LYR 2D MODEL DETAILS

"The" LYR 2D Model

After testing with different programs, USBR's SRH-2D hydrodynamic modeling algorithm was chosen, because of its excellent stability, computational efficiency, accuracy, simple usability, and technical support. SRH works in MS Windows®.

There is no one "LYR model". A suite of models exists to represent different regions of the LYR, different flow regimes and operations, and different substrate/vegetation conditions.

We have validated SRH-2D for use with several gravel-bed rivers in California, including the LYR. Like all 2D models, the LYR model has uncertainties, but it passes all standard validation tests.

LYR 2D MODEL DETAILS

Suite of LYR Models

- Model Domains
  - Englebright Dam Reach (EDR)
  - Timbuctoo Bend Reach (TBR)
  - HR (Hammon Reach)
  - DGR (Daguerre Reach)
  - FR (Feather Reach)

The LYR is broken into 5 model domains to keep the size of each computation manageable given current computer technology.

The method for making and running the models was standardized, but each model has unique attributes.

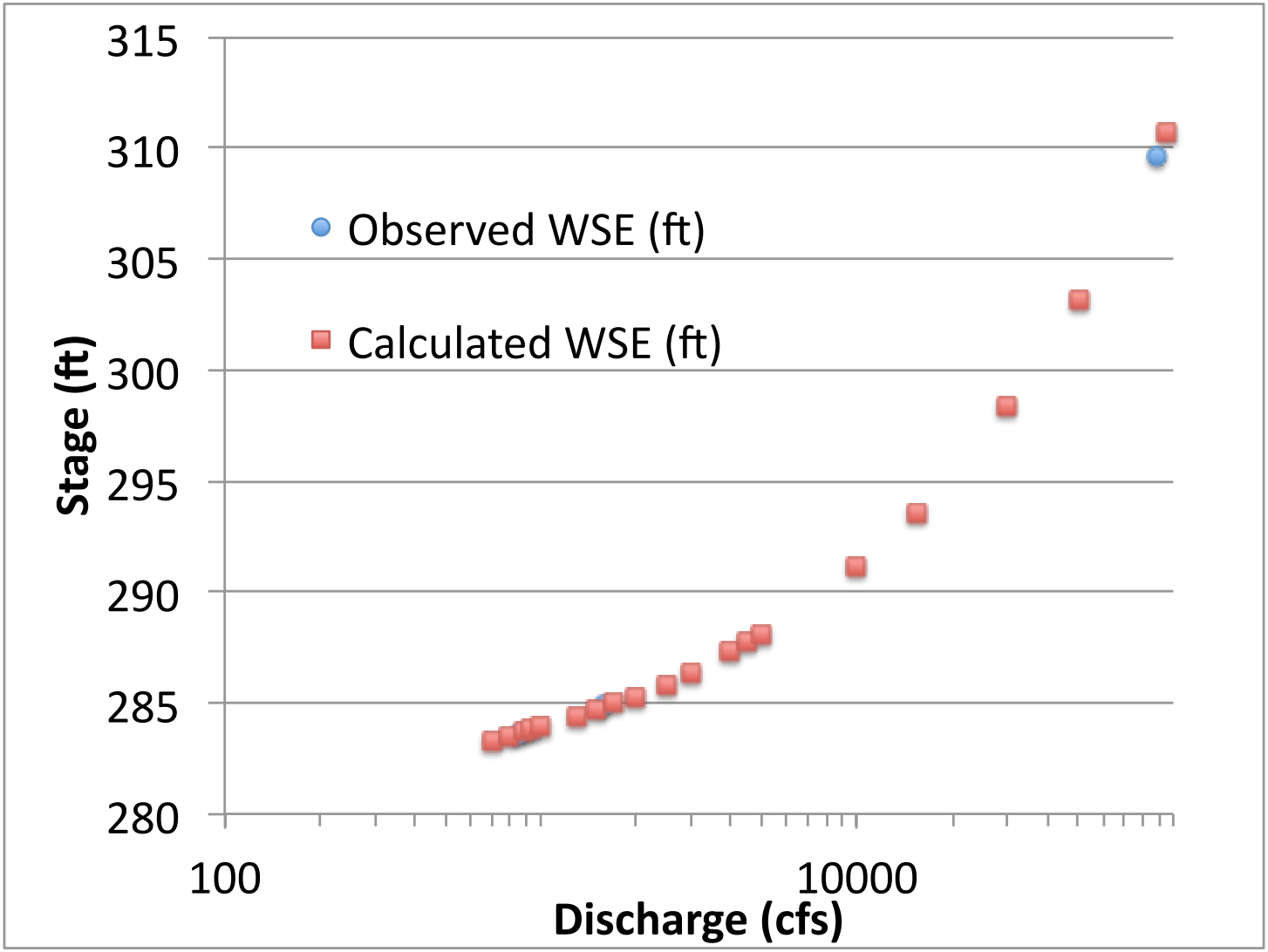
***not aligned with geomorphic reaches

LYR 2D MODEL DETAILS

Englebright Dam Reach (EDR) Model

- Model reach extends from just below the Narrows 2 Powerhouse to just upstream of the confluence with Deer Creek.
- The EDR model may be operated with different inflows from PH1 and PH2+Spill.
- All the runs were made with PH1 releasing 500 cfs no matter what, with the remainder coming from PH2+Spill.
- Rating curve includes a few observations at the downstream boundary and slope-based transference of WSEs from the YRS gage.
- Vegetation explicitly incorporated into roughness parameterization, but is the same constant value for the whole mesh, because there is no Canopy height raster for EDR.
- Manning's n was chosen to be 0.032 for all flows based on comparison of depths and water surface elevations against field observations done 2005-2009.
- Tests found that roughness did not vary systematically as a function of Q.

LYR 2D MODEL DETAILS



LYR 2D MODEL DETAILS

EDR Meshes

"lowQ" mesh

- Best for flows of <4500 cfs; can work for higher flows, but has stability issues due to hybrid mesh
- No backwater inflows.
- 183,988 elements
- Hybrid mesh with 3' internodal spacing in channel <~4500 cfs morphing to 6' internodal spacing at outer mesh edge.

"midQ" mesh

- Best for flows 5000-15400 cfs; can work for all flows 0-15400 cfs
- No backwater inflows.
- 143,975 elements
- Uniform 3' internodal spacing

"highQ" mesh

- Best for flows 15400-96100 cfs; can work for all flows 0-96100 cfs (likely higher)
- No backwater inflows.
- 213,700 elements
- Uniform 3' internodal spacing

