From: Staples, Rose
BCC To: Relicensing Participants Email Group List
Sent: Friday, January 9, 2015 6:58 PM
Subject: Don Pedro W-AR-21 Workshop No 2 Meeting Notes for Review

Attached for your review and comment are the draft workshop notes from the December 18, 2014 Don Pedro Relicensing W&AR-21 Lower Tuolumne River Floodplain Hydraulic Assessment Workshop No. 2. The PowerPoint slides shown at the workshop, the workshop agenda, and a sample animation are available on the Don Pedro Hydroelectric Project relicensing website under the CALENDAR tab (attached to the December 18 workshop announcement). If you have any difficulties accessing or downloading the files, please let me know.

An animation with sample hydraulic model outputs is also available on the relicensing website. The animation intends to show inundation extents from RM 48 to RM 49 for steady flows from 1,000 cfs to 9,000 cfs. From 1,000 cfs to 3,000 cfs, the flow interval is 250 cfs and above 3,000 cfs, the flow interval is 500 cfs. Standard video players such as Windows Media Player and QuickTime Player may be used to view the animation. QuickTime Player may be preferable due to the player's default settings. QuickTime Player's slider bar may be used to move back and forth between flows and the player speed can be adjusted as necessary.

Comments on the draft meeting notes are due by Monday, February 9, 2015 to rose.staples@hdrinc.com. Thank you.

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Don Pedro Project Relicensing
W&AR-21 Workshop No. 2
Draft Meeting Notes

Thursday, December 18, 2014

Attendees

Jenna Borovansky – HDR	Ron Yoshiyama – CCSF
Jesse Deason – HDR	Jim Hastreiter – FERC, *by phone*
John Devine – HDR	Robert Hughes – CDFW
Pani Ramalingam – HDR	Dean Marston – CDFW
Rob Sherrick – HDR	Dale Stanton – CDFW
Anna Brathwaite – MID	John Wooster – NMFS, *by phone*
Greg Dias – MID	Mark Gard – USFWS
Bill Johnston – MID, *by phone*	Peter Barnes – SWRCB, *by phone*
Noah Hume – Stillwater Sciences	Chris Shutes – CSPA, *by phone*
Maia Singer – Stillwater Sciences	Peter Drekmeier - Tuolumne River Trust, *by phone*
Jonathan Knapp – CCSF	Patrick Koepele – Tuolumne River Trust, *by phone*
Ellen Levin – CCSF	Nicola Ulibarri – Stanford
Bill Sears – CCSF	

Agenda and Purpose

Following introductions, Jenna Borovansky provided an overview of the meeting agenda. The purpose of the Lower Tuolumne River Hydraulic Floodplain Assessment (W&AR-21) modeling Workshop No. 2 is to review the hydraulic model development, present calibration and validation results, present preliminary results of the habitat analysis, and the study schedule (slide 2).

Background

Jenna provided study background (slide 3).

Study Objectives

Jenna presented the study objectives, namely to analyze floodplain inundation at specified flow intervals and estimate associated floodplain habitat availability for rearing juvenile salmon in the lower Tuolumne River (slide 4). Base case hydrology (1970-2012) from the Operations Model report is used for this study. The completed 2-D floodplain model can serve as a tool for modeling future hydrology scenarios.

Study Methodology

Jenna provided an overview of study methodology (slide 5).

Summary of Workshop No. 1

Jenna presented a summary of material covered at Workshop No. 1, held in February 2014, including recommendations that came out of workshop discussions (slides 6 & 7). The primary recommendations were the following:

- Develop three reaches for TUFLOW model
    - Model A (RM 51.4 – 40)
    - Model B (RM 40 – 21.5)
    - Model C (RM 21.5 – 0.9)
- Based on results of the sensitivity analysis, use a 2-D model cell size of 30 ft or less

Question (Patrick Koepele): What geomorphic characteristics were used to define the three study reaches?

Answer (Pani Ramalingam): Three study reaches were adopted primarily based on run-time considerations for TUFLOW. At a 30-ft cell size, the model run time for the entire lower river would be unreasonably long. Breaking the model into three separate reaches allowed us to optimize model construction, calibration, and run time. Each of the three model segments requires approximately 1-2 hours to run, allowing us to work on them simultaneously.

Answer (Noah Hume): The Tuolumne River has a major slope break from gravel bedded to sand bedded at approximately RM 29. As Pani noted, the river was divided into sub-reaches for computational efficiency.

Hydraulic Modeling Status

Pani Ramalingam presented the model reach extents (slide 8). Rob Sherrick presented a summary of the various cross section data sources used to develop model cross-sections for the 1-D (in-channel) portion of the TUFLOW model (slides 9 &10). While existing data were used where available, a considerable amount of additional cross-section data were collected by TID as necessary. Some of the survey locations of the data sources overlapped in various reaches of the river, allowing for improved spatial accuracy and model validation.

Model Components

Pani presented the TUFLOW hydrologic model components (slides 11-12).

- Ponds and pools – manually digitized and were assigned depths from bathymetry if available or assigned water level from 2012 LiDAR
- Levee like features – derived from LiDAR and captured in the model
- Narrow thin channels – derived from LiDAR and captured in the model
- Mannings 'n' (roughness or friction factor used in modeling) was derived from prior vegetation mapping studies and existing aerial photos, 2012 helicopter video and field visit photos.
- Model B – includes culverts near RM 38
- Model C – includes Dennett Dam (~RM 16)

Model Boundary Conditions

Pani described the order of model segment development. Boundary conditions were set from downstream to upstream in order to appropriately include backwater effects from the Tuolumne River-San Joaquin River confluence.

1. Model C – An analysis of backwater effects of San Joaquin River was performed. A range of USGS gage data sources were used to estimate statistical relationships of San Joaquin and Tuolumne River stages and flows (slides 13-16). This analysis revealed that backwater effects can extend up to RM 13. A discharge - water surface elevation curve (rating curve) was developed for use as boundary condition.

2. Model B - Model C was built simultaneously along with Model B and the section upstream of Modesto gage (near RM 16) was calibrated. Results from this model were then used to develop a rating curve for use as a boundary condition. It should be noted that extents of Model B and C overlap.

3. Model A – Normal depth boundary condition was used by extending the model downstream to RM 37.5 so that boundary effects are insignificant at RM 40. It should be noted that extents of Model A and B overlap.

Model Calibration and Validation

Pani described the calibration and validation steps for TUFLOW (slides 17-21). Calibration was accomplished by using a combination of model results, gage flows, and historical images. The 1-D in-channel portion of the model was calibrated first, followed by the 2-D floodplain portion of the model.

Question (Bob Hughes): How did you use Google Earth to calibrate the model?

Answer (Pani Ramalingam): We used existing images of historical flow events across a range of flows to visualize the channel wetted width. This included digitizing a series of air photos from four high flow events in the 1990s that were used in the USFWS (2008) and Stillwater Sciences (2012) floodplain studies. Google Earth also provides historical aerial imagery which allowed the observed inundation extent to be validated against the gaged flows on the date of the photo.

Question (Bob Hughes): Was there any calibration to water surface elevations?

Answer (Pani Ramalingam): Yes, in Model Segment A for RM 49 – 43, the stage data records for 3,000 cfs collected at two sites in the 2011 Pulse Flow Study was used. Water surface elevations were also used to calibrate Model Segment C using the existing USGS rating curve information at the Modesto gage.

Hydraulic Modeling Results

Pani showed inundation examples (slide 22) for Model Segment A, B, and C stepping through model results in 250/500 cfs increments (not shown in slides).

Question (Noah Hume): Are the flows entering from Dry Creek calculated using the rating curve approach for Model C or are the observed inundation areas simply due to backwater effects?

Answer (Pani Ramalingam): Backwater effects.

Question (Bob Hughes): I don't understand the interaction between the 1-D and 2-D components of the hydraulic model. Is the calibration accomplished primarily on the 1-D portion? How does TUFLOW work in general terms?

Answer (Pani Ramalingam): Calibration is undertaken for both the 1-D and 2-D portions [Pani showed a visual of the break line between the 1-D and 2-D models]. The model first undertakes calculations for the 1-D portion. Every 2 seconds the two models communicate with one another to determine if water should be crossing the break line into the 2-D portion of the model. We must begin with accurate flow predictions for the 1-D model; that is why we spent so much time collecting additional cross-section data for the 1-D model.

Habitat Analysis

Noah Hume discussed the habitat analysis approach (slides 23-24). Once the hydraulic model results were ready, we modeled habitat availability using suitability criteria for depth and velocity from the completed IFIM Study (Stillwater Sciences 2013). Cell-specific depth and velocity predictions from TUFLOW were summed across the 2-D model domain to estimate usable habitat area for juvenile and fry life stages of Chinook and *O. mykiss*. Results for Model Segment A are complete. Results are in development for model segments B and C.

Noah provided example results for Model Segment A at Riffle 4A/4B (slides 25-29):

- Habitat suitability is shown in 2,000 cfs increments
- In-channel habitat was excluded from the analysis (addressed by earlier Stillwater (2013) IFIM Study)
- Although there is a lot of inundated floodplain area, most of the suitable habitat is limited to backwater habitats and margins of flooded areas

Noah provided example results for Model Segment A at Bobcat Flat (slides 30-34):

- Hydraulic modeling is challenging in this reach due to the intact mining tailings piles and numerous deep ponds
- Given that, TUFLOW did a good job of representing flows in this reach
- Model results indicate inundation into captured gravel ponds at 7,000 and 9,000 cfs

Next we summed cell-specific habitat suitability for Model Segment A to produce the usable habitat vs discharge curve shown in slide 35.

- Note that usability of floodplain habitat for juveniles averages about 50% of total inundated area and does not fall off very quickly because they possess stronger swimming performance at increased depths and velocities
- In contrast, fry habitat usability drops off relatively quickly to less than 30% at the highest modeled flows
- The character of the usable habitat vs discharge relationships changes as we move from Model A which has some floodplain habitat; to Model B which has comparatively less floodplain habitat; to Model C nearest the San Joaquin River which has some floodplain habitat that becomes inundated at the highest flows.

O. mykiss fry life stages may be found in floodplain habitats, but generally these fish find flow refuge in gravels in main channel. Nevertheless we have included *O. mykiss* in the habitat analysis.

Area-Duration-Frequency Analysis

Noah discussed the aim of the ADF analysis – to determine the periods of maximum inundation occurring over a certain duration and at a certain frequency in the flow record (slides 36-45). This used base case (WY1971–2012) hydrology from the Operations Model (W&AR-02)

- Note that as in the example animations, even at 1,000 cfs there is a fair amount of floodplain habitat due to the presence of backwaters and pond features (e.g., 2 million ft^2).

- On a fairly regular basis (2-4 yr recurrence interval) floodplain habitat is inundated and usable for juveniles/fry.
- Flows above bankfull discharge are associated with increases in habitat.
- As with the usable habitat curves, each model reach will exhibit a slightly different character for the curves.
- For the final report, we may present habitat curves by reach, or we may combine into one lower river set of curves.
- In general, these results are consistent with prior floodplain modeling efforts.

Questions

Question: (Dale Stanton): Why limit yourself to the base case hydrology?

Answer (Jenna Borovansky): Base case hydrology is specified in the study plan, but conceivably other hydrologic scenarios could be run in the model.

Question: (Mark Gard): Would you compare results of the habitat assessment at unimpaired flows to results for base case flows? USFWS had recommended a set of flows in their comments on the study plan – what about those?

Answer (John Devine): The study plan suggests other flow scenarios, but in the FERC licensing process we are only considering the base case. The unimpaired flows represent a pre-project condition. If after FERC review there is still interest in modeling other flows, the model will be available as a tool.

Question (Bob Hughes): How much of the modeling tool will be publically available?

Answer (Jenna Borovansky): HDR has committed to having the TUFLOW model available for interested parties to run on their own. The Districts will work with agencies on the most efficient method for making the model available for use.

Answer (Noah Hume): The habitat suitability analysis is a little more involved but we could potentially provide the 'R' code used.

Answer (Rob Sherrick): The post-processing of the hydrology model results would be different for a new flow series, but TUFLOW results would be the same.

Question: Will the inundation animations be posted on the web?

Answer (Jenna Borovansky): Yes. We have some example animations for Model A that we can post – not all of the animations from today will be available since Pani ran them directly from the model for the workshop presentation.

Action Items

- The Districts will post the PowerPoint and sample animations on the relicensing website, www.donpedro-relicensing.com.
- The Districts will work with agencies to provide the model and habitat analysis files available by request, once the report is finalized.

- Following the meeting, Mark Gard (USFWS) contacted Noah Hume and requested summaries of the inundation area vs. discharge results to be provided in MS Excel format. In addition, when they are available, Mark requested velocity and depth predictions in either spreadsheet or csv format. The Districts will provide this information when the draft report is released for relicensing participant review.

Attachments

Attachment 1: Modeling Workshop Agenda

Attachment 2: Modeling Workshop No. 2 Slides

Attachment 1

Modeling Workshop No. 2 Agenda

Don Pedro Hydroelectric Project
Floodplain Hydraulic Assessment (W&AR-21)
Workshop No. 2 Agenda

Thursday, December 18
1:00 pm – 4:30 pm
MID Offices, 1231 11th Street, Modesto, CA

Phone number: 866-994-6437
Conference code: 542-469-7994
Link to online meeting: Join Lync Meeting (Lync Meeting Help)

- Review agenda and purpose of the meeting
- Study plan goals and objectives
- Overview of study methodology
  - Study flows
- Summary of Workshop No. 1
- River hydraulic model background
  - 2D TUFLOW model
  - 1D HEC-RAS model
- Model reaches
  - Model A: RM 52.2 to RM 40
  - Model B: RM 40 to RM 21.5
  - Model C: RM 21.5 to the confluence
- Data sources
- River hydraulic model calibration process (RM 52.2 – RM 21.5)
- Habitat analysis status
  - Analysis approach
  - Model A – preliminary results
    - Bobcat Flat example
    - Reach estimated usable area
    - Area-duration frequency analysis
- Next steps and schedule

Attachment 2

Modeling Workshop No. 2 Slides

Don Pedro Hydroelectric Project Relicensing

Lower Tuolumne River Floodplain Hydraulic Assessment (W&AR-21)

December 18, 2014

Agenda and Purpose

- Study Background
- Hydraulic Modeling Status
- Habitat Analysis Status
- Study Schedule

Background

- FERC ordered a hydraulic analysis of the amount of floodplain inundated in its May 21, 2013 Determination
- Draft study plan provided to relicensing participants for comment, and final study plan modified based on relicensing participant comments submitted in September 2013
  - Revised plan based on relicensing participant comment, including expanded study area and added habitat analysis
- FERC approved study plan October 18, 2013

Study Objectives

- Analyze the amount of floodplain inundated between RM 52.2 and RM 0 of the Tuolumne River at flows between approximately 1,000 cfs and 9,000 cfs
- Assess the suitability of inundated floodplain habitat for juvenile salmon rearing
- Evaluate the frequency and period of inundation over a range of flows for the base case (WY 1971-2012) hydrology

