



# Eklutna Hydroelectric Project Preliminary 2D Model Instream Flow Analysis

Technical Work Group Meeting  
February 13, 2023



# Study Goals (from Section 3.1 of the FSP (MJA 2021))

- “...the stated goal of the Instream Flow Study is to provide quantitative indices of current and potential future reach specific fish habitat-flow relationships and utilize those relationships for determining fish habitat under various alternative operational scenarios.”

# Steps Previously Completed to Support Goals

- Defined Fish Habitat-Flow Relationships via one-dimensional (1D) PHABSIM modeling
  - Based on 3 flow releases – 25 cfs, 75 cfs, and 150 cfs
  - Model extrapolation range – 10 – 375 cfs
- Completed flow analysis using four example flow levels (Level 1, 2, 3 and 4) and three flow release options (A,B,C)
  - Flow levels 1,2,3,and 4 provide 90%, 70%, 50% and 30% of maximum habitat considering three target species (Chinook, Coho, and Sockeye) and two life stages (spawning, and juvenile rearing (Chinook and Coho only)).
  - Option A – below Eklutna Dam; B – below AWWU portal; C – below drainage valve
- Compared habitat gains between the four flow levels and options and with baseline (no flow release) conditions
- Evaluated Potential Fish Barrier Conditions at 5 Locations

# Additional Steps to Support Goals

- Developed a 2D HEC-RAS hydraulic model for Reaches 10, 6, 4 and 3 (per Year 2 Study Plan)
- Defined Fish Habitat-Flow Relationships via 2D GIS-based PHABSIM modeling (focused on juvenile rearing habitat)
  - Model extrapolation range – 10 – 375 cfs
- Completed separate 2D AND Combined 1D and 2D flow analysis using four example flow levels (Level 1, 2, 3 and 4) and three flow release options (A,B,C)
- Compared habitat gains between the four flow levels and options and with baseline (no flow release) conditions

# Conclusions

- Confirms utility of the 2D HEC-RAS and habitat modeling and 1D PHABSIM for considering and balancing fish habitat needs
- Time series analysis – effective means for comparing flow releases and habitat gains
- Results indicate substantial spawning and juvenile rearing habitats can be provided via flow releases.
- *Other studies (geomorphology/sediment transport modeling, and operations modeling) needed to balance fish habitat and other water uses in the Eklutna Basin*
- Results have the most direct applicability to the current conditions and channel morphologies of the Eklutna River.

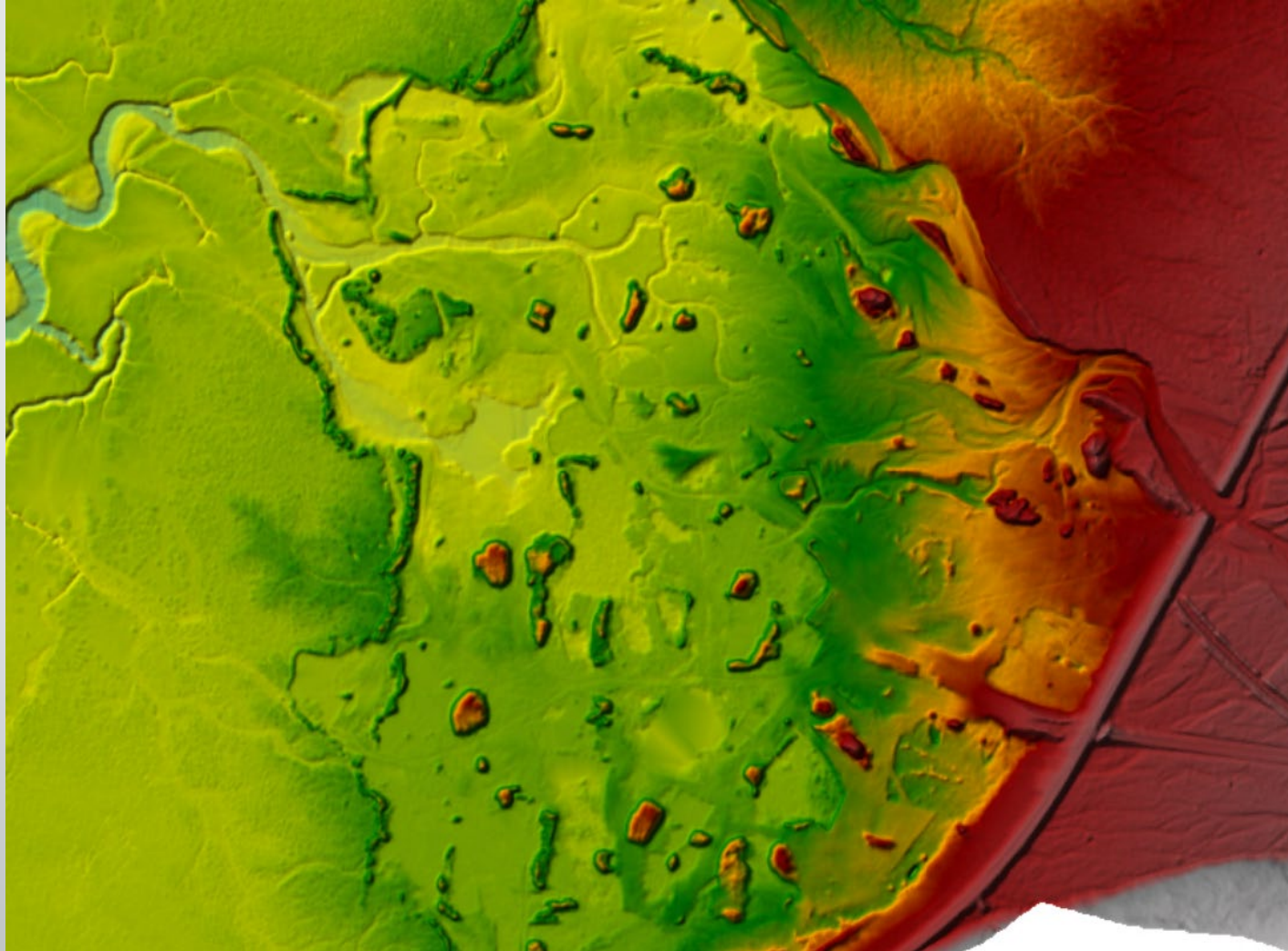
# 2D Modeling

- *Habitat-flow information missing for several reaches of the Eklutna River (R3, R4, R6, R10). These reaches were not analyzed using 1D PHABSIM approach for one or more of the following reasons:*
  - *Hydraulic complexity (Reaches 3 and 4)*
  - *Channel instability (Reaches 3, 4, and 6)*
  - *Access during 2021 flow releases (Reaches 6 and 10)*
- *2D Modeling was initiated to "fill the knowledge gaps".*

# Reach 3 – Hydraulic Complexity



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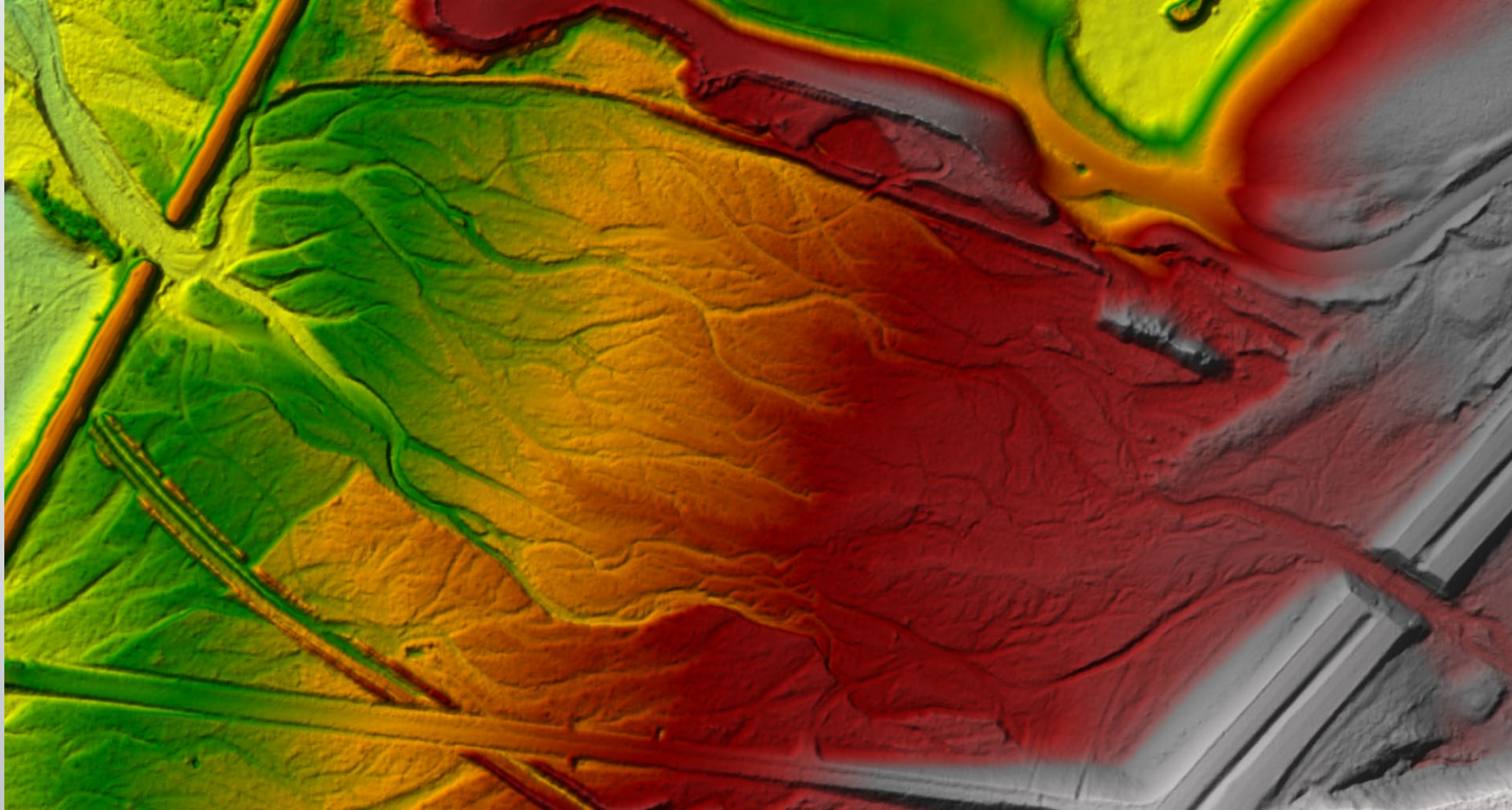




