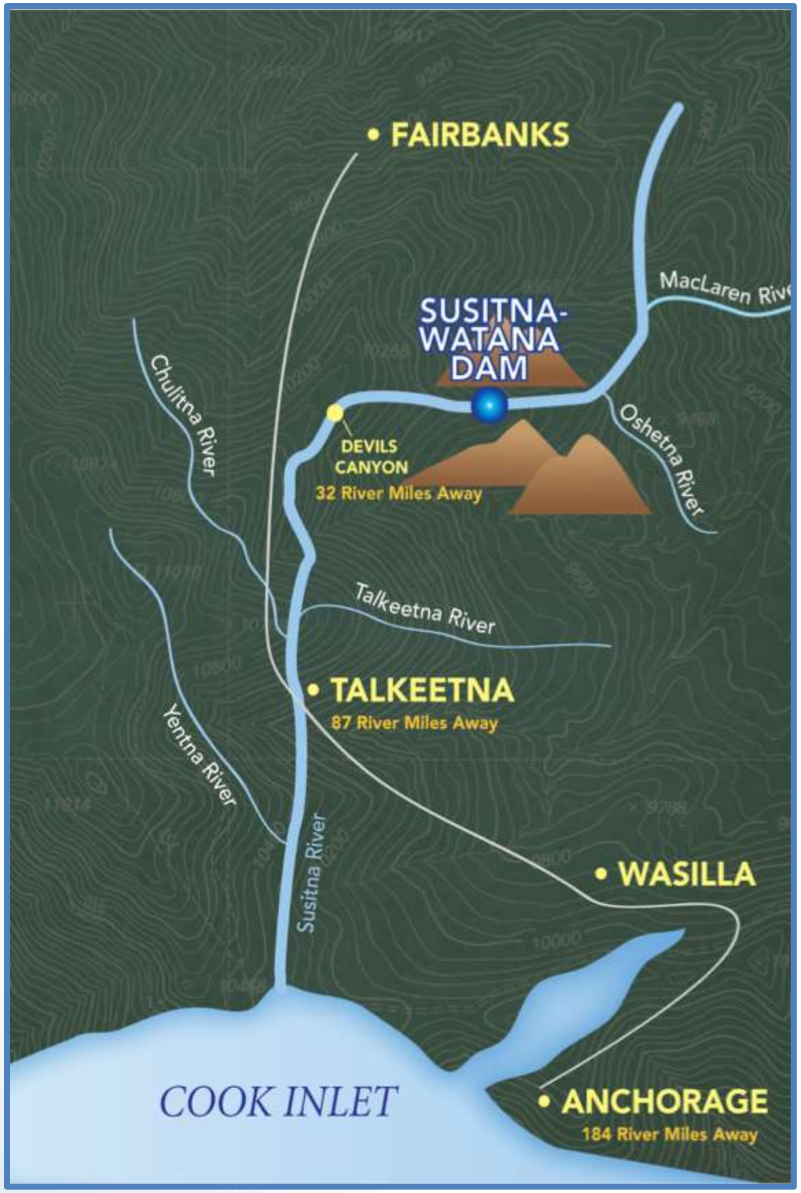

Technical Team Meeting

Riverine Modeling Proof of Concept

Open water 2-D Fish Habitat Effective Spawning/Incubation Middle River Focus Area FA-128 (Slough 8A)

