INSTREAM FLOW MODEL DEVELOPMENT STUDY
INTERIM REPORT

ATTACHMENT L

INSTREAM FLOW WORKSHOP 1 MATERIALS

Seattle City Light **MEETING AGENDA**

Skagit Hydroelectric Project Relicensing Meeting: Instream Flow Model Development – Meeting #1

April 28, 2021, 8:00 AM to 5:00 PM

Webex Meeting: https://meethdr.webex.com/meethdr/j.php?MTID=m1f46a05d3fd1fc833f6e67297851b20c
Conference Call: 1-408-418-9388 (Meeting ID: 187 224 1626)

MEETING OBJECTIVES

- Review LP comments on the bypass reach model and discuss next steps for future meetings.
- Provide an overview of the program for development of the instream flow model for the Skagit River from Gorge Powerhouse to the Sauk River.
- Provide an introduction to the identification, selection, and use of habitat suitability criteria (HSCs) for fish species of interest.

AGENDA

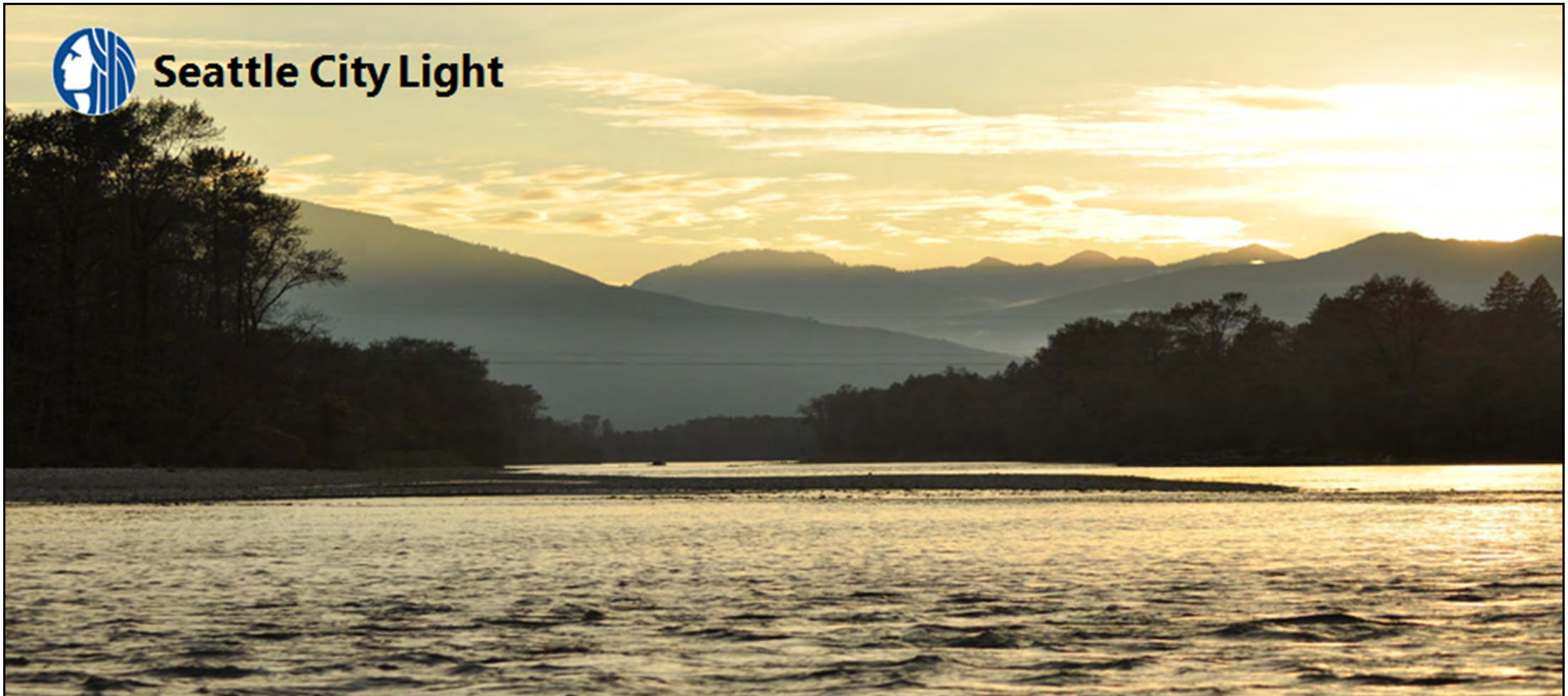
08:00 – 08:10 (10 min)	**Introductions** – *Facilitator* ▪ Roll Call Introduction
08:10 – 08:30 (20 min)	**Background, Meeting Objectives and Agenda Overview –** *Facilitator & Erin Lowery, City Light* ▪ Background ▪ Review Meeting Objectives and Agenda
08:30 – 09:00 (30 min)	**Bypass Reach Instream Flow Model –** *Jim Pacheco, Ecology* ▪ Review LP comments on the bypass reach model and discuss next steps for future meetings.
09:00 – 10:00 (60 min)	**Hydraulic Model Development** – *Chris Long, NHC* ▪ Overview of Topics ▪ Model Inputs o Terrain o Boundaries o Mesh o Physical Parameters
10:00 – 10:15 (15 min)	**Break**

10:15 – 12:00
(105 min)
	Hydraulic Model Development (cont.) – *Chris Long, NHC*
	▪ Model Setup
	  o Mesh & Timestep
	  o Solution Equations
	▪ Model Calibration
	  o Field Data
	  o Calibration Parameters
	  o Performance Evaluation
	▪ Model Outputs
	▪ Questions & Discussion

12:00 – 1:00 (1 hour)	**Break**
1:00 – 3:00 (2 hours)	**Biological and Habitat Metrics** - *HDR* ▪ Purpose and Need for Collaborative HSC and Periodicity workshop/meeting ▪ Habitat Modeling ▪ Habitat Modeling Overview ▪ HSC Specific Goals for workshop/meeting 1 ▪ Habitat Effectiveness Model for Chinook ▪ Group Discussion on Compiled Information and Additional Available Resources
3:00 – 3:15 (15 minutes)	**Break**

3:15 – 4:30
(75 minutes)
	Biological and Habitat Metrics (cont.) - *HDR*
	▪ HSC and Periodicity Next Steps
	  o Collaboration to Determine Process for HSC Selection
	  o Collaboration on Process to Determine Final Periodicity
	  o Begin to Discuss Targeted Field Validation
	  o Discussion on May Meetings, Focus and Planning

4:30 – 5:00 (30 min)	**Schedule, Action Items, Next Steps –** *Facilitator and meeting participants* ▪ Study Schedule ▪ Review Meeting Action Items ▪ Next Steps
5:00	**Meeting Adjourned**



SKAGIT RIVER INSTREAM FLOW STUDY WORKSHOP 1

April 28, 2021

STUDY BACKGROUND

- Need to update and enhance current Flow Management Tool (ESH Model) identified by the FARWG.
- New hydraulic model (needed to update the Flow Management Tool) also has utility in evaluation of other Project-related resource issues identified by LPs.
- Need to review and, if necessary, update and expand habitat suitability criteria (HSCs) which form basis for ESH model.
- Intent to continue implementation of flow management program to benefit fisheries resources and address other Project-related resource issues as part of a new FERC license

STUDY BACKGROUND

- ESH Model initially developed by conducting an Instream Flow Incremental Method (IFIM) analysis using Physical Habitat Simulation (PHABSIM) which modeled nine species and 26 life stages of Skagit River sport fish.
- Model optimization resulted in a focus on spawning and incubation criteria for Chinook, Pink, and Chum salmon, and steelhead (Crumley and Stober 1984 Vol. I).
- Model HSC were developed using a combination of site-specific data and LP consensus.
- Downramp rates, timing and amplitude; min flows also included.
- ESH Model provides season-long, flexible guidelines for instream flows to meet biological requirements while supporting Project generation needs.

STUDY ROAD MAP/SCHEDULE

	April	May	June	July	August	September	October	November	Initial study report March 2022	Alternative scenario identification and evaluation: January - September 2022
Field Data Collection										
Hydrometric data collection for model calibration	Completed March 2021 (data collection at USGS gages continues through study period).									
Bathy data collection (to fill voids in LiDar data)	Completed March 2021.									
Substrate and cover data collection										
Hydraulic Model Development										
Assemble terrain data										
Hydraulic model construction										
Hydraulic model calibration/validation										
Biological and Habitat Information										
Review and selection of HSCs										
Integration with hydraulic data										
Workshops (additional workshops to be scheduled for Spring 2021)	↑			↑ ↑		↑		↑		

WORKSHOPS

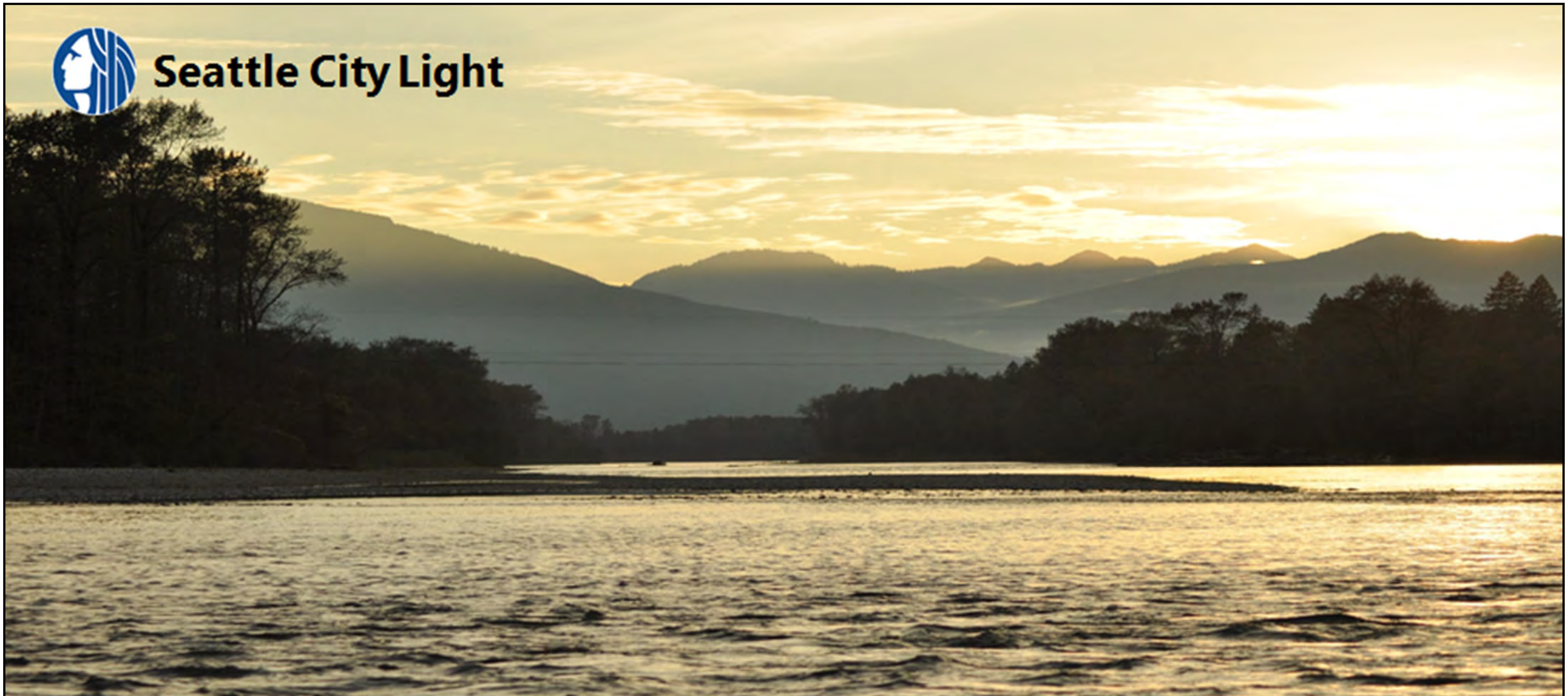
Workshop	Date	Topics
1	April 2021	Overview development of instream flow model for the Skagit River from Gorge Powerhouse to the Sauk River. Introduction to identification, selection, and use of habitat suitability criteria (HSCs) for fish species of interest.
1A	May 2021	Overview development of hydraulic and instream flow model for the Gorge Bypass Reach reach.
2	July 2021	Updates to biological and habitat metrics based on discussions and input from Workshop 1.
3	July 2021	Hydraulic model construction.
4	September 2021	Hydraulic model calibration and integration with biological/habitat data.
5	November 2021	Final hydraulic model calibration results and discussion of future model application.

Additional workshops/meetings to be scheduled for Spring 2021

MEETING OBJECTIVES

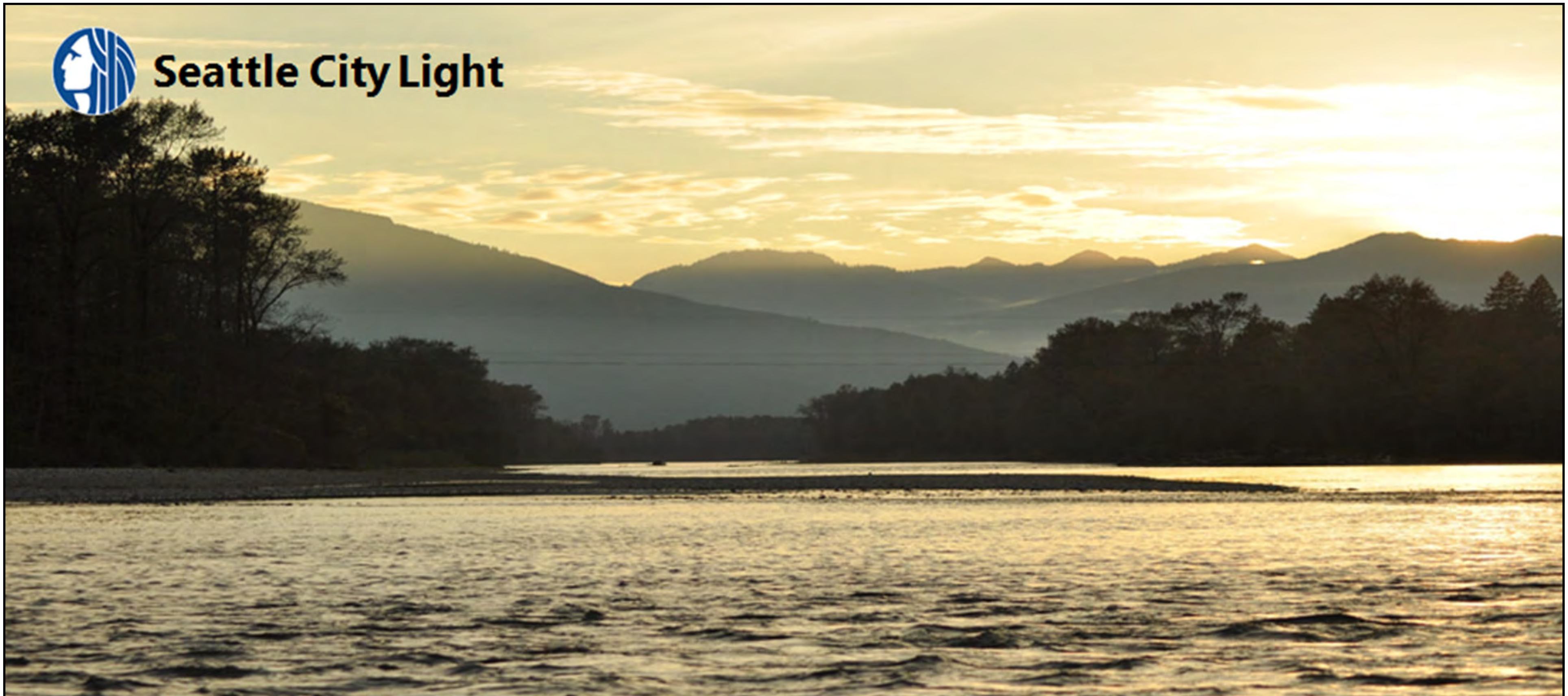
- Review LP comments on the bypass reach model and discuss next steps for future meetings.
- Overview program for development of instream flow model for Skagit River from Gorge Powerhouse to Sauk River.
- Introduce identification, selection and use of habitat suitability criteria (HSCs) for fish species of interest.

MEETING AGENDA



SKAGIT RIVER INSTREAM FLOW STUDY BYPASS REACH COMMENTS

April 28, 2021



SKAGIT RIVER INSTREAM FLOW STUDY HYDRAULIC MODELING

April 28, 2021

OVERVIEW

- Model Inputs
    - Terrain
    - Boundaries
    - Mesh
    - Physical Parameters
- Model Setup
    - Mesh & Timestep
    - Solution Equations
- Calibration
    - Field Data
    - Calibration Parameters
    - Performance Evaluation
- Model Outputs

HYDRAULIC MODELING OVERVIEW

Source Data

- Terrain
- Roughness
- Flows
- Stage

→

Model Layers

- Mesh
- Breaklines
- Structures
- Boundary Conditions

→

Run Parameters

- Time Step
- Initial Conditions
- Solution Equation
- Turbulence

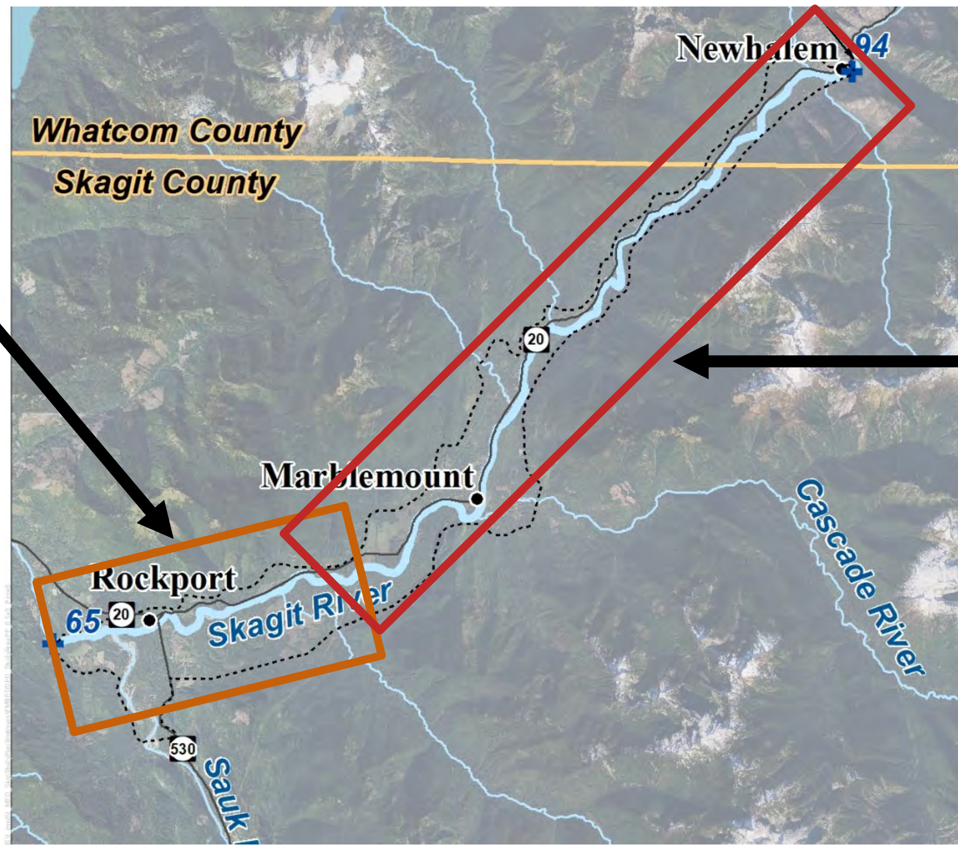
→

Outputs

- Depth
- Velocity
- WSEL
- Rating Curve
- etc.

TERRAIN - OVERVIEW

2017 LiDAR

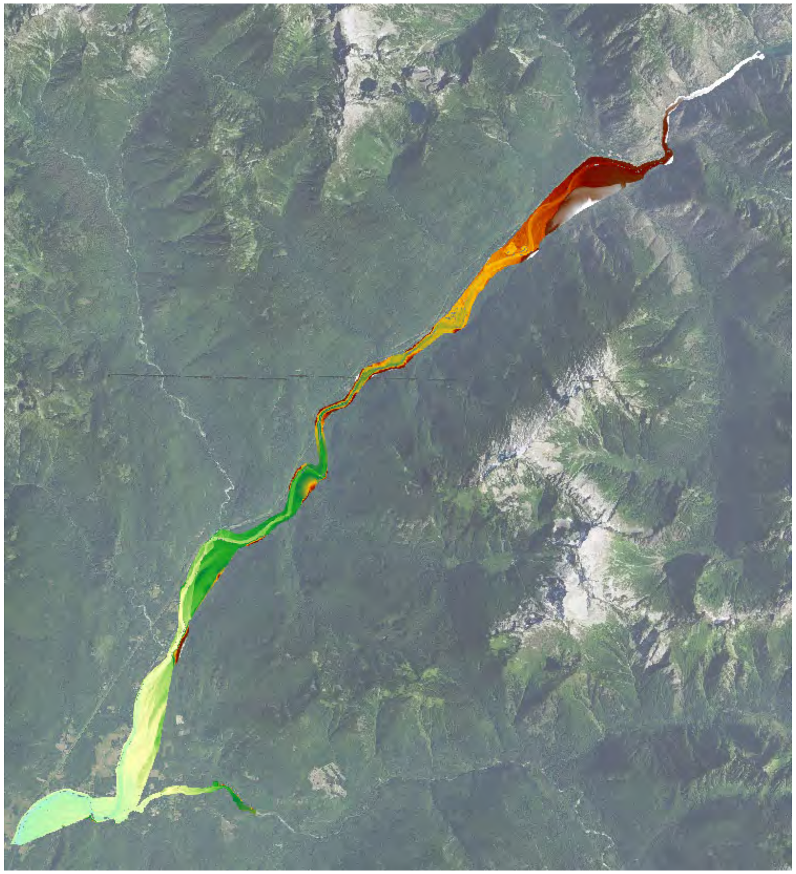


2018 LiDAR

~29 River Miles

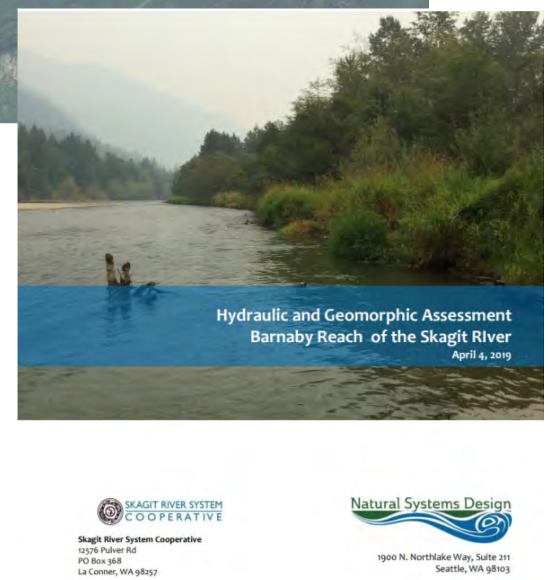
TERRAIN - QUANTUM SPATIAL 2018

- Quantum Spatial 2018
  - o "green" LiDAR
  - o Water penetrating
  - o Some voids
- Non-vegetated vertical accuracy = 0.201 feet 95% confidence
- Submerged vertical accuracy = 0.366 feet 95% confidence



TERRAIN - QUANTUM SPATIAL 2017

- Quantum Spatial 2017
  - o "green" LiDAR
- Non-vegetated Vertical Accuracy = 0.263 feet 95% confidence
- Submerged Vertical Accuracy = 0.540 feet 95% confidence
- Void filling by NSD



TERRAIN – LIDAR POINT DENSITY

- Lower Skagit (2017)

Density Type	Point Density
Ground and Bathymetric Bottom Classified Returns	0.21 points/ ft^2 2.25 points/m^2
Bathymetric Bottom Classified Returns	0.25 points/ ft^2 2.69 points/m^2

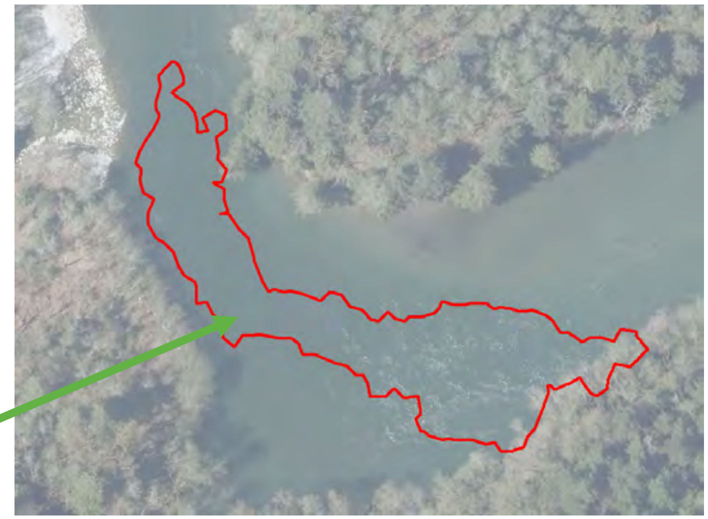
- Upper Skagit (2018)

Density Type	Point Density
Green Laser First Returns	34.79 points/m^2 3.23 points/ft^2
Ground and Bathymetric Bottom Classified Returns	5.56 points/m^2 0.52 points/ft^2
Bathymetric Bottom Classified Returns	8.61 points/m^2 2.58 points/ft^2

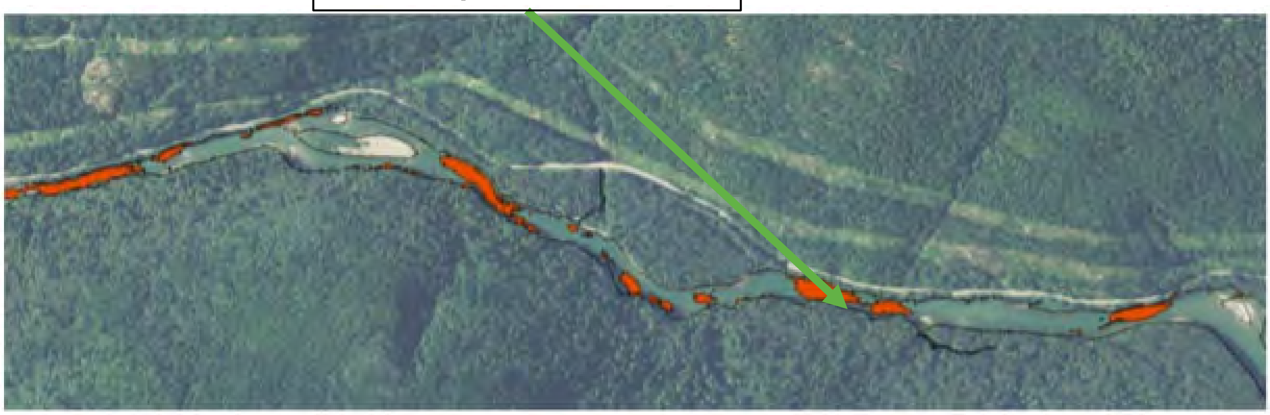
- > 3 points/m^2 –> topographically complex
- > 0.5 points/m^2 -> topographically uniform

TERRAIN – BATHYMETRY VOIDS

- Depth
- Rapids
- Overhanging vegetation
- Bottom reflectivity



Example Void

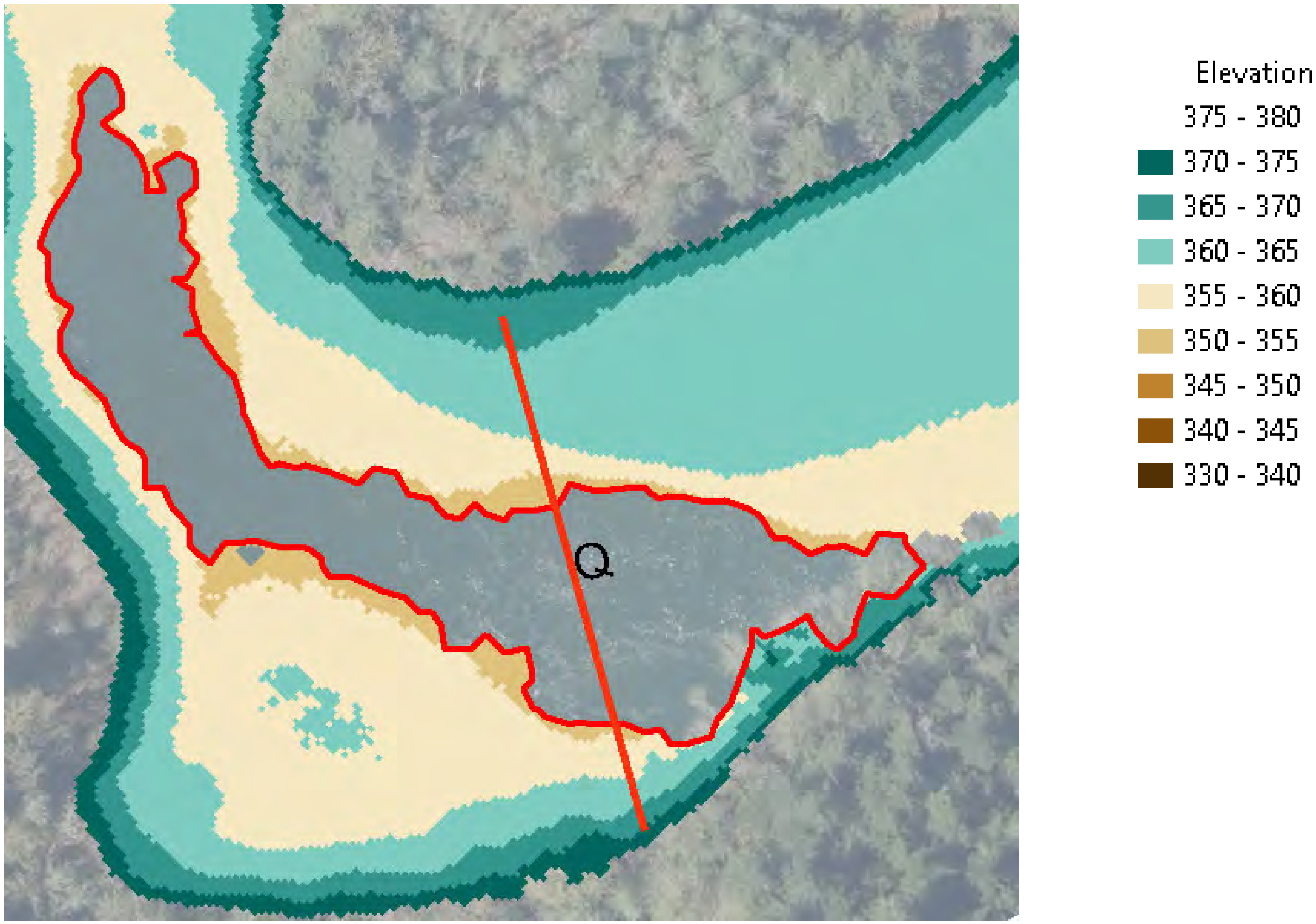


TERRAIN – VOID FILLING

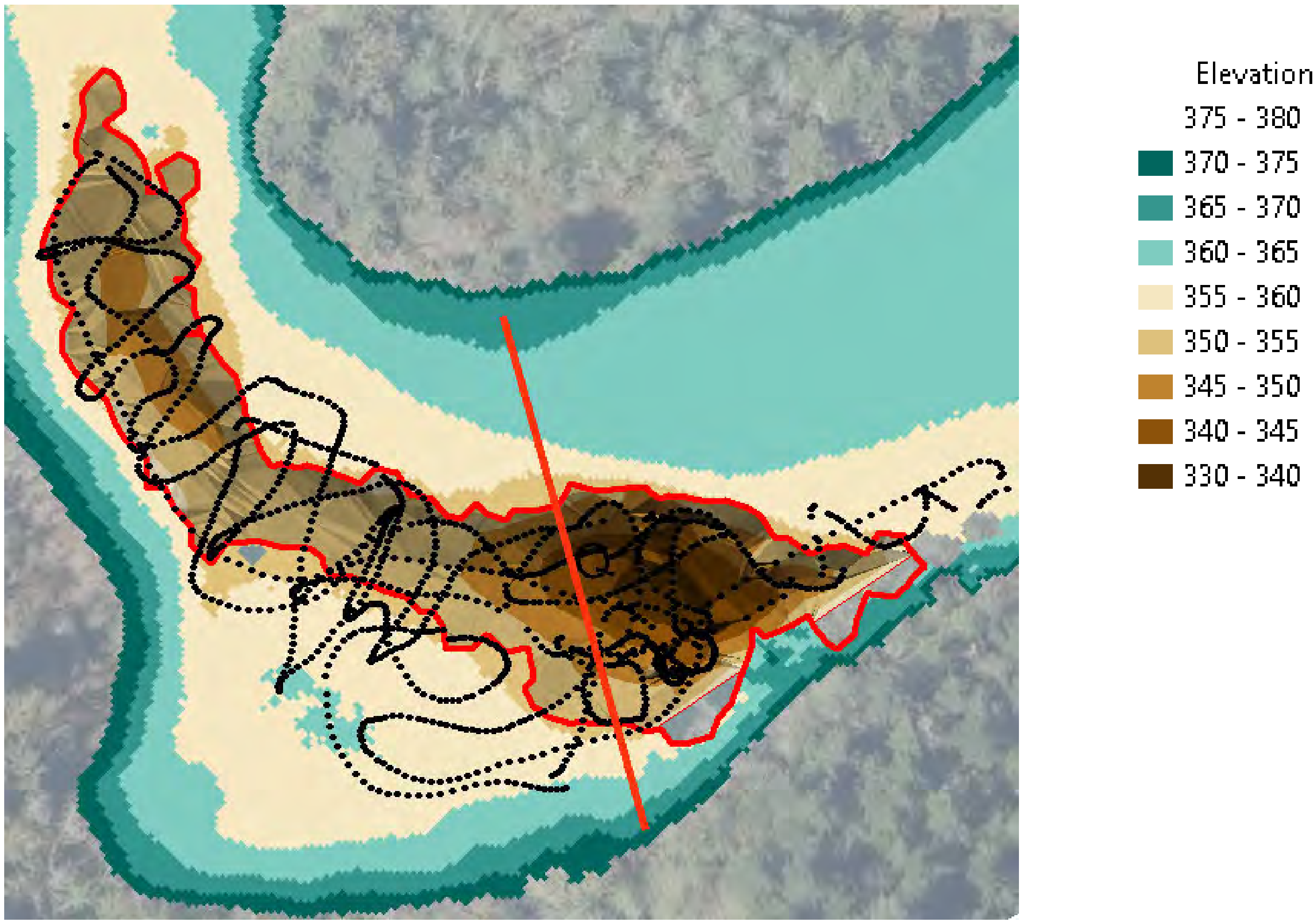
- Filled voids except:
  - < 1,000 ft^2
  - Dangerous rapids
  - Inaccessible due to trees/vegetation
- Completed:
  - 126/205 Voids (62%)
  - 34/44 Acres (77%)

- Otherwise use Quantum's interpolated surface

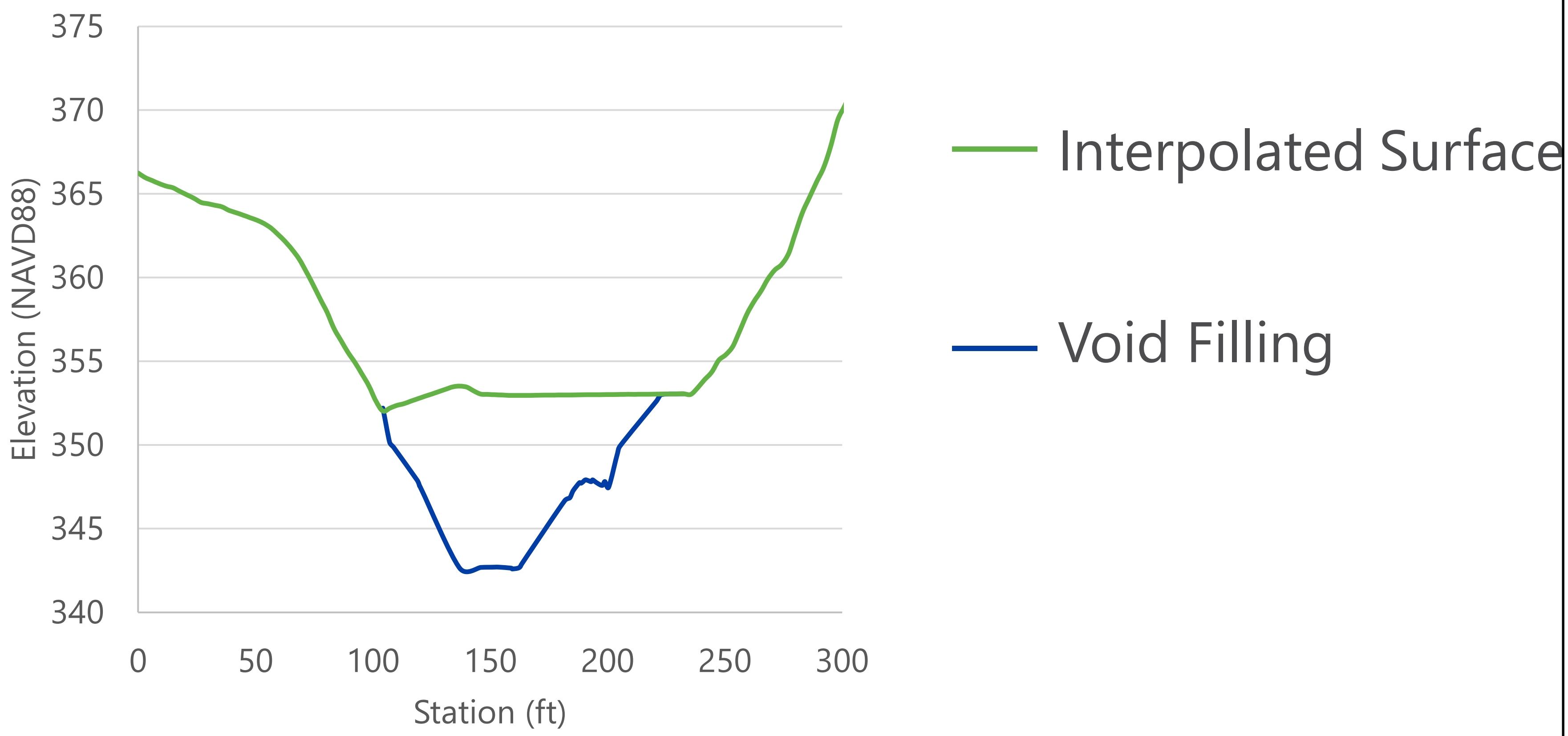
TERRAIN – VOID FILLING



TERRAIN – VOID FILLING

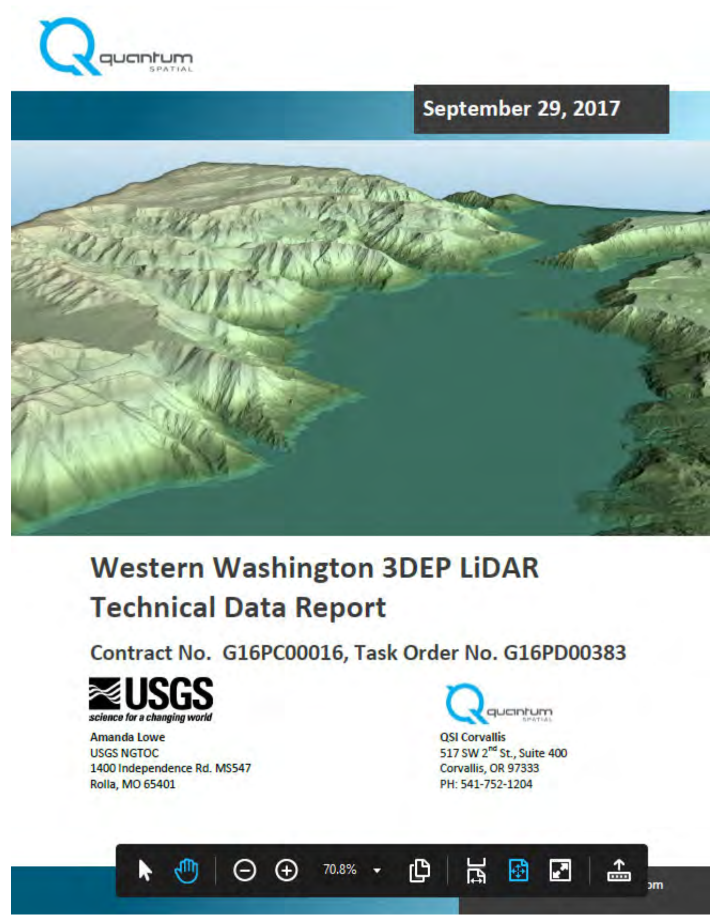


TERRAIN – VOID FILLING



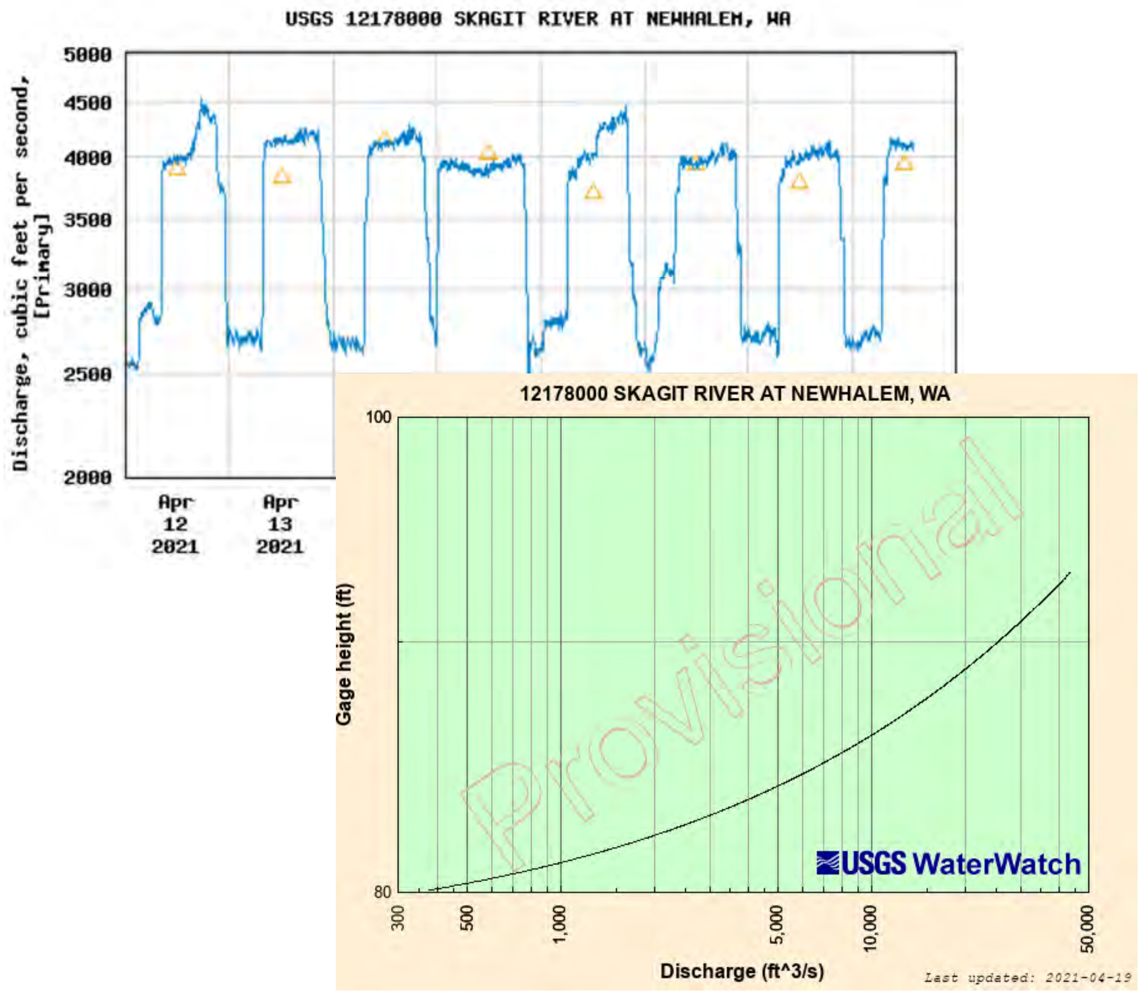
TERRAIN – FLOODPLAIN MARGINS

- Quantum Spatial 2016
  - USGS
  - “standard” LiDAR
  - Supplement floodplain



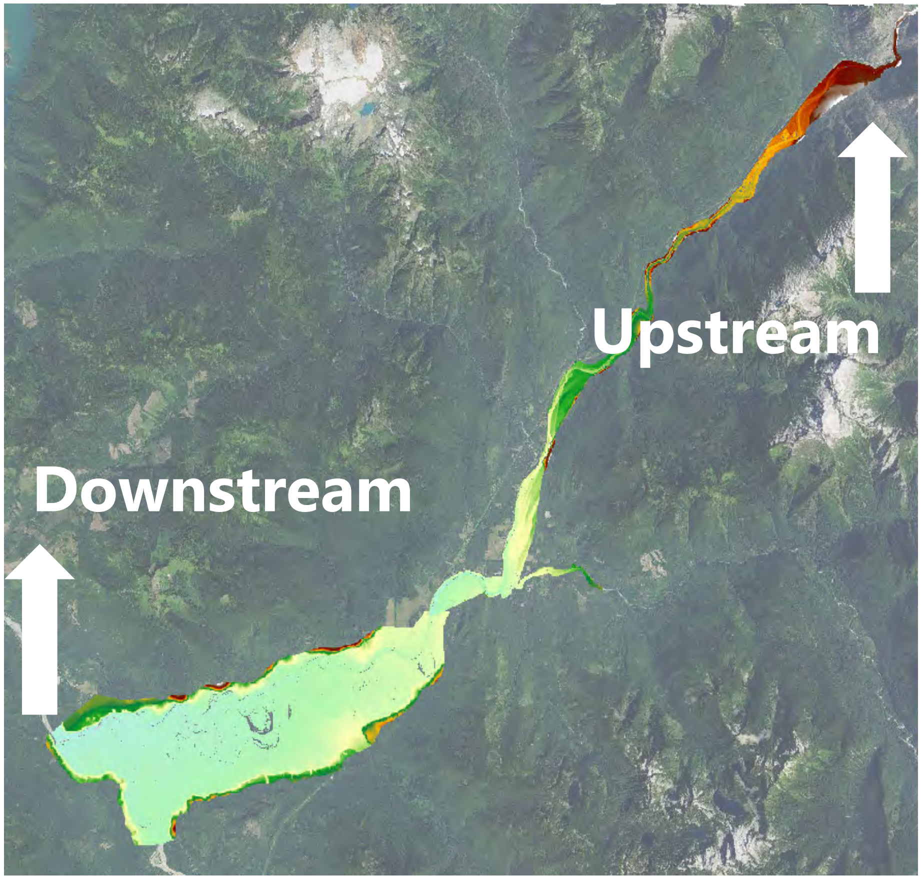
BOUNDARIES

- Flow Hydrograph
- Stage Hydrograph
- Normal Depth
- Rating Curve



BOUNDARIES – PH TO SAUK RIVER

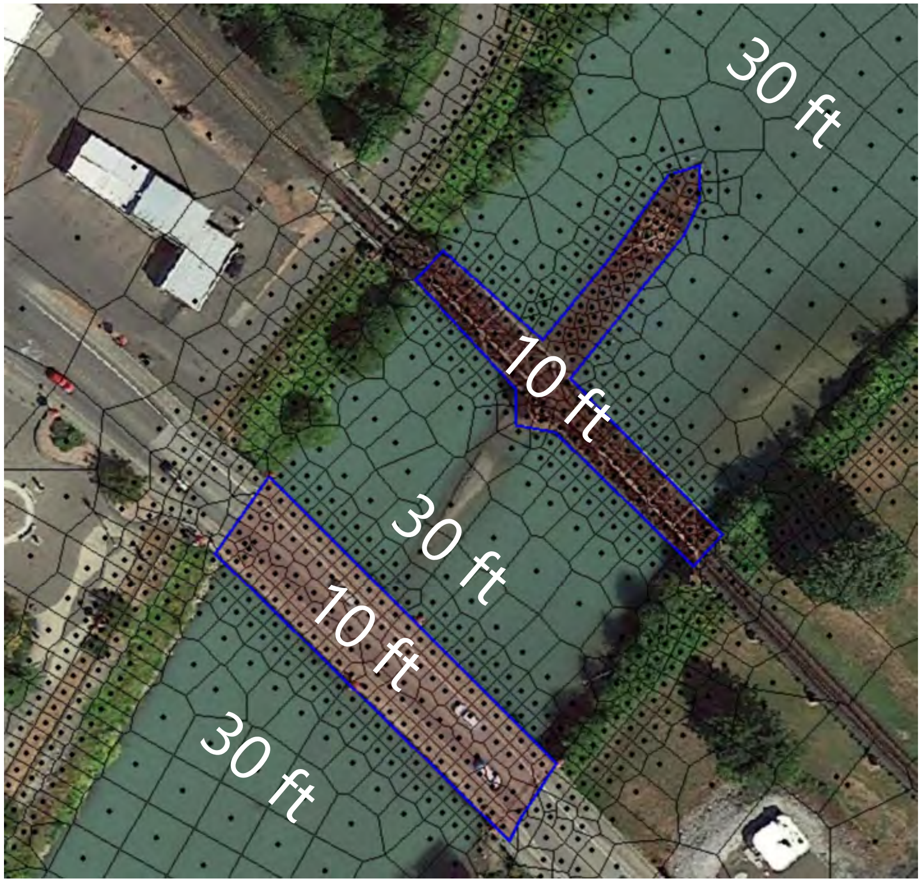
Upstream	Observed flows @ Newhalem Gage
Downstream	Observed stage @ Gage below Sauk
Intermediate	→



BOUNDARIES - TRIBUTARY INFLOWS

Tributary	Methodology
Newhalem Ck	USGS gage
Goodell Ck	Measurement
Damnation Ck	Measurement
Bacon Ck	USGS gage
Diobsud Ck	Measurement
Cascade River	USGS gage
Illabot Ck	Measurement
Sauk River	USGS gage
Ungaged Tributaries	Lumped and scaled from various sources

MESH

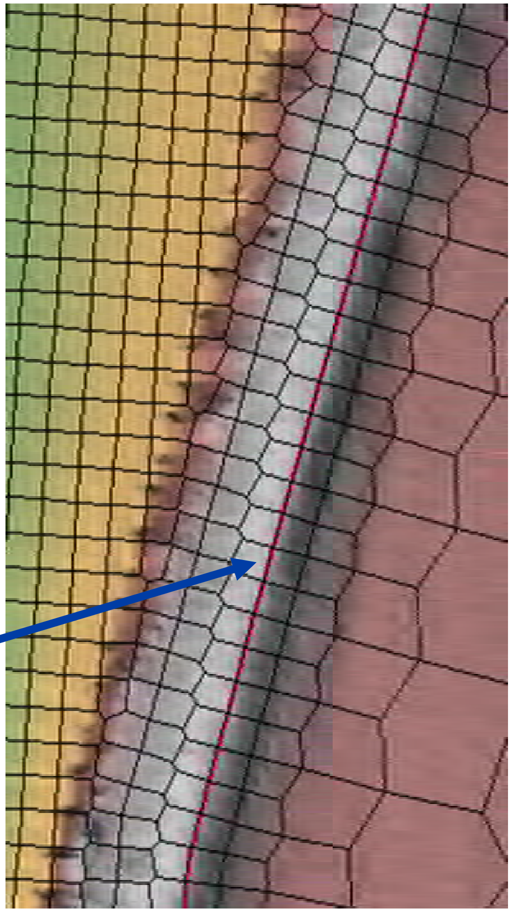


- Computations solved on mesh
- Represents terrain
- Cell size can vary
- Where water surface slope and velocity vary rapidly, smaller cells needed to capture the changing water surface and velocity

MESH - BREAKLINES

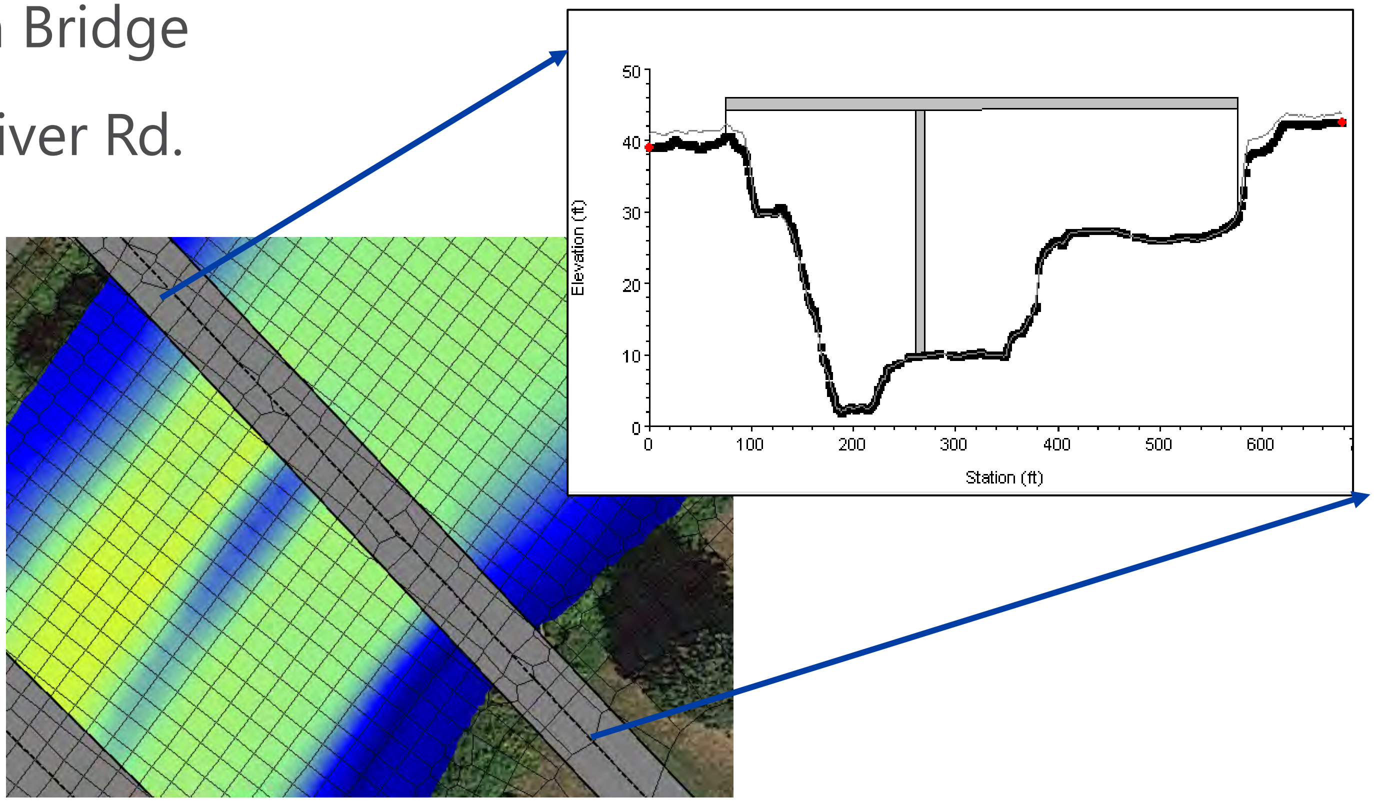
- Force cell faces along a line
- Critical to represent hydraulic controls
  - Embankments, riffle crests

Breakline



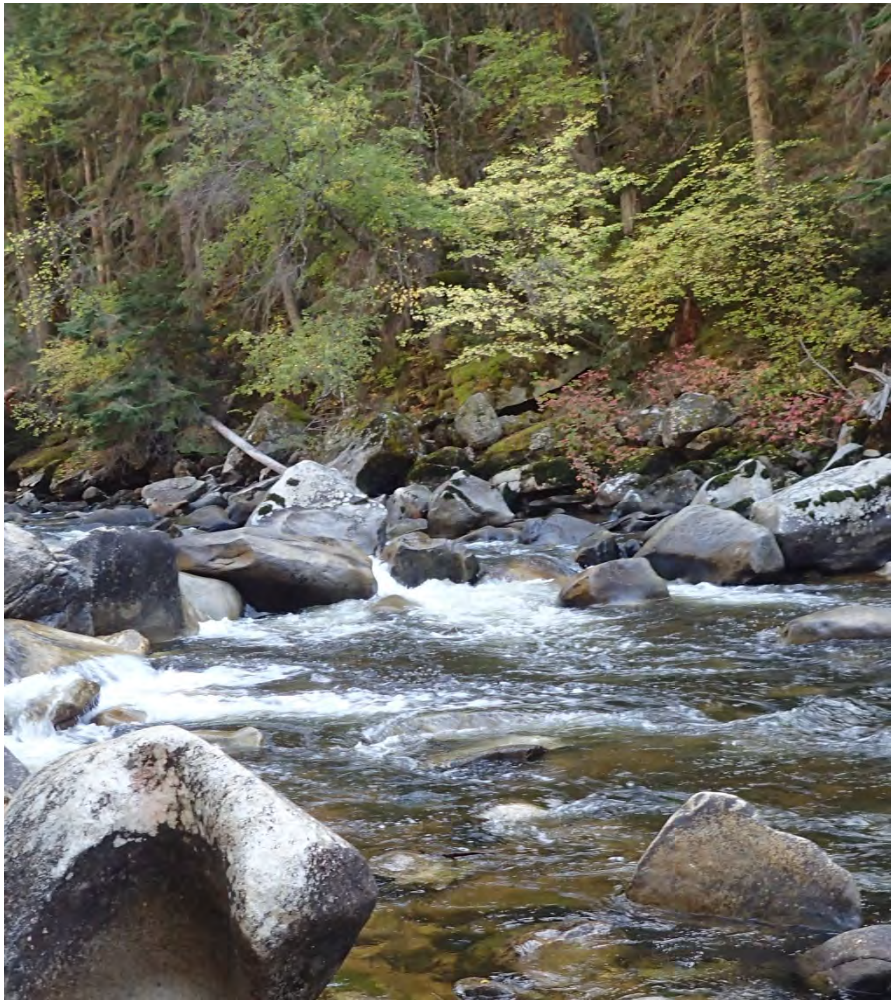
MESH - HYDRAULIC STRUCTURES

- Bridges
  - Newhalem Bridge
  - Cascade River Rd.
  - SR 530



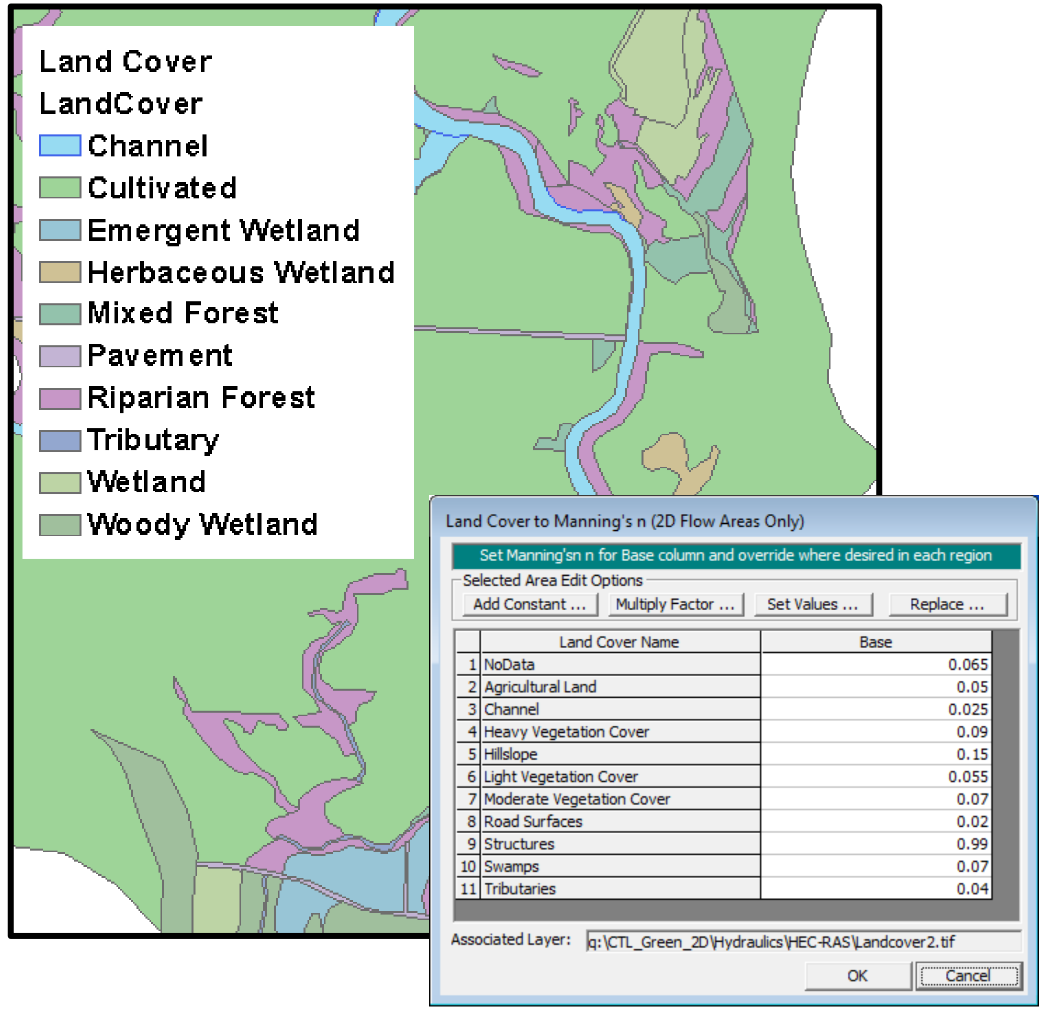
PHYSICAL PARAMETERS - ROUGHNESS

- Frictional resistance parameter
- Manning's "n" in HEC-RAS
- Losses accounted for differently from 1D model



PHYSICAL PARAMETERS - MANNING'S N

- Cell roughness defined by Manning's n layer
- Logjam options
  - Roughness
    - Composite
    - Localized
  - Blocked obstruction
  - Terrain modify

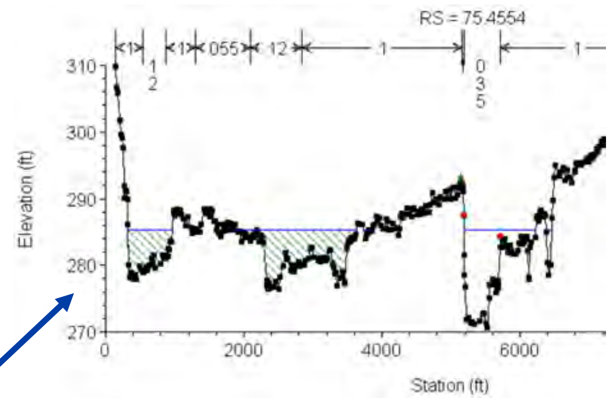


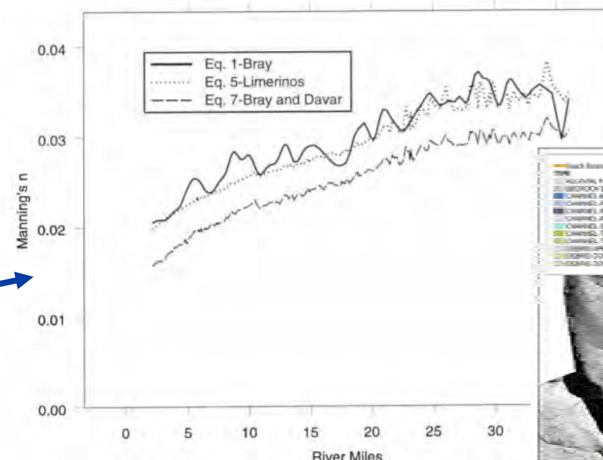
	Land Cover Name	Base
1	NoData	0.065
2	Agricultural Land	0.05
3	Channel	0.025
4	Heavy Vegetation Cover	0.09
5	Hillslope	0.15
6	Light Vegetation Cover	0.055
7	Moderate Vegetation Cover	0.07
8	Road Surfaces	0.02
9	Structures	0.99
10	Swamps	0.07
11	Tributaries	0.04

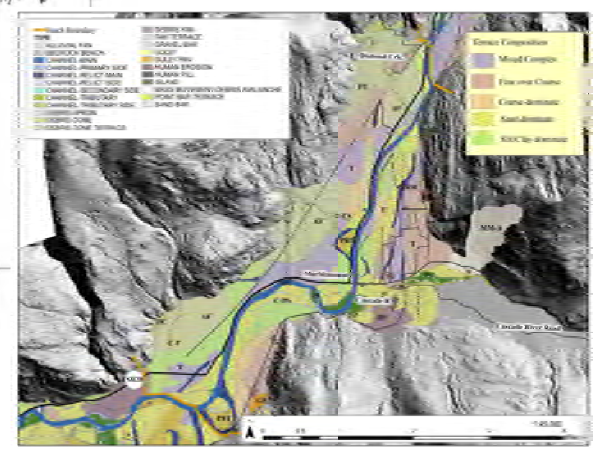
PHYSICAL PARAMETERS – INITIAL ROUGHNESS SOURCES

Sources

- Literature
- Aerial Photos
- Previous Models
- Substrate
- Landform Maps





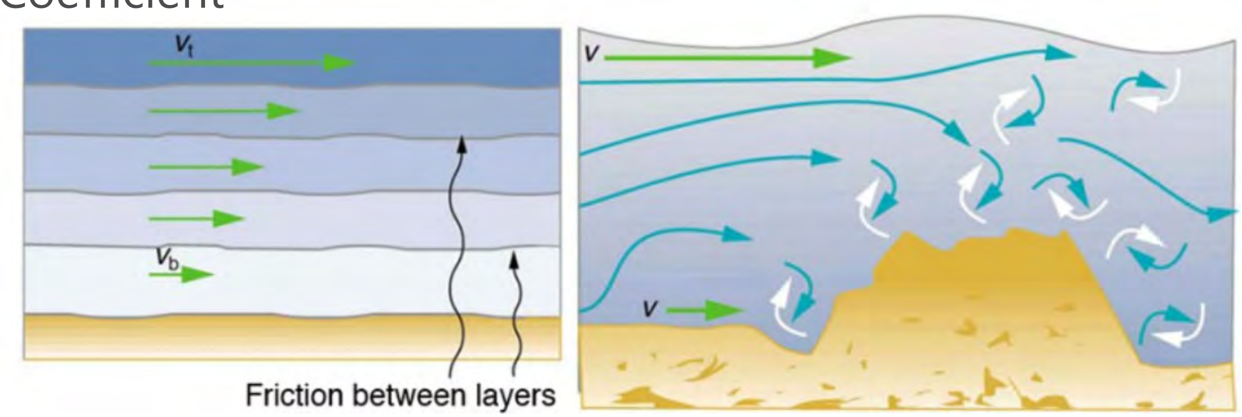


PHYSICAL PARAMETERS - TURBULENCE

- Irregular motion resulting in eddies and currents
- Particles move chaotically while fluid bulk moves forward
- Shear between fluid

PHYSICAL PARAMETERS – MODELED TURBULENCE

- Modeled as a diffusion process
  - Default -> none
  - Two formulations (conservative, non-conservative)
    - Longitudinal Mixing Coefficient
    - Transverse Mixing Coefficient
    - Smagorinsky Coefficient



Seattle City Light

DISCUSSION

MODEL SETUP

Source Data

- Terrain
- Roughness
- Flow Data

→

Model Layers

- Mesh
- Breaklines
- Structures
- Boundary Conditions

→

Run Parameters

- Time Step
- Initial Conditions
- Solution Equation
- Turbulence

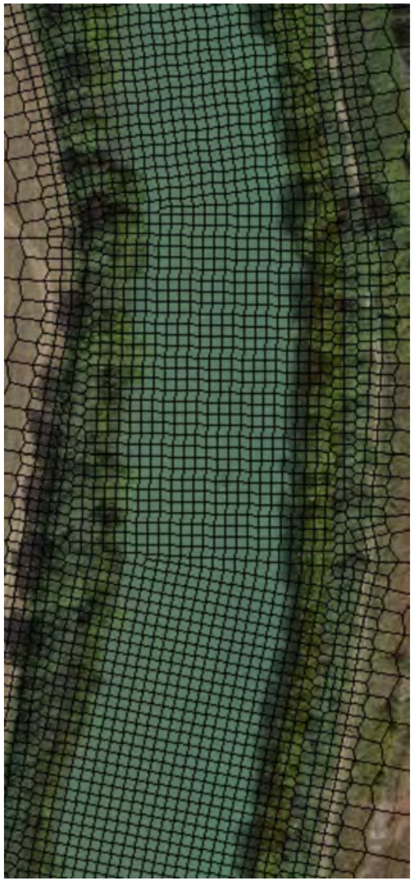
→

Outputs

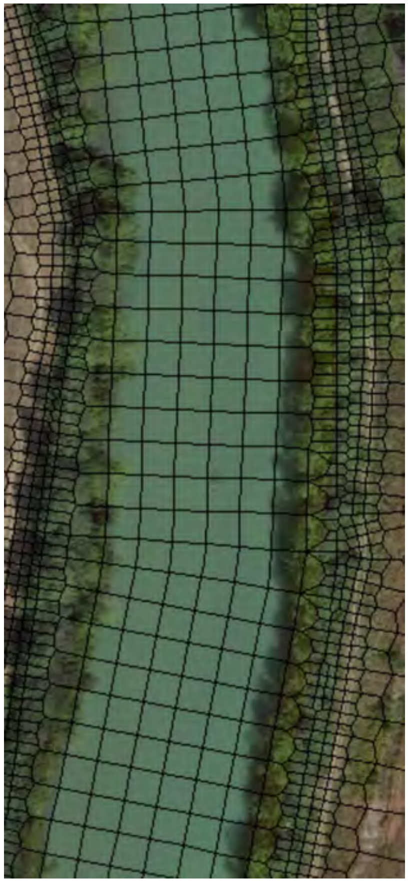
- Depth
- Velocity
- WSEL
- Rating Curve
- etc.

MODEL SETUP - CELL SIZE

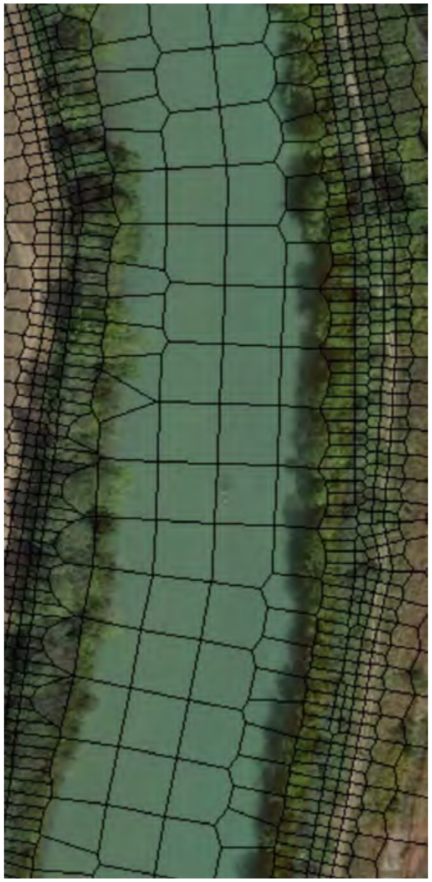
10-foot



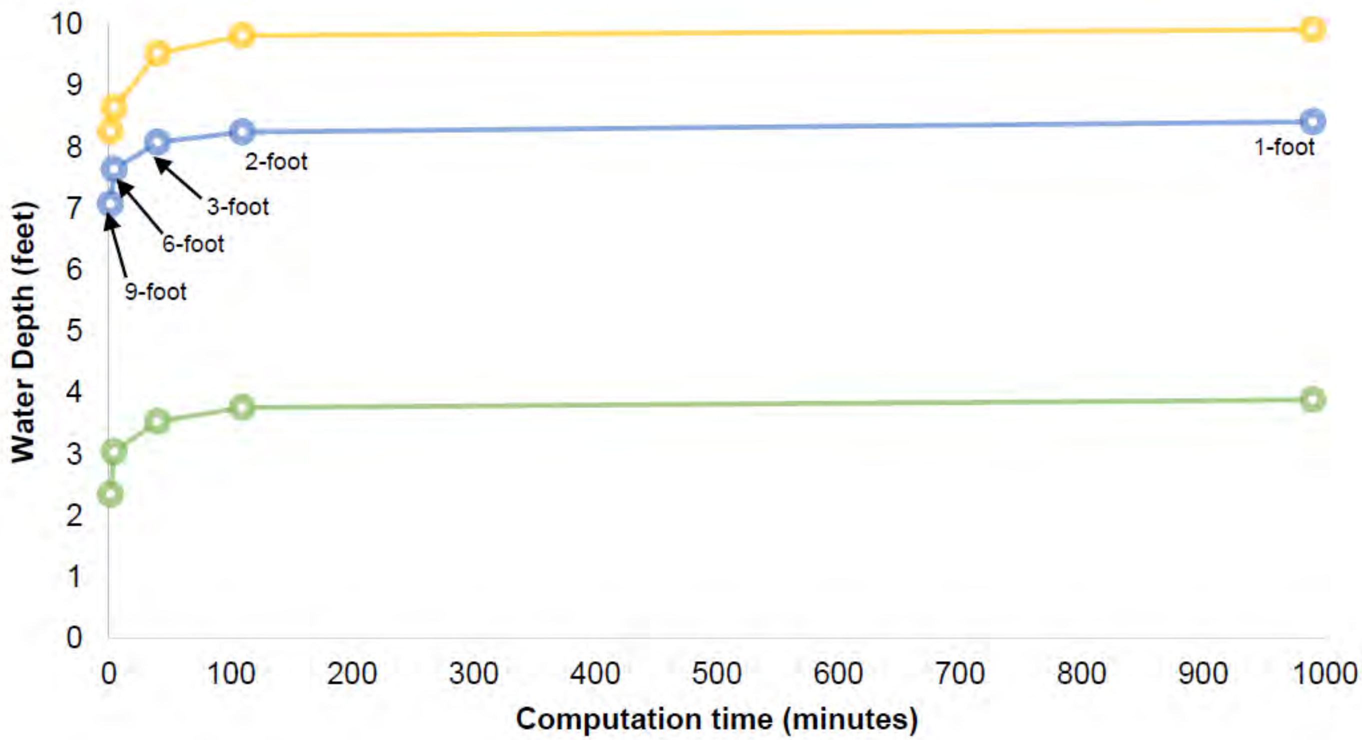
30-foot



50-foot



MODEL SETUP – CELL SIZE VS TIME

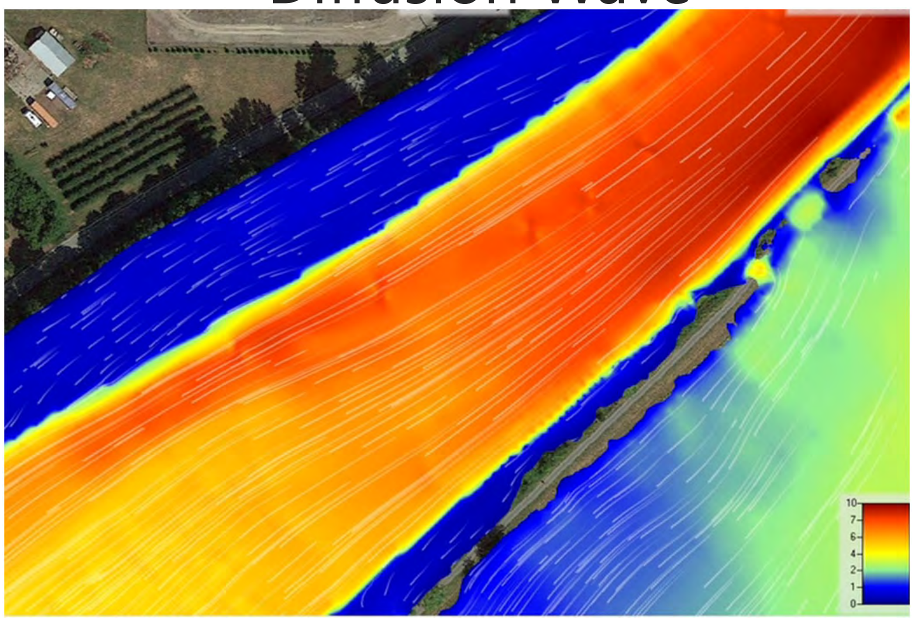


MODEL SETUP - SOLUTION EQUATIONS

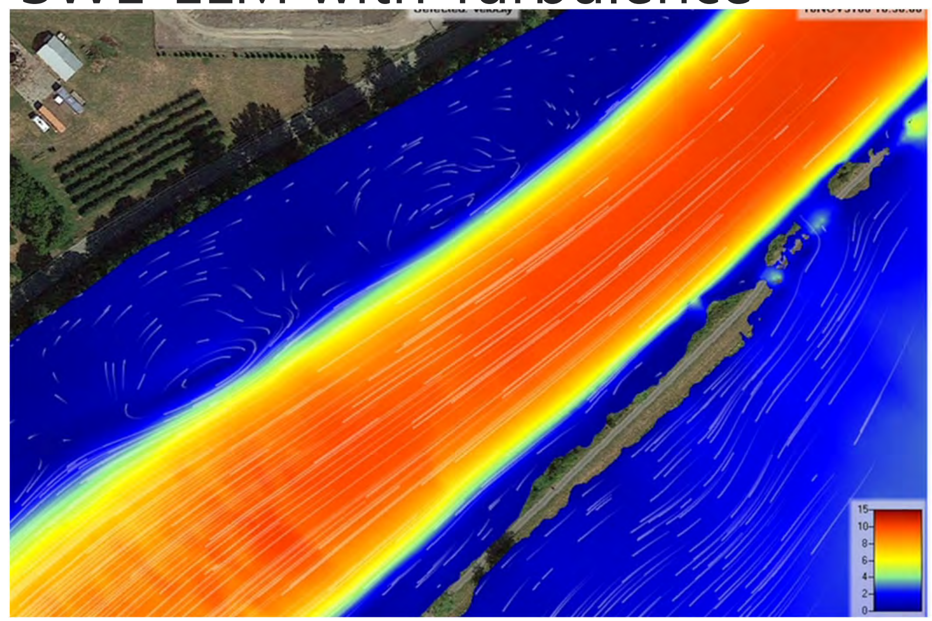
- Diffusion Wave
  - Use when inertial forces > frictional and other forces
  - Faster, more stable
- Shallow Water Equation - Eulerian-Lagrangian Method
  - Accounts for turbulence
  - Slower run times
- Shallow Water Equation - Eulerian Method
  - Most detailed at changes in water surfaces and velocity
  - Slowest run times

MODEL SETUP - SOLUTION EQUATIONS

Diffusion Wave



SWE-ELM with Turbulence



MODEL SETUP – CONCLUSIONS

- Evaluate interaction of parameters
  - Cell size
  - Time step
  - Solution equation
- Calibration begins after setup/sensitivity

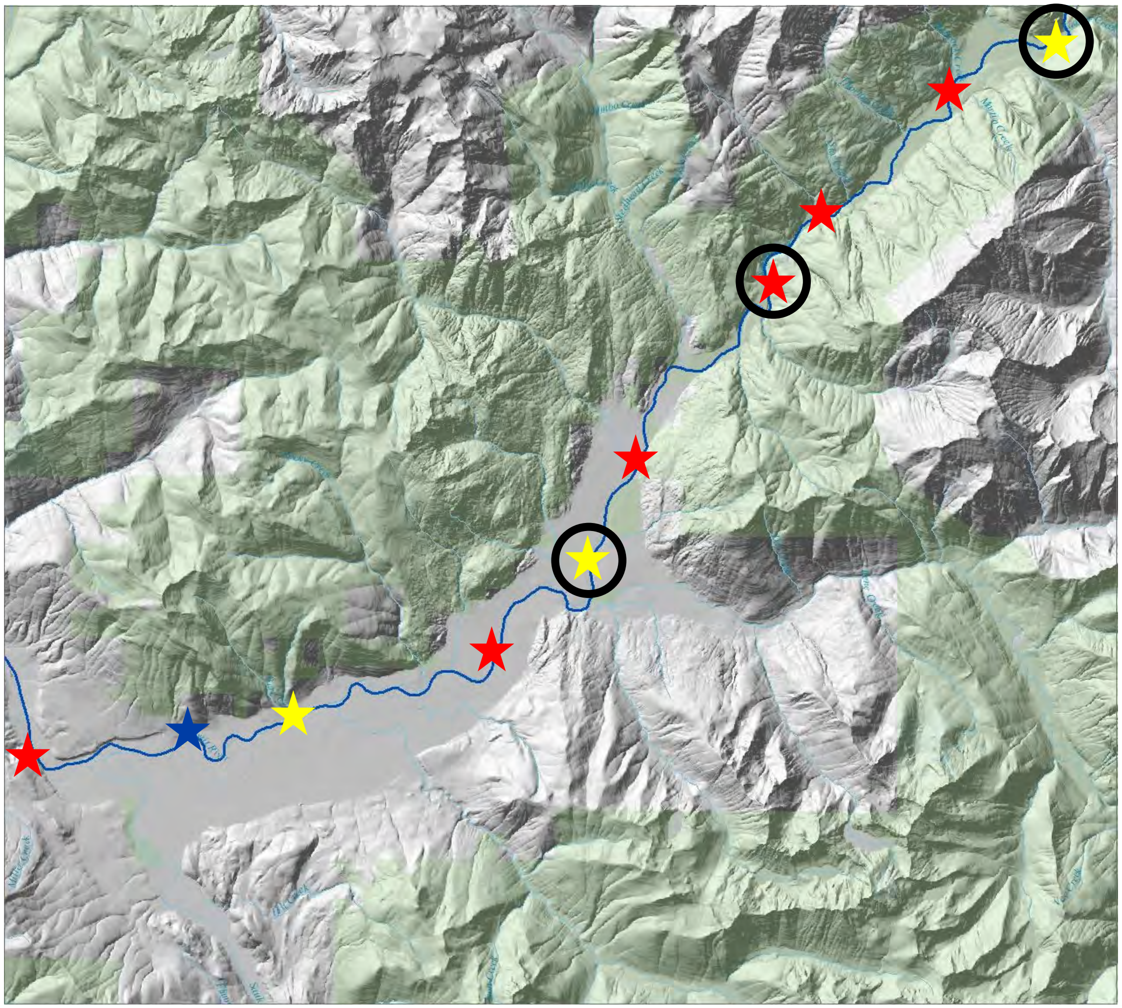
Seattle City Light

DISCUSSION

MODEL CALIBRATION OVERVIEW

- Field Data
  - o Stage/Discharge gages
  - o Data collected over 29-mile study reach
    - Low, Moderate, and High discharges
      - o Depth/Velocity/Discharge at Transects
      - o Water Surface Profile
      - o Tributary Inflows
  - o High Water Marks @ 11-5-2020 flow event
- Calibrating Parameters
- Performance Evaluation

CONTINUOUS STAGE/DISCHARGE GAGES

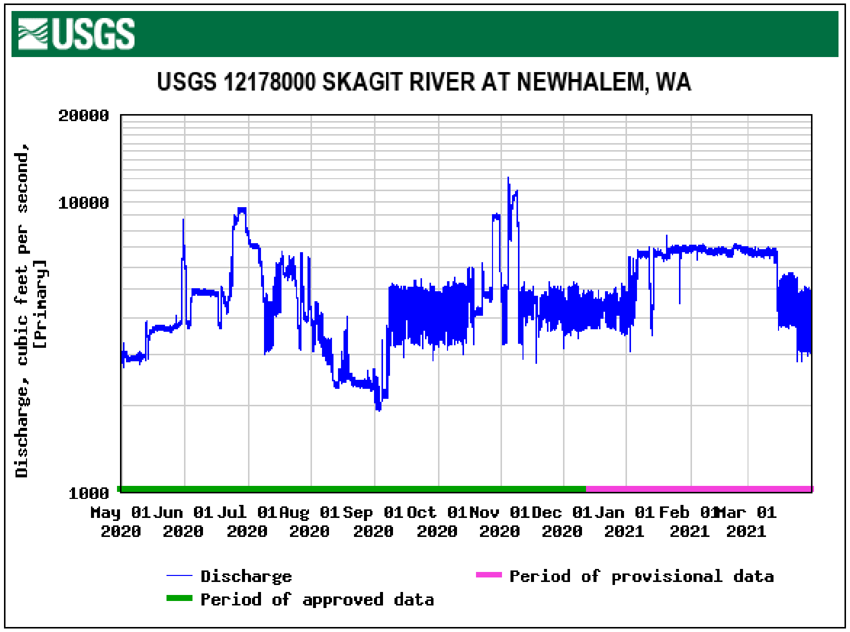


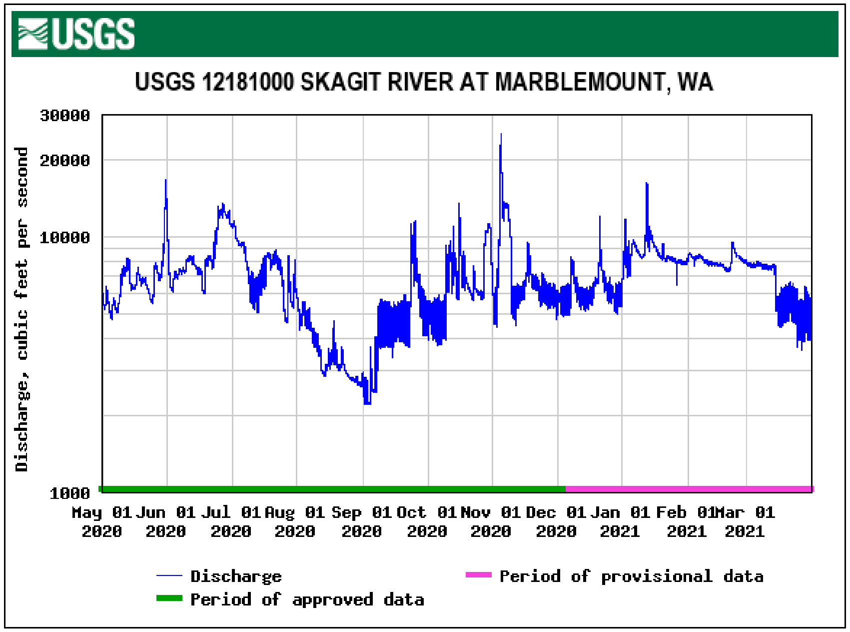
★ USGS/SCL (6)

★ SRSC (1)

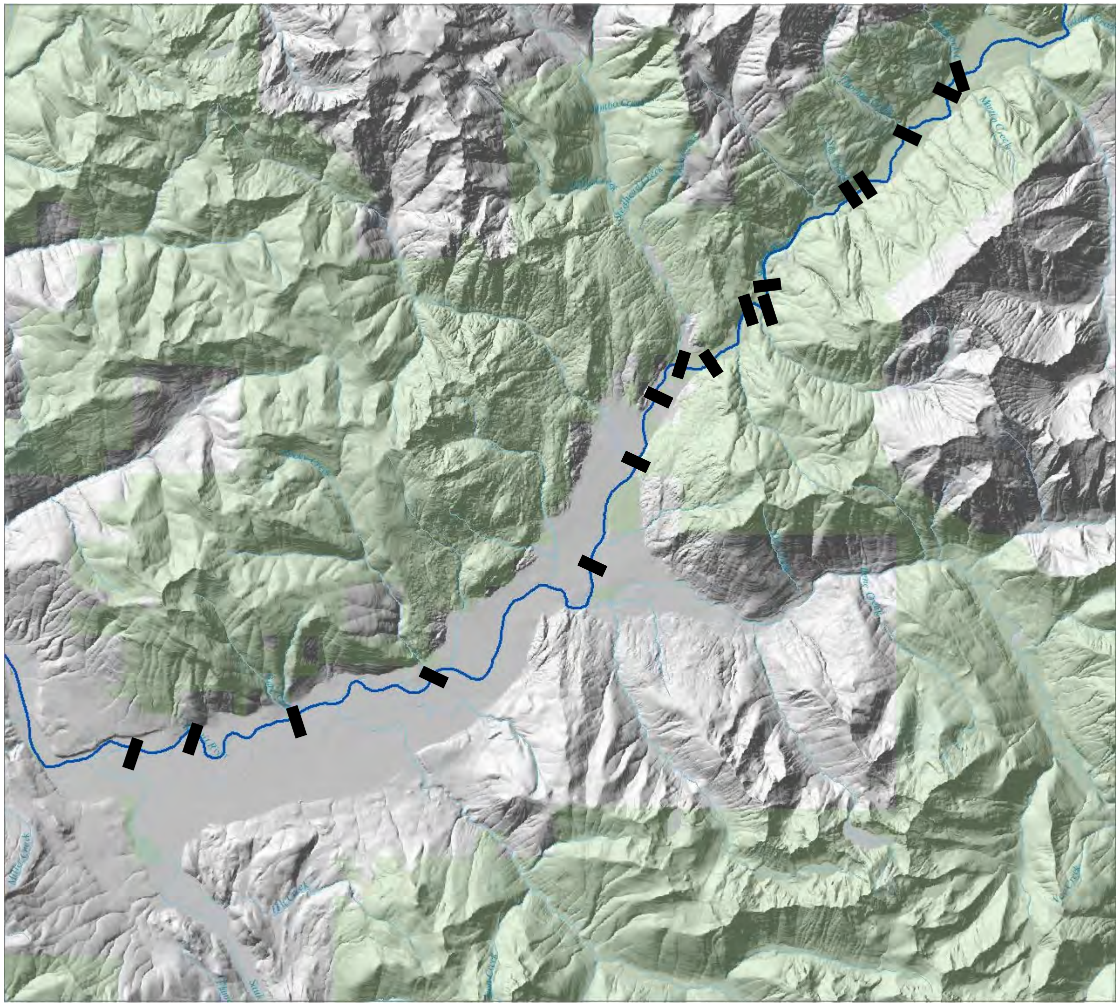
★ USGS (3)