Study Methodology

1. TUFLOW model to determine floodplain extents at:
   - 250 cfs intervals from 1,000-3,000 cfs
   - 500 cfs intervals from 3,000-9,000 cfs
2. Determine the maximum continuous wetted area for 7, 14, 21, and 30 day durations
3. Evaluate the Base Case scenario (WR 1971-2012)
4. Estimate depths and velocities in overbank areas from RM 52 to the San Joaquin River and use existing habitat suitability criteria for depth and velocity for juvenile salmonids to quantify the amount of suitable juvenile rearing habitat as a function of flow

February 13, 2014: Workshop No. 1

- Hydraulic Modeling Approach
  - Data Sources
  - TUFLOW Model
  - Overbank vs. In Channel Areas

- Habitat Analysis Approach
  - Sensitivity to grid size

Feb.13 Meeting - Recommendations

- **TUFLOW Modeling Plan**
  - **Model A - RM 52 to 40**
  - **Model B - RM 40 to 23**
  - **Model C - RM 23 to 0**

- **2D cell Size – 30ft or less**

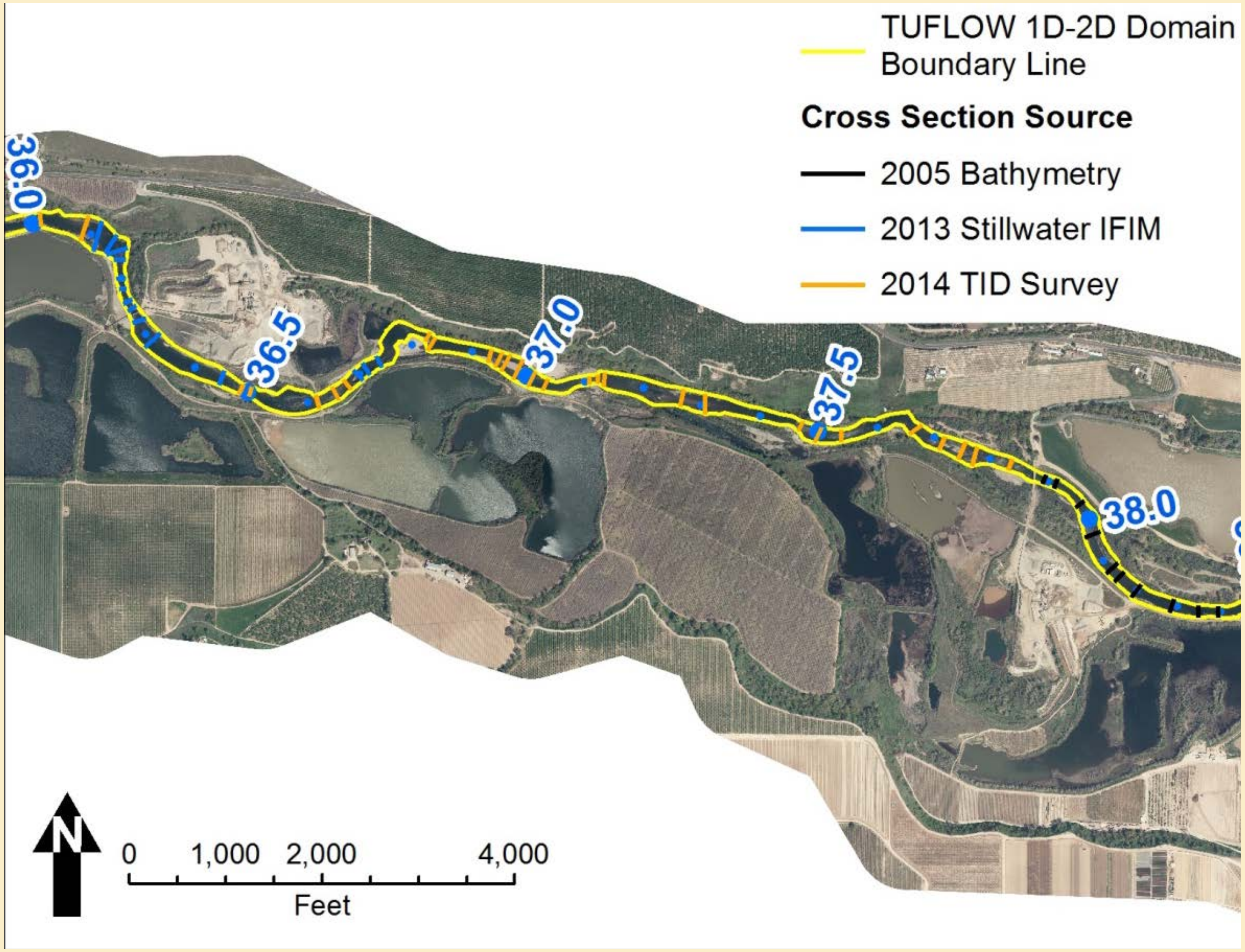
Hydraulic Modeling Status

- **TUFLOW models constructed, calibrated and QCed**
- **Model A – RM 52.2 to RM 40**
- **Model B – RM 40 to RM 21.5**
- **Model C – RM 21.5 to the confluence (RM 0.88)**
  - **San Joaquin River backwater effects analyzed**

1D Cross Section Data Sources

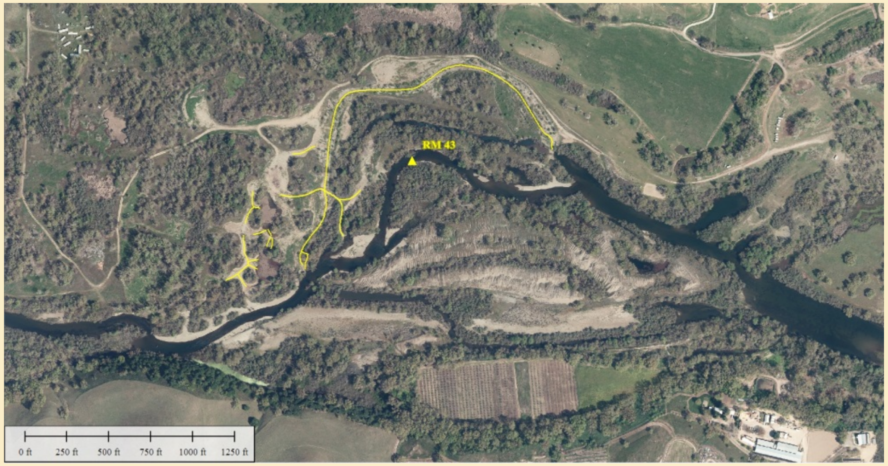
RM (USGS)	RAS Station	Source	Count
0.88-6.31	0.8252-6.3035	2014 DWR-CVFED HEC-RAS Model	28
6.71-22.78	6.715-23.0683	FEMA-CVFED HEC-RAS Model	51
13.99-31.48	13.847-31.9232	2012 HDR Survey	34
4.43-29.54	4.3978-29.98	Interpolated	37
16.13-16.41	15.9601-16.2138	USGS Gage Cross Sections	3
22.59-46.98	22.8536-47.4583	2014 TID Survey	134
24.41-25.86	24.948-26.5125	McBain&Trush SRP 9/10 Restoration	16
30.34-36.74	30.739-37.5818	2013 Stillwater IFIM	19
37.9-45.77	38.9536-46.27	2005 Bathymetry	167
45.78-51.66	46.2985-51.6734	2012 Bathymetry	133
		TOTAL:	622

Sample Cross Section Source Integration



Model Components

- **1D Low flow channel**
- **Ponds & pools**
- **Levee like features**
- **Narrow thin channels**
  - **connecting river and overbanks**
  - **connecting overbank ponds**

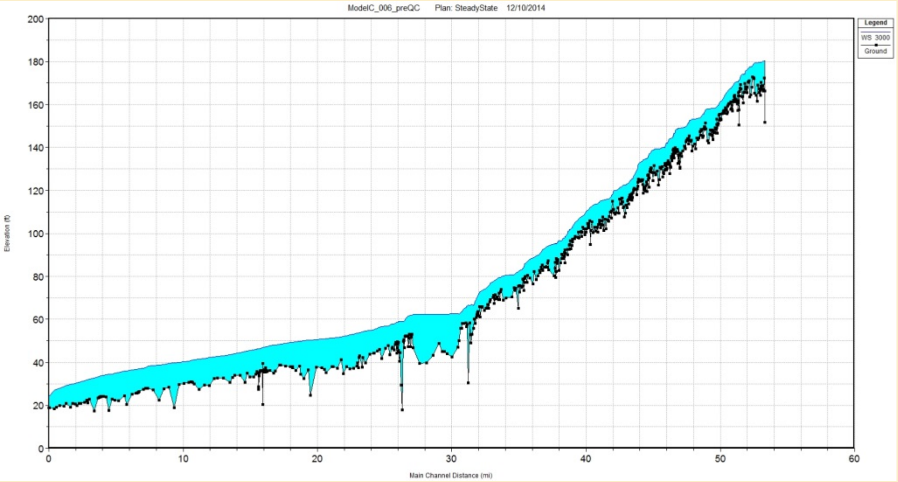


Model Components

- 2D Manning's "n" for overbank areas
- Culverts near RM 38
- Dennett Dam

Model Boundary Conditions

- **Model A – Normal depth**
- **Model B – From Model C**

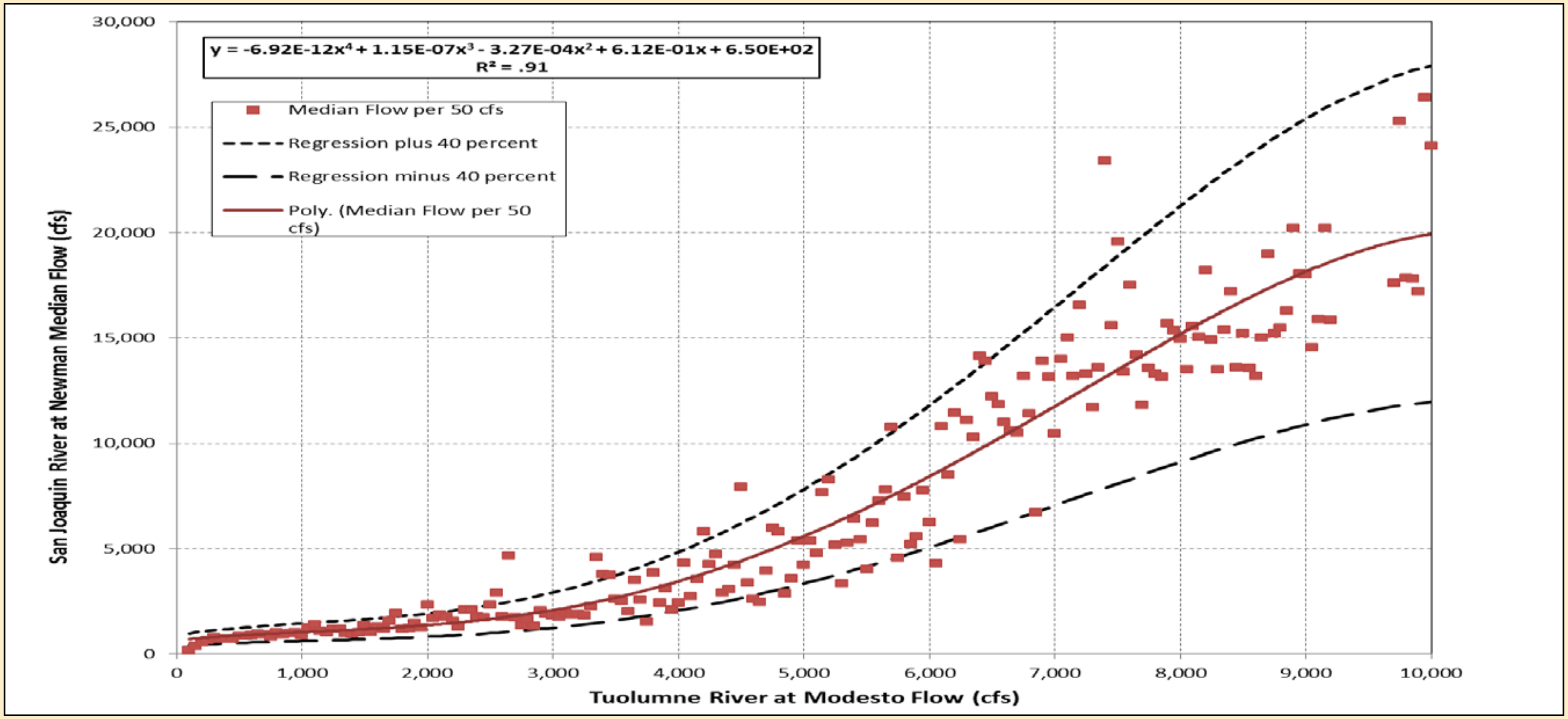


- **Model C – San Joaquin River backwater analysis**

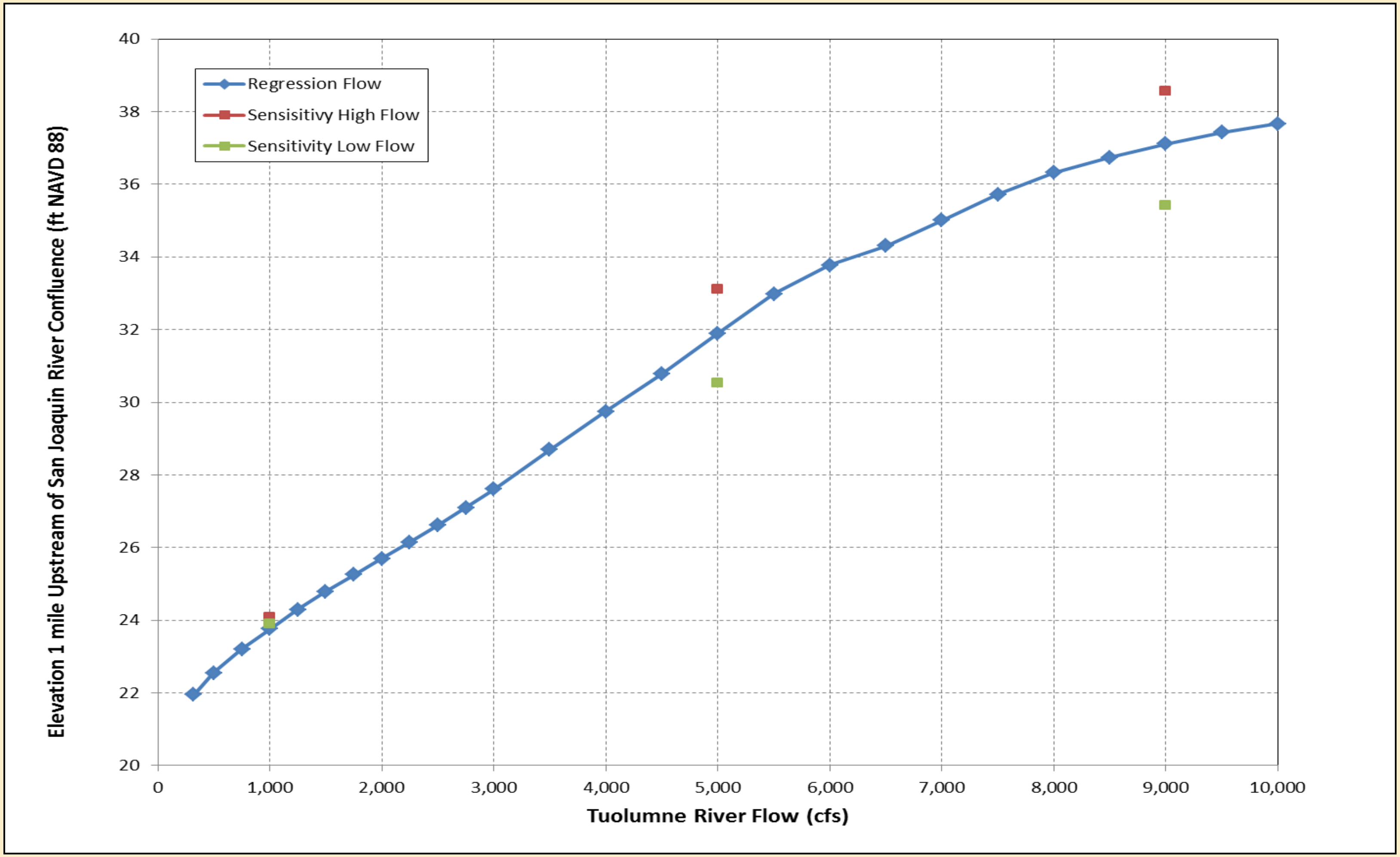
San Joaquin River Backwater Analysis

1. Use existing DWR & FEMA HEC-RAS models
2. Determine extent of backwater effects from San Joaquin River
3. Develop correlated sets of flows for Tuolumne, San Joaquin and Stanislaus Rivers (Water Years 1971 to 2012)
4. Develop a rating curve (elevation-discharge) for downstream boundary condition for Model C