April 15-17, 2014

Prepared by Miller Ecological Consultants and R2 Resource Consultants

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Overview

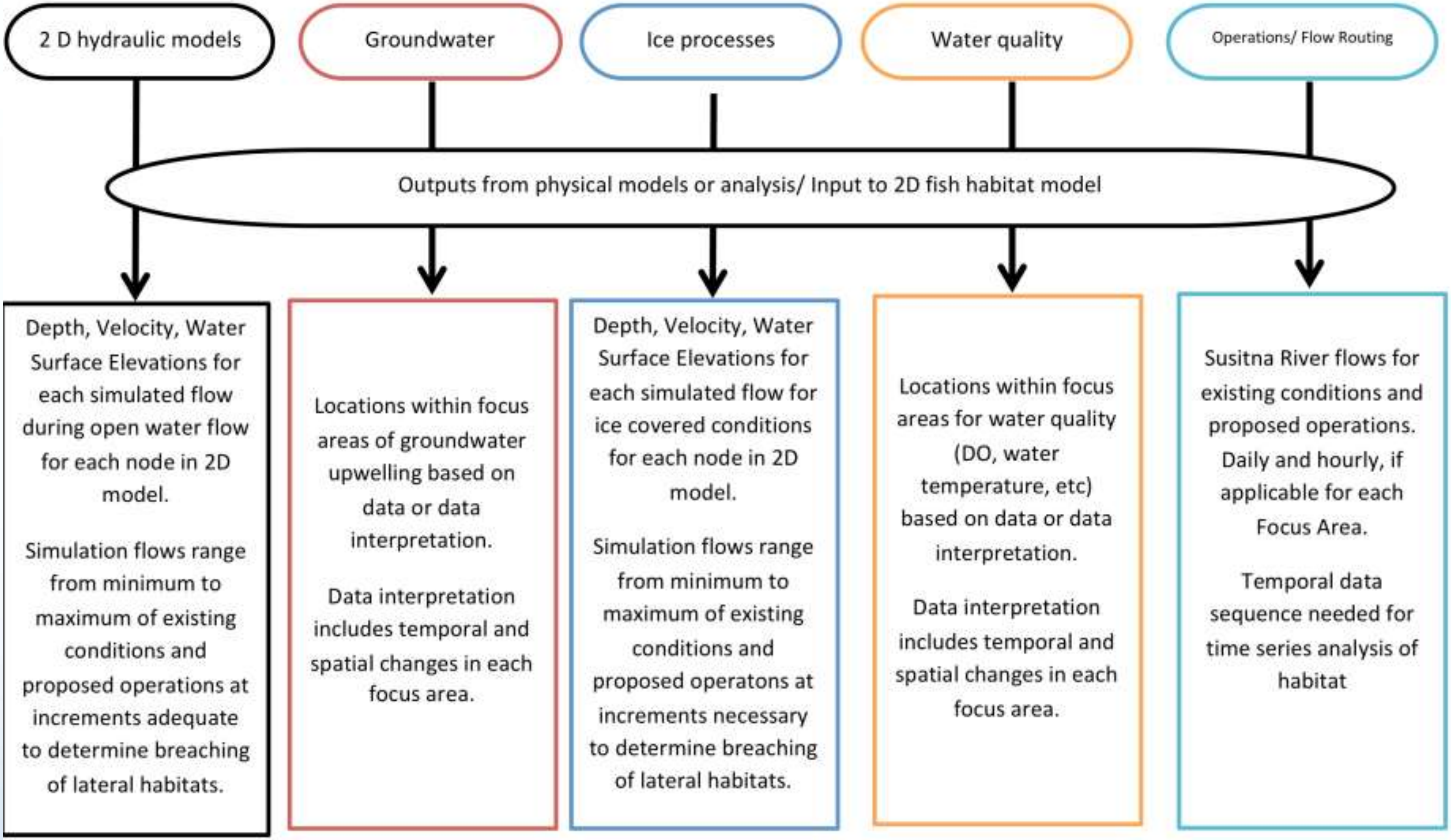
- Presentation overview:
  - Describe the 2-D habitat objectives
  - Describe the modeling approach
  - Present the work flow process and interdependencies to other models
  - Present metrics for effective spawning/incubation and salmonid rearing
- Note: The examples shown are for illustration of the process and model inputs and outputs. Any reference to specific life stage requirements or site locations are used to illustrate the steps that will be taken in the habitat modeling not actual conditions.

Objectives

- Compute usable area (square feet) for current conditions
  - Effective spawning through emergence (open water and under ice)
  - Connection between main channel and lateral habitats under ice (flooding of lateral habitat under ice)
  - Inundation (breaching) of lateral habitats in open water conditions
- Compute usable area for project operation conditions
  - Same as above
- Compare project operation to current conditions to determine change

Review of 2-D Based Habitat Model

- Incorporates concepts from traditional PHABSIM/IFIM
  - Hydraulics and suitability criteria
  - Calculates usable area
- Habitat area calculated from 2-D hydraulic model using GIS tools to combine hydraulic output data or other parameters (e.g. groundwater, water quality)
- Model uses HSC and HSI analysis for evaluation
- Data dependencies from the following: hydraulic models for open water and ice processes, substrate and cover data from field data collection, groundwater data, water quality data, HSC and HSI analysis
- Provides visual and quantitative result for decision framework


2 D hydraulic models
Groundwater
Ice processes
Water quality
Operations/ Flow Routing
Outputs from physical models or analysis/ Input to 2D fish habitat model
Depth, Velocity, Water Surface Elevations for each simulated flow during open water flow for each node in 2D model.
Simulation flows range from minimum to maximum of existing conditions and proposed operations at increments adequate to determine breaching of lateral habitats.
Locations within focus areas of groundwater upwelling based on data or data interpretation.
Data interpretation includes temporal and spatial changes in each focus area.
Depth, Velocity, Water Surface Elevations for each simulated flow for ice covered conditions for each node in 2D model.
Simulation flows range from minimum to maximum of existing conditions and proposed operatons at increments necessary to determine breaching of lateral habitats.
Locations within focus areas for water quality (DO, water temperature, etc) based on data or data interpretation.
Data interpretation includes temporal and spatial changes in each focus area.
Susitna River flows for existing conditions and proposed operations. Daily and hourly, if applicable for each Focus Area.
Temporal data sequence needed for time series analysis of habitat

POC – Effective Spawning Habitat Analysis

- **Identify potential use of discrete channel areas suitable for chum salmon spawning and track the area through the subsequent spawning and incubation period:**
  - ✓ **Dewatering***
  - ✓ **Freezing**
  - ✓ **Breached***
  - ✓ **Scour***
  - ✓ **Intragravel temperature**
  - ✓ **Intragravel dissolved oxygen**

*Available for Proof of Concept

POC – Effective Spawning Habitat Analysis

- **Data Needs:**
  - ✓ Spawning habitat suitability & distribution*
  - ✓ Substrate composition*
  - ✓ Spawning and incubation timing or periodicity*
  - ✓ Presence of groundwater upwelling*
  - ✓ Intragravel water temperature
  - ✓ Intragravel dissolved oxygen
  - ✓ Hourly water surface elevations (dewatering)*
  - ✓ Hourly air temperature (<0 Celsius)
  - ✓ Breaching flows*
  - ✓ Redd scour*

*Available for Proof of Concept

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POC – Effective Spawning Habitat Analysis