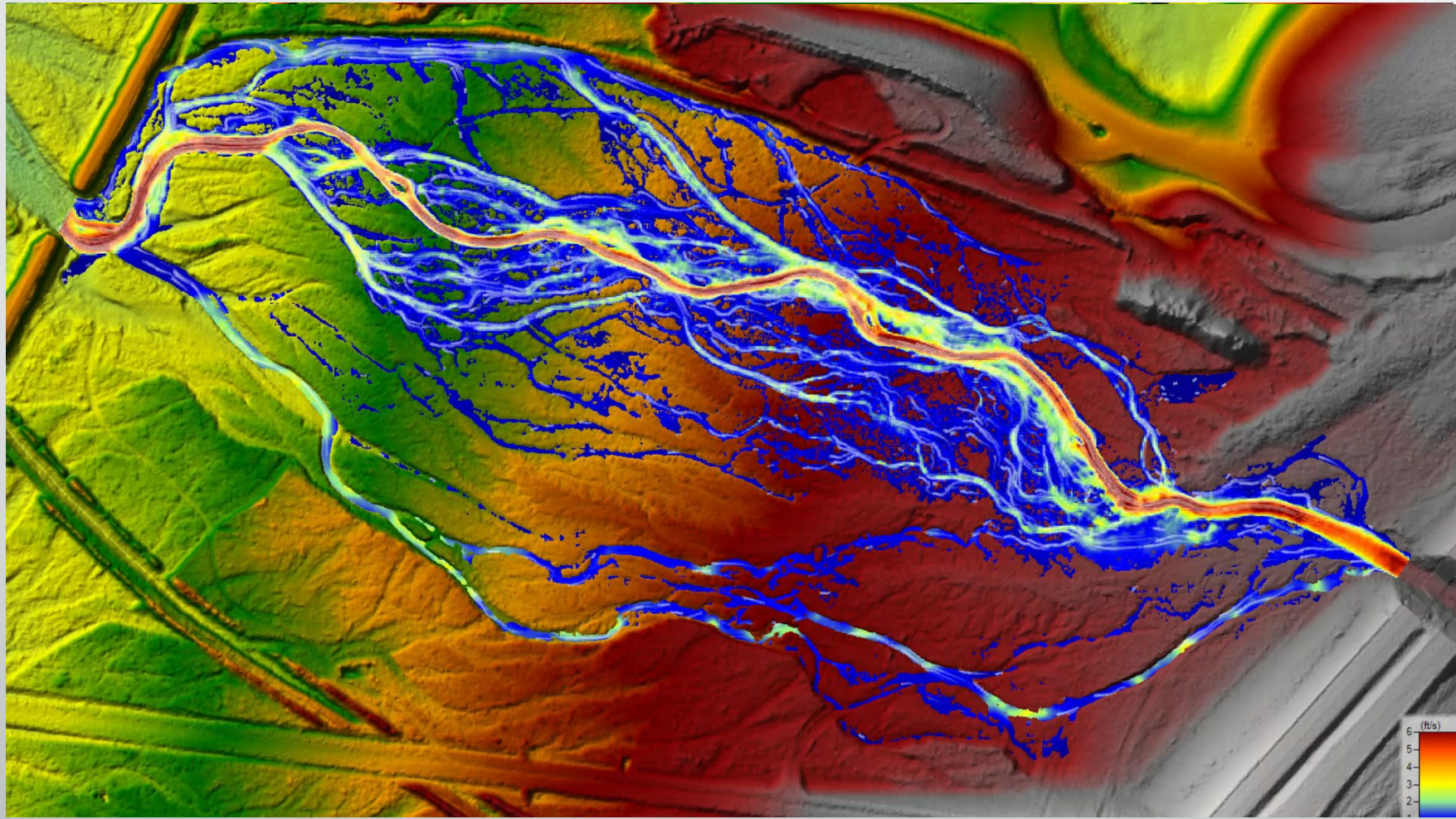
# Reach 4- Hydraulic Complexity



# Reach 4- Hydraulic Complexity



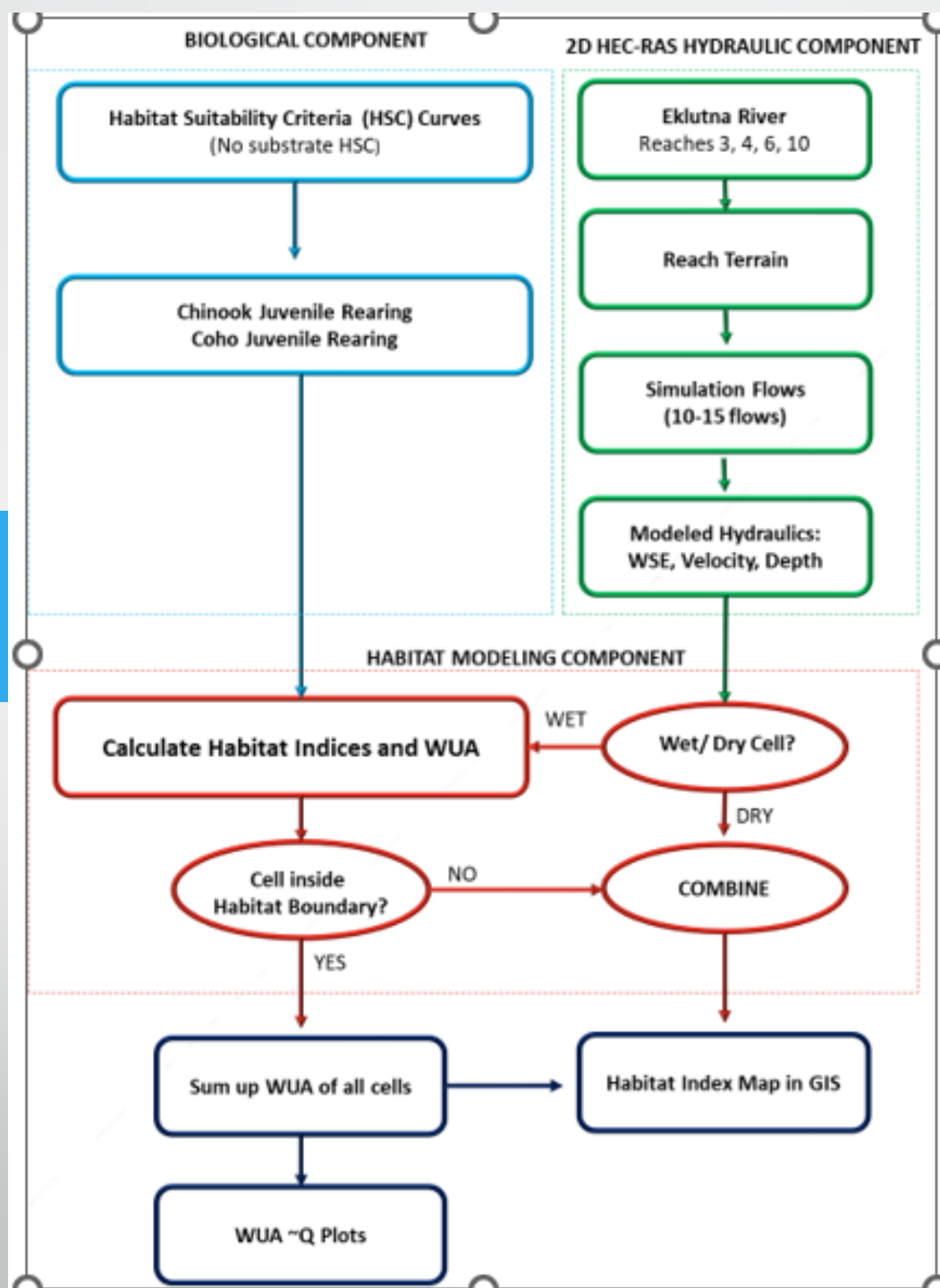
# Results Example (Reach 4 -300 CFS)



