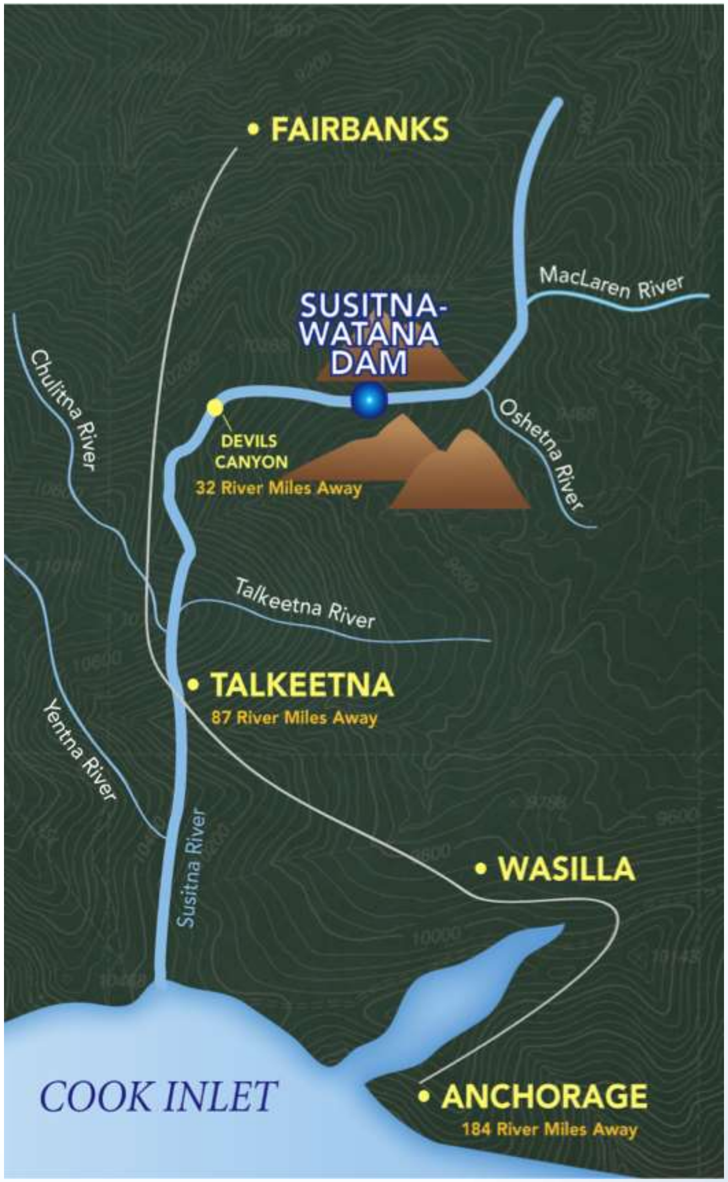
Fluvial Geomorphology Modeling

Technical Team Meeting - Riverine Modeling
November 13, 14 and 15, 2013

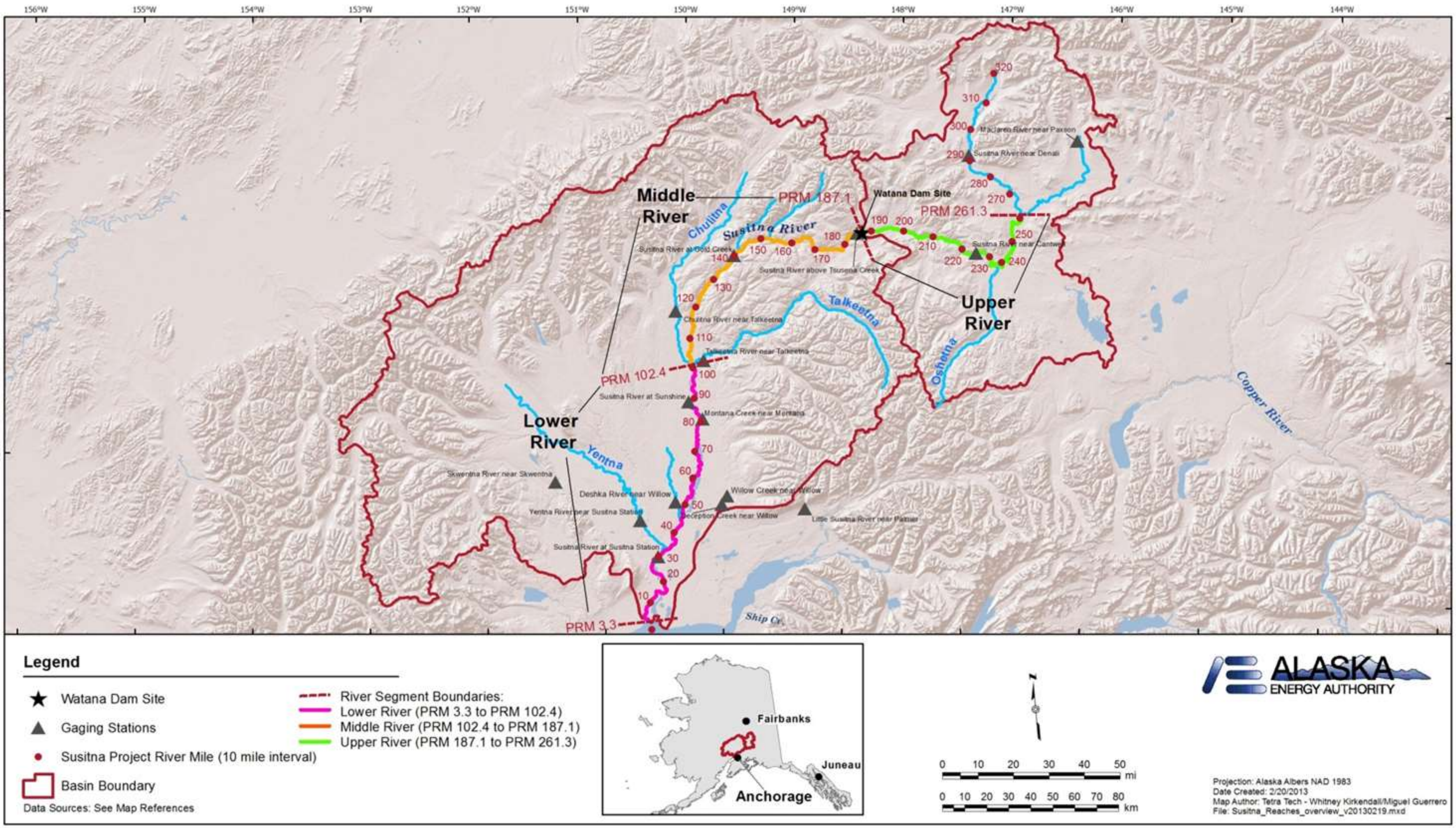
Prepared by: Tetra Tech

Prepared for: Alaska Energy Authority

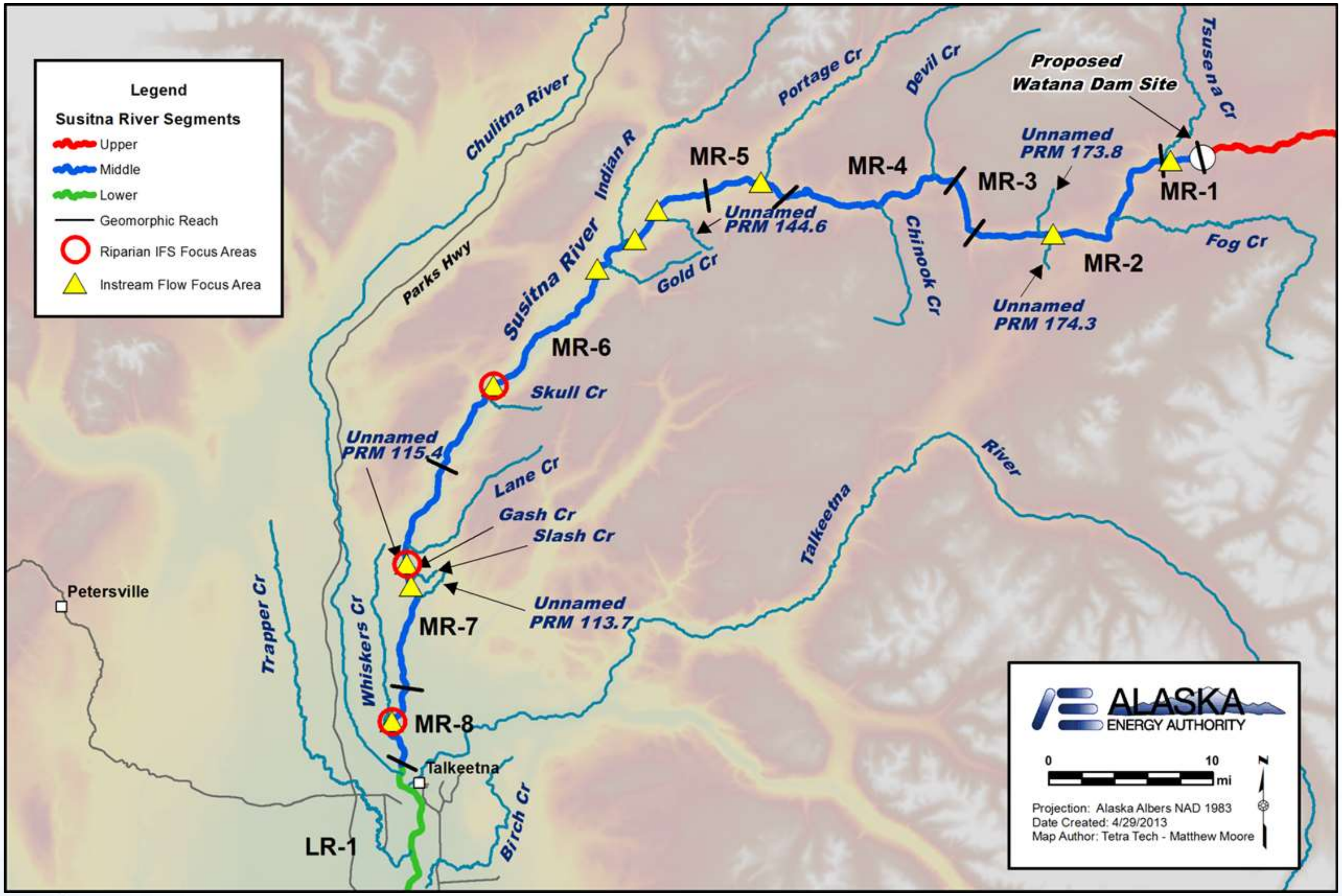


SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Fluvial Geomorphology Modeling (FGM): Middle River and Lower River Segments



Middle River FGM: Combination of 1-D and 2-D



Fluvial Geomorphology Modeling (FGM) Approach - General

1-D Tributary Sediment Transport Modeling
(HEC-RAS/Sediment Rating Curves)

1-D Morphology Modeling
(HEC-6T)

2-D Morphology Modeling
(SRH-2D or River2D)

2-D Hydraulic Modeling
(SRH-2D or River2D)

FGM Modeling Team

Study Lead: Bill Fullerton
Lead Modeler: Lyle Zevenbergen
QC: Bob Mussetter, Mike Harvey

Modelers: Dave Pizzi, Jay Smith, Dai Thomas, and Ryan Kilgren

Comprehensive Modeling Approach

1-D Reach-Scale Morphology Models

Hydro. & Sed. input: Existing & OS – continuous 50-year simulations

	Year 0	Year 25	Year 50
Geometry:	Existing	"Existing" & OS	"Existing" & OS

Provides Yr-25 & 50 sediment inflow, geometry and d/s rating curves

2-D Morphology Unsteady Models at FAs

~6 month simulations (open water period) for Yr-0, 25 & 50

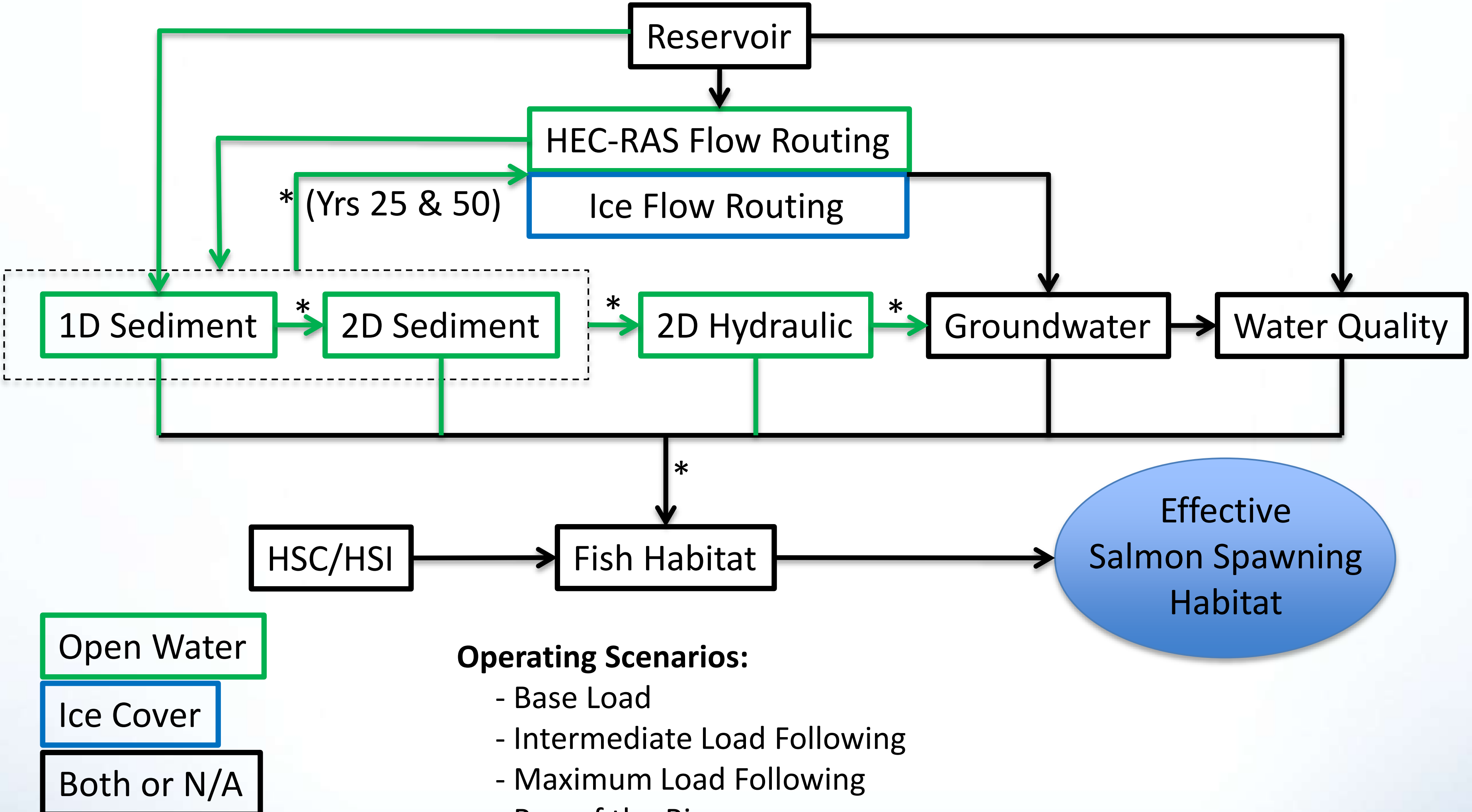
Provides input on Yr-25 & 50 substrate & lateral feature geometry

2-D Hydraulic (habitat) Steady Models at FAs

	Year 0	Year 25	Year 50 .
Geometry:	Existing	"Existing" & OS	"Existing" & OS

Provides hydraulic data to habitat models for range of flows.

Model Interdependencies Flow Chart



Operating Scenarios:

- Base Load
- Intermediate Load Following
- Maximum Load Following
- Run of the River

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

Fluvial Geomorphology Modeling – Integration

Modeling Task	Input and Results	Hydrology	Sediment	Hydraulics	Channel & Floodplain Geometry
1-D Tributary Sediment Modeling	Input	Range of steady flows	Bed material from site samples	Site-specific D/S stage-discharge	Existing at T = 0 (yr-0)[3]
	Results for:	Results for range of steady flows to develop sediment rating curves at mouth of each tributary			
	1-/2-D Morph.		trib. sediment rating curves		
	Aquatic Habitat			V, D, WSE some trib. mouths	barrier/delta change some tribs.
	Other studies				
1-D Reach-Scale Morphology Modeling	Input	50-yrs Existing & OS[1]	Existing & OS[2]	stage-discharge at Susitna Sta.	Existing at T = 0 (yr-0)[3]
	Results for:	Results for continuous 50-year simulations throughout 1-D modeling domain			
	2-D Morphology		U/S sed. rating curves at FAs	D/S stage-discharge at FAs	main channel change
	1-D Ice			stage-discharge at 3-Rivers	main channel change[4]
	Flow Routing				main channel change[4]
	Aquatic Habitat		substrate change[4]	stage-discharge relationships	main channel change[4]
	Riparian Habitat		sediment supply to overbanks	stage-discharge relationships	bar/island/floodplain change
2-D Local-Scale Morphology Modeling	Input	<1-yr wet, avg., dry with PDO, Existing & OS[1]	U/S sed. rating curves at FAs for yrs-0,25,50 for Existing & OS[5]	D/S stage-discharge at FAs for yrs-0,25,50 for Existing 3 OS[5]	Existing (yr-0)[3], yrs-25,50[5] in main channel
	Results for:	Results for range of <1-yr simulations throughout FA modeling domain			
	2-D Hydraulic		bed material gradation change[4]		lateral feature trends
	2-D Ice				lateral feature trends[4]
	Flow Routing				
	Aquatic Habitat		substrate change[4]		barrier/delta change
	Riparian Habitat		sediment supply to overbanks		bar/island/floodplain change
2-D Local-Scale Hydraulic Modeling	Input	Range of steady flows[6]	Bed material gradation change[7]	D/S stage-discharge at FAs for yrs-0,25,50 for Existing & OS[5]	Existing (yr-0)[3], yrs-25,50 main channel[5] and lateral features[7]
	Results for:	Results for range of steady flows throughout FA modeling domain			
	Ice, Flow Routing				
	Aquatic Habitat			V, D, WSE, etc. throughout FAs	
	Riparian Habitat			V, D, WSE, etc. throughout FAs	

FGM Metrics – Categories Include:

- Hydraulic variables
- Sediment transport
- Channel types and characteristics
- Floodplain and island characteristics
- *Note: Metrics are quantified spatially and temporally*

FGM Metrics - Geomorphic Results provide Information to Other Study Components to Evaluate Potential Project Effects on:

- Aquatic Habitat
- Riparian Habitat
- Ice Processes
- Flow Routing
- Groundwater
- Property/Infrastructure
- Navigability
- Recreation and Aesthetics

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

Fluvial Geomorphology Modeling – Metrics

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
Channel Top Width
Effective Discharge
Sediment Loads
Bank Instability/Channel Migration (BEI)
#/lengths/areas of types of channel

