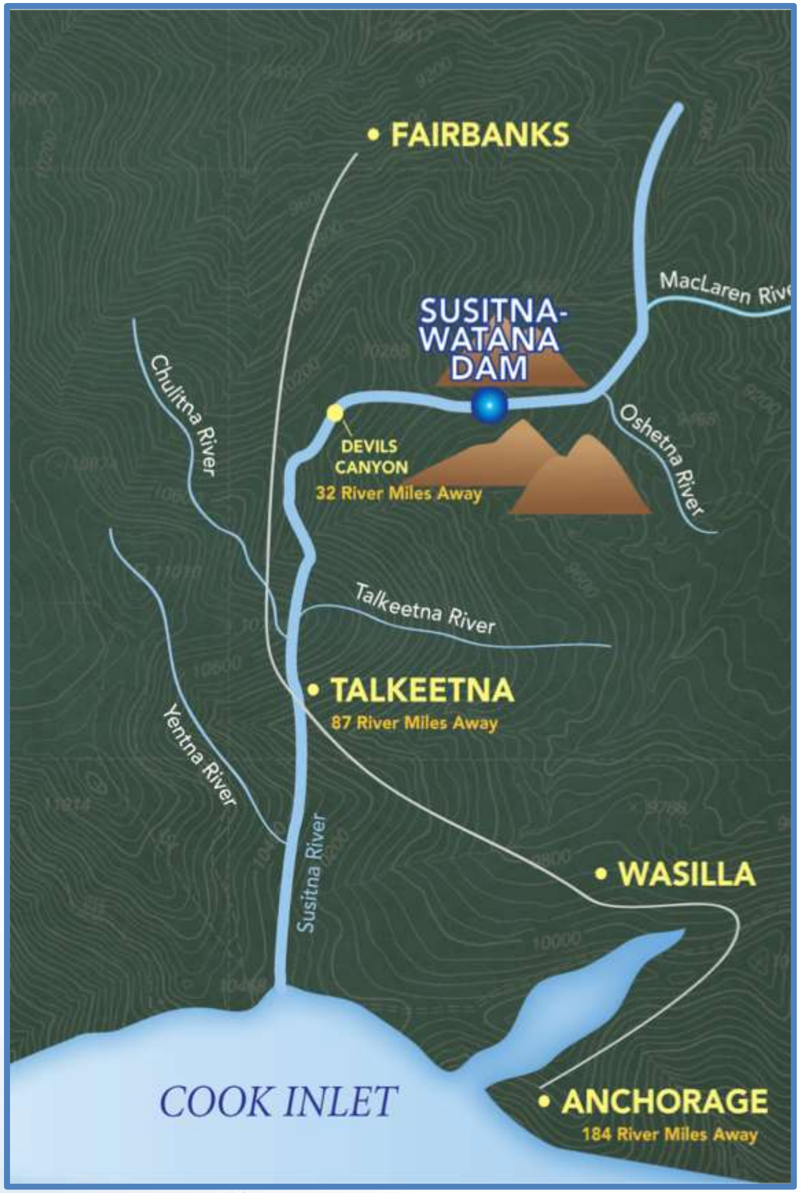


Fluvial Geomorphology: Channel / Floodplain Evolution Model; Hydraulic and Sediment Modeling Study Objectives

Riparian IFS Technical Meeting Day one

April 29 and 30, 2014

Prepared by Tetra Tech

SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Presentation Content

- Geomorphology studies relationship to Riparian IFS
- Overview of models and other products from the Geomorphology studies
- Discussion of information and metrics to be provided by the Geomorphology studies

Geomorphology Study Provides to Riparian IFS

- Overall purpose: Assist in identification and quantification of geomorphic processes
  - Inundation relationships for surfaces
  - Building/accretion of floodplain surfaces
  - Disturbance of bars and channel margins
  - Erosion of floodplain
- Metric for each of the above bullets

The Most Relevant Tools and Products from the Geomorphology Studies

- Aerial photography – Current and historical
  - Mapping of geomorphic features
  - Channel change (1950s/1980s/Current)
  - Turnover analysis (1950s -1980s/1980s-current)
- LiDAR – Elevation of surfaces
- Large woody debris mapping and assessment
- Sediment transport relationships – USGS data from 1980s and current
- Hydraulic and bed evolution modeling – 1-D and 2-D

Fluvial Geomorphology Modeling – Information to Support Other Resource Areas

Change in hydrologic and sediment supply regimes

(existing conditions and operational scenarios)

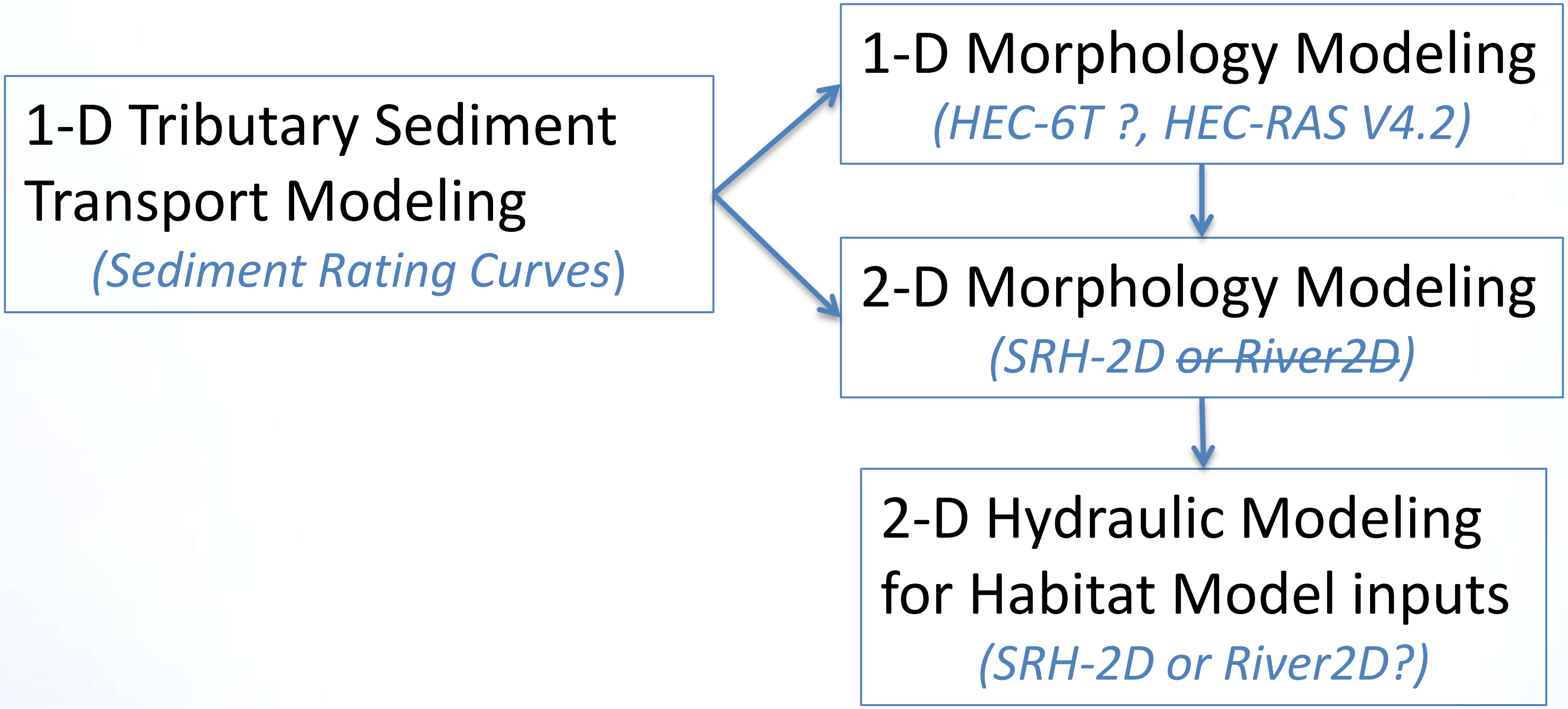
Hydraulics ⟷ **Sediment Transport** ⟷ **Geomorphology**

Potential Project Effects on location, extent, magnitude, duration, timing & frequency

Velocity	*Flow Depths*	*Water Surface Elevations*
Channel Top Width	*Shear Stress*	*Aggradation/Degradation*
Effective Discharge	*Bed Material Composition*	*Bed Material Mobility*
Sediment Loads	*Sediment Concentrations*	*Floodplain Accretion (SDI)*
Bank Instability/Channel Migration (BEI)		*LWD production/transport*
#/lengths/areas of types of channel		*Areas of Island and floodplain features*

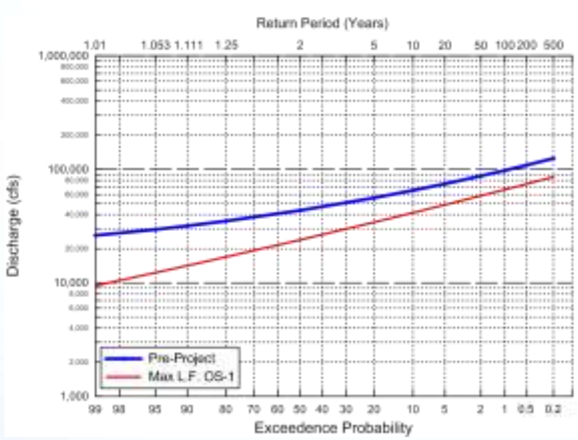
Note: Items in green directly support Riparian IFS

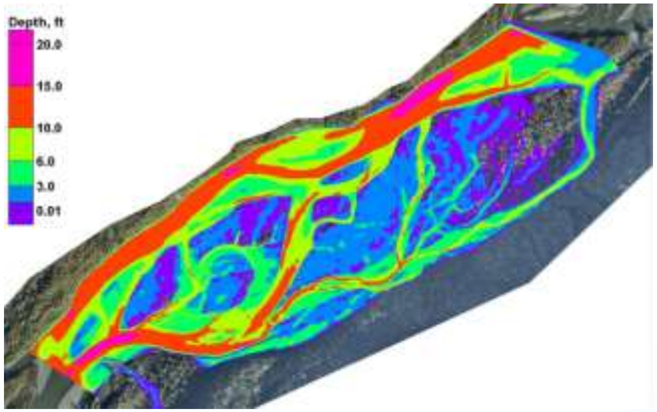
Fluvial Geomorphology Modeling (FGM) Approach - Models



Inundation Discussion and Metric

- Tools
  - Aerials and geomorphic mapping
  - Modeled water surface elevations
  - Topography (LiDAR)
  - Hydrology: Flow duration / flood frequency curves





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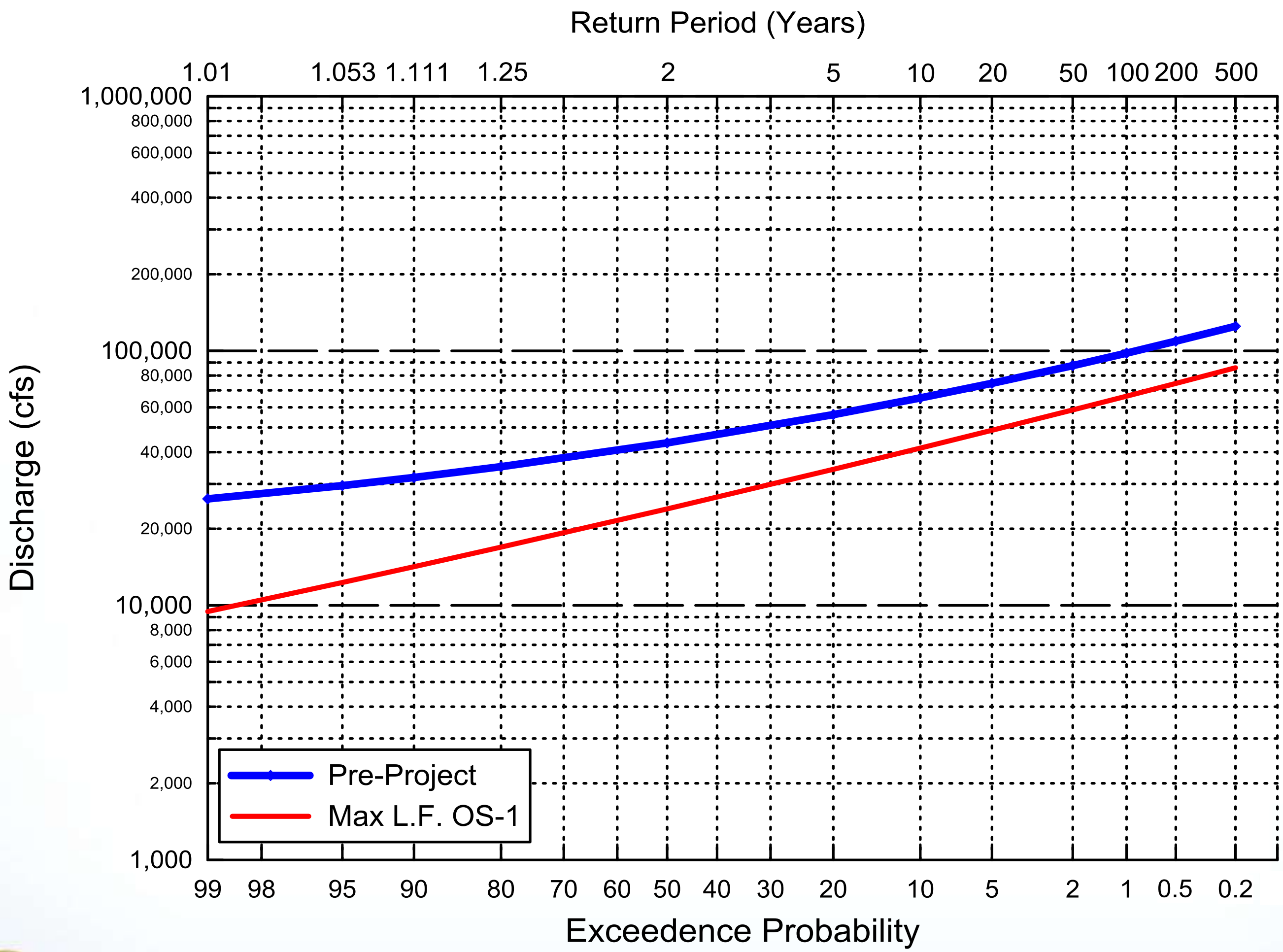
Flood Frequency



