The Pebble Project

Fish Resources: Flow-Habitat Studies

February 2, 2012

Dudley W. Reiser

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APC SERVICES, LLC
A subsidiary of Alaska Peninsula Corporation

HDR Alaska

Mine Study Area

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North Fork Koktuli River

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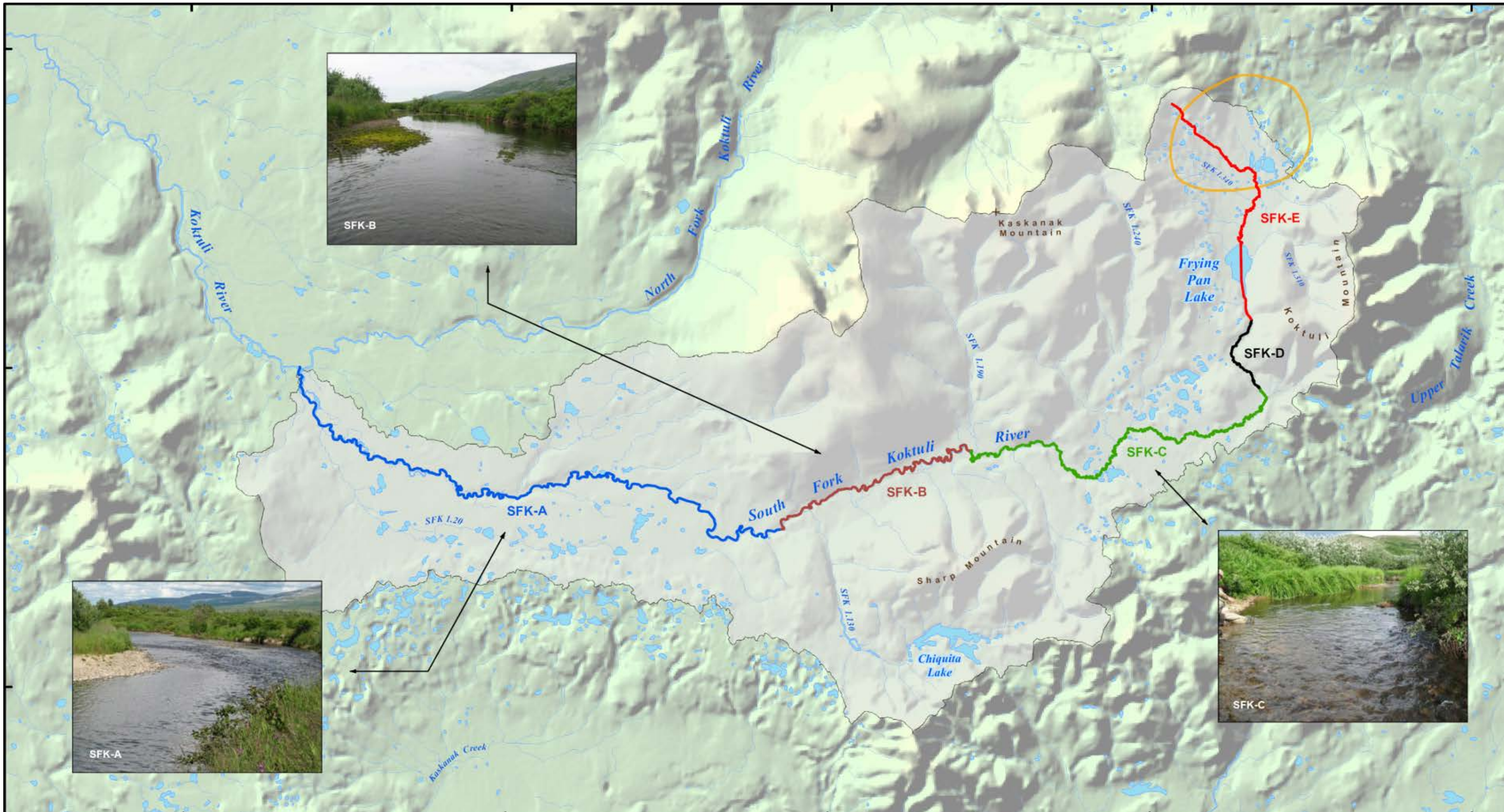
South Fork Koktuli River



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Upper Talarik Creek

Flow-Habitat Studies – topics covered

- **Mainstem Channel Flow Habitat Studies**
- **Off-Channel Flow Habitat Studies**
- **Water Temperature Monitoring/Modeling**
- **Fluvial Geomorphology and Spawning Gravel Quality Studies**

Instream Flow Study Components

- Mainstem Study
  - 1 dimensional PHABSIM modelling
  - Habitat Suitability Curve (HSC) development
  - Develop flow-habitat relationships
  - Estimate habitat quantities under different flows
- Off-channel Habitat (OCH)
  - Classify OCH Types
  - Define relationship between mainstem and OCH flow (Q)
  - Estimate connectivity under different Q

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Instream Flow Study Components

- Water Temperature Monitoring and Modelling
  - Characterize baseline thermal conditions
  - SNTEMP Model development
- Fluvial Geomorphology (channel form and function)
  - Determine channel forming flows and sediment transport characteristics
  - Assess how flow changes may affect channel form and function
  - Assess spawning gravel quality

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Potential Project Flow Related Effects Mainstem-

- No Change - hydrology not affected
- Temporal changes – alteration in the frequency and timing of flow metrics (e.g. peak flows, base flows, etc.)
- Spatial changes – alterations in hydrology at specific locations
- Flow magnitude changes
- Changes in rate of change of flow

Mainstem Flow Study Needs

- Develop an approach that would allow for the determination of when, where, and to what extent changes in flows within streams in the Pebble Project study area influence habitats of important fish species and lifestages – BASELINE CHARACTERIZATION
- Approach needs to consider local hydrologic conditions
- Approach needs to be able to quantify habitats under different flow conditions – locally, longitudinally, cumulatively.
- Approach needs to be adaptable to be able to consider potential flow related project effects.

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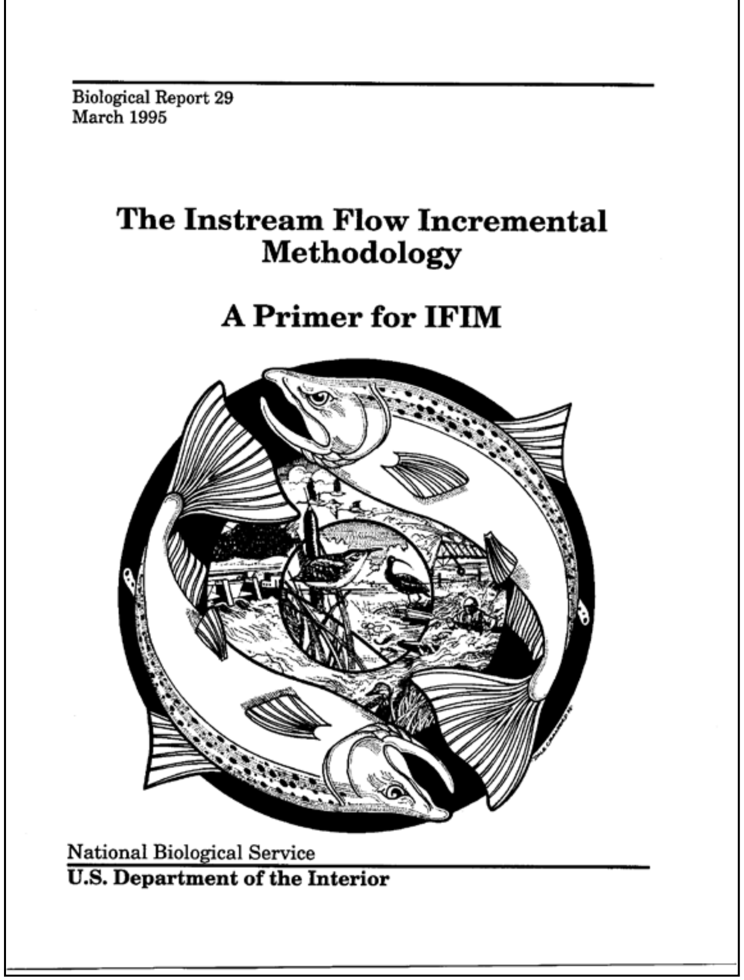
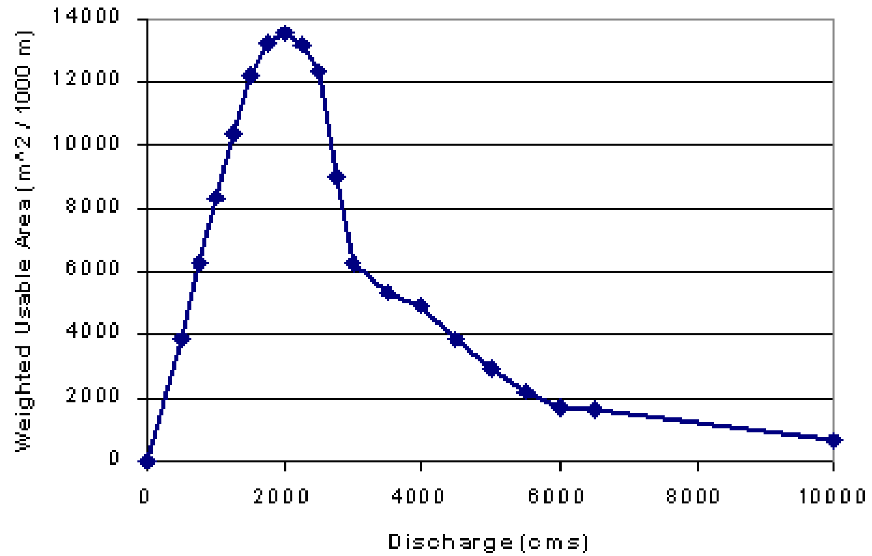

Biological Report 29
March 1995

The Instream Flow Incremental Methodology

A Primer for IFIM

National Biological Service
U.S. Department of the Interior

Primary Approach



Terminology – PHABSIM Physical Habitat Simulation

PHABSIM – is a set of computer programs that is part of the Instream Flow Incremental Methodology (IFIM) (developed by the U.S. Fish and Wildlife Service in the 1970s) that using data collected along cross-channel transects of a stream, provides predictive relationships between flow changes and habitat (termed Weighted Useable Area – WUA)

PHABSIM Components

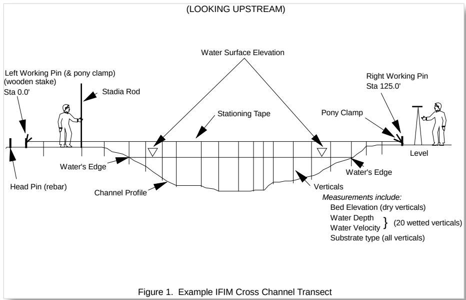
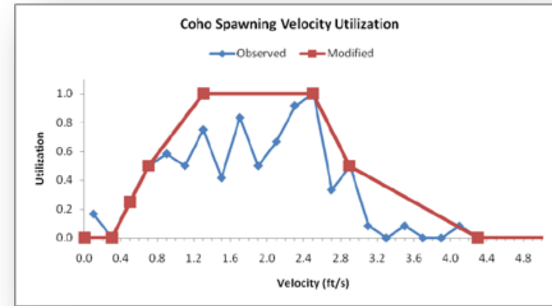


Figure 1. Example IFIM Cross Channel Transect

Transect Selection & Measurement



Habitat Mapping

PHABSIM

HSC Curves

Habitat-Q Relationships

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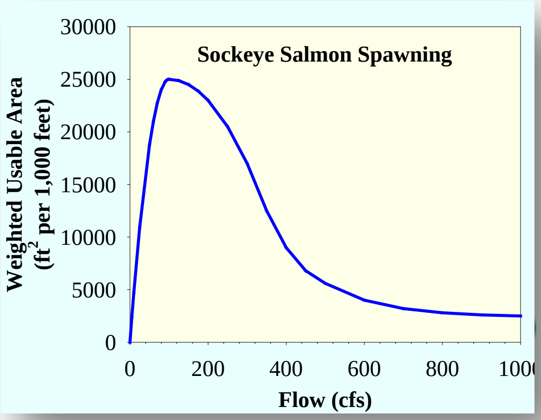
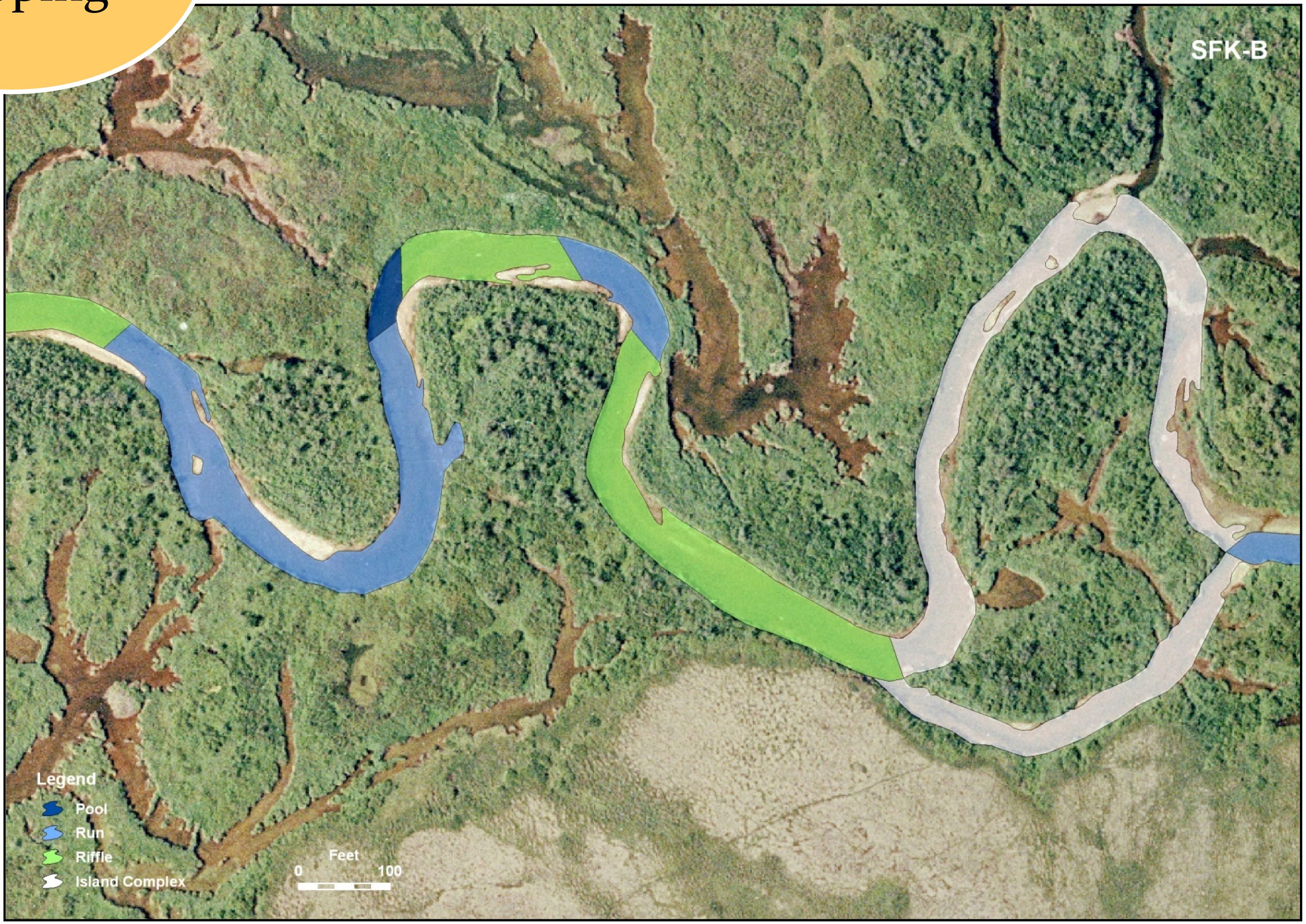


Habitat Units



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Transect Selection & Measurement

View Downstream

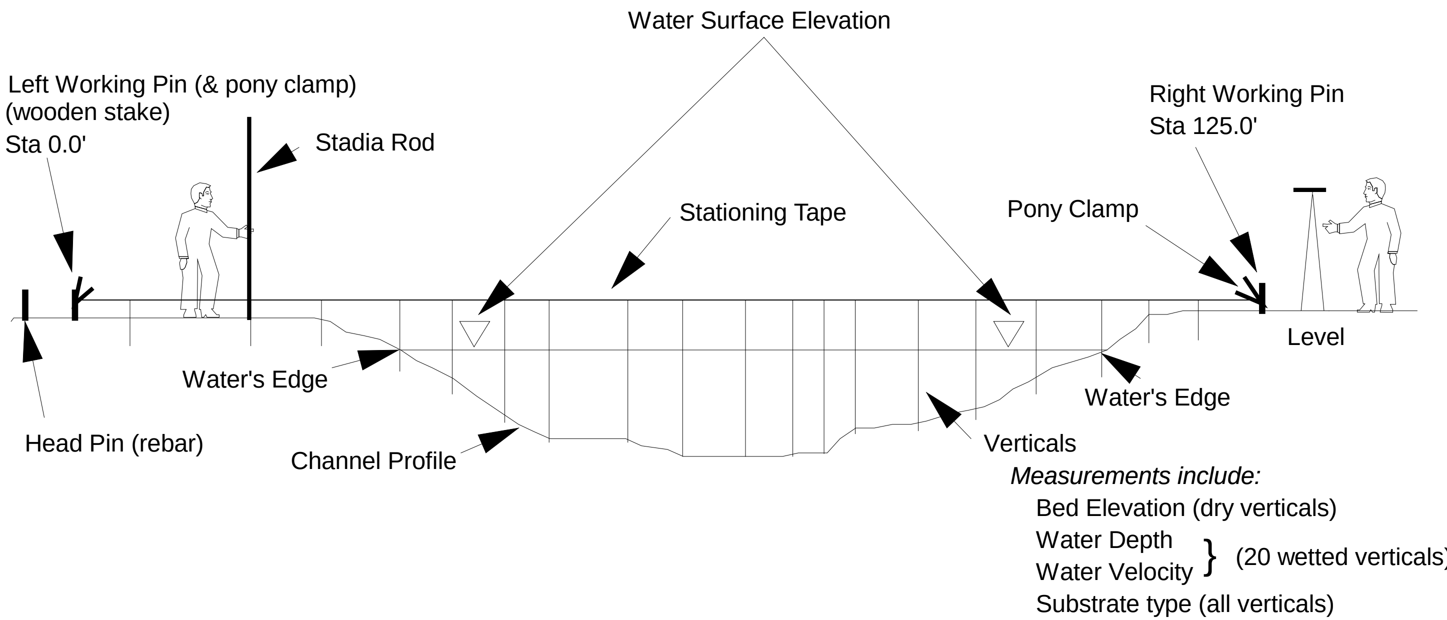

Figure 1. Example IFIM Cross Channel Transect

Primary Measurement point = Transect

Transect – A predetermined line across a section of stream along which depth, velocity and substrate measurements are made under different flows. Data serve as input into PHABSIM modeling.

Transect Selection & Measurement

PHABSIM Sites
Summary of Field Data Collection
2004 through 2008

- 2004 to 2007 – Extensive Surveys = 92 transects
- 2008 – Intensive Surveys – 46 transects

→ Total of 138 Transects measured

- Re-sampling completed on 21 transects

→ EBD Analysis – based on 117 transects

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Transect Selection & Measurement

PHABSIM Sites
Summary of Field Data Collection

Total of 117 Transects

North Fork Koktuli River Mainstem – 27 transects

North Fork Koktuli River Tributary – 3 transects

South Fork Koktuli River Mainstem – 37 transects

South Fork Koktuli River Tributary – 6 transects

Mainstem Koktuli River – 4 transects

Upper Talarik Creek Mainstem – 35 transects

Upper Talarik Creek Tributary – 5 transects

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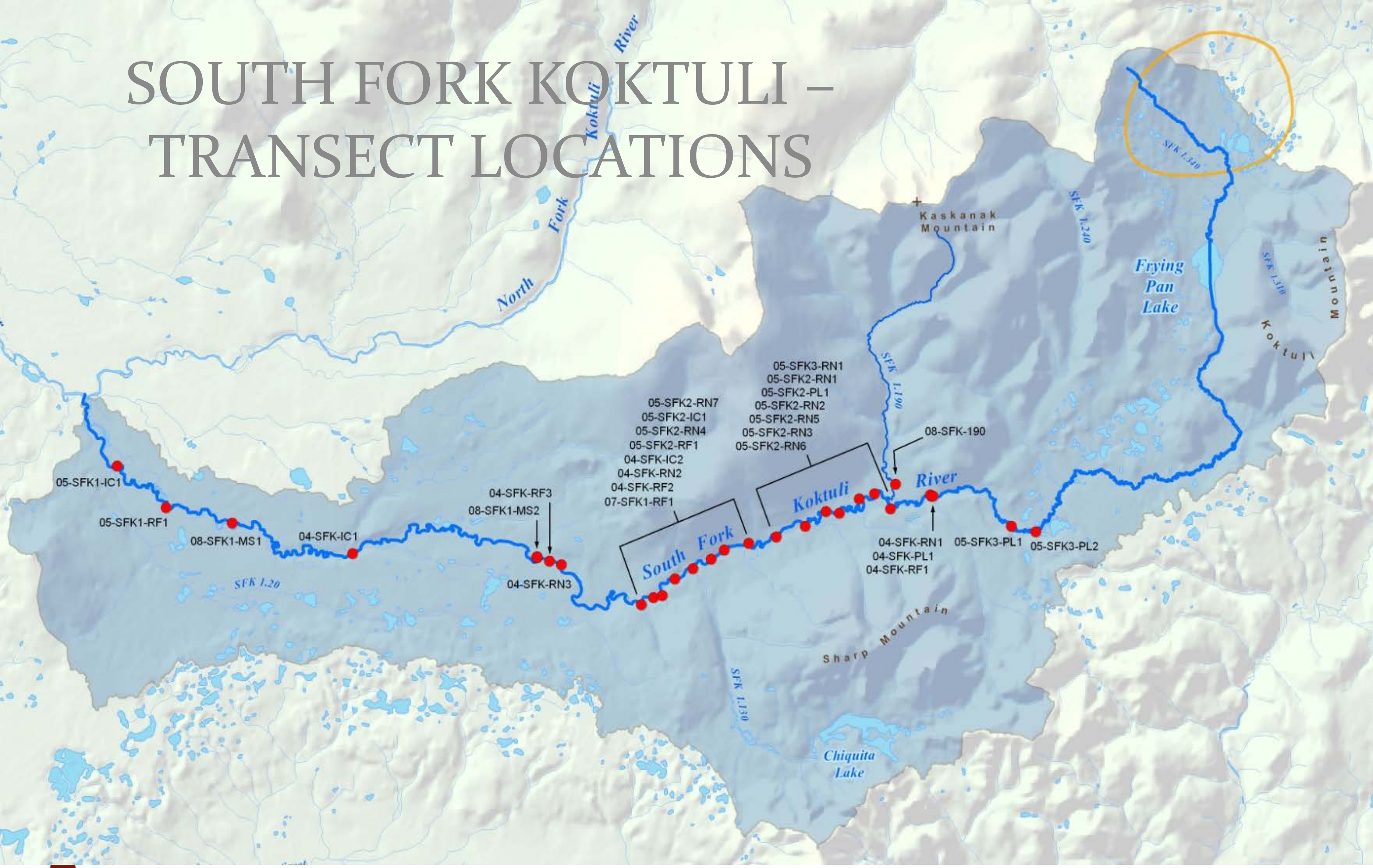
NORTH FORK KOKTULI – Transect Locations

SOUTH FORK KOKTULI – TRANSECT LOCATIONS



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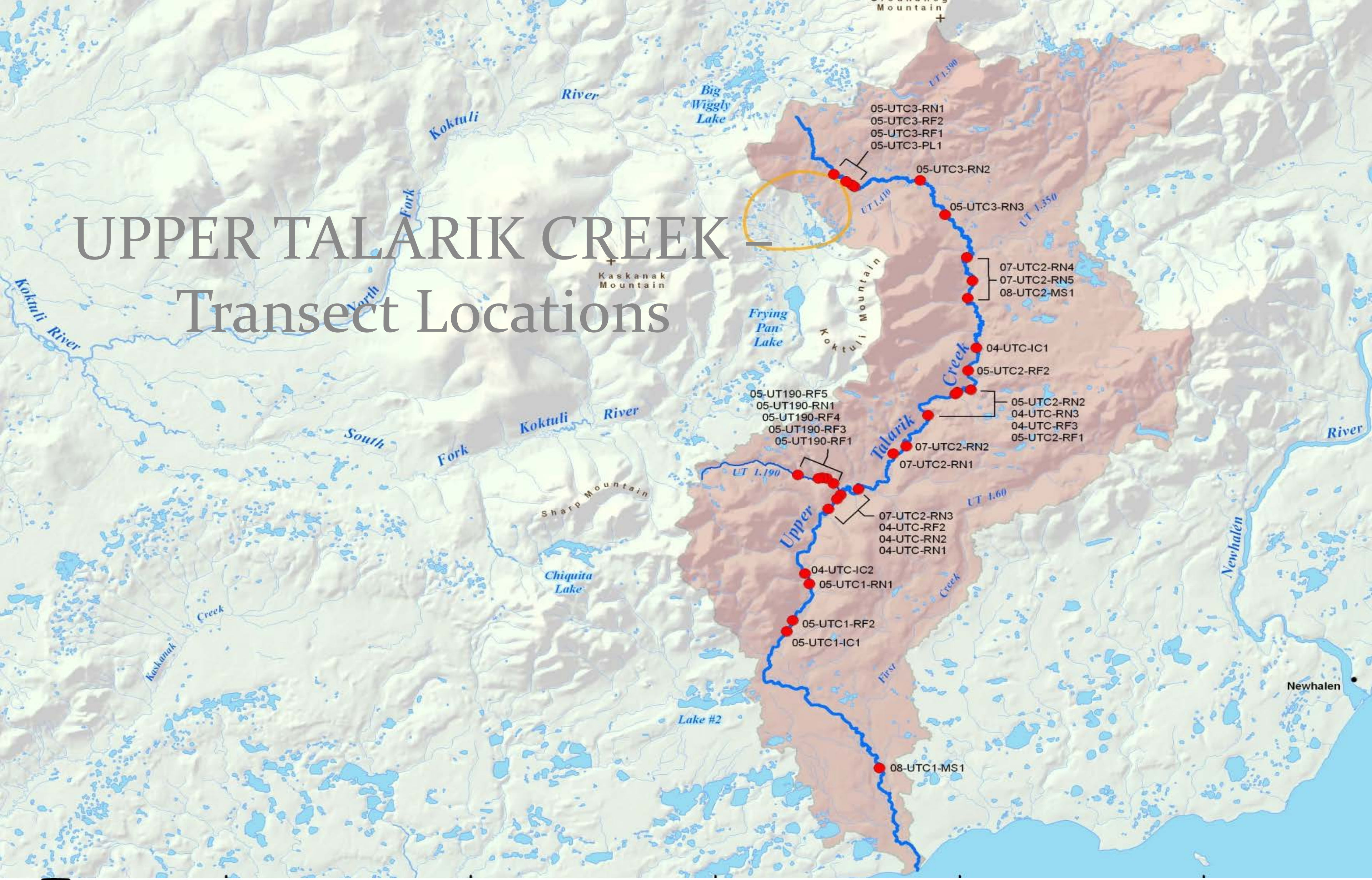
UPPER TALARIK CREEK – Transect Locations

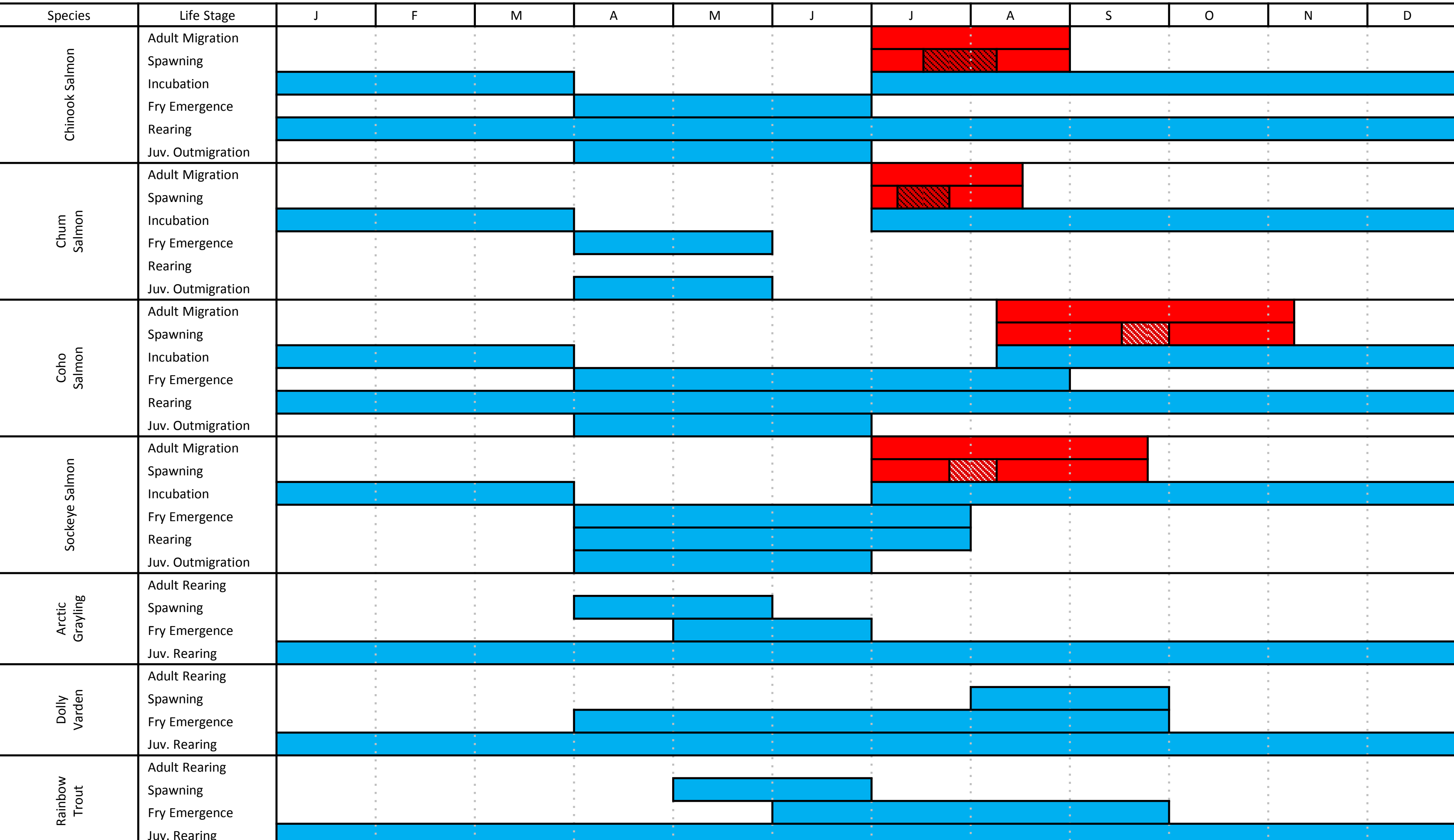


Habitat Modeling - Transects

- **Habitat Modeling**
  - ➢ Calibrated IFG4 data decks
  - ➢ Periodicity – Species and Life Stages
  - ➢ Site specific HSC curves (NFK, SFK, UT)
  - ➢ WUA (Weighted Usable Area) for individual flow

    - from HABTAV habitat model
  - ➢ Composite WUA derived from the WUAs of all measured flows of the transect .