Flow Depths
Shear Stress
Bed Material Composition
Sediment Concentrations

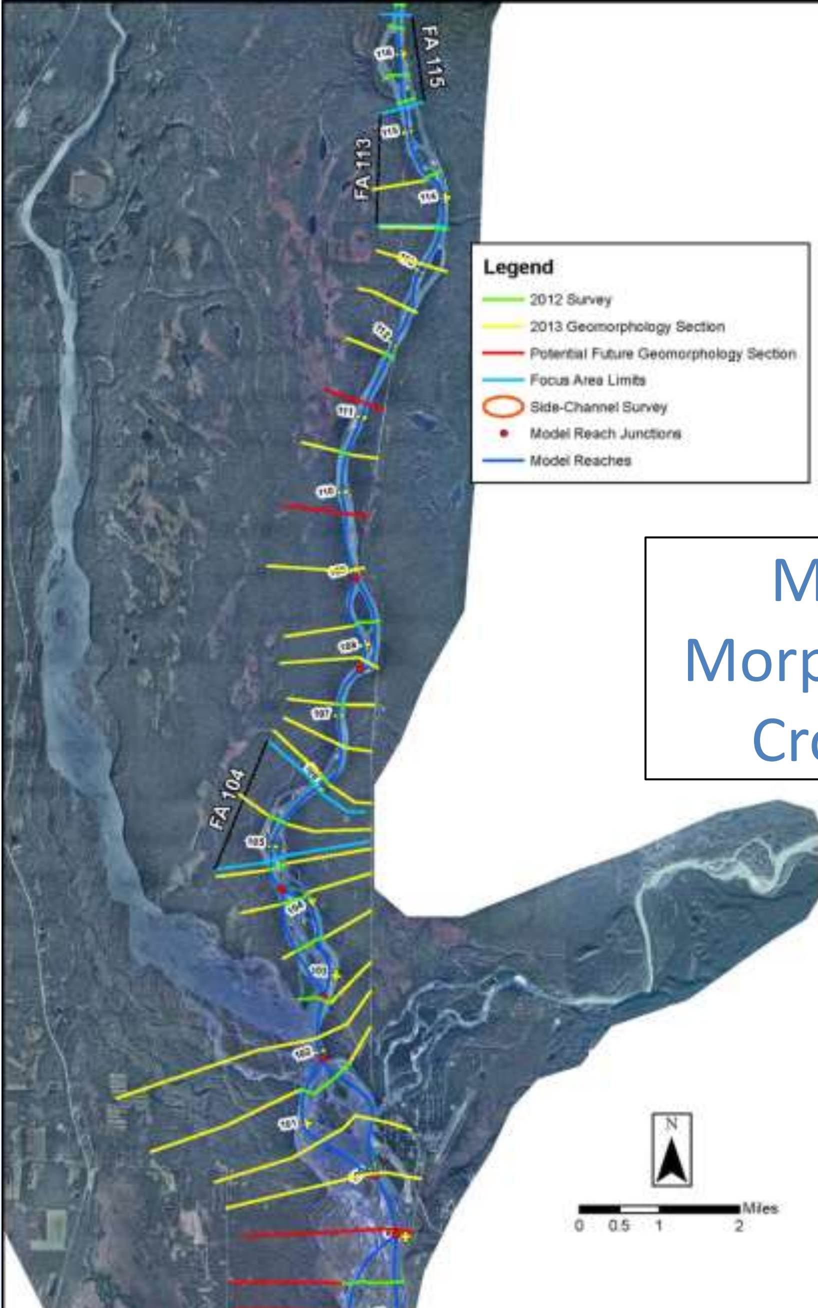
Water Surface Elevations
Aggradation/Degradation
Bed Material Mobility
Floodplain Accretion
LWD production/transport
Areas of Island and floodplain features

Note: Items in green support evaluation of Effective Spawning

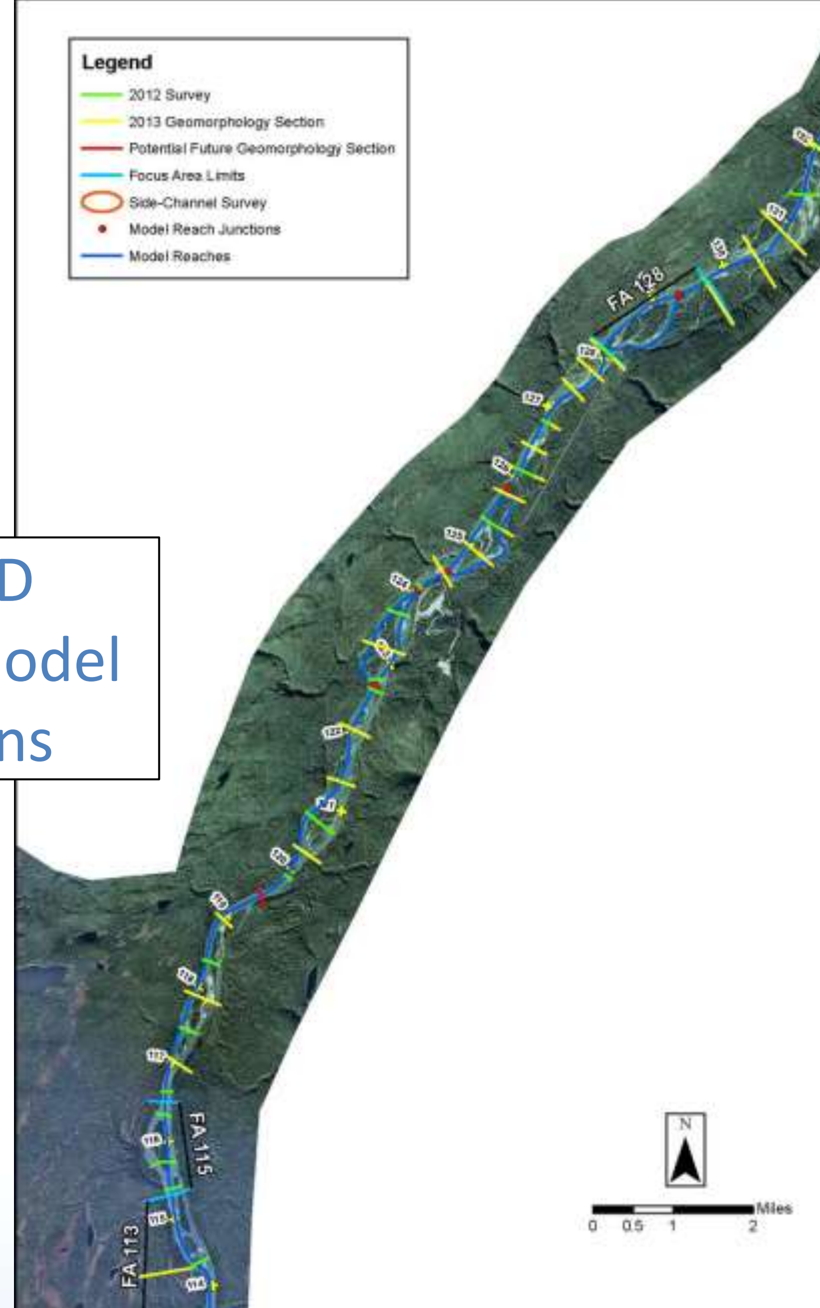
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

MR FGM – 1-D Morphology Model: Purpose

- 1-D Morphology Model (HEC-6T)
  - Reach level assessment of sediment balance
  - General aggradation, degradation response of the channel
  - Reach level changes in bed material gradation
  - Boundary conditions for 2-D morphology model
    - Downstream water surface elevation
    - Bed elevation change over decades
    - Upstream sediment supply



MR FGM 1-D Morphology Model Cross Sections



t 100 years.

MR FGM – 1-D Morphology Model: Inputs

Data/Parameter Inputs (source)

- Cross sections (Survey/Hydrosurvey/LiDAR – IFS, FGM)
- Bed material gradations (FGM)
- Channel and floodplain roughness (FGM)
- Channel width change rates (FGM and collaboration)
- D/S stage-discharge relationship (USGS Susitna Sta.)

Model Inputs from other Study Components (source)

- Discharge time series including tributaries (IFS)
- Sediment sup. of 3 major rivers (USGS) reservoir (WQ)
- Sediment supply from tributaries (1-D trib. FGM)

MR FGM – 1-D Morphology Model: Calibration

Bed Roughness

- Water Surface Elevations
  - During cross section surveys
  - Other measured WSEs
  - Gages
- ADCP (velocity and flow splits)

Sediment Transport

- Gage data including transport rates & specific gage plots
- Comparison cross sections – limited

MR FGM – 1-D Morphology Modeling: Simulations

- 50-year continuous simulations
  - Existing Conditions
  - Maximum Load Following OS-1
  - Base Load
  - Intermediate Load Following
  - Run of River (RoR)

MR FGM – 1-D Morphology Model: Results

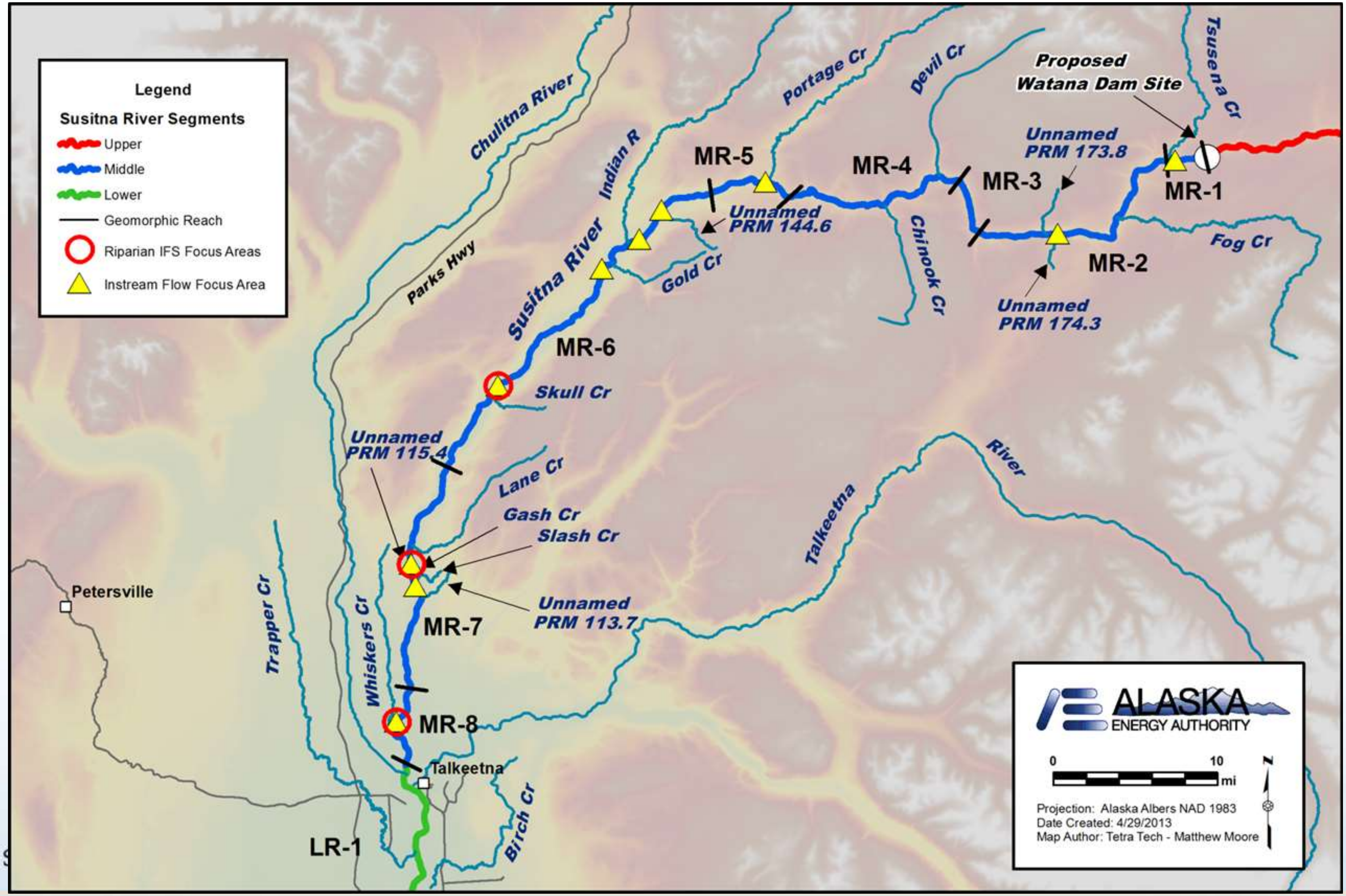
General Results to other Study Components

- Aggradation/Degradation (main channel change)
- Stage-Discharge change
- Flow distribution (in split-flow reaches)
- Bed material gradation change

Results for Focus Area Modeling (2-D Morphology)

- Main channel change (bed elevation and gradation)
- Sediment supply
- Downstream stage-discharge

MR 1-D and 2-D Morphology Model Domains



MR FGM – 2-D Morphology Model: Purpose

- 2-D Morphology Model (SRH-2D or River2D)
  - Provide level of detail and accuracy in simulating the interaction between the main channel and lateral habitats not possible with 1-D modeling
  - Determine at a local scale:
    - Bed mobilization and sediment transport conditions
    - Hydraulic conditions
    - Sediment flux to the floodplain
    - Changes in sedimentation and erosion patterns

MR FGM – 2-D Morphology Model: Inputs

Data/Parameter Inputs (source)

- Topography & Bathymetry (Survey/Hydrosurvey/LiDAR)
- Bed material gradations (FGM)
- Channel and floodplain roughness (FGM)
- Channel width change rates (FGM and collaboration)

Model Inputs from other Study Components (source)

- Discharge time series including tributaries (IFS)
- D/S stage-discharge relationships (1-D FGM)
- U/S sediment supply (1-D FGM)
- Sediment supply from tributaries (1-D trib. FGM)

MR FGM – 2-D Morphology Model: Calibration

Bed Roughness

- Water Surface Elevations
  - During cross section surveys
  - Other measured WSEs
- ADCP (velocity and flow distribution)

Sediment Transport

- Consistency with 1-D model results
- Comparison cross sections - limited

MR FGM – 2-D Morphology Model: Simulations

<1-year (~7 months) continuous simulations
for the following combinations

- Existing conditions & 4 operational scenarios (5 OS)
- Dry, avg., & wet x 2 PDOs (up to 6 hydrologic cond.)
- Apply to year-0, year-25, and year-50 geometries

Each Focus Area (FA) will have one initial model geometry at yr-0 and up to 5 initial geometries for yrs 25 and 50, and up to 30 simulations (5 OS x 6 hydrologic conditions). Each FA will have up to 90 bed morphology simulations.

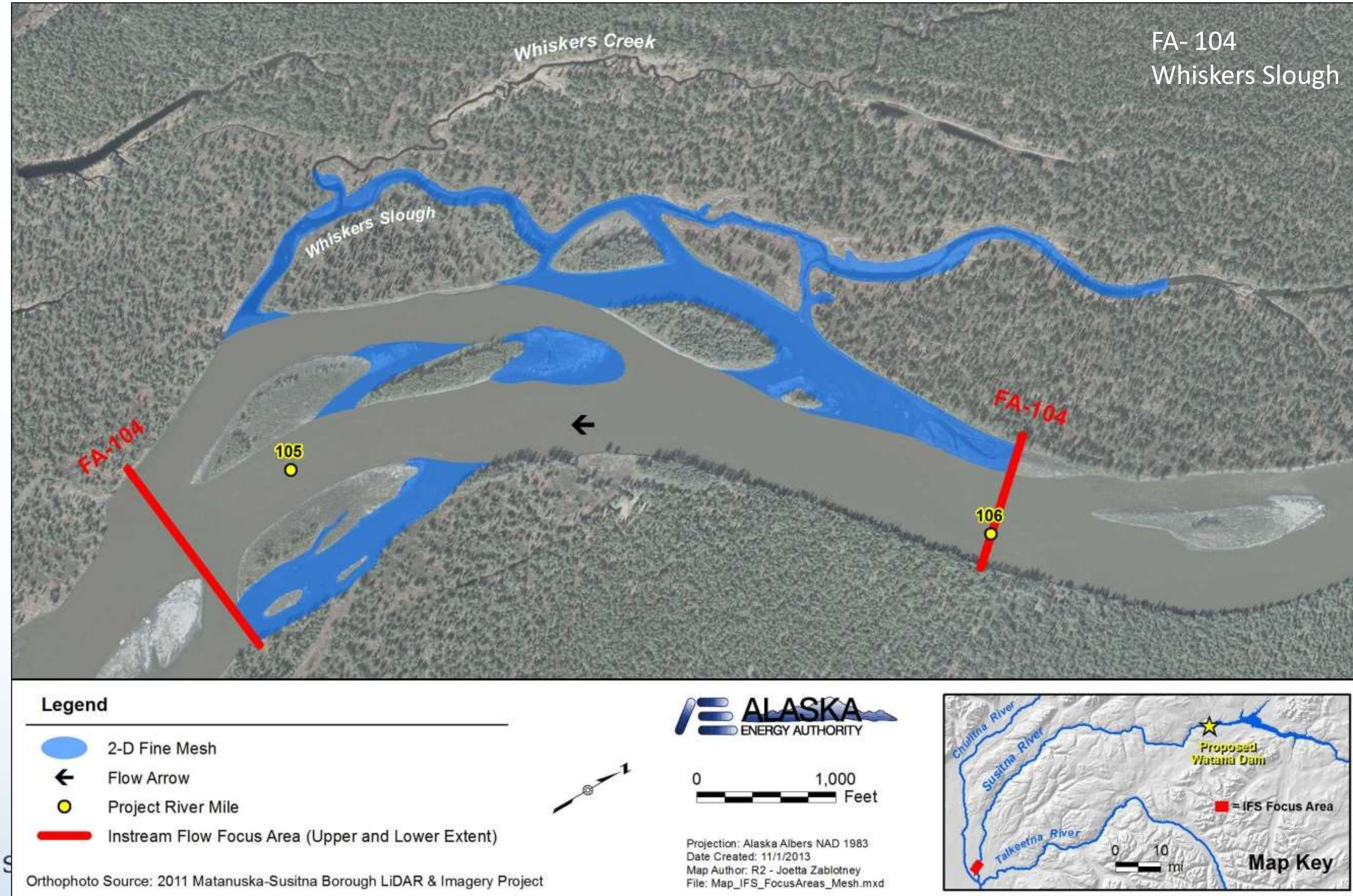
MR FGM – 2-D Morphology Model: Results

- Aggradation/degradation
- Sediment transport balance/imbalance
- Bed material composition
- Bed material mobility
- Geometry for 2-D hydraulic model

MR FGM – 2-D Hydraulic Model: Purpose

- 2-D Hydraulic Model (SRH-2D or River2D)
  - Provide rigid/fixed bed hydraulic model output within Focus Areas for the fish and aquatics instream flow modeling:
    - Depth
    - Velocity
    - Substrate
    - Inundation
    - Water surface elevation
    - Others?