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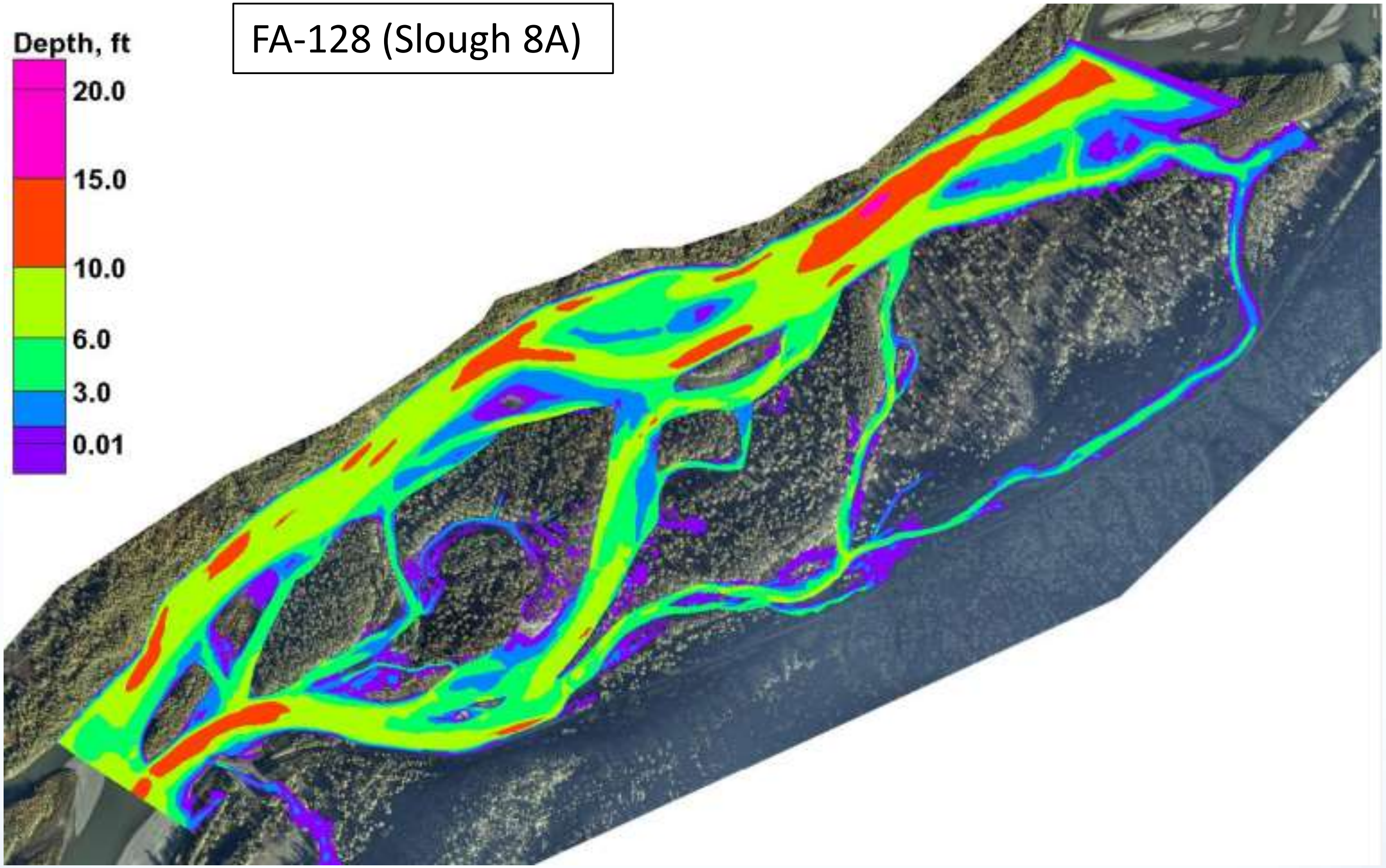
Depth (ft) 50k cfs, ~2-year



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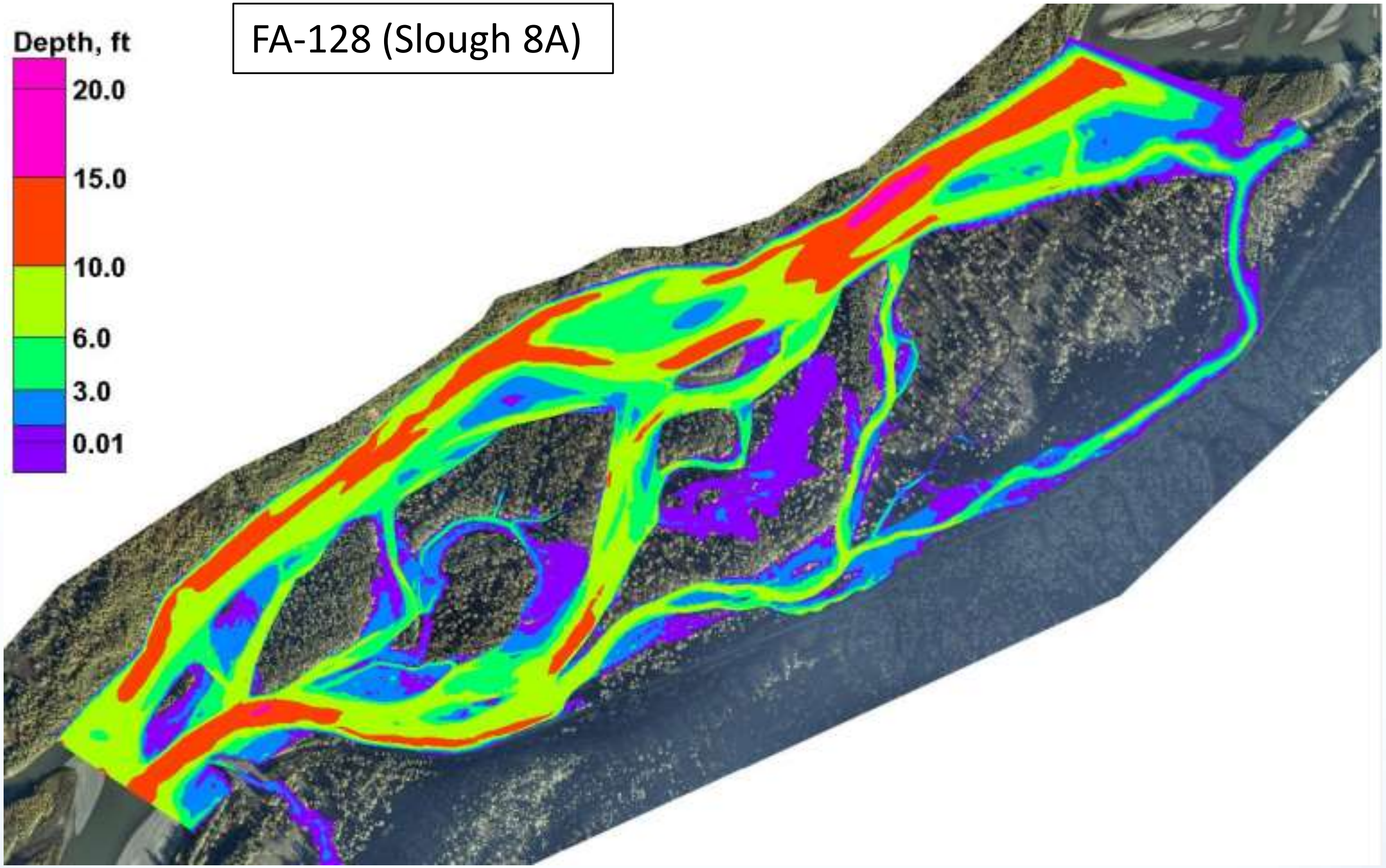
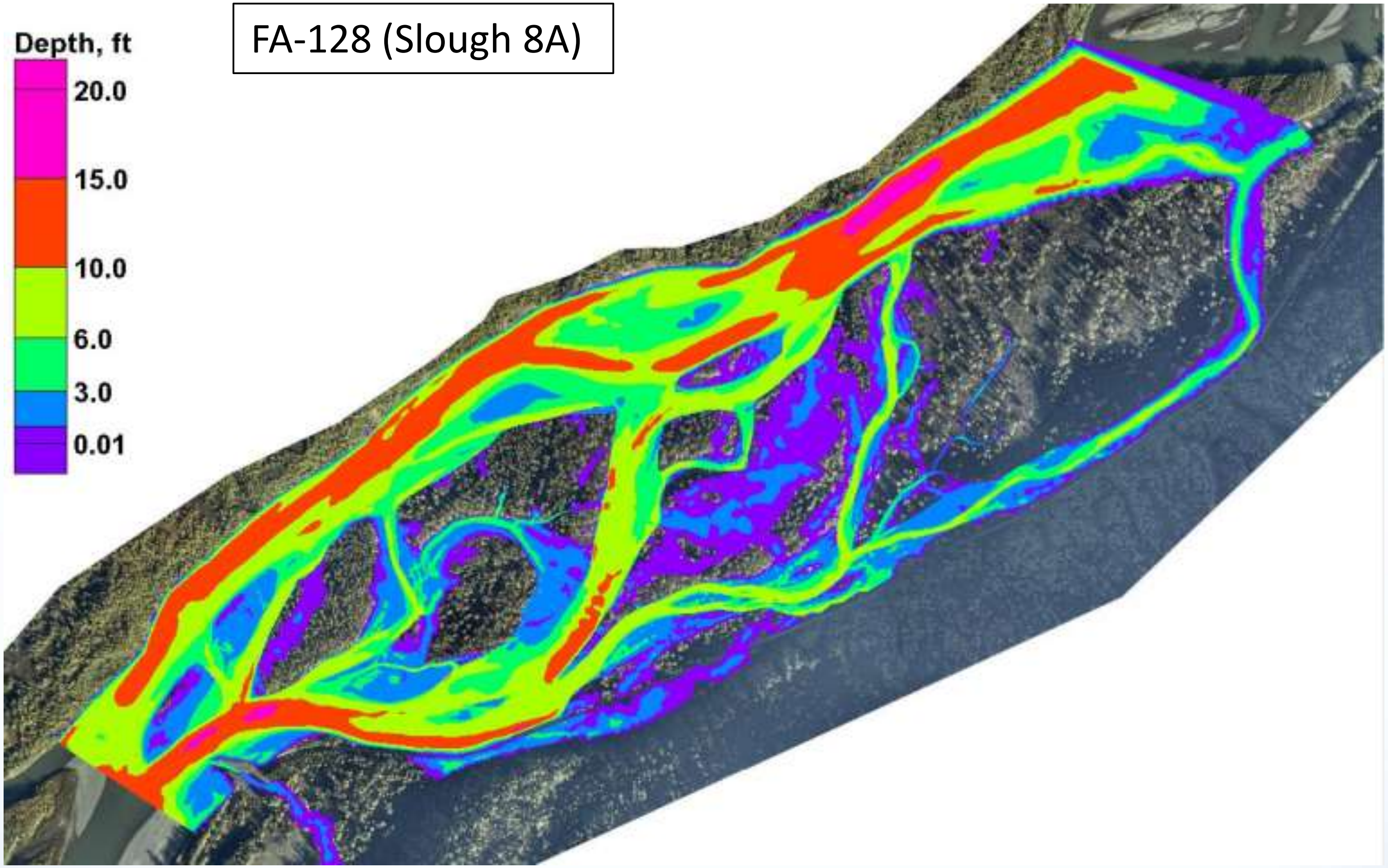
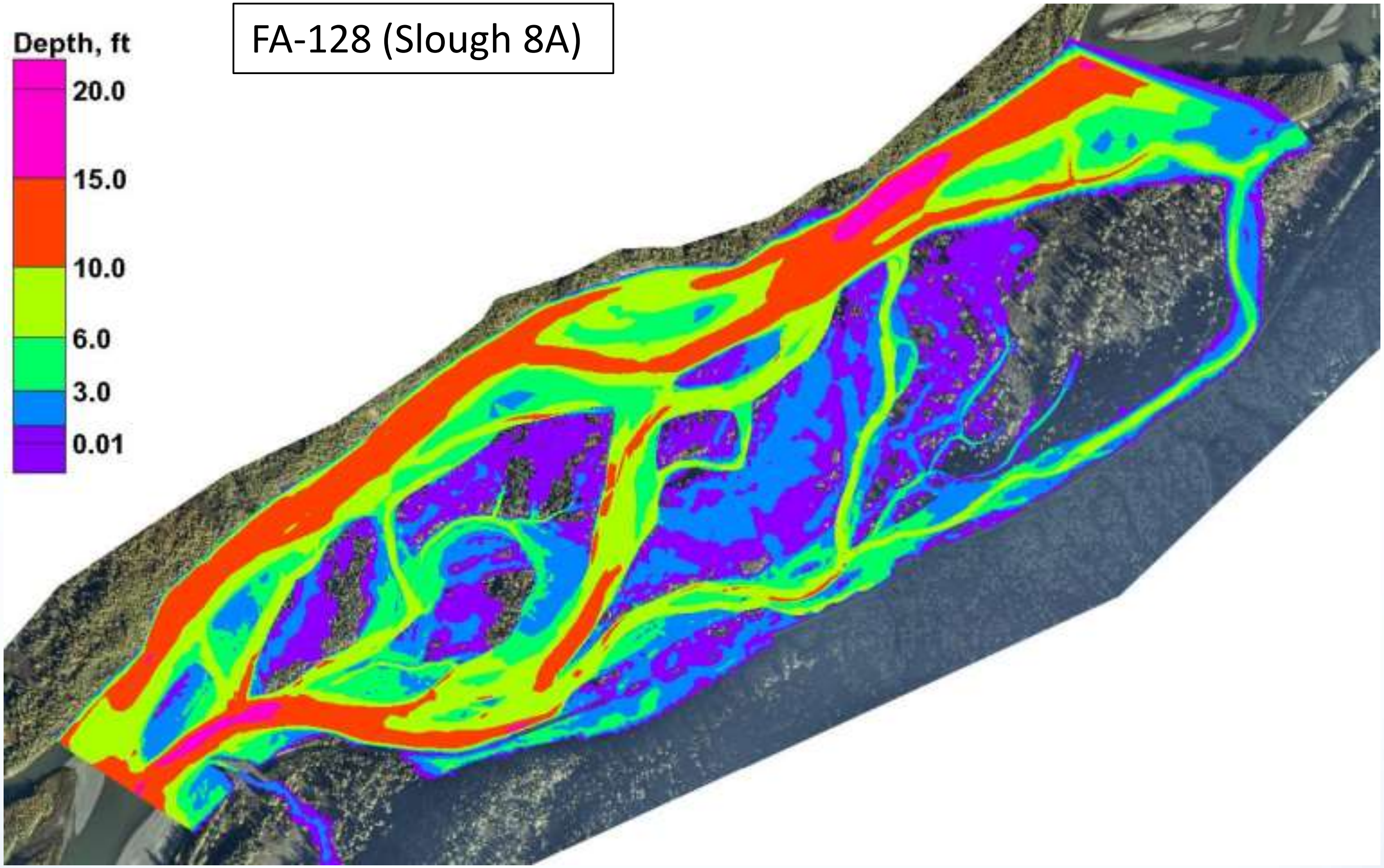
Depth (ft) 65k cfs, ~10-year