HSC Chum Spawning Model – Best Fit

$$\log\left(\frac{p}{1-p}\right) = C_k + 19depth - 18depth^2 + 6.8depth^3 - 0.91depth^4 + 3.9vel - 1.9vel^2 + \gamma_{site} + \varepsilon,$$

where

$$C_{UPGR} = -10$$
$$C_{UPCO} = -14$$
$$C_{NOGR} = -13$$
$$C_{NOCO} = -15$$

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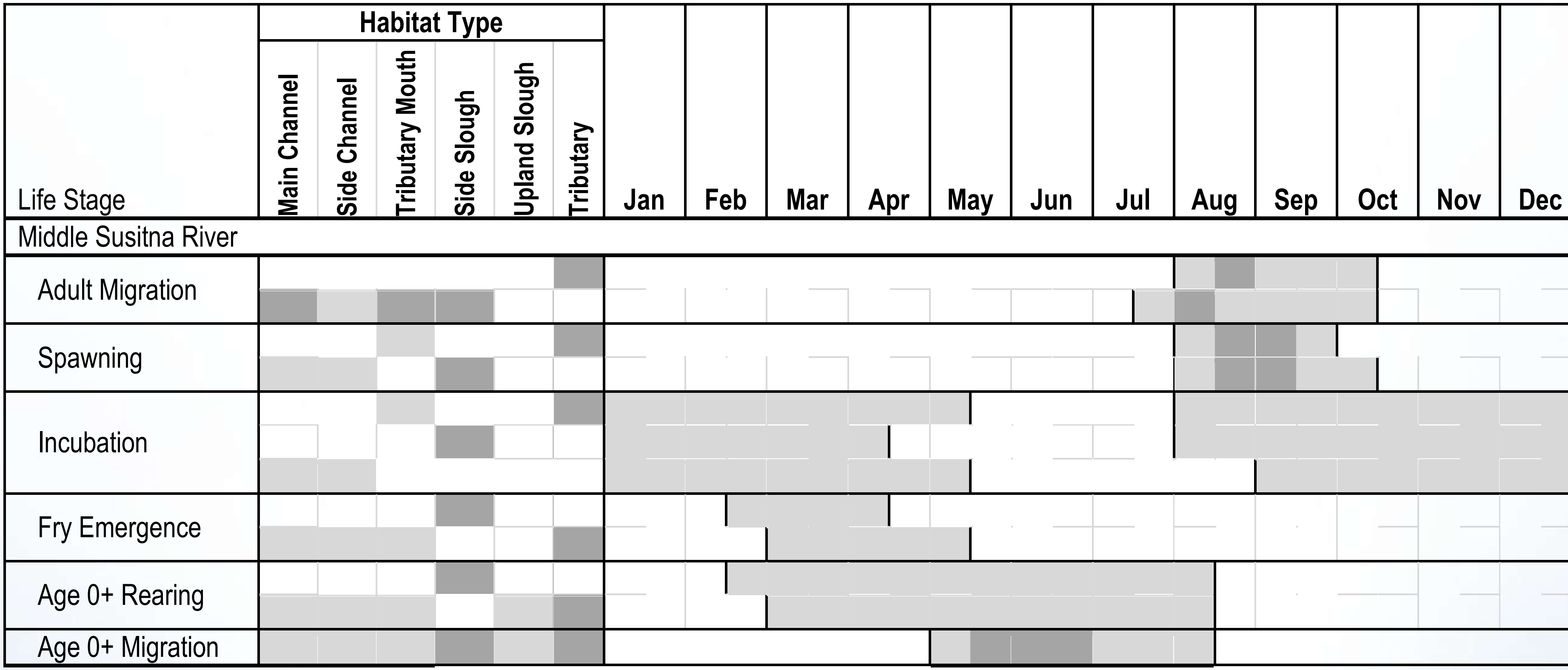
POC – Effective Spawning Habitat Analysis

Periodicity of chum salmon utilization among macro-habitat types in the Middle River Segment (PRM 187 – 102) of the Susitna River by life history stage.



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POC – Effective Spawning Habitat Analysis

Spawning Period

- Define potential spawning areas using site-specific HSC preference for chum spawning
- Define spawning periodicity based on 1980s and 2012/2013 data
- Proportion chum spawning run within the spawning period:
  - ✓ August 1 – 23 = 10% of the run
  - ✓ August 24 – September 21 = 80% of the run
  - ✓ September 22 – October 15 = 10% of the run
- Presence of groundwater upwelling using 2012/2013 TIR mapping, open leads, and positive VHG measurements

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POC – Effective Spawning Habitat Analysis