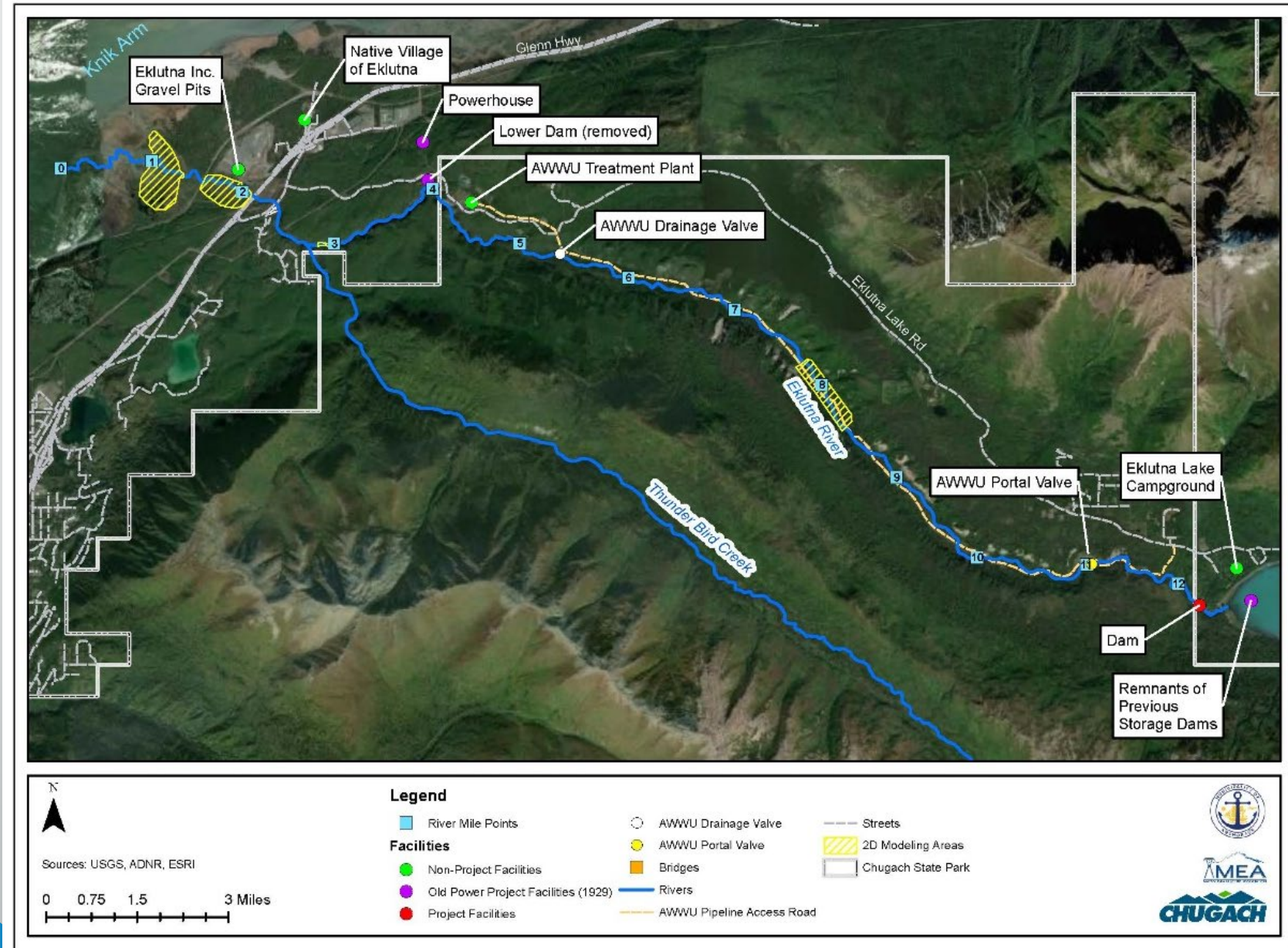
# 2D Modeling

- *Four separate 2D models constructed for reaches 3, 4, 6, and 10.*
  - *2022 LiDAR data used to create elevation terrain used for model.*
- *Models calibrated to match observed water surface elevations.*
- *Various flows analyzed using 2D model.*
  - *10-375 cfs for instream flow analysis*
  - *375-1500 cfs for sediment analysis.*
- *Depth and velocity results produced and used in 2D habitat modeling and Geomorphology/Sediment transport modeling (K.Dube).*

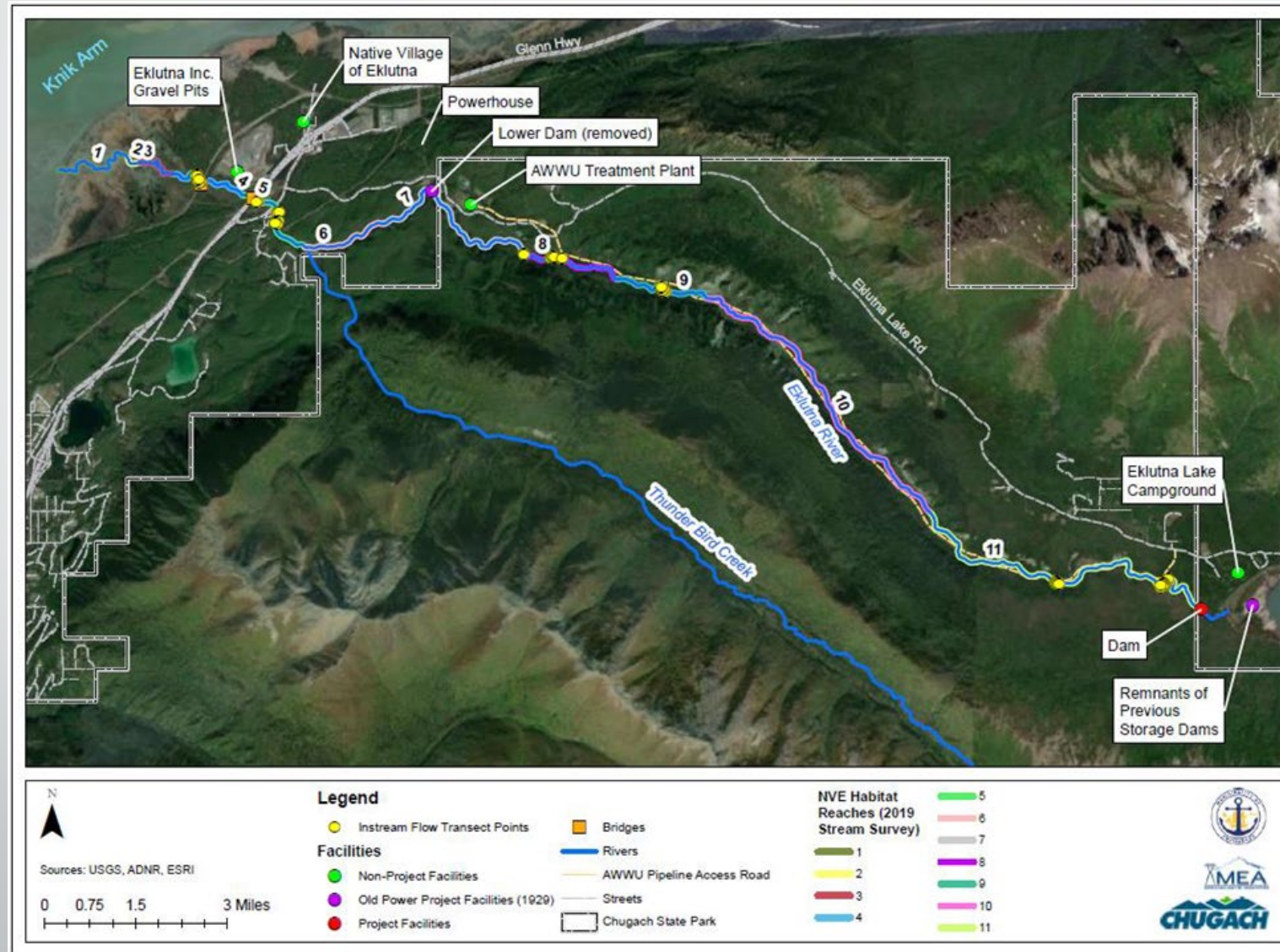
## Process and Components of 2D HEC-RAS Hydraulic and Habitat Modeling



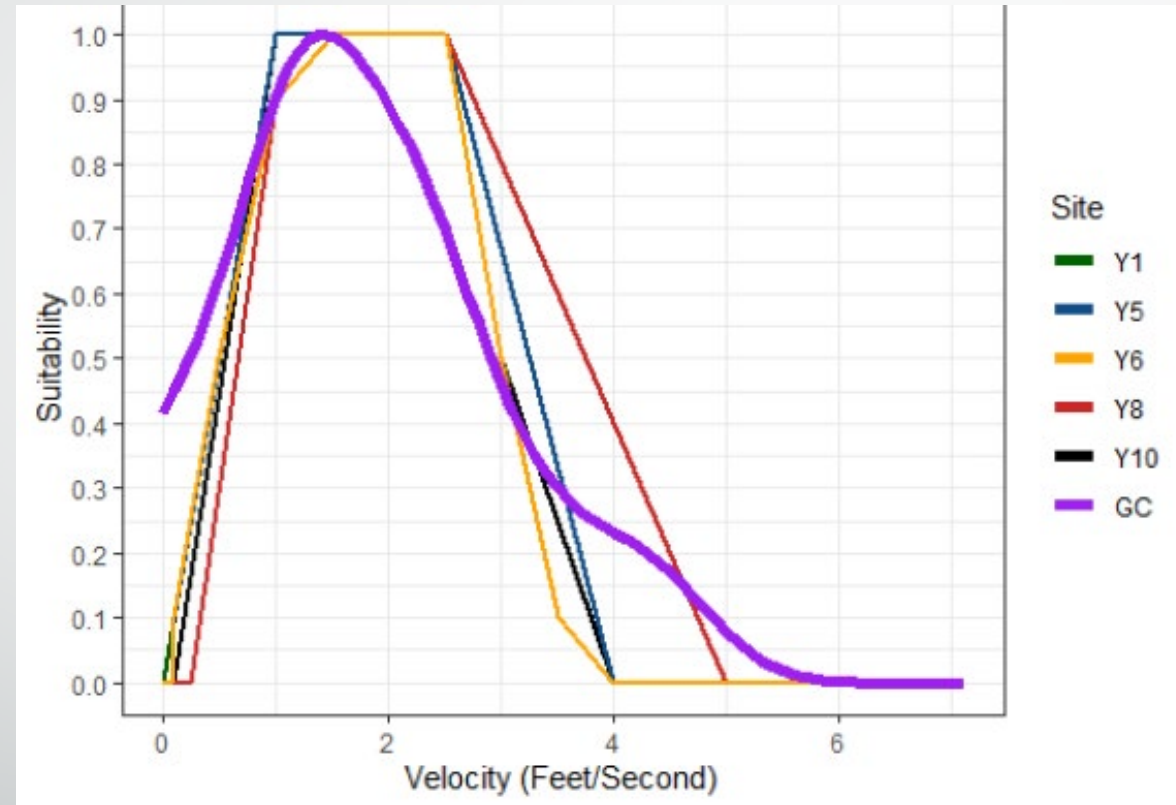
# Study Reaches of the 2D Modeling (R3, R4, R6, R10)