Depth(ft) 75k cfs, ~20-year



Depth(ft) 87k cfs, ~50-year



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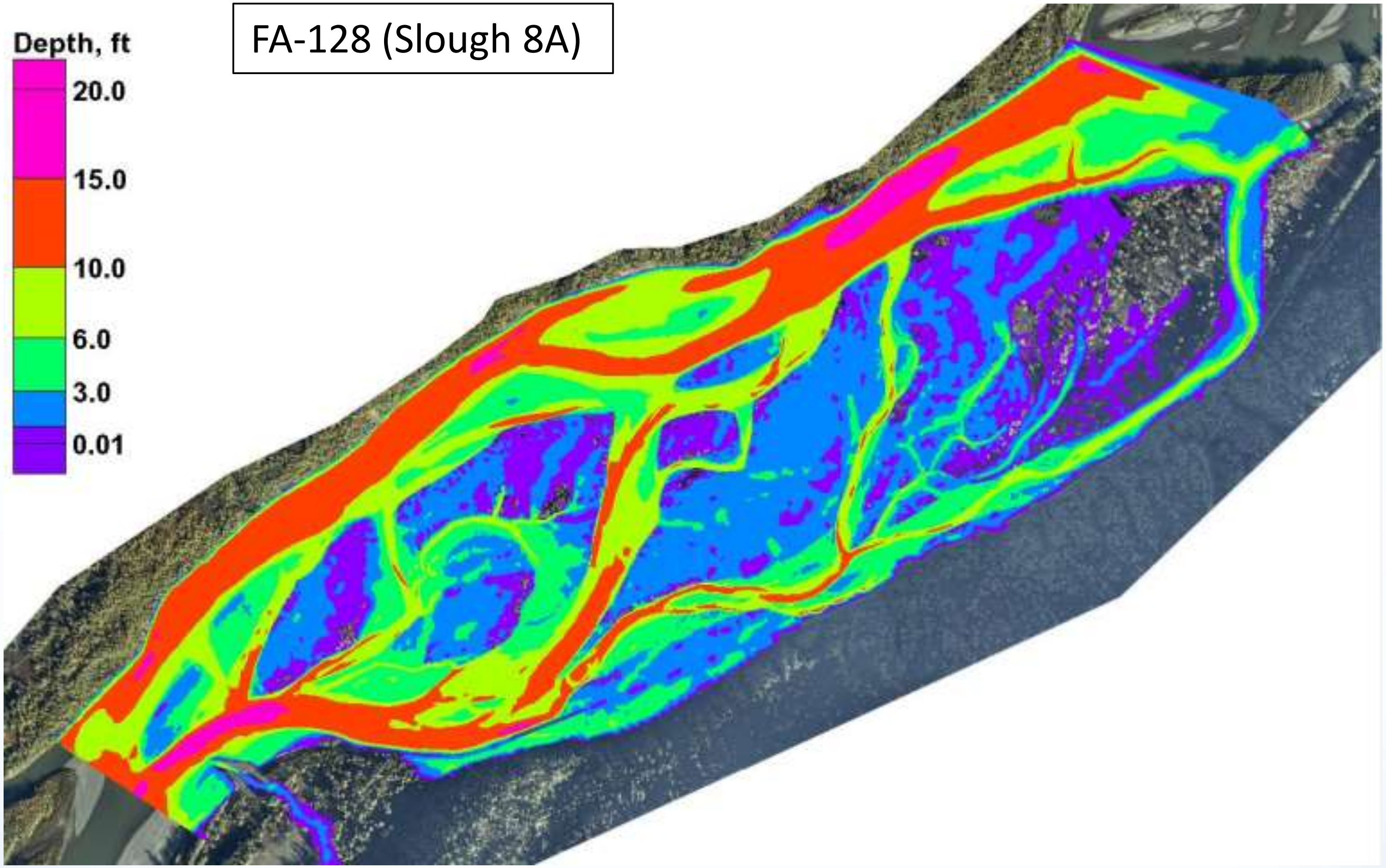
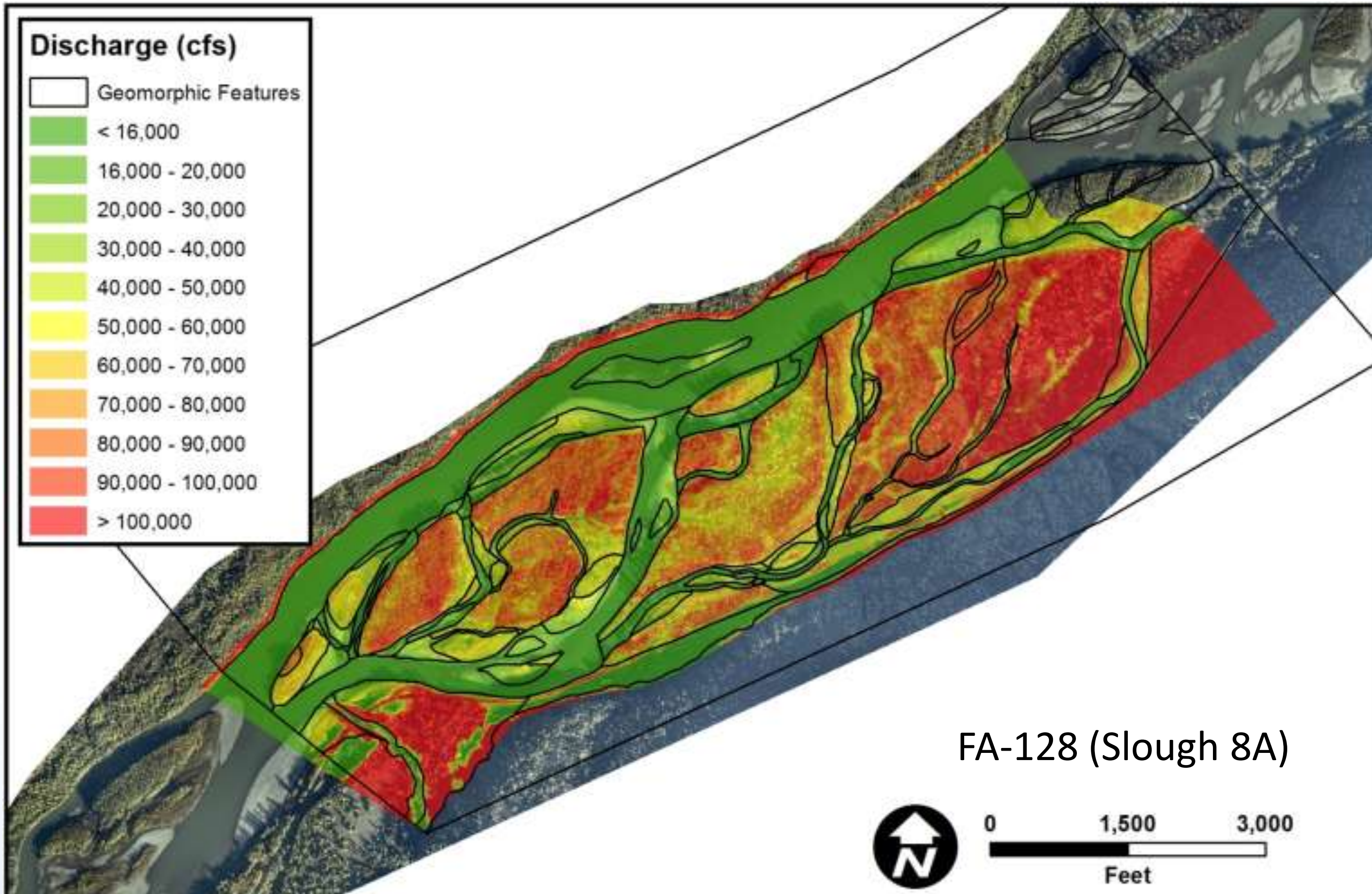
Depth(ft) 100k cfs, ~ 100-year



