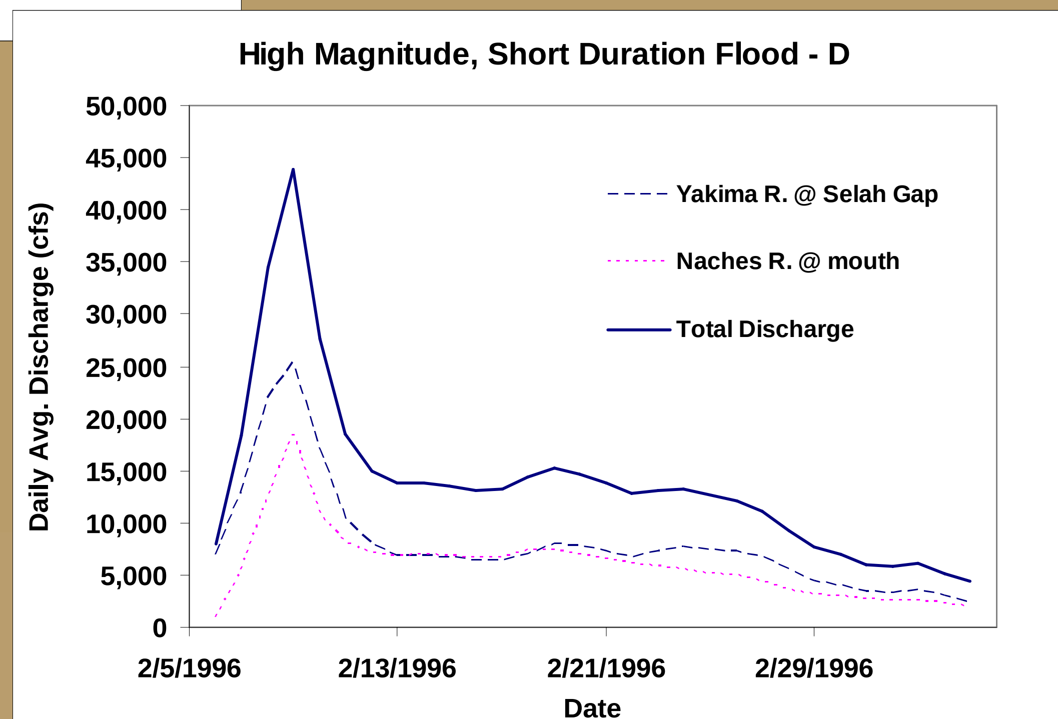

Large Magnitude, Long Duration Flood - A
60,000
50,000
40,000
30,000
20,000
10,000
0
Daily Avgerage Discharge (cfs)
Yakima R. @ Selah Gap
Naches R. @ mouth
Total Discharge
12/7/1933
12/22/1933
1/6/1934
1/21/1934
2/5/1934
2/20/1934
Date


Protracted Flood - B
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
Daily Avgerage Discharge (cfs)
Yakima R @ Selah Gap
Naches R. @ mouth
Total Discharge
2/26/1972
3/27/1972
4/26/1972
5/26/1972
6/25/1972
Date

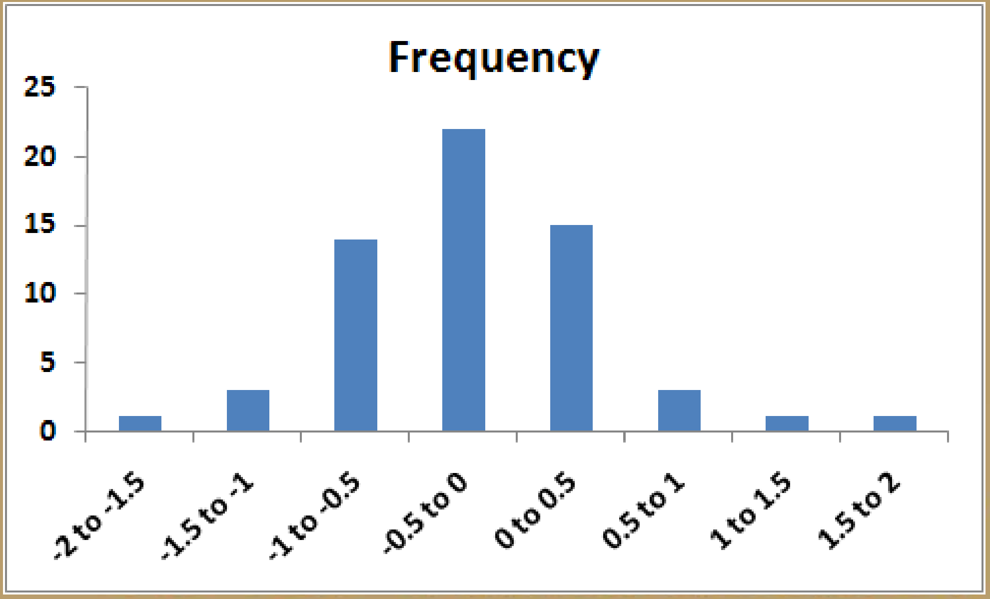

Naches Flood - C
Yakima R. @ Selah Gap
Naches R. @ mouth
Total Discharge
Daily Avg. Discharge (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
4/16/1974
5/1/1974
5/16/1974
5/31/1974
6/15/1974
6/30/1974
Date


High Magnitude, Short Duration Flood - D
Yakima R. @ Selah Gap
Naches R. @ mouth
Total Discharge
Daily Avg. Discharge (cfs)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2/5/1996
2/13/1996
2/21/1996
2/29/1996
Date

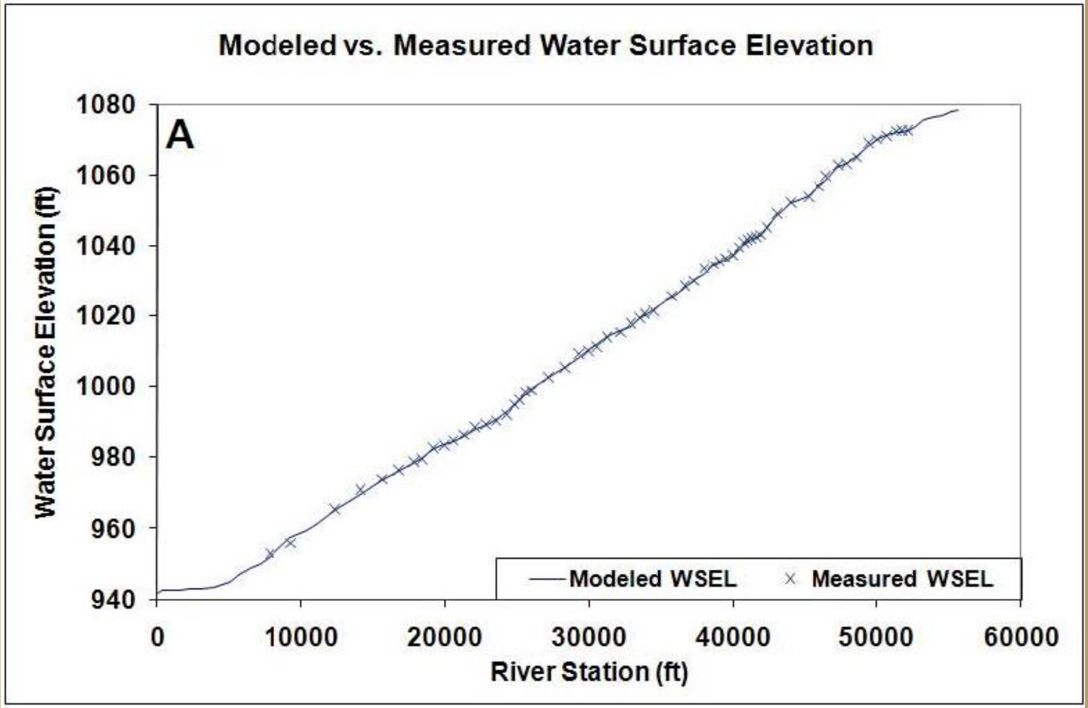
Hydraulic Model - Calibration

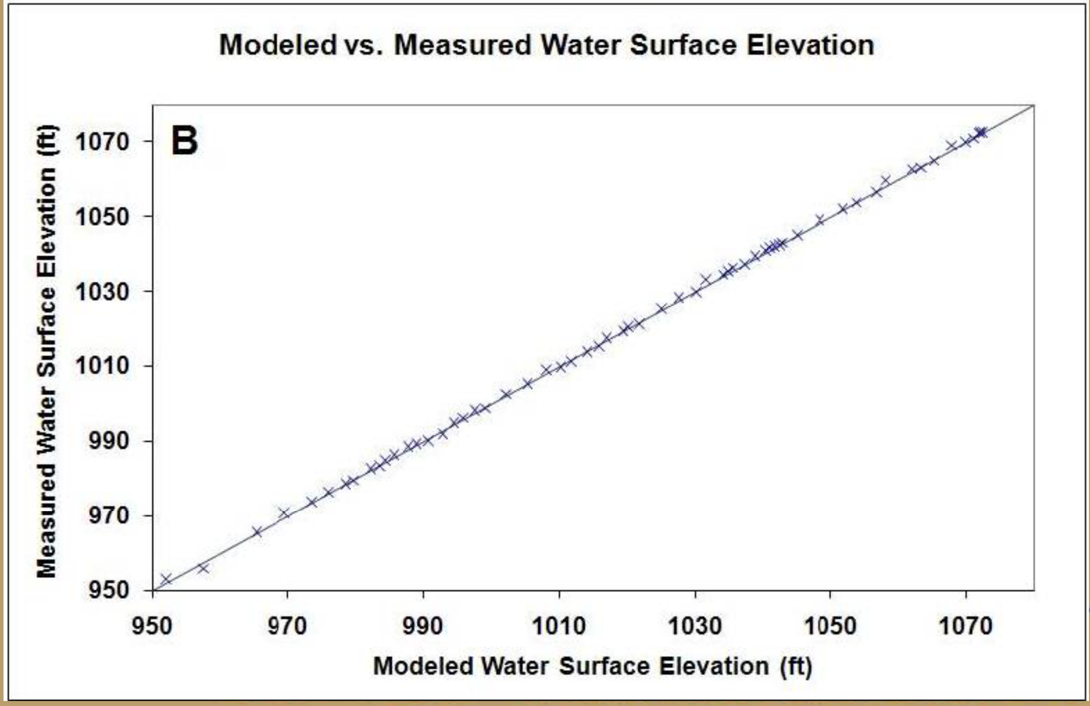
- HEC-RAS model calibrated throughout the reach using a discharge of 3,213 ft^3/s
- Calibrated at higher discharges at the USGS gage Yakima River abv. Ahtanum Cr.
  - Provides confidence in overbank roughness values

•Histogram of model error when results are compared to measured data for the calibration.
•X-axis shows error bins, Y-axis shows frequency of occurrence.
•Mean error = - 0.2 ft.
•Std. Dev. - +/- 0.6 ft



Hydraulic Model – Calibration and Verification

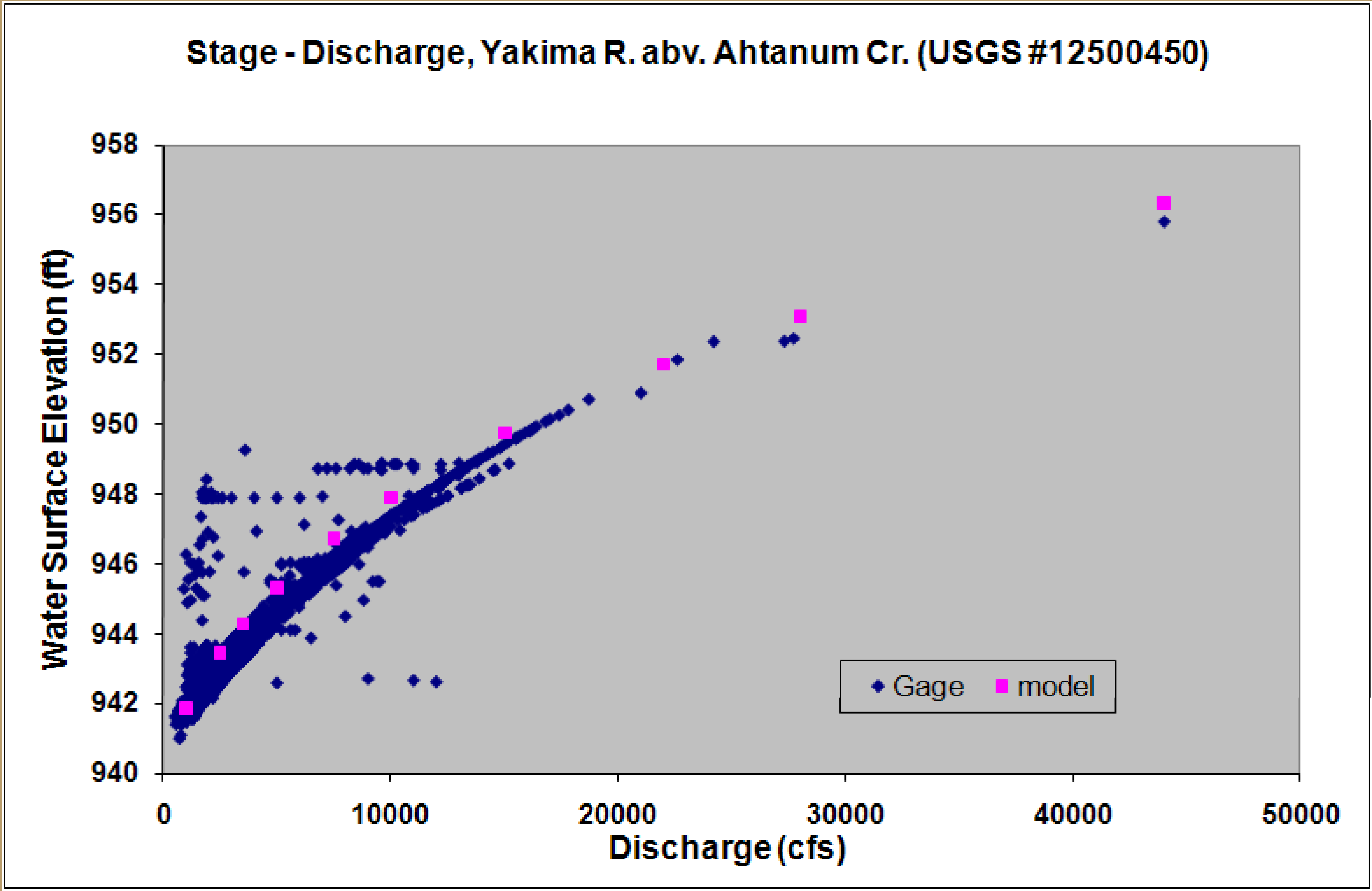




Hydraulic Model – Calibration and Verification

Verification of floodplain roughness using gage data

Stage data adjusted to elevations by matching the stage discharge curve to water surface elevations taken during the bathymetric survey



Sediment Model - Limitations

- Reliability of sediment models largely dependent on:
  - Data that can not be reliably measured
    - Sediment load
    - Bed material composition
    - Active layer thickness
  - Assumptions we know are not true
    - Cross sectional averaged properties
      - Channel velocities
      - Bed material composition
    - Hydrology is an accurate predictor of sediment transport
    - Spherical particles
  - Incomplete knowledge on the motion of coarse bed material
  - Verification that is most often sparse

Sediment Model – Calibration

- Starts with:
  - Calibrated hydraulics
  - Determination of incoming load
  - Determination of an appropriate transport equation
  - Determination of primary coefficients
    - Initiation of motion or reference shear stress
    - Hiding factor – hiding and exposure of particles
- Accomplished most successfully with measurements of sediment transport
- Accompanied by
  - Bed material distributions
    - Determination of representative bed material