CONTINUOUS STAGE/DISCHARGE GAGES





TRANSECTS

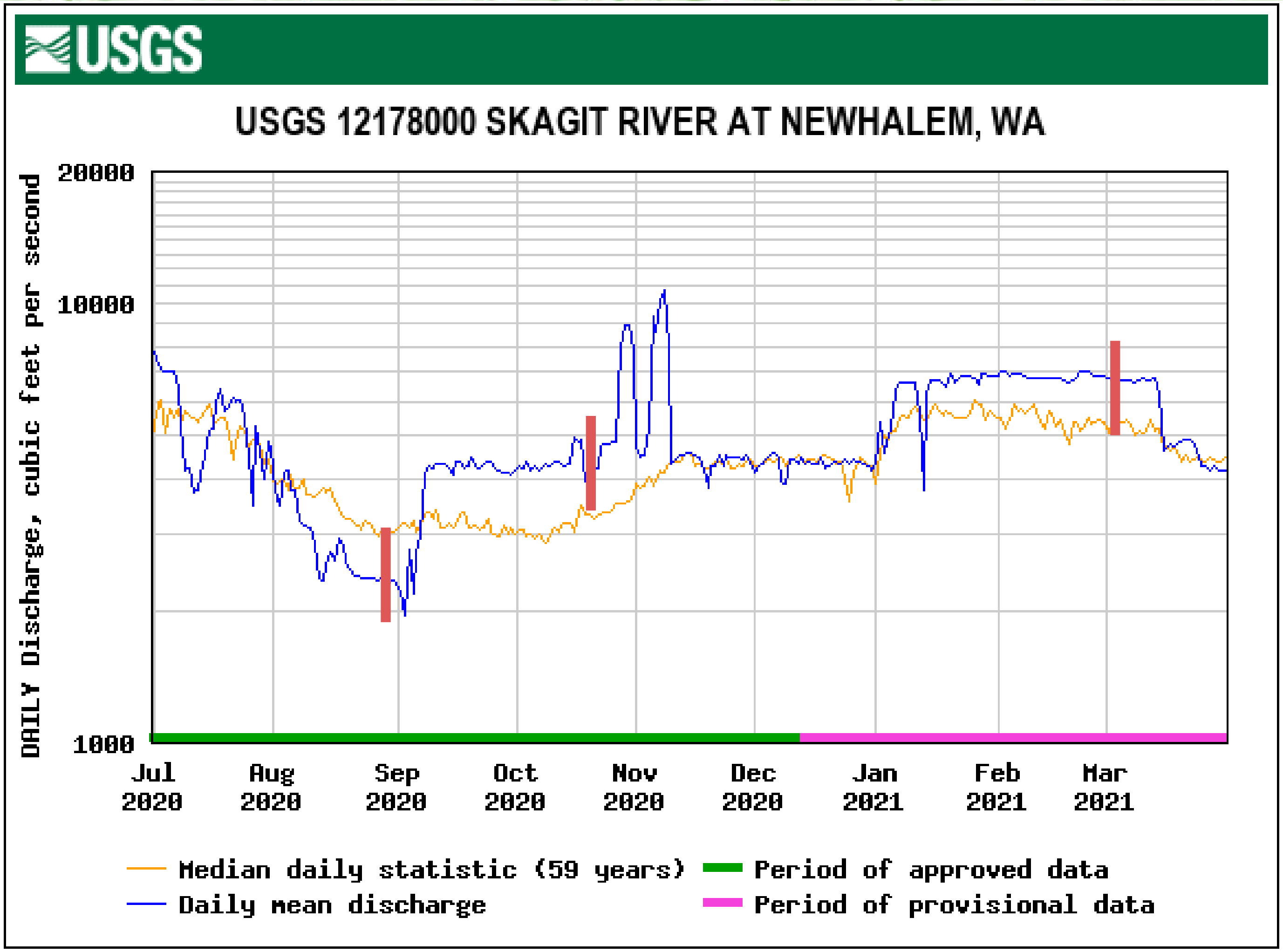


- 17 Transects
  - o WSEL
  - o Depth
  - o Velocity
- 3 Discharges

DISCHARGES DURING FIELD EFFORTS

	Date	Discharge (cfs)	Daily Exceedance Probability OR Return Period
USGS @ Newhalem			
	August 2020	2,350	94%
	October 2020	4,200	51%
	March 2021	6,700	13%
	November 5, 2020	12,200	~1.5 yr return period
USGS @ Marblemount			
	August 2020	2,900	95%
	October 2020	5,800	47%
	March 2021	7,800	21%
	November 5, 2020	25,300	~2.5 yr return period

SKAGIT RIVER AT NEWHALEM

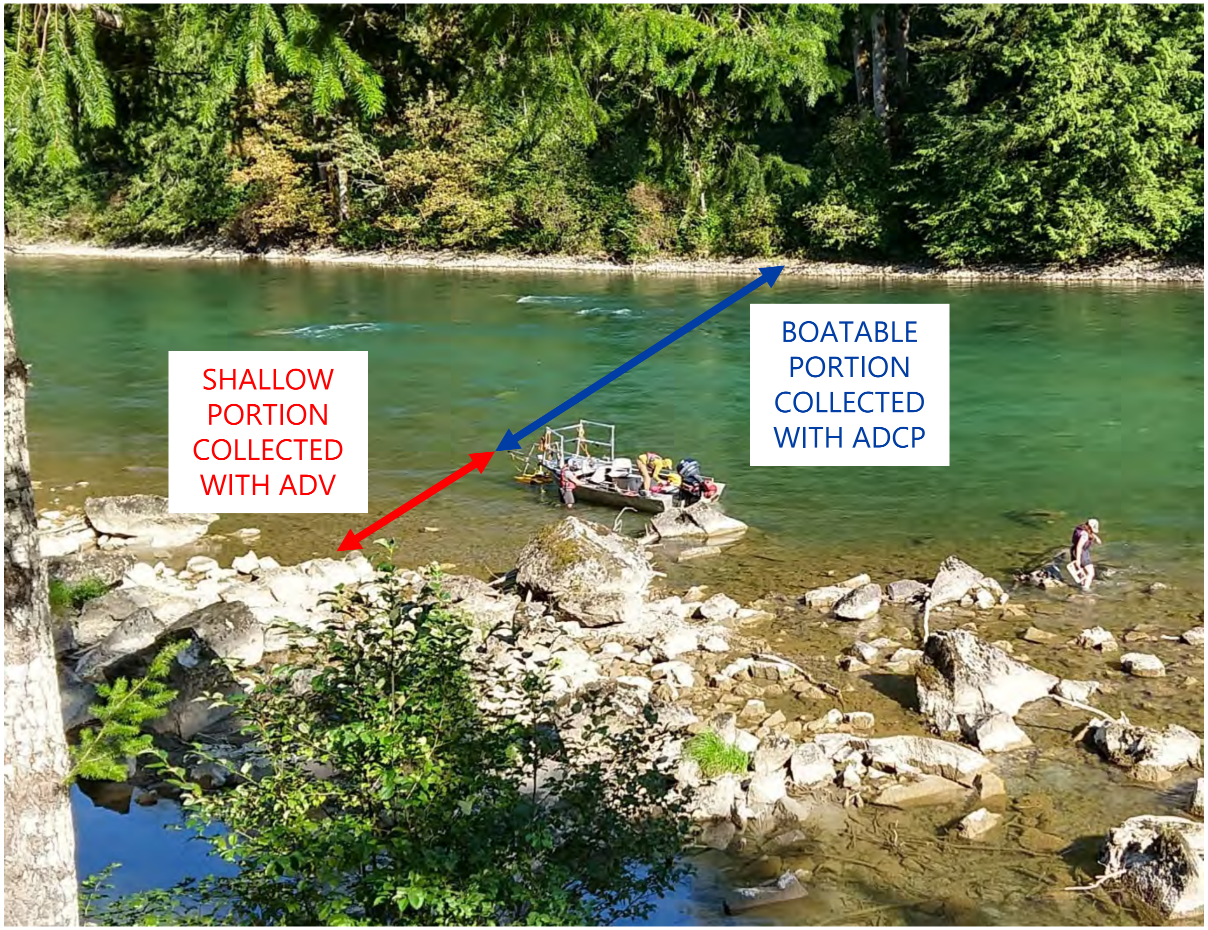


TRANSECT DATA COLLECTION

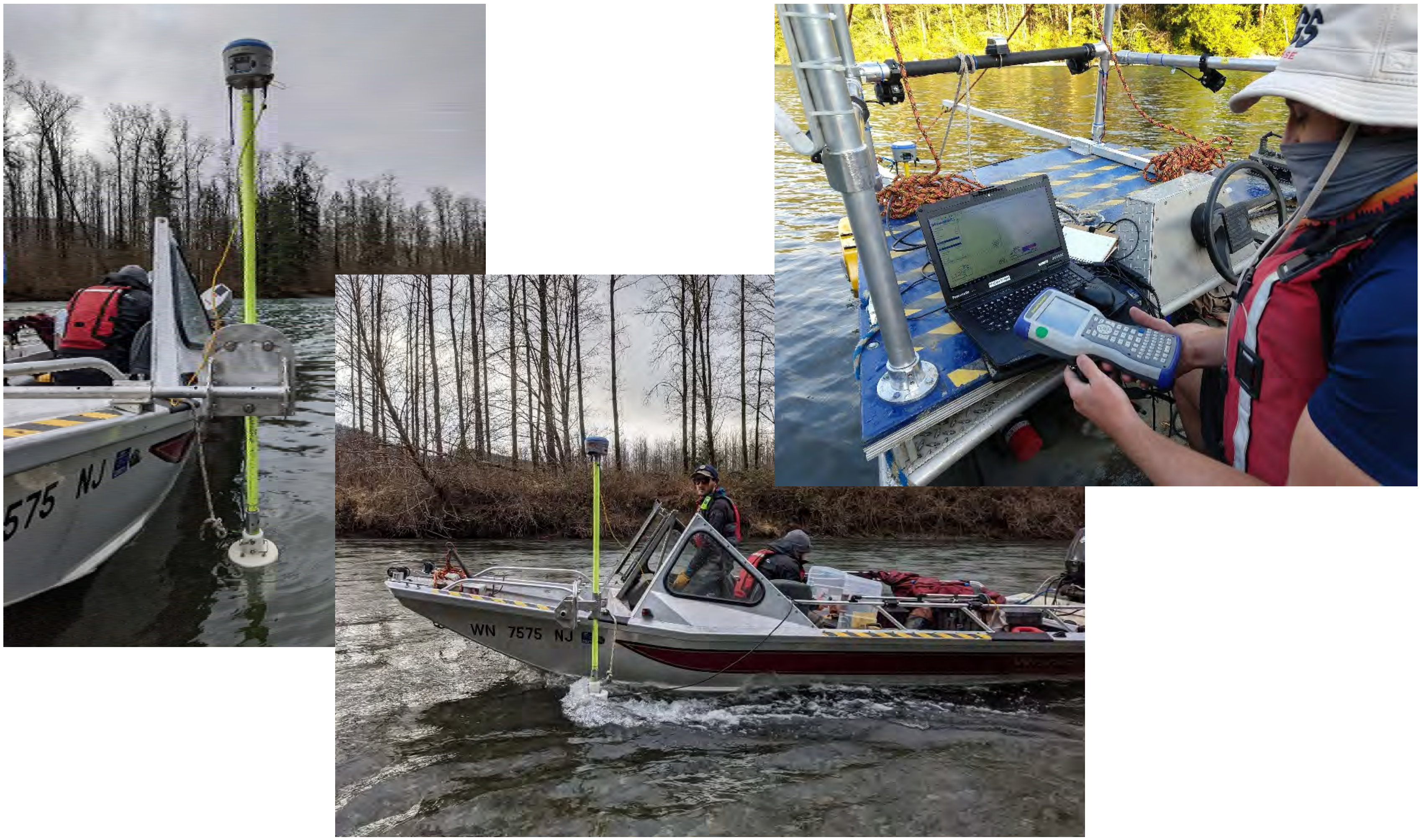
- Instruments
  - ADCP (Acoustic Doppler Current Profiler) - Sontek RiverSurveyor M9
  - ADV (Acoustic Doppler Velocimeter) - Sontek Flowtracker2
- ADCP – deep & swift
  - depth, velocity
  - WSEL, position with GPS
- ADV – shallow & slow (transect edges, side channels)
  - velocity
  - depth with rod
  - WSEL, position with GPS

TRANSECT WITH COMBINATION OF EQUIPMENT

Transect D Aug. 2020

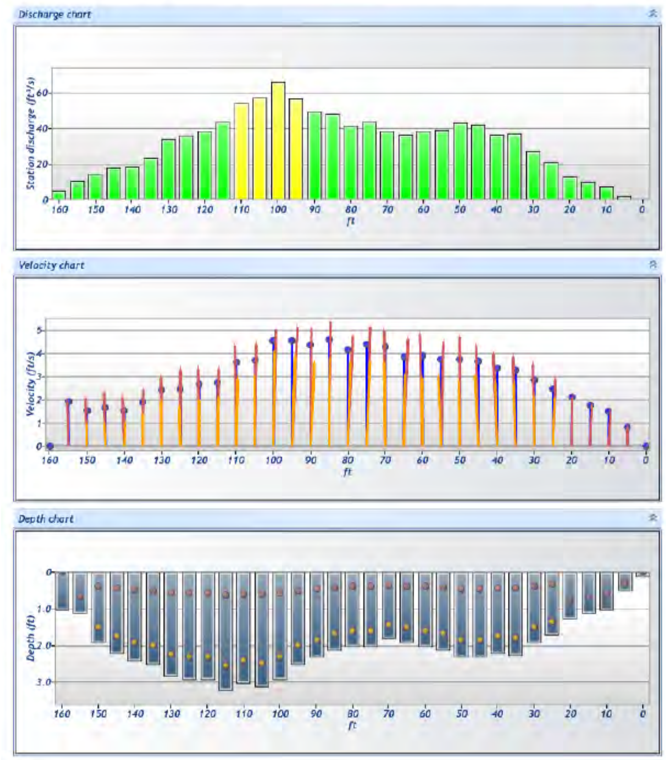


ADCP INSTRUMENTATION

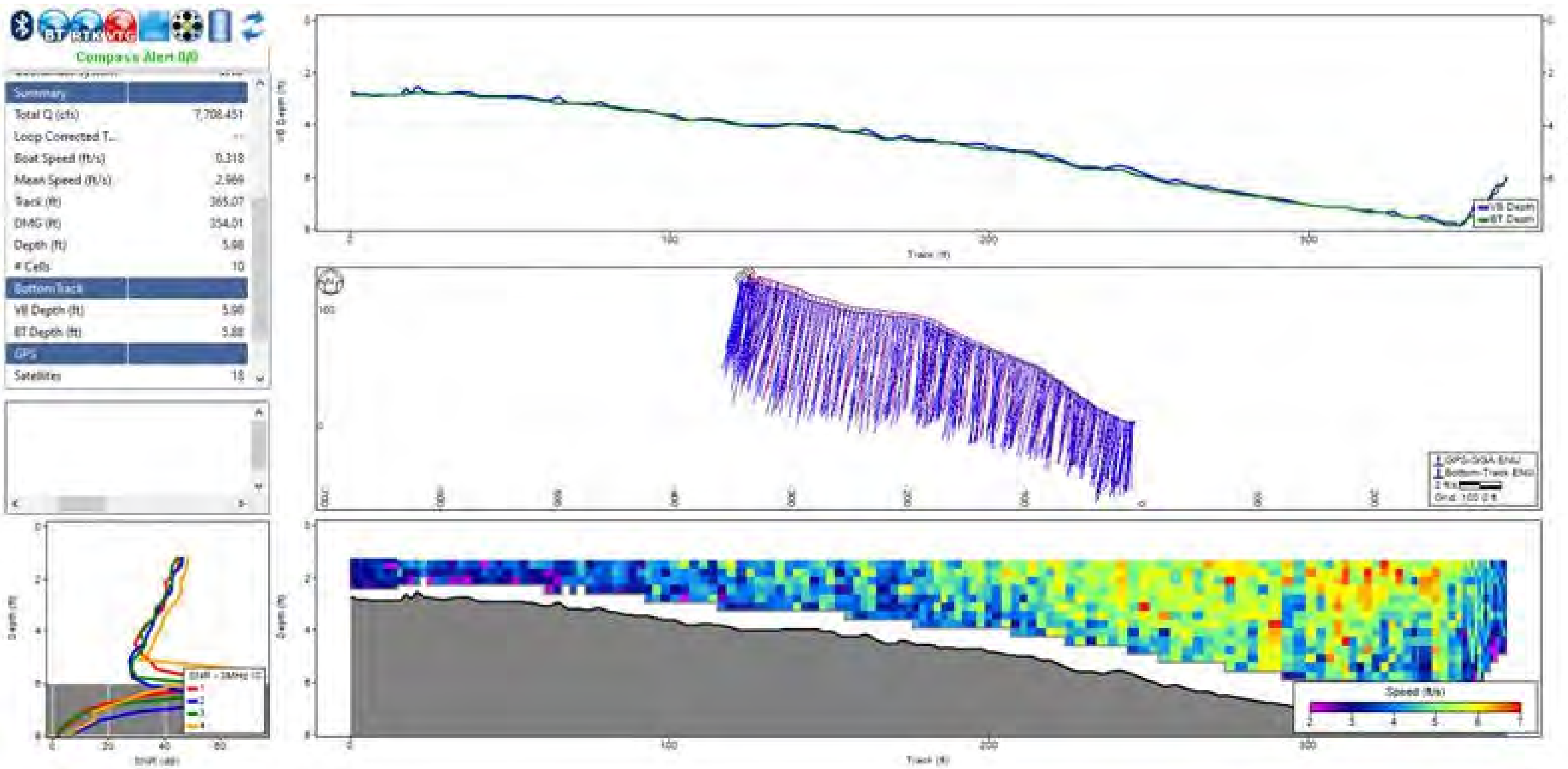


MEASUREMENT WITH ADV

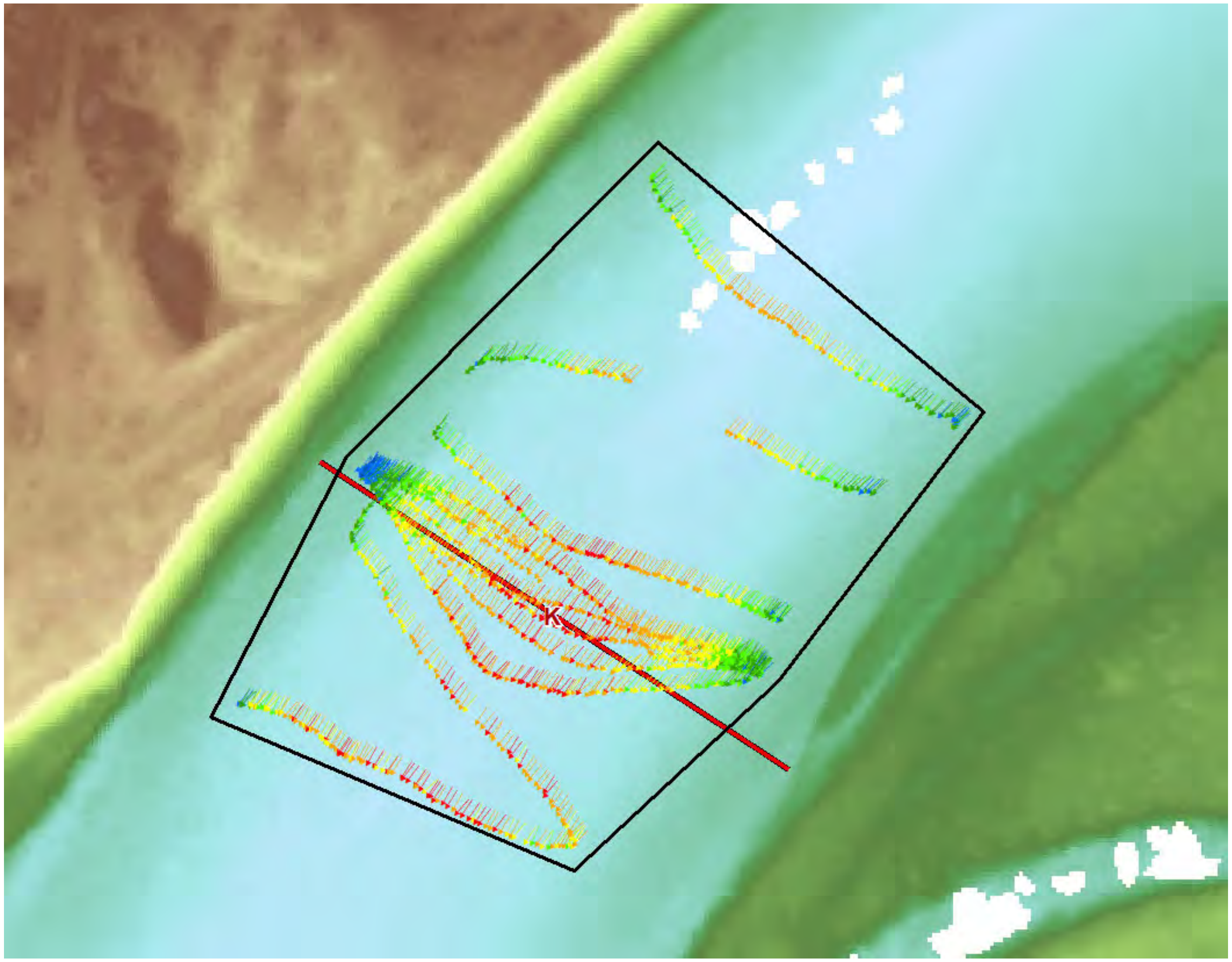
Station Warning Settings		
Station discharge OK	Station discharge < 5.00%	
Station discharge caution	5.00% >= Station discharge < 10.00%	
Station discharge warning	Station discharge >= 10.00%	



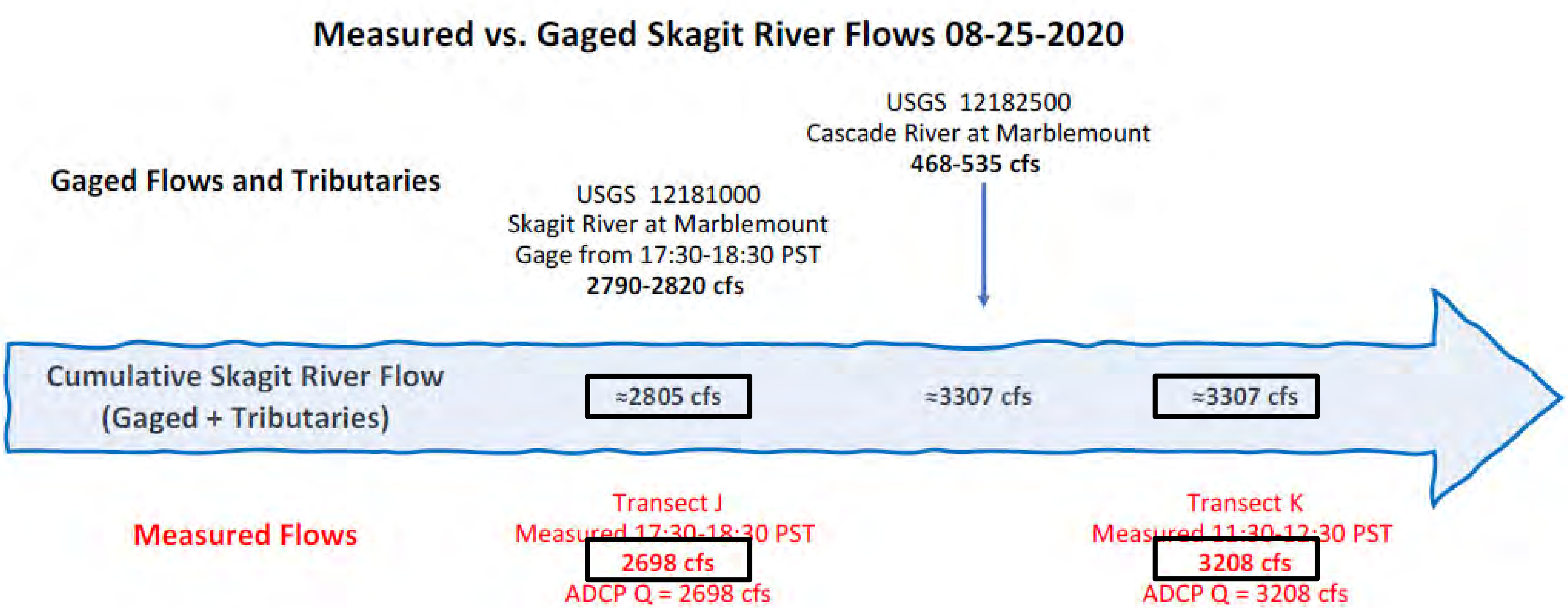
ADCP PROCESSING SCREEN



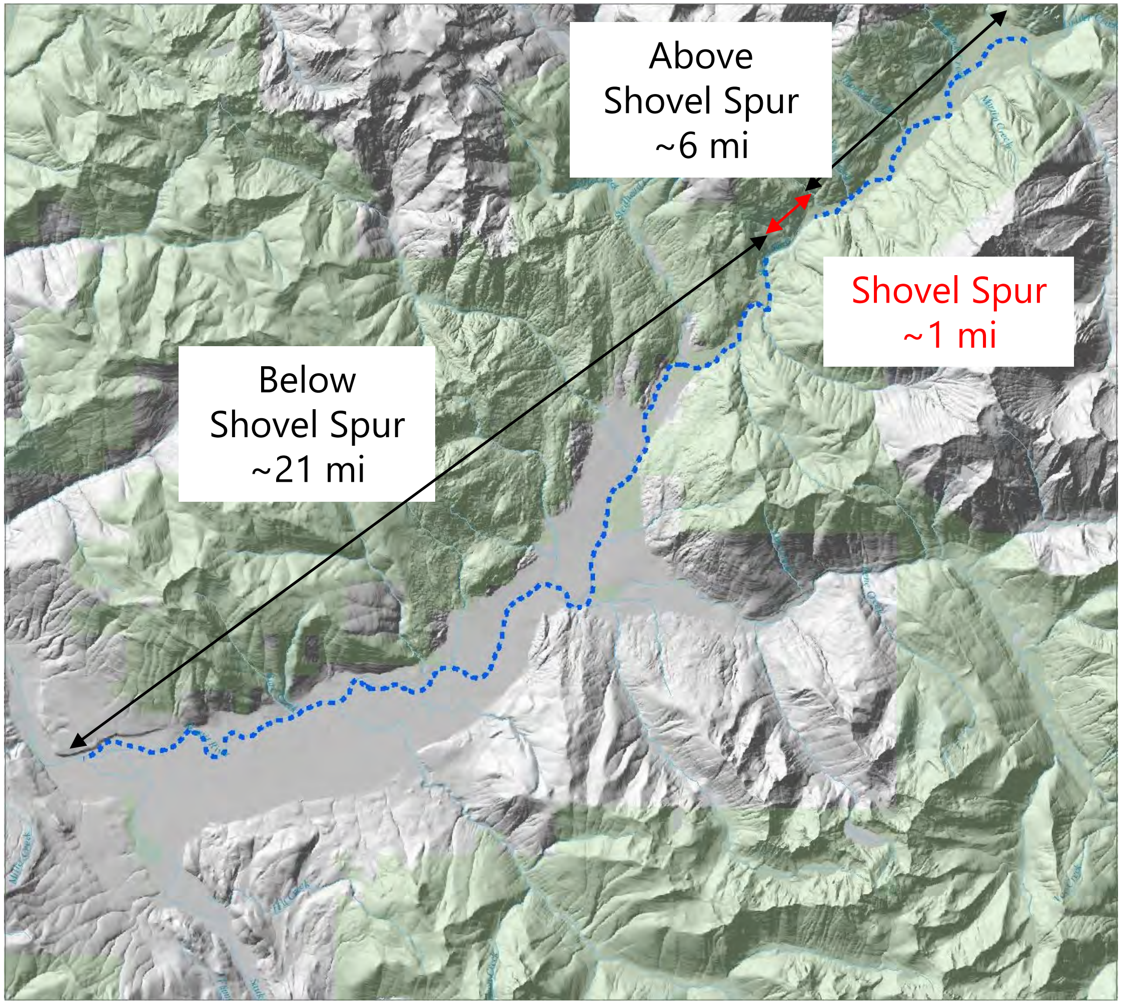
SAMPLE ADCP OUTPUT



EXAMPLE ADCP FLOWS

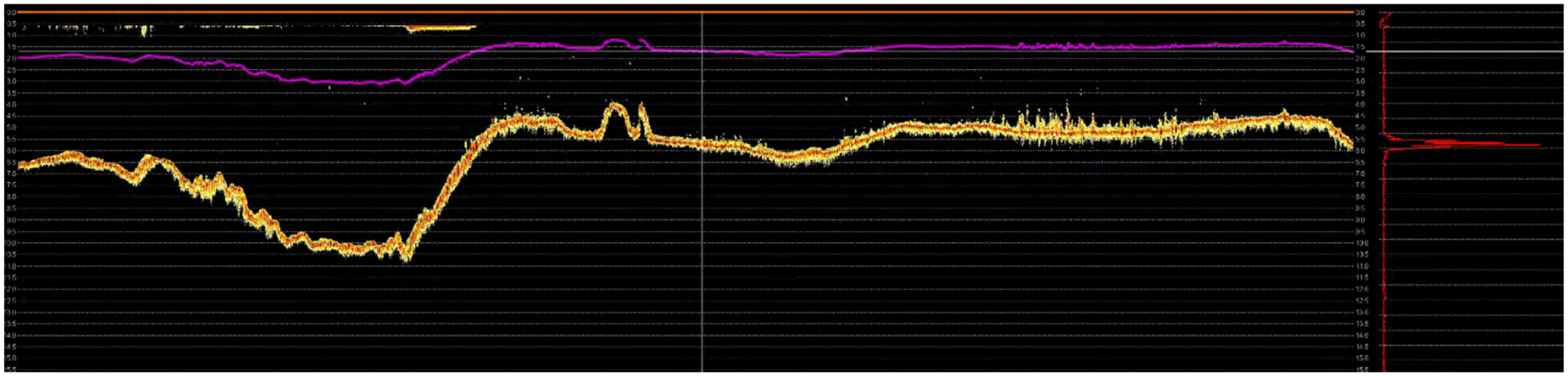


WSEL PROFILE EXTENTS

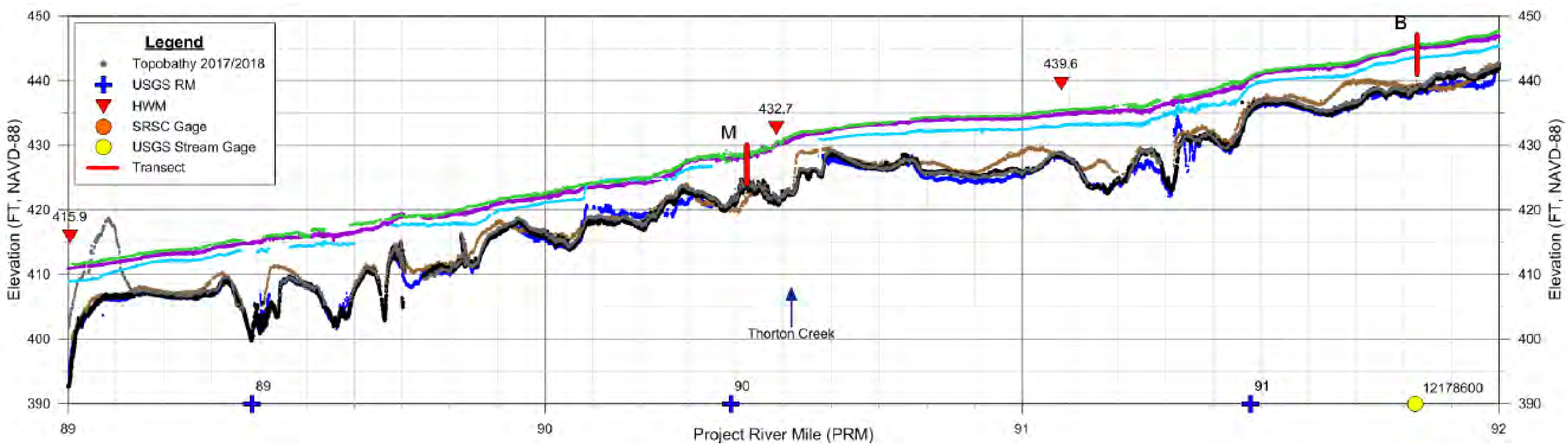


WSEL INSTRUMENTATION

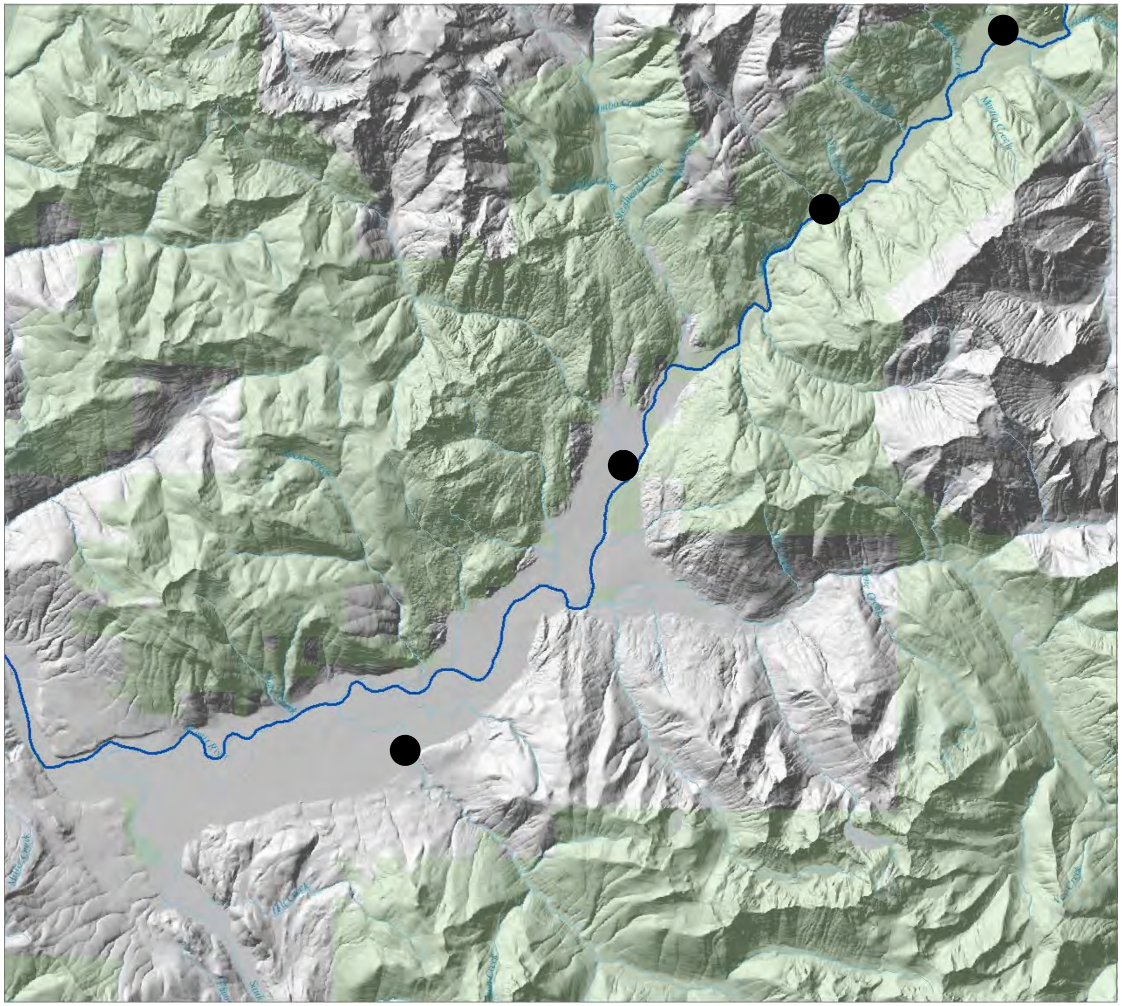
- CEE-ECHO single frequency transducer
  - o recorded WSEL and riverbed @ 6-12" intervals
- Data validation checks
  - o beginning/end of long profile surveys
- HYPACK
  - o processed raw elevations and filtered erroneous data



WSEL PROFILE SAMPLE



TRIBUTARY DISCHARGE MEASUREMENTS

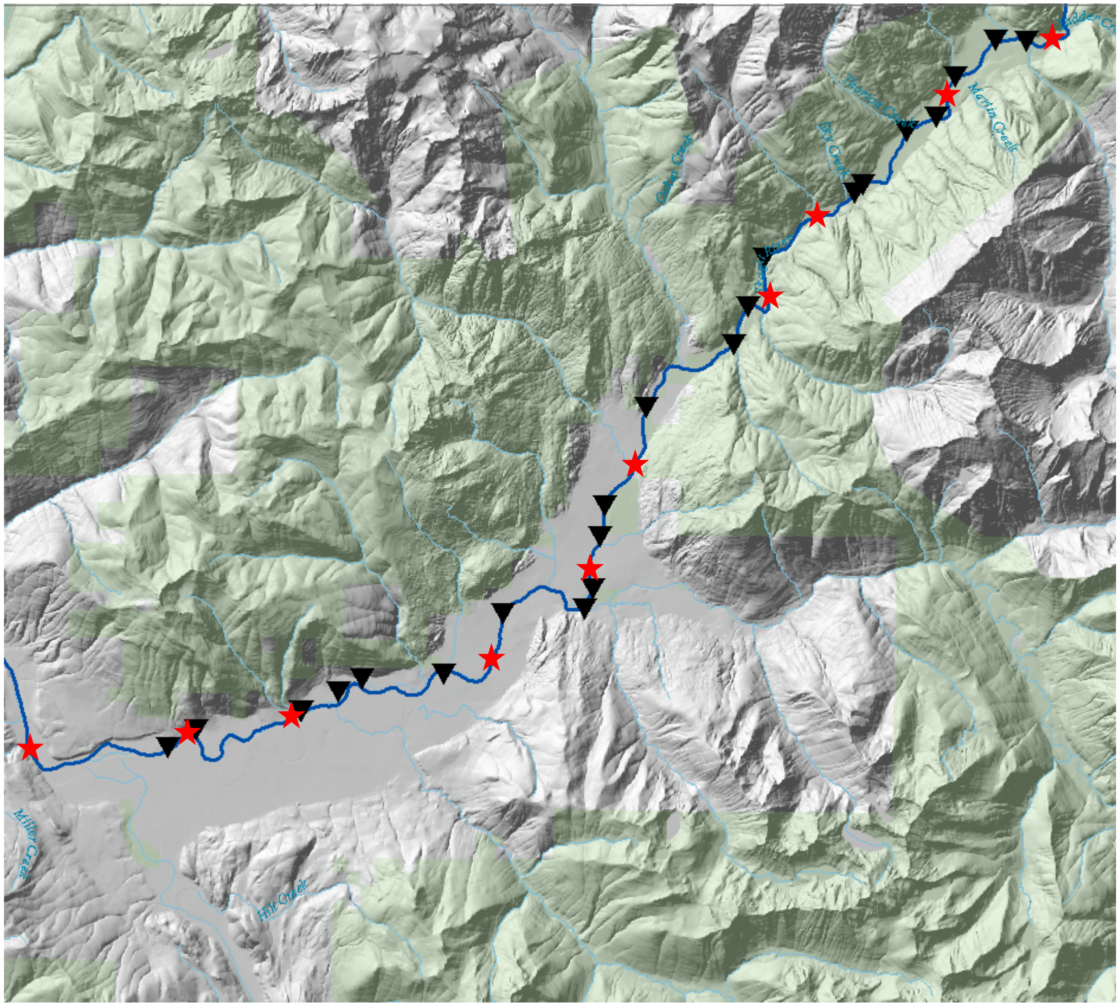


● Tributary Discharge Measurement

TRIBUTARY DISCHARGES

	August	October	March
Goodell Creek	118	507	93
Damnation Creek	8	65	18
Diobsud Creek	47	246	90
Illabot Creek	75	287	138
Skagit at Newhalem	2350	4200	6700

HIGH WATER MARKS – 11/5/2020



Surveyed Marks (19)

Continuous Gages (10)

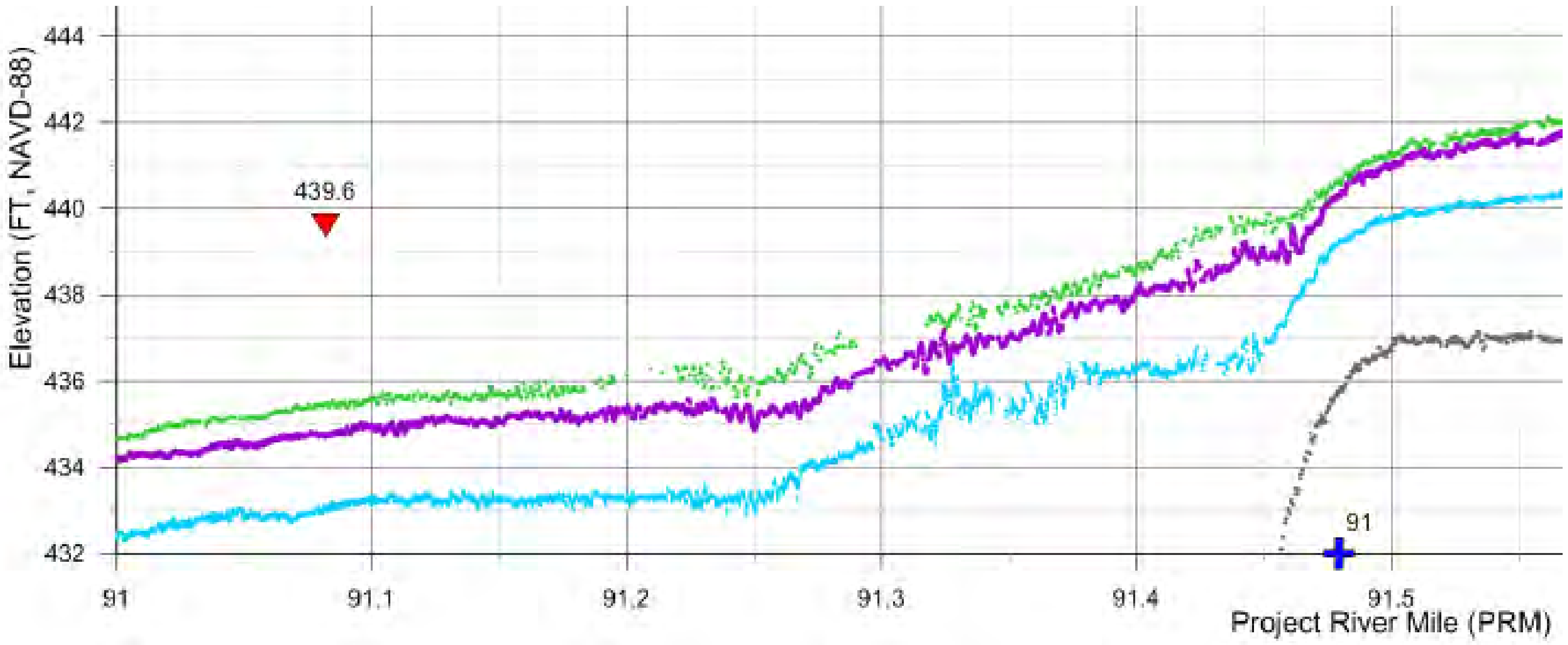
HIGH WATER MARK EXAMPLES

- Wash line

- Debris line

- Seed line

HIGH WATER MARK – PROFILE

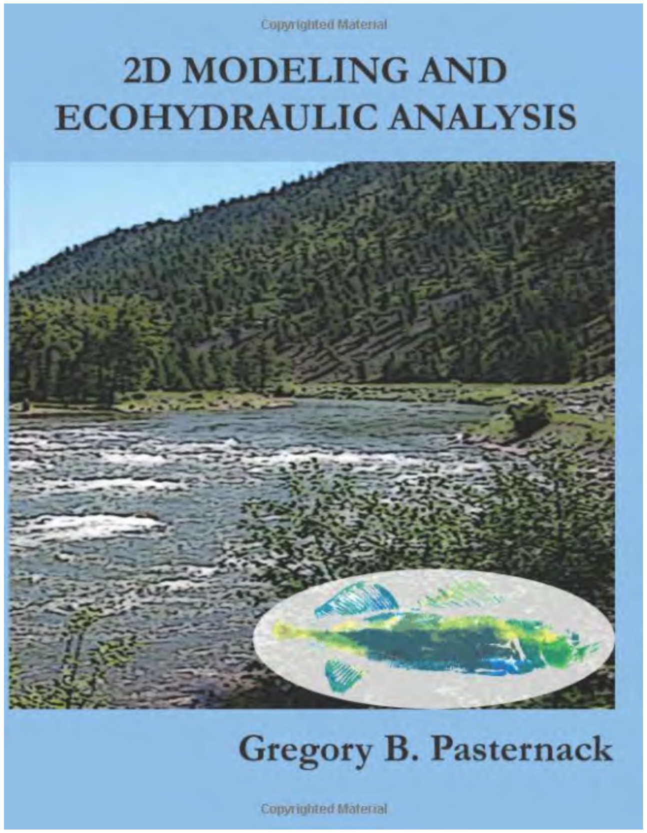


CALIBRATION PARAMETERS

- Once model setup/sensitivity complete
- Calibration
  - Roughness (Manning's n)
  - Turbulence
  - Boundaries (discharge)
  - Terrain (if necessary)

PERFORMANCE EVALUATION

- Performance evaluation standards lacking for 2D models
- Hurdle to wider adoption and acceptance
- Pasternack
  - http://pasternack.ucdavis.edu/
- Most common: WSEL, V_{mag}



PERFORMANCE EVALUATION

- Spatial distribution of hydraulics -> population
- Sub-sample ->population
- Evaluate model performance

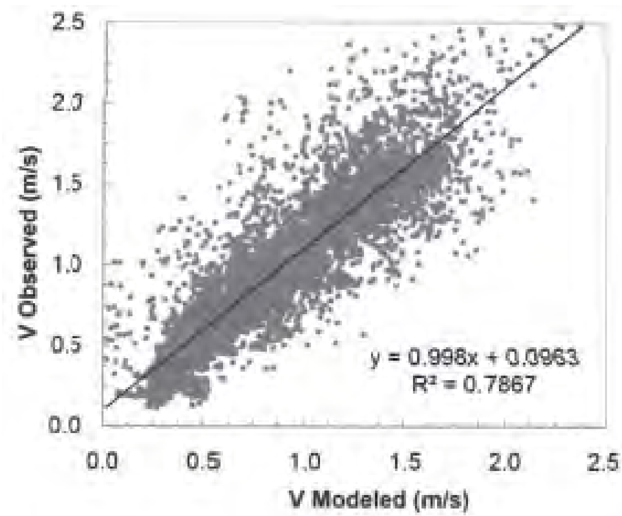
- <u>Deviation, correlation, regression statistics</u>
  - Performance Indicators
- Cross-section-based tests secondary value

QUANTITATIVE PERFORMANCE INDICATORS

- Observed vs. Modeled WSEL & V_{mag}
  - o Deviation statistics (raw, %)
  - o Coefficient of determination (r^2)
  - o Regression line slope ~1:1
  - o Zero intercept of regression line; offset?
  - o Relative cross-sectional pattern ->spatial associations model error
  - o Observed vs. Modeled hydraulic phase-space plots (D vs V_{mag})
    - compare probability distribution of depth, velocity
- NO quantitative standards for these performance indicators have been proposed or adopted through scientific consensus

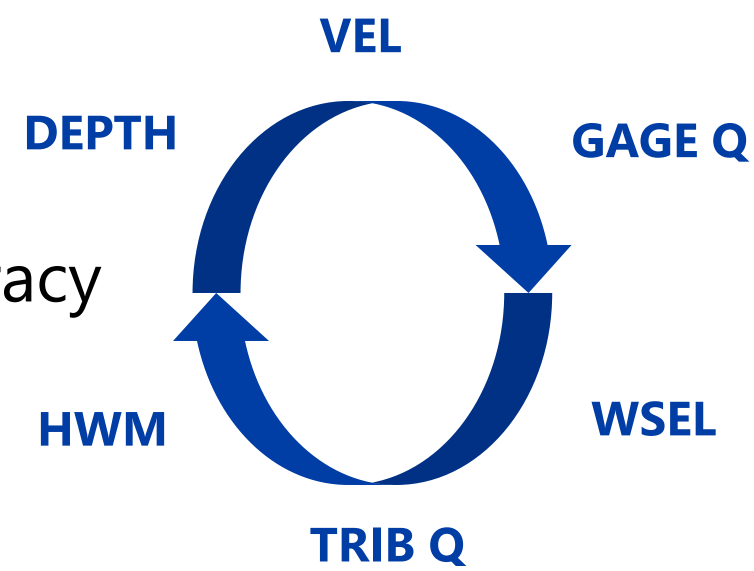
PERFORMANCE EVALUATION

- Lower Yuba River model
  - o 5,780 observations
  - o Extremely high correlation
  - o Model quality & large observation count
  - o 100-300 observations typical
  - o Number observations key
- Skagit observations
  - o Transects (~54,000 -> V_{mag}, WSEL)
  - o Long profiles (~495,000 -> WSEL)
    - (note output resolution)



PERFORMANCE EVALUATION

- Performance never perfect!
  - Uncertainty in observed data
  - Assumptions & simplifications in SWE and solution procedures
- Performance testing -> characterizing uncertainty
- LiDAR <u>submerged</u> vertical accuracy
  - 2018 - 0.37′ 95% confidence
  - 2017 - 0.54′ 95% confidence



Seattle City Light

DISCUSSION

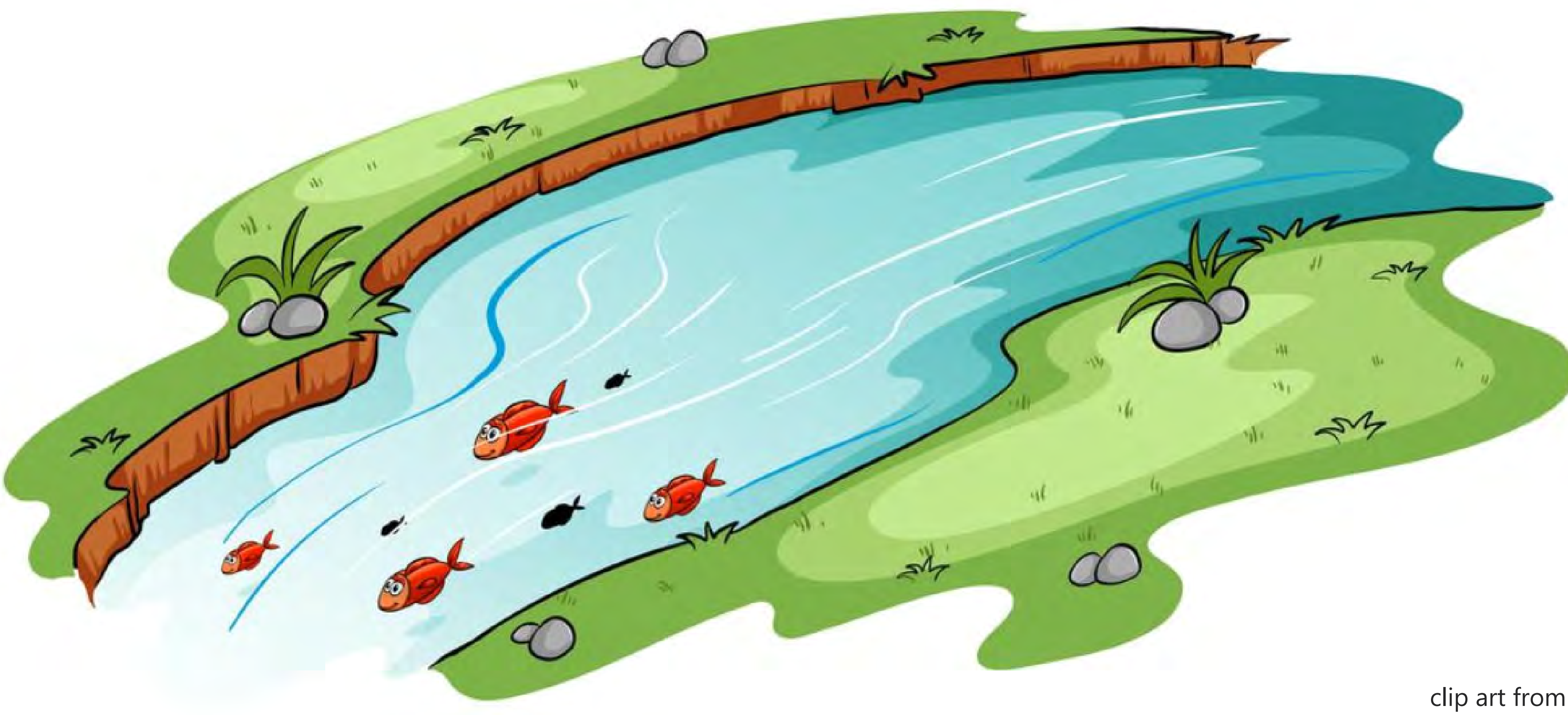
HYDRAULIC MODEL – OUTPUTS

Source Data	Model Layers	Run Parameters	Outputs
Terrain	Mesh	Time Step	Depth
Roughness	Breaklines	Initial Conditions	Velocity
Flow Data	Structures	Solution Equation	WSEL
Geospatial Layers	Boundary Conditions	Turbulence	Rating Curve
			Etc.

OVERLAY PARAMETERS

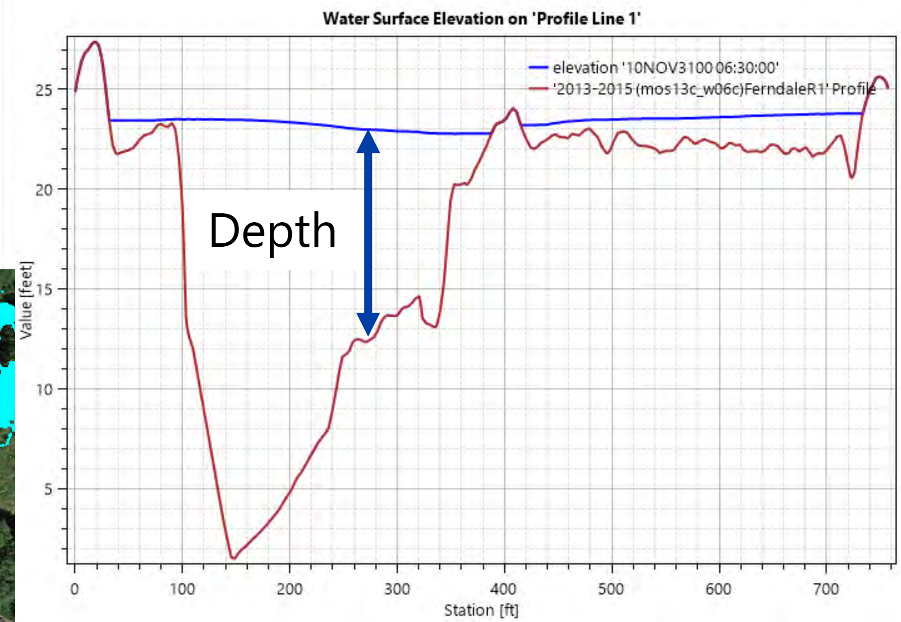
Hydraulic Properties
- Depth
- Velocity

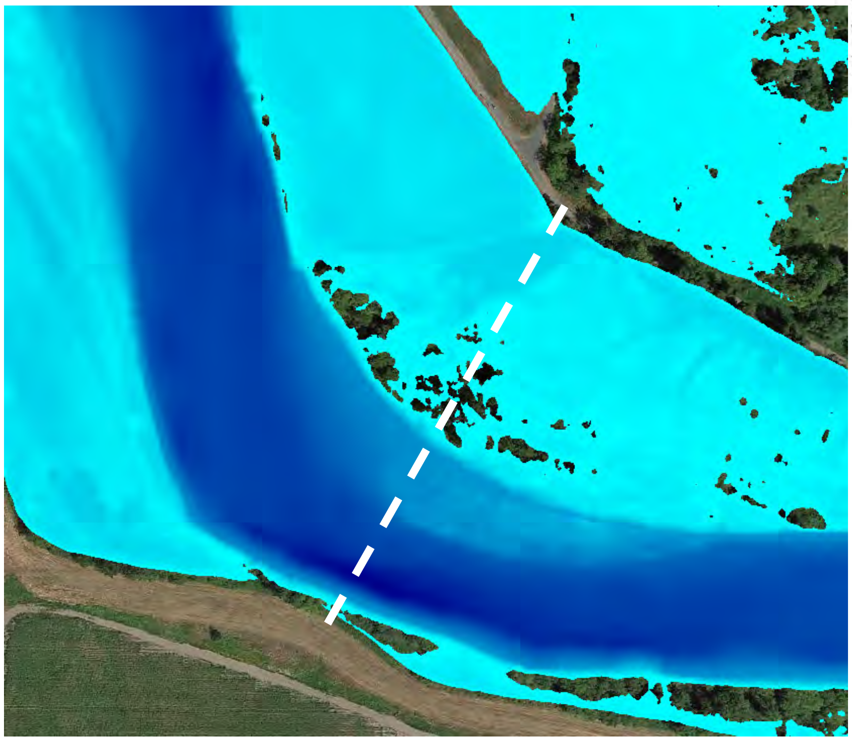
River Character
- Substrate
- Cover



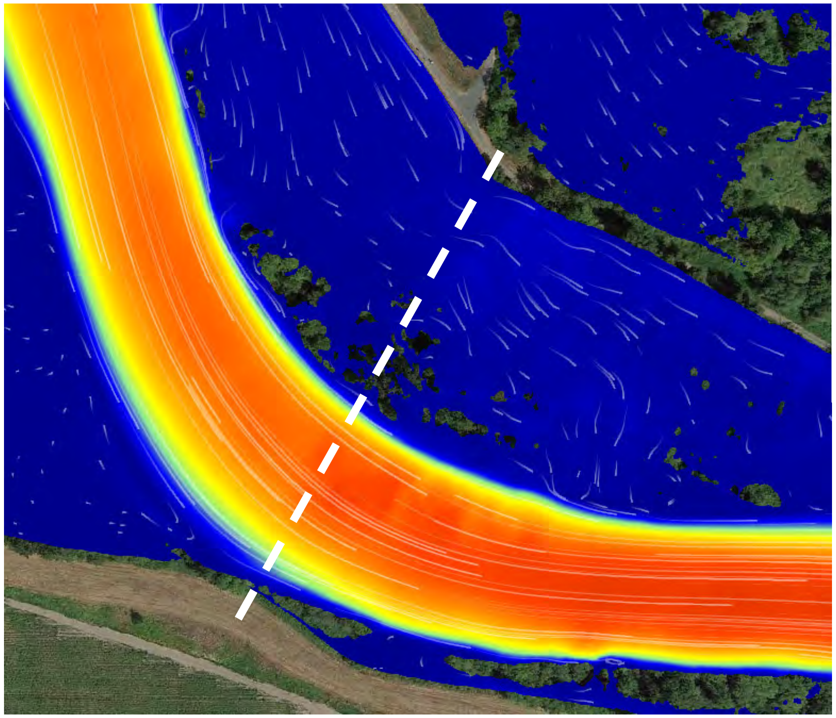
clip art from Vecteezy.com

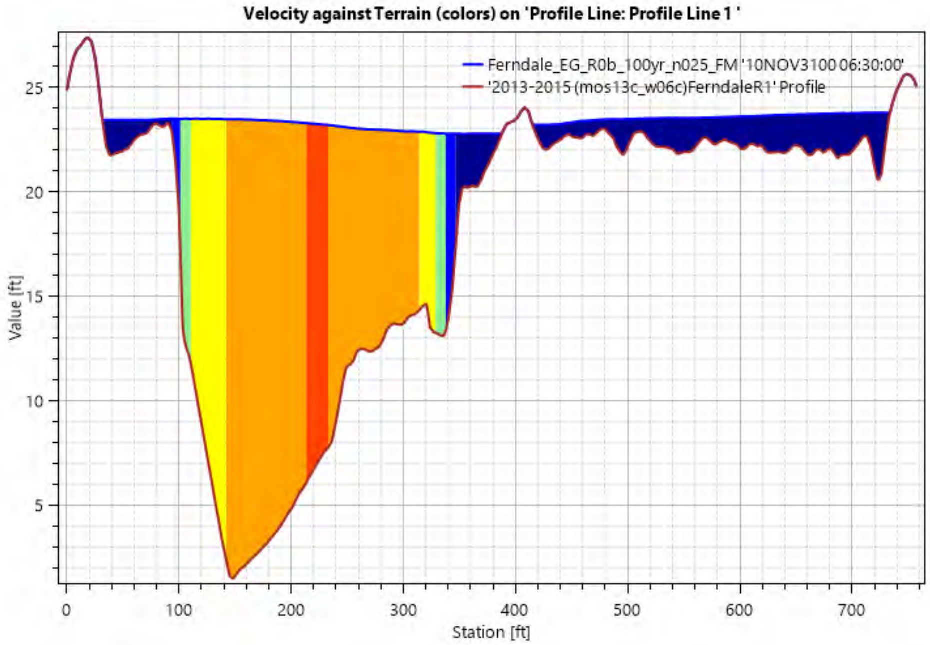
2D OUTPUT - DEPTH





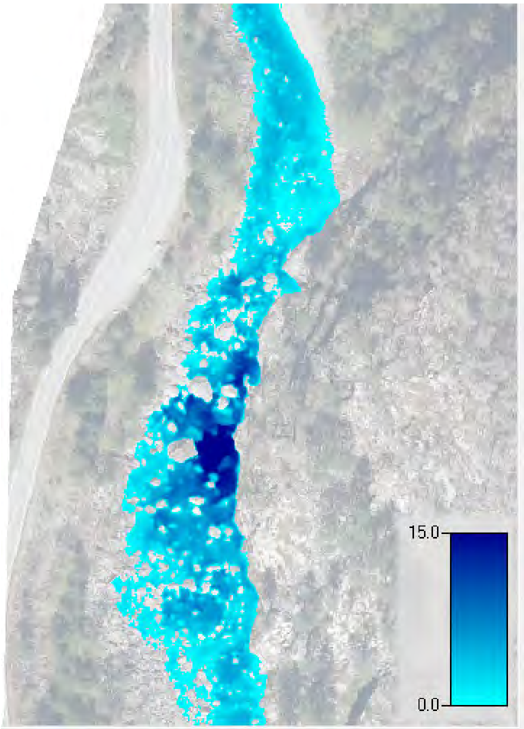
2D OUTPUT - VELOCITY



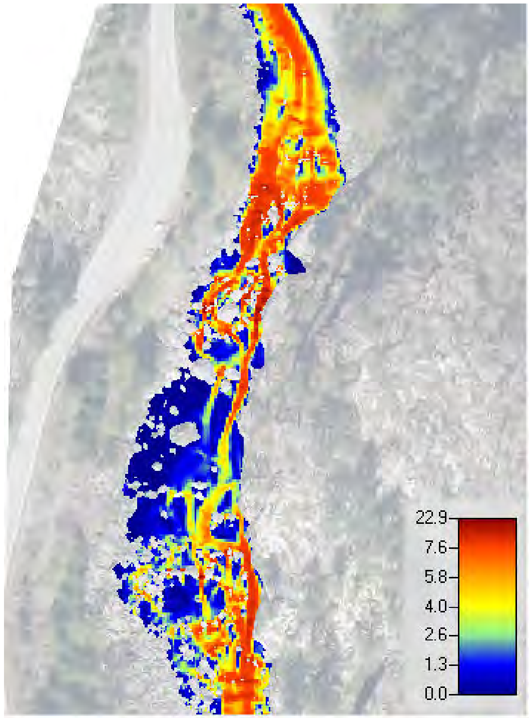


2D OUTPUT – RASTER FORMAT

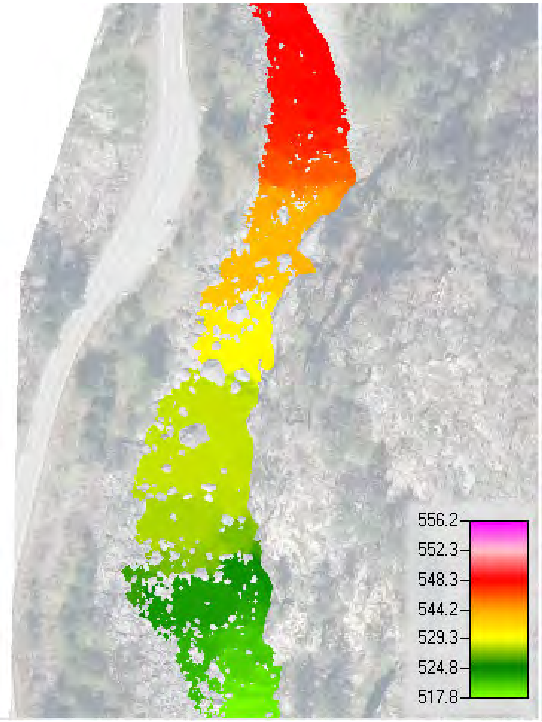
Depth



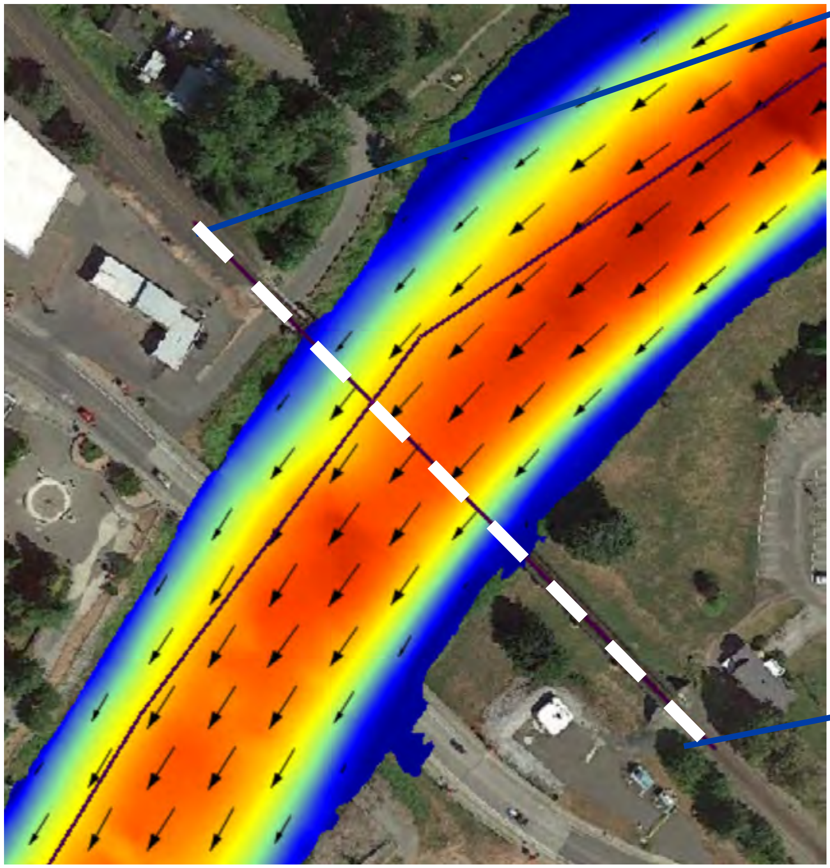
Velocity

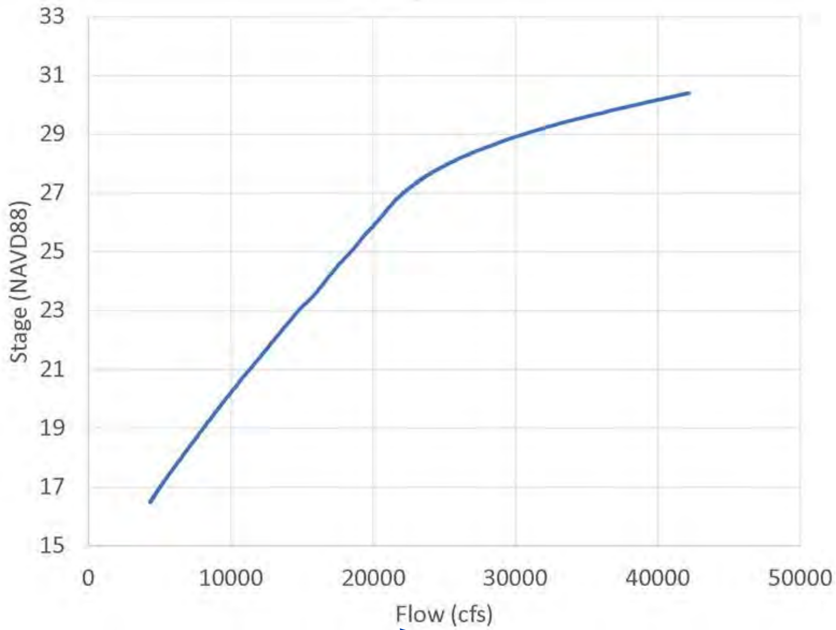


WSEL



MODEL OUTPUT – RATING CURVE





- Stage vs. Discharge

Seattle City Light

DISCUSSION

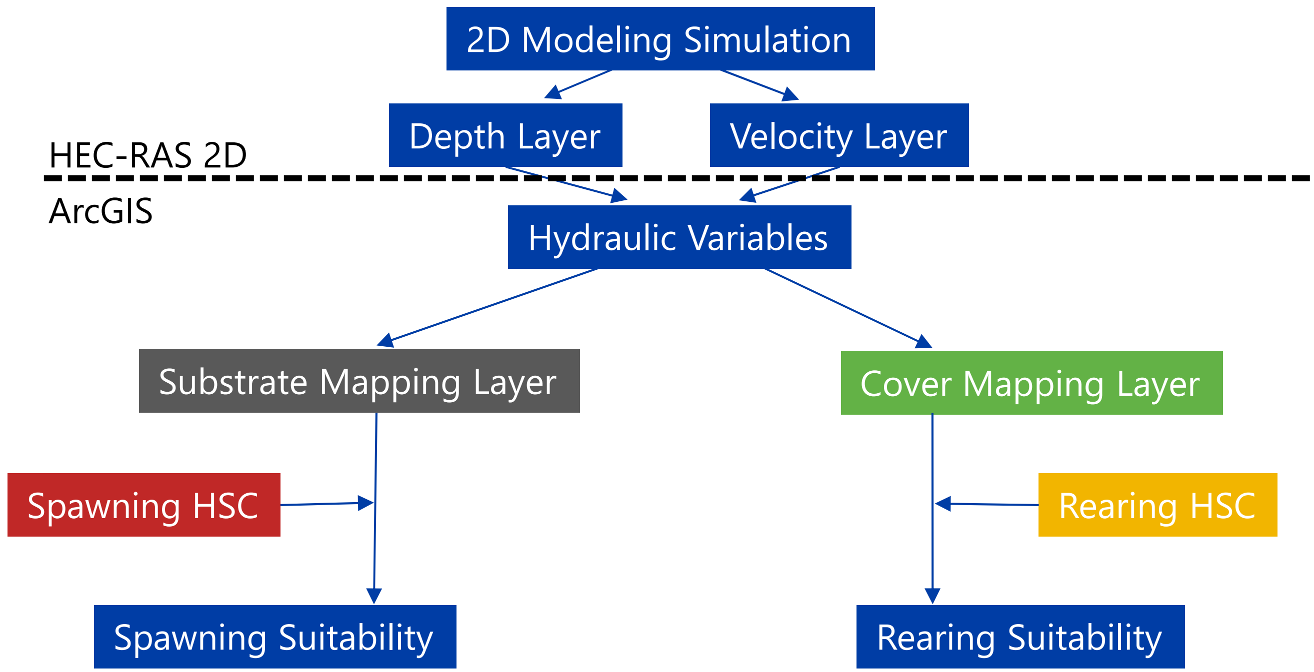
BIOLOGICAL AND HABITAT METRICS

Habitat suitability criteria (HSC) and periodicity

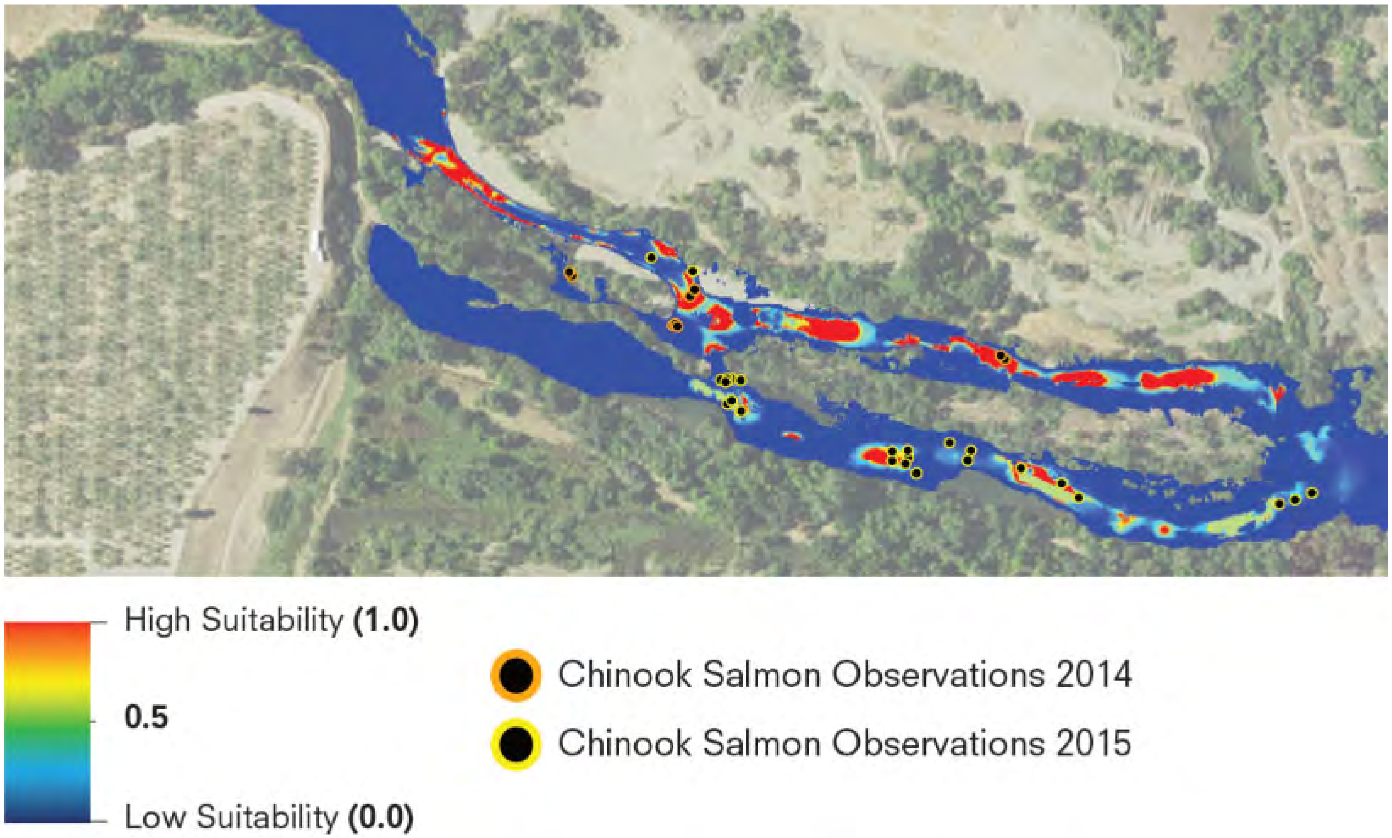
HSC AND PERIODICITY WORKSHOPS - OVERVIEW

- Workshops will be used to review (and potentially modify) existing/available HSC, identify data gaps, and determine how to address those gaps.
    - Additional literature review
    - Application of available field study data
    - Targeted field validation
    - Comparison of habitat model results to field observations
- Workshops will also review (and potentially modify) the appropriate periodicity (i.e., time of year) to be modeled for each species and life stage.

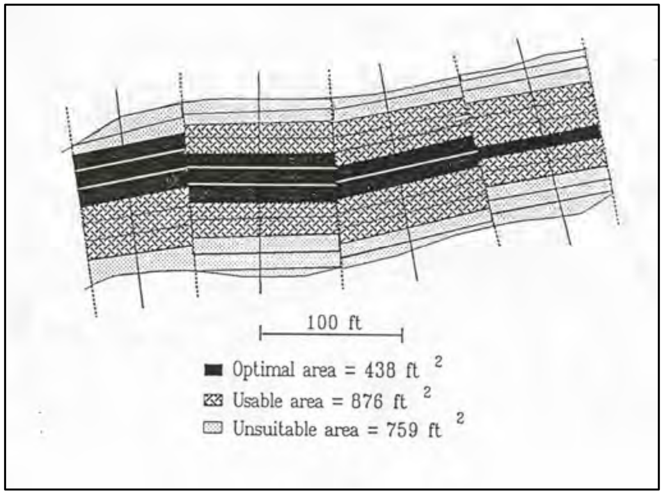
2D MODELING HABITAT SUITABILITY PROCESSING

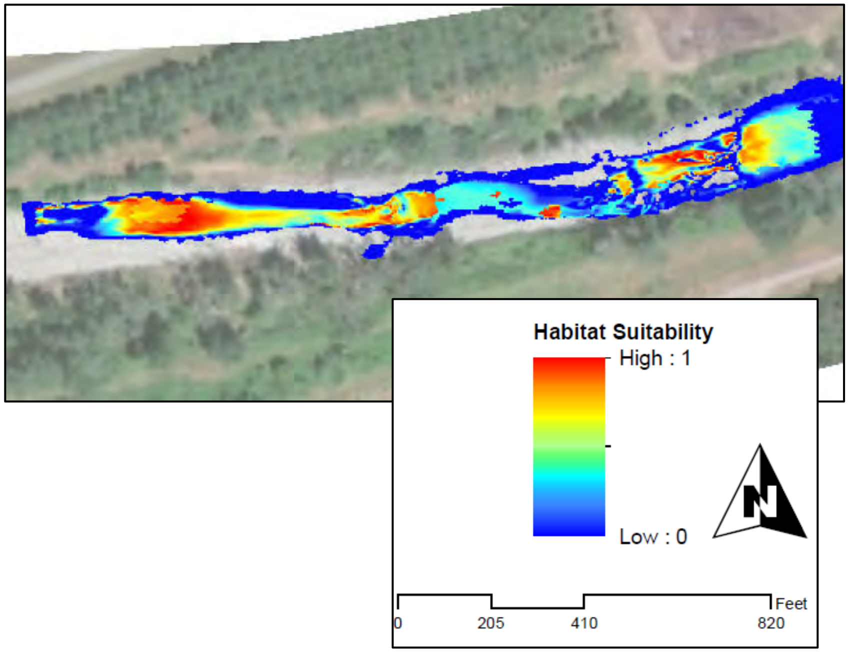


SPAWNING SUITABILITY PRODUCT



HABITAT MODELING RESULTS - USABLE AREA





SPECIES OF INTEREST

Previous Relicensing Studies
- Chinook
- Pink
- Chum
- Steelhead
- Coho
- Rainbow Trout
- Dolly Varden
- Cutthroat Trout
- Mountain Whitefish

Added from LP Comments
- Sockeye
- Sea-Run Bull Trout
- Resident Cutthroat Trout
- Sea-Run Cutthroat Trout
- Pacific Lamprey
- Western Brook Lamprey
- Salish Sucker

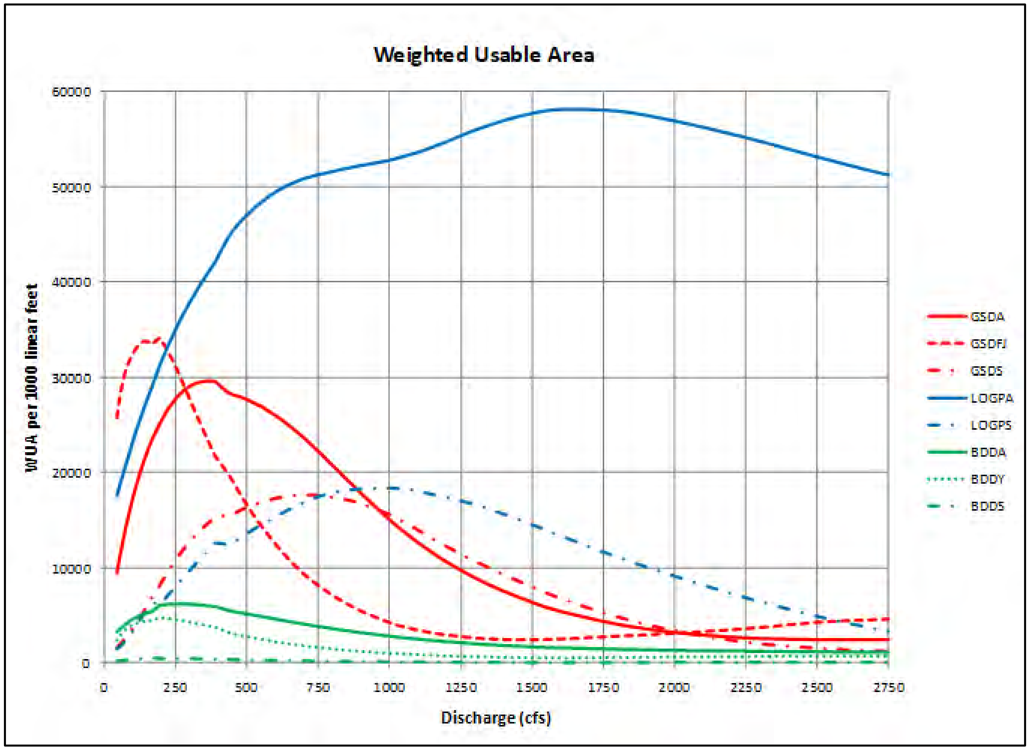
Seattle City Light

DISCUSSION

HABITAT MODELING - OVERVIEW

- All species of interest will be modeled, but we anticipate not all will drive flow management decisions, for example:
  - Habitat modeling results for several species may overlap
  - The amount of available habitat may not be sensitive to changes in flow
  - Habitat may be minimal regardless of flow
- During HSC review and selection process, groupings for some species may start to become apparent in advance of modeling results.
- During the modeling process, species sensitivity to flow changes will become apparent.

FLOW TO HABITAT CONVERSION



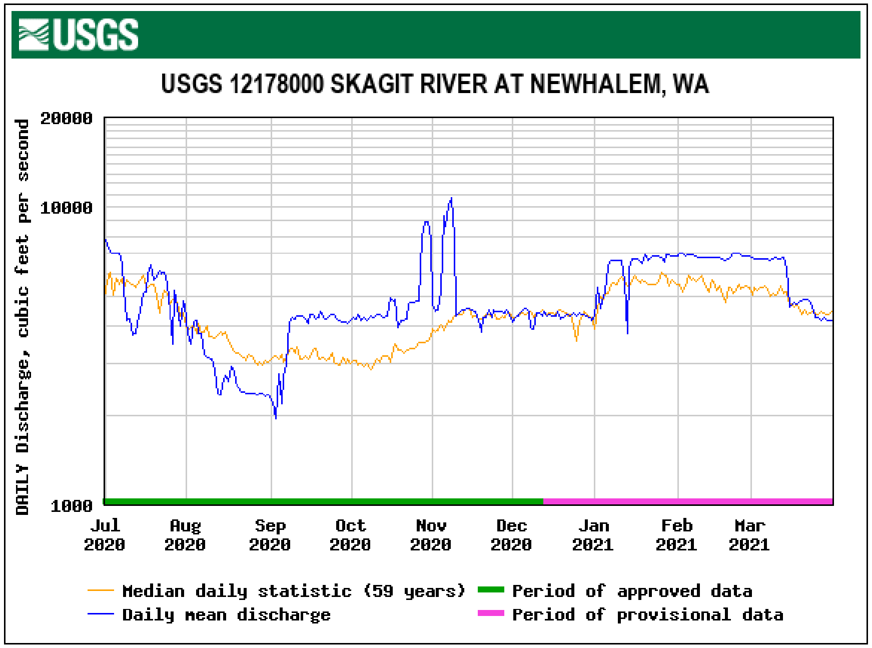
Flow (cfs)	WUA (sq ft)
100	17,797
200	45,399
400	103,250
700	160,229
850	175,466
1,000	186,424
1,300	201,513
1,600	222,192
1,900	237,339
2,200	244,524
2,425	248,115
2,500	249,012
2,800	251,654
3,250	253,453
3,700	254,366
3,850	254,003
4,000	253,375
6,000	216,044
10,000	107,434
14,000	32,198
18,500	13,367
23,000	8,345

PERIODICITY

- Periodicity introduces a seasonal component to the habitat modeling effort.