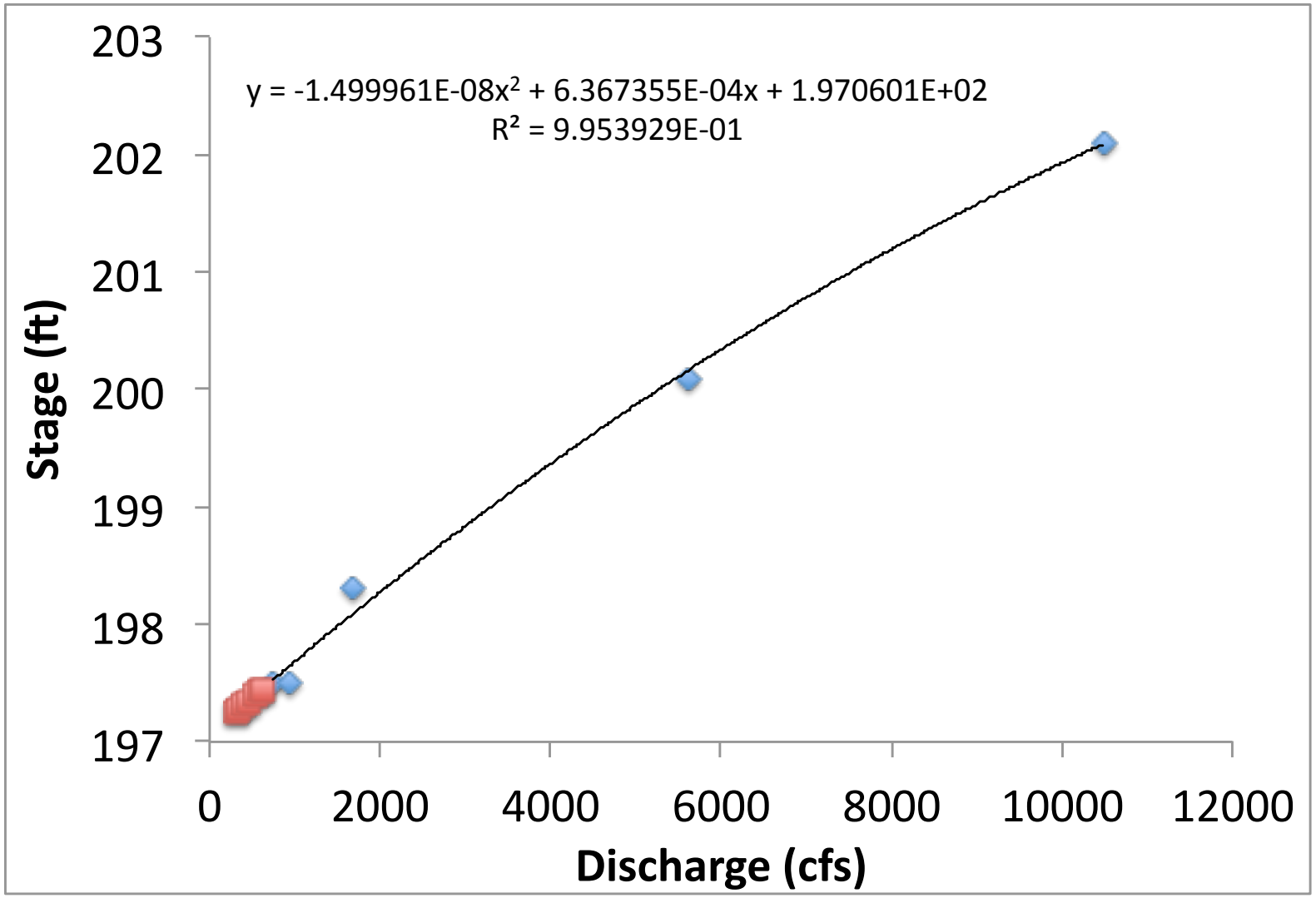
LYR 2D MODEL DETAILS

Timbuctoo Bend Reach (TBR) Model

- Model reach extends from Narrows Pool exit to just upstream of the Highway 20 bridge.
- Vegetation explicitly incorporated into roughness parameterization, but is the same constant value for the whole mesh, because there is no Canopy height raster for TBR.
- Flows 0-110,000 (likely higher).
- Flows equal sum of Smartsville (YRS) + Deer Creek (DCS) gages
- No backwater inflows.
- Manning's n chosen as 0.03 based on comparison of depths and water surface elevations against field observations done 2006-2009.
- 827,984 elements
- Hybrid mesh with 3' internodal spacing in channel <~5000 cfs; morphs to either 6' or 15' internodal spacing at outer mesh edge, depending on proximity of model outer edge to channel (i.e. closer proximity=6' spacing).

LYR 2D MODEL DETAILS

TBR Rating Curve



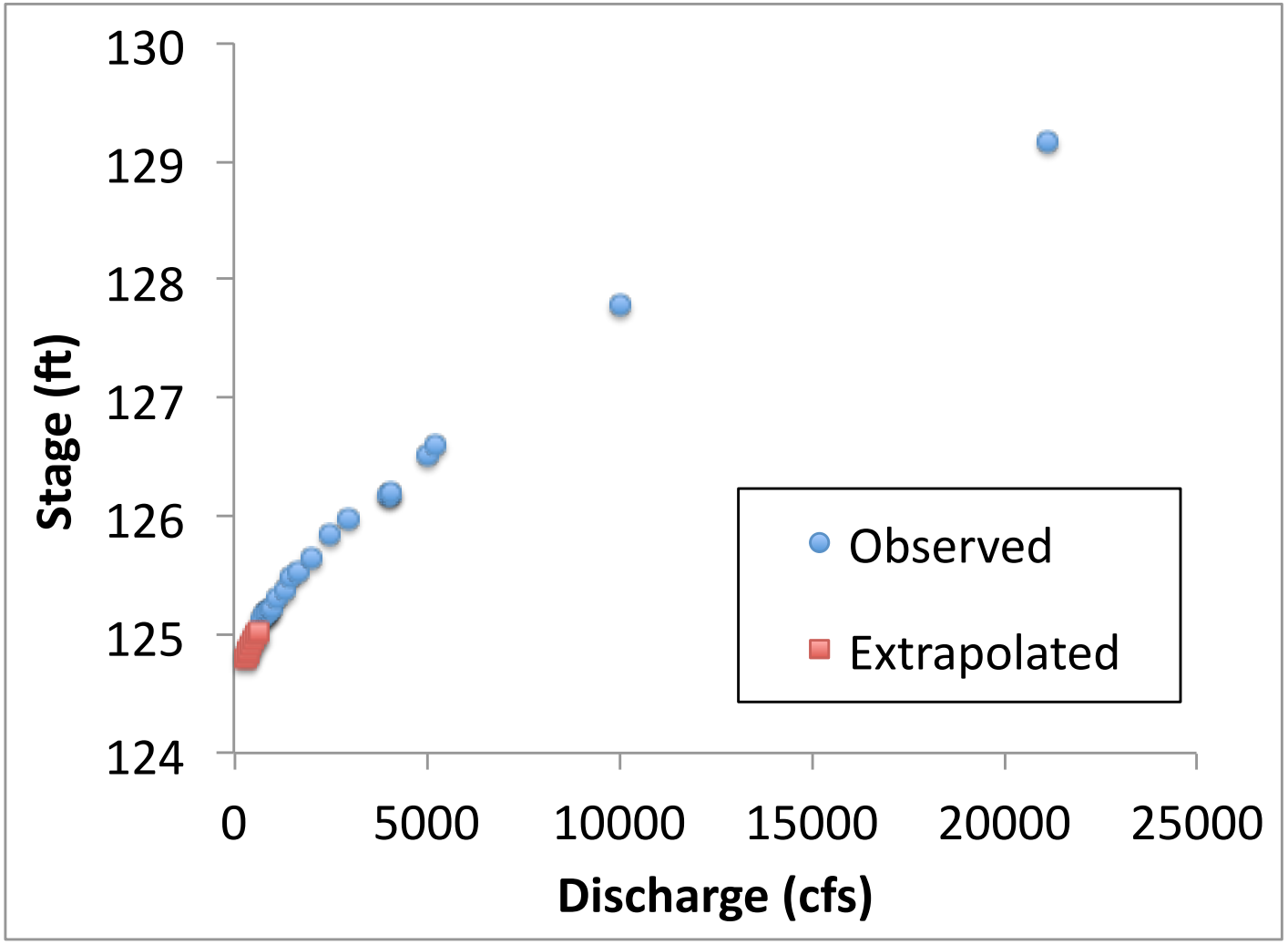
LYR 2D MODEL DETAILS

Hammon Reach (HR) Model

- Model reach extends from just upstream of the Highway 20 bridge to just upstream of Daguerre Point Dam.
- Flows of 0-21100 cfs (much higher expected)
- Flows equal sum of Smartsville (YRS) + Deer Creek (DCS) gages.
- Vegetation only explicitly incorporated into roughness parameterization for HQM and FullMesh2.
- Tributary inflow from Dry Creek (ungagged) also used. BVID provided regulated flow data for some events upon request.
- Stage-discharge rating curve constructed using water level sensor data collected 2009-2011.
- Manning's n chosen as 0.04 based on testing of 0.03, 0.04, and 0.05 options against field observations of WSE.

LYR 2D MODEL DETAILS

HR Rating Curve



LYR 2D MODEL DETAILS

HR Meshes

"BaseMesh"

- Best for flows 0-1300 cfs
- 3 cfs Dry Creek flow input
- Two Hammon backwater flow inputs (2 cfs for main channel and 1 cfs for a northern branch) to wet up backwater channel.
- 737,475 elements; Uniform 3' internodal spacing.

"HQM" (higher flow mesh)

- Best for flows 1300-5000 cfs
- Two Dry Creek inlets totaling 3 cfs.
- One Hammon backwater flow input of 3 cfs to wet up backwater channel.
- 1,351,183 elements; Uniform 5' internodal spacing.

"FullMesh2"

- Best for flows >5000 cfs
- No backwater inflows.
- 551,498 elements;
- Channel has 10' internodal spacing; morphs to 40' internodal spacing at out mesh edge.