Sensitivity Analysis



Model C Boundary Condition Rating Curve



Model Calibration & Validation

- Google Earth aerial photos (2005-2011)
- TID historic aerial photos (1993-1995)
- USGS gage at Modesto

Model A - Calibration and Validation

TUFLOW Model A - Calibration & Validation Reaches & Data Sources

Primary data set for calibration & validation

S. No.	USGS River Mile	Areas Included	Approximate Constant Flow / Google Earth Imagery Date						RM 50 Side Channel	Bobcat Flat RM 43 Restoration Work	
			1020 cfs	1590 cfs	1960 cfs	2040 cfs	2680 cfs	4030 cfs	490 cfs	5400-6000 cfs	5900-5600cfs
Reach 1	RM 48.5 to RM 51.6	Riffle 4A/4B	24-Jul-11	23-Feb-06		**30-May-10**	**6/29/2005***	-	24-May-09		
Reach 2	RM 46 to RM 48.5	Riffle 5A (Basso Bridge)	24-Jul-11	23-Feb-06	-	30-May-10		**11-Jun-05**		-	
Reach 3	RM 44 to RM 46	Zanker Property	24-Jul-11	23-Feb-06		**30-May-10**	-	11-Jun-05	-		
Reach 4	RM 42 to RM 44	Bobcat Flat	24-Jul-11(RM 43 up)	23-Feb-06		30-May-10		11-Jun-05		13-Jun-10	16-Jun-11
Reach 5	RM 38 to RM 42		-	23- Feb-06(RM 40 up)	24-Apr-10	30-May-10 (RM 40 up)		11-Jun-05		-	

*Corrected date per NAIP

Legend

Calibration Data
Validation Data
Limited validation

This data set was used more as a reference. The river/floodplain has changed significantly at several locations since the time of compilation of data.

S. No.	USGS River Mile	Approximate Constant Flow / TID Historic Inundation Imagery Year		
		3100 cfs	5300 cfs	8400 cfs
Reach 1	RM 48 to RM 51.6	1993	1995	1995
Reach 2	RM 46 to RM 48	1993	1995	1995
Reach 3	RM 44 to RM 46	1993	1995	1995
Reach 4	RM 42 to RM 44	1993	1995	1995
Reach 5	RM 38 to RM 42	1993	1995	1995

Model B - Calibration and Validation

TUFLOW Model B - Calibration & Validation Reaches & Data Sources

Primary data set for calibration & validation

S. No.	USGS River Mile	Areas Included	Approximate Constant Flow* / Google Earth Imagery Date			
			654 cfs	2130 cfs	2620 cfs	4050 cfs
1	RM 20 to RM 40		28-Jul-11	24-Apr-10	-	11-Jun-05
2	RM 20 to RM 25		28-Jul-11	24-Apr-10	10-Feb-06	11-Jun-05

*Previous day average flow to account for travel time from USGS La Grange gage

Legend

- Calibration Data
- Validation Data
- Limited validation

This data set was used more as a reference. The river/floodplain has changed significantly at several locations since the time of compilation of data.

S. No.	USGS River Mile	Approximate Constant Flow / TID Historic Inundation Imagery Year		
		3100 cfs	5300 cfs	8400 cfs
2	RM 20 to RM 40	1993	1995	1995

Model C - Calibration and Validation

TUFLOW Model C - Calibration & Validation Reaches & Data Sources

A. Primary data set for calibration & validation

S. No.	USGS River Mile	Areas Included	Approximate Constant Flow* / Google Earth Imagery Date		
			900 cfs	3320 cfs	4130 cfs
1	RM 0.88 to RM 16		28-Jul-11	-	11-Jun-05
2	RM 12 to RM 16			10-Feb-06	

*USGS Modesto Gage (RM 16)

Legend

Calibration Data
Validation Data
Limited validation

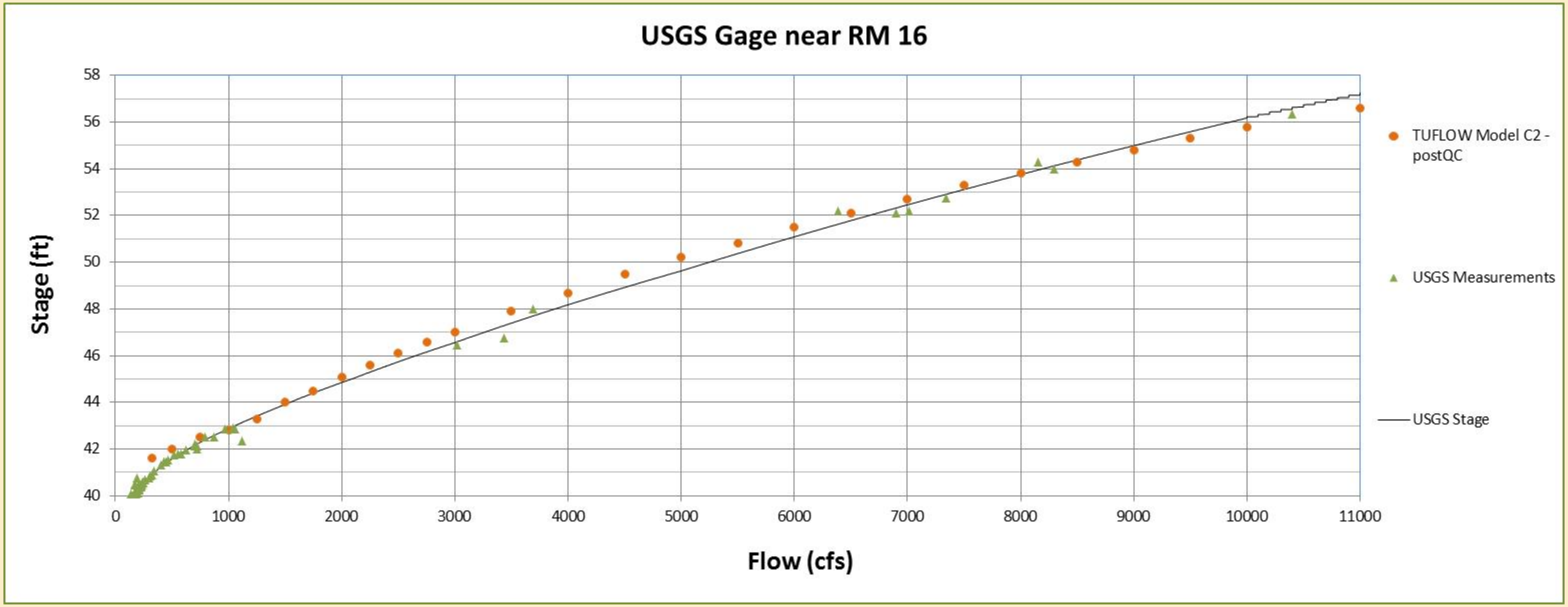
B. TID data set was used more as a reference as the river/floodplain has changed significantly at several locations since the time of compilation of data.

S. No.	USGS River Mile	Approximate Constant Flow* / TID Historic Inundation Imagery Year
		8322 cfs
2	RM 0.88 to RM 21.5	22-Apr-95

*USGS Modesto Gage (RM 16)

C. The rating curve & stage-flow measurements taken at of USGS Gage located near Modesto (near RM 16) were also used to calibrate the model for range of flows.

Model C - Calibration and Validation

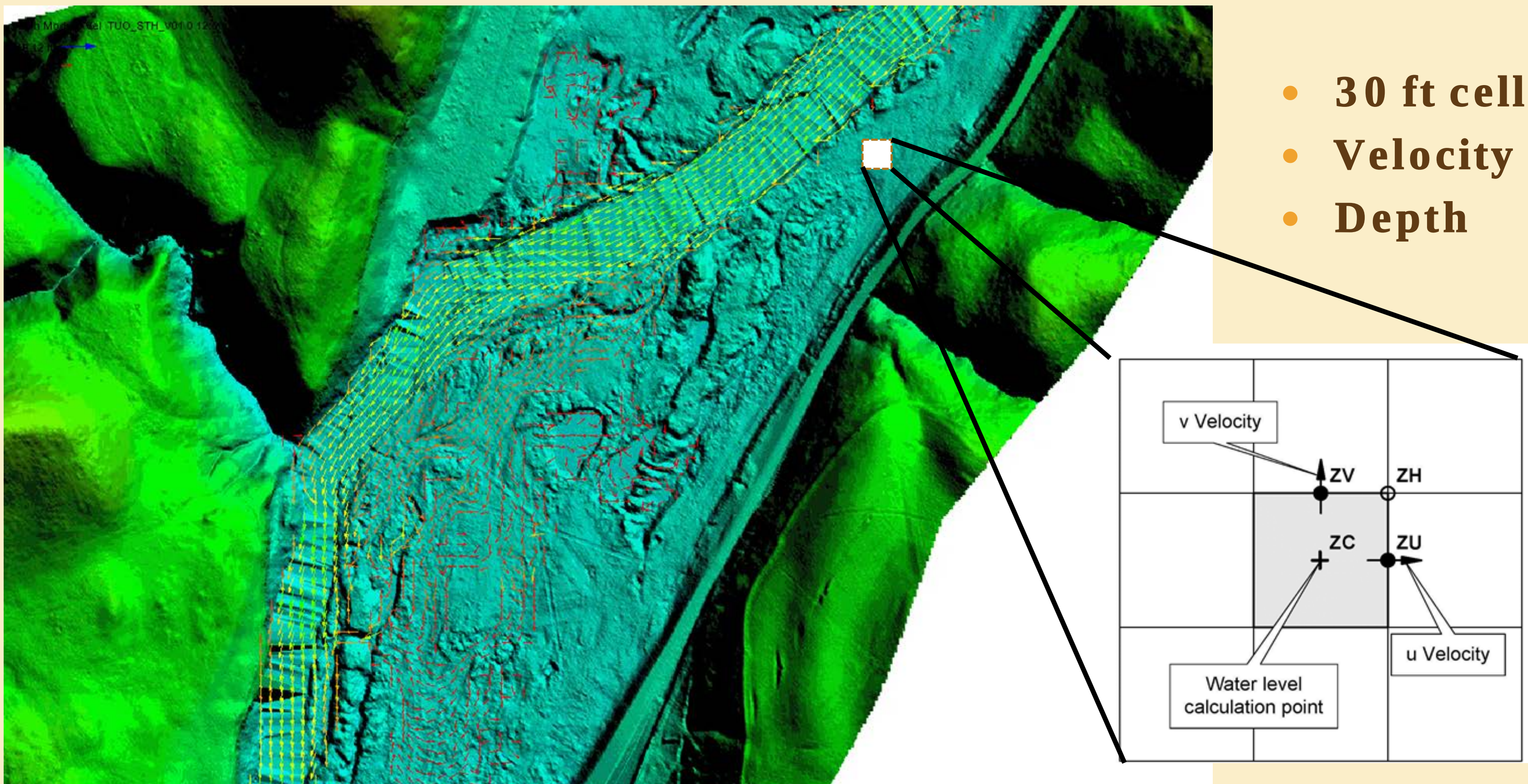


Models A, B & C - Results

- **Inundation Extents at various steady flows** (Animation)
  - 1000 to 3000 cfs @ 250 cfs interval
  - 3000 to 9000 cfs @ 500 cfs interval
- **Simulation of time varying hydrograph** (Animation)
  - 1000 to 9000 cfs and back to 1000 cfs
  - Shows flow paths, stranding potential etc.

Habitat Analysis

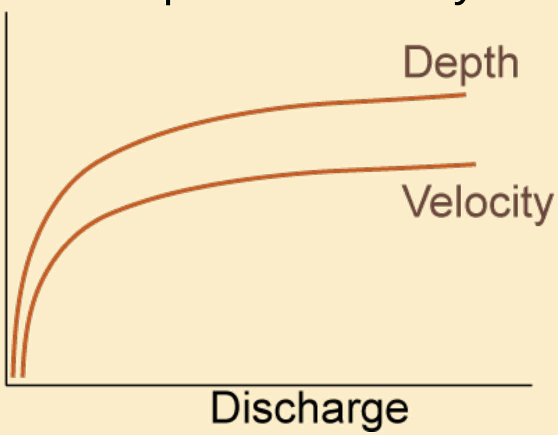
- **Cell-specific Velocity and Depth Predictions**



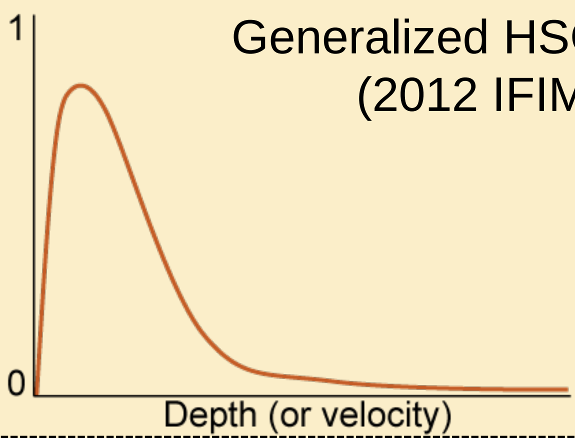
- **30 ft cell size**
- **Velocity**
- **Depth**