Species	Life History	Life Stage: Age	Life Stage: Stage	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep	Oct.	Nov.	Dec.
Chinook	Spring/Summer - NF/MF Early	Adult	Upstream migration / holding												
		Adult	Spawning												
		Incubation	Intragravel development												
		0	Rearing												
		0	Outmigration												
		1+	Rearing												
		1+	Outmigration												
Coho		Adult	Upstream migration / holding												
		Adult	Spawning												
		Incubation	Intragravel development												
		Fry <55mm	Rearing												
		Juvenile	Rearing												
		Juvenile	Outmigration												
Chum	SF/Mainstem +	Adult	Upstream migration / holding												
		Adult	Spawning												
		Incubation	Intragravel development												
		Fry													
		Juvenile	Outmigration												
Pink	Odd year	Adult	Upstream migration / holding												
		Adult	Spawning												
		Incubation	Intragravel development												
		Fry													
		Juvenile	Outmigration												
Sockeye	Stream type	Adult	Upstream migration / holding												
		Adult	Spawning												
		Incubation	Intragravel development												
		Fry/Juvenile	Rearing												
		Juvenile	Outmigration												
Steelhead	Summer	Adult	Upstream migration												
		Adult	Holding												
		Adult	Spawning												
		Adult	Outmigration												
		Incubation	Intragravel development												
		Fry <"55mm													
		Incubatio	Intragravel												
		Fry/Juvenil	Rearing												
		Juvenile	Outmigration												

TIME SERIES ANALYSIS



Seattle City Light

DISCUSSION

HSC SPECIFIC GOALS FOR WORKSHOP 1

- Describe HSC information that has been gathered to date.
  - Original ESH curves, Skagit specific and consensus based
  - Ecology statewide curves
  - Curves from other sources
- Literature based habitat information.
- Discuss additional data resources that may inform HSC.
  - Seattle City Light/FCC/NCC activities
  - Other programs/research activities

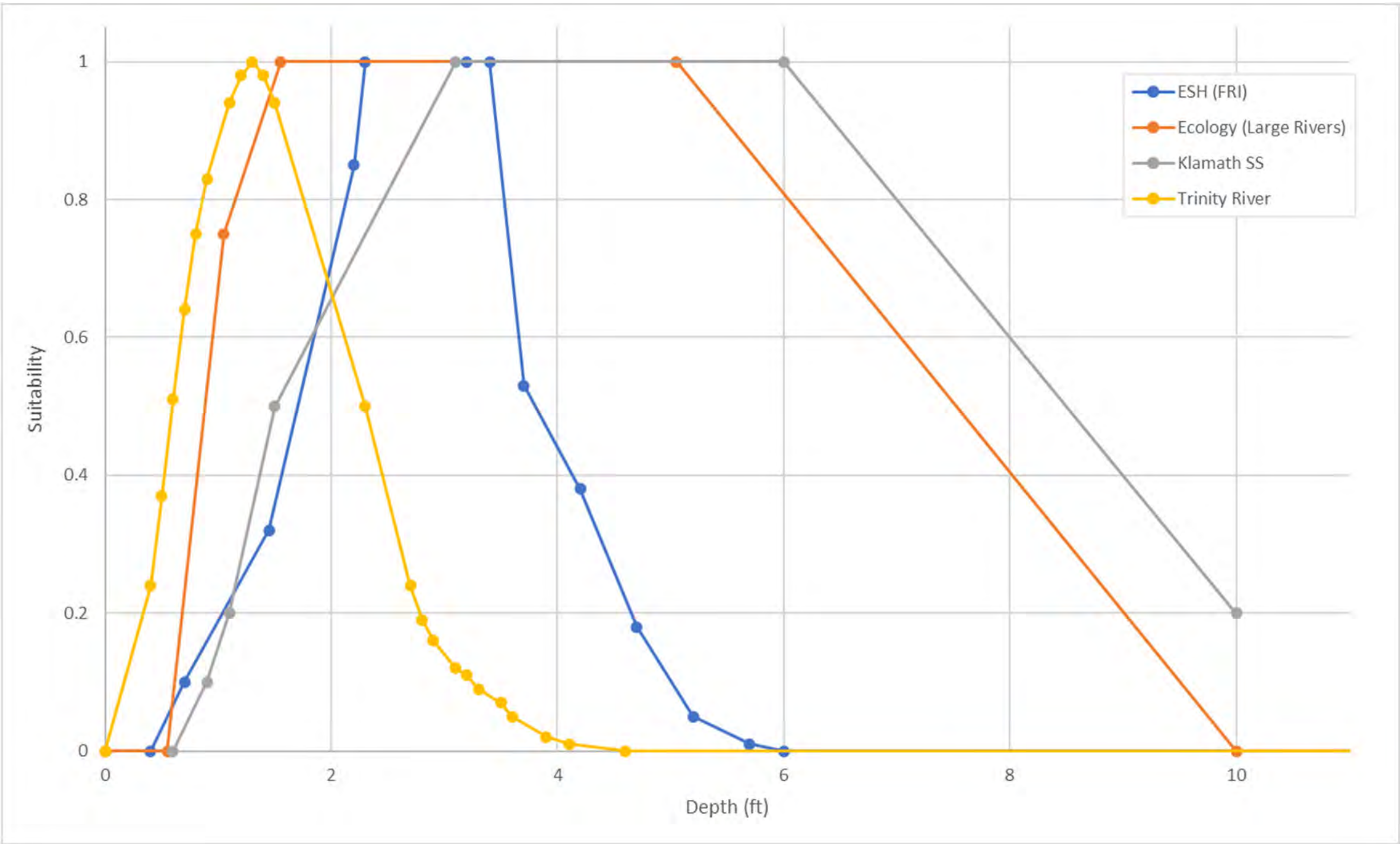
COMPILED HSC – PREVIOUSLY MODELED SPECIES

Species	Life Stage	ESH Habitat Suitability Criteria (HSC)	Ecology HSC (x=available)	Additional Compiled HSC (to date)			Further Additional HSC Resources
Chinook	Spawning	Skagit Specific	X	Klamath	Klamath (Hardin et al.)	Trinity	Klamath, Hardy and Addley (2001) (Spawning and Fry)
	Juvenile	--	X	Klamath (Hardin et al.)	Trinity	Fraser	
	Fry	Skagit Specific and WDF	--	Klamath	Trinity	Fraser (0+)	
Pink	Spawning	Skagit Specific	X				
Chum	Spawning Mainstem	Skagit Specific	X				Fraser (0+)
	Spawning Side Channel	Skagit Specific	Same as above				
Steelhead	Spawning	Skagit Specific	X	Trinity			
	Fry	Bovee	--	Trinity	Fraser (0+)		
	Juvenile	FWS, WDG, Bovee	X	Trinity	Fraser		Klamath, Hardy and Addley (2001) (1+)
	Adult	Bovee	--	Trinity			
Coho	Spawning	WDF, Bovee	X	Trinity			
	Fry	Bovee	--	Trinity			
	Juvenile	FWS, WDF	X	Trinity			
Rainbow Trout	Spawning	Bovee	X	Klamath (Allen)			
	Fry	Bovee, WDG	--	Fraser (0+)	Klamath (Allen)		
	Juvenile	Bovee, WDG	X	Fraser	Klamath (Allen)		
	Adult	Bovee, WDG	X	Klamath (Allen)			
Dolly Varden	Spawning	AEIDC	Dolly Varden/bull trout				
	Fry	AEIDC	--				
	Juvenile	AEIDC	Dolly Varden/bull trout				
Cutthroat Trout	Spawning	Bovee	X				
	Fry	WDG	--				
	Juvenile	Bovee, WDG	X				
	Adult	Bovee, WDG	--				
Mountain Whitefish	Spawning	Bovee	X				
	Fry	Bovee	--	Fraser			
	Juvenile	Bovee, WDG	--	Fraser			
	Adult	Bovee, WDG	--				

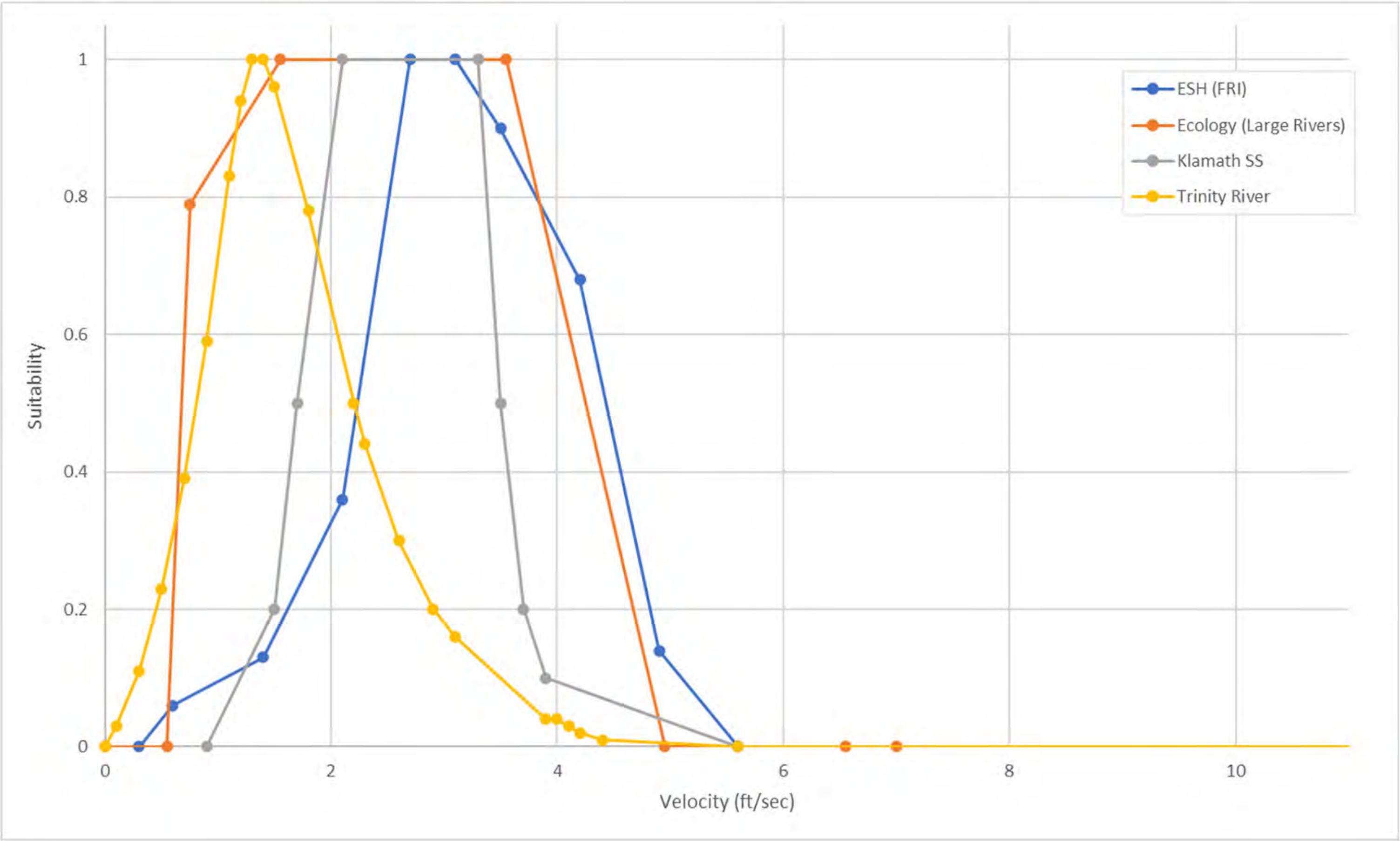
LICENSE PARTICIPANT REQUESTED SPECIES

Species	Relevant HSC Identified	Tabular Data Identified	Additional Supporting Literature
Sockeye	Limited	Ecology Spawning, Fraser (0+)	
Sea-Run Bull Trout	Limited	Ecology Spawning and Juvenile	Baxter and McPhall (1996)
Resident Cutthroat Trout	Limited	Ecology and ESH Curves	Hickman and Raleigh (1982), Katopodis and Gervais 2016*
Sea-Run Cutthroat Trout	Limited	Ecology and ESH Curves	Losee et al. (2016)
Pacific Lamprey	Limited	Lower Merced, Vadas (2013)*	Ample supporting literature
Western Brook Lamprey	None	Vadas (2013)*	Ample supporting literature
Salish Sucker	None	--	Various life history publications in process of review

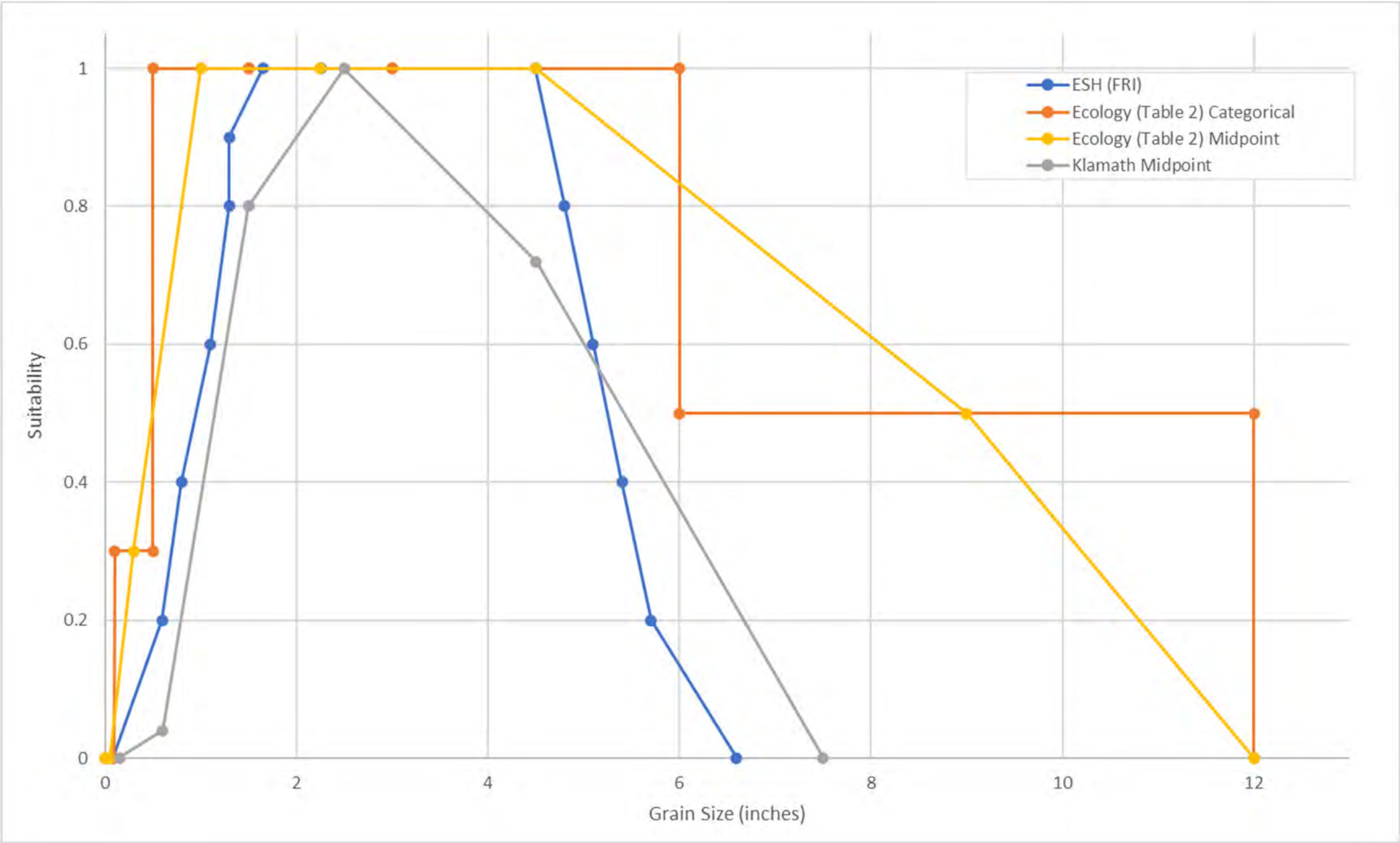
CHINOOK SPAWNING DEPTH – EXAMPLE SELECTION MATERIAL



CHINOOK SPAWNING VELOCITY



SPAWNING SUBSTRATE



Seattle City Light

DISCUSSION

HSC AND PERIODICITY NEXT STEPS

- Collaboration on process for HSC selection.
  (Possible subtopics – curve priority, species list, life stages)
- Collaboration on process to determine final periodicity.
- Begin to discuss targeted field validation.
  (Possible subtopics – key concerns, constraints, opportunities, LOE, timing)
- Separate HSC/Periodicity discussions from hydraulic model discussions and front-load schedule (additional May meetings).

Memo

Date:	Monday, April 26, 2021
Project:	Skagit River Hydroelectric Project (Skagit Project) FERC Relicensing
To:	Erin Lowery and Jeff Fisher (City Light); Jenna Borovansky and Matt Wiggs (HDR); Bao Le (HEC); License Participants
From:	Thomas DeGabriele, HDR
Subject:	Introduction to Skagit HSC and Periodicity Summary Table

The habitat suitability criteria (HSC) and periodicity summary tables identify relevant information that has been compiled to date for review and discussion during upcoming instream flow stakeholder workshops. Additional sources of information identified or made available by Seattle City Light and License Participants, will be reviewed during the stakeholder workshop process and included as appropriate.

HSC data are an important component of many instream flow habitat modeling efforts, including the Skagit, and there are several approaches that can be used to select and/or develop HSC depending on the scope of the project and availability of existing information. These approaches include HSC based on literature and best professional judgement, HSC based on physical and hydraulic measurements made in the field, and HSC based on field measurements and adjusted for habitat availability to reflect species preference more accurately.

It is important to note that HSC developed for some species and life stages may not be representative of the Skagit River as they may be from different geographic regions and/or smaller streams (compared to the Skagit River). In addition, HSC that have been modified (using a consensus-based process) to support other instream flow habitat modeling projects, have not been included in this summary. The intent of this exclusion is to prevent the professional judgement and consensus determinations from other working groups and instream flow modeling efforts from influencing HSC selection for the Skagit River instream flow study.

The HSC compiled to date and detailed in the summary table include those used in the Skagit River Interim Agreement Studies Instream Flow Fish Habitat Analysis (Crumley and Stober 1984) also referred to as the Effective Spawning Habitat (ESH) model, HSC identified in the Washington State Instream Flow Guidelines (WDFW and WDOE 2016), and other HSC from field-based HSC development efforts from larger streams.

Previously Included in the Effective Spawning Habitat (ESH) Model

Species	Life Stage	ESH Habitat Suitability Criteria (HSC)	Ecology HSC (x=available)	Relevant[1] HSC Availability	Additional Compiled HSC (to date)			Periodicity		Further Additional HSC Resources
								ESH	Nooksack	
Chinook	Spawning	Skagit Specific	X	Ample	Klamath	Klamath (Hardin et al.)	Trinity	WDF, WDG, FRI	X	Klamath, Hardy and Addley (2001) (Spawning and Fry)
	Juvenile	--	X		Klamath (Hardin et al.)	Trinity	Fraser		X	
	Fry	Skagit Specific and WDF	--		Klamath	Trinity	Fraser (0+)	WDF, WDG, FRI	X	
Pink	Spawning	Skagit Specific	X	Limited				WDF, WDG, FRI	X	
Chum	Spawning Mainstem	Skagit Specific	X	Limited				WDF, WDG, FRI	X	Fraser (0+)
	Spawning Side Channel	Skagit Specific	Same as above					WDF, WDG, FRI	X	
Steelhead	Spawning	Skagit Specific	X	Ample	Trinity			WDF, WDG, FRI	X	
	Fry	Bovee	--		Trinity	Fraser (0+)		WDF, WDG, FRI	X	
	Juvenile	FWS, WDG, Bovee	X		Trinity	Fraser		WDF, WDG, FRI	X	Klamath, Hardy and Addley (2001) (1+)
	Adult	Bovee	--		Trinity			WDF, WDG, FRI	X	
Coho	Spawning	WDF, Bovee	X	Good	Trinity			Consensus	X	
	Fry	Bovee	--		Trinity			Consensus	X	
	Juvenile	FWS, WDF	X		Trinity			Consensus	X	
Rainbow Trout	Spawning	Bovee	X	Good	Klamath (Allen)			Consensus		
	Fry	Bovee, WDG	--		Fraser (0+)	Klamath (Allen)		Consensus		
	Juvenile	Bovee, WDG	X		Fraser	Klamath (Allen)		Consensus		
	Adult	Bovee, WDG	X		Klamath (Allen)			Consensus		
Dolly Varden	Spawning	AEIDC	Dolly Varden/bull trout	Limited				Consensus		
	Fry	AEIDC	--					Consensus		
	Juvenile	AEIDC	Dolly Varden/bull trout					Consensus		
Cutthroat Trout	Spawning	Bovee	X	Limited				Consensus	X	
	Fry	WDG	--					Consensus	X	
	Juvenile	Bovee, WDG	X					Consensus	X	
	Adult	Bovee, WDG	--					Consensus	X	
Mountain Whitefish	Spawning	Bovee	X	Limited				Consensus		
	Fry	Bovee	--		Fraser			Consensus		
	Juvenile	Bovee, WDG	--		Fraser			Consensus		
	Adult	Bovee, WDG	--					Consensus		

License Participant Requested

Species	Relevant HSC Identified	Tabular Data Identified	Additional Supporting Literature	Periodicity Sources	Additional Notes
Sockeye	Limited	Ecology Spawning, Fraser (0+)		Nooksack	
Sea-Run Bull Trout	Limited	Ecology Spawning and Juvenile	Baxter and McPhall (1996)	Nooksack	
Resident Cutthroat Trout	Limited	Ecology and ESH Curves	Hickman and Raleigh (1982), Katopodis and Gervais 2016	Nooksack	
Sea-Run Cutthroat Trout	Limited	Ecology and ESH Curves	Losee et al. (2016)[2]	Nooksack	
Pacific Lamprey	Limited	Lower Merced, Vadas (2013)[3]	Ample supporting literature		
Western Brook Lamprey	None	Vadas (2013)[3]	Ample supporting literature		
Salish Sucker	None	--	Various life history publications in process of review		

Key	
Ample	Multiple sources of additional field based HSC information for all life stages had been compiled to date and further additional resources are likely available.
Good	Some additional field based HSC information for all life stages has been compiled to date and further additional resources are potentially available.
Limited	Some additional field based HSC information is available for some life stages but in general, few, if any, additional resources have been identified to date.

[1]Modern field based HSC data for larger streams that may not have already been considered in the ESH model or in the Ecology Guidelines.

[2]Potentially already incorporated in Ecology curves

[3] Yet to acquire

Skagit River Hydroelectric Project
Seattle City Light (City Light)
Instream Flow Model Development – Meeting #1
April 28, 2021

DRAFT Meeting Summary

Disclaimer: These notes are provided to serve as high-level summary of the meeting and as a communication tool for the benefit of committee continuity. They are not intended as a formal record of the meeting.

Attendance

Licensing Participants (LPs):
Brock Applegate, Washington Department of Fish and Wildlife (WDFW)
Stuart Beck, Swinomish Indian Tribal Community (Swinomish)
Curtis Clements, Upper Skagit Indian Tribe
Steve Copps, National Marine Fisheries Service (NMFS)
Jenna Friebel, Skagit Drainage and Irrigation District Consortium
Jeff Garnett, U.S. Fish & Wildlife Service
Jonathan Kohr, WDFW
Mike Larrabee, NPS
Jim Meyers, NMFS
Jim Pacheco, Washington Department of Ecology (Ecology)
Rusty Post, Ecology
Ashley Rawhouser, National Park Service (NPS)
Dudley Reiser, Swinomish
Alison Studley, Skagit Fisheries Enhancement Group (SFEG)
Kara Symonds, Skagit County
Kyle Taylor Lucas, Urban Indians Northwest
Stan Walsh, Skagit River System Cooperative (SRSC)
Eric Young, SFEG

Seattle City Light (City Light):
Maia Bellon, Cascadia Law
Leska Fore, City Light
Matt Love, Cascadia Law
Erin Lowery, City Light
Chris Townsend, City Light
Jeff Fisher, City Light

Federal Energy Regulatory Commission (FERC):
Julia Kolberg, FERC

Consultant Team:
Thomas DeGabriele, Consultant Team
Danielle Hanson, Consultant Team
Tim Hardin, Consultant Team
Bao Le, Consultant Team
Malcolm Leytham, Consultant Team
Chris Long, Consultant Team
Matt Wiggs, Consultant Team
Ty Ziegler, Consultant Team

Facilitation Team:
Joy Juelson, Facilitation Team
Thomas Christian, Facilitation Team

Meeting Materials

Materials were sent in advance (available upon request)

- Meeting Agenda
- Meeting PowerPoint Slides: Hydraulic Model Development
- Meeting PowerPoint Slides: Biological and Habitat Metrics
- The HSC and Periodicity Summary Table

Action Items

Action	Responsibility	Timeframe
LP Action Items		
Request: Share potentially useful HSC data from any other sources (e.g., literature, field studies) with the City Light habitat modeling team.	LP representatives	As soon as possible
City Light Action Items		
Provide meeting participants the 2017 and 2018 Quantum Spatial LiDAR data reports.	City Light	*Complete*
Share the preliminary HSC data library with the meeting participants before the May meeting.	City Light	*Complete*
Facilitation Team Action Items		
Schedule a half-day HSC meeting and a half-day bypass reach instream flow model meeting in May.	Triangle	*Complete*

Summary of Issues Discussed, Action Items, and Decisions

Welcome, Introductions, Agenda Overview

The facilitator, Joy Juelson, welcomed participants, led a roll call, and explained that the agenda and meeting purpose had been set in coordination with Ecology and City Light. Joy explained this meeting was intended for information sharing regarding the instream flow models and two follow-up technical meetings will be scheduled in May for further discussion and decision making. The objectives for this meeting were to:

- Review LP comments on the bypass reach model and discuss next steps for future meetings.
- Provide an overview of the program for development of the instream flow model for the Skagit River from the Gorge Powerhouse to the Sauk River.
- Provide an introduction to the identification, selection, and use of habitat suitability criteria (HSCs) for fish species of interest.

Opening Discussion

Erin Lowery, City Light, explained most of the meeting would focus on the hydraulic model and flow management tool for *FA-02 Instream Flow Model Development*. Details on the current flow management tool can be found in the Settlement Agreement that was updated in 2013. This model was developed in the 1970s and City Light is working on a new model that can evaluate multiple resource issues (spawning, incubation, rearing, etc.). Erin reviewed a chart (see meeting slides) showing the study road map. The purpose of this meeting was for City Light's modeling team to provide information about the intended process to update the model and highlight areas where there is need for LP input to be discussed at future meetings in May.

Jim Pacheco, Ecology, reiterated Erin Lowery's point and clarified there are decisions that will need to be made around Habitat Suitability Criteria (HSC) at the May, 2021 meeting.

In response to a question about what timestep City Light has proposed for the new model, Erin clarified the model will be capable of running on a sub-daily timestep.

Review Bypass Reach Instream Flow Model

Jim Pacheco provided a review of Ecology's comments on the bypass reach flow model for the *FA-05 Skagit River Gorge Bypass Reach Hydraulic and Instream Flow Model Development Study.* Jim explained this model would be discussed further at a future bypass reach model meeting in May 2021.[1] The purpose of today's agenda topic is to highlight interests and/or concerns and determine a recommended path forward for the upcoming technical meeting. He clarified that Ecology would need data from the model to approve the Clean Water Act 401 certification.

Ecology is interested in a model that can characterize steep areas in the bypass reach. Ecology indicated they are uncertain if the HEC-RAS 2D model can meet this interest.

Multiple meeting participants expressed an interest in making sure the model can characterize steep slopes in the bypass reach to help assess fish passage and were concerned that the HEC-RAS 2D model would not meet that interest.

- A representative from Swinomish suggested the U.S. Bureau of Reclamation's SRH-2D model as an alternative.
- Representatives from the Upper Skagit Indian Tribe noted it would be helpful to understand how 2D models have been used in reaches with steep slopes to assess fish passage in the past.
- Representatives from Swinomish and the Upper Skagit Indian Tribe identified a need to determine the model flow simulation range necessary to evaluate fish passage.

Jim Pacheco explained there are a limited number of models that can be used and suggested that 3D models be considered. He clarified Ecology's understanding is the intention of the model is to assess the flow versus habitat relationship and to determine conditions in the partial passage barrier reaches. Jim also noted there is a time sensitive need to hold further discussions on model development so City Light's team can move forward with data collection this field season.

Instream Flow Study Hydraulic Model Overview

Chris Long, Consultant Team, provided an overview of the hydraulic model for the *FA-02 Instream Flow Model Development Study.* This study addresses instream flows on the Skagit River between the Newhalem US Geological Survey (USGS) gage (USGS 12178000) and the USGS gage below the Sauk River confluence (USGS 12189700). Chris reviewed terrain, boundaries, mesh, and physical parameter model inputs (see meeting slides for details).

- Terrain – The modeling team is developing a seamless topographic surface. The model will use 2017 and 2018 data sets from Quantum Spatial to span the Newhalem to Sauk River confluence reach. Chris highlighted how the modeling team is filling bathymetry data voids via fieldwork.
- Boundaries – The model will cover the Skagit River from the USGS gage at Newhalem to the USGS gage just below the Sauk River confluence. It will also include inputs from eight tributaries along the 29-mile reach, four of which have gaged inputs (Newhalem, Bacon, Cascade, and Sauk) and the other four (Goodell, Danmation, Diobsud, and Illabot) will have measured

[1] The bypass reach model meeting occurred on May 17, 2021.

inputs based on discharge data collected during the field data collection program and scaling against gaged tributaries.

- Mesh – The mesh cell sizes will vary as needed to create an overall effective and efficient mesh from a modeling perspective. Where velocity or slope changes, cell size will be adjusted accordingly to characterize the changing conditions.
- Physical parameters – The modeling team will use aerial photography to inform cell roughness parameters.

Discussion on Model Inputs

- In response to a question, Chris clarified that the model outputs will be at a finer scale than the mesh size – output is at the topography raster scale as opposed to the model mesh size.
- Jenna Friebel, Skagit Drainage and Irrigation District Consortium, expressed an interest in ensuring the model is calibrated to large flood events and suggested using the Skagit River near Concrete gage (USGS 12194000) to better understand large tributary inputs during flood events. Jenna expressed an interest in a model that will inform flood operations.
- Malcom Leytham, Consultant Team explained the modeling team is using a November 2020 highwater event in the model. They will continue to track highwater events and will incorporate new data as appropriate. The HEC RAS 2D model can be updated if a larger flood event is observed. LPs expressed an interest in including data from a flood event larger than the November 2020 high water event currently proposed for the model.
- Meeting participants discussed the process for scaling inputs at the four ungaged tributaries. Rusty and Jim from Ecology will coordinate on this approach to address any concerns.
- Meeting participants discussed LPs' interest in modeling floodplain inundation flows.

Action Item: The modeling team will provide LPs the 2017 and 2018 Quantum Spatial LiDAR data reports.

Overview of Model Setup

- Chris Long reviewed the model mesh setup and details about cell orientation and shape (see meeting packet for further details).
- Chris clarified that in the HEC RAS 2D model, outputs are depth averaged. Jim Pacheco clarified that Ecology's data output need is mean column velocity.
- Stan Walsh, Skagit River System Cooperative, expressed an interest in modeling side channels and the floodplain and ensuring the mesh size is adequate to address seasonal flooding outside the mainstem channel. Other LPs echoed the interest in modeling the floodplain.
- Meeting participants discussed use of a 3-foot raster to understand fish passage in the bypass reach and determined a need to follow-up on this topic at the upcoming May meeting.

Model Calibration

- Chris reviewed the data inputs, including transect locations and stage and discharge gage locations that will be used to calibrate the model, along with other calibration parameters (see meeting slides for details).
- Meeting participants discussed how the model performance will be evaluated. The modeling team explained there are tests that can be run to identify uncertainty in the model and determine how well the model is calibrated to observed data.

Meeting participants discussed initial differences between consultant team field data and data fromand calibration with the USGS gages. The City Light modeling team mentioned an apparent discrepancy between their field data and USGS data from the Marblemount gage and indicated that they would work with the USGS as needed to resolve that discrepancy. [The discrepancy was resolved following the meeting and stemmed from a typographical error in the consultant team data].are working with USGS to understand an observed discrepancy between the model and observed data.

Floodplain Modeling Discussion

Meeting participants identified that there is disagreement between the City Light modeling team and some LPs about the level of detail in proposed modeling of side channels and the floodplain. This will need further discussion.

- LPs clarified their interest in modeling the floodplain is based on a need to understand floodplain connectivity for fish.
- The City Light modeling team clarified that the model can assess the full floodplain but not at the same resolution as the main stem. Erin clarified that City Light's purpose for this study is to develop a solid model foundation for the main stem and then use that foundation to model the floodplain in the future. The modeling team further explained that the main stem has to be calibrated before the model could be used to model the side channel and floodplain areas and that once the instream flow model is set up for the main stem, more detailed modeling of specific floodplain areas could be performed by breaking out and refining that section of the model can be broken out for specific floodplain/channel areas.
- Meeting participants asked City Light if a second phase of the model for the floodplain could be developed within the integrated licensing process (ILP) timeline.
- Erin Lowery explained that City Light hopes to complete calibration of the instream flow model by the end of this year which will allow next year to further to refine elements and questions related to the floodplain.

Biological and Habitat Metrics

Ty Ziegler, Tom DeGabriele, and Tim Hardin from the Consultant Team are working on the habitat modeling component of the instream flow study. Ty, Tom, and Tim provided an overview of the HSC information and the need for input from LPs at a future May meeting. The May meeting will be used to review and potentially modify existing/available HSC, identify data gaps, and determine how to address those gaps. The meeting will also need to affirm periodicity (i.e., time of year) to be modeled for each species and lifestage.

Meeting participants discussed the physical parameters (i.e., depth, velocity, substrate, and cover) that form the basis of the HSC that will be used in the habitat modeling effort. LPs noted several variables that also affect fish habitat that are not included in the model inputs, including turbidity and groundwater upwelling.

Meeting participants discussed the species of interest list, including those that City Light has added in response to LP comments (see meeting slides for further detail). WDFW suggested adding sea-run cutthroat (*Oncorhynchus clarki clarki*), Pacific lamprey (*Entosphenus tridentatus*), Salish sucker (*Catostomus sp.*), Dolly Varden (*Salvelinus malma*), western brook lamprey (*Lampetra richardsonii*), river lamprey (*Lampetra tridentate*) and white sturgeon (*Acipenser transmontanus*) to the species of interest list. Jim Pacheco cautionedexplained that habitat modeling for the additional species proposed by LPs has not been done before, so LPs will need to provide information sufficient for development of HSC for those species and lifestages to be modeled.bring species data to the upcoming May meeting.

HSC Development

Tom DeGabriele explained it is common for HSCs to be developed through a collaborative process and anticipate implementing this type of process with Ecology and LPs. The City Light modelers and Ecology are working on a table to meet Ecology's need. As an example, Tom reviewed HSCs for Chinook spawning from multiple sources. Tom explained that it will be important to discuss which types of HSC curves are appropriate to use for the Skagit River at the May meeting.

Jim Pacheco noted the difference between effective habitat and suitable habitat as a key consideration. Erin Lowery explained that City Light is interested in using the model to monitor the effectiveness of habitat restoration.

Dudley Reiser, representing the Swinomish Tribe, requested a road map from the City Light modeling team showing how the instream flow study fits in with other licensing studies to inform flow management objectives.different inputs from other studies fit into the instream flow study to assess habitat. Other meeting participants agreed it will be important to understand the linkages between various studies.

In response to a question from Kaya Symonds, Skagit County, the modeling team explained that once the model is developed, City Light will be able to use it to evaluate the effectiveness of other restoration activities.

Next Steps Toward May HSC Meeting

Jim Pacheco explained to meeting participants that there is a time sensitivity element to the HSC discussion, particularly if LPs are interested in field data collection for HSC validation purposes. Multiple LPs indicated a spring spawning survey is a high priority.

Dudley Reiser suggested the Sultan River HSCs could be a resource to the modeling team.

Action Item: The City Light team will share the preliminary HSC data library with the meeting participants before the May meeting.

Action Item: Meeting participant will share potentially useful HSC data from other sources with the City Light modeling team.

Periodicity Tables

Jim Pacheco recommended the habitat modeling team develop two periodicity tables: one for the mainstem Skagit River and the other for the bypass reach. He explained the habitat modeling team should request input from the Tribes and Federal agencies who spend a lot of time on the Skagit River to help refine the periodicity tables. An important consideration would be determining the timing of the first large influx of species into the river. It was noted that climate change will also need to be taken into consideration as it may affect the timing of fish returning to the river in the future.

Review Action Items and Next Steps

The facilitator reviewed the action items from the meeting and noted that Triangle will work with City Light, Ecology, and other LPs to schedule a half-day HSC meeting and a half-day bypass reach instream flow model meeting in early to mid-May, 2021.

> ***Action Item:*** Triangle will work with City Light, Ecology, and other LPs to schedule a half-day HSC meeting and a half-day bypass reach instream flow model meeting in May.

The meeting was adjourned early at 3:00 p.m.

INSTREAM FLOW MODEL DEVELOPMENT STUDY
INTERIM REPORT

ATTACHMENT M

INSTREAM FLOW WORKSHOP 3 MATERIALS

Seattle City Light DRAFT **MEETING AGENDA**

Skagit Hydroelectric Project Relicensing Meeting

FA-02 Instream Flow Model Development Workshop #3

August 12, 2021, 8:30 am – 1:30 pm

Webex Link: Click Here to Join the Meeting

Conference Call: +1-510-338-9438,,1822189174#48279772#

MEETING PURPOSE

- Provide an overview of the program for development of the instream flow model for the Skagit River from Gorge Powerhouse to the Sauk River.
- Review data sources and methodology for hydraulic model construction: terrain, boundary conditions, and geometry.
- Provide update on hydraulic model sensitivity testing, computation times, and conditions.

FACILITATOR

Joy Juelson, Triangle Associates

AGENDA

08:30 – 08:45 (15 minutes)	**Introduction** – *Facilitator, Triangle* ▪ Roll Call Introduction
08:45 – 09:00 (15 minutes)	**Hydraulic Model Overview** – *Erin Lowery, City Light and Chris Long, NHC* ▪ Background ▪ Review Meeting Objectives and Agenda

09:00 – 10:15
(75 minutes)
	Terrain – *Tyler Rockhill, NHC*
	▪ Void Infilling
	  ▪ Instream Flow Void Infilling
	  ▪ Barnaby Reach Void Infilling
	▪ Channel Migration
	▪ Transect Stability
	  ▪ Transect Profile Examples from 2020/2021 bathymetric surveys and LiDAR sets
	▪ Dynamic Equilibrium
	▪ Questions and Discussion (30 minutes)

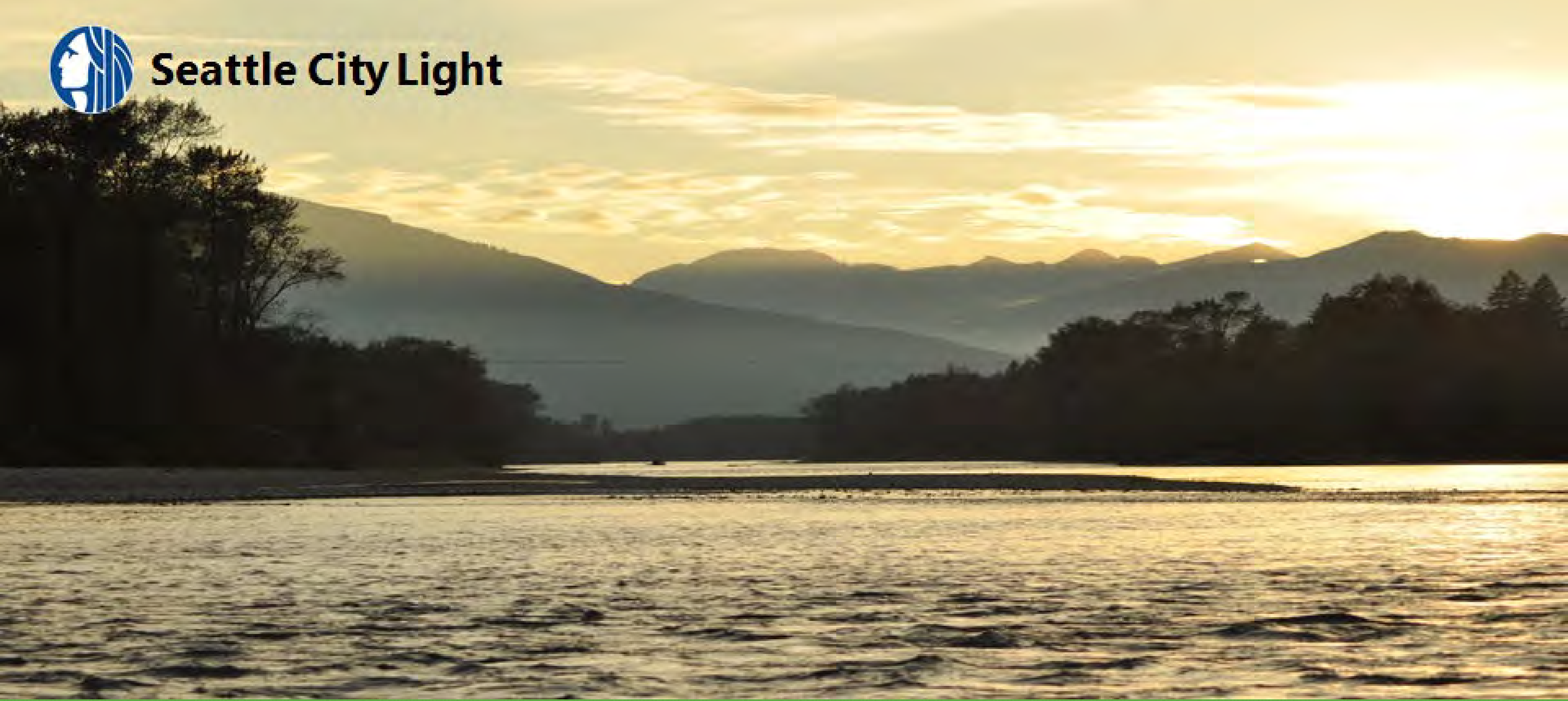
10:15 – 10:30 (15 minutes)	**Break**
10:30 – 10:50 (20 minutes)	**Hydraulic Model Boundary Conditions** – *Malcolm Leytham, NHC* ▪ Calibration Events – Tributary inflows ▪ Gage Comparison ▪ Questions and Discussion (10 minutes)

10:50 – 11:20 (30 minutes)	**Hydraulic Model Geometry** – *Chris Long, NHC* ▪ Mesh ▪ Roughness ▪ Full Model ▪ Questions and Discussion (15 minutes)
11:20 – 11:35 (15 minutes)	**Break**
11:35 – 1:00 (85 minutes)	**Hydraulic Model Sensitivity Results** – *Tyler Rockhill, NHC* ▪ Subset Model ▪ Cell Size ▪ Roughness ▪ Questions and Discussion (20 minutes)
1:00 – 1:15 (15 minutes)	**Next Steps** – *Chris Long, NHC* ▪ Full model development ▪ Model calibration and validation
1:15 – 1:30 (15 minutes)	**Action Item Review and Agenda Items for Next Meeting –** *Triangle and NHC*
1:30	**Meeting Adjourned**

ACTION ITEMS FROM PREVIOUIS INSTREAM FLOW MODEL WORKSHOP: APRIL 28, 2021

Action Items

Action	Responsibility	Timeframe
LP Action Items		
Request: Share potentially useful HSC data from other sources with the City Light modeling team.	LP representatives	*Complete*
City Light Action Items		
Provide meeting participants the 2017 and 2018 Quantum Spatial LiDAR data reports.	City Light	*Complete*
Share the HSC data library with the meeting participants before the May meeting.	City Light	*Complete*
Facilitation Team Action Items		
Schedule a half-day HSC meeting and a half-day bypass reach instream flow model meeting in May.	Triangle	*Complete*



SKAGIT RIVER INSTREAM FLOW STUDY WORKSHOP 3

August 12, 2021

STUDY BACKGROUND

- Need to update and enhance current Flow Management Tool (ESH Model) identified by the FARWG
- New hydraulic model also has utility in evaluation of other Project-related resource issues identified by LPs
- Intent to continue implementation of flow management program to benefit fisheries resources and address other Project-related resource issues as part of a new FERC license

STUDY ROAD MAP/SCHEDULE

	April	May	June	July	August	September	October	November	December	January	February		
Field Data Collection												Initial study report March 2022	Alternative scenario identification and evaluation: February - September 2022
Hydrometric data collection for model calibrati	Completed March 2021 (data collection at USGS gages continues through study period).												
Bathy data collection (to fill voids in LiDAR)	Surveys Oct 2020 & Mar 2021. Additional survey Sep 2021.												
Substrate and cover data collection													
Hydraulic Model Development													
Assemble terrain data													
Hydraulic model construction													
Hydraulic model calibration/validation													
Biological and Habitat Information													
Review and selection of HSCs													
Integration with hydraulic data													
Workshops (HSC focussed workshops not shown)	↑				↑		↑			↑			

WORKSHOPS

Workshop	Date	Topics
~~1~~	~~April 2021~~	~~Overview development of instream flow model for the Skagit River from Gorge Powerhouse to the Sauk River~~ ~~Introduction to identification, selection, and use of habitat suitability criteria (HSCs) for fish species of interest~~
~~1A~~	~~May 2021~~	~~Overview development of hydraulic and instream flow model for the Gorge Bypass Reach reach~~
~~2~~	~~July 2021~~	~~Updates to biological and habitat metrics based on discussions and input from Workshop 1~~
3	August 2021	Hydraulic model construction ongoing
4	October 2021	Hydraulic model calibration ongoing
5	January 2021	Final hydraulic model calibration results and discussion of future model application

Additional workshops/meetings to be scheduled for Spring 2021

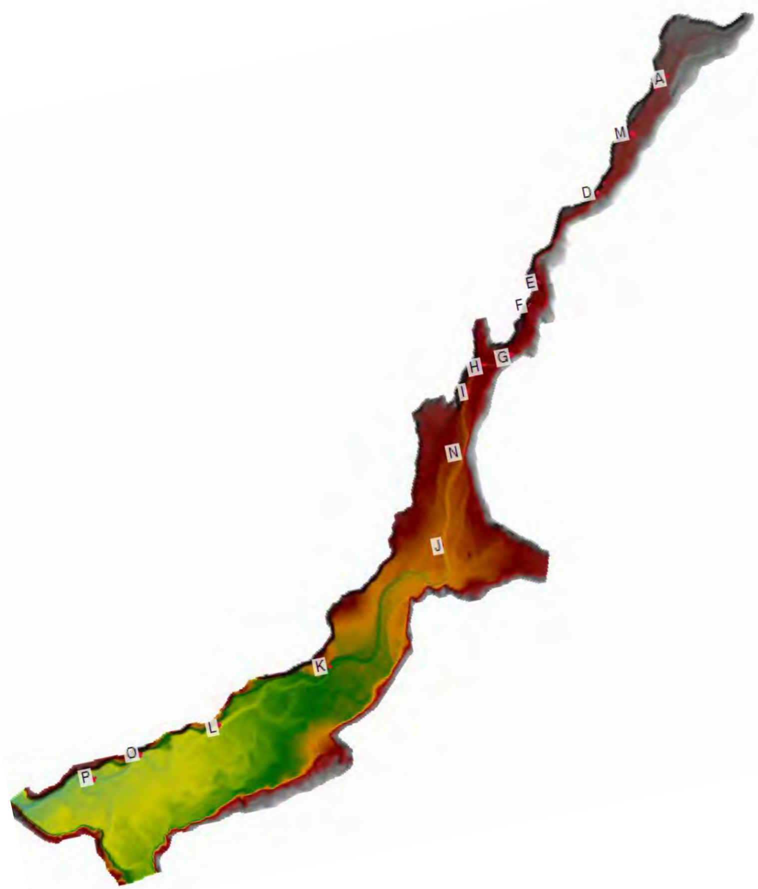
Seattle City Light

HYDRAULIC MODEL TERRAIN

August 12, 2021

OVERVIEW

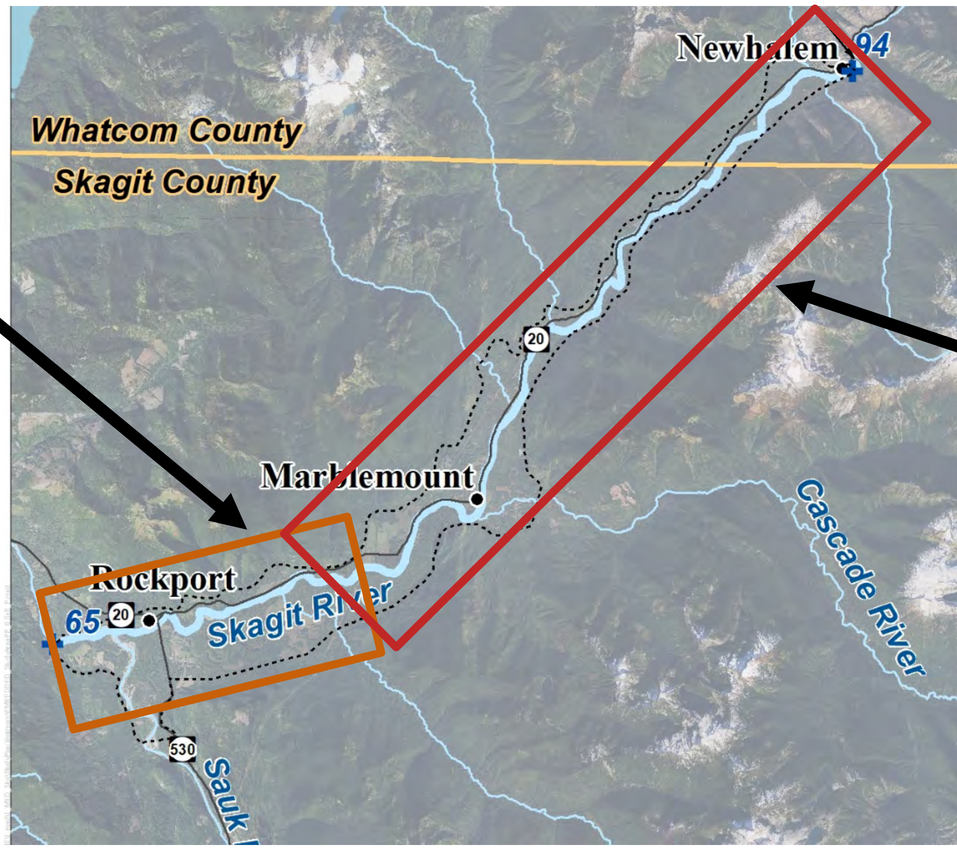
- Terrain Overview
- Void Infilling
- Channel Migration
- Transect Stability
  - Channel Migration
  - Transect Cross Sections
- Dynamic Equilibrium
- Questions/Discussion



TERRAIN - OVERVIEW

2017 LiDAR

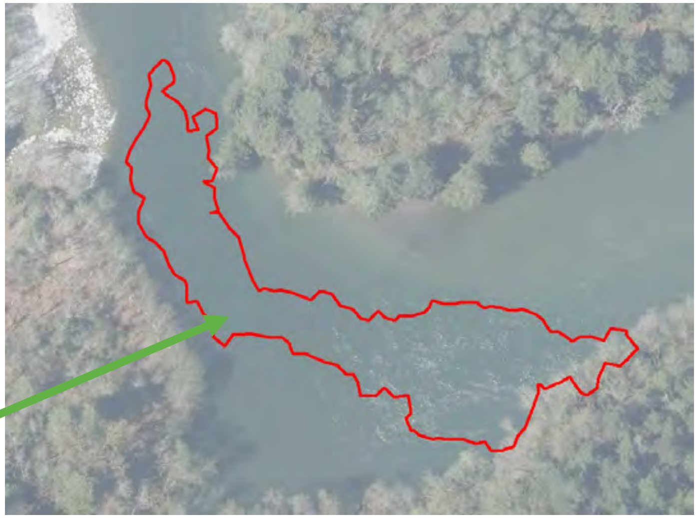
2018 LiDAR



~29 River Miles

TERRAIN – BATHYMETRY VOIDS

- Depth
- Rapids
- Overhanging vegetation
- Bottom reflectivity

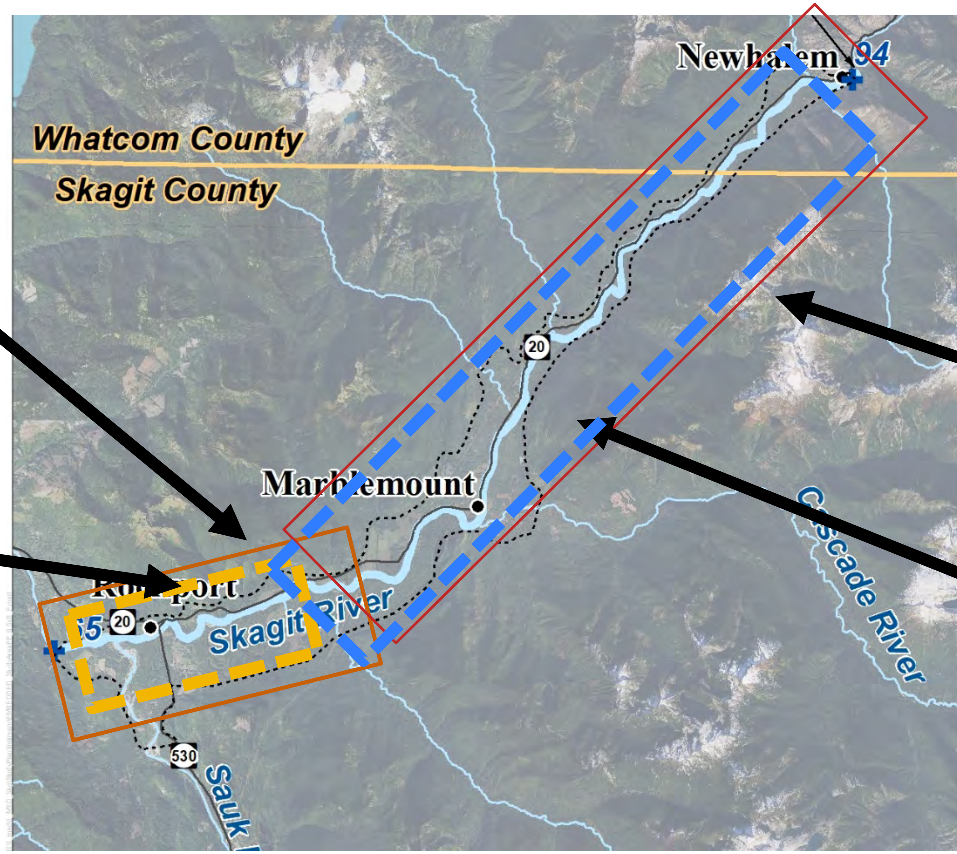


Example Void

TERRAIN - OVERVIEW

2017 LiDAR

Barnaby Reach Infilling



2018 LiDAR

2020/2021 Infilling

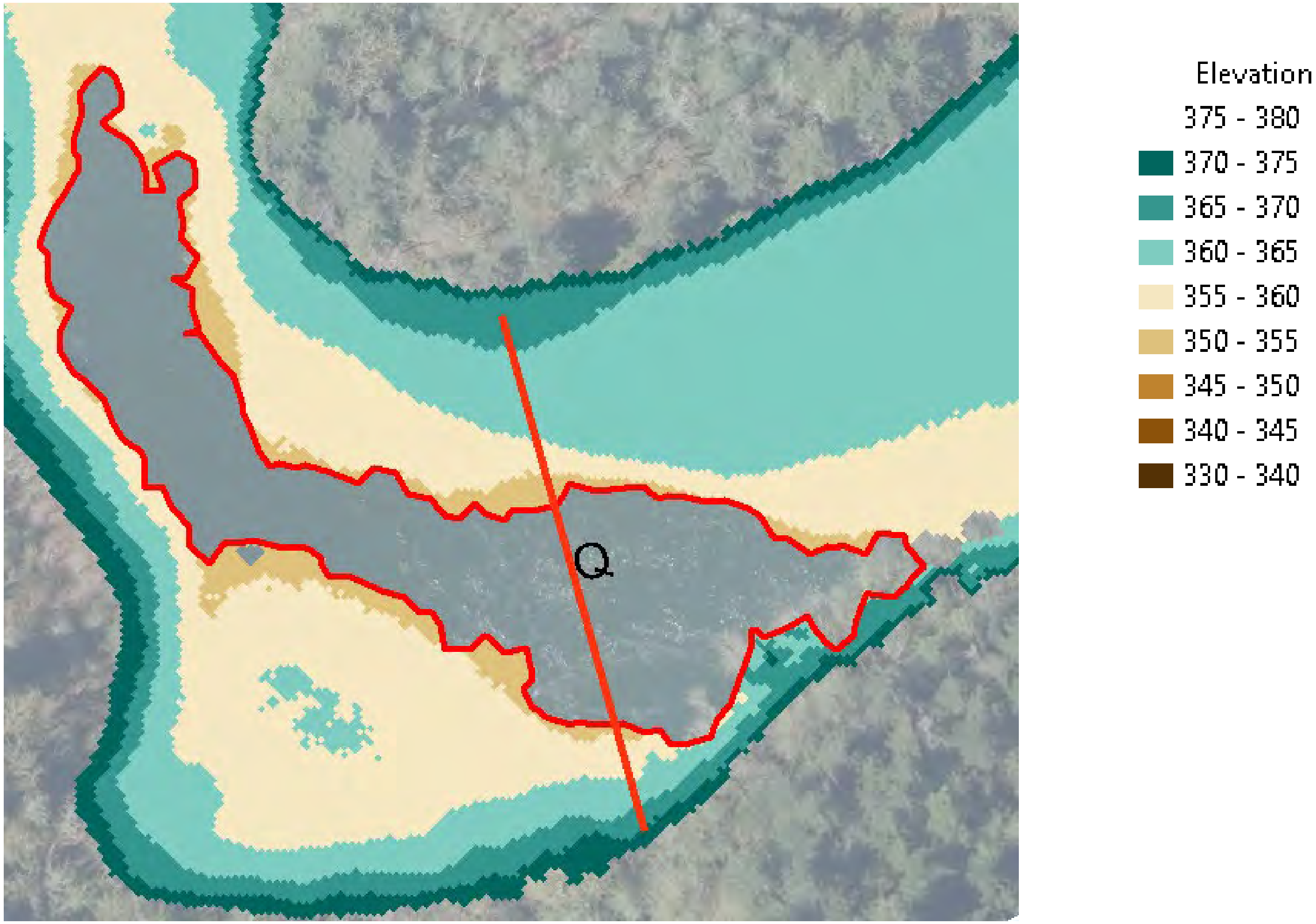
~29 River Miles

NHC TERRAIN – VOID INFILLING

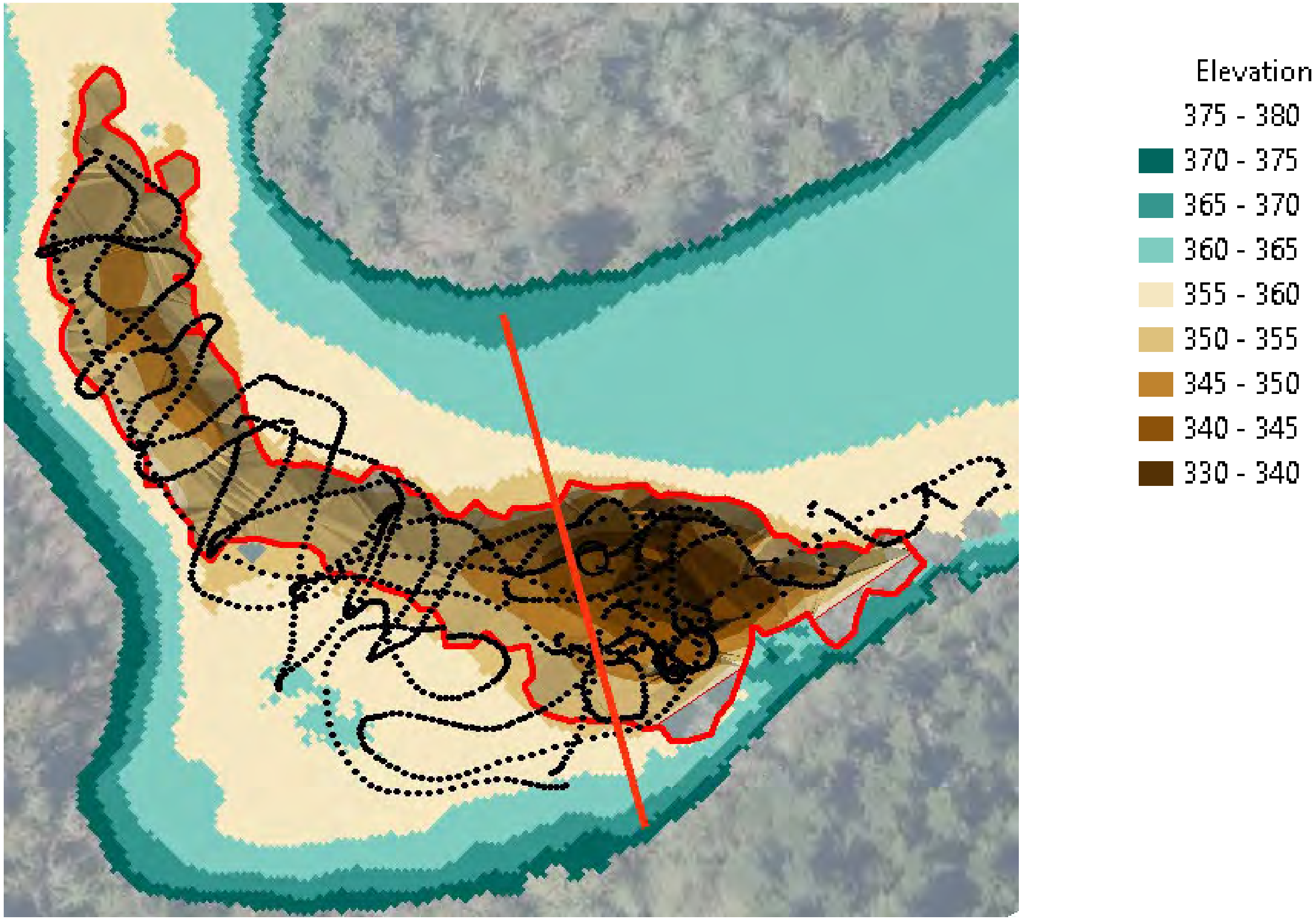
- Filled voids except:
  - < 1,000 ft^2
  - Dangerous rapids
  - Inaccessible due to trees/vegetation
- Completed:
  - 126/205 Voids (62%)
  - 34/44 Acres (77%)

- Otherwise use Quantum Spatial's interpolated surface

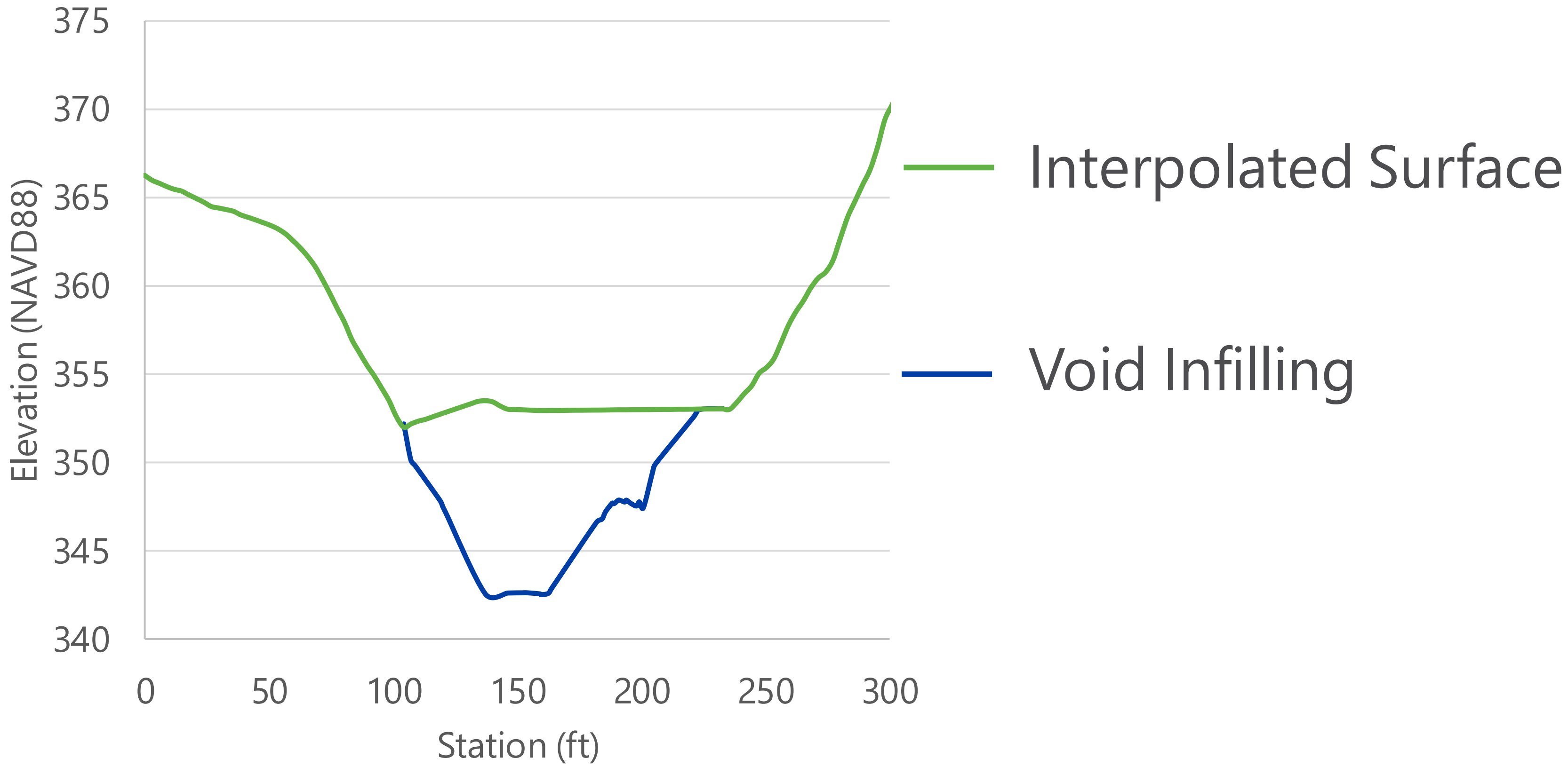
TERRAIN – VOID FILLING



TERRAIN – VOID FILLING



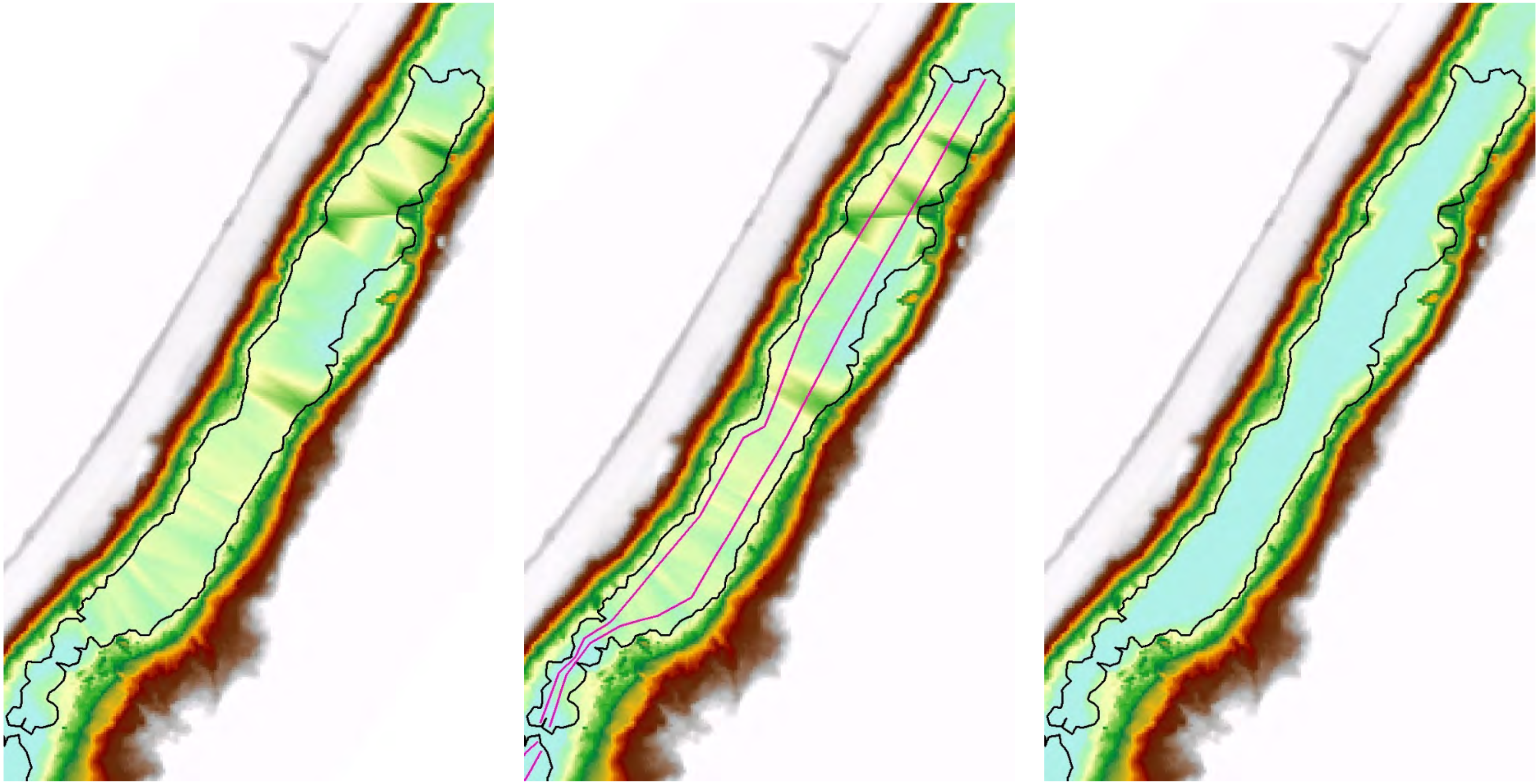
TERRAIN – VOID FILLING



PHOTOS OF INACCESSIBLE AREAS

VOIDS THAT WERE NOT SURVEYED

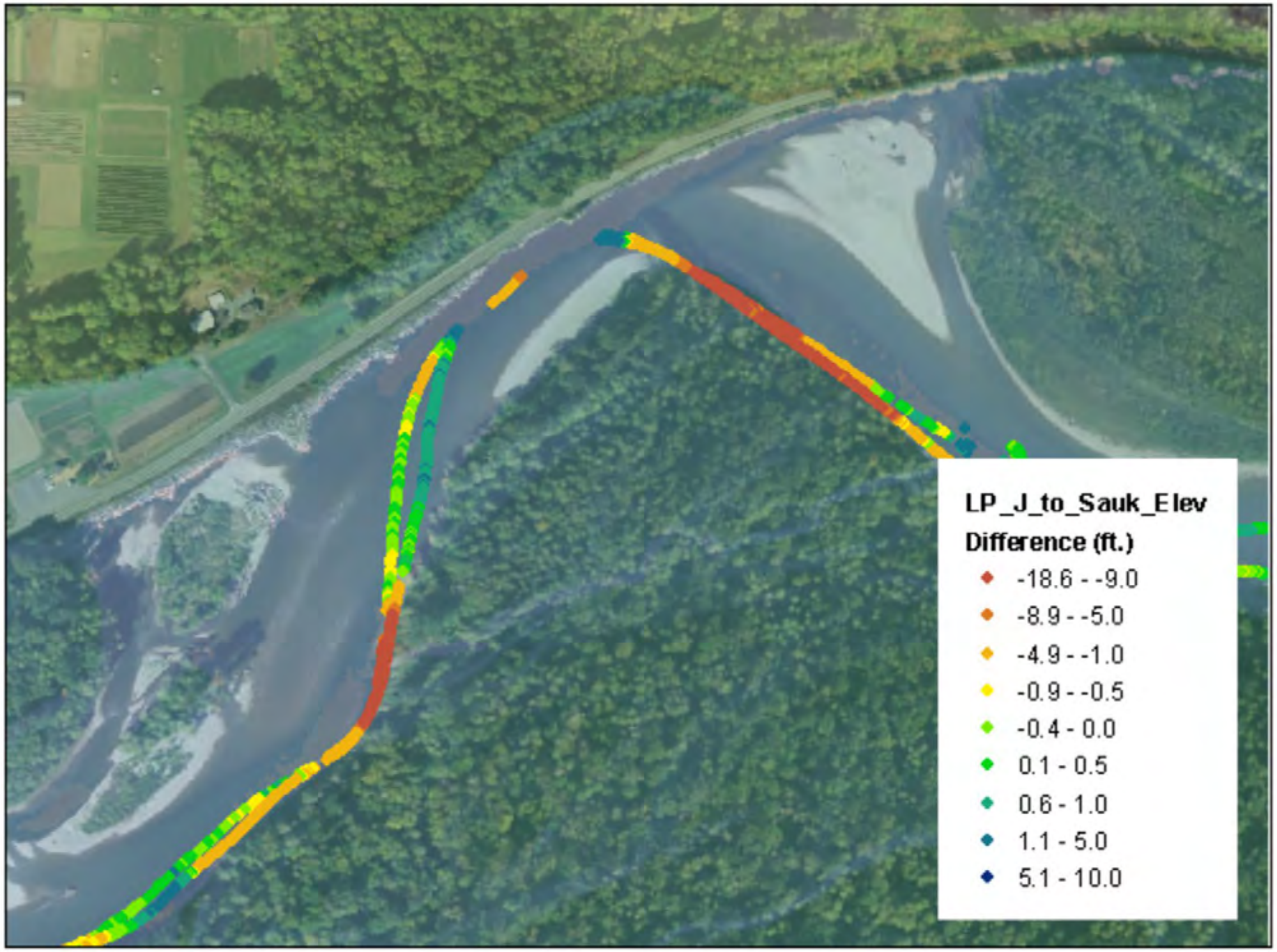
- Shovel Spur rapids – safety concern



BARNABY REACH VOID INFILLING

- Best available data was used for the Barnaby Reach hydraulic model
- The intended use of the Barnaby Reach model was substantially different than Instream Flow Model
- Study plan assumes use in Instream Flow Model
- Plan to survey voids in Barnaby Reach Sep 1-3
  - Same methodology/resolution
  - 183 voids >1000 sf in Main Channel, 62 Acres

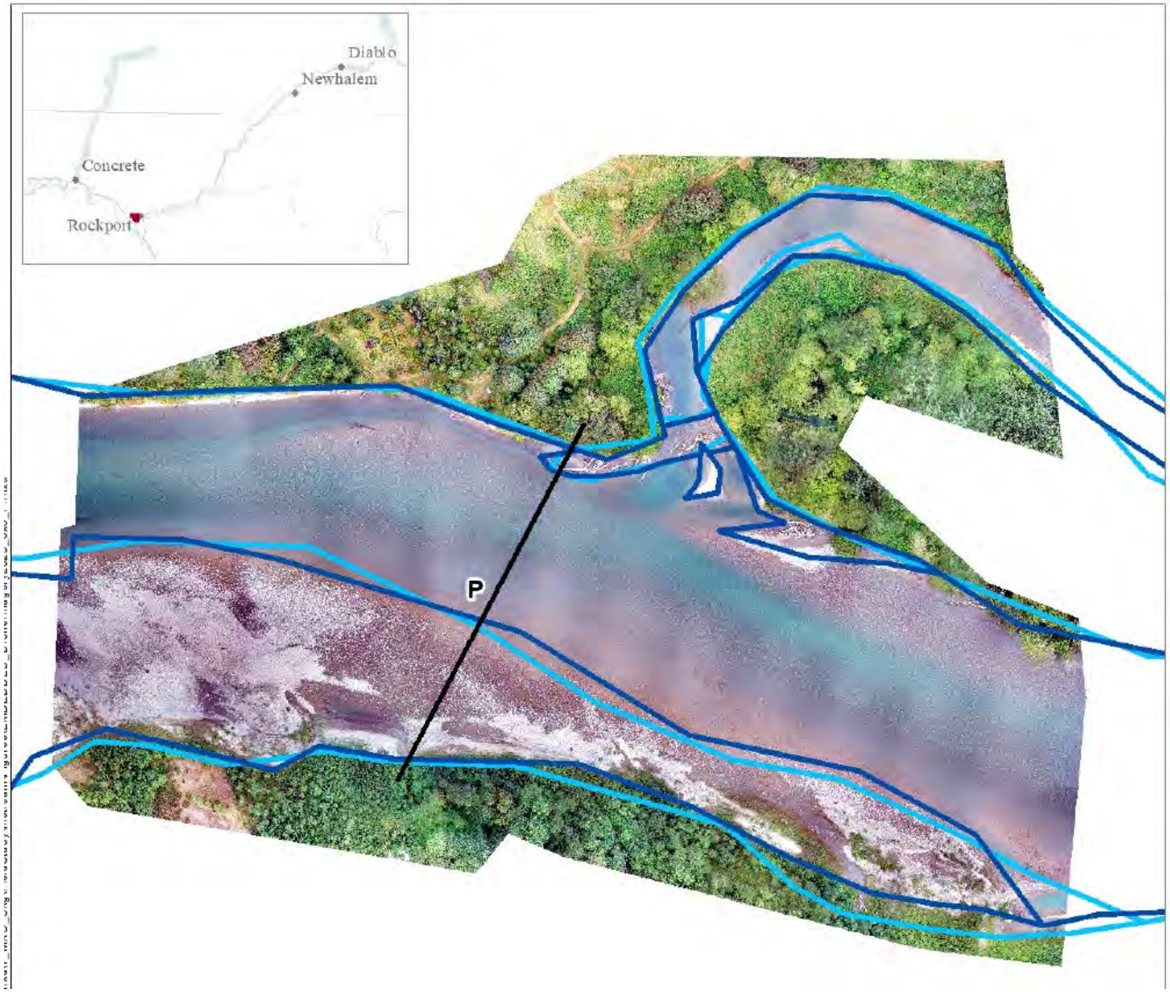
CHANNEL MIGRATION



CHANNEL MIGRATION

- Focused desktop analysis of bank migration from PRM 65-78 between 2015 and 2019
- Compare bank lines from NAIP aerial imagery
  - 2015
  - 2017
  - 2019
- Compare August 2020 imagery and bathymetry collected at transects

TRANSECT P CHANNEL MIGRATION



CHANNEL MIGRATION

- Skagit River has been generally stable upstream of PRM 74 between 2017 and 2019
- PRM 65 to 74 has been much more dynamic
- The calibration transects downstream of PRM 74 are located in areas of greater stability than the surrounding channel

TRANSECT BATHYMETRY

Transect
A
B
M
C
D
E
Q
F
G
H
I
N
J
K
L
O
P

↑ **Stable**

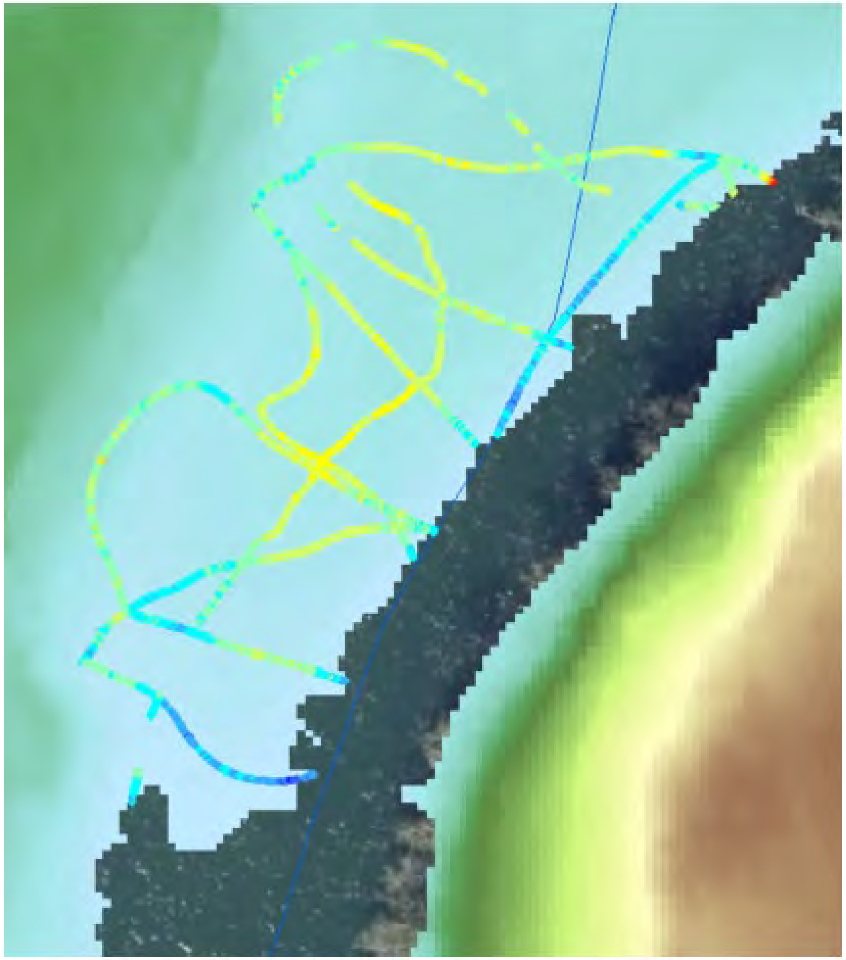
↑ **Dynamic**

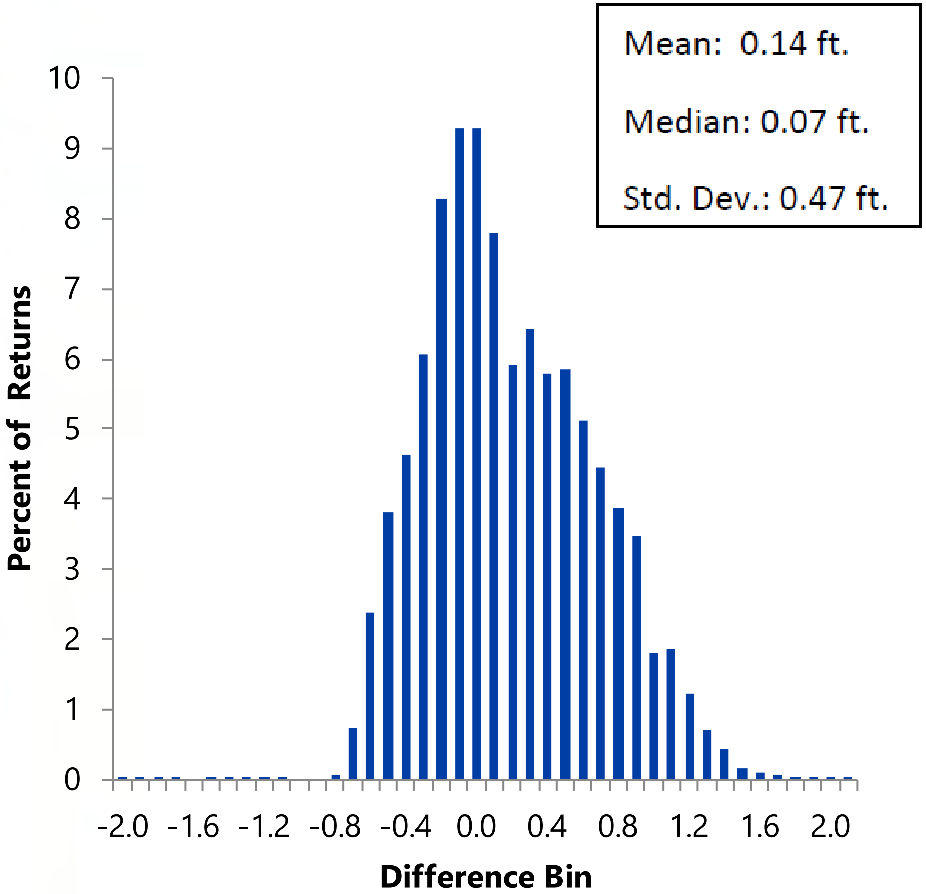
Examples

TRANSECT BATHYMETRY COMPARISON

- Bathymetry collected at select transects during August 2020 and March 2021
- Bathymetry typically spans +/- 200 ft from transect line
- Comparing 2020/2021 bathymetry to 2017 LiDAR indicates bed elevation change

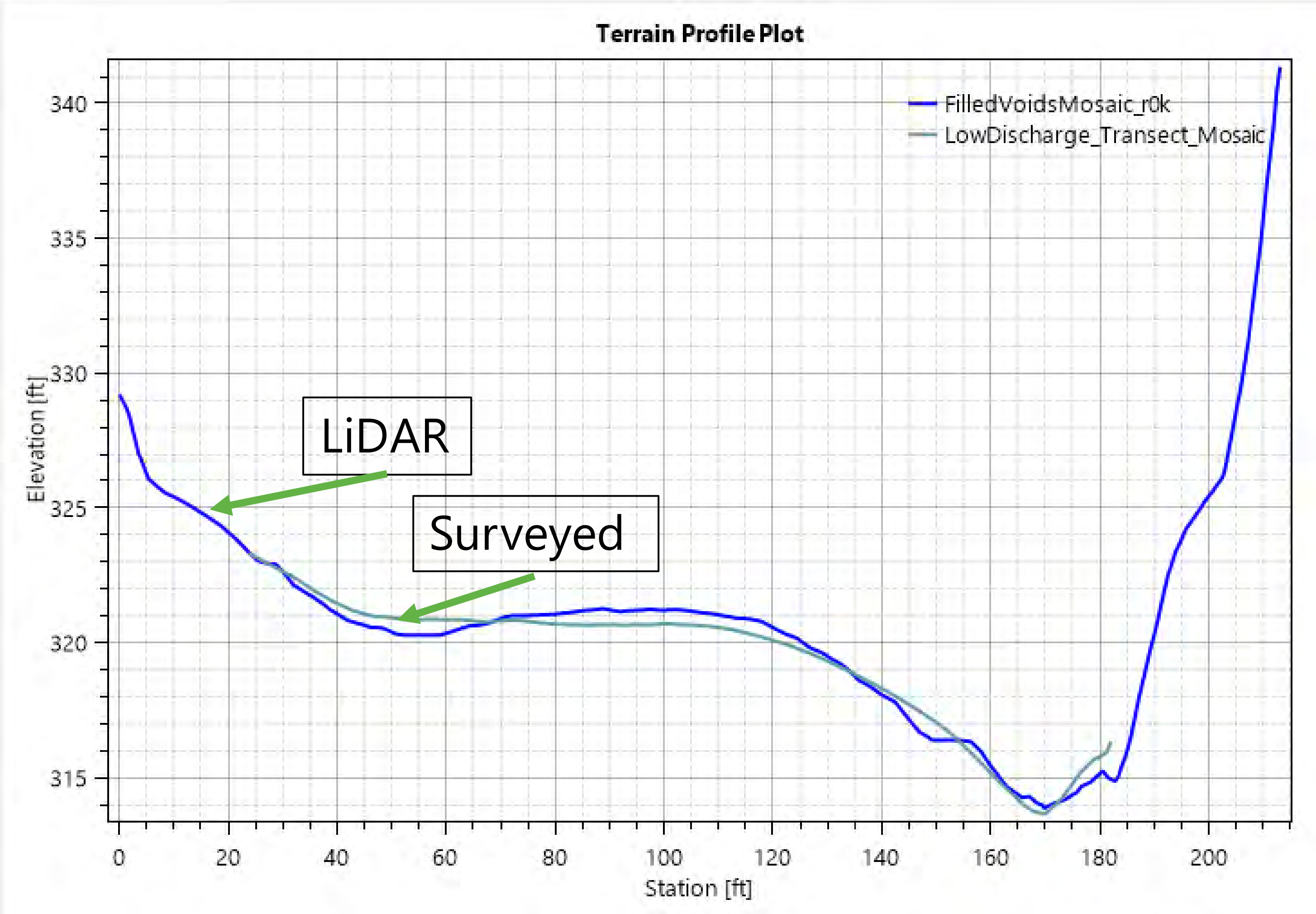
TRANSECT N





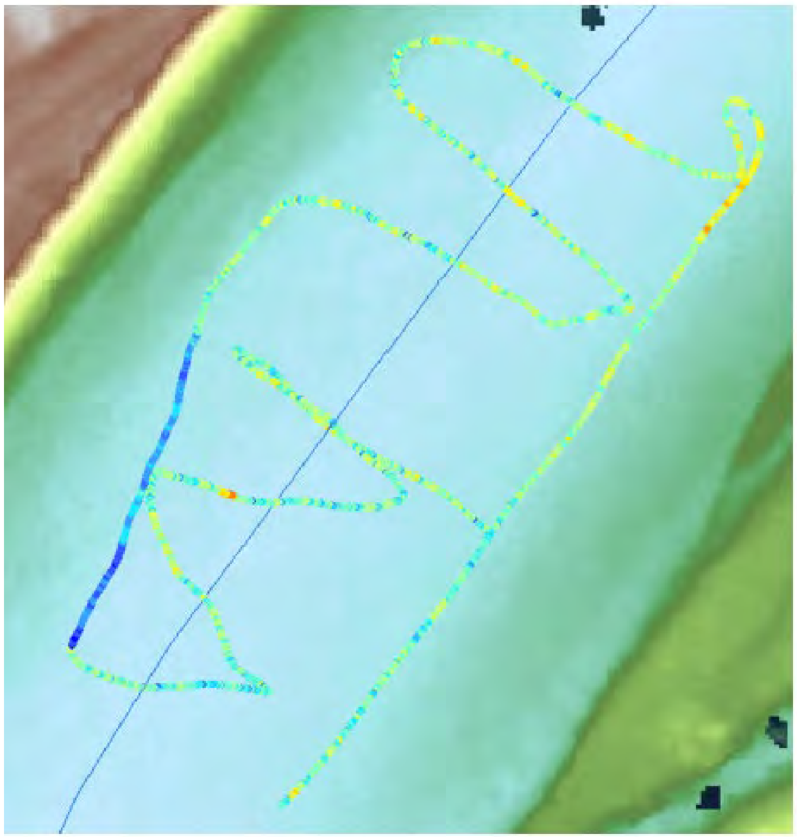
Mean: 0.14 ft.
Median: 0.07 ft.
Std. Dev.: 0.47 ft.
Percent of Returns
0
1
2
3
4
5
6
7
8
9
10
-2.0 -1.6 -1.2 -0.8 -0.4 0.0 0.4 0.8 1.2 1.6 2.0
Difference Bin

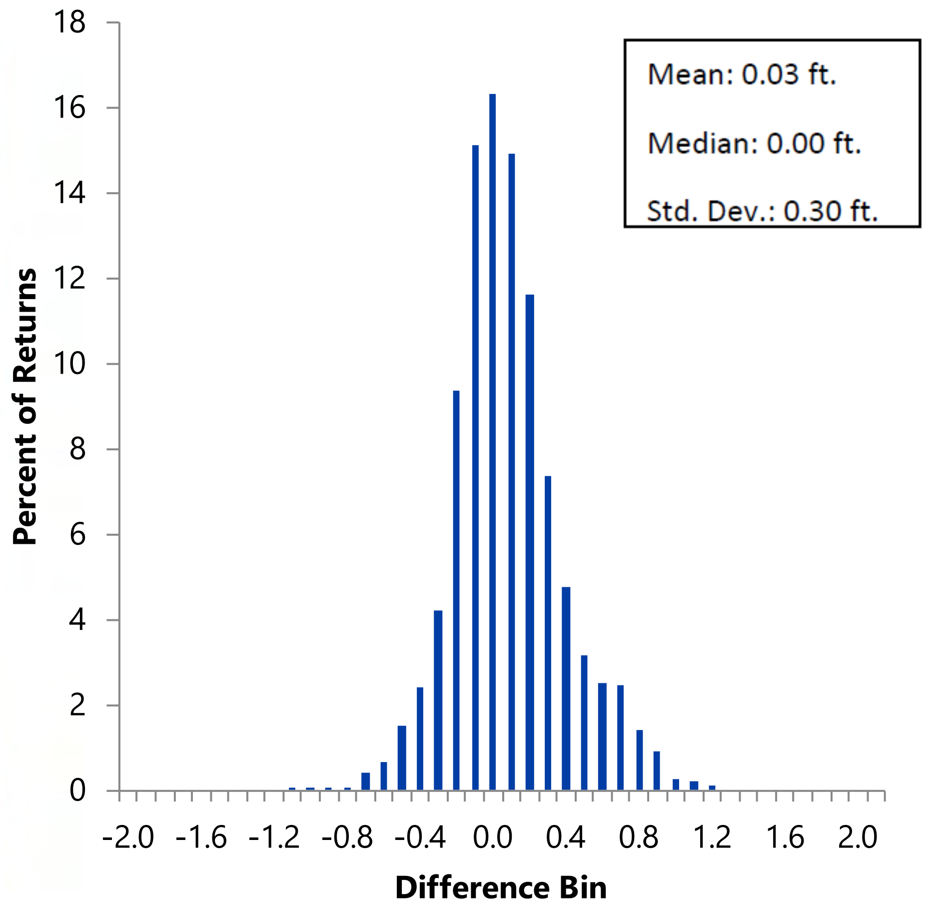
TRANSECT N



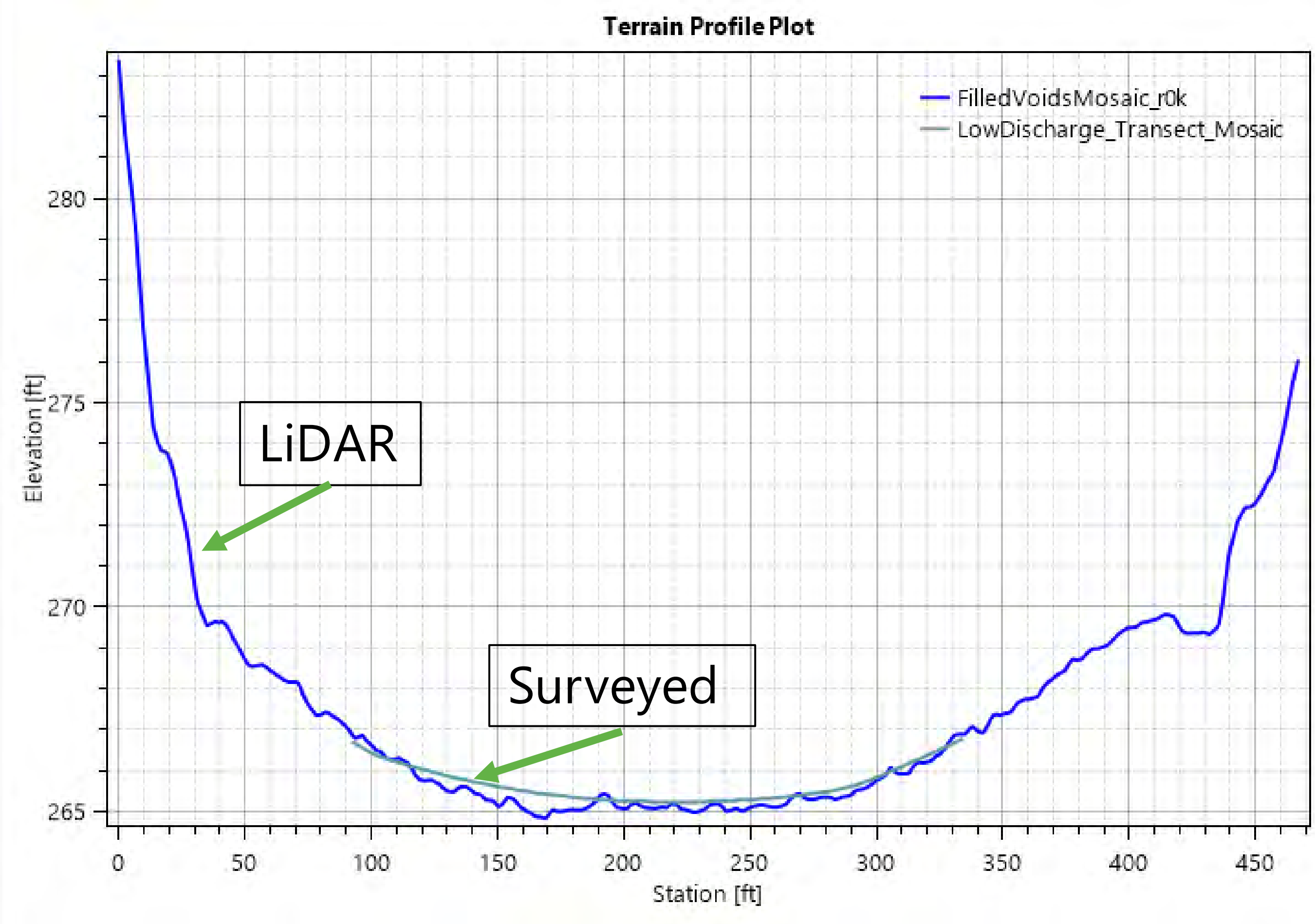
Terrain Profile Plot
FilledVoidsMosaic_r0k
LowDischarge_Transect_Mosaic
Elevation [ft]
340
335
330
325
320
315
0
20
40
60
80
100
120
140
160
180
200
Station [ft]
LiDAR
Surveyed

