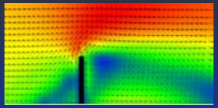
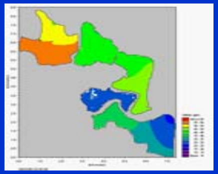
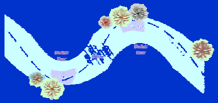
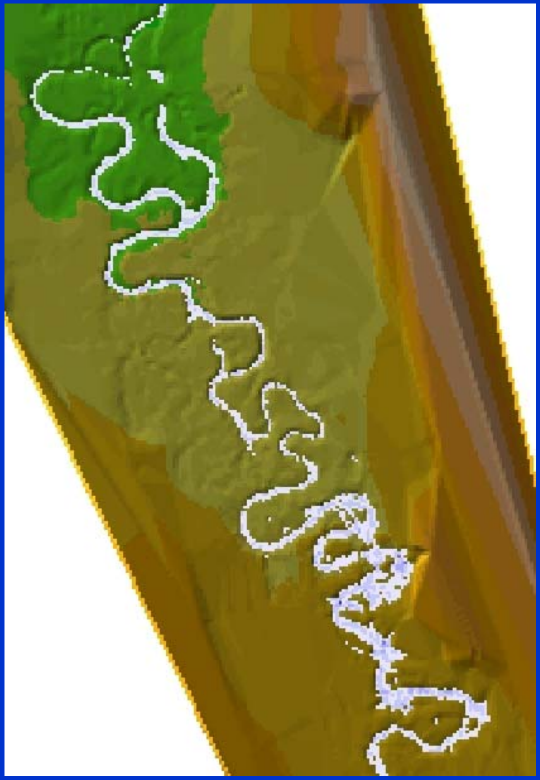
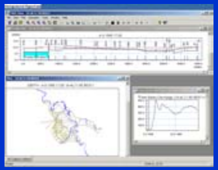


Modeling as a Tool for Floodplain Restoration





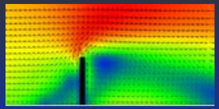


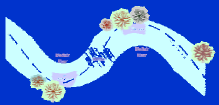


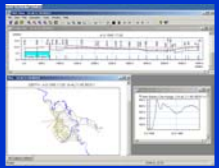
February 24, 2004, 4:15pm to 6:00pm

California Water and Environmental Modeling Forum, 2004 Annual Meeting

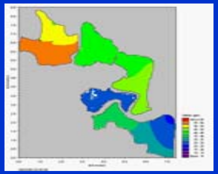
Dr. Chris Bowles, Mr. Tom Smith, Dr. Michael Anderson








Introductions


Chris Bowles, Ph.D.

Associate Principal

PWA Ltd., Sacramento

Thomas W. Smith, P.E., G.E.

Regional Manager

Water Resources/Geotechnical Engineer

Ayres Associates

Michael Anderson, Ph. D.

Principal Associate

Civil and Environmental Engineering

UC Davis

Questions for the session:

1. What are the significant challenges and pitfalls of floodplain restoration modeling?
2. Can better - more advanced - modeling tools produce better floodplain restoration design?
3. What level of modeling is justified (technically and financially) as a floodplain restoration planning tool?

Maintain focus on our objectives…

Engineering and modeling should not be considered in isolation……

"Restoration means restoring physical processes - not gardening…" (Phil Williams, 2001)

What are the significant challenges and pitfalls of floodplain restoration modeling?

CHALLENGES:

- Predicting the interactions between river and floodplain zones.
- How to model a range of hydrologic conditions to understand the probabilistic site conditions (event modeling vs continuous modeling)

PITFALLS:

- "Over modeling" - modeling for the sake of modeling.
- Models being accepted as the truth.
- Assumption of static conditions in a dynamic world

Can better - more advanced - modeling tools produce better floodplain restoration design?

A qualified "YES":

- If sufficient data exists to support level of effort.
- If the system is understood sufficiently to warrant modeling the system - the more it is understood the more it is simplified.
- What is the level of model simplicity capable of predicting the results to an acceptable level of accuracy?

Model selection

- Question to be answered
- Quality of input data
- Quality of calibration data (response variables)
- Required accuracy
- Spatial scale of problem
- Budget

The Dimensionality of Models

- Various dimensions of numerical modeling
- Applicability of models for different scenarios: hydraulic, temperature, sediment transport, water quality
- Relative costs (numerical and financial)
- Relative limitations of models of different dimensions (0-D, 1-D, 2-D and 3-D)
- Criteria for the selection of suitable models

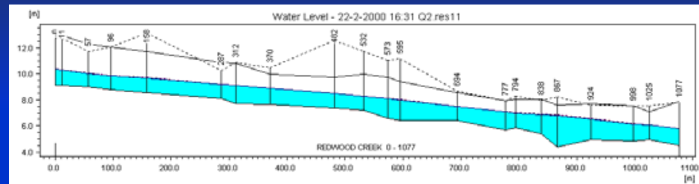
Can better - more advanced - modeling tools produce better floodplain restoration design?

- Simplify reality as the number of modeling dimensions is reduced.
- 1D modeling – more engineering judgment required.
- Selection of modeling tools depends on what physical processes are to be represented.

- Case studies:
  - SJRNWR – 1D versus 2D

WHICH DIMENSION FOR WHICH JOB?

1D

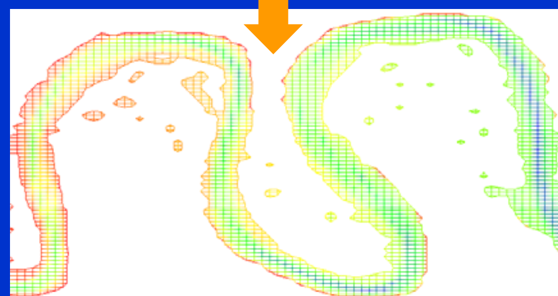


2D

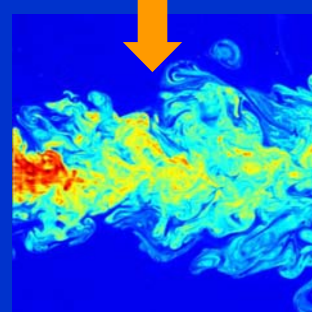
+

Degree of Approximation

–



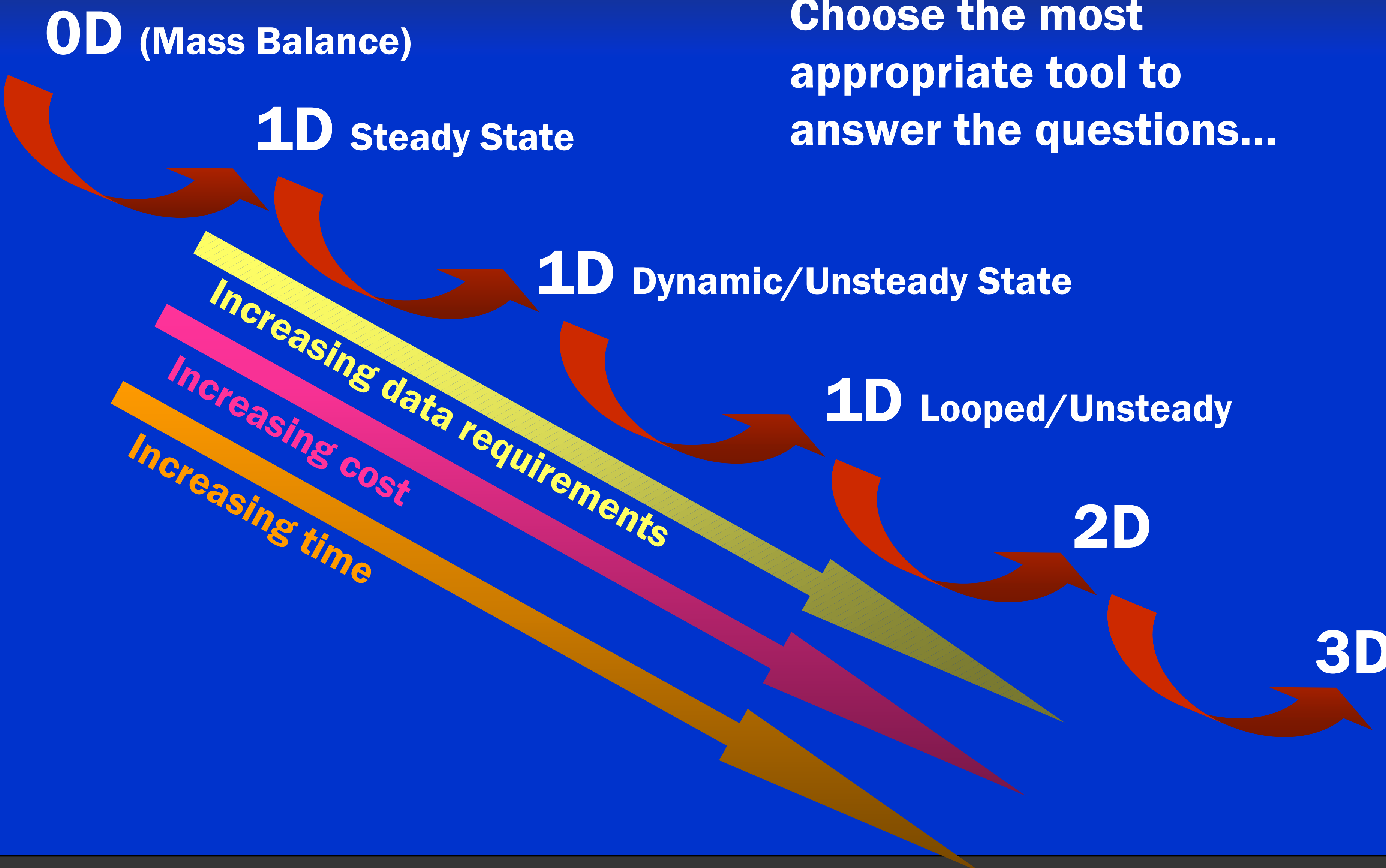
3D



- Large scale flood analyses (reaches on the scale of miles)
- Sediment transport, water quality modeling at the reach scale
- Morphological modeling
- Floodplain modeling
- Flow around structures (obstacles such as groins, ELJs, etc)

WHICH DIMENSION FOR WHICH JOB?

Choose the most appropriate tool to answer the questions…



DATA REQUIREMENTS

- Availability of data important in selection of model
- No point applying complex 3D if only cross section information is spaced at one mile intervals and is 10 years old!
- Should be sufficient data to:
  1. Understand recent historic evolution of channel
  2. Calibrate model based on recent hydrologic event
  3. Validate performance of model based on independent hydrologic event
  4. Verify predictions of model using post project data
  5. Confirm long term viability of project by establishing long term monitoring program

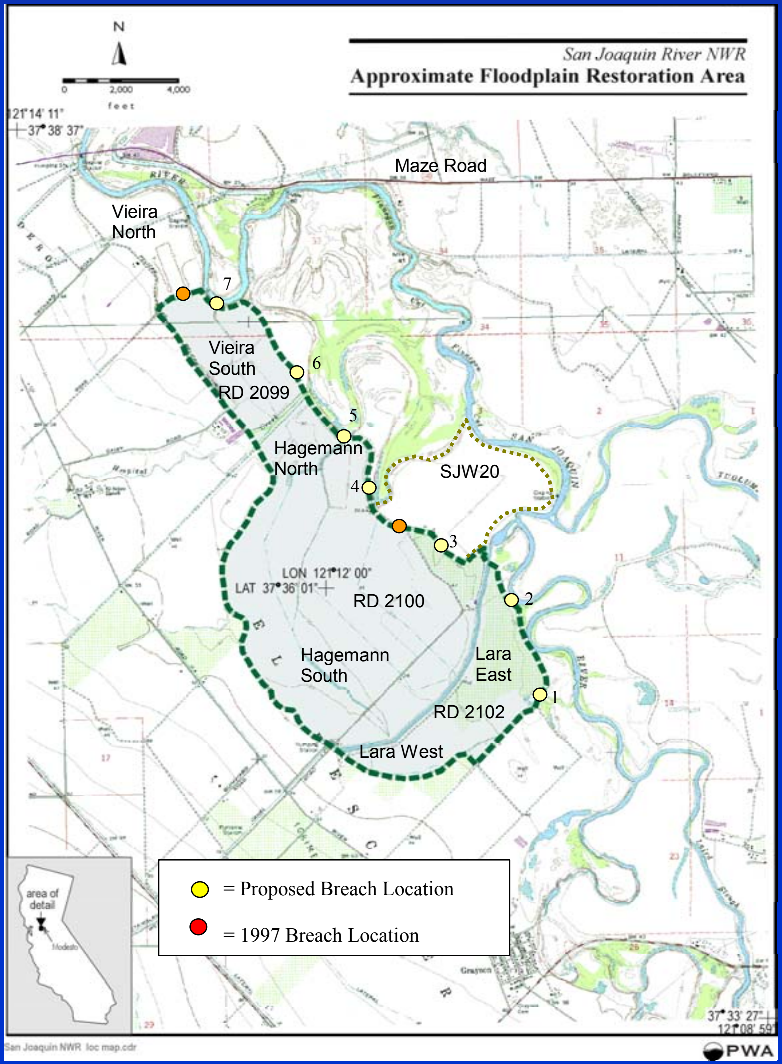
PWA

Can better – more advanced – modeling tools produce better floodplain restoration design?

