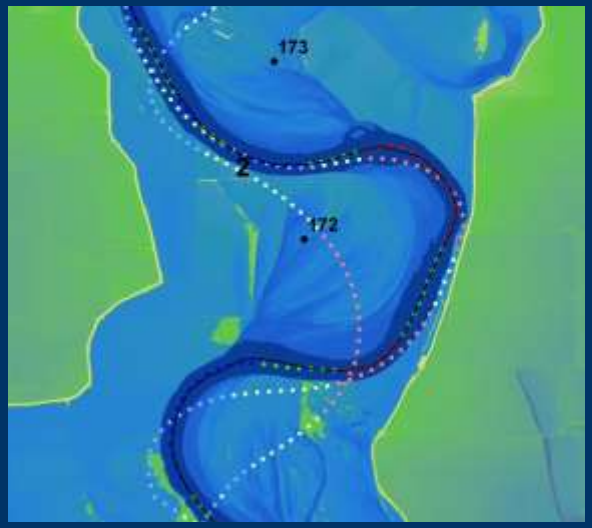


AN INTEGRATIVE APPROACH TO MODELING EFFECTS OF REACTIVATION OF RIVER MIGRATION ON AQUATIC AND FLOODPLAIN HABITATS

GLEN LEVERICH [1]
NOAH HUME [1]
RAFAEL REAL DE ASUA [1]
ERIC LARSEN [2]
RAY MCDOWELL [3]
ADAM HENDERSON [3]
STACY CEPELLO [3]

2014 Bay-Delta Conference
Modeling & Physical Science
30 Oct 2014

1 Stillwater Sciences
2 UC DAVIS UNIVERSITY OF CALIFORNIA
3 CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM
FloodSAFE CALIFORNIA

Conservation Framework of the CVFPP

- Increase flood protection levels
- Improve agricultural and ecological values
- Enhance natural dynamic hydro-geomorphic processes
- Add to recovery of native species

Strategy → Expand floodway corridors

CVFPP Areas (CDWR 2012)

Study Goals

- Assess potential effects of reactivation of meander migration on fish habitat
- Hypothetical revetment removal and levee setbacks
- Develop repeatable, cost-effective approach

Approach → River Migration (Larsen) and
Aquatic Habitat models

Modeling Approach

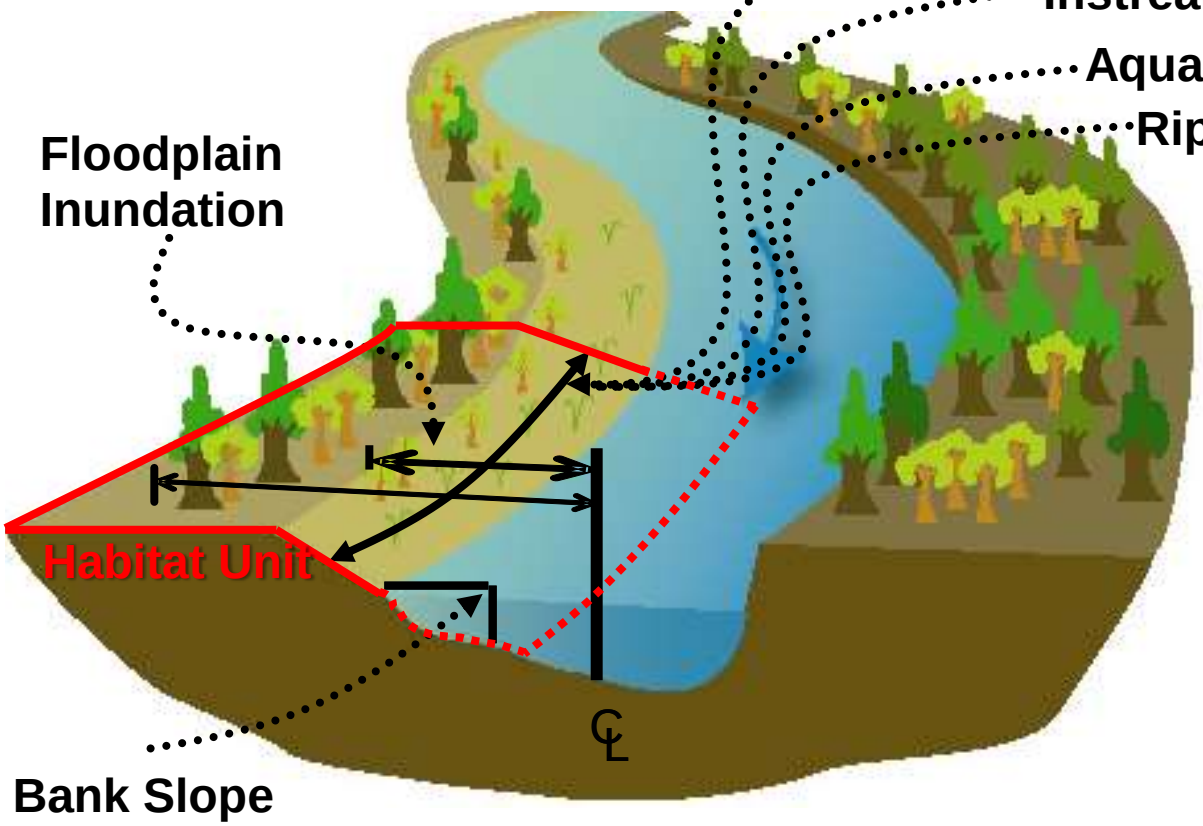
- Meander Migration model – Eric Larsen (UCD)
- SRBPP SAM to assess effects of conceptual project actions on nearshore habitat of listed fish populations
- Enhance SAM to incorporate 1-D meander-migration
- Pilot sites along middle Sacramento River

Standard Assessment Methodology

- SAM is a habitat assessment protocol developed for the SRBPP
- Considers habitat requirements for seven T&E fish populations:
  - Chinook salmon (4 seasonal runs)
  - Central Valley steelhead *(Threatened)*
  - Delta smelt *(Threatened)*
  - Green sturgeon *(Threatened)*