Overtopping Discharge



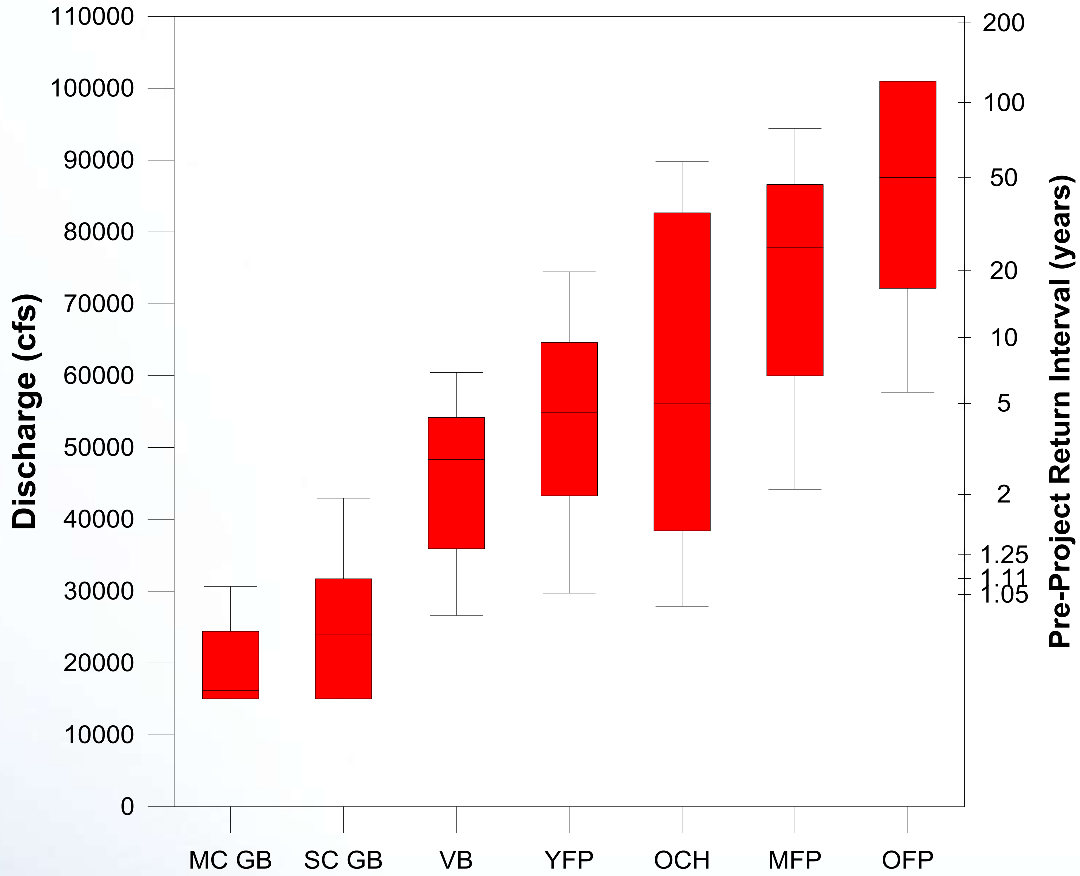
Overtopping Discharge – FA-128 (Slough 8A)

Geomorphic Feature	Overtopping Discharge (cfs)	Flood Frequency (years)	Flow Duration (days/year)
		Pre-Dam	Pre-Dam
Main Channel Gravel Bar	16,190	<1	101
Side Channel Gravel Bar	24,030	<1	44
Vegetated Bar	48,320	2.7	1.2
Young Flood Plain	54,840	4.5	0.7
Overbank Channel	56,080	5.0	0.6
Mature Flood Plain	77,870	25	0.1
Old Flood Plain	87,570	50	--

Inundation Metric

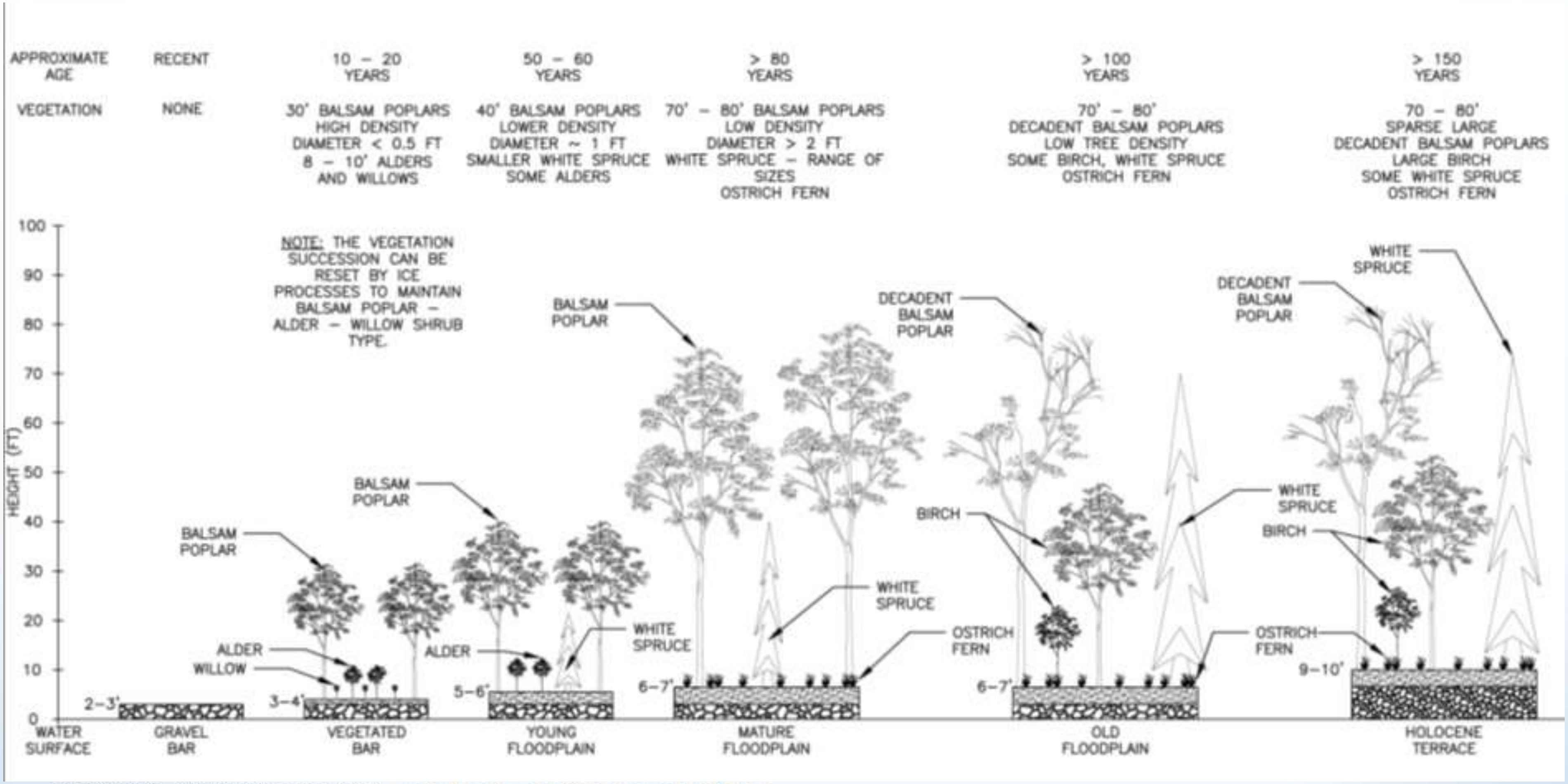
- Information
  - 2-D model results indicating discharge that inundates various surfaces
  - Flow duration providing time interval discharges are exceeded
- Using GIS develop, time interval various elevations in the Focus Areas are inundated pre- and post-Project

Overtopping Discharge FA-128 (Slough 8A)



Abr.	Geomorphic Feature
MC GB	Main Channel Gravel Bar
SC GB	Side Channel Gravel Bar
VB	Vegetated Bar
OCH	Overbank Channel
YFP	Young Flood Plain
MFP	Mature Flood Plain
OFP	Old Flood Plain

Geomorphic Succession

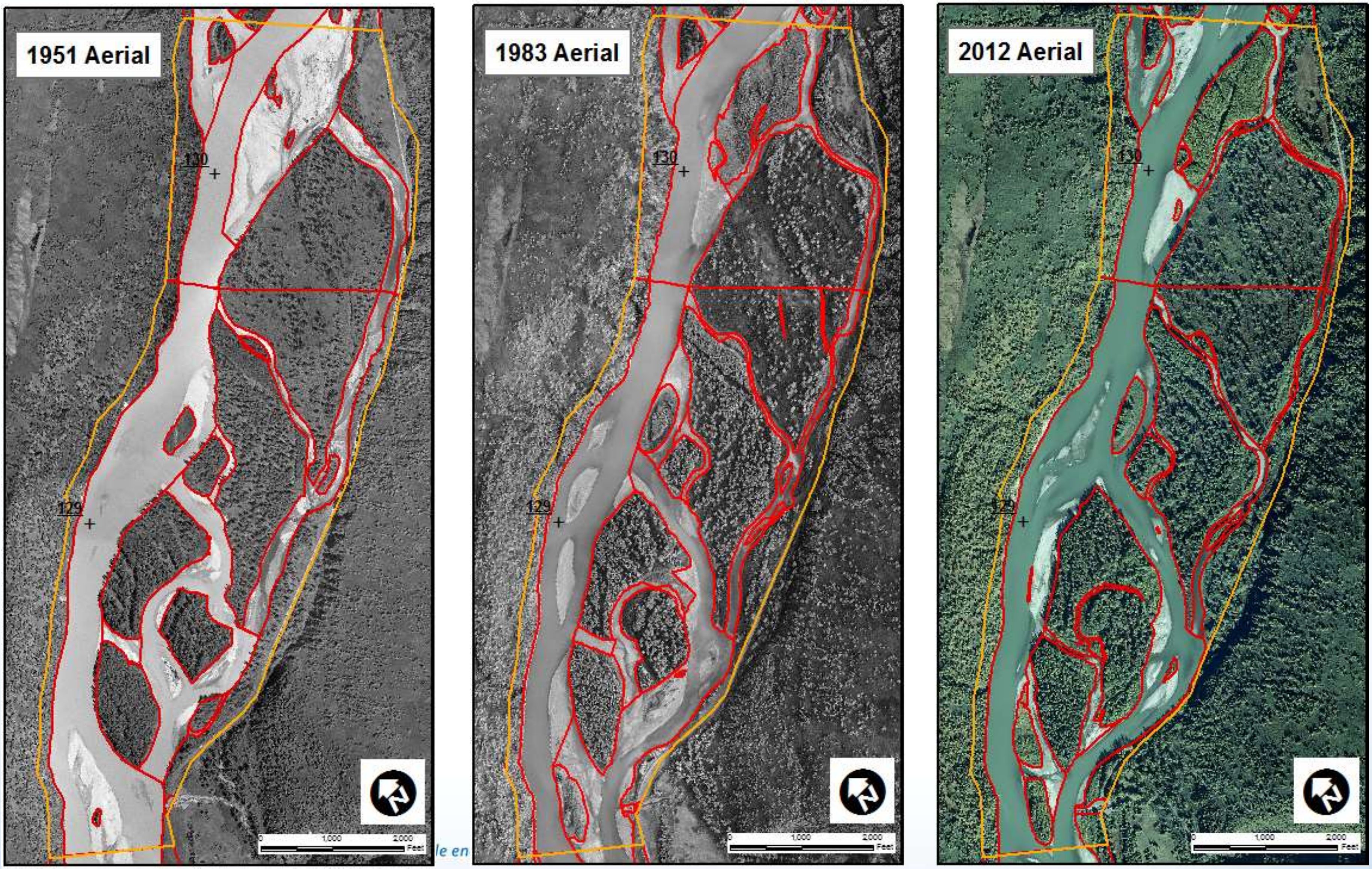


Discussion - Aerial Photography

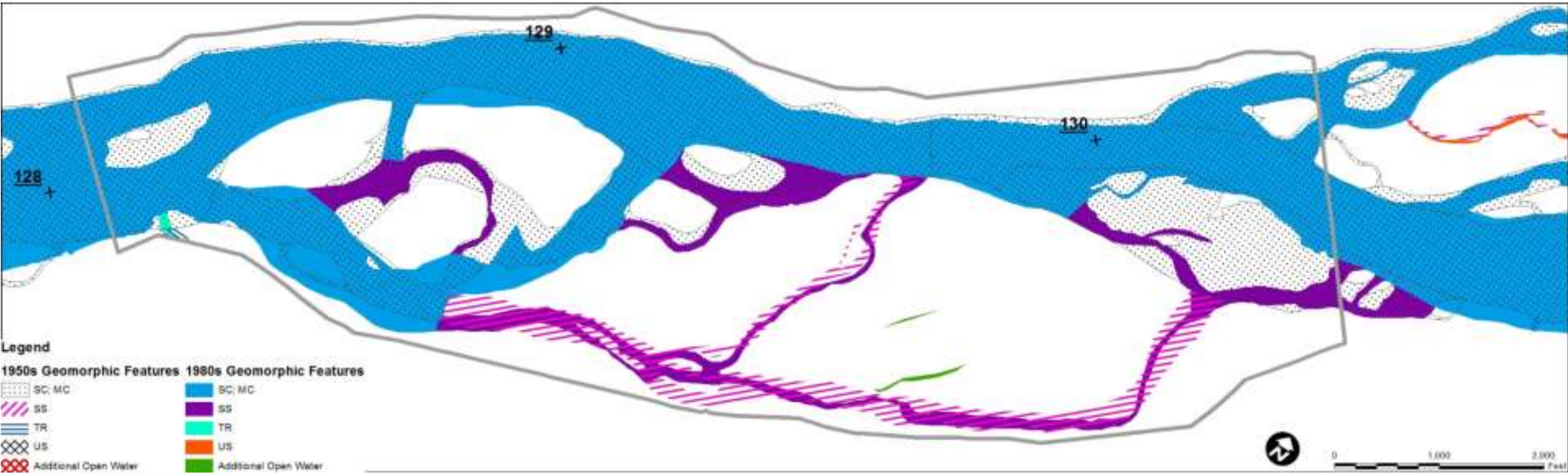
- Aerial Photography: 1950s, 1980s and current
- Products
  - Geomorphic feature mapping
  - Channel change
  - Turnover analysis