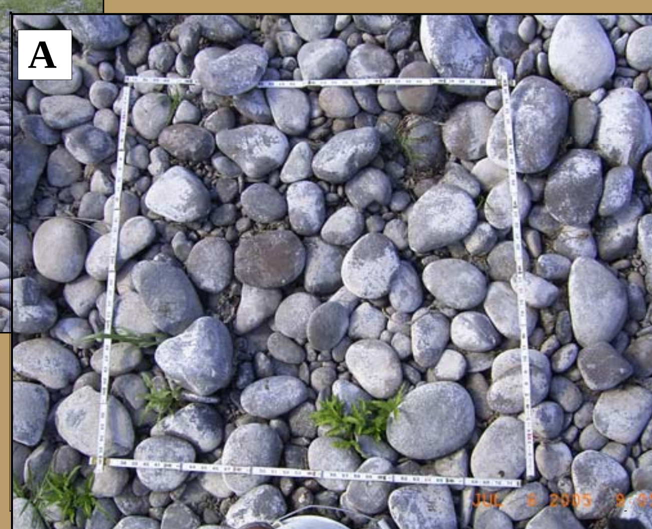
RECLAMATION

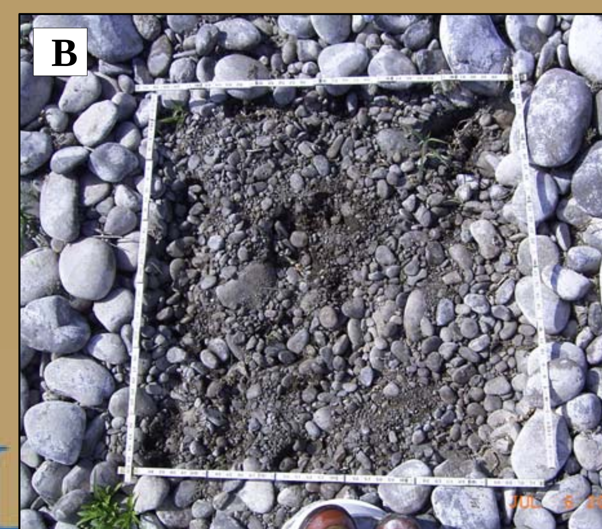
Sediment Model - Calibration

- **USGS (Tacoma Office, Higgins et al.) measured sediment transport at two locations**
  - **I-82 Bridge in Selah Gap on the Yakima R.**
  - **I-82 Bridge on the Naches R. Near the mouth**
    - **Three measurements at each location during peak of runoff in 2008**

Sediment Model - Calibration

- **Volumetric sampling of bed material gradations**
  - 4 locations in the Gap to Gap reach in sampled in 2005
  - 4 more locations sampled in 2008
  - 1 location on the Naches R.
    - 8 volumetric measurements in 10 river miles





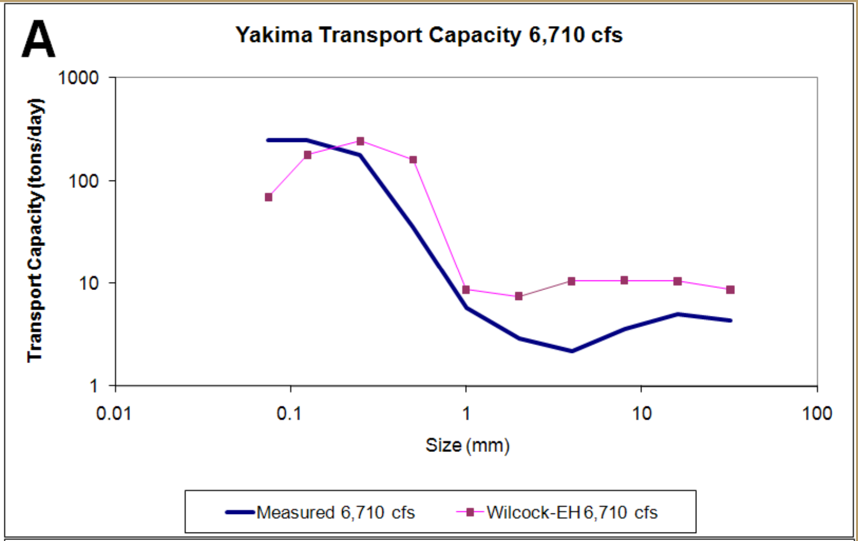
Sediment Model - Calibration

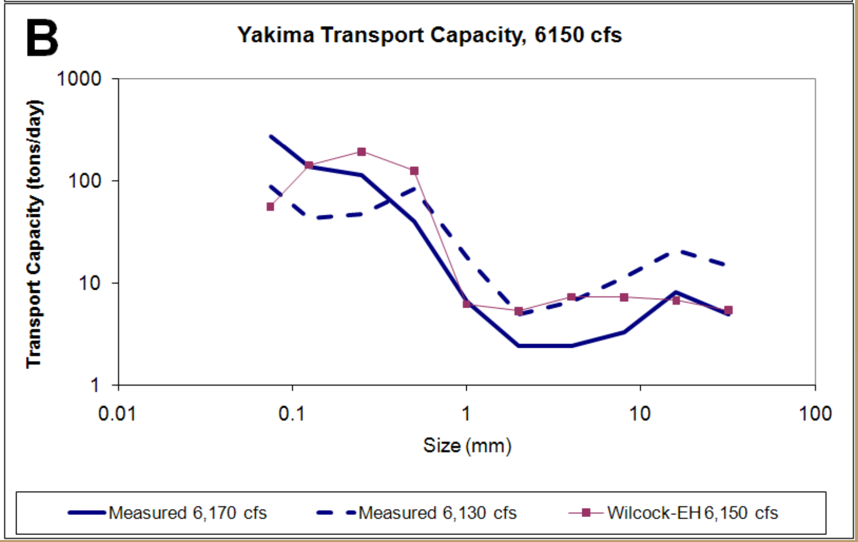
- Appropriate transport equations and associated coefficients are evaluated and results are compared to measured quantities
  - Meyer-Peter and Muller (1948) as modified by Wong and Parker (2006)
  - Ackers and White (1973) with updated coefficients by HR Wallingford (1990)
  - Engelund and Hansen (1966)
  - Brownlie (1981)
  - Parker (1990) combined with Engelund-Hansen
  - Wilcock and Crow (2003) combined with Engelund-Hansen
  - Wu et al. (2004)

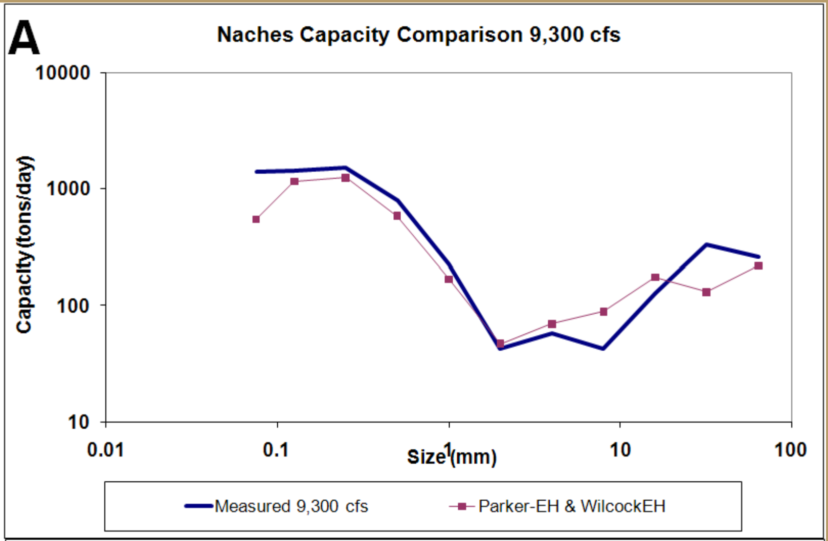
RECLAMATION

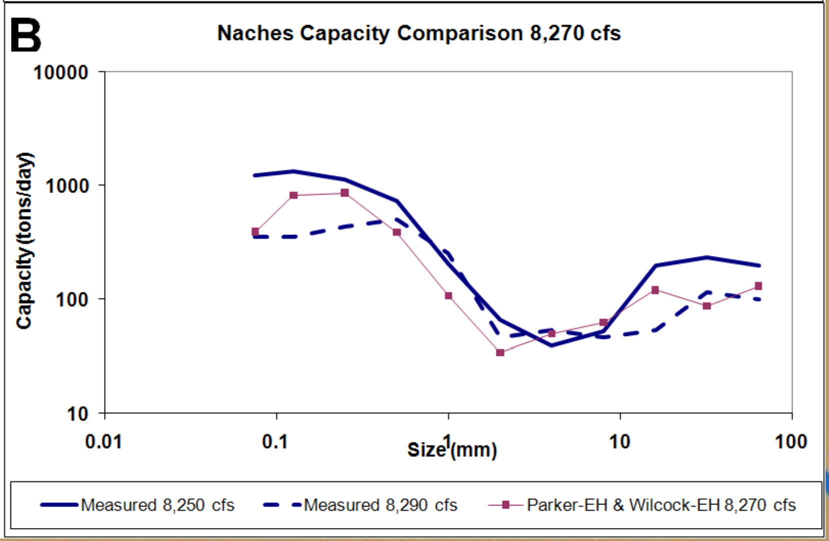
Sediment model - Calibration

- **Incoming modeled load vs. measured load**



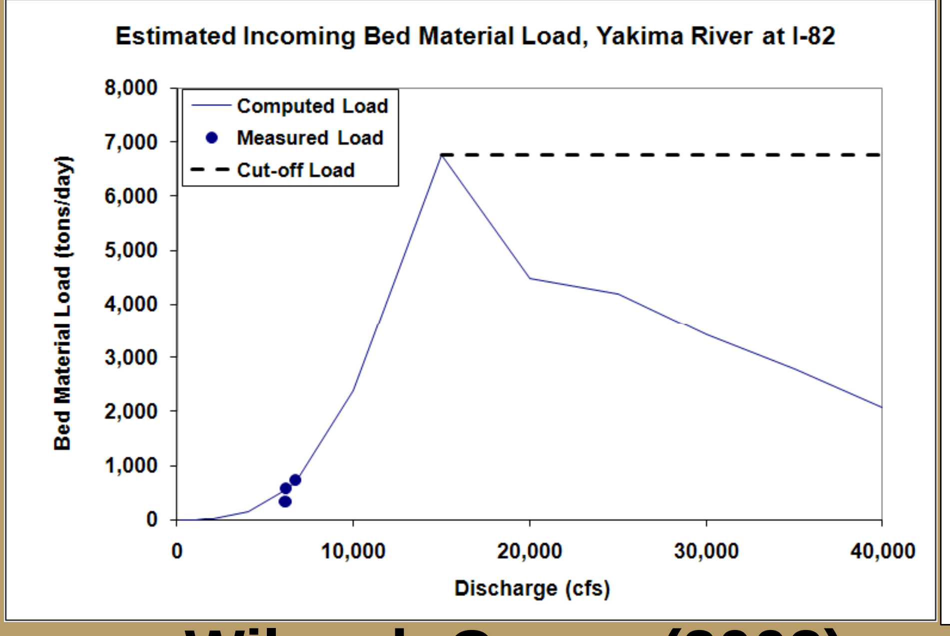


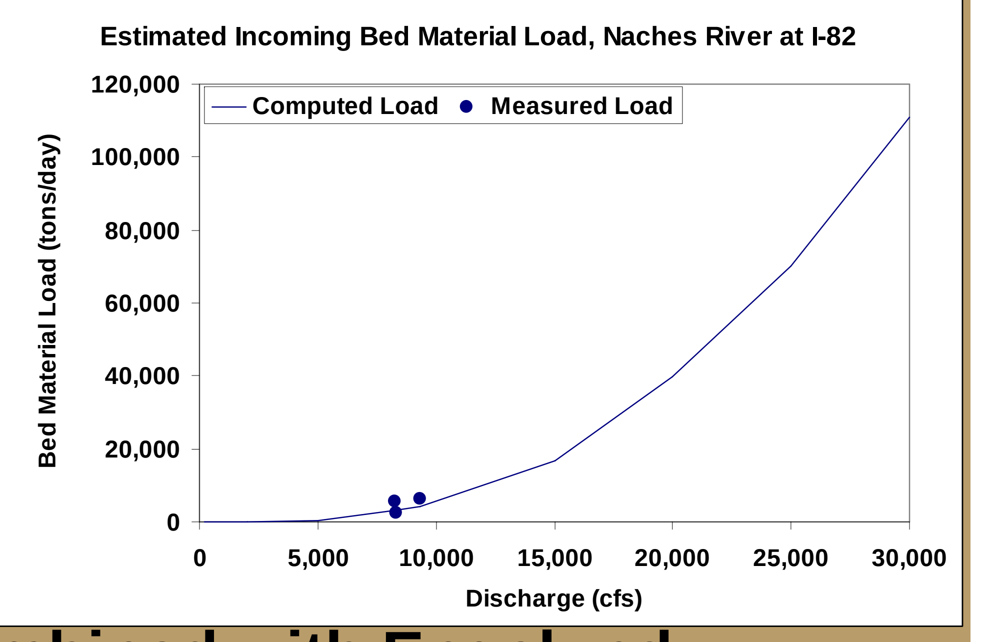




Sediment Model - Input

- **Incoming sediment loads**
  - <u>Yakima River</u> (Constriction at measurement point causing computed load to decrease at Q > 15,000 ft^3/s)
  - <u>Naches River</u>