North Fork Koktuli River Periodicity



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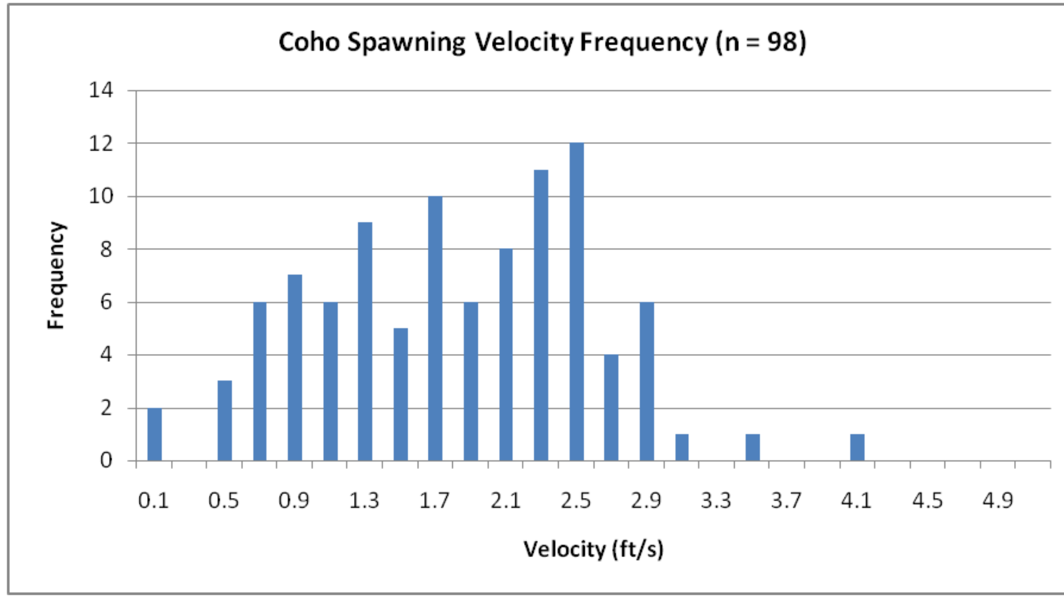
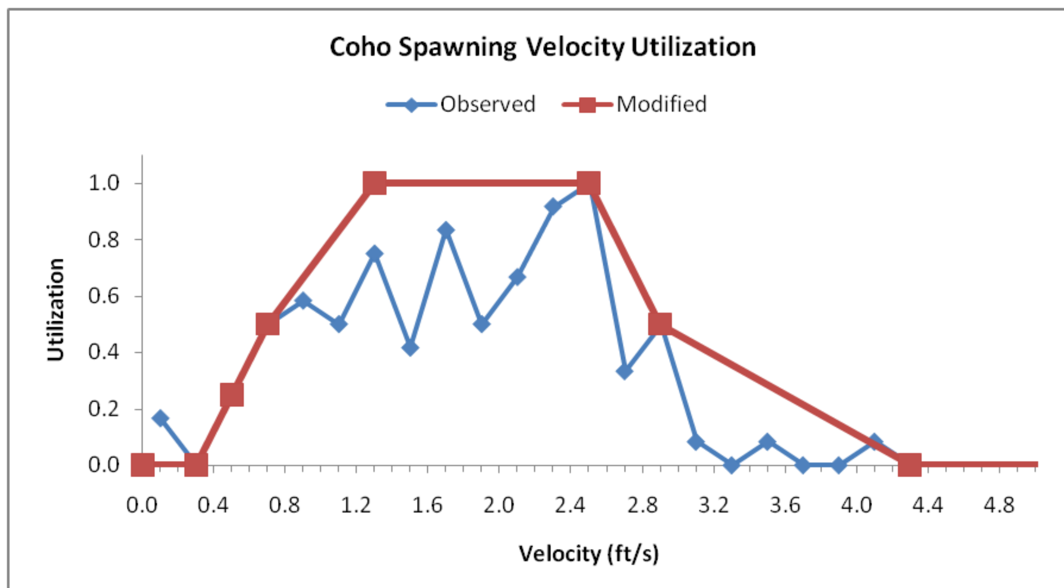
Habitat Suitability Curves (e.g.) – Velocity

HSC Curves

Velocity	Modified Utilization
0.0	0.00
0.3	0.00
0.5	0.25
0.7	0.50
1.3	1.00
2.5	1.00
2.9	0.50
4.3	0.00
99.0	0.00





HSC Data Collection

<u>General Parameters</u>

- Species
- Water Depth
- Mean Column Velocity
- Substrate

<u>Redd Parameters</u>

- Pit Depth
- Tail Depth
- Length
- Width

<u>Juv./Adult Parameters</u>

- Lifestage/Length
- Cover
- Focal Depth
- Focal Velocity
- Habitat Type

HSC Observations (N) as of October 2008

Species	Lifestage	HDR			R2			Total
		NFK	SFK	UTC	NFK	SFK	UTC	
Sockeye	Fry/Juv	1	5	9		3	1	19
	Spawning	40	85	32	122	79	117	475
Chinook	Fry/Juv	11	11	24	17	15	35	113
	Spawning	47	40		49	35		171
Coho	Fry/Juv	16	21	48	62	40	126	313
	Spawning				52	43	3	98
Chum	Spawning					7		7
Rainbow	Adult			1	7			8
	Fry/Juv			7			25	32
Dolly Varden	Adult						1	1
	Fry/Juv	2	7	4	1	4	1	19
Grayling	Adult	1	3	2	22	2	10	40
	Fry/Juv	1	11	13				25
Whitefish	Adult	1			8	1		10
Total		120	183	140	340	229	319	1331

Some Example
WUA – Flow Relationships

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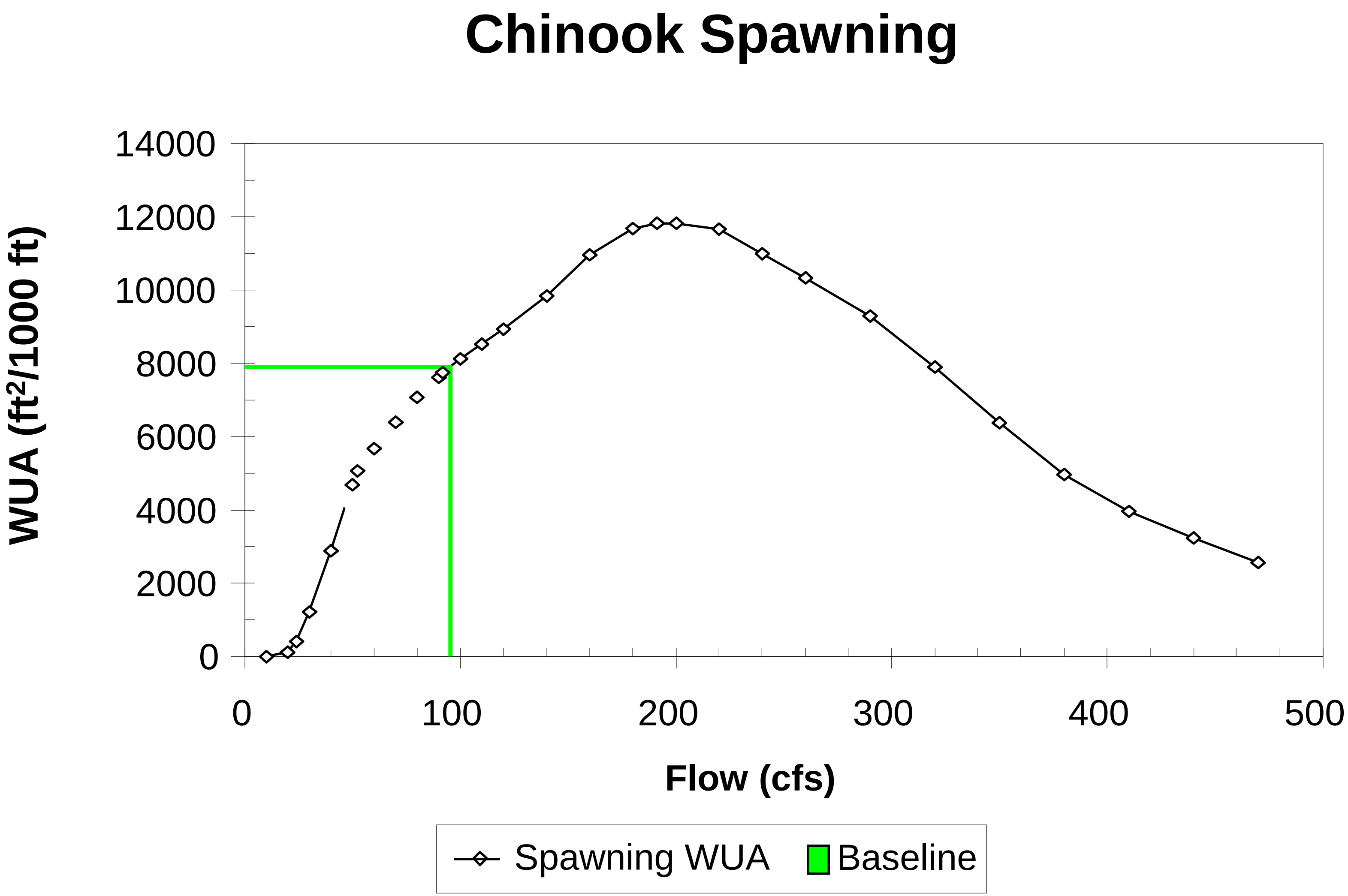
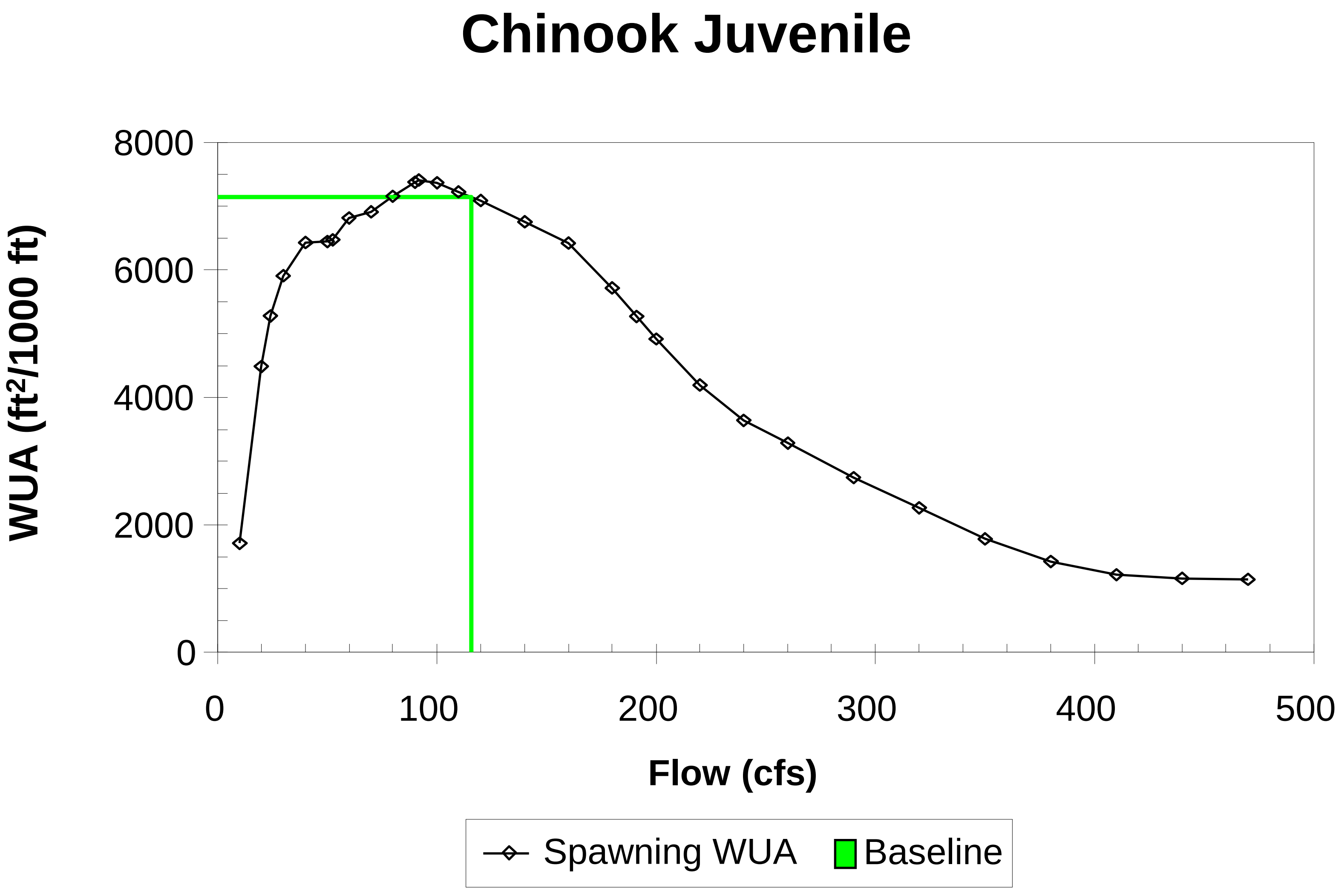
05-SFK2-RN7

Average Year



05-SFK2-RN7

Average Year



Habitat Modeling - Hydrology

- **Hydrology – Knight Piesold**
  - 68 years of monthly flows at 30 hydrology sites

    - Baseline (Natural) flow $Q_{pre\text{-}mine}$

    Interpolate flow at each PHABSIM transect and reach breakpoint using methodology developed by KP
  - Flows greater than February 10% exceedance flow are assumed to be dominated by surface water – interpolate based on drainage area
  - Flows less than February 10% exceedance flow are assumed to be dominated by groundwater – interpolate based on longitudinal distance

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How to expand results from Transect location to other locations in the stream?

GIS Based Habitat Mapping

Identify and quantify mesohabitat units of the same type (i.e. pool, run, riffle) and summarize by reach.

Habitat Modeling – Mesohabitat Mapping

Number of Habitat Units – 1955 for all streams

Stream System	Reach	# of Habitat Units	Reach Length (km)	Cumulative Length (km)	Length per Habitat Unit (km)
NFK	NFK-A	75	13.81	13.81	0.184
	NFK-B	42	7.42	21.23	0.177
	NFK-C	152	15.59	36.83	0.103
	NFK-190	272	8.03	8.03	0.030
SFK	SFK-A	179	24.79	24.79	0.139
	SFK-B	78	9.10	33.89	0.117
	SFK-C	201	17.52	51.41	0.087
	SFK-190	95	6.86	6.86	0.072
UT	UT-B	72	16.98	16.98	0.236
	UT-C	93	8.08	25.06	0.087
	UT-D	158	11.73	36.80	0.074
	UT-E	131	8.98	45.78	0.069
	UT-F	399	14.28	60.06	0.036
	UT-190	8	2.76	2.76	0.346

Note: Tributary results are from field habitat surveys

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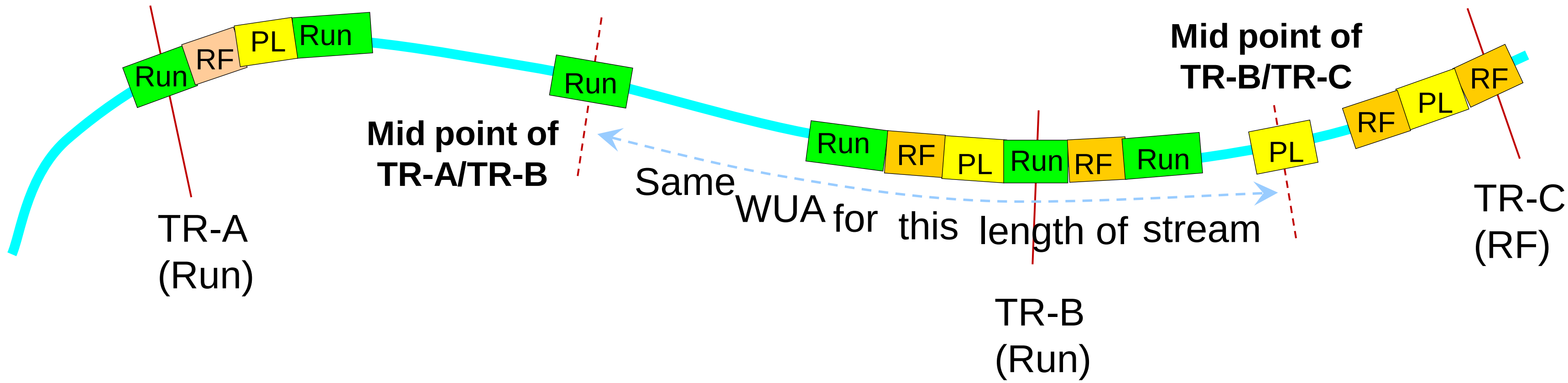
Habitat Modeling – Habitat Area
(Approach applied in EBD)



(1) Same WUA applied to the reach length between the mid point of TR-A/TR-B and the mid point of TR-B-/TR-C, regardless of habitat types within the reach.

(2)Habitat areas may be over/under-estimated.

(3)Different habitat types not considered individually.

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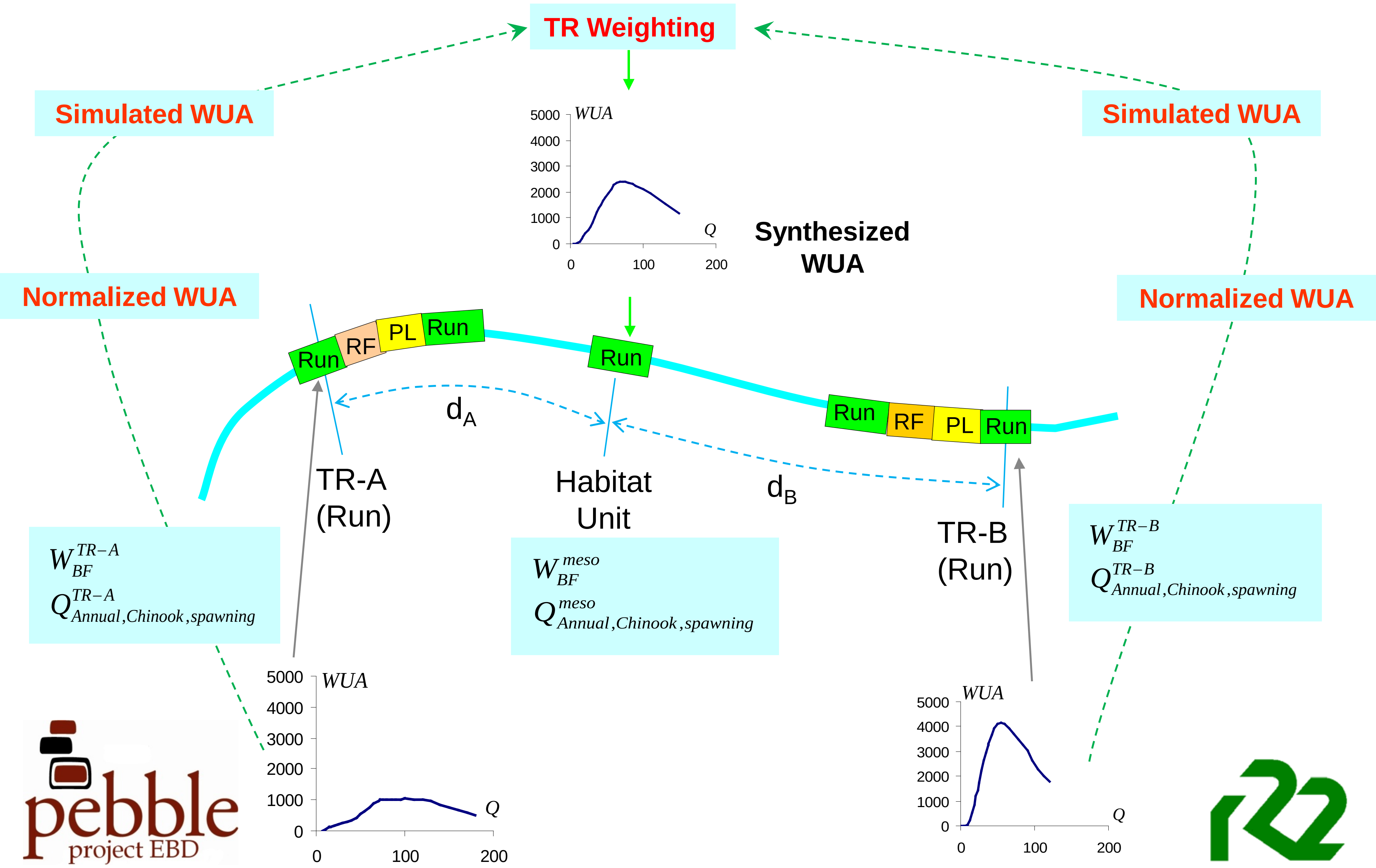
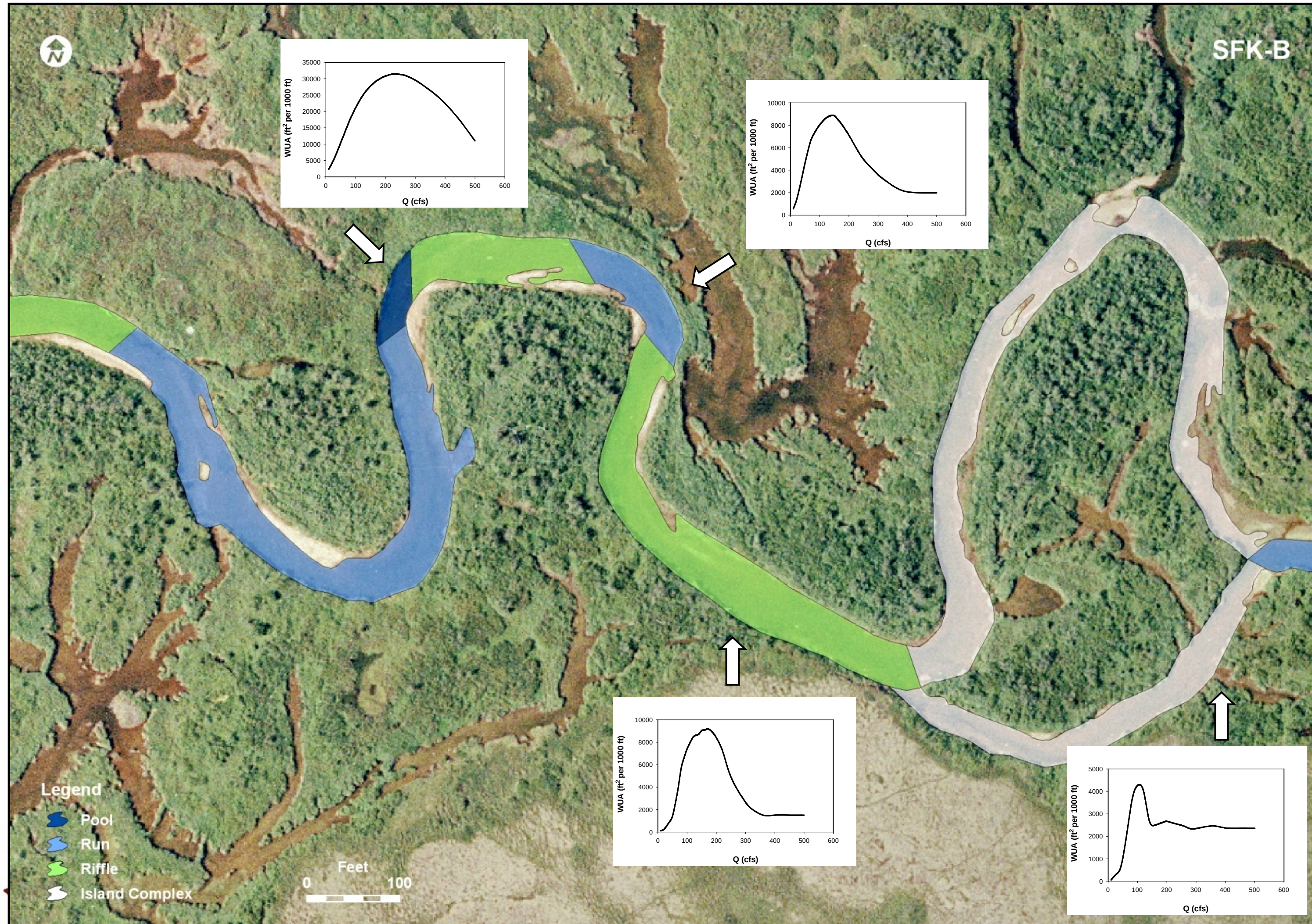
Habitat Modeling – Habitat Unit WUA
(Refined method)



End Product - WUA Curves For All Habitat Units



Habitat Modeling – Baseline Habitat Characterization

Analysis of flows on fish habitat

- Develop several metrics:
  - a) Weighted Usable Area (WUA), habitat area per 1000 ft stream length
  - b) Weighted Usable Width (WUW), habitat area per unit stream length
  - c) Cumulative habitat area along the stream
  - d) Time series and habitat duration analysis

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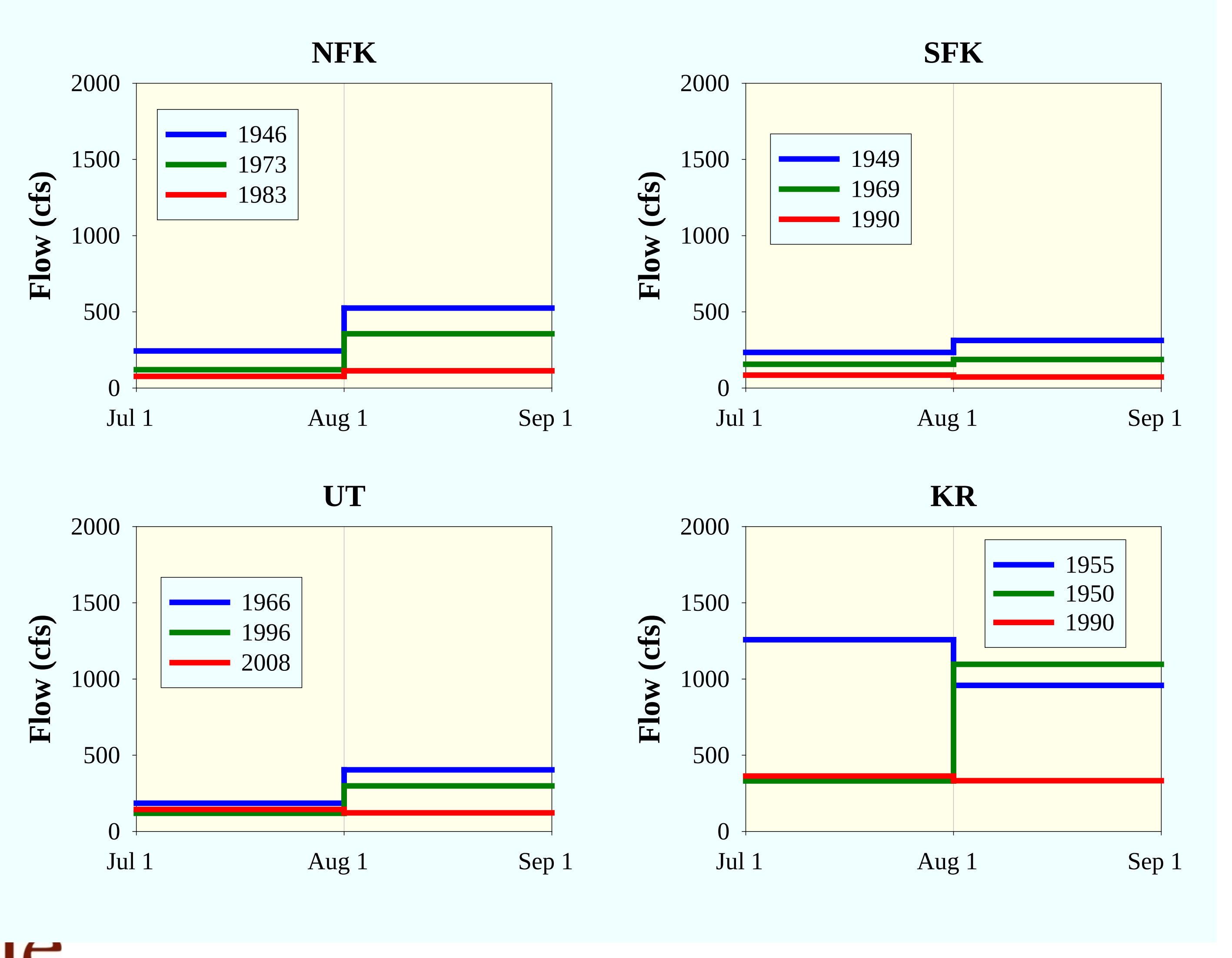
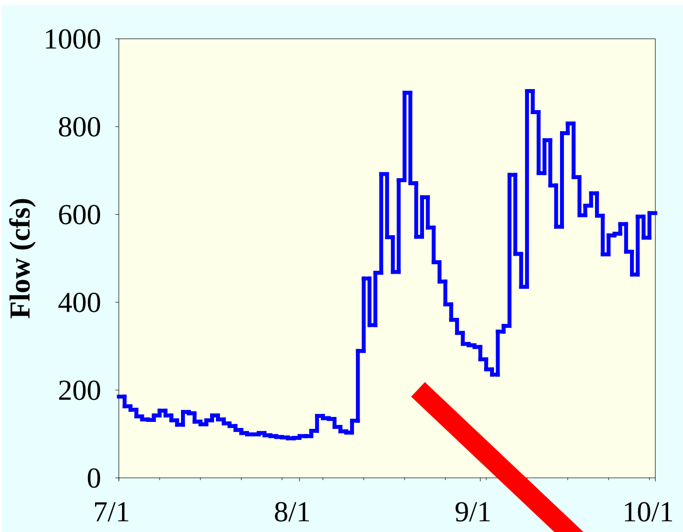
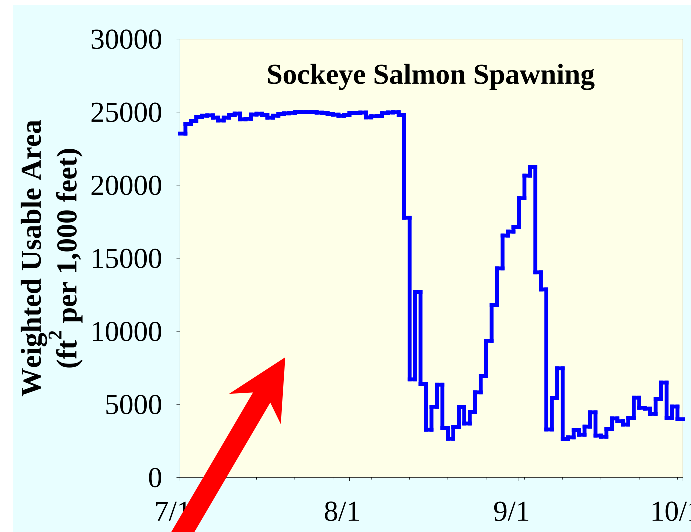
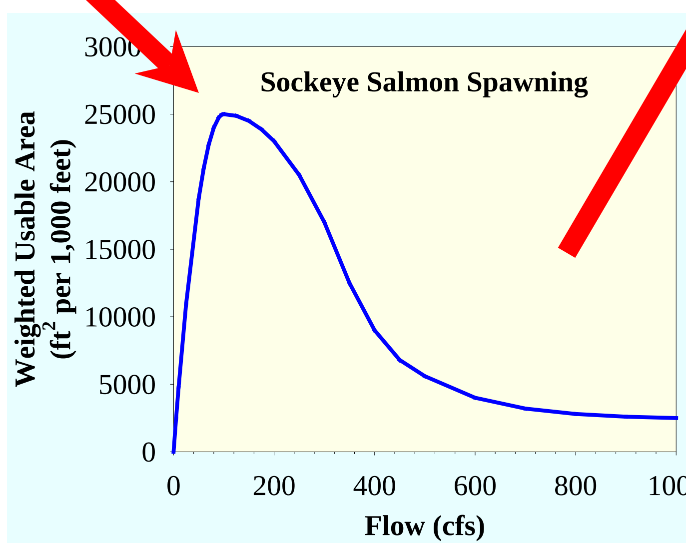
Wet, Average, and Dry Years
Chinook Spawning Periodicity