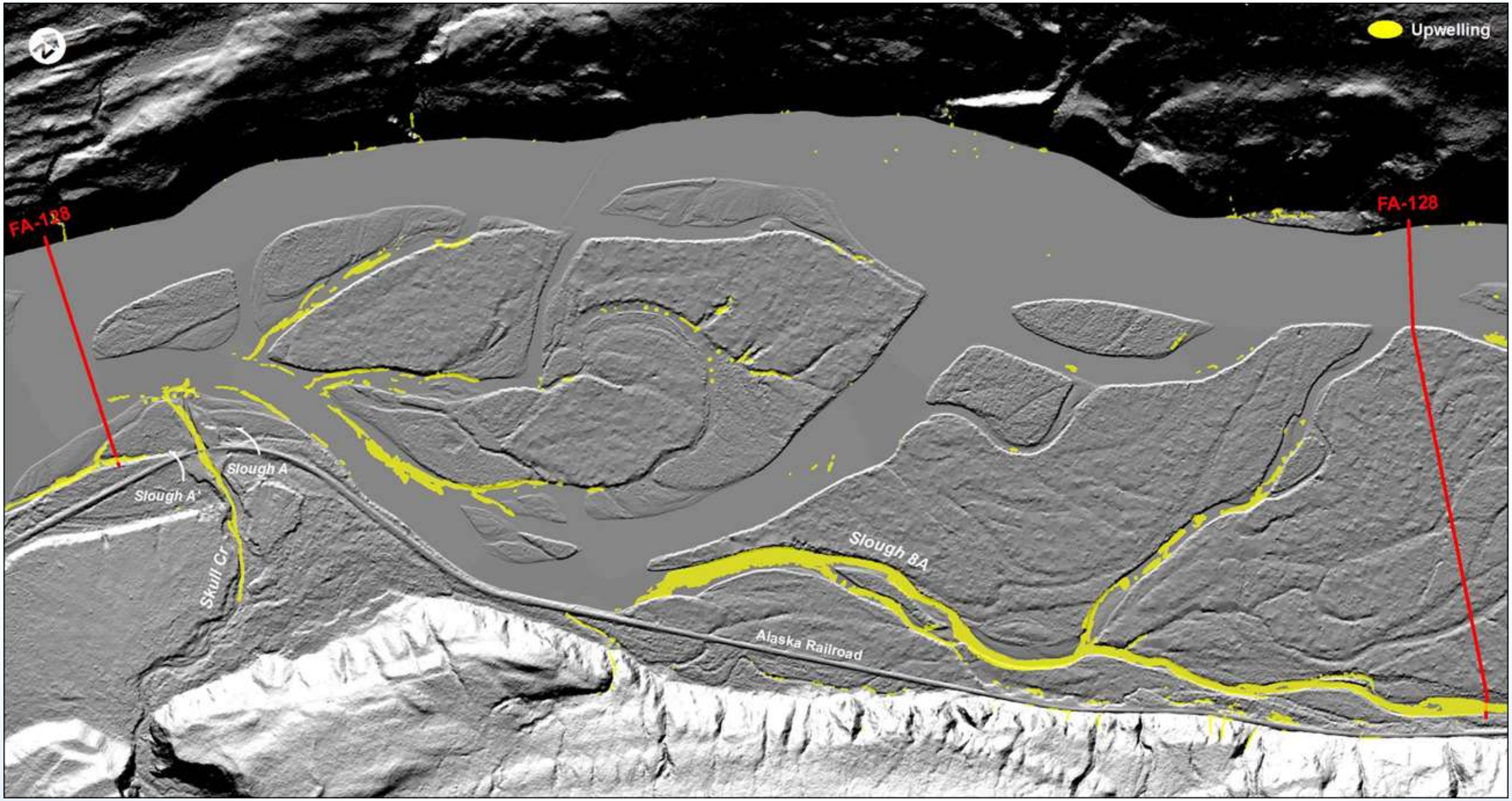
Incubation Period (phases)

Define phases of chum incubation: egg/embryo, alevin, and emergence

- Egg and alevin phase have different sensitivities to water temperature, dissolved oxygen, dewatering, and freezing
- Number of days to achieve each phase is driven by **intragravel** water temperature and accumulated thermal units (ATU)

POC – Effective Spawning Habitat Analysis

FA-128 (Slough 8A) Areas of predicted groundwater upwelling



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POC – Effective Spawning Habitat Analysis

Incubation Period (dewatering)

Spawning areas with and without upwelling:

- With upwelling: No mortality due to dewatering
- Without upwelling: if dewatered >48-hrs during egg phase then lose spawning area; if dewatered >1-hr during alevin phase then lose spawning area

POC – Effective Spawning Habitat Analysis

Incubation Period (freezing)

Spawning areas with and without upwelling:

- With upwelling: No mortality due to egg freezing
- Without upwelling: if spawning area dewatered and air temp. <0 c for >24-hrs during egg phase, then lose spawning area

POC – Effective Spawning Habitat Analysis

Incubation Period (breaching flows)

Off-Channel Spawning areas with upwelling:

- If cold surface water (<1 c) is forced into the intragravel environment during egg phase for >48-hrs, then lose spawning area

POC – Effective Spawning Habitat Analysis

Incubation Period (redd scour)

All Spawning areas:

- If spawning area experiences scour during any phase of incubation, then spawning area is lost

POC – Effective Spawning Habitat Analysis

Incubation Period (Dissolved Oxygen)