Habitat Analysis

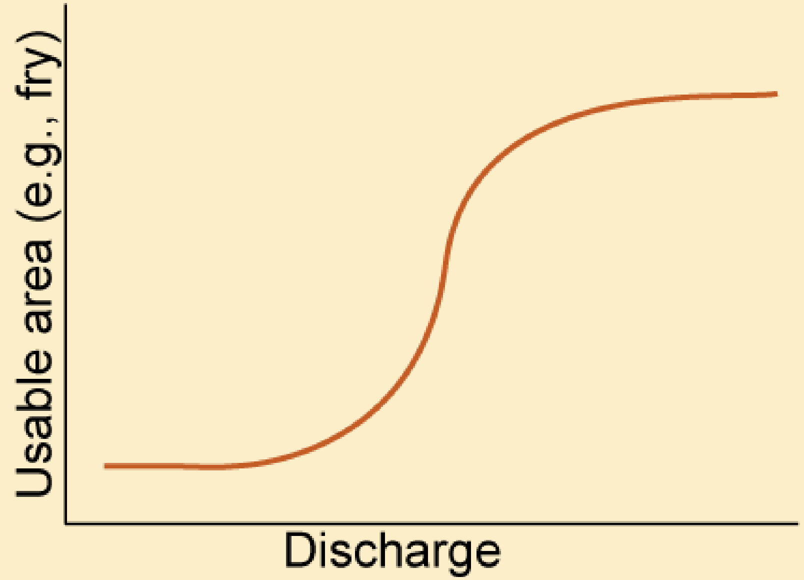
Cell-specific Velocity and Depth



Generalized HSC
(2012 IFIM)

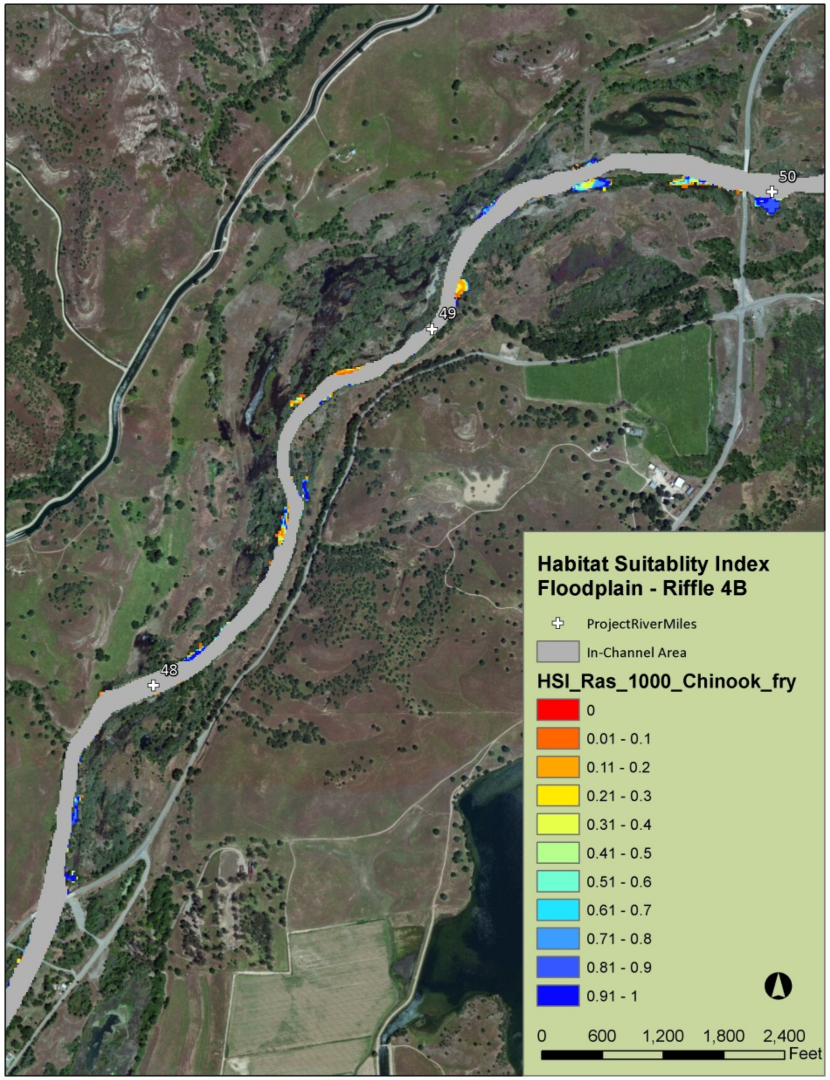


$$Area = \sum_{i=1}^{n} A_i \times HSC(depth, velocity)$$



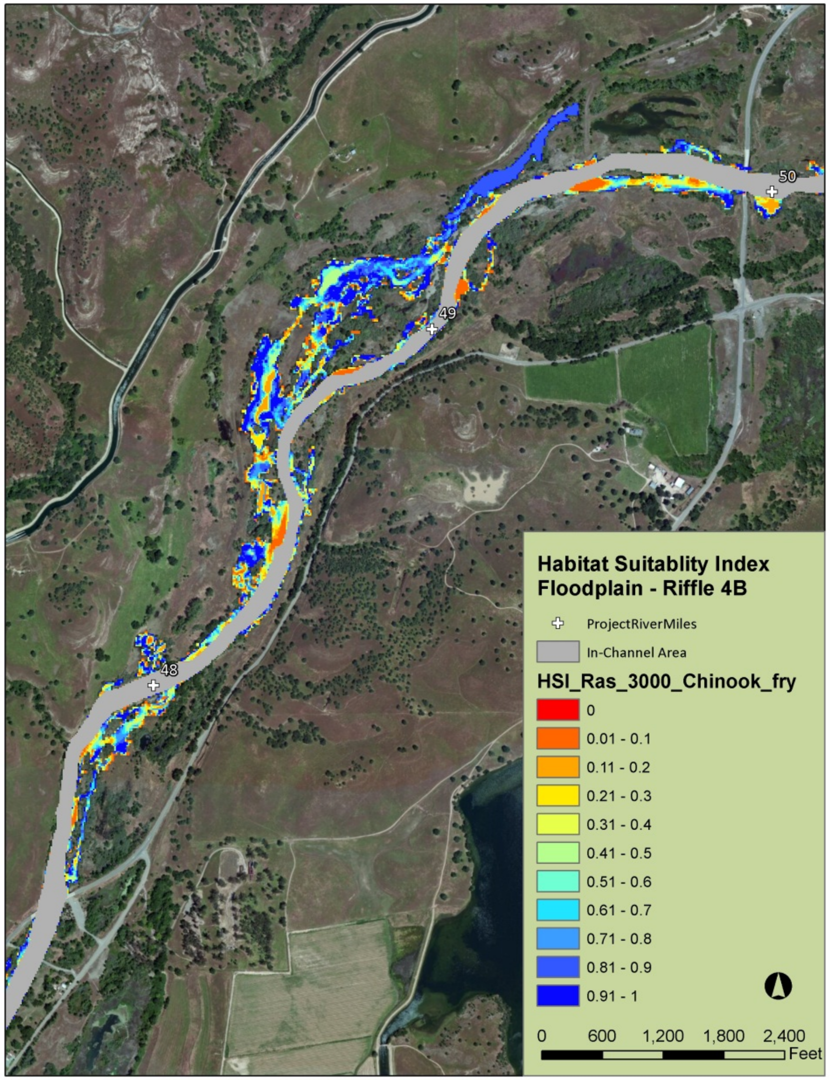
Habitat Analysis Results
Example at Riffle 4A/4B (RM 49)

- Overbank habitat at 1,000 cfs
- Little floodplain inundation evident



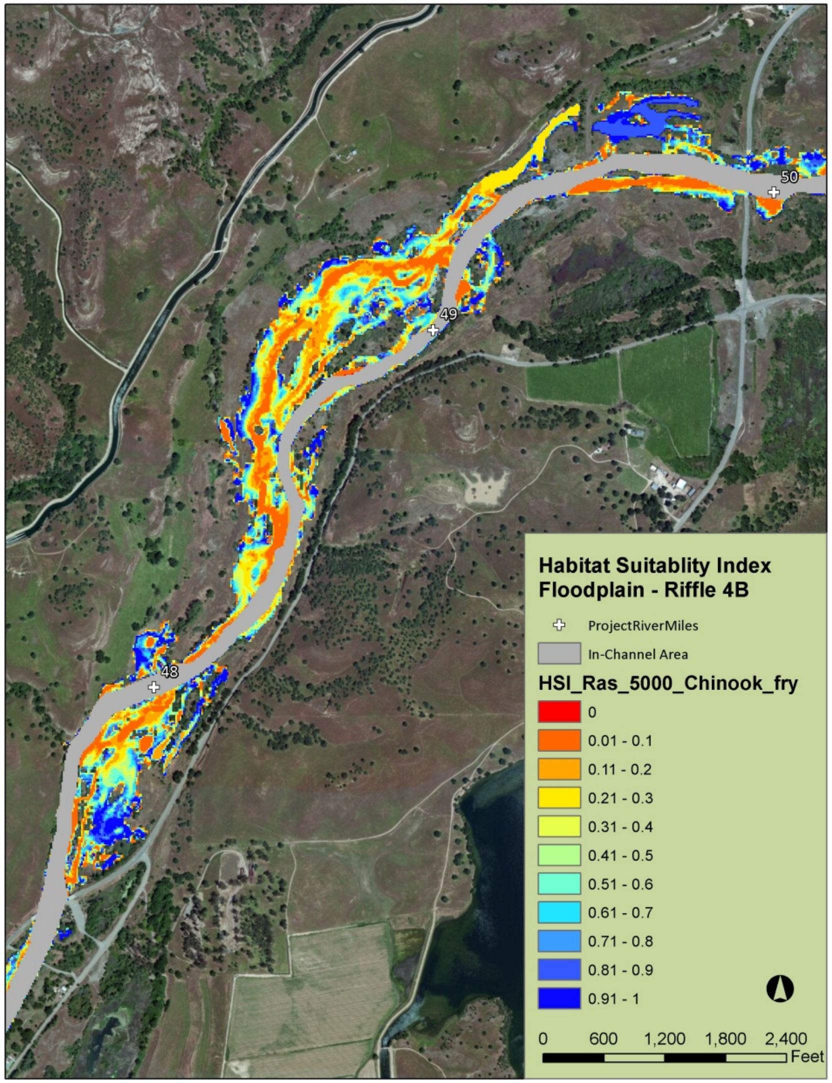
Habitat Analysis Results Example at Riffle 4A/4B (RM 49)

- Overbank habitat at 3,000 cfs
- Inundation of side-channels and floodplain
- Chinook fry habitat suitability (0-100%) greatest in areas with low velocities



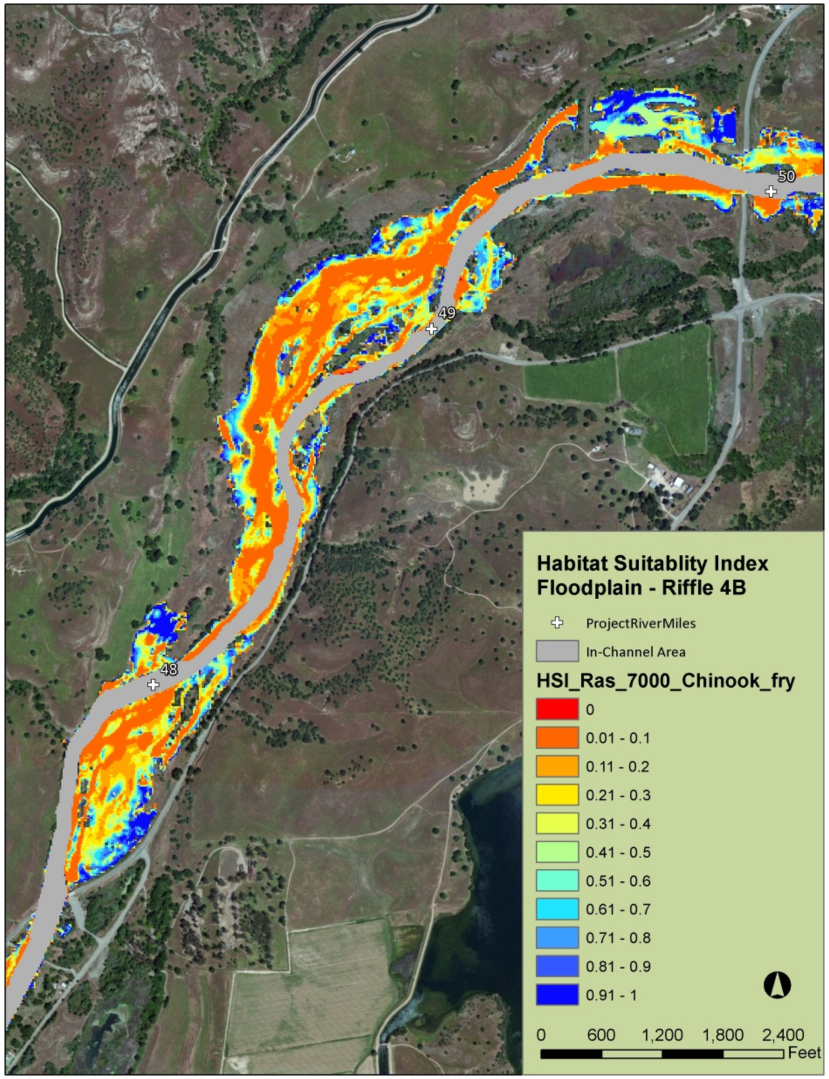
Habitat Analysis Results
Example at Riffle 4A/4B (RM 49)

- **Overbank habitat at 5,000 cfs**
- **Broad inundation of floodplain habitat**
- **Chinook fry habitat suitability (0-100%) greatest in areas with low velocities**



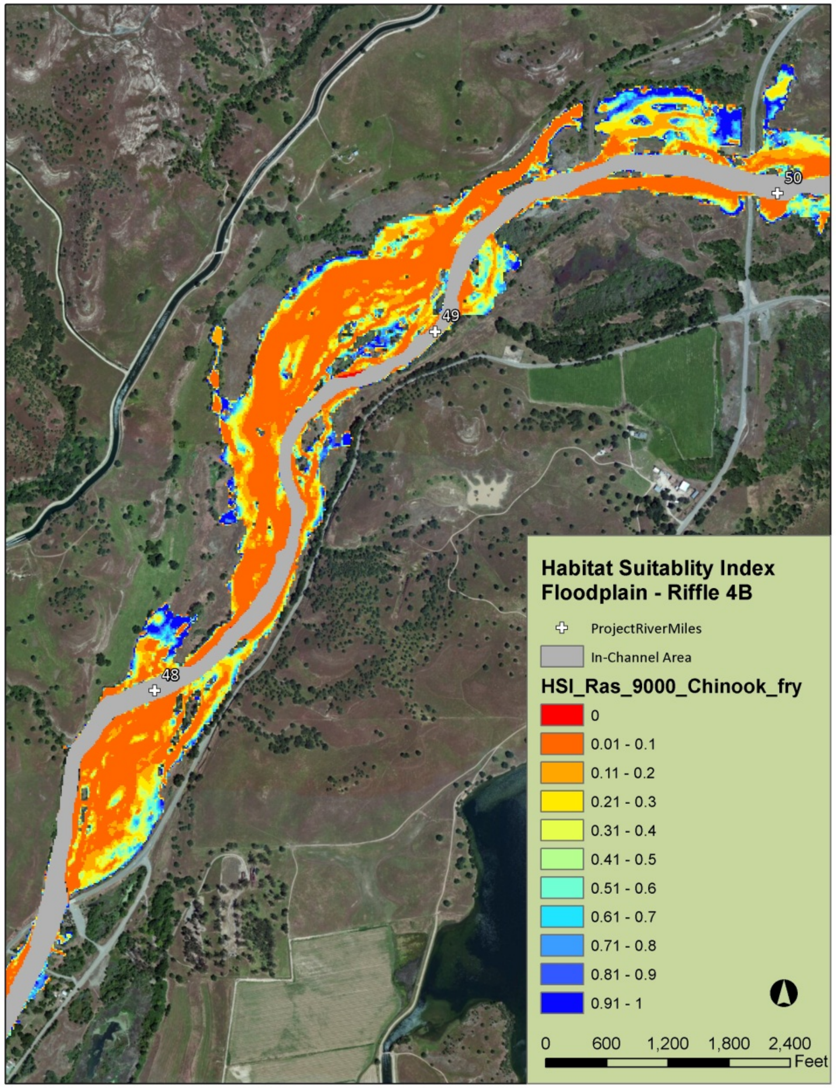
Habitat Analysis Results
Example at Riffle 4A/4B (RM 49)