TRANSECT K



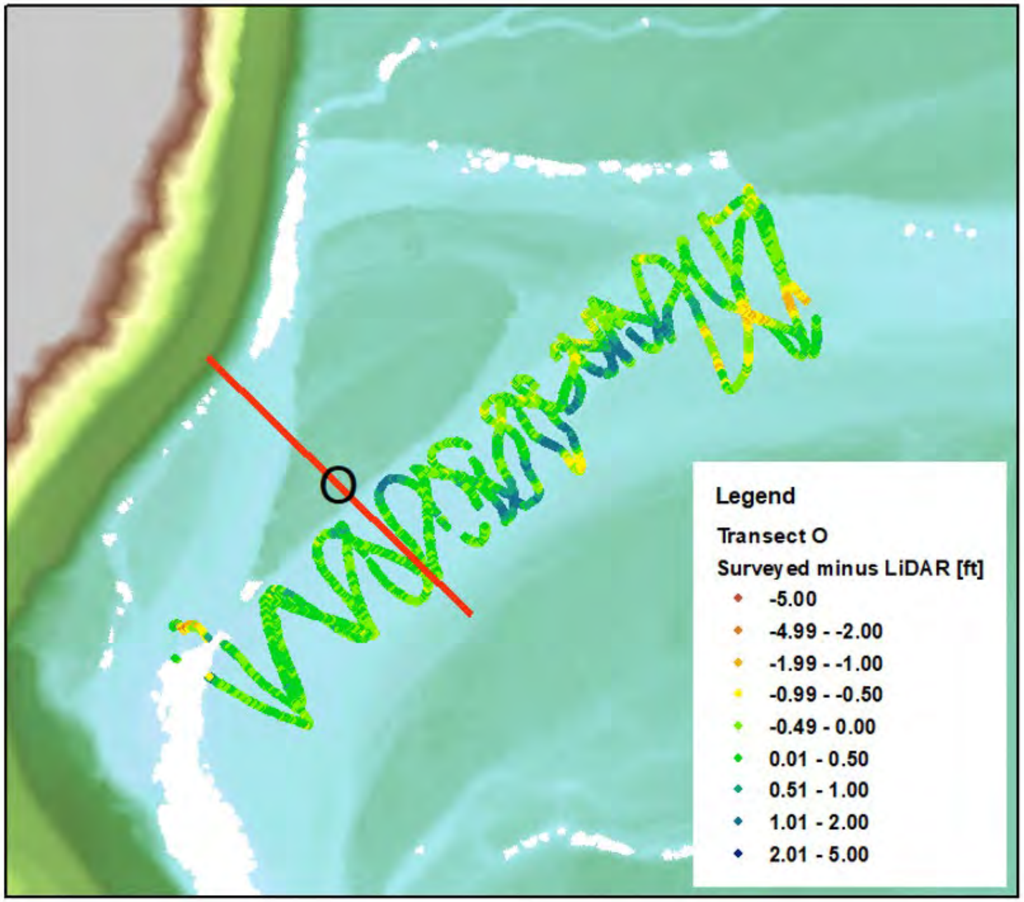

Mean: 0.03 ft.
Median: 0.00 ft.
Std. Dev.: 0.30 ft.
Percent of Returns
Difference Bin
0
2
4
6
8
10
12
14
16
18
-2.0 -1.6 -1.2 -0.8 -0.4 0.0 0.4 0.8 1.2 1.6 2.0

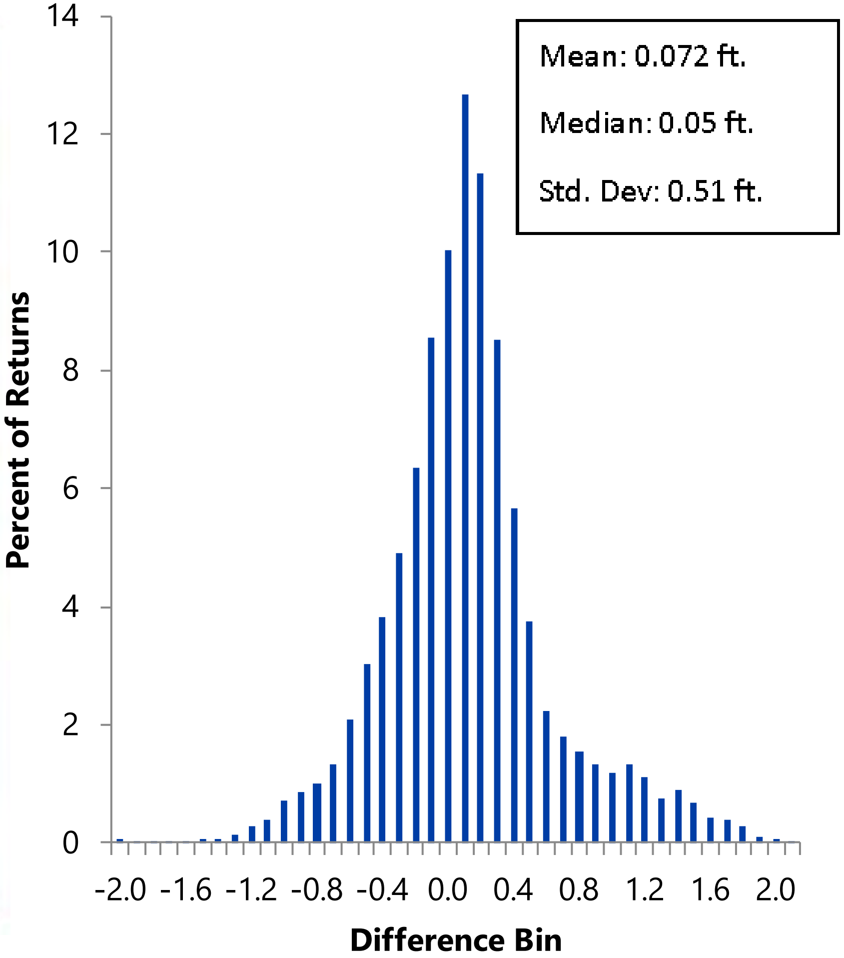
TRANSECT K



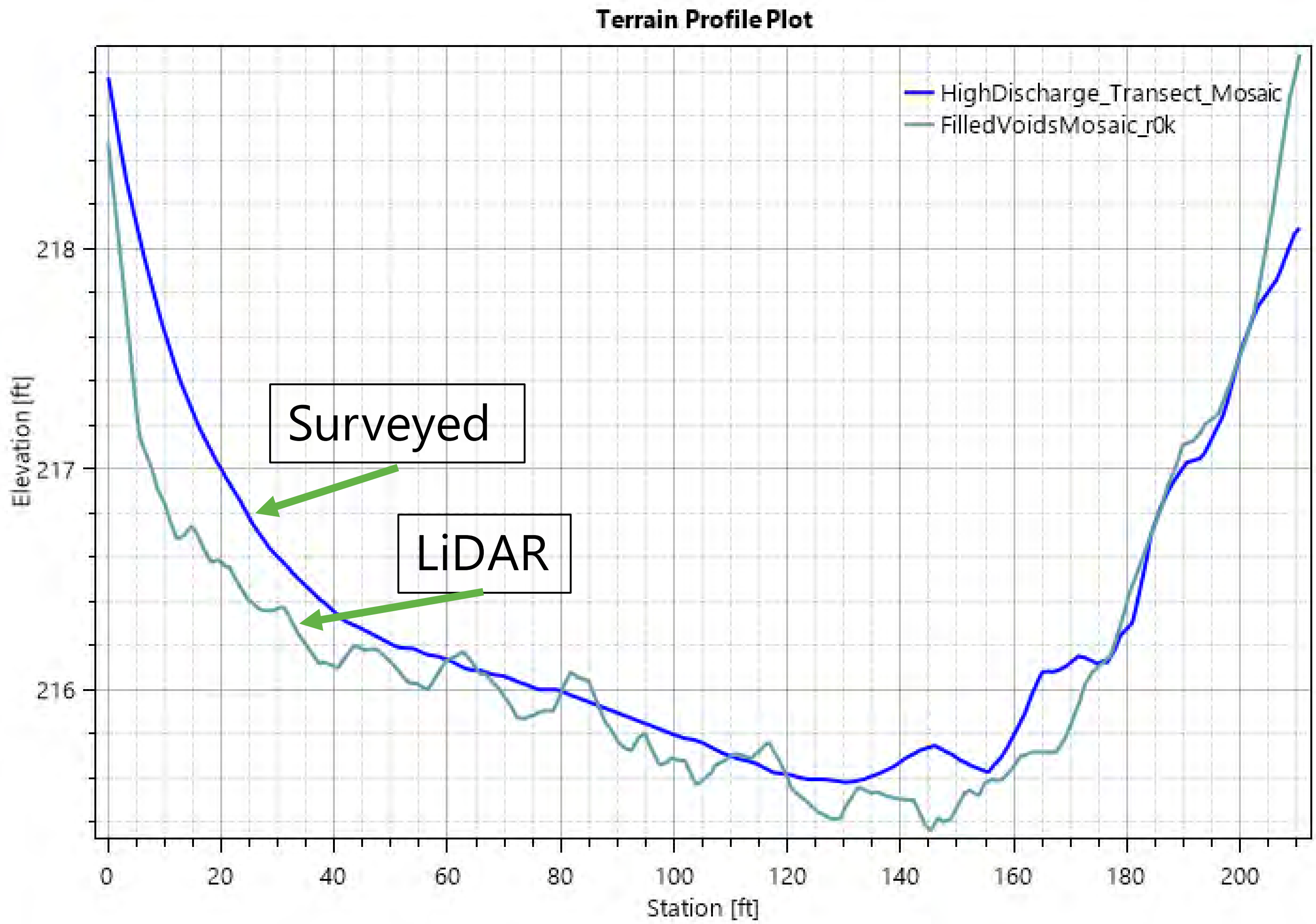
Terrain Profile Plot
FilledVoidsMosaic_r0k
LowDischarge_Transect_Mosaic
Elevation [ft]
280
275
270
265
0
50
100
150
200
250
300
350
400
450
Station [ft]
LiDAR
Surveyed

TRANSECT O – HIGH FLOW

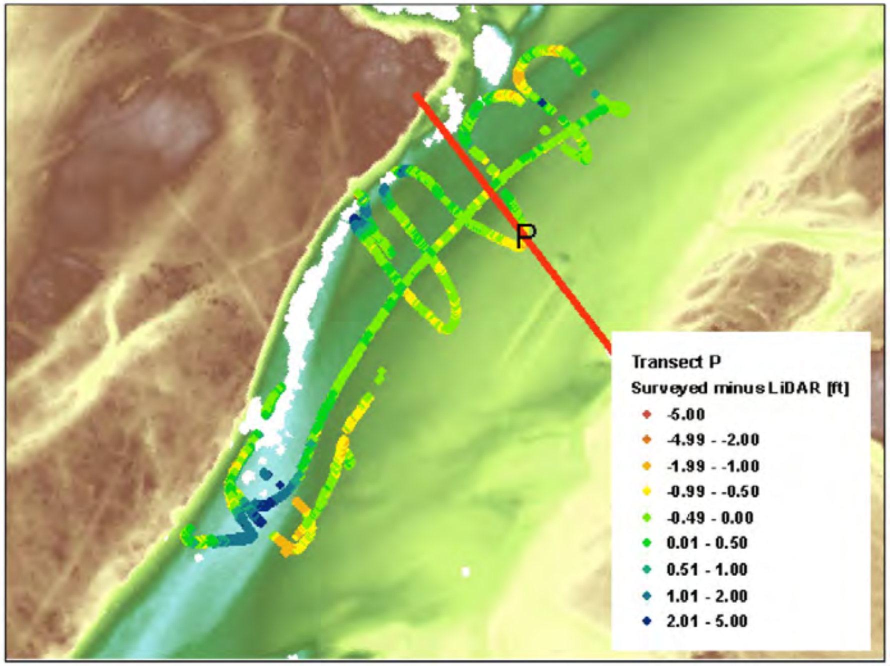


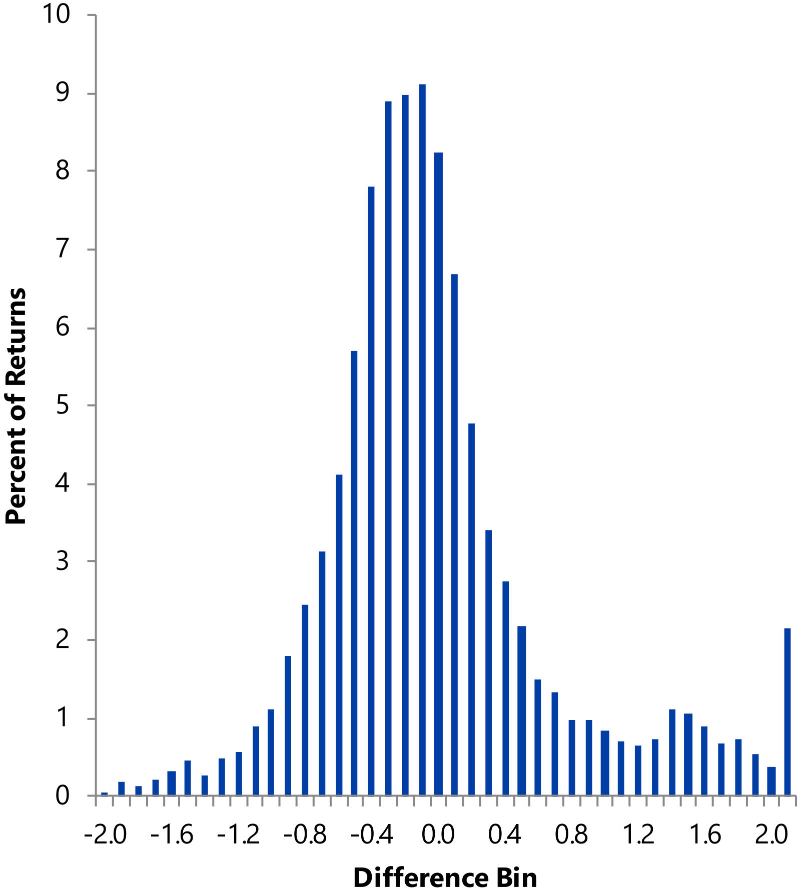


TRANSECT O – HIGH FLOW

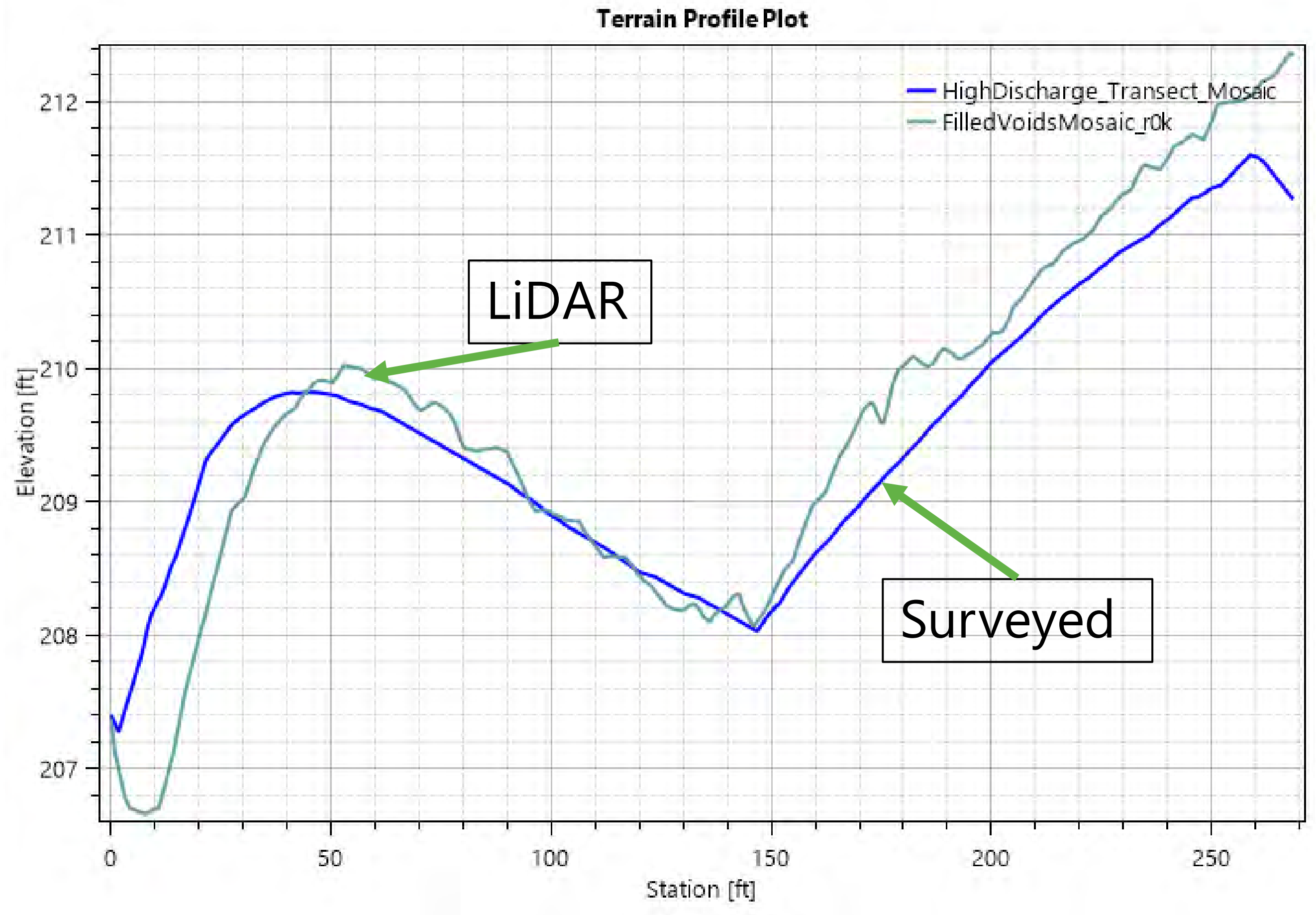


TRANSECT P – HIGH FLOW





TRANSECT P – HIGH FLOW



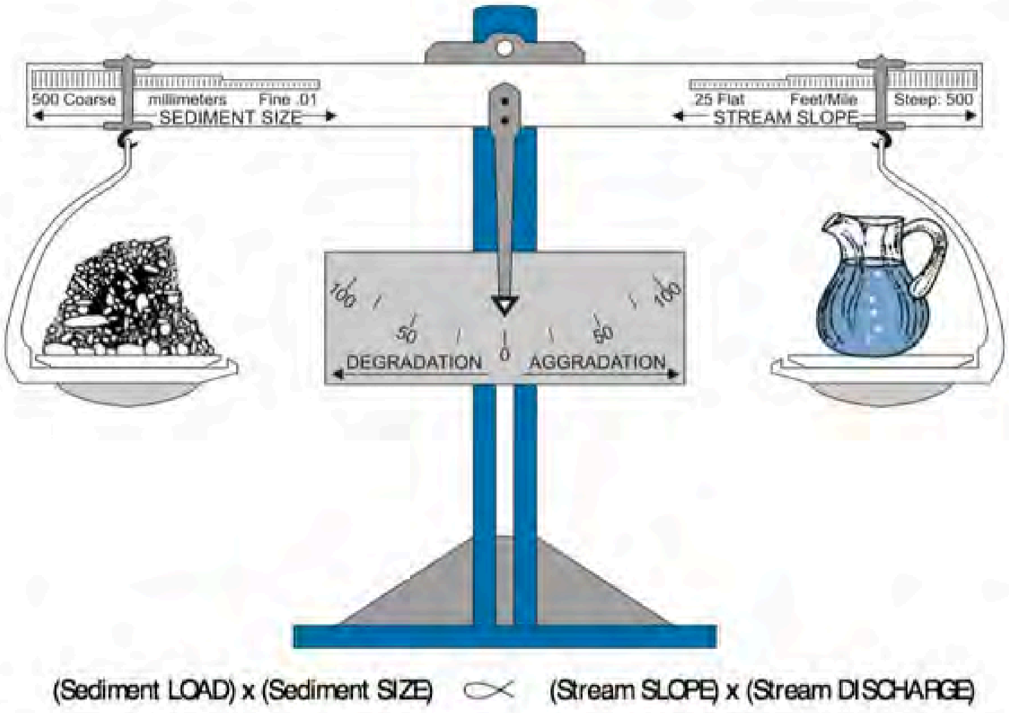
TRANSECT BATHYMETRY CHANGE

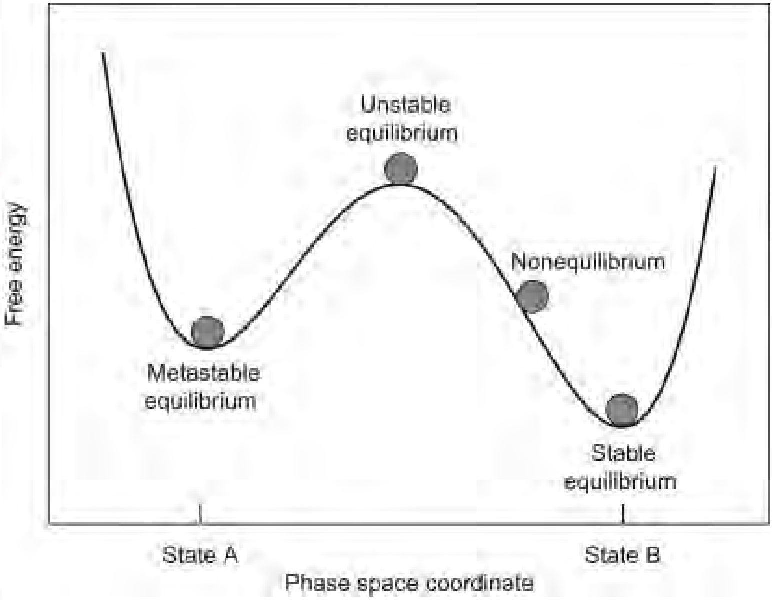
Transect	Mean Difference (ft)	Median Difference (ft)	Standard Deviation (ft)	% Points Compared
C	0.76	0.74	0.76	**40**
E	0.46	0.46	0.56	77
F	0.59	0.50	0.64	**37**
N	0.14	0.07	0.47	73
K	0.03	0.00	0.30	100
L	0.38	0.39	0.59	76
O	0.07	0.05	0.51	99
P	-0.05	-0.18	0.72	94

- Positive values indicate higher surveyed elevation

DYNAMIC EQUILIBRIUM

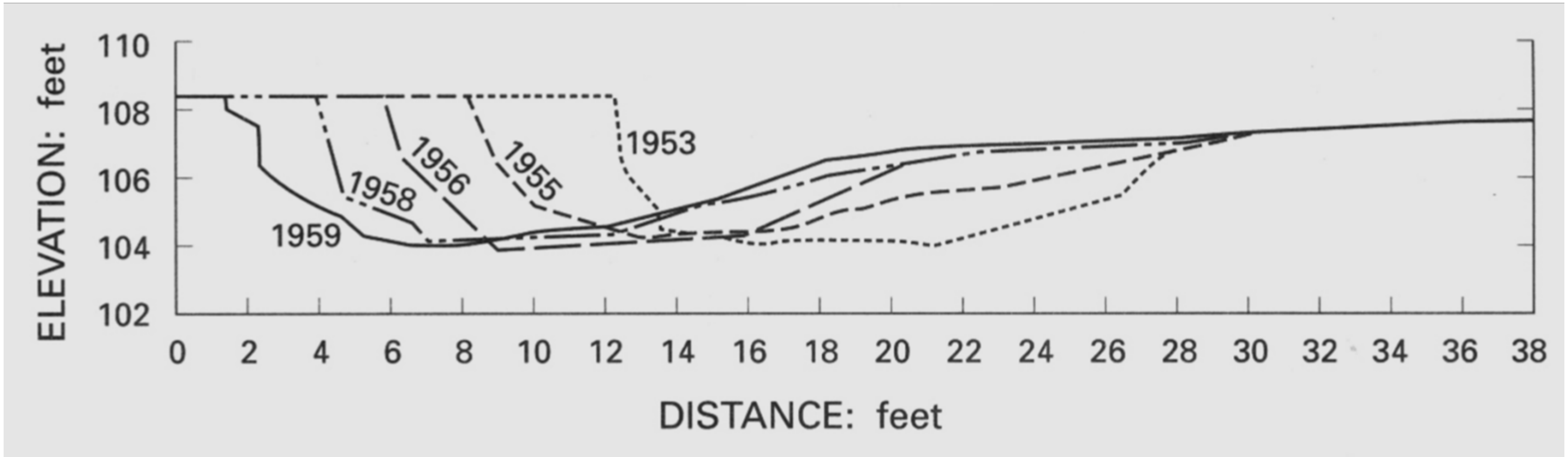
- “Streams seek a state of dynamic equilibrium between the imposed conditions of valley slope, discharge, and sediment supply, and channel adjustments”





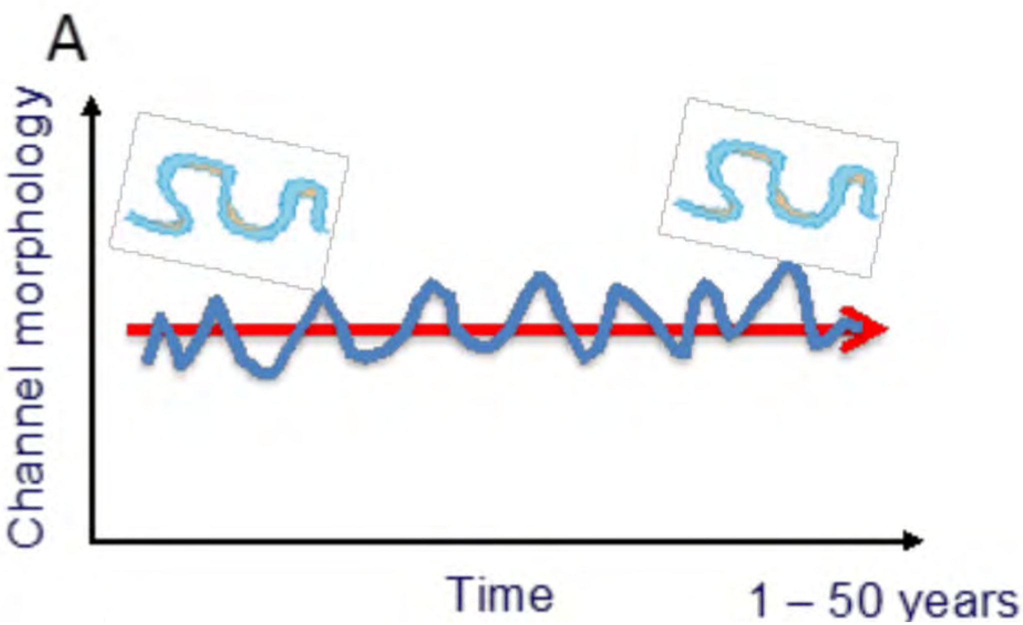
DYNAMIC EQUILIBRIUM

- Even as channels meander dynamic equilibrium can be observed



DYNAMIC EQUILIBRIUM

- Observation of channel changes does not necessarily imply channel instability



CONCLUSION

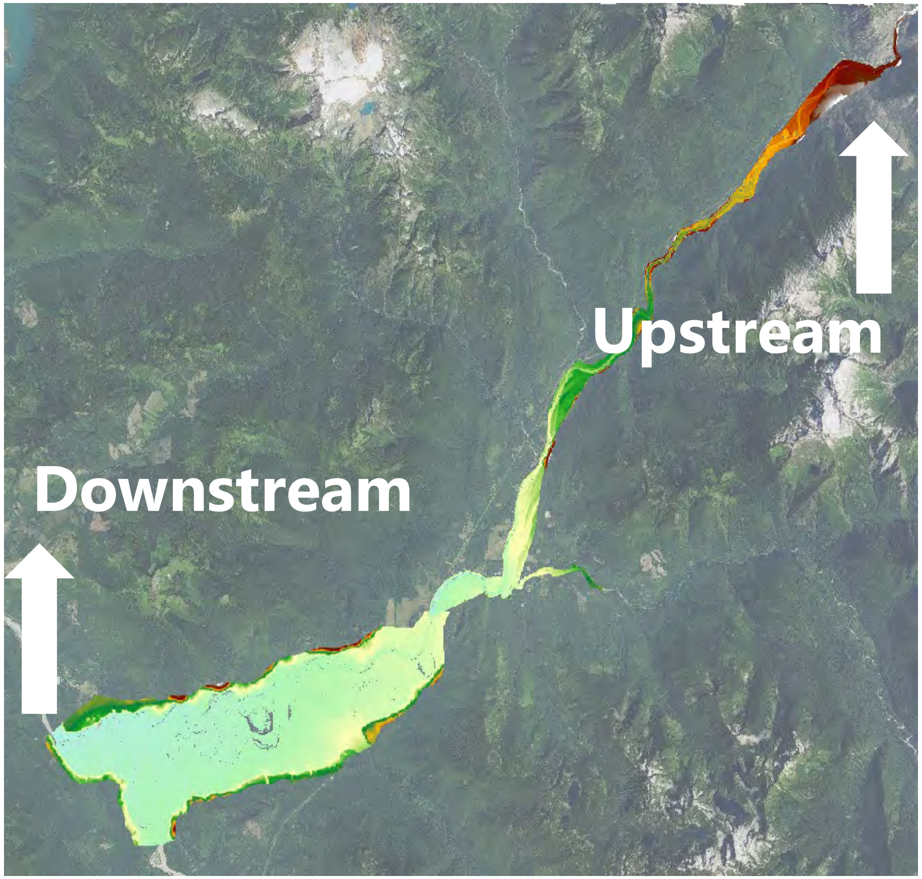
- Channel Migration
  - Dynamic conditions between PRM 65 and 74
- Transect Stability
  - Transects broadly stable, even within dynamic reaches
- Dynamic equilibrium
  - Because rivers are dynamic and will continue to be in the future, the hydraulic model should be used to define a representative condition
  - Not a precise representation of future conditions

Seattle City Light

DISCUSSION

BOUNDARIES – GORGE PH TO SAUK RIVER

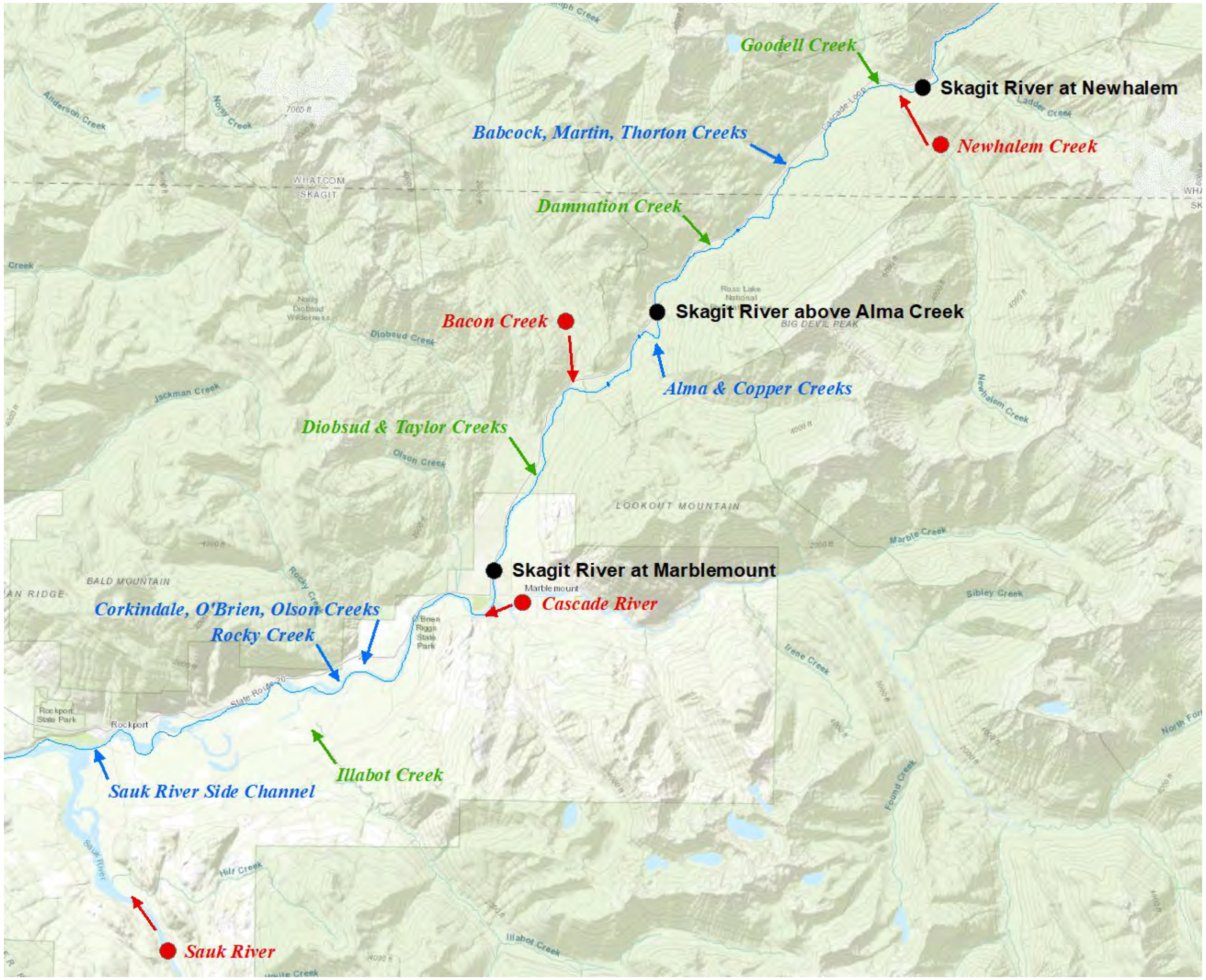
Upstream	Observed flows @ Newhalem Gage
Downstream	Observed stage @ Gage below Sauk
Intermediate	→



TRIBUTARY INFLOWS

- 13 Tributary Inflows
- 4 Calibration events
  - Low Flow - August 2020
  - Moderate Flow - October 2020
  - High Flow – March 2021
  - High Water Mark - November 2020

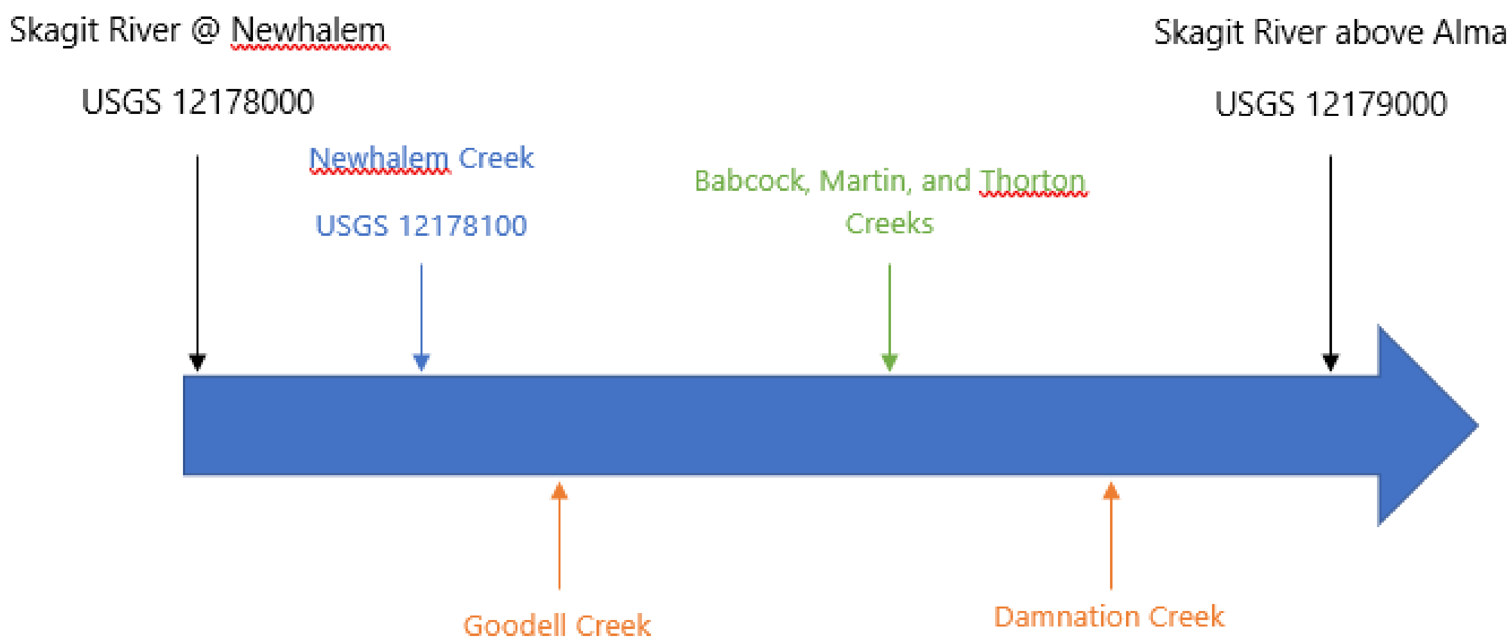
MODEL TRIBUTARY INFLOW LOCATIONS



BOUNDARIES - TRIBUTARY INFLOWS

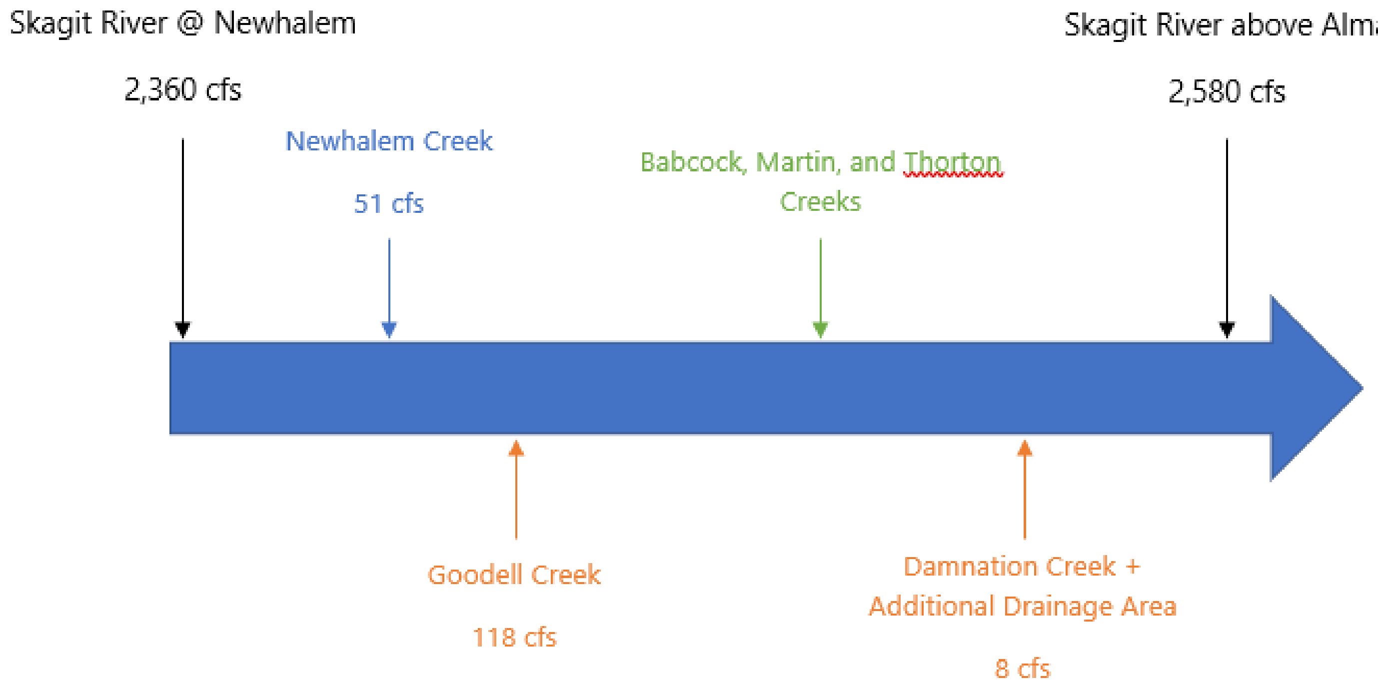
Tributary	Methodology
Newhalem Ck	USGS gage
Goodell Ck	Measurement
Damnation Ck	Measurement
Bacon Ck	USGS gage
Diobsud Ck	Measurement
Cascade River	USGS gage
Illabot Ck	Measurement
Sauk River	USGS gage
Ungaged Tributaries	Lumped and scaled from various sources

TRIBUTARY FLOW ESTIMATION



1. Calculated difference in flow between Skagit USGS gages
2. Step 1 flow minus gaged tributary flow
3. Tributary flow measurement scaled against Bacon Creek @ same date/time
4. Residual flow assigned to smaller tributaries by basin area

EXAMPLE WITH VALUES



1. Skagit @ Newhalem – Skagit above Alma = 220 cfs
2. Residual – Newhalem Crk = 169 cfs
3. Residual – Goodell Crk = 51 cfs
4. Residual – Damnation Crk (measurement scaled up based on additional DA) = 19 cfs
5. Residual to Babcock, Martin, and Thoron Crks = 19 cfs

COMPARISON OF USGS GAGE FLOWS AND MEASURED FLOWS AT TRANSECTS

Location Transect / USGS Gage	NHC Measured Flow	USGS Gage Flow	Difference
A / Newhalem	2554	2390	+7%
E / Alma	2449	2540	-4%
J / Marblemount	2698	2820	-4%

Low

Location Transect / USGS Gage	NHC Measured Flow	USGS Gage Flow	Difference
A / Newhalem	4650	4170	+12%
E / Alma	4879	5170	-6%
J / Marblemount	6065	6260	-3%

Mod

Location Transect / USGS Gage	NHC Measured Flow	USGS Gage Flow	Difference
A / Newhalem	6872	6580	+4%
E / Alma	6977	7210	-3%
J / Marblemount	7860	7780	+1%

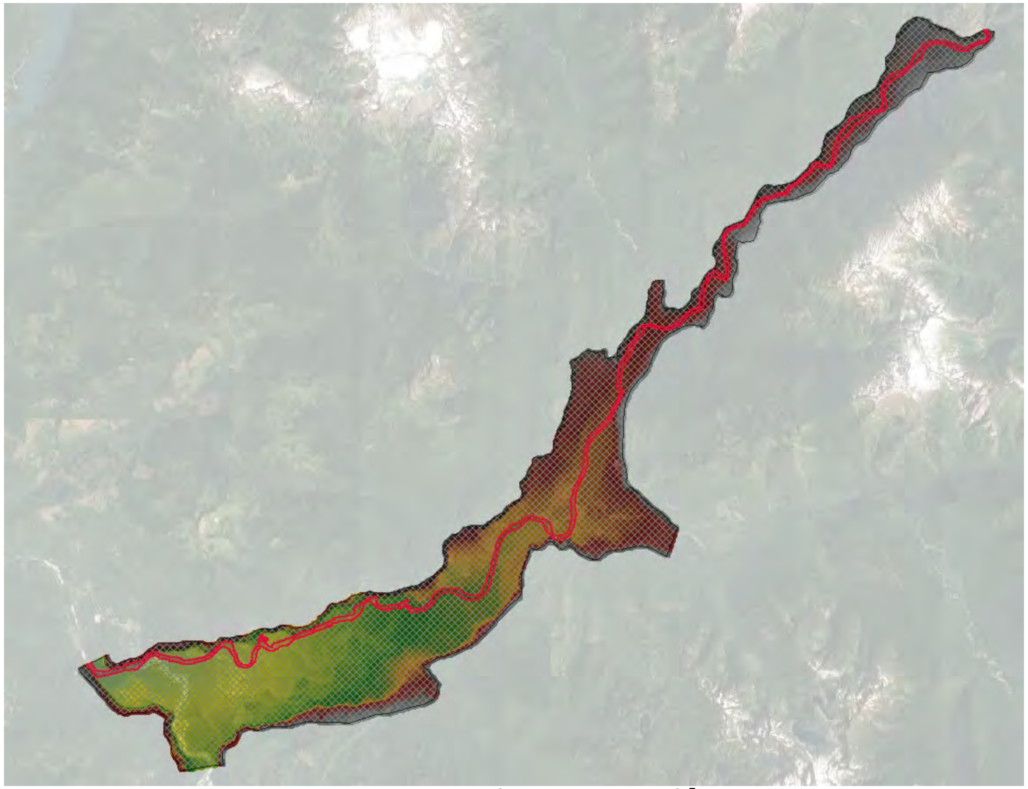
High

Seattle City Light

DISCUSSION

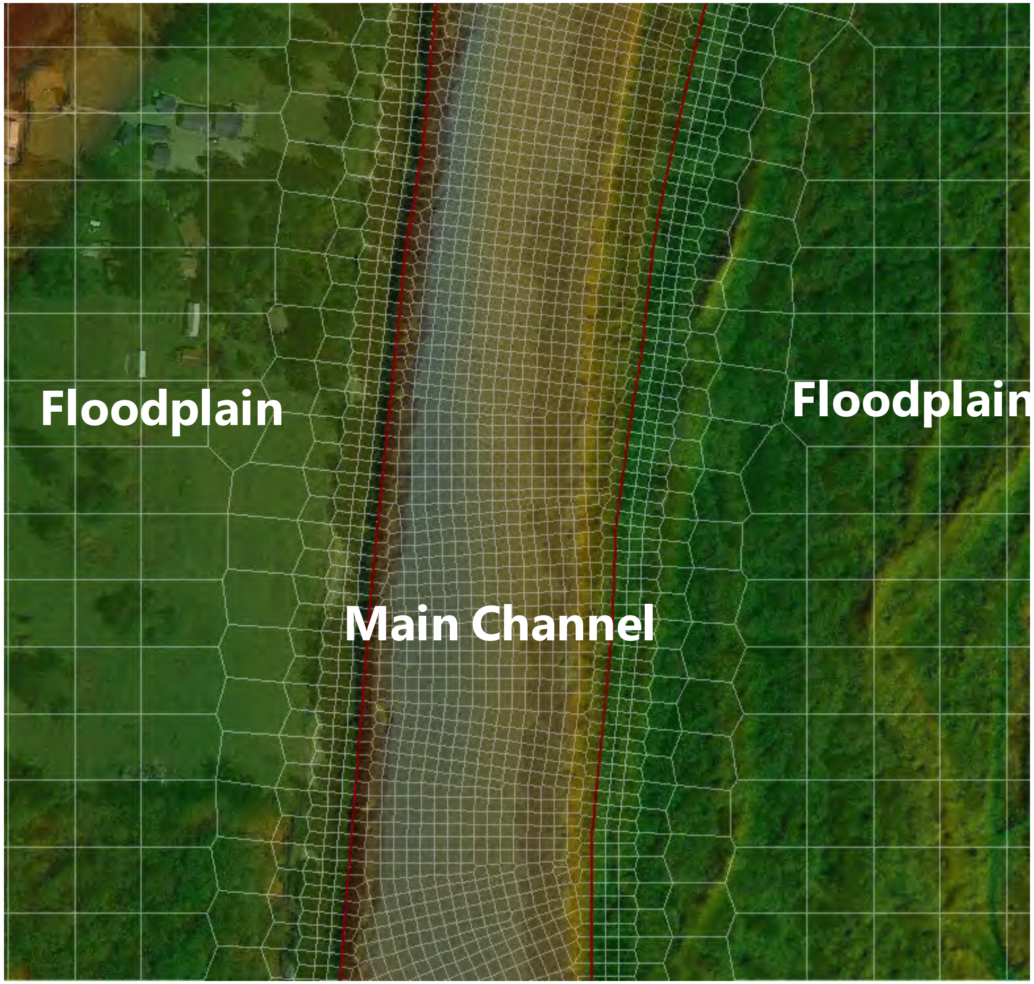
MODEL EXTENT

- HEC-RAS 2D solves for hydraulic properties at the cell level



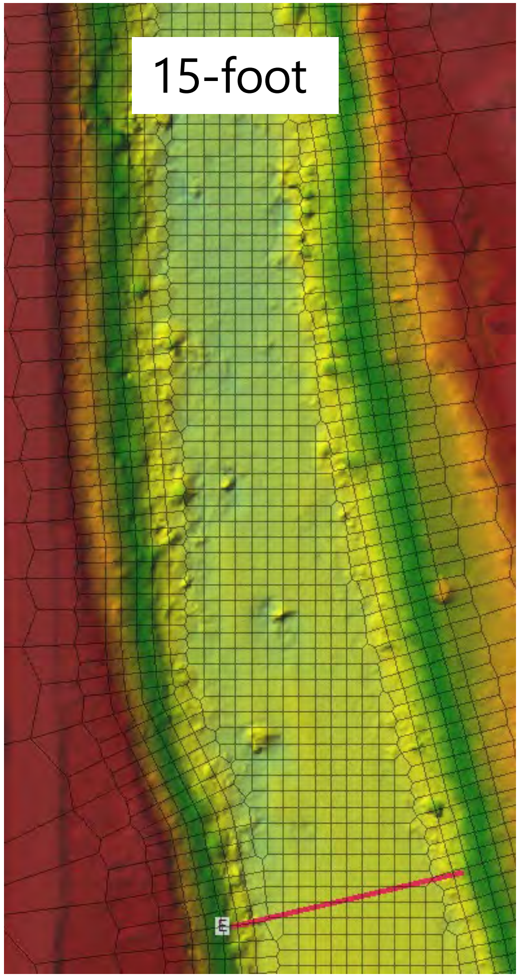
~29 River Miles

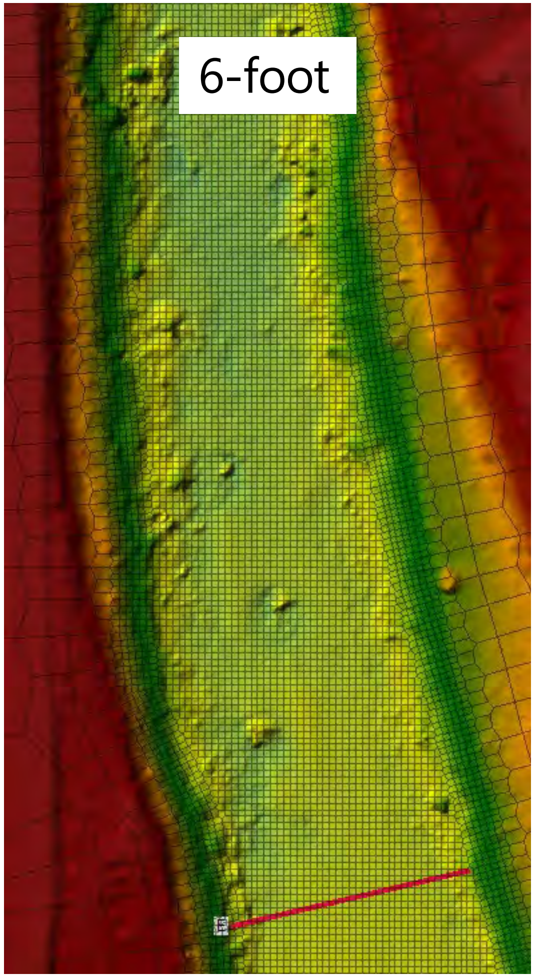
CELL SIZE TRANSITION



CELL SIZES MODELED

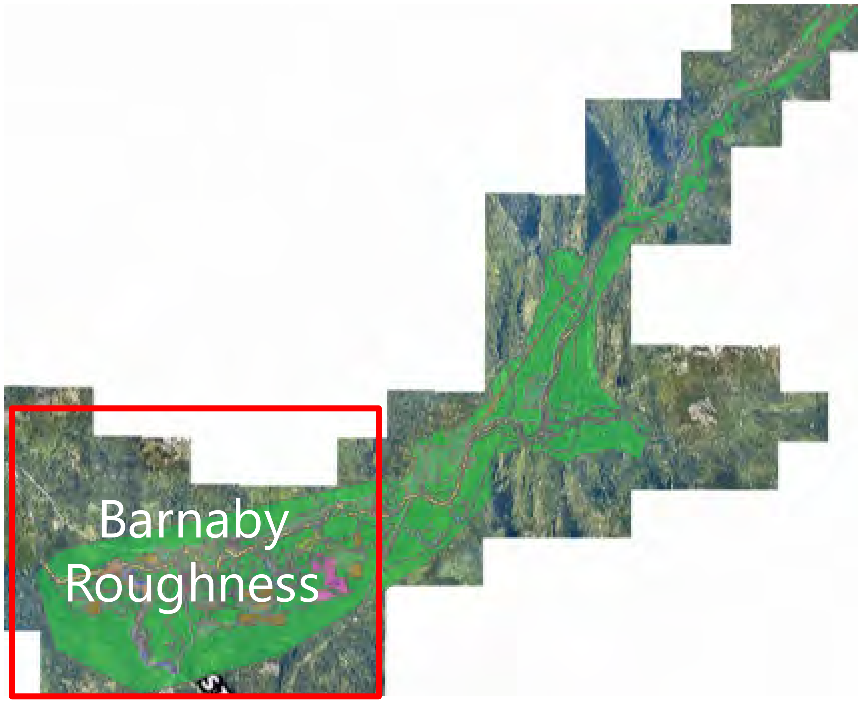
- 30′
- 20′
- 15′
- 10′
- 6′





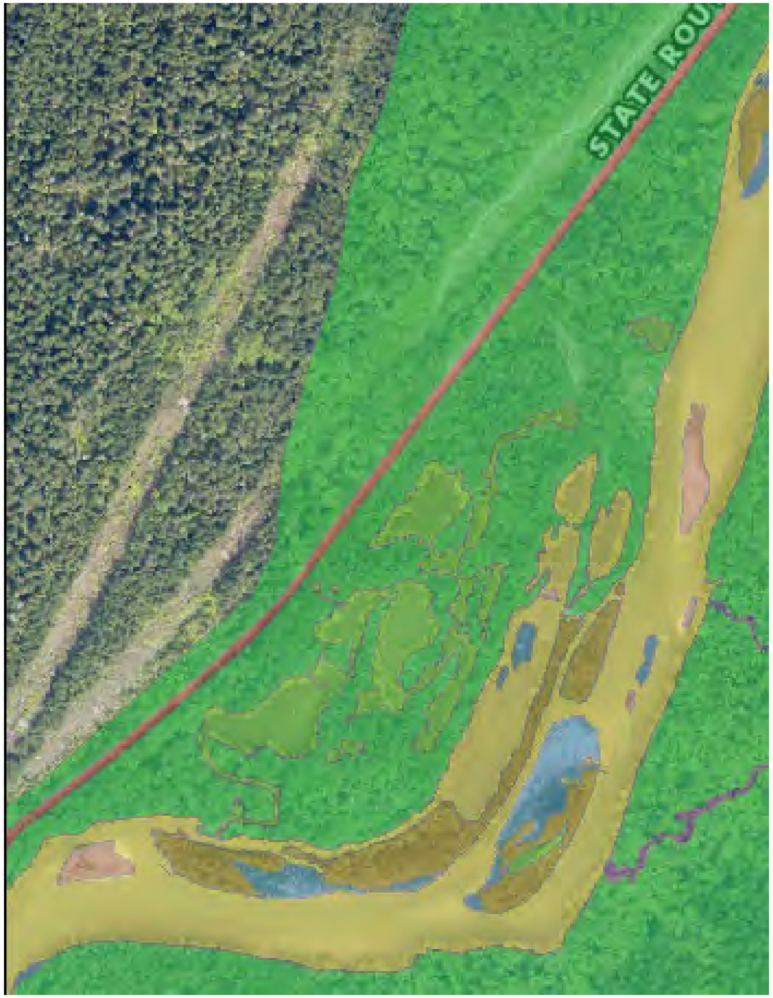
ROUGHNESS AREA DELINEATION

- LiDAR-based edge of water used to delineate wetted channel area
  - o 2018 collected @ 5,000 cfs
  - o 2017 collected @ 8,000 cfs
- Bars and Floodplain – manual delineation from 2018 aerial imagery (1:2000 scale)
- Large Wood delineation from GE-04 Study
- Barnaby Reach delineation used as-is



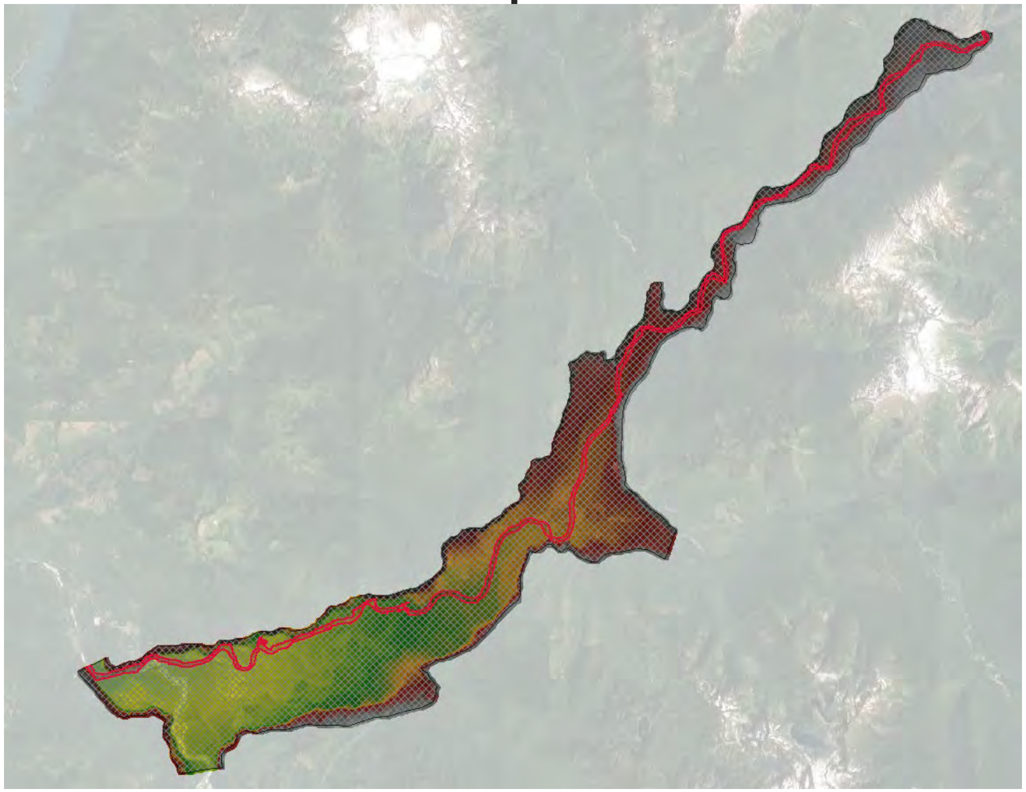
ROUGHNESS CATEGORIES

- Wetland
- Main Channel
- Main Channel Sauk
- Side Channel
- Slough
- Forest
- Pasture
- Clearcut Forest
- Gravel bar
- Vegetated Gravel Bar
- Logjam
- Riprap
- Gravel Road
- Paved Road
- Young Forest
- Tributary



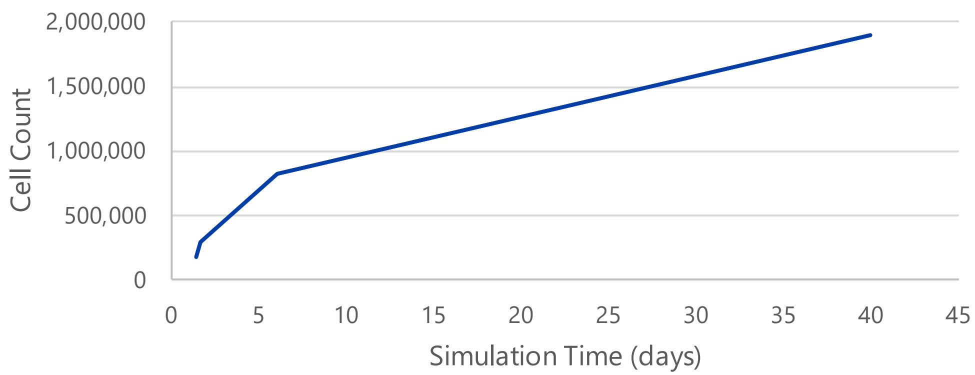
FULL MODEL

- Inflows run through full model on cloud computer
- Calibration will be completed on the full model



FULL MODEL CELL COUNT & COMPUTATION TIME

Cell Size (ft)	Number of Cells	5-Day Simulation Computer Run Time (days)
30	183,000	1.4
20	291,000	1.7
15	427,000	3.4
10	817,000	6.0
6	1,900,000	>40



Seattle City Light

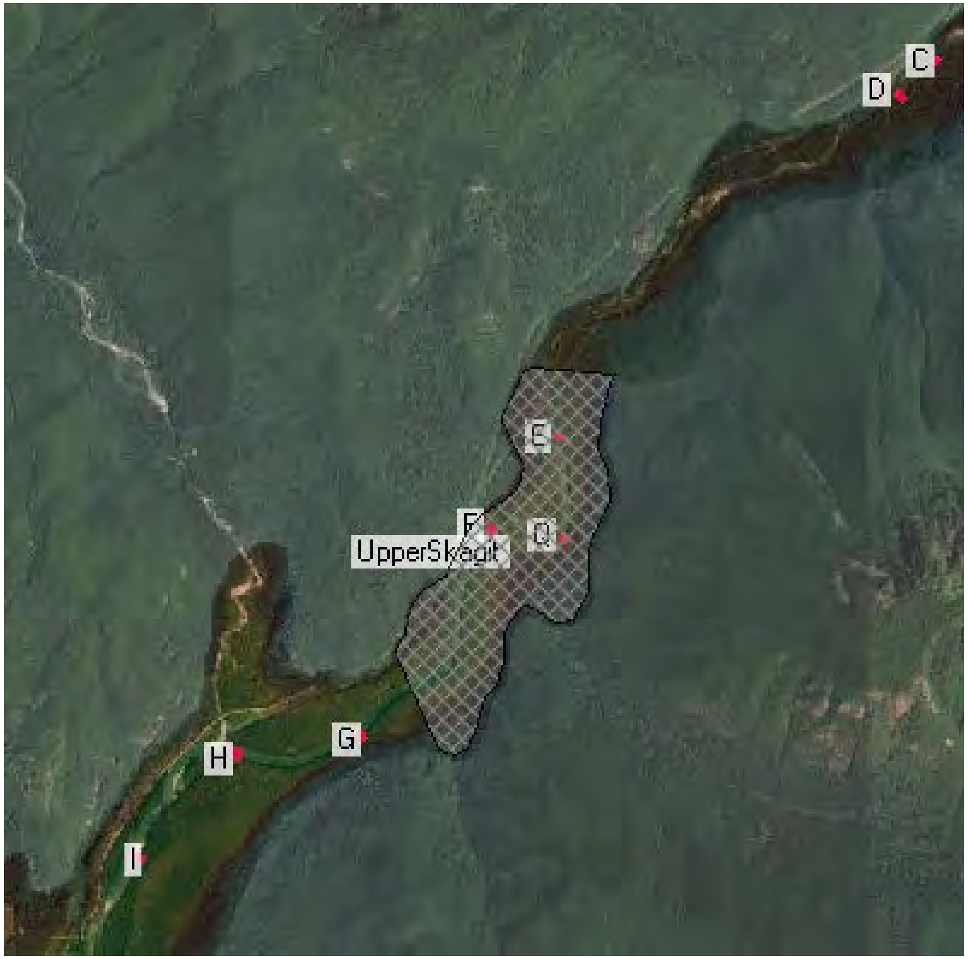
DISCUSSION

"SUBSET" MODEL

- Used a "subset" model for sensitivity analysis
- Allows testing of model parameters at significantly reduced run times
- Created two subset models
    - Transects E, Q, and F (1.5 Miles)
    - Transects I, N, and J (4 Miles)

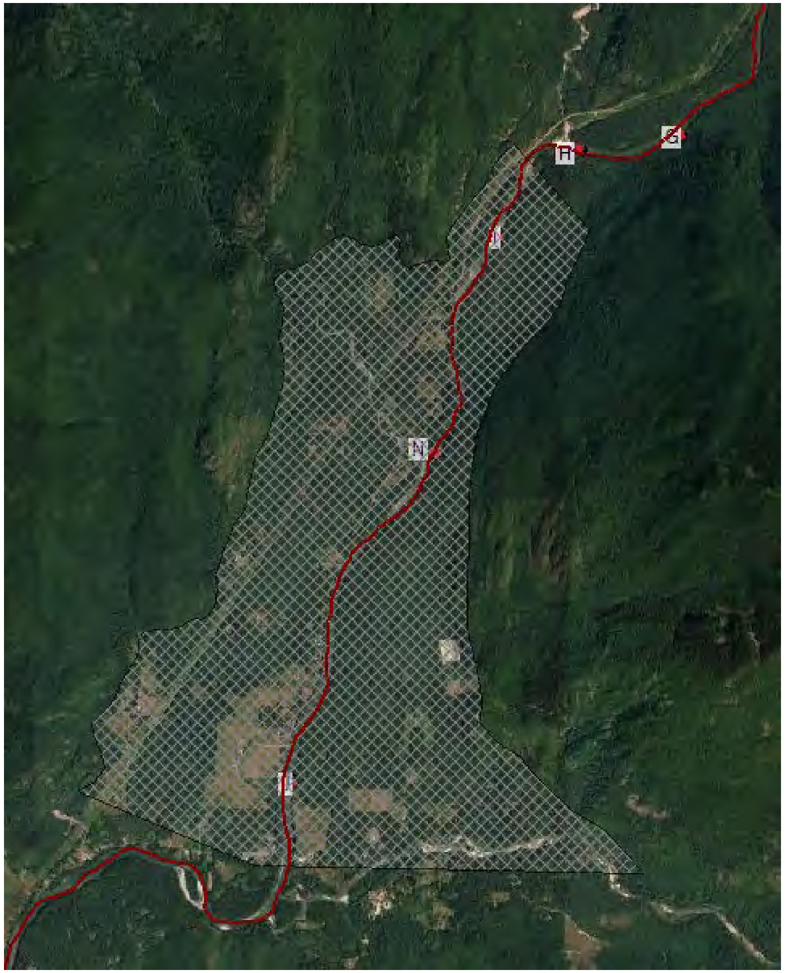
E,Q,F SUBSET MODEL

- Includes pools, riffles, and runs
- Close transect spacing
- Coincident with USGS Alma Gage



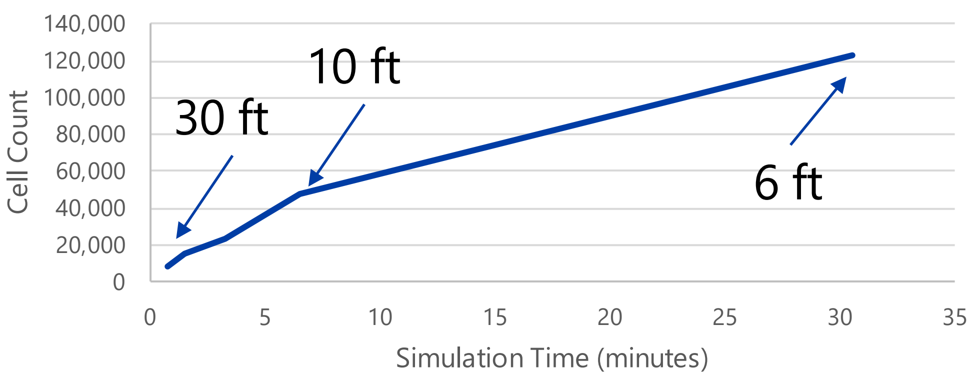
I,N, J SUBSET MODEL

- Planform and slope representative of relatively large portion of domain
- Coincident with USGS Marblemount Gage



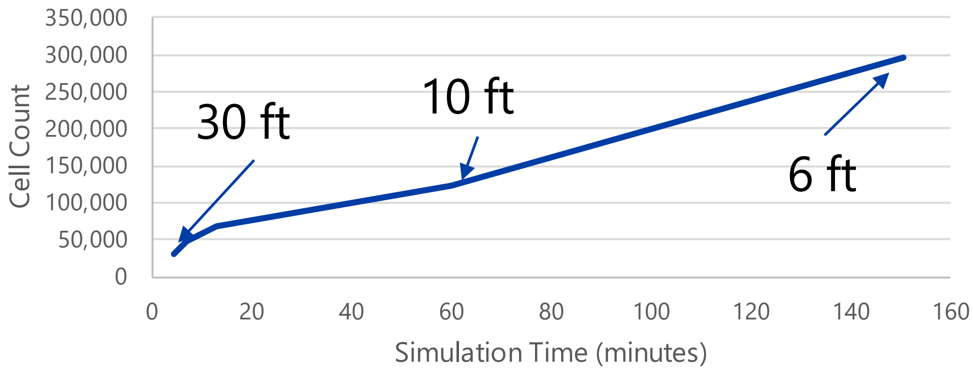
E,Q,F SUBSET MODEL CELL COUNTS & COMPUTATION TIME

Cell Size (ft)	Number of Cells	4-Hour Steady Run Time (minutes)
30	8,000	0:44
20	15,000	1:28
15	24,000	3:14
10	48,000	6:27
6	123,000	30:49

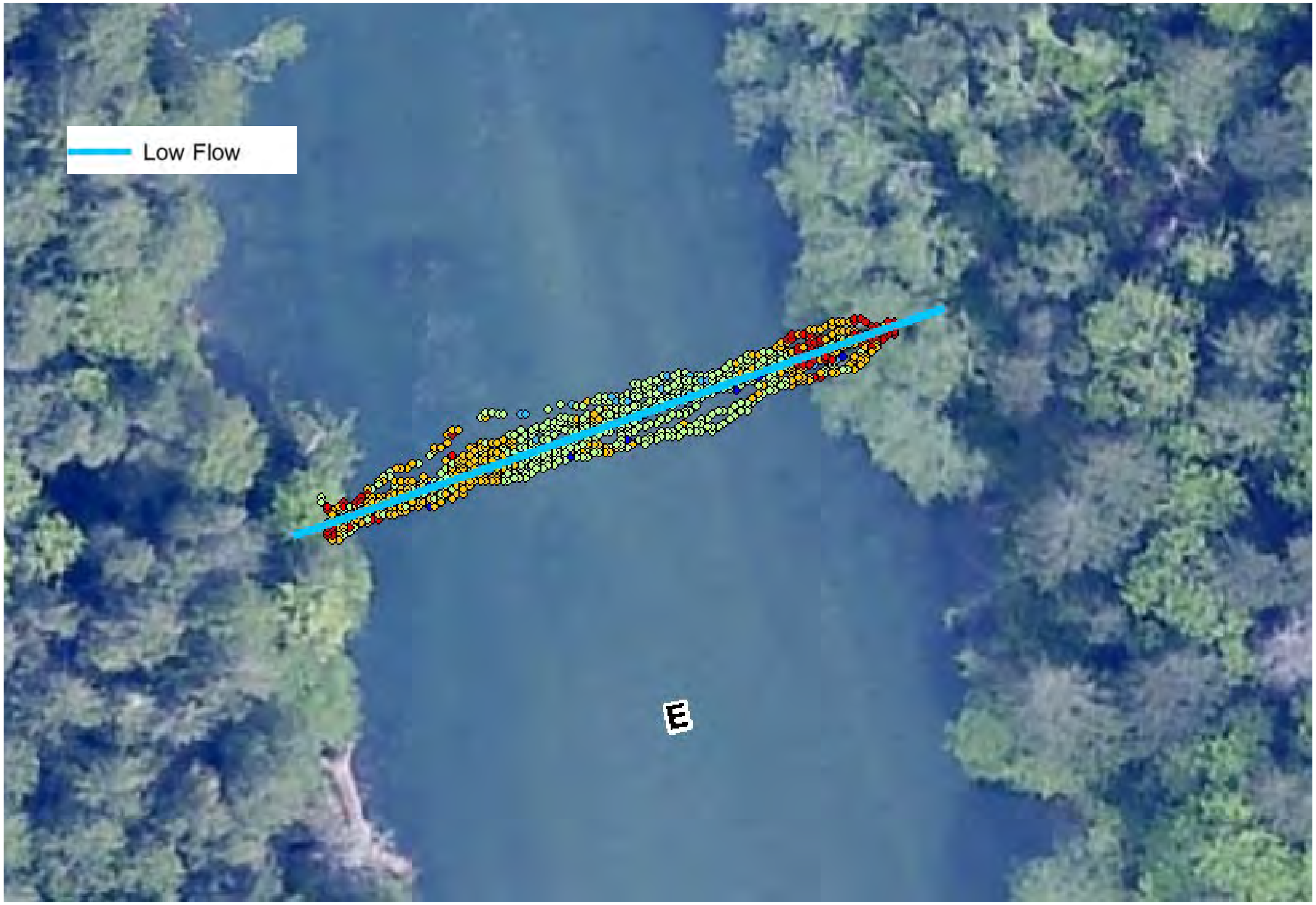


I,N,J SUBSET MODEL CELL COUNTS & COMPUTATION TIME

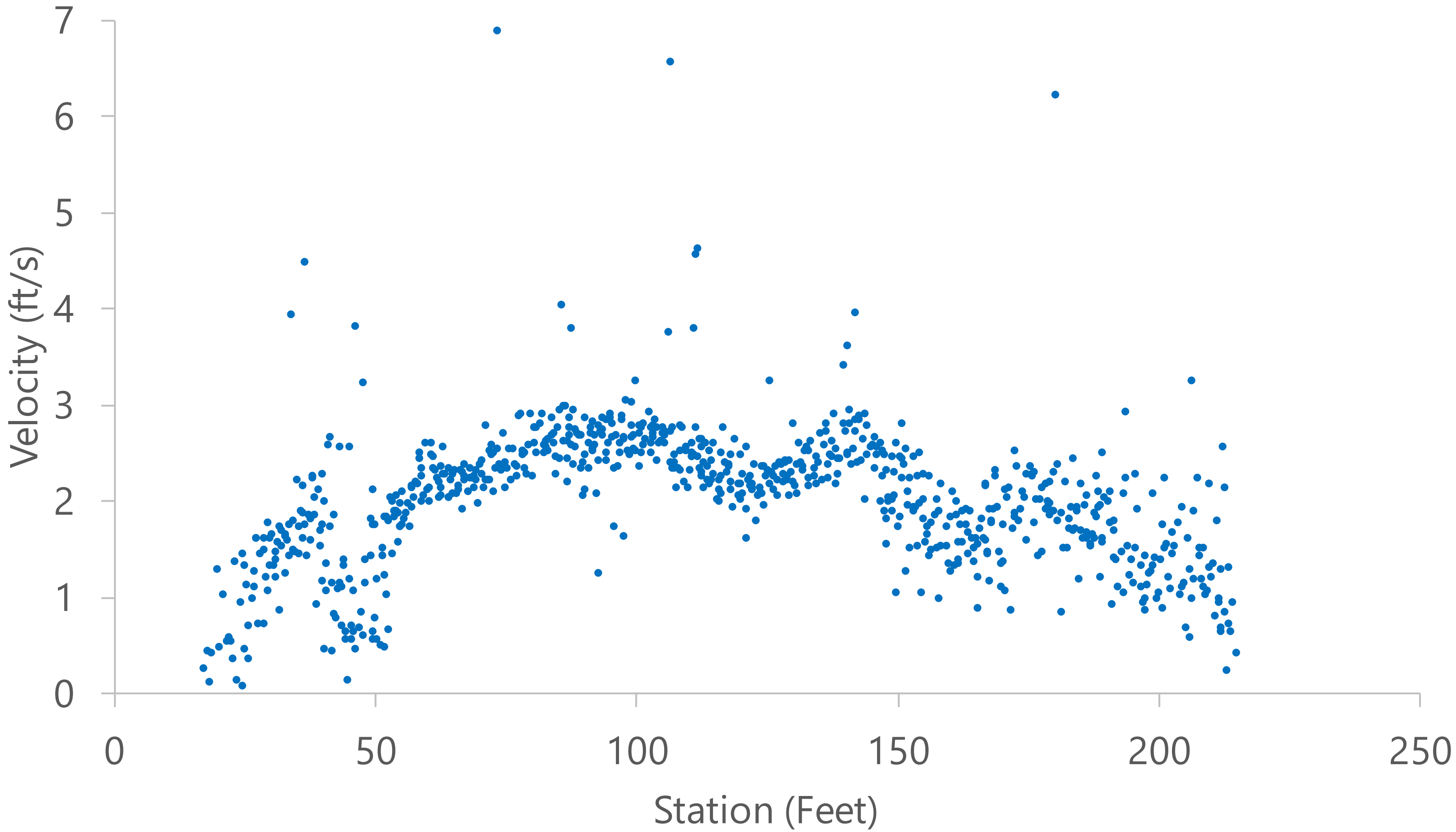
Cell Size (ft)	Number of Cells	4-Hour Steady Run Time (**minutes**)
30	31,000	4:29
20	47,000	7:10
15	67,000	12:40
10	123,000	60:01
6	295,000	150:31



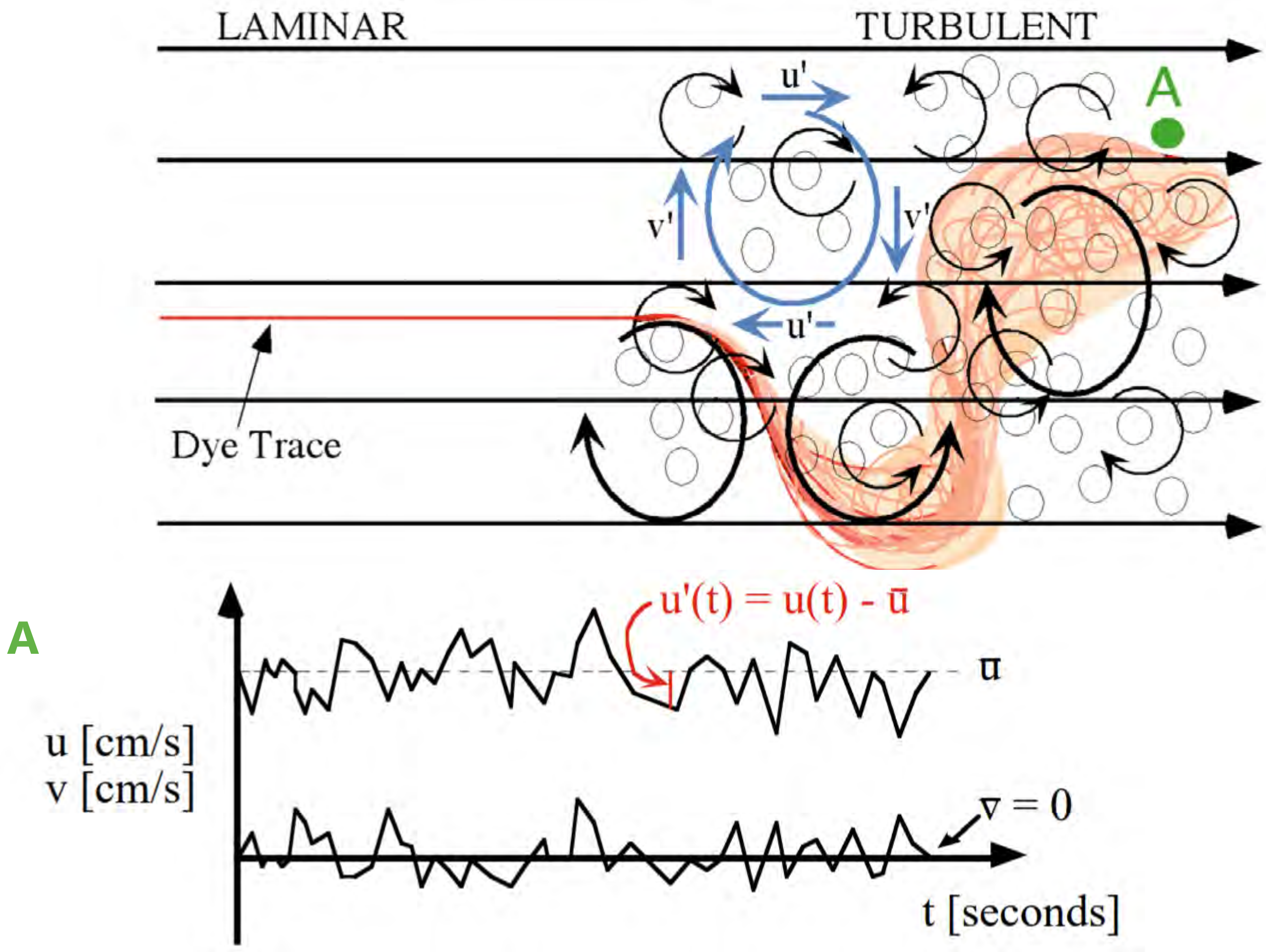
EXAMPLE TRANSECT E DATA



MEASURED VELOCITY – TRANSECT E

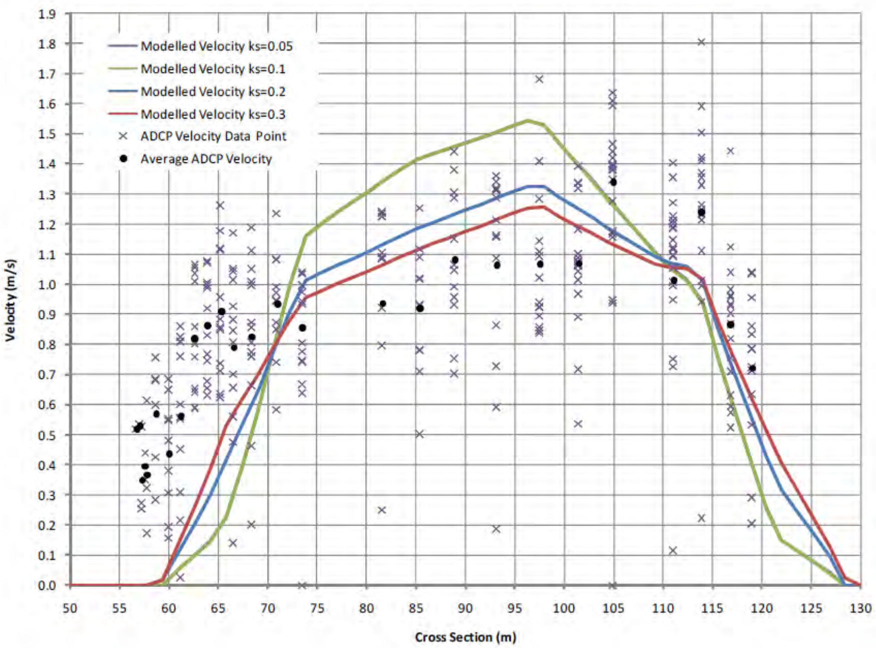


NOTE ON VELOCITY DATA



VELOCITY DATA FROM OTHER STUDIES

Figure 31. Modelled and ADCP velocities near Cooper Creek (KM 7.2).