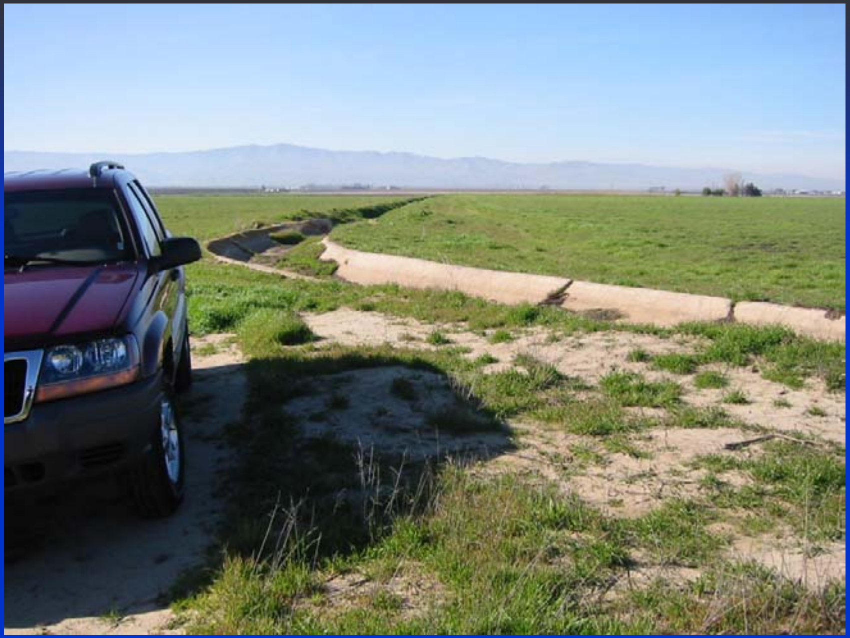
Case studies:

- SJRNWR – 1D versus 2D

San Joaquin River National Wildlife Refuge



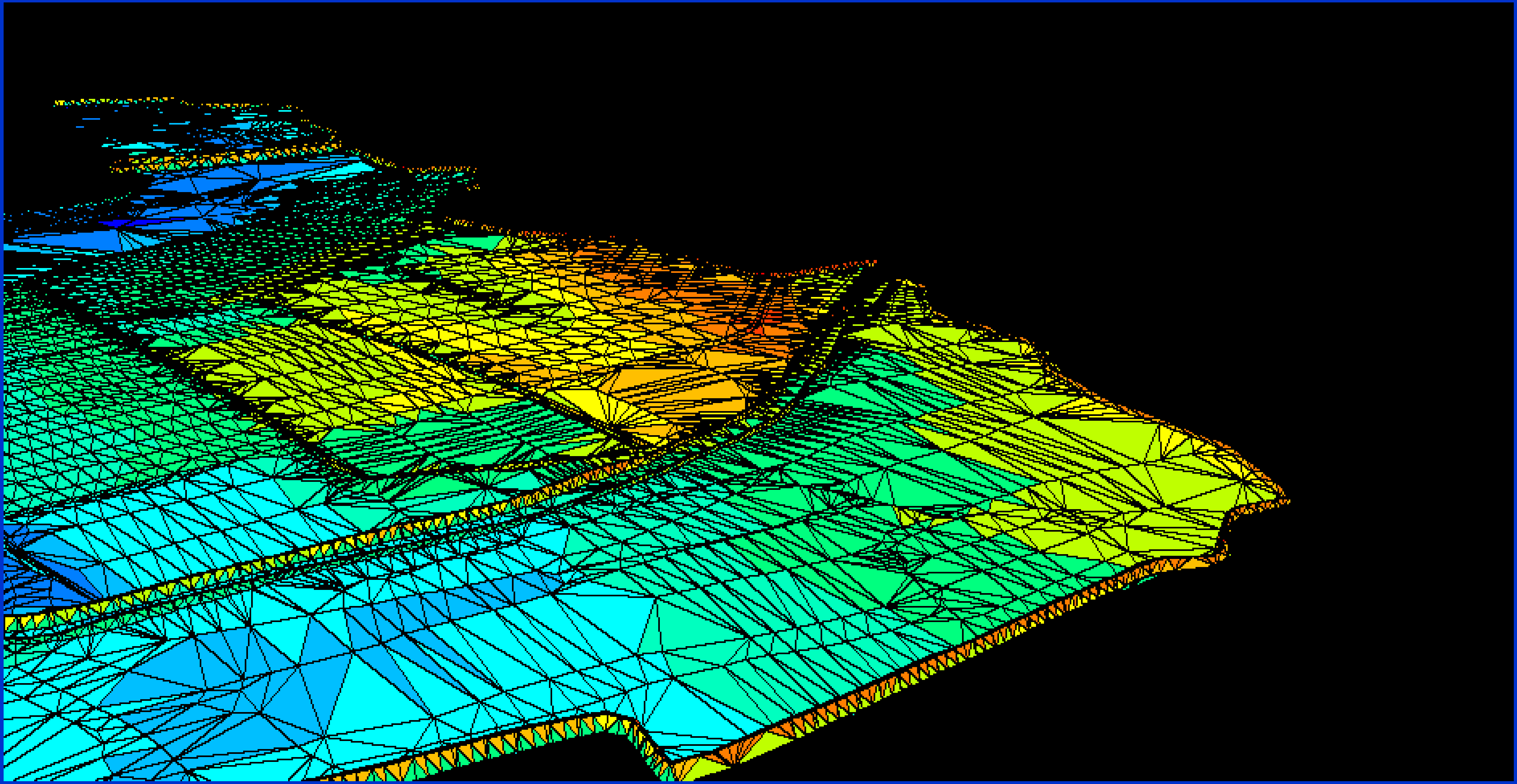
Comparison of 1-D to 2D



Topographical Data

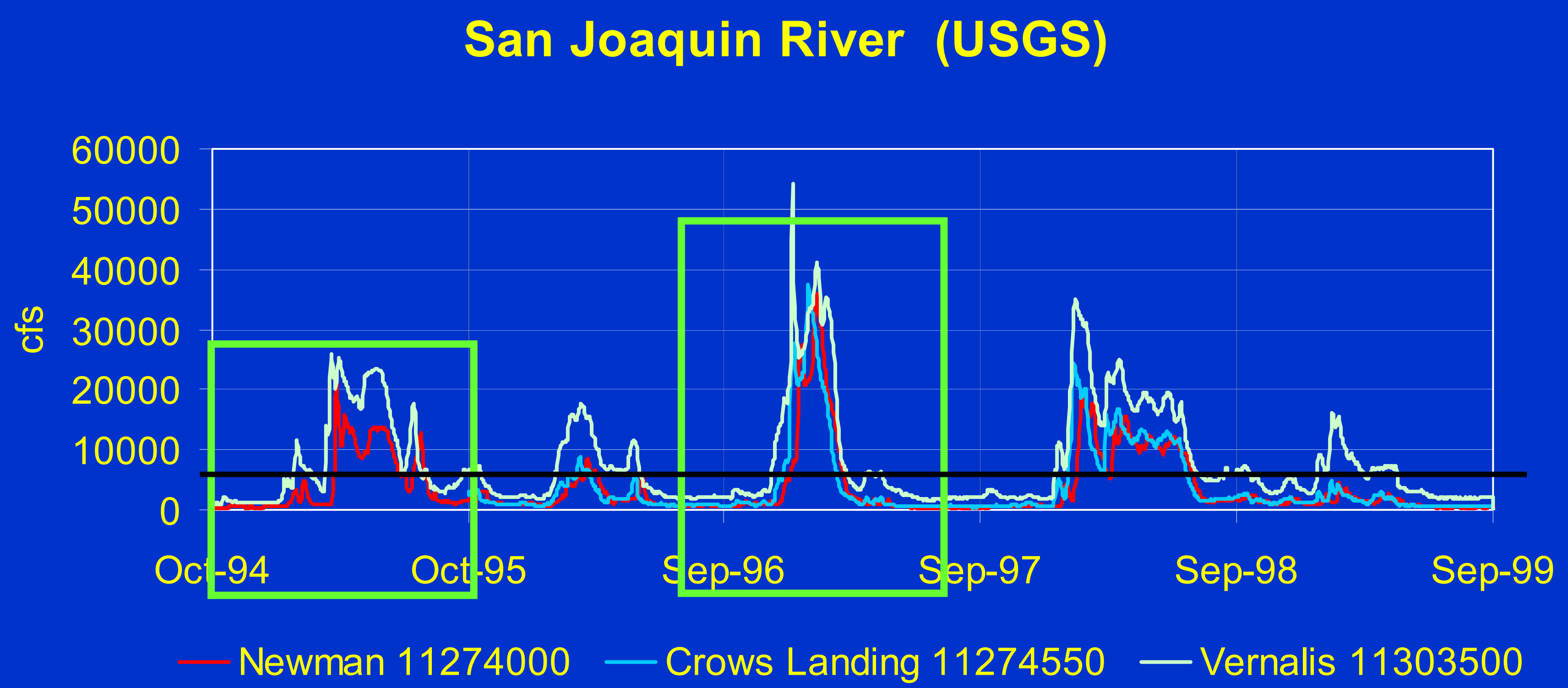
- USACE Central Valley Comprehensive Study (CVCS)
  - Coverage of Digital Terrain Model (DTM) – 300 feet either side of main channel to project levees
  - no photogrammetry
  - Defines main channel and parts of floodplain
- USGS 30 meter Digital Elevation Model (DEM) to supplement DTM of main channel and parts of floodplain provided by CVCS.
  - Contour intervals = 5 feet
  - Not ideal but the best available