Flow Hydrograph/WUA Curve/Habitat Time Series







EXAMPLE ANALYSIS

- By species and lifestage
- By reach and stream
- With and Without project operations

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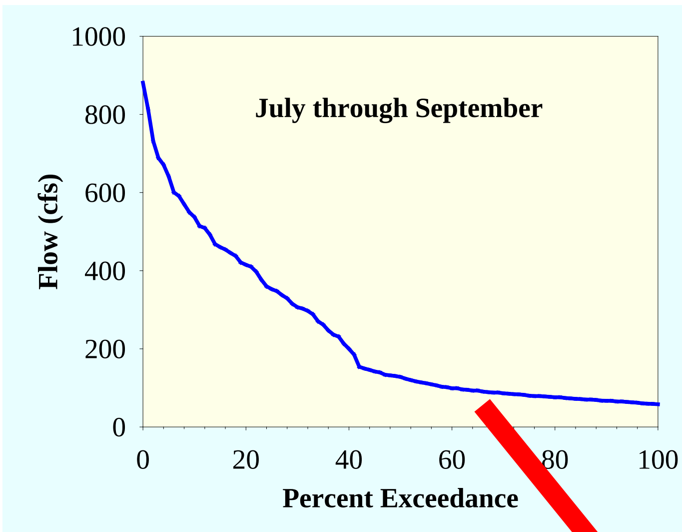
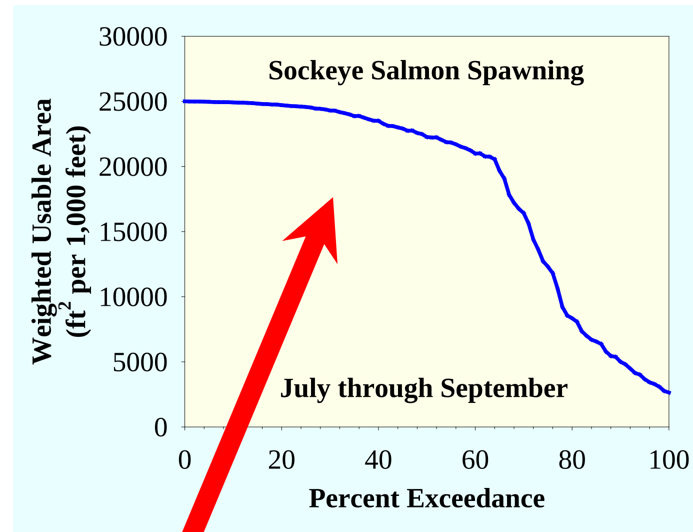
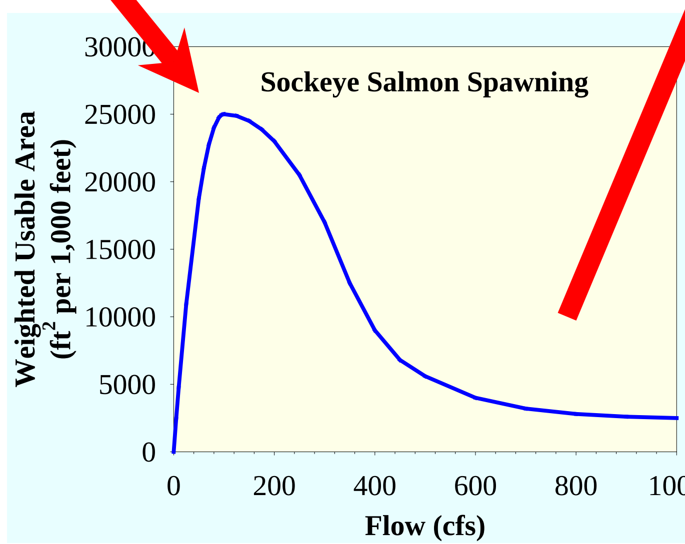
Flow Duration/WUA Curve/Habitat Duration







EXAMPLE ANALYSIS

- By species and lifestage
- By reach and stream
- With and Without project operations

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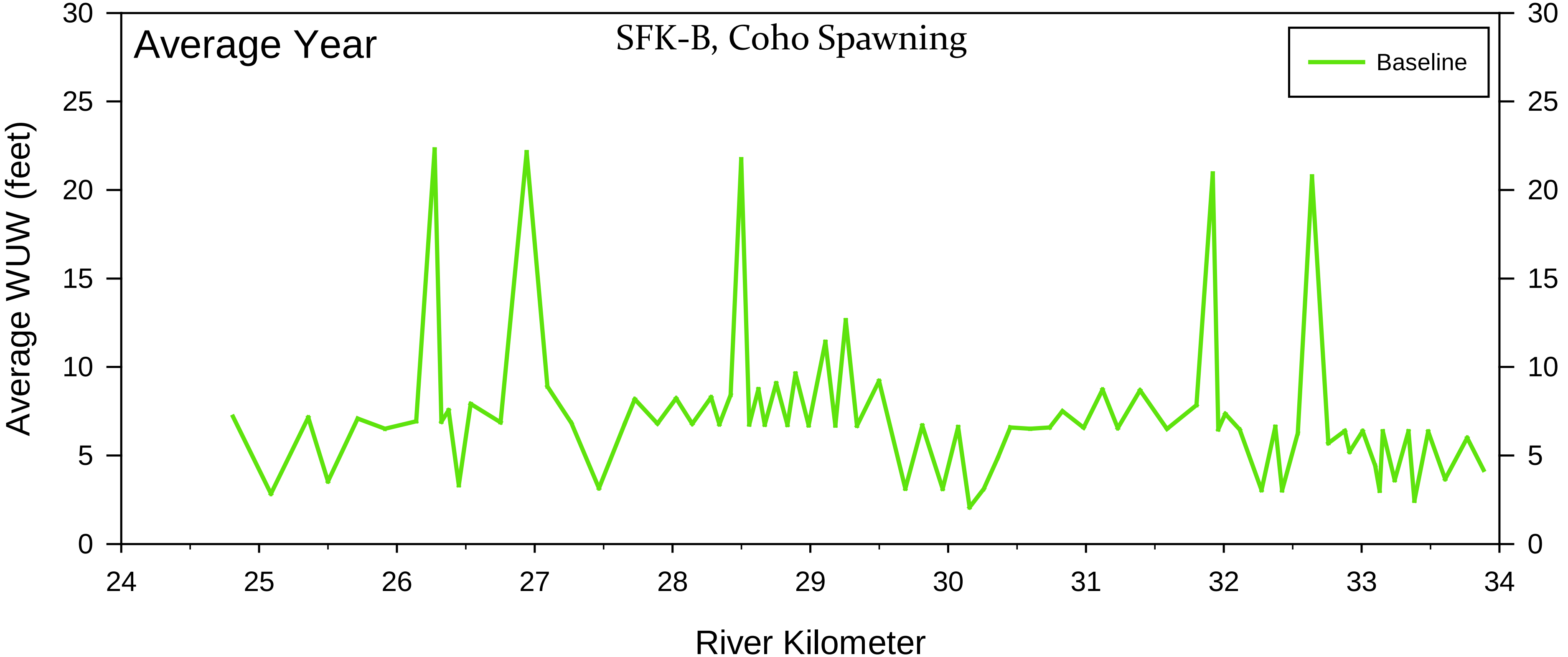
R2

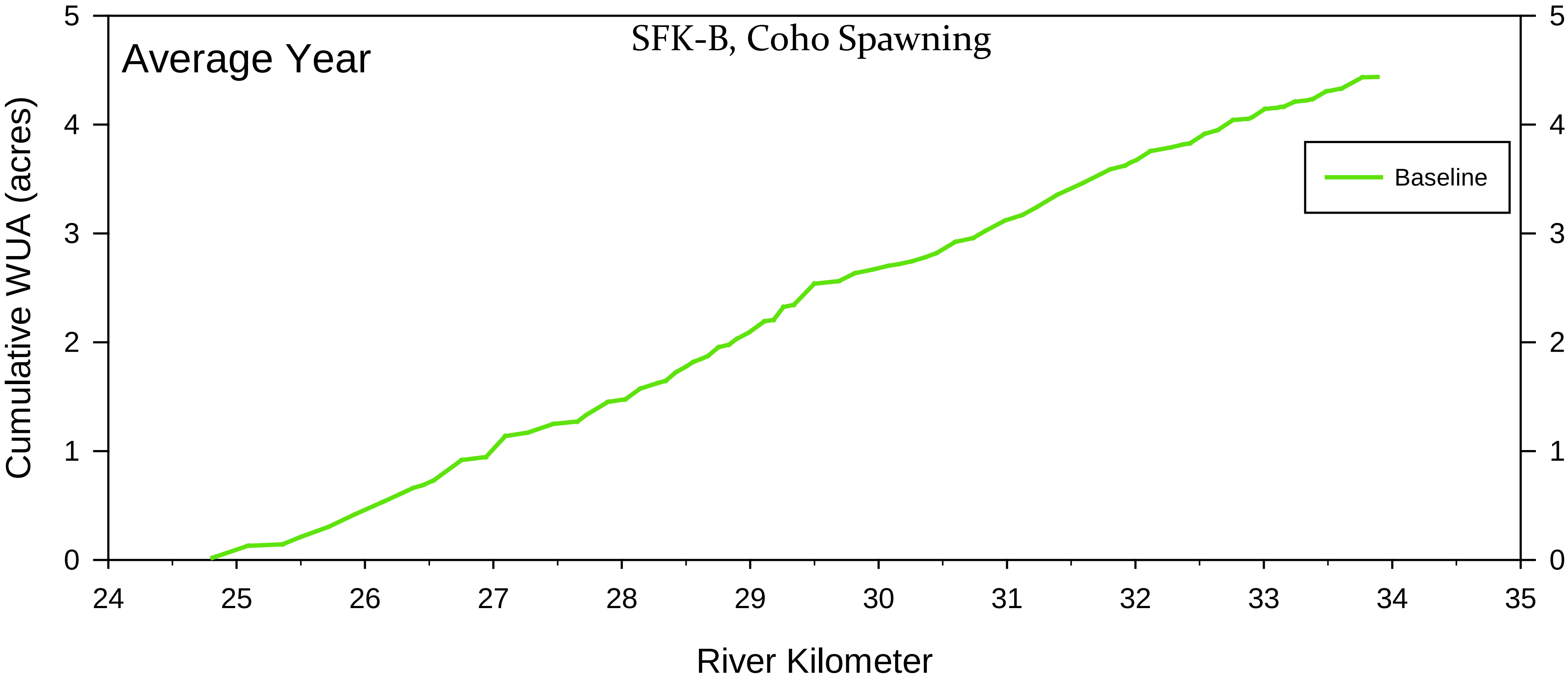
Weighted Usable Width (WUW)

Weighted Usable Width (WUW) = habitat area divided by the length of the habitat unit. Area is dependent on the habitat unit length, but WUW is not.

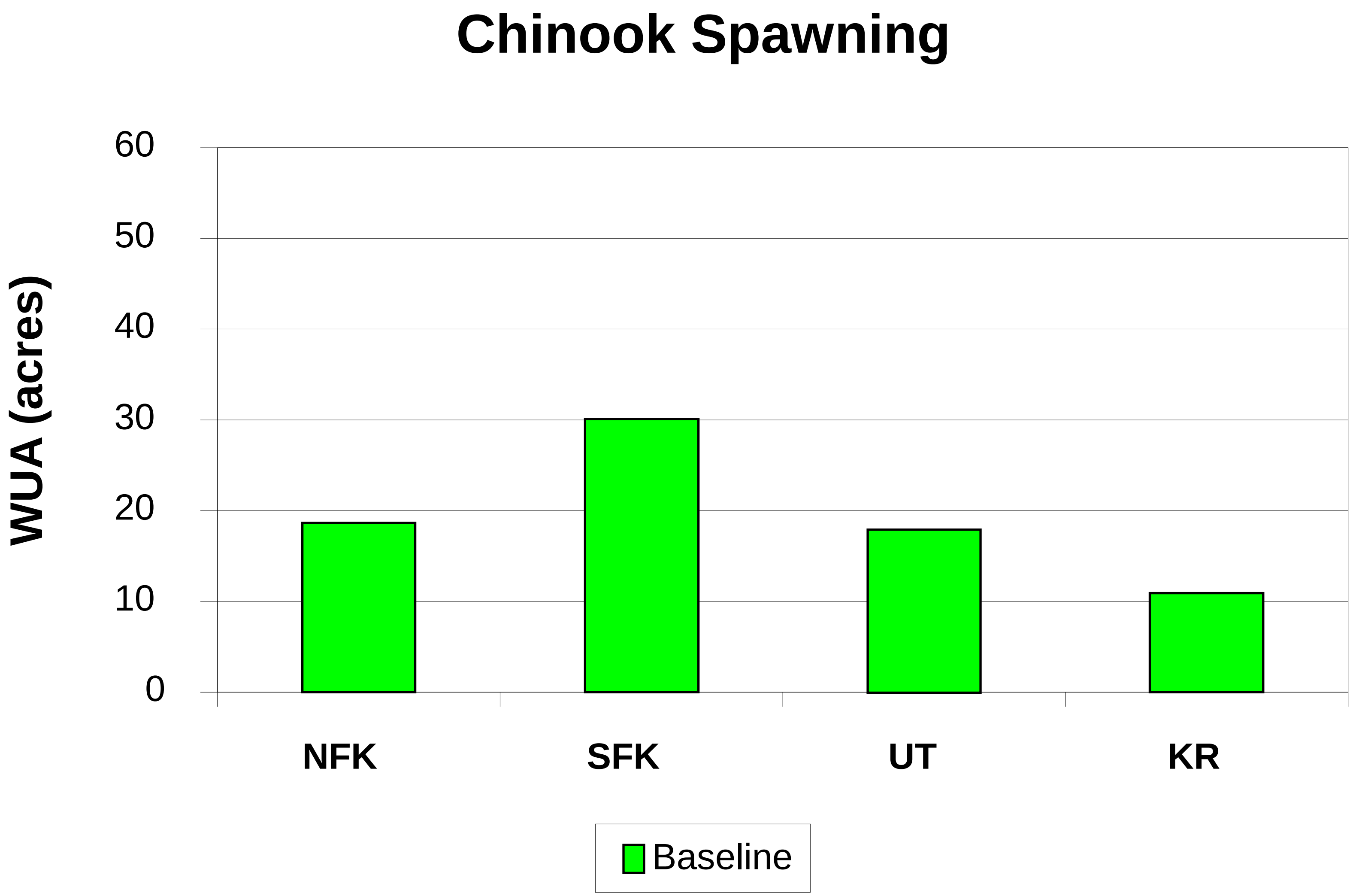


Cumulative Habitat Area

Cumulative habitat areas along the stream reach can be calculated for Baseline Conditions and compared with conditions under differing project operations.

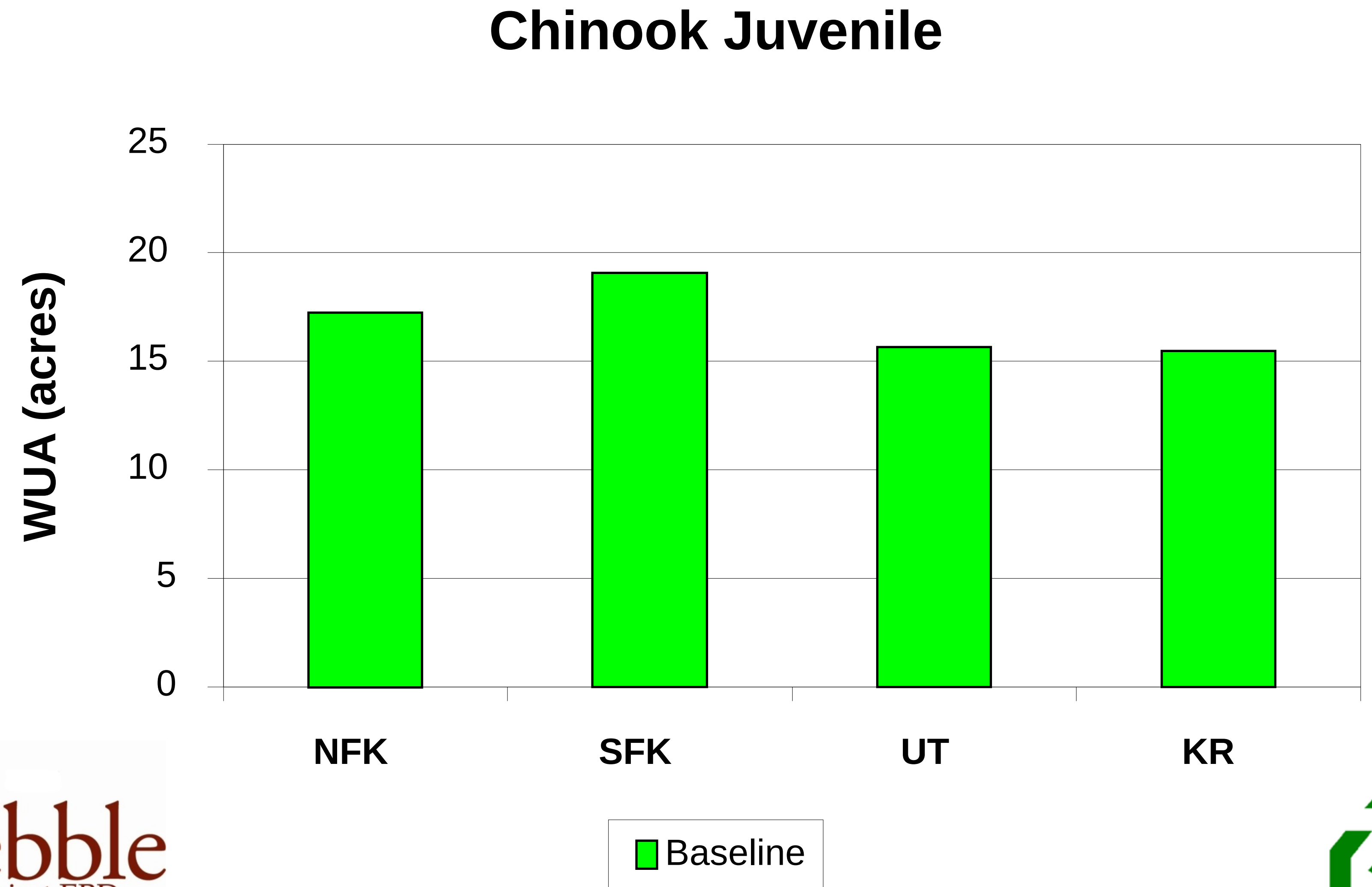


Summary
Average Year



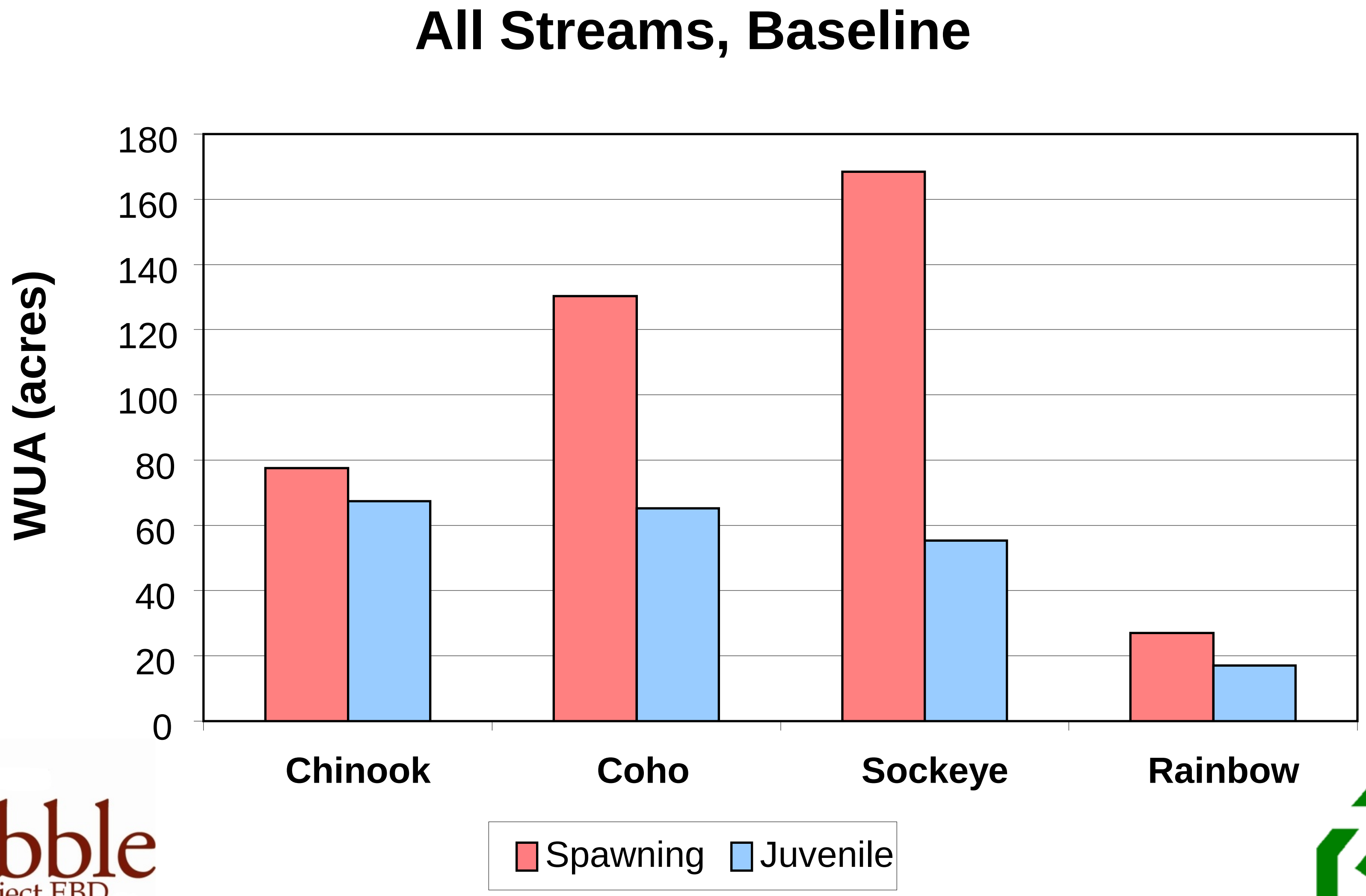
Summary

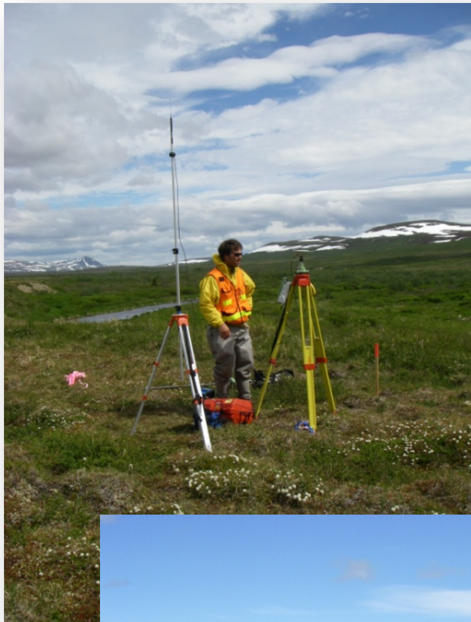
Average Year



Summary

Average Year





Off Channel Habitat Surveys: conducted as component of Flow study

- Measure transect geometry at 6 sites in NFK
- Identify and classify all OCH features encountered along transect
- Depth/substrate/velocity at 3 flows for each OCF feature identified
- <u>SFK and UT sites surveyed by HDR Alaska;</u>

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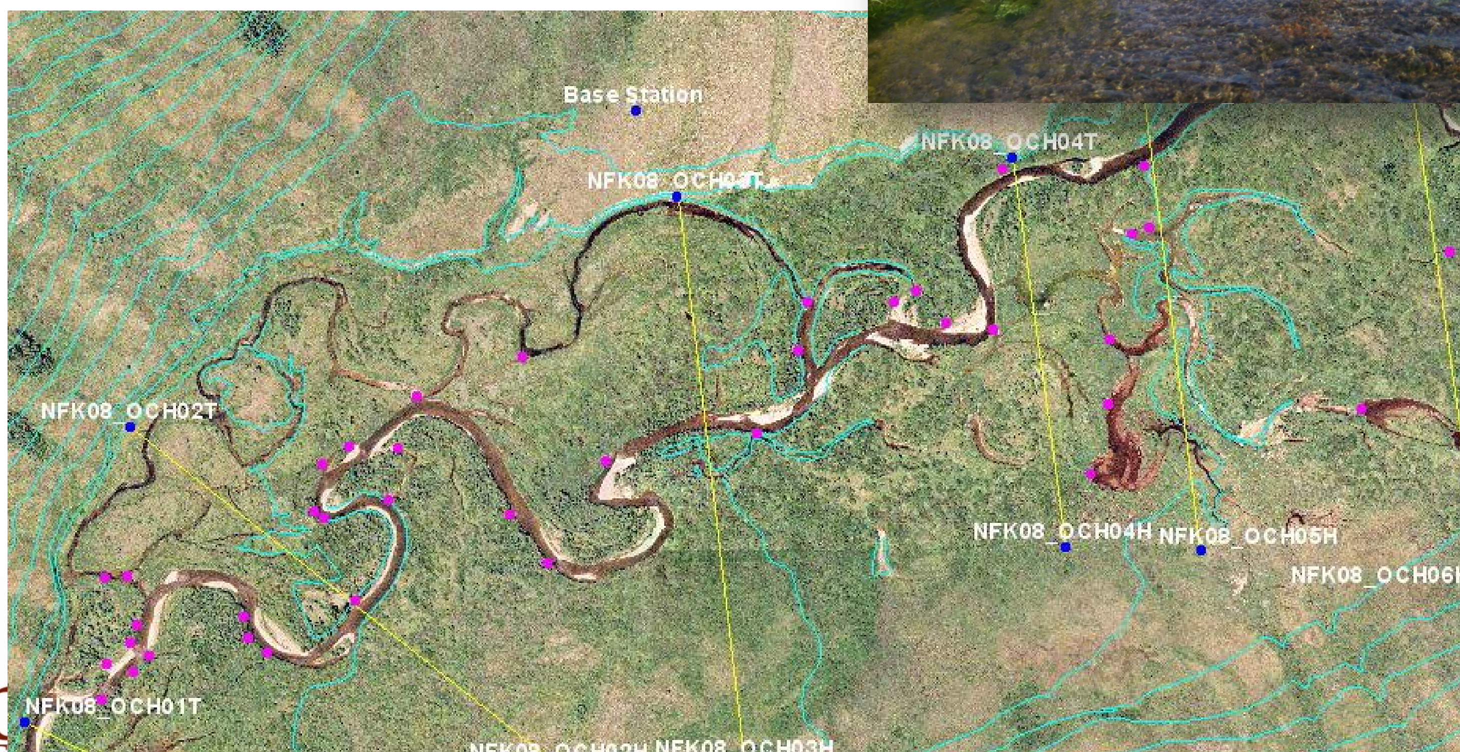
Off Channel Habitat surveys (cont.)

- Inlet connectivity relative to mainstem for all OCH features in each study reach (North Fork Koktuli, South Fork Koktuli and Upper Talarik Creek)



08 NFK OCH TR 3D – Side Channel



- Side channels connected at upstream end and have measurable velocity
- Substrate generally gravel to cobble
- WSE strongly correlated with the mainstem

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08 NFK OCH TR 3C – Backwater Slough

- Backwater sloughs are directly connected to the mainstem at the downstream end
- No velocity, substrate tends to consist of fines and organic matter
- WSE strongly correlated with mainstem

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08 NFK OCH TR 3B – Isolated pond

- Isolated sloughs are not connected to the mainstem except during major overbank flows
- No velocity, substrate consists of fines and organic matter
- WSE appears to track mainstem (Ground water? Rain events?)