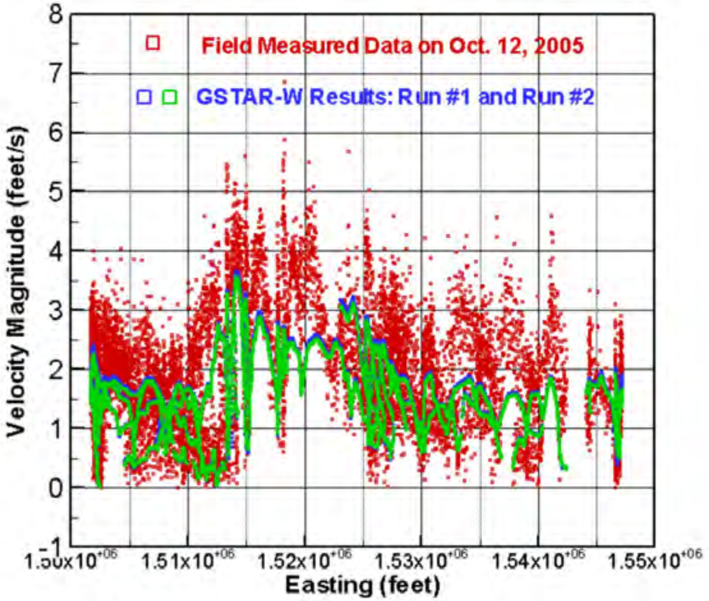
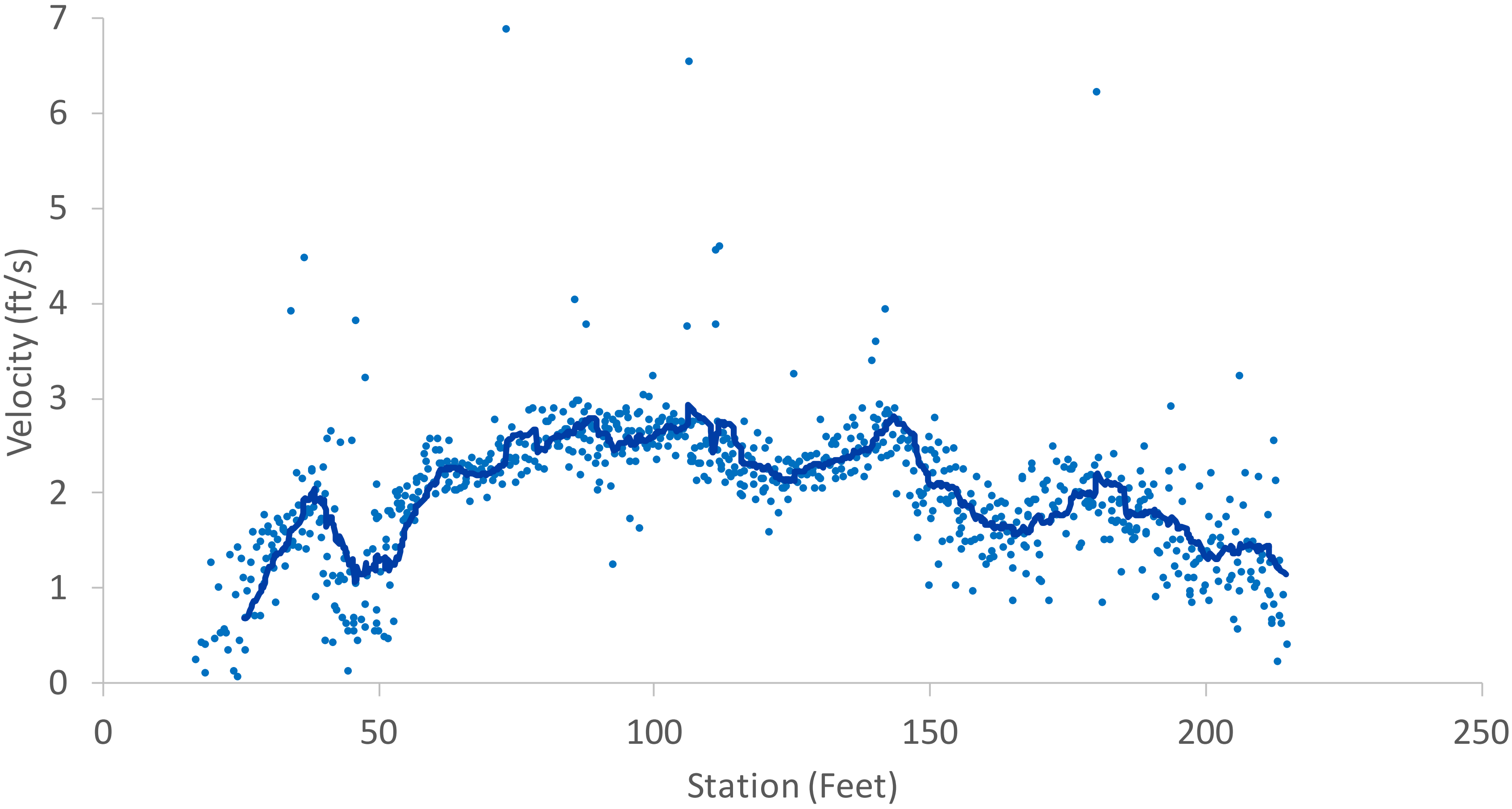
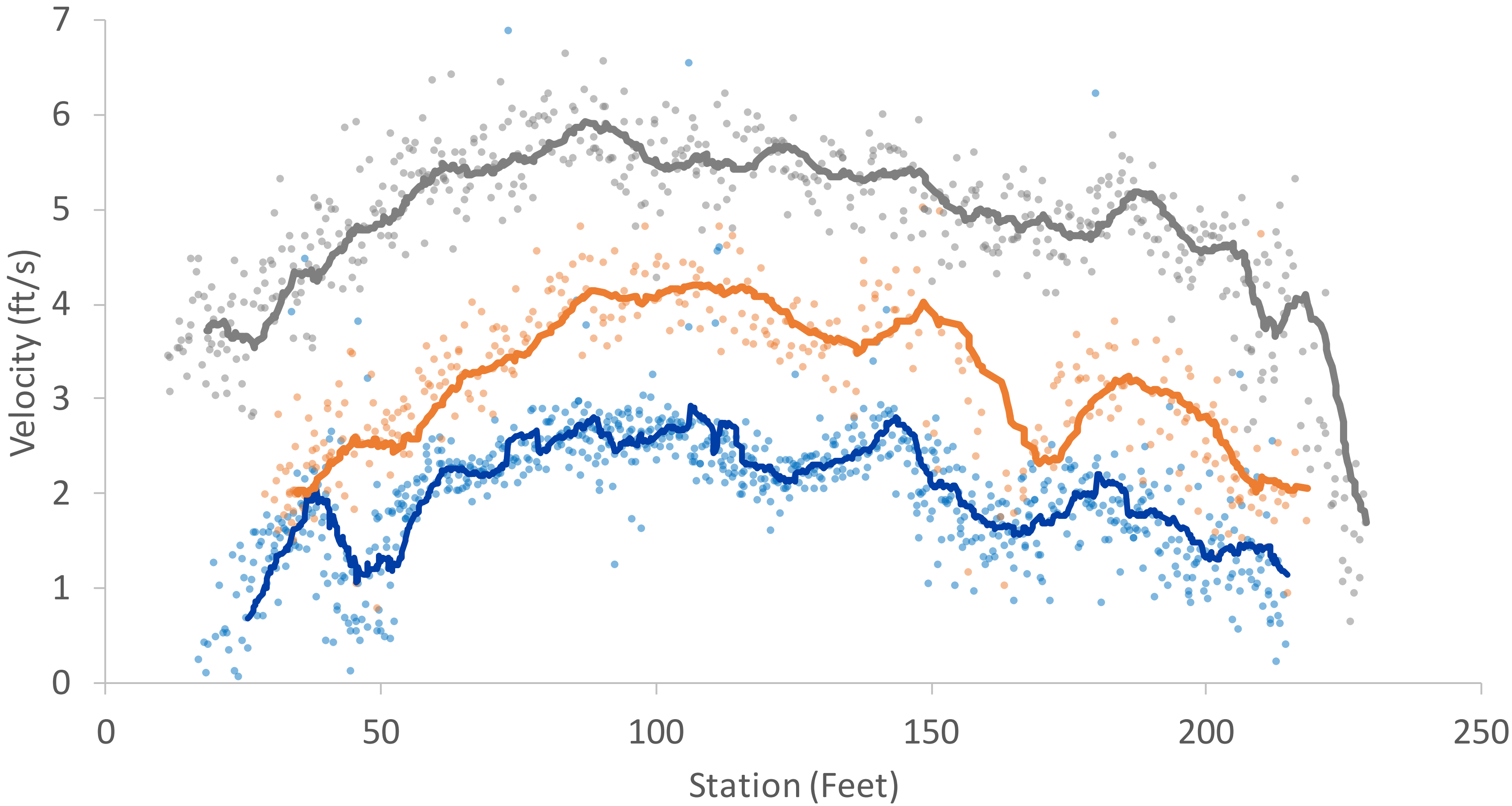


Figure 37. Comparison of simulated and field-measured velocity magnitudes along the Columbia River reach for October 12, 2005 flow conditions (GSTAR-W is the former name of SRH-2D)

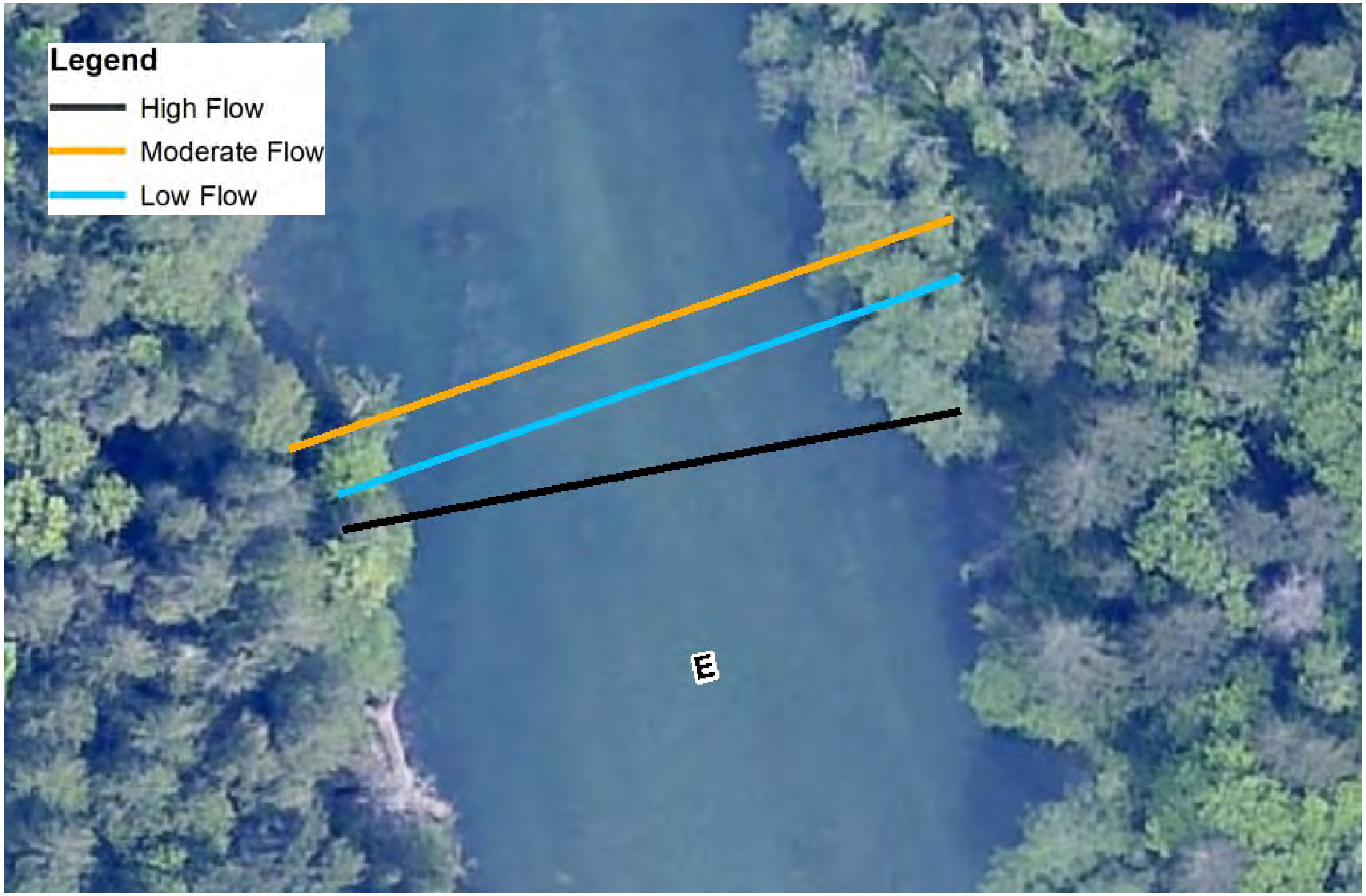
MEASURED VELOCITY TRANSECT E



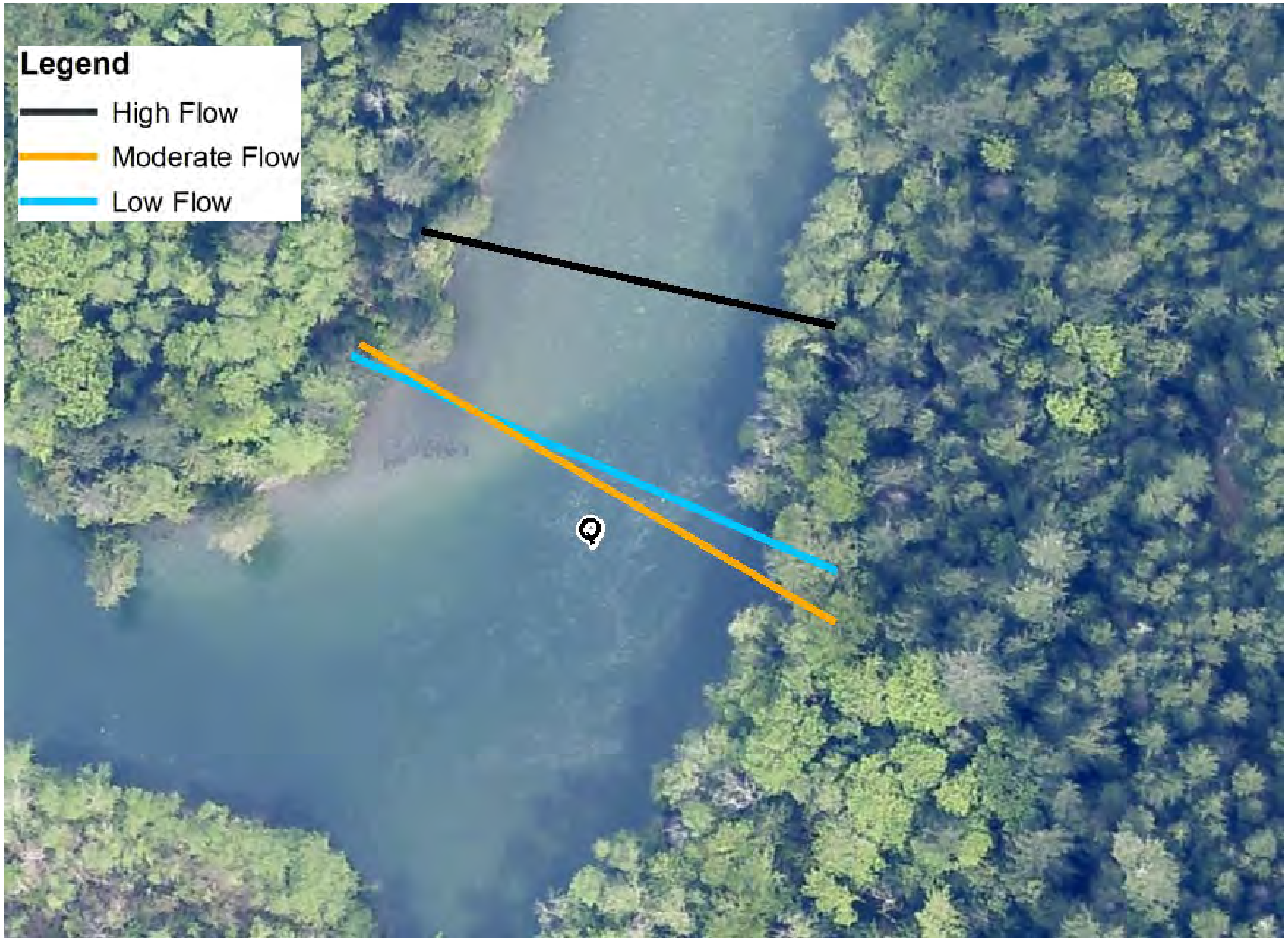
MEASURED VELOCITY TRANSECT E



NON-COINCIDENCE OF MEASUREMENT TRANSECTS



NON-COINCIDENCE OF MEASUREMENT TRANSECTS



HYDRAULIC MODEL SENSITIVITY TESTS

- Subset model E,Q,F and I,N,J sensitivity

Cell Size
30-ft
20-ft
15-ft
10-ft
6-ft

Roughness
+40%
+20%
+10%
-10%
-20%
-40%

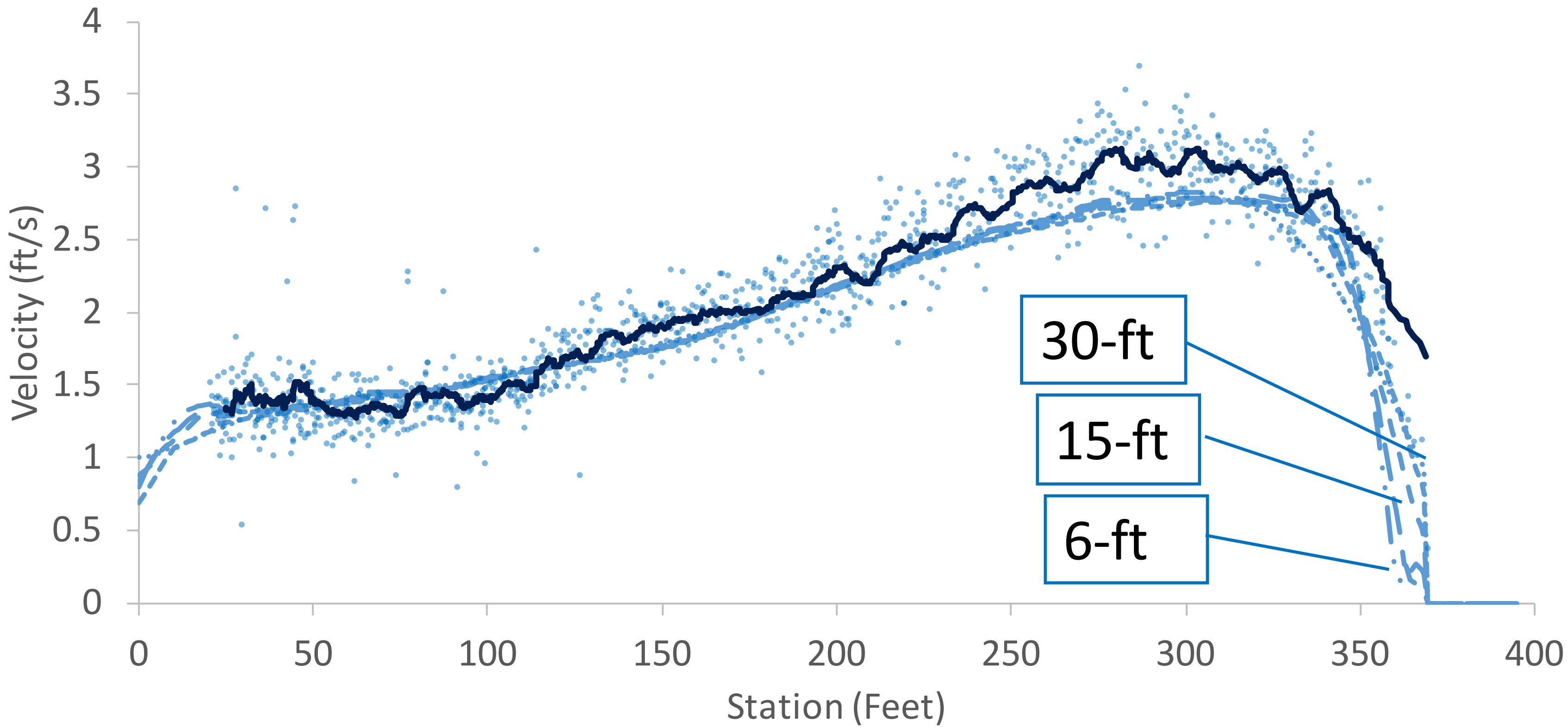
WSEL

Velocity

- Charts of measured vs. simulated values
  - Shown to provide reference to sensitivity
  - Not at the calibration stage

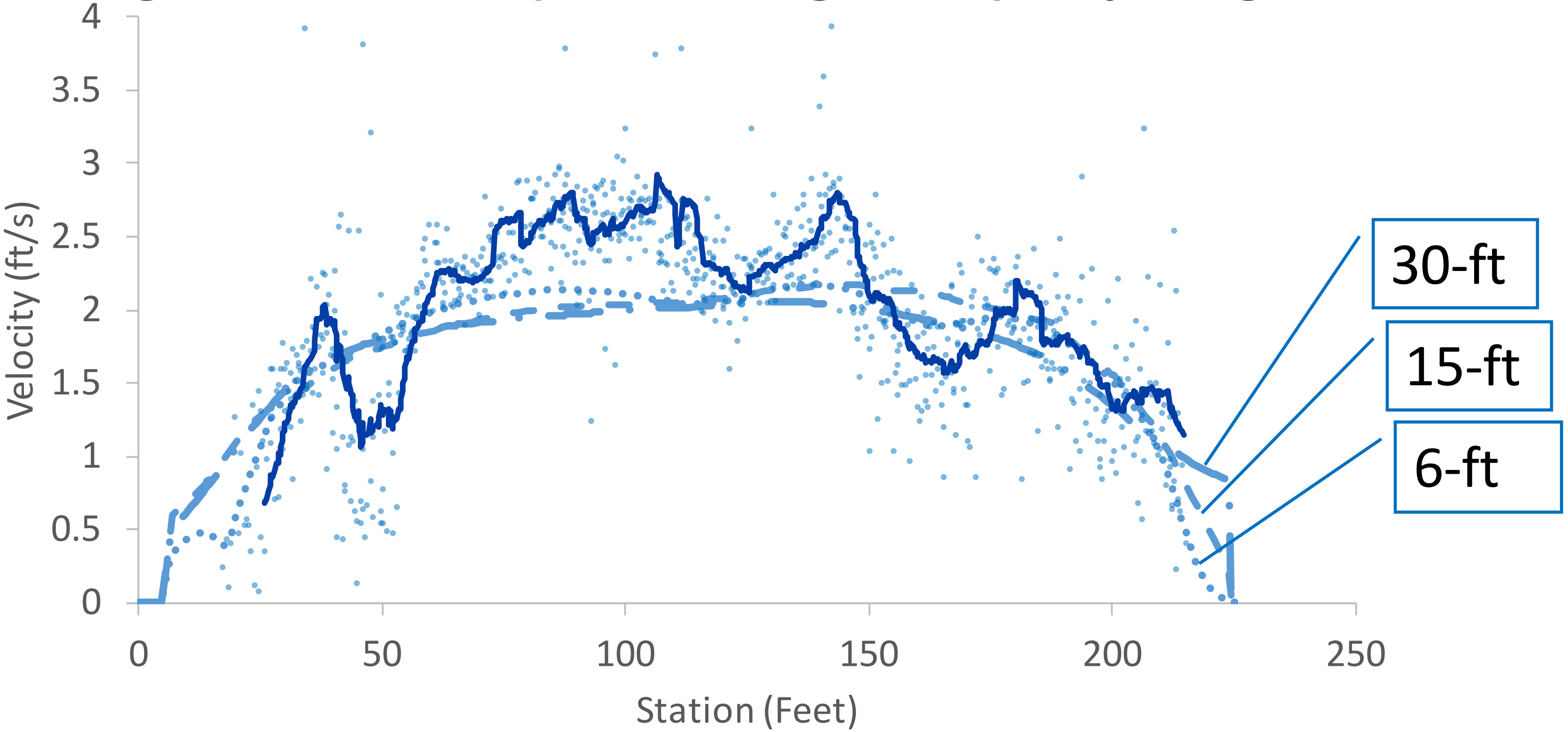
SENSITIVITY RESULTS – CELL SIZE AND VELOCITY

- Velocity is not sensitive to cell size where velocity changes gradually (e.g. Transect J)



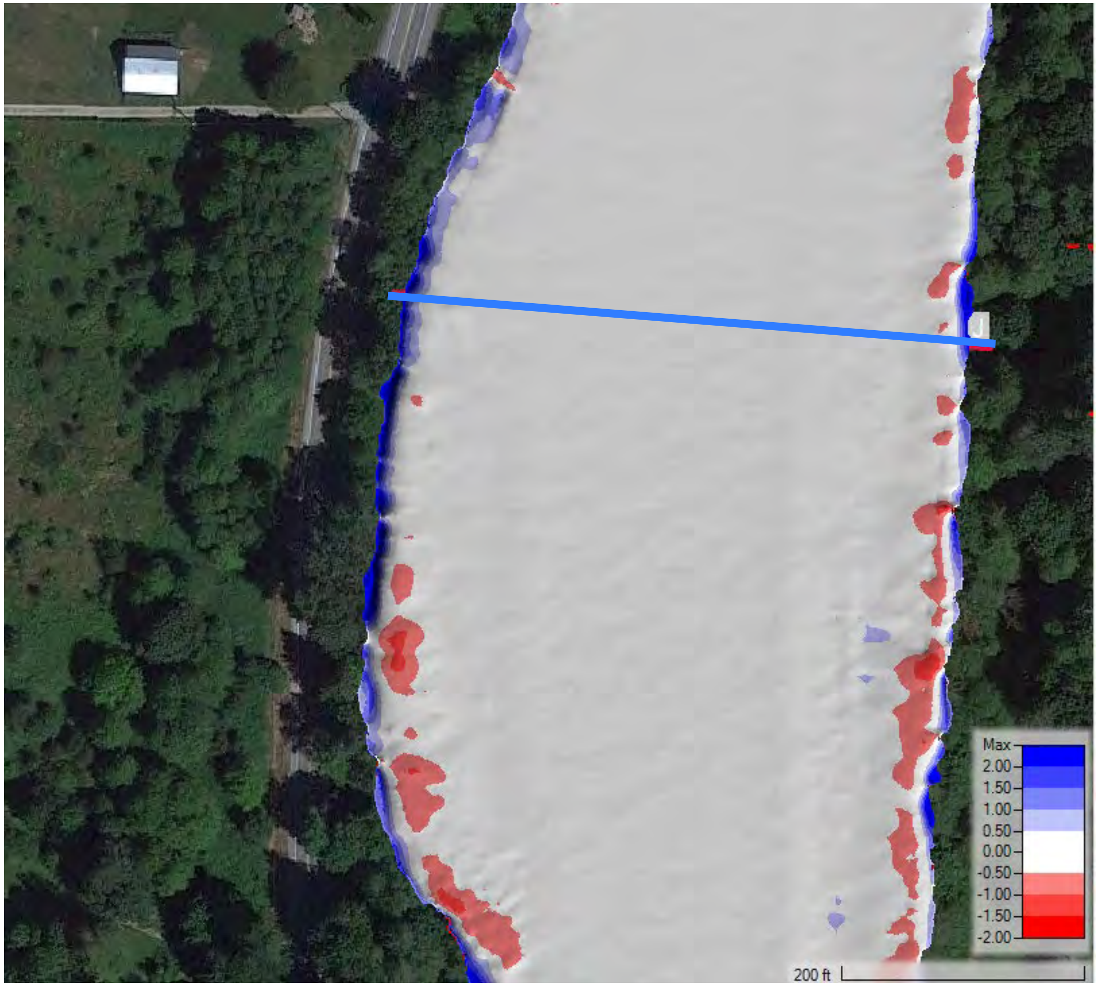
SENSITIVITY RESULTS – CELL SIZE AND VELOCITY

- Velocity is typically more sensitive along channel margin where depth changes rapidly (e.g. Transect E)



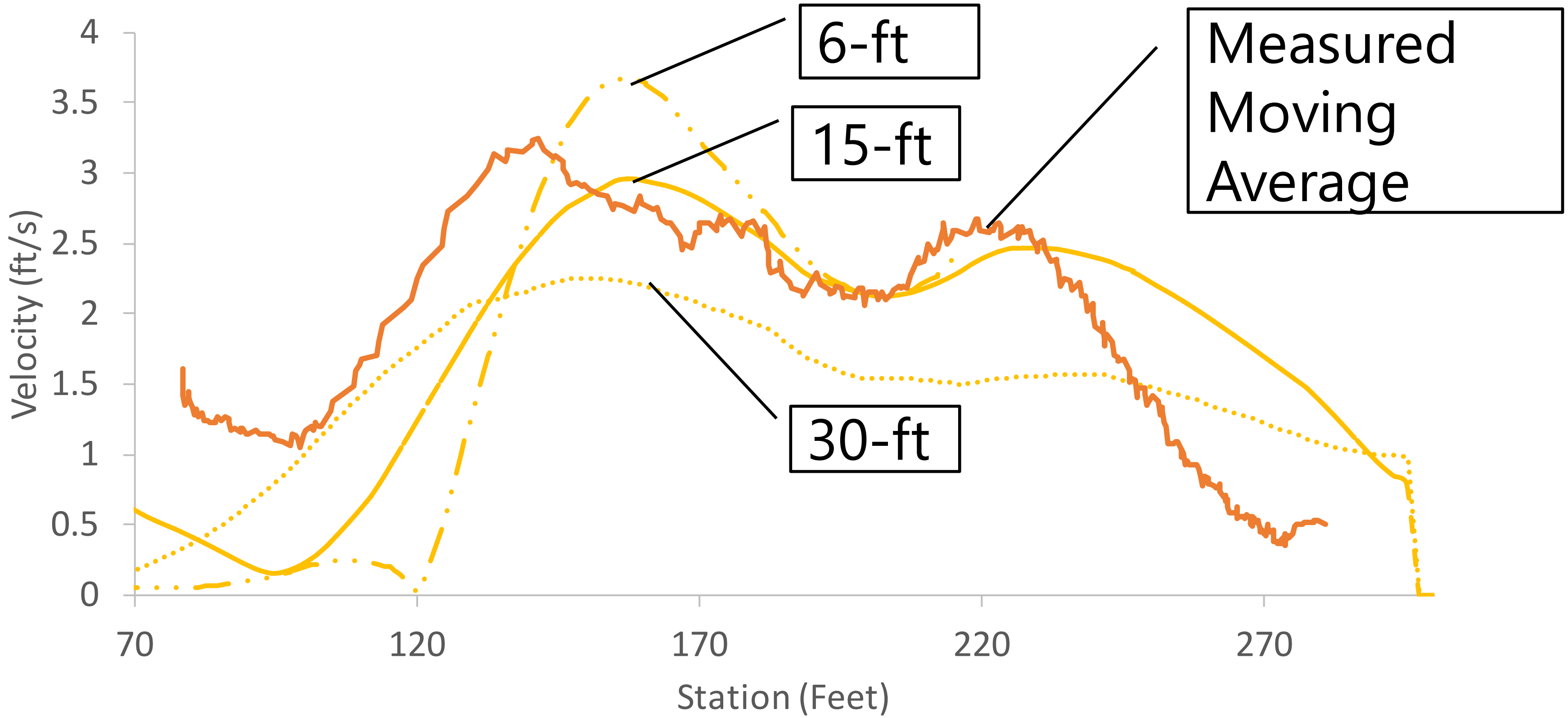
SENSITIVITY RESULTS – CELL SIZE AND VELOCITY

- Trends seen in 1D cross sections tend to apply in 2D space



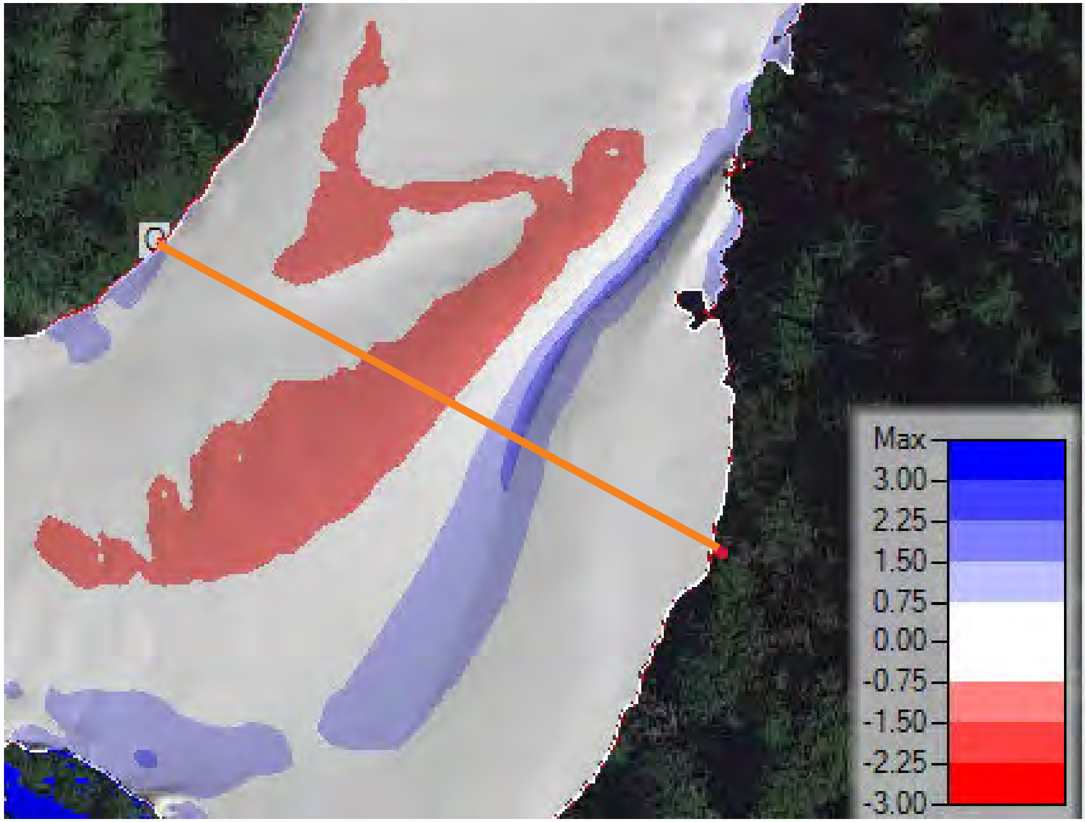
SENSITIVITY RESULTS – CELL SIZE AND VELOCITY

- Cell size can alter the location and magnitude of velocities (e.g. Transect Q)



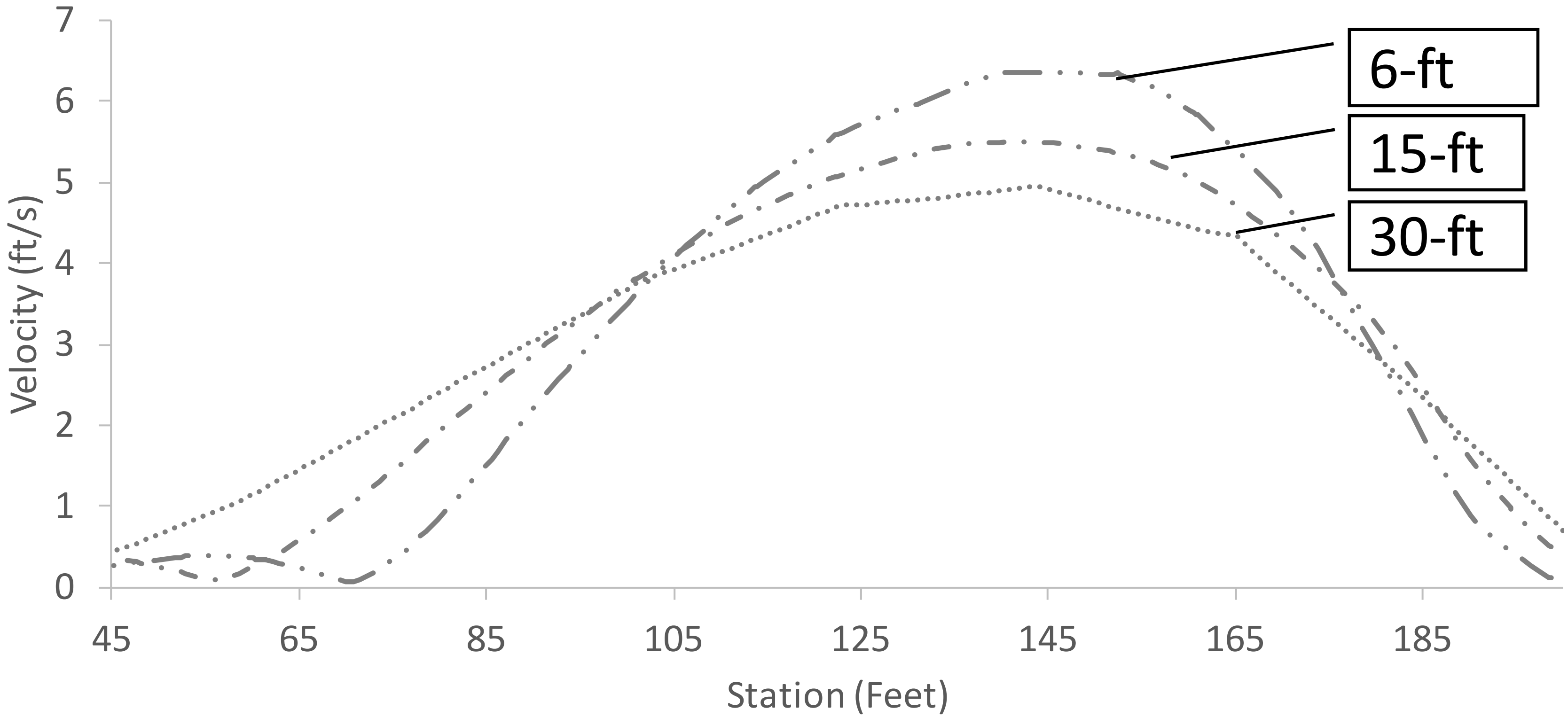
SENSITIVITY RESULTS – CELL SIZE AND VELOCITY

- Velocity magnitude & location shift visible in 2D space



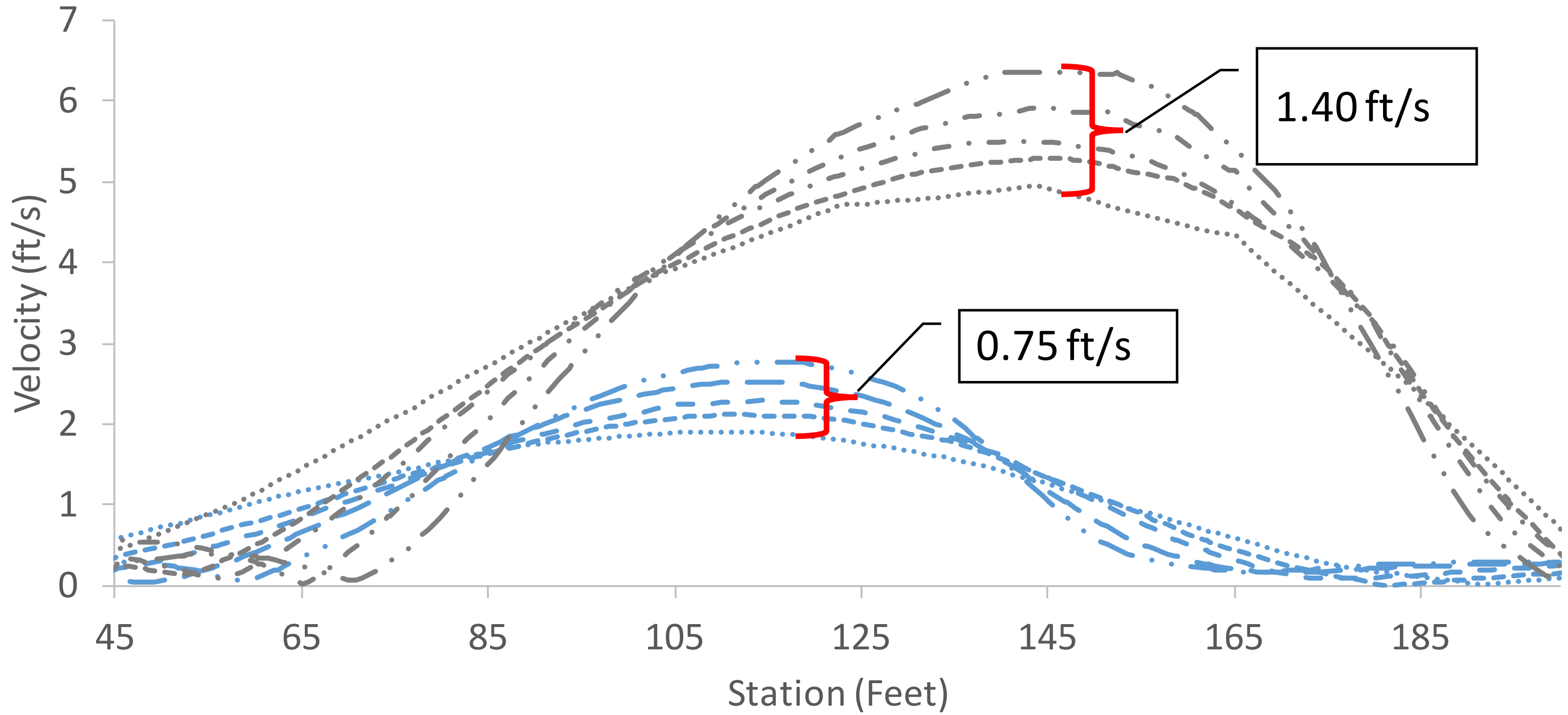
SENSITIVITY RESULTS – CELL SIZE AND VELOCITY

- Smaller cell sizes tend to predict higher high velocities and lower low velocities (e.g. Transect F)



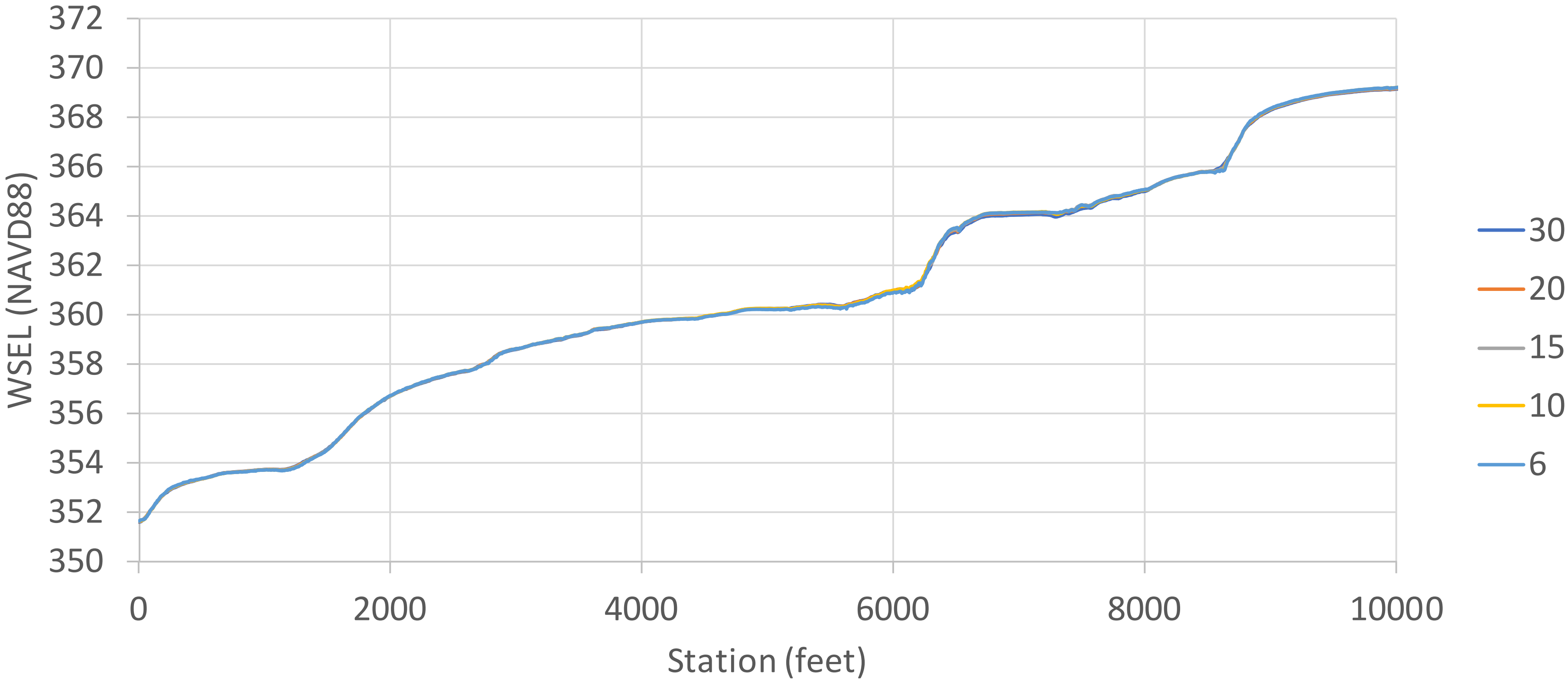
SENSITIVITY RESULTS – CELL SIZE AND VELOCITY

- Sensitivity to cell size varies with velocity magnitude (e.g. Transect F)



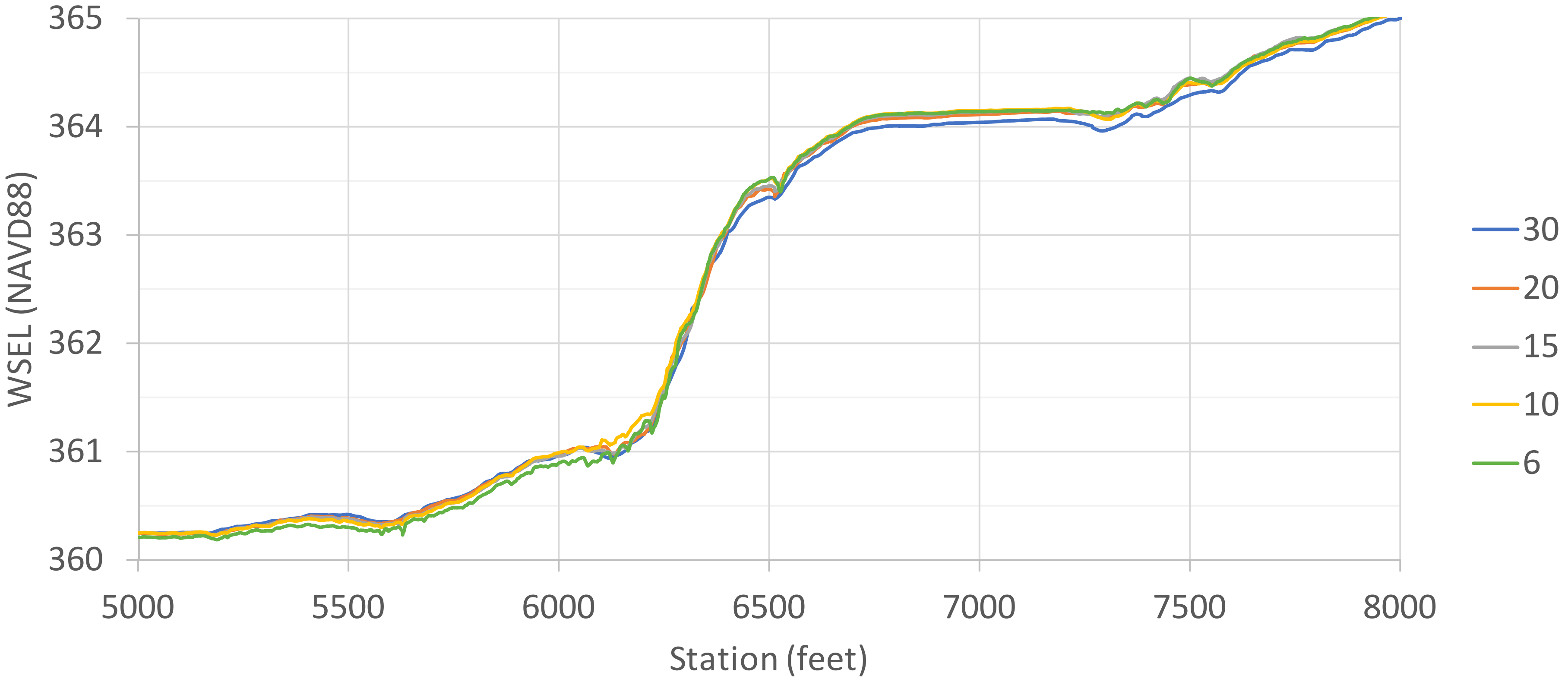
SENSITIVITY RESULTS – CELL SIZE AND WSEL

- Where water surface slope is gradual, WSEL is not sensitive to cell size



SENSITIVITY RESULTS – CELL SIZE AND WSEL

- Where water surface slope is steeper, WSEL is slightly sensitive to cell size (up to 0.35 feet)

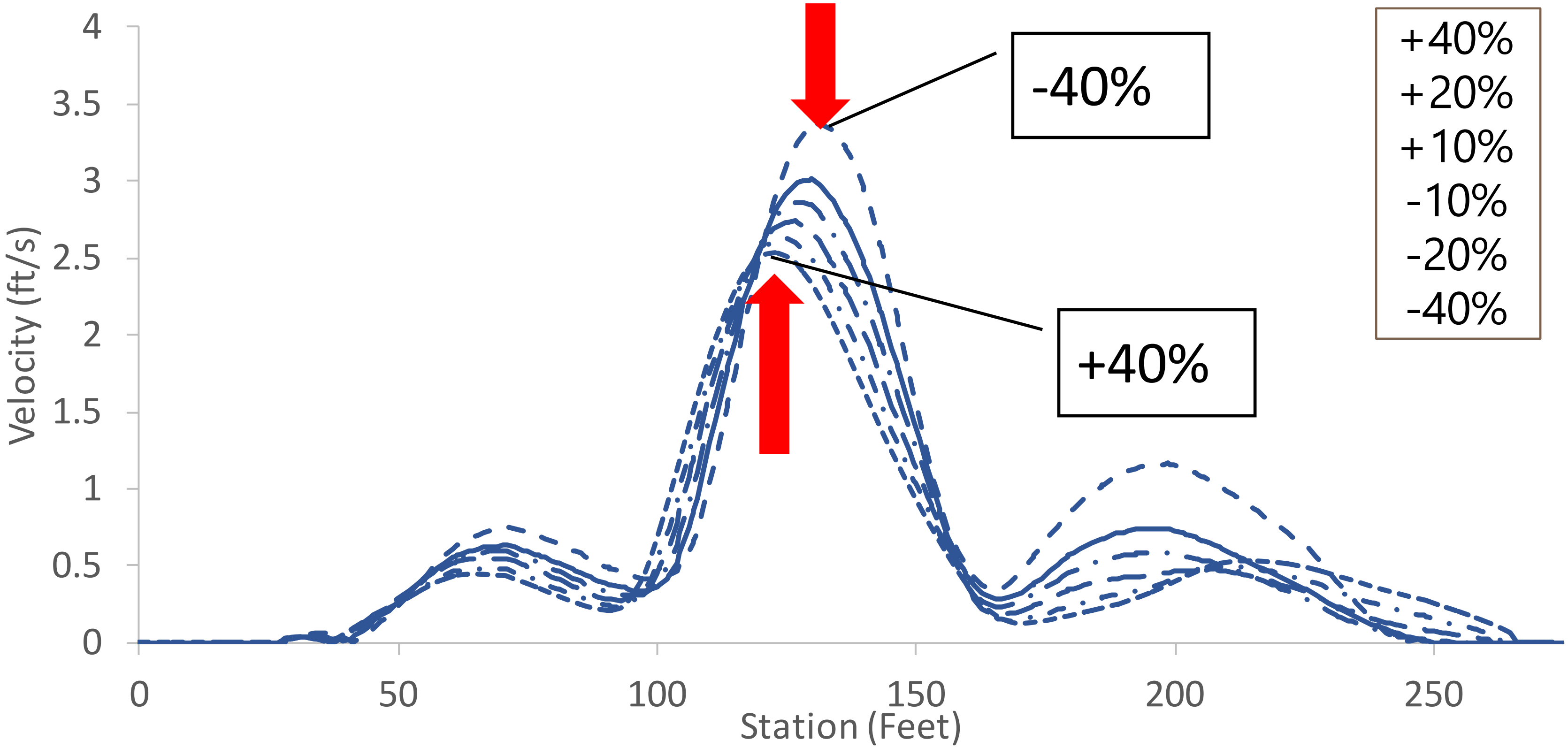


CELL SIZE SENSITIVITY SUMMARY

- Smaller cells tend to simulate higher high velocities and lower low velocities (e.g. Transect F)
- Cell size can alter the location and magnitude velocities (e.g. Transect Q)
- Velocity is not sensitive to cell size where velocity changes gradually (e.g. Transect J)
- Sensitivity to cell size varies with velocity magnitude (e.g. Transect F)

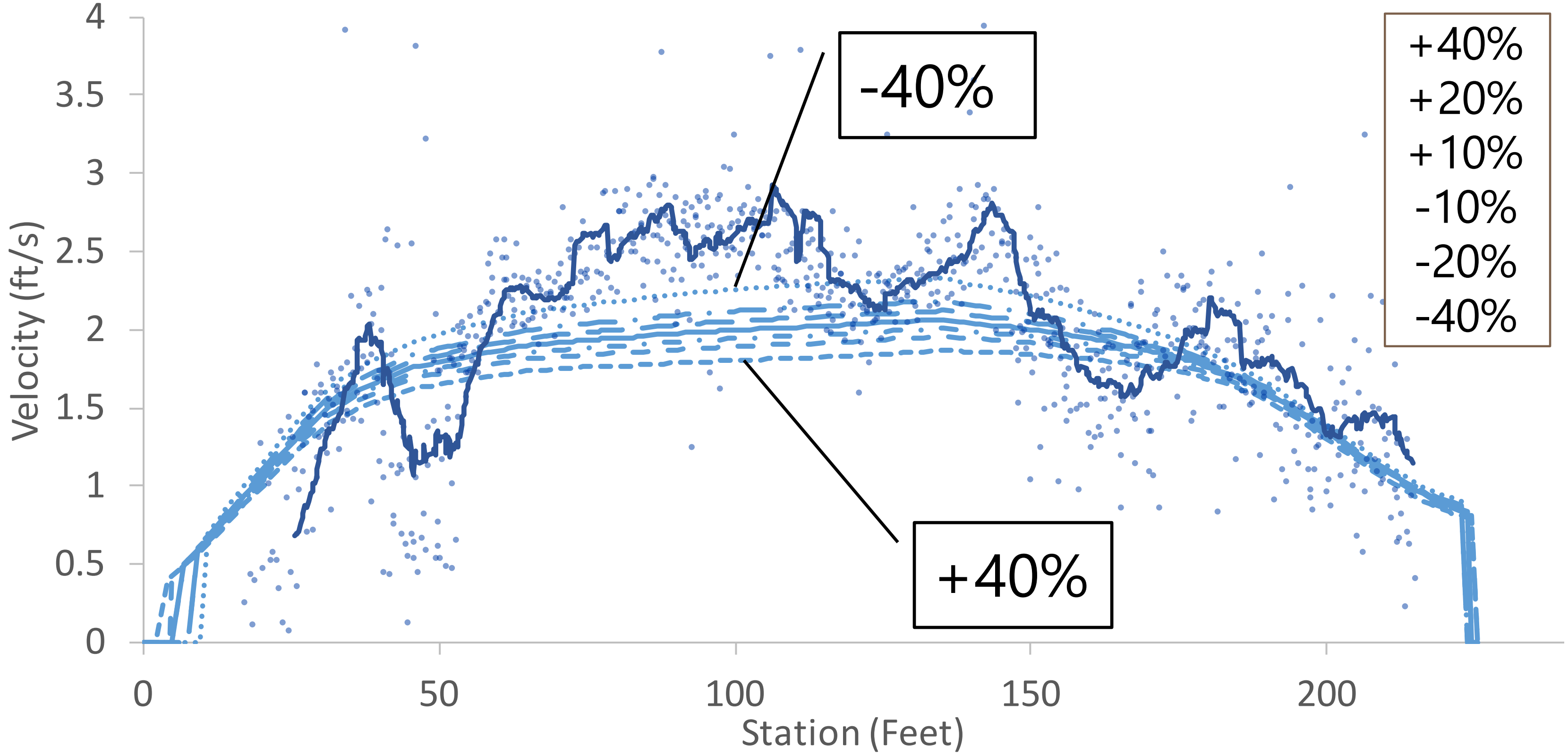
SENSITIVITY RESULTS – ROUGHNESS AND VELOCITY

- Roughness can change the location and magnitude of velocity (e.g. Transect Q)



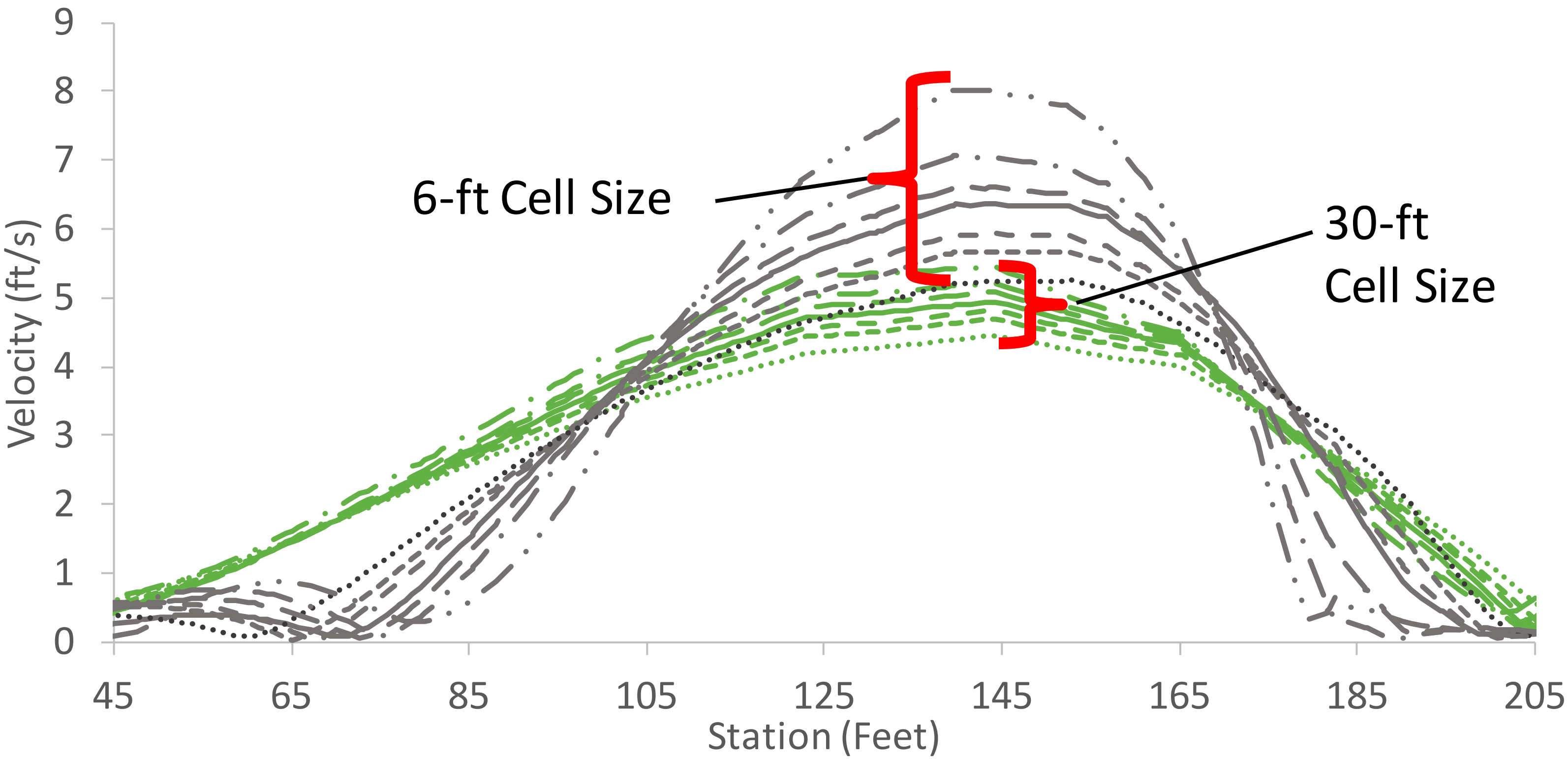
SENSITIVITY RESULTS – ROUGHNESS AND VELOCITY

- Sensitivity to roughness increases with velocity (e.g. Transect E)



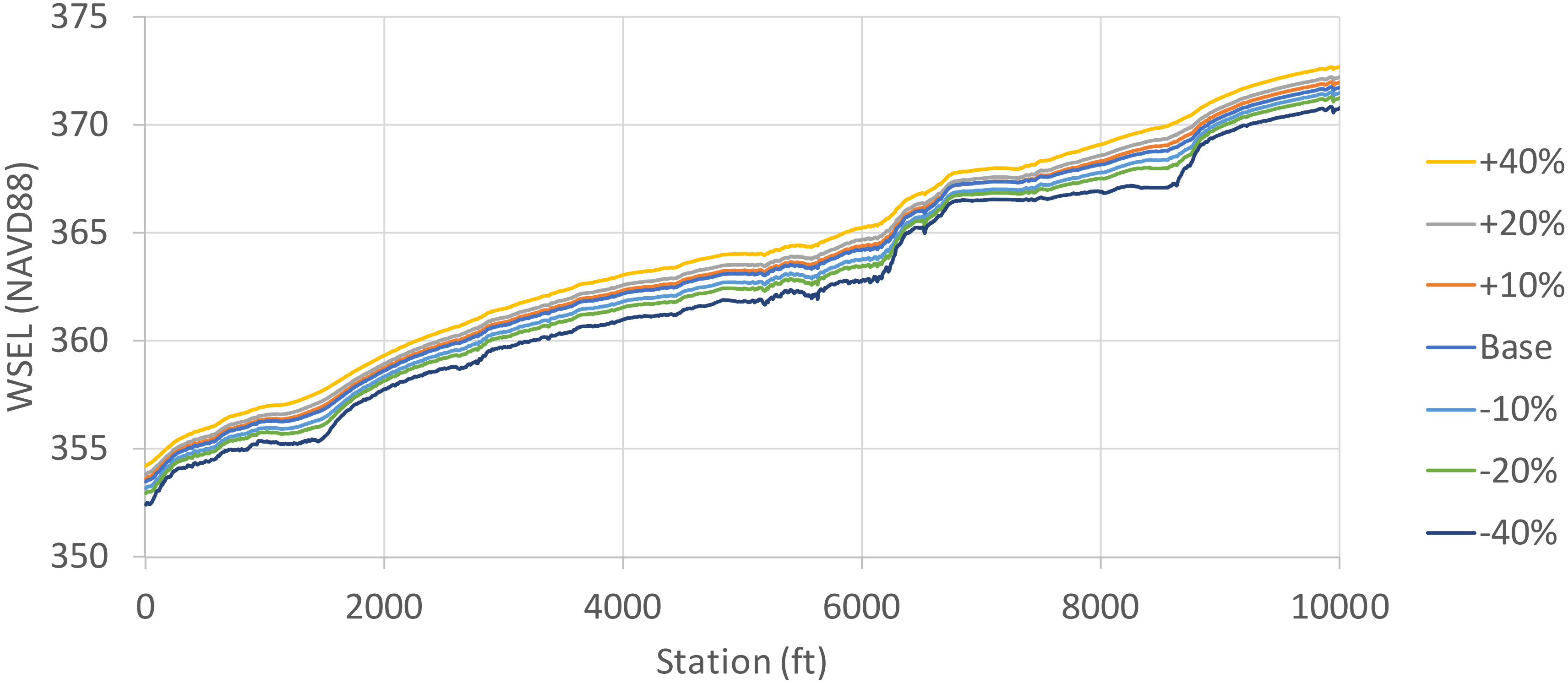
SENSITIVITY RESULTS – ROUGHNESS AND VELOCITY

- Cell size and roughness are interrelated (e.g. Transect F)



SENSITIVITY RESULTS – ROUGHNESS AND WSEL

- WSEL sensitive to changes in roughness (up to 3 feet)



ROUGHNESS SENSITIVITY SUMMARY

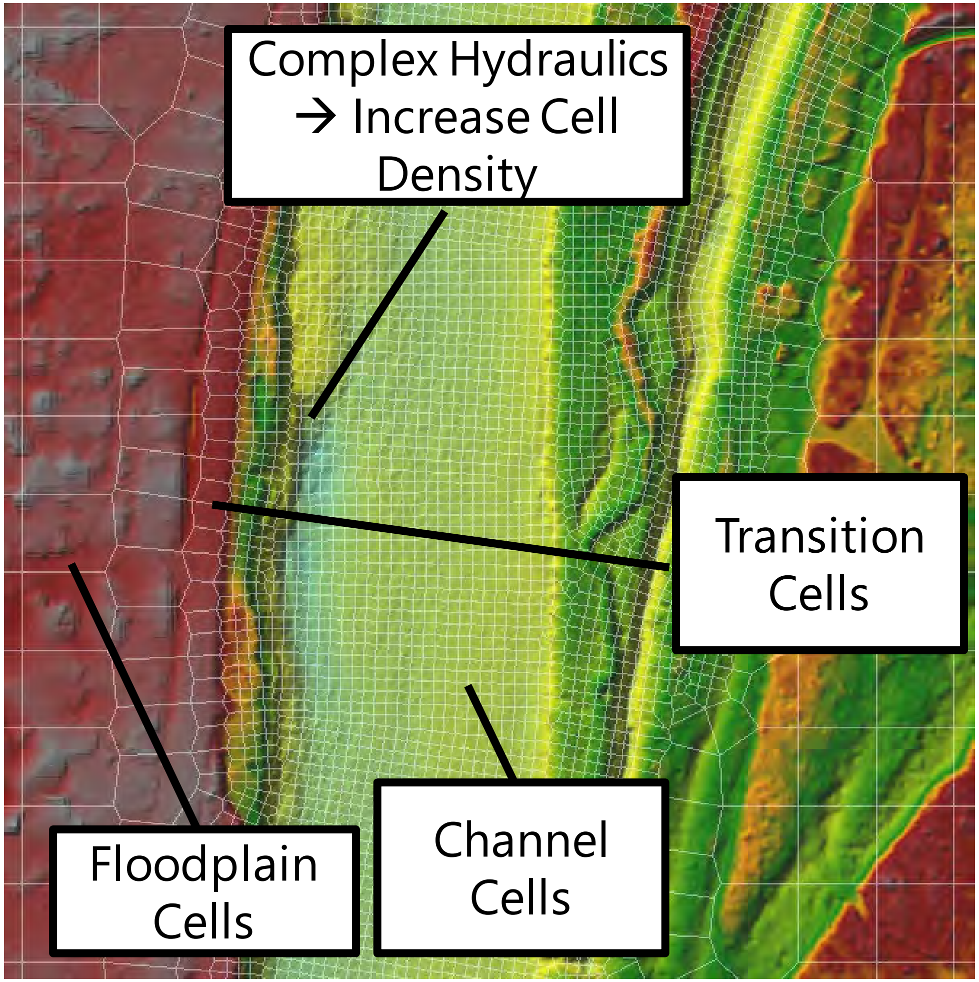
- Roughness can change the location and magnitude of velocity (e.g. Transect Q)
- Sensitivity to roughness increases with velocity (e.g. Transect E)
- Cell size and roughness are interrelated (e.g. Transect F)
- WSEL is highly sensitive to roughness

CONCLUSIONS

- Run time increases with cell size
  - Implications for this study and future use
- Cell size and roughness are interrelated
- Context and location of resolution is important
  - Greatest variation occurs at peak velocities and along channel margins

PRELIMINARY PATH FORWARD

- Channel Cells: 6-15 feet
- Floodplain Cells: 100-300 feet
- Balance of run time and representation of channel features
- Will be determined during calibration



Seattle City Light

DISCUSSION

MODEL NEXT STEPS

- Complete setup/sensitivity
  - Within August
- Initiate calibration (September)
  - Roughness
  - Turbulence
  - Boundaries
  - Terrain (if necessary)

MODEL CALIBRATION DATA

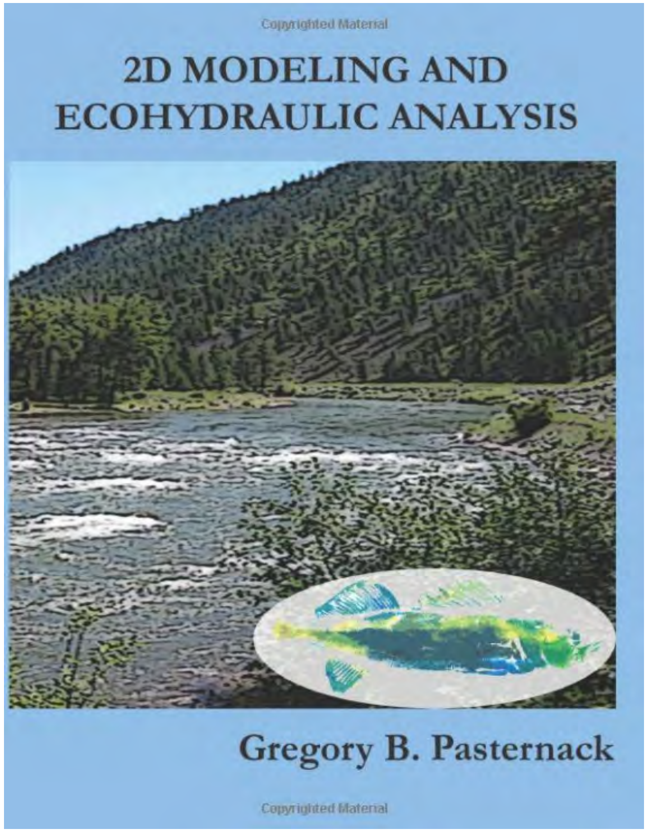
- Stage/Discharge gages
- Data collected over 29-mile study reach
  - o Low, Moderate, and High discharges
    - Depth/Velocity/Discharge at 17 Transects
    - Water Surface Profile
    - Tributary Inflows
- High Water Marks @ 11-5-2020 flow event

DISCHARGES DURING FIELD EFFORTS

	Date	Discharge (cfs)	Daily Exceedance Probability OR Return Period
USGS @ Newhalem			
	August 2020	2,350	94%
	October 2020	4,200	51%
	March 2021	6,700	13%
	November 5, 2020	12,200	~1.5 yr return period
USGS @ Marblemount			
	August 2020	2,900	95%
	October 2020	5,800	47%
	March 2021	7,800	21%
	November 5, 2020	25,300	~2.5 yr return period

PERFORMANCE EVALUATION

- Performance evaluation standards lacking for 2D models
- Hurdle to wider adoption and acceptance
- Pasternack
  - http://pasternack.ucdavis.edu/
- Most common: WSEL, V_{mag}



PERFORMANCE EVALUATION

- Spatial distribution of hydraulics -> population
- Sub-sample ->population
- Evaluate model performance

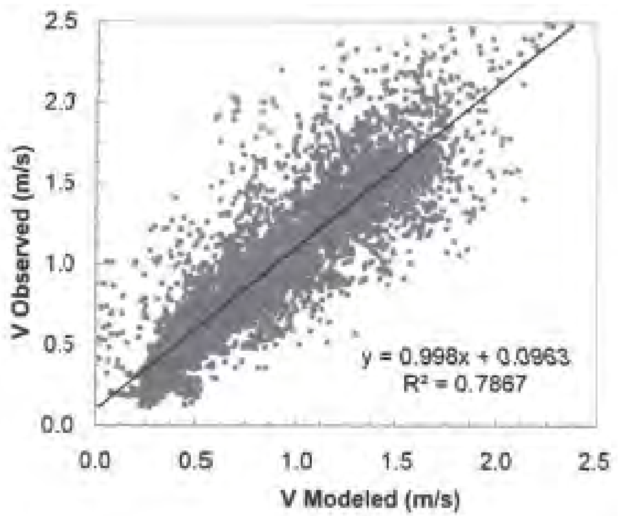
- Deviation, correlation, regression statistics
  - Performance Indicators
- Cross-section-based tests secondary value

QUANTITATIVE PERFORMANCE INDICATORS

- Observed vs. Modeled WSEL & V_{mag}
  - o Deviation statistics (raw, %)
  - o Coefficient of determination (r^2)
  - o Regression line slope ~1:1
  - o Zero intercept of regression line; offset?
  - o Relative cross-sectional pattern ->spatial associations model error
  - o Observed vs. Modeled hydraulic phase-space plots (D vs V_{mag})
    - compare probability distribution of depth, velocity
- NO quantitative standards for these performance indicators have been proposed or adopted through scientific consensus

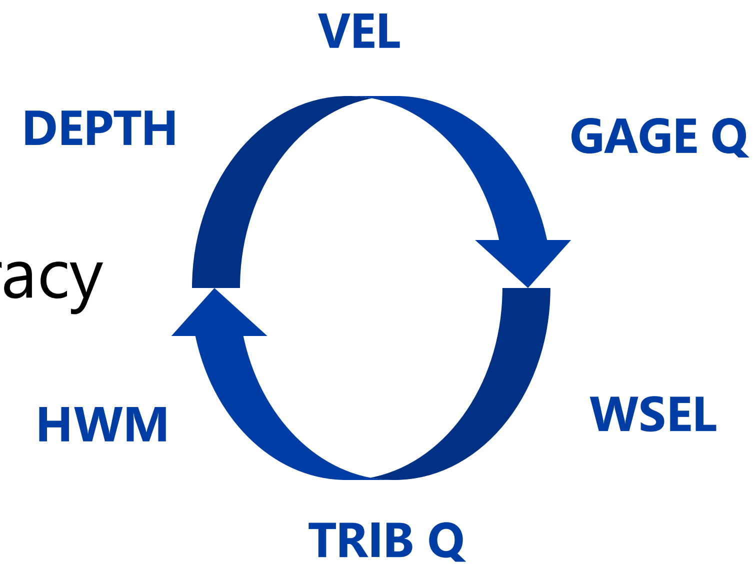
PERFORMANCE EVALUATION

- Skagit observations
  - o Transects (~54,000 -> V_{mag}, WSEL)
  - o Long profiles (~495,000 -> WSEL)
    - (note output resolution)



PERFORMANCE EVALUATION

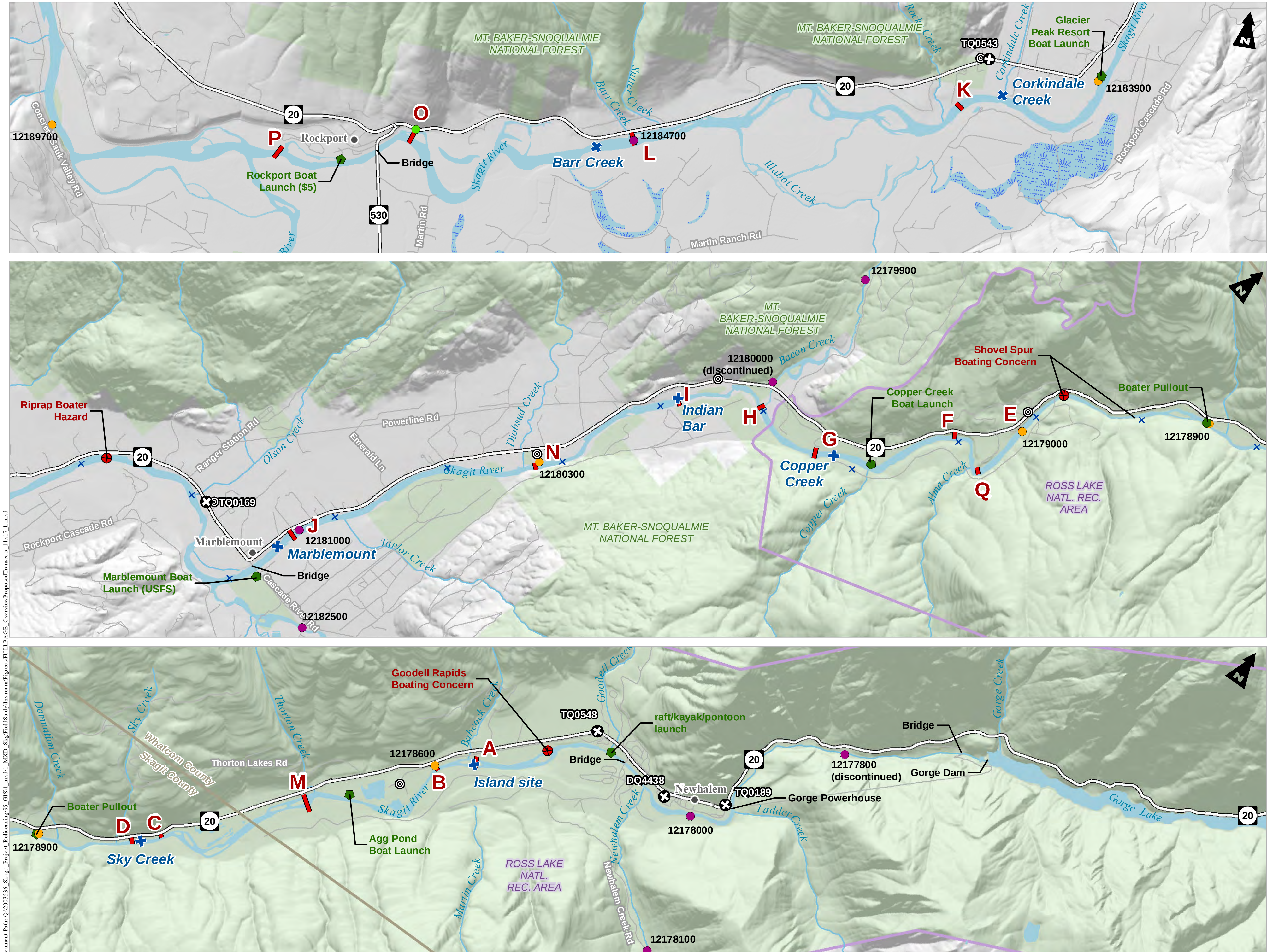
- Performance never perfect!
  - Uncertainty in observed data
  - Assumptions & simplifications in SWE and solution procedures
- Performance testing -> characterizing uncertainty



- LiDAR <u>submerged</u> vertical accuracy
  - 2018 - 0.37′ 95% confidence
  - 2017 - 0.54′ 95% confidence

Seattle City Light

DISCUSSION



Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\FULLPAGE_OverviewProposedTransects_11x17_L.mxd

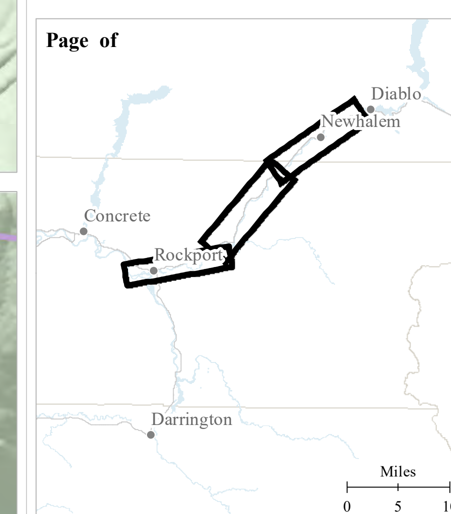
RECONNAISSANCE FIELD MAP

Legend

- Boat Launch
- Base/Repeater Location
- Boating Hazard
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- 1984 Transect Segment
- NGS Monument
- Proposed Calibration Transect
- Highway
- Road
- National Park / National Recreation Area Boundary
- County

0 2,000 4,000 Feet

Page of

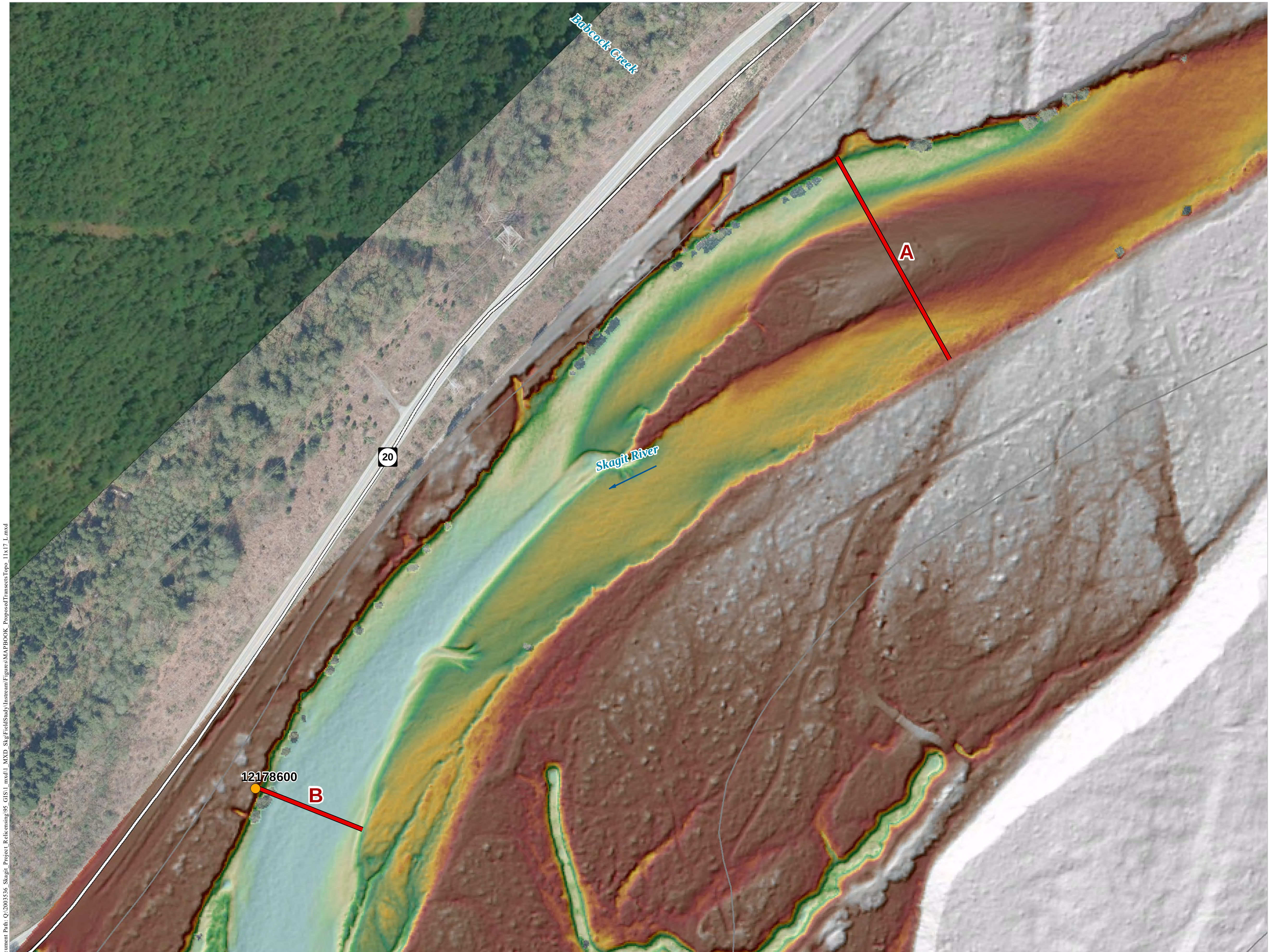


DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 9/17/2020 by HDR for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].



TRANSECT A & B

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2018 Topography (ft)

- > 440
- 430
- < 420

Scale - 1:2,400

0 100 200 Feet

N

Page 1 of 14

DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

TRANSECT A & B

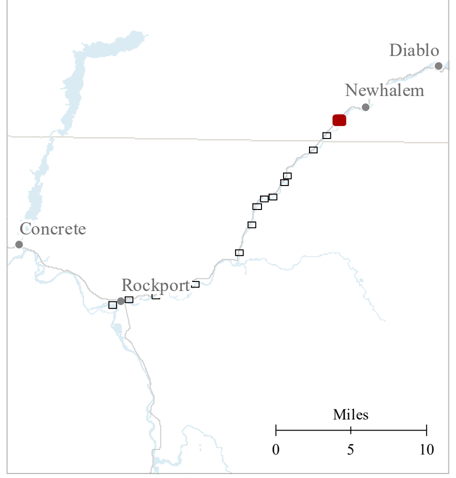
Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

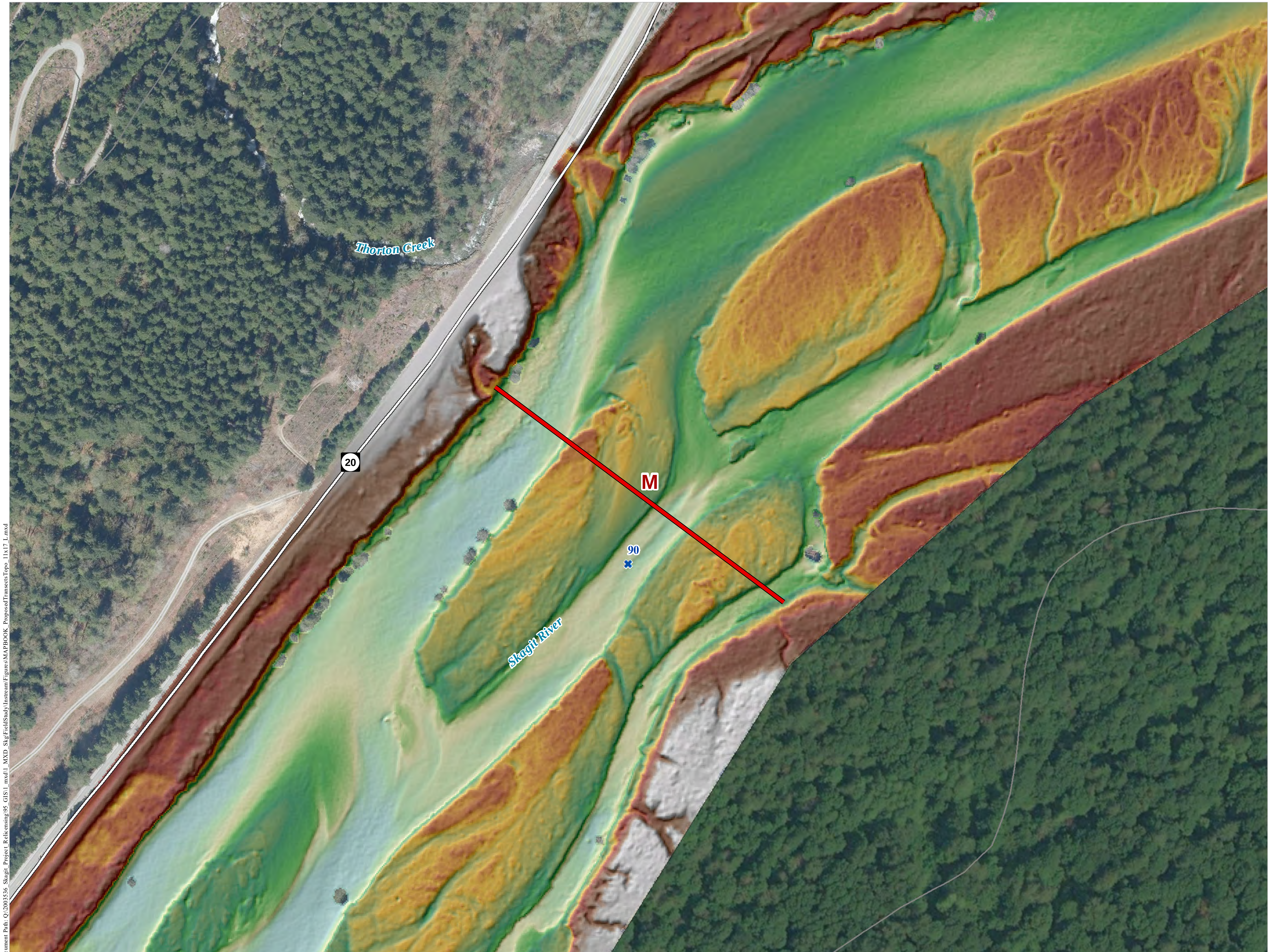
Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd

TRANSECT M



Legend

- ✖ River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2018 Topography (ft)

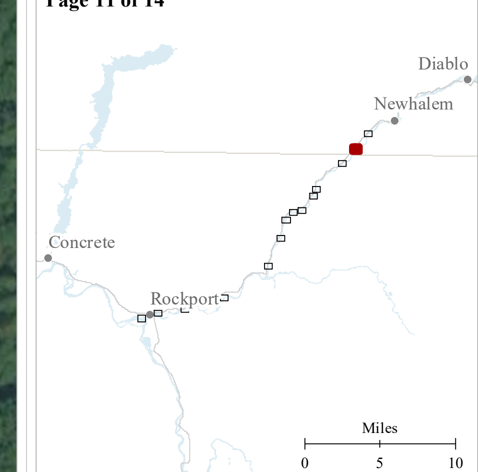
- > 450
- 435
- < 420

Scale - 1:2,400

0 100 200 Feet

N

Page 11 of 14



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

TRANSECT M

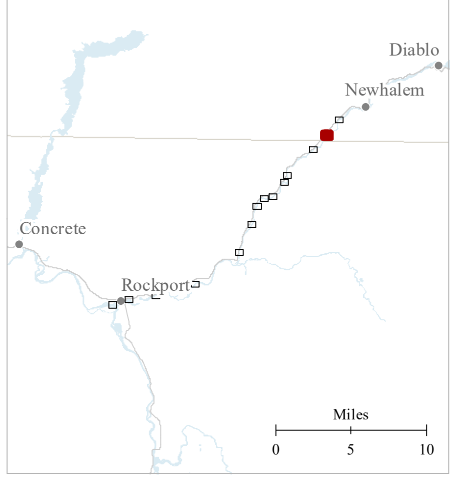
Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

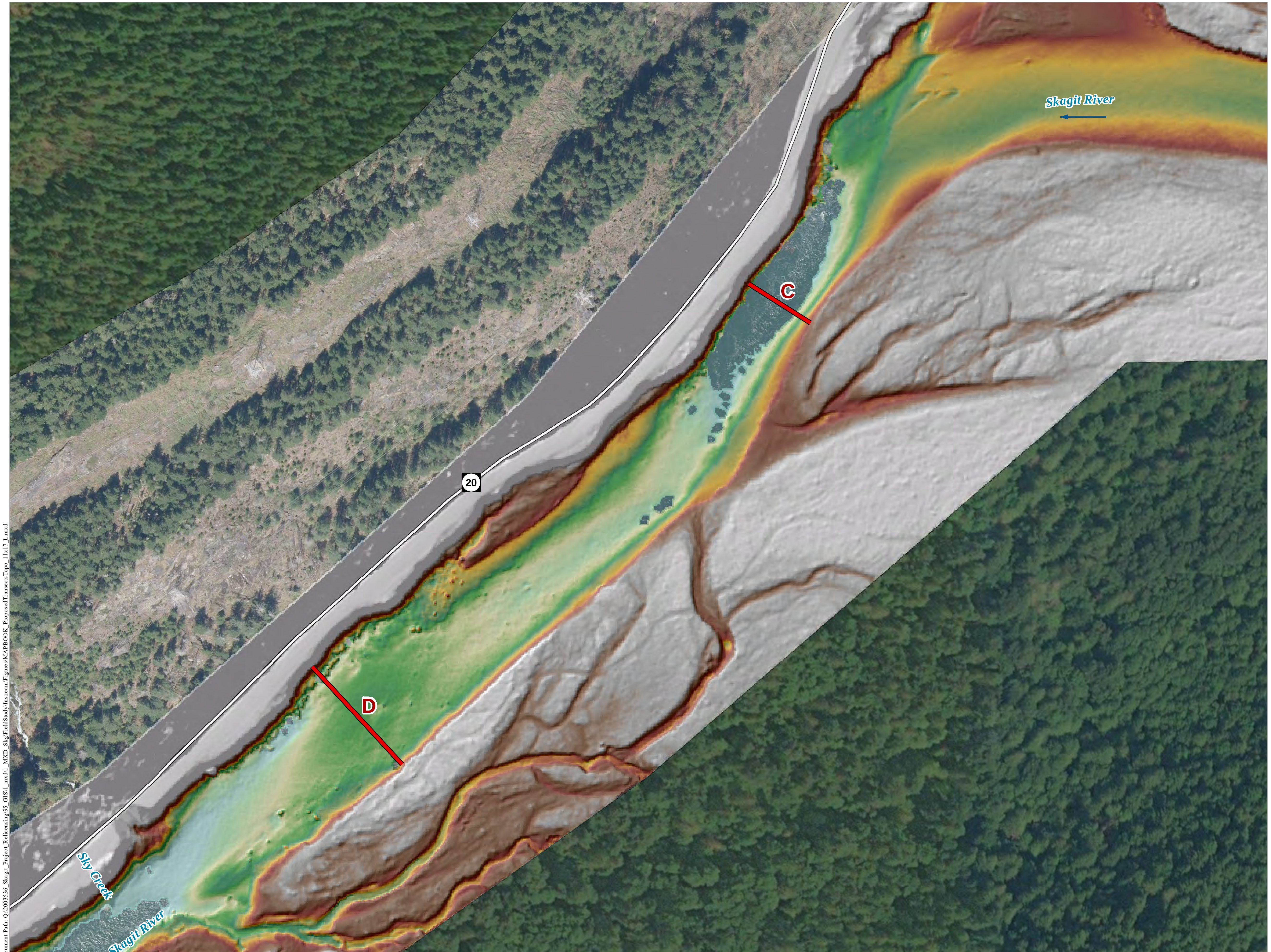
Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd

TRANSECT C & D



Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

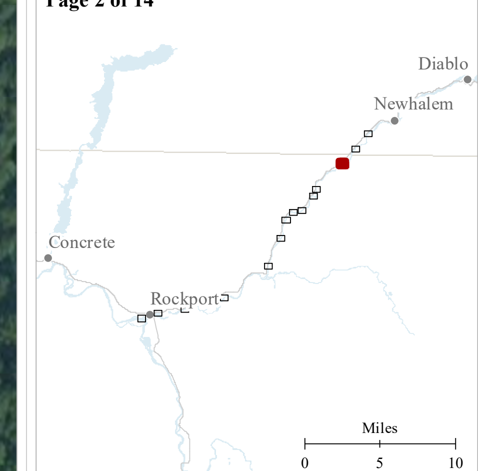
2018 Topography (ft)

- > 420
- 410
- < 400

Scale - 1:2,400

0 100 200 Feet

N



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_SkgFieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd

TRANSECT C & D

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

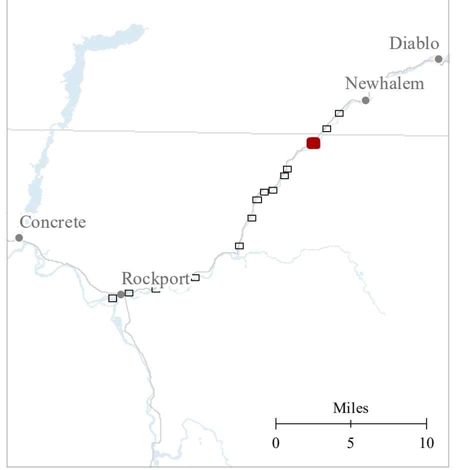
Background image from 2018

Scale - 1:2,400

0 100 200 Feet

N

Page 2 of 14



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

TRANSECT E

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2018 Topography (ft)

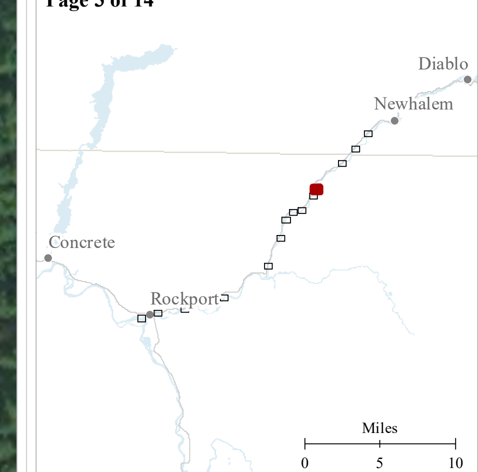
- > 380
- 370
- < 360

Scale - 1:2,400

0 100 200 Feet

N

Page 3 of 14



Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

TRANSECT E

Legend

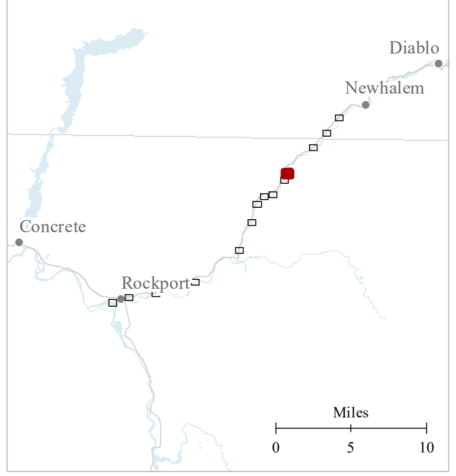
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet

N



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

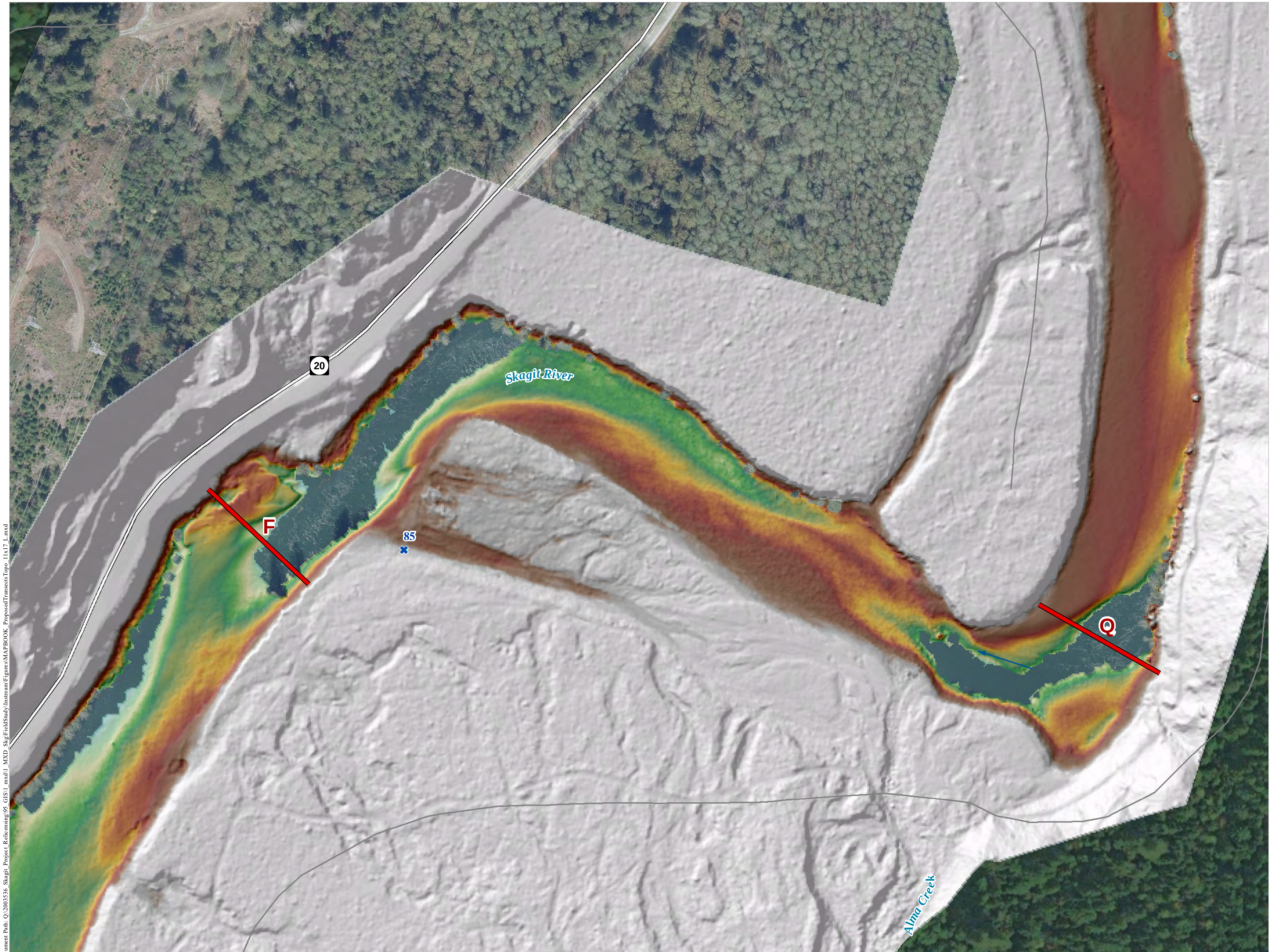
Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd

TRANSECT Q & F



Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2018 Topography (ft)

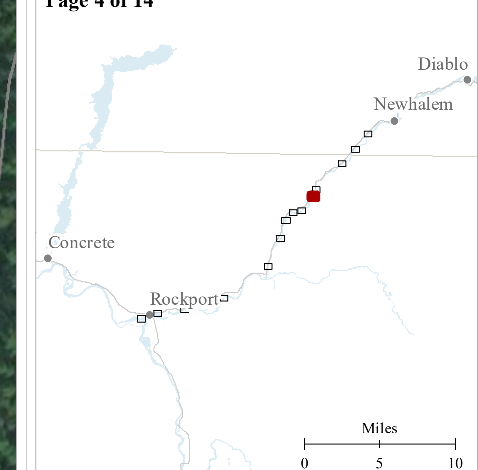
> 370
360
< 350

Scale - 1:2,400

0 100 200 Feet

N

Page 4 of 14



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

TRANSECT Q & F

Legend

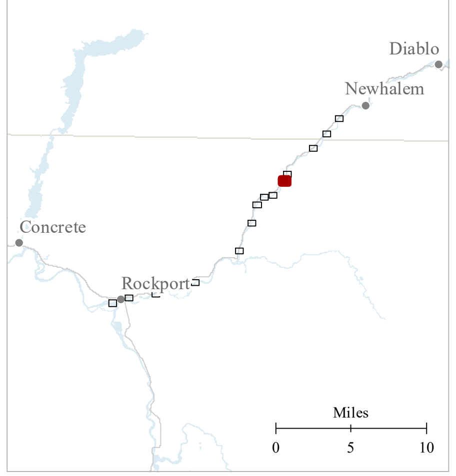
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet

N



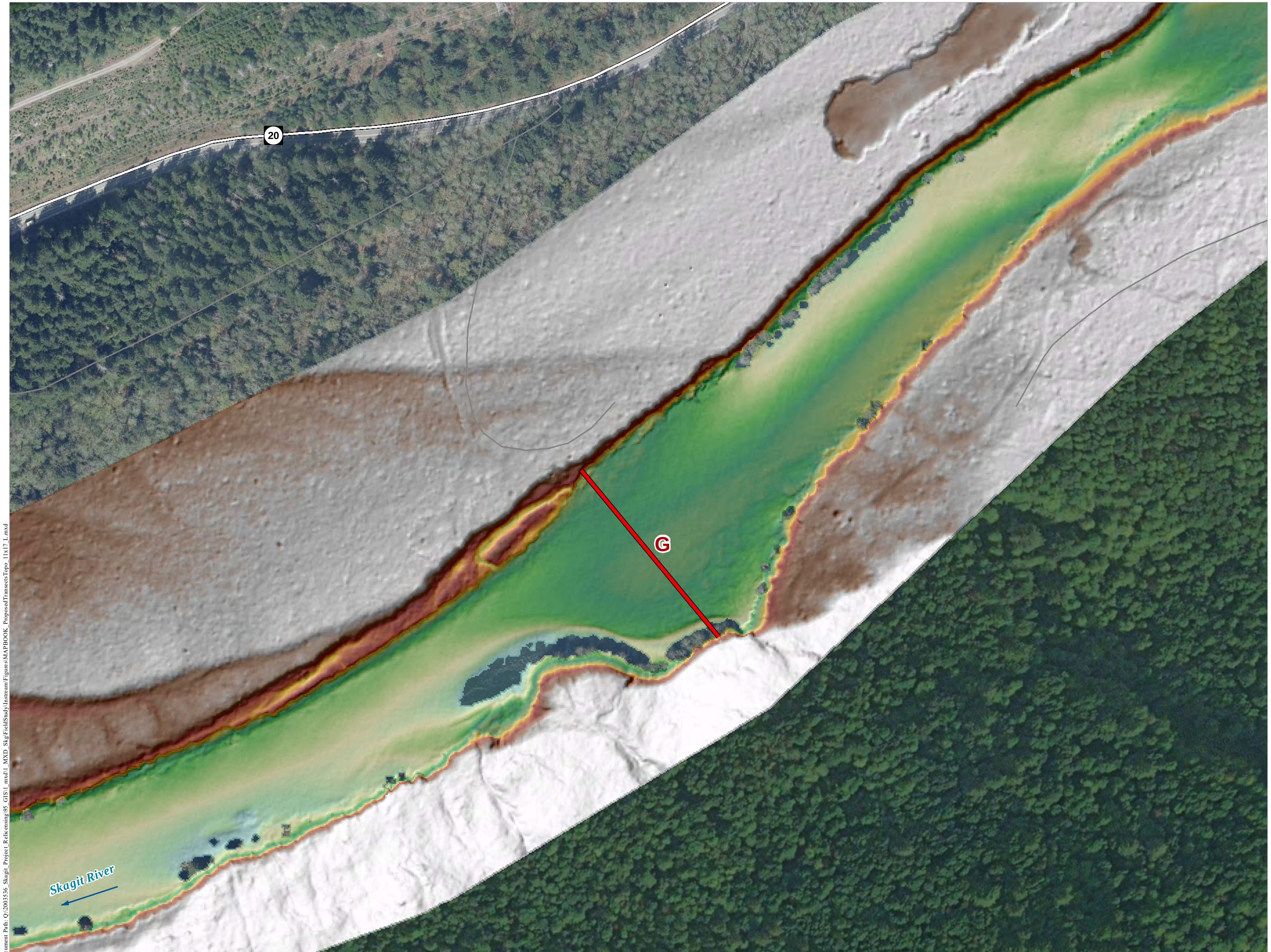
DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd



TRANSECT G

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2018 Topography (ft)

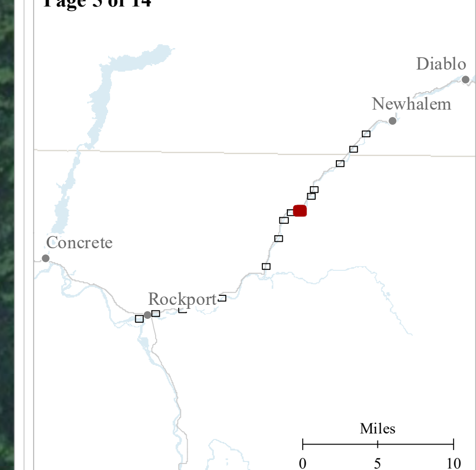
- > 370
- 355
- < 340

Scale - 1:2,400

0 100 200 Feet

N

Page 5 of 14



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

TRANSECT G

Legend

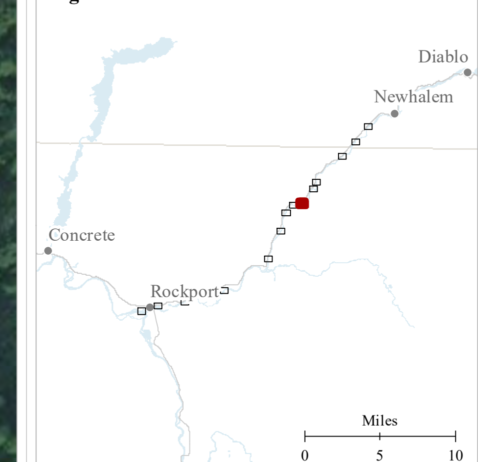
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet

N



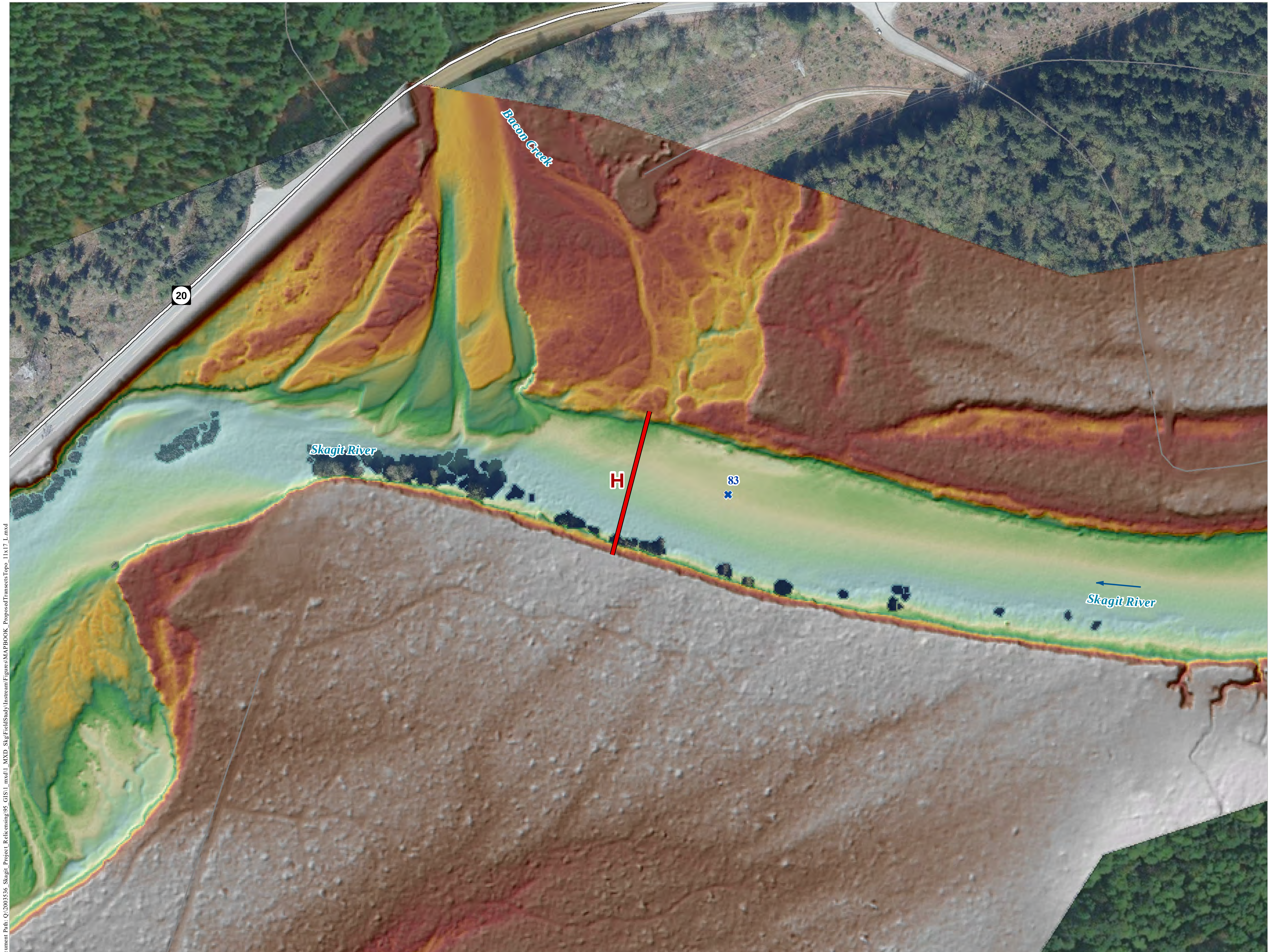
DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd



TRANSECT H

Legend

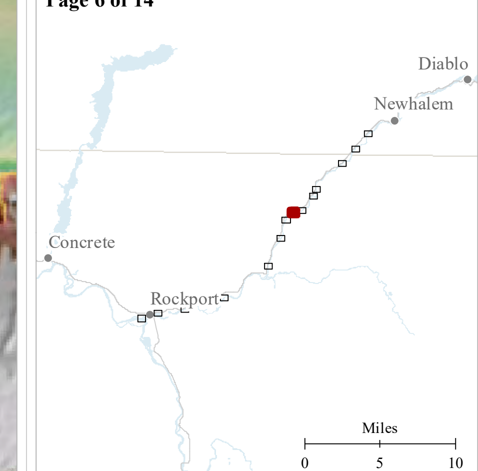
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2018 Topography (ft)

- > 370
- 355
- < 340

Scale - 1:2,400

0 100 200 Feet



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

TRANSECT H

Legend

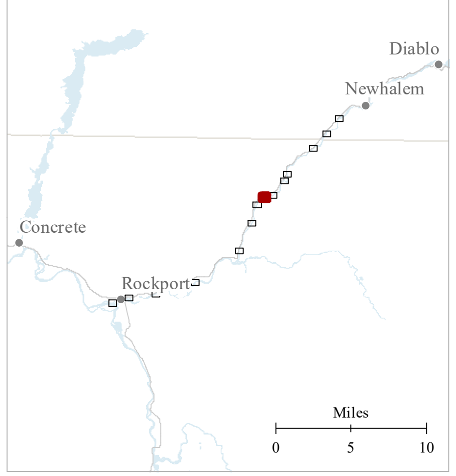
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet

N



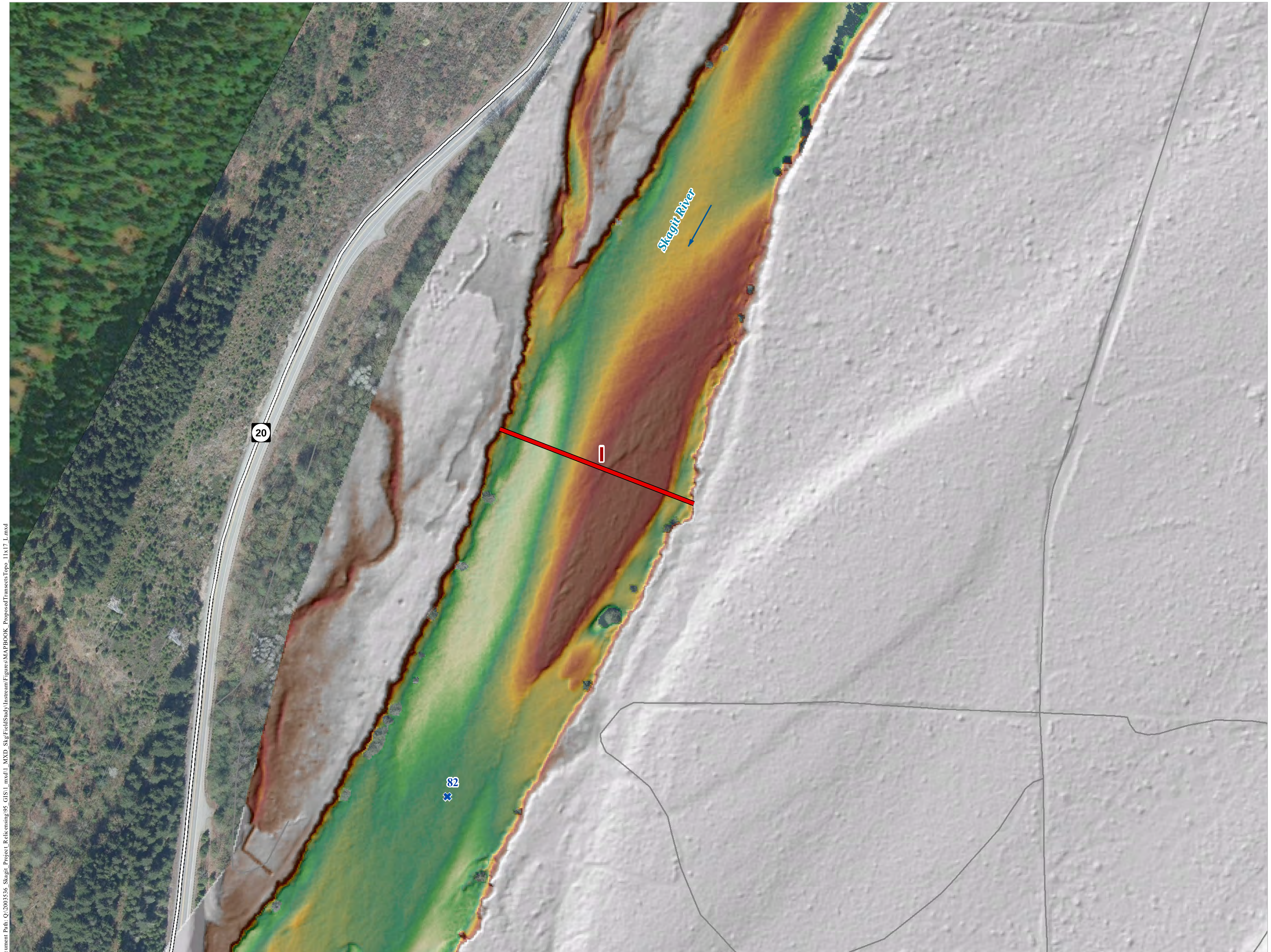
DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd



TRANSECT I

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

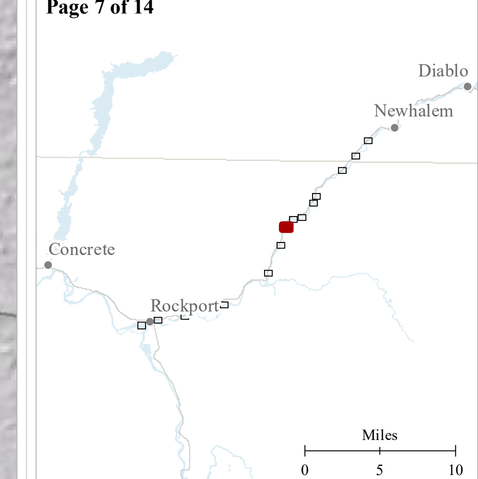
2018 Topography (ft)

- > 350
- 340
- < 330

Scale - 1:2,400

0 100 200 Feet

N



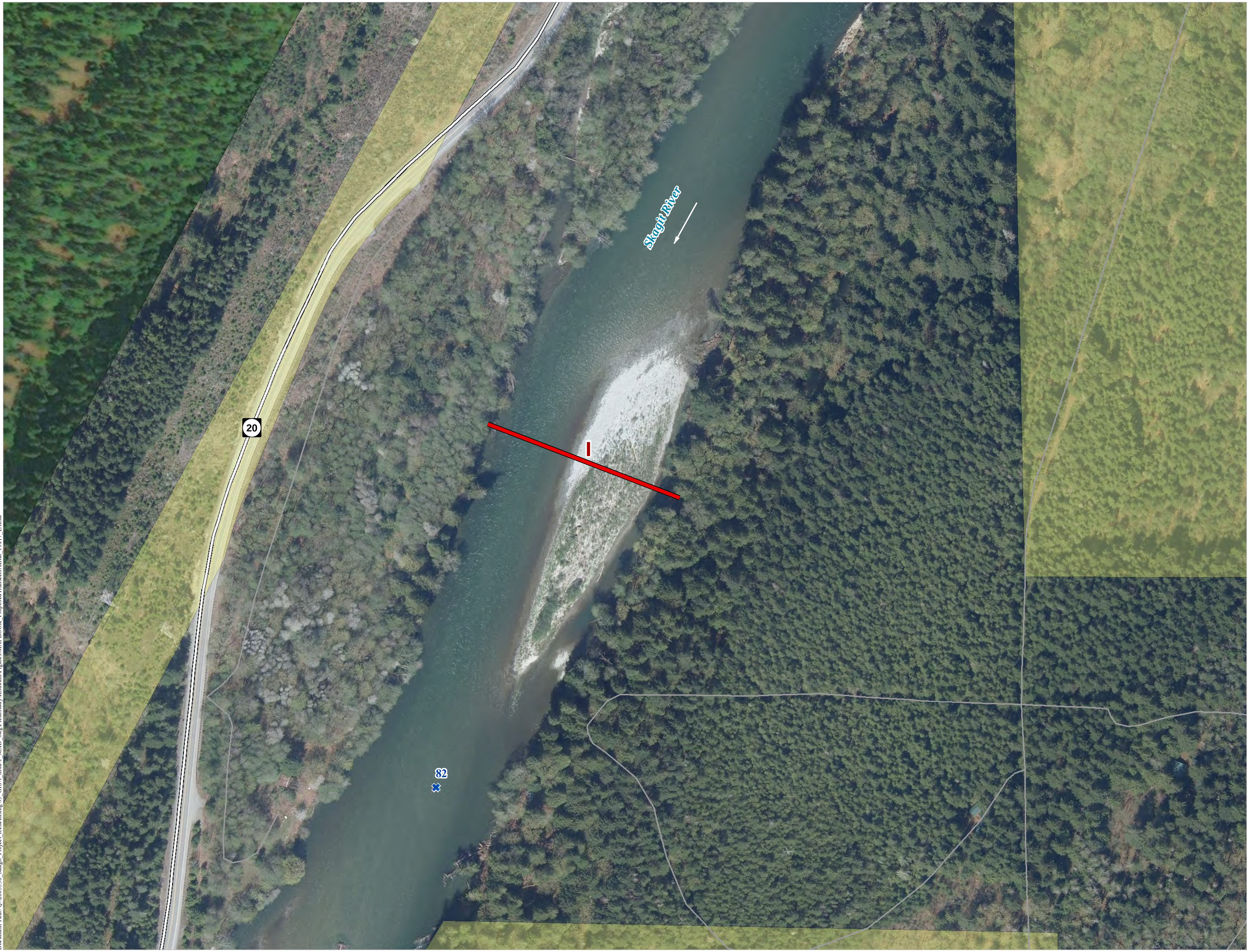
DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd



TRANSECT I

Legend

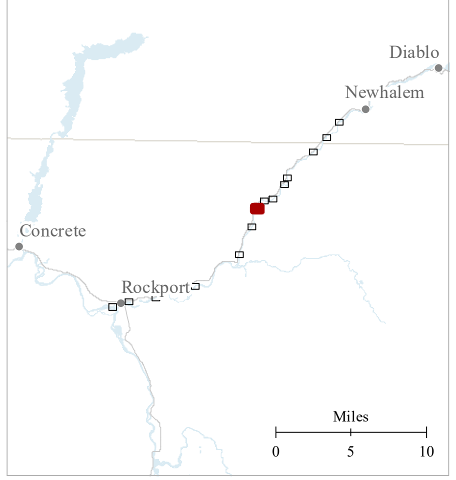
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet

N



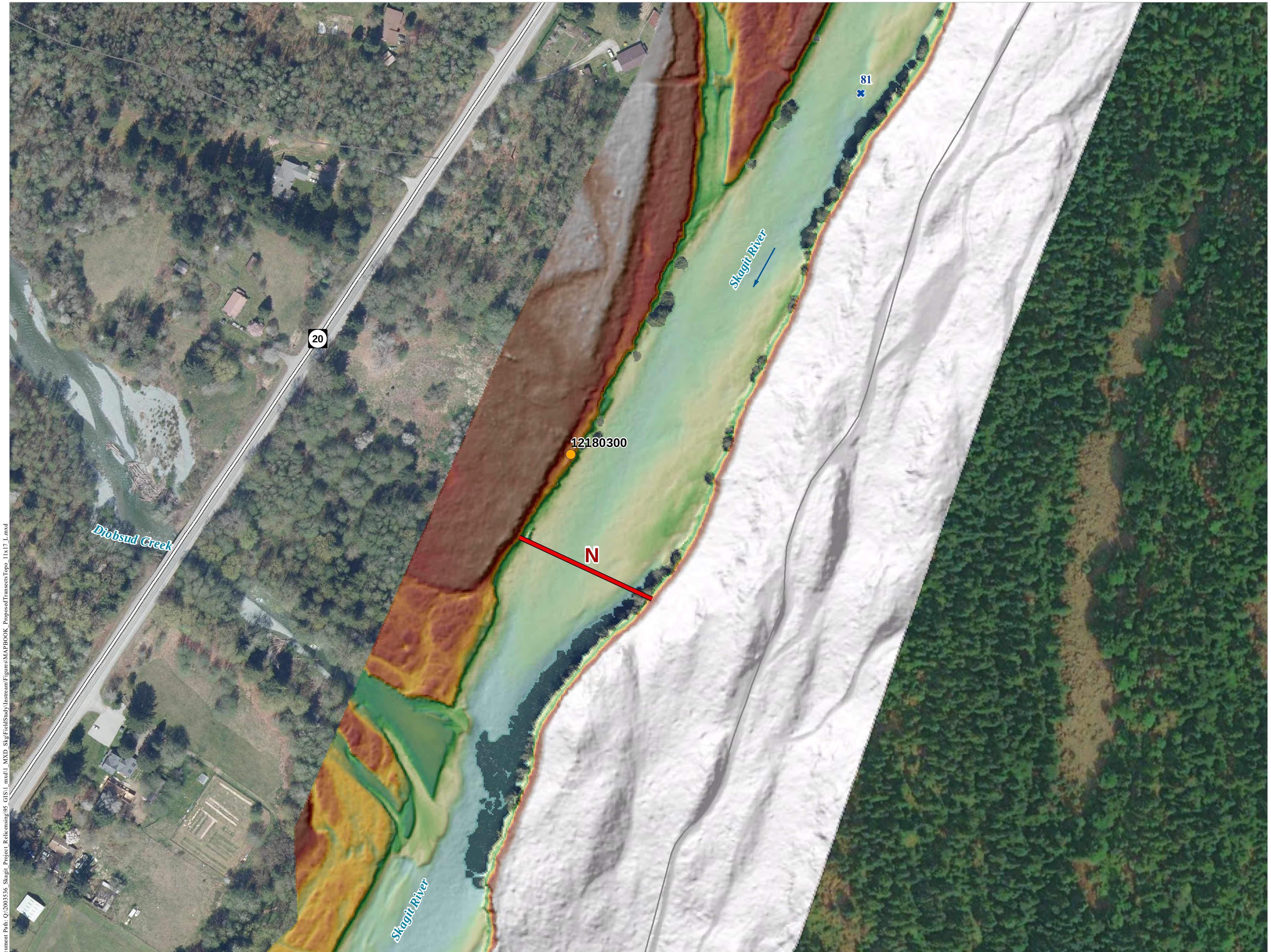
DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd



TRANSECT N

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

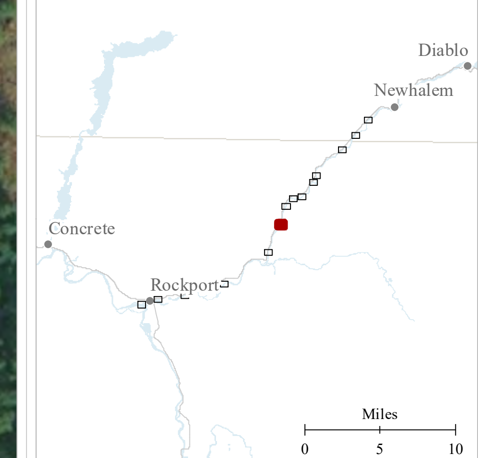
2018 Topography (ft)

> 350
335
< 320

Scale - 1:2,400

0 100 200 Feet

N



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

TRANSECT N

Legend

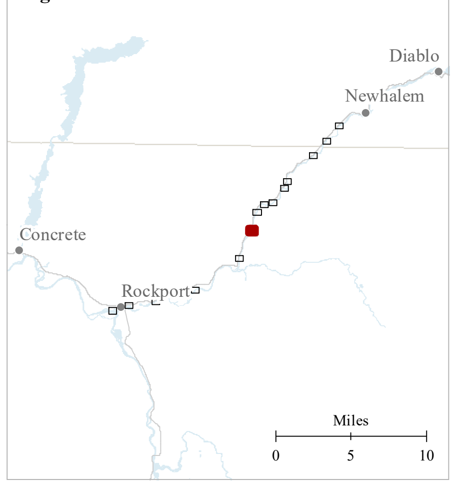
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet

N



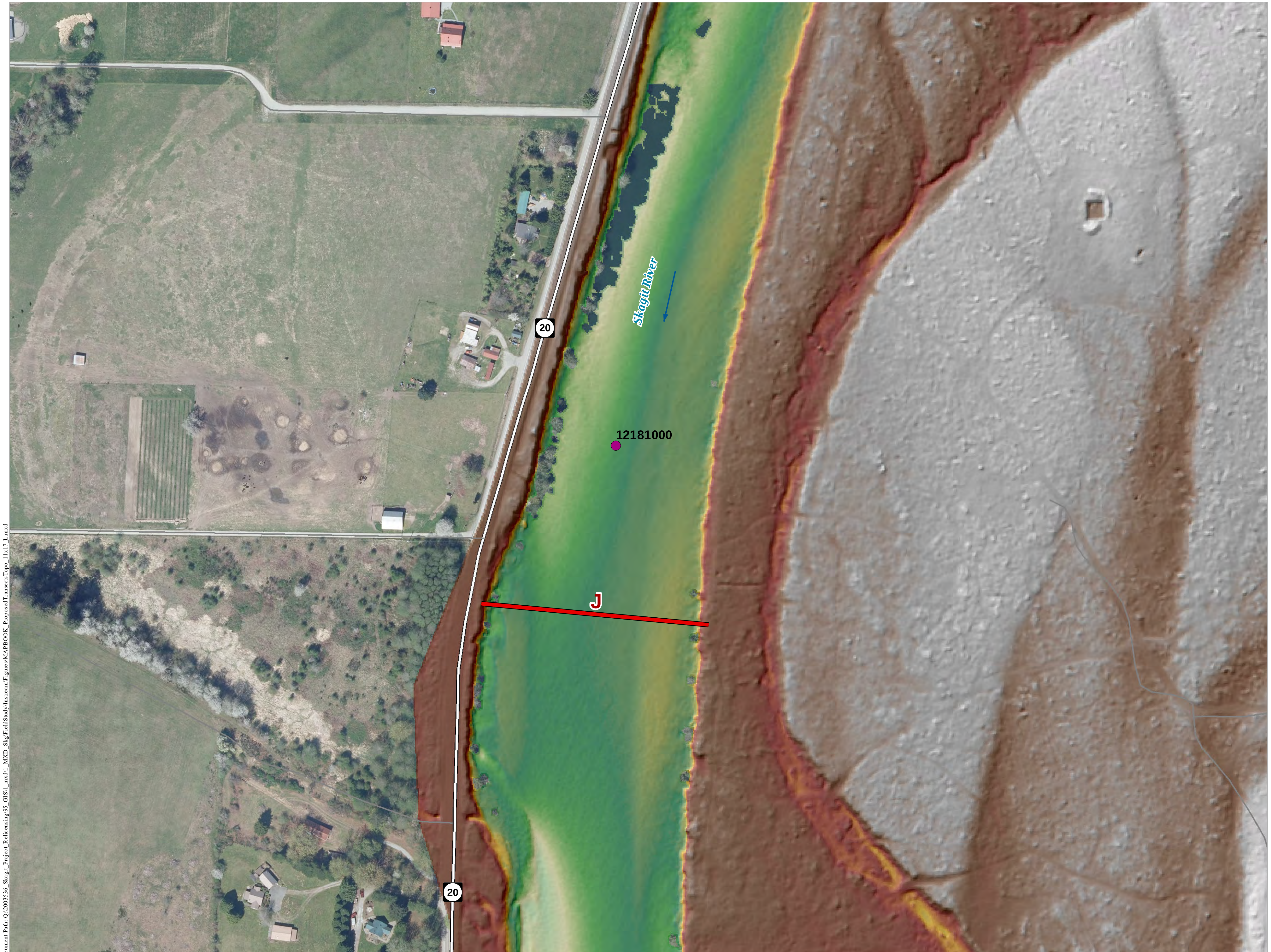
DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd



TRANSECT J

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2018 Topography (ft)

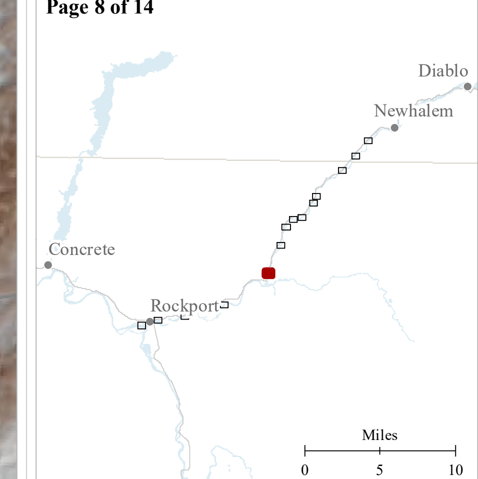
- > 330
- 315
- < 300

Scale - 1:2,400

0 100 200 Feet

N

Page 8 of 14



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

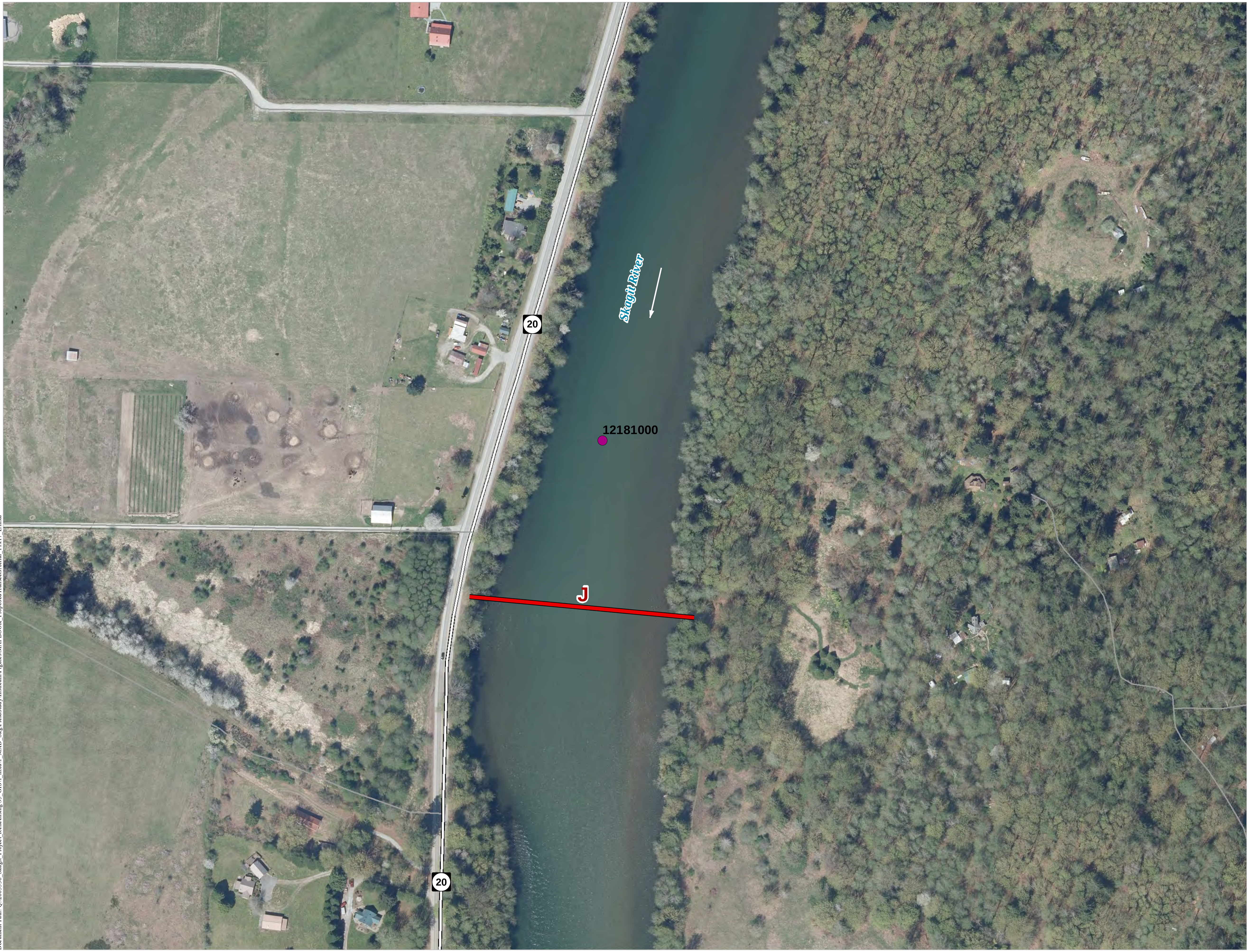
Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

TRANSECT J



Legend

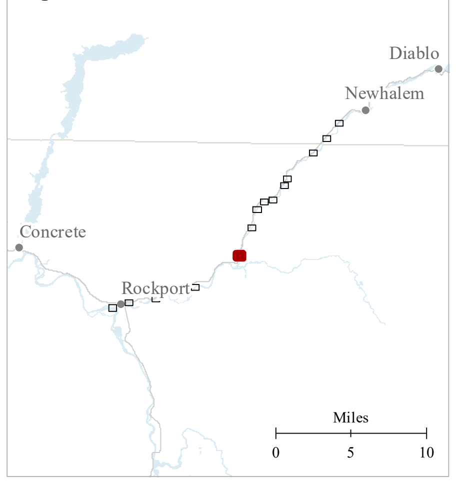
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2018

Scale - 1:2,400

0 100 200 Feet

N



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

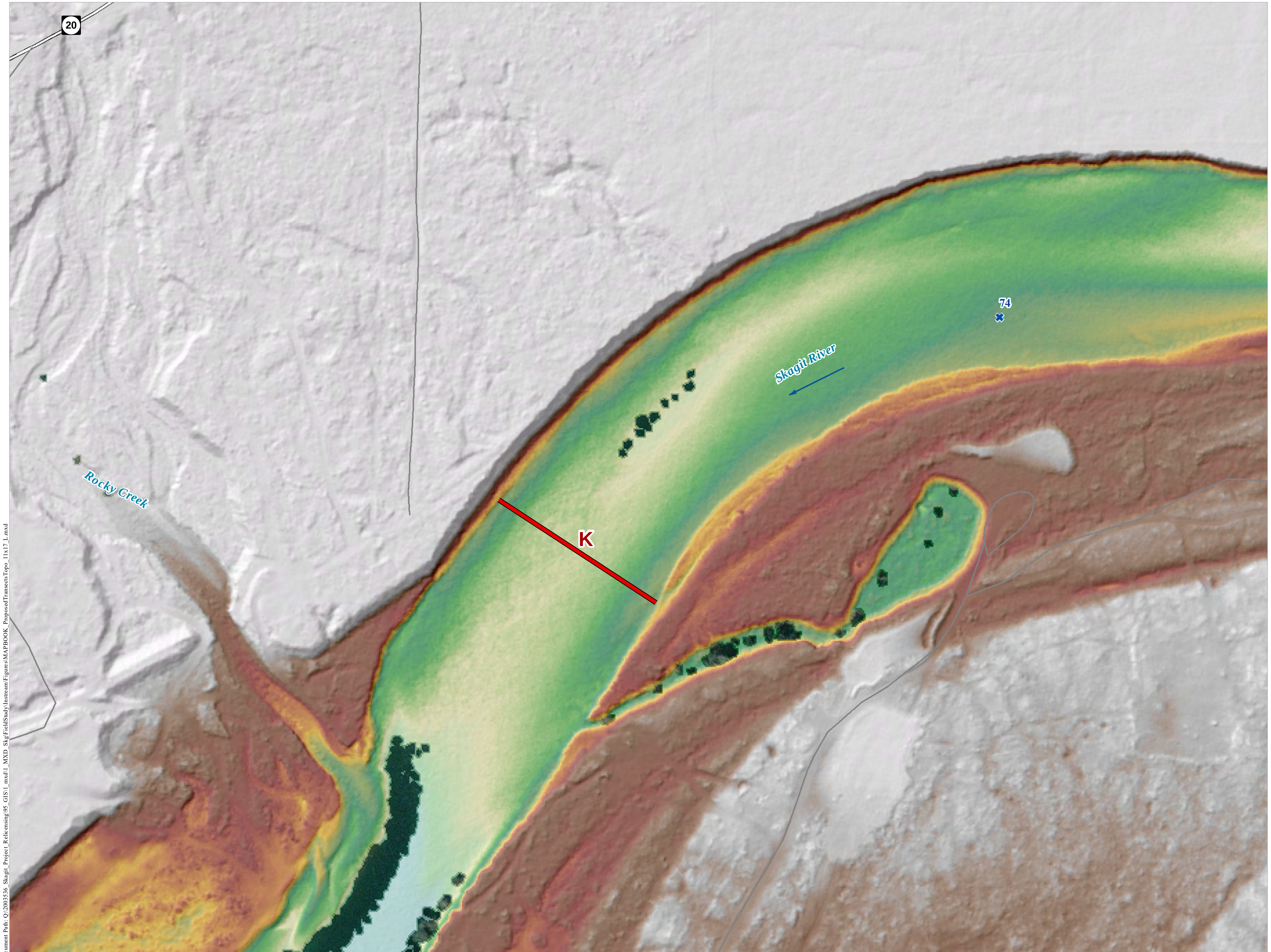
SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.

Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd

TRANSECT K



Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2017 Topography (ft)

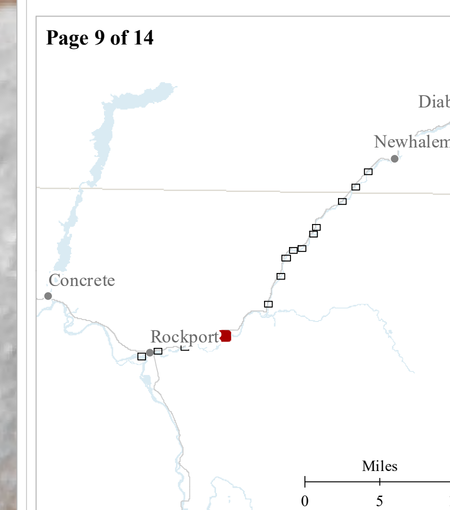
- > 290
- 275
- < 260

Scale - 1:2,400

0 100 200 Feet

N

Page 9 of 14



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

TRANSECT K

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

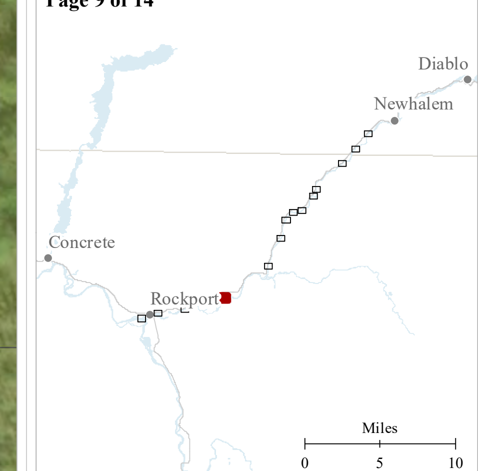
Background image from 2019

Scale - 1:2,400

0 100 200 Feet

N

Page 9 of 14



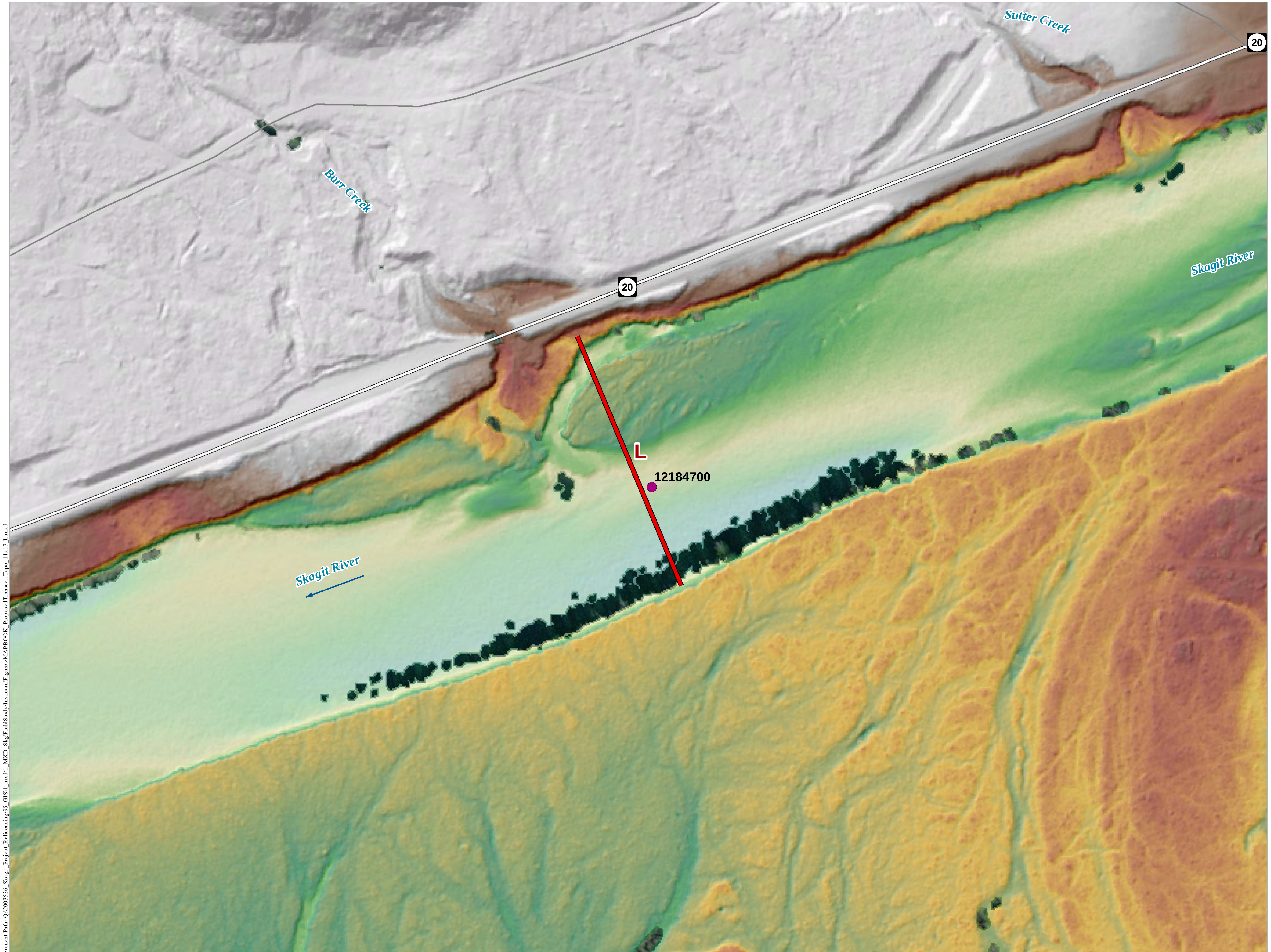
DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd



TRANSECT L

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2017 Topography (ft)

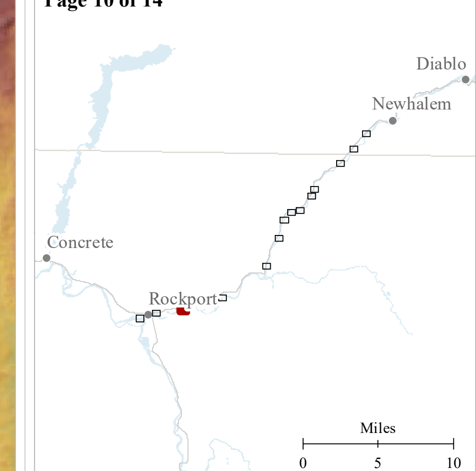
- > 270
- 250
- < 230

Scale - 1:2,400

0 100 200 Feet

N

Page 10 of 14



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

TRANSECT L

Legend

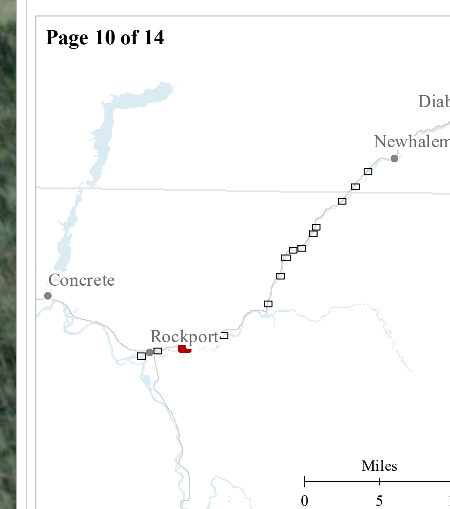
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2019

Scale - 1:2,400

0 100 200 Feet

N



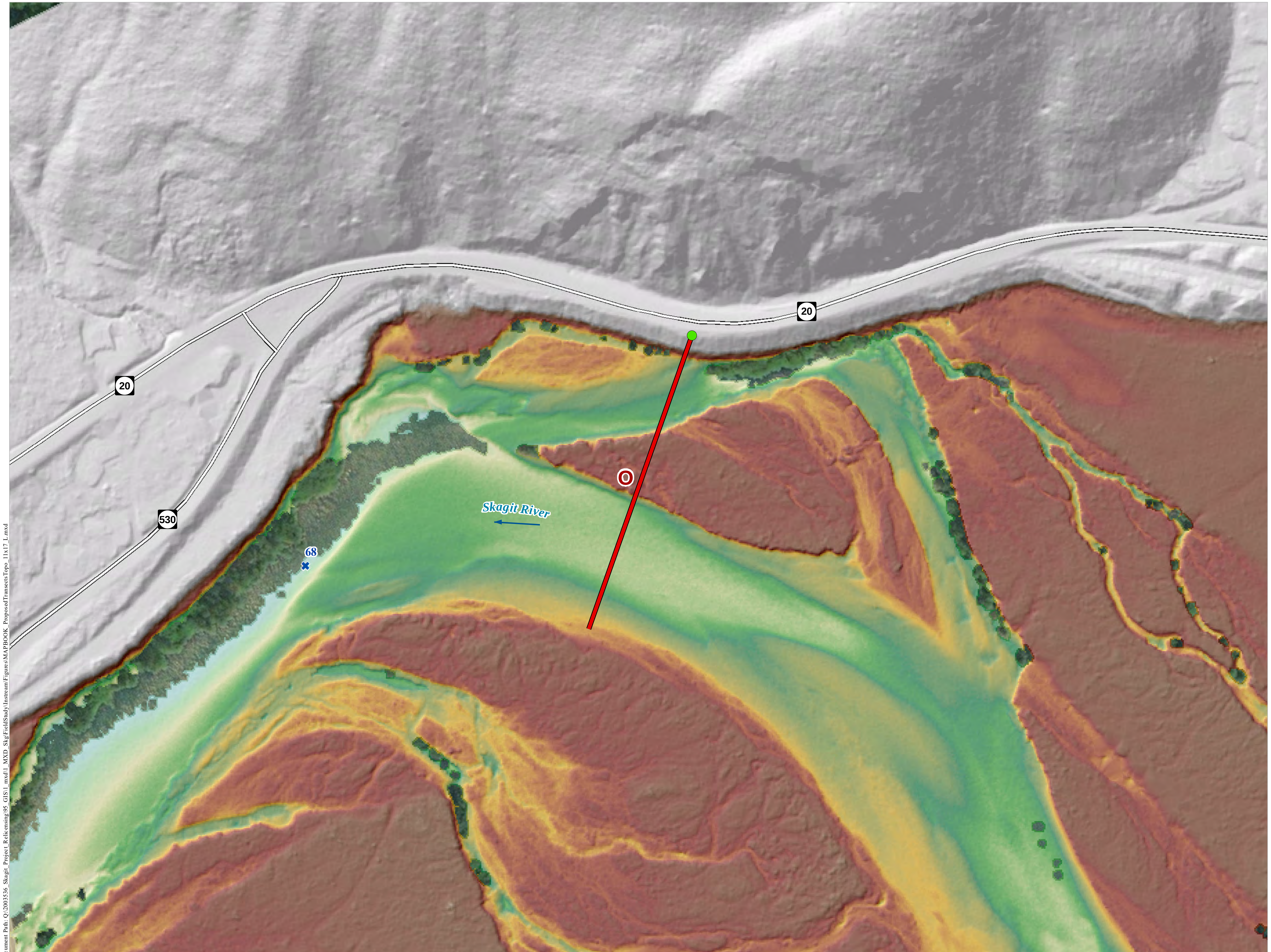
Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd

TRANSECT O



Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

2017 Topography (ft)

- > 240
- 225
- < 210

Scale - 1:2,400

0 100 200 Feet

N

DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsTopo_11x17_L.mxd

TRANSECT O

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2019

Scale - 1:2,400

0 100 200 Feet

N

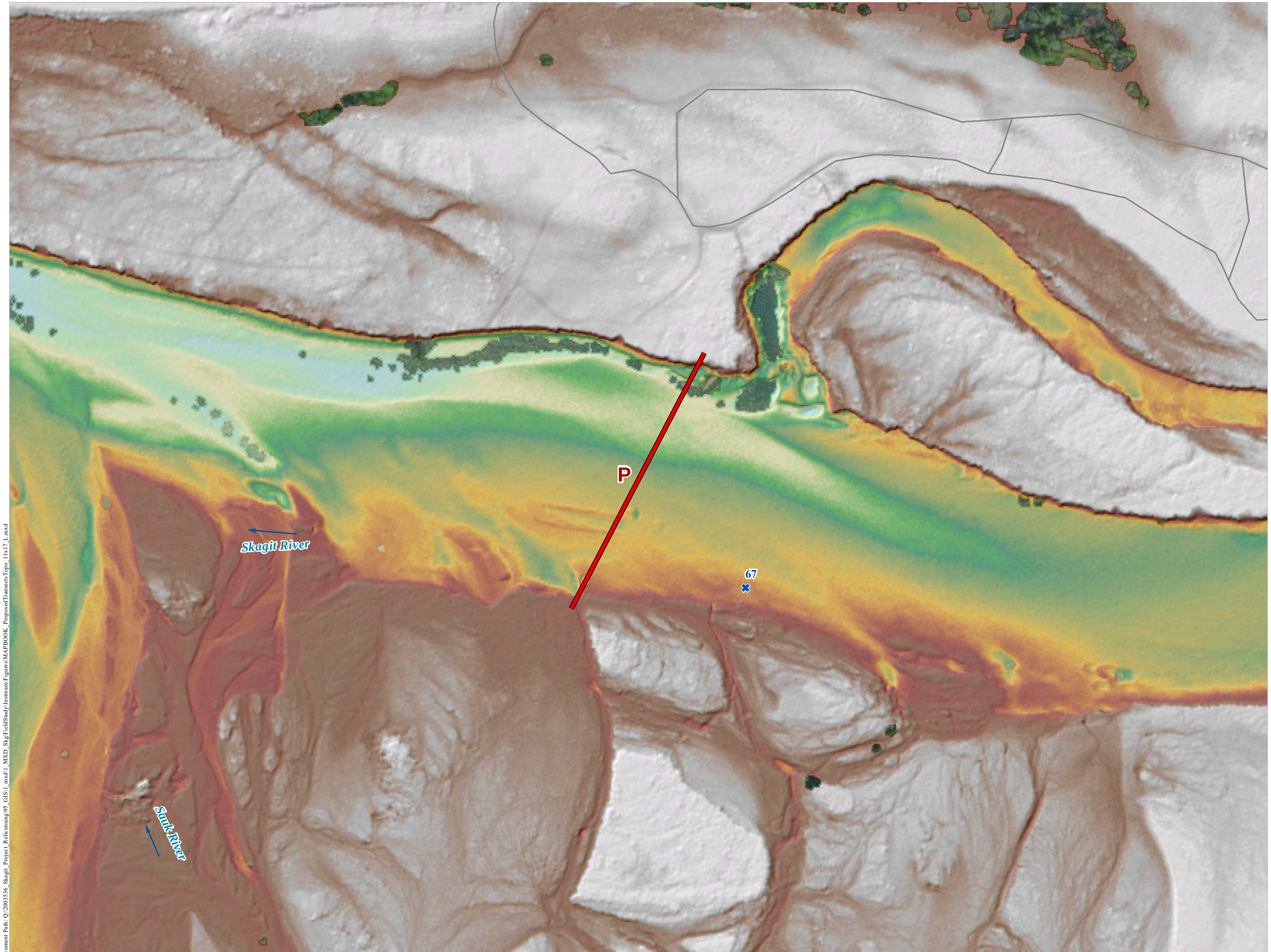
DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd



TRANSECT P

Legend

- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road

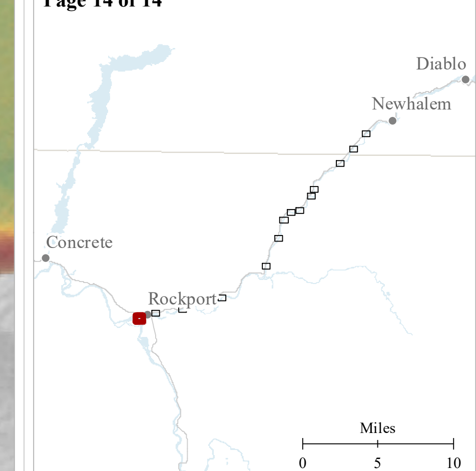
2017 Topography (ft)

> 225
215
< 205

Scale - 1:2,400

0 100 200 Feet

N



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

TRANSECT P

Legend

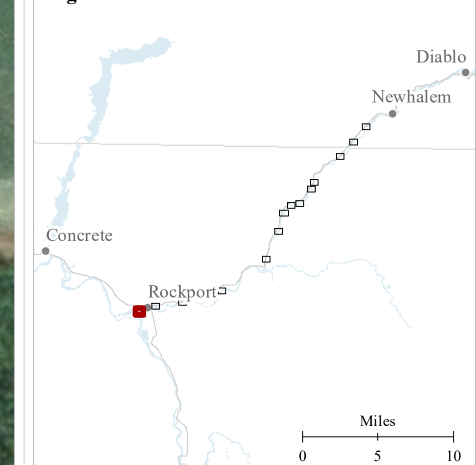
- River Mile (USGS)
- SRSC Gage
- Stream Gage (SCL)
- Stream Gage (USGS)
- Proposed Calibration Transect
- Highway
- Road
- SCL Owned Parcel

Background image from 2019

Scale - 1:2,400

0 100 200 Feet

N



DRAFT - PRIVILEGED
Attorney Work Production/Deliberative Process Communication

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

Created on 8/18/2020 by NHC for Seattle City Light.
City Light provides no warranty, expressed or implied, as to the accuracy, reliability or completeness of this data.
Data Source: [XXXXX].

Document Path: Q:\2003536_Skagit_Project_Relicensing\95_GIS\1_mxd\1_MXD_Skg\FieldStudy\Instream\Figures\MAPBOOK_ProposedTransectsAerial_11x17_L.mxd

Skagit River Hydroelectric Project
Seattle City Light (City Light)
FA-02 Instream Flow Model Development Workshop #3
August 12, 2021

Meeting Summary

Disclaimer: These notes are provided to serve as a high-level summary of the meeting and as a communication tool to benefit work group continuity. They are streamlined and focused on action items, unresolved issues, future discussion items, and high-level discussion points. They are not intended as a formal record of the meeting.

Attendance

Licensing Participants (LPs):
Brock Applegate, Washington Department of Fish and Wildlife (WDFW)
Susannah Erwin, National Park Service (NPS)
Jeff Garnett, US Fish and Wildlife Service (USFWS)
Kiza Gates, WDFW
Rick Hartson, Upper Skagit Indian Tribe (USIT)
Mike Larrabee, NPS
Jim Myers, National Marine Fisheries Services (NMFS)
Jim Pacheco, Washington Department of Ecology (Ecology)
David Price, NMFS
Ashley Rawhouser, NPS
Dudley Reiser, Kleinschmidt Group (for Swinomish Tribe)
Devin Smith, Skagit River System Cooperative (SRSC)
Kara Symonds, Skagit County
Stan Walsh, SRSC

Seattle City Light (City Light):
Andrew Bearlin, City Light
Erin Lowery, City Light

Cascadia Law:
Matt Love, Cascadia Law

Consultant Team:
Lisa Dosch, Consultant Team
Bao Le, Consultant Team
Malcolm Leytham, Consultant Team – NHC
Chris Long, Consultant Team – NHC
Tyler Rockhill, Consultant Team – NHC

Facilitation Team:
Joy Juelson, Facilitation Team
Alex Sweetser, Facilitation Team

Meeting Materials

- Meeting Agenda
- Meeting Slides: Skagit River Instream Flow Study Workshop 3 Presentation

Action Items

Action	Responsibility	Deadline
LP Action Items		
City Light, in collaboration with LPs and Triangle, will hold a special meeting in August, 2021 to discuss the location and timing of level logger installation and model calibration.	LP representatives / City Light	~~As soon as possible~~ Complete (Meeting held on September 1)

Consider how the installation of the level loggers will intersect with the GE-04 and FA-04 studies.	LP representatives / City Light	~~Before August special meeting~~ Complete (Discussed during September 1 meeting)
City Light Action Items		
Provide LPs with an overview map of instream flow transect locations.	City Light	~~As soon as possible~~ Complete (Provided to Triangle on August 13)
Consider what type of sensitivity analysis could be done for terrain and how this analysis would influence the model.	City Light	Before next workshop
Facilitation Team Action Items		
Prepare draft meeting summary and send it to LPs for review.	Triangle	Two weeks
Coordinate with City Light and LPs to identify dates and times for a special meeting in August to discuss the location and timing of level logger installation and model calibration.	Triangle	As soon as possible

Summary of Issues Discussed, Action Items, and Decisions

Welcome, Introductions, Agenda Overview

The facilitation team welcomed the group and led a roll call. The facilitator, Joy Juelson, walked through the agenda and briefly reviewed the completed action items from the last FA-02 Instream Flow meeting, held on April 28, 2021. Chris Long, Consultant Team, noted that there is dedicated discussion time for each agenda item. The facilitator shared the objectives of this meeting are to:

- Provide an overview of the program to develop the instream flow model of the Skagit River from Gorge Powerhouse to the Sauk River.
- Review data sources and methodology for hydraulic model construction: terrain, boundary conditions, and geometry.
- Provide an update on hydraulic model sensitivity testing, computation times, and conditions.

Hydraulic Model Overview

Erin Lowery, City Light, provided background information on the FA-02 study and an overview of the study's Gantt chart. He noted this meeting primarily focuses on construction of the hydraulic model, and the next workshop in late October will focus on calibration of the hydraulic model.

Terrain

Tyler Rockhill, Consultant Team, provided a presentation on the Hydraulic Model Terrain (see slides 5 – 36). This presentation included:

- An overview of the model topographic surface (terrain~~) mapping through~~ sourced from two LiDAR data sets from 2017 and 2018,
- Information on terrain void filling through field ~~sampling~~survey,
- ~~Details~~Results of a limited desktop channel migration assessment~~, from a desktop analysis~~
- Summary of bathymetric change at~~Outcomes of a~~ calibration transects, and an ~~stability analysis~~
- Explanation of the concept of dynamic equilibrium and how this applies to the model.

Commented [A(1]: What follows "and an," if anything?

Void Infilling

Tyler explained that the model terrain ~~potion of the model~~ is largely informed by two LiDAR datasets for two adjacent segments of the river, collected in 2017 and 2018. Wherever the data did not meet ~~the needs for the~~ Quantum Spatial's photogrametric standards ~~analysis tool~~, it was classified as a void. To infill the voids, field~~work~~ surveys ~~was~~ were conducted in 2020 and 2021 for the 2018 LiDAR segment, and existing data from ~~the~~a hydraulic model of the Barnaby Reach was used for the 2017 segment. The modeling team will use ~~the~~ Quantum Spatial's interpolated surface ~~tool to fill the voids~~ in ~~areas~~voids that were unsafe or inaccessible during field ~~analyses~~surveys. Additional field sampling in the Barnaby Reach is planned for early September to fill voids in the 2017 segment.

Channel Migration and Transect Stability

Tyler explained ~~the~~ a limited desktop channel ~~migration~~stability assessment ~~was completed using a desktop analysis, which~~ revealed the Skagit River has been generally stable upstream of project river mile (PRM) 74, but much more dynamic between PRM 65 and 74. The ~~transect stability~~ analysis revealed ~~river~~ model calibration transects were broadly stable, even within dynamic reaches, and most differences were less than 0.5ft. Chris and Tyler clarified the LiDAR ~~data~~surface was ~~at~~ a 3ft raster with one elevation per cell, whereas bathymetry data from the field had a better resolution.

Dynamic Equilibrium

Tyler explained the concept of dynamic equilibrium (see slides 32-34). He noted that rivers are dynamic, and will continue to be in the future, so the hydraulic model should define a representative condition. However, it is not a precise representation of future conditions.

Discussion and Questions

- In response to a question about the potential for voids to bias the analysis near channel margins, Tyler and Chris explained there is no inherent bias because the voids were not included in the statistical analysis pertaining to channel planform stability slides. ~~If confidence was not high enough after field sampling, the data point was labeled as a void.~~
- Jim Pacheco, Ecology, noted that the LiDAR data collection method results in far more data than traditional instream flow data collection methods. Even though the data is at a lower resolution, he explained, it is a very useful method for understanding river conditions.
- To better understand the location of transects in the river, LPs requested an overview map of instream flow transect locations. The Consultant Team agreed to provide this map.

Commented [A(2]: I believe that you end up with far more data points with LIDAR, than through traditional instream flow data collection. The larger data set with LIDAR makes up for the lower resolution.

- LPs from NPS requested a sensitivity analysis to ~~improve~~demonstrate ~~the~~ confidence ~~of~~ in the model. The group discussed the need for a sensitivity analysis noting surveying gaps, the largely positive differences in bathymetry changes (see slide 31), and the importance of a bathymetric mean difference of 0.5ft. The Consultant Team agreed to consider the need for a sensitivity analysis.
- In response to a question from Dudley Reiser, Swinomish Tribe, Erin clarified that a bed evolution model will be developed as part of the geomorphology studies to understand how bed morphology may change in the future and could be used to estimate future habitat conditions.
- Noting surveying data gaps and lower data confidence in Transects C and F, Jim Pacheco clarified that Ecology will decide if they want data double-checked for these transects.
- Chris clarified ~~surveying data and~~ void infilling will not occur in the side-channels or floodplains. Erin elaborated that the model domain is broad and will show when side-channels or floodplains would be connected if the river elevation is high enough.
  - Several LPs expressed concern about installing level loggers in the floodplains to measure water level and temperature. They requested level loggers be installed in the floodplains by this November. They also noted that installing level loggers is ~~also~~ important to the GE-04 and FA-01 studies.
  - City Light and LPs agreed to further discussion of the location and timing of level logger installation and decided to schedule a special meeting in August for this discussion.

Action Item: City Light will provide LPs with an overview map of instream flow transect locations.

Action Item: City Light will consider what sort of sensitivity analysis could be done for the terrain and how this analysis would influence the model.

Action Item: City Light, in collaboration with LPs and Triangle, will hold a special meeting in August to discuss the location and timing of level logger installation and model calibration.

Action Item: City Light and LPs will consider how the installation of level loggers will intersect with the GE-04 and FA-04 studies.

Hydraulic Model Boundary Conditions

Malcolm Leytham, Consultant Team, presented on the hydraulic model boundar~~y~~ies ~~conditions~~ (see slides 37 – 44). He reviewed the calibration model inflow methodology noting there are 13 tributar~~y~~ies ~~inflows~~ and four calibration events. Additionally, he compared the flows measured at ~~this study's~~select transects to flows measured ~~from~~at nearby USGS gages and noted the ~~relatively low differences~~ close agreement between the two data sets.

- ~~Rick Hartson, USIT, noted the Goodell data was incorporated into the data set.~~

Hydraulic Model Geometry

Chris presented on the hydraulic model geometry (see slides 45 – 52). He noted the HEC-RAS 2D model utilizes a ~~mapped~~ grid system of varying cell sizes (i.e., mesh sizes)~~,~~ and said the Consultant Team is still trying to define areas where they need ~~either~~ more or less accuracy. Importantly, they need to balance model accuracy with computation times as the smallest cell size of 6ft would require approximately 40 days to simulate 5 days of flows. When reviewing roughness categories, Chris noted the addition of a "tributary" category to those itemized in the prior hydraulic model of the Barnaby Reach.

Hydraulic Model Sensitivity Results

Tyler provided an overview of the hydraulic model sensitivity results (see slides 53 – 84).

Subset Model and Cell Size Sensitivity

Tyler noted the modeling team ~~would~~ used a "subset" model for sensitivity analysis, which allowed~~s for~~ model parameters to be tested at greatly reduced run times. He presented several results from the transects and noted the following conclusions:

- Smaller cells tend to simulate higher high-velocities and lower low-velocities.
- Cell size can alter the location and magnitude of velocities.
- Velocity is not sensitive to cell size when velocity changes gradually.
- Sensitivity to cell size varies with velocity magnitude.

Sensitivity Results: Roughness and Velocity

Tyler presented the model sensitivity results for roughness and~~ velocity. He~~ noted the following outcomes:

- Roughness can change the location and magnitude of velocity.
- Sensitivity to roughness increases with velocity.
- Cell size and roughness are interrelated and need to be modeled together.
- WSEL is highly sensitive to roughness – different compared to cell size.

Conclusions

Tyler reviewed the hydraulic model sensitivity results noting the following outcomes:

- Run time increases with cell count, which has implications for this study and future uses of the model.
- Cell size and roughness are interrelated and need to be modeled together.
- The context and location of resolution are important. For example, the greatest variations occur at peak velocities and along channel margins.
- For the path forward, the model will likely use cells ranging from 6–15ft ~~cells~~ in the main channel to balance run times and representation of hydraulic features.

Questions and Discussion

- In response to a question, Chris clarified the base channel roughness value in the model is 0.03~~7~~5 but would be varied longitudinally during model calibration stage.~~, and the model enables them to understand how roughness is linked to velocity.~~
- In response to a question on whe~~n~~re different cell sizes will be selected~~ to model depth and velocity~~, Chris clarified the model will have smaller cells ~~sizes~~ in locations where there is a

change in terrain elevation to capture the river complexity or ~~hydraulic~~ features that may locally affect ~~velocity~~hydraulics. Due to ~~the~~ long computation~~al~~ times for smaller cells, he noted the modelers will assess the benefit of smaller cell sizes to balance run times and hydraulic feature representation.

- ~~In response to a question about model confidence in the channel boundary, Chris clarified there is no known bias in the data and the Consultant Team has equipment that can adapt to better measure boundary types such as banks or steep drops.~~

Model Next-Steps

Chris provided an overview of the next steps for developing the model (see slides 85 – 93). The Consultant Team expects to conclude model setup and sensitivity analysis in August, 2021 and will begin calibration around roughness, turbulence, boundaries, and terrain ~~parameters~~ (~~as~~ if necessary) in September, 2021. Chris also provided an overview of data that will be used to calibrate the model and performance evaluation ~~methodologies~~metrics.

- In response to a question about the decision-making process for selecting different cell sizes, Chris clarified they would ~~evaluate the data and~~ utilize 2D difference plots and charted points (both methods demonstrated today). These methods and results will be presented and discussed at the next workshop in October, 2021.
- Jim Pacheco recommended using smaller cell sizes in channel margins because this part of the river tends to have higher sensitivity.
- In response to a question on the plan for active side channels, Erin clarified that active side channels have been identified and included in this model. The Geomorphology Consultant Team is currently in the field gathering data to confirm these locations.

Review Action Items and Next Steps

The facilitator reviewed the action items and next steps from the meeting.

Action Item: City Light will provide LPs with an overview map of instream flow transect locations.

Action Item: City Light will consider what type of sensitivity analysis could be done for terrain and how this analysis would influence the model.

Action Item: City Light, in collaboration with LPs and Triangle, will hold a special meeting in August to discuss the location and timing of level logger installation and model calibration.

Action Item: City Light and LPs will consider how the installation of the level loggers will intersect with the GE-04 and FA-04 studies.

Action Item: Triangle will prepare a draft meeting summary and send it to LPs for review.

The meeting was adjourned at 1:20 p.m.

INSTREAM FLOW MODEL DEVELOPMENT STUDY
INTERIM REPORT

ATTACHMENT N

INSTREAM FLOW WORKSHOP 4 MATERIALS

Seattle City Light **PROPOSED MEETING AGENDA**

Skagit Hydroelectric Project Relicensing Meeting

FA-02 Instream Flow Model Development Workshop #4

December 7, 2021, 8:30 am – 2:00 pm

Webex Link: Join the meeting here

Conference Call: +1-510-338-9438

Access code: 2550 694 3033

Meeting Password: piYuJPVP755 (74985787 from phones and video systems)

MEETING PURPOSE

- Provide an overview of the program for development of the instream flow model for the Skagit River from Gorge Powerhouse to the Sauk River.
- Review data sources and methodology for hydraulic model construction: terrain, geometry, and solution parameters.
- Provide update of ongoing hydraulic model calibration activities.
- Discuss next steps regarding model calibration and validation.
- Begin discussion and identify next steps on NOA item regarding Skagit River stranding and trapping from Gorge Powerhouse to Sauk River.

RESOURCES/MATERIALS

- NOA Commitments
- Work Group Discussion Tracker
- Presentation
- Summary from last FA-02 meeting (8/12)

FACILITATION TEAM

- Joy Juelson, Facilitator, Triangle Associates
- Alex Sweetser, Facilitation Support Staff, Triangle Associates

AGENDA

08:30 – 08:45 (15 minutes)	**Introduction** – *Facilitator, Triangle and Erin Lowery, City Light* ▪ Roll Call Introduction ▪ Review agenda items and meeting objectives. ▪ Review meeting context and previous summary and action items
08:45 – 09:25 (40 minutes)	**Hydraulic Model Overview** – *Erin Lowery, City Light (presenter) and Chris Long, NHC (technical support)* *Desired Outcome: Quick orientation to meeting agenda. Review of model scope and identify any issues.* ▪ Background ▪ Review Meeting Objectives and Model Scope ▪ Questions and Discussion (20 minutes)

09:25 – 10:10 (45 minutes)	**Terrain** – *Tyler Rockhill, NHC (presenter)* *Desired Outcome: Inform LPs how final model topo surface was derived.* ▪ Void Infilling ▪ Final Terrain ▪ Terrain Sensitivity ▪ Questions and Discussion (15 minutes)
10:10 – 10:25 (15 minutes)	**Break**
10:25 – 11:10 (45 minutes)	**Hydraulic Model Geometry** – *Tyler Rockhill, NHC (presenter)* *Desired Outcome: Inform LPs how current state of model geometry was derived.* ▪ Mesh ▪ Roughness ▪ Structures ▪ Questions and Discussion (15 minutes)
11:10 – 12:25 (75 minutes)	**Hydraulic Model Calibration** – *Tyler Rockhill (presenter) and Chris Long (technical support), NHC* *Desired Outcome: Inform LPs of calibration approach and illustrate comparison to observed data.* ▪ Calibration Methodology ▪ Calibration Metrics ▪ Calibration Progress ▪ Calibration Results ▪ Questions and Discussion (25 minutes)
12:25 – 12:35 (10 minutes)	**Break**
12:35 – 1:20 (45 minutes)	**Next Steps** – *Chris Long, NHC (Presenter) and Ty Ziegler, HDR (technical support)* *Desired Outcome – Inform LPs how model will finally be assessed as calibrated and approach to HSC integration.* ▪ Model calibration finalization and validation ▪ HSC Integration ▪ Questions and Discussion (30 minutes)
1:20 – 1:50 (30 minutes)	**Introduction: Skagit River from Gorge Powerhouse to Sauk River - Stranding and Trapping** – *Erin Lowery, CL (Presenter)* *Desired Outcome –Inform LPs how S&T are evaluated in the Skagit River below Gorge Powerhouse and discuss potential next steps to address this NOA item.* ▪ Note this is a "kick off" discussion and is not intended to reach resolution on this item. ▪ Review history of stranding and trapping activities in this reach and current program protection. ▪ Review available materials to support further discussions (linked here). ▪ Discuss proposed next steps. ▪ Questions and Discussion (15 minutes)
1:50 – 2:00 (10 minutes)	**Action Item Review and Agenda Items for Next Meeting –** *Triangle*
2:00	**Meeting Adjourned**

SKAGIT RIVER INSTREAM FLOW STUDY WORKSHOP 4

December 7, 2021

STUDY BACKGROUND

- Need to update and enhance current Flow Management Tool (ESH Model) identified by the FARWG
- New hydraulic model also has utility in evaluation of other Project-related resource issues identified by LPs
- Intent to continue implementation of flow management program to benefit fisheries resources and address other Project-related resource issues as part of a new FERC license

PURPOSE OF STUDY

- Purpose of study:
  - 1) develop model
  - 2) produce flow-habitat relationships
- Purpose of model: Produce depth and velocity raster for production run flows
- 1,400 to 7,000 cfs at Newhalem– currently used in effective spawning habitat model

STUDY ROAD MAP/SCHEDULE

	April	May	June	July	August	September	October	November	December	January	February	March		
Field Data Collection													Initial study report March 2022	Alternative scenario identification and evaluation: February - September 2022
Hydrometric data collection for model calibration	Completed March 2021 (data collection at USGS gages continues through study period).													
Bathy data collection (to fill voids in LiDAR)	Surveys Oct 2020 & Mar 2021 & Sep 2021.													
Substrate and cover data collection														
Hydraulic Model Development														
Assemble terrain data														
Hydraulic model construction														
Hydraulic model calibration/validation														
Biological and Habitat Information														
Review and selection of HSCs														
Integration with hydraulic data														
Workshops (HSC focussed workshops not shown)	↑ 1				↑ 3				↑ 4			↑ 5		

Seattle City Light

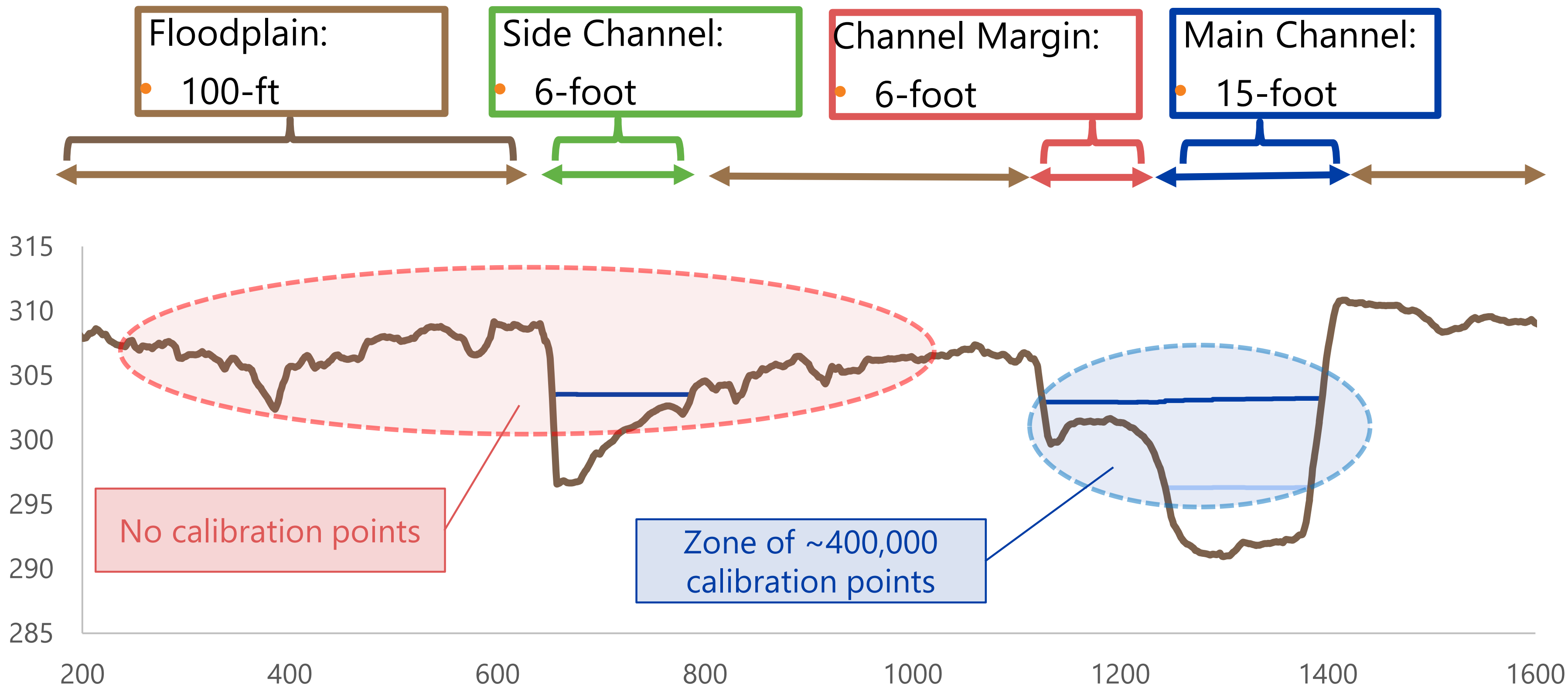
WORKSHOPS

Workshop	Date	Topics
~~1~~	~~Apr 28, 2021~~	~~Overview development of instream flow model for the Skagit River from Gorge Powerhouse to the Sauk River~~ ~~Introduction to identification, selection, and use of habitat suitability criteria (HSCs) for fish species of interest~~
~~2~~	~~July 2021~~	~~Updates to biological and habitat metrics based on discussions and input from Workshop 1~~
~~3~~	~~Aug 12, 2021~~	~~Hydraulic model construction ongoing~~
	~~Sep 24, 2021~~	~~Hydraulic model calibration (WDFW & DOE only)~~
	~~Nov 3, 2021~~	~~Hydraulic model calibration (WDFW only)~~
4	Dec 7, 2021	Hydraulic model calibration ongoing
5	Mar 1, 2022	Final hydraulic model calibration results and discussion of future model application

FA-02 INSTREAM FLOW MODEL SCOPE

- Relicensing study, and hydraulic model, focused on instream flow assessment
- Study/model development goal is to replace/update Effective Spawning Habitat (ESH) model (Crumley & Stober) used to support current license flow management program
- Model calibrated in-channel with:
  - ~50,000 transect points @ 3 flows
  - ~350,000 long-profile points @ 3 flows

INSTREAM FLOW MODEL CELL RESOLUTION



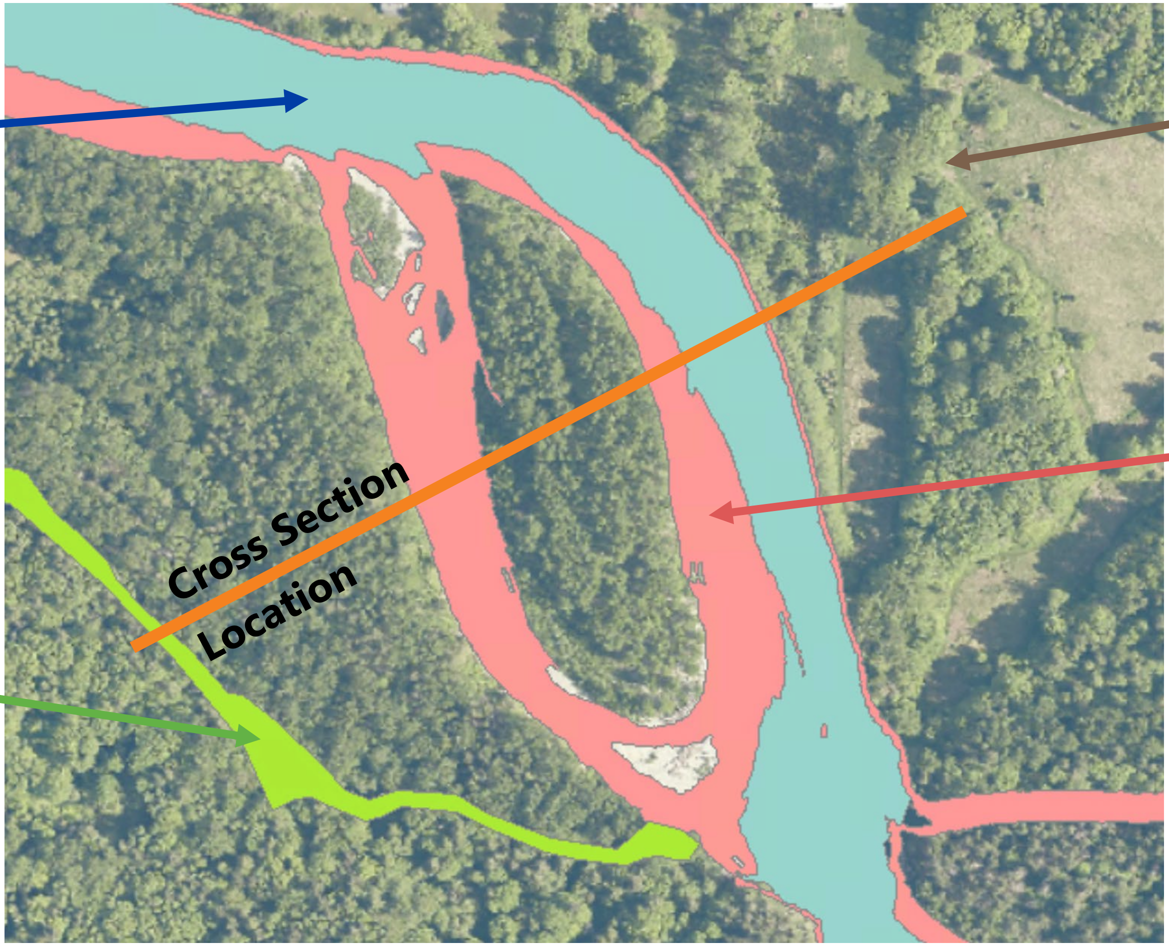
INSTREAM FLOW MODEL SCOPE

Main Channel:
- 15-foot mesh
- Calibration data

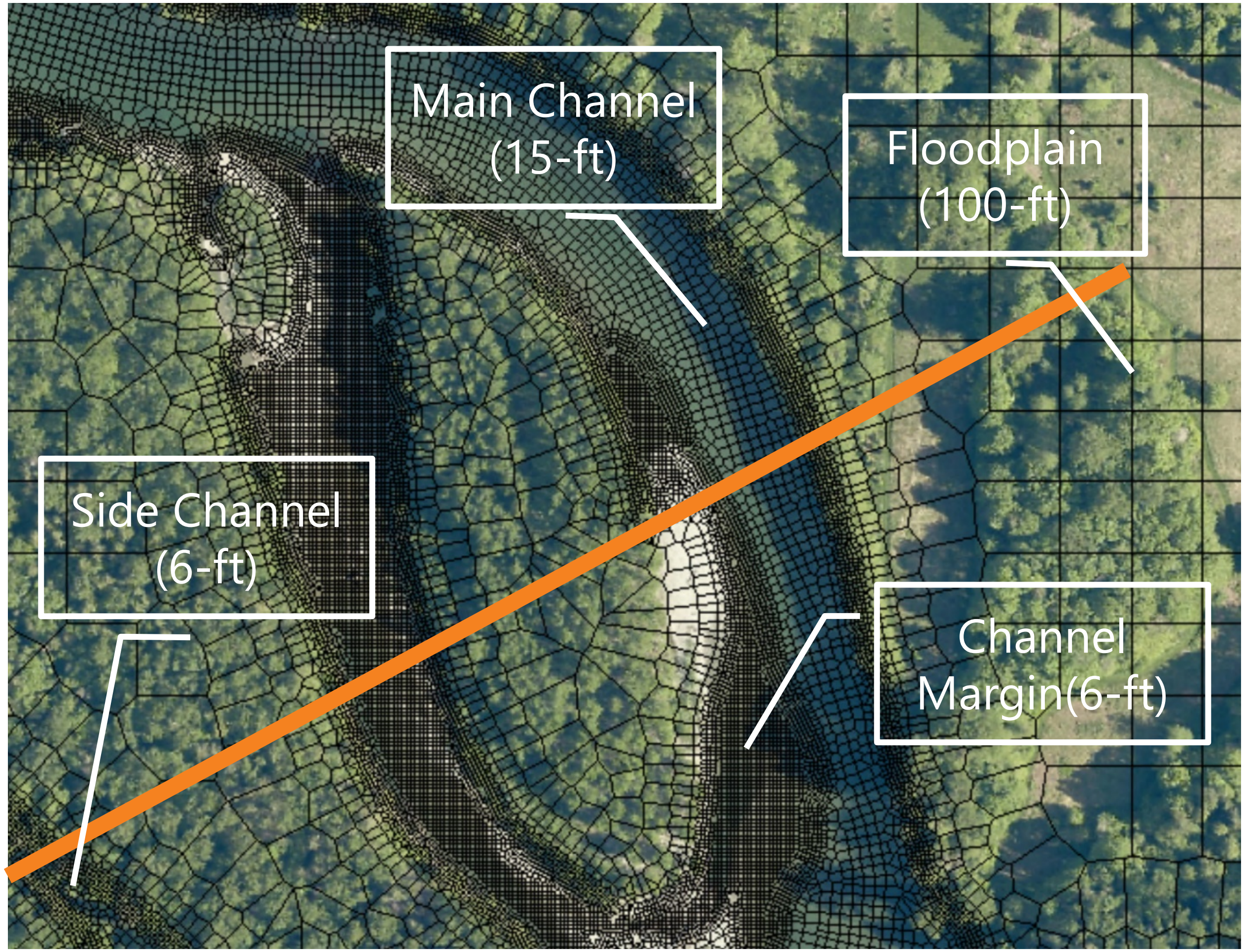
Floodplain:
- 100-foot mesh
- No calibration data

Channel Margin:
- 6-foot mesh
- Some calibration data

Side Channel:
- 6-foot mesh
- No calibration data



MODEL MESH



Main Channel
(15-ft)
Floodplain
(100-ft)
Side Channel
(6-ft)
Channel
Margin(6-ft)

FA-02 INSTREAM FLOW MODEL SCOPE

- LPs have expressed interest in potential flow management scenarios associated with off-channel and floodplain areas, process flows, etc.
- Other studies and NOA commitments to support this interest include GE-04, SY-01, floodplain logger installation, topobathy verification, etc.
- While this version of the FA-02 instream flow model is only calibrated in-channel, it can support these interests.

FUTURE OFFSHOOTS OF INSTREAM FLOW MODEL?

- Instream flow model has been referred to as "Version 1"
- Model adaptable to address other questions and areas of interest that may arise as results from other studies become available.
- Potential examples include:
  - Greater definition in specific floodplain areas of interest for flow management
  - More detailed modeling of future restoration areas
  - Model simulated with flows greater than instream flow analysis discharges (process flow, flood flow, etc.)?