Standard Assessment Methodology

Modeled Variables

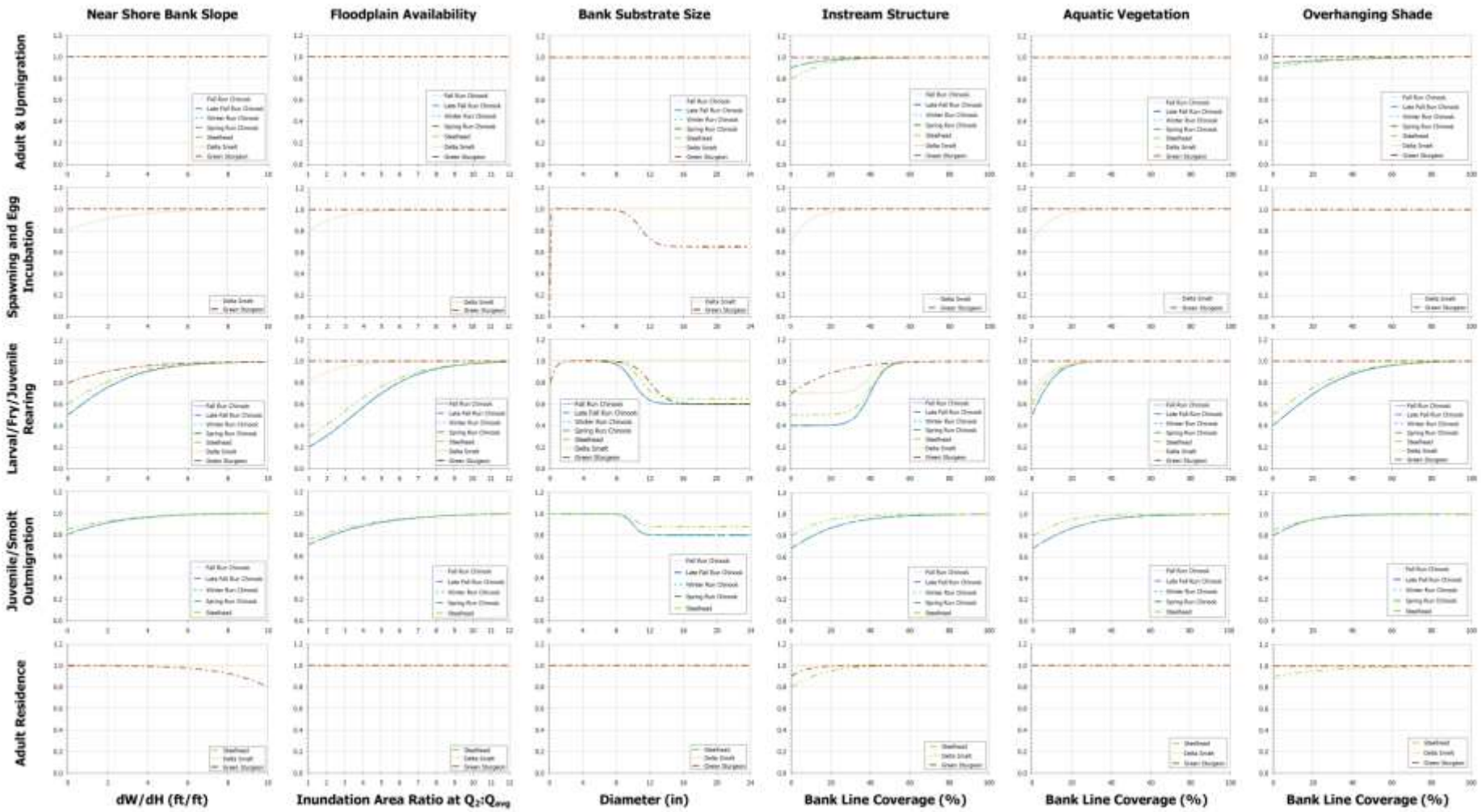


Selected Variables by their Relevance to:

- Life history requirements
- Habitat use
- Sensitivity to SRBPP actions
- Ease of field measurement or computer-based modeling

Standard Assessment Methodology

Modeled Variables



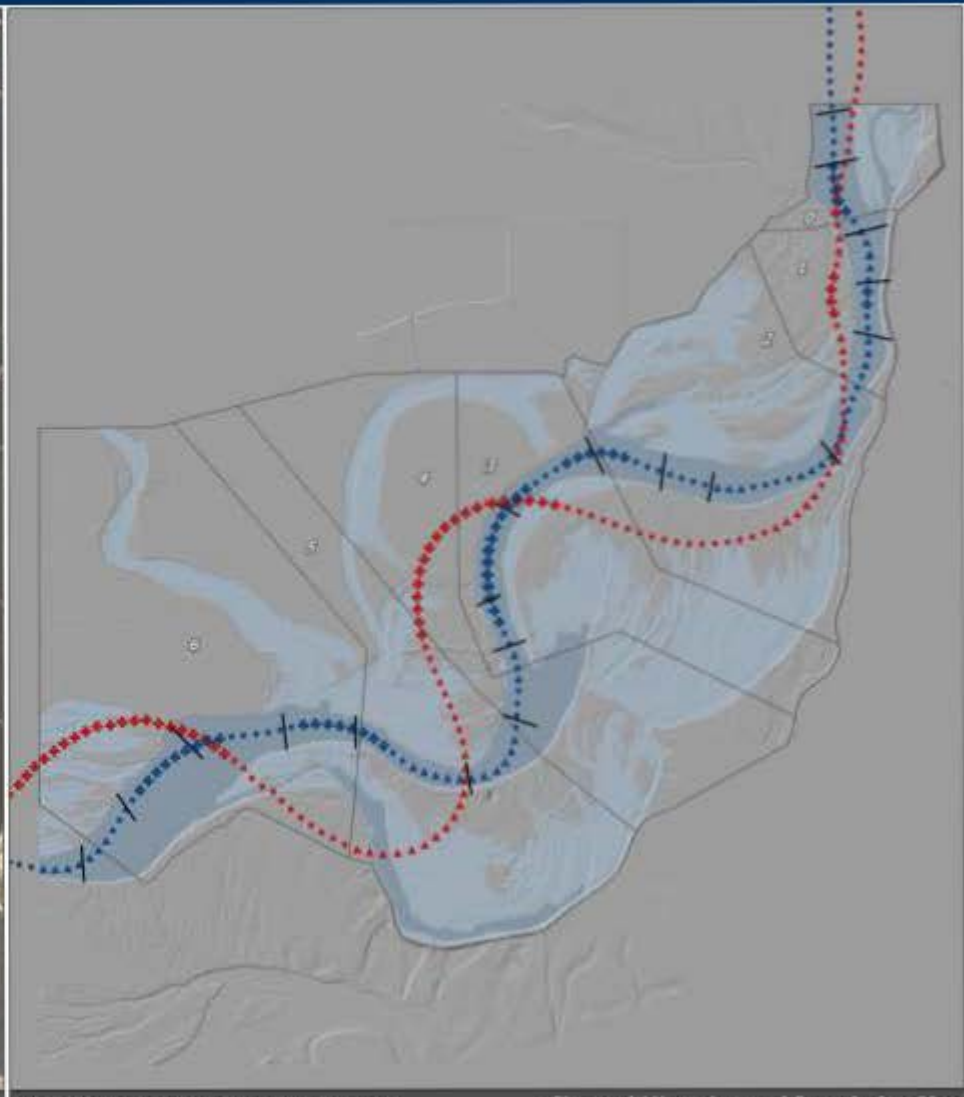
SAM Modeling Approach

Parameter	Data Source
Wetted Area	Seasonal water surface elevations | Topo-bathymetric surface
Bankline Length	
Bank Slope	
Inundation Availability	Seasonal and Q2 water surface elevations | Topo-bathymetric surface
Bank Substrate	Revetment database | Aerial photos
Instream Structure	
Aquatic Vegetation	
Overhead Shade	

Challenge:

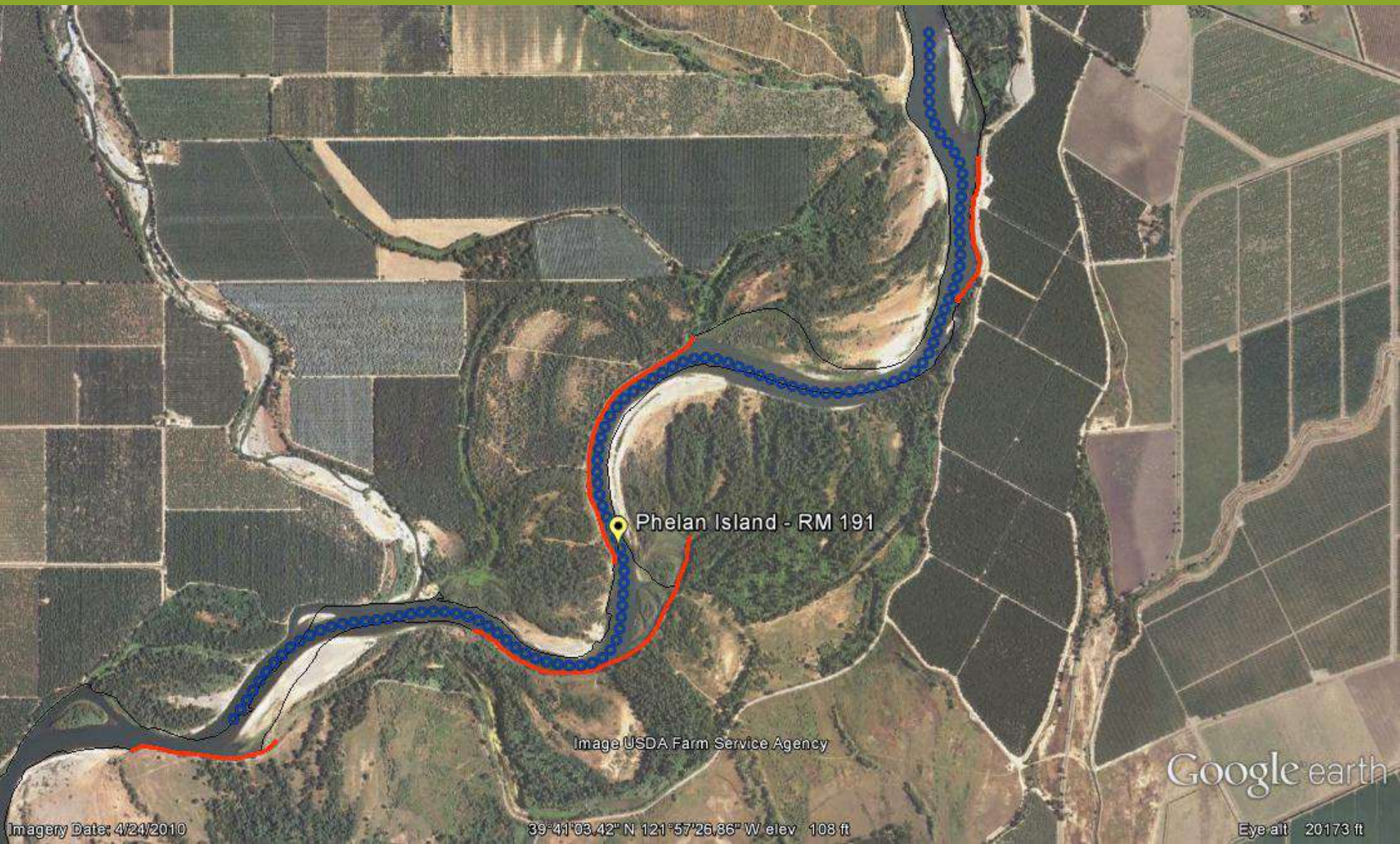
How to convert 1-D channel centerline points for existing and future conditions into usable format for SAM input variables…?

Sac RM 191 – Bank Revetment Removal



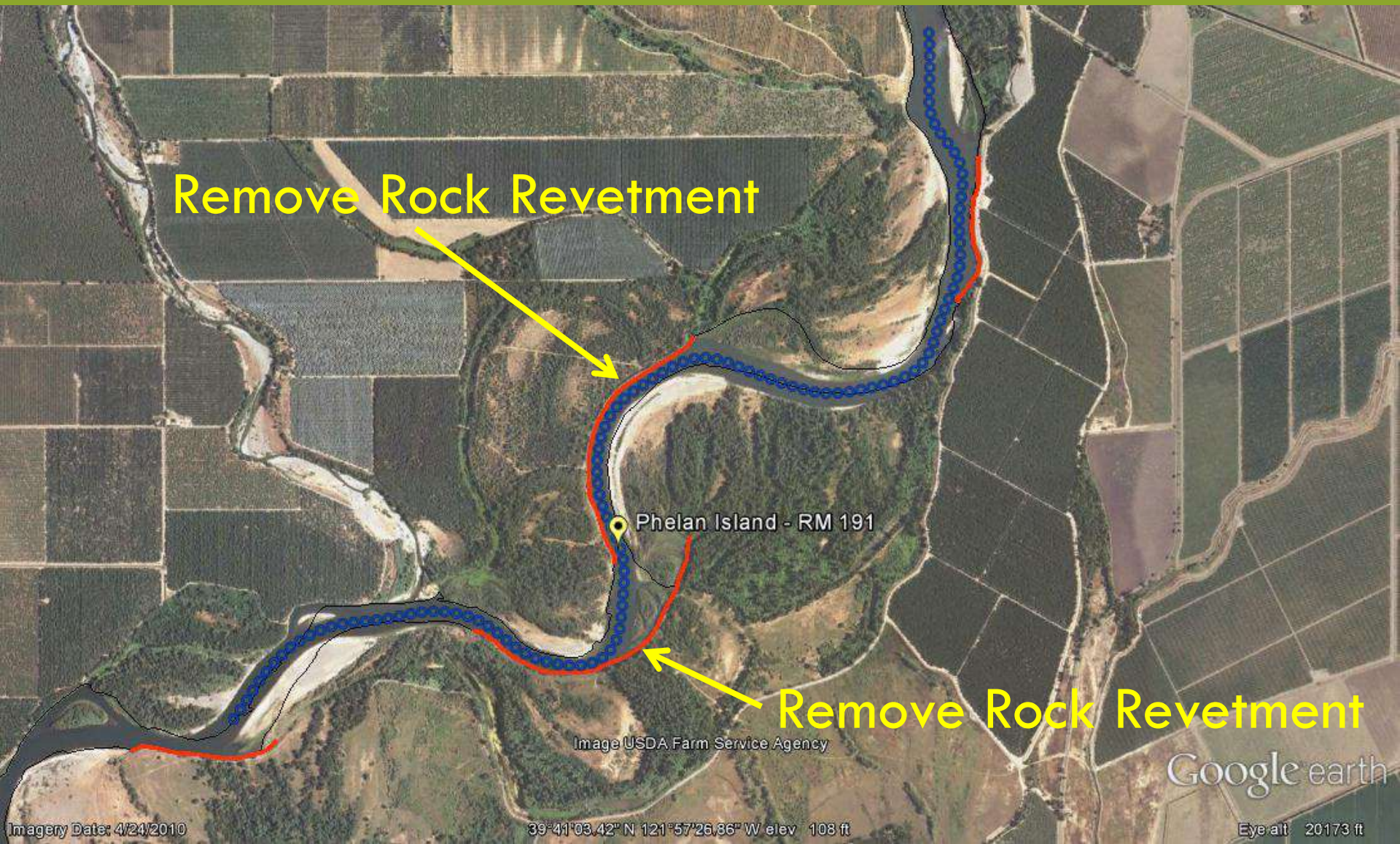
Sac RM 191 – Bank Revetment Removal

Eric Larsen's Meander Migration Modeling | 2010 Channel Centerline (in blue)