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08 NFK OCH TR 2C – Overflow

August 24

- Overflow channels rarely found to have obvious inlet channel; most connect via surface inflow only during overbank flows
- Overflow channels tend to be fed by groundwater (hyporheic flow) and thus remain connected to the mainstem and accessible to fish even at summer low flow

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08 NFK OCH TR 2D – Beaver Complex

August 24

- Many beaver complexes have only seasonal (high flow) surface inflows from the mainstem
- Beaver complexes fill during runoff, then slowly release water to mainstem - maintain a downstream connection/access for fish

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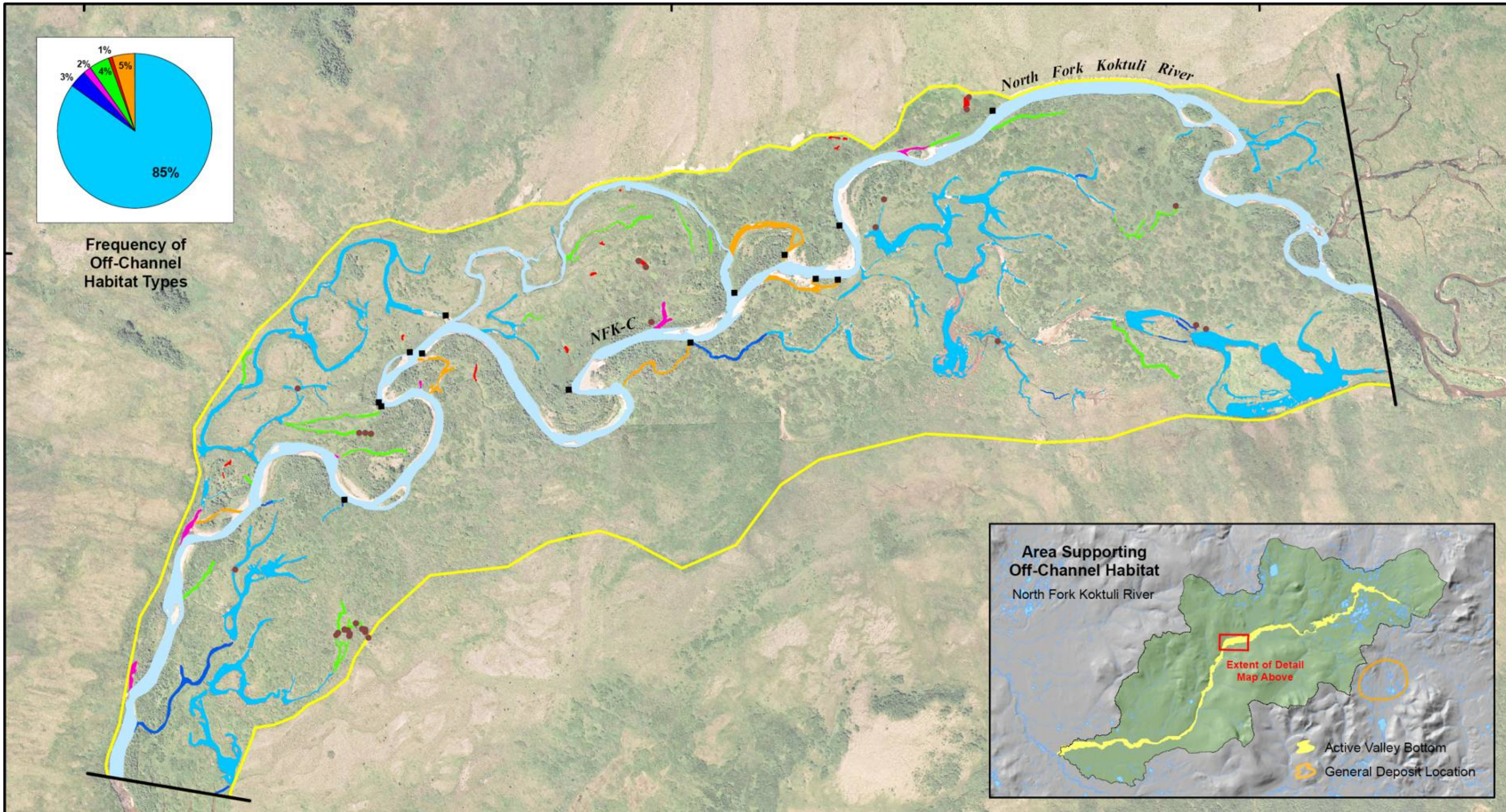
Distribution and Frequency of Off-channel Habitat Types in NFK



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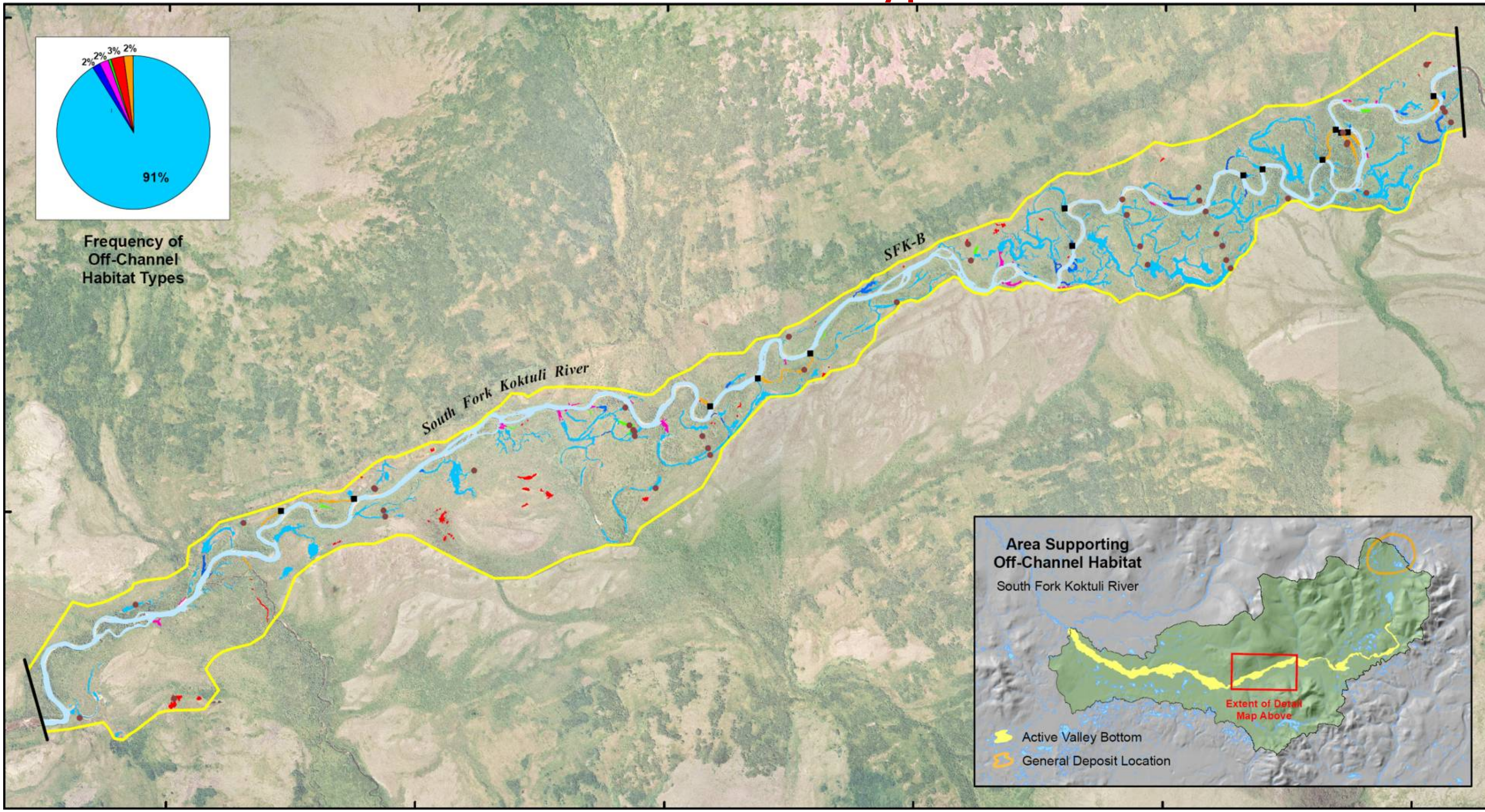
Distribution and Frequency of Off-channel Habitat Types in SFK



Legend

- Beaver Pond
- Beaver Pond Outlet Channel
- Alcove
- Isolated Pond
- Side Channel
- Percolation Channel
- Study Area Extents
- Inlets
- Fish Sampling Sites
- Mainstem
- Active Valley Bottom

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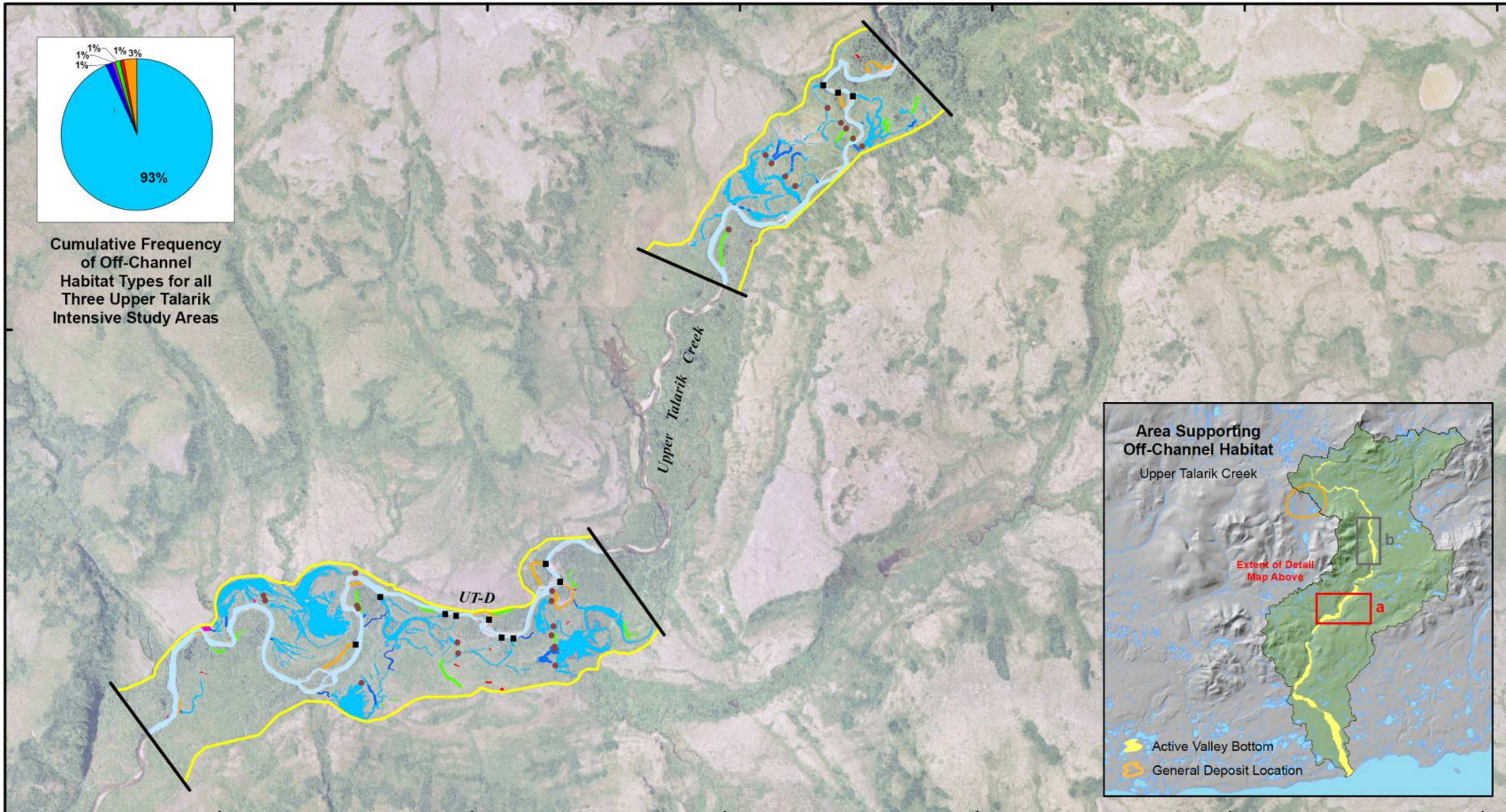
Distribution and Frequency of Off-channel Habitat Types in UT



Legend

- Beaver Pond
- Beaver Pond Outlet Channel
- Alcove
- Isolated Pond
- Side Channel
- Percolation Channel
- Study Area Extents
- Inlets
- Fish Sampling Sites
- Mainstem
- Active Valley Bottom

Water Temperature

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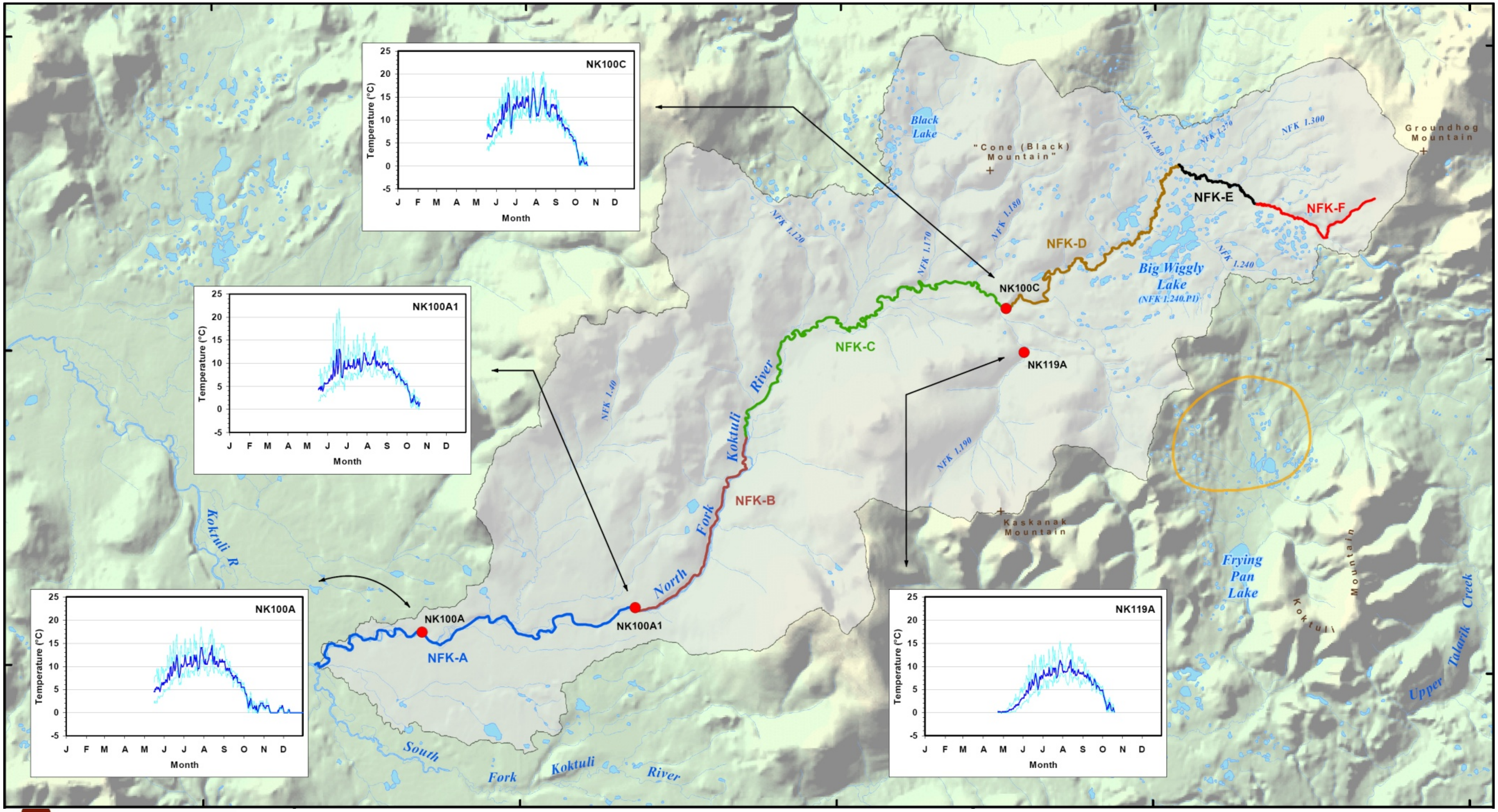
R2

NFK Temperature at Selected Sites 2007



11 Temperature Monitoring Sites

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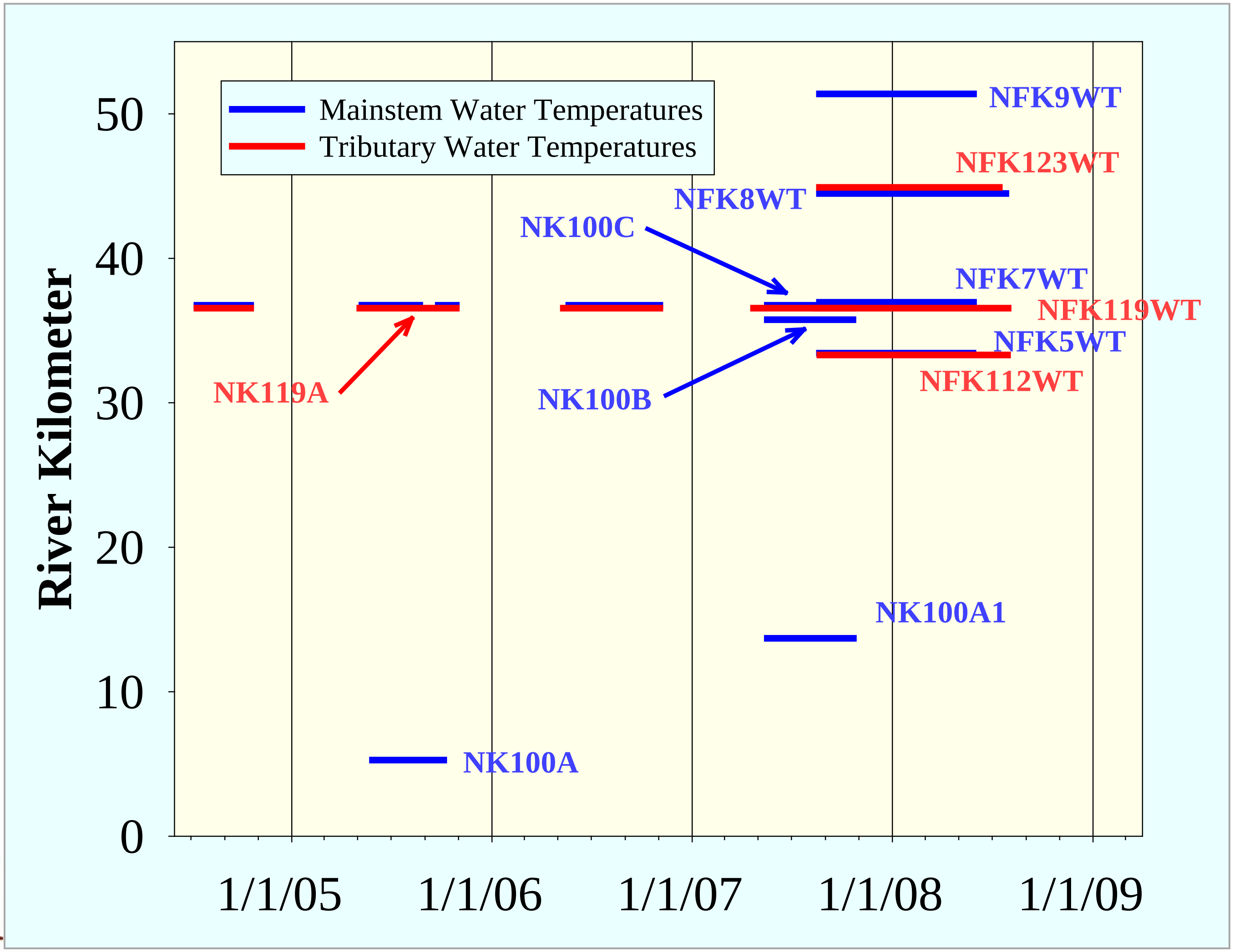
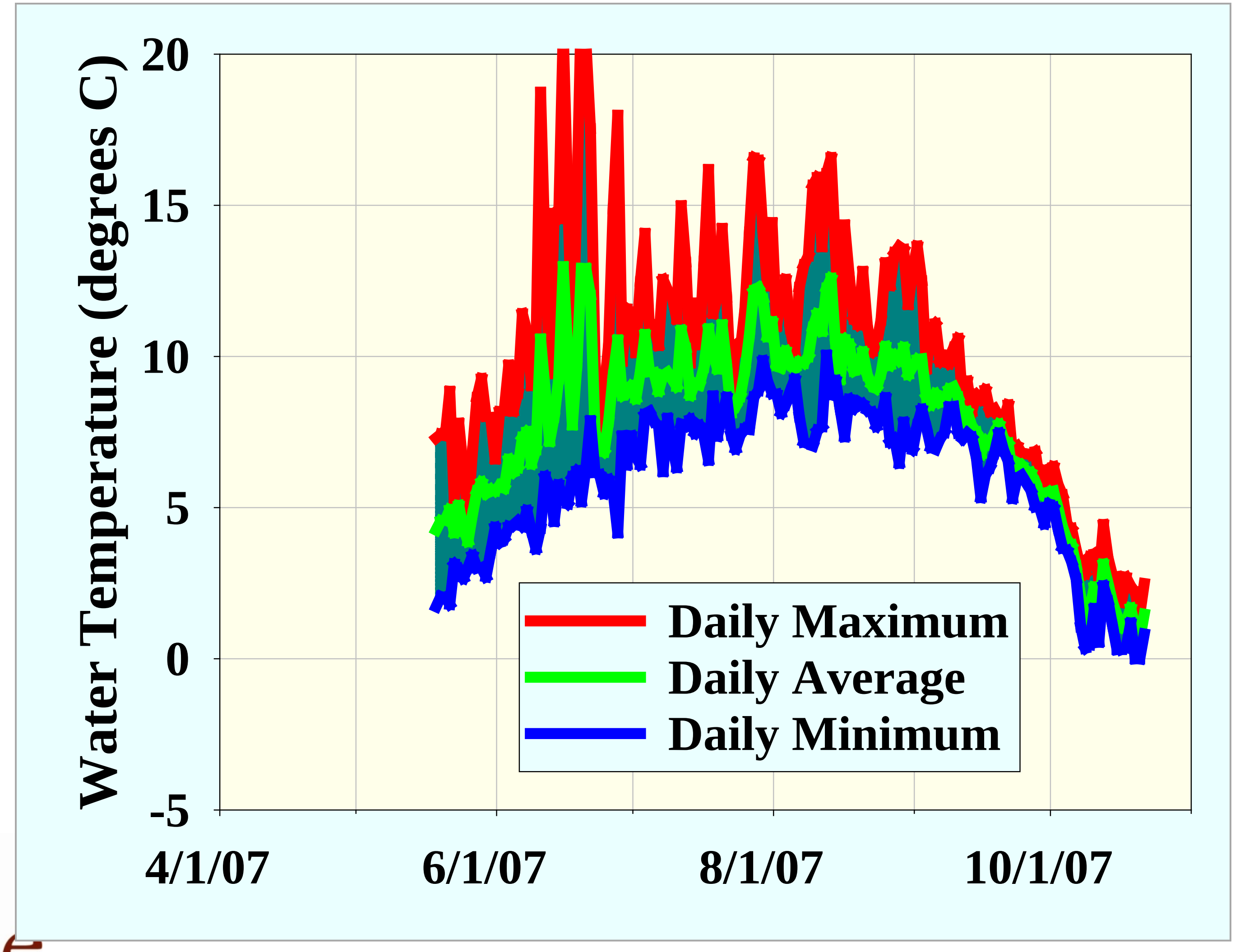
Spatial and Temporal Inventory of Water Temperatures Measured in the North Fork Koktuli River



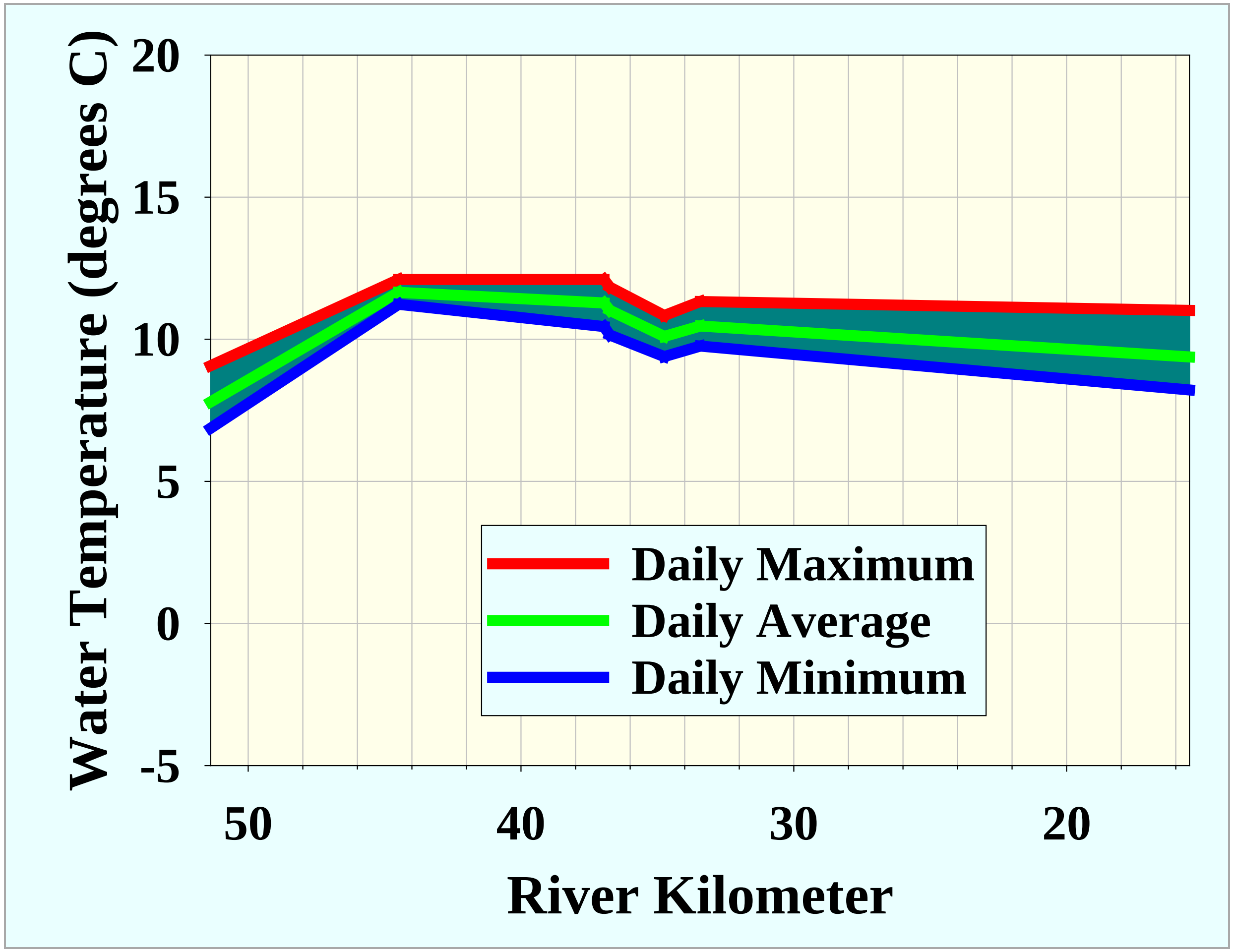
North Fork Koktuli River
NK100A1, River Kilometer 13.7