FA-02 / FA-05 MILESTONES

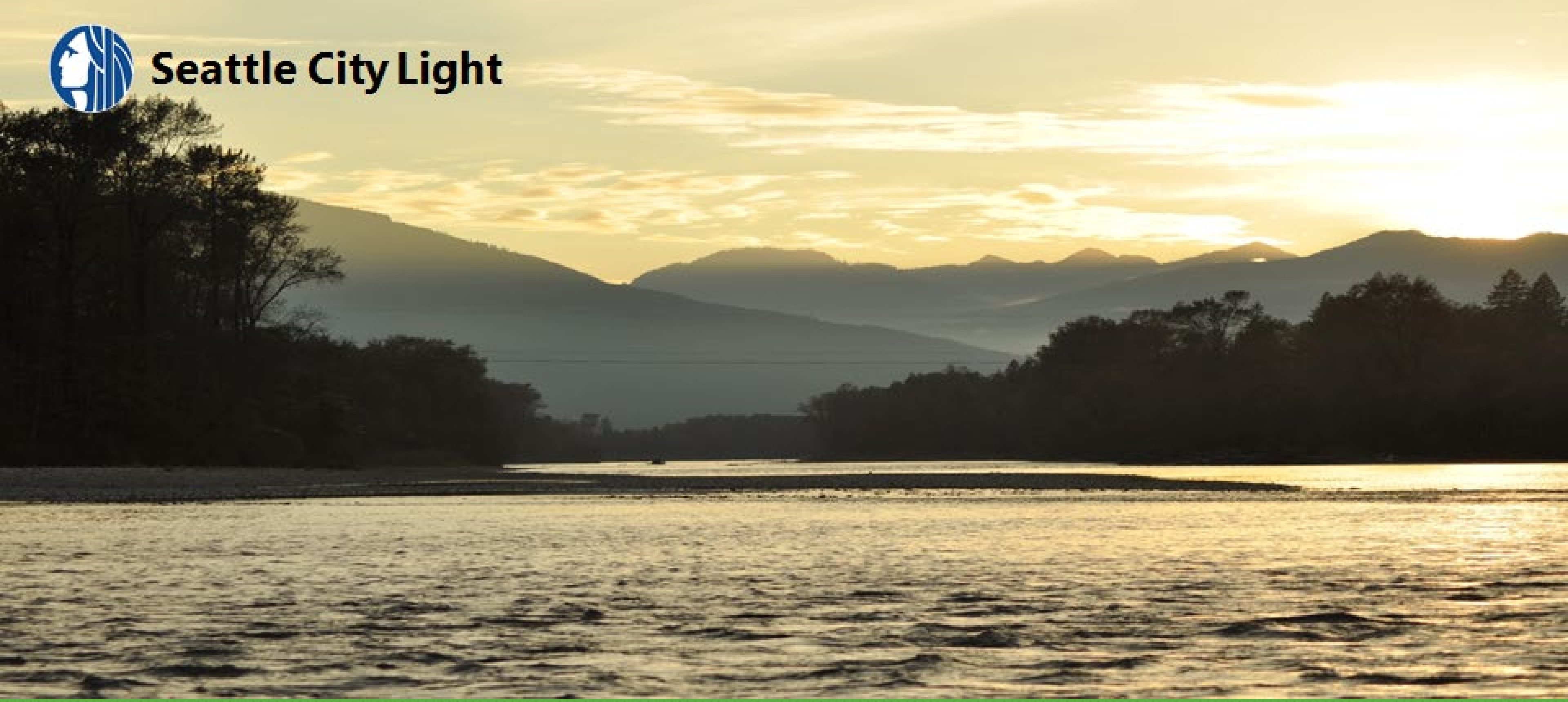
FA-02 / 05
- Gorge Dam to Sauk River
- Final HSC curves and periodicity
- Present at Jan 6 Workshop

FA-05
- Bypass Reach
- Final calibration to Jun/Jul 2021 observations
- Production run flows defined
- Present at Feb 1 Workshop

FA-02
- PH to Sauk River
- Final calibration to Aug 2020 – Mar 2021 observations
- Production run flows established
- Present at Mar 1 Workshop

FA-02 / 05
- Gorge Dam to Sauk River
- Hydraulic model production runs
- Overlay the hydraulic and biological maps with HSC
- Processing Mar - Jun

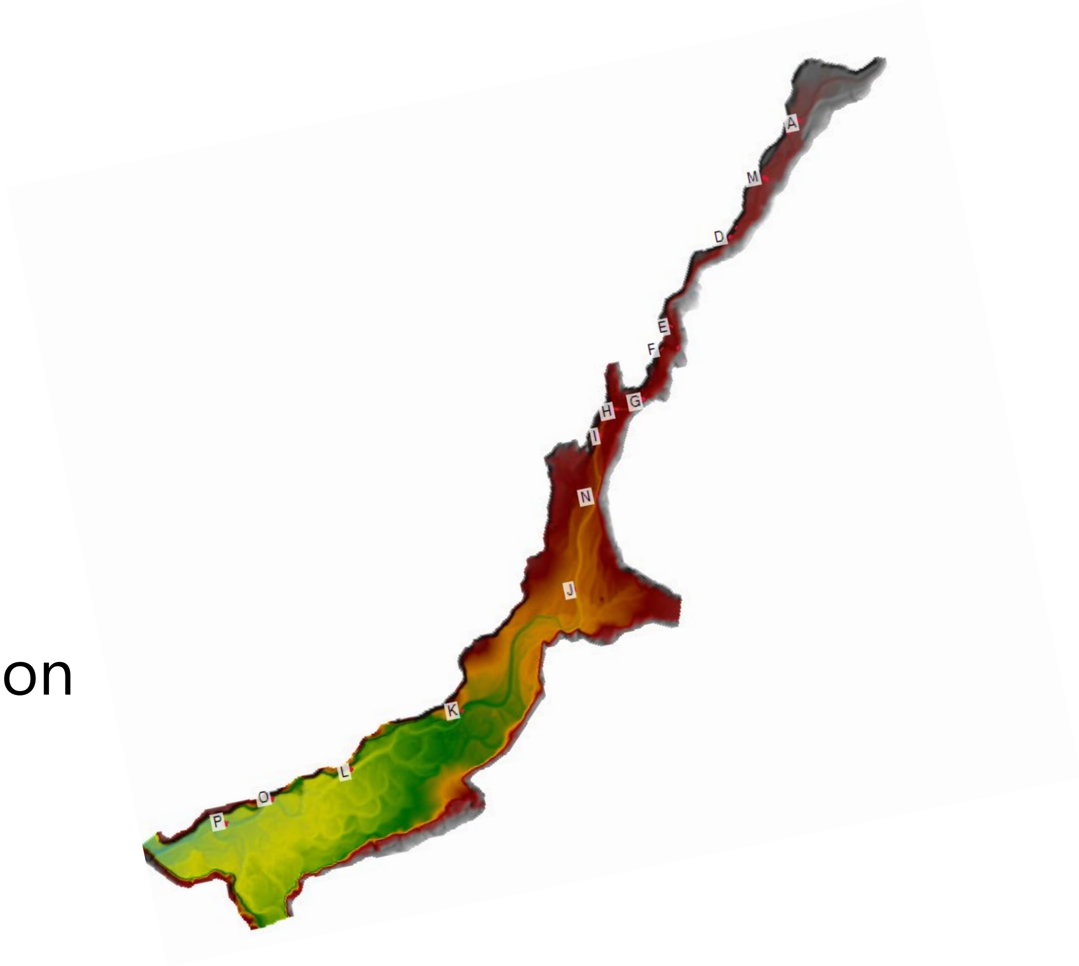
Jan 2022 | Feb | Mar | Apr | May | Jun



HYDRAULIC MODEL TERRAIN

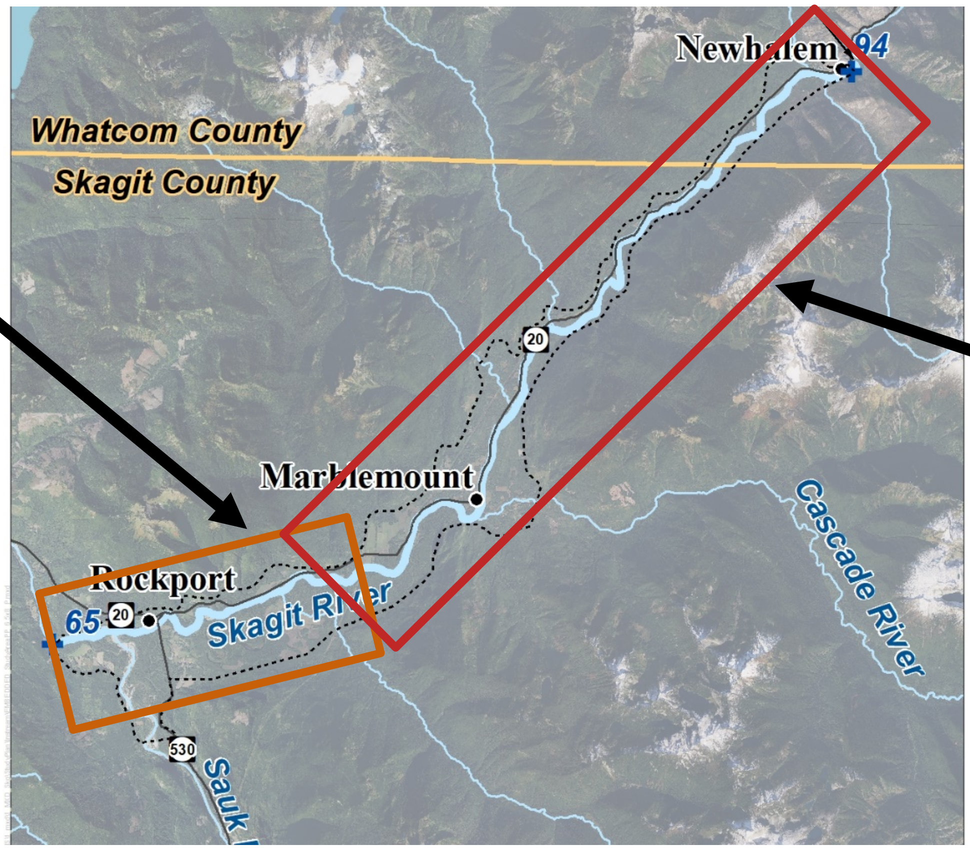
OVERVIEW

- Terrain Overview
- Void Infilling
- Final Terrain
- Terrain Sensitivity
- Questions and Discussion



TERRAIN - OVERVIEW

2017 LiDAR

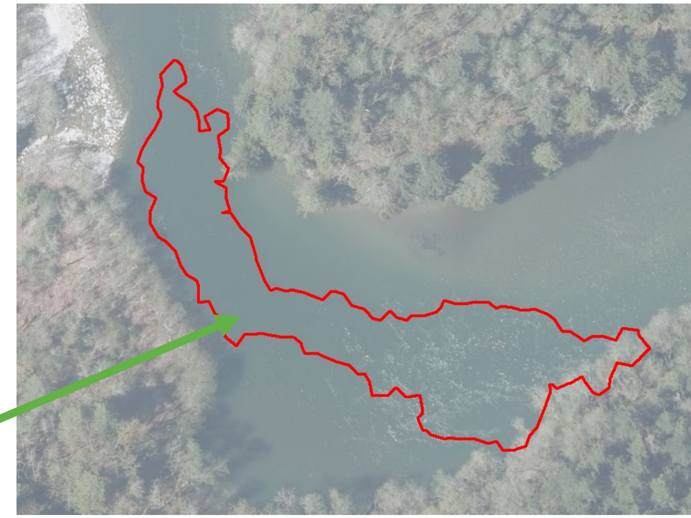


2018 LiDAR

~29 River Miles

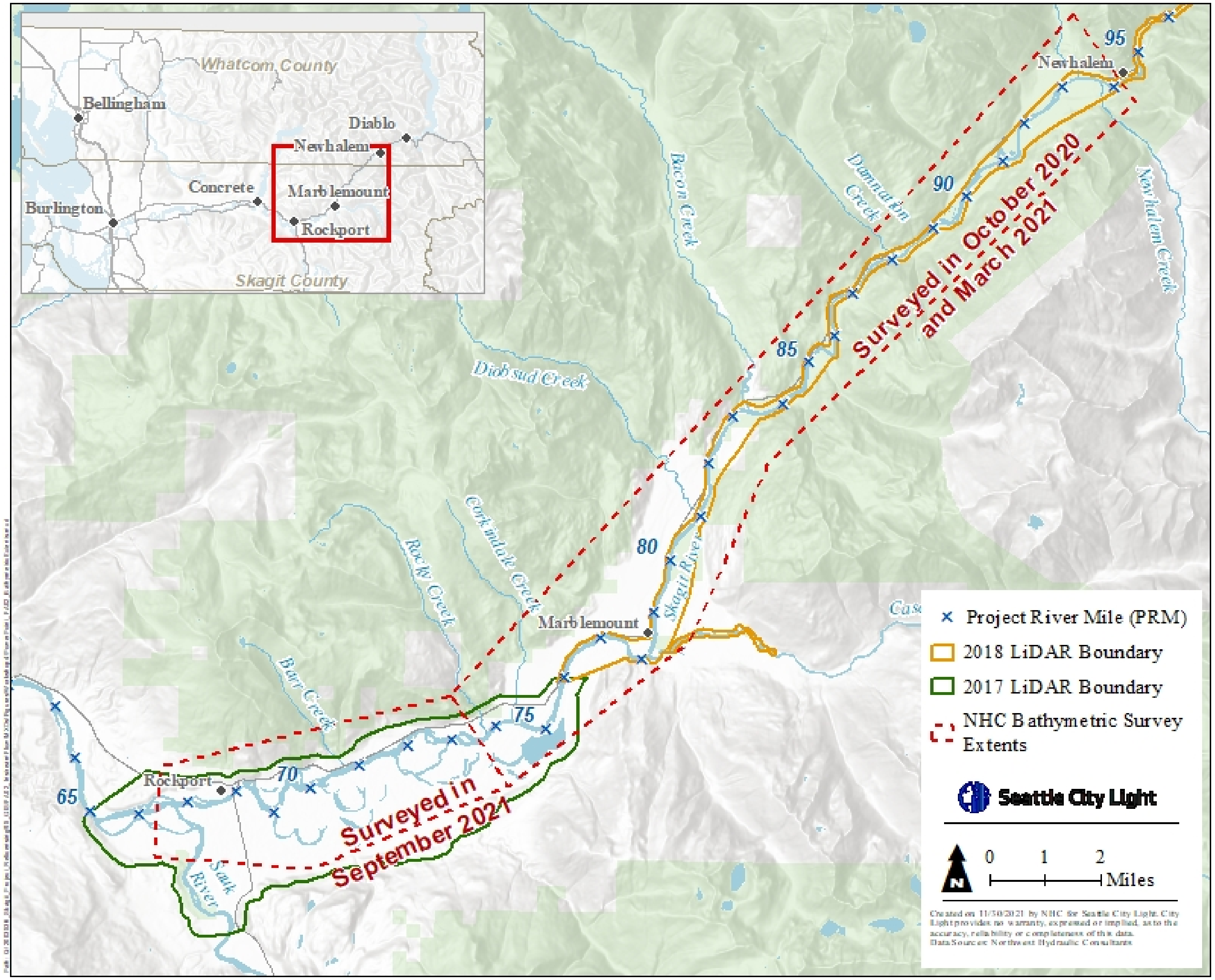
TERRAIN – BATHYMETRY VOIDS

- Depth
- Rapids
- Overhanging vegetation
- Bottom reflectivity



Example Void

TERRAIN - OVERVIEW



NHC TERRAIN – VOID INFILLING

- Filled voids except:
  - < 1,000 ft^2
  - Dangerous rapids
  - Inaccessible due to trees/vegetation
- Otherwise use Quantum Spatial's interpolated surface

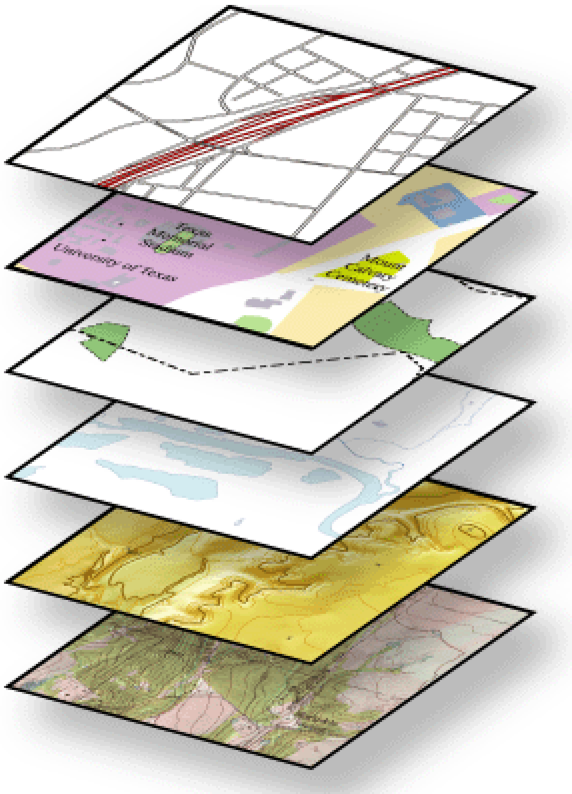
TERRAIN – VOID FILLING

River Segment	Void Area within Main Channel (acres)	Void Area not Selected (<1000) in mainstem	Area of Voids Selected for Survey (acres)	Area Surveyed (acres)	% selected area surveyed
Powerhouse to Newhalem Creek	5.1	N/A	N/A	N/A	N/A
Newhalem Creek to Shovel Spur	12.8	2.3	10.5	7.0	66%
Shovel Spur	5.7	N/A	N/A	N/A	N/A
Shovel Spur to PRM 73.4	33.1	4.3	28.7	27.4	96%
PRM 73.4 to Sauk River confluence	38.2	5.0	33.2	31.4	94%
Total	94.8	11.6	72.4	67.1	

Voids < 1,000 sf in close proximity to voids selected for survey were also surveyed where possible

FINAL TERRAIN

- Mosaic of data sources:



Bathymetric Void Infilling Survey

Barnaby Reach Survey

2017/2018 Quantum Spatial Interpolated Voids

*2016 Quantum Spatial Standard LiDAR used to fill in occasional floodplain margin

TERRAIN SENSITIVITY

- Agenda item from Workshop 3:
  - "For unsurveyed voids, can we quantify the impact of the interpolation?"

1. Total Main Channel Interpolated Area = 29 Acres = 3.0% of Main Channel
   - 25% of interpolated area is Shovel Spur and upstream of Newhalem Creek
   - 2.25% of main channel excluding SS and U/S Newhalem Creek
2. Statistical Analysis
   - Compare survey to interpolation in surveyed voids

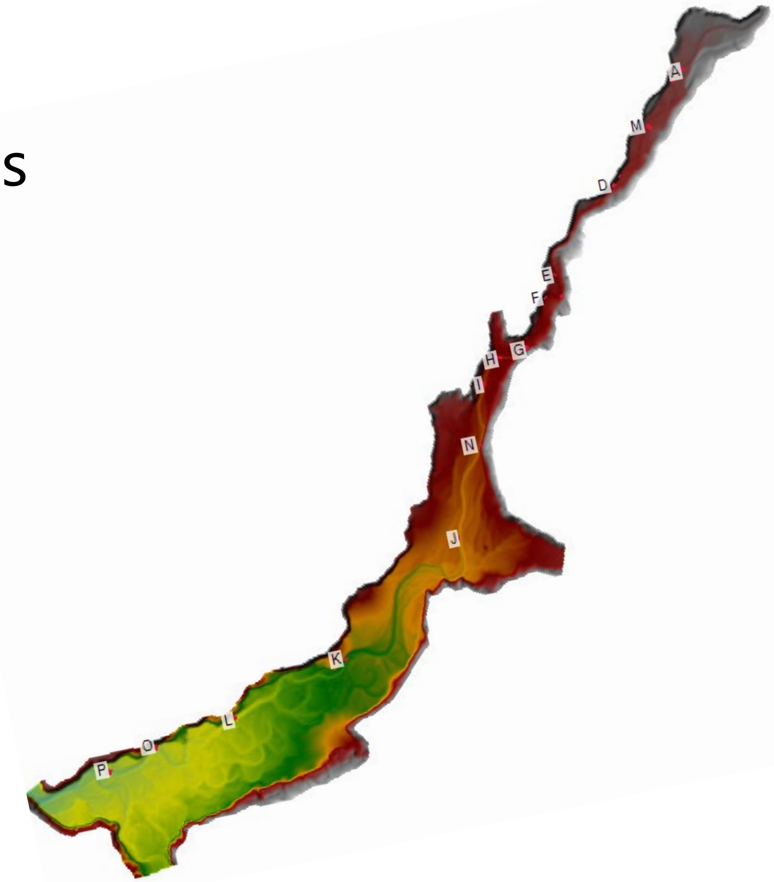
Seattle City Light

DISCUSSION

HYDRAULIC MODEL GEOMETRY

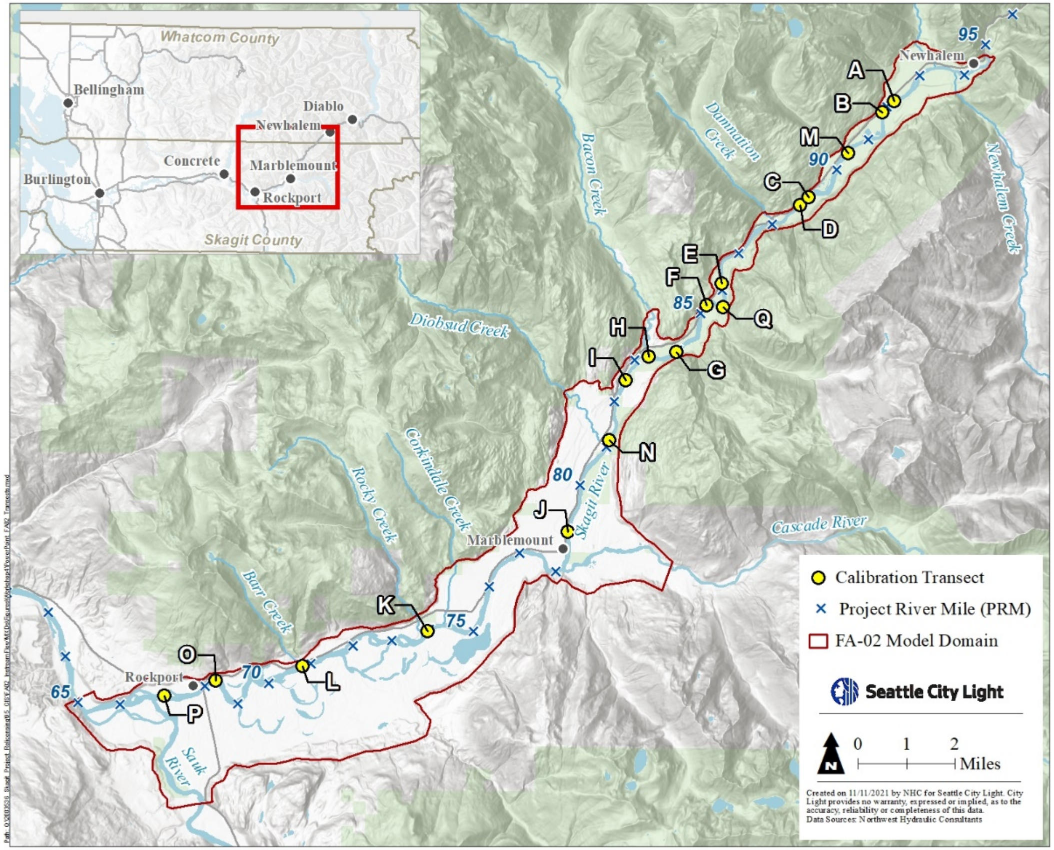
OVERVIEW

- Model Mesh
- Model Hydraulic Roughness
- Structures
- Questions and Discussion



MODEL EXTENT

- HEC-RAS 2D solves for hydraulic properties at the cell level

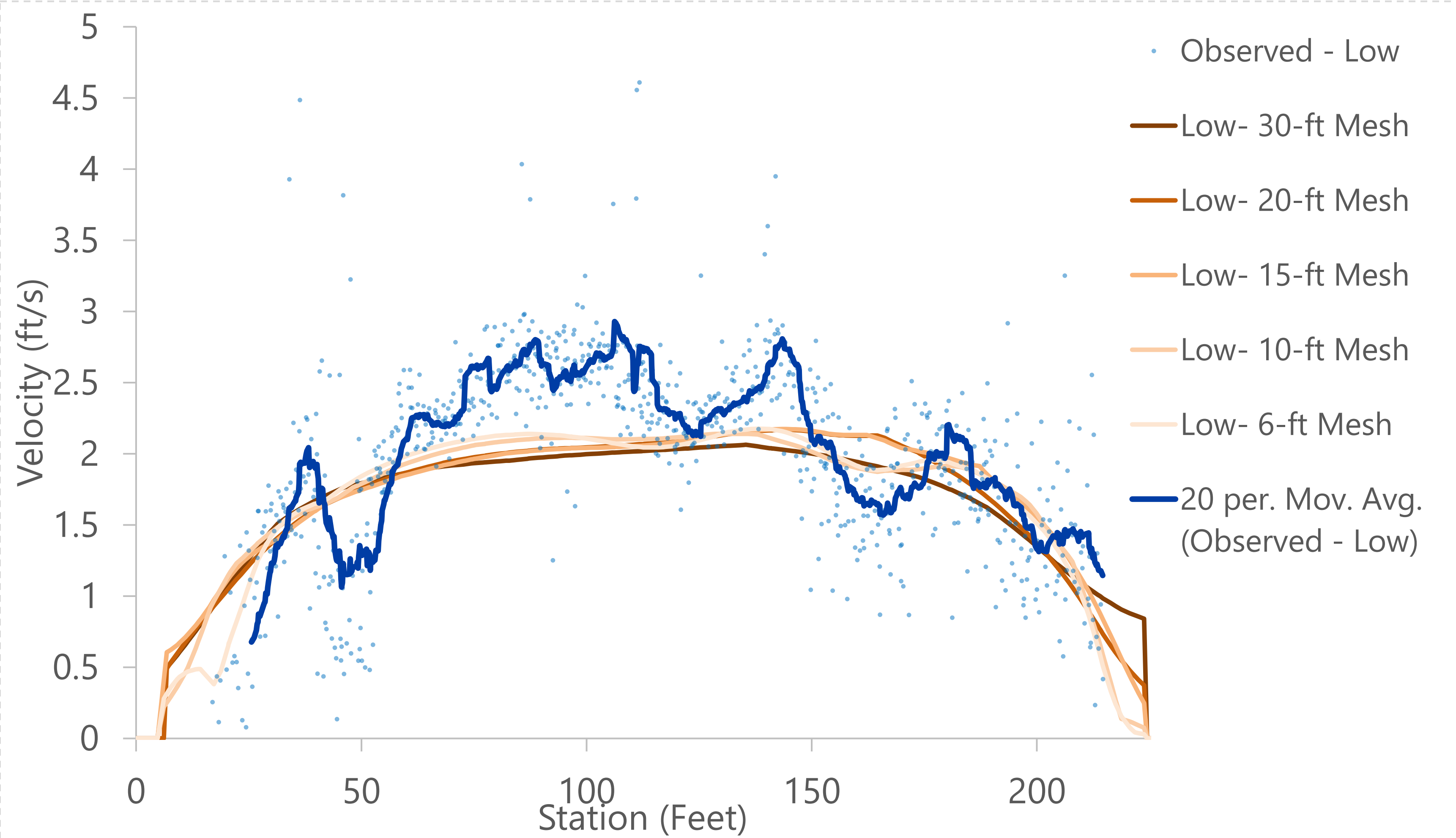


~29 River Miles

WORKSHOP 3 CELL SIZE SENSITIVITY SUMMARY

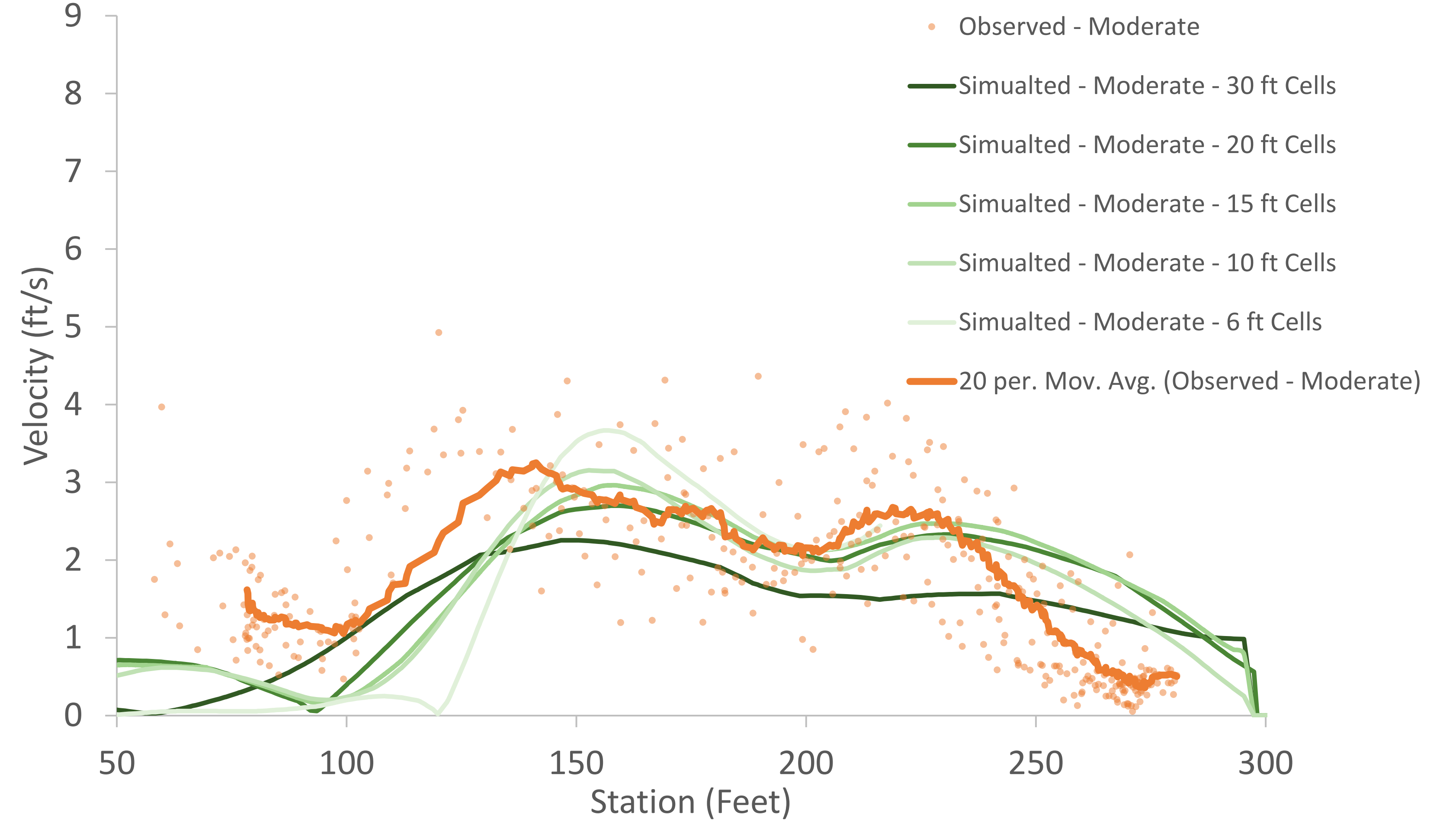
- Smaller cells tend to simulate higher high velocities and lower low velocities
- Cell size can alter the location and magnitude velocities
- Velocity is not sensitive to cell size where velocity changes gradually
- Sensitivity to cell size varies with velocity magnitude

TRANSECT E



Velocity (ft/s)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Station (Feet)
Observed - Low
Low- 30-ft Mesh
Low- 20-ft Mesh
Low- 15-ft Mesh
Low- 10-ft Mesh
Low- 6-ft Mesh
20 per. Mov. Avg. (Observed - Low)

TRANSECT Q



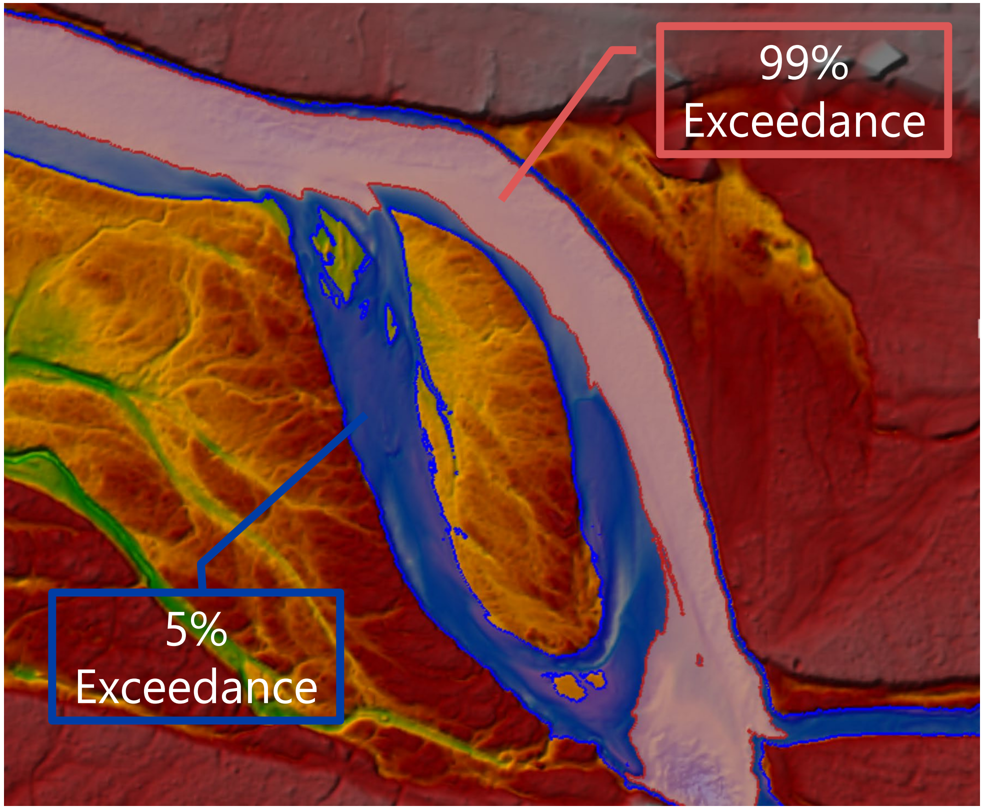
Velocity (ft/s)
9
8
7
6
5
4
3
2
1
0
50
100
150
200
250
300
Station (Feet)
Observed - Moderate
Simualted - Moderate - 30 ft Cells
Simualted - Moderate - 20 ft Cells
Simualted - Moderate - 15 ft Cells
Simualted - Moderate - 10 ft Cells
Simualted - Moderate - 6 ft Cells
20 per. Mov. Avg. (Observed - Moderate)

CONCLUSIONS

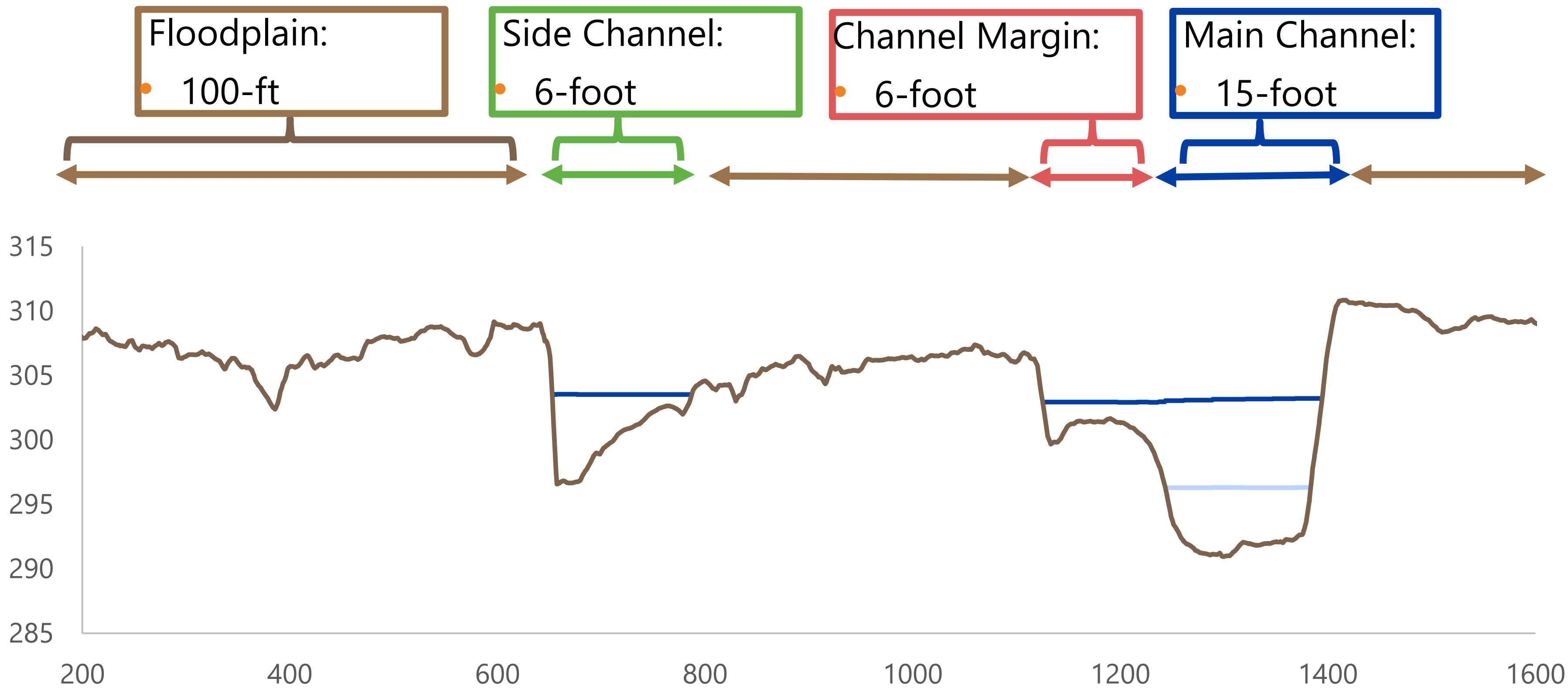
- Run time increases with cell count
  - Implications for this study and future use
- Context and location of resolution is important
  - Greatest variation occurs at peak velocities and along channel margins

CHANNEL MARGIN DEFINITION

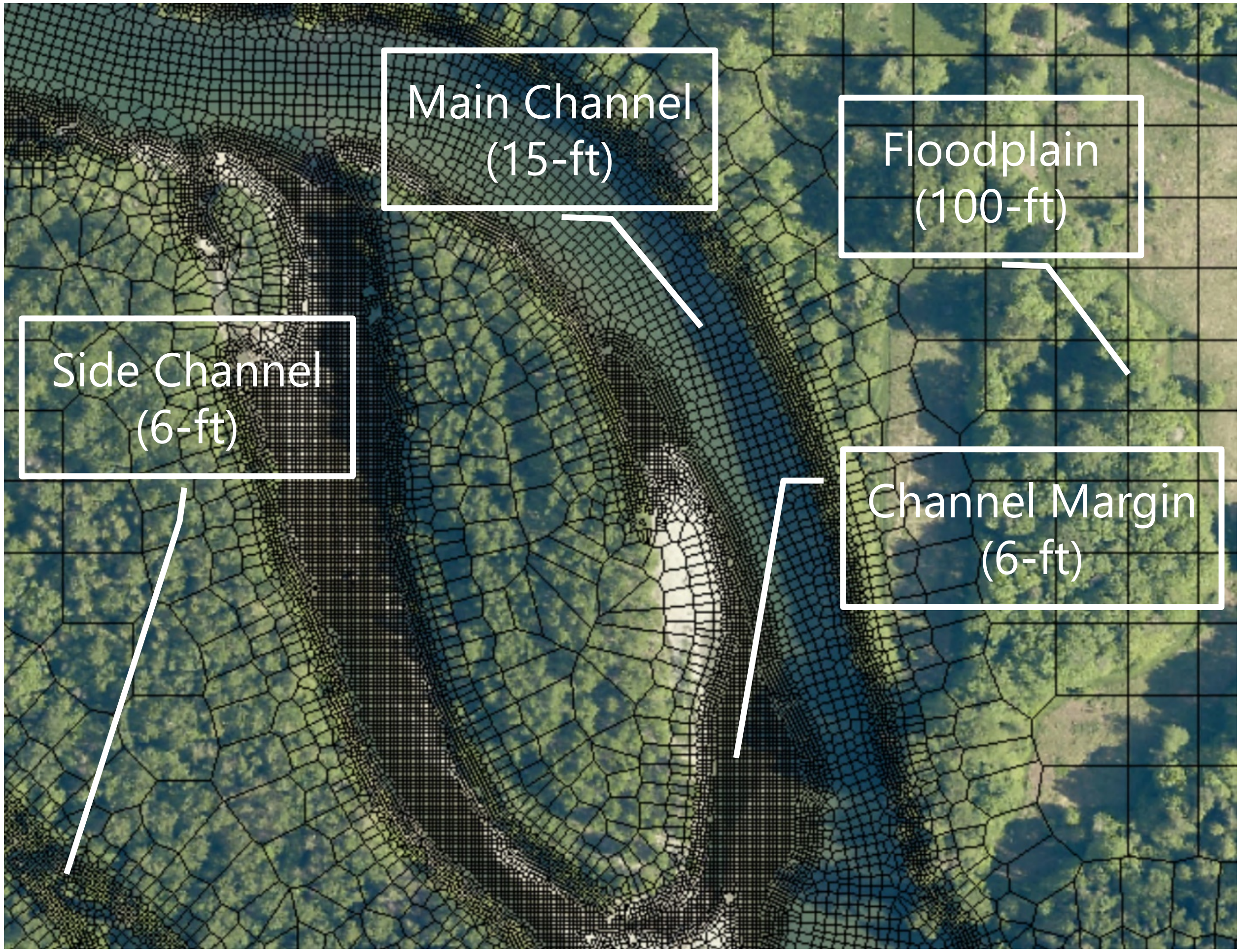
- Difference between area inundated by 5% and 99% exceedance interval average daily flows



INSTREAM FLOW MODEL SCOPE



MODEL MESH


Main Channel
(15-ft)
Floodplain
(100-ft)
Side Channel
(6-ft)
Channel Margin
(6-ft)

MODEL RUN TIMES

- Model Run time = ~27 hours
  - 2-second time step
- Time Step depends on cell size and meeting Courant conditions
  - HEC-RAS Courant requirement < 3.0

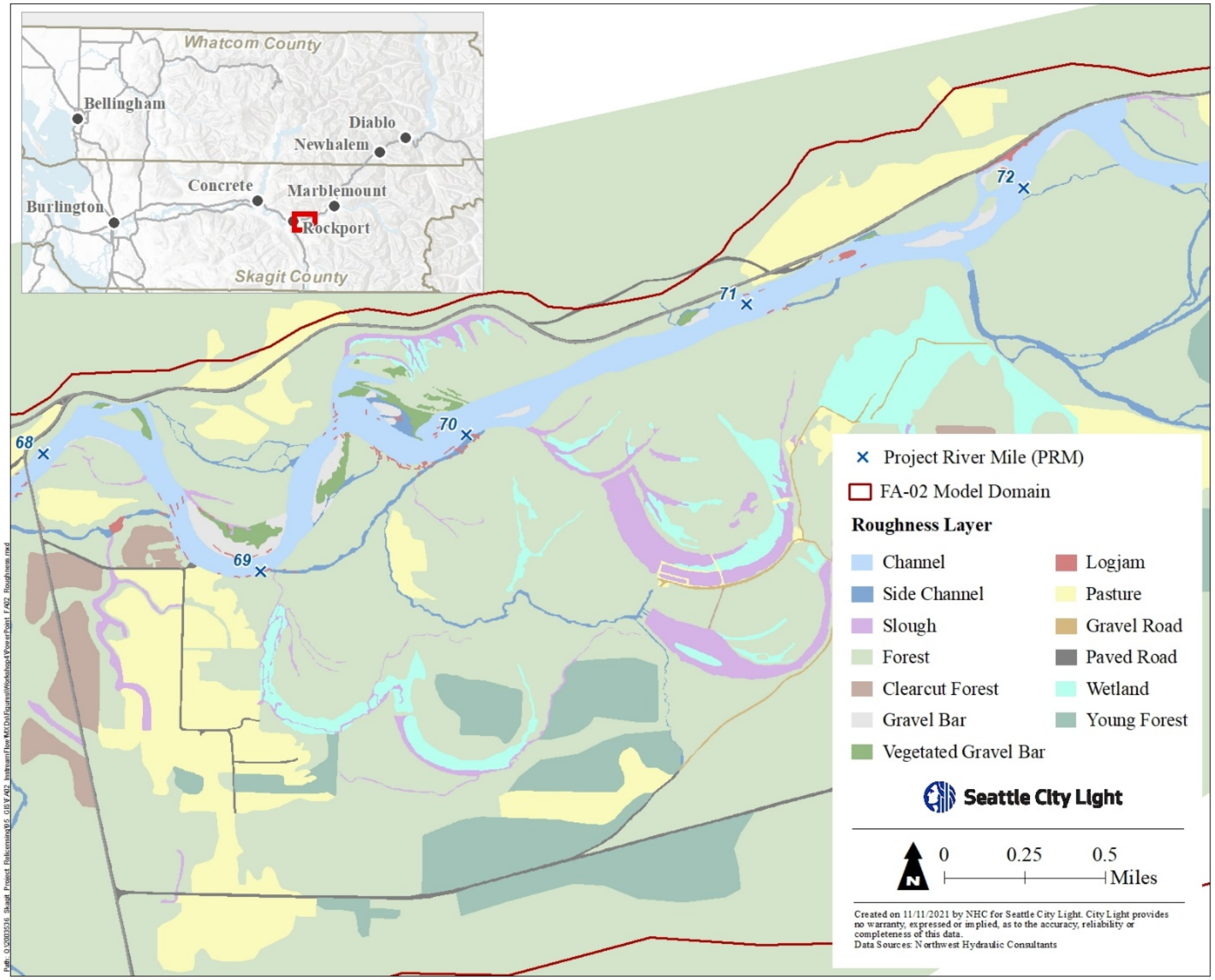
ROUGHNESS OVERVIEW

- Hydraulic roughness delineation
  - Land Cover
  - Active Channel Zones
    - Reach-varied
    - Depth-varied
    - Flow-varied
- Substrate mapping only recently available, not yet incorporated

ROUGHNESS AREA DELINEATION

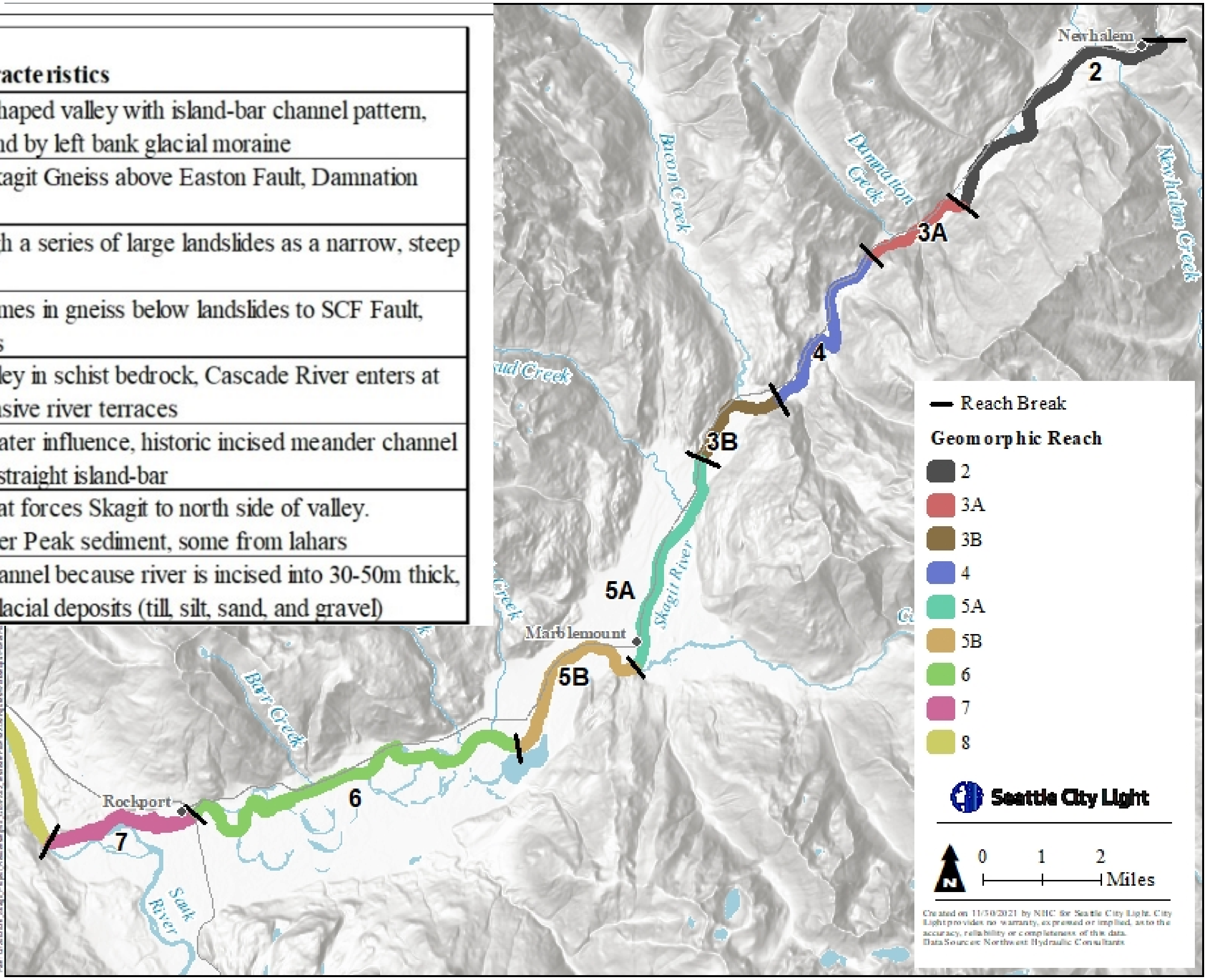
- LiDAR-based edge of water used to delineate wetted channel area
  - 2018 collected @ 5,000 cfs
  - 2017 collected @ 8,000 cfs
- Bars and Floodplain – manual delineation from 2018 aerial imagery (1:2000 scale)
- Large Wood delineation from GE-04 Study

ROUGHNESS CATEGORIES

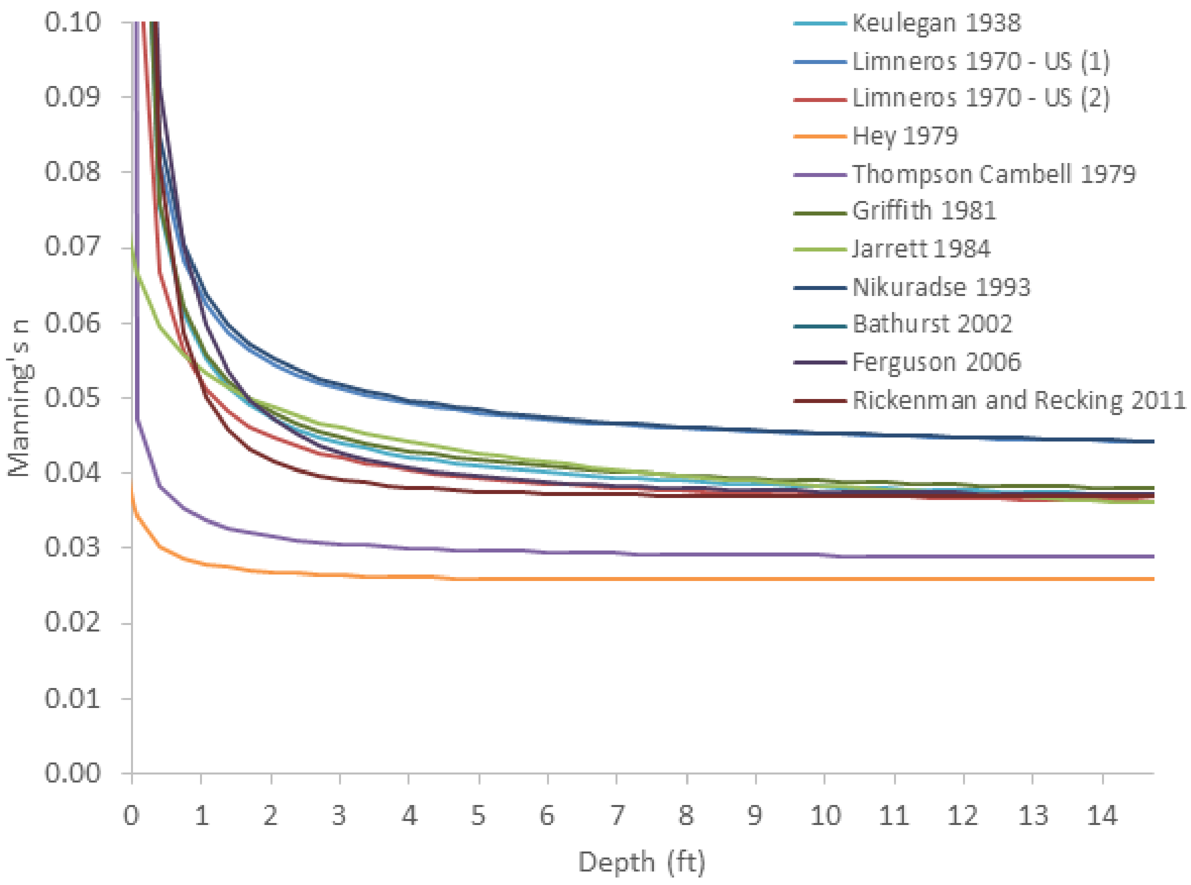


REACH DELINEATION

Approximate Reach Boundaries	River Mile	Geomorphic Characteristics
2 - SG to alpine valley glacier limit	94.1-89	Wide glaciated U-shaped valley with island-bar channel pattern, confined in upper end by left bank glacial moraine
3A - End of AVG to R3	89 - 87	Narrow valley in Skagit Gneiss above Easton Fault, Damnation Creek enters
4 - Landslide Zone	87 - 83.5	River passes through a series of large landslides as a narrow, steep single channel
3B - R4 to Straight Cr Fault	83.5 - 81.6	Narrow valley resumes in gneiss below landslides to SCF Fault, Bacon Creek enters
5 - SCF to Rocky Creek	81.6 - 74	Extremely wide valley in schist bedrock, Cascade River enters at Marblemount, extensive river terraces
6 - Barnaby Reach	74 - 68	Strong Sauk backwater influence, historic incised meander channel pattern changed to straight island-bar
7 - Sauk River Alluvial Fan	68 - 65	Wide alluvial fan that forces Skagit to north side of valley. Influenced by Glacier Peak sediment, some from lahars
8 - Sauk Alluvial fan to Baker Mouth	65 - 56.5	Steep, narrowed channel because river is incised into 30-50m thick, over-consolidated glacial deposits (till, silt, sand, and gravel)

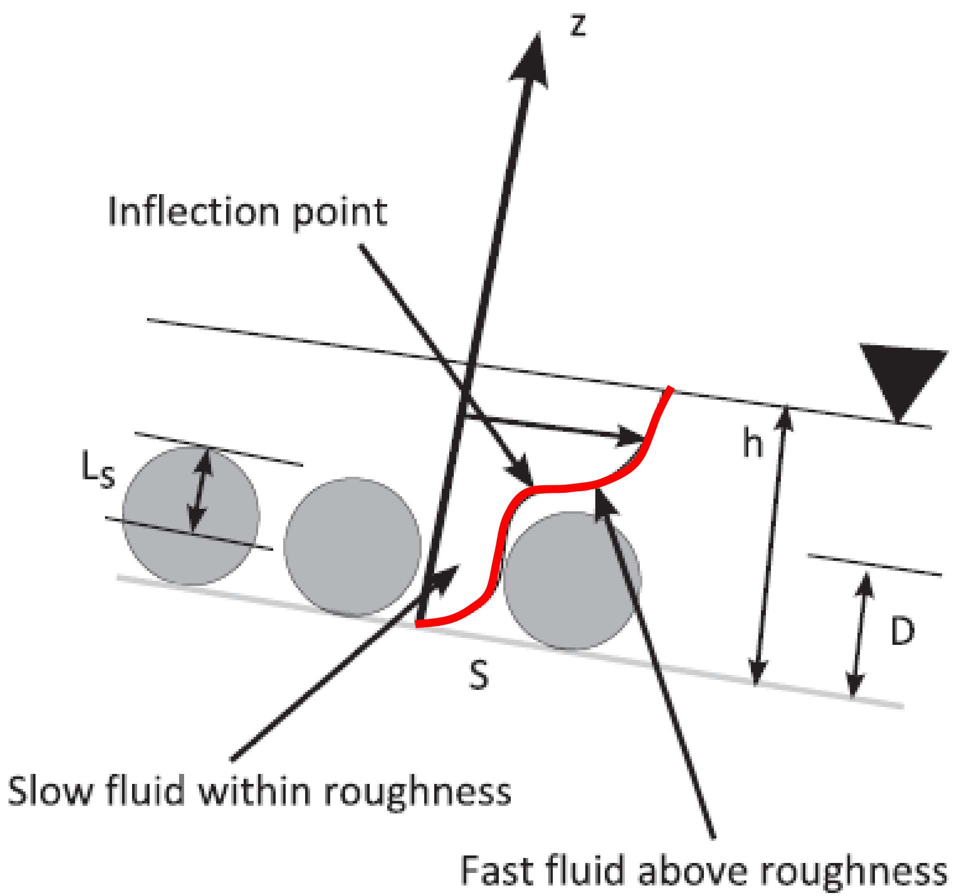


DEPTH-VARIED ROUGHNESS

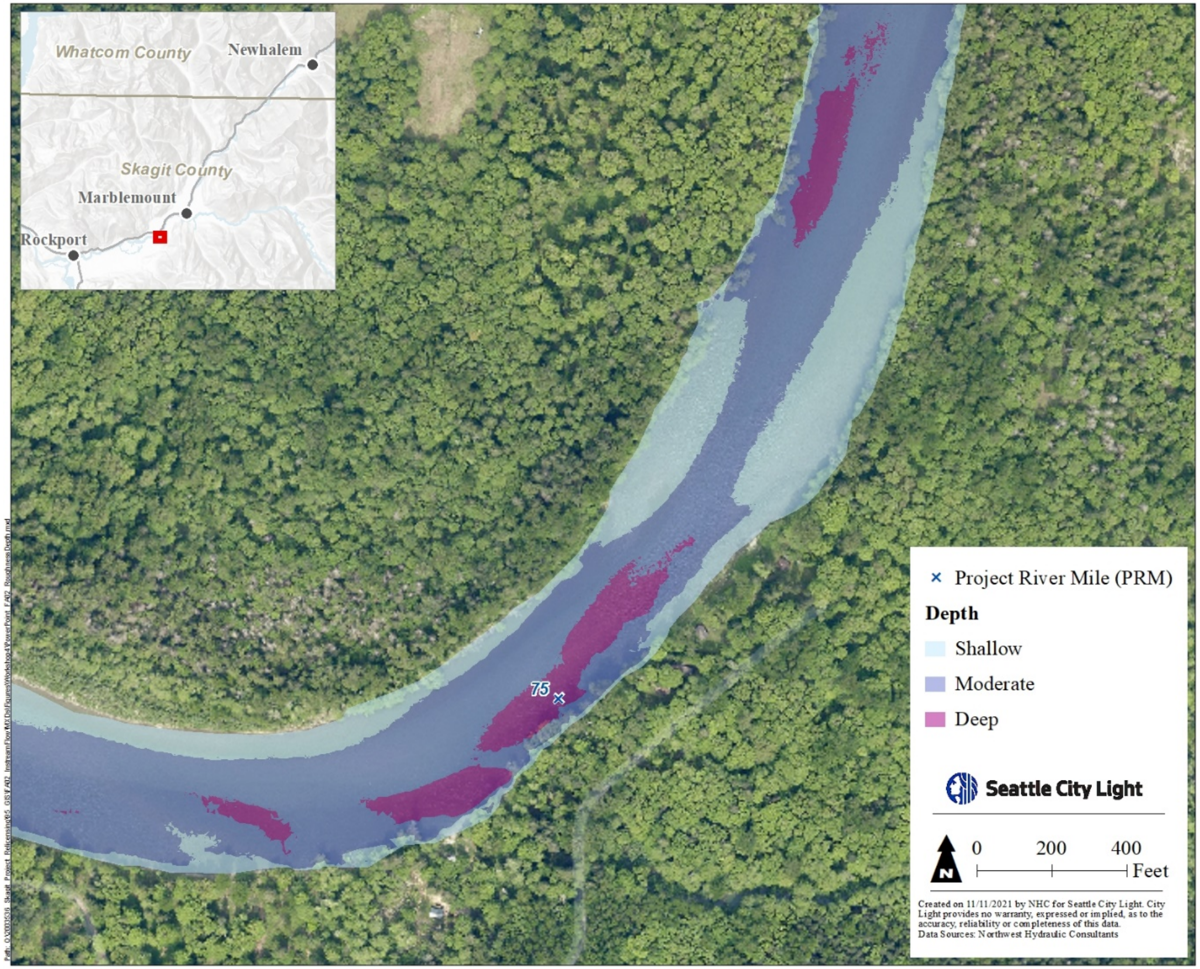


- Many studies have developed approaches for quantifying depth-varied roughness
  - Most rely on relative submergence (depth/D_{84})

DEPTH-VARIED ROUGHNESS



DEPTH-VARIED ROUGHNESS



STRUCTURES

SR 530 (Rockport, WA)

Cascade River Rd (Marblemount, WA)

Seattle City Light

DISCUSSION

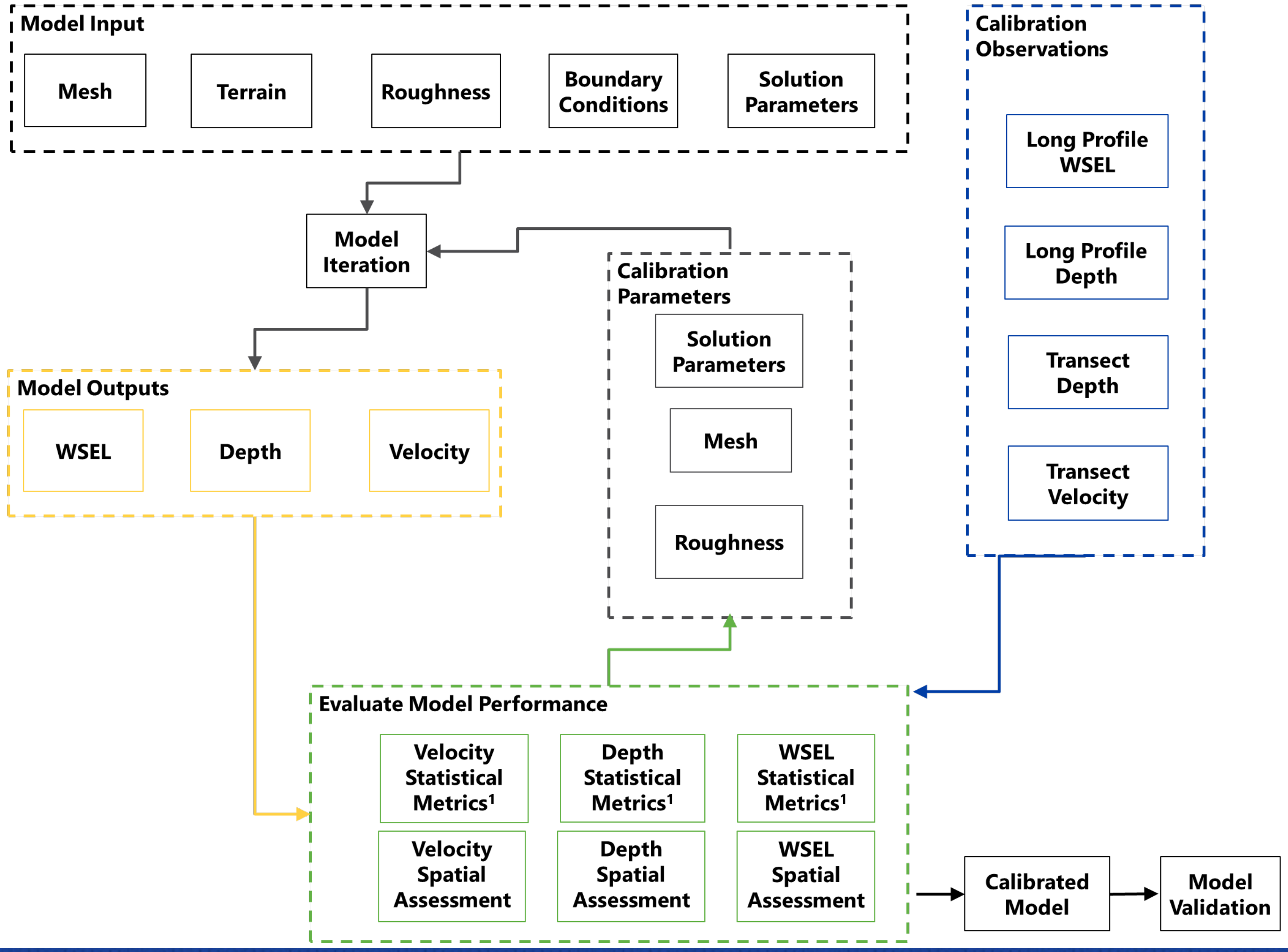
Seattle City Light

HYDRAULIC MODEL CALIBRATION

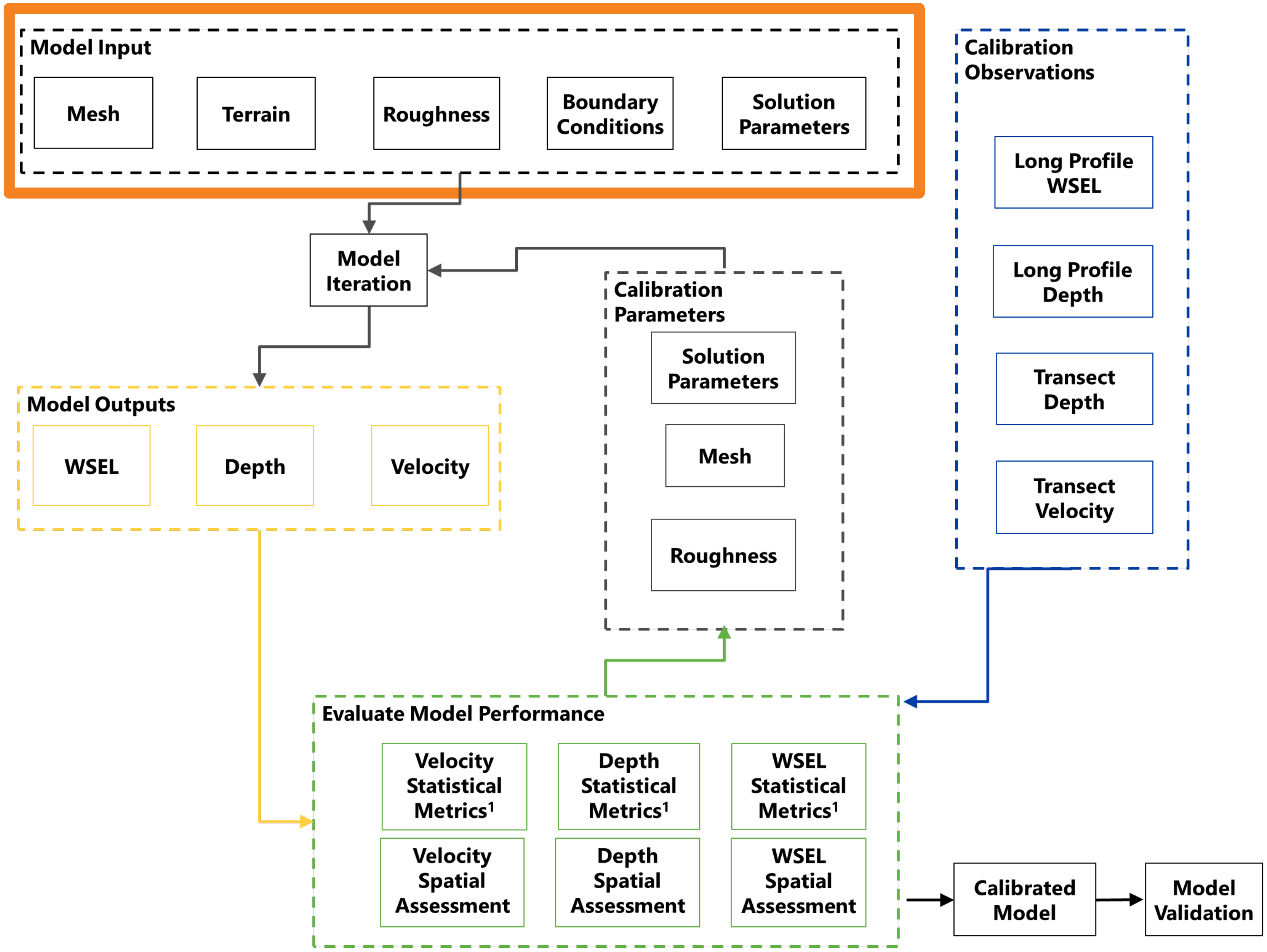
AGENDA

- Calibration Methodology
- Performance Metrics
- Model Performance
- Questions and Discussion

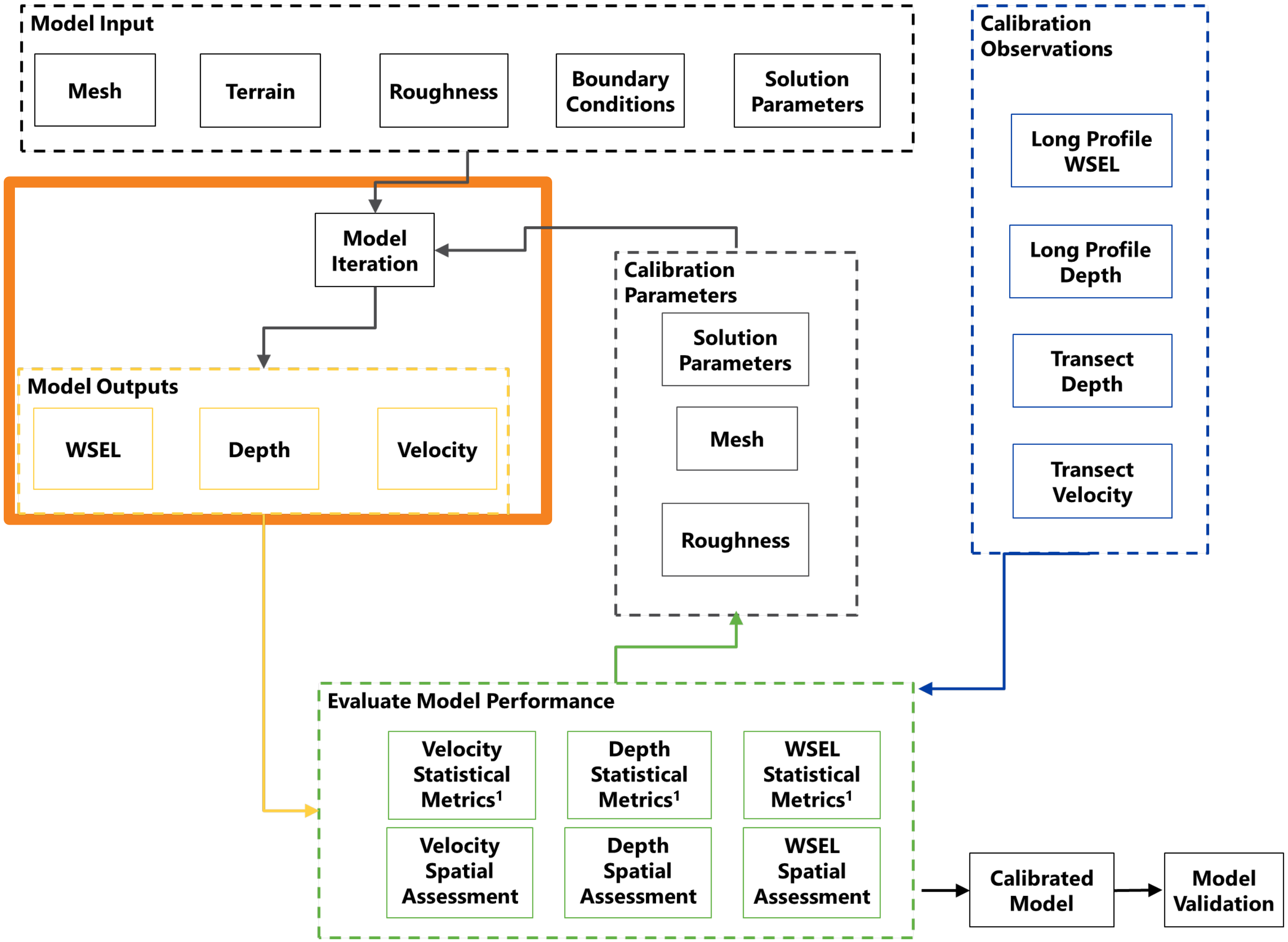
CALIBRATION METHODOLOGY



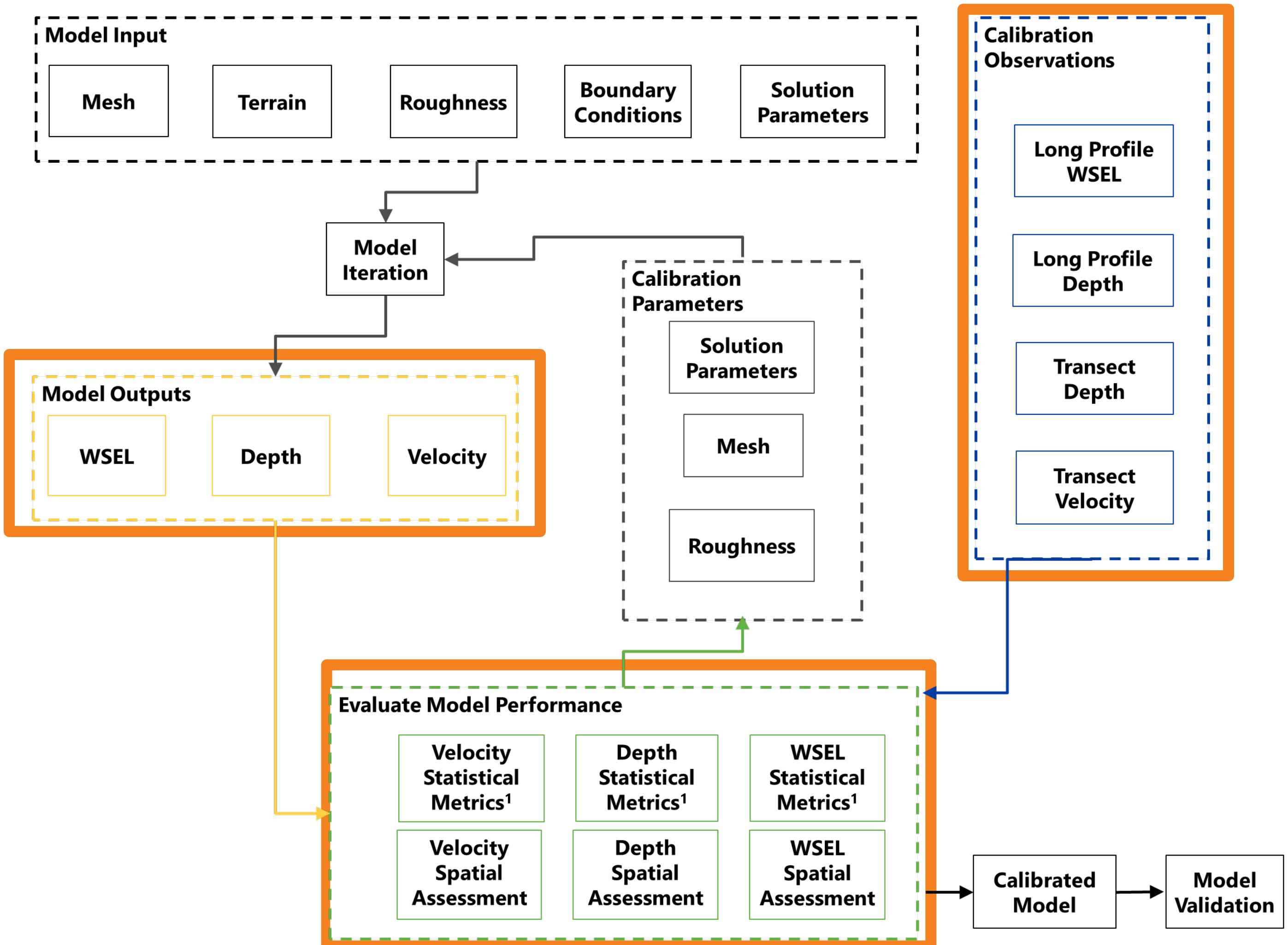
CALIBRATION METHODOLOGY



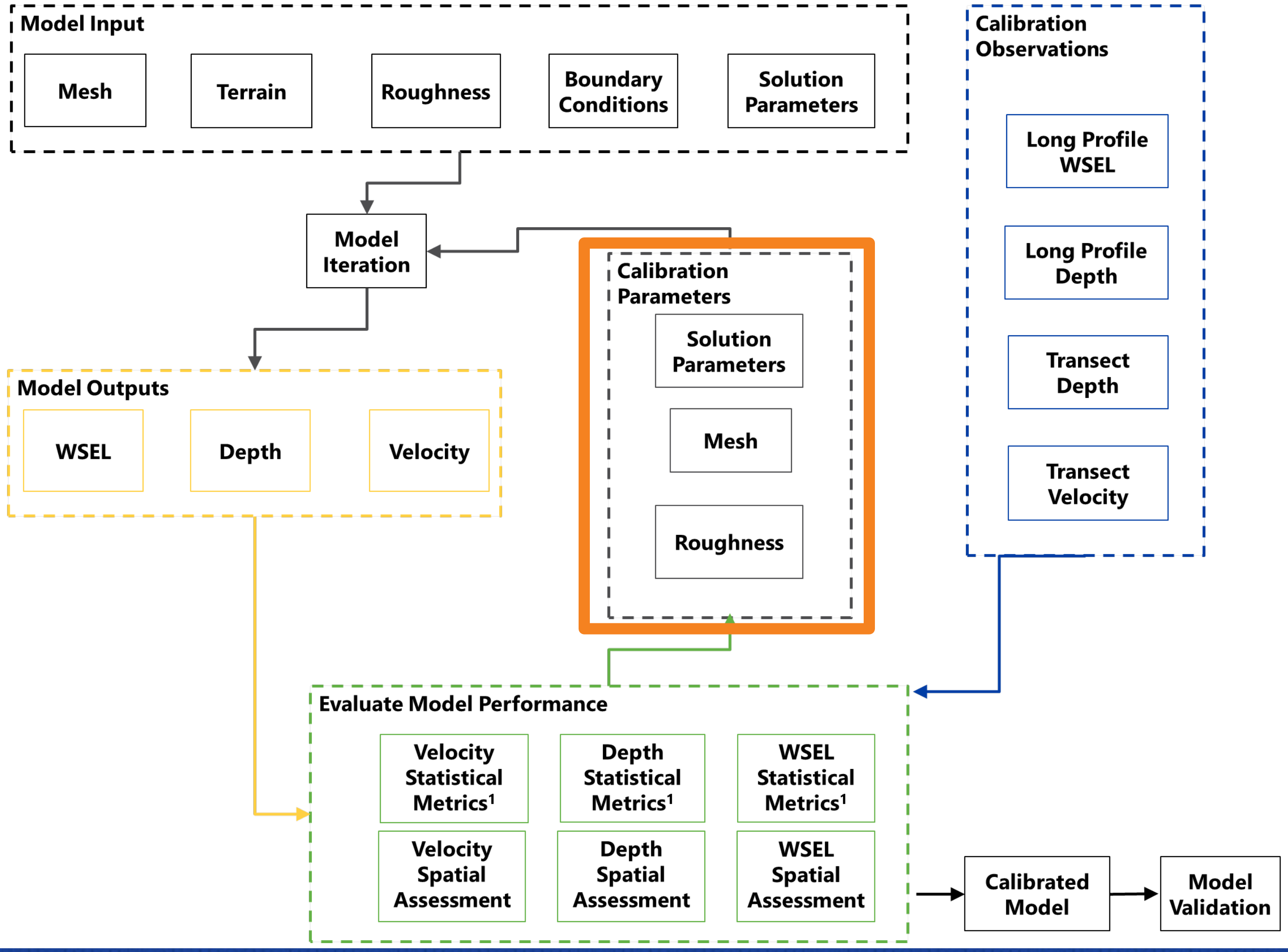
CALIBRATION METHODOLOGY



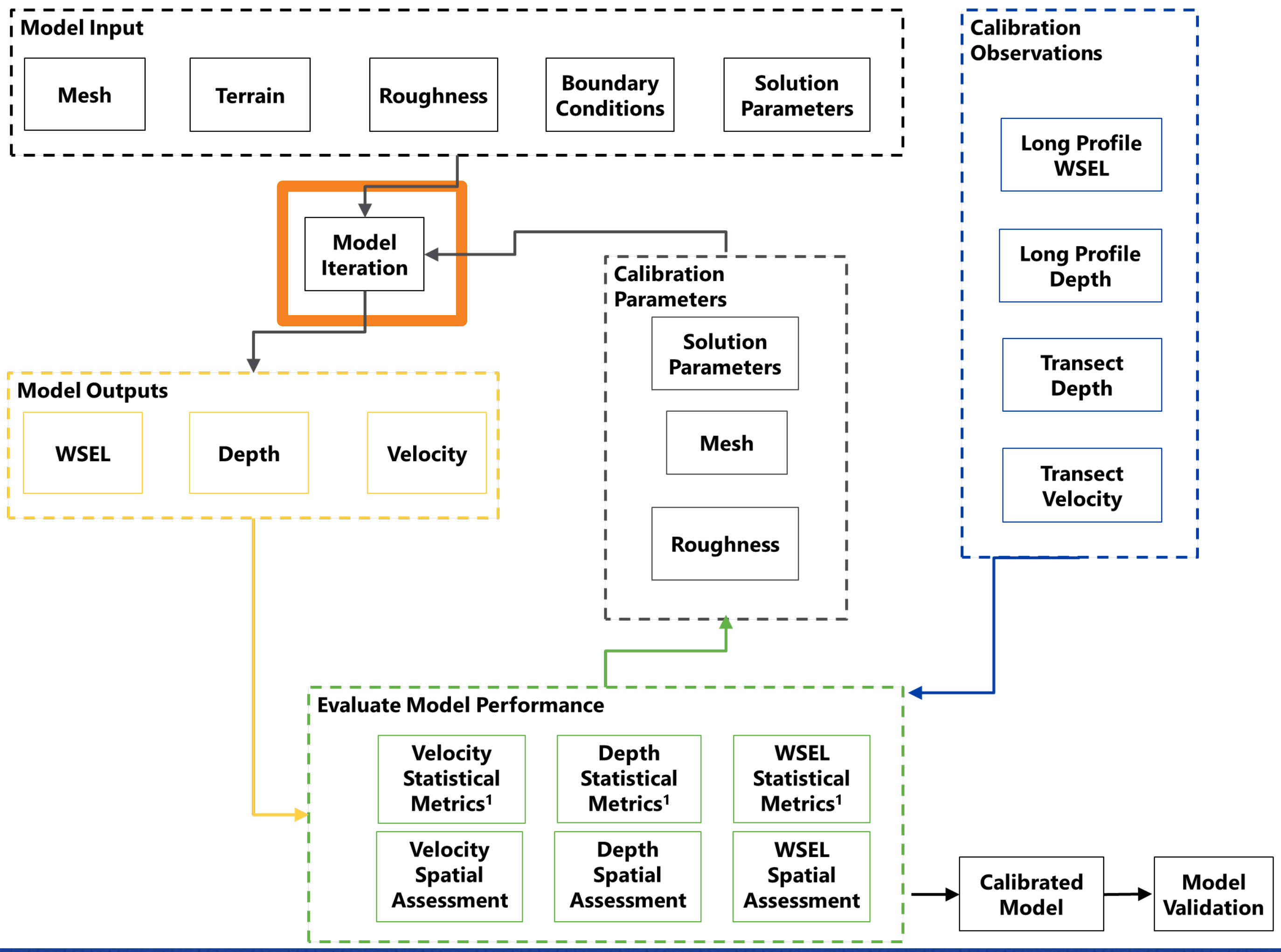
CALIBRATION METHODOLOGY



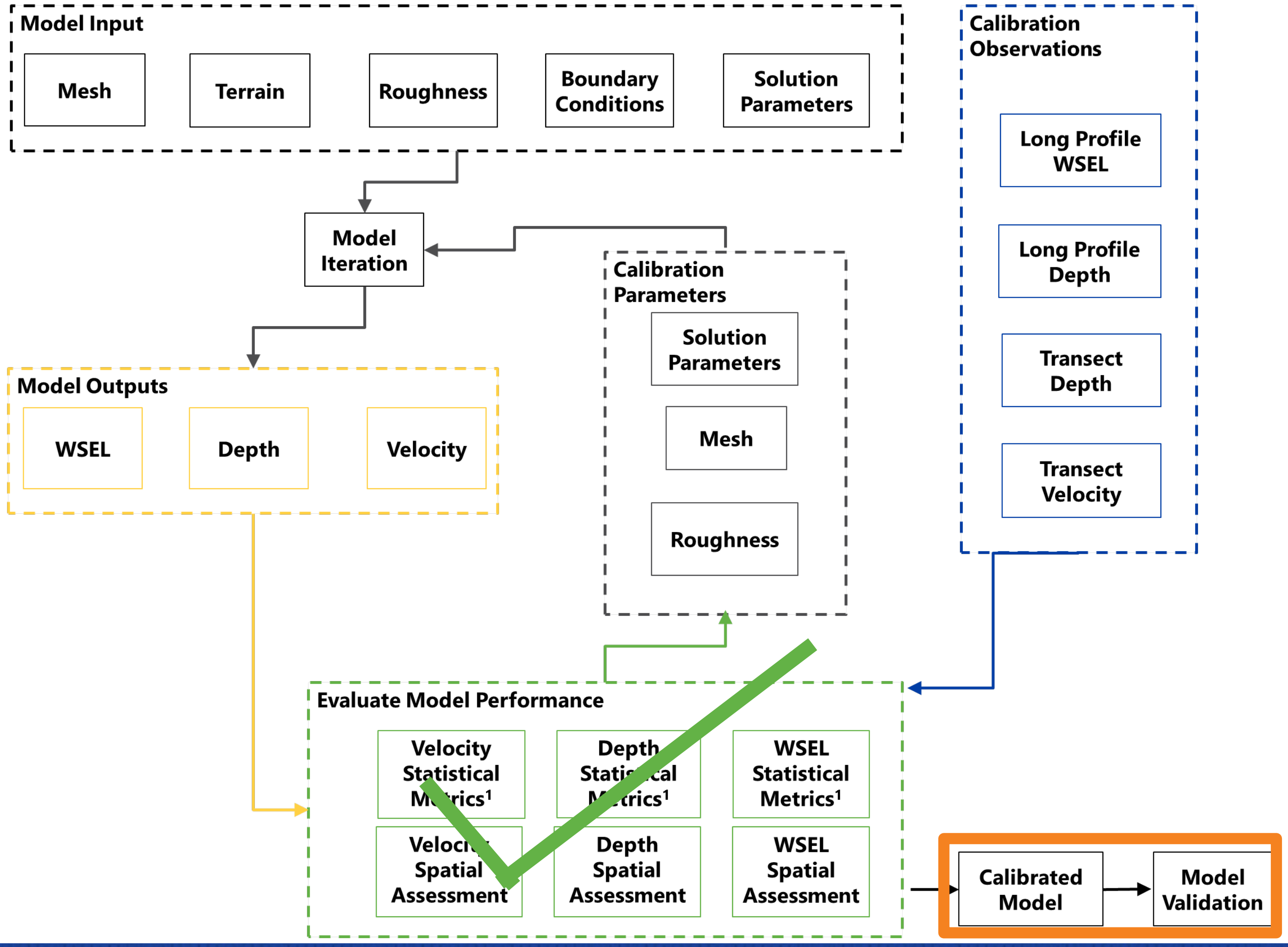
CALIBRATION METHODOLOGY



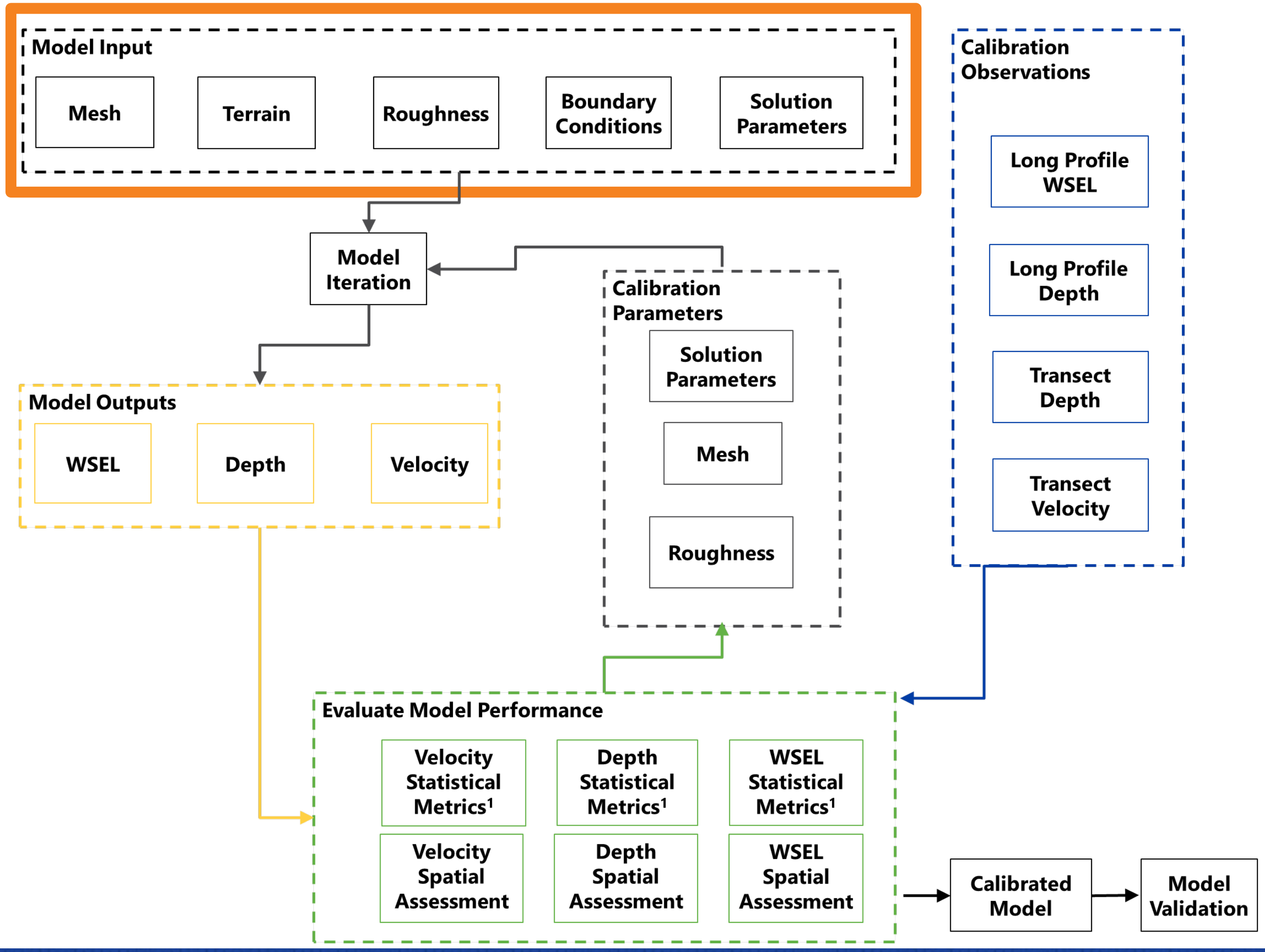
CALIBRATION METHODOLOGY



CALIBRATION METHODOLOGY



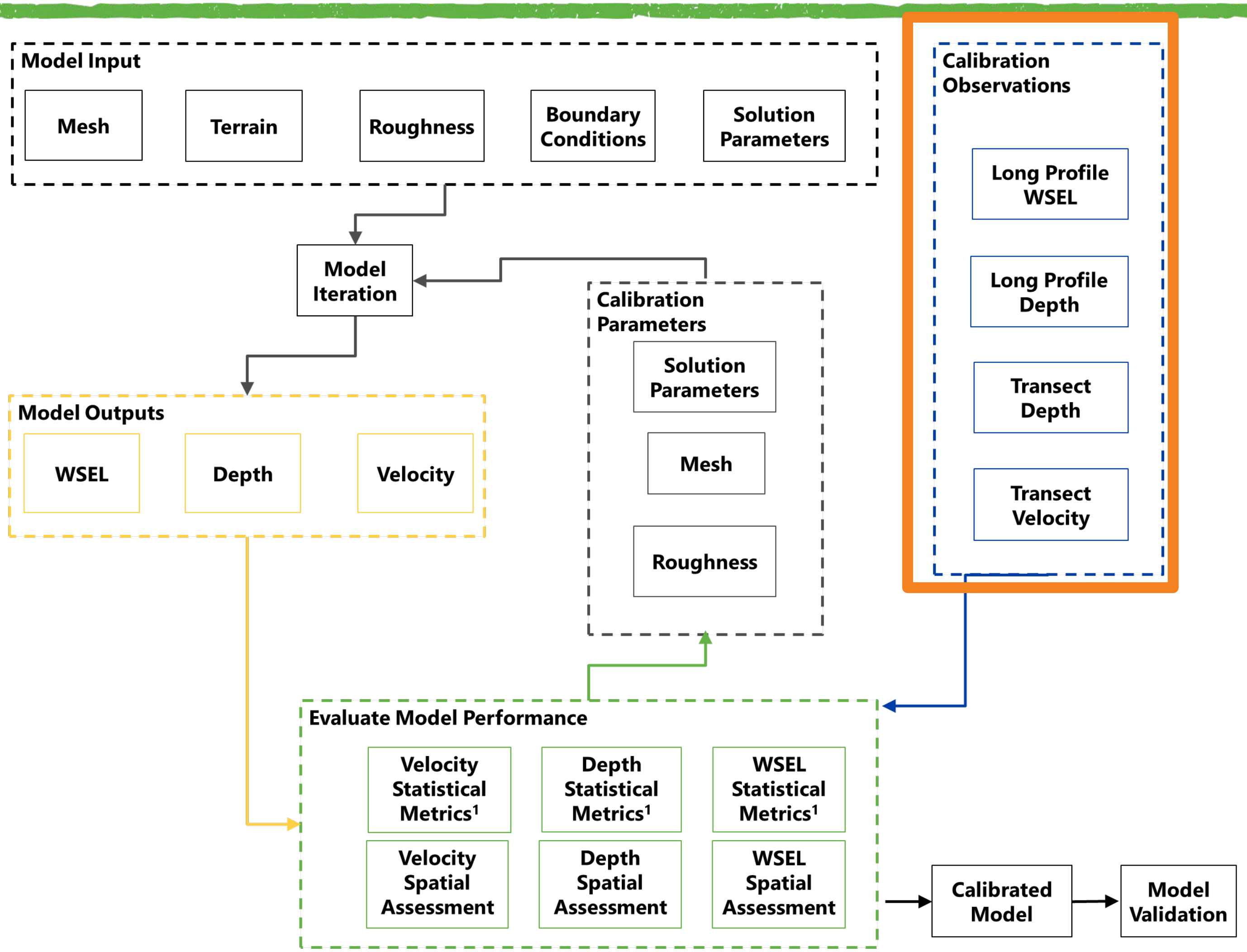
MODEL INPUT


Model Input
Mesh
Terrain
Roughness
Boundary Conditions
Solution Parameters
Calibration Observations
Long Profile WSEL
Long Profile Depth
Transect Depth
Transect Velocity
Model Iteration
Calibration Parameters
Solution Parameters
Mesh
Roughness
Model Outputs
WSEL
Depth
Velocity
Evaluate Model Performance
Velocity Statistical Metrics[1]
Depth Statistical Metrics[1]
WSEL Statistical Metrics[1]
Velocity Spatial Assessment
Depth Spatial Assessment
WSEL Spatial Assessment
Calibrated Model
Model Validation