2D Hyd. Model Resolution Varies w/in a Focus Area



MR FGM – 2-D Hydraulic (fixed bed) Model: Inputs

Data/Parameter Inputs (source)

- Topography & Bathymetry (Survey/Hydrosurvey/LiDAR – IFS and FGM)
- Channel and floodplain roughness (FGM)

Model Inputs from other Study Components (source)

- Discharge range (IFS)
- Main channel change (1-D FGM)
- Lateral feature change (2-D FGM)
- D/S stage-discharge relationships (1-D FGM)

MR FGM – 2-D Hydraulic Model: Calibration

Bed Roughness

- Water Surface Elevations (WSE)
  - During cross section surveys
  - Other measured WSEs
- ADCP (velocity and flow distribution)

MR FGM – 2-D Hydraulic Model: Simulations

Year 0

- Range of flows for initial condition geometry

Years 25 and 50

- Geometric conditions representing various operational scenarios (OS) at year 25 and year 50
- Range of flows for each OS

Multiple steady flow simulations covering the range of discharges required by IFS

MR FGM – 2-D Hydraulic Model: Results

Year 0, 25 and 50

- Velocity and depth throughout FA model domain over range of flows
- Other results such as bed mobilization, shear stress, beaching flows can be supplied
- Note: *Substrate from 2-D morphology model*

MR FGM – 1-D Tributary: Purpose

- 1-D Trib. Sed. Transport (HEC-RAS)
  - Develop bed material load rating curve for supply to 1-D and 2-D morphology models
  - Evaluation of potential for sediment deposits at mouth and associated fish access issues
  - Note: *Similar modeling will be performed on selected Lower River tributaries.*

MR FGM: Tributaries

Tributary Name	PRM	Bank	Geo. Reach	Focus Area	Sed. Input only	1-D or 2-D
Tsusena Creek	184.6	RB	MR-2		X	1-D
Fog Creek	179.3	LB	MR-2		X	1-D
Unnamed	174.3	LB	MR-2	FA173		2-D
Unnamed	173.8	RB	MR-2	FA173		2-D
Portage Creek	152.3	RB	MR-5	FA151		2-D
Unnamed*	144.6	LB	MR-6	FA144		2-D
Indian River*	142.1	RB	MR-6	FA141		2-D
Gold Creek*	140.1	LB	MR-6		X	1-D
Skull Creek*	128.1	LB	MR-6	FA128		2-D
Lane Creek*	117.2	LB	MR-7		X	1-D
Unnamed*	115.4	RB	MR-7	FA115		2-D
Gash Creek*	115.0	LB	MR-7	FA113		2-D
Slash Creek*	114.9	LB	MR-7	FA113		2-D
Unnamed*	113.7	LB	MR-7	FA113		2-D
Whiskers Creek*	105.1	RB	MR-8	FA104		2-D

* Tribs that will be analyzed in 2013

MR FGM – 1-D Tributary: Inputs

Data/Parameter Inputs (source)

- Cross sections (FGM)
- Bed material gradation (FGM)
- Channel and floodplain roughness (FGM)

Model Inputs from other Study Components (source)

- Discharge range for each tributary (IFS)

MR FGM – 1-D Tributary: Calibration/Output

Calibration

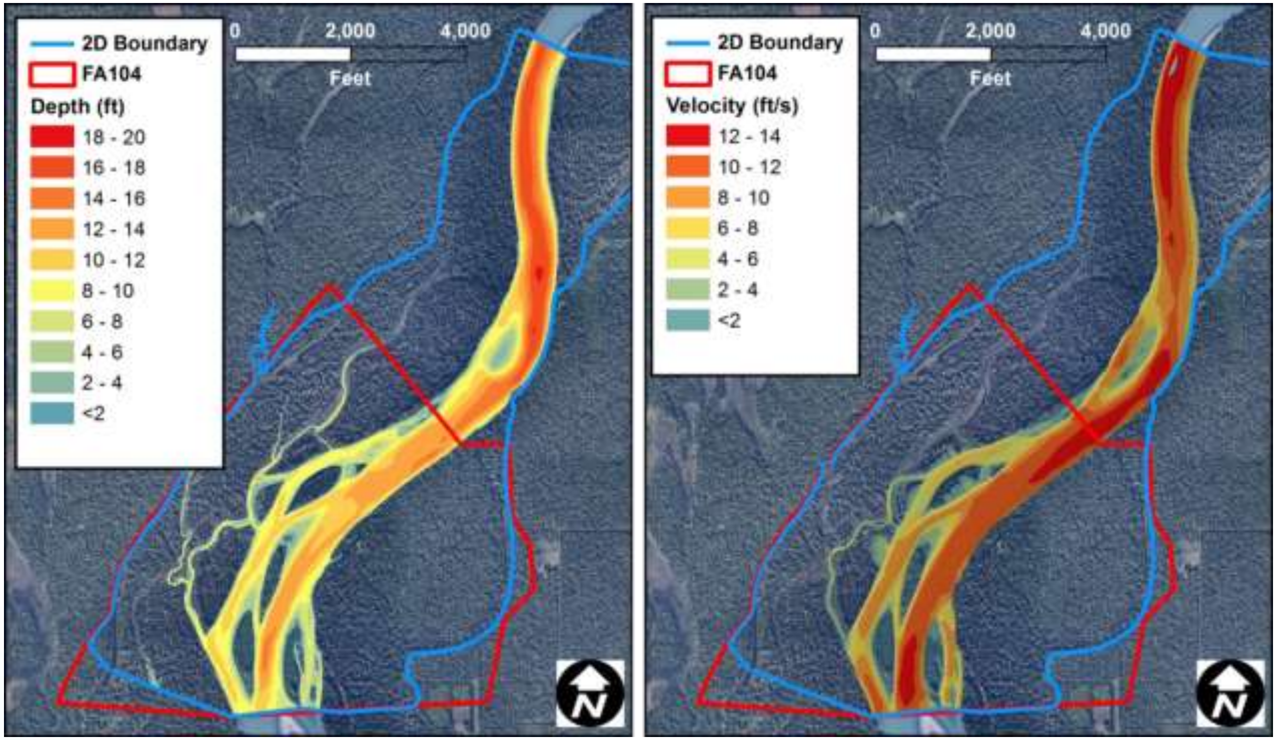
- Channel roughness from observed water surfaces

Model output to other Study Components (to)

- Sediment-discharge rating curves
  - 1-D Morphology Models (FGM)
  - 2-D Morphology Models (FGM)
  - 1-D Tributary Delta Models (FGM)

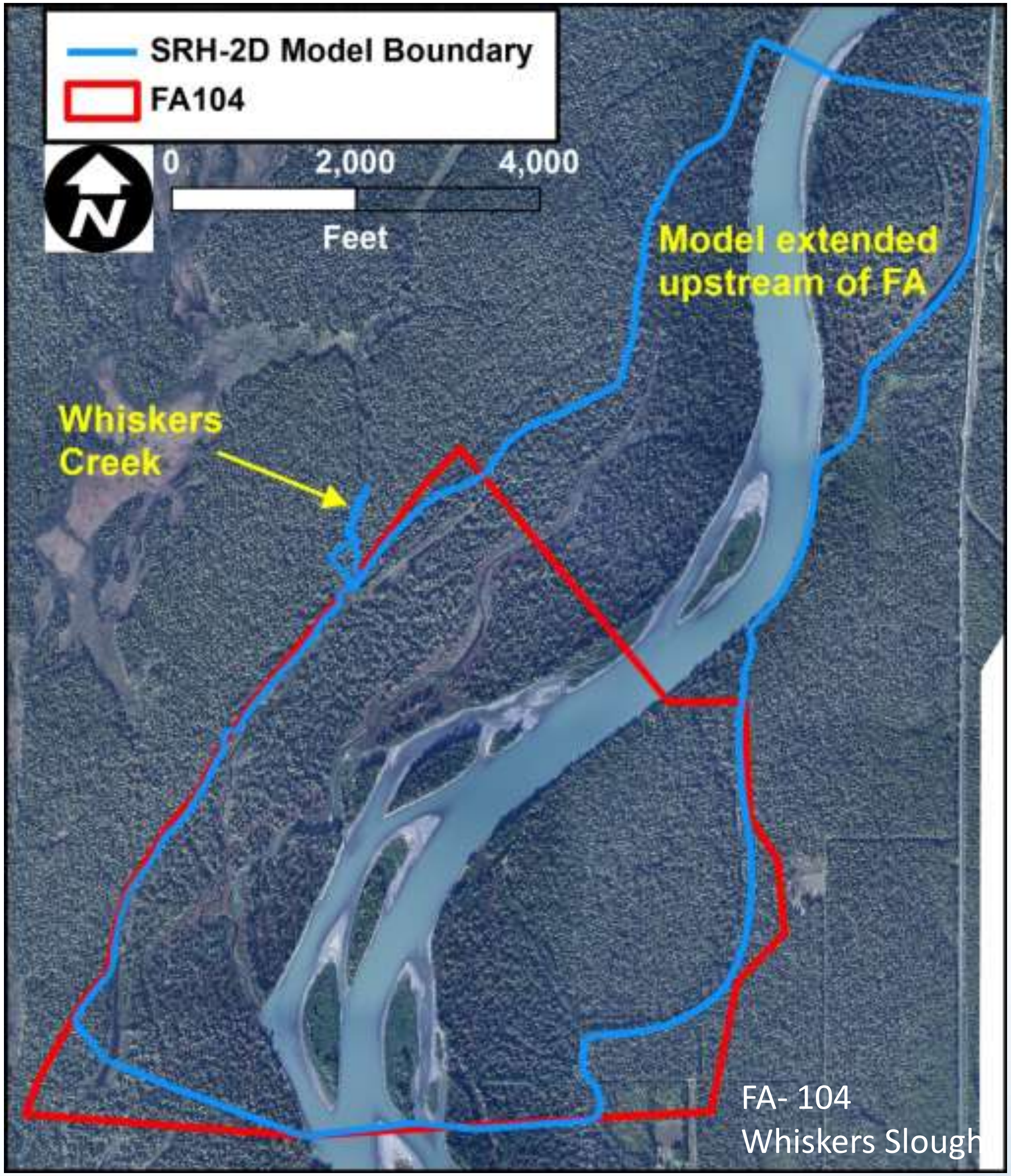
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Focus Area Modeling Example: FA-104 (Whiskers Slough) 2-D Hydraulics



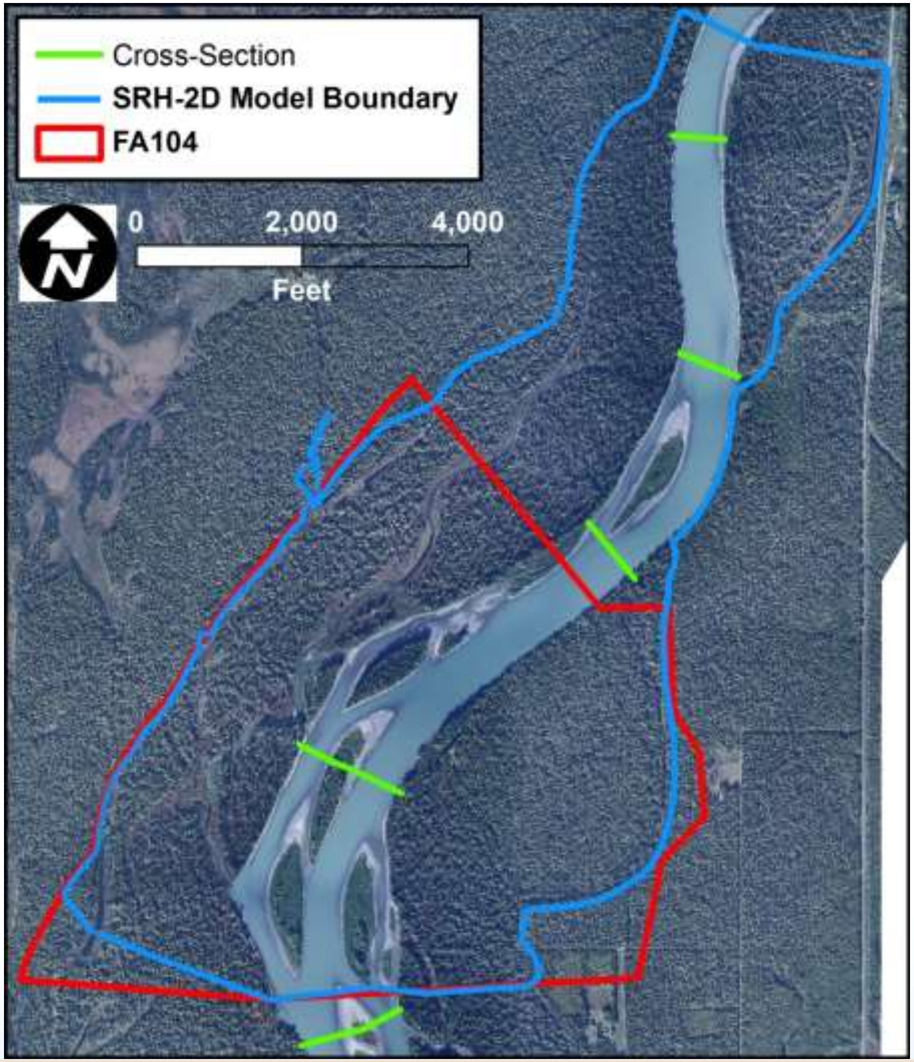
Note – All 2-D model results are preliminary and for illustration purposes only. The model has not been calibrated.

SRH-2D Hydraulic Model Initial Extents FA-104 (Whiskers Slough)



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

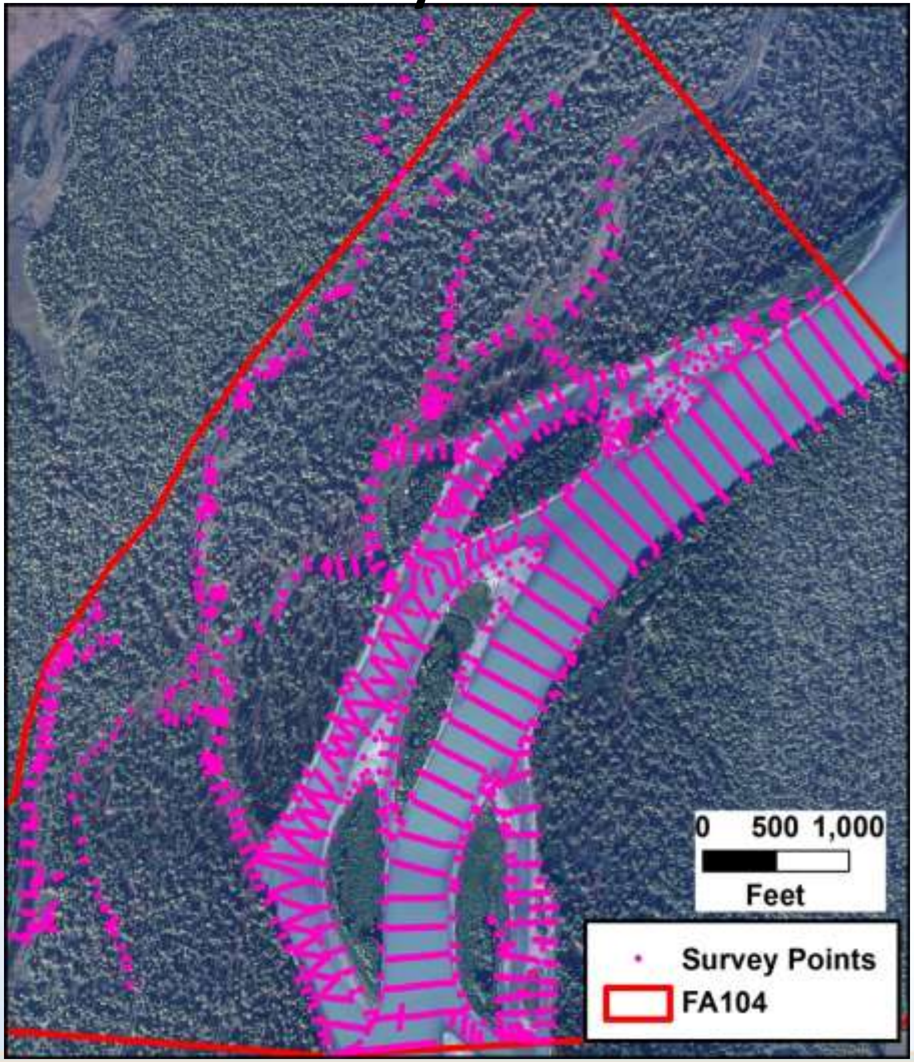
2012 and 2013 Cross-Sections FA-104 (Whiskers Slough)