- **Overbank habitat at 7,000 cfs**
- **Broad inundation of floodplain habitat**
- **Chinook fry habitat suitability (0-100%) greatest in areas with low velocities**



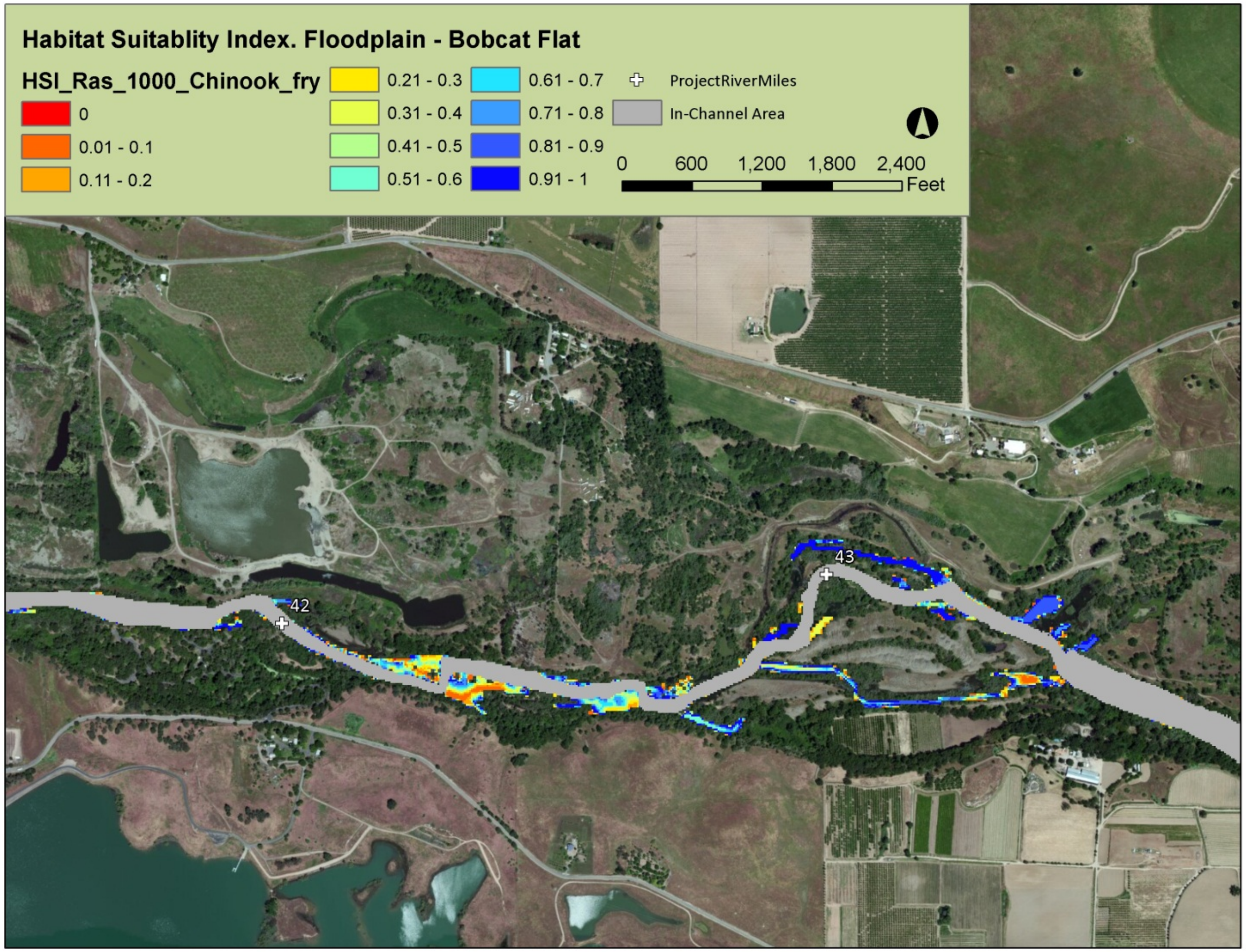
Habitat Analysis Results
Example at Riffle 4A/4B (RM 49)

- **Overbank habitat at 9,000 cfs**
- **Broad inundation of floodplain habitat**
- **Chinook fry habitat suitability (0-100%) greatest in areas with low velocities**



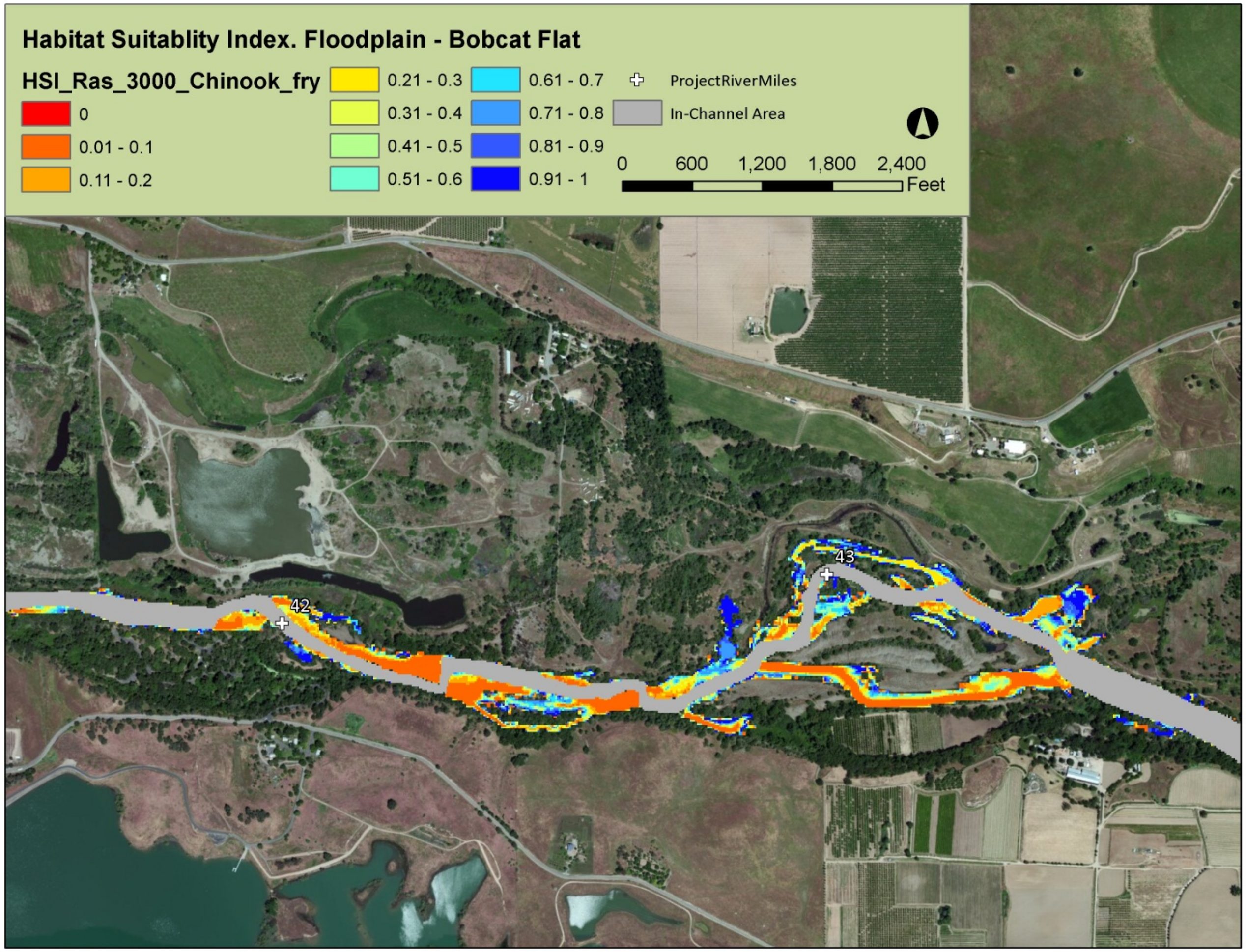
Habitat Analysis Results
Example at Bobcat Flat (RM 43)

- Overbank habitat at 1,000 cfs
- Some side channel and backwater habitat evident



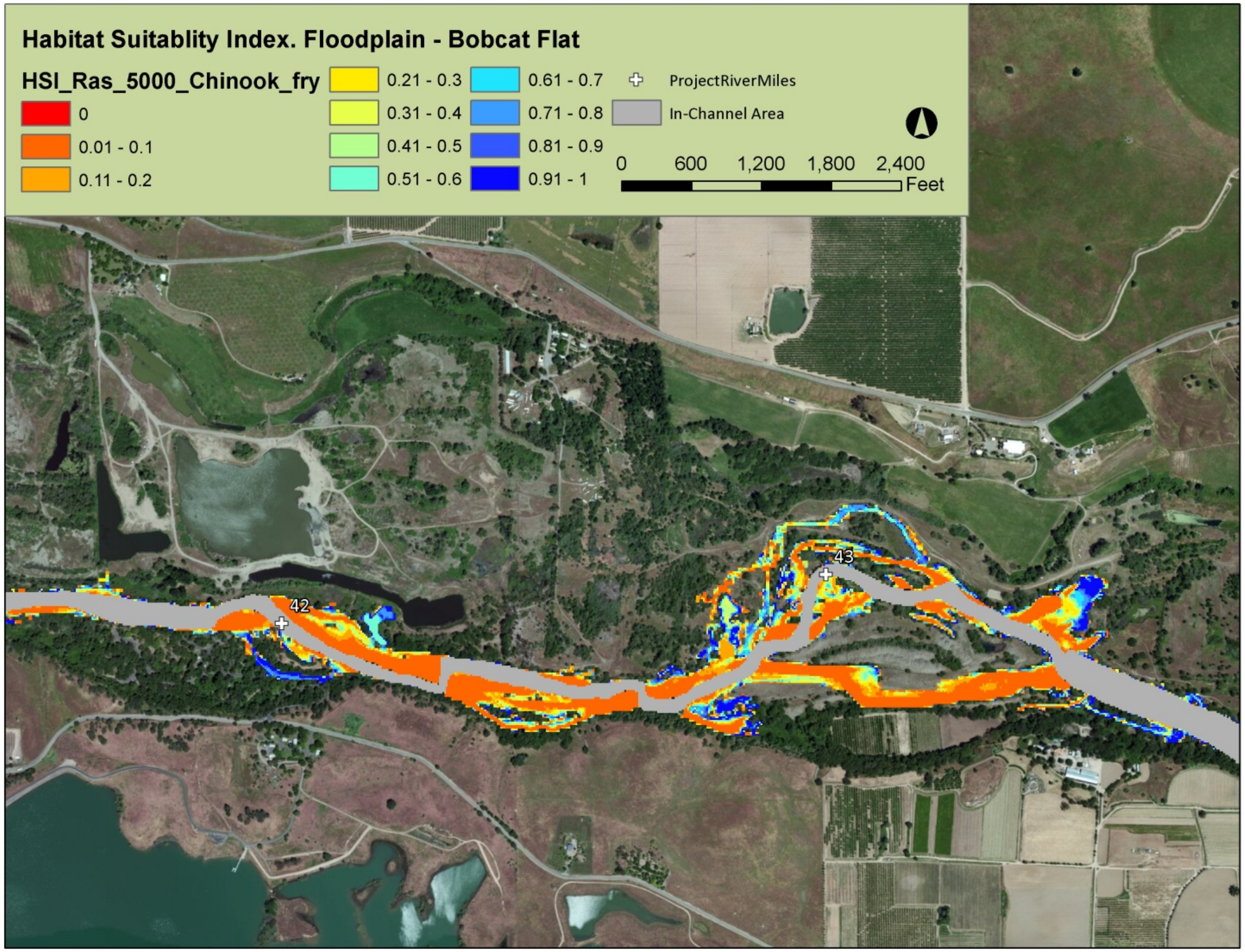
Habitat Analysis Results
Example at Bobcat Flat (RM 43)

- **Overbank habitat at 3,000 cfs**
- **Increasing depths and velocities at channel margins limit Chinook fry habitat suitability**



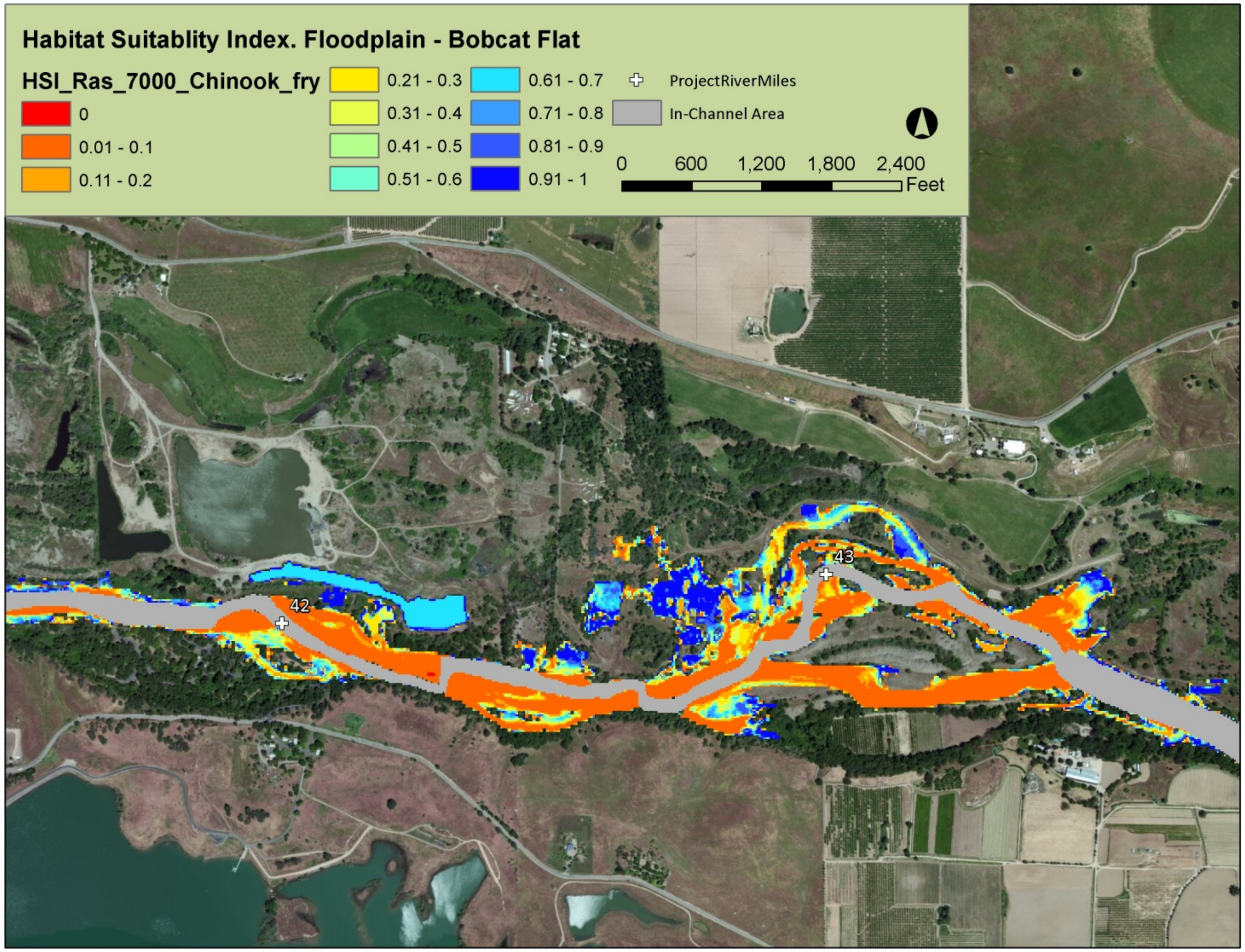
Habitat Analysis Results Example at Bobcat Flat (RM 43)