Topographical Data

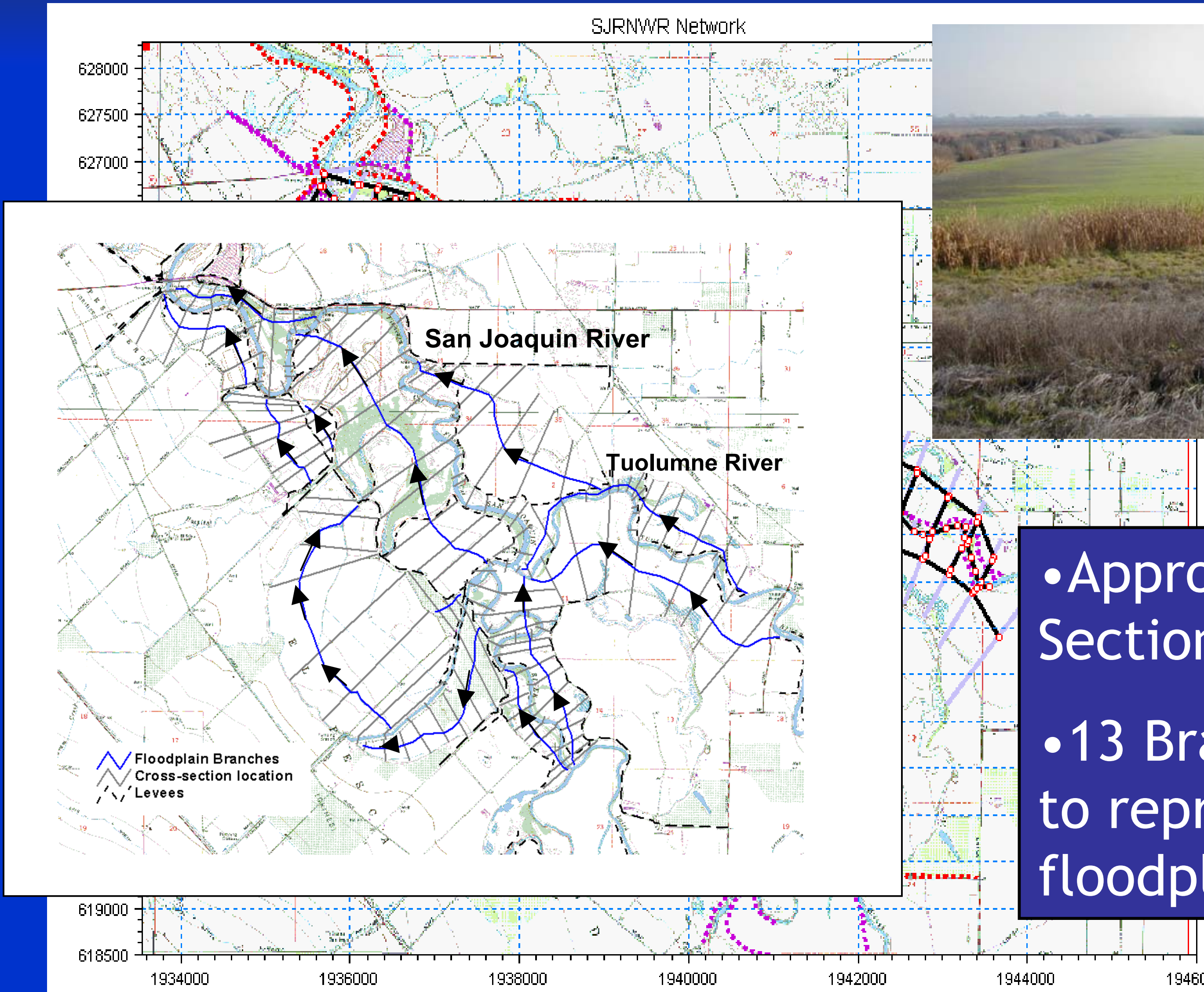


Hydrologic Data

Hydrologic Data

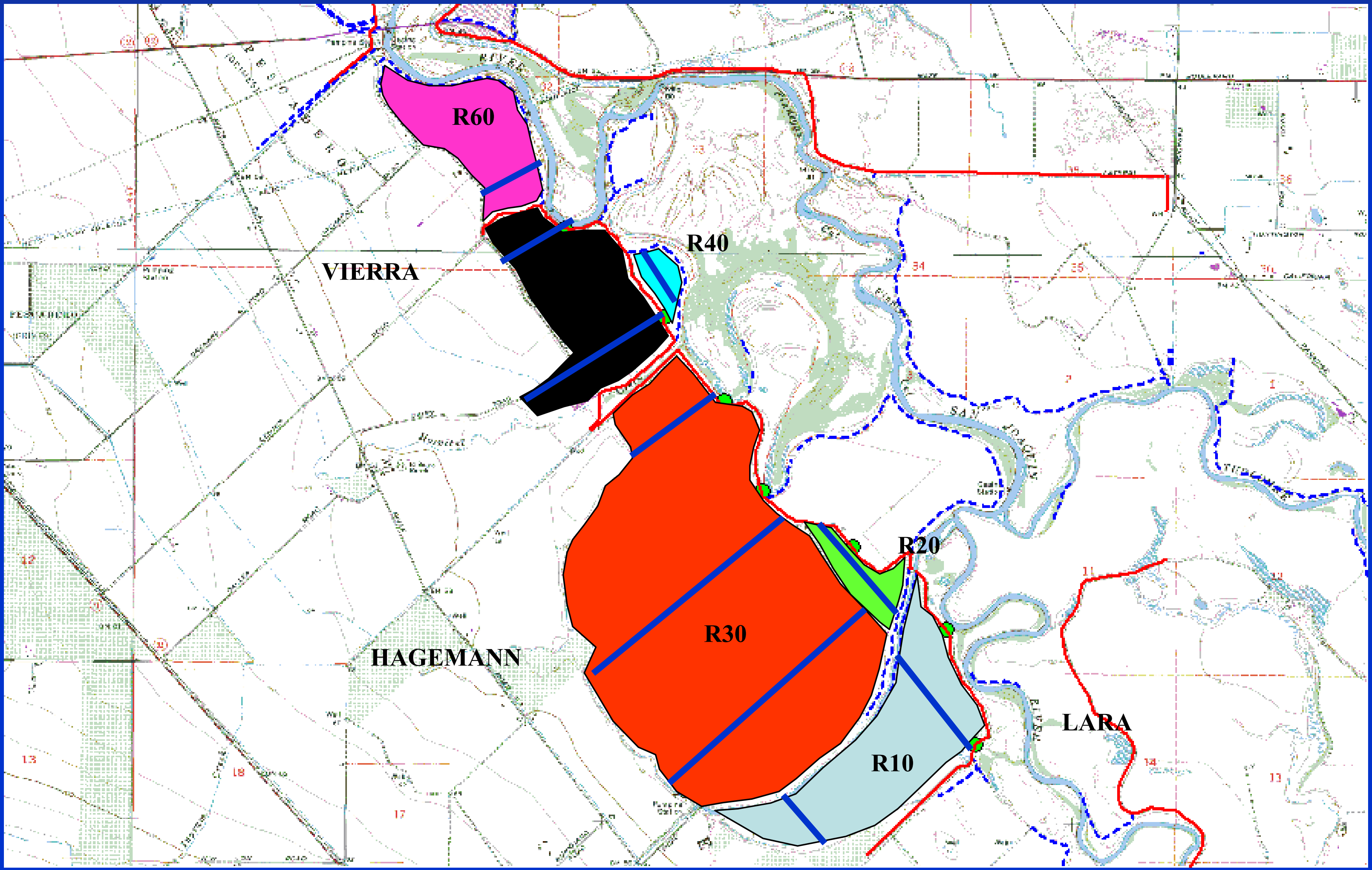


Model Schematization



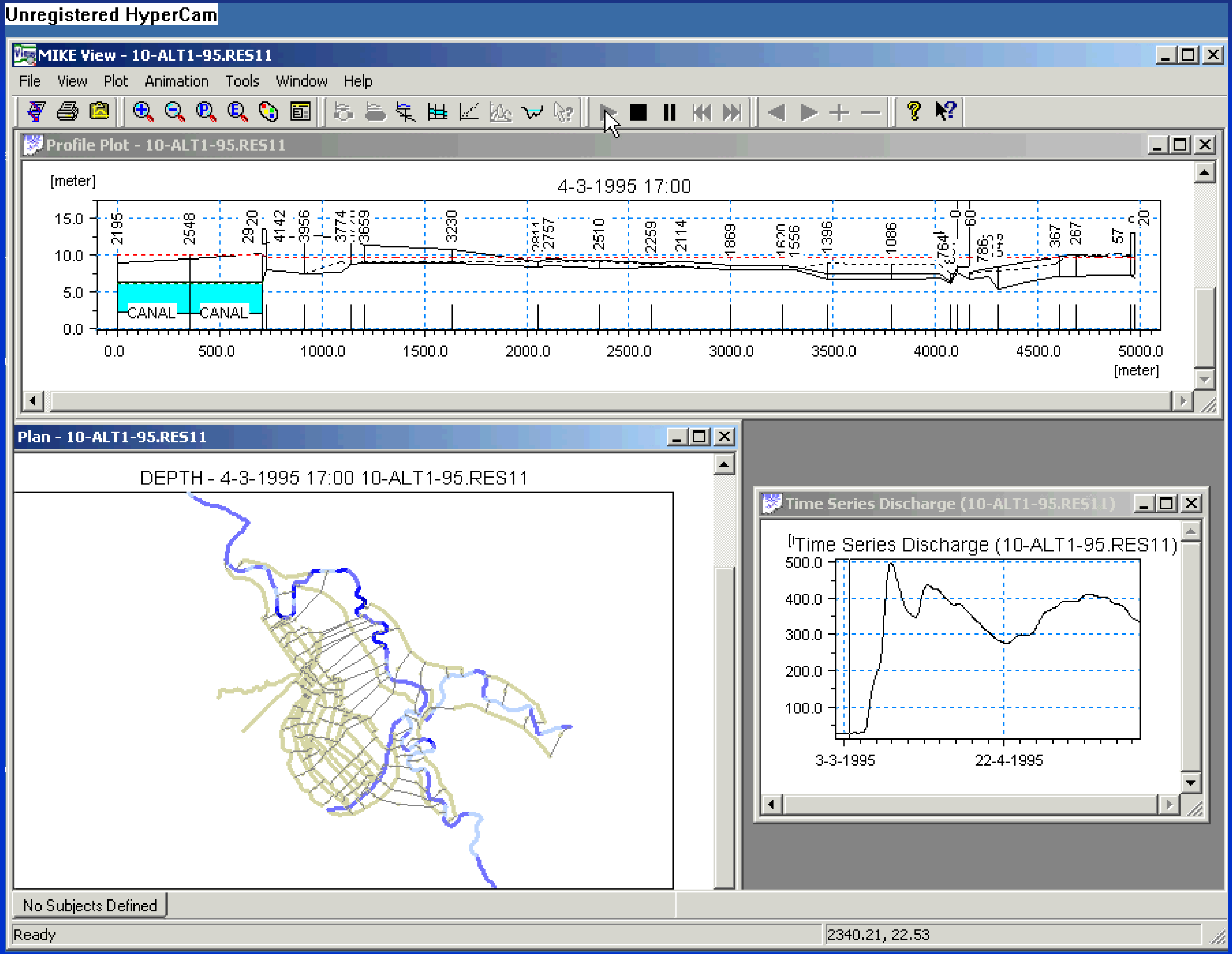
- Approx 300 Cross Sections
- 13 Branch channels to represent floodplains

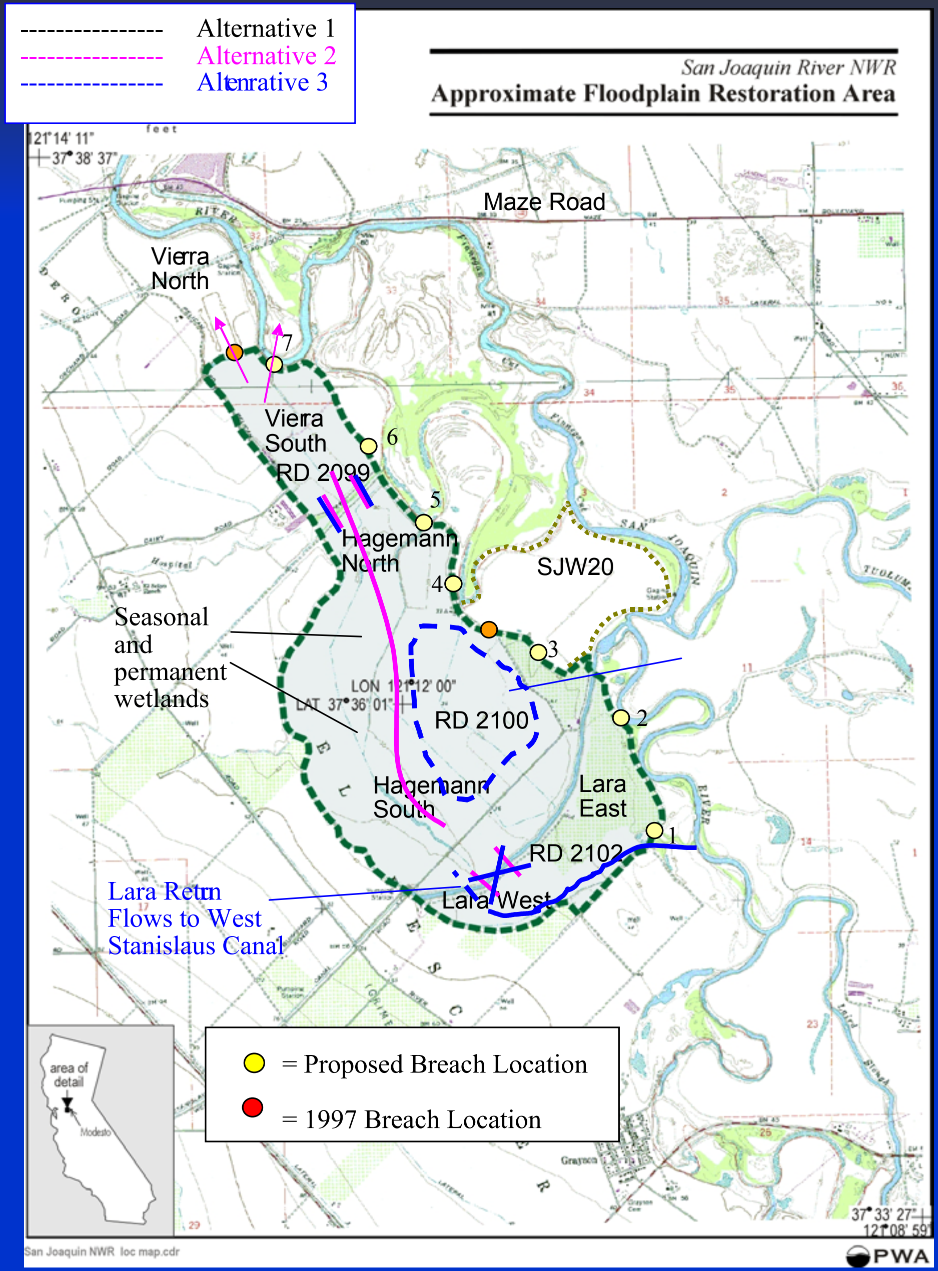
Model Areas



PWA

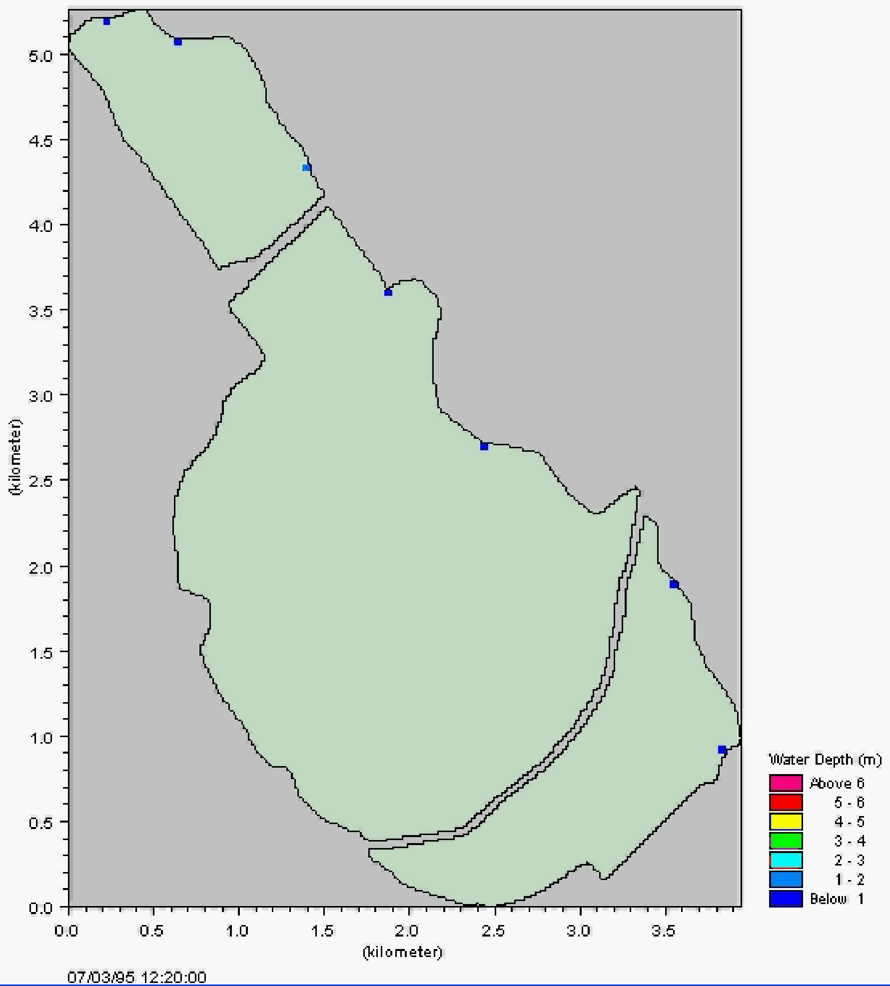
Looped 1D Model - San Joaquin River National Wildlife