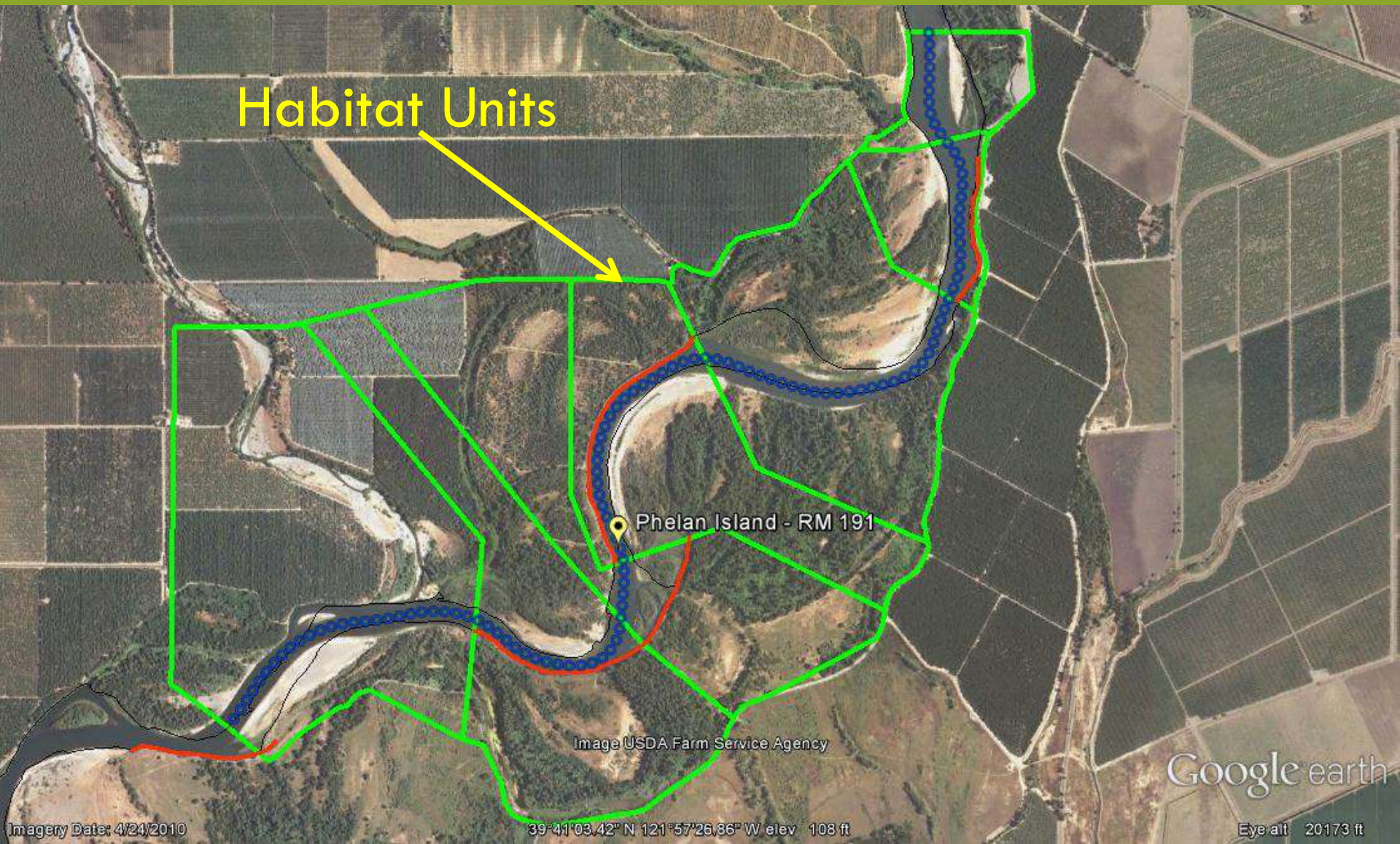
Sac RM 191 – Bank Revetment Removal

Eric Larsen's Meander Migration Modeling | 2010 Channel Centerline (in blue)



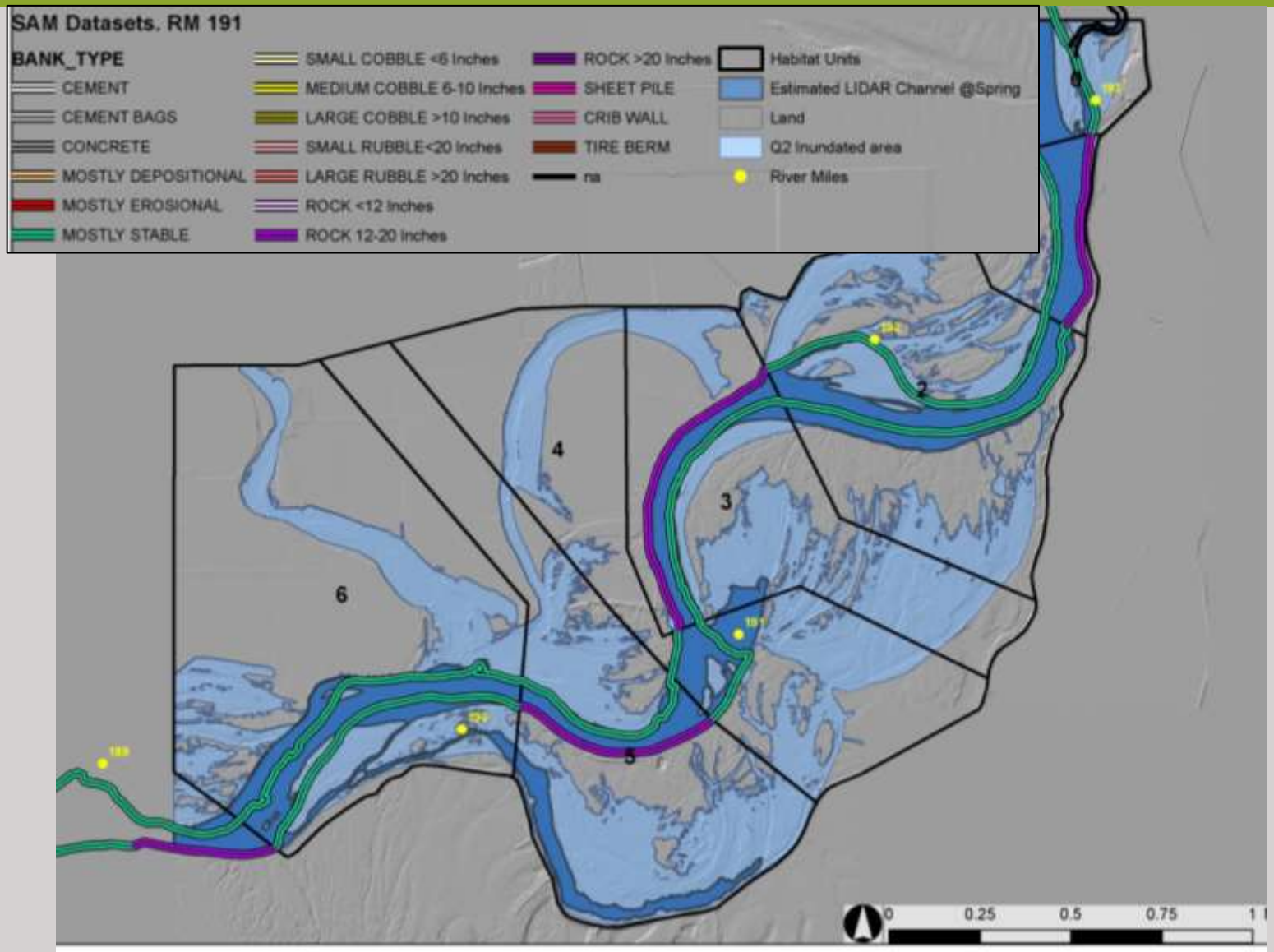
Sac RM 191 – Bank Revetment Removal

Create Habitat Units for SAM Model | Based on Dominant Bank Type (Revetment DB)