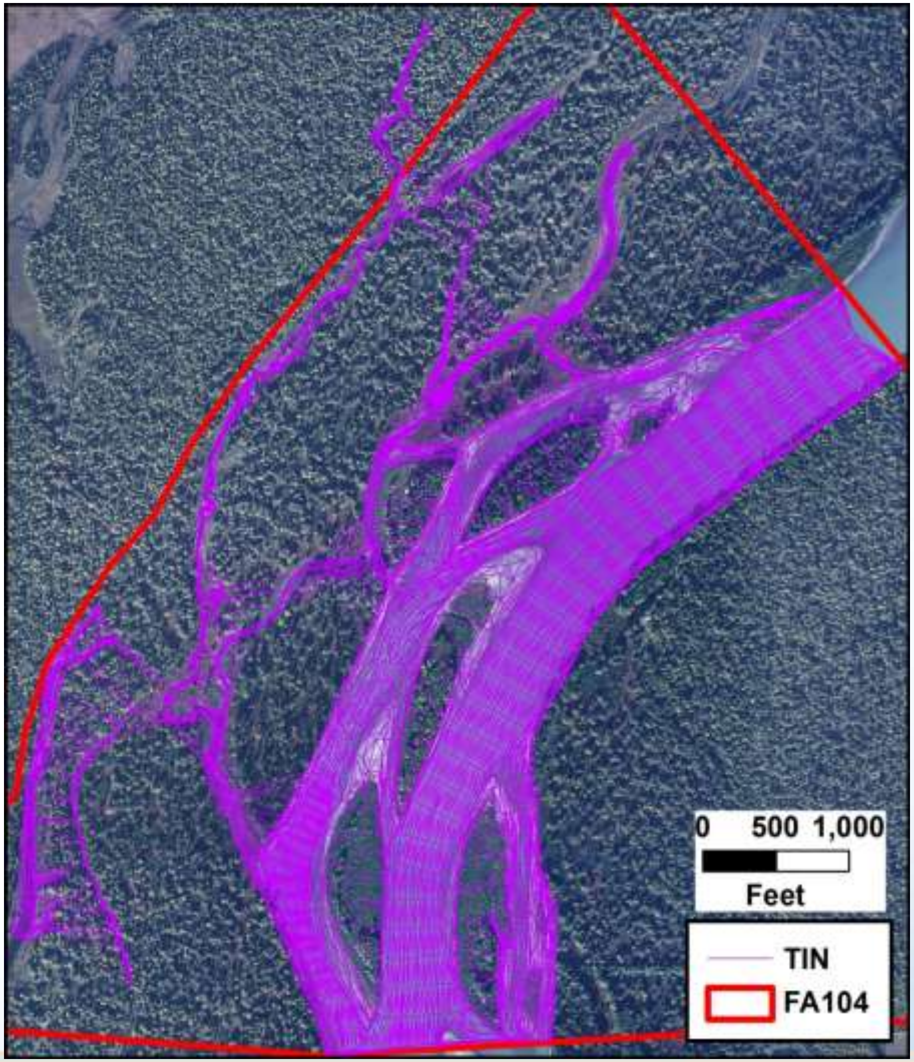
SUSITNA-WATANA HYDRO

2013 Bathymetric and Topographic Surveys
FA-104 (Whiskers Slough)

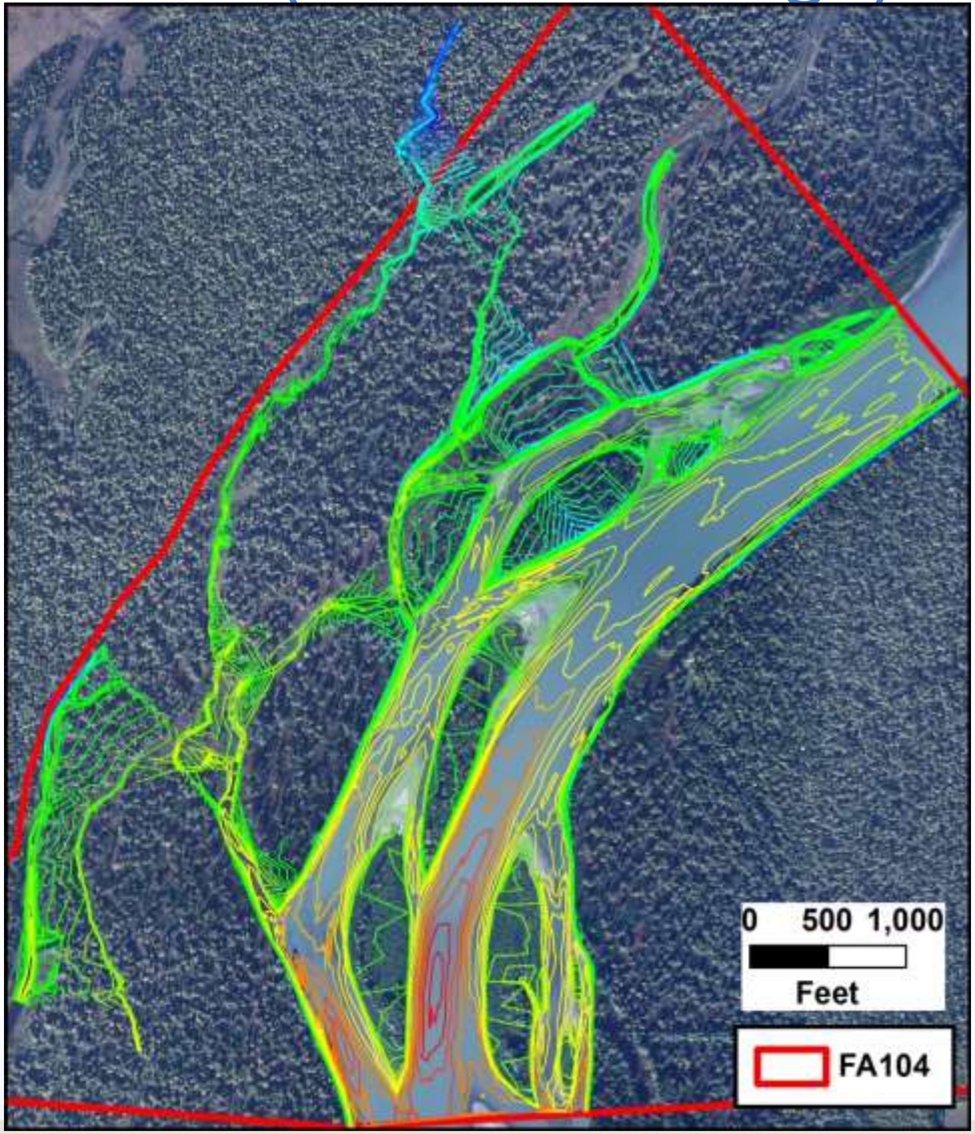
Survey Points



Generated TIN

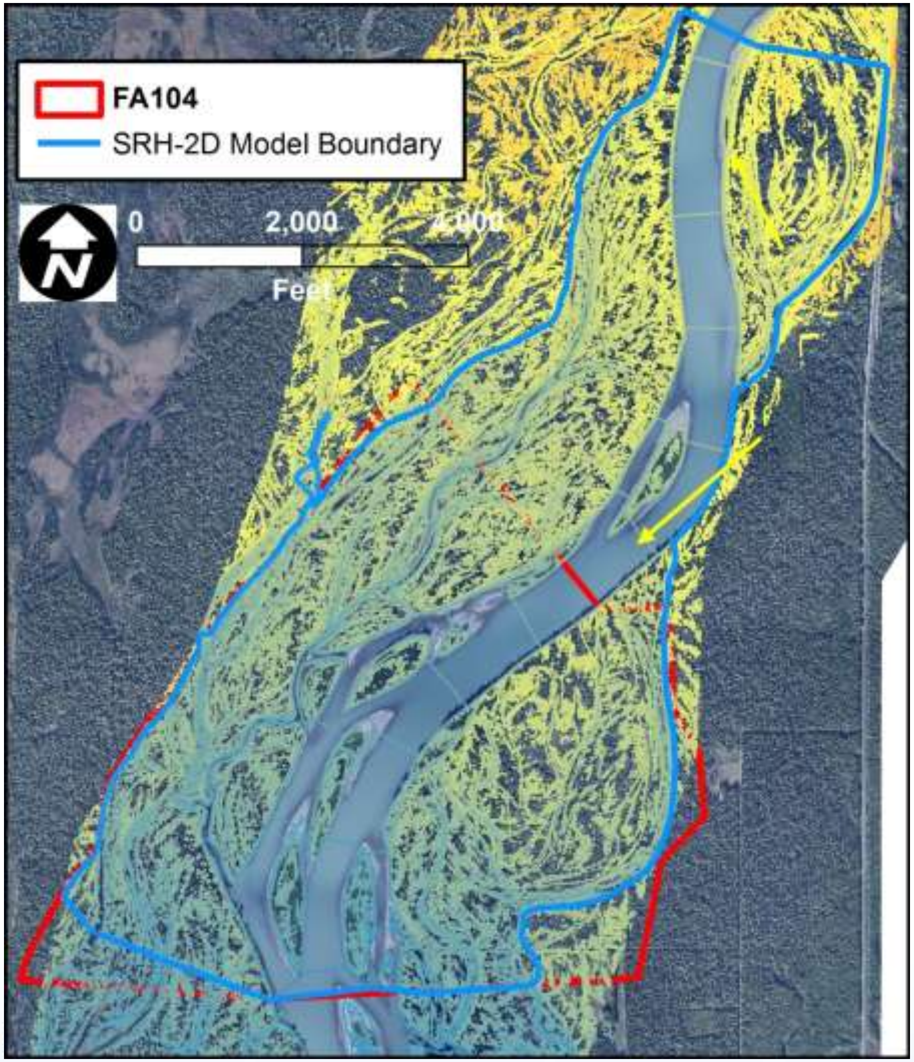


Generated Contours from TIN FA-104 (Whiskers Slough)



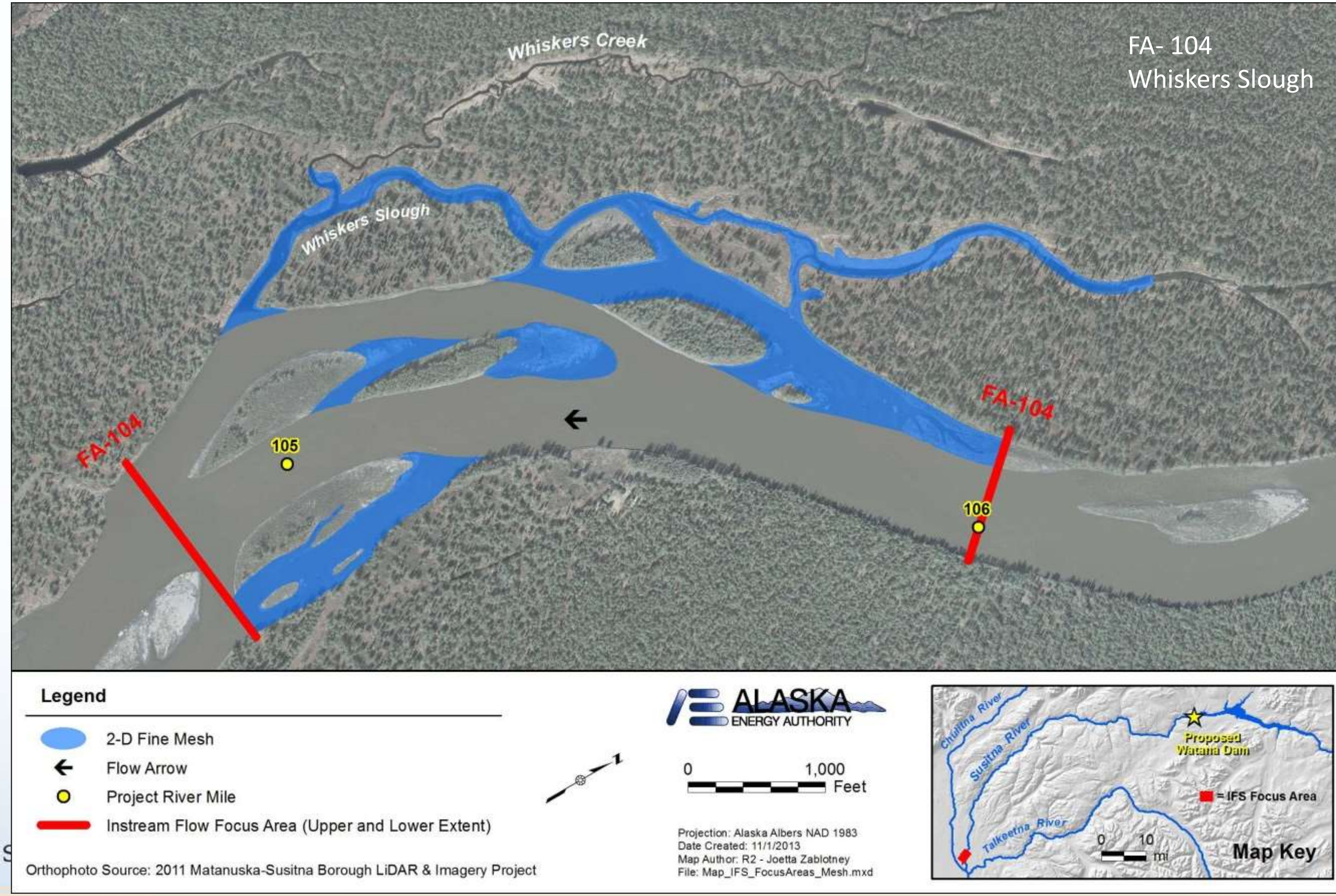
SUSITNA-WATANA HYDRO

LiDAR Used to Fill in Floodplain FA-104 (Whiskers Slough)

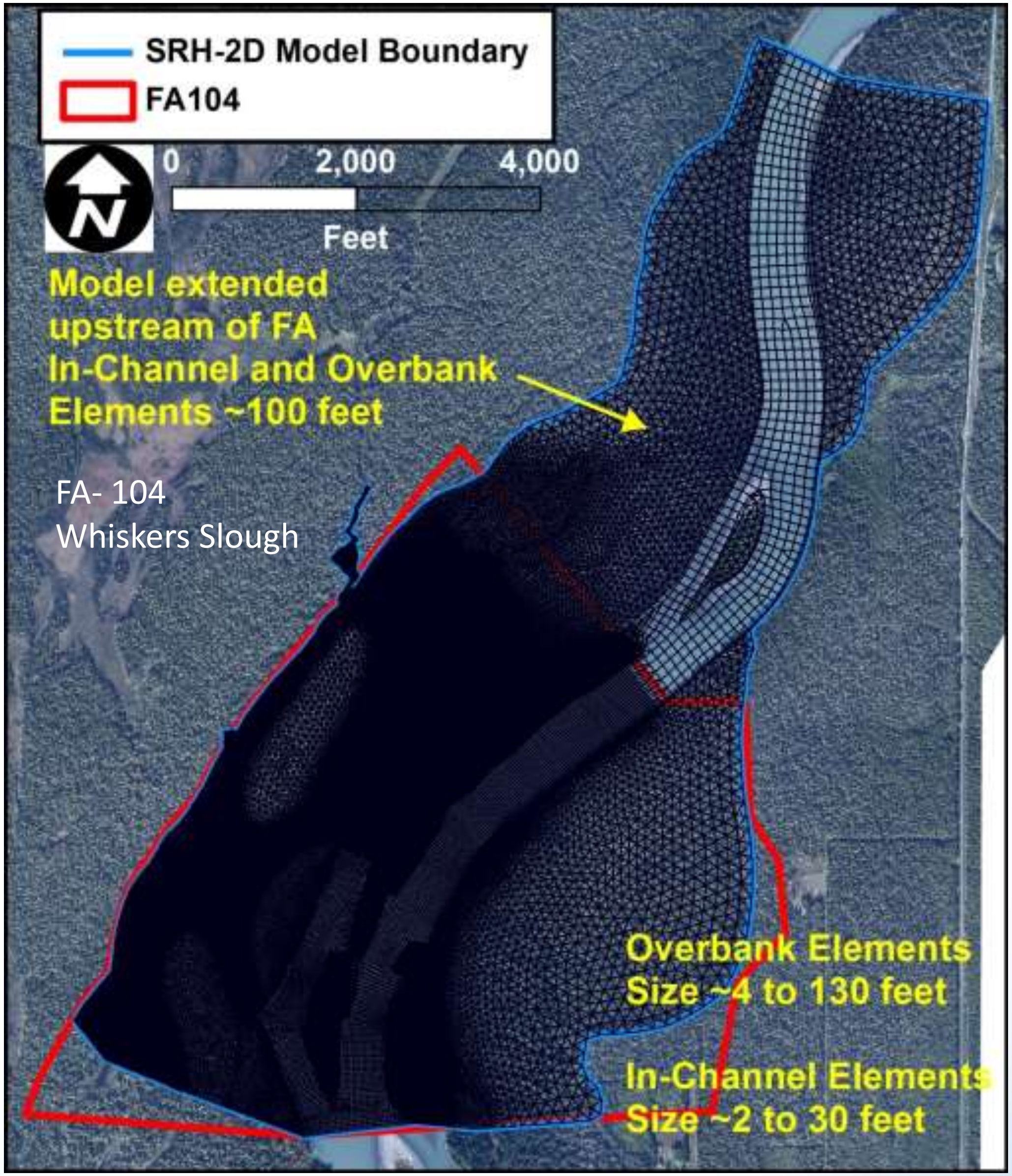


SUSITNA-WATANA HYDRO

2D Hyd. Model Resolution Varies w/in Each FA



SRH-2D Hydraulic Model Resolution in FA-104 (Whiskers Slough) – Overall View of ~ 230,000 Elements



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

SRH-2D hydraulic model resolution in FA-104 (Whiskers Slough) – close-up at Whiskers Creek and Slough

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

Manning's n roughness values (areas correspond to geomorphic mapping)

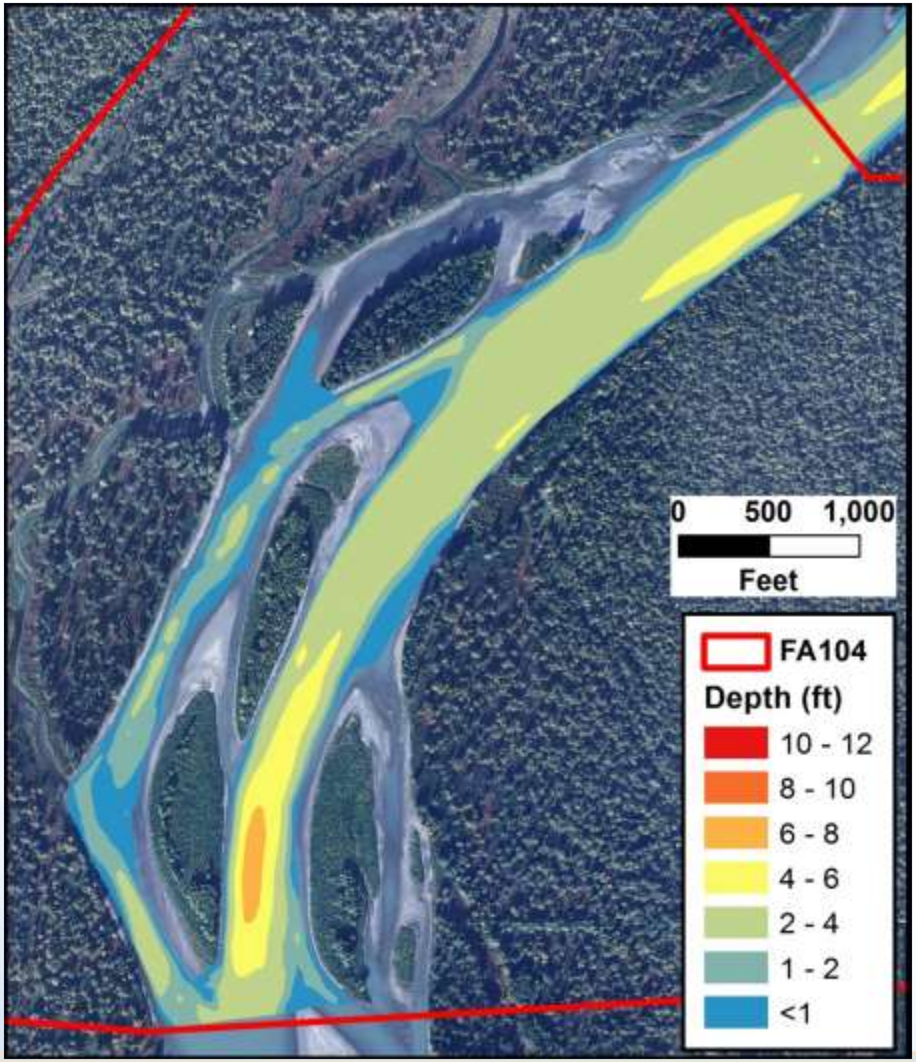
Description	N-Value
Bed Rock	0.05
Channel	0.04
Fan	0.08
Gravel Bar	0.05
Grano Diorite	0.15
Main Channel	0.03
Mature Flood Plain	0.17
Moraine	0.17
Overbank Channel	0.12
Overbank Floodplain	0.15
Outwash Terrace	0.17
Paleo Channel	0.12
Rail Road Rip Rap	0.05
Side Channel	0.03
Side Slough	0.03
Terrace	0.17
Tributary	0.035
Upland Slough	0.04
Vegetated Bar	0.12
Young Flood Plain	0.15

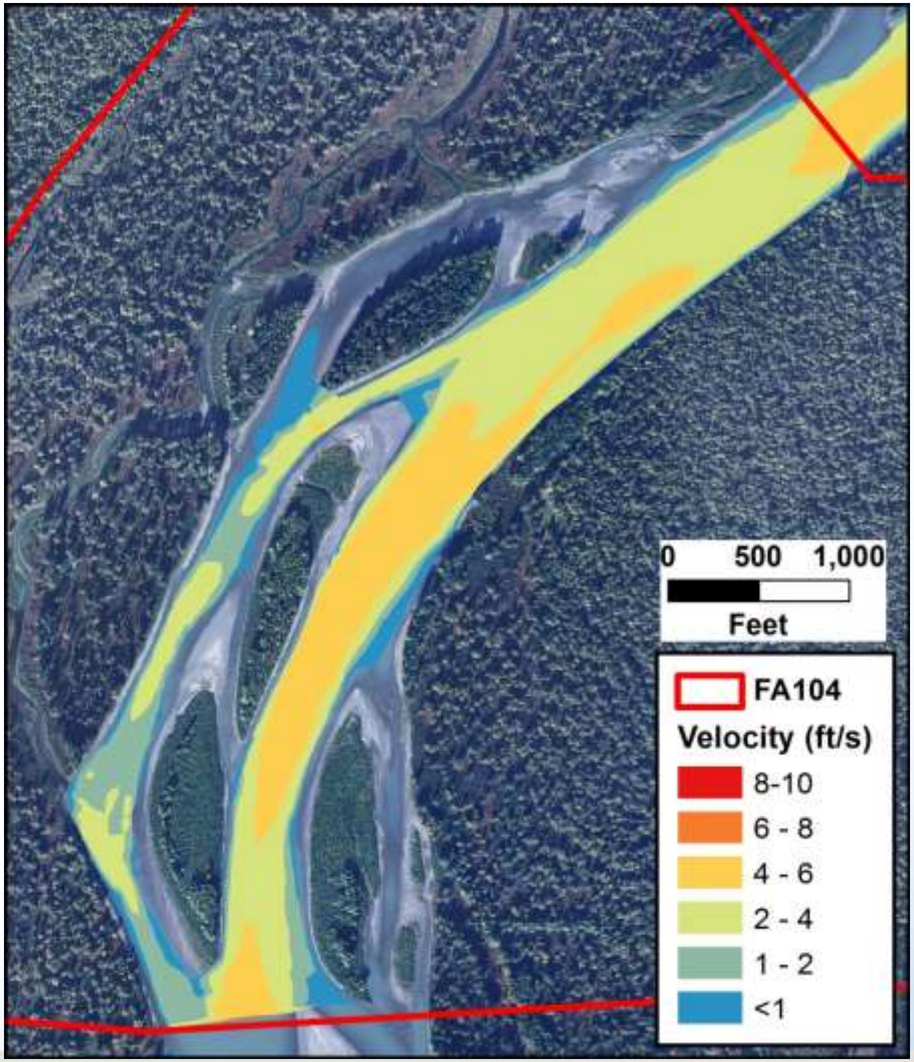
Example 2-D Hydraulic Model Simulations

- 6,000 cfs (For 2-D habitat model)
- 14,000 cfs (For 2-D habitat model)
- 24,000 cfs (For 2-D habitat model)
- 100,000 cfs (~ 100-year peak flow event)
- 2,000 cfs (Example low flow)
- Notes:
  - Downstream boundary conditions developed from preliminary HEC-RAS model (Open Water Flow Routing)
  - Note: All 2-D model results are preliminary and for illustration purposes only. The model has not been calibrated.