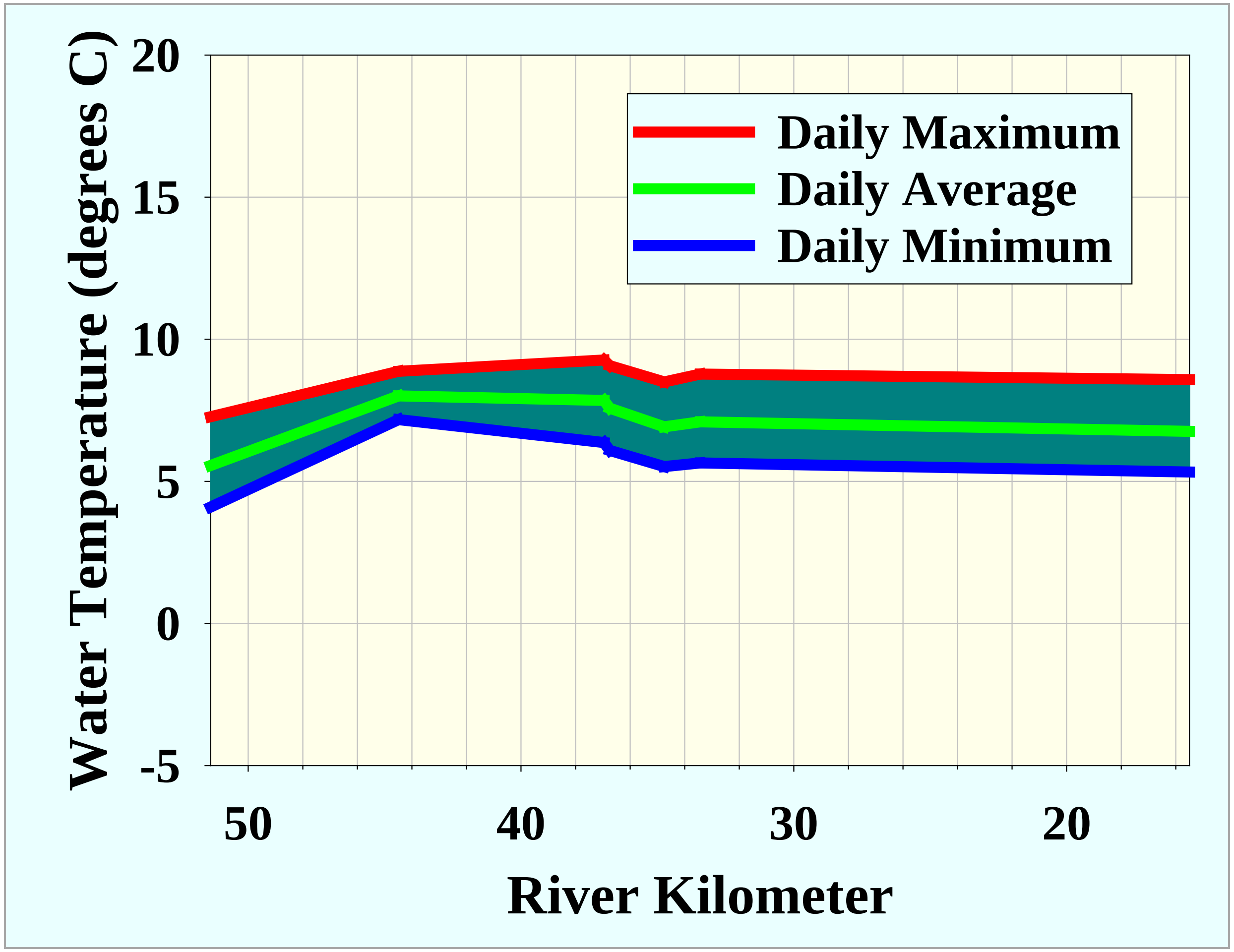
North Fork Koktuli River

August 21, 2007

Flow = 138 cfs at USGS Gage



North Fork Koktuli River
September 15, 2007
Flow = 363 cfs at USGS Gage



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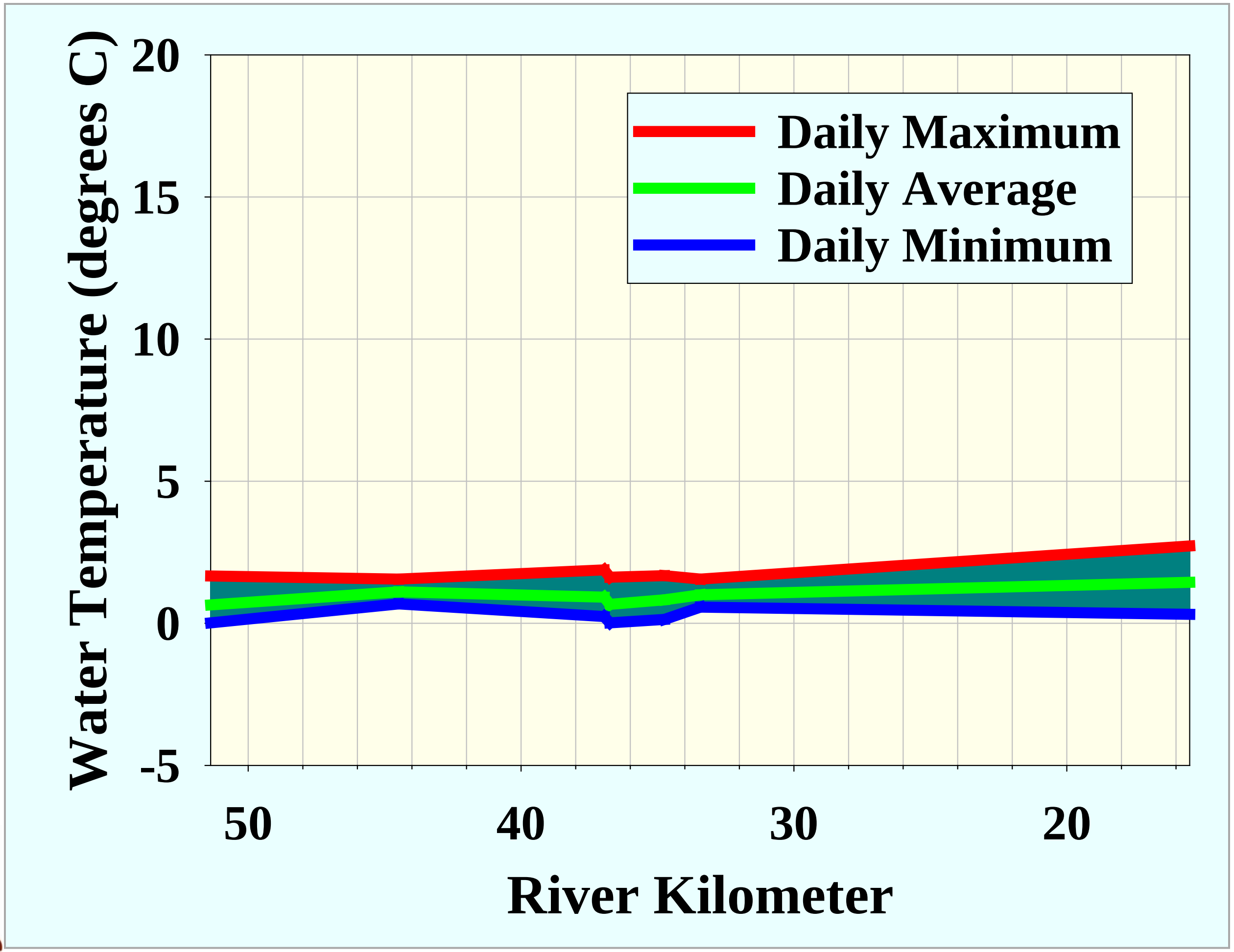
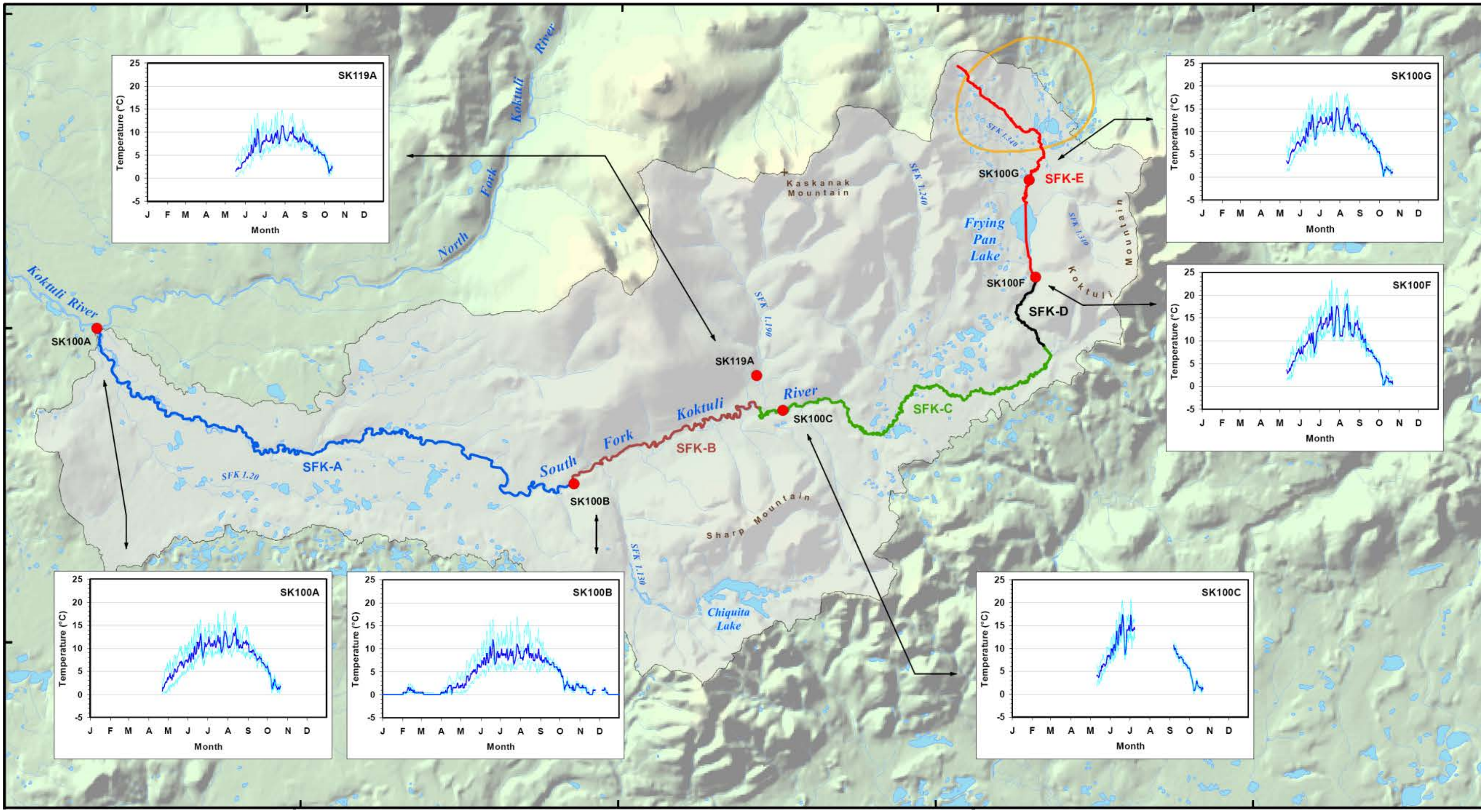
North Fork Koktuli River

October 15, 2007

Flow = 283 cfs at USGS Gage

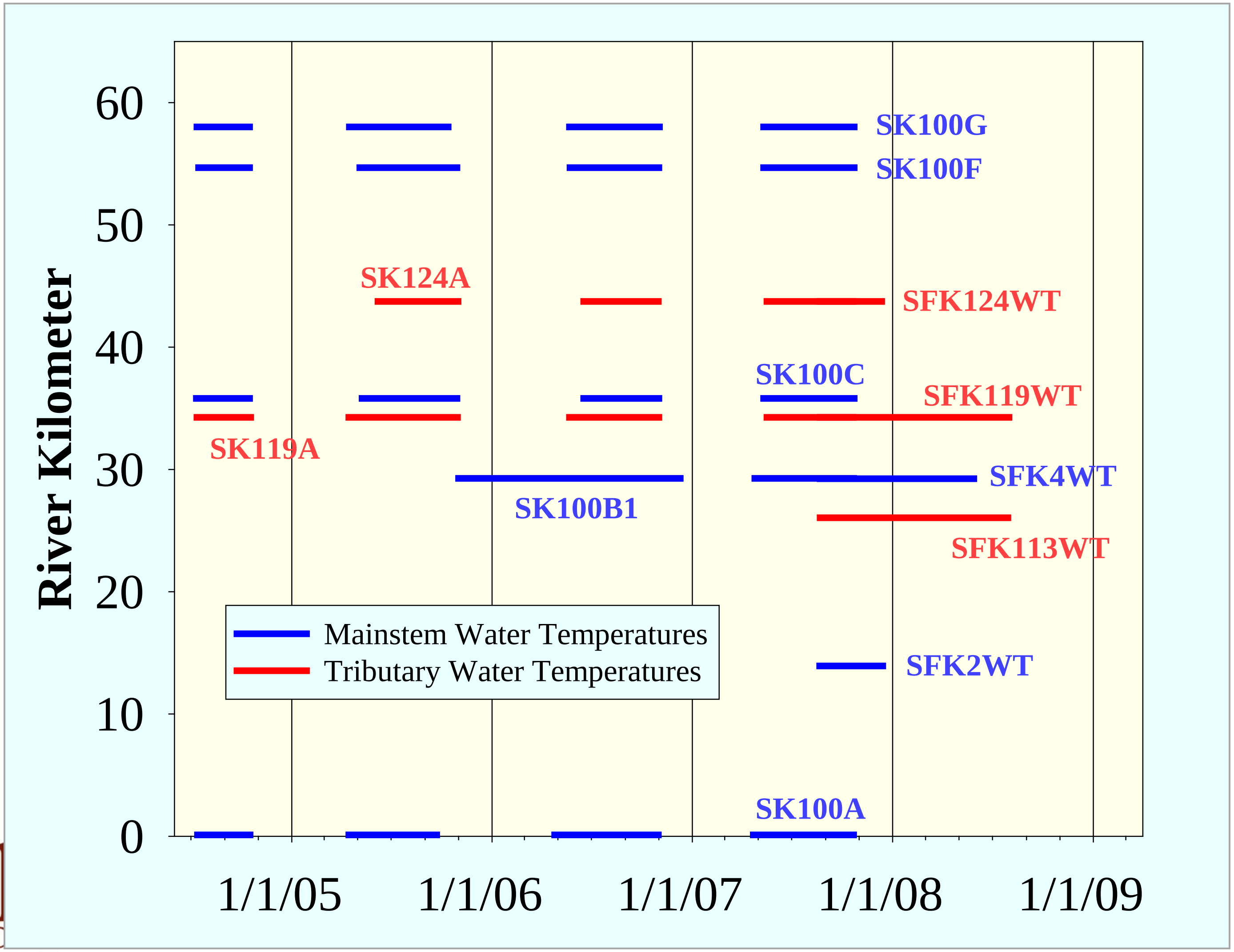


SFK Temperature at Selected Sites 2007

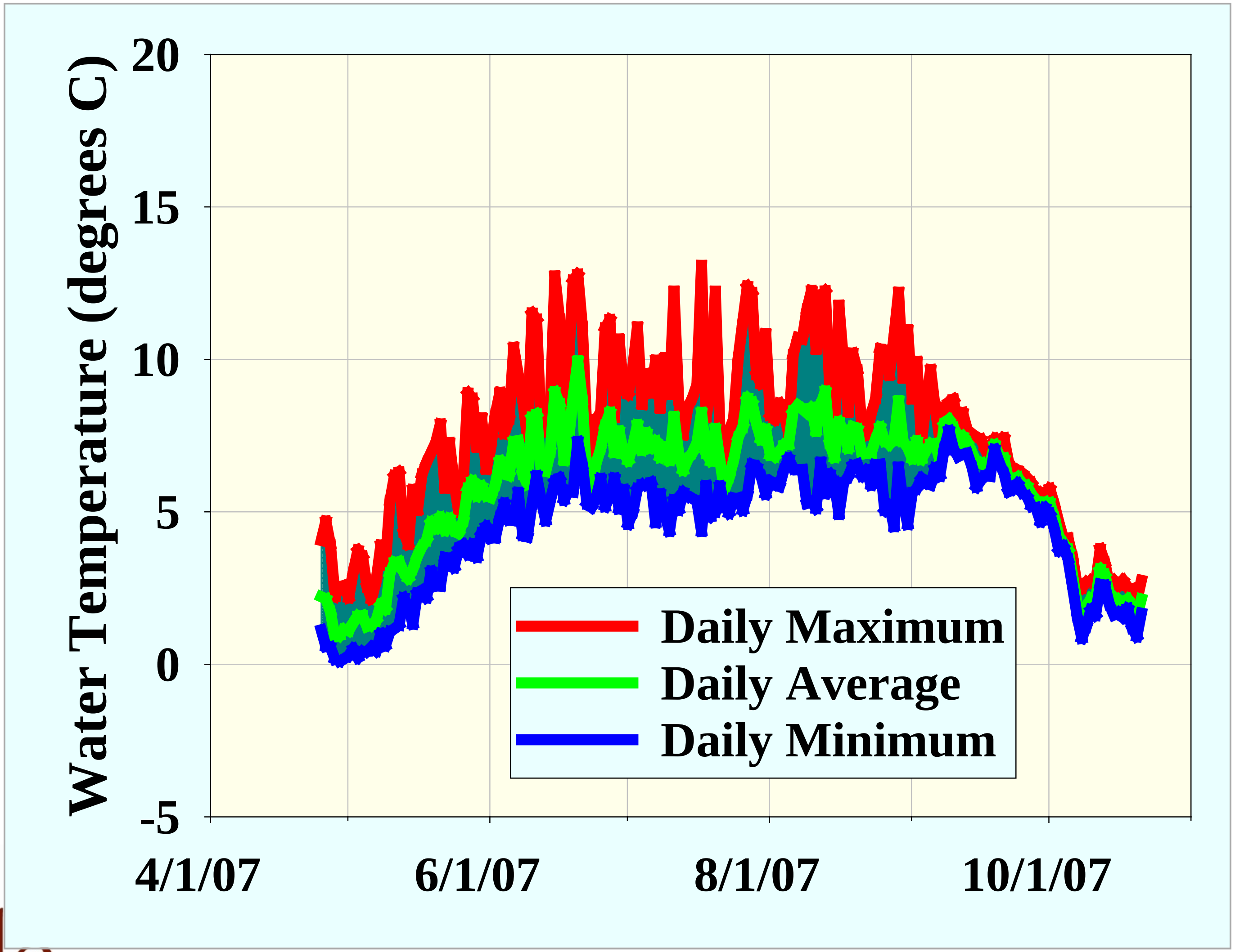


12 Temperature Monitoring Sites

Spatial and Temporal Inventory of Water Temperatures Measured in the South Fork Koktuli River



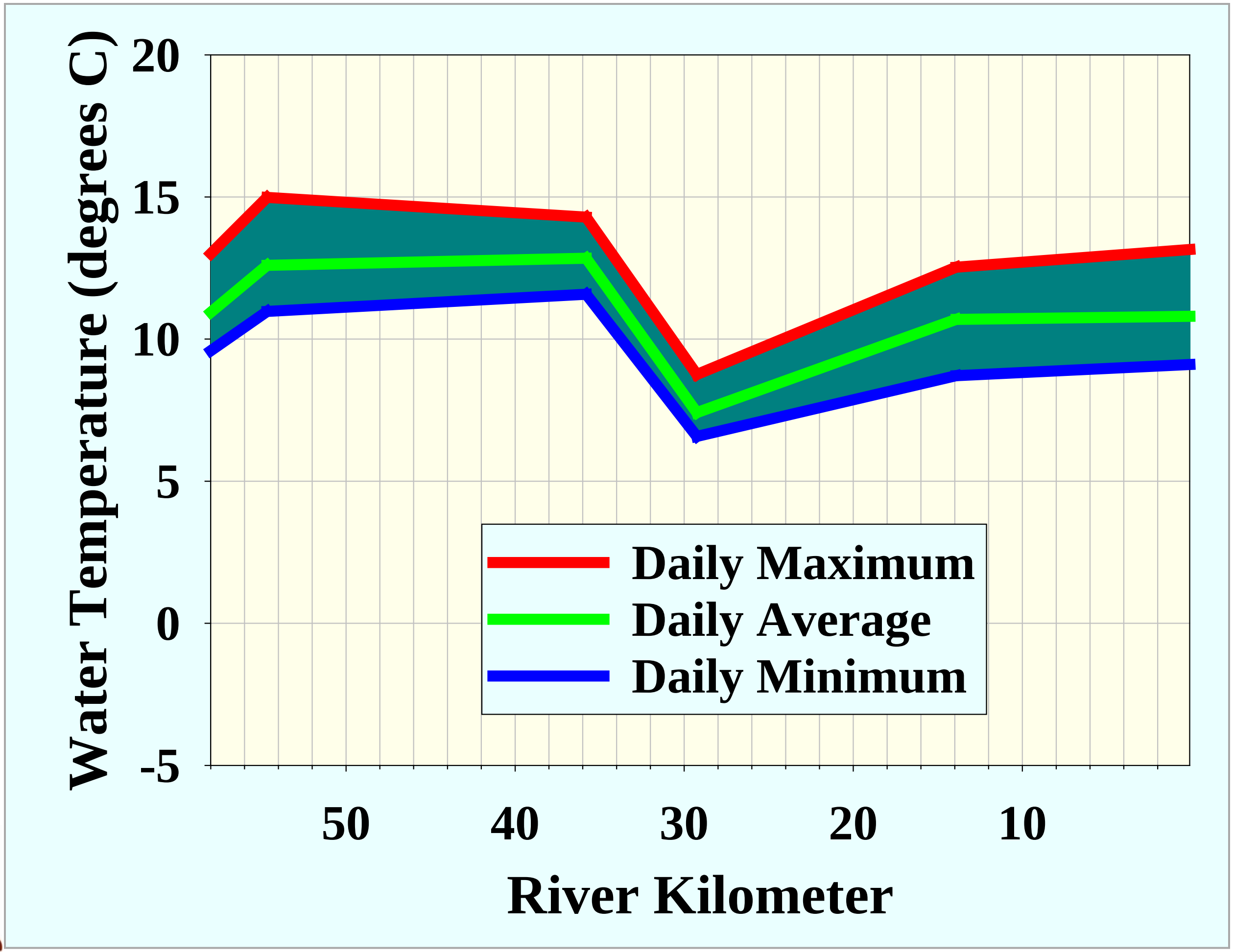
South Fork Koktuli River
SK100B1, River Kilometer 29.3



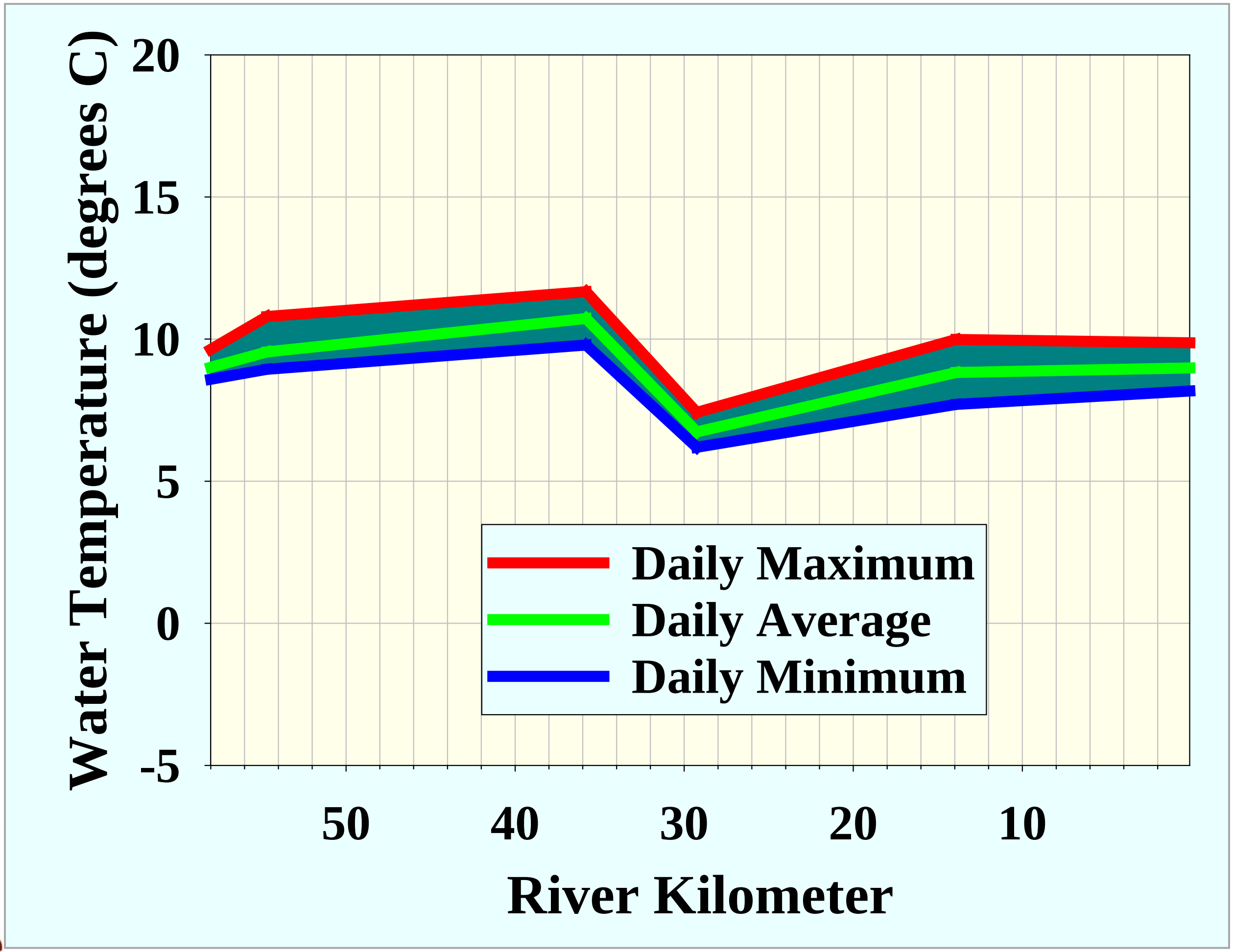
South Fork Koktuli River

August 24, 2007

Flow = 76 cfs at USGS Gage



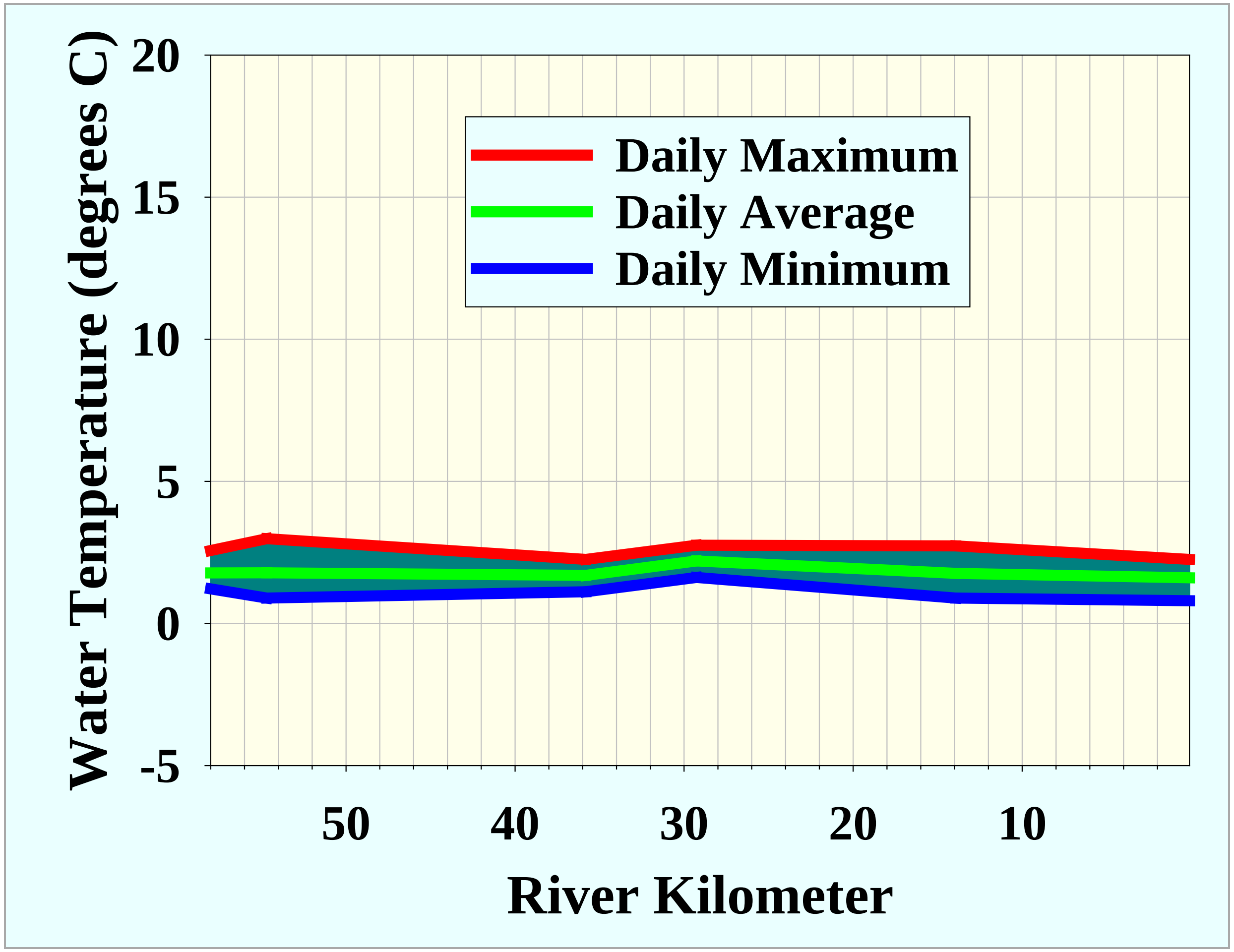
South Fork Koktuli River
September 7, 2007
Flow = 103 cfs at USGS Gage