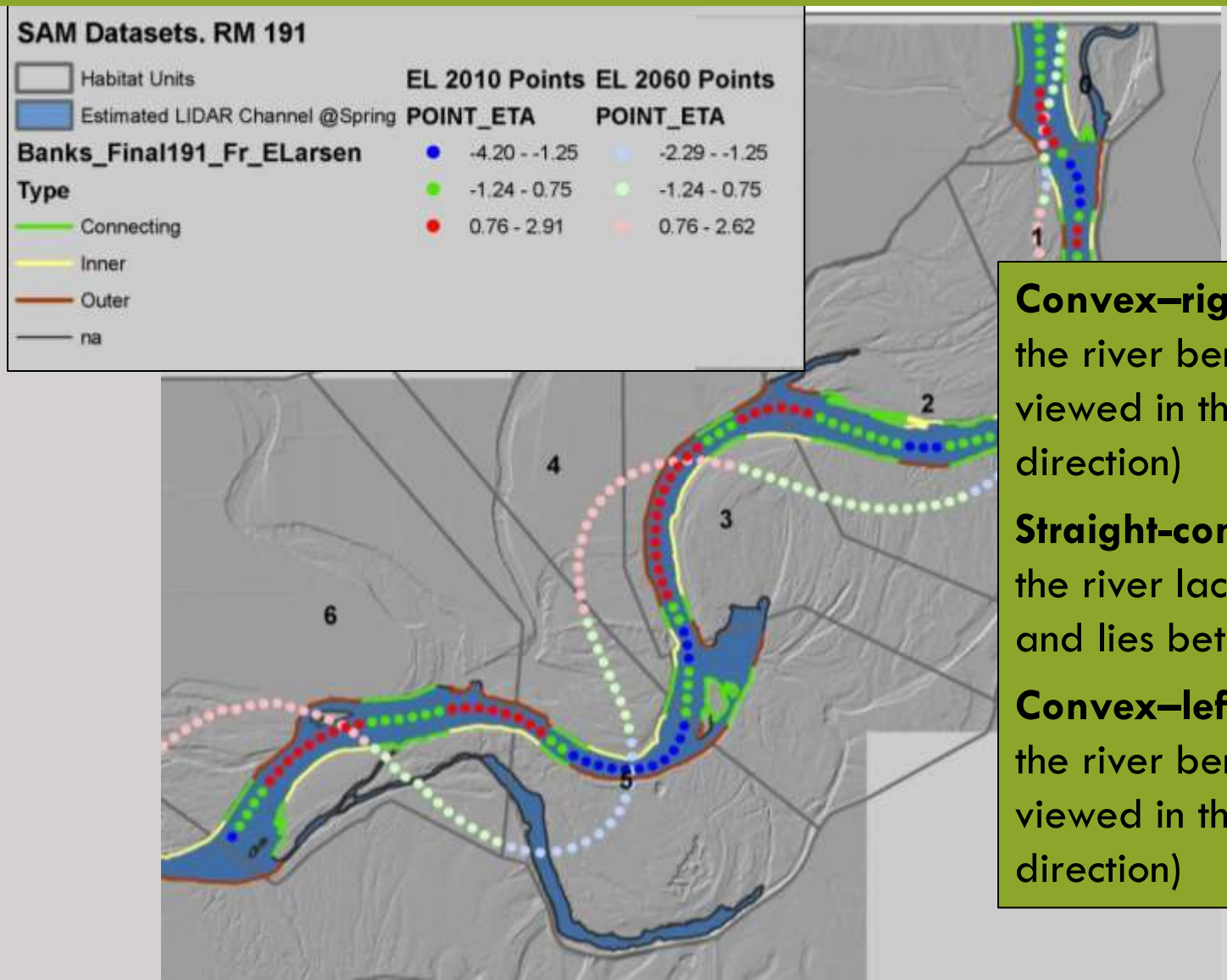
Sac RM 191 – Bank Revetment Removal

Q2 Inundation Area | Based on River Gage and Topographic DEM



Sac RM 191 – Bank Revetment Removal

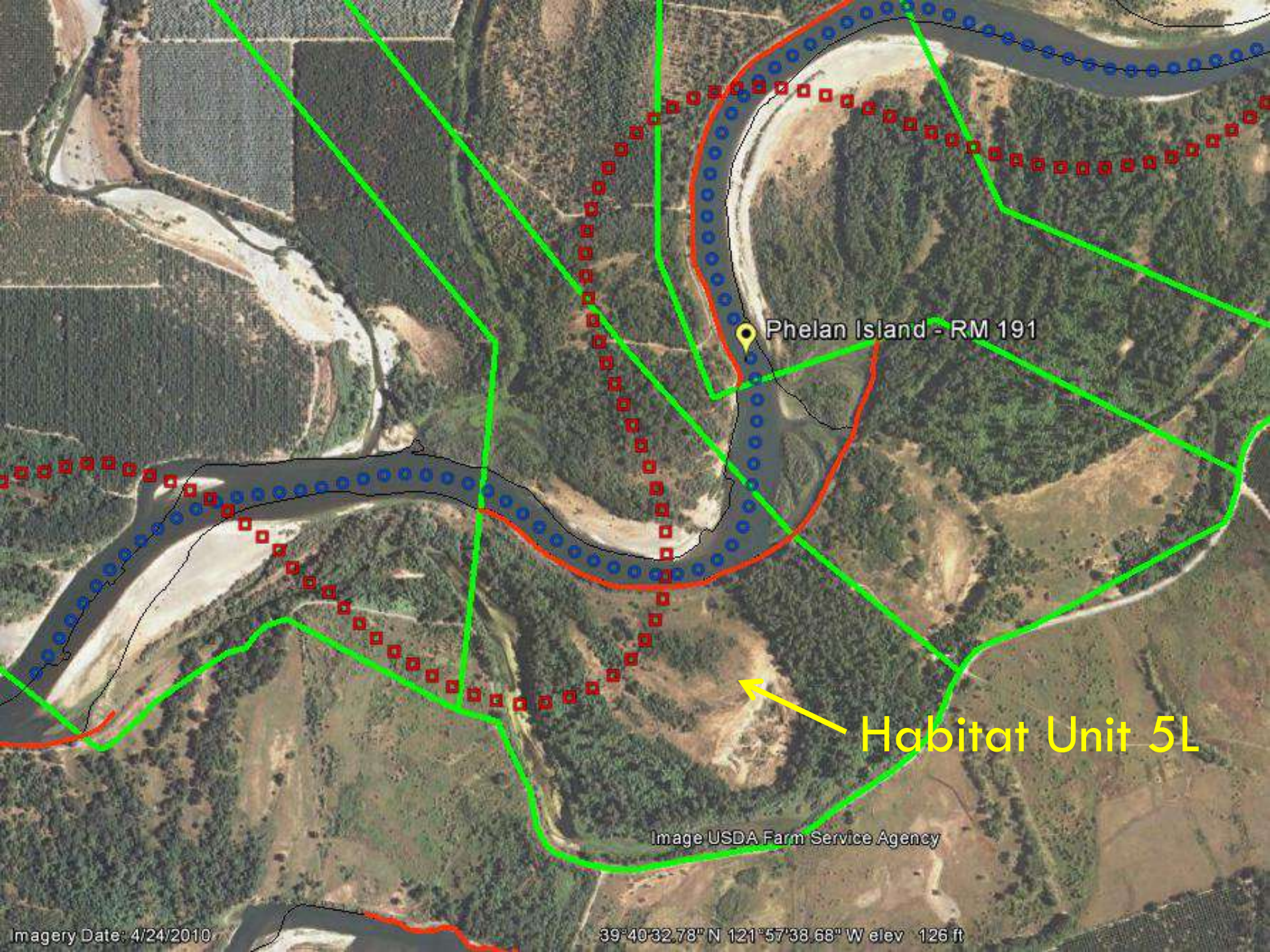
Eric Larsen's Meander Migration Modeling | Channel Curvature



Convex–right bank: Where the river bends to the right (as viewed in the downstream direction)