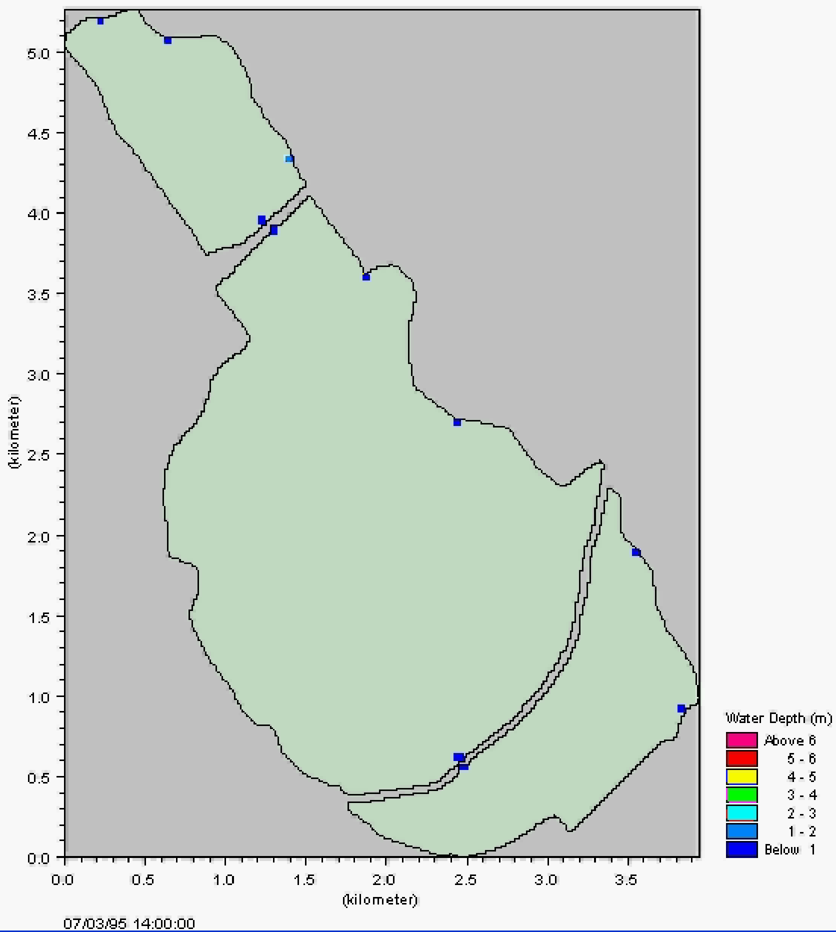
SJRNWR – Phase 2 Modeling of Alternatives

Phase 2 Results

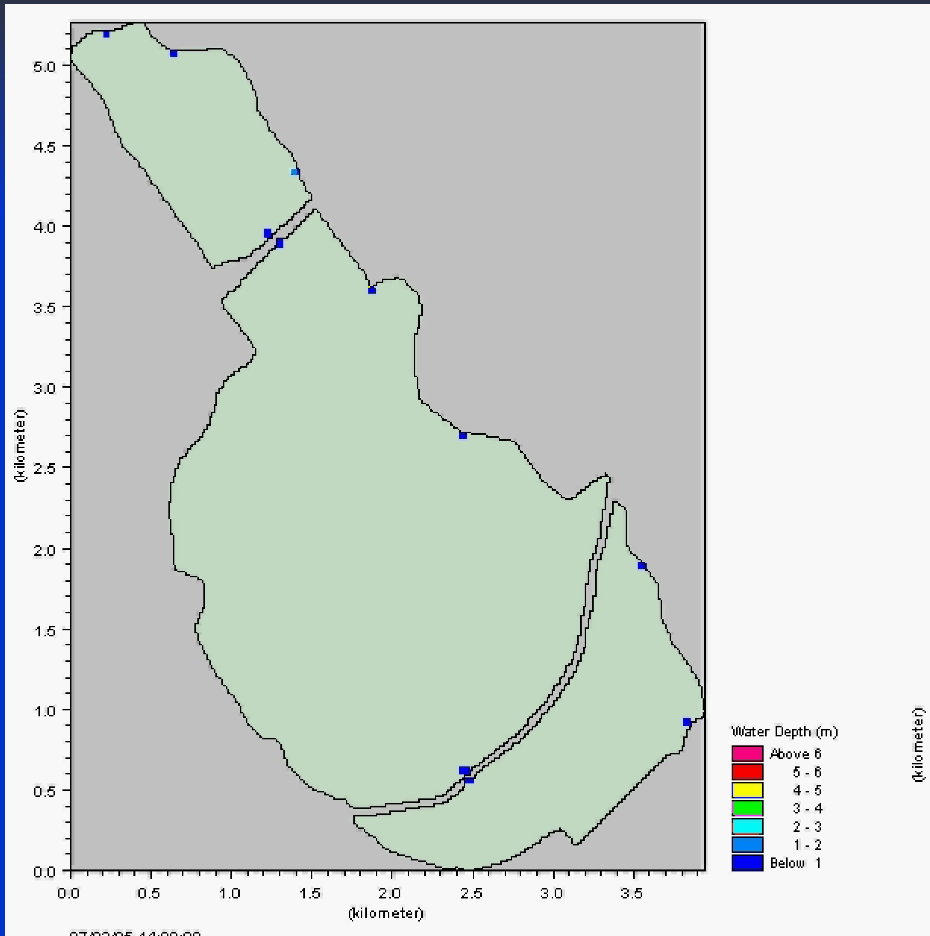


Alternative 1

Alternative 2

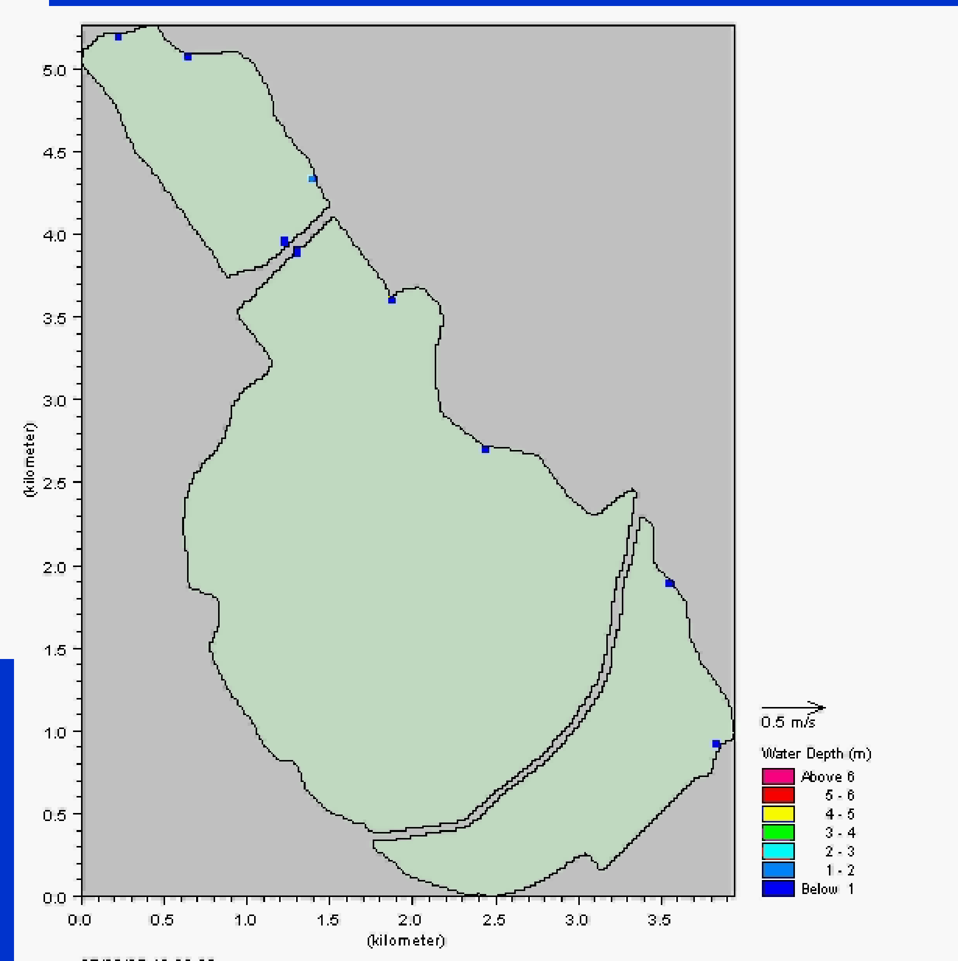


Phase 2 Results



Alternative 2

Alternative 3



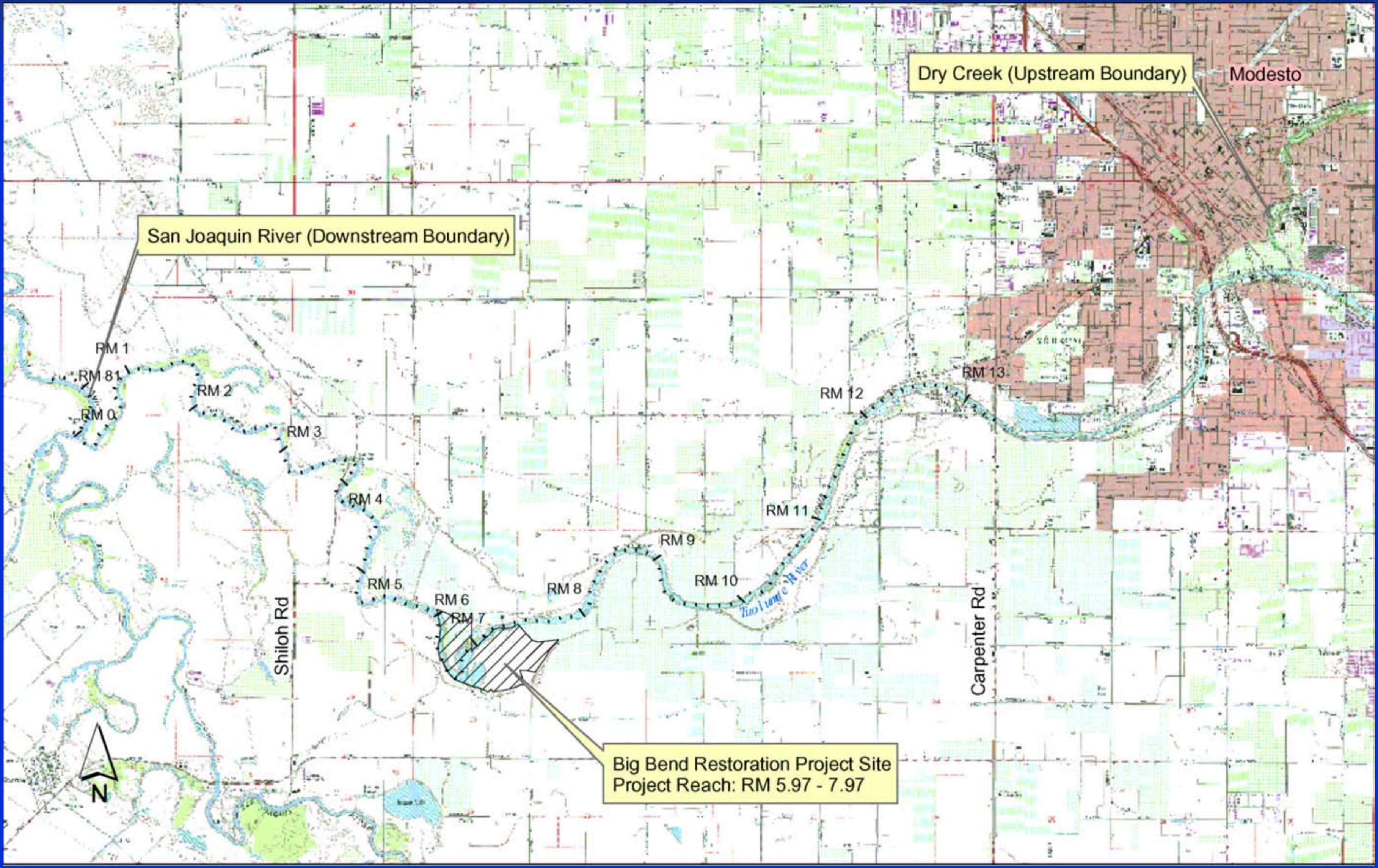
Habitat Evaluation Criteria

PARAMETER	VALUE	SPECIES	BIOLOGICAL IMPORTANCE
Recurrence Interval	Minimum 2-3 year return period	Splittail	Ensure adequately-frequent spawning
Timing of flooding	Late February to April	Splittail	Principal spawning and rearing months
	May	Splittail	Spawning and rearing may extend into May
	December to May	Chinook salmon	Rearing habitat for juveniles
	Prior to February	Splittail	May increase habitat value by providing additional forage for adults
	December to May	Phytoplankton Zooplankton	Improved production prior to arrival of juvenile and adult salmon, splittail
Duration of flooding/mean hydraulic residence time	> 2 days	Phytoplankton	Improved production
	14 days – several weeks	Zooplankton	Improved production
	> 14 days	Splittail, chinook salmon	Adult spawning, incubation and larvae to develop sufficiently to move with receding flow
End of inundation; connectivity	Avoid non-draining floodplain with depressions > 1ft	Non-native fish	Avoidance of predator or non-native fish and reduction of salmon spltittail stranding
Velocity and depth	Mean Velocity >0, <3 ft/sec	Splittail Chinook salmon	Adult splittail spawning in faster water, juvenile splittail use of slower water; salmon rearing only in moving water; both need flow cues to avoid stranding
	Total surface area between 6" and 6' in depth	Splittail Salmon	Slpittail spawning, splittail and salmon habitat