MODEL INPUT DATA

Inflows	Steady State - Match Observed at Transects
Terrain	Final Void Filled Terrain
Roughness	Channel Roughness varied by reach, flow, and depth
Cell Size	Variable cell size based on location (6- to 100-feet)
Number Cells	1.5 Million
Solution Equation	Shallow Water Equation (SWE-ELM)
Time Step	2 seconds
Turbulence	None
Run Time	27 hours to reach steady state

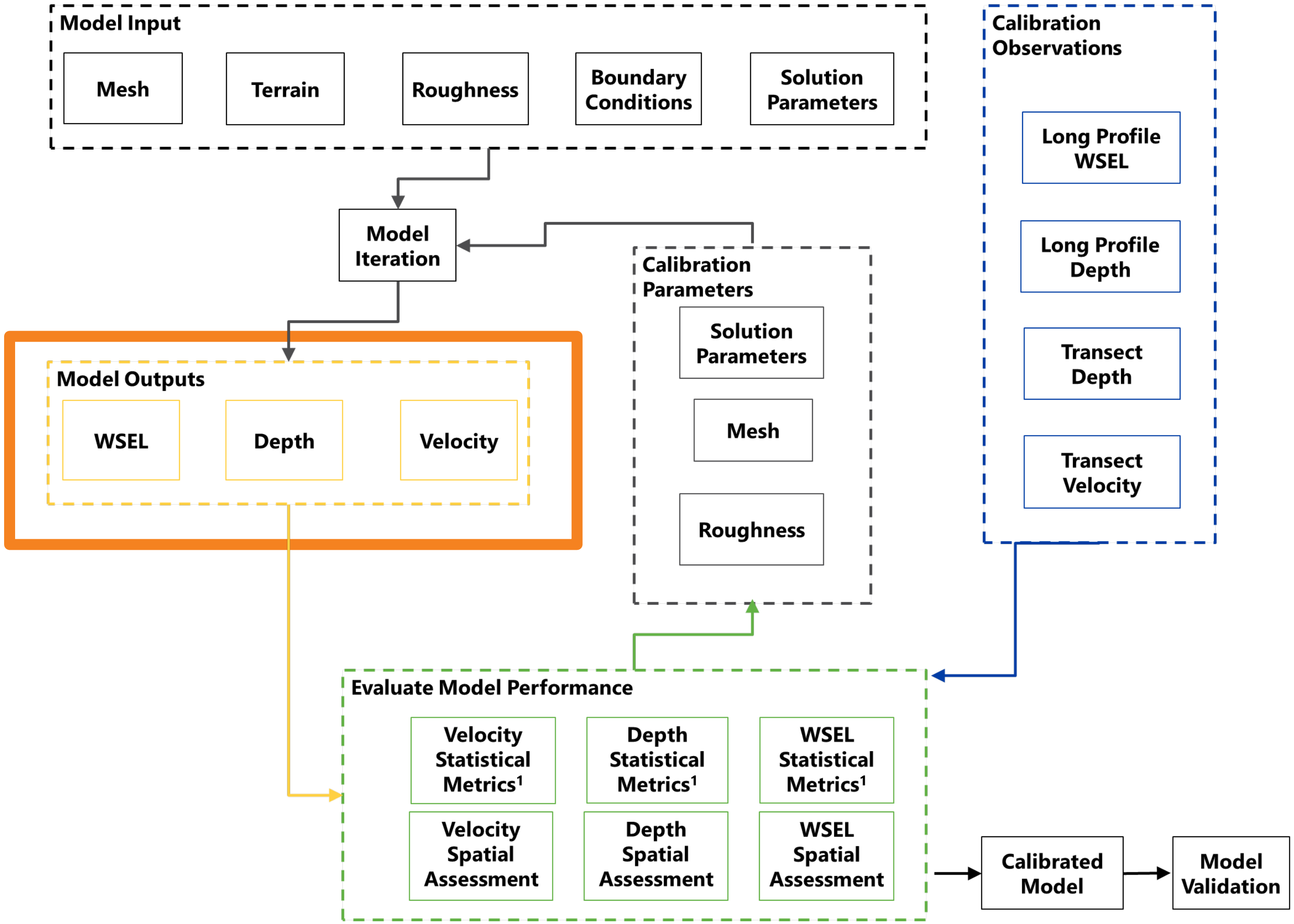
CALIBRATION OBSERVATIONS



MODEL CALIBRATION DATA

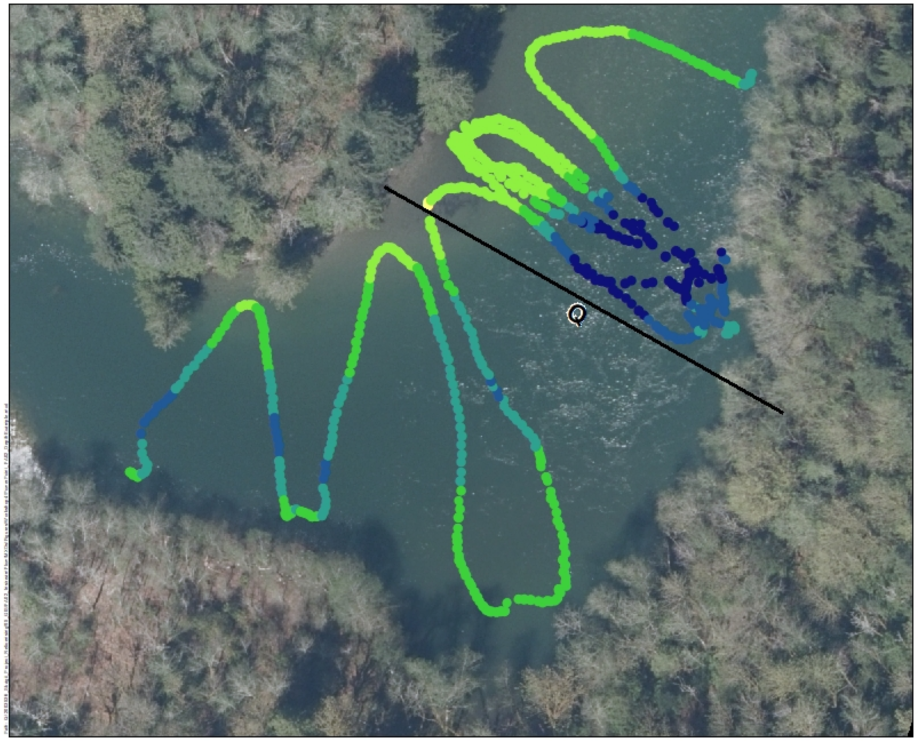
- Data collected over 29-mile study reach
  - Low (2,400 cfs)
  - Moderate (4,200 cfs)
  - High discharges (6,700 cfs)
    - Depth/Velocity/Discharge at 17 Transects
    - Water Surface Profile
- High Water Marks @ 11-5-2020 flow event

MODEL OUTPUT DATA

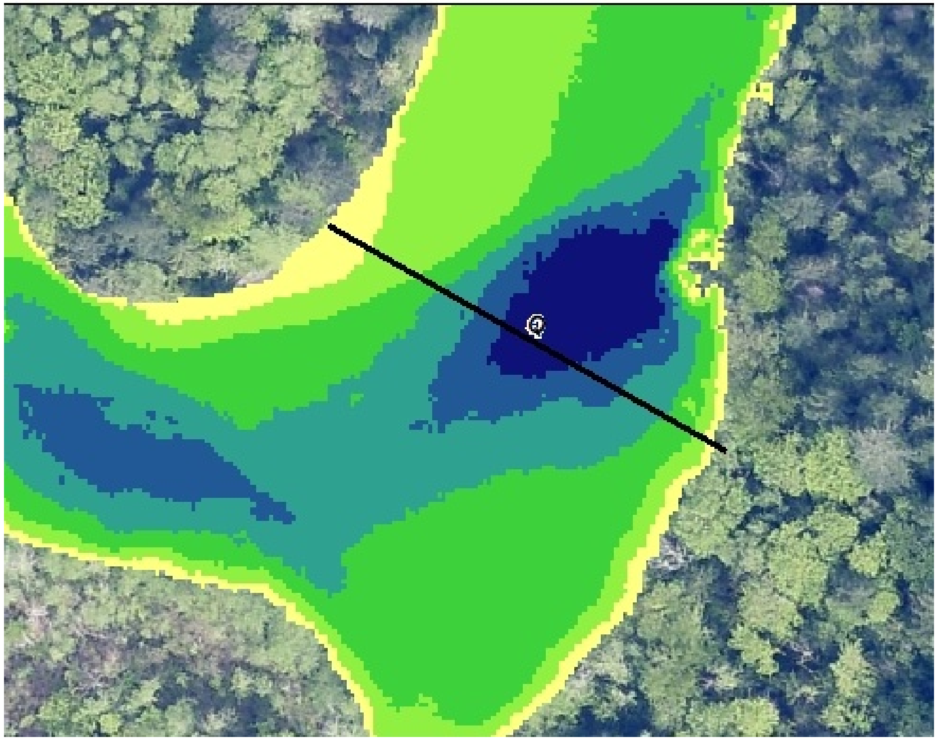


DATA COMPARISON - DEPTH

- Observed Data

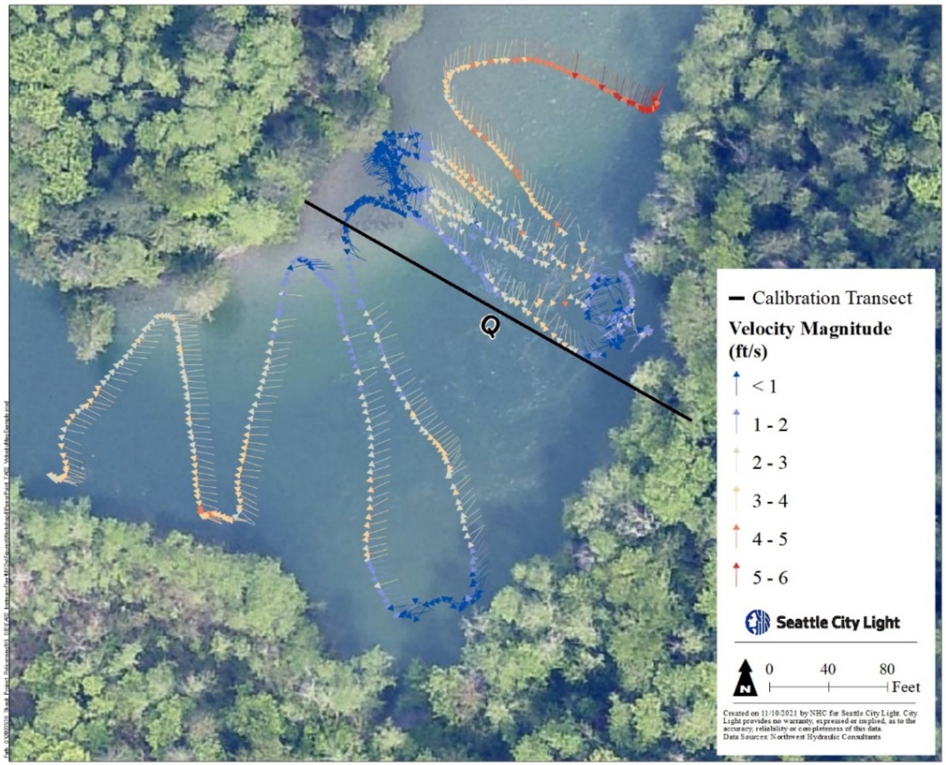


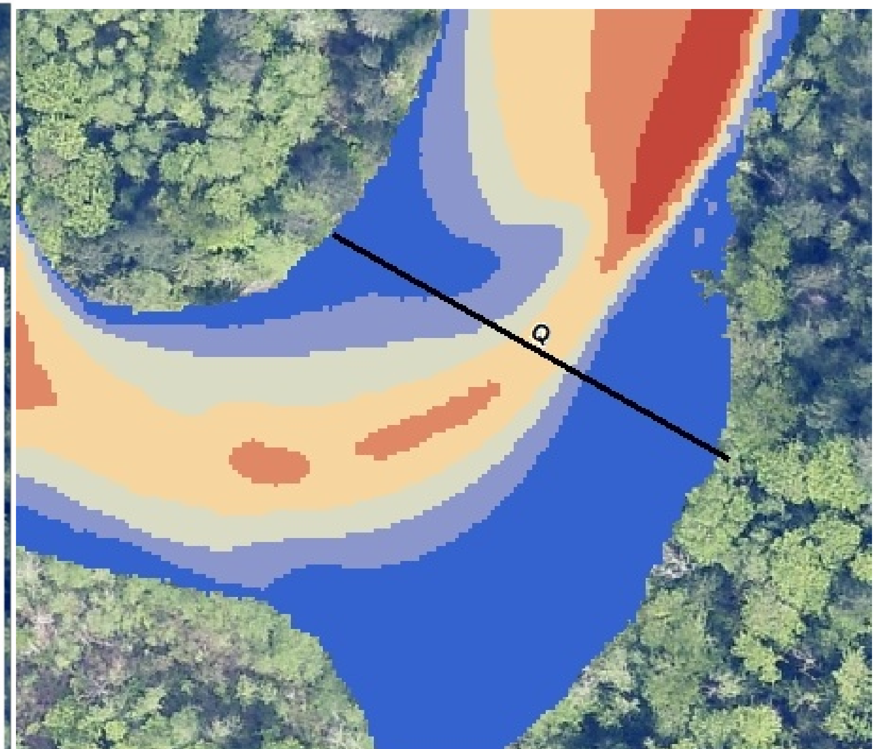
- Simulated Data



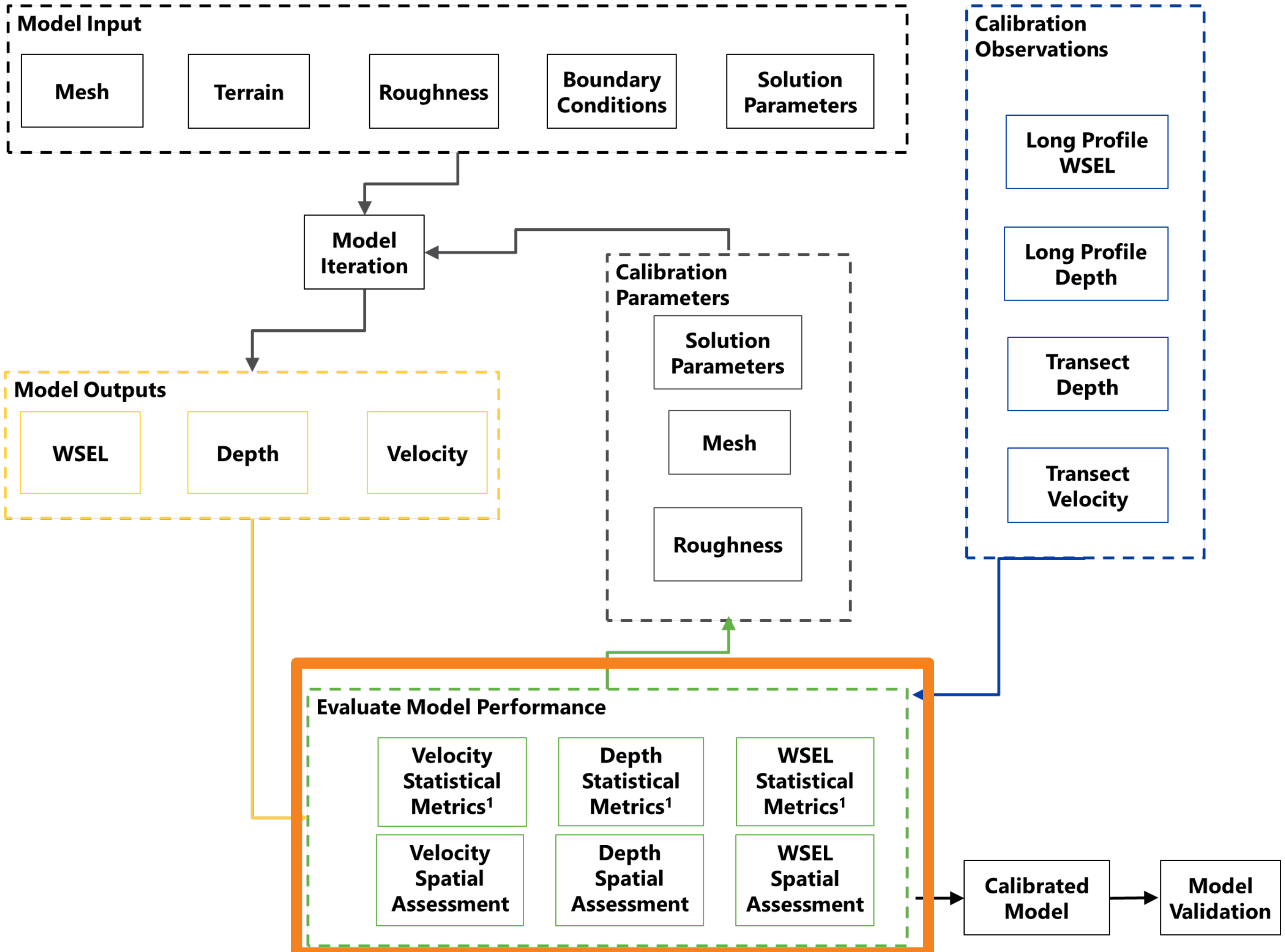
DATA COMPARISON - VELOCITY

- Observed Data
- Simulated Data





CALIBRATION METHODOLOGY



PERFORMANCE METRICS

- Spatial
  - For velocity, WSEL, and depth (as appropriate)
    - Difference Map
    - Cross sectional Plot
- Statistical
  - For velocity, WSEL, and depth (as appropriate)
    - Linear Regression
      - Slope
      - R^2
      - Y-Intercept
    - Mean Error
    - Absolute Mean Error

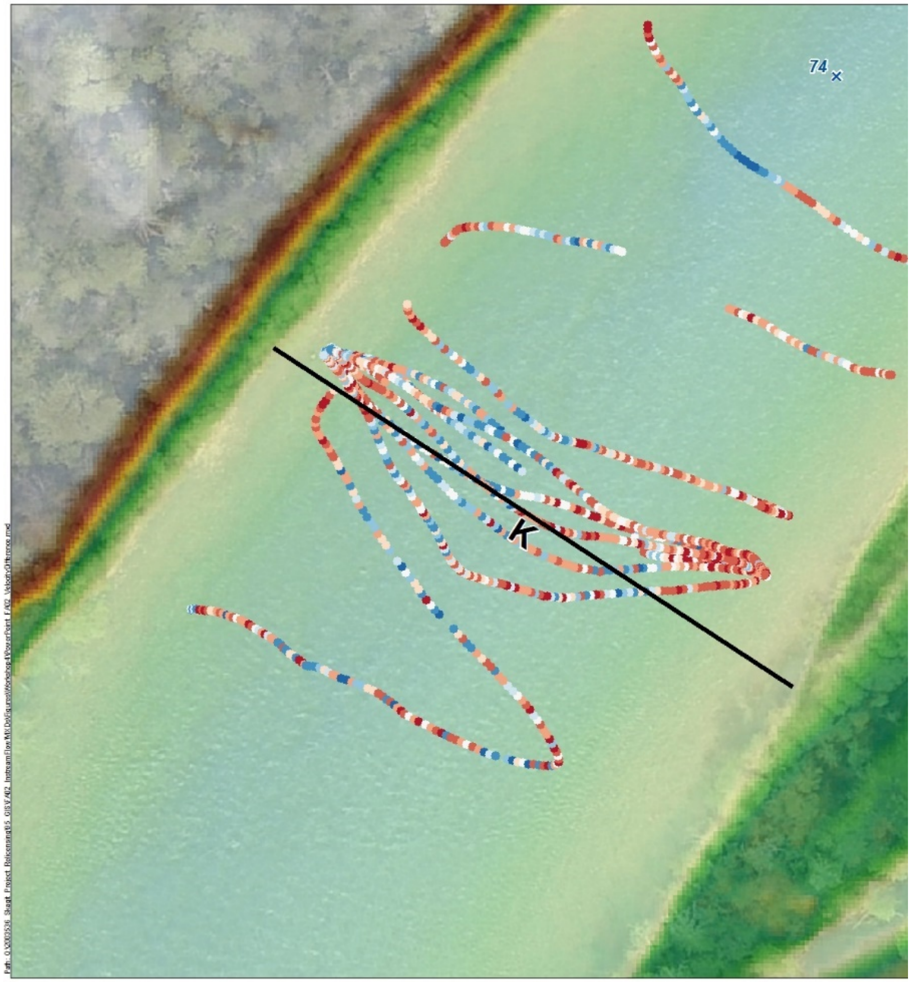
PERFORMANCE METRICS - SPATIAL

- Spatial
  - Velocity difference plan view

Difference in Velocity (ft/s)

●	< -2.00	●	-0.09 - 0.10
●	-2.00 - -1.00	●	0.11 - 0.25
●	-0.99 - -0.50	●	0.26 - 0.50
●	-0.49 - -0.25	●	0.51 - 1.00
●	-0.24 - -0.10	●	1.01 - 2.00

* Red (negative) values indicate underestimation
* Blue (positive) values indicate overestimation



PERFORMANCE METRICS - SPATIAL

- Spatial
  - WSEL difference plan view

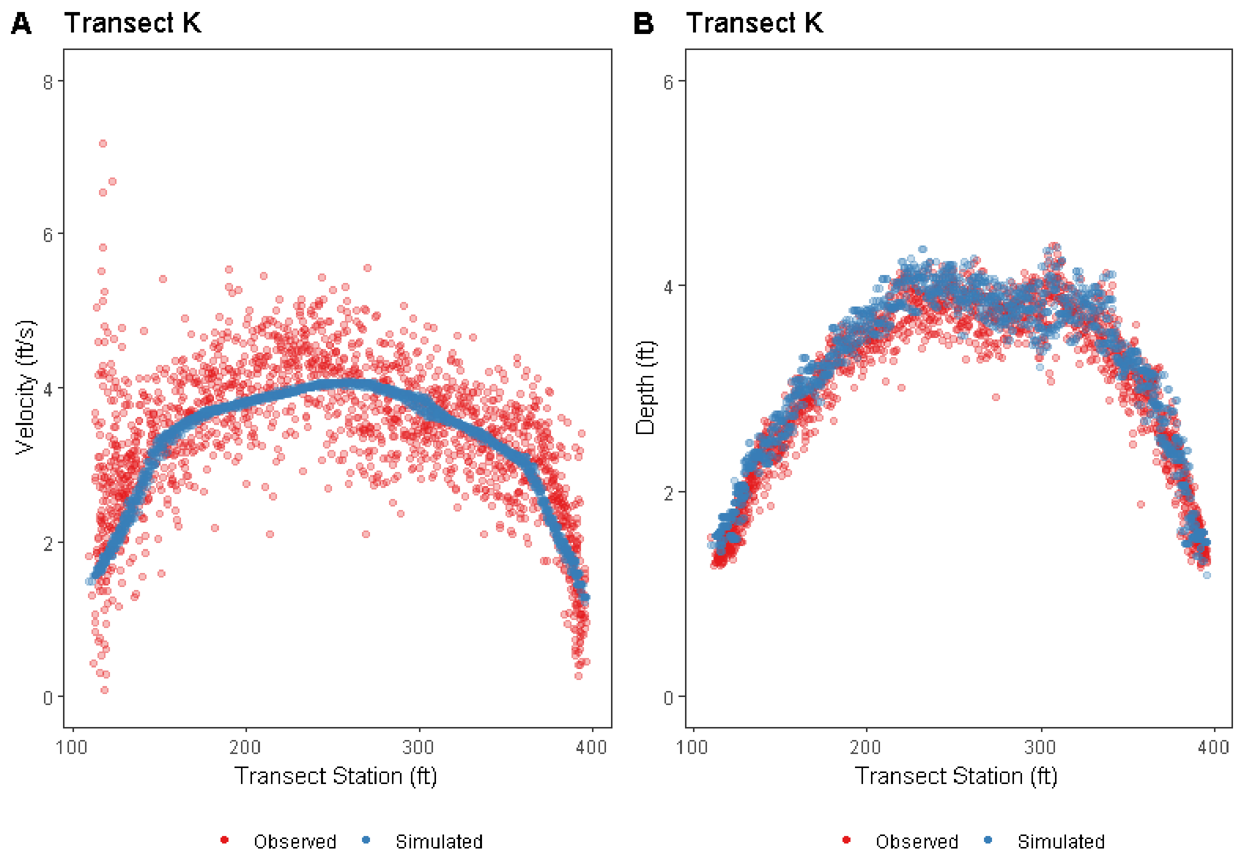
Difference in WSEL

< -2.00	-0.09 - 0.10
-2.00 - -1.00	0.11 - 0.25
-0.99 - -0.50	0.26 - 0.50
-0.49 - -0.25	0.51 - 1.00
-0.24 - -0.10	1.01 - 2.00

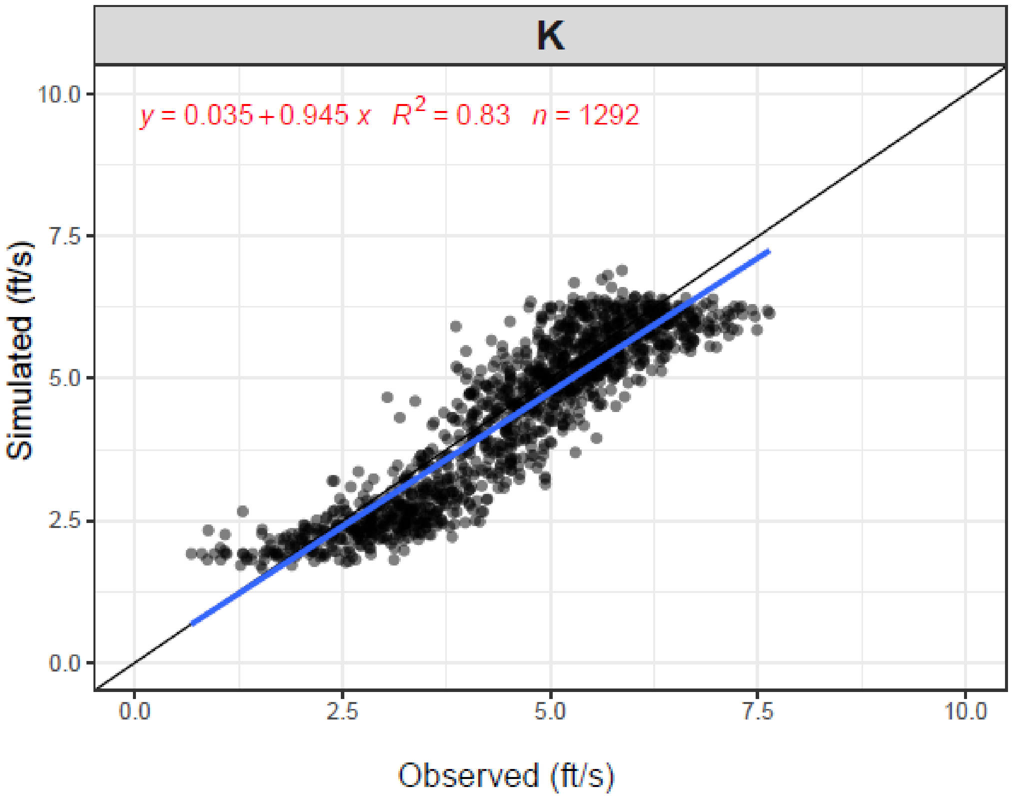
* Orange (negative) values indicate underestimation
* Purple (positive) values indicate overestimation

PERFORMANCE METRICS - SPATIAL

- Spatial
  - Cross sectional depth and velocity plot



PERFORMANCE METRICS - STATISTICAL



- Statistical
  - Linear Regression
    - Slope
    - R^2
    - Y-Intercept

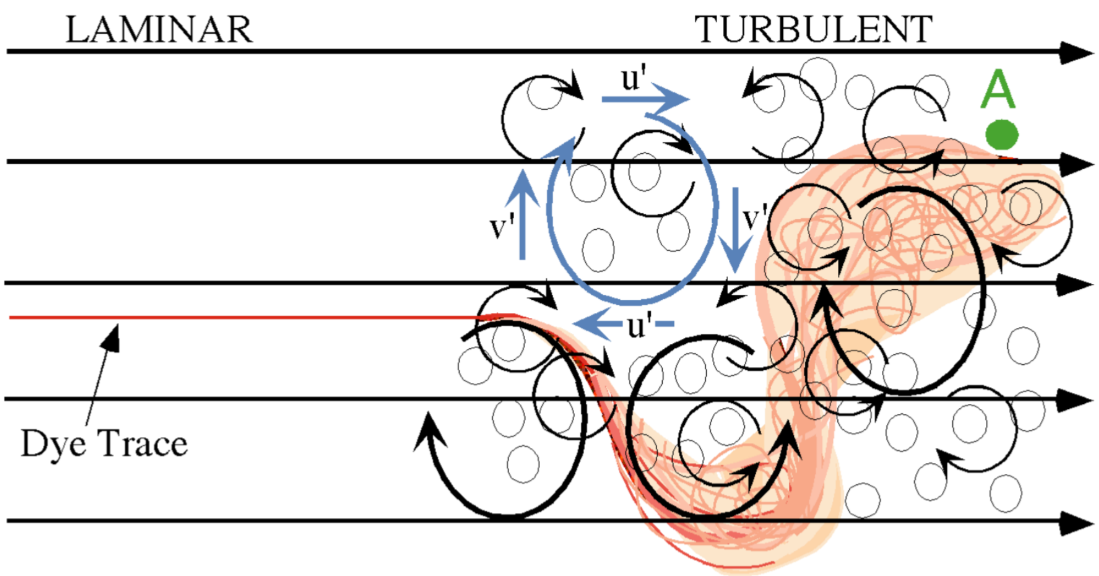
PERFORMANCE METRICS - STATISTICAL

Reach	R^2 of Linear Regression	Mean WSEL Error (ft)	Number of Points
2	1.000	0.11	8360
3A	0.993	0.39	1883
4	0.993	0.06	5062
3B	0.995	0.05	3688
5A	0.999	-0.04	7638
5B	0.999	-0.01	5970
6	0.999	0.08	12712
7	0.987	0.00	2745

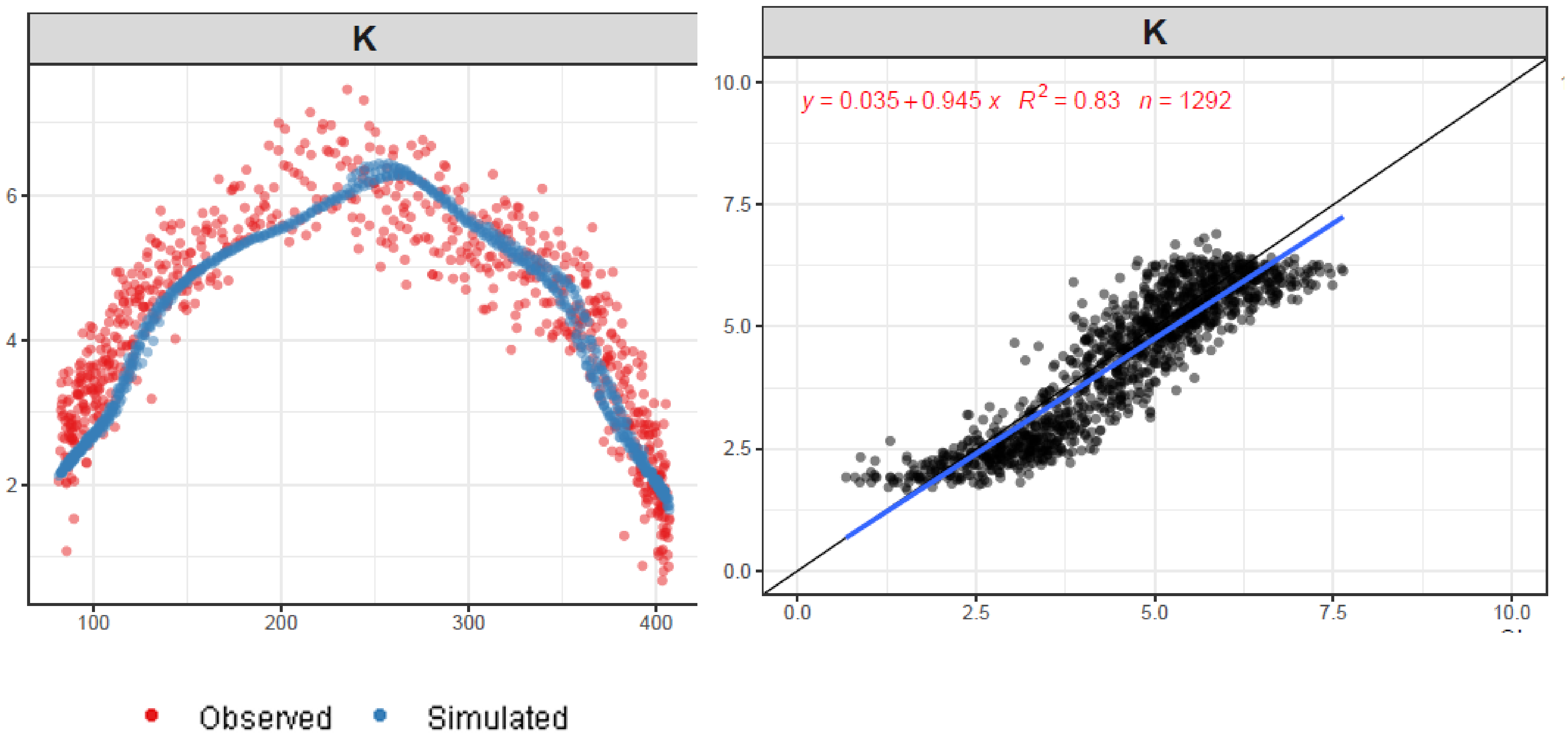
- Statistical
  - Mean Error
  - Absolute Mean Error

KEY FINDINGS

- Inherent velocity variability impacts R^2
  - Turbulence - chaotic changes in flow velocity
  - Instrument variability
  - Sub-terrain bathymetry resolution (one point per three feet)



VELOCITY TURBULENCE



MODEL PERFORMANCE CRITERIA

- NO quantitative standards for these performance indicators have been proposed or adopted through scientific consensus
- Primary model performance ideals:
  - WSEL
    - Centered around zero mean error
  - Depth
    - Centered around zero mean error
    - Deviation within 95% confidence interval of terrain
  - Velocity
    - Slope of linear regression approaching 1
    - R^2 of linear regression approaching 1
    - Y-Intercept approaching zero
    - Centered around zero mean error

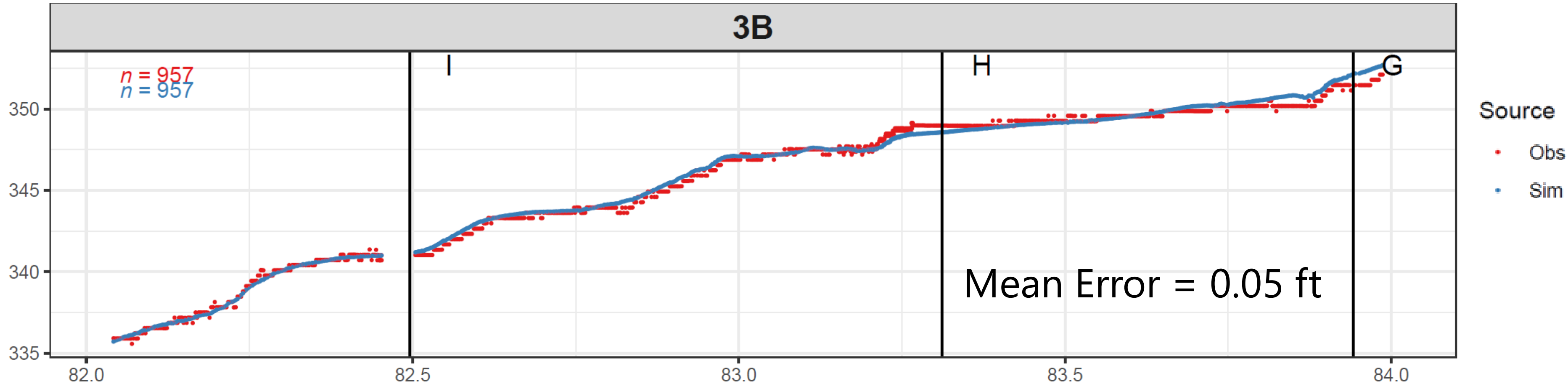
WSEL/DEPTH PERFORMANCE

- WSEL > depth calibration
  - Depth = WSEL – Terrain Elevation
  - Therefore, if WSEL is “correct” and depth is “incorrect”, terrain has inaccuracies
- LiDAR submerged vertical accuracy
  - 2018 - 0.37′ 95% confidence
  - 2017 - 0.54′ 95% confidence

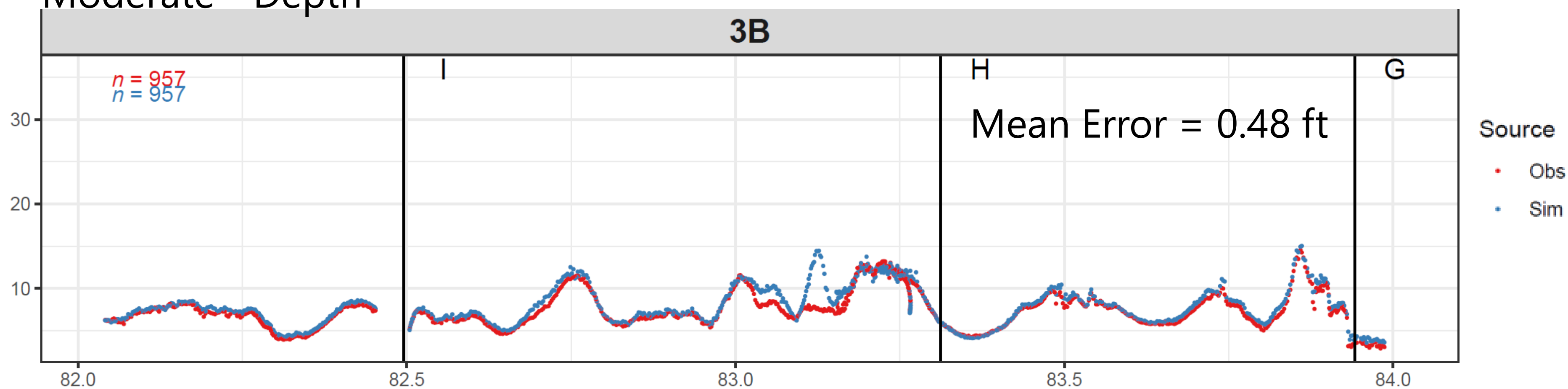
Reach	Mean Error (ft)
2	0.11
3A	0.39
4	0.06
3B	0.05
5A	-0.04
5B	-0.01
6	0.08
7	0.00

WSEL/DEPTH PERFORMANCE - EXAMPLE

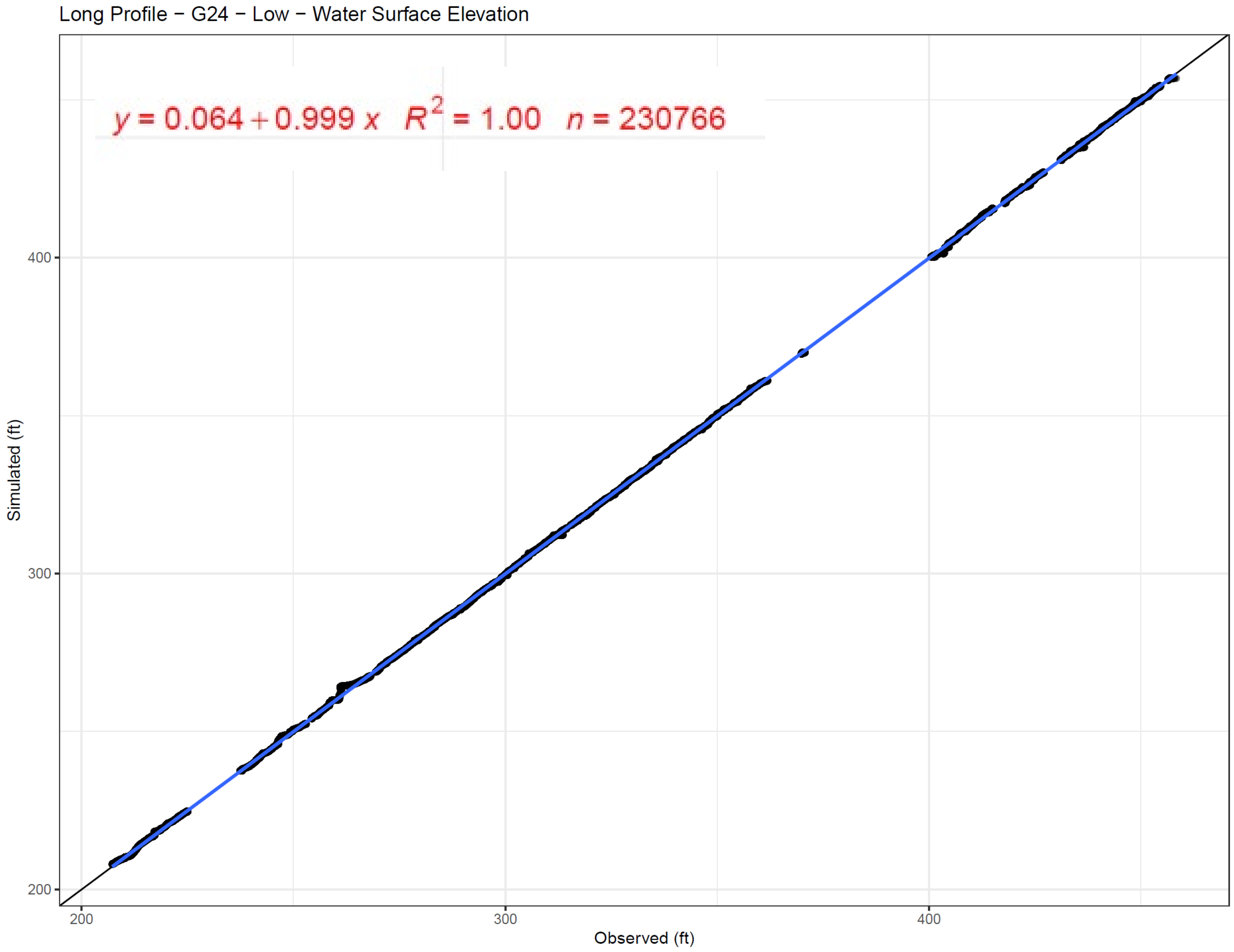
Moderate - WSEL



Moderate - Depth

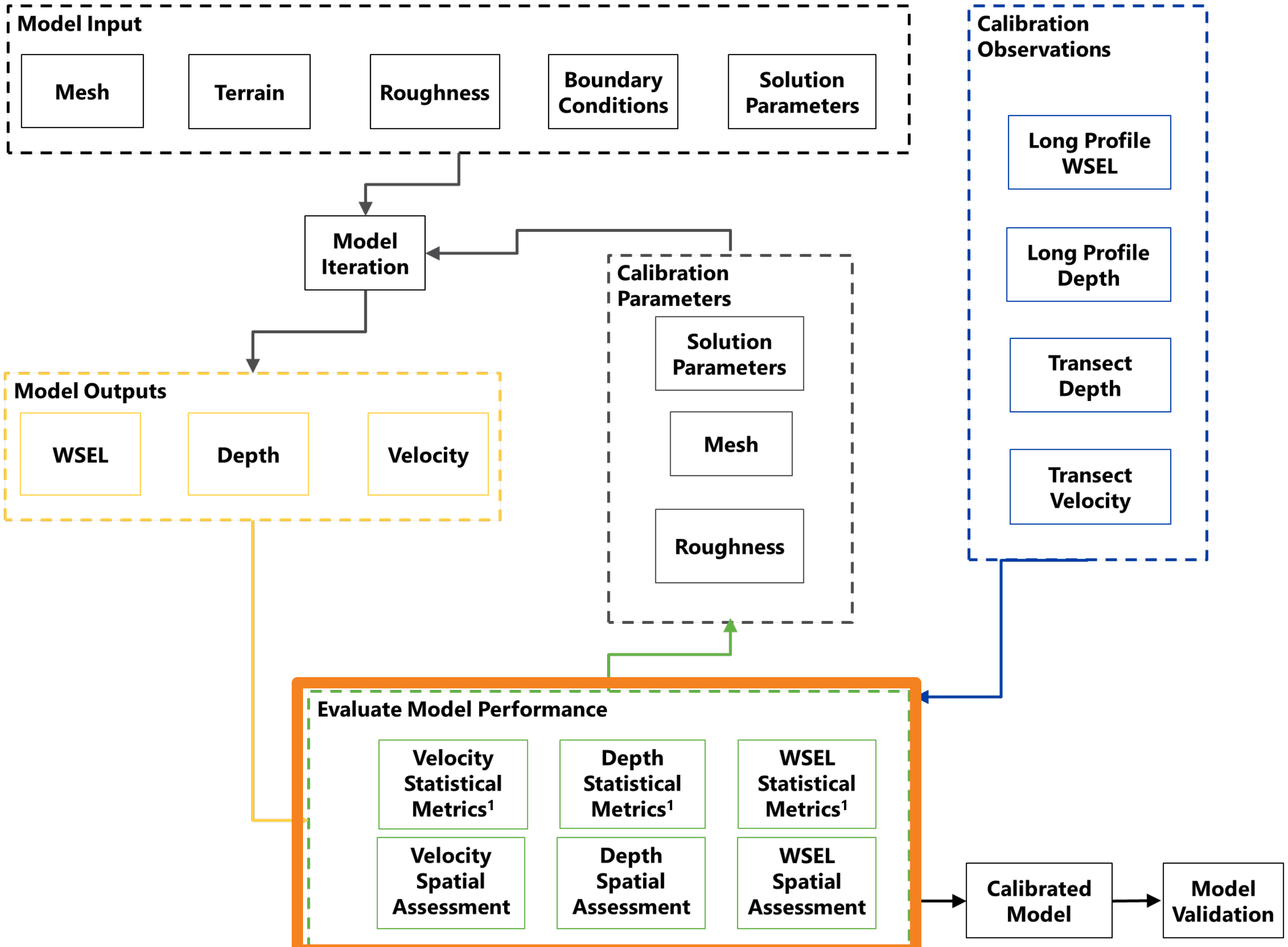


WSEL/DEPTH PERFORMANCE - EXAMPLE



VELOCITY PERFORMANCE - EXAMPLE

CALIBRATION METHODOLOGY



TRANSECT PERFORMANCE METRICS - CURRENT

Metric	Low	Mod	High	Avg
Velocity Slope	0.76	0.78	0.84	0.80
Velocity R^2	0.68	0.66	0.67	0.67
Velocity Y-Int (ft/s)	0.34	0.28	0.19	0.26
Velocity Mean Error (ft/s)	-0.37	-0.54	-0.59	-0.51
Depth Slope	1.01	0.99	0.97	0.99
Depth R^2	0.86	0.94	0.94	0.92
Depth Y-Int (ft)	0.45	0.67	0.59	0.58
Depth Mean Error (ft)	0.47	0.66	0.42	0.51
Number of Points	13,182	16,688	19,593	49,463

* Mean Error = simulated - observed

LONG PROFILE PERFORMANCE METRICS - CURRENT

Metric	Low	Mod	High	Avg
WSEL Mean Error (ft)	-0.12	0.17	-0.08	-0.07
WSEL Mean Absolute Error (ft)	0.28	0.36	0.34	0.30
Depth Slope	0.67	0.59	0.72	0.67
Depth R^2	0.62	0.65	0.67	0.63
Depth Y-Int (ft)	2.17	3.54	3.01	2.51
Depth Mean Error (ft)	0.04	0.41	0.95	0.25
Number of Points	241,859	52,041	58,328	352,300

* Mean Error = simulated - observed

MODEL PERFORMANCE CONCLUSIONS

- Depth/Flow/Reach-varied roughness has improved model performance, however further refinement is ongoing
- Mean error of velocity indicates overall underestimation of velocity
- Further refinement to WSEL needed in some reaches
  - Balance with velocity calibration

Reach	Mean Error (ft)
2	0.11
3A	0.39
4	0.06
3B	0.05
5A	-0.04
5B	-0.01
6	0.08
7	0.00

Seattle City Light

DISCUSSION

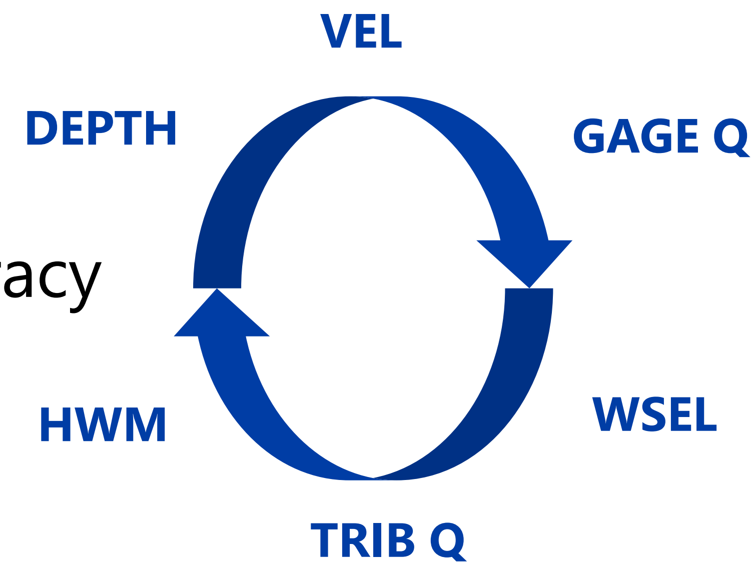
HYDRAULIC MODEL NEXT STEPS

INSTREAM MODEL NEXT STEPS

- Complete Calibration/Validation to existing field observations
  - Present at Workshop 5 March 1, 2022
- HSC Integration
  - Overview
  - Schematic

PERFORMANCE EVALUATION

- Performance never perfect!
  - Uncertainty in observed data
  - Assumptions & simplifications in SWE and solution procedures
- Performance testing -> characterizing uncertainty



- LiDAR <u>submerged</u> vertical accuracy
  - 2018 - 0.37′ 95% confidence
  - 2017 - 0.54′ 95% confidence

MODEL PERFORMANCE GOALS

- Primary model performance drivers:
  - WSEL/Depth
    - Centered around zero mean error
    - Deviation similar to 95% confidence interval of terrain
  - Velocity
    - Slope of linear regression (>0.9)
    - R^2 of linear regression (> 0.6)
    - Y-Intercept approaching (< 5% of V_{max})
    - Absolute Mean Error (< 25%)

* recommended from Pasternack (2011)

MODEL VALIDATION

- RSP states 5 (of 17) transects reserved for validation

Option 1

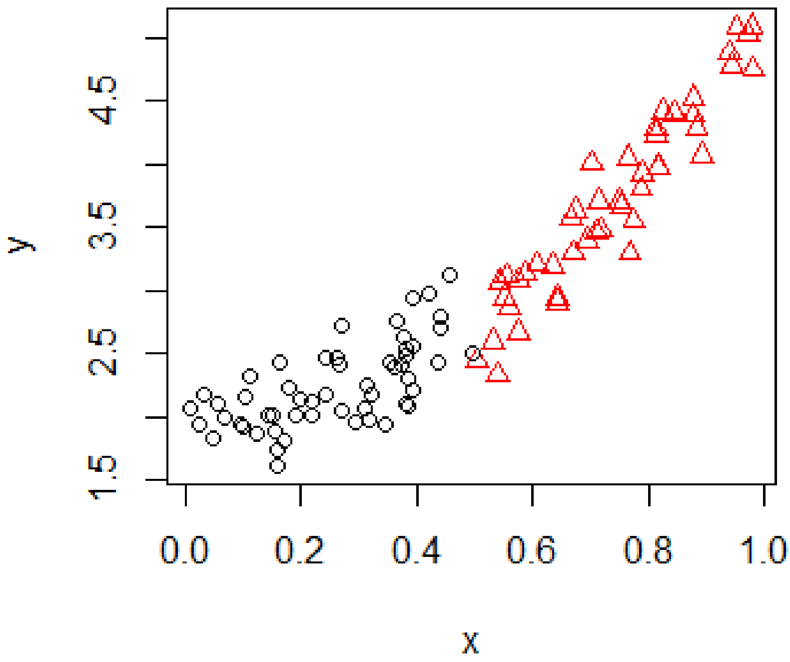
- Going forward, remove 5 transects from calibration statistics
- Only applies to velocity and depth statistics (not long profiles)
- Run performance statistics on 5 reserved transects
- Compare calibration and validation performance metrics
- If validation worse…?

Option 2

- Utilize all available data for calibration to best resolve underlying physical properties
- Quantify uncertainty to all observations

SUBSET ANALYSIS?

- Test if subsets of data have similar performance as entire set
- Subsets of particular interest ?
  - Velocities < 5 ft/s ?
  - Depths < 5 ft ?



INTEGRATION WITH BIOLOGICAL/HABITAT DATA

December 7, 2021

HSC OVERVIEW

- Substrate and Cover Mapping Update
- HSC and Periodicity Development Update
- Aquatic & Biologic Habitat Integration Preview

SUBSTRATE/COVER MAPPING

- Field-based substrate/cover mapping occurred during July – October 2021.
- Finalizing filling in data gaps for areas that were difficult to access and where visibility was poor due to turbidity and/or depth. This process was necessary to create a more complete map of substrate and cover for the bypass reach and mainstem.
- Mapping data will be shared with Geomorphology Team.

HABITAT SUITABILITY CRITERIA (HSC)

- HSC Development – Small Group Technical Meetings
  - Comprised of LPs, City Light and Consultant Team members
  - Initial focus of the group has been on developing preliminary HSC curves based on existing curves, studies and/or literature.
  - Current efforts are focused on species/life stages where field validation data has been collected.
  - HSC curves to be used for both bypass reach and below Gorge Powerhouse instream flow modeling.
  - Anticipate review of preliminary HSC curves with LPs in early January 2022.

HSC FIELD VALIDATION STUDIES

- Focus species / life stages
  - Steelhead spawning (Spring)
  - Chinook, Pink, Chum spawning (Fall/Winter)
  - Steelhead, Chinook, Bull Trout juveniles
- Data from these studies will be used to help validate (and/or potentially modify) existing HSC curves that will be used in the habitat modeling.

PERIODICITY

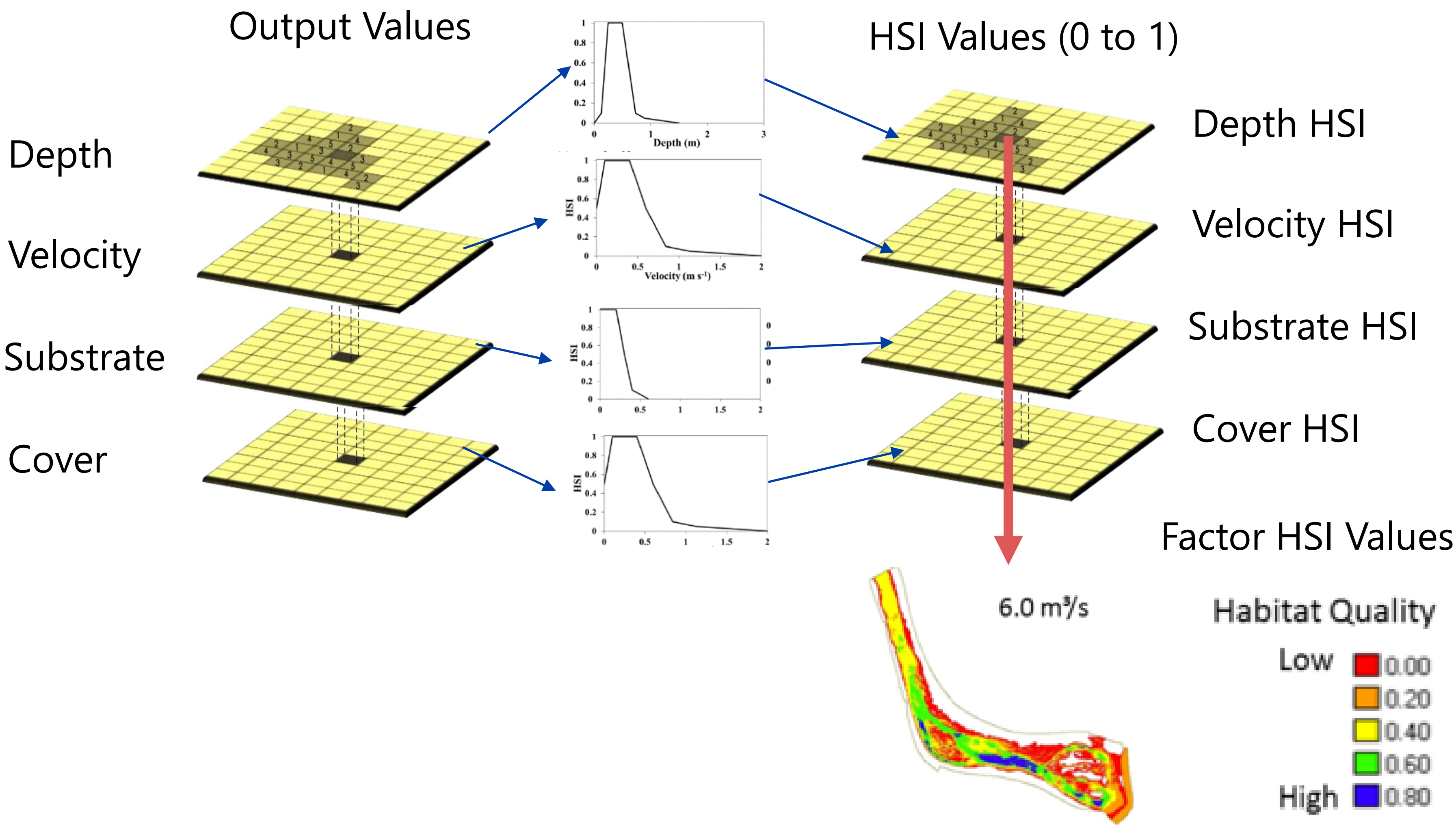
- Periodicity Technical Group Meetings
  - Periodicity is used to help focus habitat model results on periods that are relevant to each species/life stage being modeled.
  - Smaller technical working group comprised of LPs, City Light and Consultant Team members has been meeting to review existing information and recommend modifications to the preliminary periodicity table.
  - Periodicity is relevant to not only the FA-02 and FA-05 instream flow model studies, but several other fisheries-related studies.

AQUATIC & BIOLOGIC HABITAT INTEGRATION PREVIEW

magnitude of available aquatic habitat; not frequency

- Calculate combined HSI and UA (not ***W***UA)
  - Substrate & cover layers
  - Modeled depths & velocities for each flow scenario
  - HSI curves for depth, velocity, substrate and cover per fish species and life stage
  - Calculate HSI and UA values
    - Calculate HSI at each point by multiplying:
      - (DEPTH HSI) * (VELOCITY HSI) * (SUBSTRATE HSI) * (COVER HSI)
    - Calculate UA values at each point by multiplying:
      - AREA * combined HSI
- Output: tabular and/or maps

IFIM SCHEMATIC



Seattle City Light

DISCUSSION

FISH TRAPPING AND STRANDING (SKAGIT RIVER BELOW PROJECT)

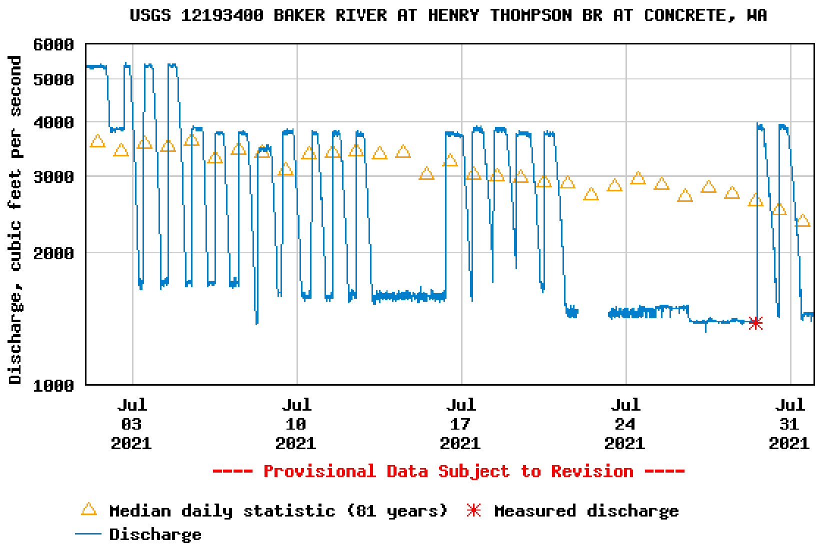
- Efficacy of "lower Skagit River" stranding and trapping protection raised by LPs
- Notice of Certain Agreements filed on June 9, 2021 – "a re-evaluation of the existing methodology for assessing downstream salmonid and other fish stranding, trapping, and predation risk."
- Today's objective:
  - Overview of current program
  - Brief Q&A
  - Discuss next steps (LP review of information/identification of issues, process for issue resolution, etc.)

FISH TRAPPING AND STRANDING

- History
- Types
- Investigation
- Application

HISTORY

- Stranding and Trapping Committee: Agencies, Tribes, City Light
- Stranding and Trapping due to Peaking at Gorge
- Investigations into effects 1969-1984
  - Focused on Downramping Rate



TYPES OF TRAPPING AND STRANDING FEATURES

- Pothole
  - Depressions
- Gravel Bar
  - Substrate
  - Slope

INVESTIGATION

- Potholes
  - Elevation, Size, Cover, Density
- Gravel Bars
  - Slope, Substrate Size

Common Metrics: Fry Species/Size/Density, Ramp Rate, Amplitude, Location (distance from Gorge PH), and Day vs. Night

INVESTIGATION: STUDY DESIGN

- Potholes
  - Physical features
  - Hydrologic conditons/Time of Day
  - Biological
  - Residence Time
- Gravel Bars
  - Identify Measurable Factors
  - Examine the relationship between factors
  - Determine Vulnerability (timing, species, size)
  - Determine extent of stranding

INVESTIGATION: STUDY DESIGN

- Unit plots
- Treatments
- Project Operations

INVESTIGATION: RESULTS

- Index of Relative Stranding Risk
- Amplitude: 4k greater than 2k
- Rate: >1k
- Substrate: <3" vs >3"
- Slope: <5% vs >5%
- Location: Upstream vs. Downstream
- Day vs. Night

APPLICATION

- Downramp restrictions
  - Rate
  - Amplitude
  - Season
  - Timing
  - Monitoring

Seattle City Light

DISCUSSION

INSTREAM FLOW MODEL DEVELOPMENT STUDY
INTERIM REPORT

ATTACHMENT O

HSC WORKSHOP 1 MATERIALS

Seattle City Light **MEETING AGENDA**

Skagit Hydroelectric Project Relicensing Meeting

Habitat Suitability Criteria and Periodicity – Technical Meeting

May 12, 2021, 1:00 PM to 5:00 PM

Webex Meeting: https://meethdr.webex.com/meethdr/j.php?MTID=mc1805fd7de532a5103158606bdbfed46

Conference Call: 1-408-418-9388 (Meeting ID: 187 946 5184)

MEETING OBJECTIVES

- **HSC Targeted Validation Studies** – determine the scope, timing, and methodology of targeted HSC field validation studies this year in the Skagit River. Because of timing, the initial focus is on spring spawners.
- **HSC Hierarchy** – discuss the hierarchy process for selection/development of HSC curves.
- **HSC Data Gaps** – discussion on the approach for rounding out HSC for species/life stages where little (or no) HSC information is readily available.
- **Periodicity** – discussion on differences between mainstem Skagit and bypass reach periodicity.

AGENDA

1:00 – 1:10 p.m. (10 min)	**Introductions**– *Facilitator (Triangle)* ▪ Roll Call Introduction
1:10 – 1:25 p.m. (15 min)	**Meeting Objectives and Agenda Overview –** *Facilitator (Triangle)*, *Ty Ziegler (HDR) and Erin Lowery (SCL)* ▪ Review Meeting Objectives and Agenda ▪ Review HSC Methodologies - Type 1-3 HSC curves and newer methods: ESH curves, Bioenergetics

1:25 – 2:50 p.m.
(85 min)
 	
Note: this is a time sensitive discussion and may take more time then allocated on the agenda.
	HSC Review and Potential Targeted Validation Studies (Spring spawning) – *Tom DeGabriele (HDR), Tim Hardin (consultant), and Erin Lowery (SCL)*
	▪ Review of existing information: methodology, number of observations, location
	▪ Factoring in site-specific field studies/data
	▪ Discuss hierarchy for selecting/developing HSC curves
	▪ Discussion:
	  o Data gap and new study determination
	  o Flow and visibility considerations
	  o Permitting or other potential requirements
	
	Desired Outcome: Initial HSC library and field study/schedule for spring spawners.

2:50 – 2:55 p.m. (5 min)	**Break**

2:55 – 3:40 p.m. (45 min)	**HSC Review and Potential Targeted Validation Studies (Rearing lifestages)** – *Tom DeGabriele (HDR), Tim Hardin (consultant), and Erin Lowery (SCL)* ▪ Review of Existing Information: methodology, number of observations, location ▪ Factoring in site-specific field studies/data ▪ Discuss hierarchy for selecting/developing HSC curves ▪ Discussion: o Data gap and new study determination o Flow and visibility considerations o Permitting or other potential requirements
3:40 – 3:45 p.m. (5 min)	**Break**
3:45 – 4:30 p.m. (45 min)	**HSC Review and potential Targeted Validation Studies (Fall/Winter spawner)** – *Tom DeGabriele (HDR), Tim Hardin (consultant), and Erin Lowery (SCL)* ▪ Review of Existing Information: methodology, number of observations, location ▪ Factoring in site-specific field studies/data ▪ Discuss hierarchy for selecting/developing HSC curves ▪ Discussion: o Data gap and new study determination o Flow and visibility considerations o Permitting or other potential requirements
4:30 – 5:00 p.m. (30 min)	**Schedule, Action Items, Next Steps** – *Facilitator (Triangle) and meeting participants* ▪ Objective review, need for additional meeting ▪ New study recommendations and schedule ▪ Review meeting action items ▪ Next steps
5:00 p.m.	**Meeting Adjourned**

INSTREAM FLOW MODEL DEVELOPMENT STUDY
INTERIM REPORT

ATTACHMENT P

HSC WORKSHOP 2 MATERIALS

Skagit Hydroelectric Project Relicensing Meeting

Habitat Suitability Criteria and Periodicity – Technical Meeting

June 23, 2021, 12:00 PM to 4:30 PM

Microsoft Teams Meeting Link: Click here to join the meeting
Or call in: +1 872-242-8913,,550114003#

Phone Conference ID: 550 114 003#

MEETING OBJECTIVES

- **HSC Targeted Validation Studies** – update on Steelhead spring spawning HSC field validation study and discuss upcoming juvenile/rearing field validation studies. Note potential field validation studies for winter spawners will be added to future workshop agendas in July and August.
- **HSC Data Gaps** – identify and vet potential HSC sources/references relevant to the Skagit River.
- **HSC Hierarchy** – discuss and agree to a hierarchy process for selection/development of HSC curves including habitat modeling approach for species/life stages where little (or no) HSC information is readily available.
- **Periodicity** – discussion on differences between mainstem Skagit and bypass reach periodicity.

AGENDA

12:00 – 12:10 p.m. (10 min)	**Introductions**– *Facilitator (Triangle)* ▪ Roll Call Introduction ▪ Context and Background from the HSC Meeting #1 on May 12
12:10 – 12:25 p.m. (15 min)	**Review Agenda, Meeting Objectives, and Previous Action Items –** *Erin Lowery (SCL), Ty Ziegler (HDR), Tom DeGabriele (HDR)* ▪ Review Meeting Objectives and Agenda
12:25 – 1:10 p.m. (45 min)	**Steelhead Spring Spawning HSC Validation Study Update and Discussion**– *Erin Lowery (SCL), Tim Hardin (consultant)* ▪ Review of methodology and study period ▪ Results of the field component ▪ Results of the desktop analysis ▪ Discuss process for applying data for HSC validation
1:10 – 2:10 p.m. (60 min)	**HSC Review and Potential Targeted Validation Studies (Juvenile/Rearing Lifestages)** – *Erin Lowery (SCL), Tom DeGabriele (HDR), Tim Hardin (consultant)* ▪ Species selected during 5/12/2021 Workshop: o Chinook o Bull Trout o Chum ▪ Discussion: o Barnaby Reach data and if/how it may inform Chinook juvenile rearing

2:10 – 2:20 (10 min)	**Break**
2:20 – 2:35 p.m. (15 min)	**Update on Data Gaps/Additional Information** – *Tom DeGabriele (HDR), Tim Hardin (consultant)* ▪ Discuss LP provided sources of information received (studies, literature, etc.) that could inform HSC selection/development
2:35 – 3:20 p.m. (45 min)	**HSC Hierarchy – Development and Approval Process** – *Tim Hardin (consultant), Tom DeGabriele (HDR)* ▪ Grouping HSC life stages based on types of data available ▪ Factoring in site-specific field studies/data ▪ Options for selecting/developing/approving HSC curves based on types of data available ▪ Discuss species with limited/representative available data and potential use of HSC information from smaller rivers (compared to Skagit)
3:20 – 3:25 p.m. (5 min)	**Break**
3:25 – 4:10 (45 min)	**Periodicity** – *Tom DeGabriele (HDR), Tim Hardin (consultant)* ▪ Discuss differences in periodicity specific to the bypass reach ▪ What are the field studies/observations that could be used to differentiate mainstem Skagit from bypass reach? ▪ Differences in species list between mainstem Skagit and bypass reach?
4:10 – 4:30 p.m. (20 min)	**Schedule, Action Items, Next Steps** – *Facilitator (Triangle) and meeting participants* ▪ Objectives review, need for additional meetings ▪ Study recommendations and schedule ▪ Review meeting action items ▪ Next steps
4:30 p.m.	**Meeting Adjourned**

INSTREAM FLOW MODEL DEVELOPMENT STUDY
INTERIM REPORT

ATTACHMENT Q

HSC WORKSHOP 3 MATERIALS

Seattle City Light

MEETING AGENDA

Skagit Hydroelectric Project Relicensing Meeting

Habitat Suitability Criteria and Periodicity – Technical Meeting

July 30, 2021, 9:00 AM to 12:00 PM

WebEx Link: Click here to join the meeting
Meeting Number: 1820 06 3240
Meeting password: duSDGeVV242
Or call in: +1-510-338-9438
Access code: 1820063240

Meeting Objectives

- **HSC Hierarchy** – discuss and agree to a hierarchy process for selection/development of HSC curves including habitat modeling approach for species/life stages where little (or no) HSC information is readily available.
- **HSC Targeted Validation Studies** – update on any recommended adjustments to the HSC curves based on Steelhead spring spawning HSC field validation study and review of the Barnaby Reach data. Further discuss upcoming juvenile/rearing field validation studies and begin discussions on potential field validation studies for winter spawners.

  HSC Data Gaps – identify and vet potential HSC sources/references relevant to the Skagit River. Since HSC Workshop #2 and the last call for HSC sources/references, LPs have provided additional information for Pacific Lamprey (Brock Applegate) and White Sturgeon (Rick Hartson).
- **Periodicity** – review preliminary periodicity information proposed for the mainstem Skagit River. Discussion on differences between mainstem Skagit and bypass reach periodicity.

AGENDA

9:00 – 9:10 a.m. (10 min)	**Introductions**– *Facilitator (Triangle)* ▪ Roll Call Introduction ▪ Context and Background from the HSC Meeting #2 on 6/23/2021 and subsequent action item meetings on 7/7/2021 and 7/21/2021
9:10 – 9:20 a.m. (15 min)	**Review Agenda, Meeting Objectives, and Previous Action Items –** *Erin Lowery (SCL), Ty Ziegler (HDR), Tim Hardin (consultant), and Tom DeGabriele (HDR)* ▪ Review Meeting Objectives and Agenda
9:20 – 10:05 a.m. (45 min)	**HSC Hierarchy – Development and Approval Process** – *Tim Hardin (consultant), Erin Lowrey (SCL)* ▪ Review updates to the HSC Hierarchy Table based on discussions during HSC Workshop #2 (6/23/2021) and subsequent action item meetings on 7/7/2021 and 7/21/2021 **Group A:** include additional species/lifestages from Group B as noted below. **Group B:** Chum and pink spawning and steelhead juvenile moved up to group A for field validation.

	Group C: default is to go with WDOE curves. Possibly use field verification results from group A to tweak depth and velocity preference on some Group C curves. **Group D:** Develop consensus curves based on available literature. **Group E:** HSC based on general literature and consensus approach. Given the uncertainty of HSC for this group (as it applies to the Skagit River), it is unlikely that habitat model results will be used for flow management decisions, however, the habitat model results will be included in the Appendix. **Group F:** HSC either not available or based on general literature and consensus approach. Similar to Group E, habitat model results for species with HSC will be included in the Appendix. For species where no HSC is available, general reference materials will be included in the Appendix.
10:05 – 10:15 (10 min)	**Break**
10:15 – 11:15 a.m. (60 min)	**HSC Validation Study Updates and Discussion**– *Erin Lowery (SCL), Tim Hardin (consultant)* ▪ Steelhead Spring spawning update ▪ Juvenile/rearing field validation study updates (Chinook, Bull Trout, Chum) ▪ Barnaby Reach data review update and if/how it may inform Chinook juvenile rearing and additional species if able (e.g., Chum) Initial discussion on potential field validation studies for Fall/Winter spawners; identify LPs interested in one-off meeting to discuss study methods, timing, etc.
11:15 – 11:45 (30 min)	**Periodicity** – *Tom DeGabriele (HDR), Tim Hardin (consultant)* ▪ General overview of preliminary periodicity table (including reference sources) ▪ Are there any suggested/recommended modifications needed? ▪ Do any adjustments need to be made for species/lifestages in the bypass reach? ▪ Do we need to schedule a separate meeting focused on the bypass reach?
11:45 – 12:00 p.m. (15 min)	**Schedule, Action Items, Next Steps** – *Facilitator (Triangle) and meeting participants* ▪ Objectives review, need for additional meetings ▪ Study recommendations and schedule ▪ Review meeting action items ▪ Next steps
12:00 p.m.	**Meeting Adjourned**

ACTION ITEMS FROM PREVIOUIS HSC TECHNICAL MEETINGS: JUNE 23, 2021

Action	Responsibility	Timeframe
LP Action Items		
Request to LPs: Last call to provide any additional HSC information (e.g., literature, reports, field data, etc.) on species in the Skagit River HSC Library to inform development/refinement of existing curves.	All LP representatives Pacific Lamprey (Brock Applegate) White Sturgeon (Rick Hartson)	7/9/2021
Provide City Light and LPs background on the different sizes of rivers that were used to develop the WDOE HSC curves.	LP representatives from Ecology (Jim Pacheco)	Before 7/30/2021 HSC Workshop #3
LPs and City Light review the HSC Library for Group C species/lifestages (listed in the HSC Hierarchy Table)	City Light / LP representatives	Discussed during 7/7/2021 one-off meeting
LPs and City Light to discuss the WDOE HSC curves for Group C species in the HSC Hierarchy Table to determine if modifications (e.g. shifts to the right or left based on river size) are justified based on existing studies/literature and are defensible.	City Light / LP representatives	Discussed during 7/7/2021 one-off meeting
Review Group F species in the HSC Hierarchy Table and determine if future discussions are required to develop a conceptual HSC based on professional, scientific judgement.	All LP representatives	Ongoing
Review Periodicity Table and provide City Light comments for discussion at the next HSC and Periodicity Workshop.	All LP representatives	Before 7/30/2021 HSC Workshop #3
City Light Action Items		
City Light and LPs will schedule a one-off meeting to discuss the following topics: 1) Methods for addressing Steelhead HSC Validation; 2) The utility of Barnaby data/predictive model data and whether modification of future study activities or separate study is more appropriate; and 3) begin discussions on potential modifications (if any) to Group C species listed in the HSC Hierarchy Table based on size of river (if time allows).	City Light / LP representatives	One-off meeting held 7/7/2021
Follow up with USFWS for bull trout spawning data.	City Light	Completed 7/9/2021

Document assessment process/methodology for species that will not have HSCs developed and include in an appendix.	City Light	Ongoing
City Light to provide additional information on the Steelhead spawning observations made during the May/June 2021 field validation study (i.e., location, river flow and stage, etc.). Also provide a summary of the Crumley & Stober (1984) Steelhead spawning observations for context.	City Light	Follow-up to one-off meeting held 7/21/2021
Facilitation Team Action Items		
Prepare draft meeting summary and send to LPs for review.	Triangle	Next week
Coordinate with Rick Hartson to gather Sturgeon Reports and forward to City Light.	Triangle	Completed 7/21/2021

ACTION ITEMS FROM PREVIOUIS HSC TECHNICAL MEETINGS: MAY 12, 2021

Action	Responsibility	Status
LP Action Items		
Provide any additional HSC information (e.g., literature, reports, field data, etc.) on species in the Skagit River HSC Library to inform development/refinement of existing curves.	All LP representatives	Received information from Dudley Reiser (consultant to Swinomish). No other information received from LPs. Chum salmon rearing (Tim Hardin found data on Fraser)
Compile any additional information on lamprey, white sturgeon, and rainbow trout. - Salish sucker – DFW request - Rainbow and steelhead differentiation of redd size (DFW - Johnathan and Brock)	LP representatives from WDFW (Brock Applegate and Jonathan Kohr) and Upper Skagit Indian Tribe (Rick Hartson)	Pending Poll group at 6/23 meeting. Dudley Reiser forwarded white sturgeon HSC data from McConnel 1989 Salish suckers – Chehalis data with low N.
City Light Action Items		

Meet to discuss the logistics and feasibility of a steelhead spring spawning validation study.	City Light / LP representatives from WDFW and ECY	Completed 6/3/21
Meet to discuss the details of a study design for chinook rearing including the potential for using the existing research studies to inform rearing HSC validation.	City Light (Erin Lowery) / LP representatives from WDFW, ECY, and SRSC	Meeting with LP representatives scheduled 6/16/21
Review literature for information on chum fry behavior and habitat use.	City Light	Complete
Provide LPs the HSC data and development sections in the Crumley and Stober (1984) report.	City Light	Completed 6/3/21
Follow-up on any additional permit requirements for studies.	City Light / Cascadian Law Group	Completed

INSTREAM FLOW MODEL DEVELOPMENT STUDY
INTERIM REPORT

ATTACHMENT R

HSC WORKSHOP 4 MATERIALS

Seattle City Light

MEETING AGENDA

Skagit Hydroelectric Project Relicensing: Flows Work Group Meeting

Habitat Suitability Criteria and Periodicity – Status Update Meeting

November 4, 2021, 1:00 PM to 2:30 PM

WebEx Link: Click here to join the meeting

Meeting Number: 2556 566 6087

Meeting password: piYuJPVP755

Or call in: +1-510-338-9438

Access code: 25565666087

Meeting Objectives:

- **HSC Hierarchy Table and Updates** – Recent updates to the HSC Hierarchy Table (resulting from the HSC Technical Group work sessions) will be reviewed.
- **HSC Validation Studies** – Targeted field validation studies have been performed for several species and life stages. A high-level summary of results will be provided.
- **HSC Curve Updates** – A high-level update of progress made from HSC Technical Group work sessions will be provided.
- **Periodicity Update**– A high-level update of progress made from the Periodicity Technical Group work sessions to the Periodicity Table will be provided.

AGENDA

1:00 – 1:10 p.m. (10 min)	**Introductions**– *Facilitator (Triangle)* ▪ Roll Call Introduction
1:10 – 1:20 p.m. (10 min)	**Review Agenda, Meeting Objectives, and Background –** *Ty Ziegler (HDR), Erin Lowery (SCL)* • Review Meeting Objectives and Agenda • Context and Background from the HSC Meeting #3 on 7/30/2021 and subsequent technical group meetings from August – October 2021.
1:20 – 1:30 p.m. (10 min)	**HSC Hierarchy Review** –*Ty Ziegler (HDR) and Tim Hardin (Consultant)* ▪ Review updates to the HSC Hierarchy Table based on discussions during HSC Technical Group meetings from August – October 2021 **Group A:** field studies will be used to help validate/confirm existing HSC curves. **Group C:** will use WDFW/WDOE Type III HSC curves as a default (may modify based on results of Group A field validation studies). **Group D:** will use consensus process to modify existing HSC curves. **Group E:** will use consensus process to develop composite fry HSC curves. **Group F:** will use consensus process to develop HSC curves from literature.

1:30 – 1:50 p.m. (20 min)	**HSC Validation Studies Update** – *Erin Lowery (SCL)* ▪ Steelhead Spring spawning update ▪ Juvenile/rearing field validation study updates (Steelhead, Chinook, Bull Trout, Chum) ▪ Validation methods ▪ Fall/Winter spawners update (Chinook, Pink, Chum)
1:50 – 2:10 p.m. (20 min)	**HSC Curve Updates** – *Ty Ziegler (HDR) and Tim Hardin (Consultant)* ▪ Review status of HSC curve updates for each Hierarchy Group
2:10 – 2:20 p.m. (10 min)	**Periodicity Update** – *Ty Ziegler (HDR), Erin Lowery (SCL), and Tim Hardin (Consultant)* ▪ High-level review of Periodicity Table, recommended modifications, and next steps.
2:20 – 2:30 p.m. (10 min)	**Schedule, Action Items, Next Steps** – *Facilitator (Triangle) and meeting participants* ▪ Study recommendations and schedule ▪ Review meeting action items ▪ Next steps
2:30 p.m.	**Meeting Adjourned**

Action Items from 7/30 HSC Meeting

Meeting materials and outcomes from HSC and Periodicity Small Group working sessions held in September and October can be found within this SharePoint folder.

Action Items

Action	Responsibility	Deadline
LP Action Items		
Request to LPs: Reach out within your organization to identify staff or partners best suited to review the Periodicity Table at a one-off meeting.	All LP representatives	Done by HSC Small Group
Request to LPs: If you would like to be part of the periodicity or HSC one-off meetings, please connect with City Light, the Consultant Team, and Triangle to be included in communication and scheduling.	All LP representatives	Done by HSC Small Group
Provide City Light and LPs with the WDFW's sampling guidance document.	LP representatives from WDFW (Jonathan Kohr and Kiza Gates)	Done by Triangle
Conduct a final review of the HSC hierarchy groupings to confirm classifications based on the presence or absence of previous HSC curves.	City Light / LP representatives	Done by HSC Small Group
City Light Action Items		
Provide LPs with an updated HSC Hierarchy Table to reflect decisions made at the workshop on groupings.	City Light	Done by Triangle

City Light and LPs will schedule a one-off meeting to review and discuss the Periodicity Table.	City Light / LP representatives	Done by HSC Small Group
City Light, in collaboration with LPs, will develop a path forward to establish small working groups that will review HSC curves at one-off meetings. Results from the working groups will be brought back to full workshops with LPs for approval.	City Light / LP representatives	Done by HSC Small Group
Facilitation Team Action Items		
Prepare draft meeting summary and send to LPs for review.	Triangle	Done by Triangle
Coordinate with City Light to identify dates and times for the periodicity one-off meeting and send Doodle Poll to LPs.	Triangle / City Light	Done by HSC Small Group

INSTREAM FLOW MODEL DEVELOPMENT STUDY
INTERIM REPORT

ATTACHMENT S

HSC WORKSHOP 5 MATERIALS

Seattle City Light

MEETING AGENDA

Skagit Hydroelectric Project Relicensing Meeting

Habitat Suitability Criteria and Periodicity – Status Update Meeting

February 3, 2022, 1:00 PM to 4:00 PM

WebEx Link: Click here to join the meeting

Meeting Number: 2550 365 0017

Meeting password: CMdwnnnZ937

Or call in: +1-510-338-9438

Call in Password: 26396669

MEETING OBJECTIVES:

- **HSC Development Summary** – The preliminary recommended HSC curves resulting from the HSC Technical Group work sessions will be reviewed.
- **Periodicity Development Summary** – Provide an update on the preliminary recommended Periodicity Table resulting from the Periodicity Technical Group work sessions.

RESOURCES

- NOA Commitments Table
- Work Group Discussion Tracker
- HSC/Periodicity Technical Small Group Meeting Materials Folder
- Preliminary HSC Summary Excel Workbook and Updated Periodicity Table
- Previous Meeting Summary from 11/02/2021

FACILITATION TEAM

Joy Juelson, Triangle Associates, Facilitation
Alex Sweetser, Triangle Associates, Documentation

AGENDA

Agenda Topic Goals: I=Information, A=Advise, C= Concurrence

1:00 – 1:15 p.m. (15 min)	▪ **Introductions**– *Facilitator (Triangle) and Ty Ziegler (HDR)* ▪ Roll Call Introduction ▪ Previous Meeting Summary ▪ Context of HSC/Periodicity Technical Small Group
1:15 – 1:20 p.m. (5 min)	**Review Agenda, Meeting Objectives, and Background –** *Ty Ziegler (HDR), Erin Lowery (SCL)* ▪ Review Meeting Objectives and Agenda
1:20 – 3:20 p.m. (120 min)	**HSC Development Summary** –*Ty Ziegler (HDR), Erin Lowery (SCL), and Tim Hardin (Consultant)* ***(I and C)*** ▪ Provide an overview of the HSC evaluation process. ▪ Review preliminary recommended HSC curves by species.
3:20 – 3:35 p.m. (15 min)	**Break –** Floating break during HSC agenda item

3:35 – 3:50 p.m. (15 min)	**Periodicity Development Summary** – *Ty Ziegler (HDR), Erin Lowery (SCL), and Tim Hardin (Consultant)* ***(I)*** ▪ Provide an overview of the Periodicity evaluation process. ▪ Status update on preliminary recommended Periodicity by species.
3:50 – 4:00 p.m. (10 min)	**Schedule, Action Items, Next Steps** – *Facilitator (Triangle) and meeting participants* ▪ Study recommendations and schedule ▪ Review meeting action items ▪ Next steps
4:00 p.m.	**Meeting Adjourned**