Straight-connector: Where the river lacks any curvature and lies between river bends

Convex–left bank: Where the river bends to the left (as viewed in the downstream direction)


Phelan Island - RM 191
Habitat Unit 5L
Image USDA Farm Service Agency
Imagery Date: 4/24/2010
39°40'32.78" N 121°57'38.68" W elev 126 ft

SAM Model Inputs

Habitat Inputs | Example for Habitat Unit No. 5 Left (5L) under EXISTING conditions

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Wetted Area	2010	857,132	857,132	857,132	857,132
(square feet)	2060	857,132	857,132	857,132	857,132
Shoreline Length	2010	3,044	3,044	3,044	3,044
(feet)	2060	3,044	3,044	3,044	3,044
Bank Slope	2010	3.5	3.5	3.5	3.5
(dH:dV)	2060	3.5	3.5	3.5	3.5
Floodplain Inundation Ratio	2010	1.0	8.0	8.0	1.0
(AQ2:AQavg)	2060	1.0	8.0	8.0	1.0
Bank Substrate Size	2010	16	16	16	16
(inches)	2060	16	16	16	16
Instream Structure	2010	0	0	0	0
(% shoreline)	2060	0	0	0	0
Aquatic Vegetation	2010	13	63	63	13
(% shoreline)	2060	13	63	63	13
Overhead Shade	2010	3	1	2	3
(% shoreline)	2060	3	1	2	3

Assumes static state with rock revetment being left in place indefinitely

SAM Model Inputs

Habitat Inputs | Example for Habitat Unit No. 5 Left (5L) under WITH-PROJECT conditions

		Seasonal Values			
Habitat Parameter	Water Year	Fall	Winter	Spring	Summer
Wetted Area (square feet)	2010	857,132	857,132	857,132	857,132
	2060	1,390,581	1,390,581	1,390,581	1,390,581
Shoreline Length (feet)	2010	3,044	3,044	3,044	3,044
	2060	4,939	4,939	4,939	4,939
Bank Slope (dH:dV)	2010	3.5	3.5	3.5	3.5
	2060	3.7	3.7	3.7	3.7
Floodplain Inundation Ratio (AQ2:AQavg)	2010	1.0	8.0	8.0	1.0
	2060	1.0	5.0	5.0	1.0
Bank Substrate Size (inches)	2010	0.3	0.3	0.3	0.3
	2060	0.3	0.3	0.3	0.3
Instream Structure (% shoreline)	2010	0	0	0	0
	2060	18	18	18	18
Aquatic Vegetation (% shoreline)	2010	13	63	63	13
	2060	13	63	63	13
Overhead Shade (% shoreline)	2010	3	1	2	3
	2060	27	7	20	27

Post-rock removal and meander migration conditions: (1) channel length (and area) increase (from meander-migration model), (2) banks are now native substrate (post-rock removal), (3) increased IWM, vegetation, and canopy from channel migration into existing riparian forest.

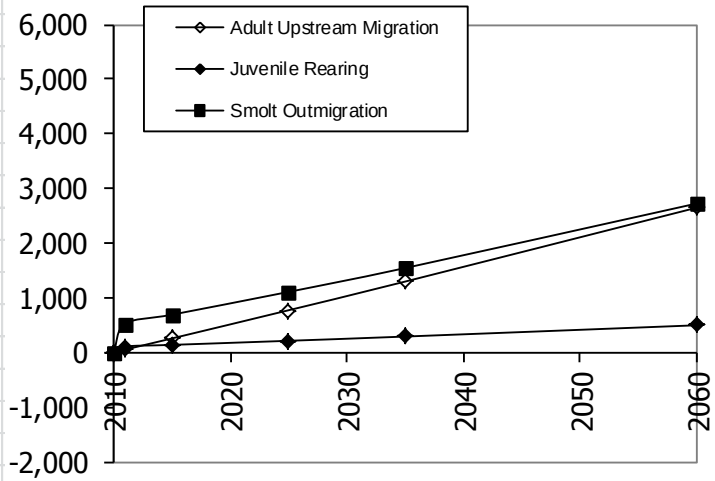
SAM Results

Winter run Chinook

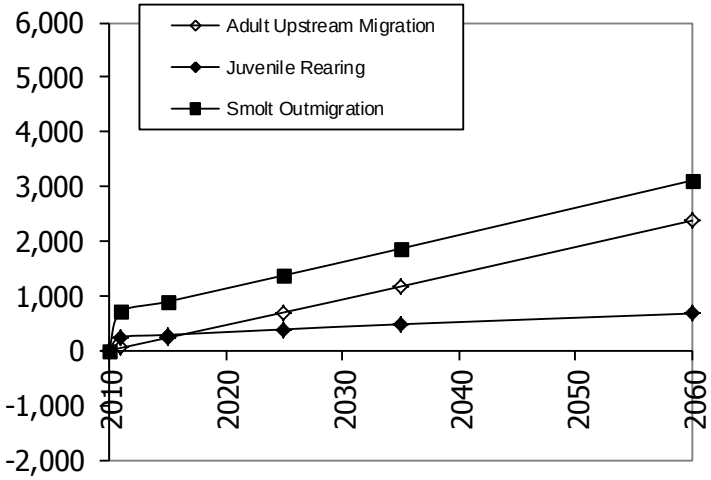
Graphical output of SAM results (example is Chinook salmon)

Bankline-weighted habitat responses (indices) in feet over time (2010–2060)