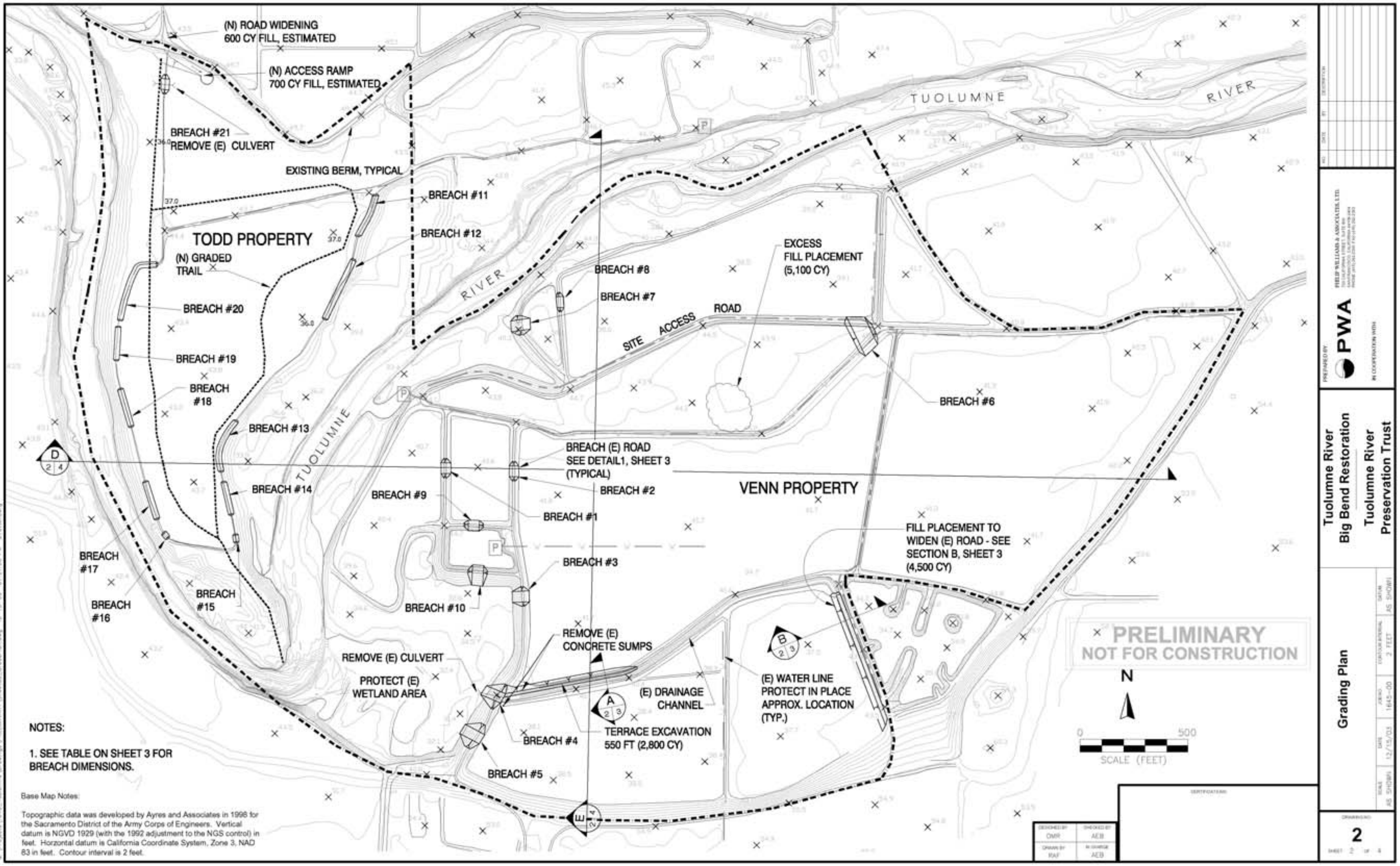
What level of modeling is justified (technically and financially) as a floodplain restoration planning tool

- Two case studies:
  - Tuolumne – 1D for Rec Board purposes
  - SRNWR – 1D for flood hazard reduction and ecosystem restoration

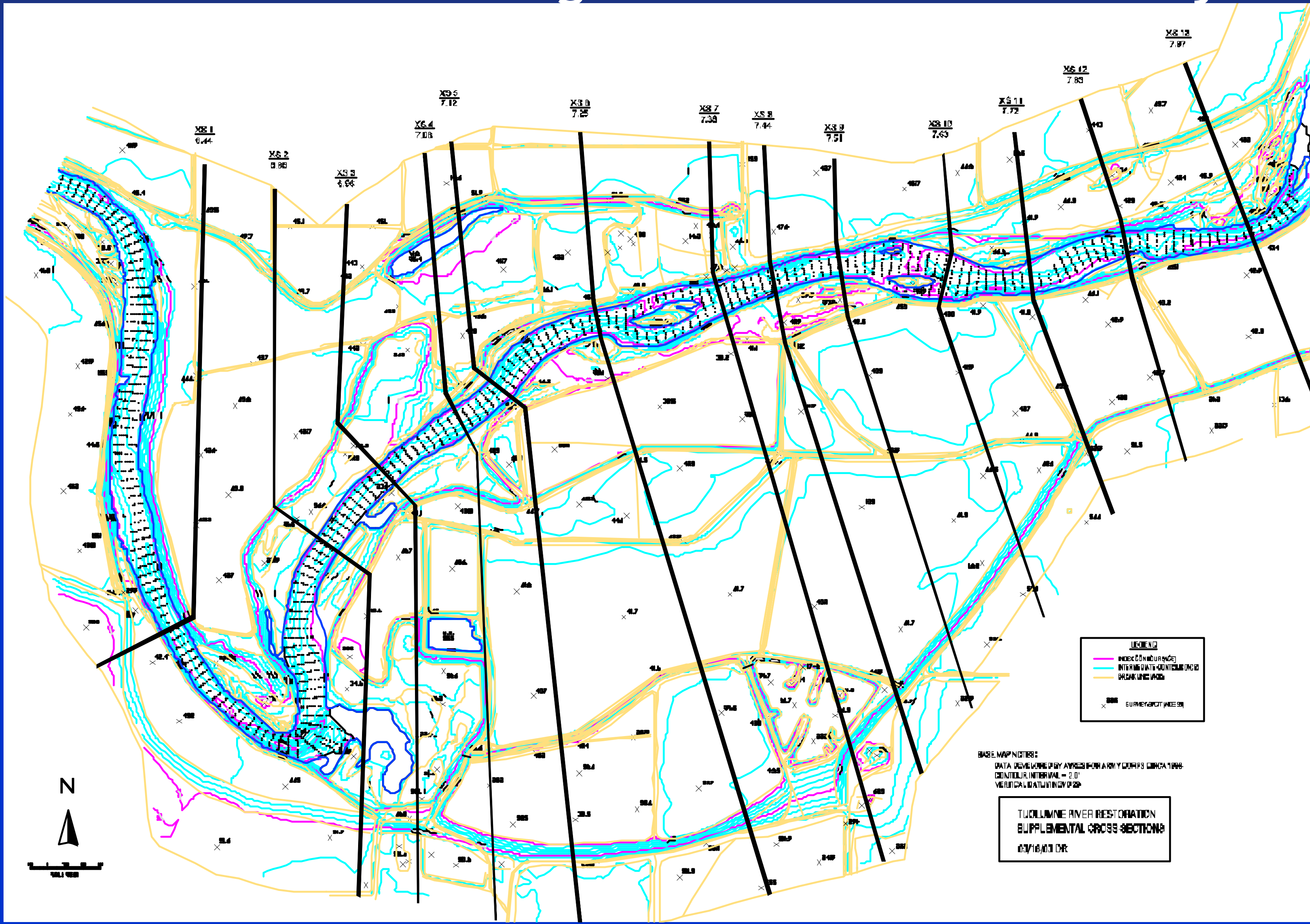
Tuolumne River – Big Bend – Restoration Project



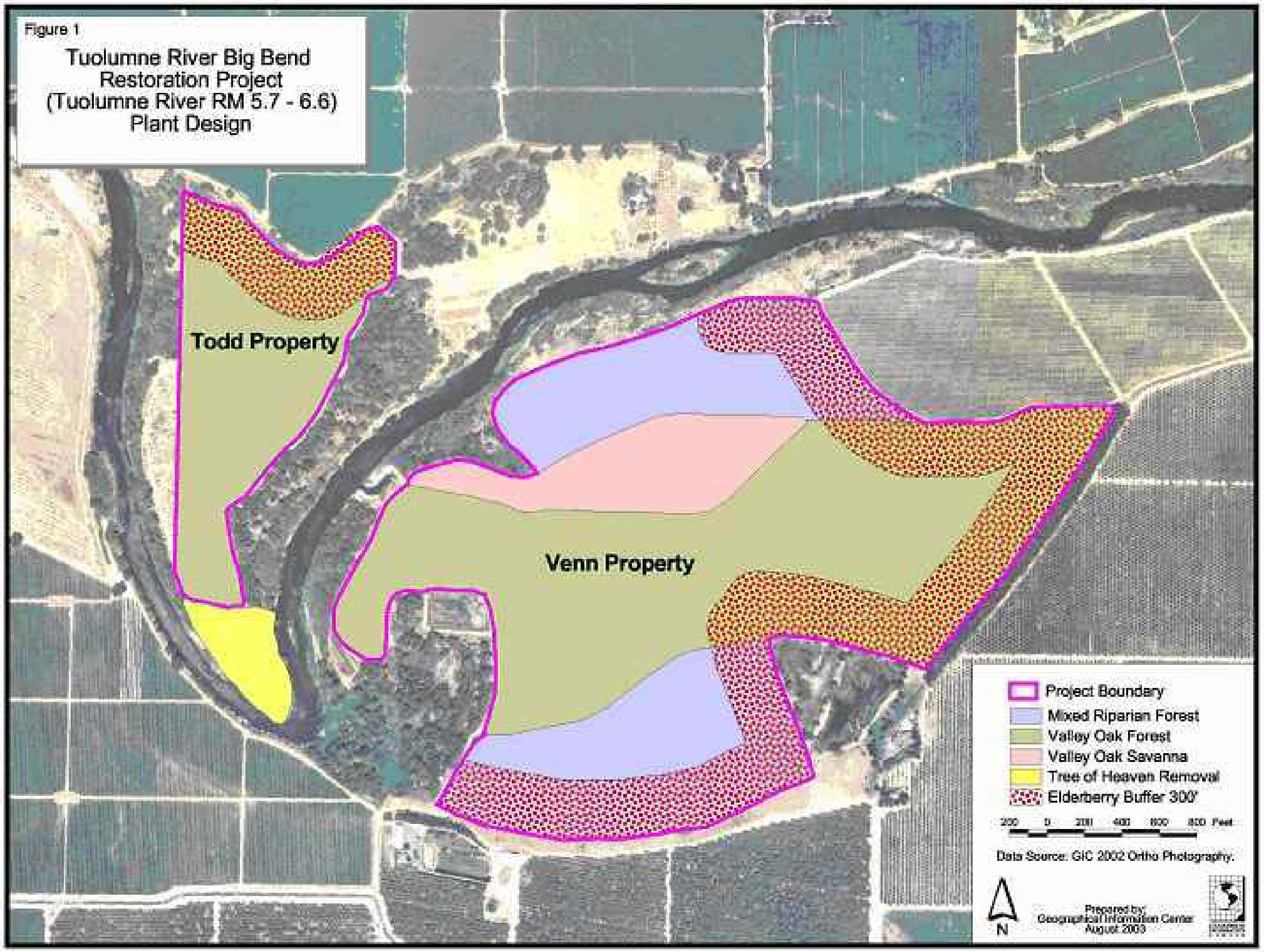
Tuolumne River – Big Bend – Restoration Project