# Study Reaches and Instream Flow Transect Locations



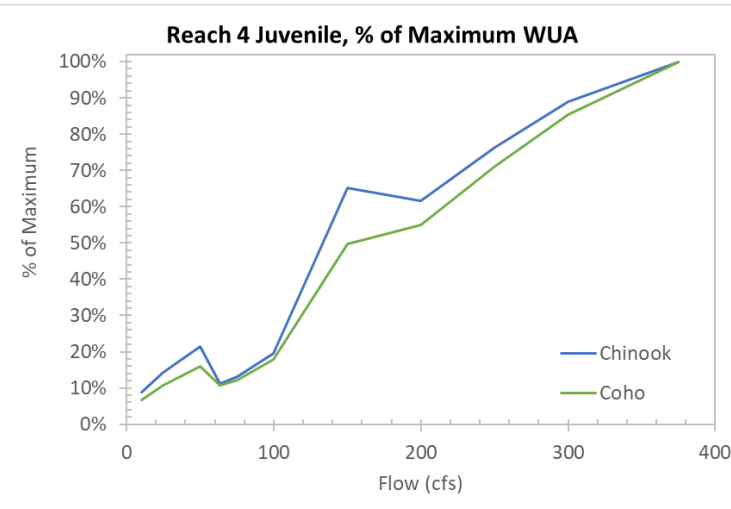
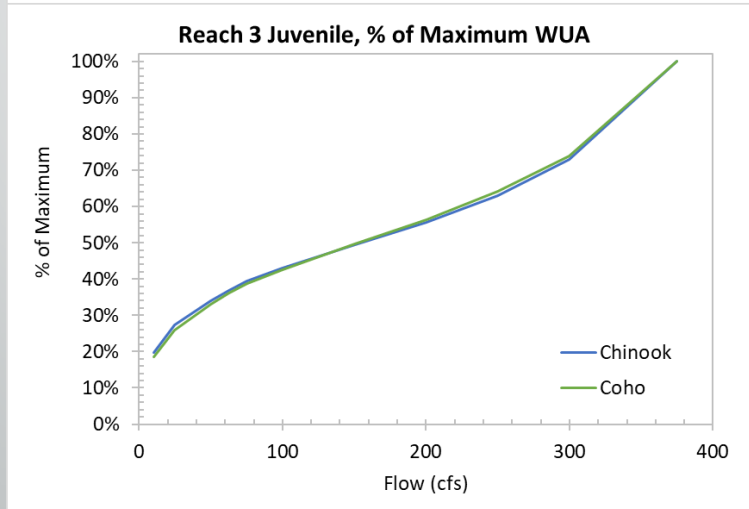
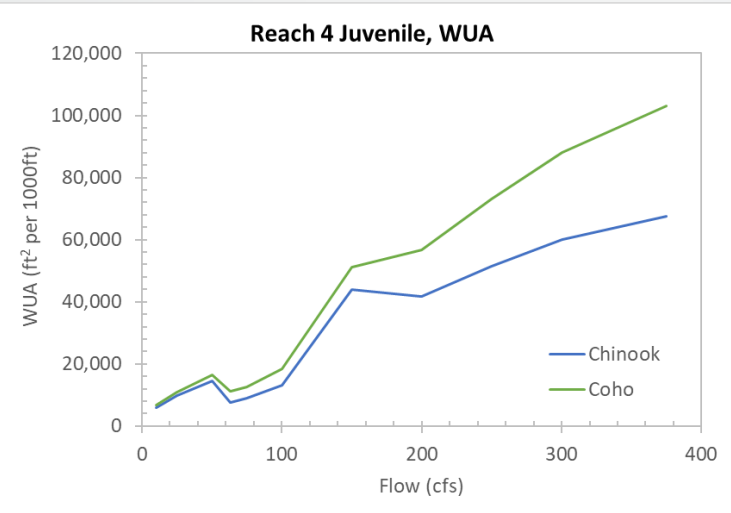
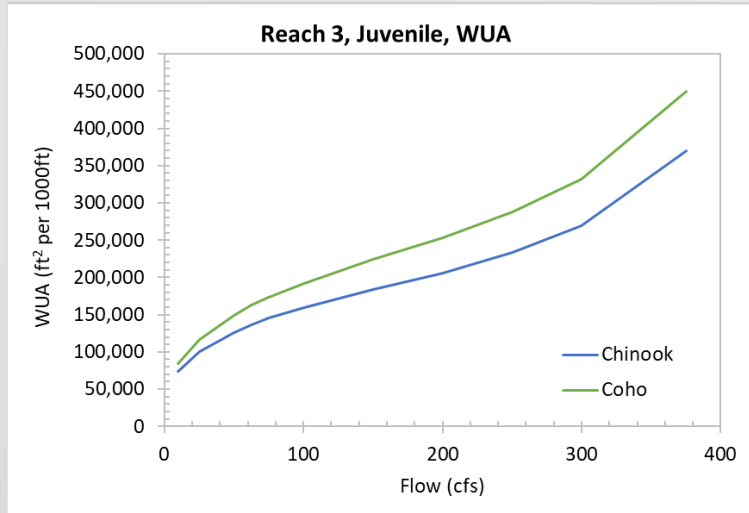
# Example Habitat Suitability Criteria (HSC) curve for Coho Salmon



The purple curve was selected and based on Grant Creek data.  
Other curves from other Alaska streams



# Reach 3 and 4 Habitat-flow Curves

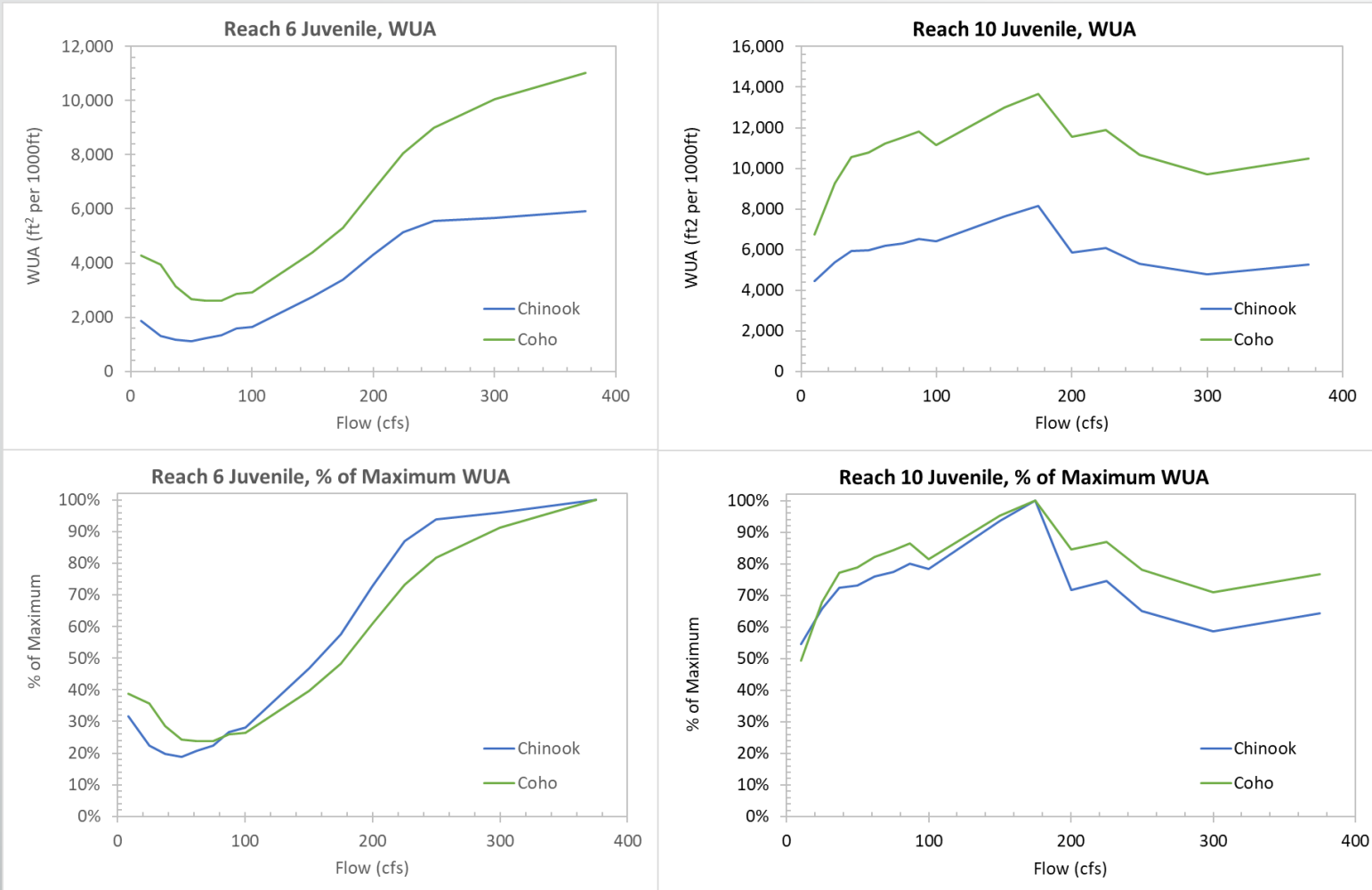


Habitat-flow as sq ft/1000ft of stream

Note - Reach 3 and 4 are below Thunderbird Creek and were not used in setting flow levels but were considered in the time series analysis.

Habitat-flow relationships for Chinook and Coho juvenile rearing habitat for Reach 3 (left panels) and Reach 4 (right panels) produced from 2D habitat modeling. Relationships of habitat area to flow are shown in the upper figures; lower figures depict the same data normalized as a percentage of habitat maximum to flow.