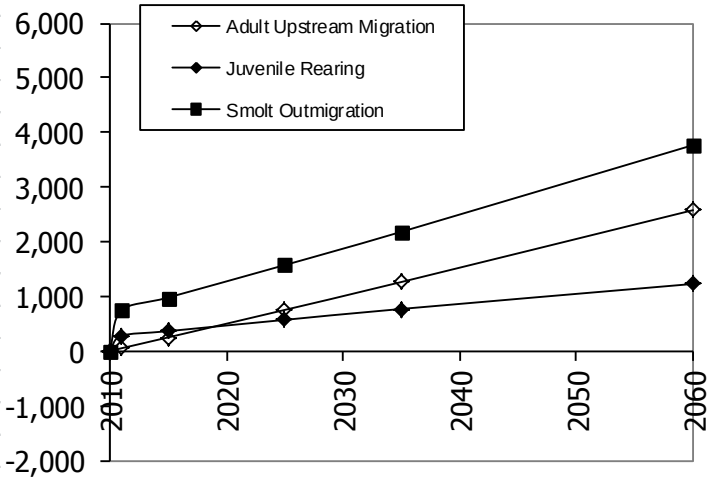
FALL



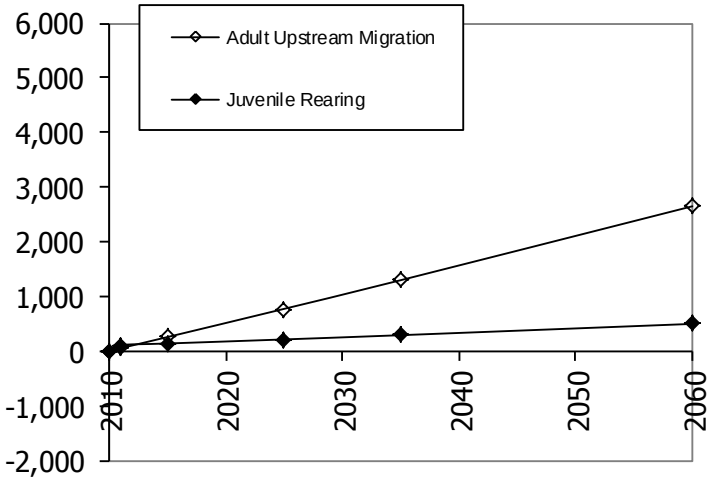
WINTER



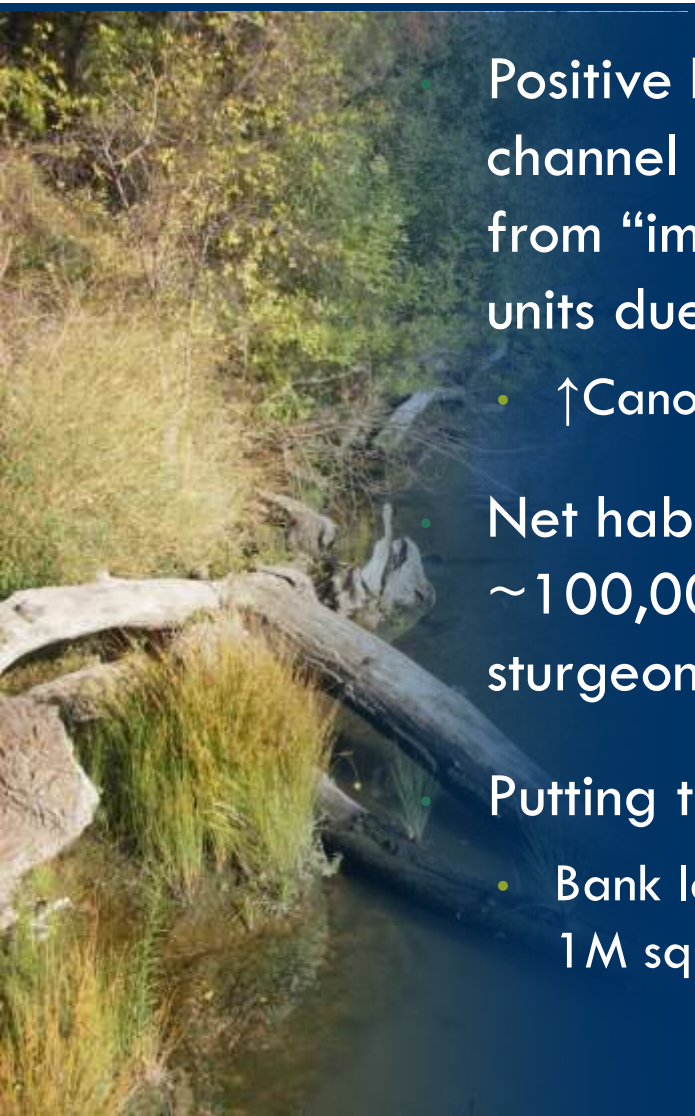
SPRING



SUMMER



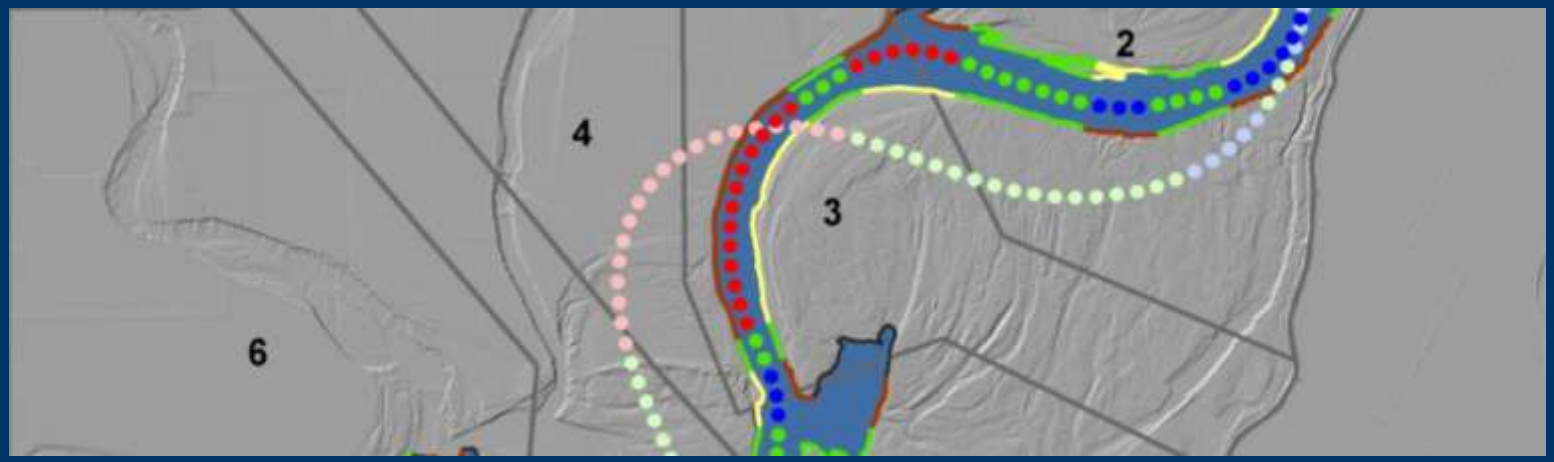
Significance of Results



- Positive habitat gains from combination of increased channel dimensions (i.e., length [sinuosity]) and some from "improved" bank-cover attributes in most habitat units due to migration into dense riparian forest:
  - ↑Canopy → ↑IWM recruitment
- Net habitat gains range ~500–4,000 linear ft and ~100,000–1,000,000 square ft for salmonids and sturgeon
- Putting this increase in perspective:
  - Bank lengths increases by ~4,000 ft and wetted area by 1M sq ft:

Conclusions - Methodology

- Enhanced typical SAM approaches to incorporate 1-D meander-migration results and interpret associated riverine processes, including change in channel position and profile, point-bar development, riparian forest succession, and woody material recruitment.
- The new techniques provide a repeatable means of extrapolating future habitat variables from the spatially limited datasets.



Conclusions - Results

- Greatest benefits would be achieved by promoting active channel migration capable of increasing channel sinuosity and/or forming cutoffs, which would increase length of shallow shoreline habitat.
- Analysis provides initial confirmation that expansion of the river floodway will potentially improve aquatic habitat conditions

Technical Preparation	Management Review	Independent Review
Glen Leverich *Stillwater Sciences* *Senior Geomorphologist*	Stacy Cepello *DWR-FESSRO* *Program Manager II*	Steve Chainey *AECOM* *Senior Ecologist*
Noah Hume *Stillwater Sciences* *Senior Aquatic Ecologist*	Adam Henderson *DWR-FESSRO* *Senior Environmental Scientist*	Lynn Hermansen *AECOM* *Restoration Ecologist*
Rafael Real de Asua *Stillwater Sciences* *GIS Analyst*	Ray McDowell *DWR-FESSRO* *Program Manager I*	Eric Larsen *UC Davis* *Associate Research Scientist*
	Ron Melcer *DWR-FESSRO* *Senior Environmental Scientist*	