- **Overbank habitat at 5,000 cfs**
- **Increasing depths and velocities at channel margins limit Chinook fry habitat suitability**



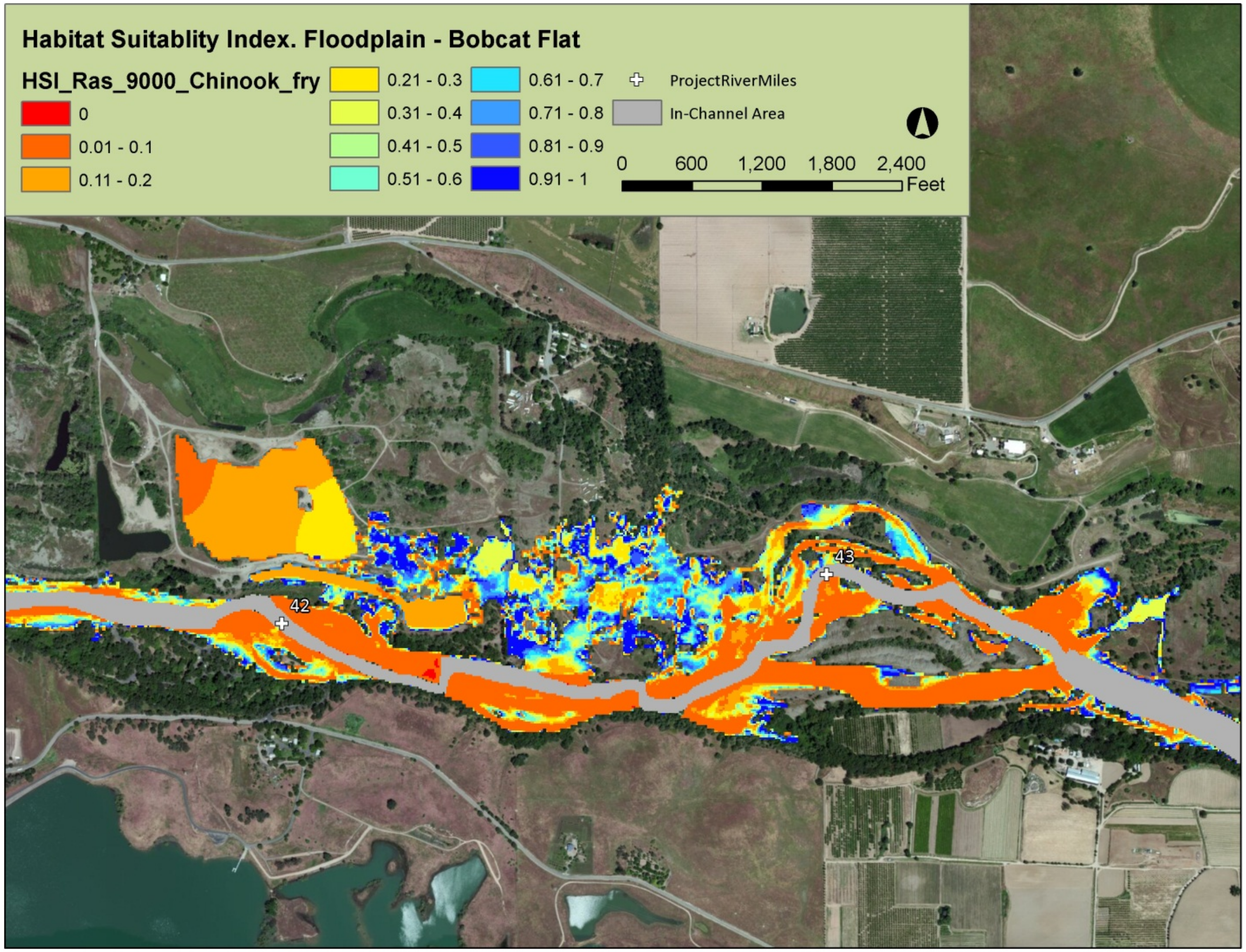
Habitat Analysis Results
Example at Bobcat Flat (RM 43)

- Overbank habitat at 7,000 cfs
- Floodplain inundation in tailings areas
- Chinook fry habitat suitability (0-100%) greatest in shallow areas and low velocities



Habitat Analysis Results
Example at Bobcat Flat (RM 43)

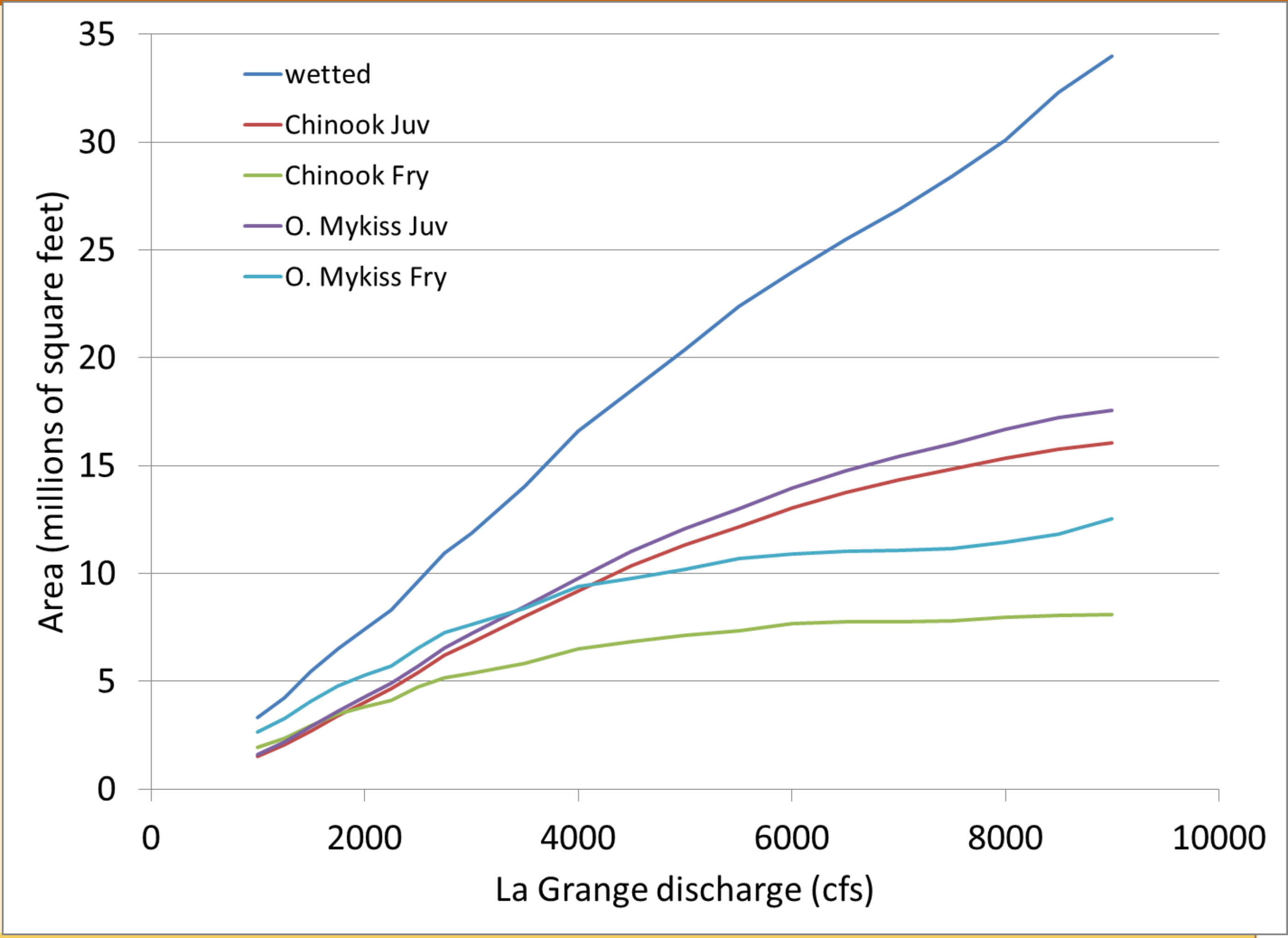
- Overbank habitat at 9,000 cfs
- Floodplain inundation in tailings areas
- Captured mining pit
- Chinook fry habitat suitability (0-100%) greatest in shallow areas and low velocities



Habitat Analysis Results
Model A

- **Approx. 60-80% of inundated area usable by Chinook and *O. mykiss* fry at the lowest flows modeled, falling to 30-40% at 9,000 cfs**

- **Approx. 50-60% of inundated area usable by Chinook and *O. mykiss* juveniles**

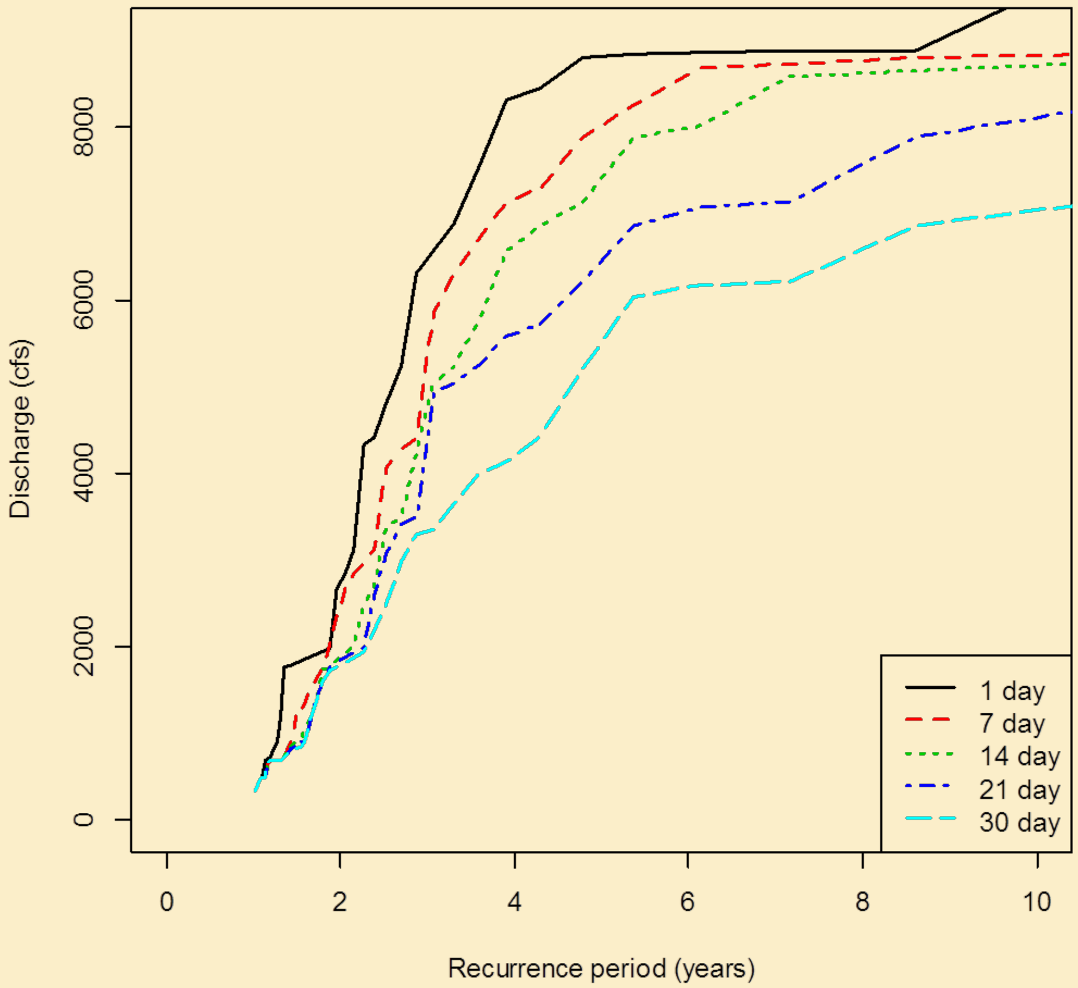


Area-Duration-Frequency Analysis

- Using Base Case hydrology (1971-2012), define floodplain inundation "events" by combinations of:
  - Duration (7, 14, 21, and 30 days)
  - Flow magnitude 1,000–9,000 cfs
- Calculate annual recurrence probabilities of each event (i.e., discharge and duration)
- Combine flow-duration frequency with TUFLOW and HSC analyses to show:
  - Total inundation area-duration-frequency (ADF)
  - Usable habitat ADF by salmonid life stage