# Reach 6 and 10 Habitat-flow Curves

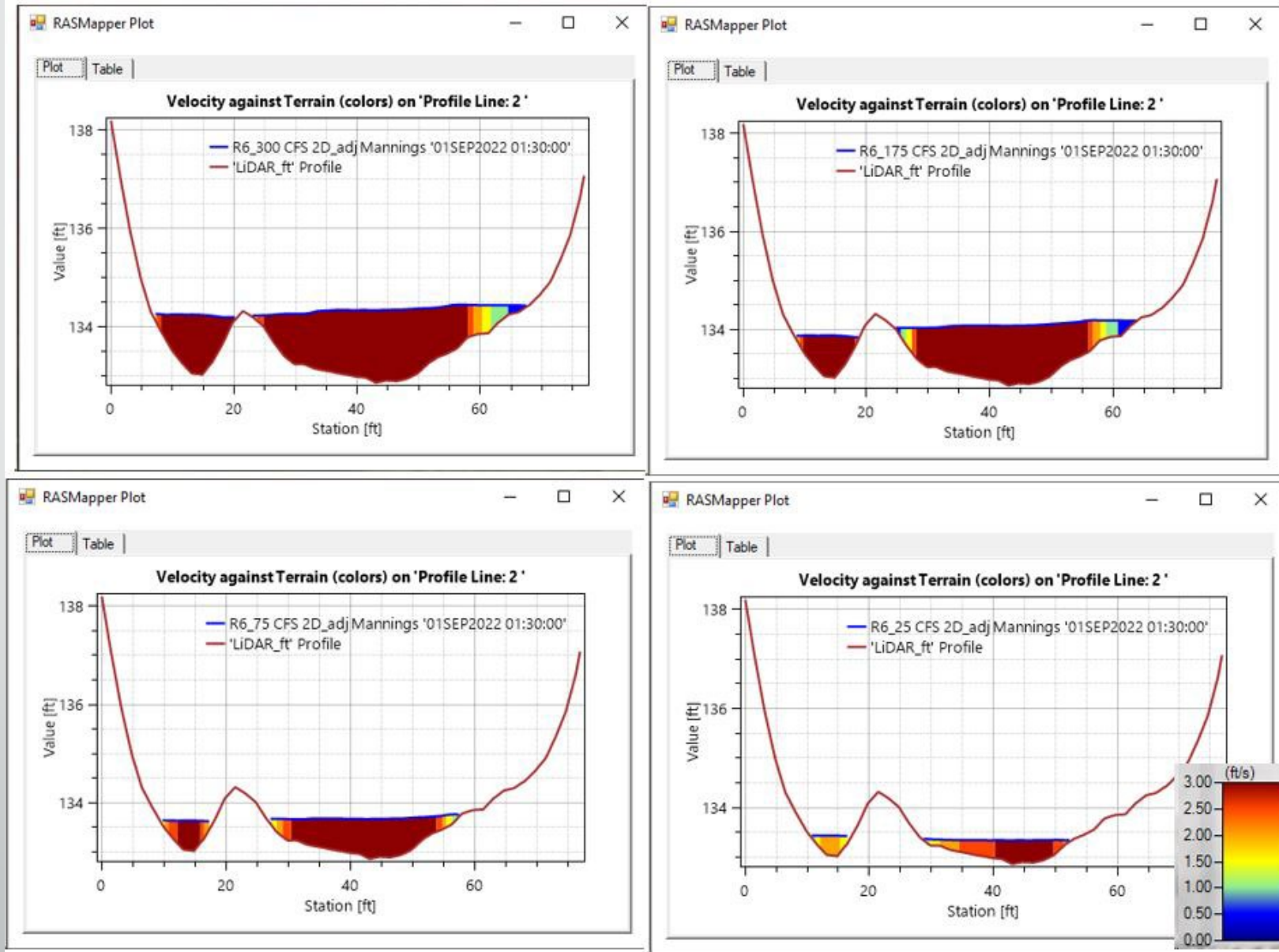


Habitat-flow as sq  
ft/1000ft of stream

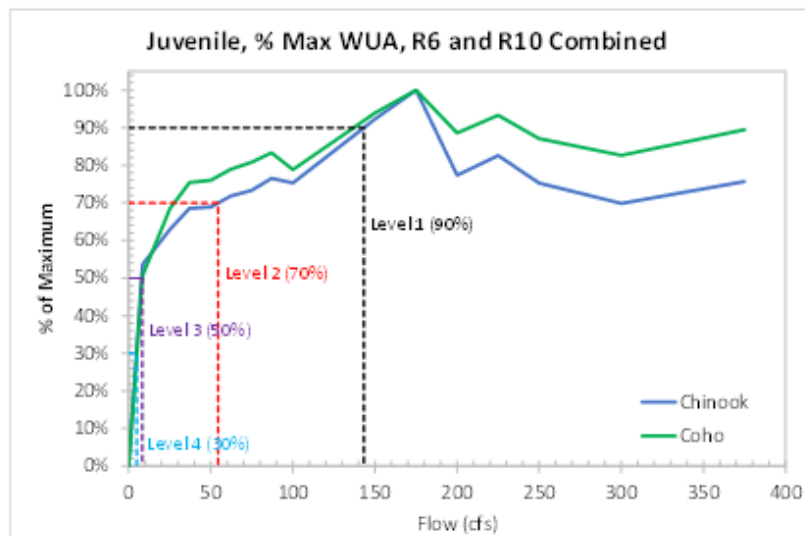
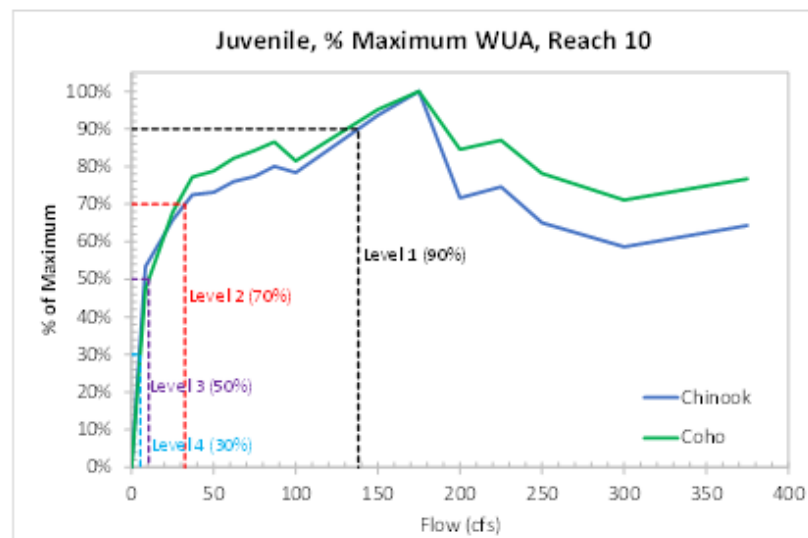
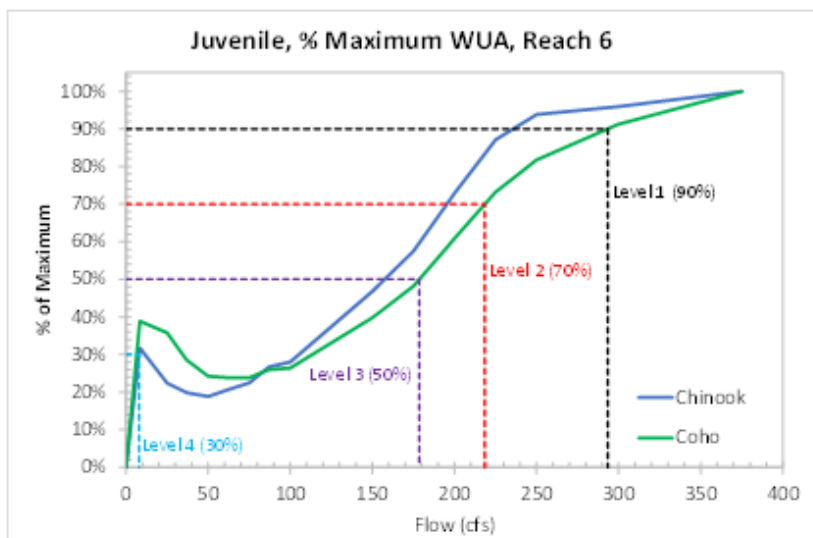
**Note - Reach 6 and 10  
are above Thunderbird  
Creek and were used in  
setting the four flow  
levels and were also  
considered in the time  
series analysis.**

Habitat-flow relationships for Chinook and Coho juvenile rearing habitat for Reach 3 (left panels) and Reach 4 (right panels) produced from 2D habitat modeling. Relationships of habitat area to flow are shown in the upper figures; lower figures depict the same data normalized as a percentage of habitat maximum to flow.

# Variation of velocity under four flow conditions (300 cfs – upper left, 175 cfs – upper right, 75 cfs – lower left, 25 cfs – lower right) for a subsection of R6 of the Eklutna River



# Example Flow Release Levels –R6, R10 and Composited



Example flow release levels based on river reaches above Thunderbird Creek

Normalized habitat vs. flow relationships for juvenile rearing showing the Level 1 – 90%, Level 2 – 70%, Level 3 – 50%, and Level 4 – 30% example flow levels identified for the flow release schedules. Flow levels are displayed separately for R6 and R10 (upper figures) and composited for R6 and R10 (lower figure).

# Fish Species Use Timing

## 2D modeling focused on juvenile rearing

Life Stage	Species	Month												
		J	F	M	A	M	J	J	A	S	O	N	D	
Adult Migration	Coho									■	■	■		
	Chinook							■	■	■				
	Sockeye*							■	■	■				
Adult Spawning	Coho									■	■	■		
	Chinook							■	■	■				
	Sockeye*								■	■	■			
Egg Incubation and Emergence *	Coho	■	■	■	■	■					■	■	■	■
	Chinook	■	■	■	■	■		■	■	■	■	■	■	■
	Sockeye	■	■	■	■	■			■	■	■	■	■	■
Juvenile Rearing (parr)	Coho	■	■	■	■	■	■	■	■	■	■	■	■	■
	Chinook	■	■	■	■	■	■	■	■	■	■	■	■	■
	Sockeye*													
Juvenile Outmigration *	Coho						■	■	■					
	Chinook						■	■	■					
	Sockeye						■	■	■					

\* Not assessed during 2021 River Fish Sampling. Data presented from USACE (2011)

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# Two Time Series Analyzed

- Time Series A – based on 2D Juvenile Habitat Analysis for all 12 months
- Time Series B – incorporate results from both 2D Juvenile habitat analysis and 1D PHABSIM spawning habitat analysis
- Option C applied the same flow release schedules used for Option B (based on composited results from R10 and R6) rather than basing solely on R6 results:
  - R6 does not contain representative off-channel juvenile rearing habitat – channel is confined and flows through a narrow relatively steep canyon that lacks a broad floodplain and complex side-channel and off-channel habitats.
  - R6 habitat-flow relationships show little juvenile rearing habitat and what is available is primarily limited to fringe/channel margins.
  - Use of R6 alone for setting flow releases would not be biologically justified.

# Flow Releases – Time Series A

Scenario		Flow <sup>1</sup> Released to Eklutna River (cfs)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline		0	0	0	0	0	0	0	0	0	0	0	0
Option A	Flow Level 1	143	143	143	143	143	143	143	143	143	143	143	143
	Flow Level 2	54	54	54	54	54	54	54	54	54	54	54	54
	Flow Level 3	8	8	8	8	8	8	8	8	8	8	8	8
	Flow Level 4	5	5	5	5	5	5	5	5	5	5	5	5
Option B	Flow Level 1	143	143	143	143	143	143	143	143	143	143	143	143
	Flow Level 2	54	54	54	54	54	54	54	54	54	54	54	54
	Flow Level 3	8	8	8	8	8	8	8	8	8	8	8	8
	Flow Level 4	5	5	5	5	5	5	5	5	5	5	5	5
Option C	Flow Level 1	143	143	143	143	143	143	143	143	143	143	143	143
	Flow Level 2	54	54	54	54	54	54	54	54	54	54	54	54
	Flow Level 3	8	8	8	8	8	8	8	8	8	8	8	8
	Flow Level 4	5	5	5	5	5	5	5	5	5	5	5	5

Note 1: These data are based on the modeled habitat-flow relationships developed during 1D and 2D instream flow modeling. There may be limitations of existing or potential-future infrastructure to deliver flows of this magnitude to the river. These limitations will be discussed in the Engineering Feasibility Report.

# Flow Releases Time Series B

Scenario		Flow <sup>1</sup> Released to Eklutna River (cfs)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline		0	0	0	0	0	0	0	0	0	0	0	0
Option A	Flow Level 1	143	143	143	143	143	143	102	102	102	102	143	143
	Flow Level 2	54	54	54	54	54	54	30	30	30	30	54	54
	Flow Level 3	8	8	8	8	8	8	18	18	18	18	8	8
	Flow Level 4	5	5	5	5	5	5	13	13	13	13	5	5
Option B	Flow Level 1	143	143	143	143	143	143	99	99	99	99	143	143
	Flow Level 2	54	54	54	54	54	54	25	25	25	25	54	54
	Flow Level 3	8	8	8	8	8	8	17	17	17	17	8	8
	Flow Level 4	5	5	5	5	5	5	12	12	12	12	5	5
Option C	Flow Level 1	143	143	143	143	143	143	99	99	99	99	143	143
	Flow Level 2	54	54	54	54	54	54	25	25	25	25	54	54
	Flow Level 3	8	8	8	8	8	8	17	17	17	17	8	8
	Flow Level 4	5	5	5	5	5	5	12	12	12	12	5	5

Note 1: These data are based on the modeled habitat-flow relationships developed during 1D and 2D instream flow modeling. There may be limitations of existing or potential-future infrastructure to deliver flows of this magnitude to the river. These limitations will be discussed in the Engineering Feasibility Report.