glen@stillwatersci.com

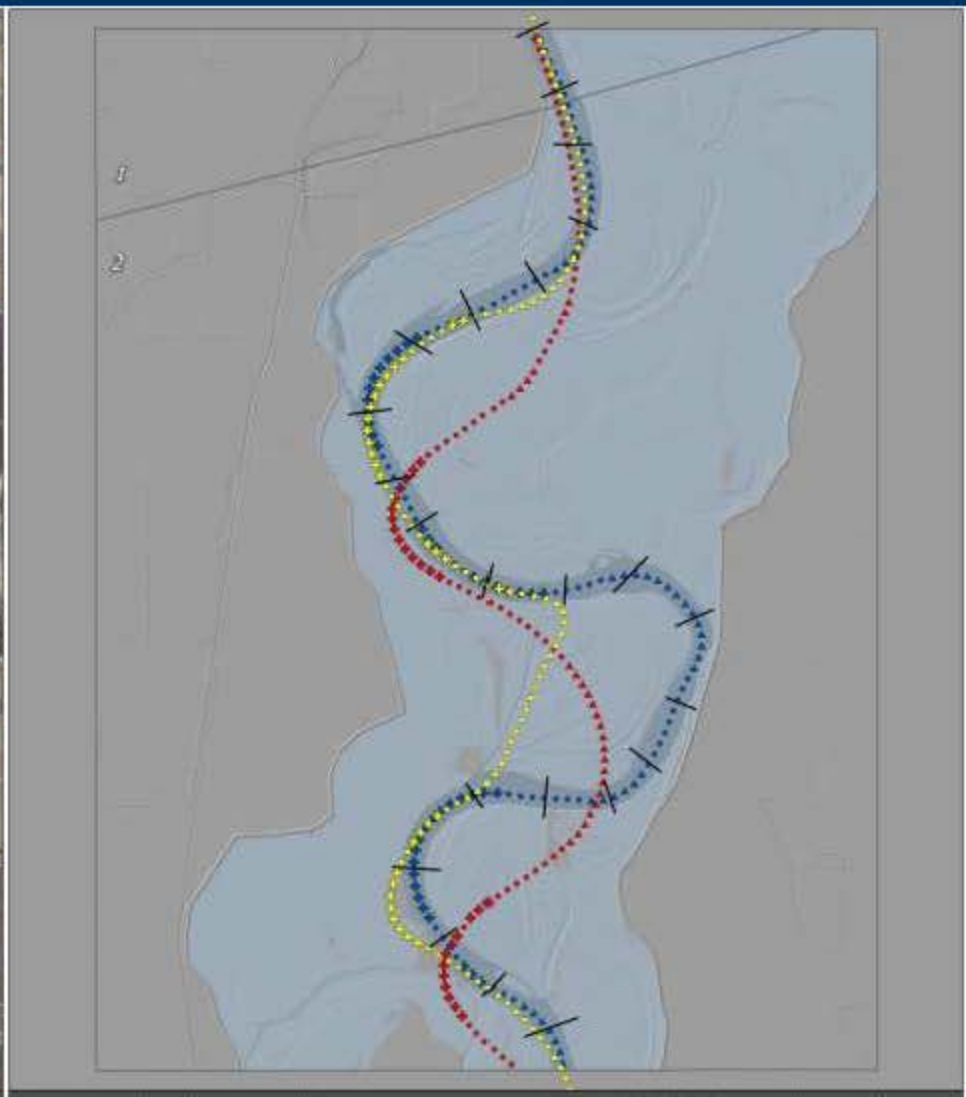
Stillwater Sciences

Future Considerations / Data Needs

- Adequate consideration of downstream habitat responses
- Programmatic approach to evaluating site suitability
- Other onsite habitat enhancement/mitigation features
- Adult migration response to changing channel dimensions
- Consideration of steelhead spawning at upper sites…?

- Reach-specific hydraulic data
- Updated, seamless elevation surfaces
- 2-D meander-migration modeling → x-sect profiles
- Field inventory of existing habitat conditions
- Other site-evolution models (e.g., EAH, riparian growth, IWM)

Sac RM 172 – Natural Meander Cut-off



Sac RM 172 – Natural Meander Cut-off

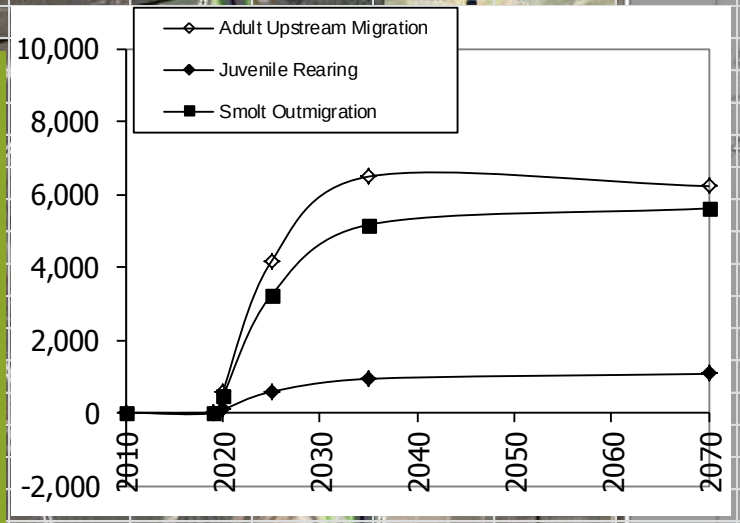
Winter run Chinook

Site dimensions increased in future conditions due to oxbow formation

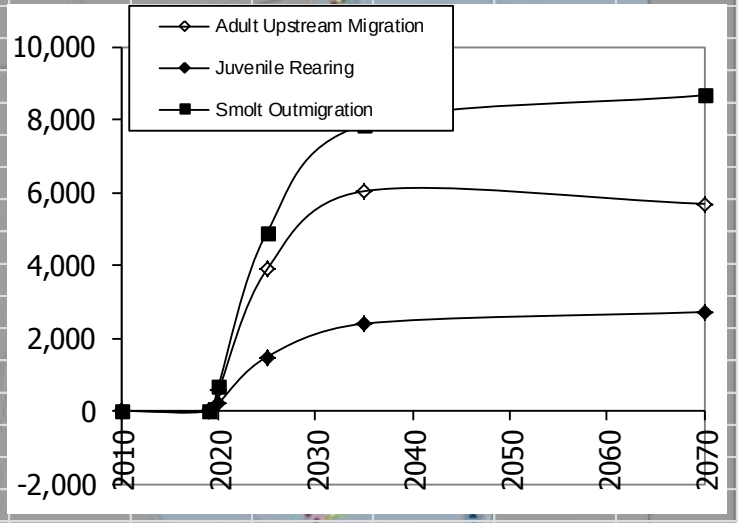
→ Positive habitat responses for all populations life-stages starting in 2020

→ Slight reduction 2020–2070 due to reduction of oxbow channel dimensions (active channel re-migrating into oxbow position)

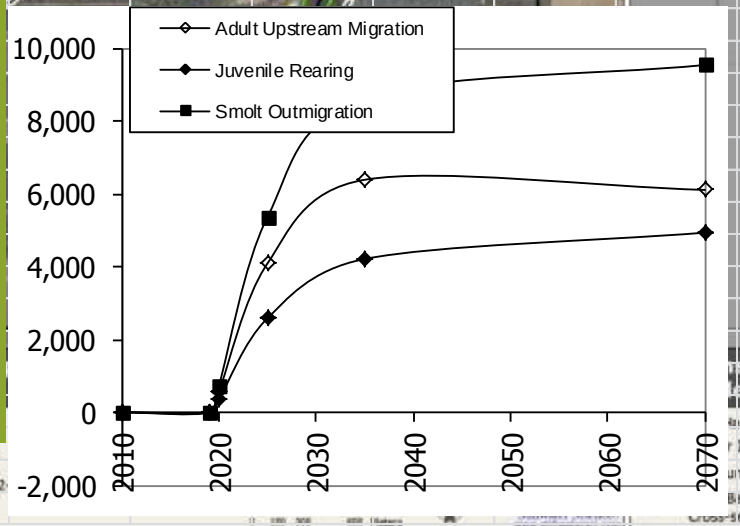
FALL



WINTER



SPRING



SUMMER