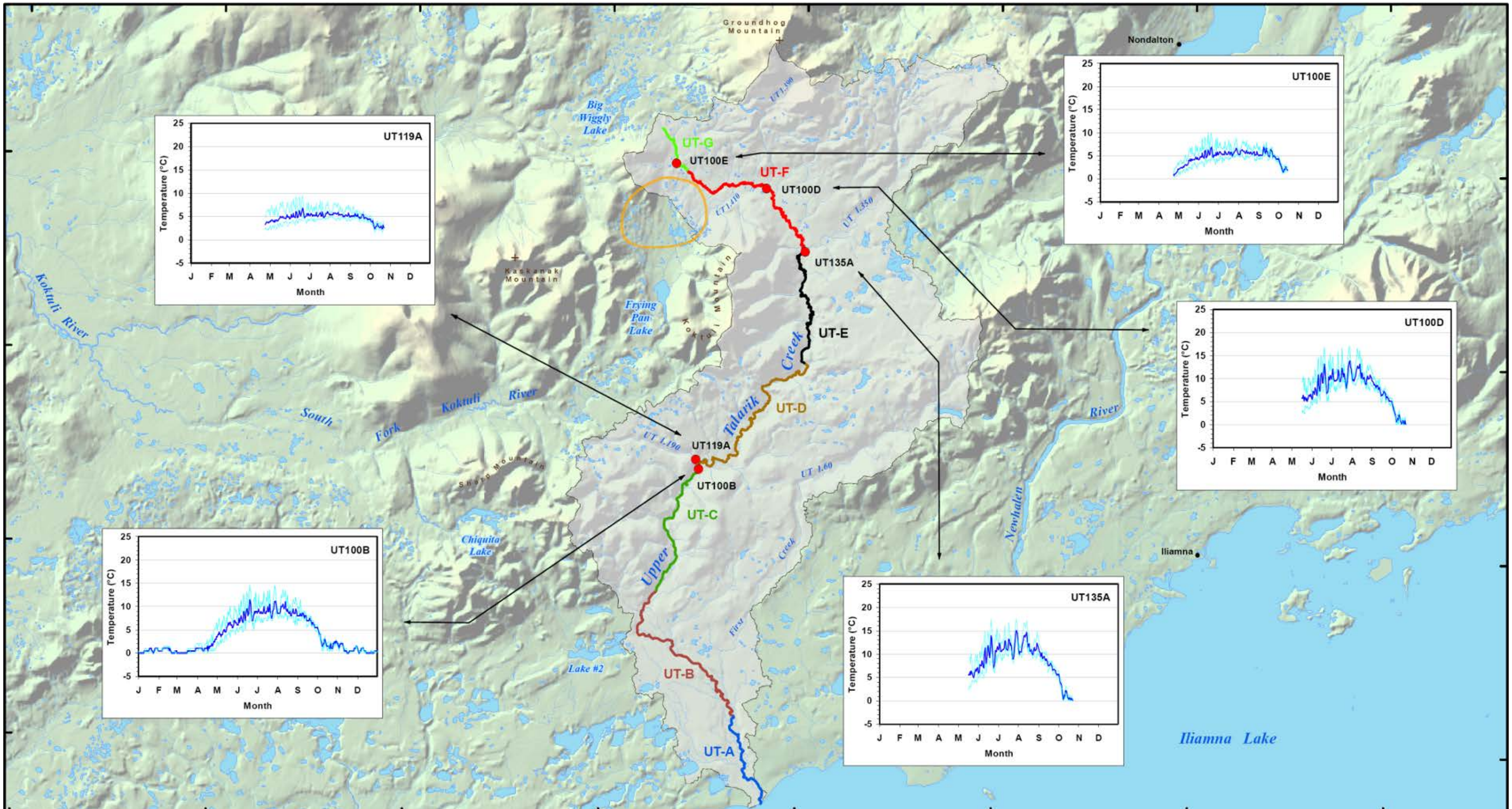
South Fork Koktuli River

October 15, 2007

Flow = 305 cfs at USGS Gage



UT Temperature at Selected Sites 2007



13 Temperature Monitoring Sites

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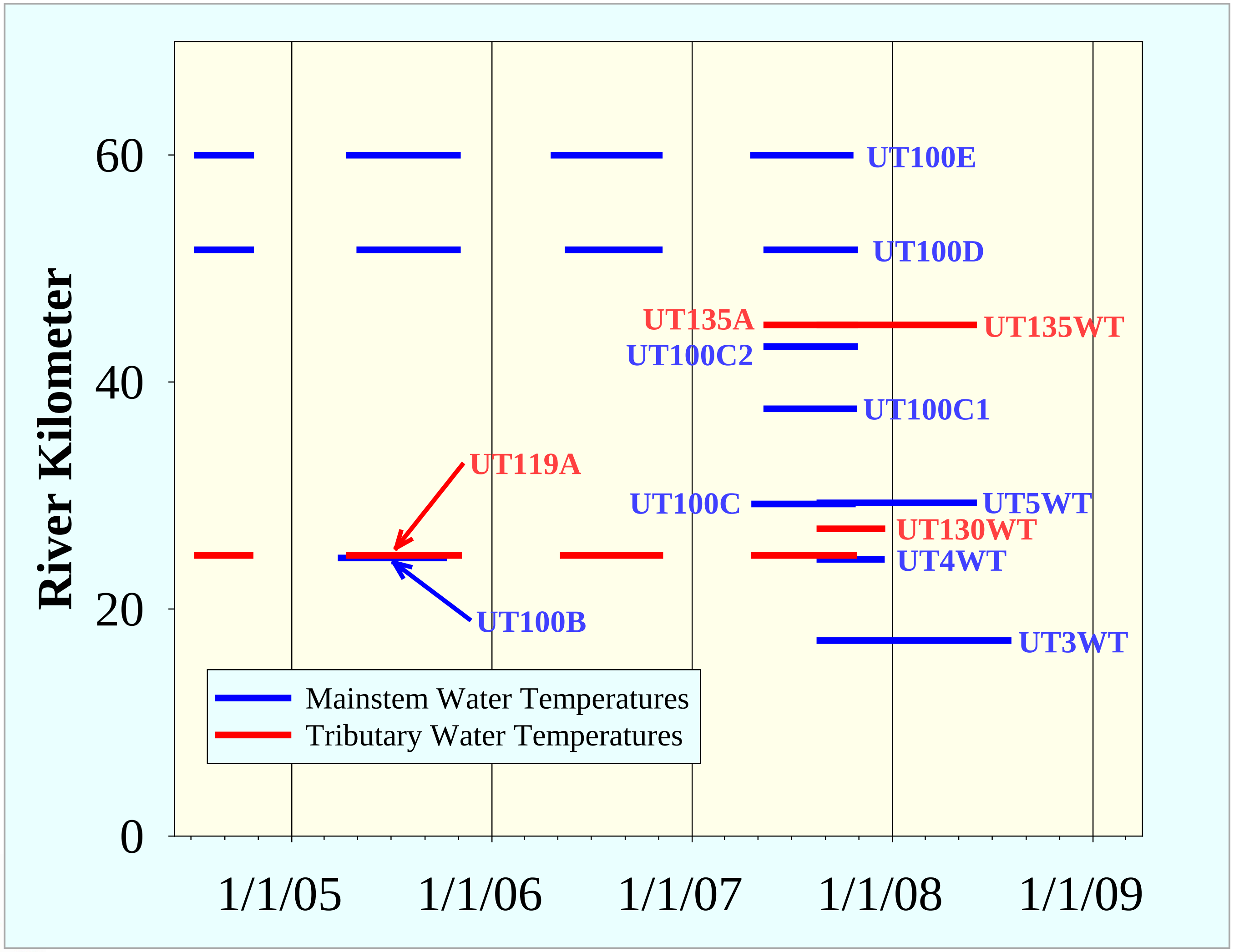
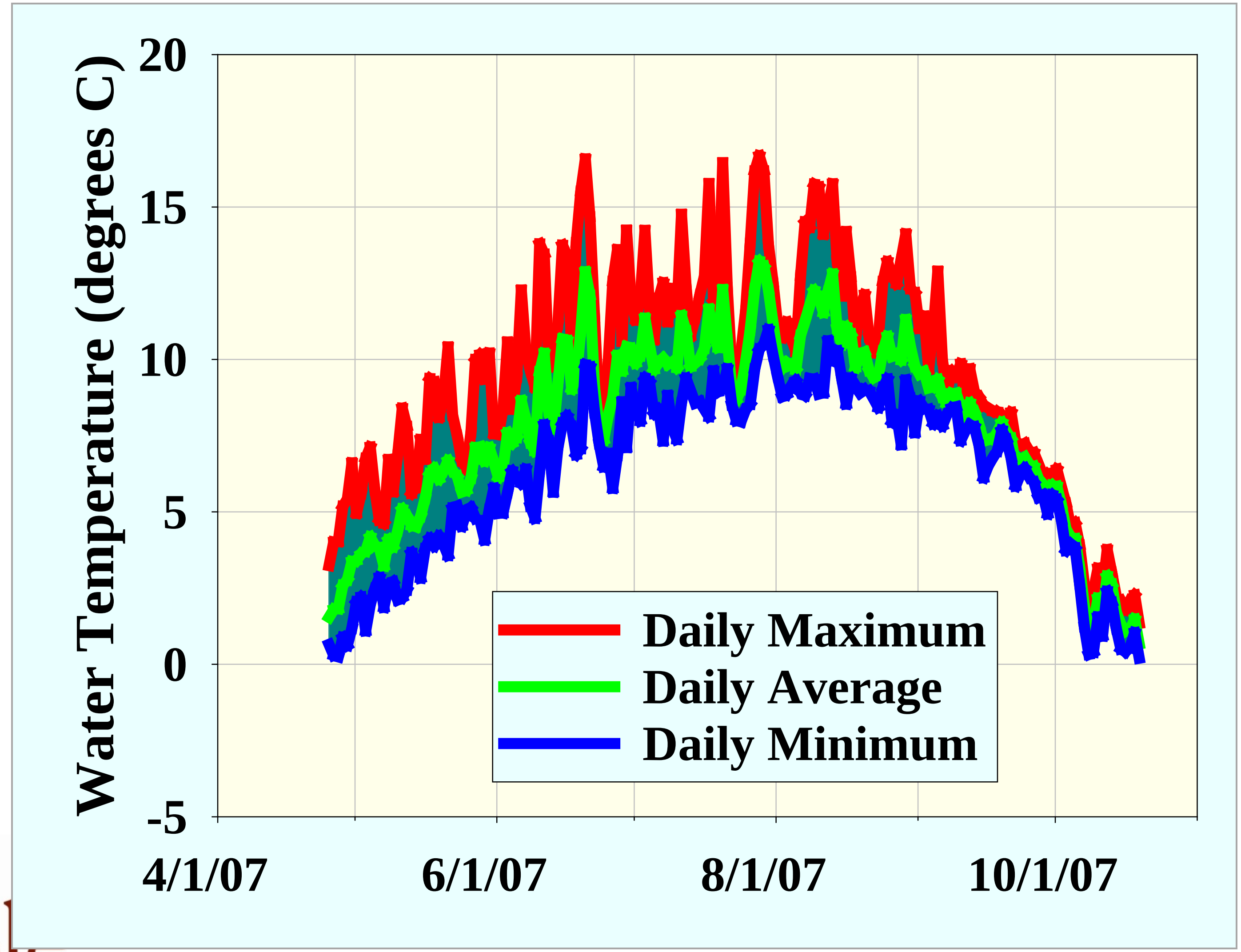
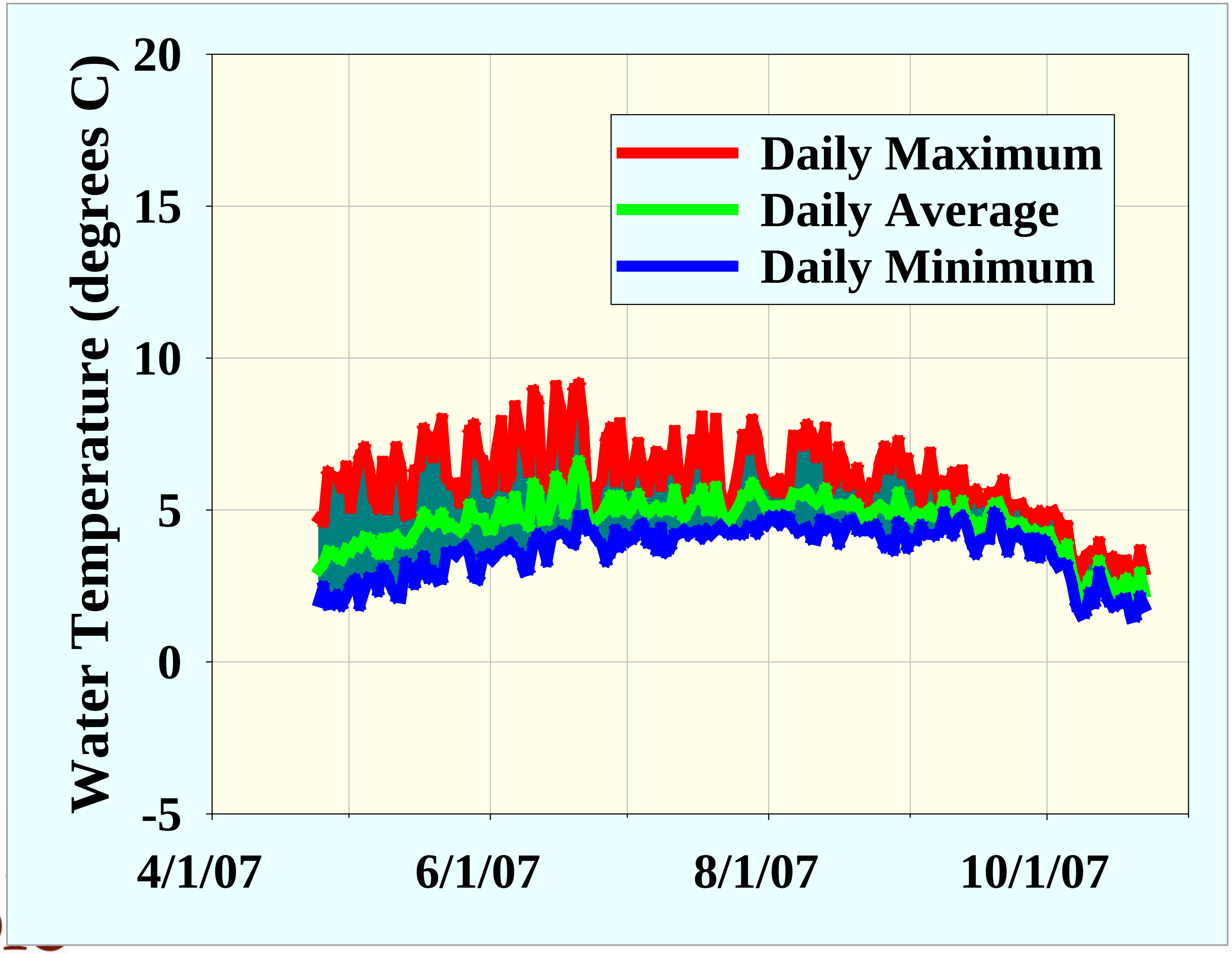
Spatial and Temporal Inventory of Water Temperatures Measured in Upper Talarik Creek



Upper Talarik Creek
UT100C, River Kilometer 29.3



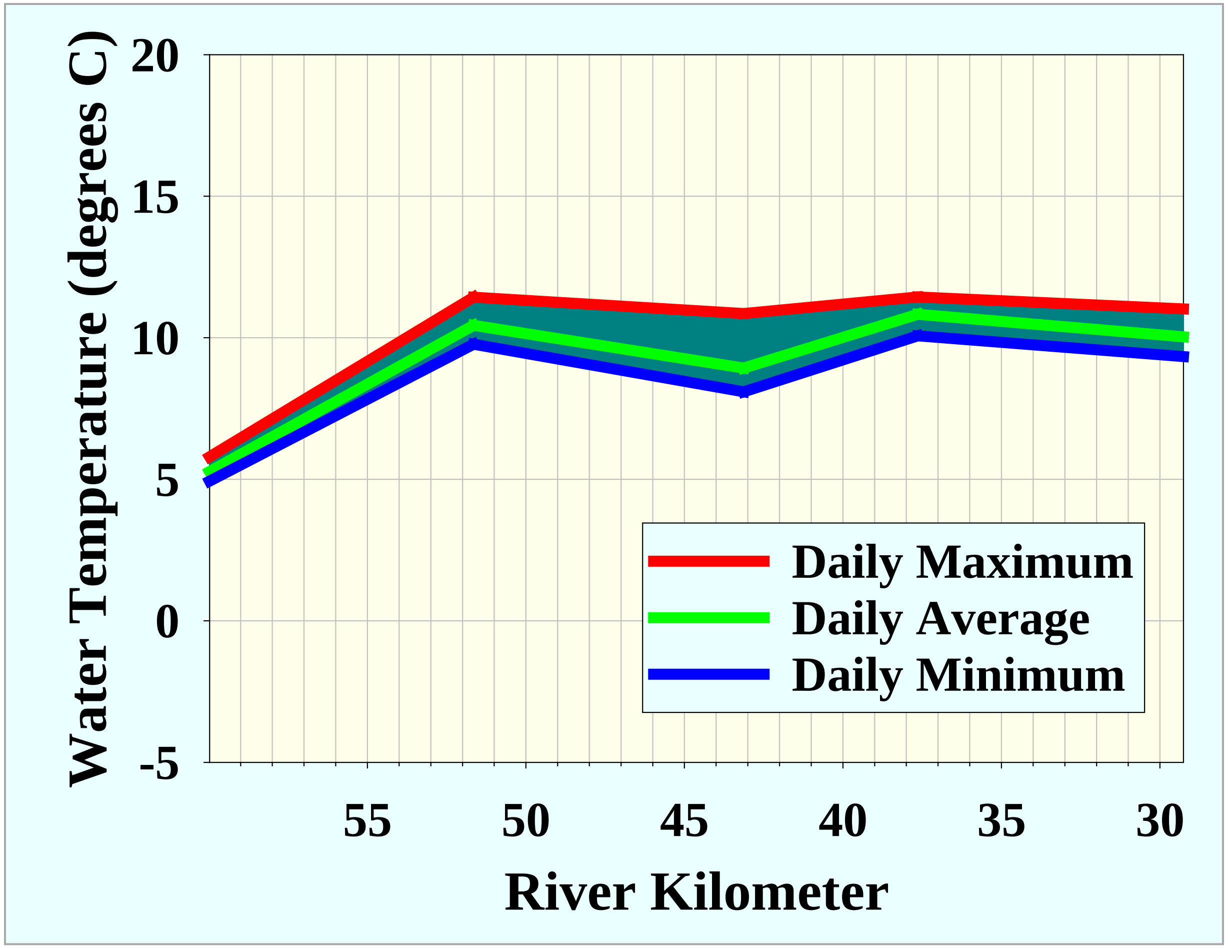
Upper Talarik Creek Tributary 190



Upper Talarik Creek

August 1, 2007

Flow = 118 cfs at USGS Gage



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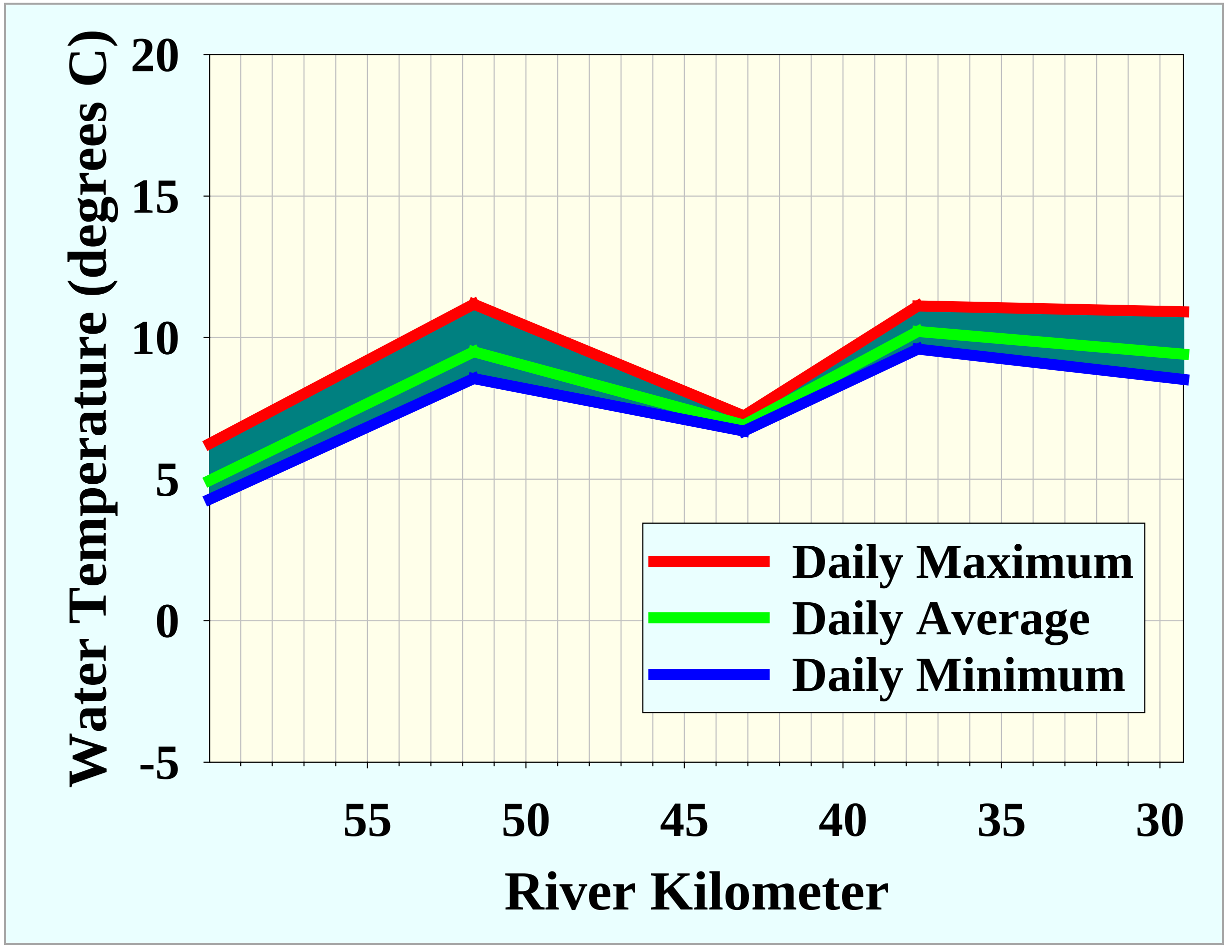
Upper Talarik Creek

September 1, 2007

Flow = 124 cfs at USGS Gage



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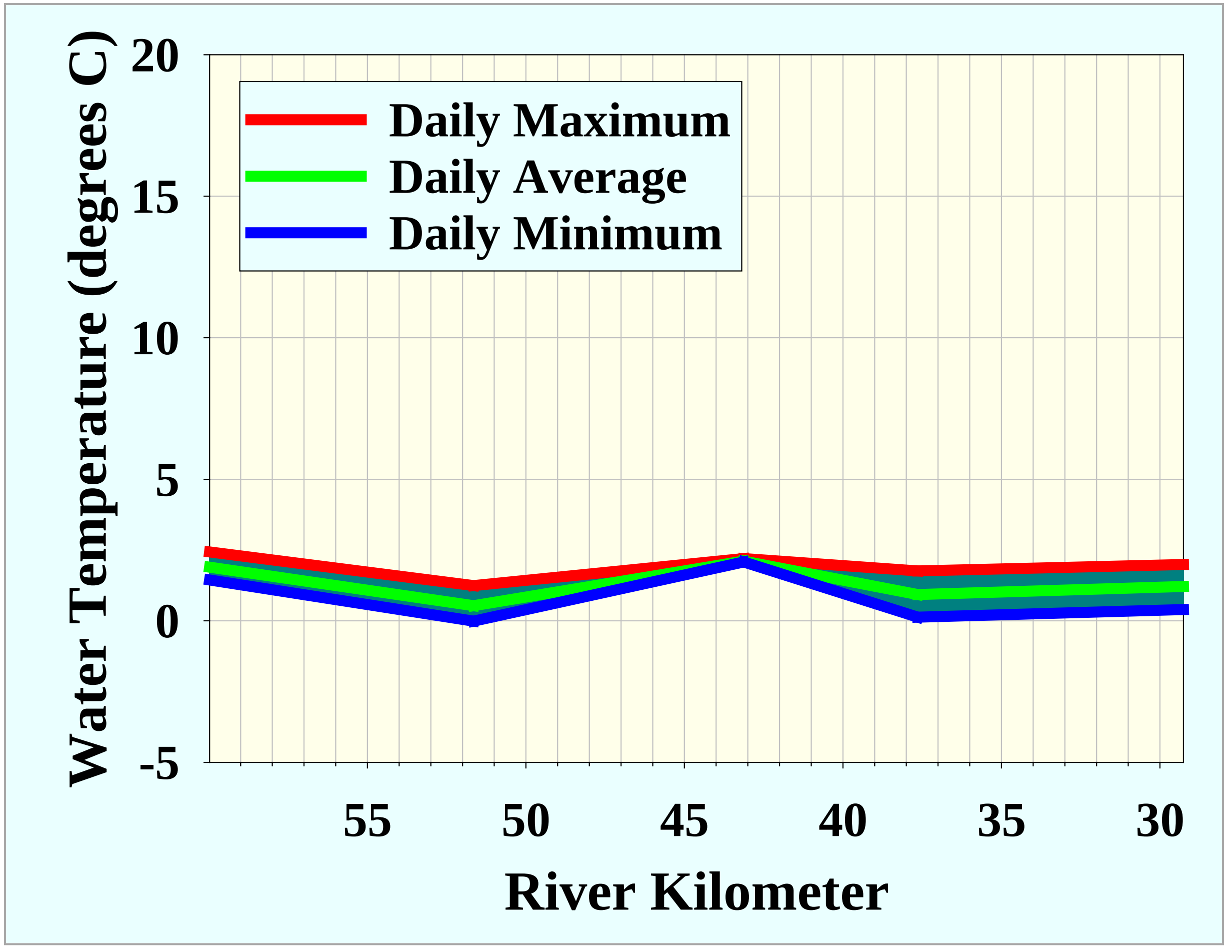
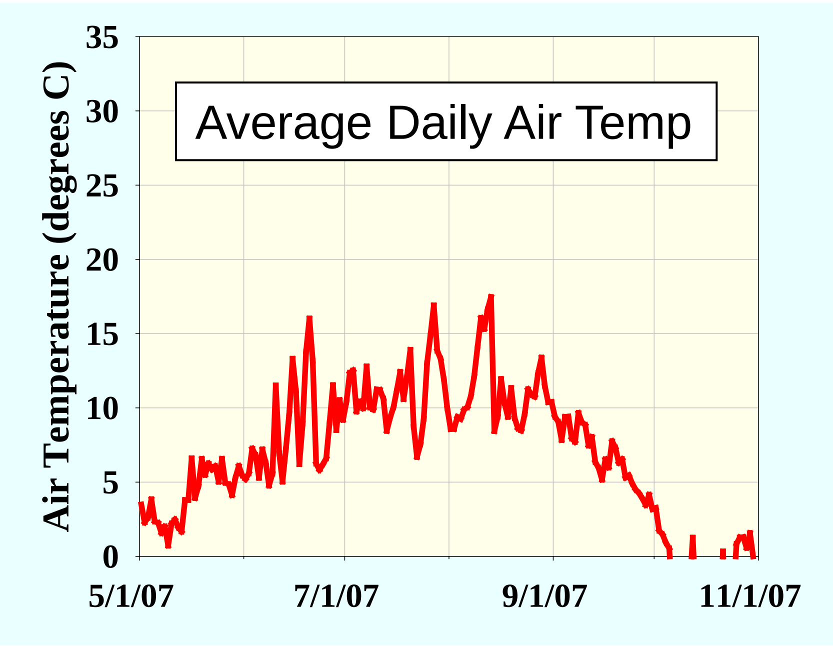
Upper Talarik Creek
October 15, 2007
Flow = 272 cfs at USGS Gage

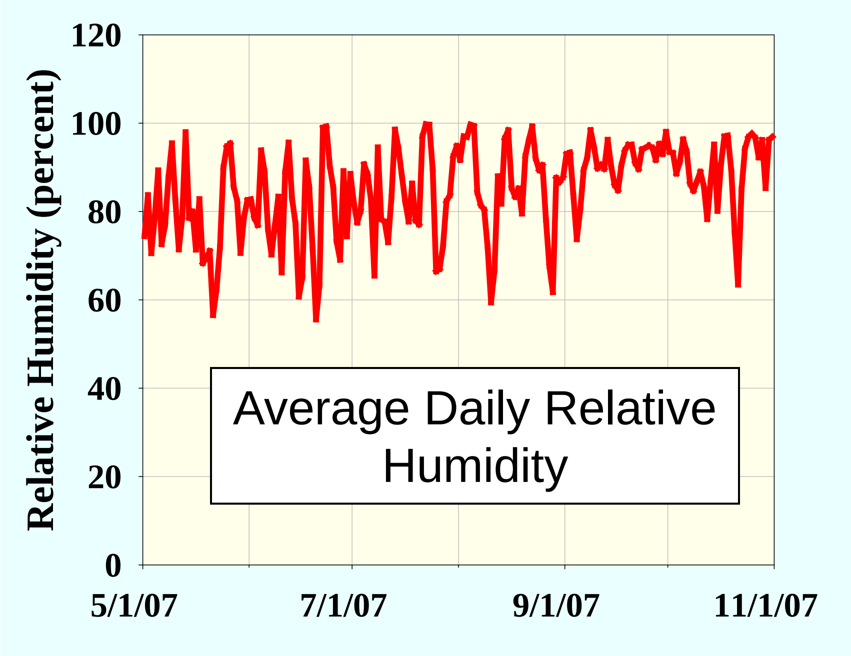


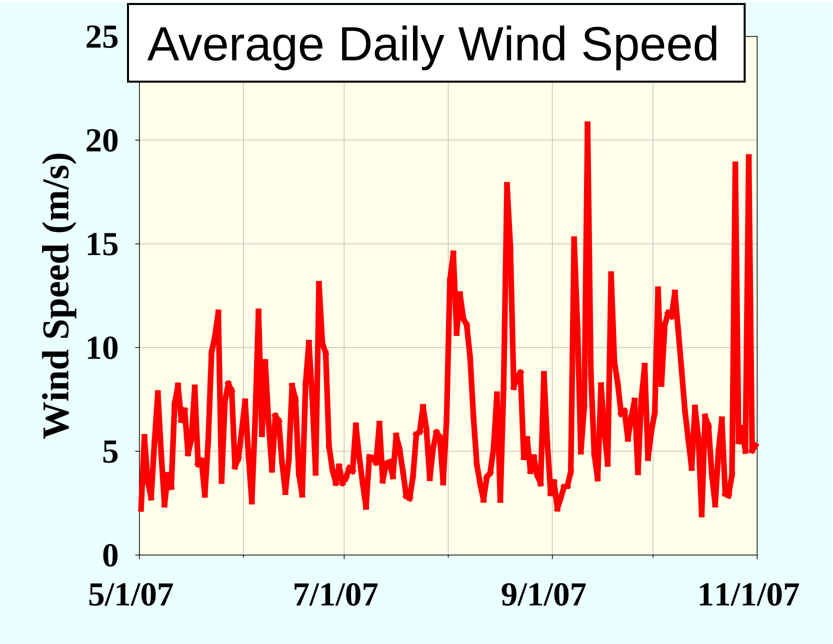
SNTEMP: Stream Network Temperature Model

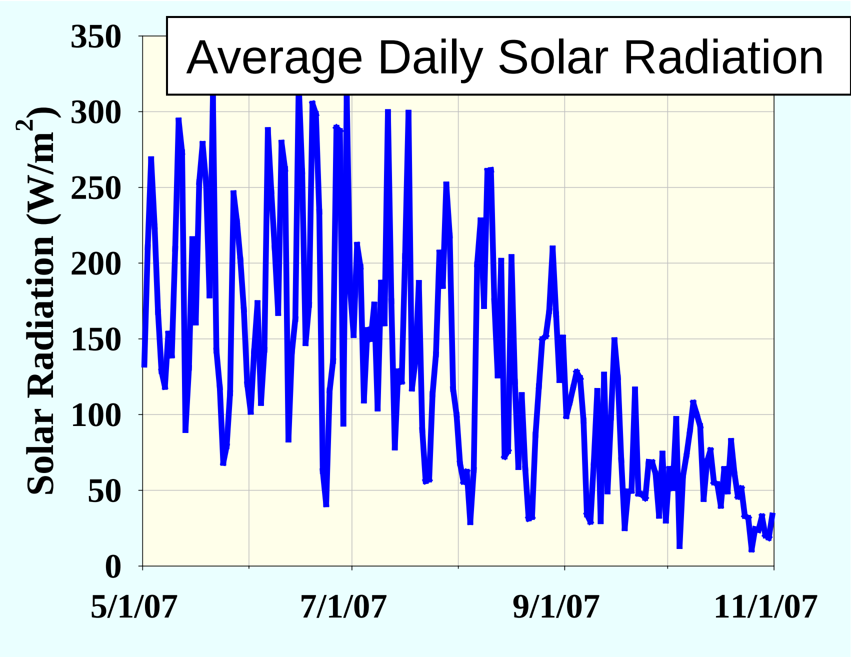
- Hydrologic Data
- Water Temperature Data
- Meteorological Data
- River/Valley Morphology Data
- Riparian Vegetation Data
- Seasonal Thermal Characteristics