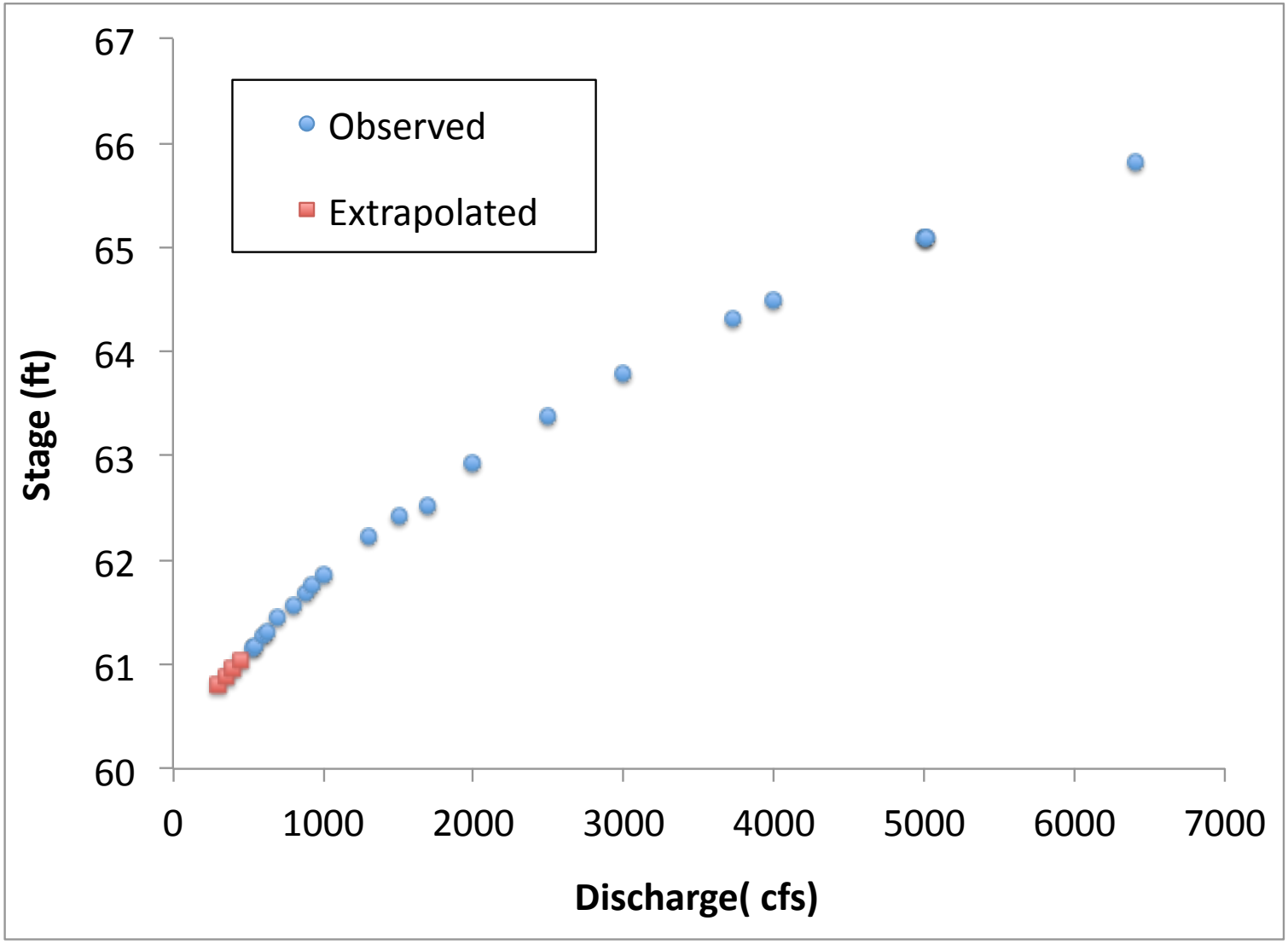
LYR 2D MODEL DETAILS

Daguerre Reach (DGR) Model

- Model reach extends from just upstream of Daguerre Point Dam to the Maryville gaging station.
- Vegetation only explicitly incorporated into roughness parameterization for HQM and FullMesh2.
- Flows of 0-21100 cfs (much higher expected, but untested so far)
- Flows equal sum of Smartsville (YRS) + Deer Creek (DCS) gages
- Floods spread over Gold Fields area, so it is not anticipated to model that full extent.
- Stage-discharge relation comes from the Marysville gage, so this is the best one
- Manning's n chosen as 0.04 based on testing of 0.03, 0.04, and 0.05 options against field observations of WSE.

LYR 2D MODEL DETAILS

DGR Rating Curve (MRY gage data)



LYR 2D MODEL DETAILS

DGR Meshes

"BaseMesh"

- Includes DPD
- Best for flows 0-1300 cfs
- 6 backwater flow inputs of 0.2-1 cfs to wet up all the backwater channels.
- 544,949 elements; Uniform 5' internodal spacing.

"HQM" (higher flow mesh)

- Includes DPD
- Best for flows 1300-5000 cfs
- 5 backwater flow inputs of 3 cfs to wet up all the backwater channels.
- 1,333,183 elements; Uniform 5' internodal spacing.

"FullMesh2"

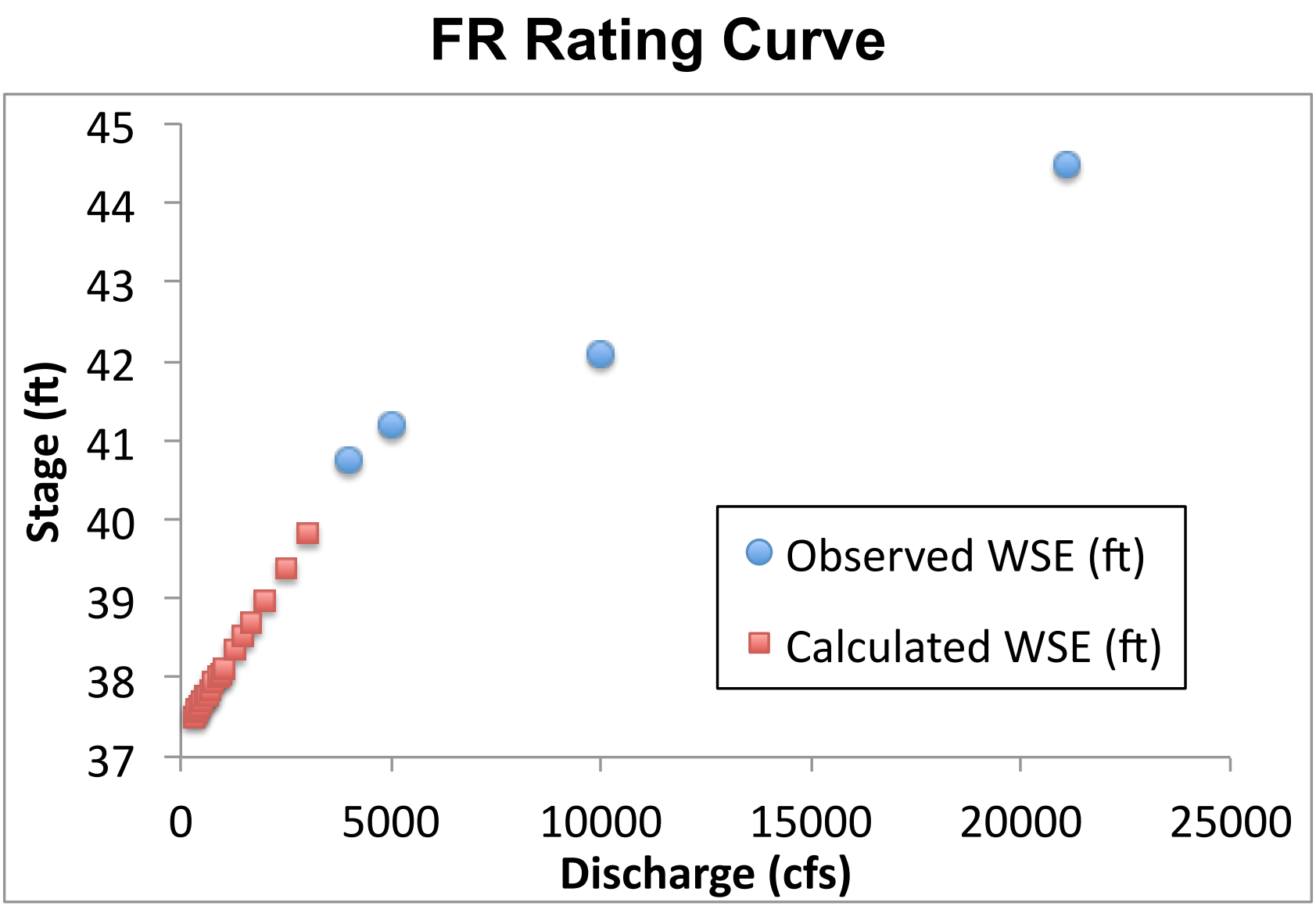
- Includes DPD, but there is a 5' gap between HR FullMesh 2 and DGR Full Mesh 2
- Best for flows >5000 cfs
- No backwater inflows.
- 775,786 elements; Uniform 10' internodal spacing.

LYR 2D MODEL DETAILS

Feather Reach (FR) Model

- Model reach extends from the Maryville gaging station to just upstream of the confluence with the Feather River.
- Vegetation only explicitly incorporated into roughness parameterization for HQM and FullMesh2.
- Flows of 0-21100 cfs (somewhat higher expected, but untested so far).
- Flows obtained from Marysville (MRY) gage.
- Floods may spread over vast area, so it is not anticipated to model that full extent.
- Stage-discharge relation comes from water level sensor at the confluence with the Feather River. This is the most uncertain one, because the Feather River exerts a strong backwater control on the lower Yuba. Also, the riverbed seems to be changing often enough to cause the rating to shift over time.
- Stage-discharge data for 0-3000 cfs was collected December 2009-March 2010.
- Stage-discharge data for 3000-21100 was collected December 2010.
- Manning's n chosen as 0.04 based on testing of 0.03, 0.04, and 0.05 options against field observations of WSE.