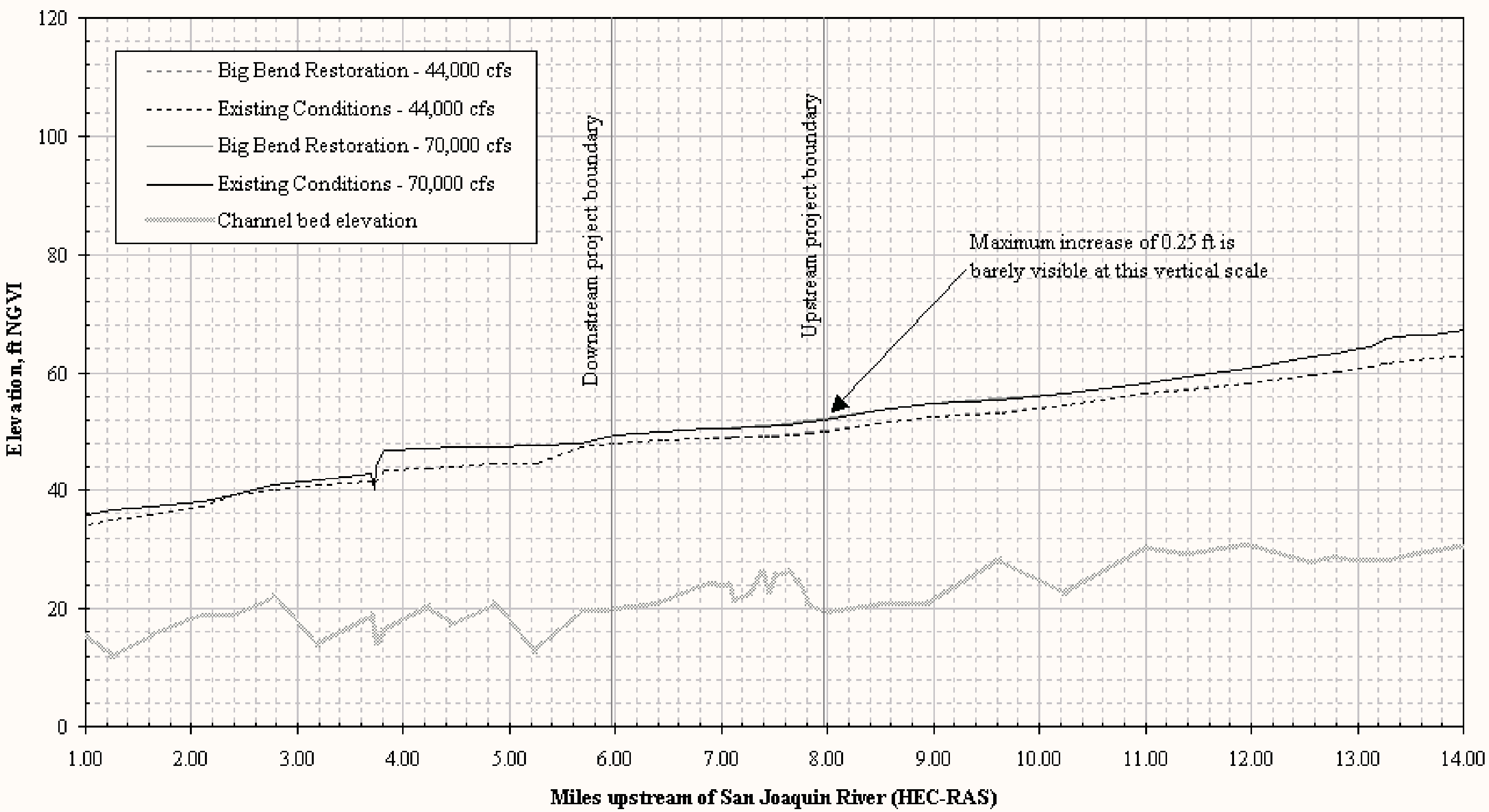
Tuolumne River – Big Bend – Restoration Project



Tuolumne River – Big Bend – Restoration Project



Tuolumne River – Big Bend – Restoration Project



Notes: BigBend.prj; Plans: Steady-10 (BigBend.p18), Design-4 (BigBend.p22), and Design-4-70k (BigBend.p23); locations are approximate; not to scale.

figure 6-2

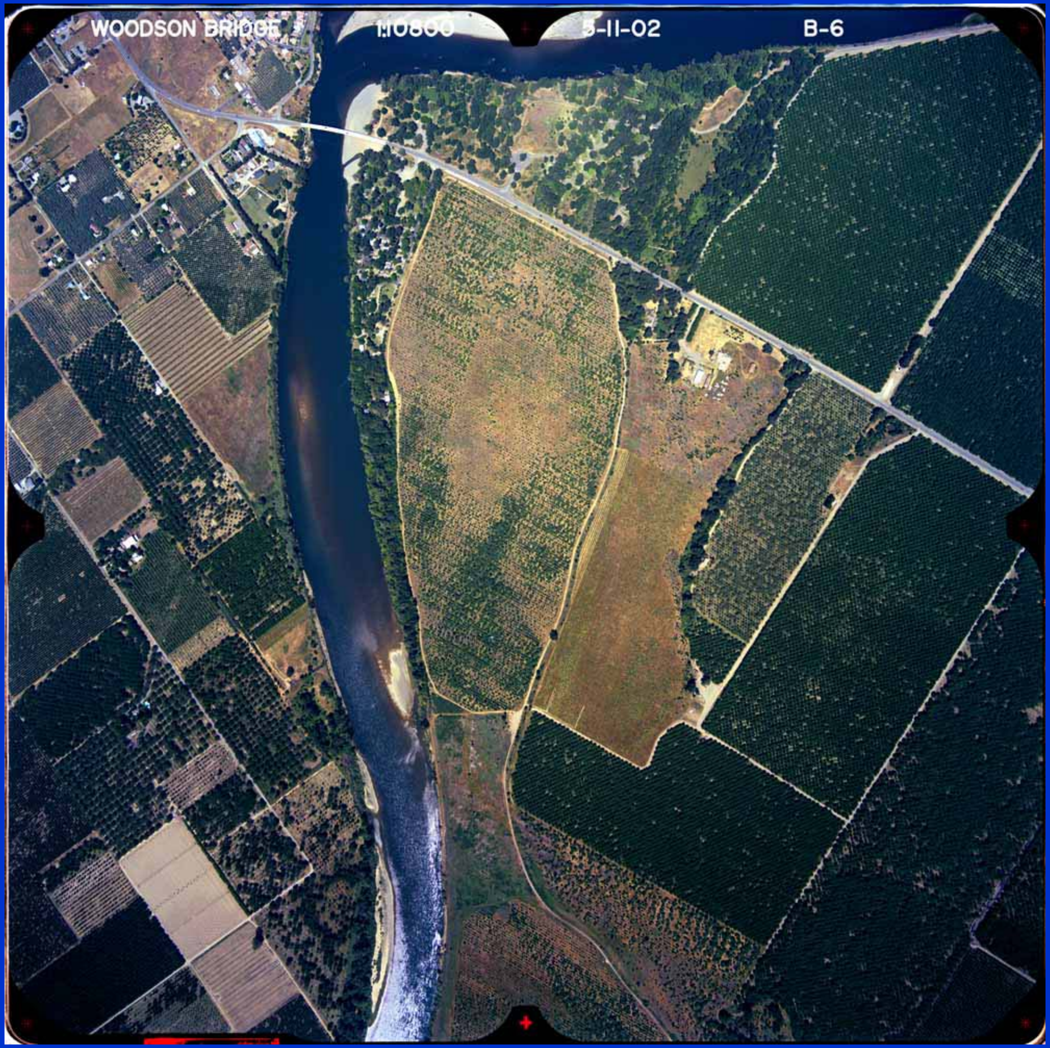
Tuolumne River Big Bend Restoarion Flood Impact Analysis

Design Water Surface Profiles for Base & Project Conditions

PWA REF 1646

PWA

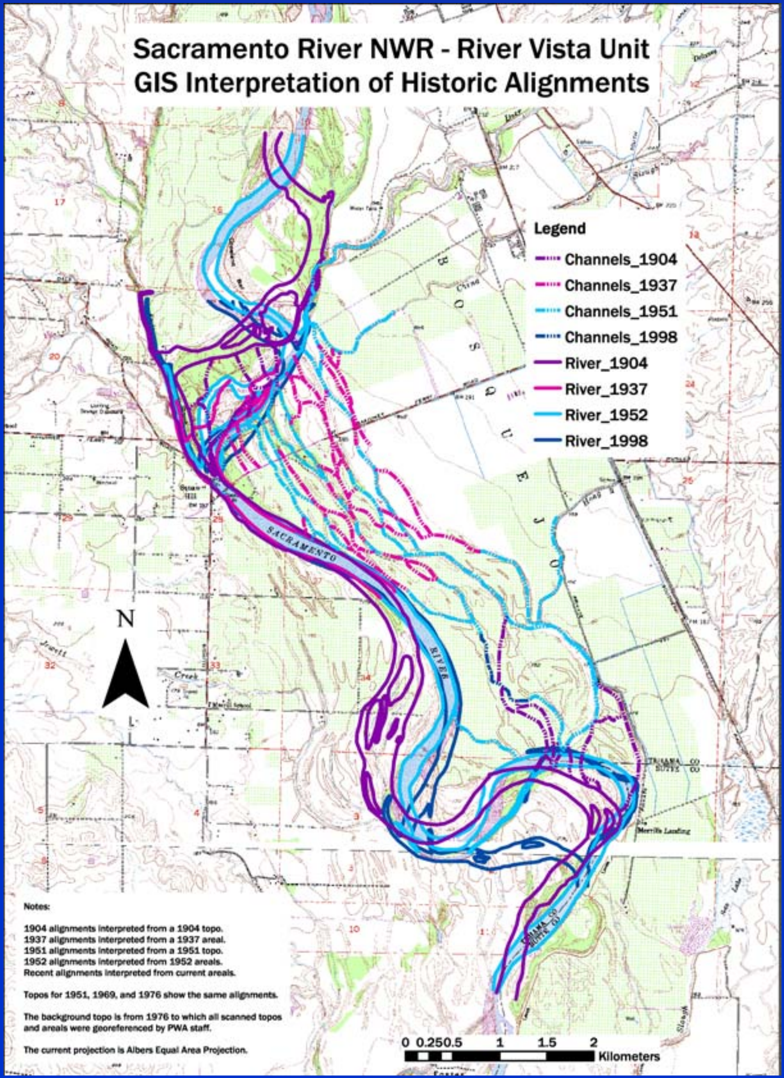
Sacramento River National Wildlife Refuge
Rio Vista Unit – Floodplain Restoration Project



- Sacramento River – RM 216-219
- Woodson Bridge State Park
- Define opportunities and constraints for restoration
- Existing conditions (geomorphology, hydraulic modeling)
- Two alternatives for localized flood hazard reduction and restoration of braided system