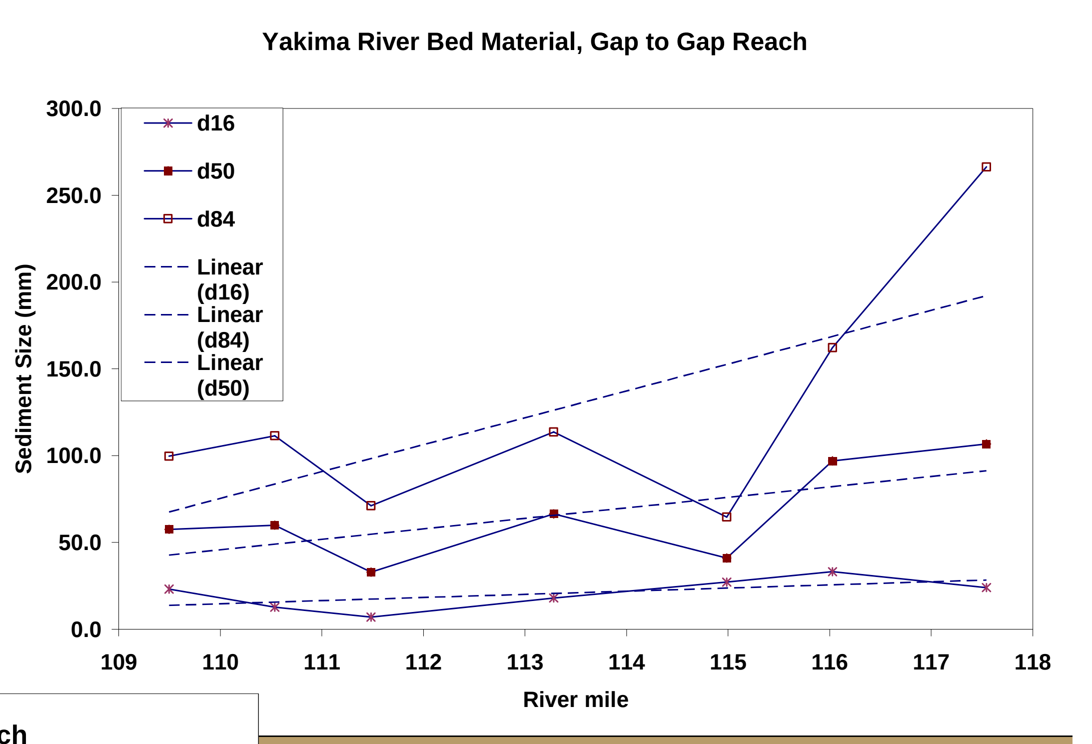


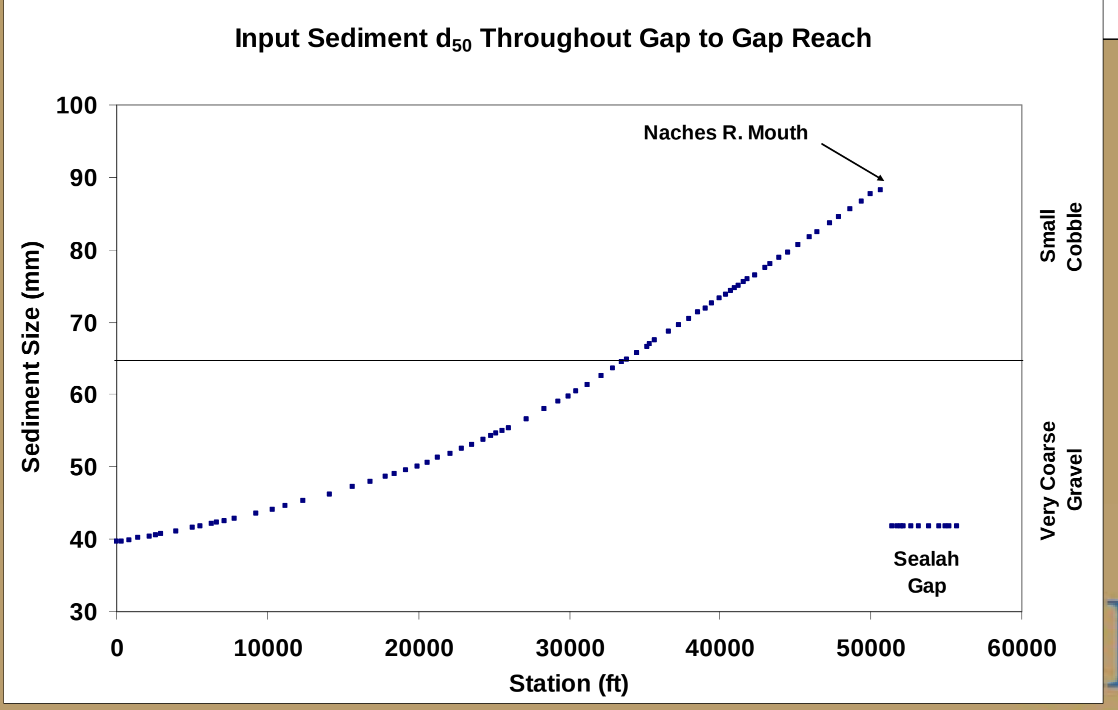
- **Wilcock-Crowe (2003) combined with Engelund-Hansen (1966) used to evaluate sediment transport through the Gap to Gap reach**

RECLAMATION

Sediment Model - Input

- Bed Material Distributions

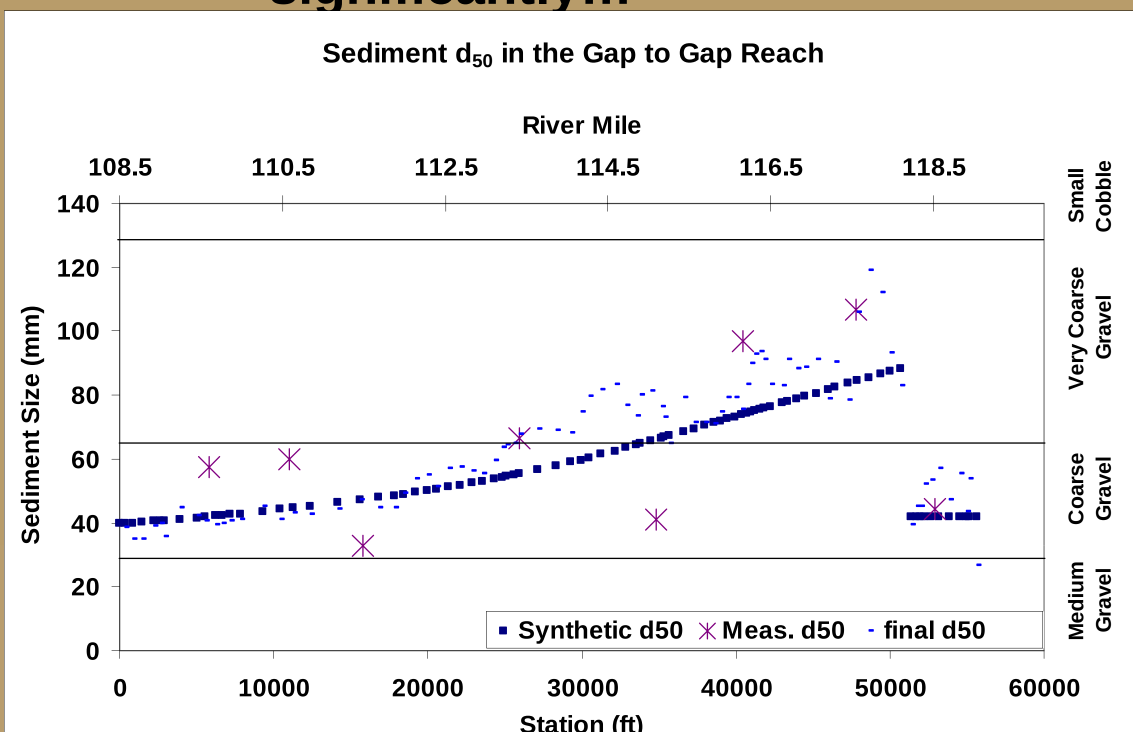




ECLAMATION

Sediment Model – Verification and Sensitivity Analysis

- Very little data with which to verify the model
  - Locations of aggradation and degradation very similar to period between 1969 and 2005
  - Assuming that bed composition does not change significantly…

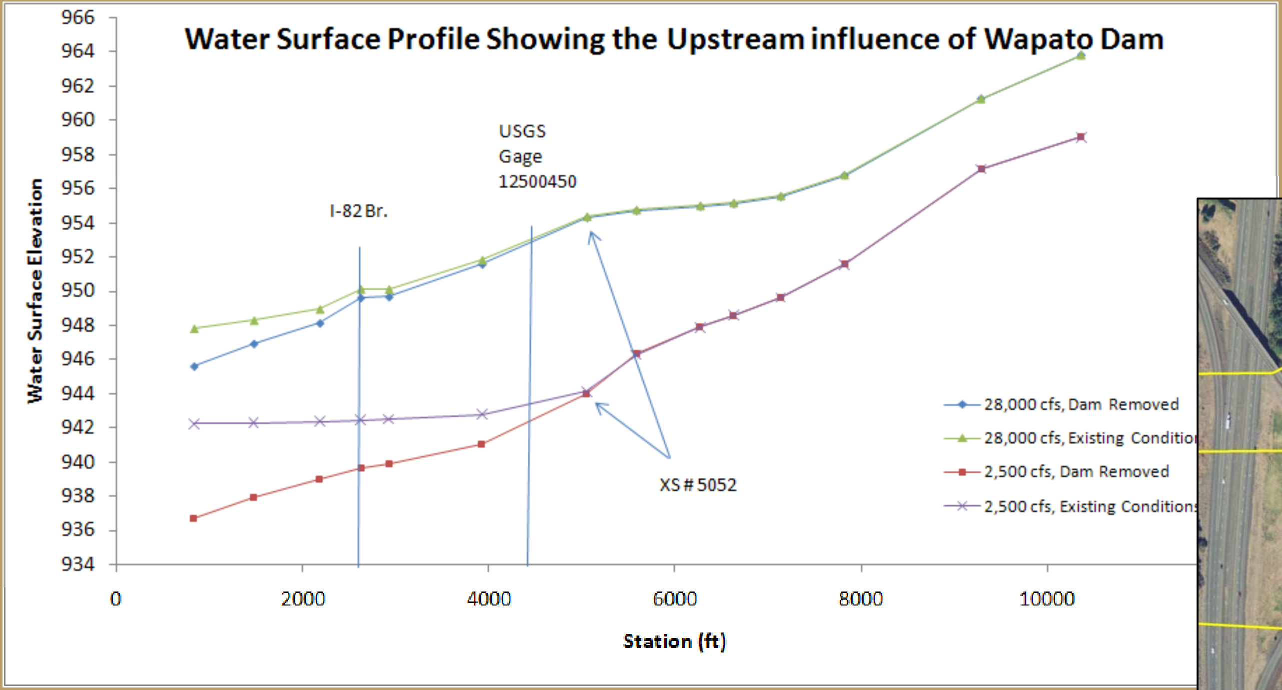


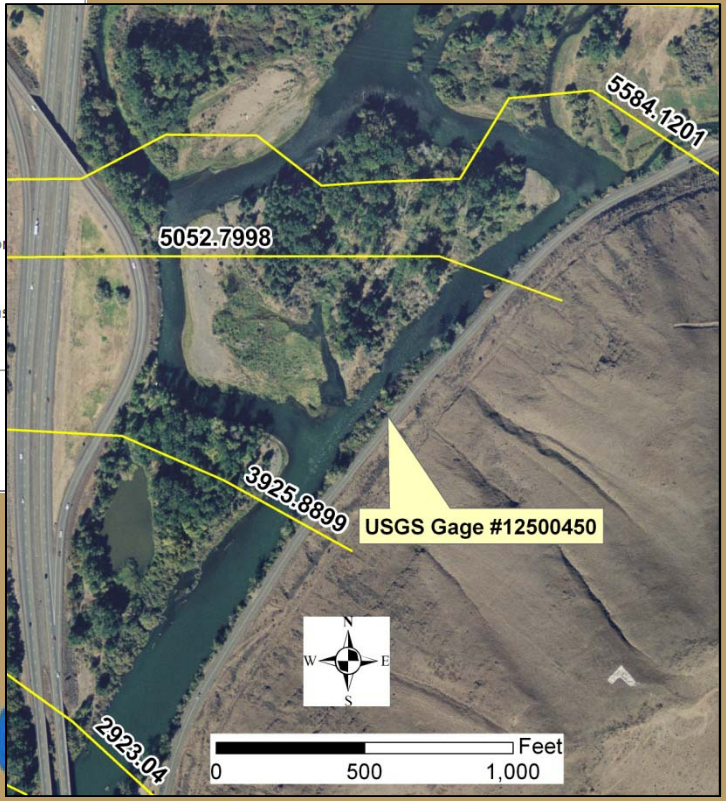
Modeling- Results

- Results are evaluated in 5 segments described earlier
  - Segment 1 at upstream end
  - Segment 5 at downstream
- Nomenclature
  - Initial condition (time = 0)
  - Final condition (time = 25 years)

Model Results - Hydraulics

- Examining the upstream effect of Wapato Dam





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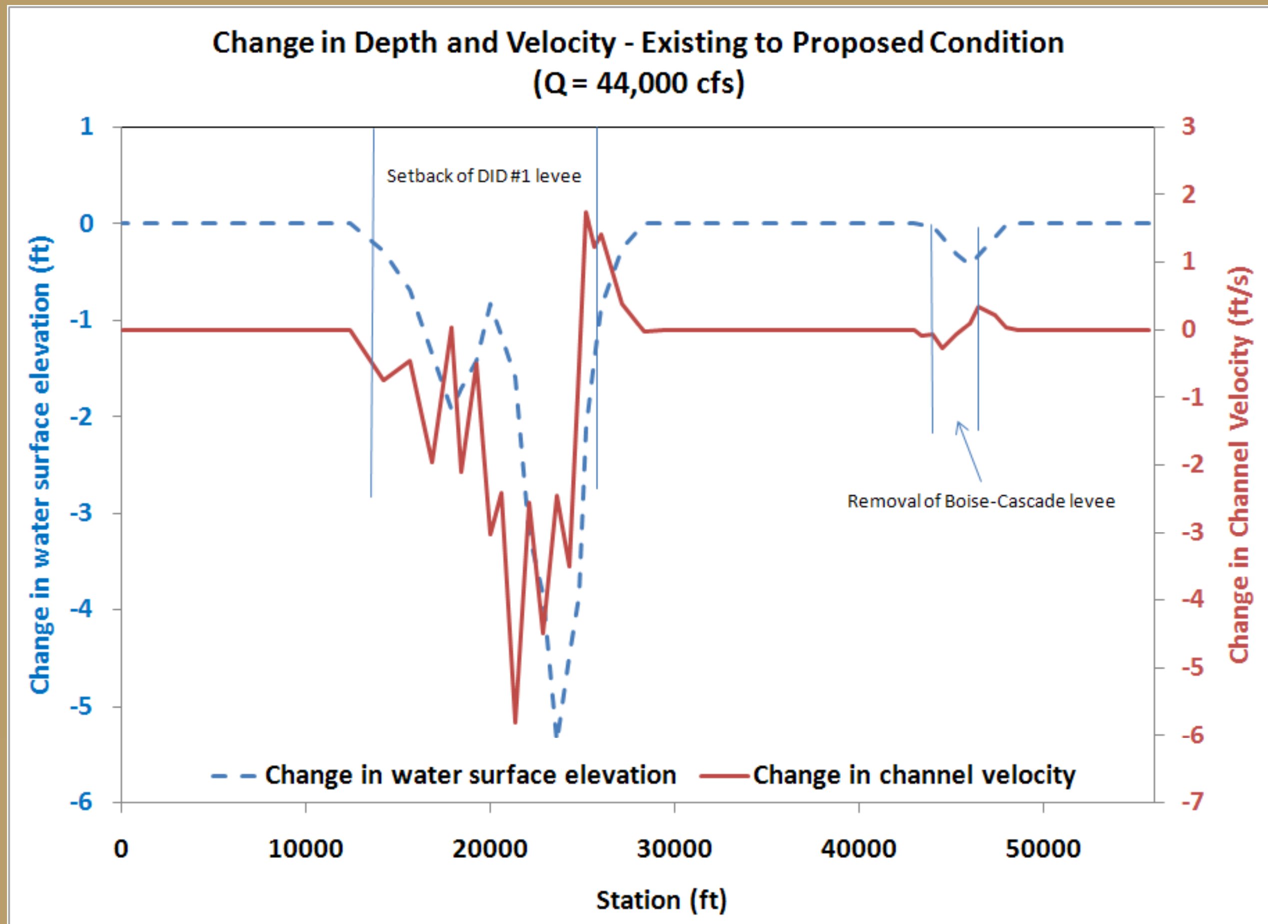
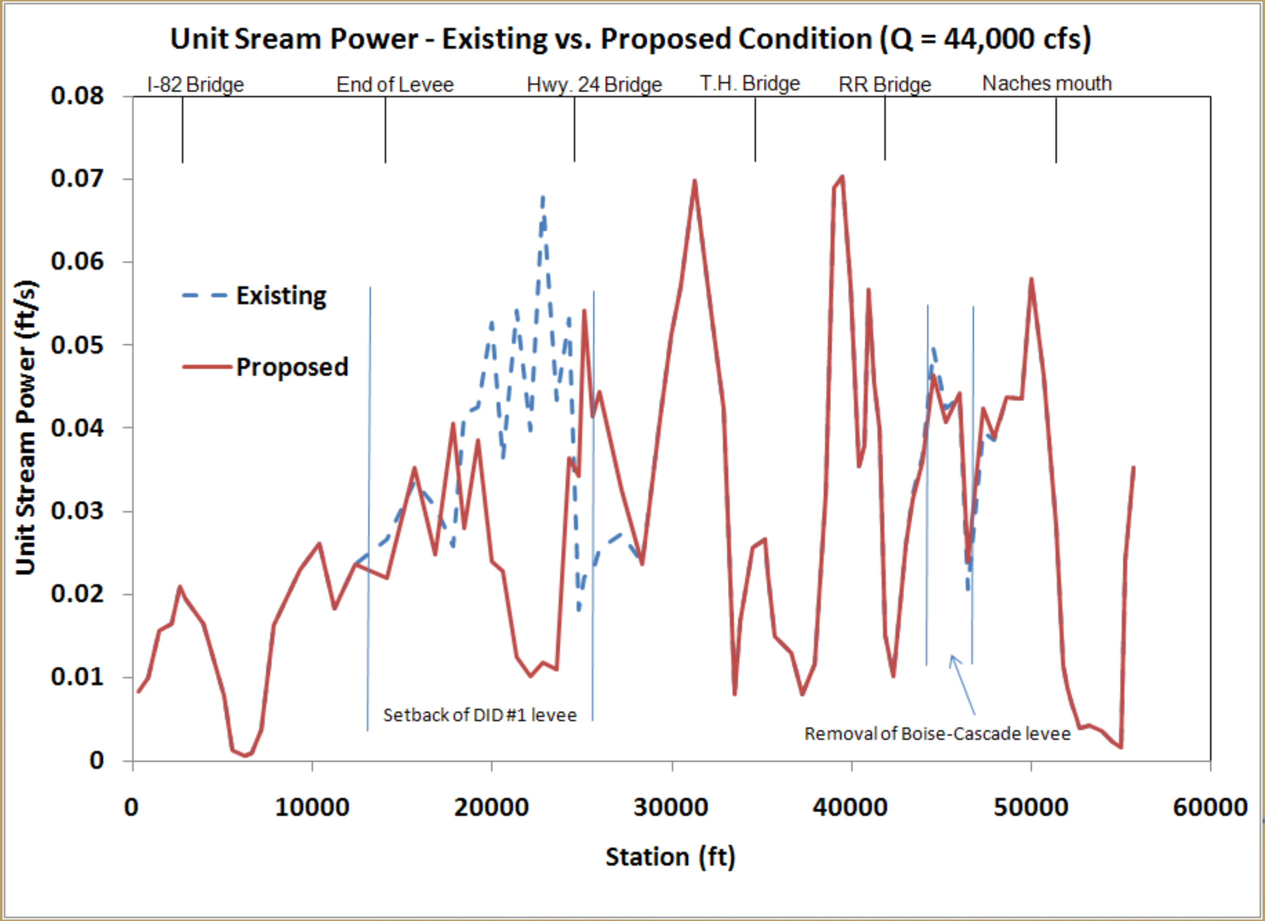
Model Results - Hydraulic