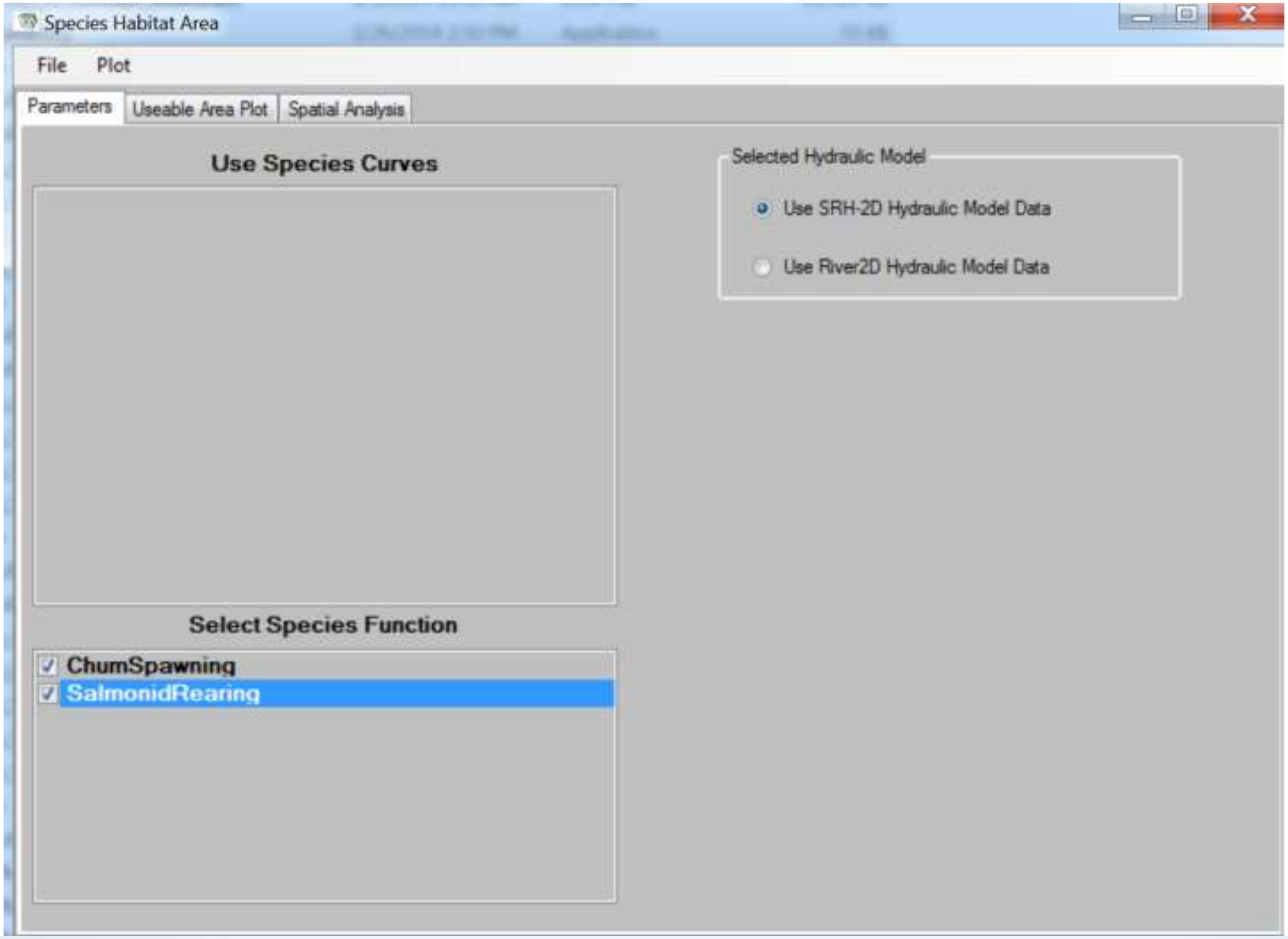
All Spawning areas:

- If intragravel D.O. falls below 3 mg/l for >48-hrs during the egg phase, then spawning area is lost