LYR 2D MODEL DETAILS



LYR 2D MODEL DETAILS

FR Meshes

"BaseMesh"

- Best for flows 0-1300 cfs; No backwater inflows.
- 474,722 elements; Uniform 5' internodal spacing.

"HQM" (higher flow mesh)

- Best for flows 1300-5000 cfs; No backwater inflows.
- 856,245 elements; Uniform 5' internodal spacing.

"FullMesh2"

- There is a 5' gap between DGR FullMesh 2 and FR Full Mesh 2
- Best for flows >5000 cfs; No backwater inflows.
- 562535 elements; Uniform 10' internodal spacing.

What Makes a Good 2D Model

THERE ARE NO AGREED UPON STANDARDS FOR DECIDING WHETHER A 2D MODEL IS ACCURATE OR NOT.

Kinds of things one can check:

- Compare WSE or depths against observations at points
- Compare velocity magnitude against observations at points
- Compare spatial pattern of flow against quantitative flow vectors or qualitative drawings of flow patterns, such as eddies behind boulders.

LYR 2D MODEL DETAILS

Specific 2D Model Performance Benchmarks

WSE predicted vs observed:

- deviations centered on zero (bias indicates incorrect Manning's n value or eddy viscosity coefficient value).
- deviations having similar statistical distribution as that for topo point QA/QC deviations.

Velocity predicted vs observed:

- R^2 → 0.4-0.8 (watch out for reports of R, not R^2)
- Velocity error statistics for each point observation → average error of 20-30%, with range up to 200 % for low velocities.
- 1:1 linearity → not commonly used, but should be >0.9 if no bias present
- Zero intercept→ not commonly used, but should be < 5% of V_{max}.
  ·Represents a bias in model to underpredict high velocities. Can be assessed by analyzing residuals.
- XS accuracy → visually looks "good".
- Flow Direction → not commonly tested. Within 10°?

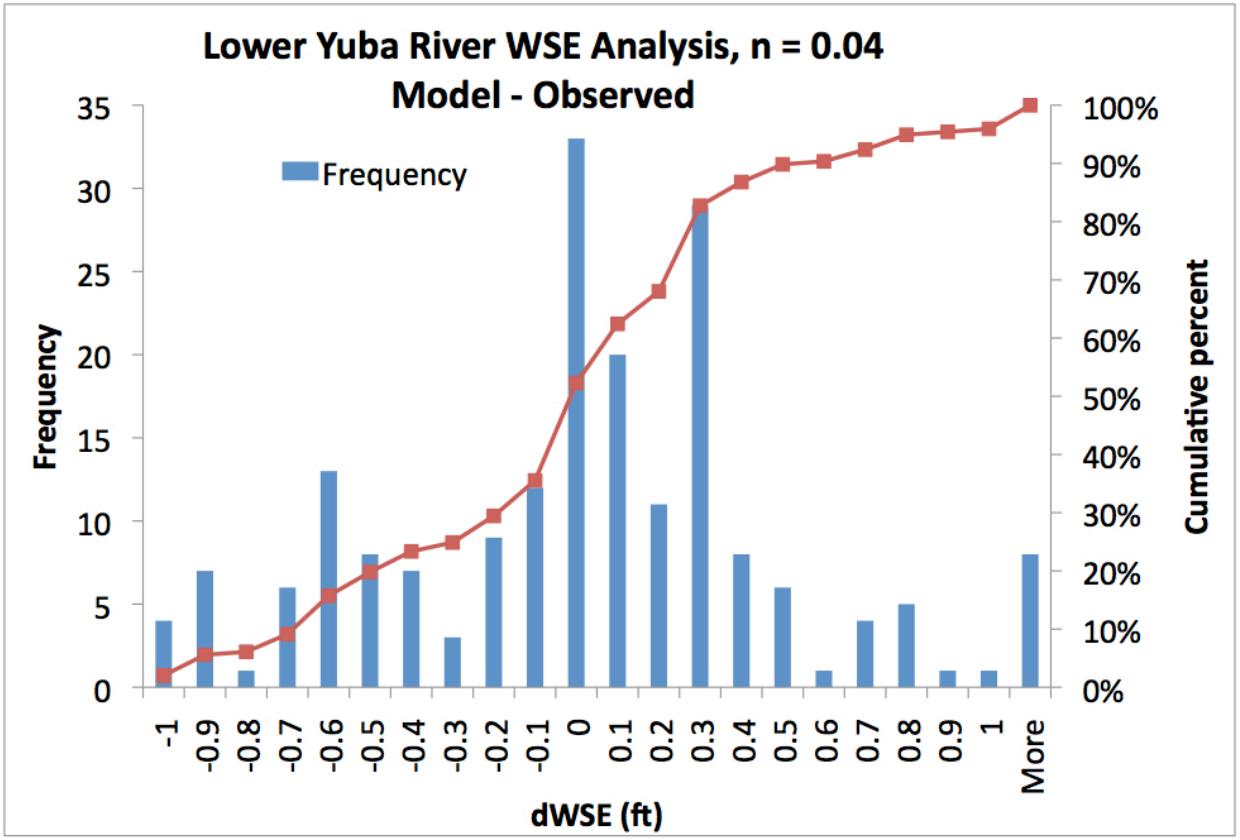
LYR WSE Performance at 880 cfs

- Deviations centered on zero ✔
  - Mean raw deviation is -0.006’

- Deviation distribution as good as topo QA/QC distribution ✔
- 27% of WSE predictions within 0.1’
- 49% within 0.25’
- 70% within 0.5’
- 94% within 1’

197 observations

Manning’s n value of 0.04 passes model performance tests ✔

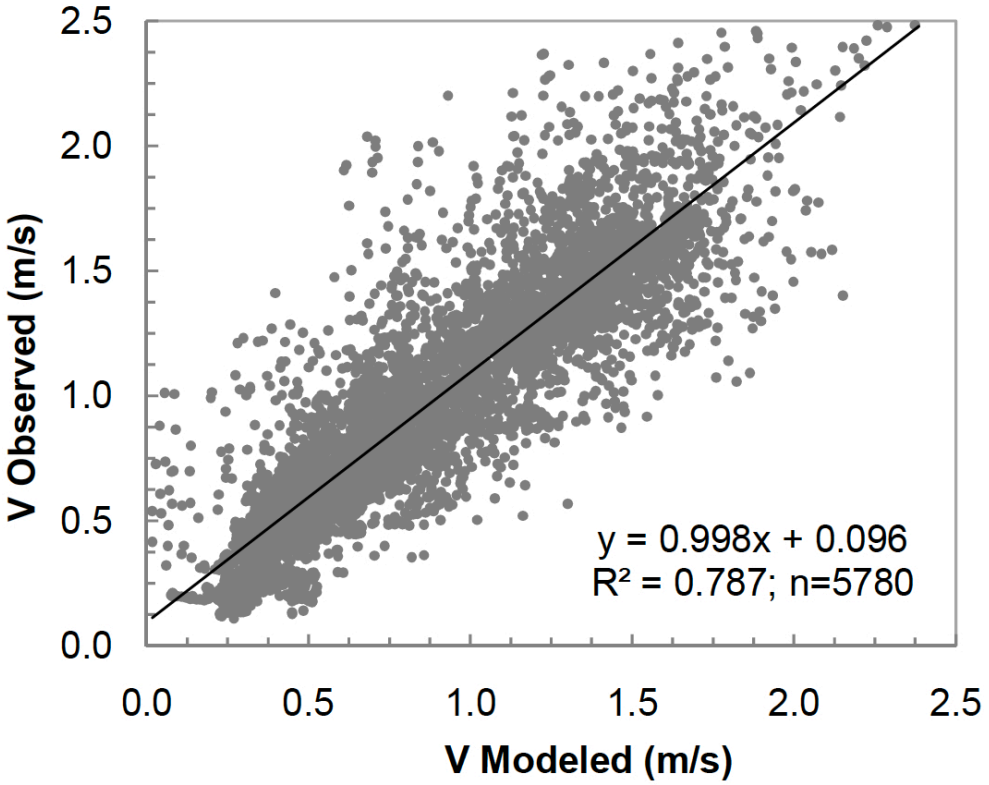


Rapid Velocity Method Test Results

- Derived conversion from surface velocity to mean velocity was found to be 0.72, which is a realistic value ✔
- High coefficient of determination (R^2) = 0.787 ✔
- Median error → 16% ; mean error → 21% ✔

530-5010 cfs spanned 5780 observations!