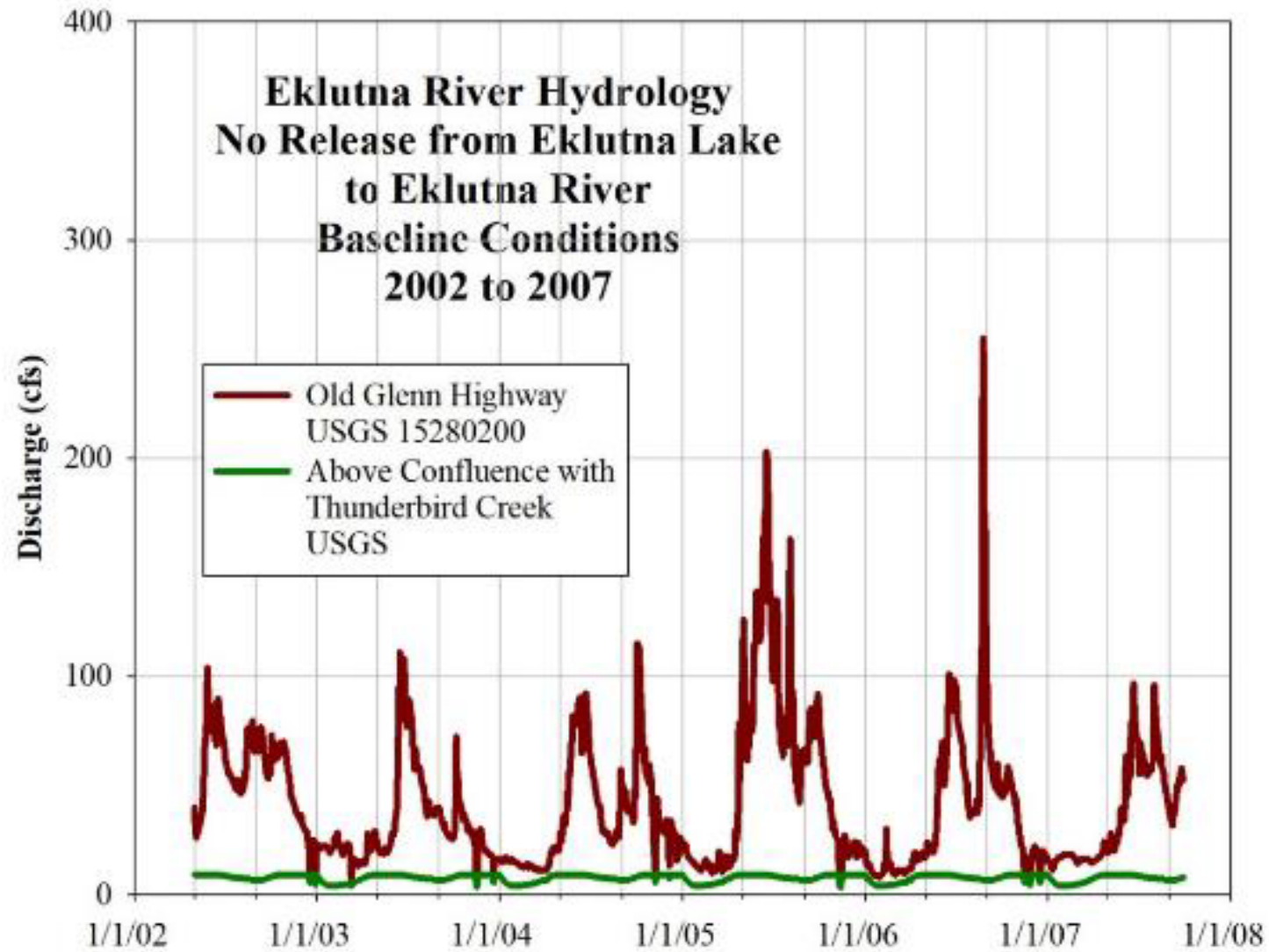
## Time Series B – time averaged habitats for juvenile rearing and spawning for three flow release options

Scenario		Time-Averaged Habitat Expressed as Weighted Usable Area (acres)				
		Chinook		Coho		Sockeye
		Spawning	Juvenile Rearing	Spawning	Juvenile Rearing	Spawning
Baseline		0.5	11.9	1.2	14.8	1.0
Option A	Flow Level 1	1.5	30.6	3.1	41.3	2.5
	Flow Level 2	1.4	22.6	3.1	30.4	2.7
	Flow Level 3	1.2	17.6	2.8	22.8	2.4
	Flow Level 4	1.0	16.2	2.6	20.8	2.2
Option B	Flow Level 1	1.2	28.1	2.4	37.5	2.1
	Flow Level 2	1.1	20.4	2.5	27.2	2.3
	Flow Level 3	1.0	16.3	2.4	21.0	2.1
	Flow Level 4	0.9	15.2	2.2	19.4	1.9
Option C	Flow Level 1	0.5	22.9	1.4	29.0	1.3
	Flow Level 2	0.6	16.0	1.6	20.6	1.5
	Flow Level 3	0.6	13.3	1.6	16.9	1.5
	Flow Level 4	0.6	12.9	1.5	16.3	1.5

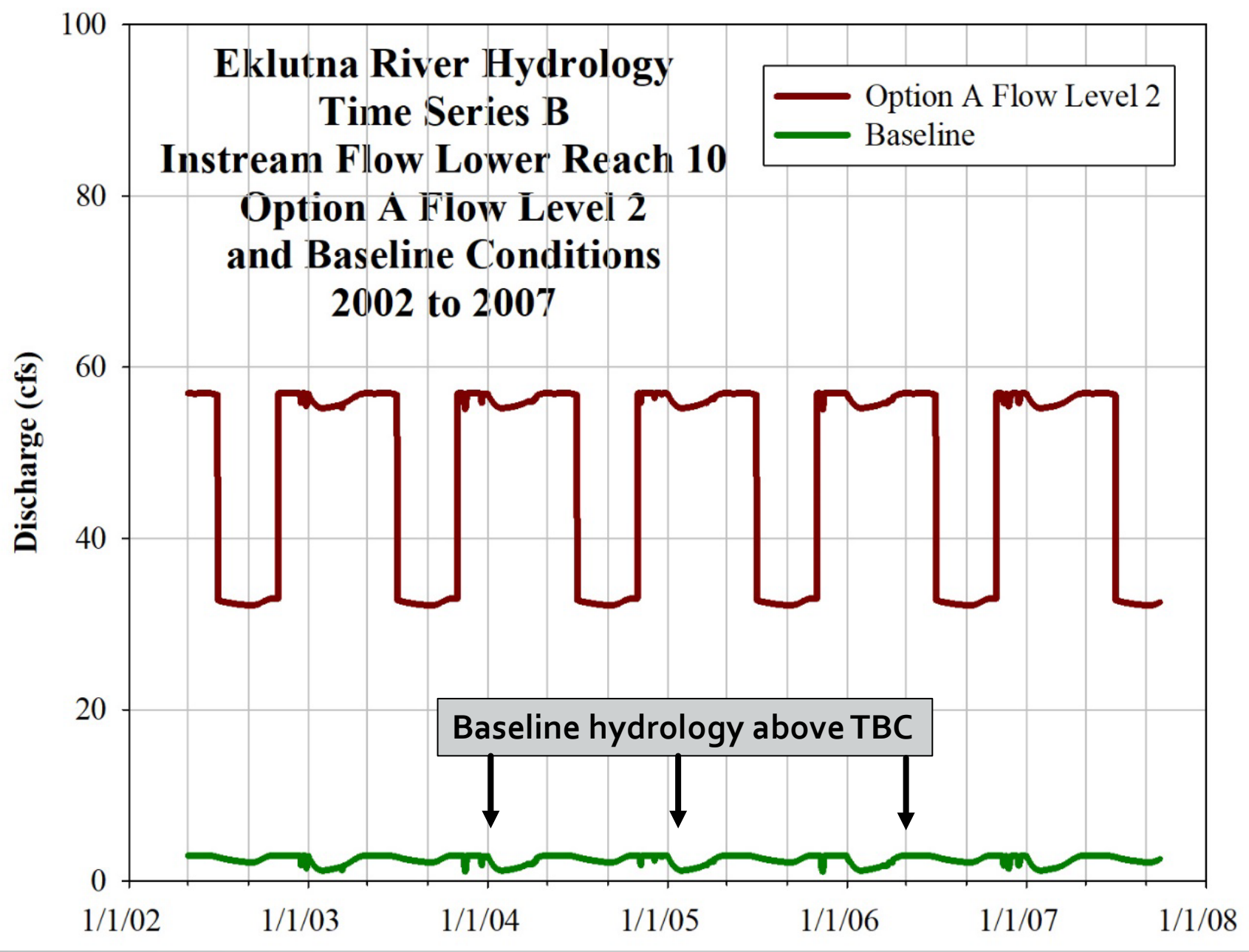
Note: The Level 1, Level 2, Level 3, and Level 4 releases represent flows that provide 90%, 70%, 50%, and 30% of the maximum habitat as determined from the habitat vs. flow relationships for Chinook, Coho, and Sockeye salmon.