- **Change in depth and velocity comparing existing and initial proposed conditions**

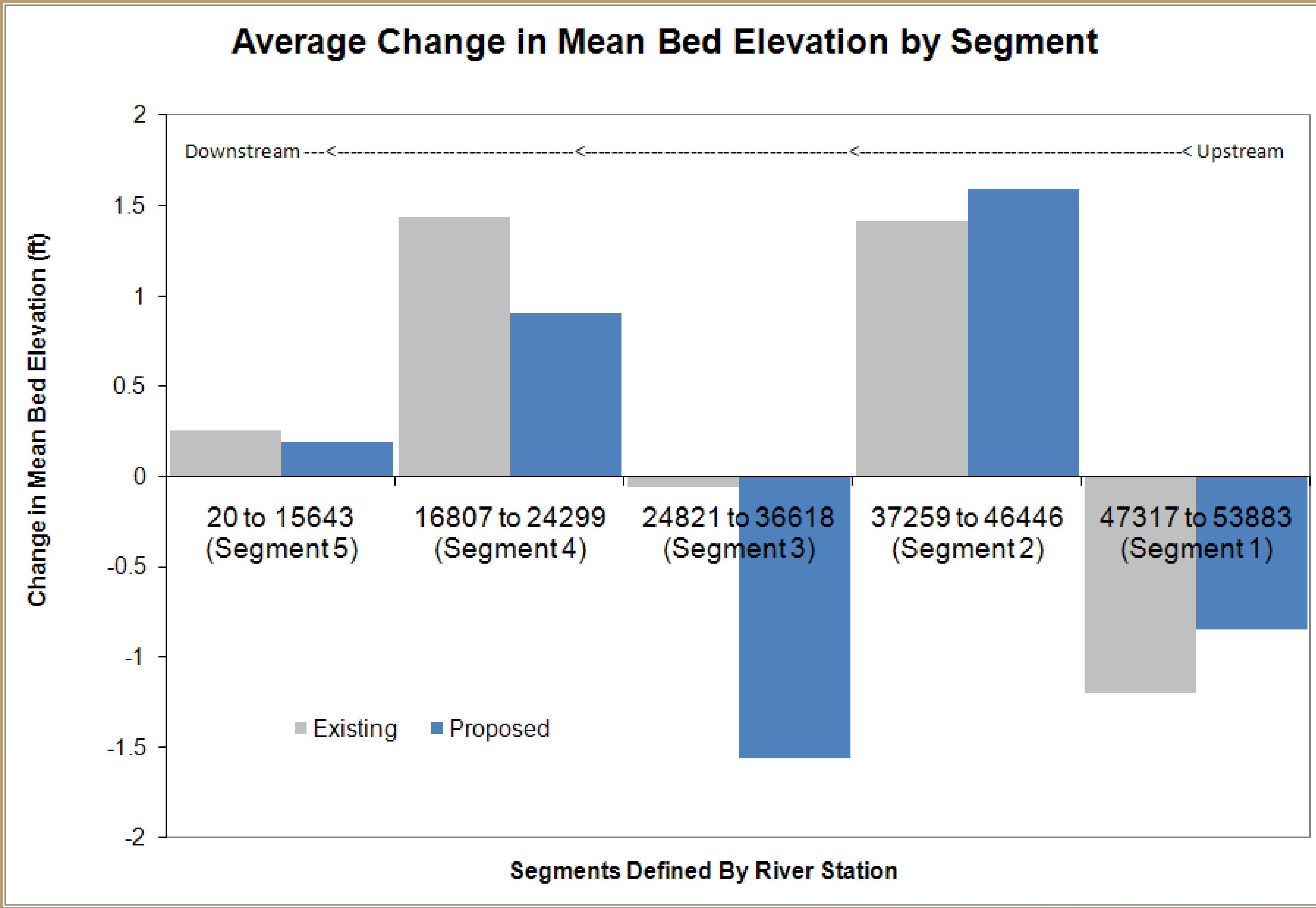


Model Results - Hydraulic

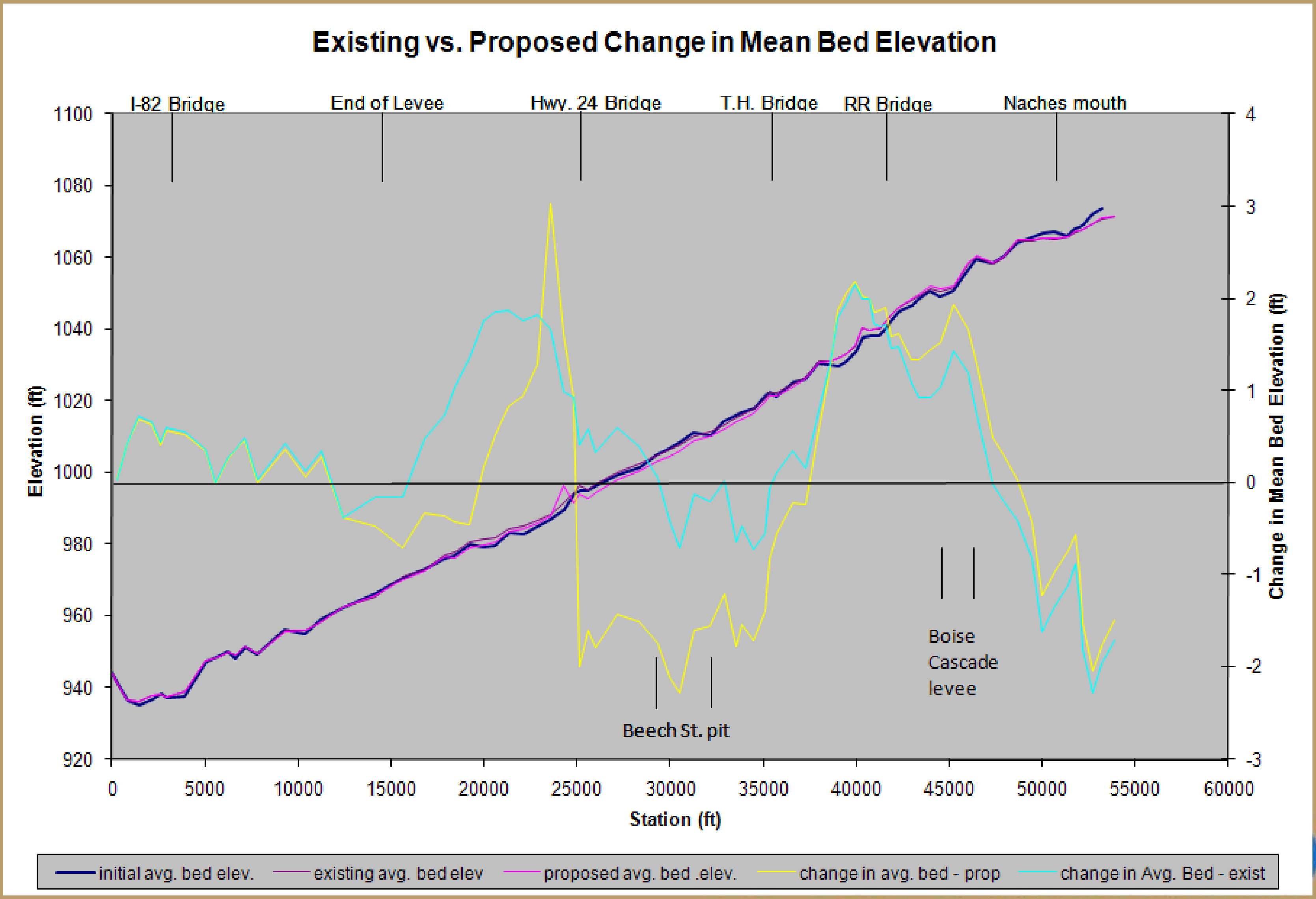
- **Change in unit stream power (VS product) comparing existing and initial proposed conditions**