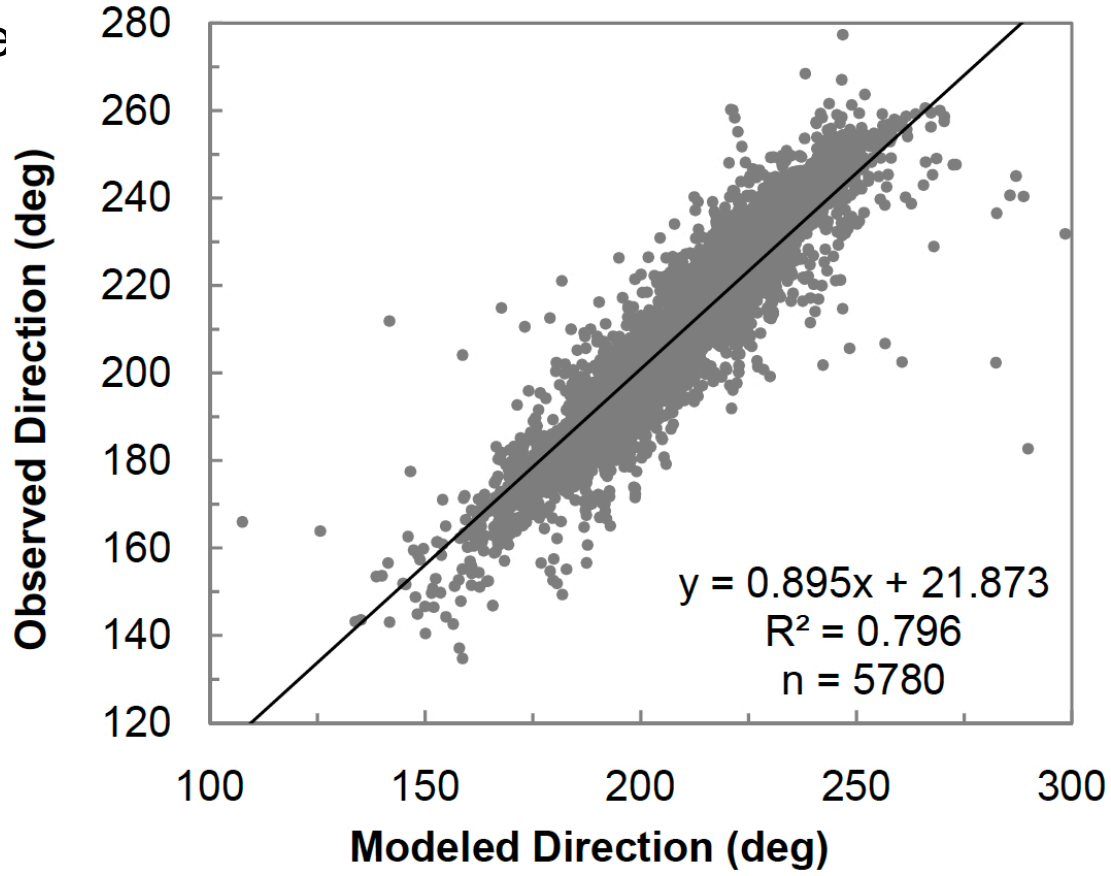
- Model lows are too high and highs are too low (common with 2D models).
- **2D model performance is better than almost all other published studies for RIVER2D, FESWMS, and SRH.**
- **Kayak approach worked great**



Flow Direction Test Results

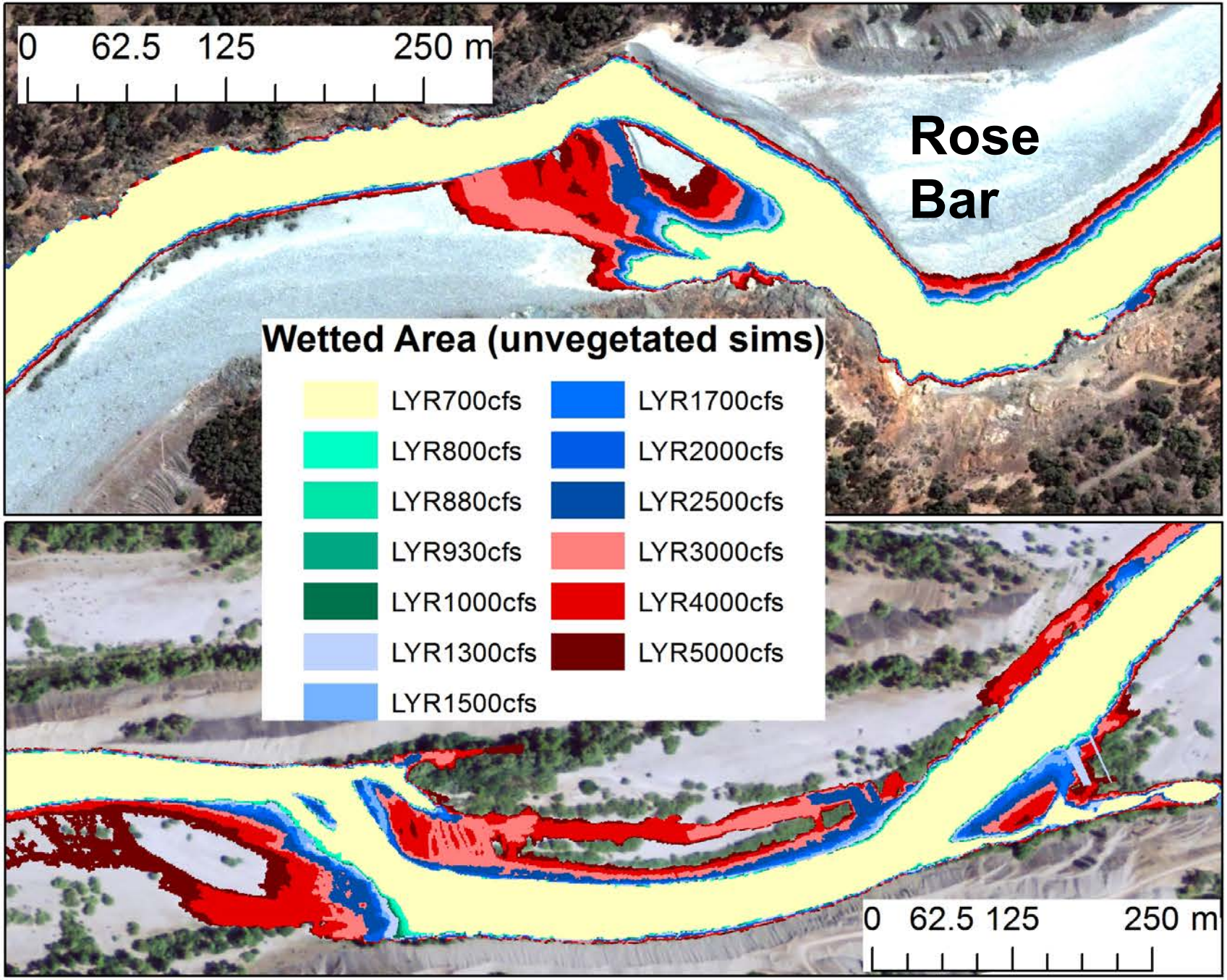
- Very high coefficient of determination (R^2) = 0.895 ✔
- Median error → 3.8% ; mean error → 5.5% ✔
- 61% of deviations within 5 de
- 86% within 10 deg ✔
- **No pre-existing baseline for comparison, but these values seem very good.**
- **Kayak approach worked great**

530-5010 cfs spanned 5780 observations!