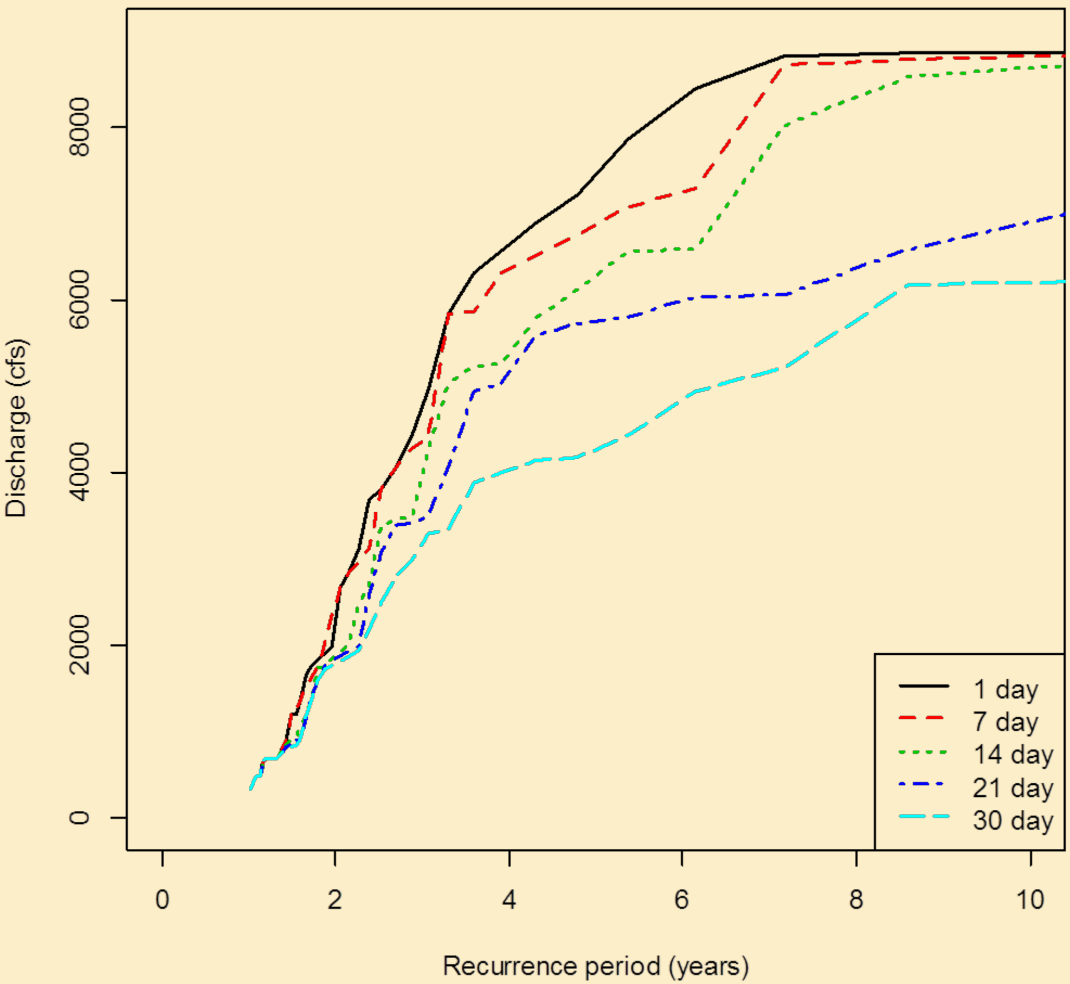
Flow Frequency Analysis Results

- **Base Case hydrology for 1971-2012**
- **Annual recurrence period for 1,000 – 9,000 cfs discharge**



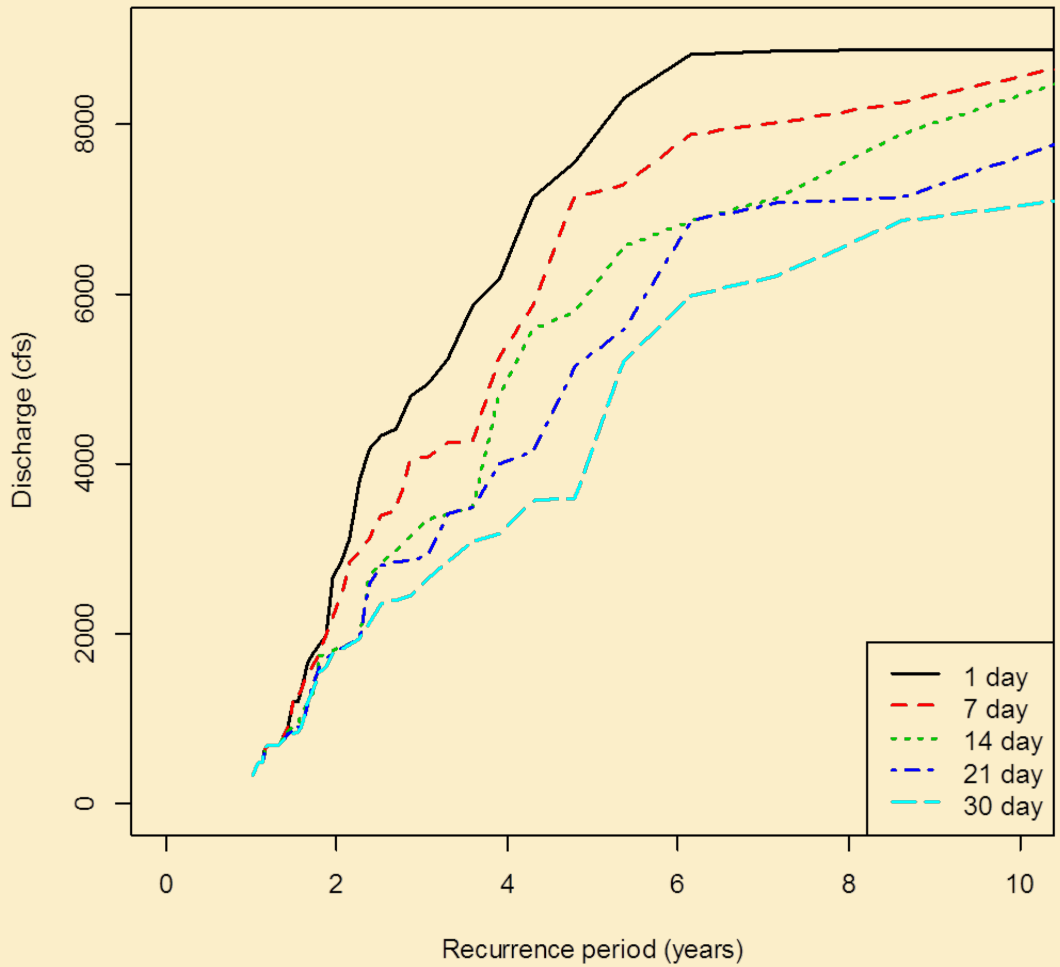
Flow Frequency Analysis Results

- **Base Case hydrology for 1971-2012**
- **Annual recurrence period for 1,000 – 9,000 cfs discharge between February and May**

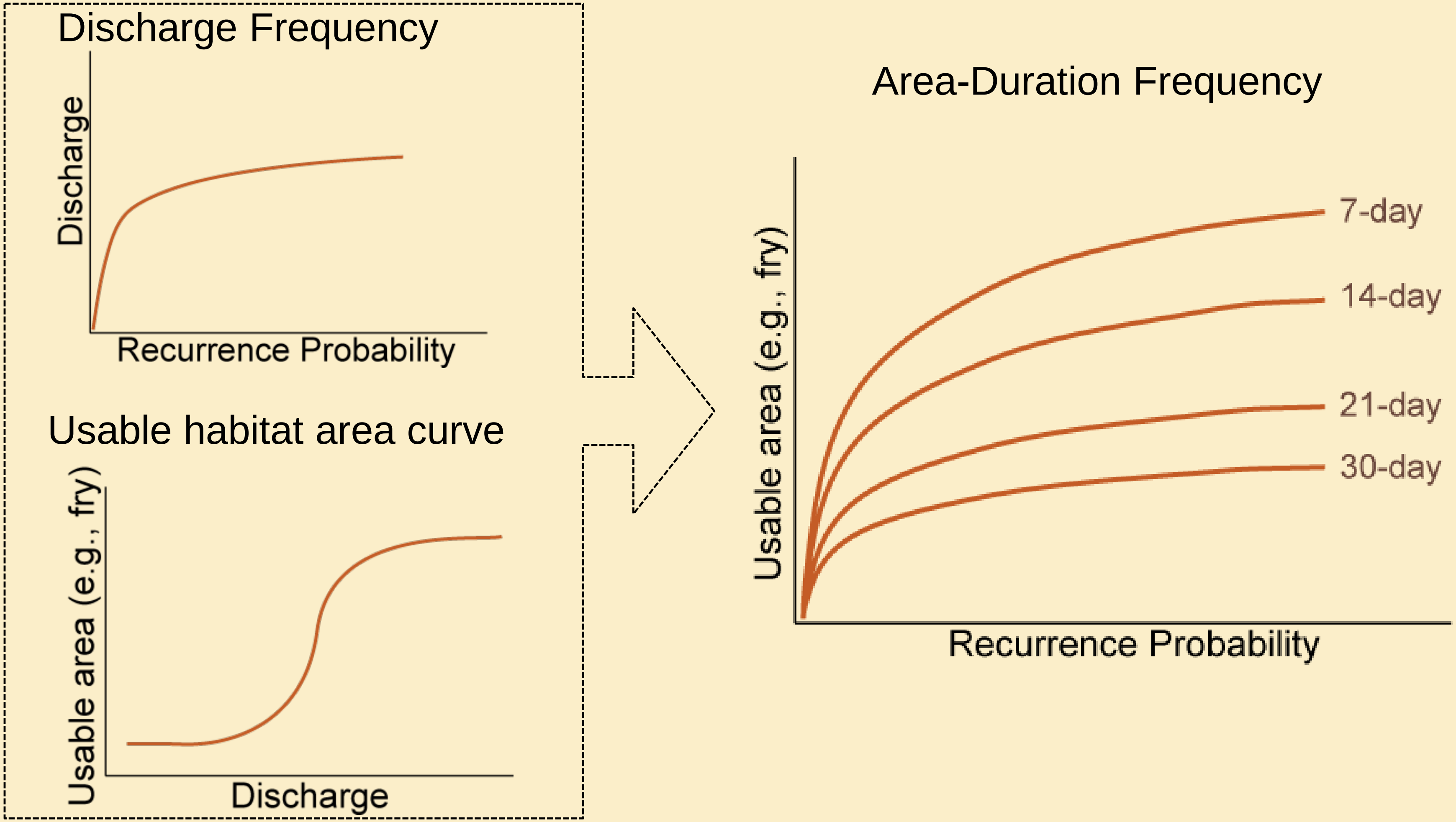


Flow Frequency Analysis Results

- **Base Case hydrology for 1971-2012**
- **Annual recurrence period for 1,000 – 9,000 cfs discharge between March and September**