Sacramento River NWR

1937 Aerial



Sacramento River NWR

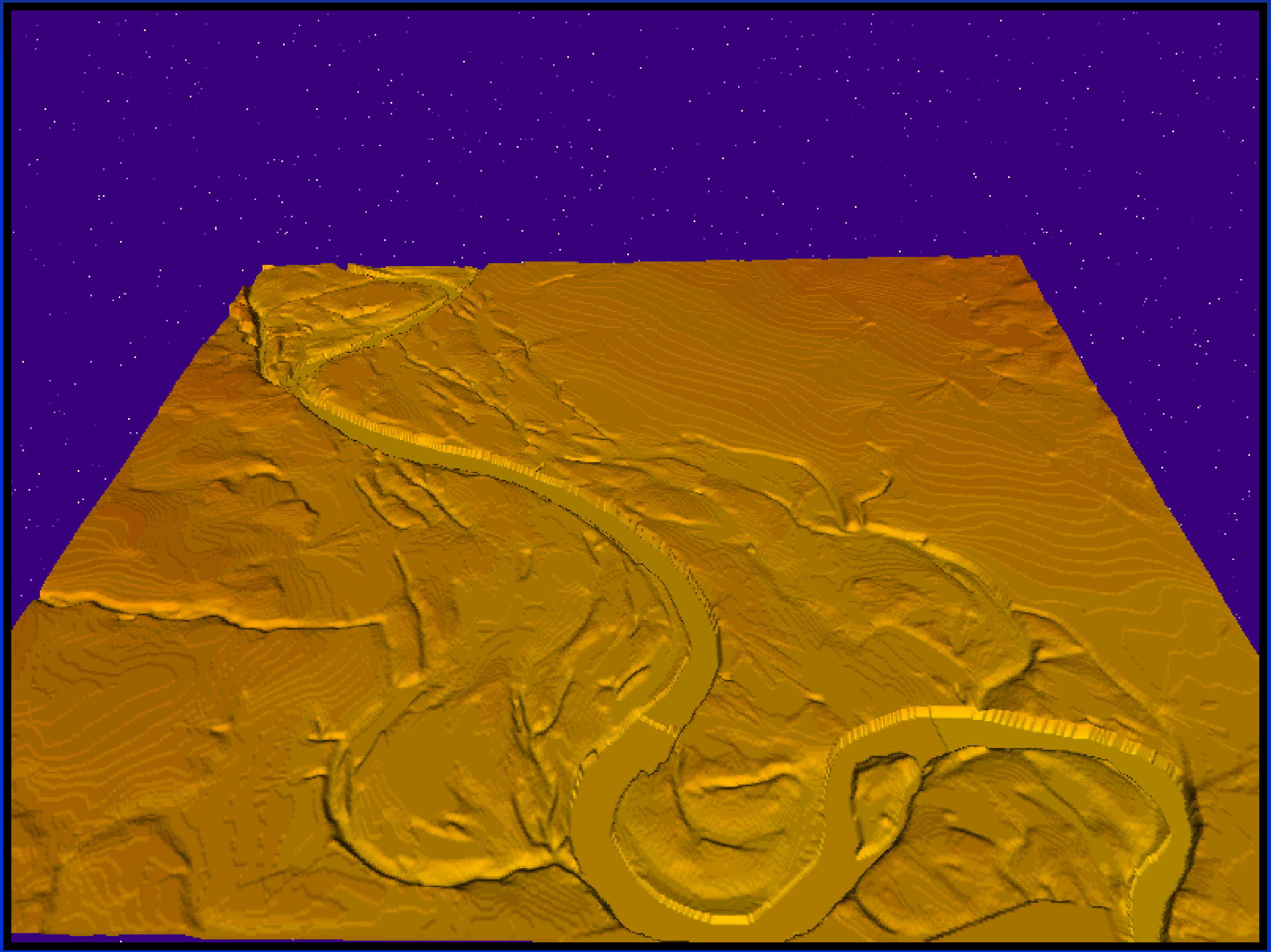
Sacramento River NWR

1937 Aerial

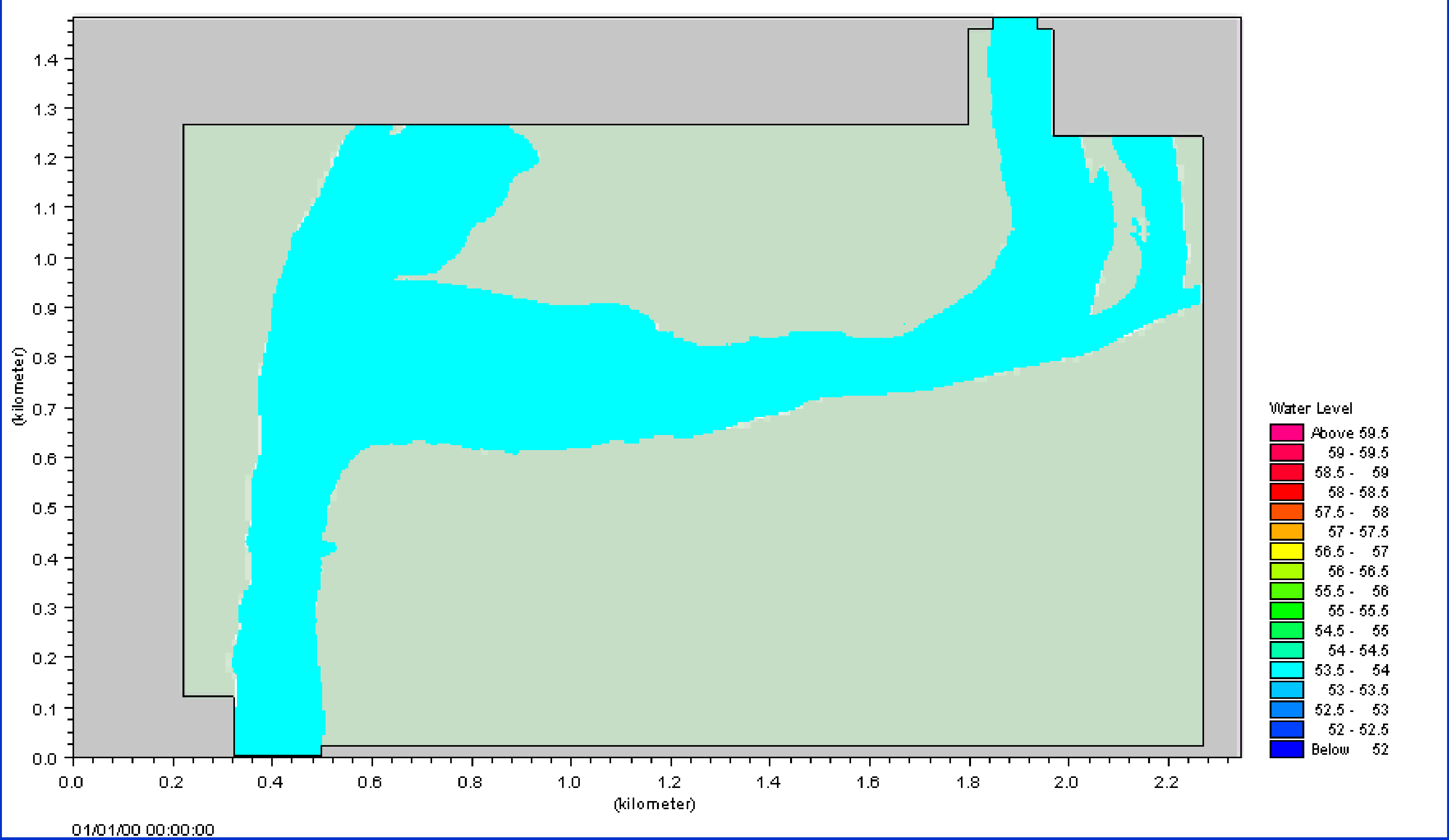
Question:

Under what conditions will significant flood water and erosive energy reach the floodplain?