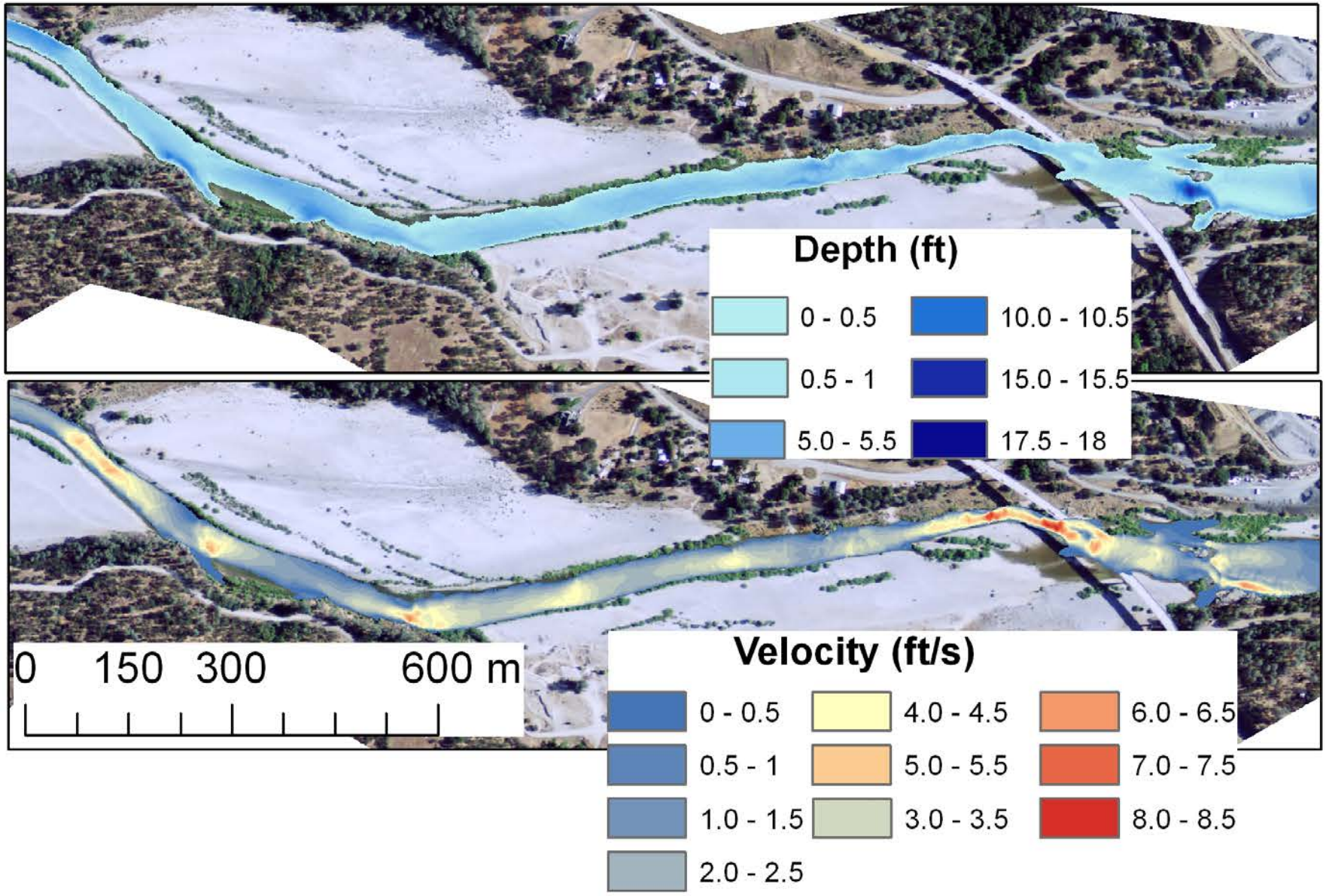


LYR 2D Model Validation Conclusions

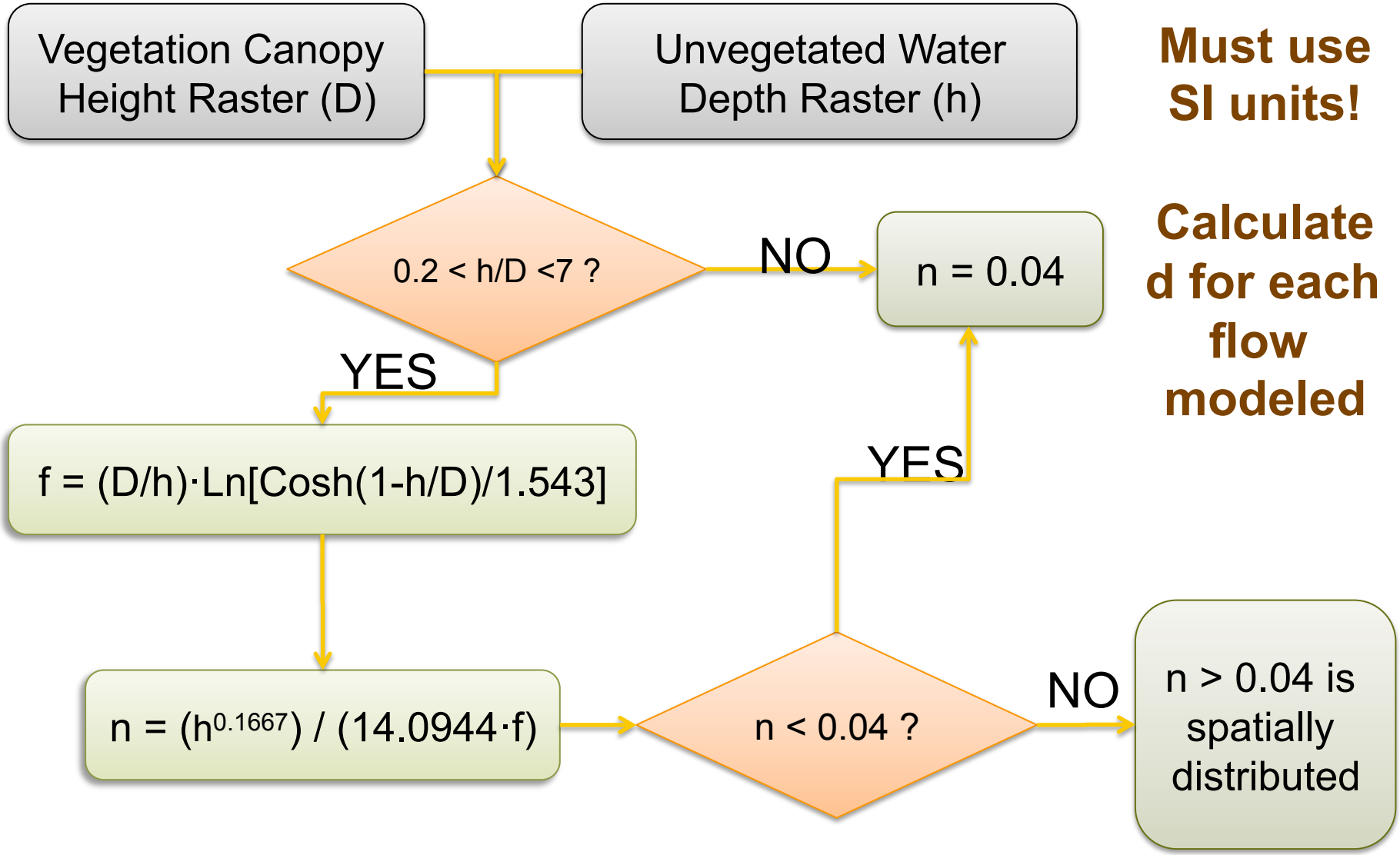
- 2D models, like all other predictive models, have limitations.
- We have performed a comprehensive assessment of the L2D model.
- WSE and depth checks showed that model uncertainty was within DEM uncertainty; Manning's n = 0.04 is appropriate.
- Speed tests showed high-quality performance, but with typical problems all 2D models have due to local topo problems and turbulence simplification.
- Direction analysis showed very good model performance.


0 62.5 125 250 m
Rose Bar
Wetted Area (unvegetated sims)
LYR700cfs
LYR800cfs
LYR880cfs
LYR930cfs
LYR1000cfs
LYR1300cfs
LYR1500cfs
LYR1700cfs
LYR2000cfs
LYR2500cfs
LYR3000cfs
LYR4000cfs
LYR5000cfs
0 62.5 125 250 m

LYR Hydraulics (880 cfs)