METEOROLOGICAL DATA – Pebble One Station



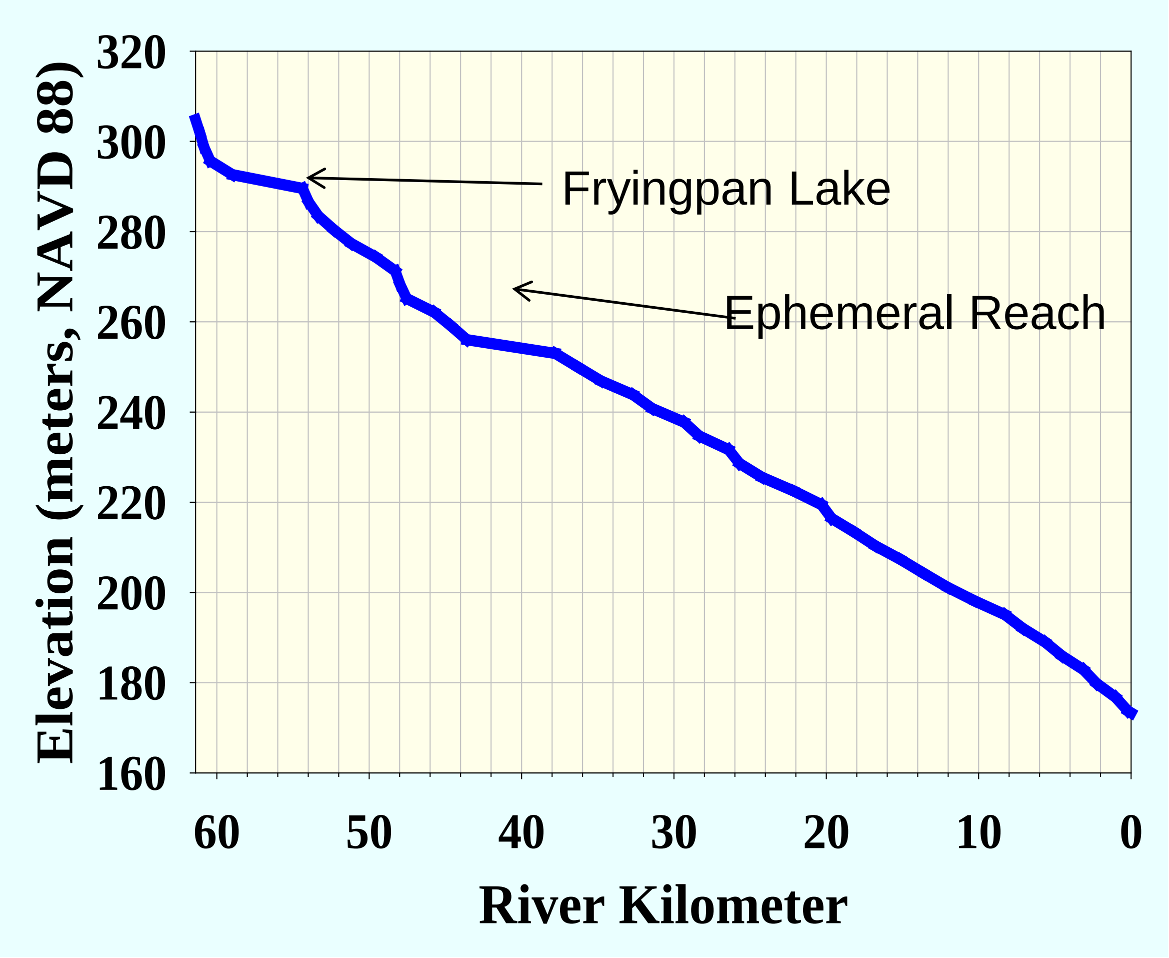






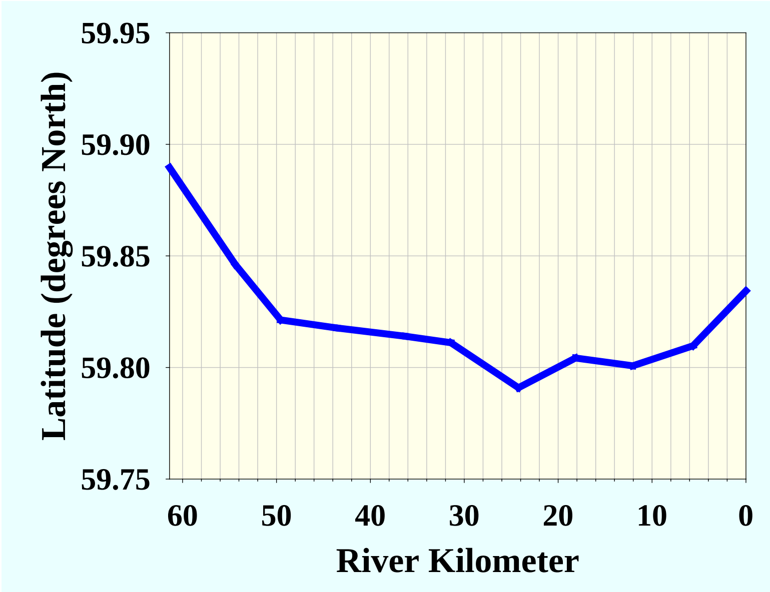
River/Valley Morphology Data

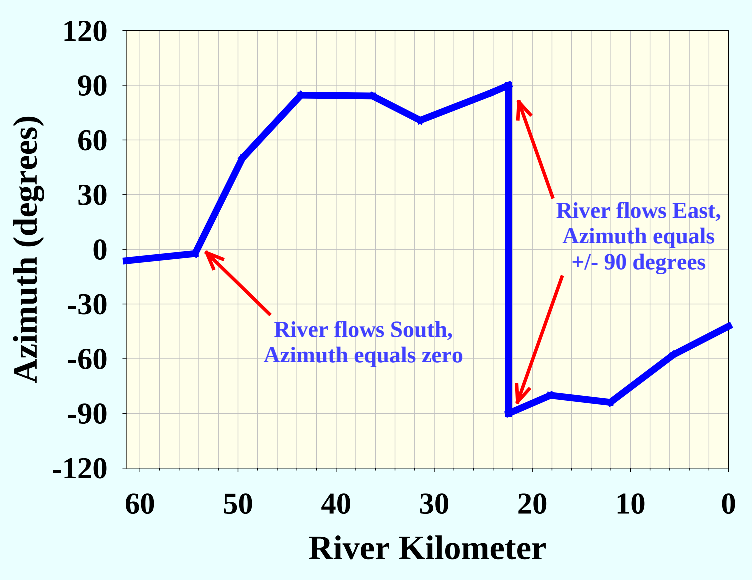
Longitudinal Profile – needed to perform orographic adjustments to meteorological conditions and to calculate travel time.



River/Valley Morphology Data (e.g. SFK)

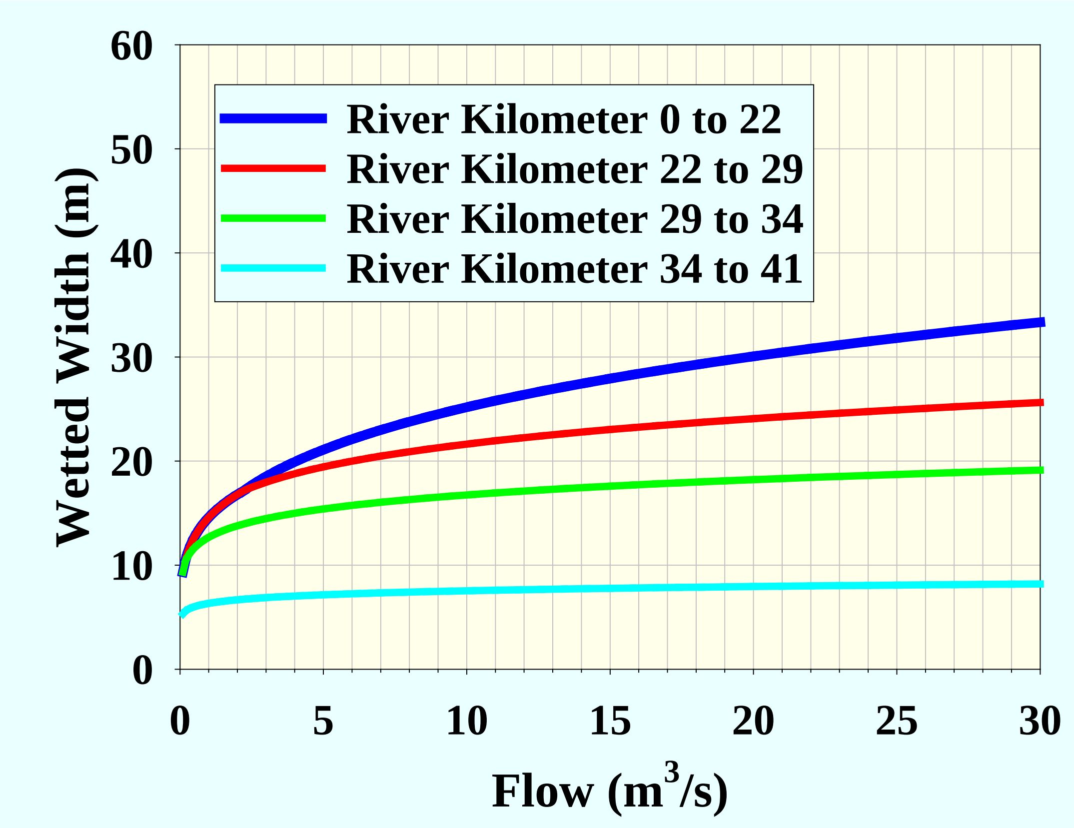
- ***Latitude*** – needed to calculate heat input from sunshine.
- ***Azimuth*** - Used to calculate solar radiation that reaches the stream surface, after accounting for shading effects of valley walls and riparian vegetation





River/Valley Morphology Data

- ***River Channel Width*** – needed to calculate heat input from sunshine and to determine travel time.
- ***Topographic Altitude (Lateral Valley Slope)*** – specified for both sides of the river and needed to calculate heat input from sunshine.



SNTEMP Models Developed for SFK, NFK, and UT

- Calibrated models can be used to assess the impacts of water regulation on the downstream thermal regimes of the three river systems

- Useful to evaluate potential impacts on timing of incubation and emergence; growth rates of fish; and overall productivity of the ecosystems (e.g production of periphyton, macroinvertebrates, etc)

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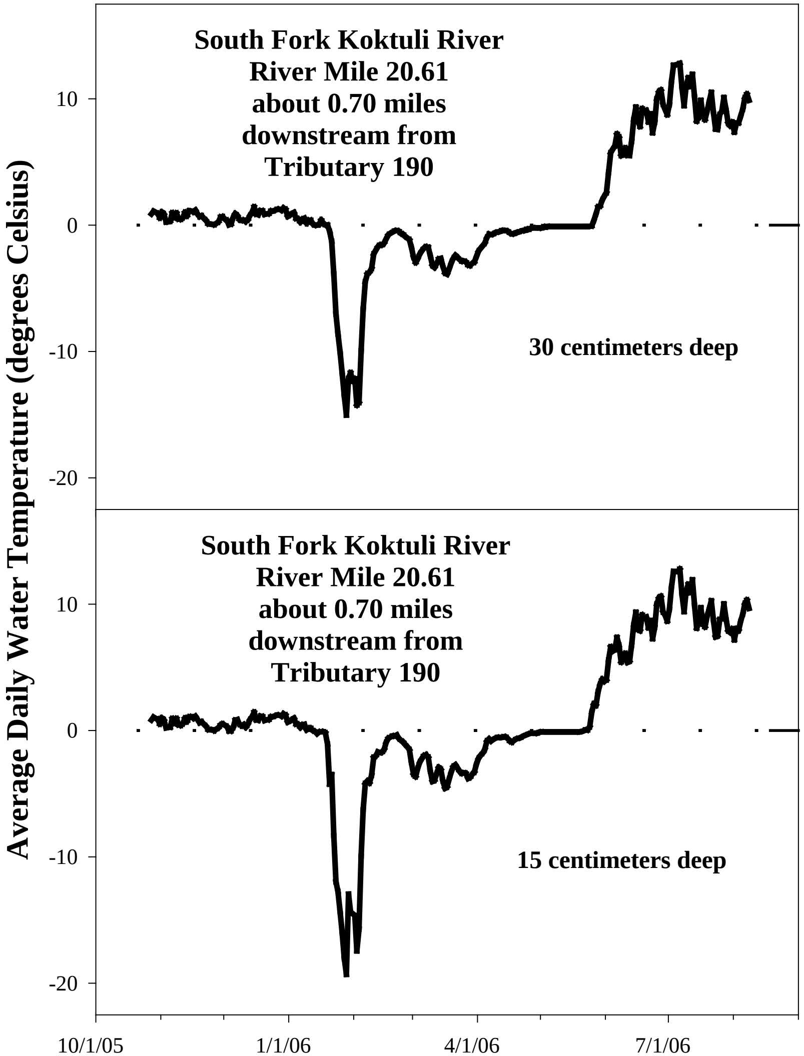
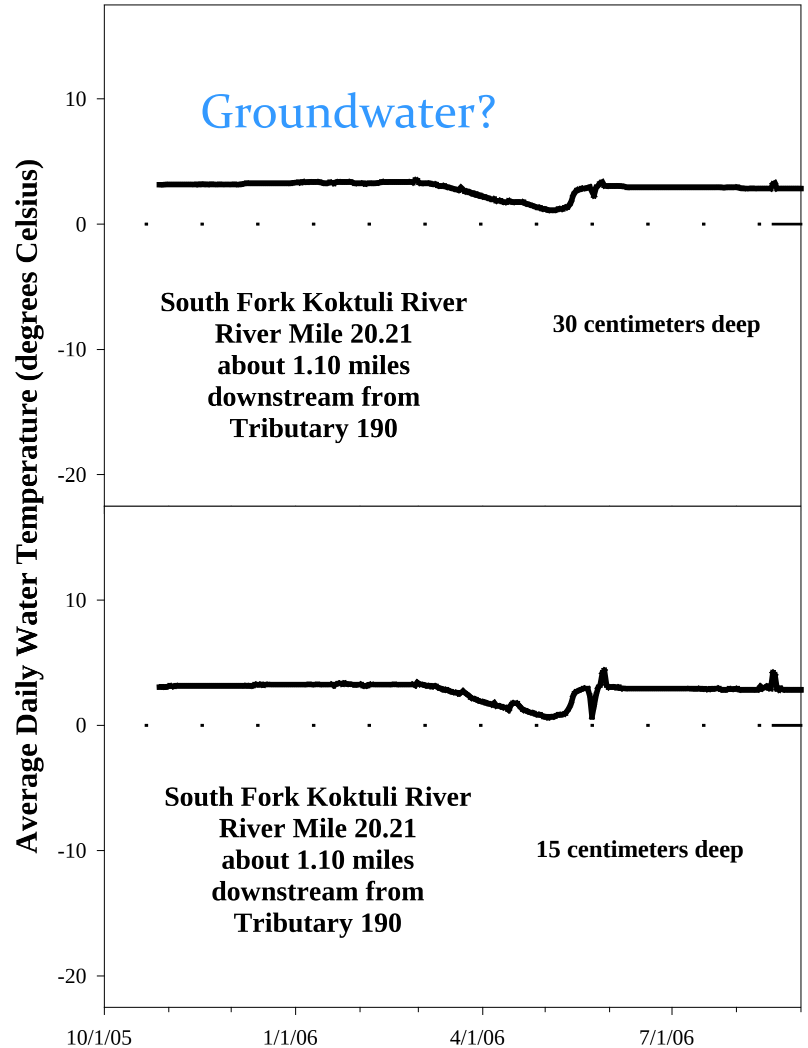
INTRAGRAVEL TEMPERATURES - SFK





Fluvial Geomorphology

- Channel Forming Flows
- Evaluate Flow Related Project Effects on Channel Form
- Spawning Gravel Quality

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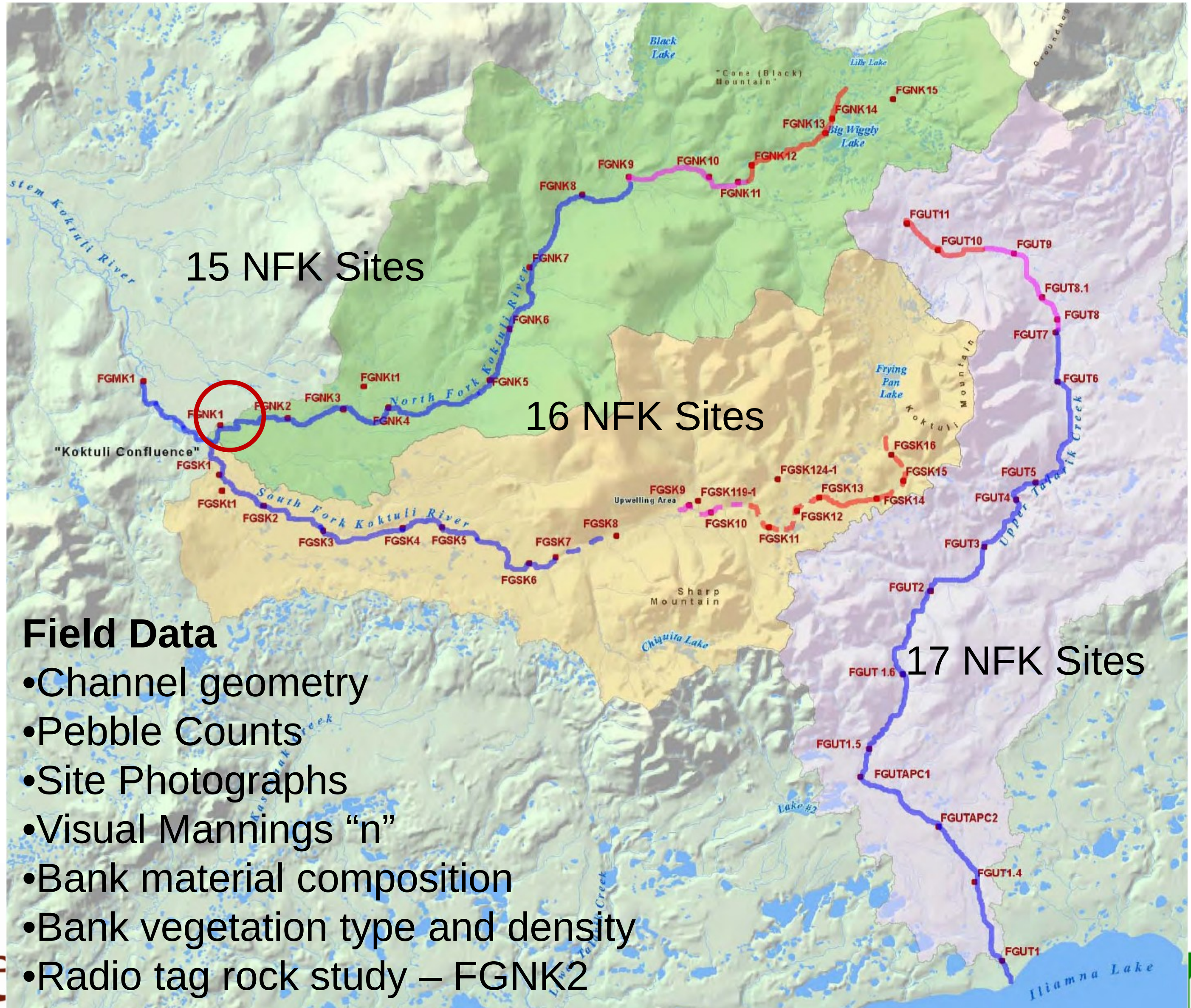
Geomorphology Study Sites



Field Data

- Channel geometry
- Pebble Counts
- Site Photographs
- Visual Mannings "n"
- Bank material composition
- Bank vegetation type and density
- Radio tag rock study – FGNK2

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Particle Mobility Study – Radio tagged Rock Study – FGNK2

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Fluvial Geomorphology Approach

- Regime Theory: Develop Hydraulic Geometry Relations
  - Bankfull Geometry ~ Channel Forming Flow
- Relate to Hydrology Changes
  - Channel Forming Flows ~ Hydrology (2 year and 10 year flood event peak flows)
- Predict Changes in Channel Size
- Consider Adjustment to Instream Flow Data to Evaluate Change in Habitat Quantity

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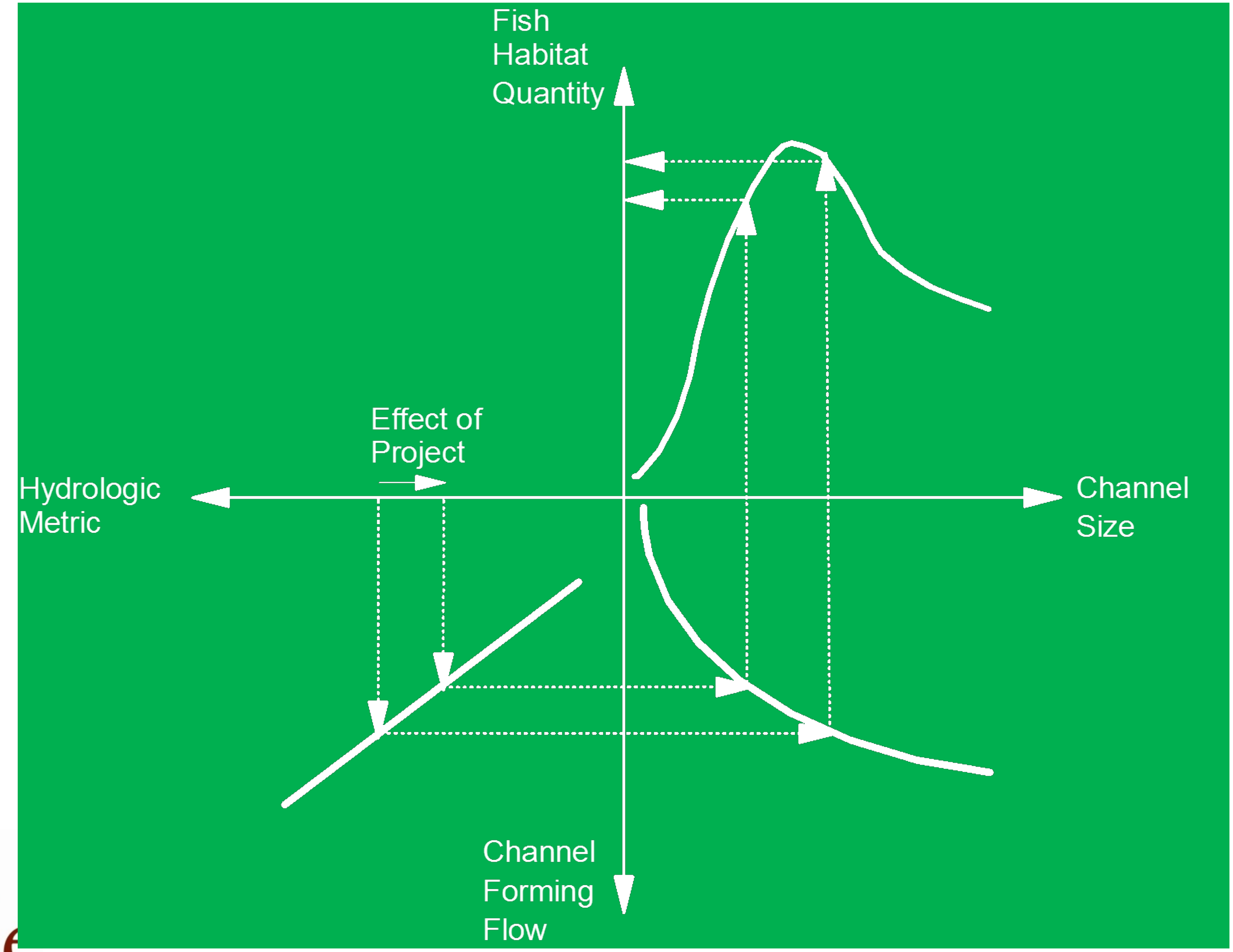
Fish Habitat-Fluvial Geomorphology Linkage Concept



Habitat Response to Altered Hydrology

Current Habitat

Current Morphology
Current Hydrology

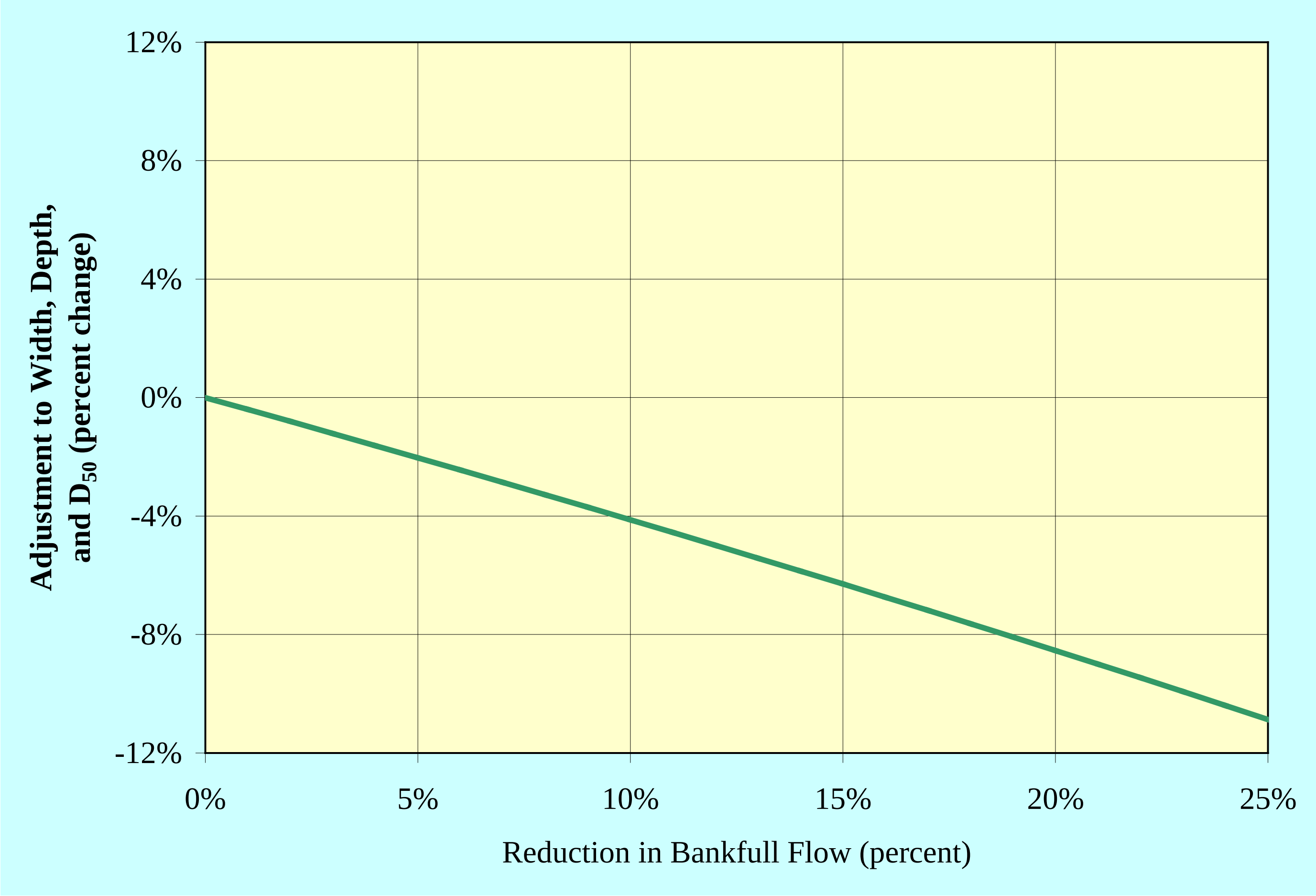
Short-Term Habitat Response

Current Morphology
Altered Hydrology

Long-Term Habitat Response

Altered Morphology
Altered Hydrology

Example of Gravel Bed Regime Relationship



Parker, Gary, Carlos M. Toro-Escobar, Michael Ramey, and Stuart Beck. 2003. Effect of floodwater extraction on mountain steam morphology, Journal of Hydraulic Engineering, ASCE, Vol. 129, No. 11, November, pp 885-895.