2-D Hyd. Model Output - 6,000 cfs FA-104 (Whiskers Slough)

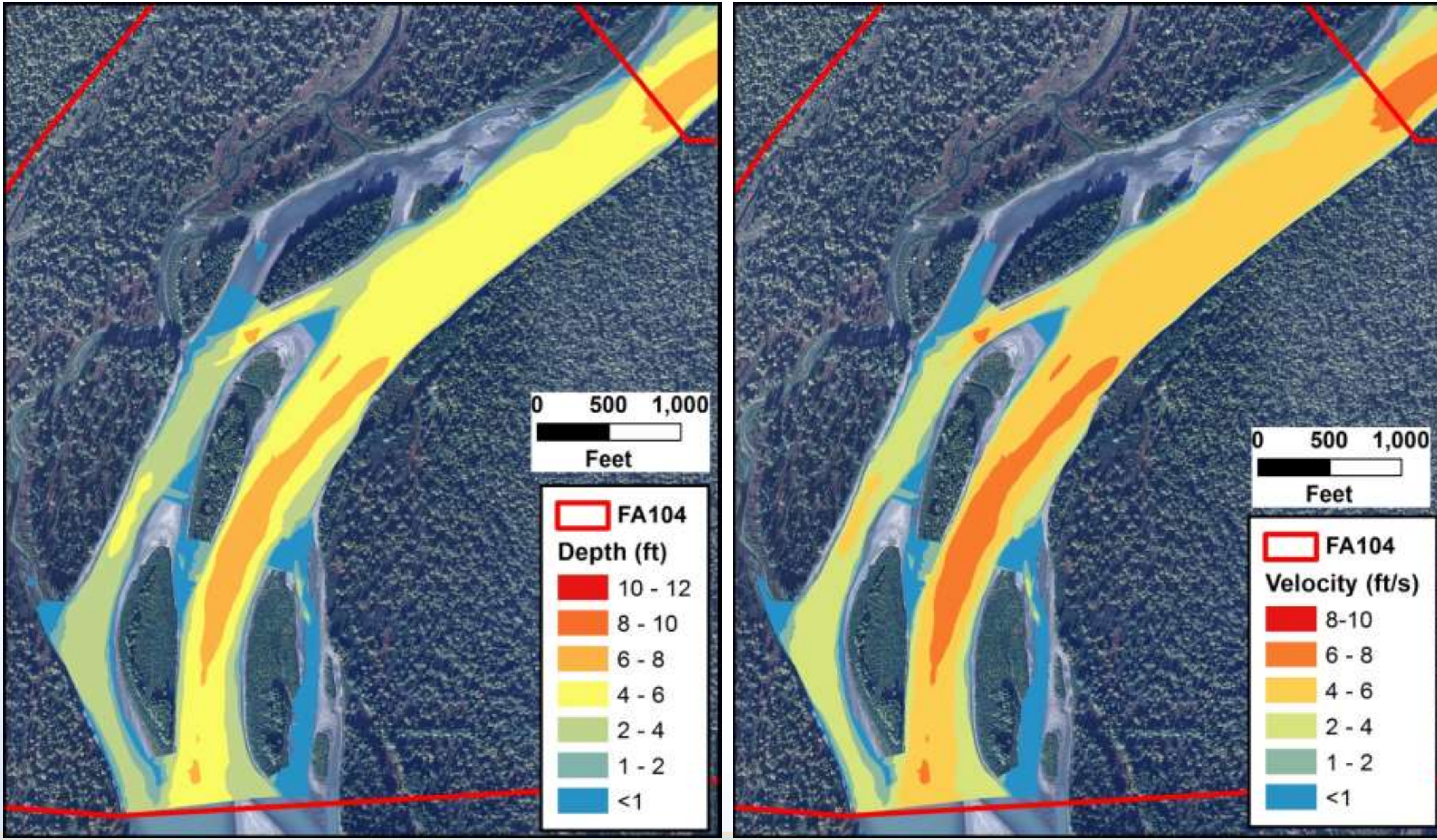
Note: All 2-D model results are preliminary and for illustration purposes only. The model has not been calibrated.





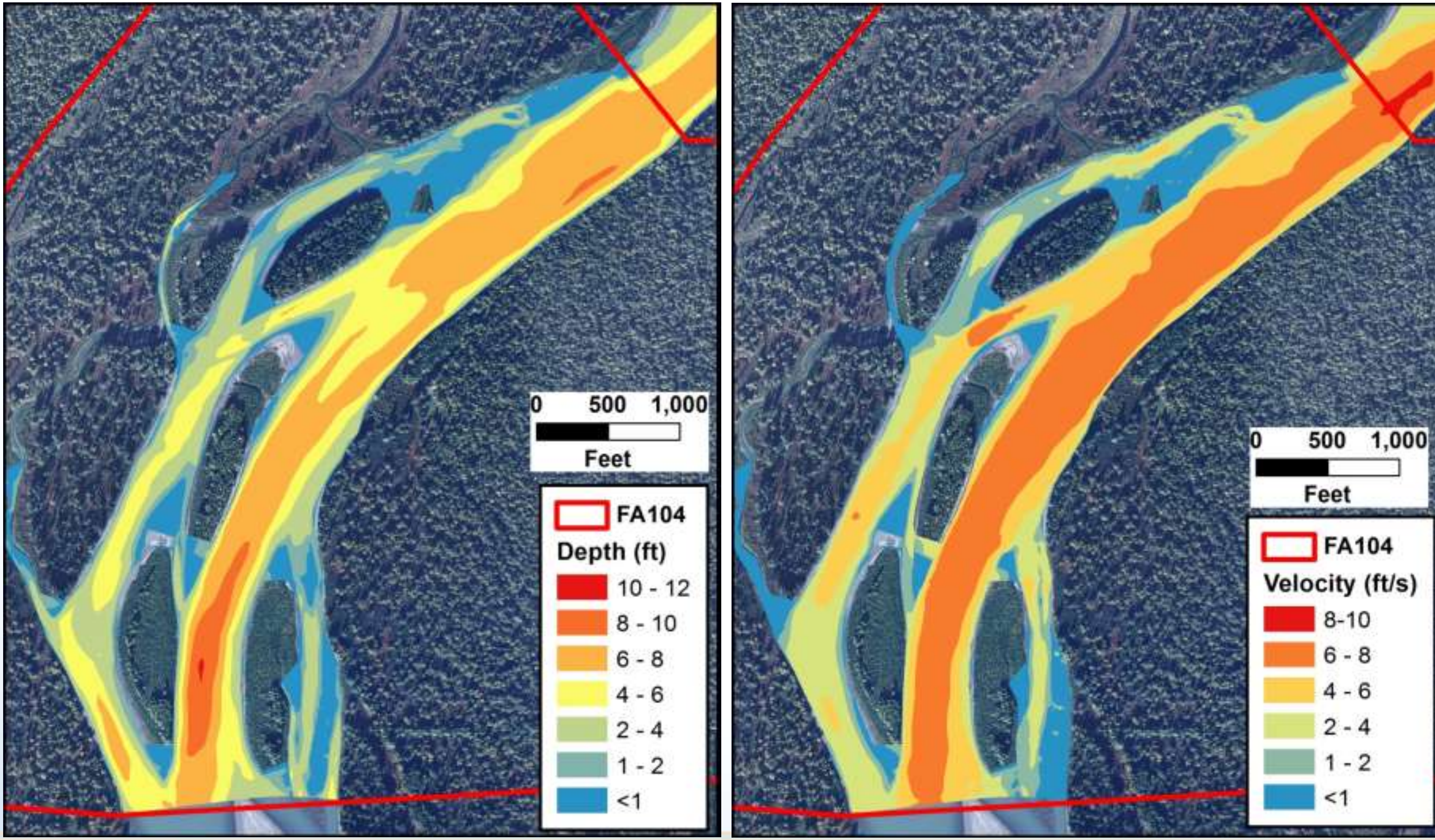
2-D Hyd. Model Output: 14,000 cfs FA-104 (Whiskers Slough)

Note: All 2-D model results are preliminary and for illustration purposes only. The model has not been calibrated.



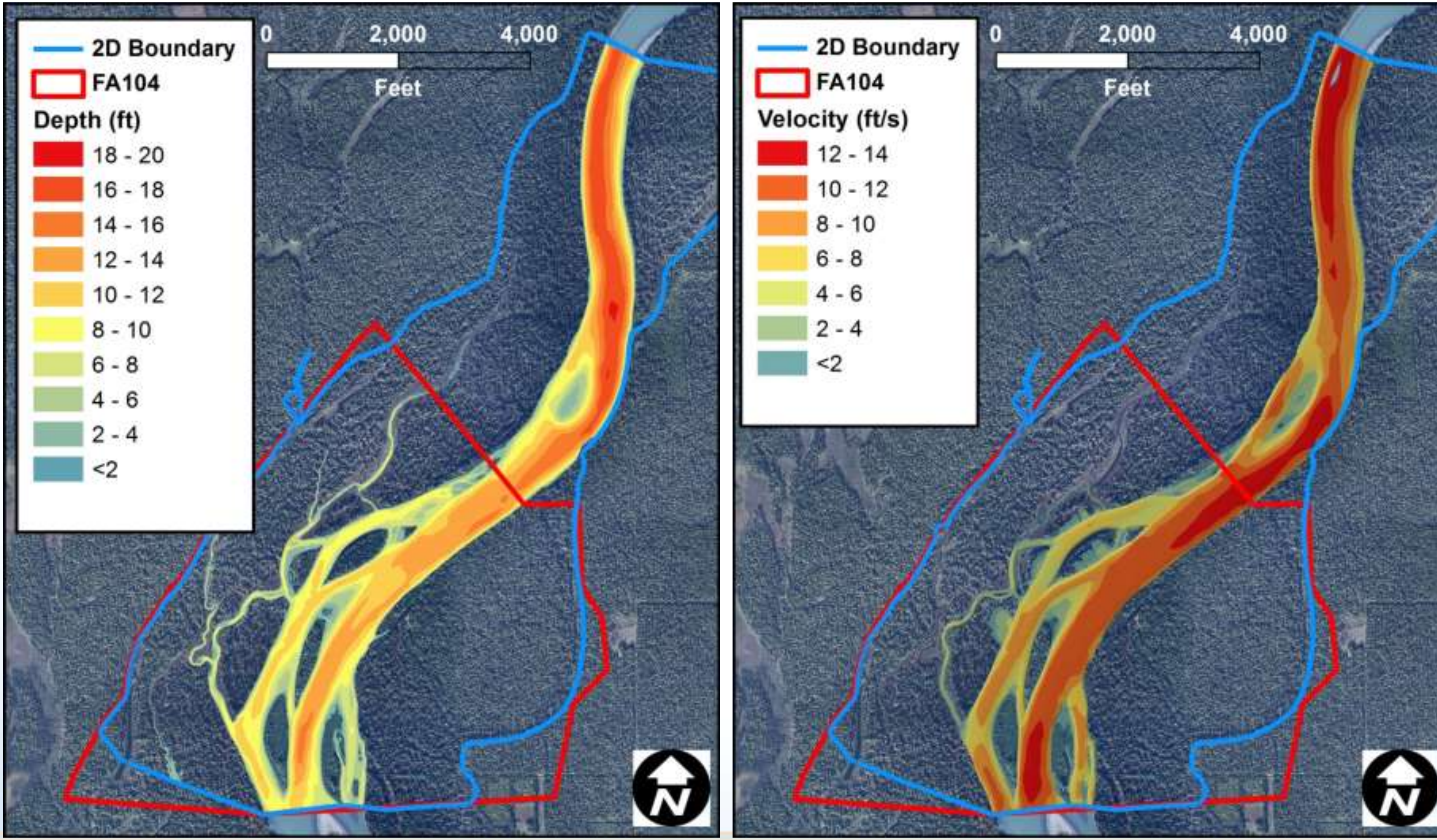
2-D Hyd. Model Output: 24,000 cfs FA-104 (Whiskers Slough)

Note: All 2-D model results are preliminary and for illustration purposes only. The model has not been calibrated.



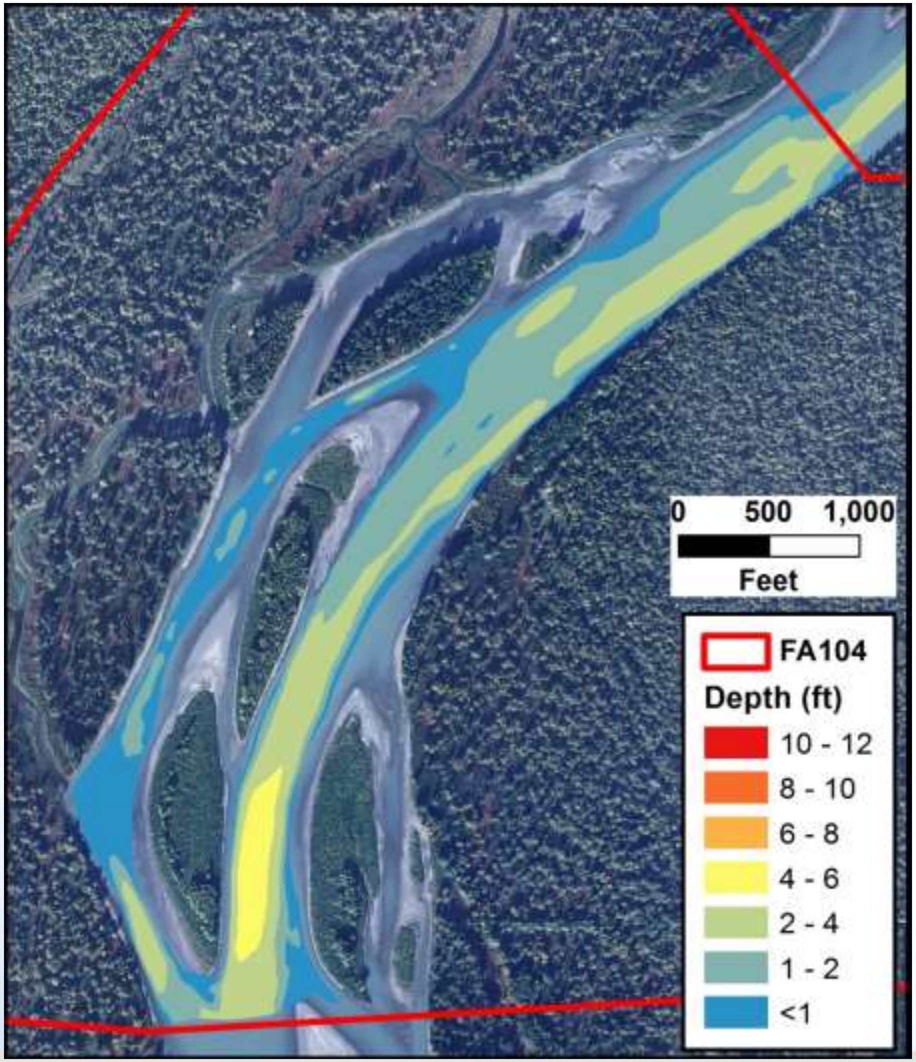
2-D Hyd. Model Output: 100,000 cfs FA-104 (Whiskers Slough)

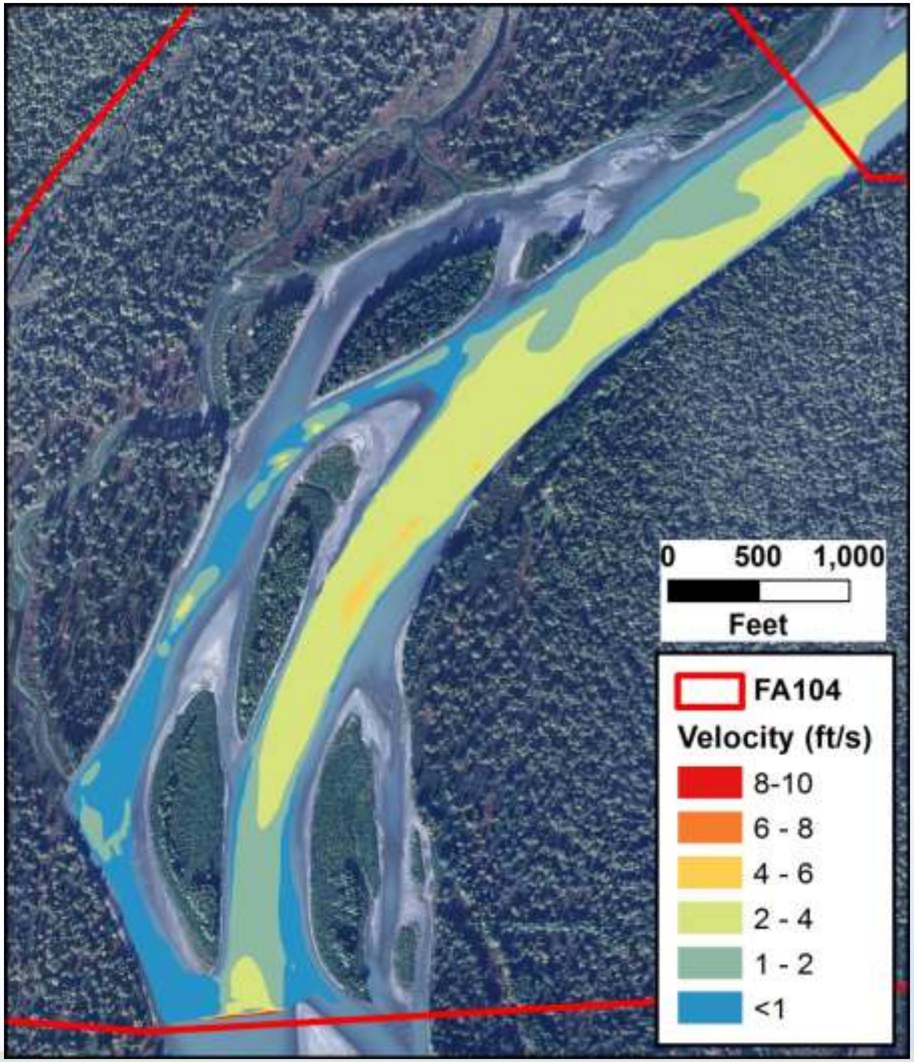
Note: All 2-D model results are preliminary and for illustration purposes only. The model has not been calibrated.