2D-Model Vegetation Roughness Procedure

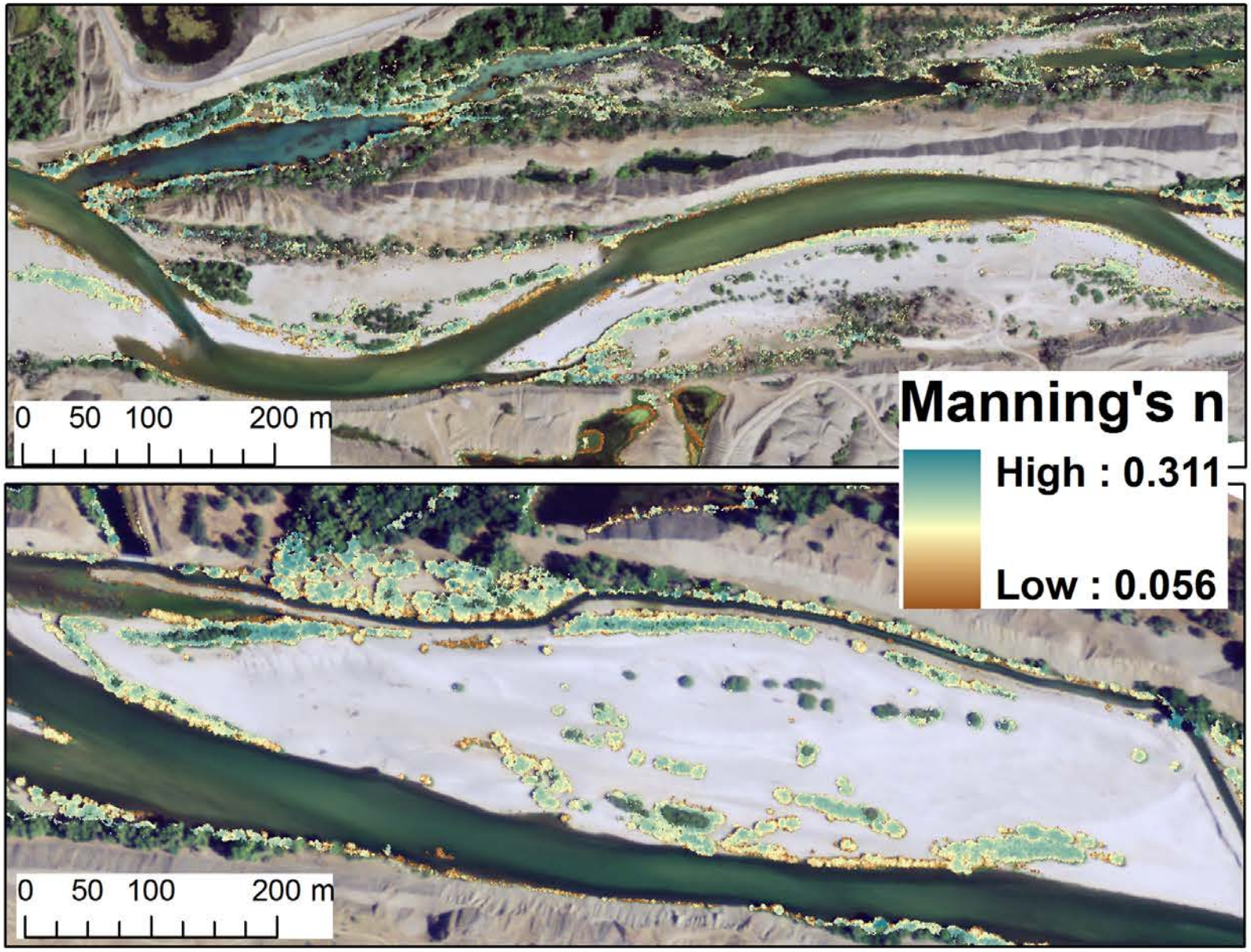


Must use SI units!

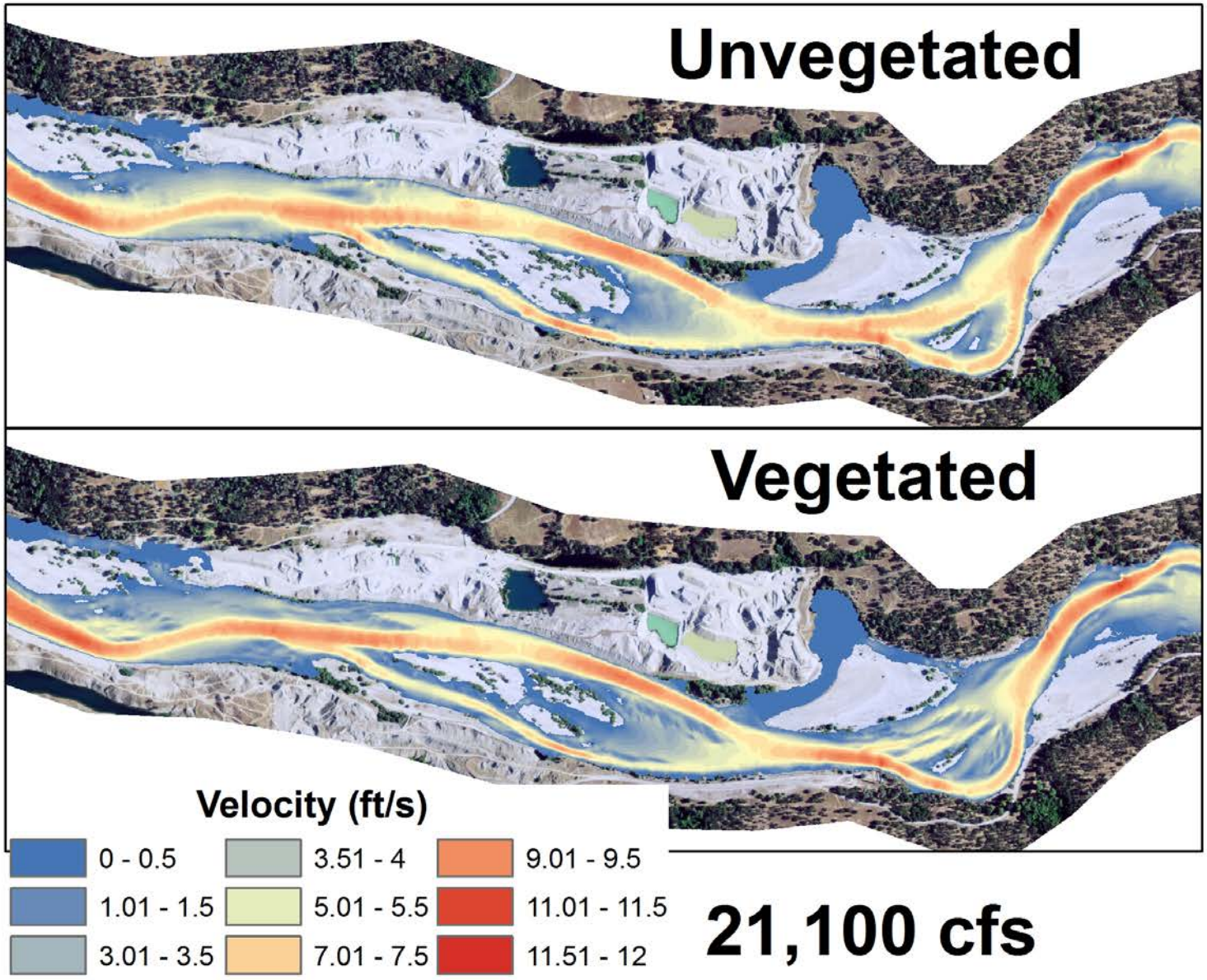
Calculate d for each flow modeled

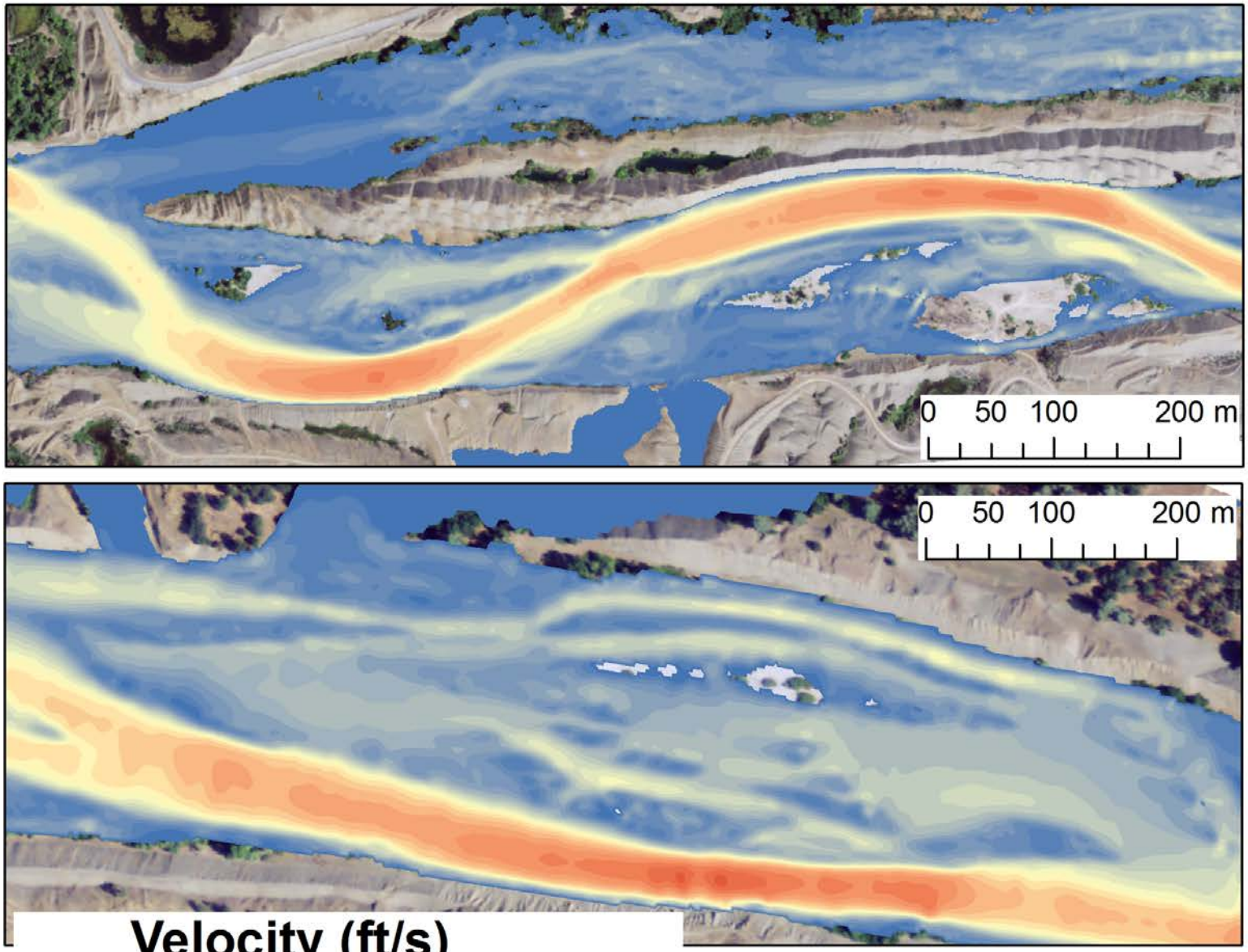
(adaptation of Casas et al., 2010)