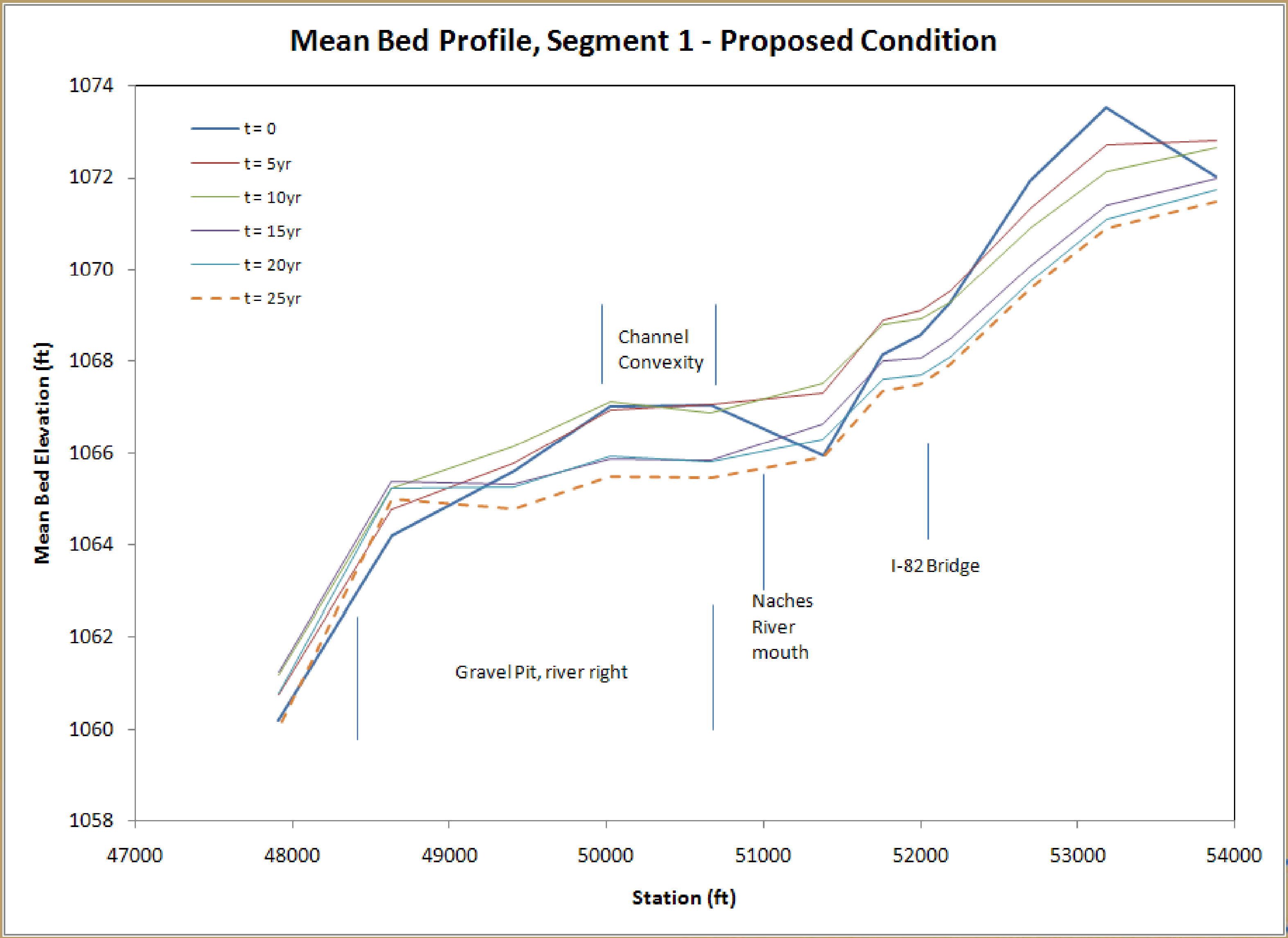
Model Results - Sedimentation



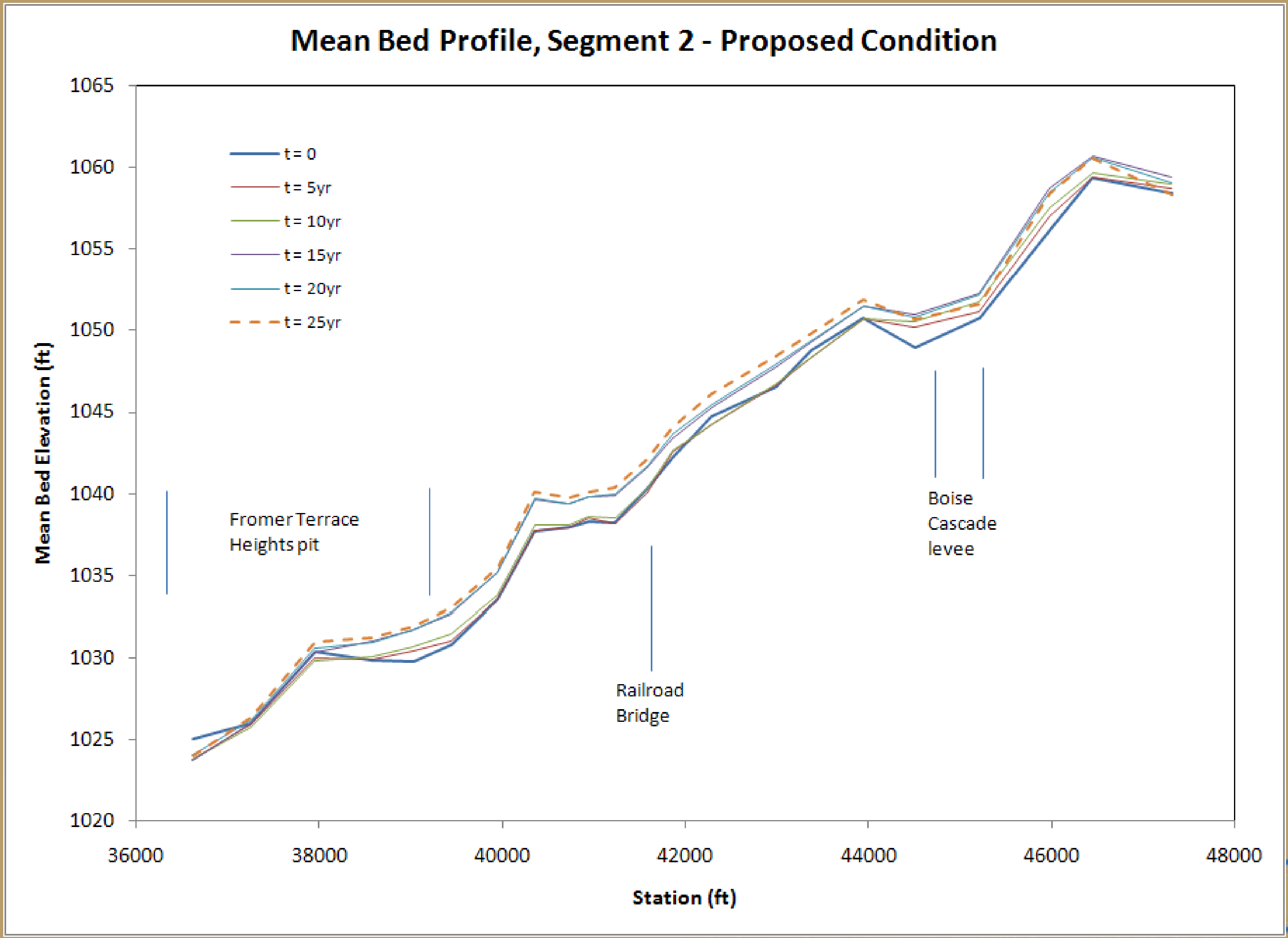
Model Results - Sedimentation



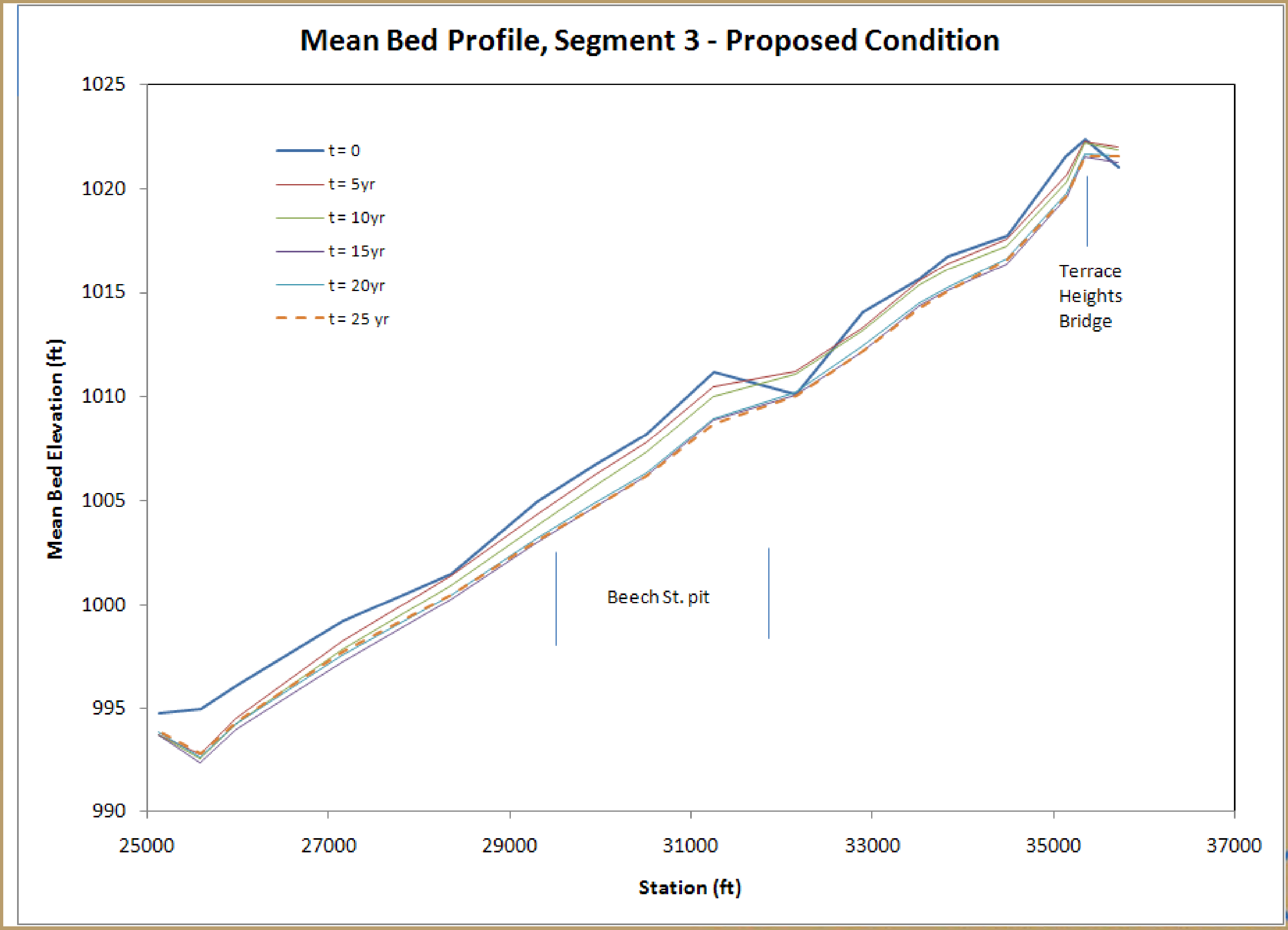
Model Results - Sedimentation



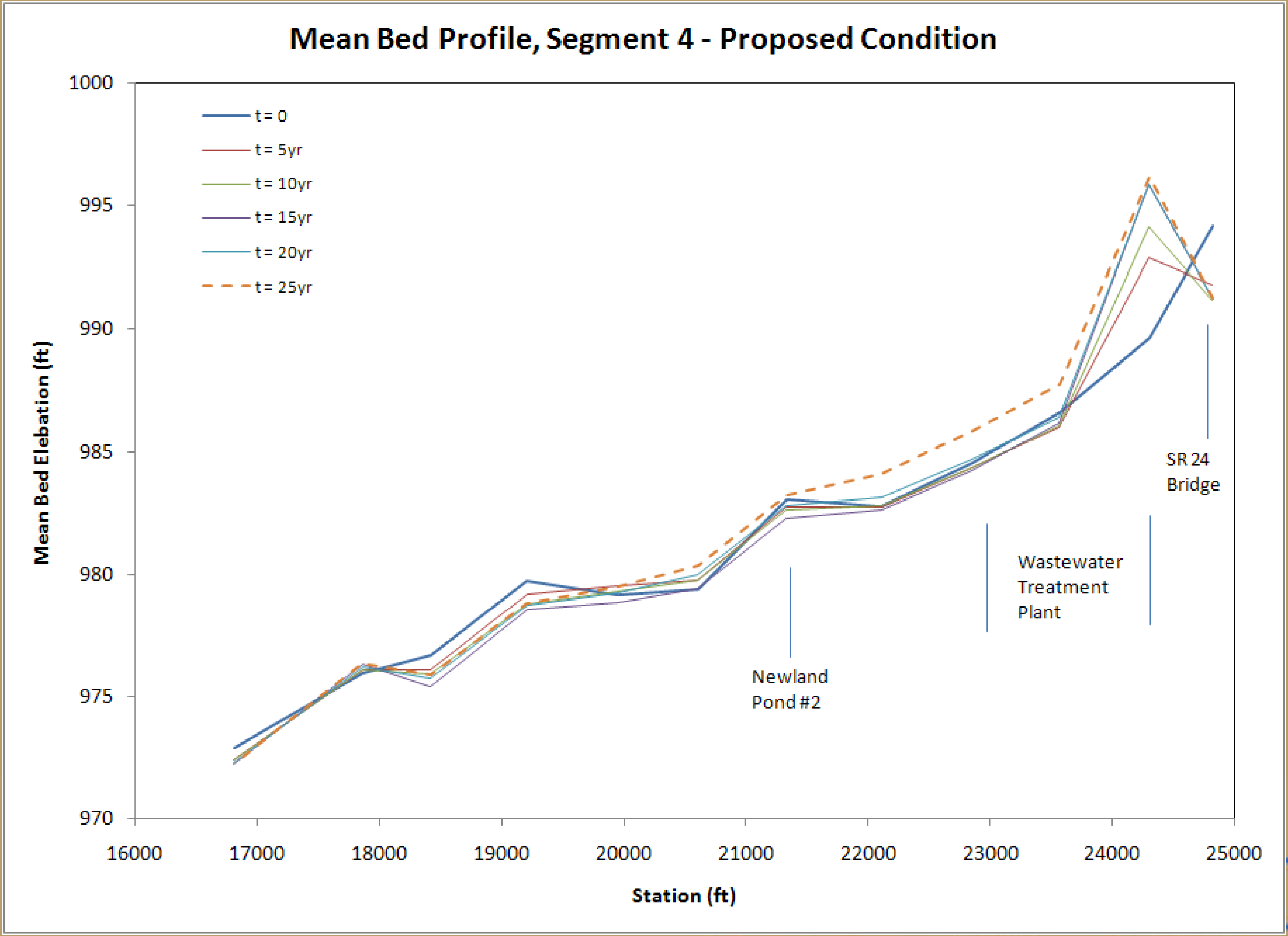
Model Results - Sedimentation



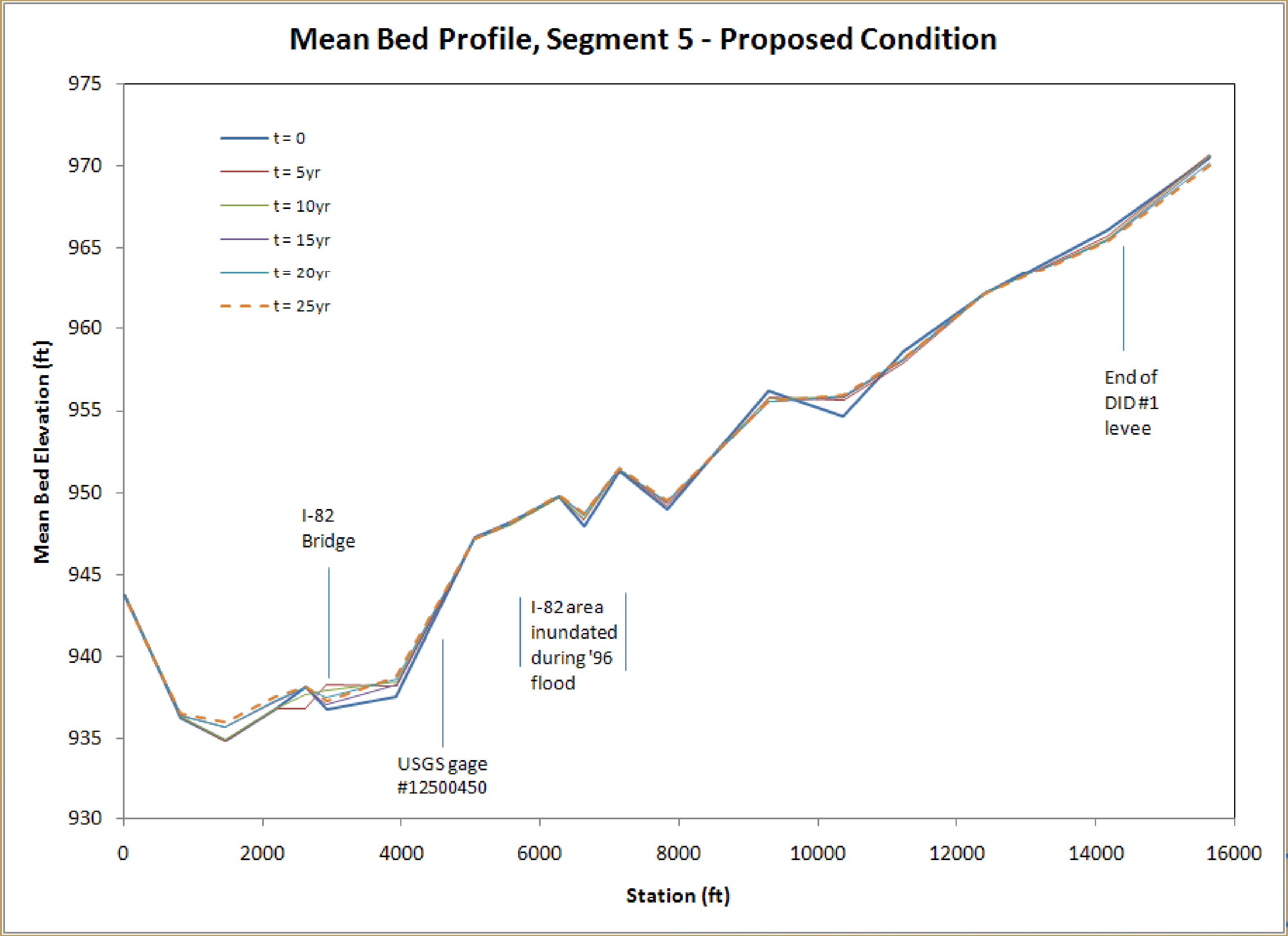
Model Results - Sedimentation



Model Results - Sedimentation



Model Results - Sedimentation



Model Results - Sedimentation

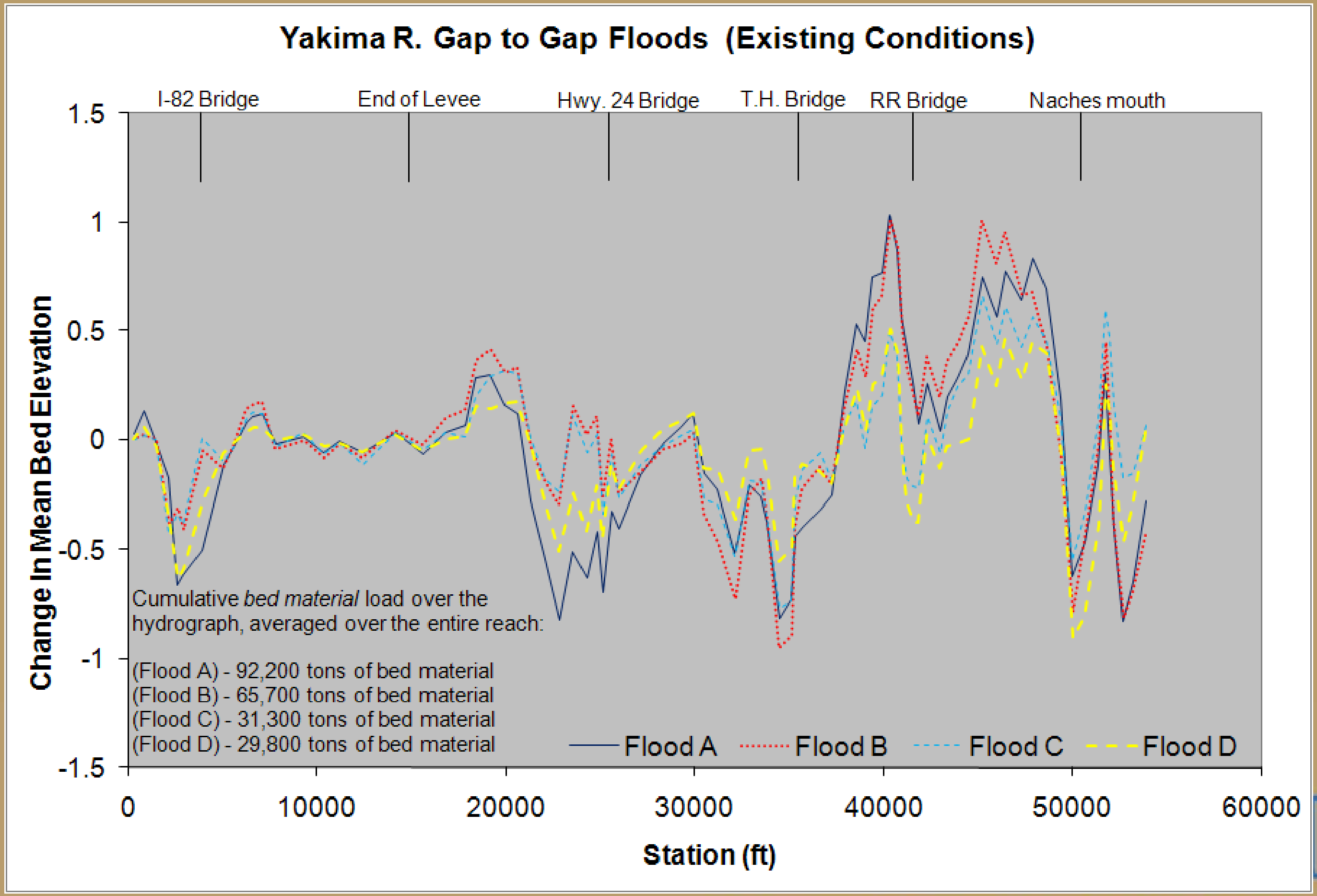
- Wet and dry hydrographs
  - Little change from dry to average period
  - Significant change from average to wet period

	Change in mean bed elevation (ft)					
Segment #	Existing Conditions			Proposed Conditions		
	dry	average	wet	dry	average	Wet
1	-1.0	-1.2	-3.5	-0.7	-0.9	-3.5
2	1.4	1.4	0.1	1.4	1.6	-0.1
3	0.0	-0.1	0.7	-1.1	-1.6	-1.3
4	1.4	1.4	3.5	0.4	0.9	4.4
5	0.3	0.3	0.6	0.3	0.2	0.5

	Average Annual Bed Material Load for Each Segment (tons/year)					