2- D Hyd. Model Output: 2,000 cfs FA-104 (Whiskers Slough)

Note: All 2-D model results are preliminary and for illustration purposes only. The model has not been calibrated.

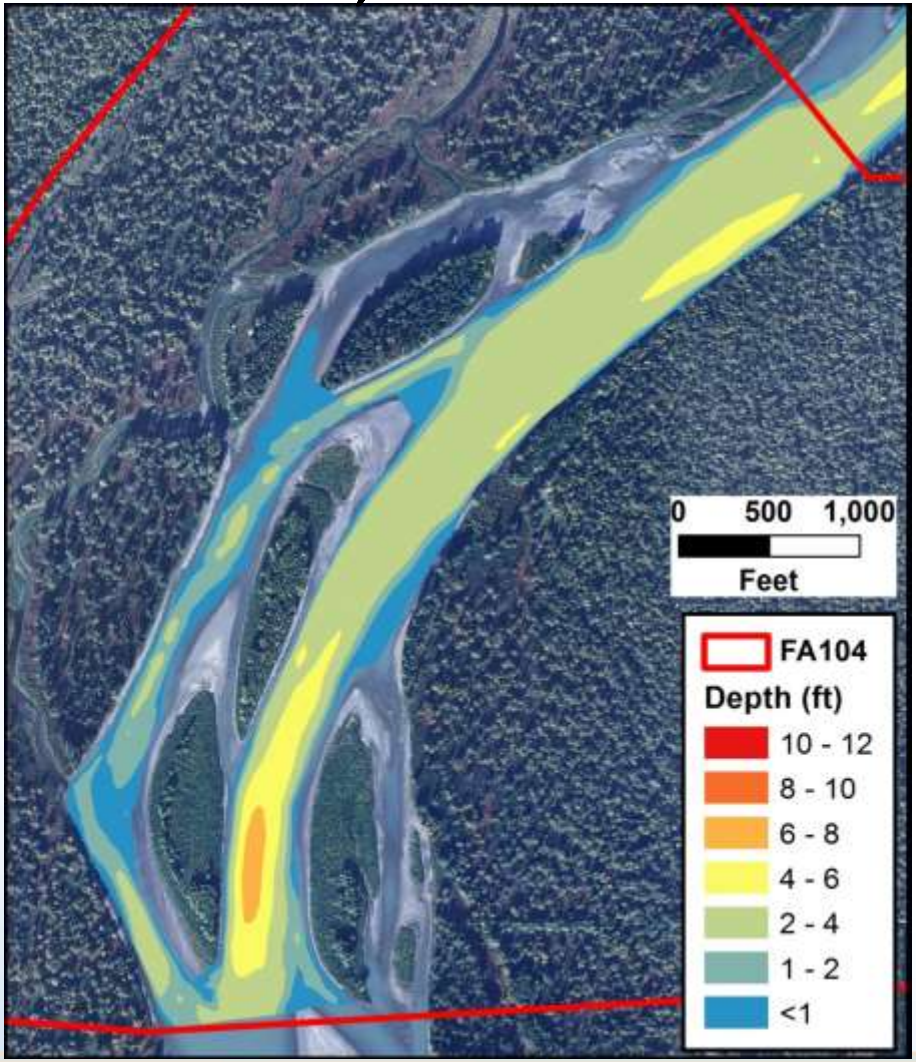




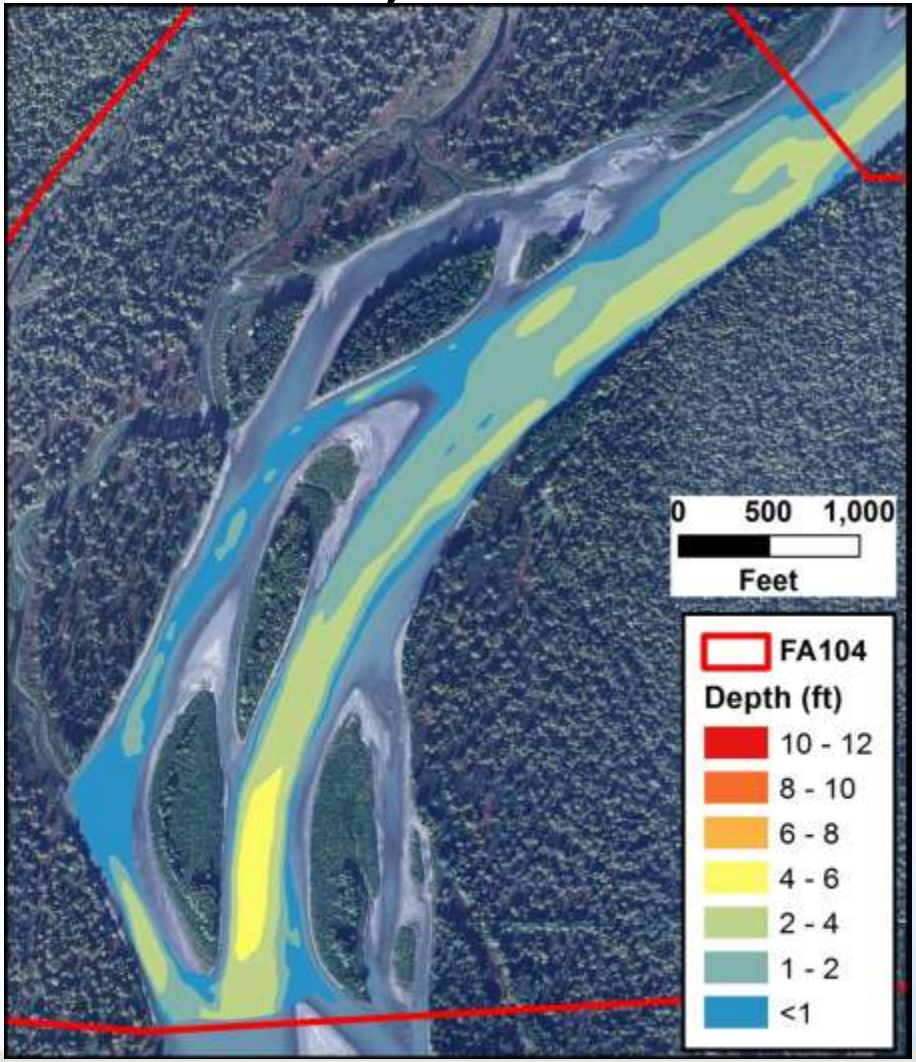
2-D Hyd. Model Comparison: 6,000 and 2,000 cfs FA-104 (Whiskers Slough)

Note: All 2-D model results are preliminary and for illustration purposes only. The model has not been calibrated.

6,000 cfs



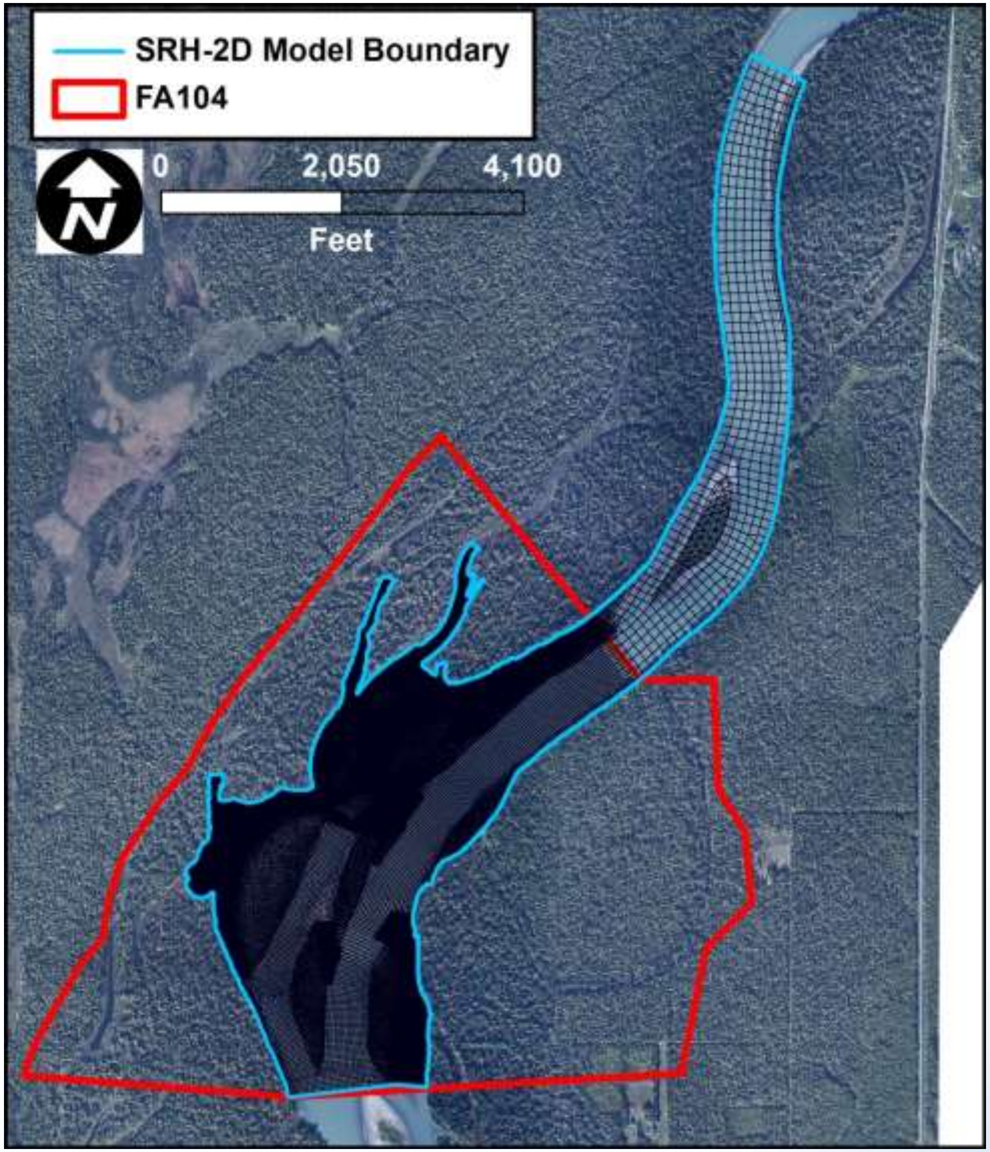
2,000 cfs



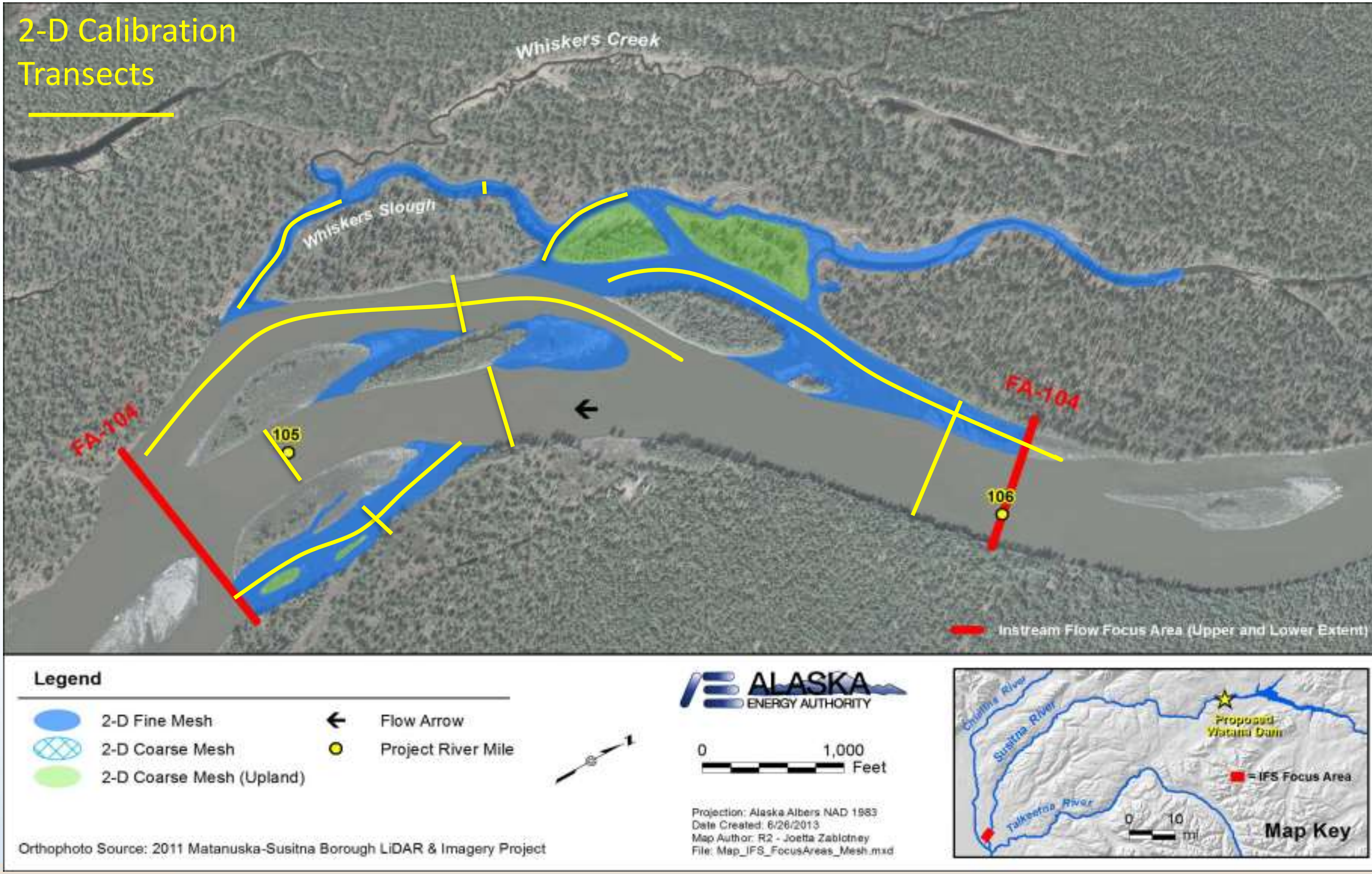
Continued 2-D Model Development

- Trim mesh
- Develop sediment Model

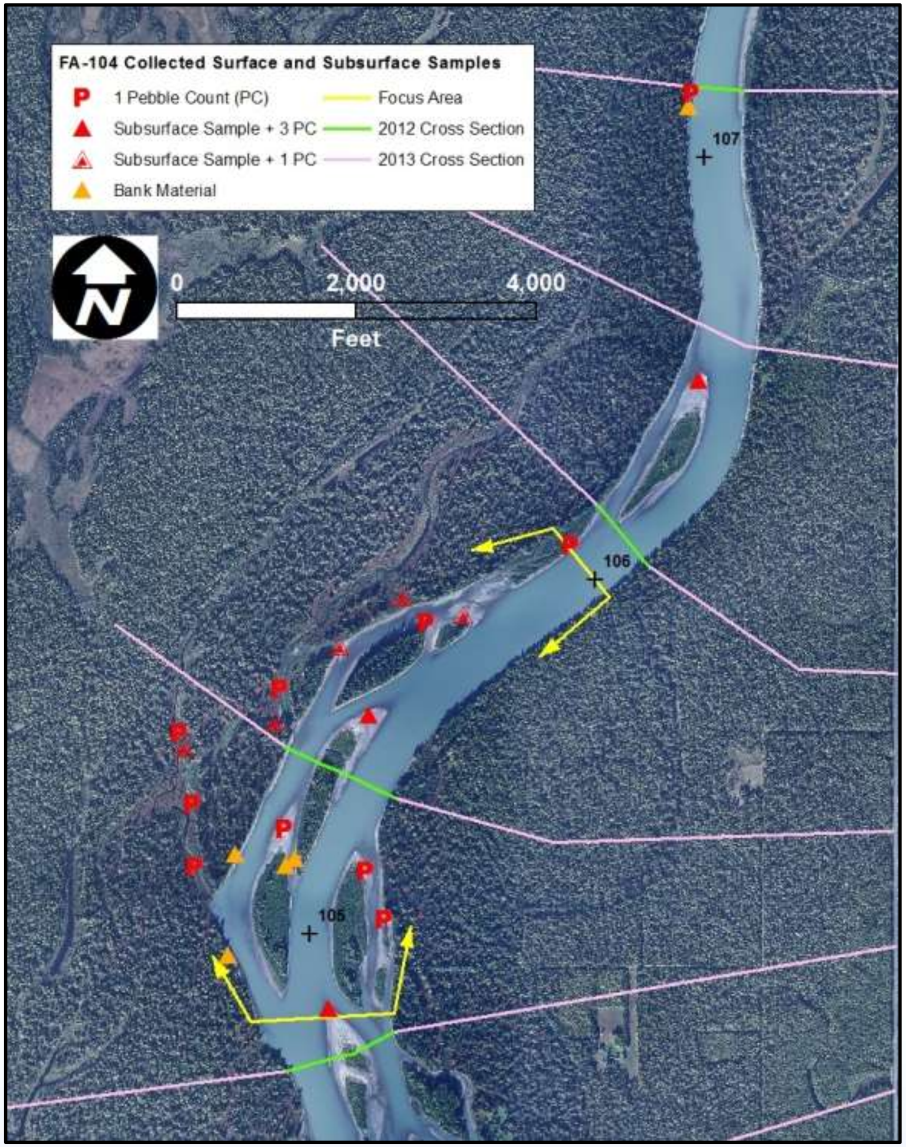
Subsequent mesh trimmed to ~140,000 elements to eliminate dry elements FA-104 (Whiskers Slough)



ADCP Velocity and Discharge Measurements for Calibration FA-104 (Whiskers Slough)