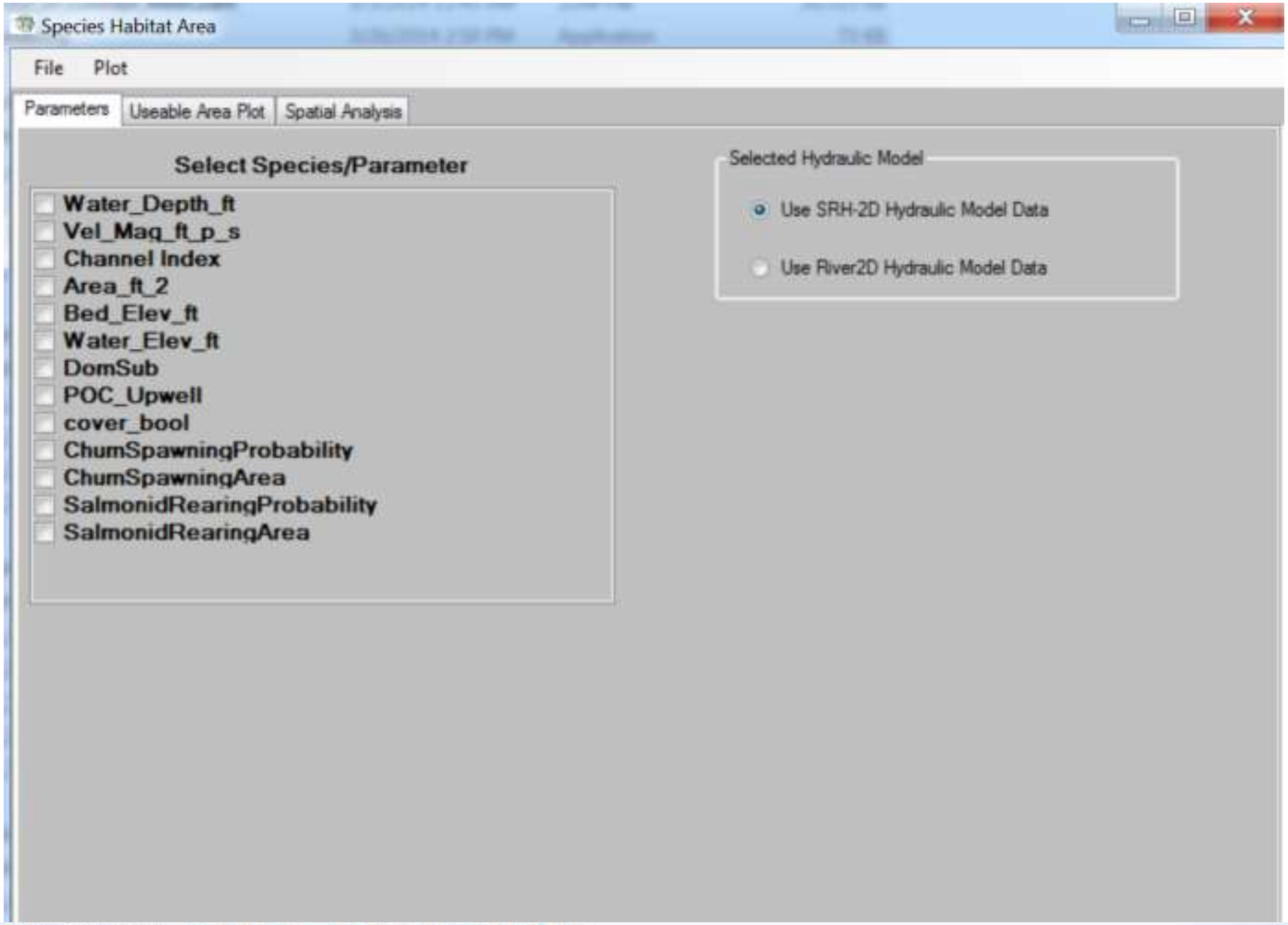
2-D Fish Habitat Spatial Analysis

- Process Hydraulic Flow Data
  - CSV file geo-referenced data x,y,z, velocity, depth, channel index
- Create spatial data layers for each flow
- Conduct the Usable Area Modeling/HSI modeling
  - Combine spatial data and habitat equations
- Produce habitat graphics and CSV files with habitat values at each node
- Produce habitat versus discharge response functions

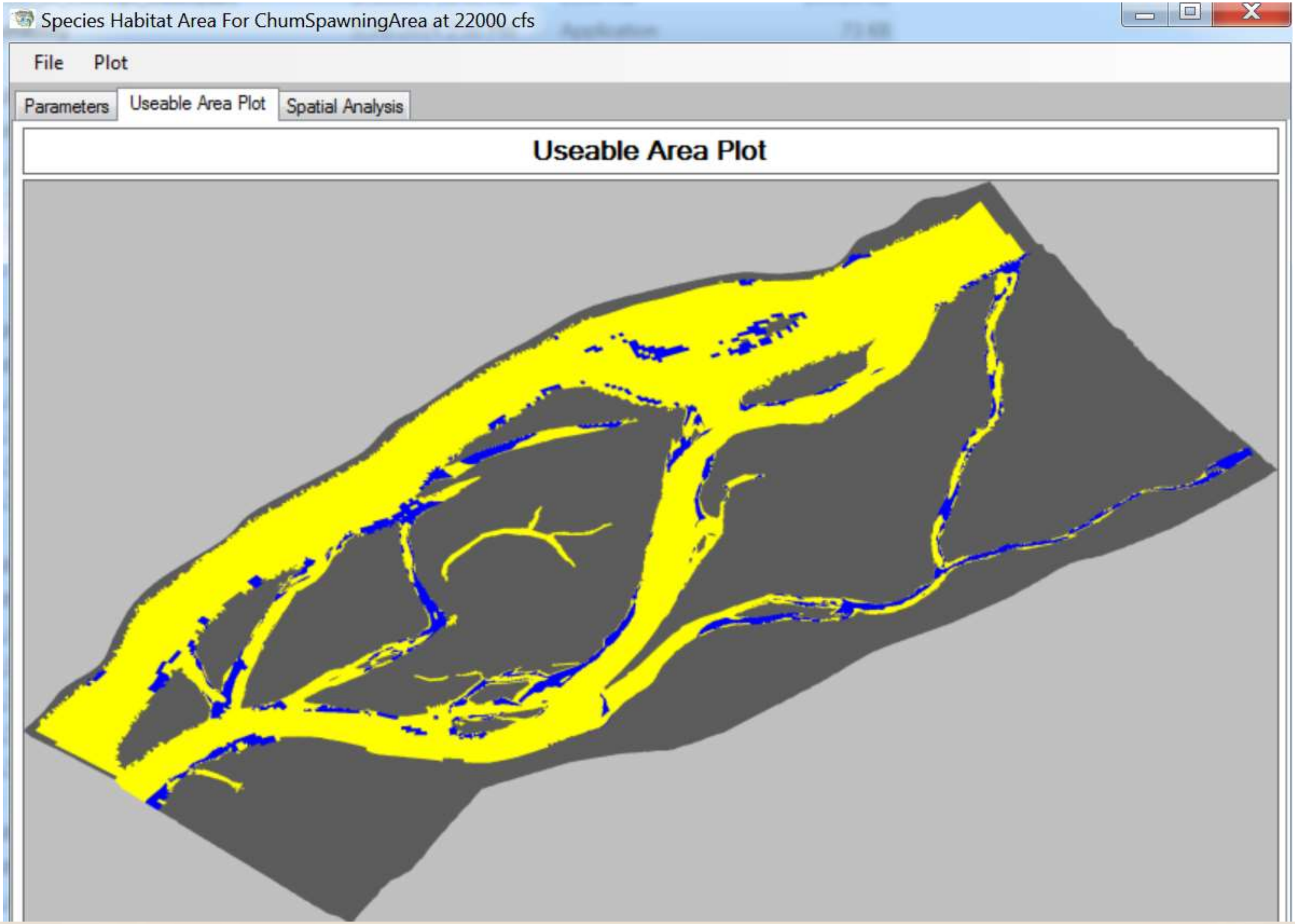
Example of Visual Basic (VB) interface to run usable habitat calculations