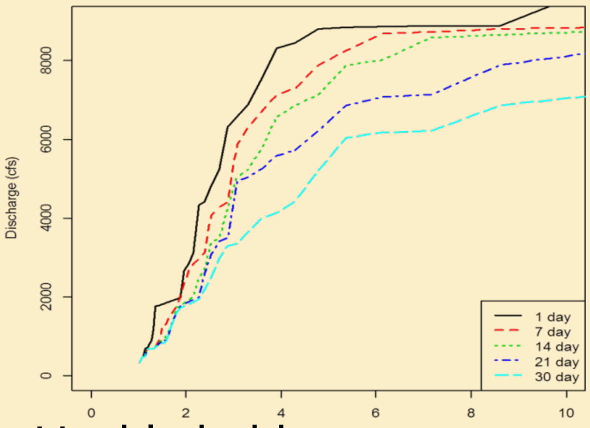


Area-Duration-Frequency Analysis

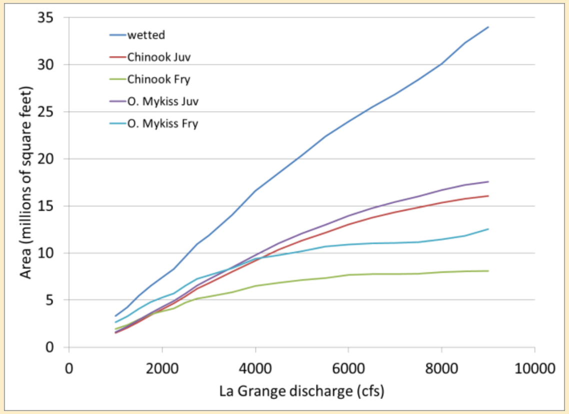


Area-Duration-Frequency Curves to Show Useable Habitat Area

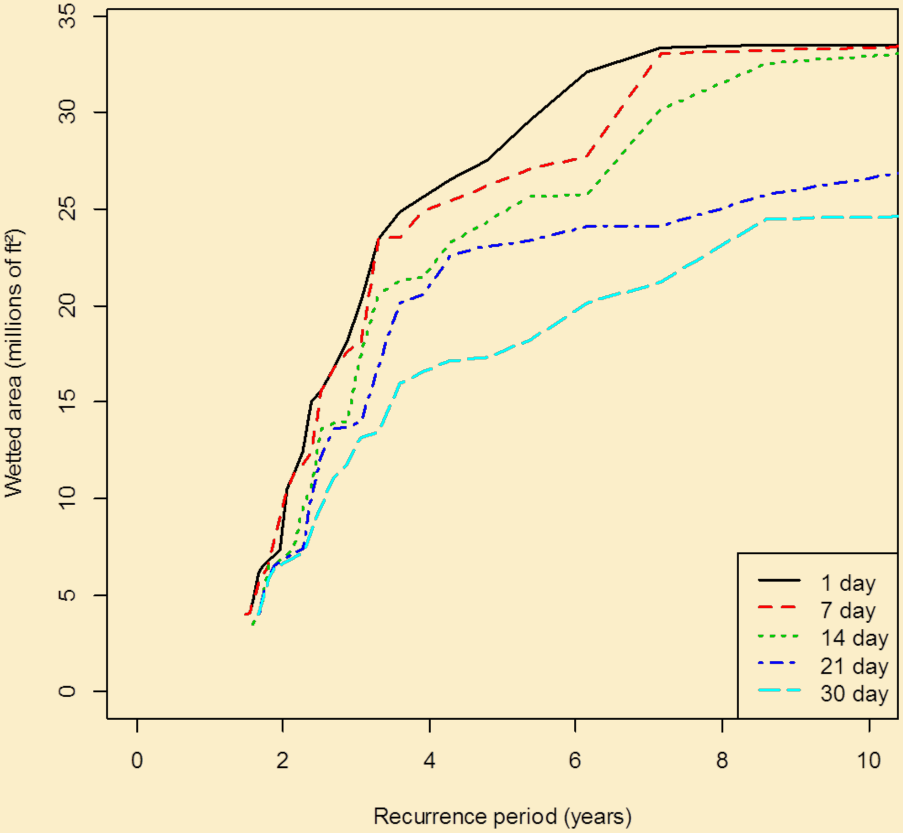
Discharge Frequency



Usable habitat area curve

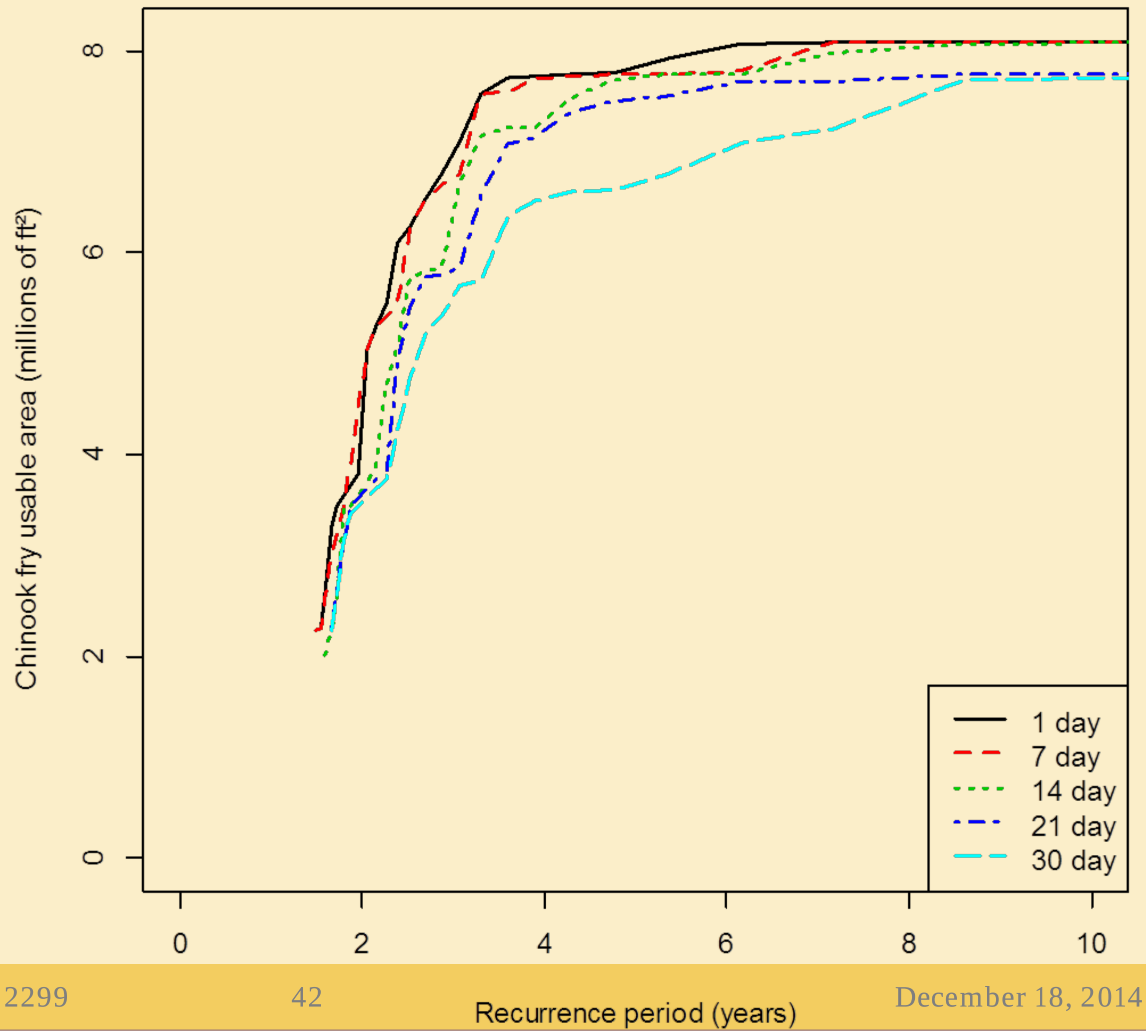


Area-Duration Frequency



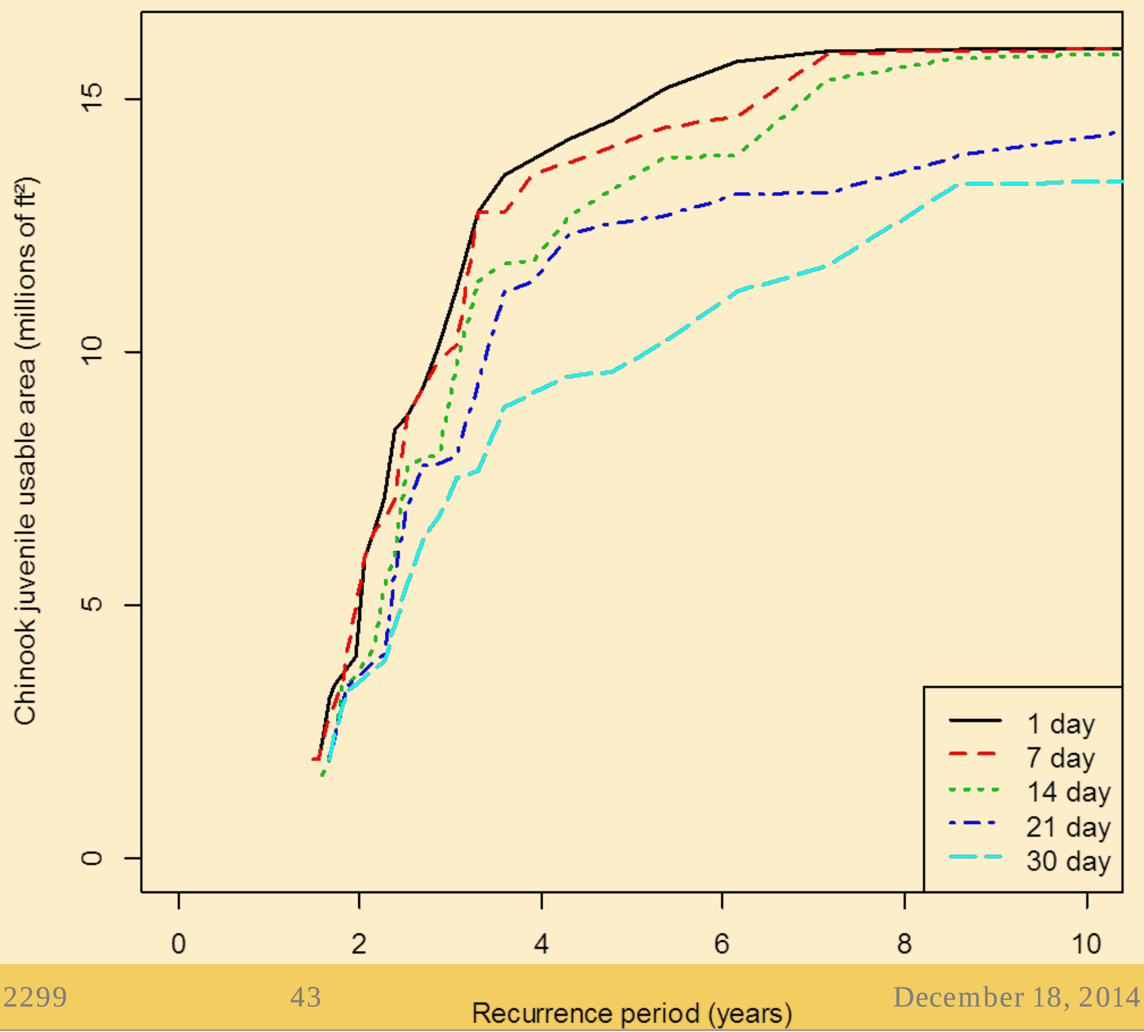
Area Duration Frequency Analysis Results for Model A

- **Base Case hydrology for 1971-2012 between *February and May***
- **Annual recurrence period for inundation of floodplain habitat for *Chinook fry***
- **Large increases in floodplain habitat inundation events (1, 7, 14, 21, 30 days) on a 2-3 yr recurrence period**



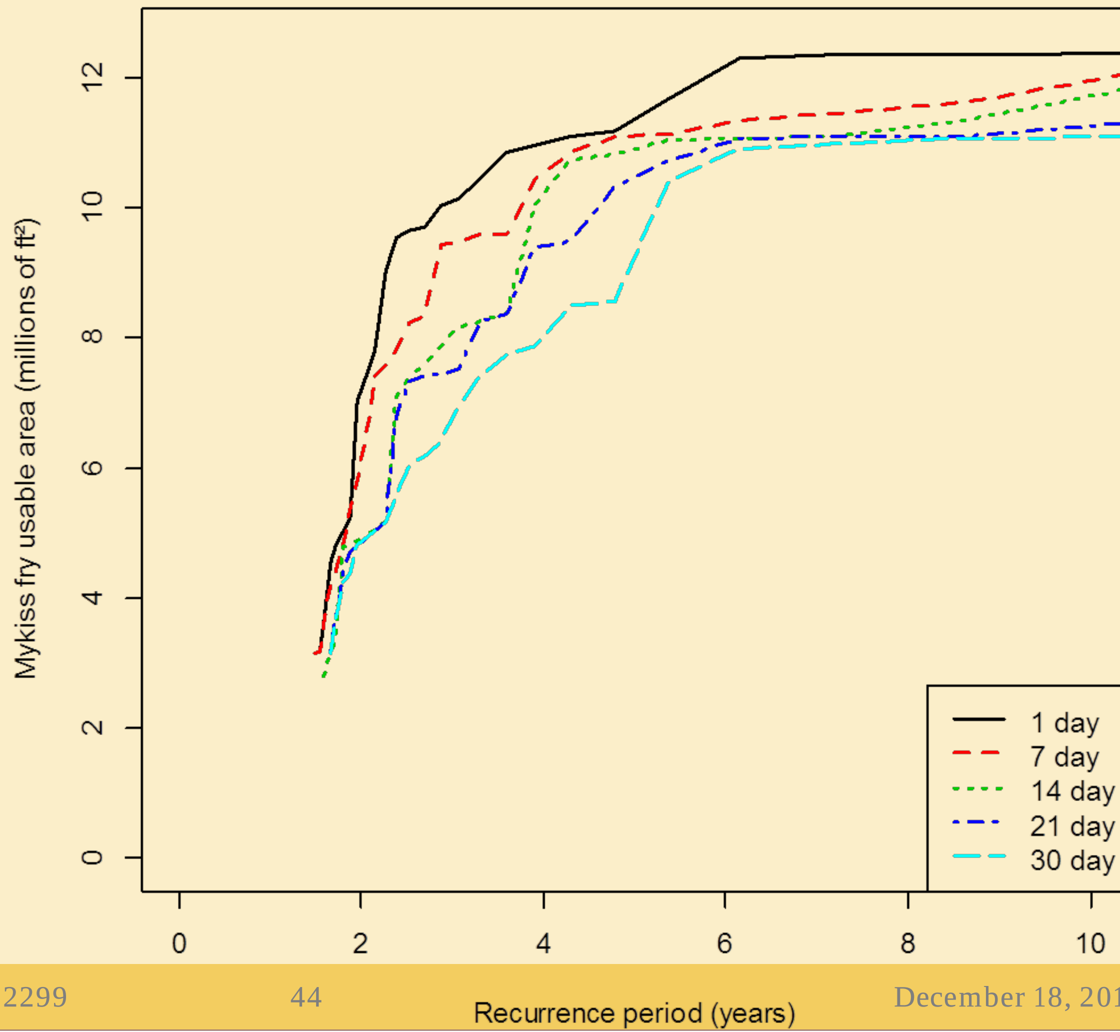
Area Duration Frequency Analysis Results for Model A

- **Base Case hydrology for 1971-2012 between *February and May***
- **Annual recurrence period for inundation of floodplain habitat for *Chinook juveniles***
- **Large increases in floodplain habitat inundation events (1, 7, 14, 21, 30 days) on a 2-3 yr recurrence period**



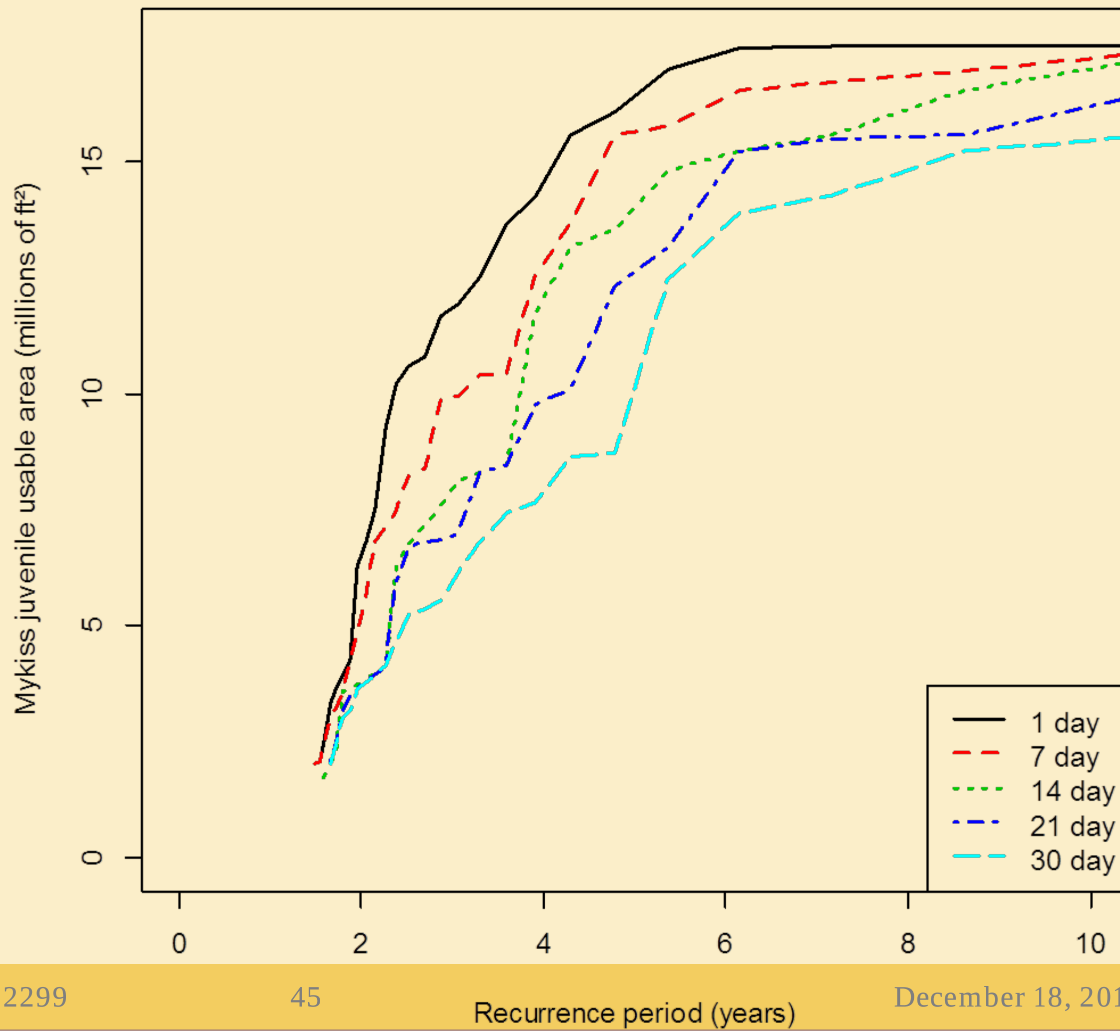
Area Duration Frequency Analysis Results for Model A

- **Base Case hydrology for 1971-2012 between *March and September***
- **Annual recurrence period for inundation of floodplain habitat for *O. mykiss fry***
- **Large increases in floodplain habitat inundation events (1, 7, 14, 21, 30 days) on a 2-3 yr recurrence period**



Area Duration Frequency Analysis Results for Model A

- **Base Case hydrology for 1971-2012 between *March and September***
- **Annual recurrence period for inundation of floodplain habitat for *O. mykiss juveniles***
- **Large increases in floodplain habitat inundation events (1, 7, 14, 21, 30 days) on a 2-3 yr recurrence period**



Habitat Analysis Summary

- **Model A – RM 52.2 to RM 40**
  - **Flows above bankfull discharge (1,500-2,000 cfs) associated with large increases in usable habitat for rearing Chinook salmon and *O. mykiss***
  - **For short duration events (e.g., 1, 7 days), approx. 200% increase in usable habitat area occurs between 1.5 to 2 year recurrence periods under the Base Case (WY1971-2012)**
  - **Longer duration inundation events lasting 14-days and occurring at a 4 year recurrence period are associated with usable habitat area increases on the order of 300%**
- **Models B and C to be provided with Draft study report**

Questions?

Photo Credit: Tuolumne River TAC

Floodplain Hydraulic Assessment Schedule

Draft Report Preparation	November to December 2014
Draft Report Provided to Relicensing Participants for 30-day review and comment	January 2015
Relicensing Participant Comments Due	February 2015
Final Report Filing with FERC	March 2015