Manning’s Roughness Map (21,100 cfs)



Wetted Area and Velocity Are Sensitive to Presence/Absence of Vegetation in Model




0 50 100 200 m
0 50 100 200 m
Velocity (ft/s)
0 - 0.5
1.01 - 1.5
3.01 - 3.5
5.01 - 5.5
7.01 - 7.5
9.01 - 9.5
10.51 - 11

21,100 cfs

Stage-Dependent Flow Convergence

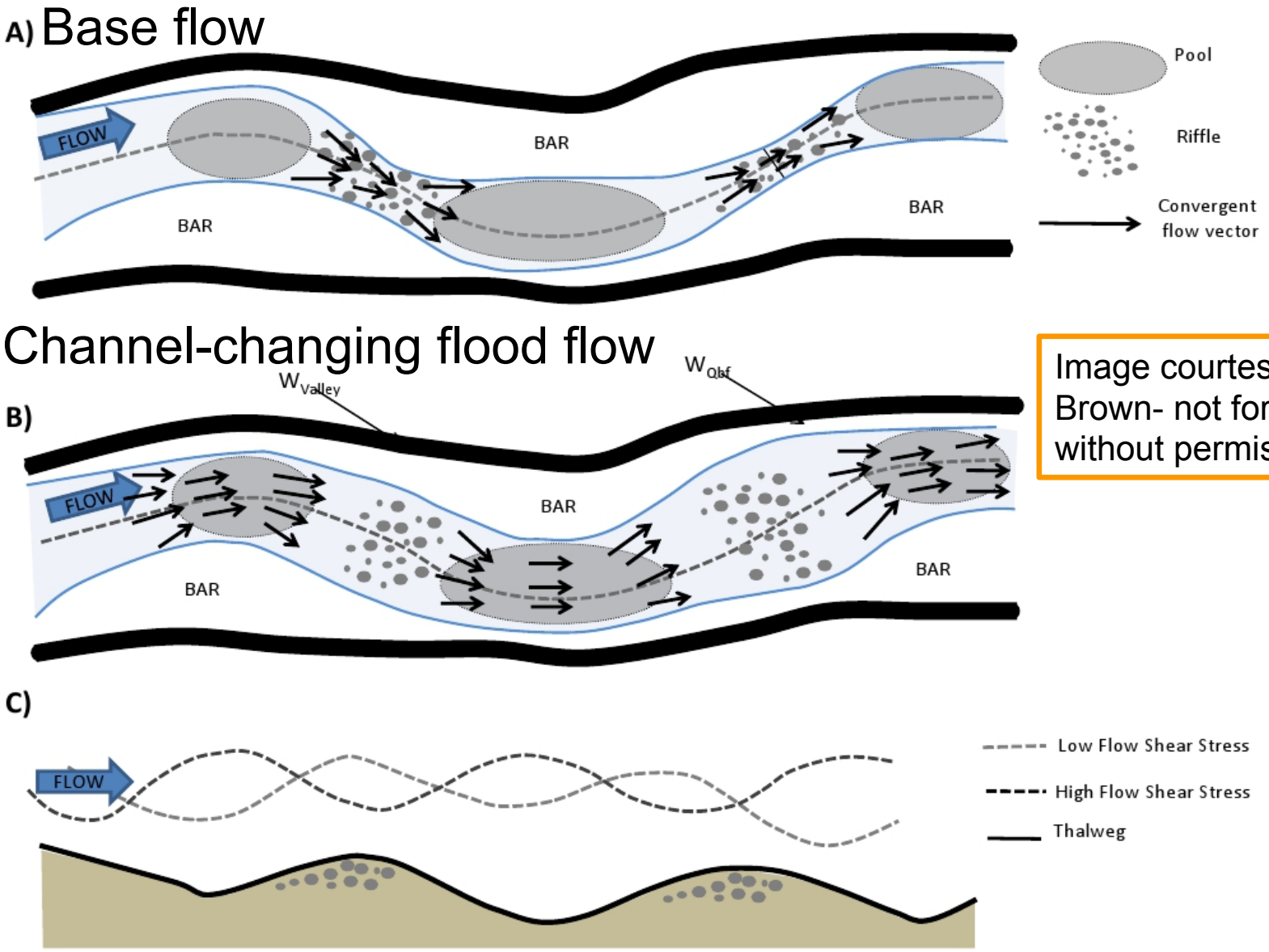
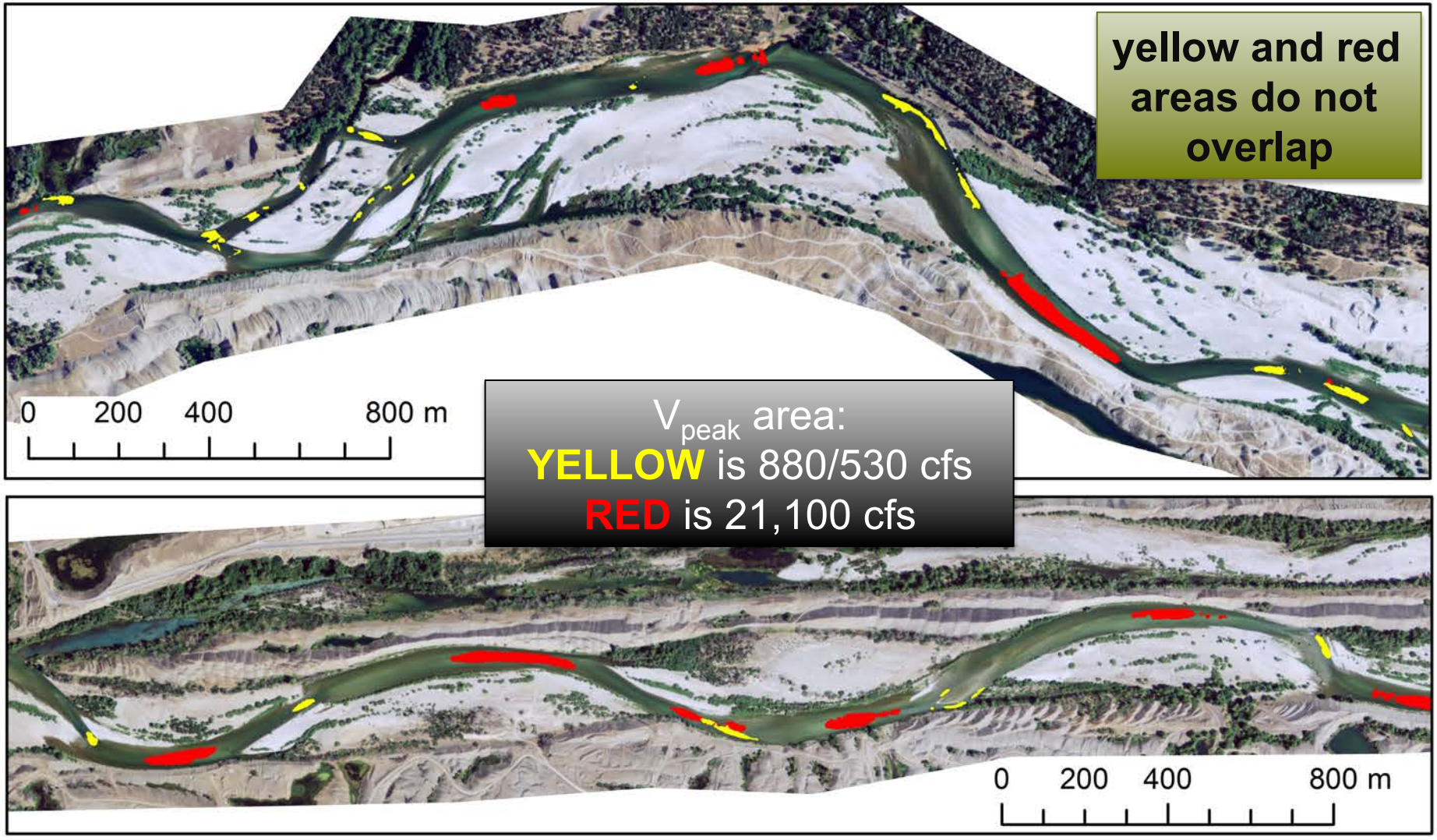


Image courtesy Rocko Brown- not for use without permission.

Stage-Dependent Flow Convergence Is Widespread on the LYR



LYR 2D MODEL DETAILS

LYR Modeling Conclusions

- Maps and 2D models are validated and operational
- Landforms in the river are organized and dynamic
- Over 10 years, ~10^6 cut and fill; ~10^4 export.
- Not yet adjusted to cumulative historic impacts
- Physical processes link flows and dynamic landforms
- Stage-dependent flow convergence is widespread
- Pool-riffle relief is stable, despite long-term loss of sediment
- Micro-Habitat analysis pending HSC decisions.
- Riparian analyses and historical analyses pending by other collaborators