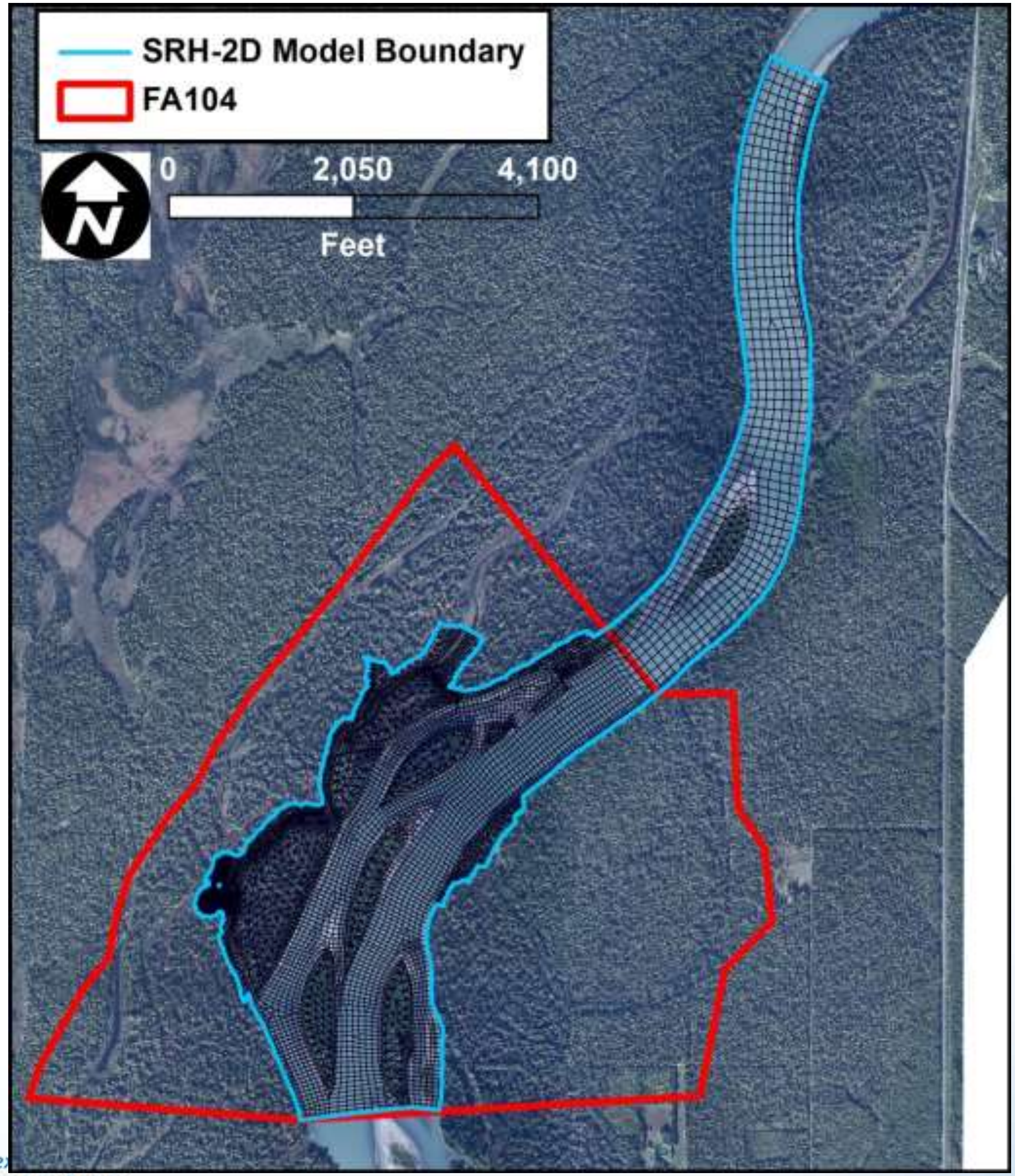


Bed and Bank Samples FA-104 (Whiskers Slough)



SUSITNA-WATANA HYDRO

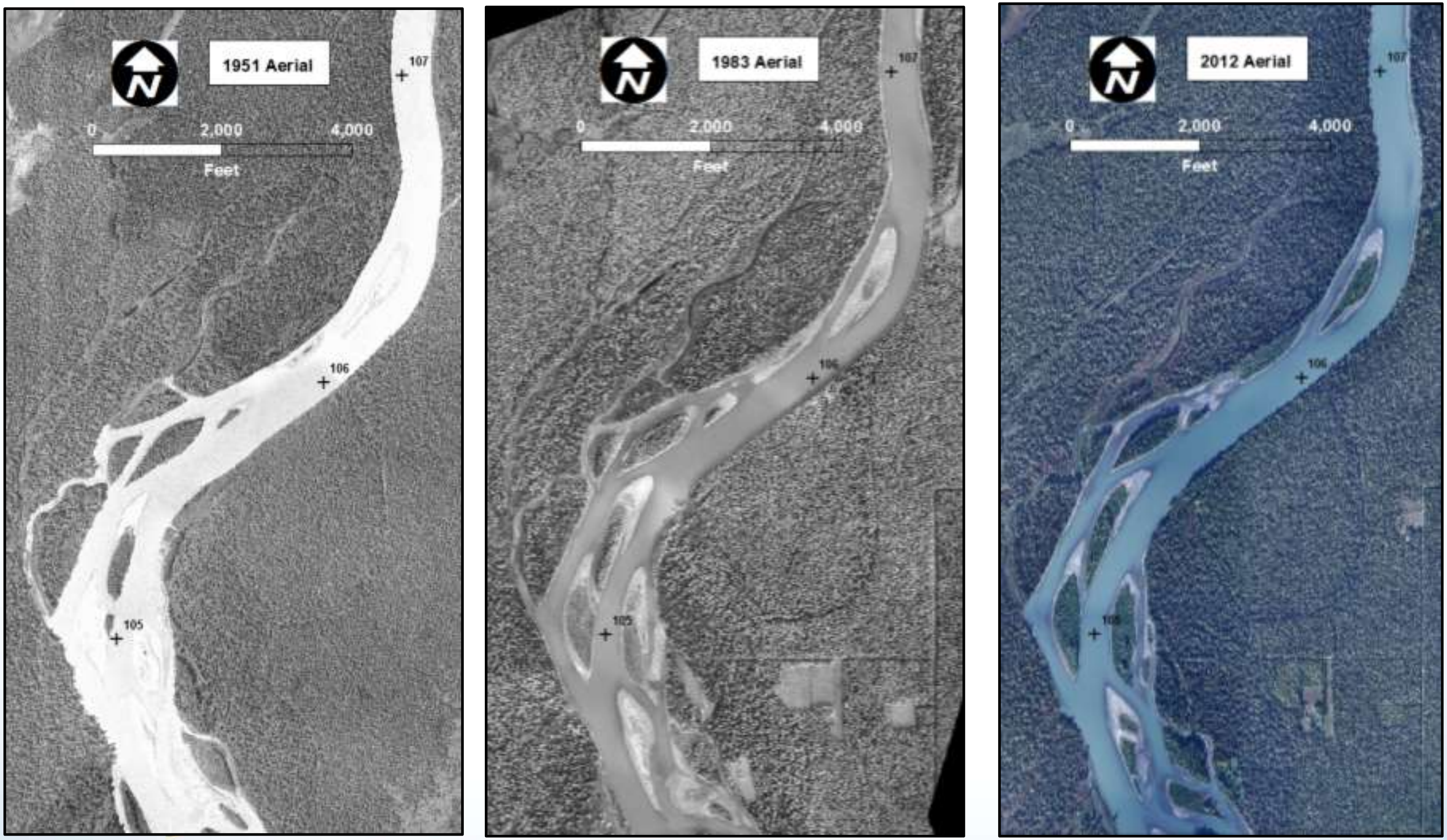
Create sediment transport mesh: Preliminary example has ~10,000 elements, FA-104 (Whiskers Slough).



Integration of Modeling with Geomorphic Processes

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

Comparative Era Aerials FA-104 (Whiskers Slough)

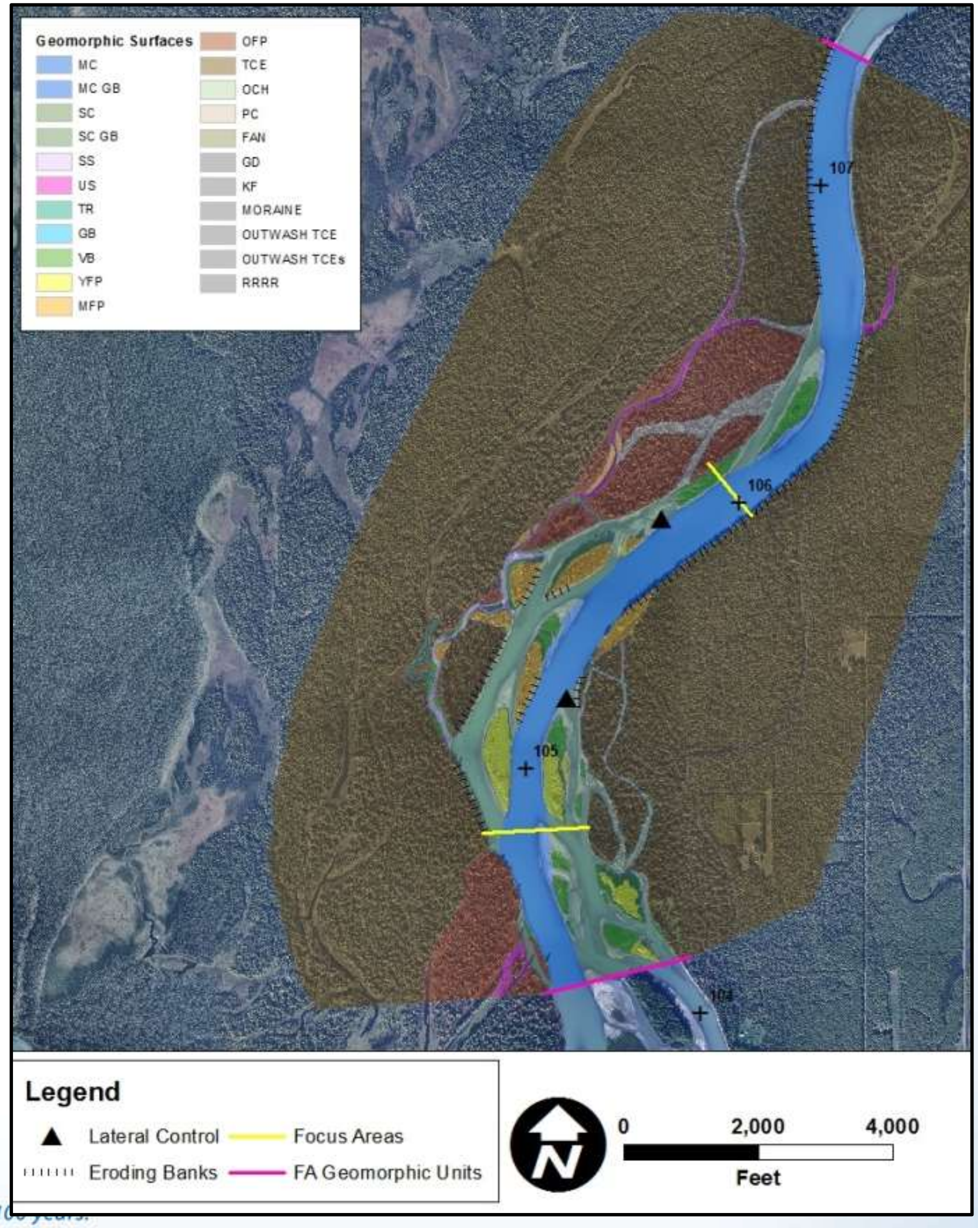


SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Geomorphic Surface Mapping in FA-104 (Whiskers Slough)

MC = Main Channel
MC GB = Main Channel Gravel Bar
SC = Side Chanel
SC = Side Channel Gravel Bar
SS = Side Slough
US = Upland Slough
TR = Tributary
VB = Vegetated Bar
YFP = Young Floodplain
MFP = Mature Floodplain

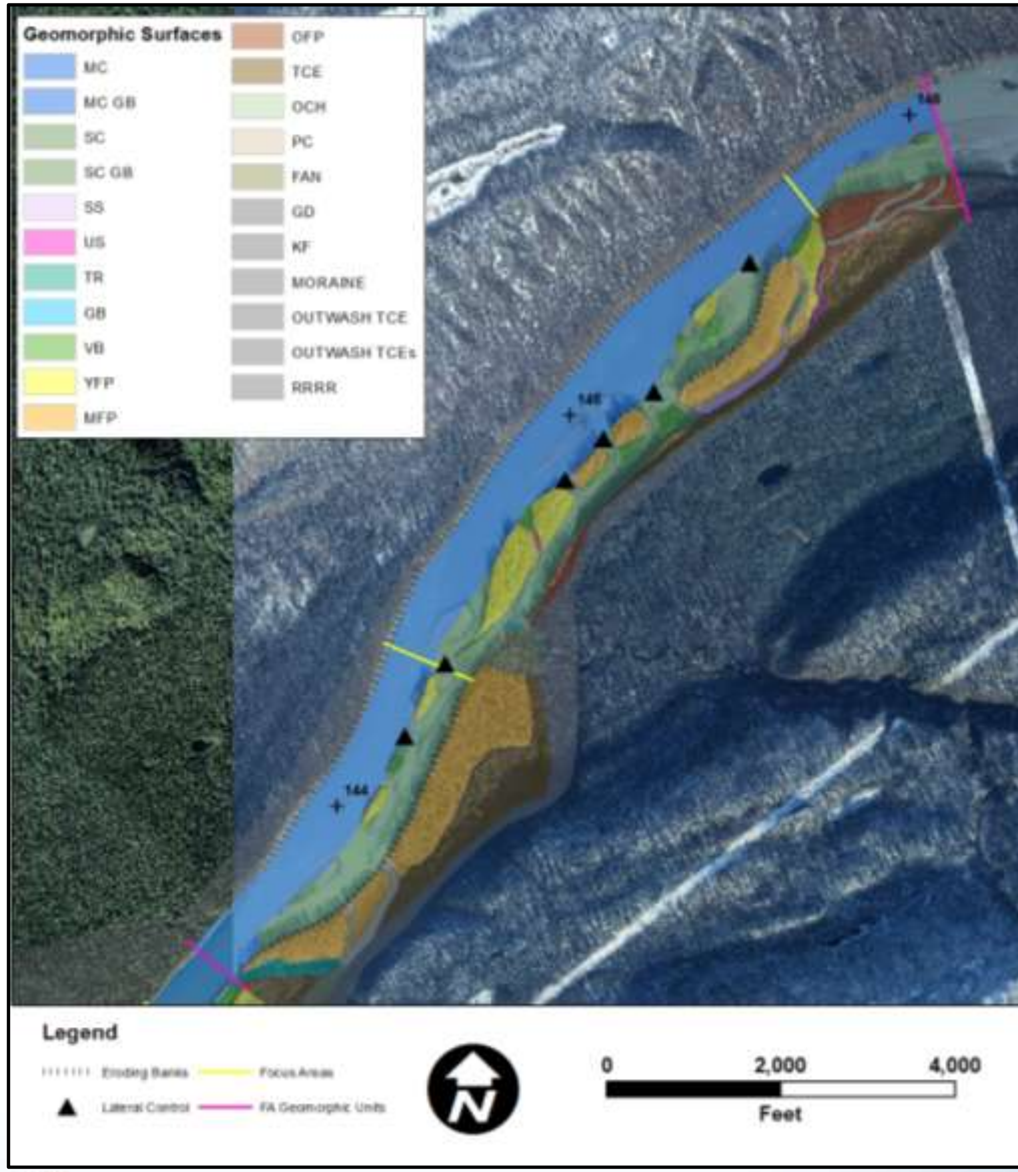
OFP = Old Floodplain
TCE = Terrace
OCH = Overflow Channel
PC = Paleo Channel
FAN = Alluvial Fan
GD = Grano Diorite
KF = Kahlitna Flysch
RRRR = Railroad Rip-Rap



SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 10

Geomorphic Surface Mapping in FA-144 (Slough21)

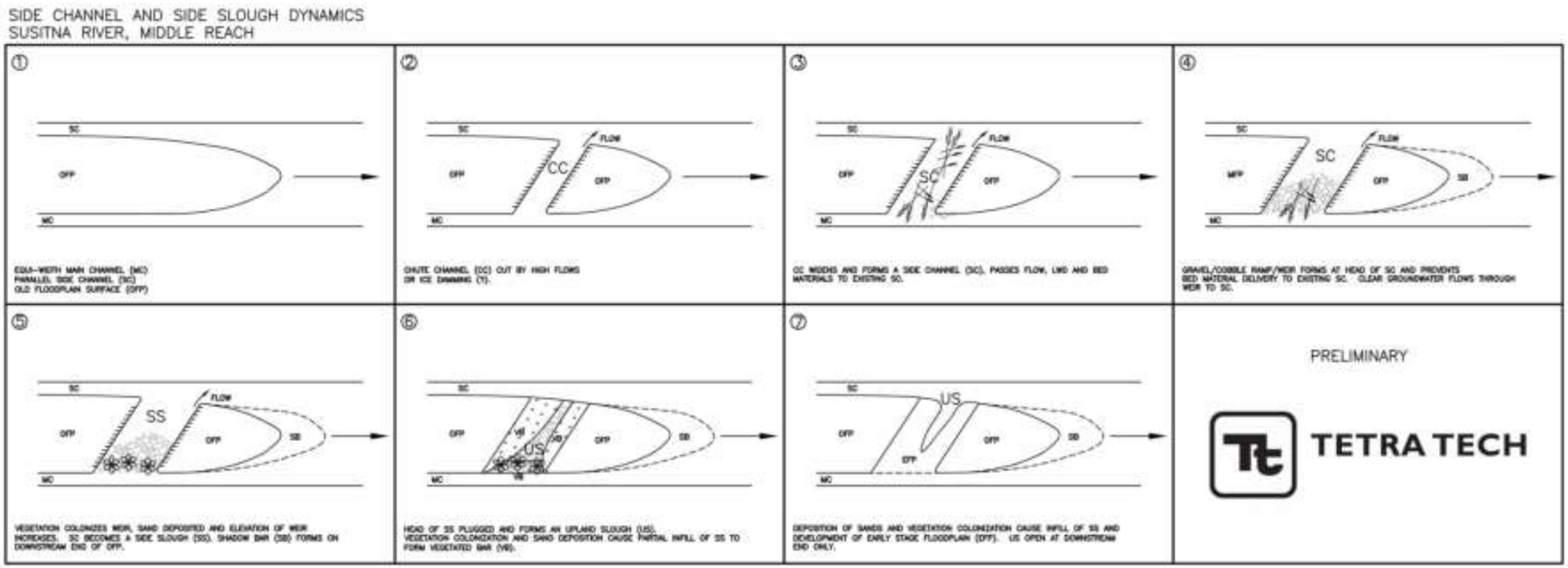


MC = Main Channel
MC GB = Main Channel Gravel Bar
SC = Side Chanel
SC = Side Channel Gravel Bar
SS = Side Slough
US = Upland Slough
TR = Tributary
VB = Vegetated Bar
YFP = Young Floodplain
MFP = Mature Floodplain

OFP = Old Floodplain
TCE = Terrace
OCH = Overflow Channel
PC = Paleo Channel
FAN = Alluvial Fan
GD = Grano Diorite
KF = Kahlitna Flysch
RRRR = Railroad Rip-Rap