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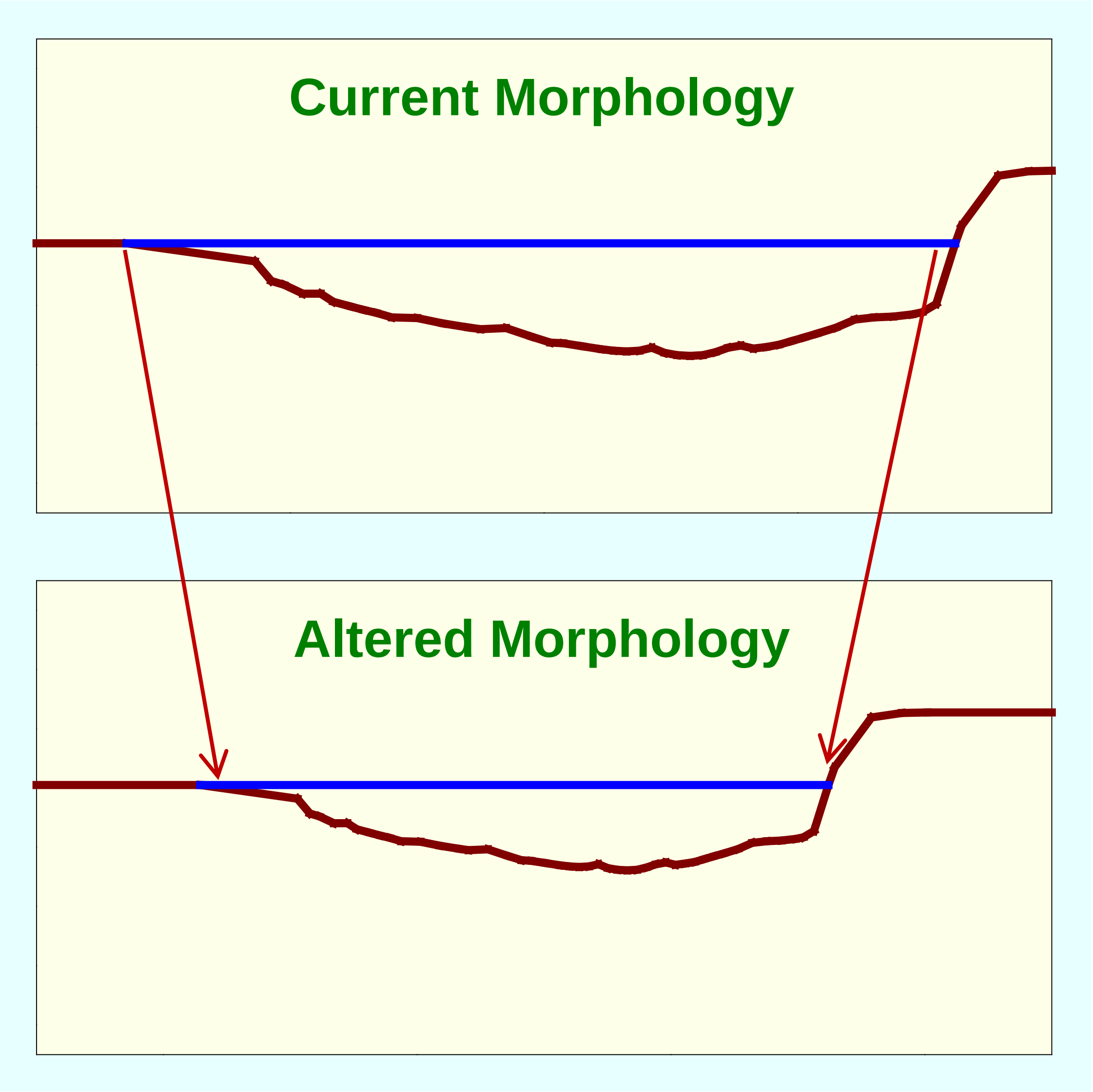
Example – Bankfull Flow Reduced 50%



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Spawning Gravel Characterization

- Part of Baseline Studies – Pebble Prospect
- Focus on Spawning and Incubation Environment

- Evaluate difference in gravel quality:
  - Pre-spawning vs Post-spawning AND
  - Pre-spawning vs Post-fall rains

- Information useful for future impact assessment

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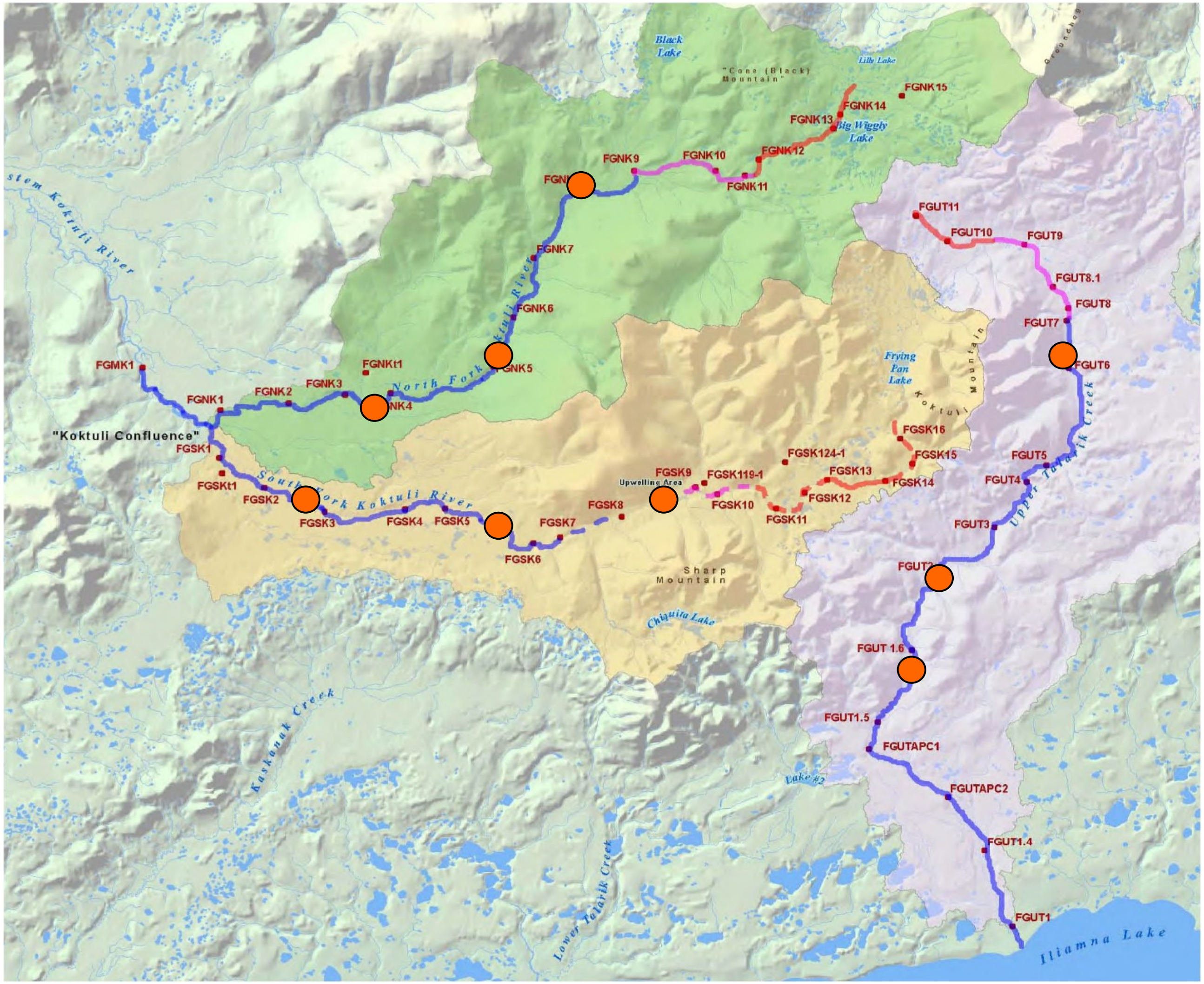
r2



● **Spawning Gravel Sites**

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Questions Addressed

- Baseline characterization of spawning gravel quality
- Questions:
  1. What is the quality of spawning gravels within watersheds?
  2. Do fall freshets affect post-spawning gravel quality
  3. Underlying question – when is "best" time to characterize gravel quality?

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Typical Hydrologic Pattern

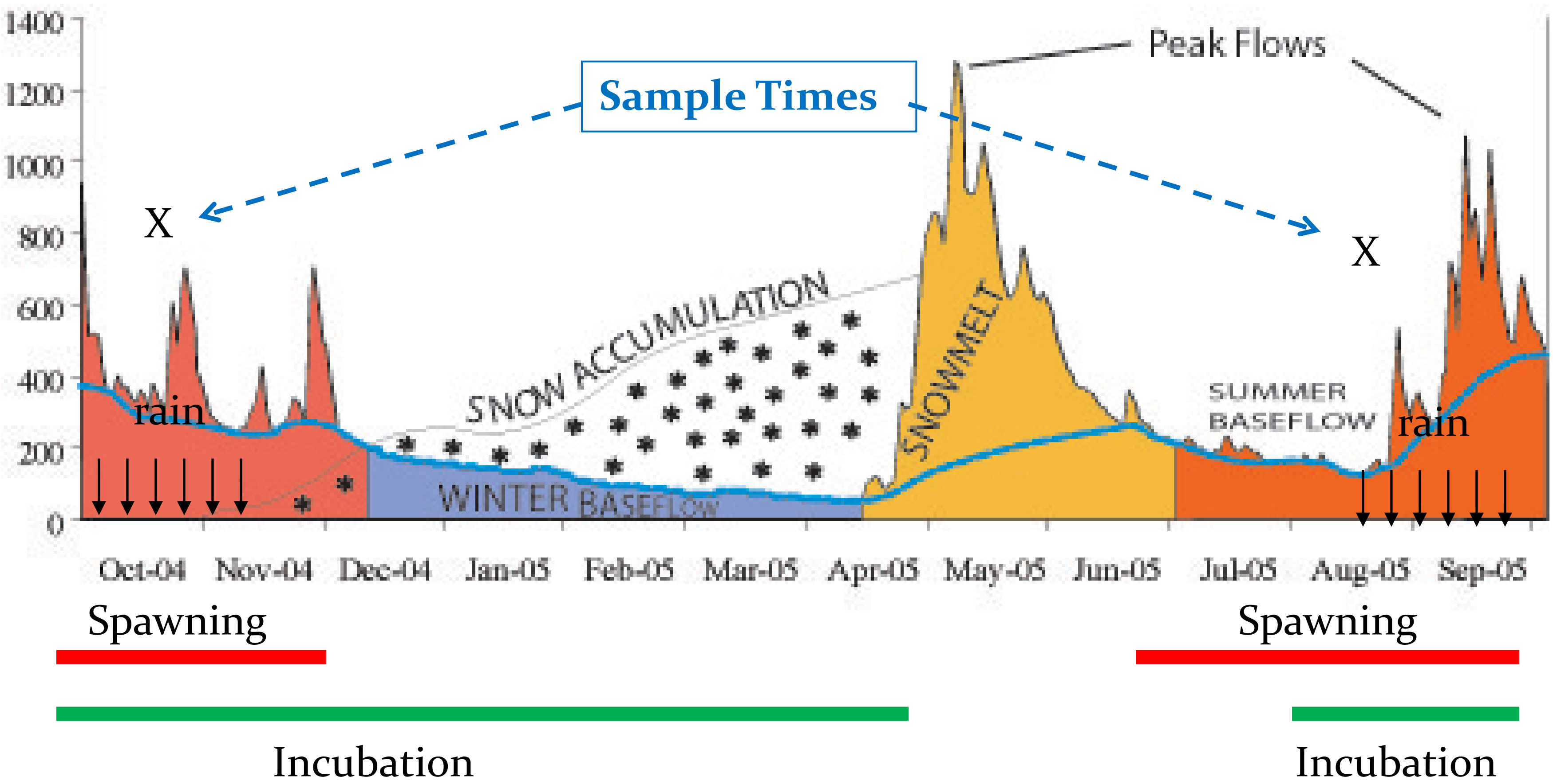

Figure courtesy of HDR Alaska

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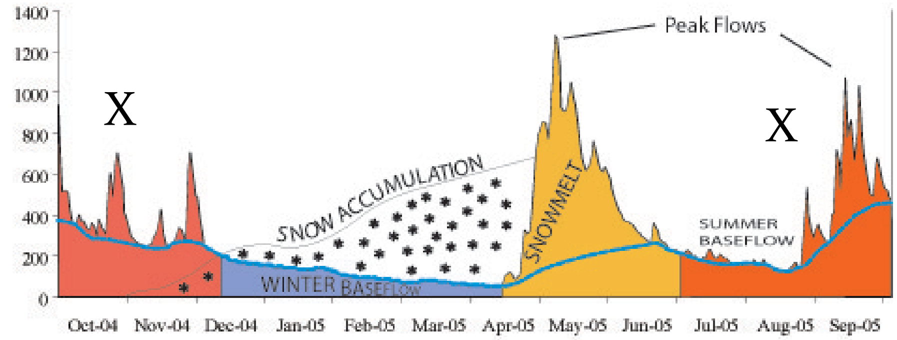
Gravel Sampling

- August 2008:
  - 9 Spawning Gravel Sites
    - 6 Replicates/Site
    - Pre-Spawning
- October 2008:
  - 9 Spawning Sites
    - 3 Replicates/Site
    - Post-Spawning
    - Post-Fall Freshets
    - Pre-Freeze-Up



•30 gallon open-ended drum
•depth – up to 15 cm
•Sample wt – 50-75 lbs

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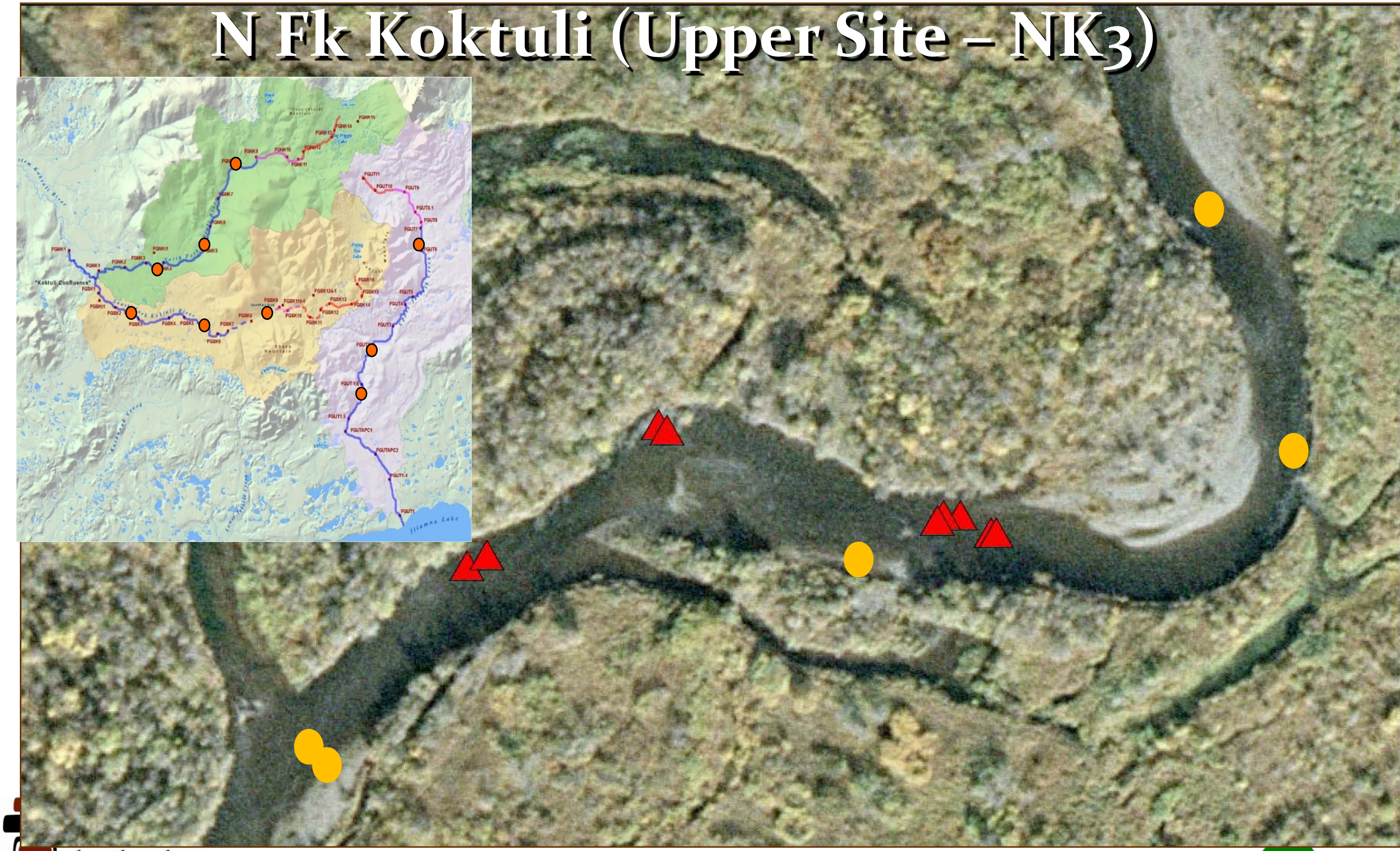
Spawning Gravel Sample Locations:

N Fk Koktuli (Upper Site – NK3)



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October Spawning Gravel Samples

- Eggs Found in ~1/3 of the Samples
  - Hit Top of Egg Pocket
  - Majority = Sockeye

- Alevins Found in 1 Redd
  - Chum or Chinook?

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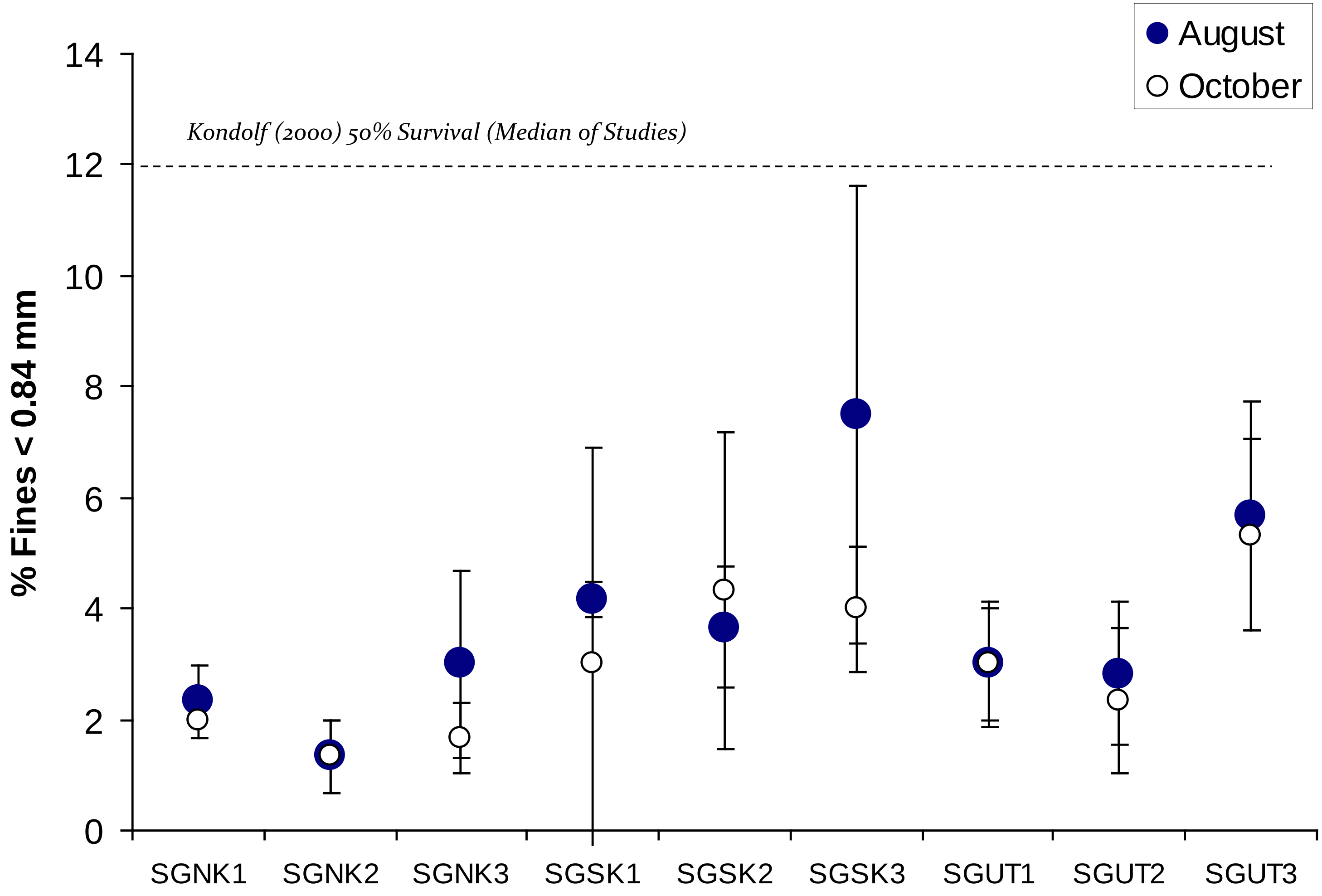
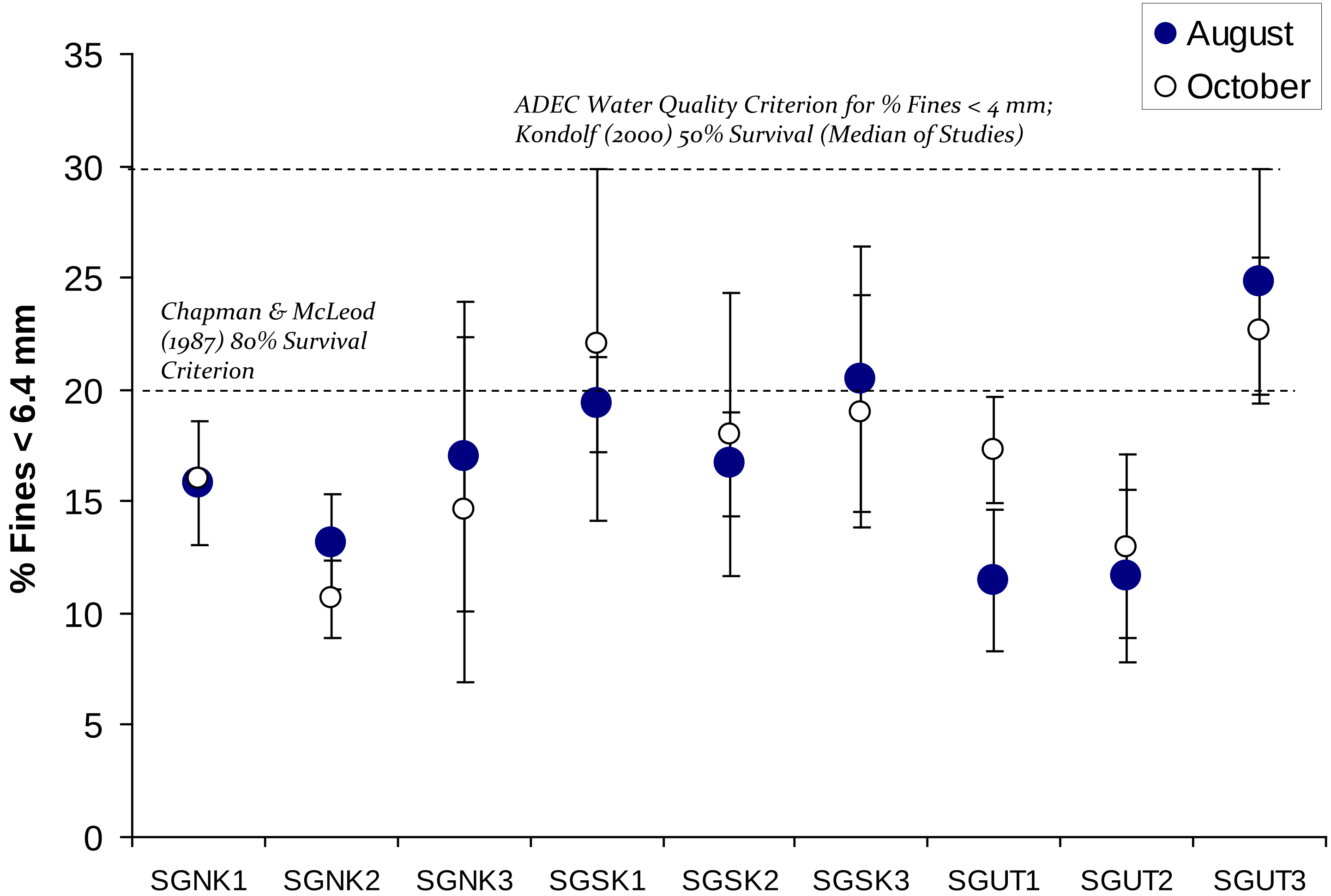
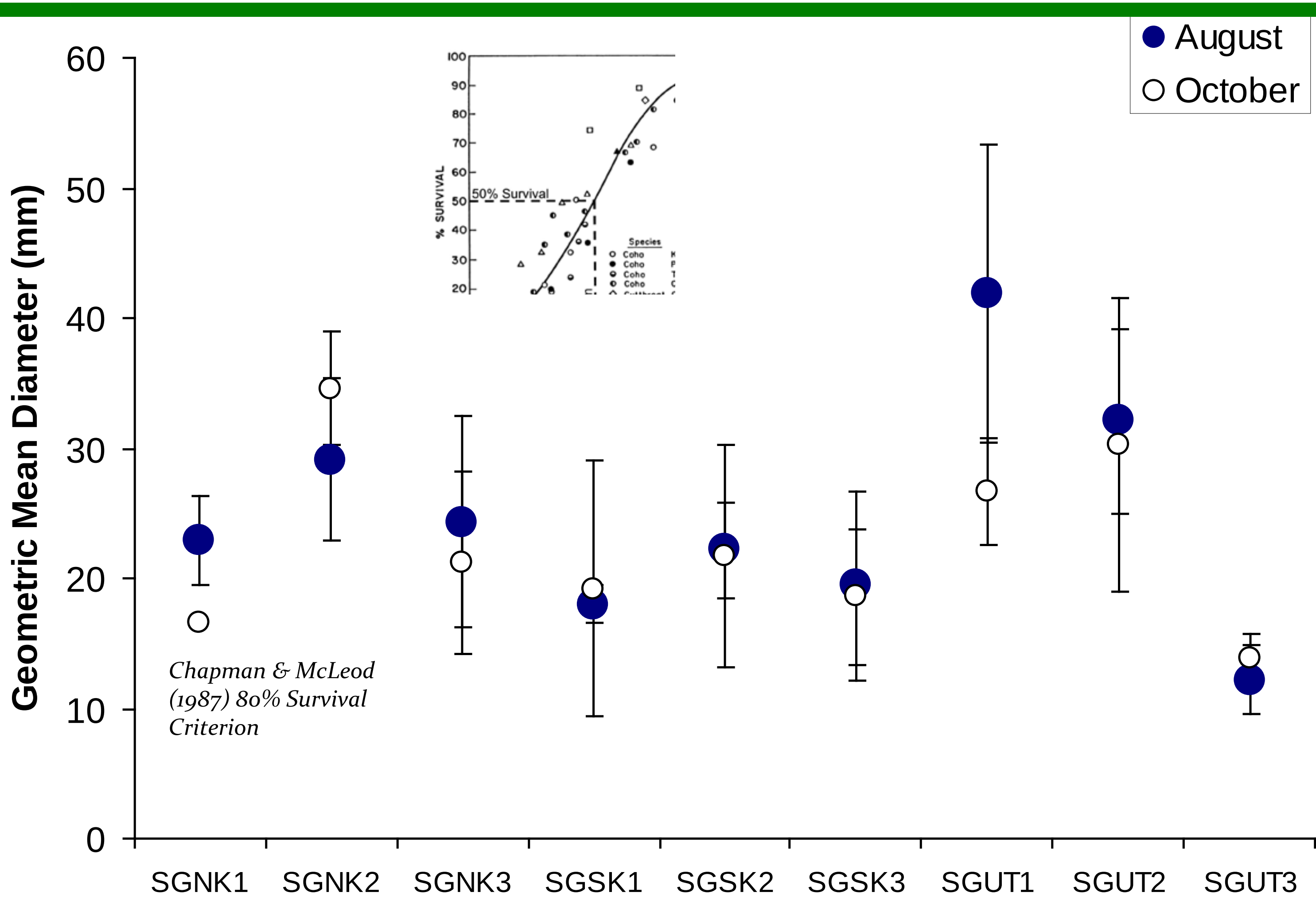
Results:
% Fines < 0.84 mm



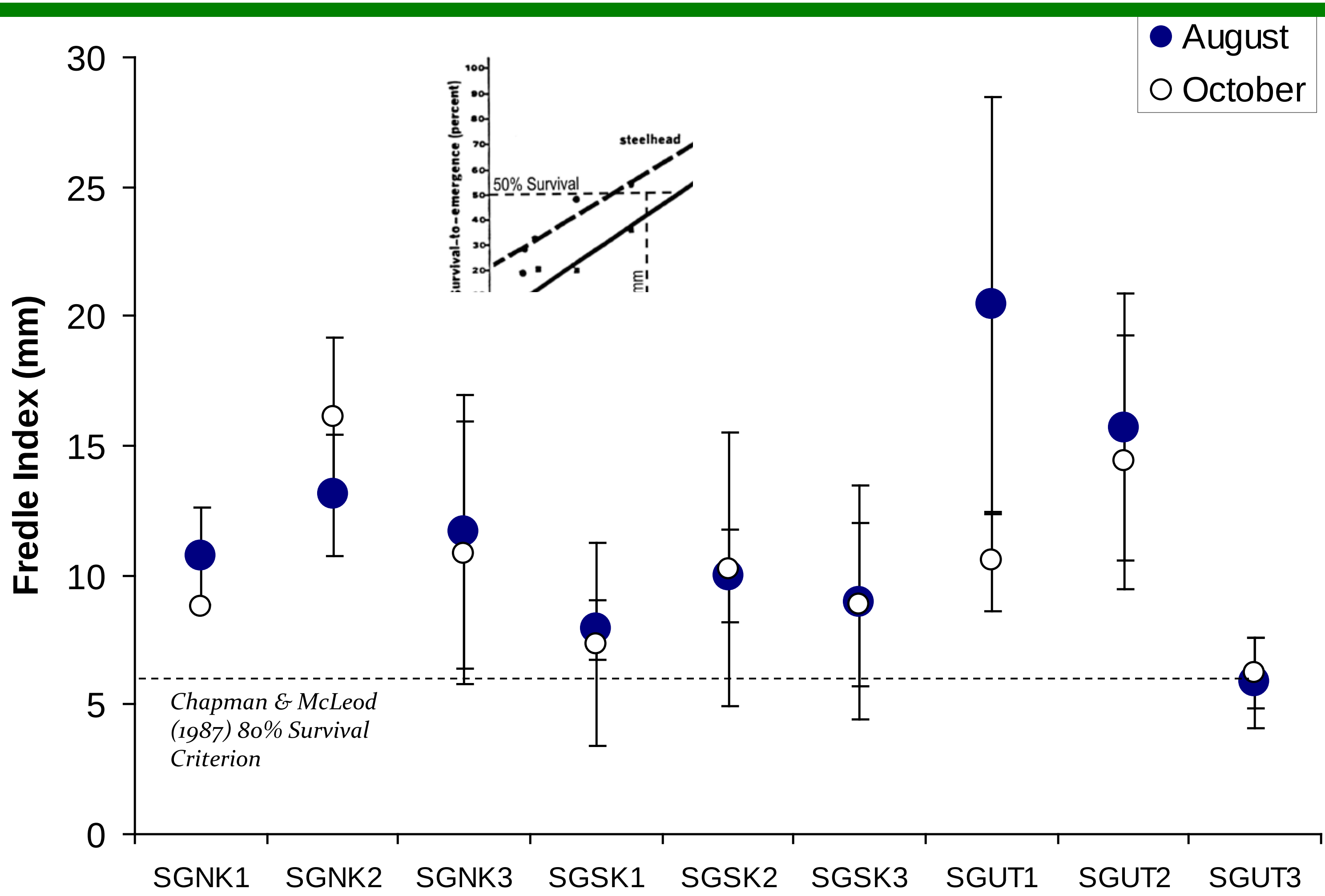
Results:
% Fines < 6.4 mm



Results: Geometric Mean Diameter



Results: Fredle Index



Results – Gravel Quality

- Generally Favorable Incubation Conditions
- Redd Fines Levels in August Similar to Levels in October
  - As Expressed by:
    - Geometric Mean Diameter
    - Fredle Index
    - % Fines < 0.84 mm (incubation survival metric)
    - % Fines < 6.4 mm (emergence survival metric)
  - Exception: Lower Site on Upper Talarik (SGUT1)
    - Redds w/ More Fines in October Than in August

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Questions ?