Segment #	Existing Conditions			Proposed Conditions		
	dry	average	wet	dry	average	wet
1	25,093	29,914	83,654	24,461	29,237	83,271
2	27,151	34,514	104,869	21,475	27,820	101,962
3	14,228	18,333	73,423	13,732	20,397	88,152
4	7,548	9,563	35,768	6,267	9,062	43,431
5	1,980	2,499	6,503	1,845	2,188	4,742

Model Results - Sedimentation

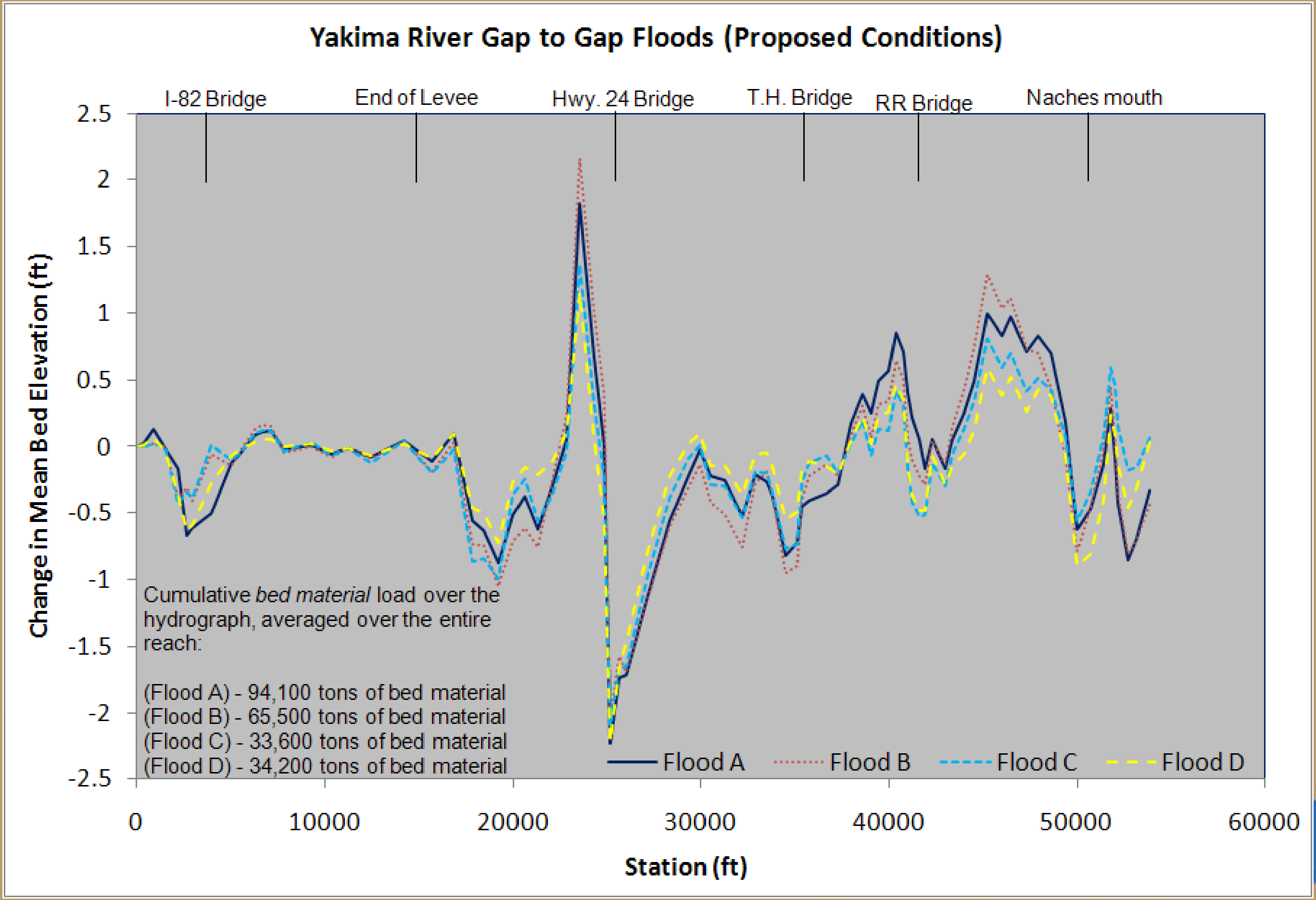
- **Event Based Sediment Transport**
  - **Existing conditions**



TION

Model Results - Sedimentation

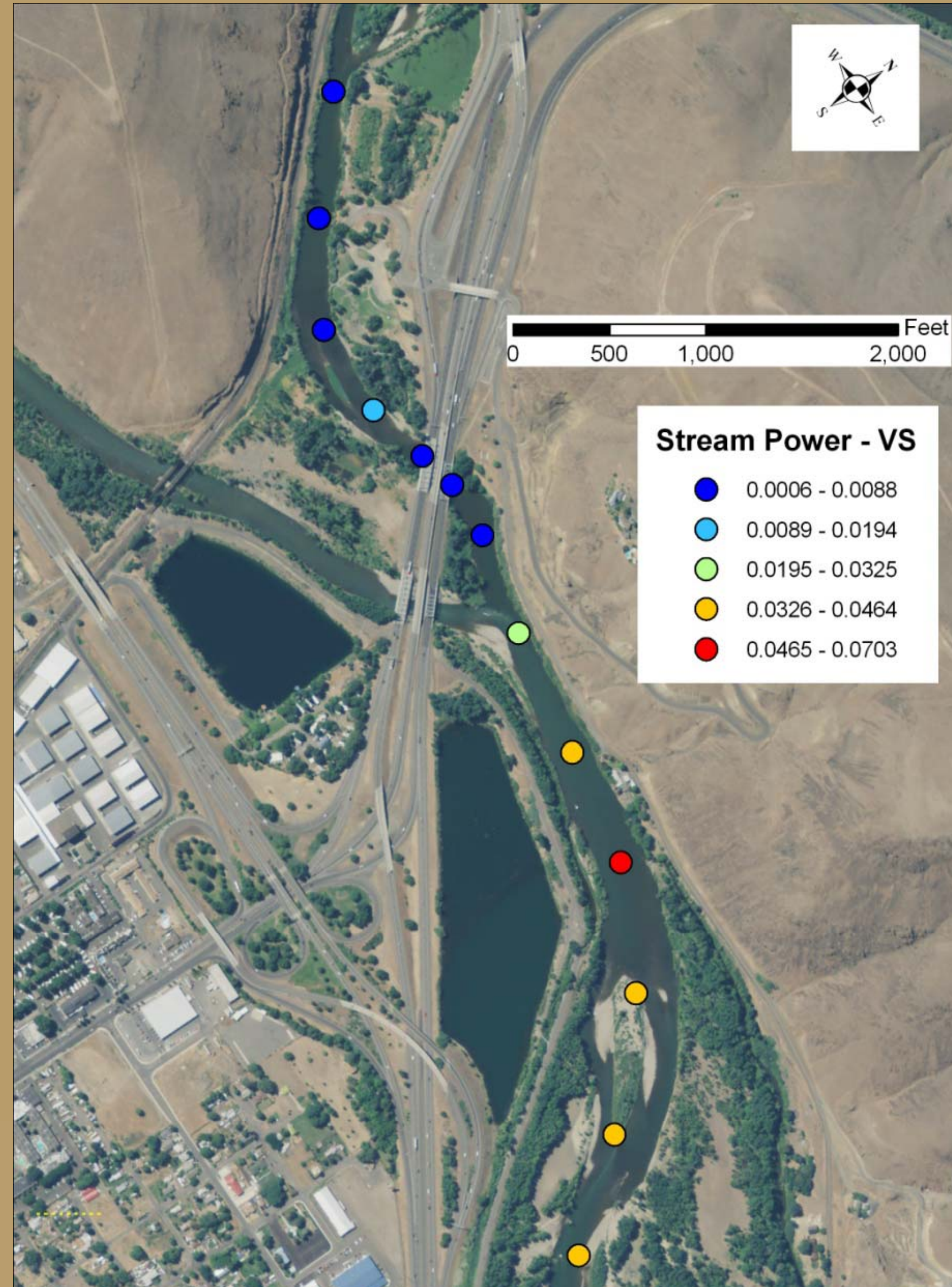
- **Event Based Sediment Transport**
  - **Proposed conditions**



TION

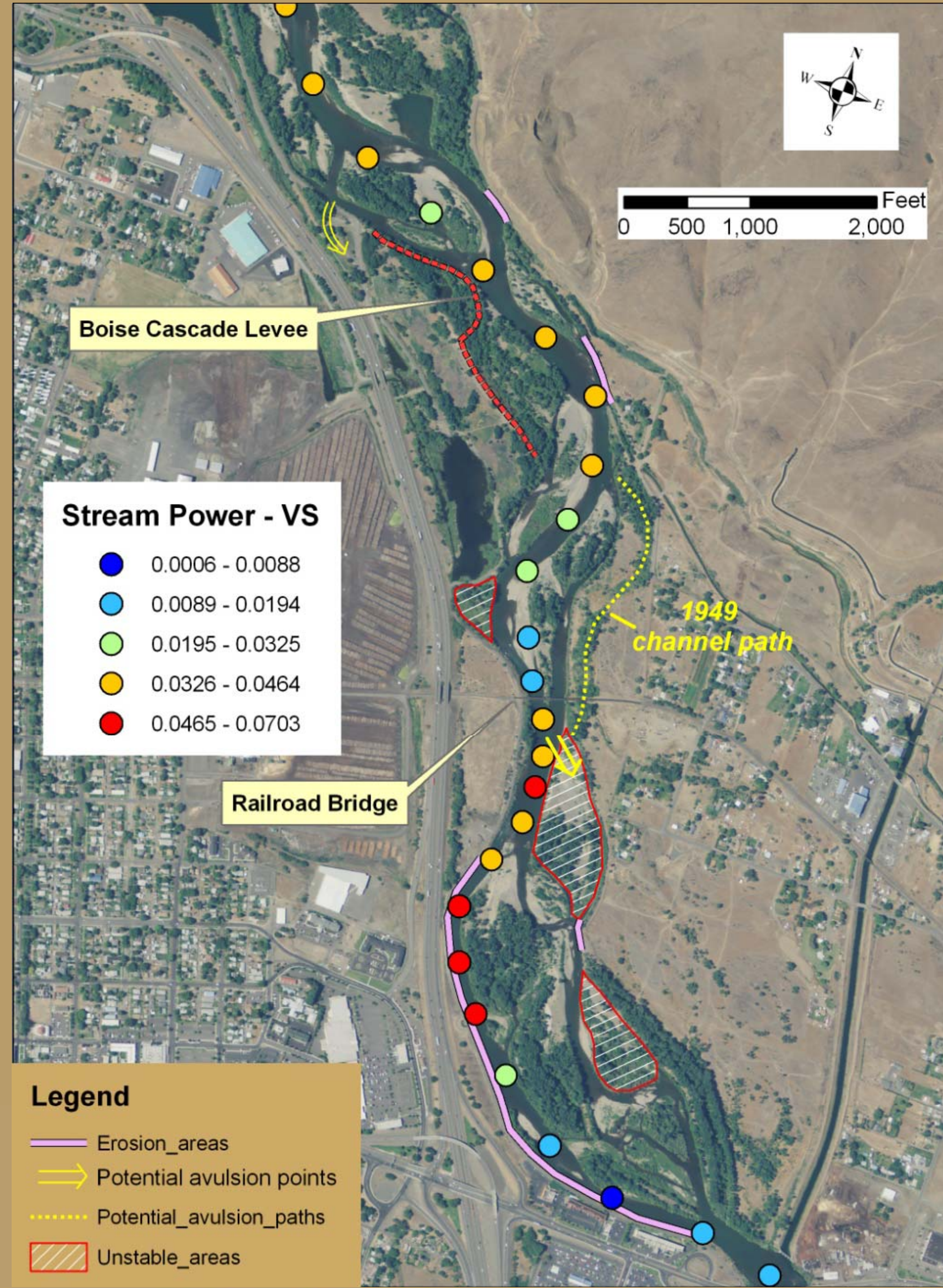
Future Channel Condition

- **SEGMENT 1**
  - No change in levee configuration
  - No change in stream power
  - No locations of active or predicted lateral channel change
  - No active bank erosion
  - Degradation predicted; -0.9 ft. proposed, -1.2 ft. existing
  - Channel convexity expected to remain