## Time Series B – time averaged habitats expressed as percentage (%) increases above baseline for juvenile rearing and spawning for three flow release options

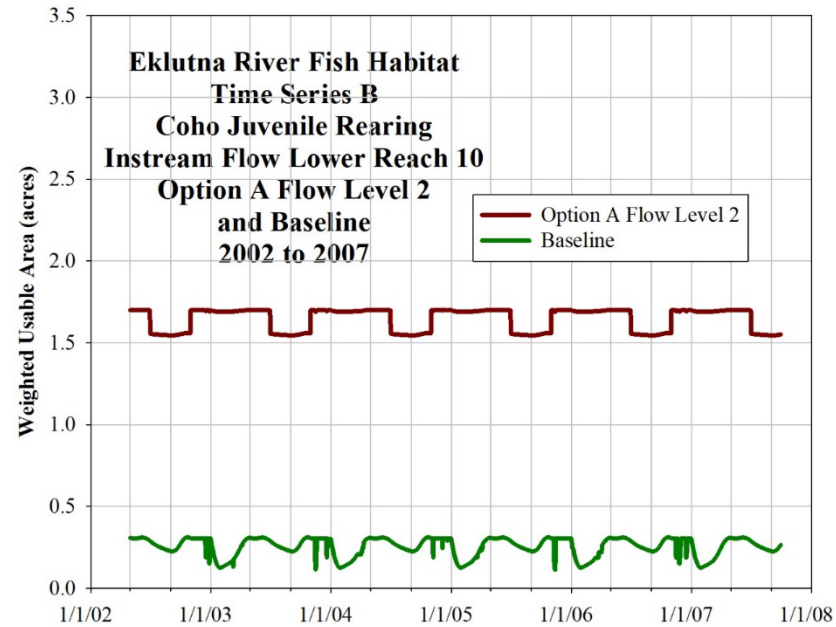
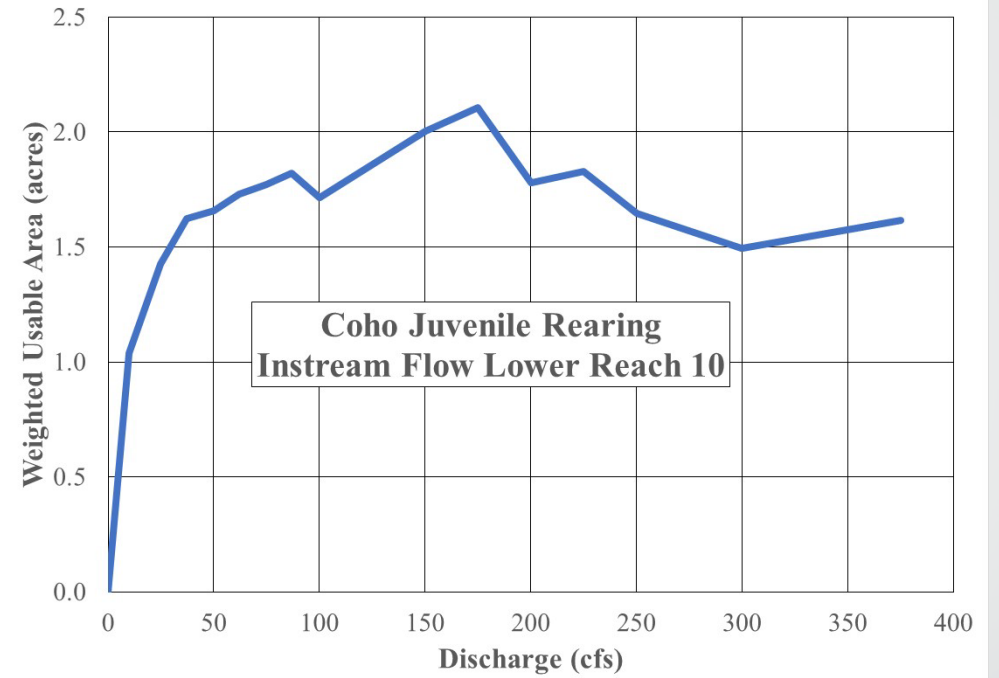
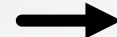
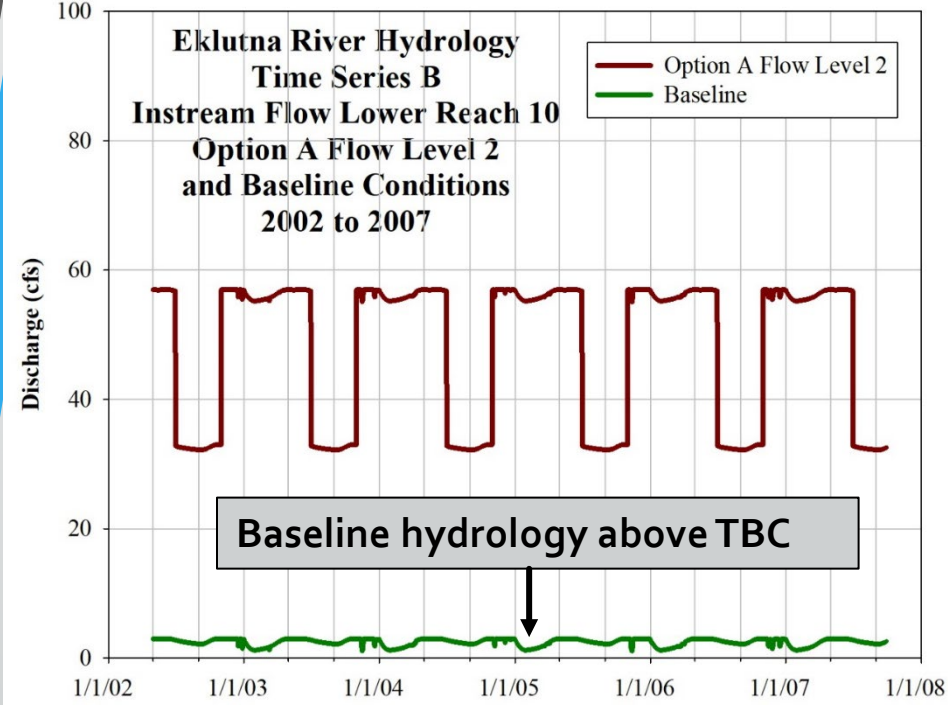
Scenario		Time-Averaged Habitat Expressed as Percent Increase above Baseline				
		Chinook		Coho		Sockeye
		Spawning	Juvenile Rearing	Spawning	Juvenile Rearing	Spawning
Baseline		0%	0%	0%	0%	0%
Option A	Flow Level 1	200%	160%	170%	180%	150%
	Flow Level 2	170%	90%	160%	110%	170%
	Flow Level 3	130%	50%	140%	50%	140%
	Flow Level 4	100%	40%	120%	40%	110%
Option B	Flow Level 1	130%	140%	110%	150%	100%
	Flow Level 2	120%	70%	120%	80%	130%
	Flow Level 3	100%	40%	100%	40%	110%
	Flow Level 4	70%	30%	90%	30%	90%
Option C	Flow Level 1	0%	90%	20%	100%	30%
	Flow Level 2	30%	30%	40%	40%	50%
	Flow Level 3	20%	10%	30%	10%	50%
	Flow Level 4	20%	10%	30%	10%	50%



Baseline hydrology above TBC



# Time Series Analysis



## Time Series A – 2D Juvenile Habitat Under Three Flow Release Options Expressed as Areas (left) and as Percentage Increases Above Baseline (right)

Scenario		Time-Averaged Habitat Expressed as Weighted Usable Area (acres)		Scenario		Time-Averaged Habitat Expressed as Percent Increase above Baseline	
		Juvenile Rearing				Juvenile Rearing	
		Chinook	Coho			Chinook	Coho
Baseline		11.0	13.3	Baseline		0%	0%
Option A	Flow Level 1	23.8	30.5	Option A	Flow Level 1	120%	130%
	Flow Level 2	16.8	21.4		Flow Level 2	50%	60%
	Flow Level 3	12.8	15.8		Flow Level 3	20%	20%
	Flow Level 4	12.2	15.0		Flow Level 4	10%	10%
Option B	Flow Level 1	23.8	30.5	Option B	Flow Level 1	120%	130%
	Flow Level 2	16.8	21.4		Flow Level 2	50%	60%
	Flow Level 3	12.8	15.8		Flow Level 3	20%	20%
	Flow Level 4	12.2	15.0		Flow Level 4	10%	10%
Option C	Flow Level 1	22.0	27.5	Option C	Flow Level 1	100%	110%
	Flow Level 2	15.4	18.9		Flow Level 2	40%	40%
	Flow Level 3	12.0	14.5		Flow Level 3	10%	10%
	Flow Level 4	11.7	14.1		Flow Level 4	10%	10%

## Time Series B – 2D Juvenile Habitat and 1D Spawning Habitat based Comparison of Fish Habitat Areas for Baseline and Four Example Flow Release Scenarios

Scenario		Time-Averaged Habitat Expressed as Weighted Usable Area (acres)				
		Chinook		Coho		Sockeye
		Spawning	Juvenile Rearing	Spawning	Juvenile Rearing	Spawning
Baseline		0.5	11.9	1.2	14.8	1.0
Option A	Flow Level 1	1.5	30.6	3.1	41.3	2.5
	Flow Level 2	1.4	22.6	3.1	30.4	2.7
	Flow Level $\beta$	1.2	17.6	2.8	22.8	2.4
	Flow Level 4	1.0	16.2	2.6	20.8	2.2
Option B	Flow Level 1	1.2	28.1	2.4	37.5	2.1
	Flow Level 2	1.1	20.4	2.5	27.2	2.3
	Flow Level 3	1.0	16.3	2.4	21.0	2.1
	Flow Level 4	0.9	15.2	2.2	19.4	1.9
Option C	Flow Level 1	0.5	22.9	1.4	29.0	1.3
	Flow Level 2	0.6	16.0	1.6	20.6	1.5
	Flow Level 3	0.6	13.3	1.6	16.9	1.5
	Flow Level 4	0.6	12.9	1.5	16.3	1.5