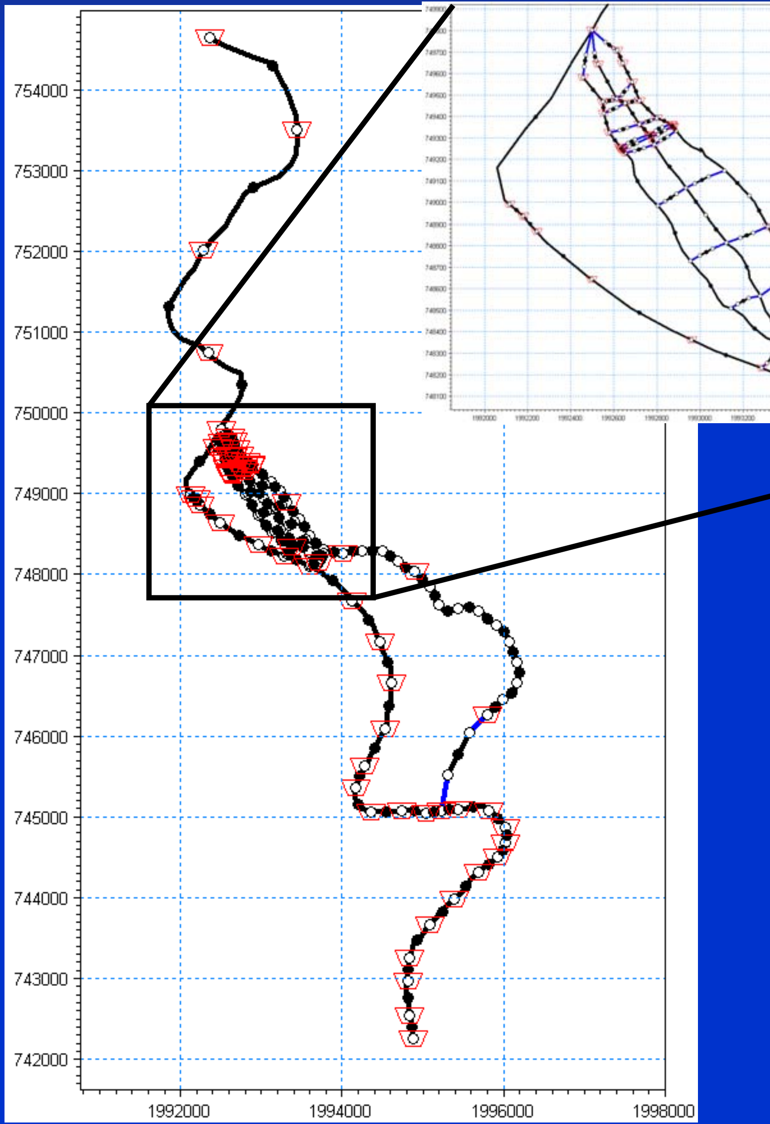
Sacramento River NWR

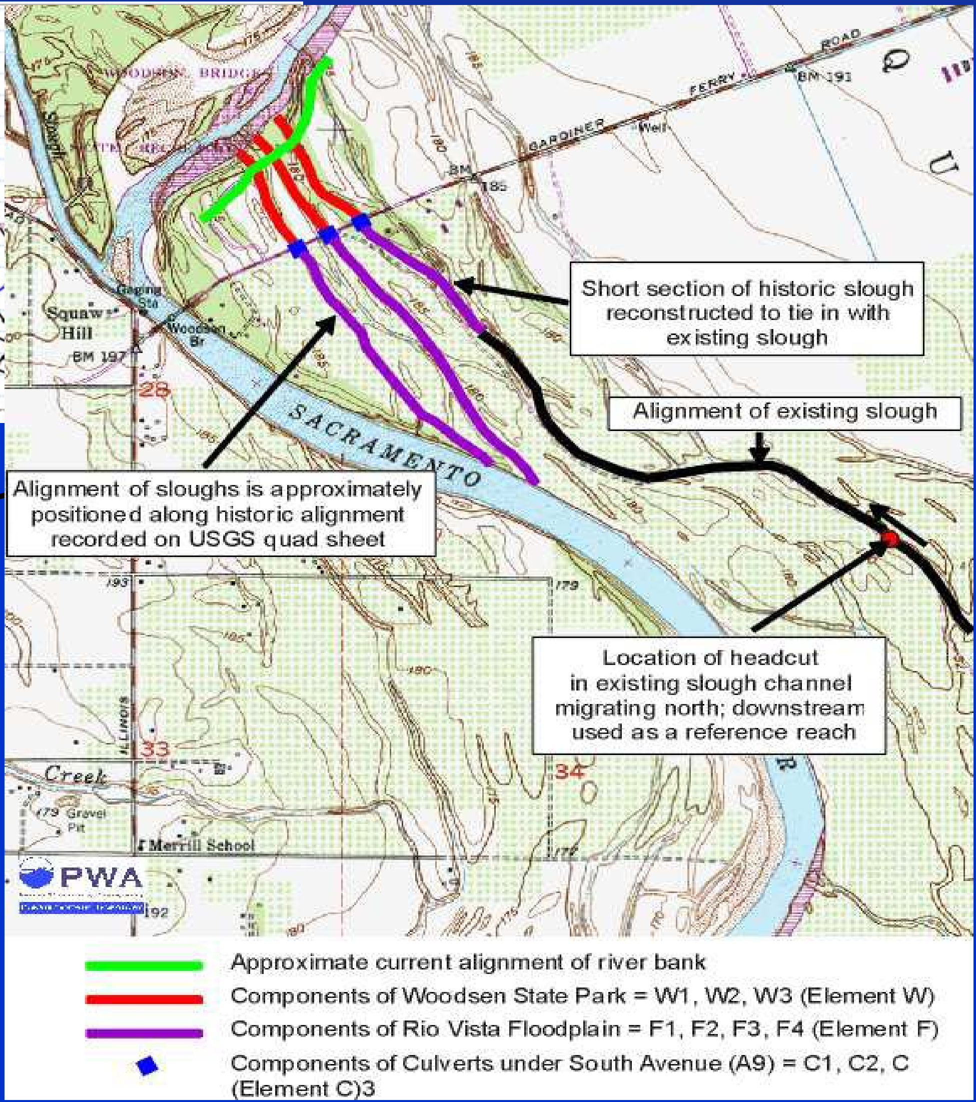


Sacramento River NWR

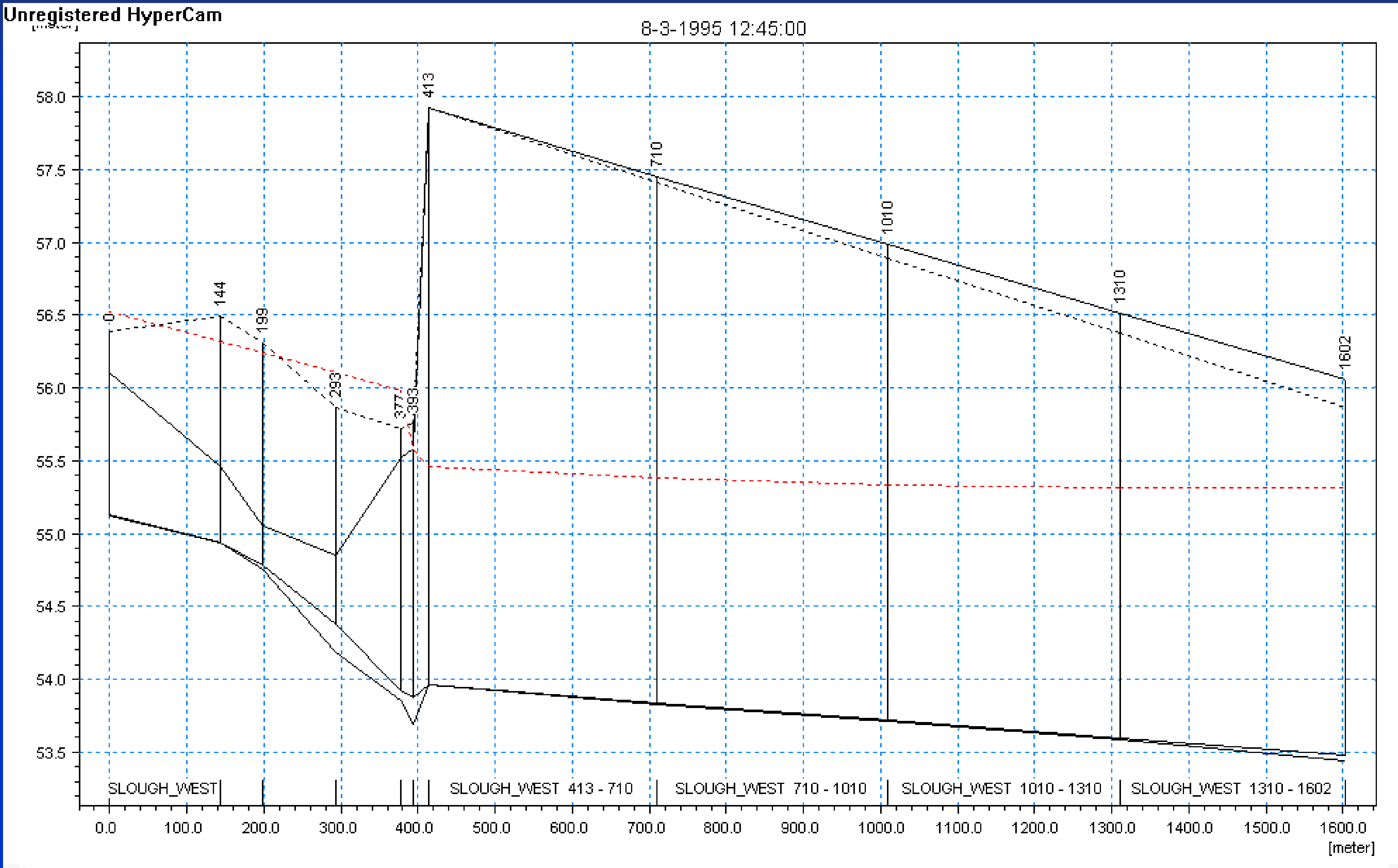


Sacramento River NWR

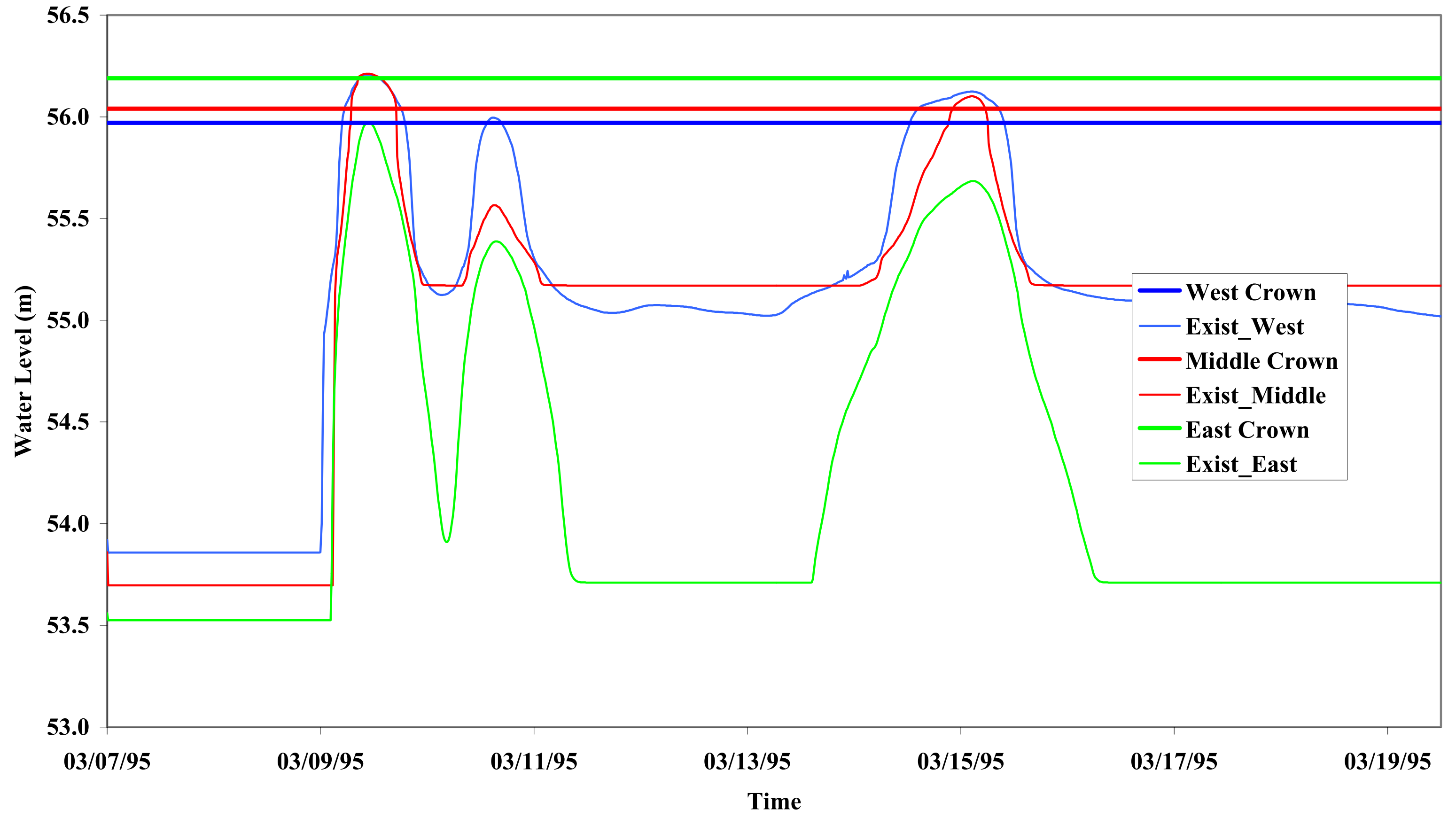




Sacramento River NWR



Sacramento River NWR



Notes
Source

figure 5.8

SRNWR - Rio Vista Unit: Conceptual Restoration and Flood Hazard Reduction Plan

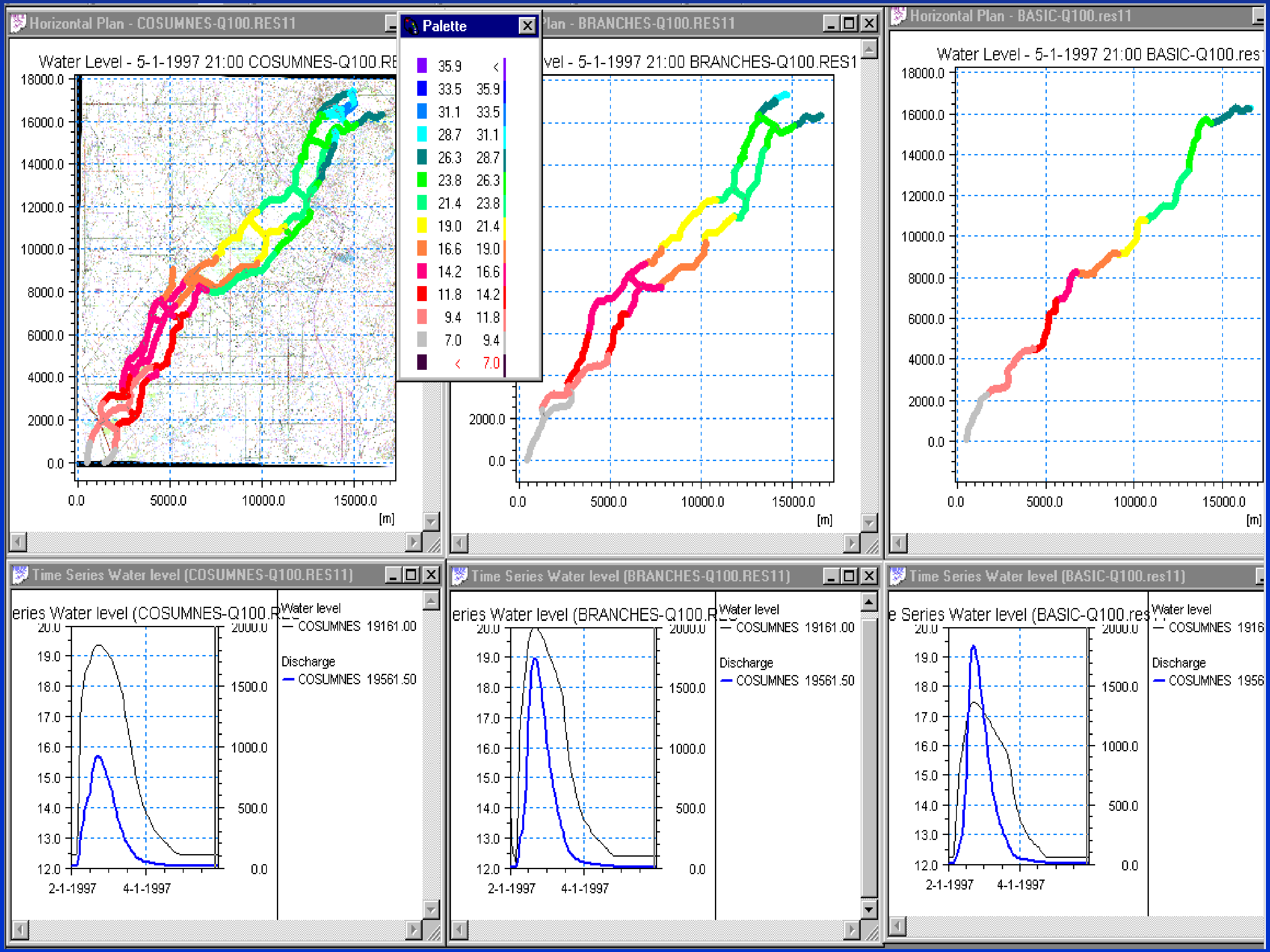
Highway A9 inundation during the 1995 snowmelt event - existing

PWA REF 1635

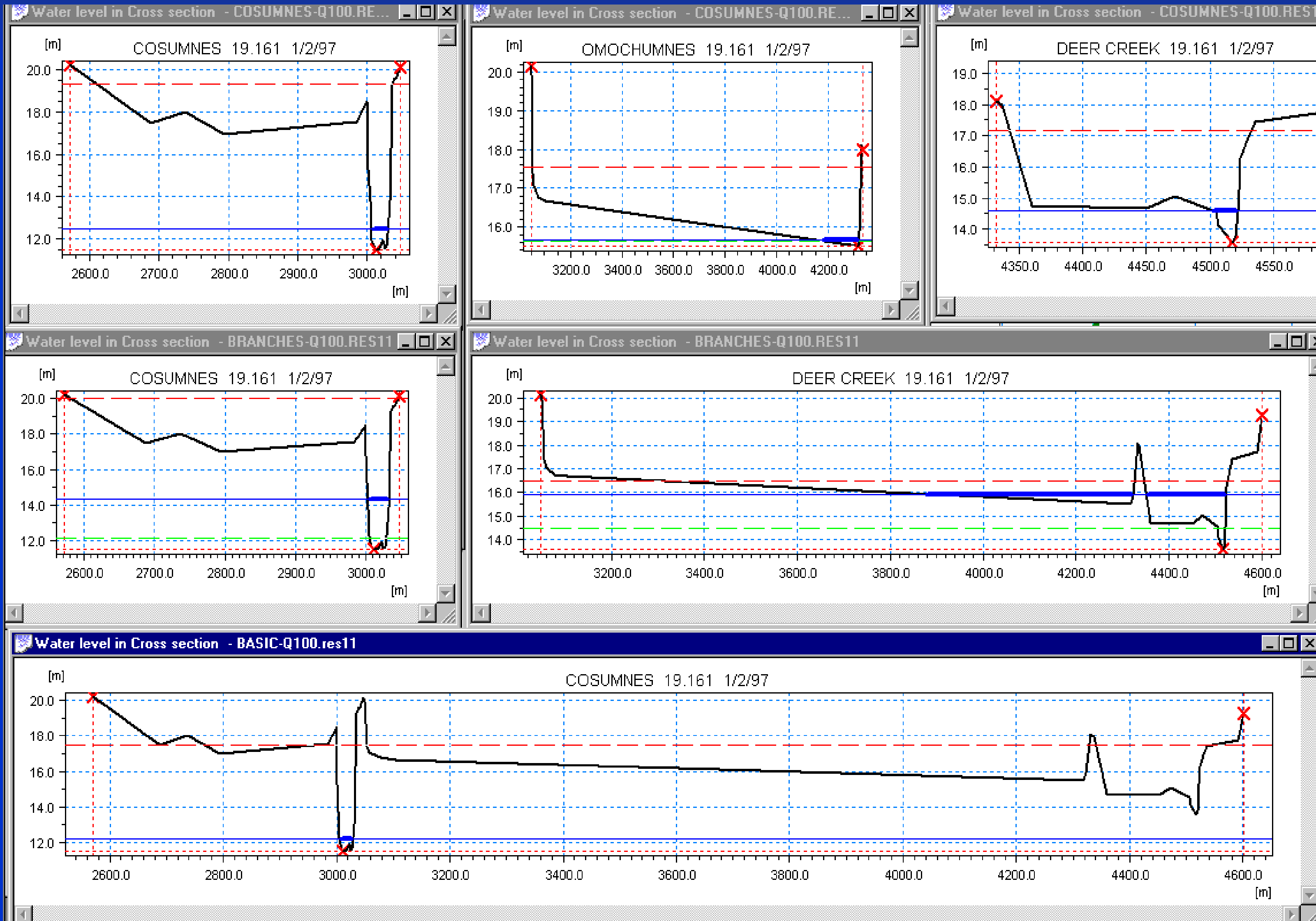
PWA

PWA

1D vs 1D Looped Models



1D vs 1D Looped Models



MODEL SPECIFICATION

1. The extent of the computational domain
2. Selection of model grid or nodal points (spatial mesh)
3. Representation of boundaries and physical processes in the model
4. Choice of empirical relationships for representing features of the prototype

RELATIVE COSTS - Financial & Numeric

Dimension	$ Cost	Numerical Cost	Examples	Application
0D	$0 - $100	Seconds to minutes	Excel, MATLab	Spreadsheet programming, simple hydraulics, hydrology, sed. transp., etc
1D Steady	$0	Minutes	HEC-RAS, Excel, HEC-1, HEC-6	Backwater modeling, standard step, hydrology, sed. transp.
1D Unsteady	$0 - $5,000	Minutes to hours	HEC-RAS, MIKE 11, ISIS, RMA	Hydrodynamic modeling, sed. transp., water quality
2D	$0 – 30,000	Minutes to days	MIKE 21, SMS(RMA), River 2D, CCHE2D Telemac, DIVAST	Hydrodynamic modeling, sed. transp., water quality
3D	$0 – $100,000	Hours to weeks	MIKE 3, CCHE3D, CH3D, Trim3D, SSIIM, Telemac, TriVAST, Fluent	Hydrodynamic modeling
LES, DNS	Research	Weeks to months		Detailed modeling of flow structures

SUMMARY

1. Traditional engineering models have oversimplified ecosystem processes
2. Hydrodynamic models can better simulate ecosystem processes
3. 1D and 2D models are routine applications. 3D are specialty applications
4. Dynamic output can quickly inform engineers, biologists, policy-makers

And Remember…

"All models are wrong; some are useful."

W. Edwards Deming

"It is better to be roughly right than precisely wrong."

John Maynard Keynes

Acknowledgements

- Ryan Luster, Mike Roberts – The Nature Conservancy
- Kelly Moroney, Jeff McLain, J.D. Wikert, Kim Forrest, Bob Parris, Dennis Woolington – USFWS
- Patrick Koepele – Tuolumne River Preservation Trust