Example of Visual Basic (VB) interface to run usable habitat calculations



Example of VB visualization

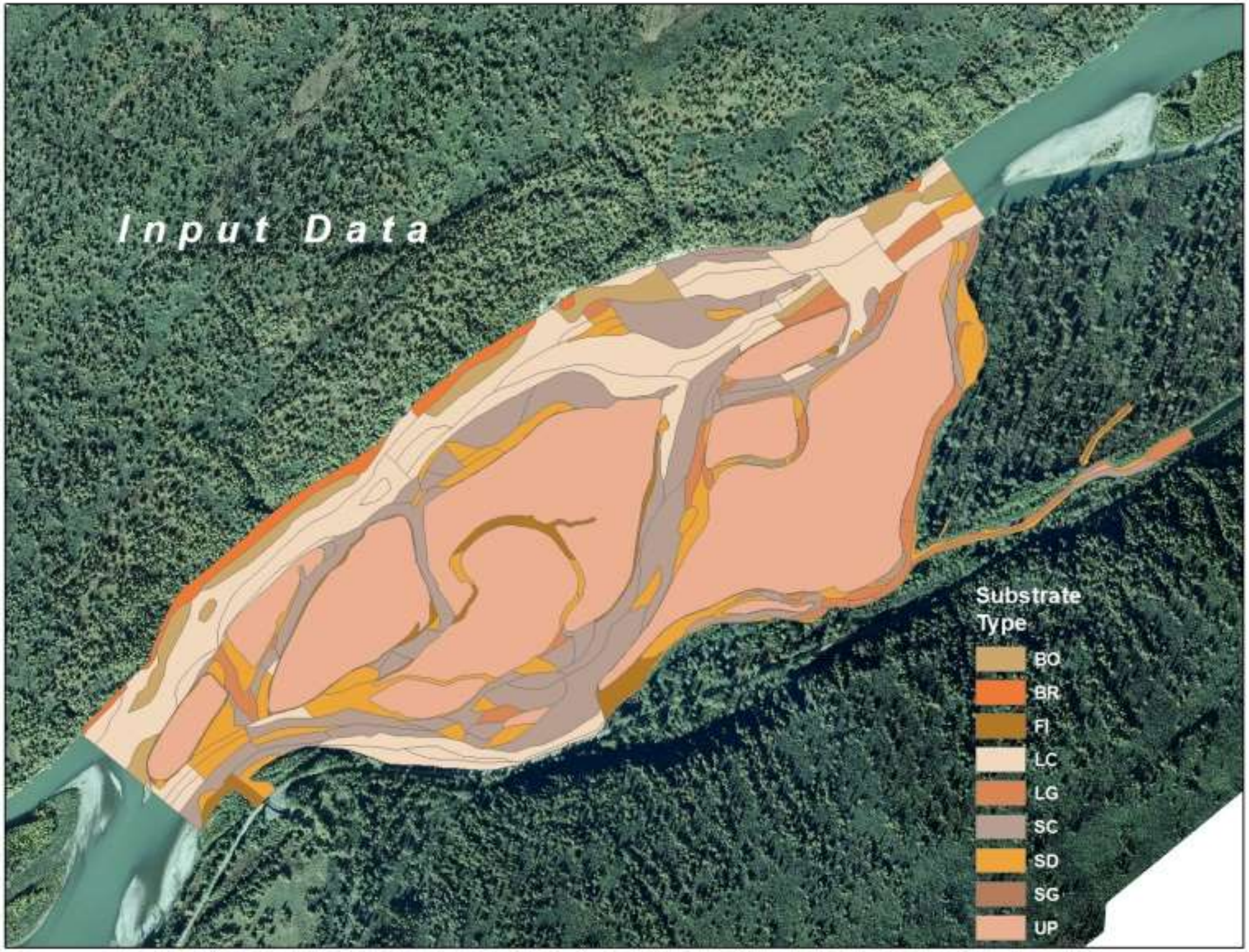


GIS Habitat Model

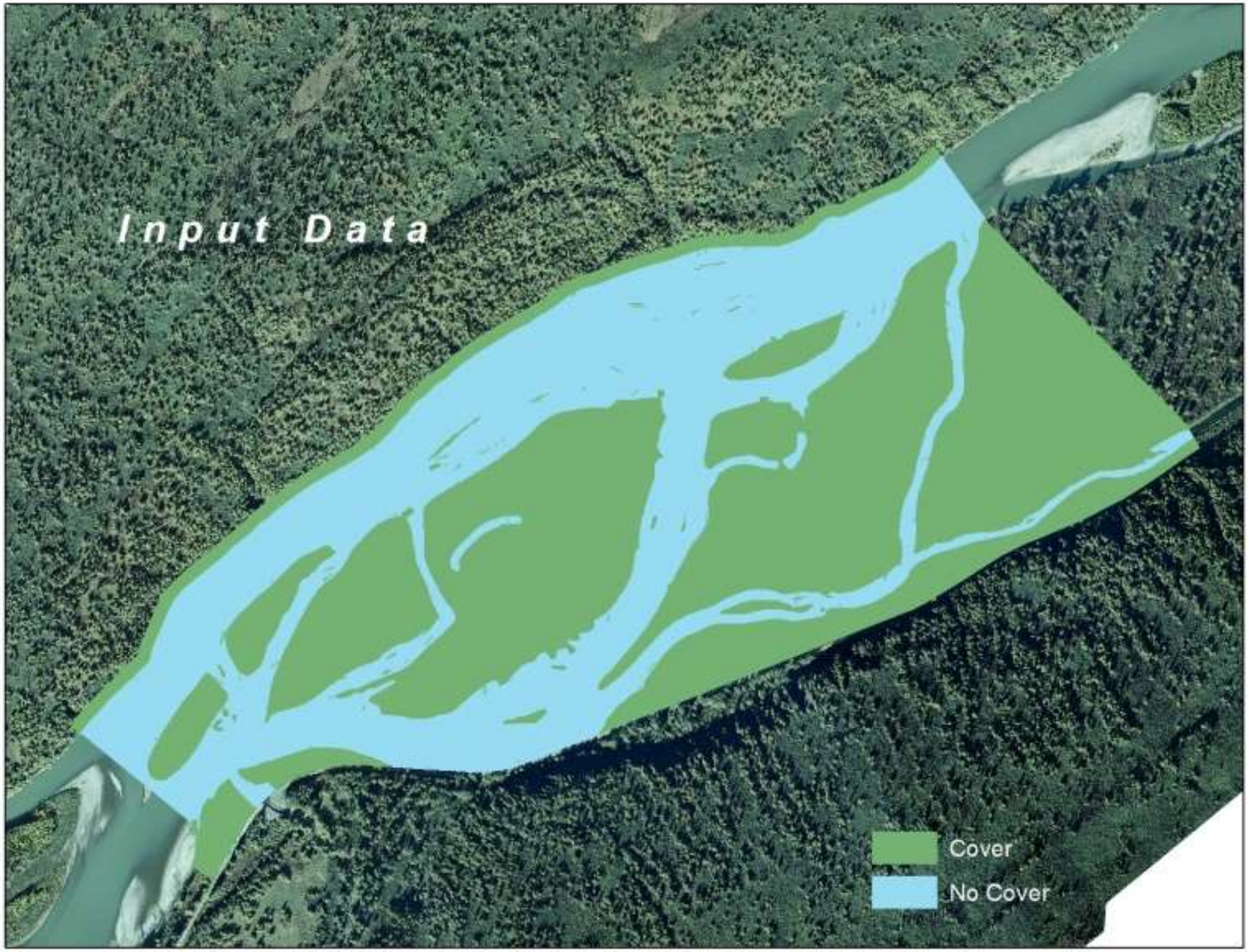
- Used for pre-processing data into single data set for VB model (open water and ice cover)
- Spatial analysis to track fixed locations