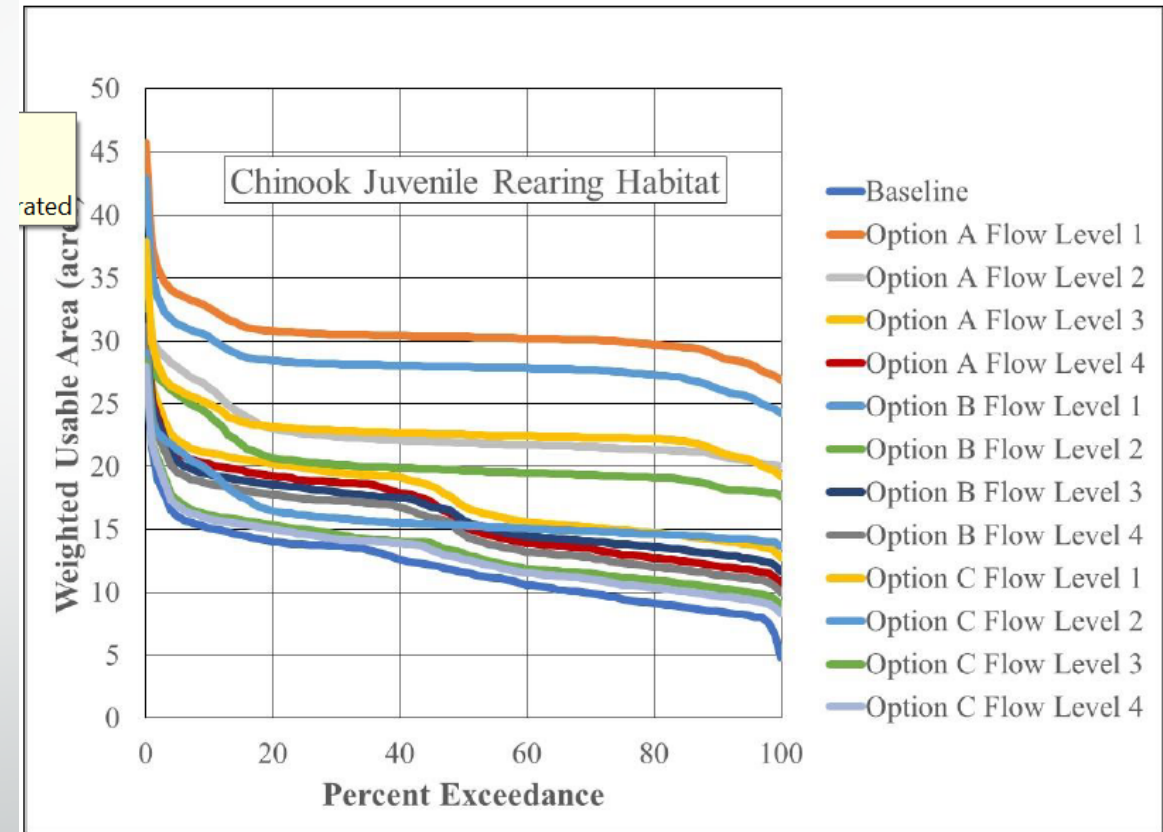
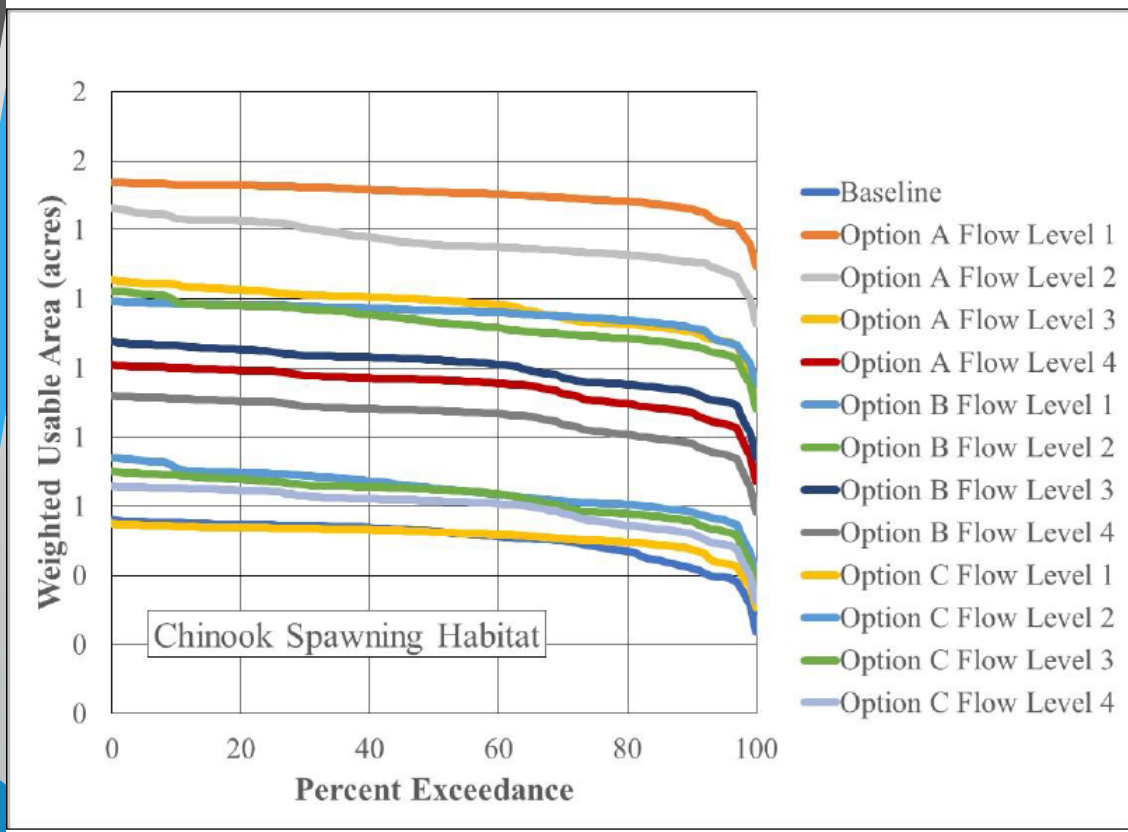
Note: The Level 1, Level 2, Level 3, and Level 4 releases represent flows that provide 90%, 70%, 50%, and 30% of the maximum habitat as determined from the habitat vs. flow relationships for Chinook, Coho, and Sockeye salmon.

# Time Series B - Comparison of Percentage Increases in Fish Spawning and Juvenile Rearing Habitat Areas Over Baseline

Scenario		Time-Averaged Habitat Expressed as Percent Increase above Baseline				
		Chinook		Coho		Sockeye
		Spawning	Juvenile Rearing	Spawning	Juvenile Rearing	Spawning
Baseline		0%	0%	0%	0%	0%
Option A	Flow Level 1	200%	160%	170%	180%	150%
	Flow Level 2	170%	90%	160%	110%	170%
	Flow Level 3	130%	50%	140%	50%	140%
	Flow Level 4	100%	40%	120%	40%	110%
Option B	Flow Level 1	130%	140%	110%	150%	100%
	Flow Level 2	120%	70%	120%	80%	130%
	Flow Level 3	100%	40%	100%	40%	110%
	Flow Level 4	70%	30%	90%	30%	90%
Option C	Flow Level 1	0%	90%	20%	100%	30%
	Flow Level 2	30%	30%	40%	40%	50%
	Flow Level 3	20%	10%	30%	10%	50%
	Flow Level 4	20%	10%	30%	10%	50%



# Habitat Duration Curves – Time Series B



## Comparison of Juvenile Rearing Habitats by Reach with Baseline: habitats expressed as acres and percent of total of entire river

Chinook Juvenile Rearing - Time Series B				
	Baseline		Option A - Level 1	
	Acres	Percent of Total	Acres	Percent of Total
Reach 3	9.7	81%	16.7	55%
Reach 4	1.0	8%	4.1	13%
Reach 5	0.4	3%	0.3	1%
Reach 6	0.2	2%	0.3	1%
Reach 7	0.2	2%	0.9	3%
Reach 8	0.2	2%	0.7	2%
Reach 9	0.1	1%	0.4	1%
Reach 10	0.2	1%	1.8	6%
Reach 11	0.0	0%	5.4	18%
Lower Eklutna	11.0	93%	21.1	69%
Upper Eklutna	0.9	7%	9.5	31%
<b>Total</b>	<b>11.9</b>	<b>100%</b>	<b>30.6</b>	<b>100%</b>

# Conclusions

- Confirms utility of the 2D HEC-RAS and habitat modeling and 1D PHABSIM for considering and balancing fish habitat needs
- Time series analysis – effective means for comparing flow releases and habitat gains
- Results indicate substantial spawning and juvenile rearing habitats can be provided via flow releases.
- *Other studies (geomorphology/sediment transport modeling, and operations modeling) needed to balance fish habitat and other water uses in the Eklutna Basin*
- Results have the most direct applicability to the current conditions and channel morphologies of the Eklutna River.

# 1D PHABSIM Based Flow Releases

Scenario	Flow Released from Eklutna Lake to Eklutna River (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Baseline	0	0	0	0	0	0	0	0	0	0	0	0	
Option A	Flow Level 1	133	133	133	133	133	133	102	102	102	102	133	133
	Flow Level 2	48	48	48	48	48	48	30	30	30	30	48	48
	Flow Level 3	15	15	15	15	15	15	18	18	18	18	15	15
	Flow Level 4	7	7	7	7	7	7	13	13	13	13	7	7
Option B	Flow Level 1	135	135	135	135	135	135	99	99	99	99	135	135
	Flow Level 2	49	49	49	49	49	49	25	25	25	25	49	49
	Flow Level 3	14	14	14	14	14	14	17	17	17	17	14	14
	Flow Level 4	7	7	7	7	7	7	12	12	12	12	7	7
Option C	Flow Level 1	118	118	118	118	118	118	26	26	26	26	118	118
	Flow Level 2	24	24	24	24	24	24	20	20	20	20	24	24
	Flow Level 3	9	9	9	9	9	9	16	16	16	16	9	9
	Flow Level 4	6	6	6	6	6	6	12	12	12	12	6	6

Notes:

Option A – flow released to Eklutna River just downstream from Eklutna Dam

Option B – flow released to Eklutna River about 1.2 miles downstream from Eklutna Dam

Option C – flow released to Eklutna River about 6.8 miles downstream from Eklutna Dam

# Flow Releases Time Series B

Scenario		Flow <sup>1</sup> Released to Eklutna River (cfs)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline		0	0	0	0	0	0	0	0	0	0	0	0
Option A	Flow Level 1	143	143	143	143	143	143	102	102	102	102	143	143
	Flow Level 2	54	54	54	54	54	54	30	30	30	30	54	54
	Flow Level 3	8	8	8	8	8	8	18	18	18	18	8	8
	Flow Level 4	5	5	5	5	5	5	13	13	13	13	5	5
Option B	Flow Level 1	143	143	143	143	143	143	99	99	99	99	143	143
	Flow Level 2	54	54	54	54	54	54	25	25	25	25	54	54
	Flow Level 3	8	8	8	8	8	8	17	17	17	17	8	8
	Flow Level 4	5	5	5	5	5	5	12	12	12	12	5	5
Option C	Flow Level 1	143	143	143	143	143	143	99	99	99	99	143	143
	Flow Level 2	54	54	54	54	54	54	25	25	25	25	54	54
	Flow Level 3	8	8	8	8	8	8	17	17	17	17	8	8
	Flow Level 4	5	5	5	5	5	5	12	12	12	12	5	5

Note 1: These data are based on the modeled habitat-flow relationships developed during 1D and 2D instream flow modeling. There may be limitations of existing or potential-future infrastructure to deliver flows of this magnitude to the river. These limitations will be discussed in the Engineering Feasibility Report.

# CK and CO spawning and juvenile habitat duration curves derived from the total habitat from Reaches 11, 10, 9, 8, 7, 6, 5, 4, and 3 for Time Series B