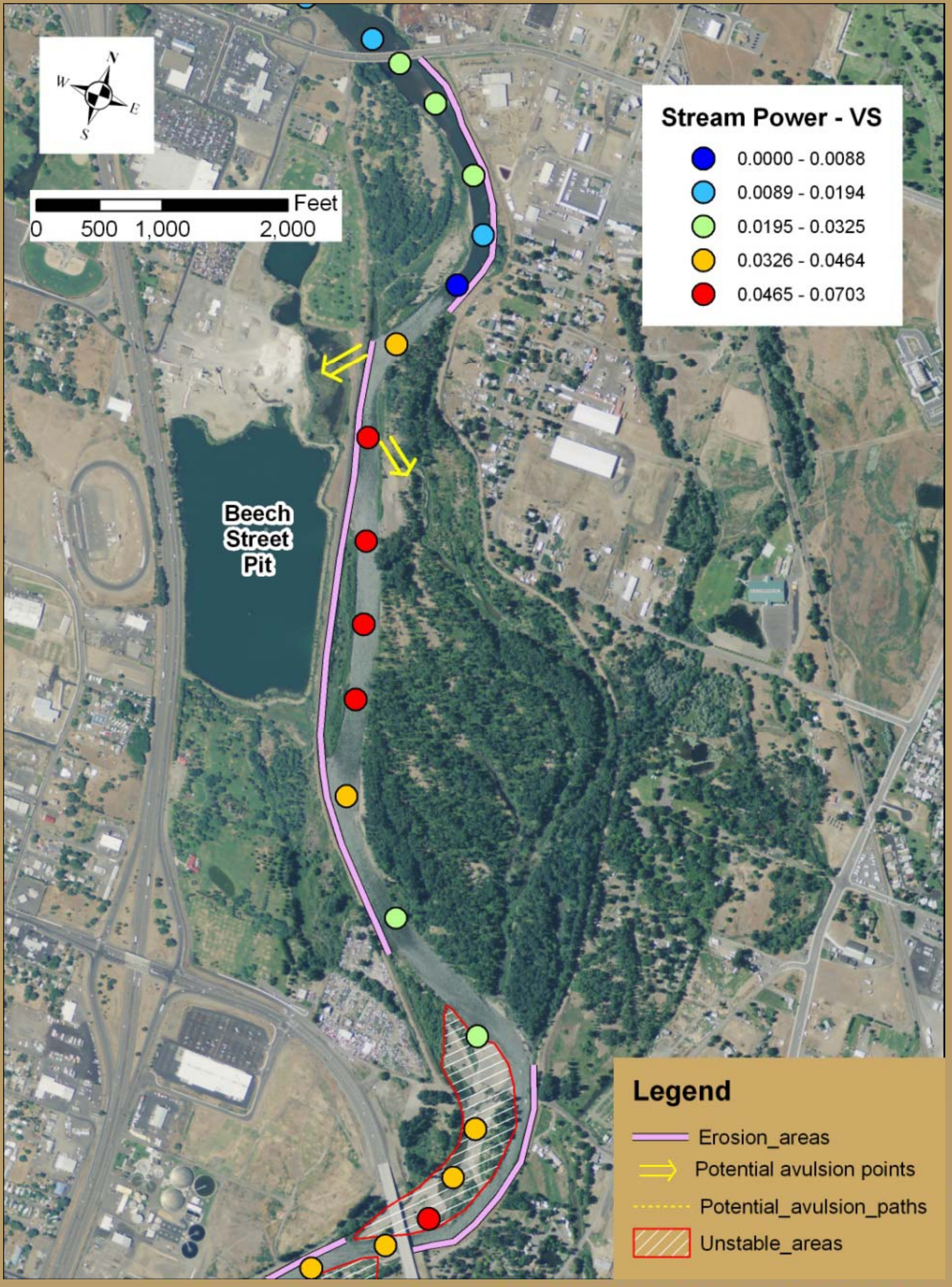
Future Channel Condition

- **SEGMENT 2**
  - Includes proposed removal of Boise Cascade levee
  - Stream power:
    - Decreases slightly in vicinity of levee
    - Increased slightly upstream of levee
  - Avulsion points identified
  - Eroding banks identified
  - Unstable areas identified
  - Aggradation; 1.4 ft. existing, 1.6 ft. proposed



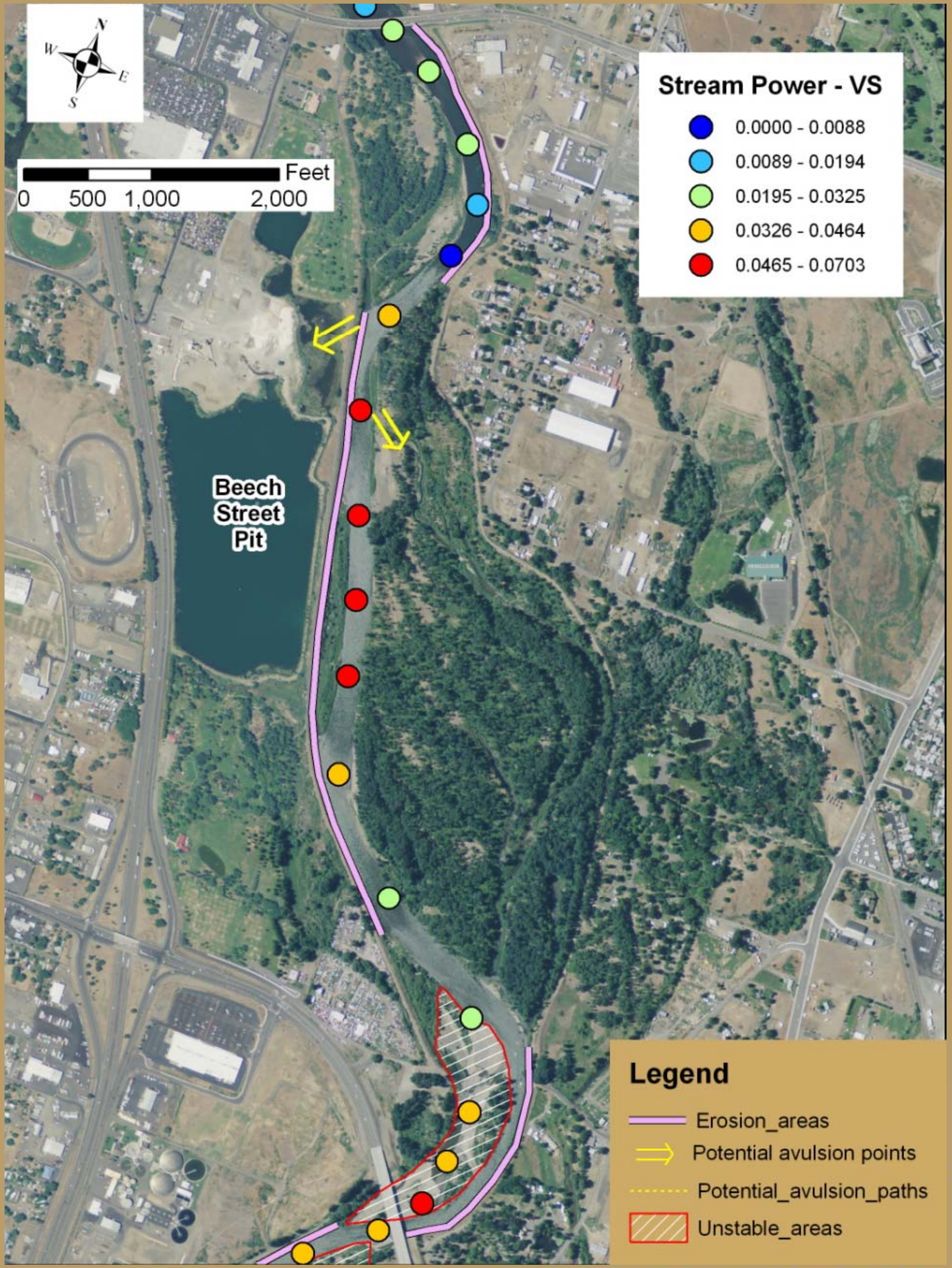
Future Channel Condition

- **SEGMENT 3**
  - Setback of KOA levee on left bank
  - Stream power unchanged
  - Avulsion points identified
  - Eroding banks along levees observed
  - Unstable area upstream of SR 24
  - ~2 feet of degradation anticipated under proposed conditions



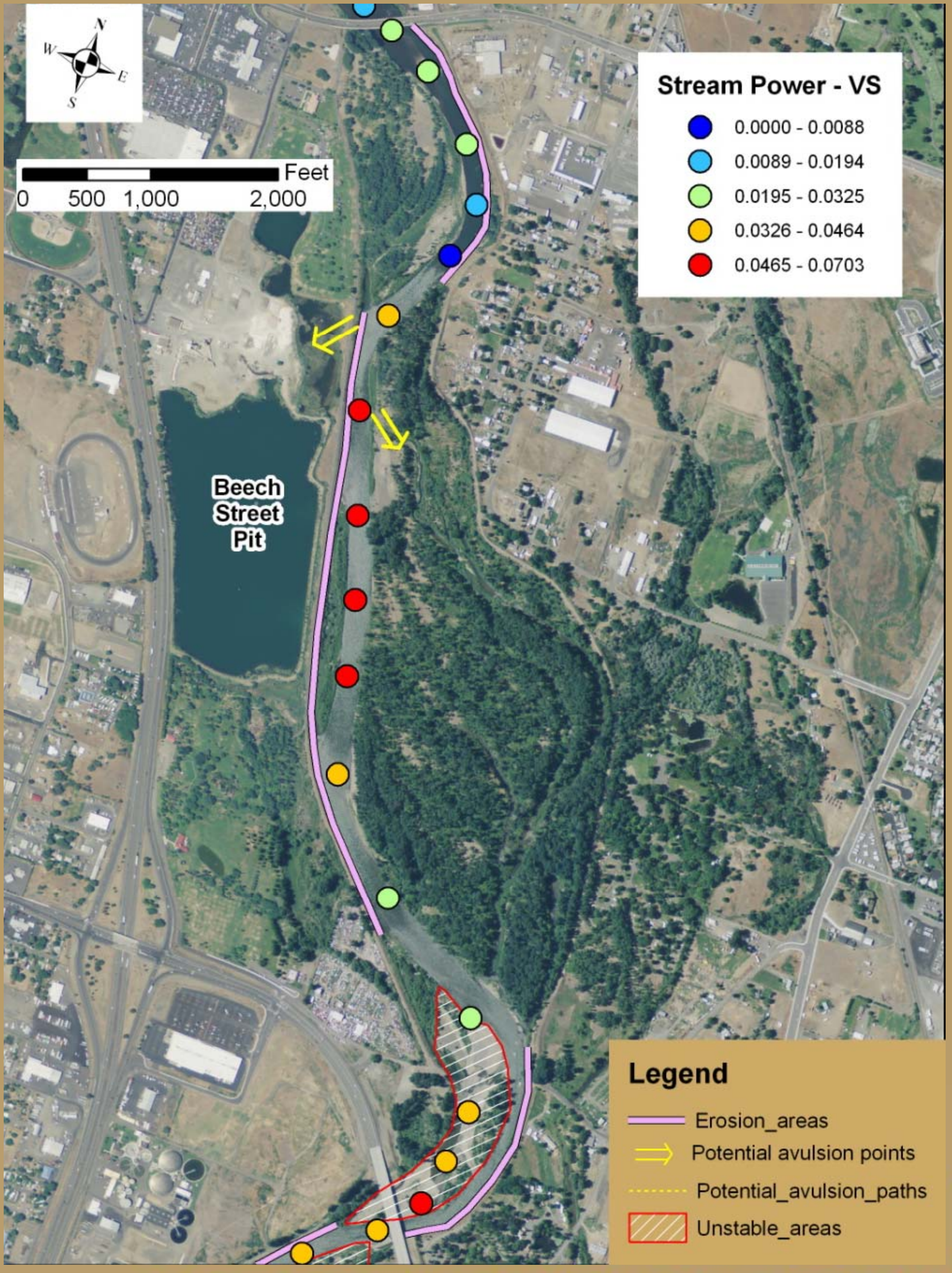
Future Channel Condition

- **Beech Street Pit**
  - **Actively eroding levees have been observed**
  - **High stream power throughout length of the pit**
  - **Anticipated degradation under proposed conditions will increase risk of erosion along levee toe**



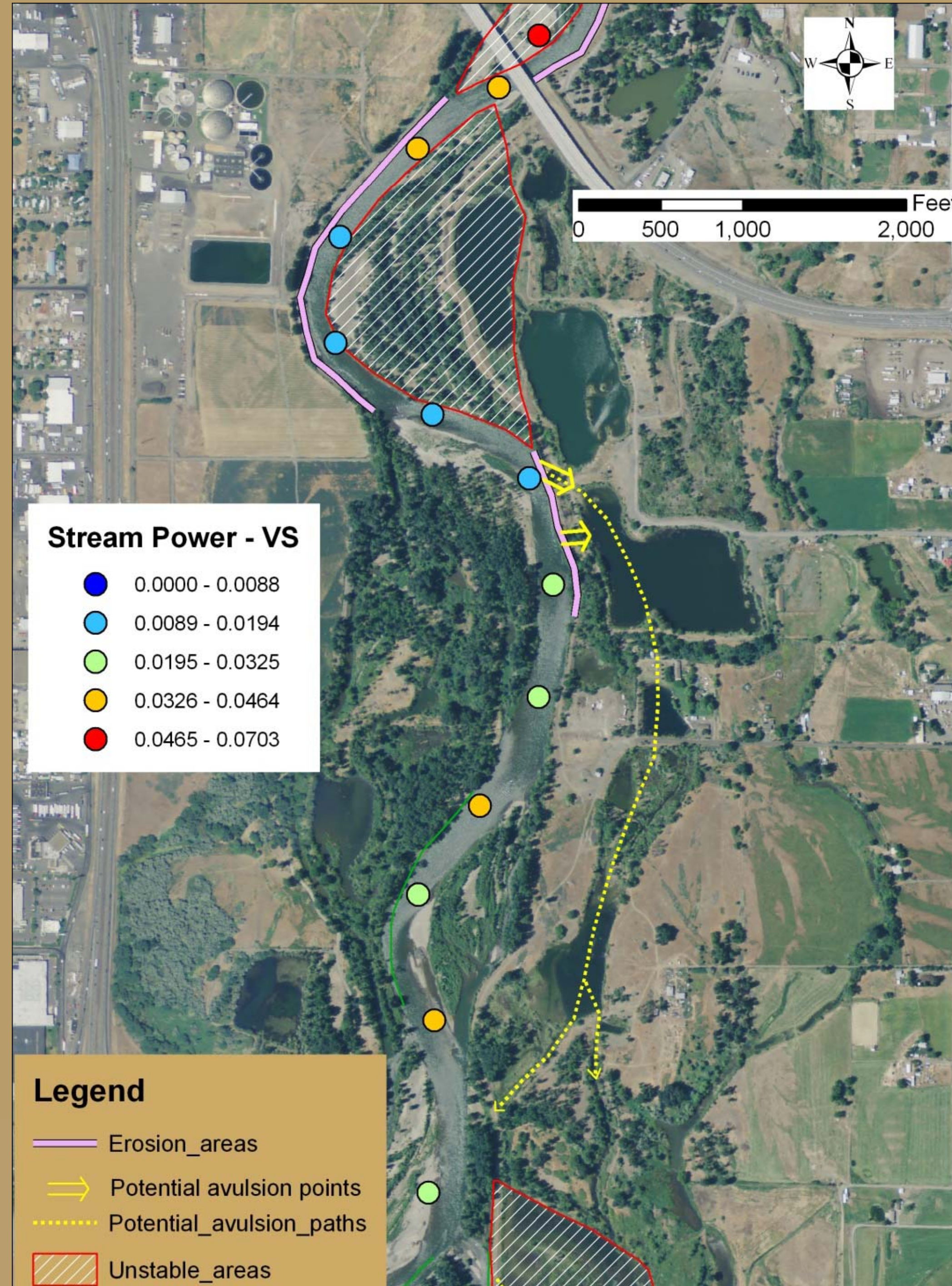
Future Channel Condition

- **SR 24 Bridge and KOA Levee**
  - **Setback of KOA levee reduces (not eliminates) the constriction in this area**
    - **Levee at auto salvage yard ~ 650 ft. width here vs. bridge span of ~1300 ft.**
    - **Channel here has been laterally active historically.**
      - **Most recently avulsed in January 2009**