Comparative Era Aerials

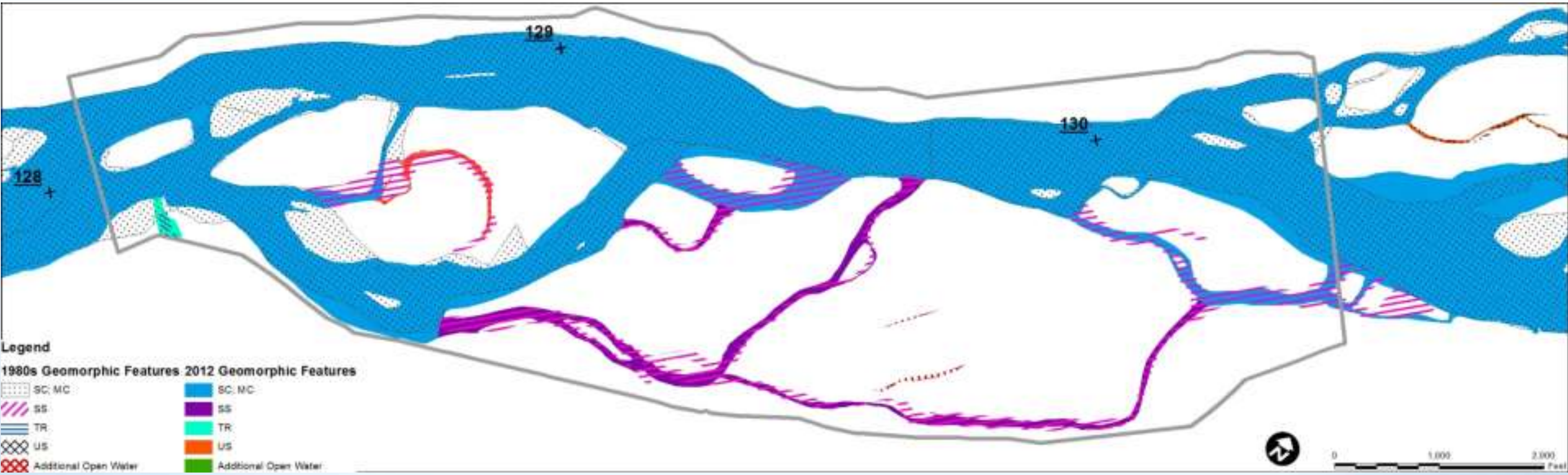
Comparative Geomorphic Features in FA-128 (Slough 8A)



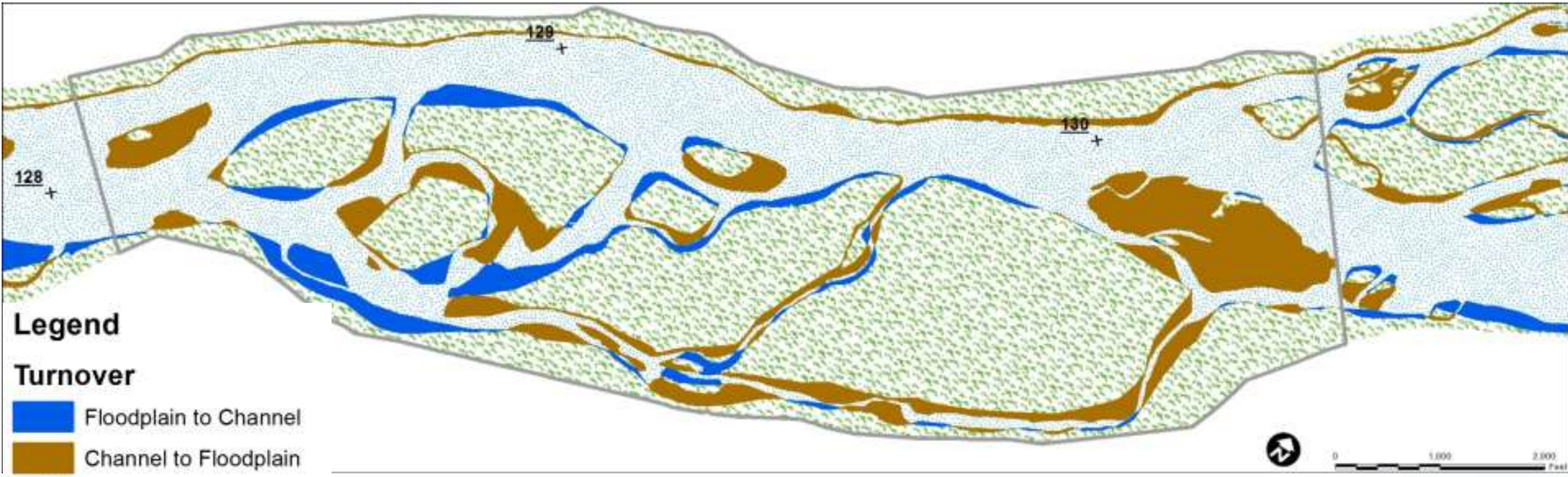
1950s to 1980s Channel Change in FA-128 (Slough 8A)



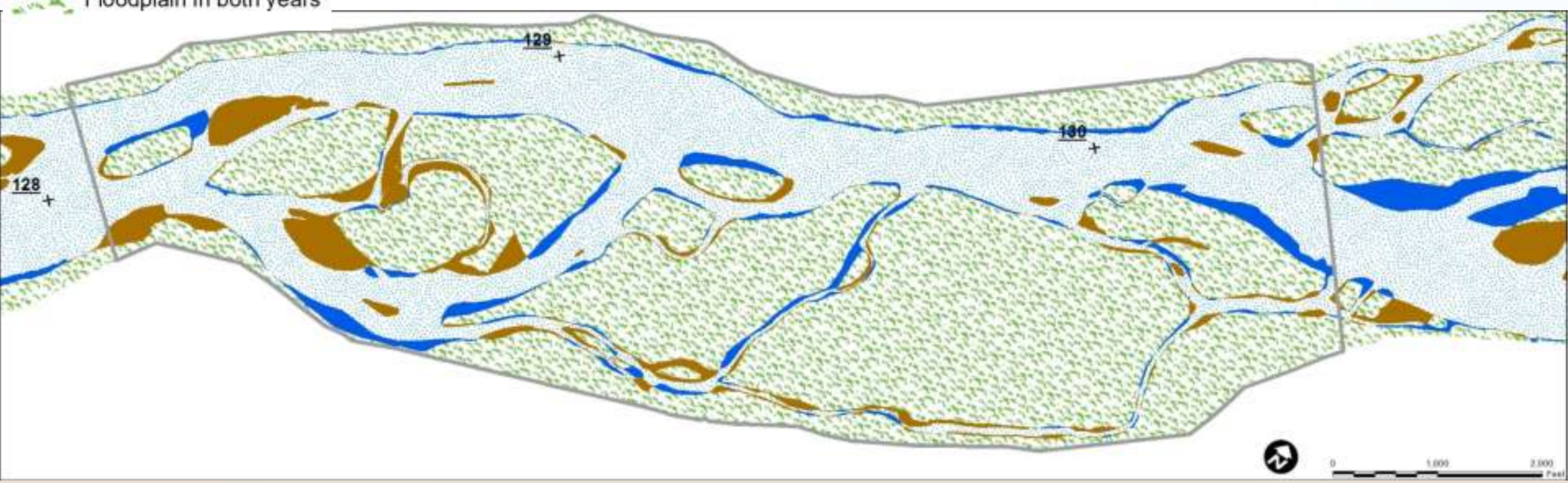
1980s to 2012 Channel Change in FA-128 (Slough 8A)



1950s to 1980s Turnover in FA-128 (Slough 8A)



1980s to 2012 Turnover in FA-128 (Slough 8A)



Turnover Areas – *FA-128 (Slough 8A)*

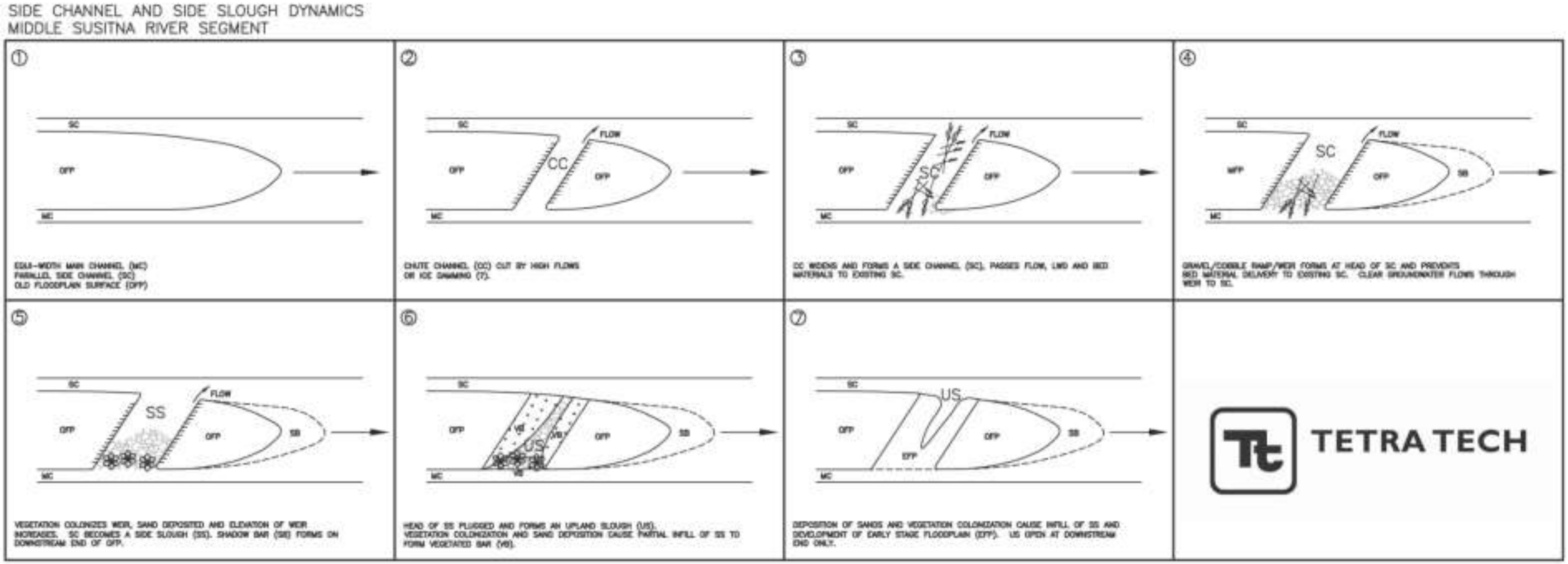
1950s to 1980s

Date	1980s Land (ac)	1980s Chan. (ac)	Total Area (ac)
1950s Land	412	37	450
1950s Channel	103	285	389
Total Area	516	323	838

1980s to 2012

Date	2012 Land (ac)	2012 Chan. (ac)	Total Area (ac)
1980s Land	486	30	516
1980s Channel	45	278	323
Total Area	530	308	838