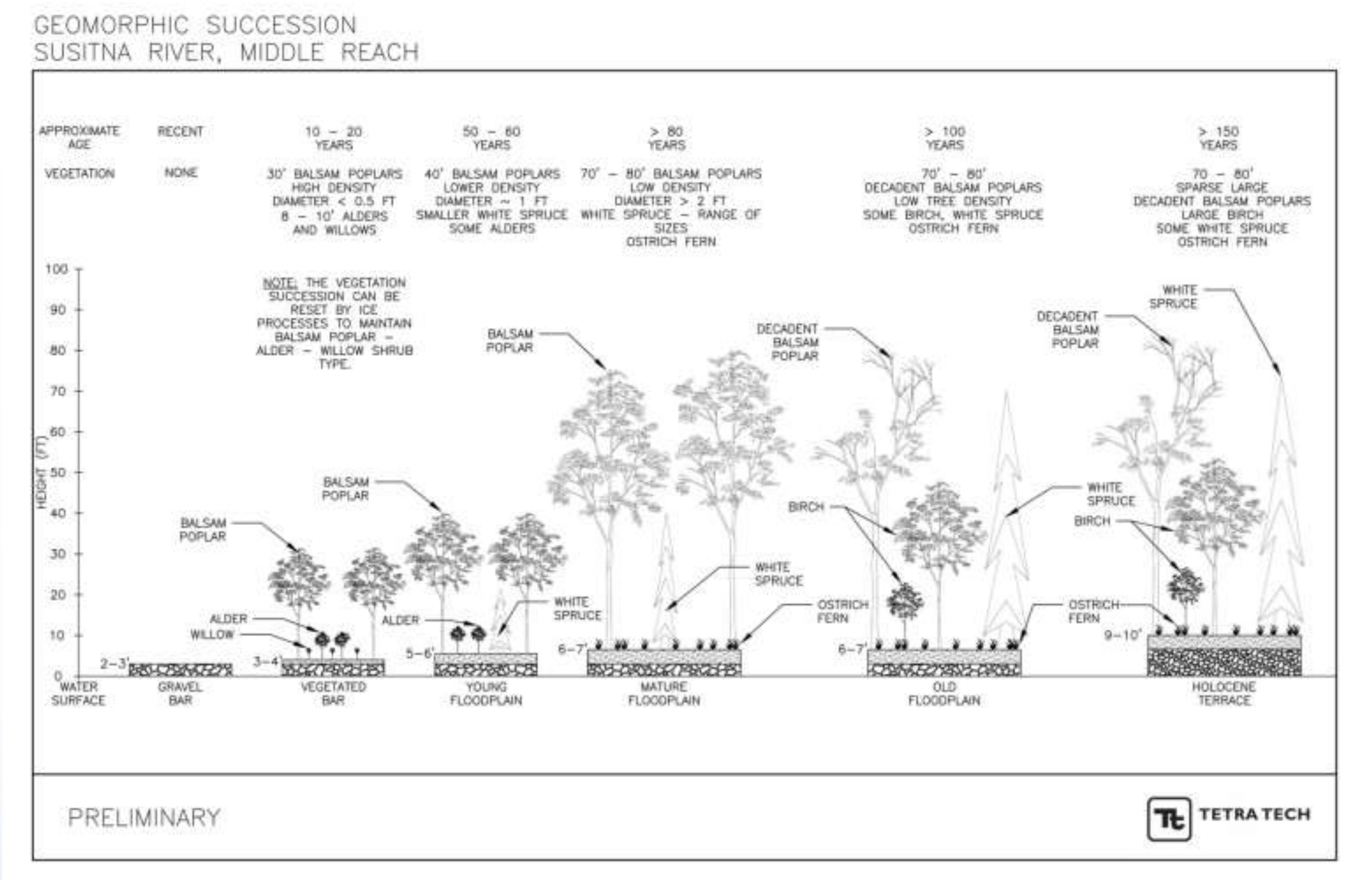
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Conceptual Geomorphic Model: Side Channel and Side Slough Dynamics



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

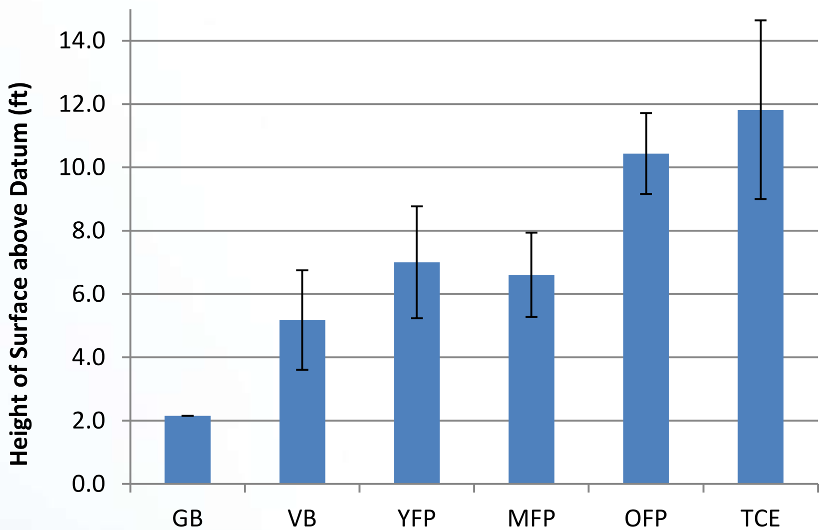
Conceptual Geomorphic Model: Geomorphic Succession



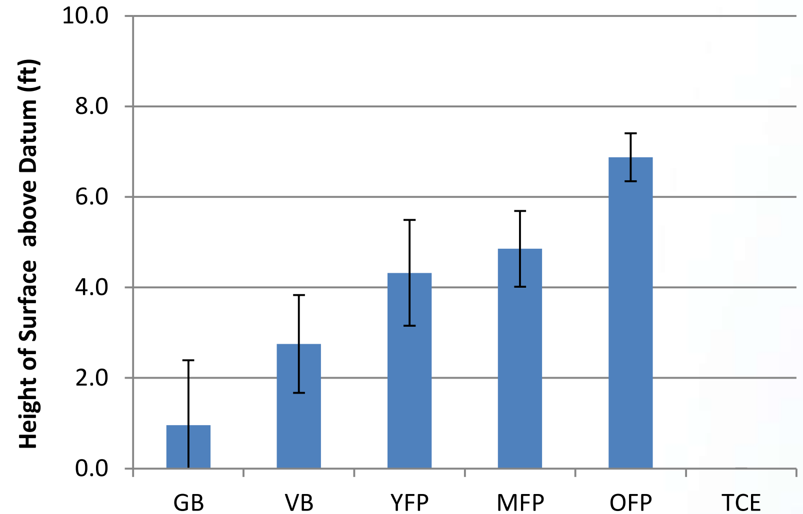
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Geomorphic Surface Heights
Mean and Standard Deviation

FA-104 (Whiskers Slough)



FA-144 (Slough 21)



KEY

GB = Gravel Bar	MFP = Mature Floodplain
VB = Vegetated Bar	OFP = Old Floodplain
YFP = Young Floodplain	TCE = Terrace

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

Preliminary Analysis – Return Period of Overtopping Flows on Geomorphic Surfaces

Focus Area	Return Period (yr)				
	VB	YFP	MFP	OFP	TCE
FA-104 Whiskers Slough	23	117	82	> 1000	> 1000
FA-113 Oxbow I	9	38	38	61	> 500
FA-115 Slough 6a	6	n/a	75	125	> 500
FA-128 Slough 8a	6	4	35	59	n/a
FA-138 Gold Creek	6	73	97	134	329
FA-141 Indian River	3	14	10	n/a	37
FA-144 Slough 21	13	82	153	> 1000	n/a

KEY

VB = Vegetated Bar
YFP = Young Floodplain
MFP = Mature Floodplain
OFP = Old Floodplain
TCE = Terrace

- Return Period determined with mean elevation for each geomorphic surface
- Relative surface heights gathered in field. Respective elevations derived from Flow-Routing Model Rating Curves
- No return period calculated if geomorphic surface was not observed/measured in field.

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

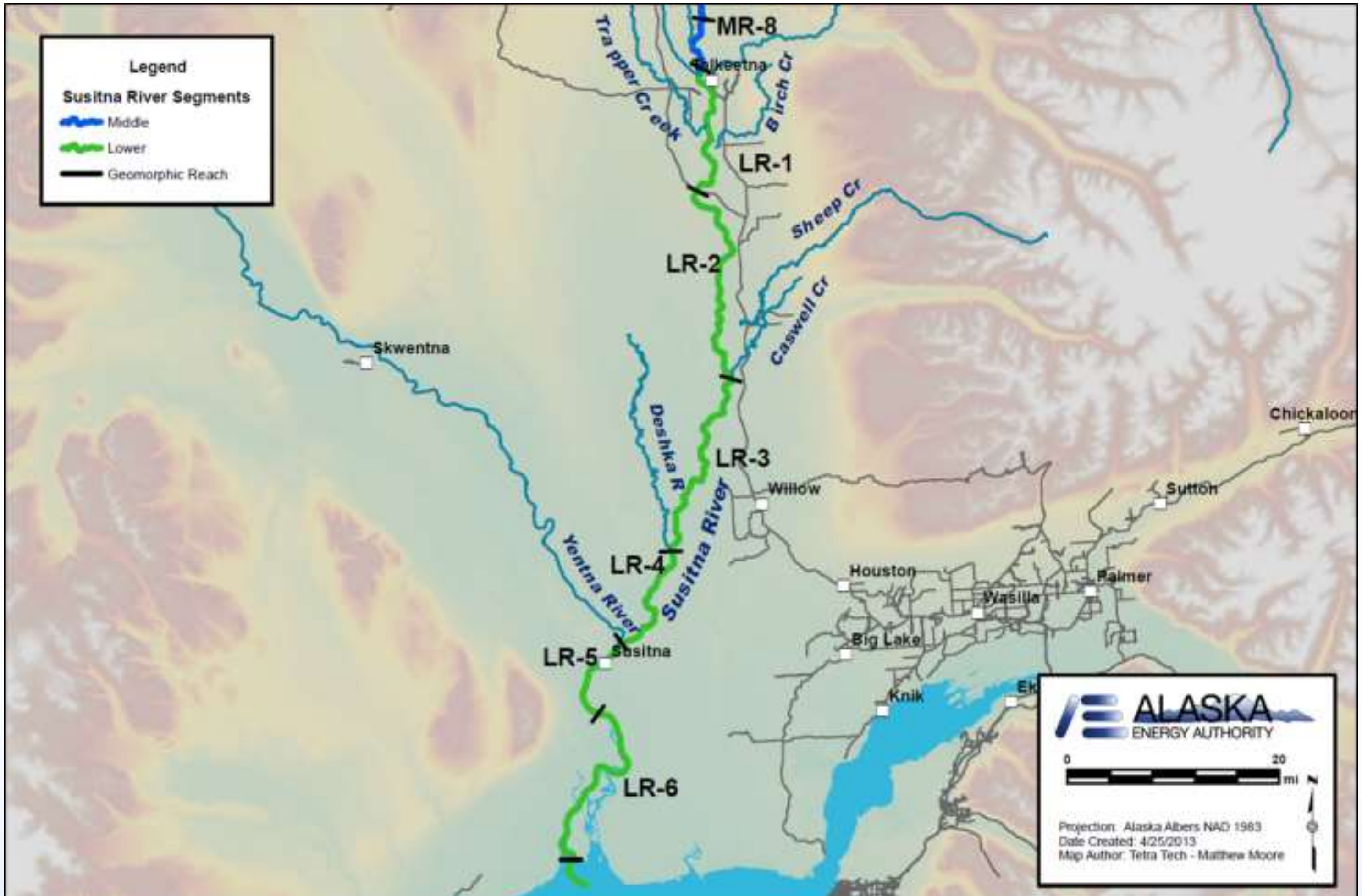
Role of Ice?

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

Other FGM Efforts:
Lower River
Three Rivers Confluence

(Will be Discussed Time Permitting)

Lower River (LR):
Fluvial Geomorphology Model (FGM) Domain



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

LR FGM – 1-D Tributary: Purpose

- 1-D Trib. Sed. Transport (HEC-RAS)
  - Evaluation of potential for sediment deposits at mouth and associated fish access issues
  - Bed material load rating curve for supply to 1-D morphology model (expect to be minor)

LR FGM: Tributaries

Tributary Name	PRM	Bank	Geo. Reach	Focus Area	Sed. Input only	1-D or 2-D
Trapper Creek*	94.5	RB	LR-1			1-D
Birch Creek*	92.5	LB	LR-1			1-D
Sheep Creek	69.5	LB	LR-2			1-D
Caswell Creek	67.0	LB	LR-2			1-D
Deshka River*	45.0	RB	LR-3			1-D

* Tribs that will be analyzed in 2013

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

LR FGM – 1-D Tributary: Inputs

Data/Parameter Inputs (source)

- Upstream cross sections (FGM)
- Downstream cross sections (IFS)
- Bed material gradation (FGM)
- Channel and floodplain roughness (FGM)

Model Inputs from other Study Components (source)

- Discharge range for each tributary(IFS)

LR FGM – 1-D Tributary: Calibration/Output

Calibration

- Channel roughness from observed water surfaces

Model output to other Study Components (to)

- Sediment-discharge rating curves
  - 1-D Morphology Models (FGM)
  - 2-D Morphology Models (FGM)
  - 1-D Tributary Delta Models (FGM)

LR FGM – 1-D Morphology Model: Purpose

- 1-D Morphology Model (HEC-6T)
  - Reach level assessment of sediment balance
  - General aggradation, degradation response of the channel
  - Reach level changes in bed material gradation
  - *Not applicable: Boundary conditions for 2-D morphology model since no LR Focus Areas*

LR FGM – 1-D Morphology Modeling: Inputs

Data/Parameter Inputs (source)

- X-sections (Survey/Hydrosurvey/LiDAR – IFS & FGM)
- Bed material gradations (FGM)
- Channel and floodplain roughness (FGM)
- Channel width change rates (FGM and collaboration)
- D/S stage-discharge relationship (Susitna Sta.)

Model Inputs from other Study Components (source)

- Discharge time series including tributaries (IFS)
- Sediment supply MR & TRC 1-D models, USGS Yentna
- Sediment supply from tributaries (1-D trib. FGM/minor)

LR FGM – 1-D Morphology Model: Calibration

Bed Roughness

- Water Surface Elevations
  - During cross section surveys
  - Other measured WSEs
  - Gages
- ADCP (velocity and flow splits)

Sediment Transport

- Gage data including transport rates & specific gage plots
- Note: *Comparison cross sections not available in LR*

LR FGM – 1-D Morphology Model: Simulations

- 50-year continuous simulations
  - Existing Conditions
  - Maximum Load Following OS-1
  - Base Load
  - Intermediate Load Following
  - Run of River (RoR)

LR FGM – 1-D Morphology Model: Results

General Results to other Study Components

- Aggradation/degradation (main channel change)
- Stage-discharge change
- Flow distribution (in split-flow reaches)
- Bed material gradation change

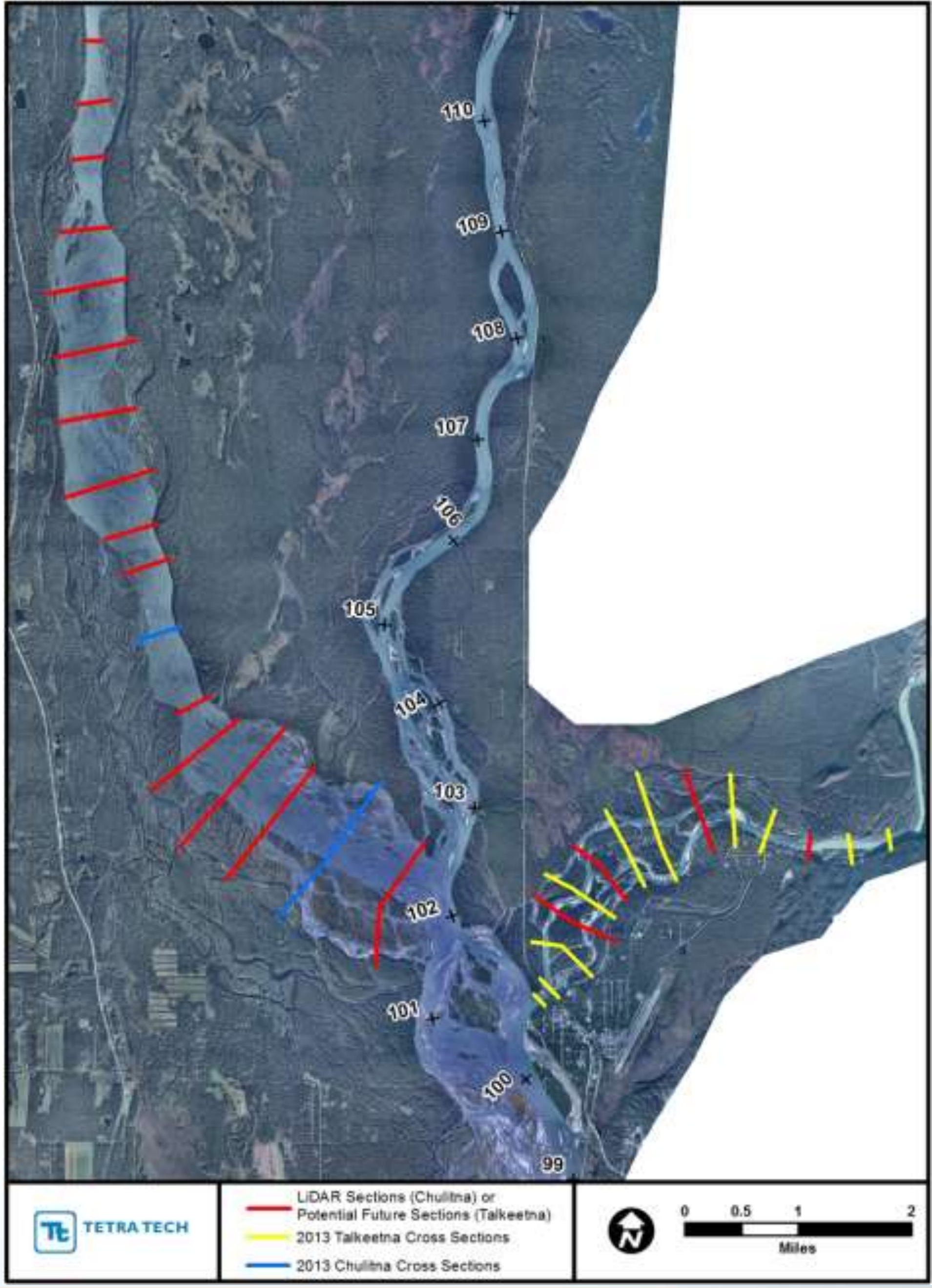
Results for Focus Area Modeling (2-D Morphology)

- *Not applicable to LR – no Focus Areas*

TRC FGM – 1-D Morphology Model: Purpose

- 1-D Morphology Model (HEC-6T)
  - Potential Project effects on the morphology of the Chulitna and Talkeetna rivers in the TRC area
    - Degradation /aggradation
    - Change in sediment loading
  - Potential changes in flood levels in the TRC area
    - Change in coincident flooding
    - Change in Susitna River flows
    - Bed elevation changes
  - *Note: Not performed for aquatic habitat evaluation purposes*

Three Rivers Confluence (TRC): Fluvial Geomorphology Modeling (FGM) Domain



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

TRC FGM – 1-D Morphology Model: Overall

- Will be integrated into a single 1-D model along with MR and LR
- Modeling details similar to LR 1-D morphology model with exceptions below:
  - Inputs: channel width change rate NA, no tributary inflows
  - Simulations: same as LR and MR
  - Calibration: transport data only
  - Results: used by the Geomorphology Study

LR FGM – Potential Modeling below PRM 29.9

- Primarily related to potential Project effects on Beluga whale habitat
- Developing approach
- Zone of tidal influence important
  - Indications are it starts somewhere below PRM 17
  - Installed 3 level loggers in September to qualitatively evaluate
- In tidally influenced area Project effects are expected to be further muted
- Extension also dependent on results of LR 1-D morphology model run

END