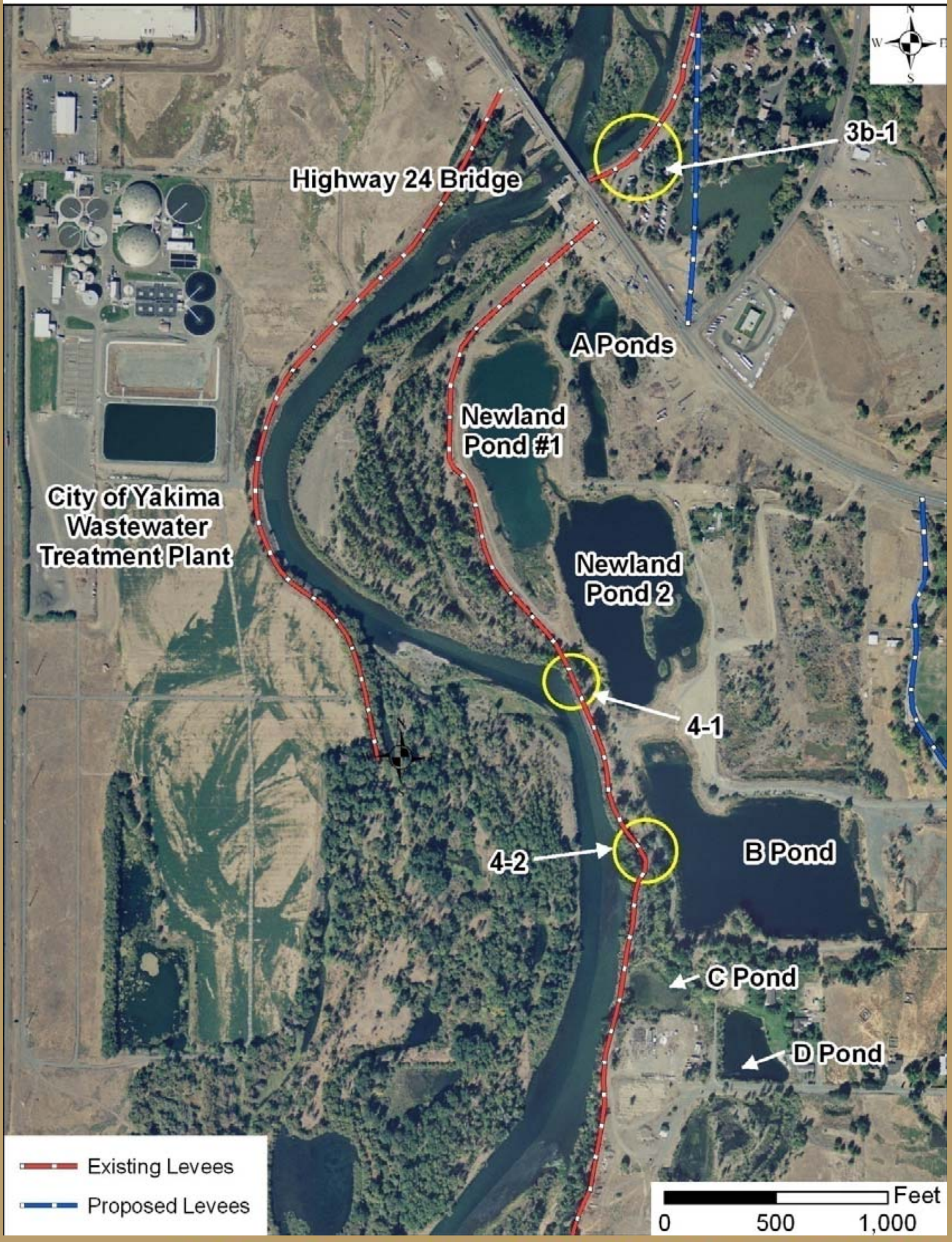
Future Channel Condition

- **SEGMENT 4**
  - DID #1 levee setback on left bank
  - Stream power decreases significantly under proposed conditions
  - Avulsion points identified
  - Unstable areas identified
  - Eroding banks identified
  - ~ 2 feet of aggradation anticipated
  - Greatest uncertainty in model results



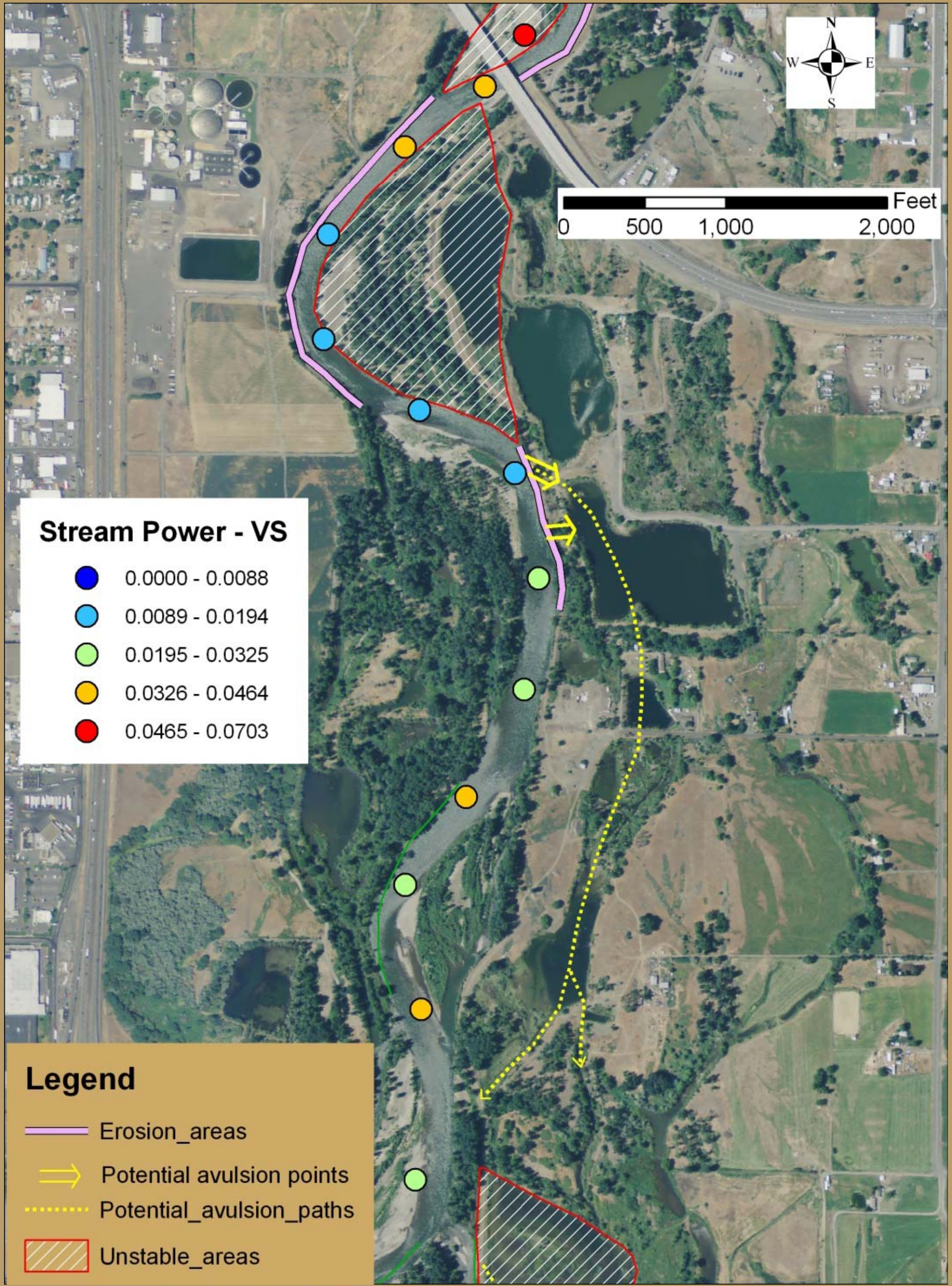
Future Channel Condition

- **Newland Ponds**
  - Avulsion into one or more of these pits could put infrastruccture at risk through headcutting and nickpoint erosion
  - Interrupt sediment flow for decades
  - Ecological consequences



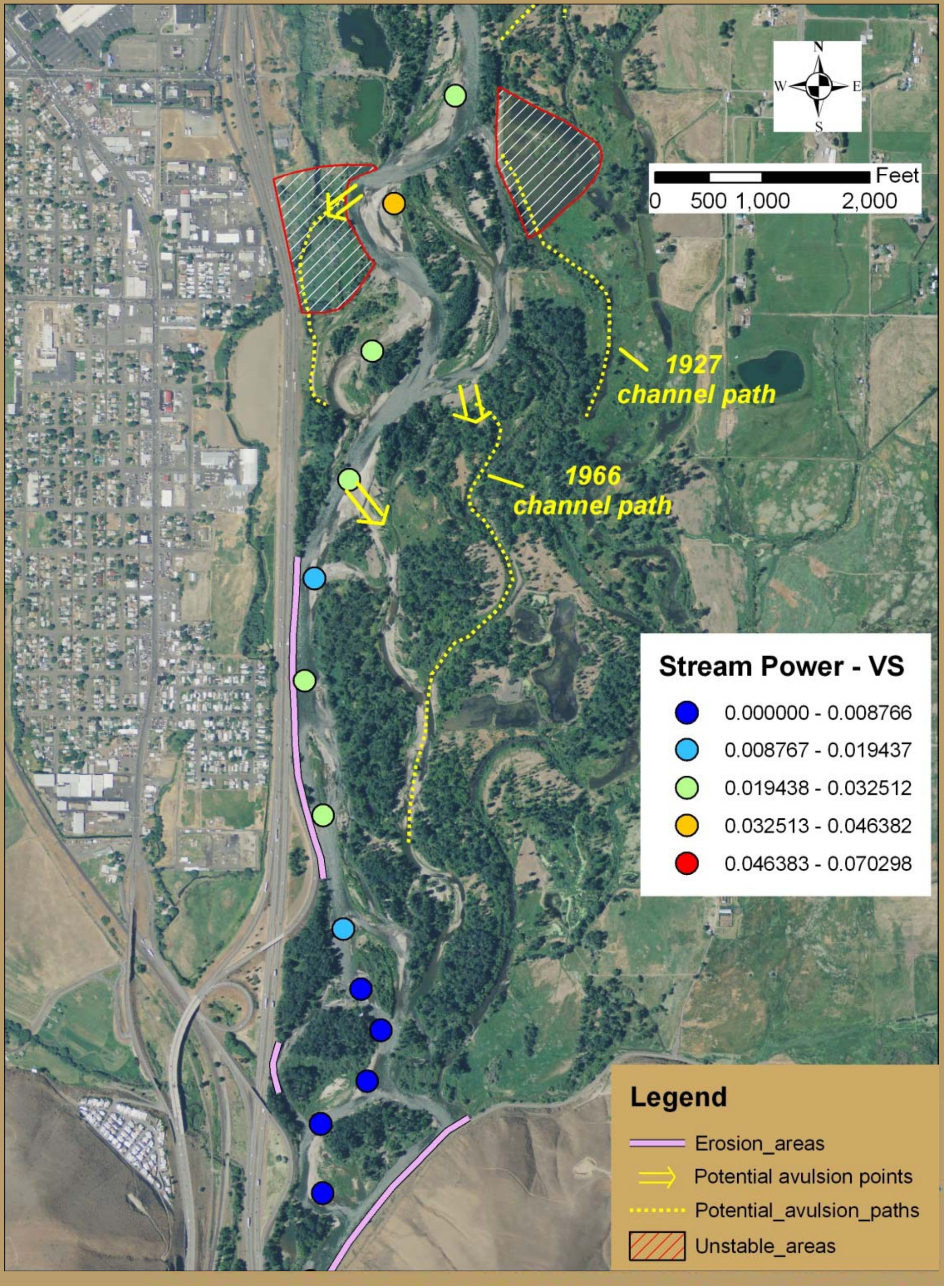
Future Channel Condition

- **Wastewater Treatment Plant**
  - Actively eroding bank
  - Decrease in water surface elevation along the length of the right bank levee following levee setback
    - Predicted to aggrade ~2+ ft.
    - 5’ at t = 0, ~ 2 ft. at t = 25 yr
  - Split channel likely in this location



Future Channel Condition

- **SEGMENT 5**
  - No changes to levee configuration
  - No changes in stream power, existing to proposed
  - No changes in aggradation/degradation existing to proposed
  - Multiple avulsion points identified
  - Actively eroding banks where river contacts I-82
  - Unstable areas identified at the upstream of the segment



Recommendations

- Regular survey of channel profile
- Collection of LiDAR and photography
  - 5-yr cycle or after a large flood
- Use monumented cross sections to consistently compare survey data for tracking:
    - Erosion/degradation
    - Changes in planform
    - Changes in slope
- Perform pebble counts downstream of Wapato Dam to learn what sediment sizes pass over the dam
  - Provides greater insight to how Wapato Dam affects upstream sedimentation

RECLAMATION

Recommendations

- Develop an engineered plan for Newland pits
  - Survey their bathymetry
  - Explore possibilities of infilling with existing floodplain sediment
  - Determine elevation and width for upstream entrance and downstream exit to the pit(s)
    - Planned breech to slowly fill pit with river sediment
- Monitor encroachment on levee freeboard due to anticipated aggradation upstream and downstream of the RR bridge
- Investigate the adequacy of the levee system that protects Yakima and Union Gap

RECLAMATION

Conclusions

- Removal of Boise Cascade levee has a limited impact to future aggradation/degradation
  - Area more likely to become laterally active
    - Ripe for change under existing conditions
  - About 1.5 feet of aggradation anticipated under both existing and proposed conditions through most of segment 2
- Setback of KOA levee reduces constriction
  - Causes segment 3 to degrade under proposed conditions
  - Segment 3a remains aggradation/degradation neutral under existing conditions
  - Segment 3b remains somewhat aggradational under existing conditions

Conclusions

- Setback of DID #1 levee also greatly reduces the existing constriction
  - Reduces water surface elevations locally
  - Places many gravel pits within the floodplain
    - Potential for pit capture
  - Creates an aggradational condition in vicinity of wastewater treatment plant and Newland pits, ~2+ feet
    - With an overall reduction in water surface elevation of ~2 ft.
  - Does not appear to affect sedimentation in segment 5
  - Contributes to degradation in segment 3

RECLAMATION

QUESTIONS?

- Contact info:
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  - Denver, CO
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- E-mail: rhilldale@usbr.gov
- www.usbr.gov.pmts/sediment