Side Channel and Side Slough Dynamics



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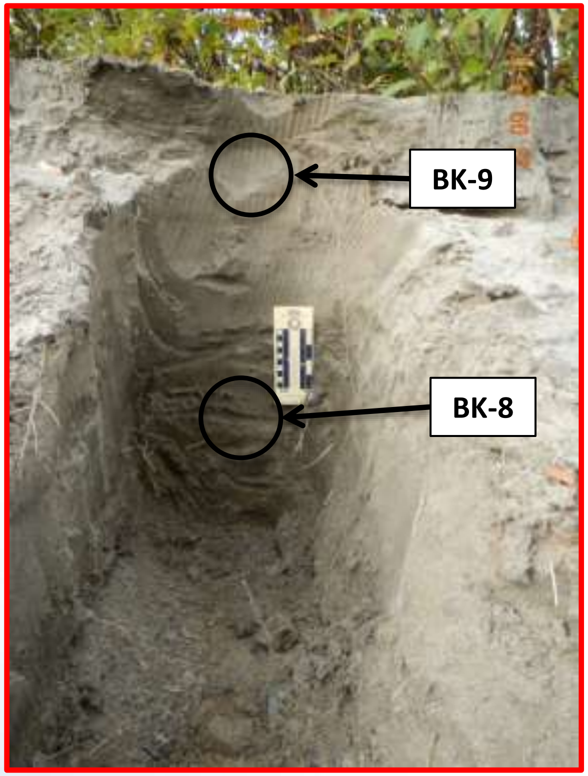
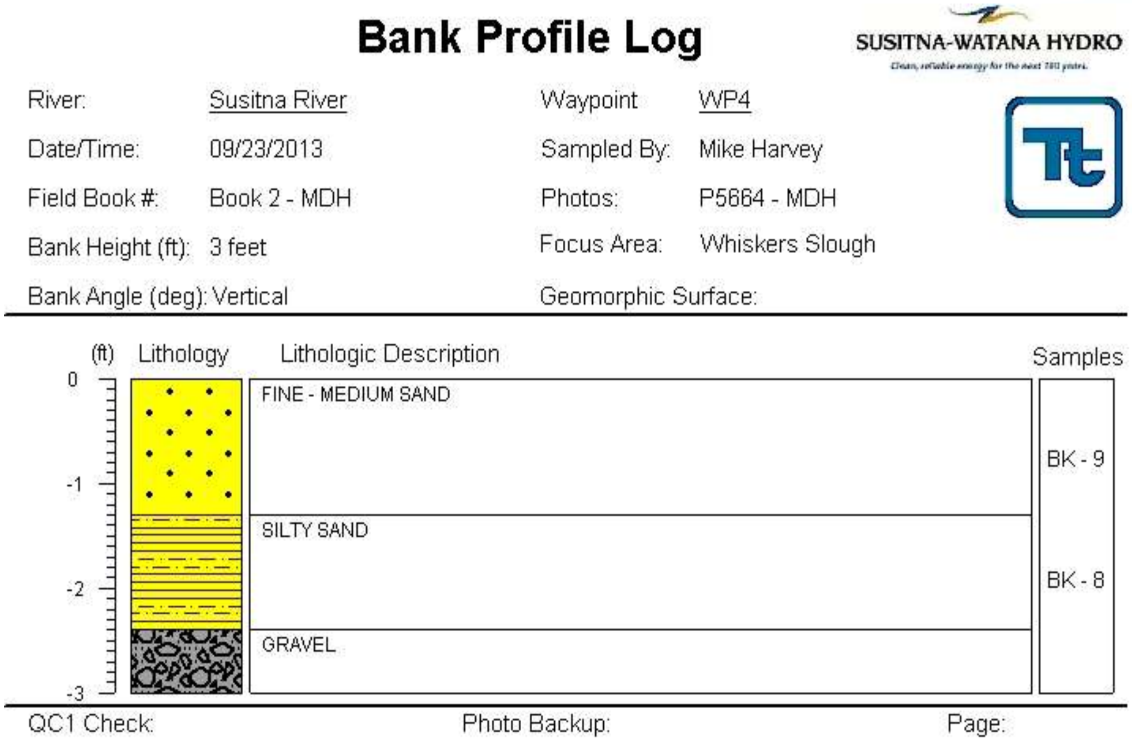
Discussion – Floodplain Accretion Metric

- **S**ediment **D**elivery **I**ndex (SDI)
  - Duration of inundation
  - Suspended sediment load

2013 Field Observations

BANK SAMPLE:
Young Floodplain Surface





Bank Profile Log

SUSITNA-WATANA HYDRO

River:	Susitna River	Waypoint	WP4
Date/Time:	09/23/2013	Sampled By:	Mike Harvey
Field Book #:	Book 2 - MDH	Photos:	P5664 - MDH
Bank Height (ft):	3 feet	Focus Area:	Whiskers Slough
Bank Angle (deg):	Vertical	Geomorphic Surface:	

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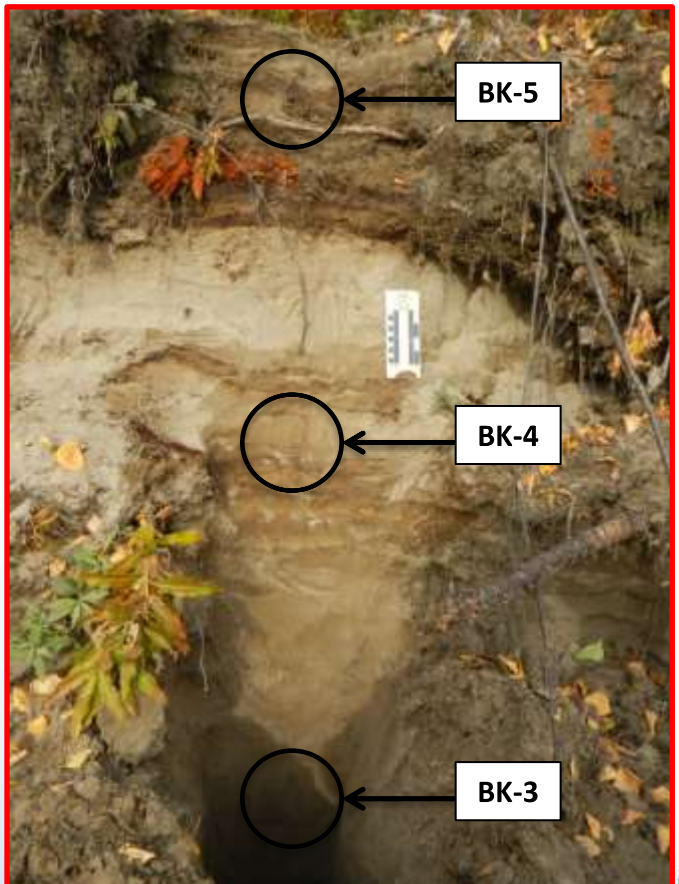
2013 Field Observations

BANK SAMPLE:
Terrace Surface



Bank Profile Log

SUSITNA-WATANA HYDRO

River:	Susitna River	Waypoint	WP2
Date/Time:	09/23/2013	Sampled By:	Mike Harvey
Field Book #:	Book 2 - MDH	Photos:	P5662 - MDH
Bank Height (ft):	7 feet	Focus Area:	Whiskers Slough
Bank Angle (deg):	Vertical	Geomorphic Surface:	

(ft)	Lithologic Description	Samples
0	SAND	
	SILTY SAND	BK - 5
	SAND AND SILT WITH ORGANICS	
-1	SAND	
	SAND, SILT AND CLAY WITH ORGANICS	
	FINE - MEDIUM SAND	
-2	SILTY SAND AND SAND INTERBEDDED	BK - 4
-3	MEDIUM SAND	BK - 3
-6	GRAVEL	
-7		

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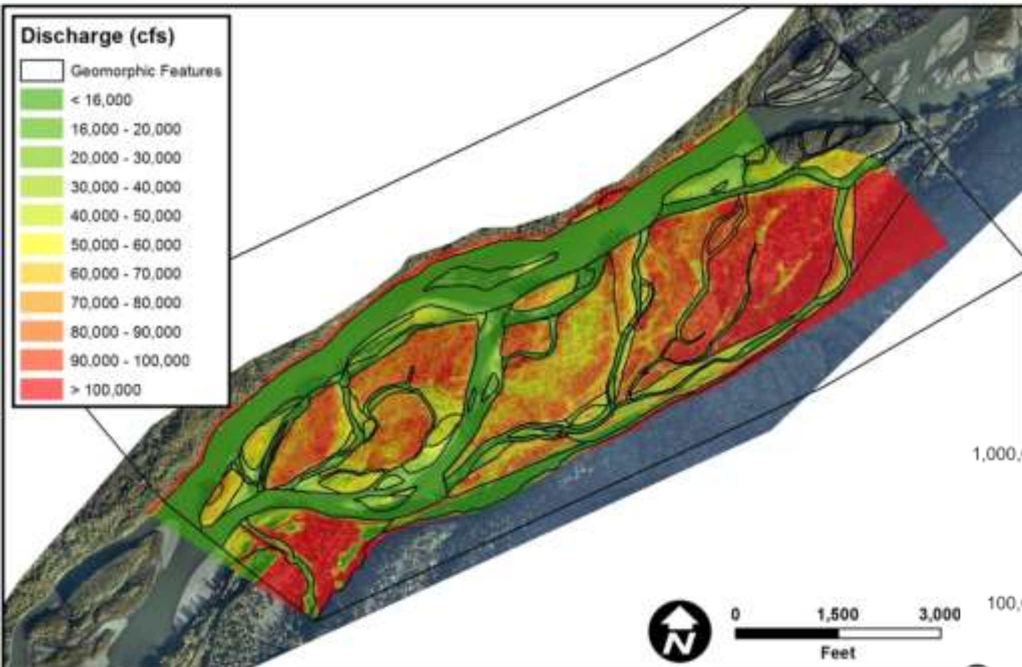
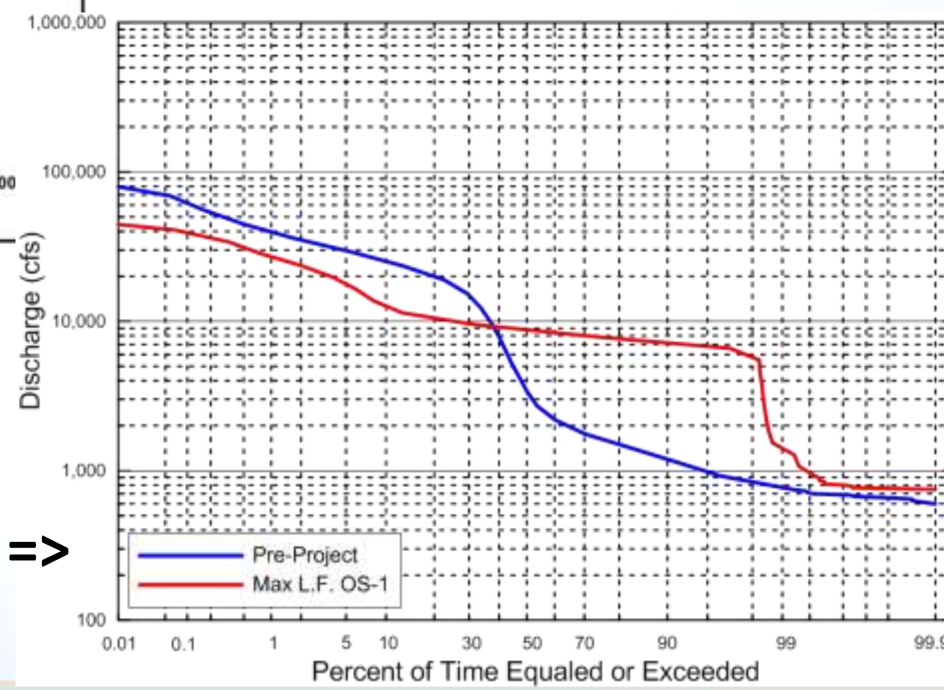
Duration of Inundation



Builds on inundation metric

Inundation discharge

Flow duration =>



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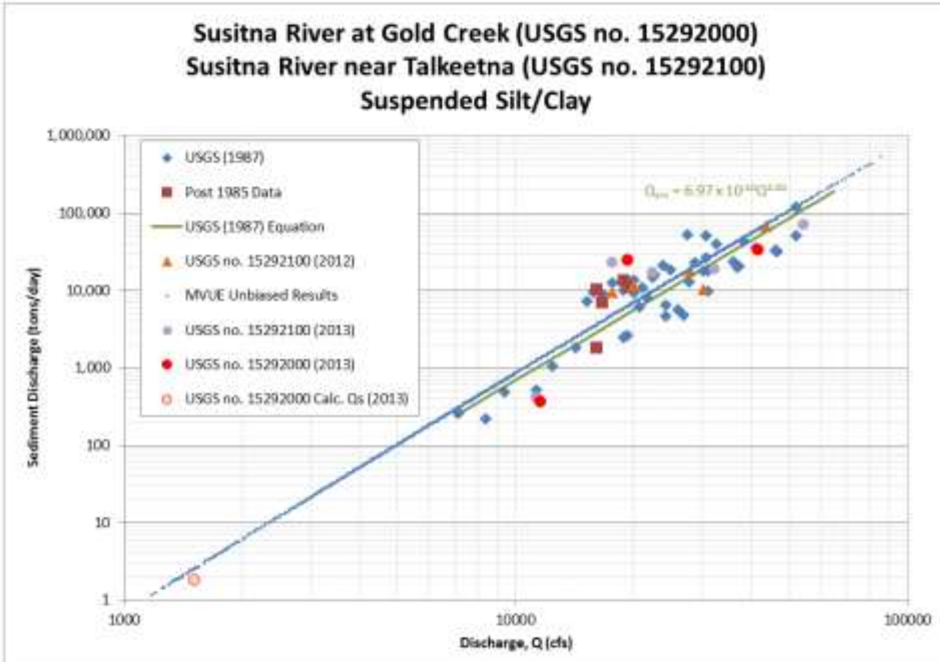
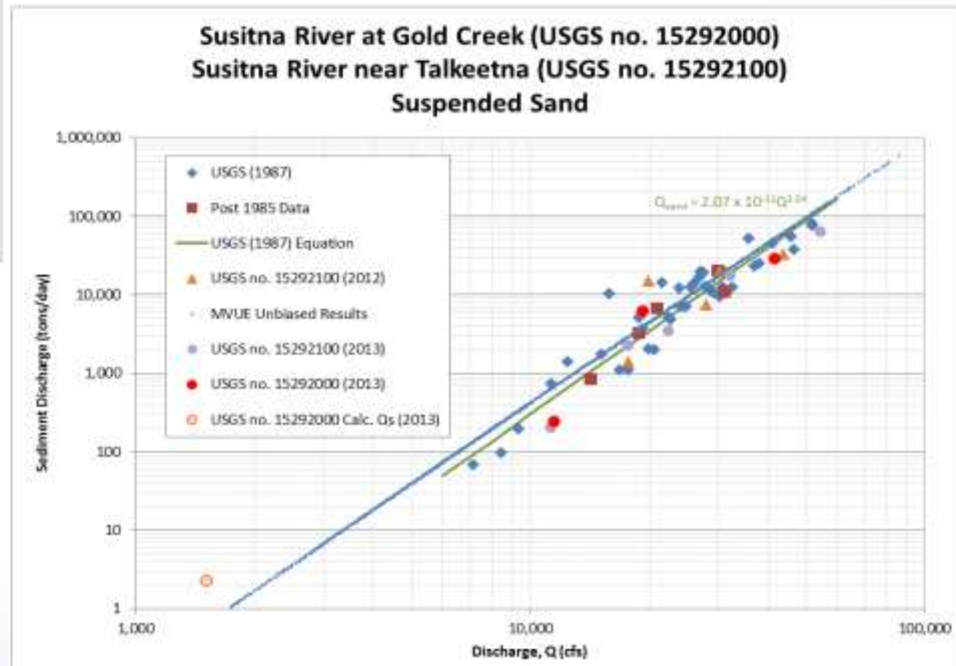
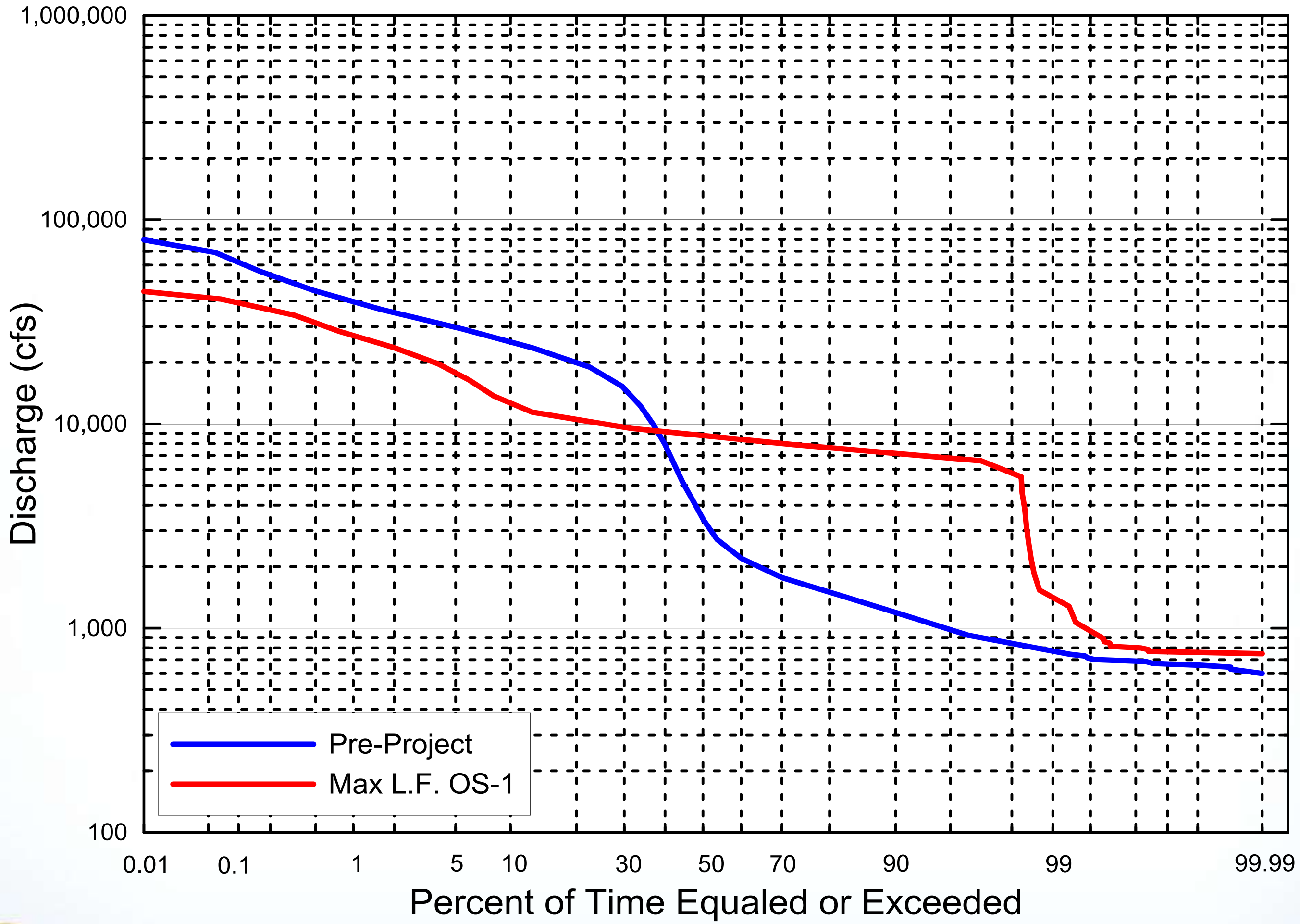
Suspended Sediment Load





Flow Duration



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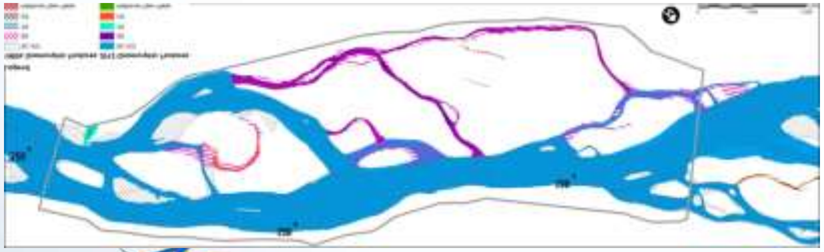
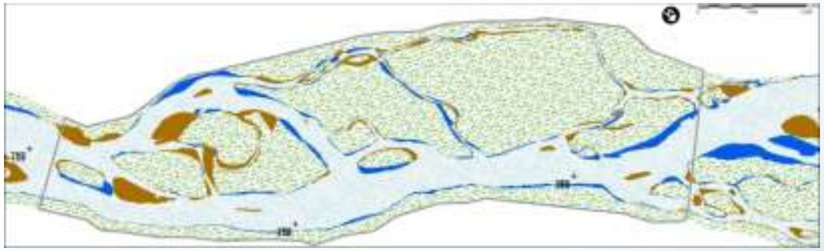
Sediment **D**elivery **I**ndex (SDI) Metric

- Determine SDI for existing conditions
- Identify current rates of accretion from Riparian study
- Relate or normalize to existing SDI
- Determine SDI for altered frequency of inundation and suspended sediment load for various surfaces under Project Scenarios
- Post-Project accretion rates is existing accretion rate multiplied by ratio of post-Project SDI / pre-Project SDI

Discussion – Channel Migration and Bank Erosion Metric (BEI)

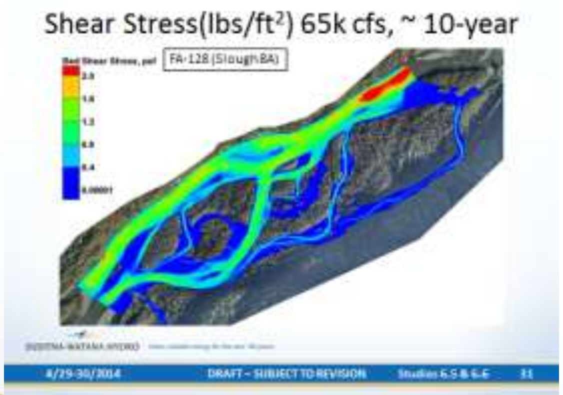
- **B**ank **E**nergy **I**ndex (BEI) Metric
  - Quantifies energy expended on the banks
  - Does not account for erodibility of bank materials or local controls
  - Comparative analysis
    - Among locations with similar material and erodibility
    - Among alternatives at a specific location

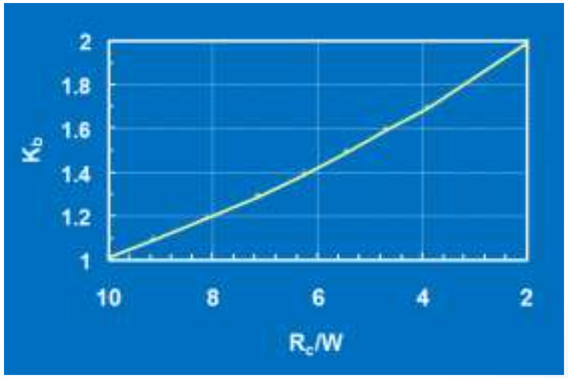




Components of BEI Analysis

- Hydrology
- Hydraulics
- Effects of bend geometry on shear stress against bank





How is BEI Calculated?

- Integrate stream power over flow duration curve:

$$BEI_0 = \int \Omega dt$$

Ω = Stream power
= $v^* \tau$
v = avg channel velocity
τ = shear stress
= $K_b * \gamma *$ Depth*Slope

- Accounts for both:
  - Range of hydraulic conditions
  - Duration of flows

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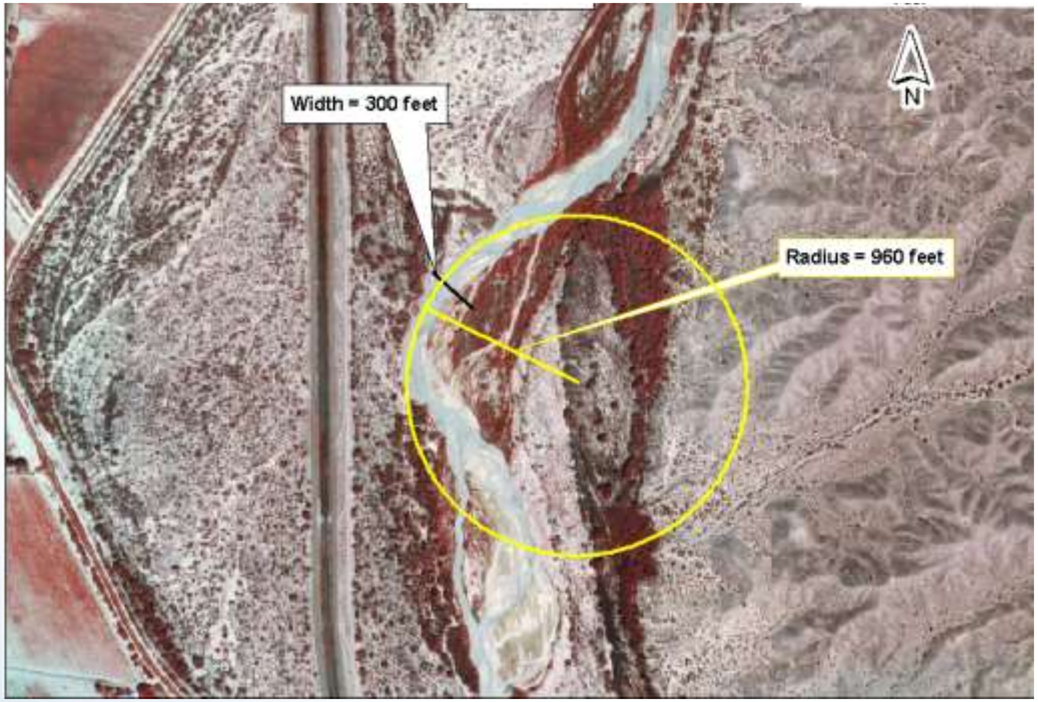
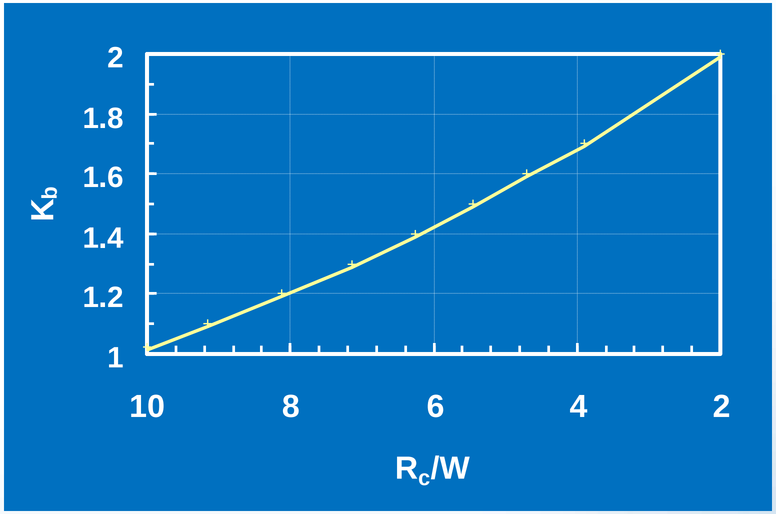
Adjustment Factor for Bend Effects



- Shear stress (and stream power) increase as function of bend geometry



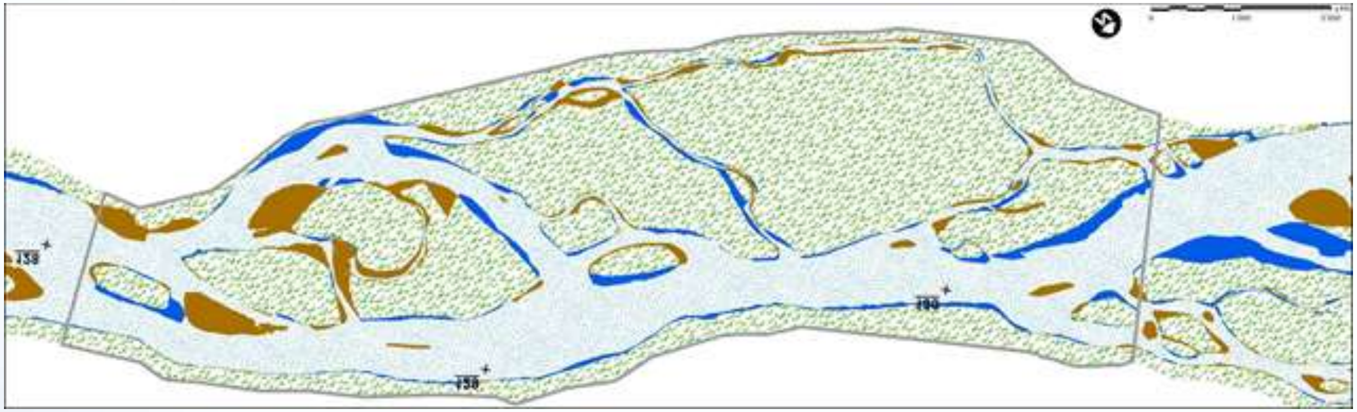
What do we mean by “Normalized”?

Normalized BEI = BEI_0 / Reach-averaged BEI

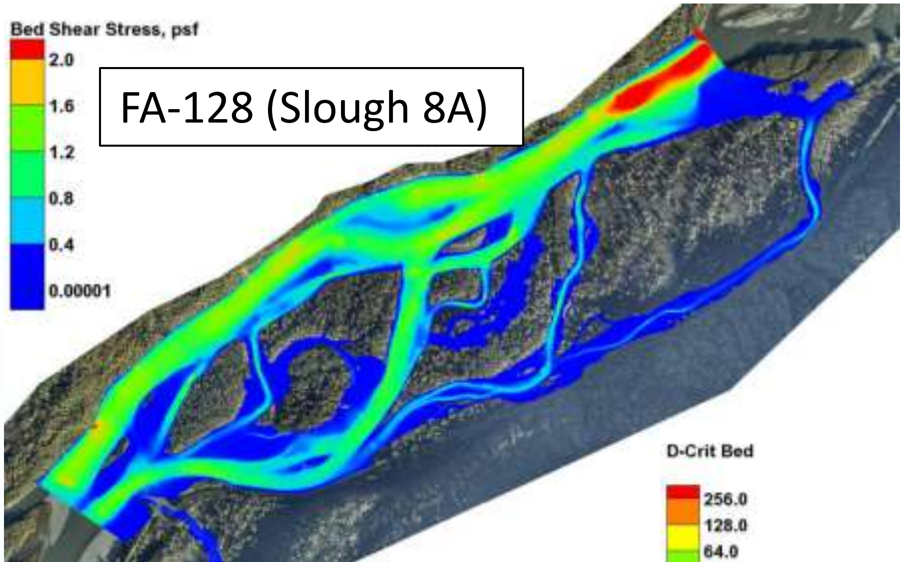
BEI=1 → Same as reach-average

BEI<1 → Less than reach-average (less erosion potential)

BEI>1 → Greater than reach-average (more erosion potential)



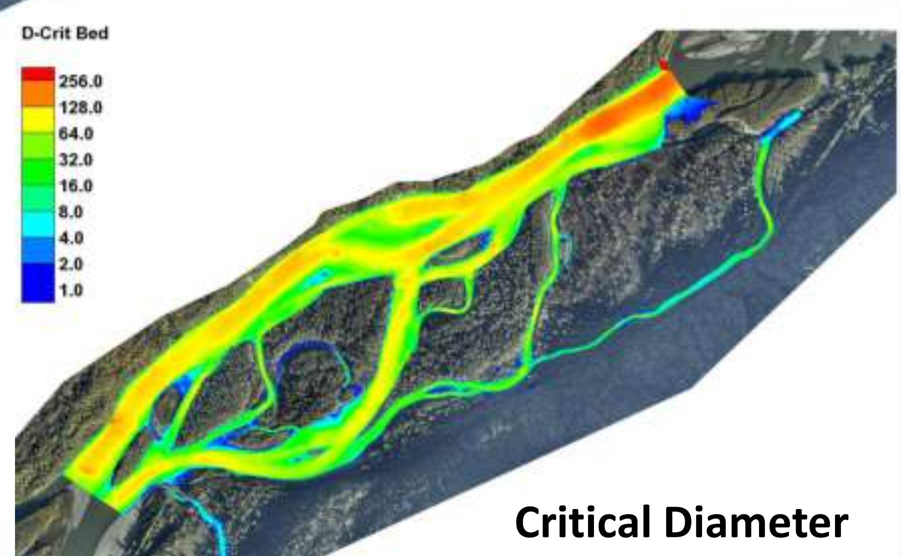
Discussion – Disturbance by Flow



Metrics from 2-D model:

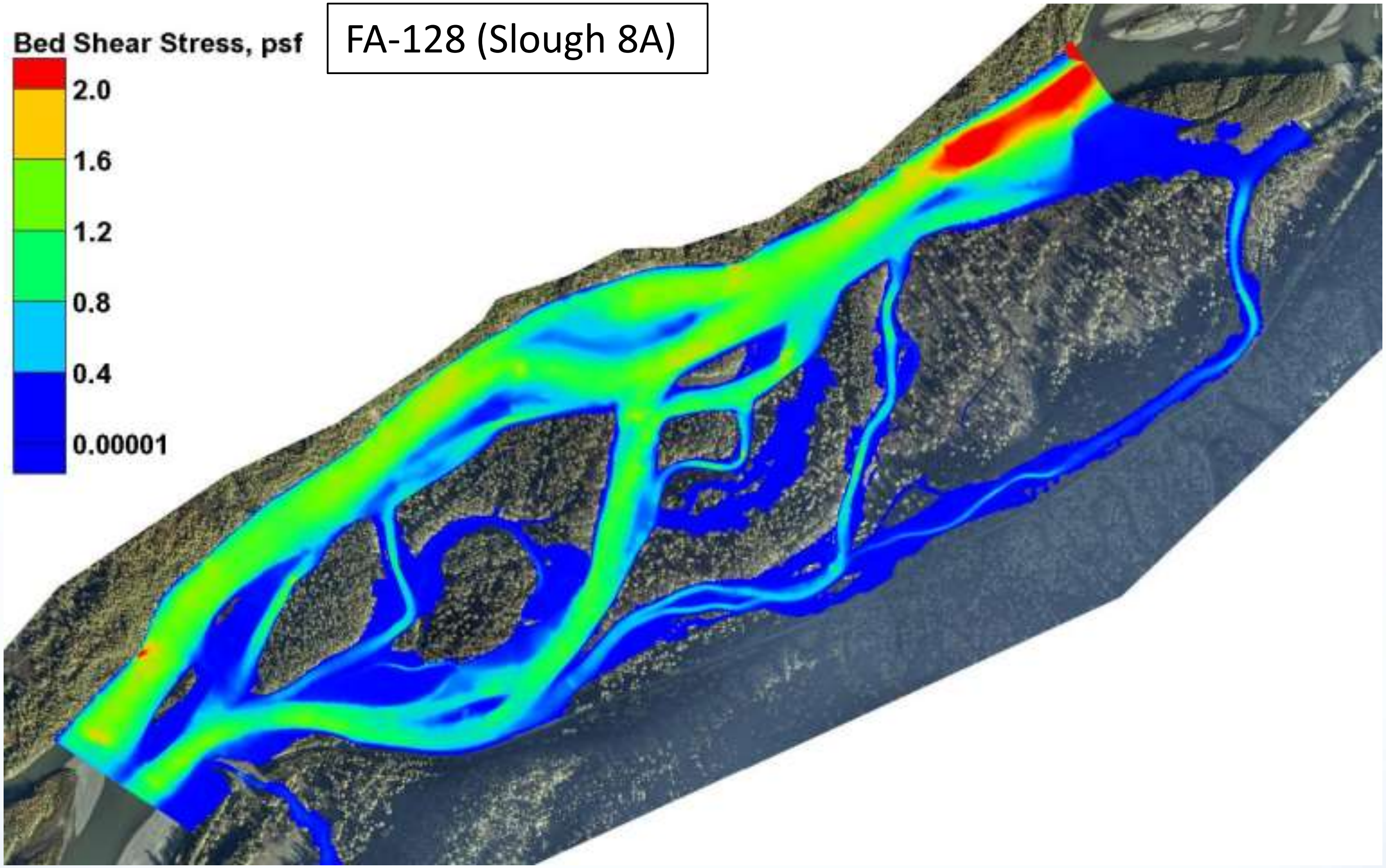
- **Shear stress**
- **Bed mobilization**

Bed Shear Stress (psf)



Critical Diameter (mm)

Shear Stress(lbs/ft^2) 65k cfs, ~ 10-year



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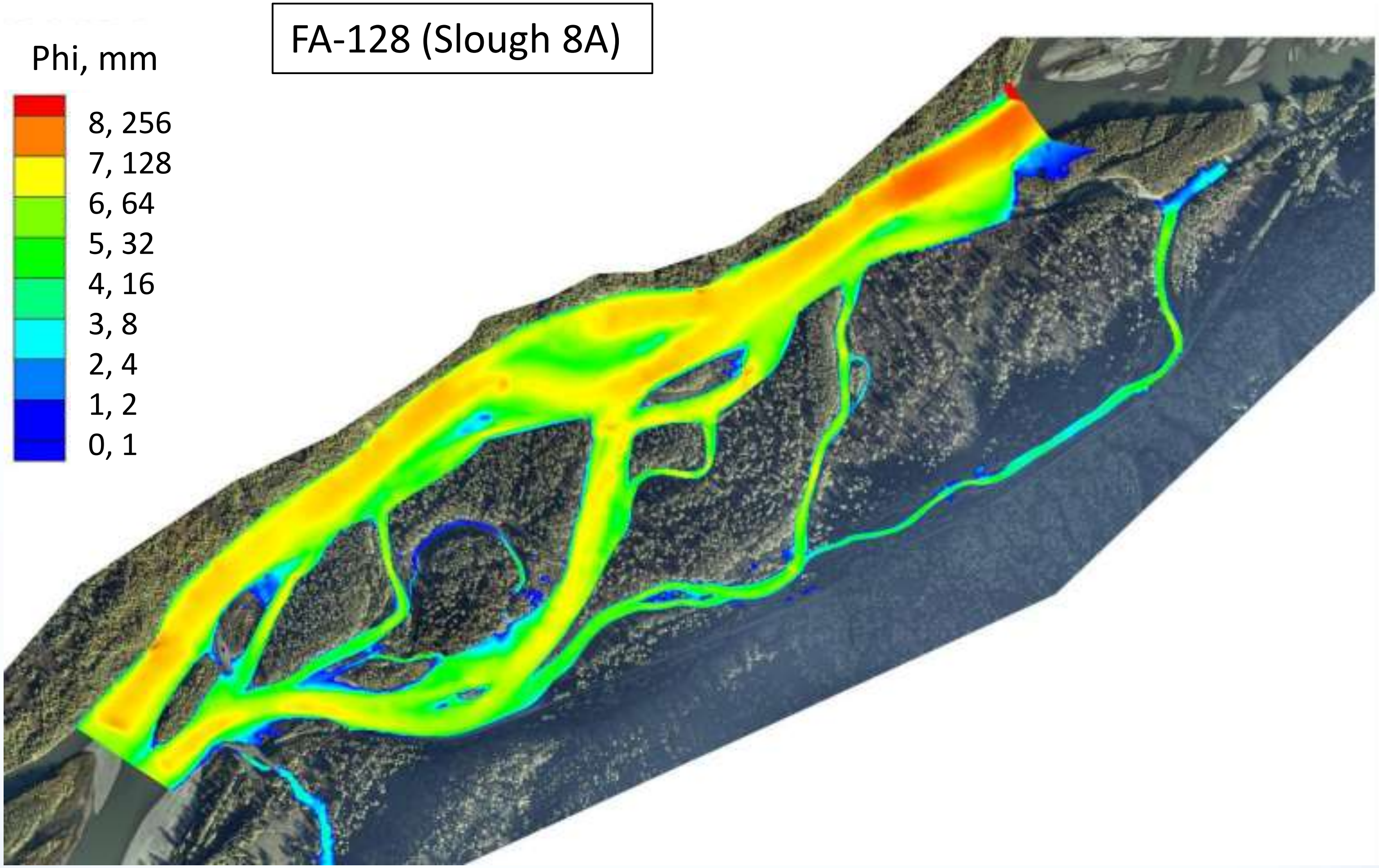
$D_{critical}$(mm) 65k cfs , ~ 10-year



Questions and Further Discussion