- Spatial depiction of habitat at fixed flow rates

Hydraulic model data

Substrate data



Cover data

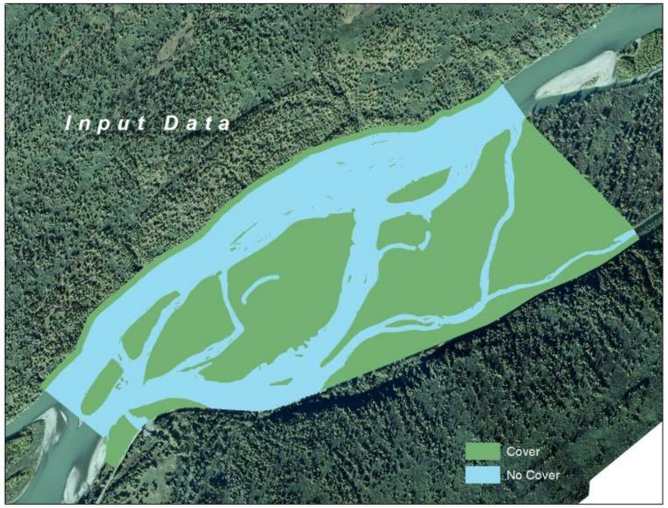


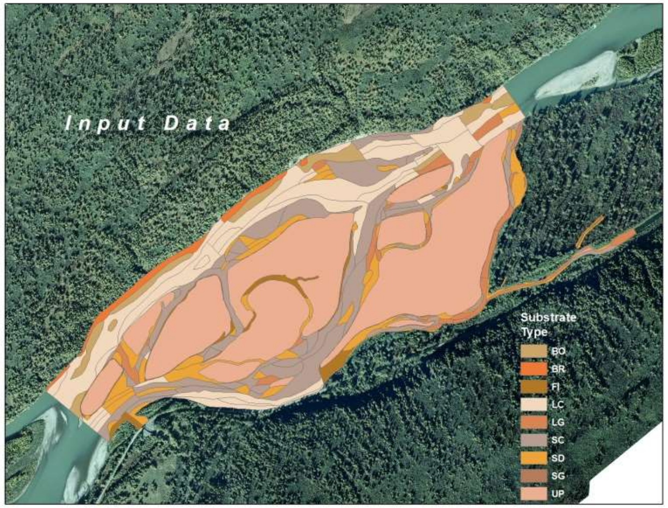
Groundwater data

GIS Model Flow Chart

Input Data

- Cover
- Substrate
- Groundwater
- Hydraulic





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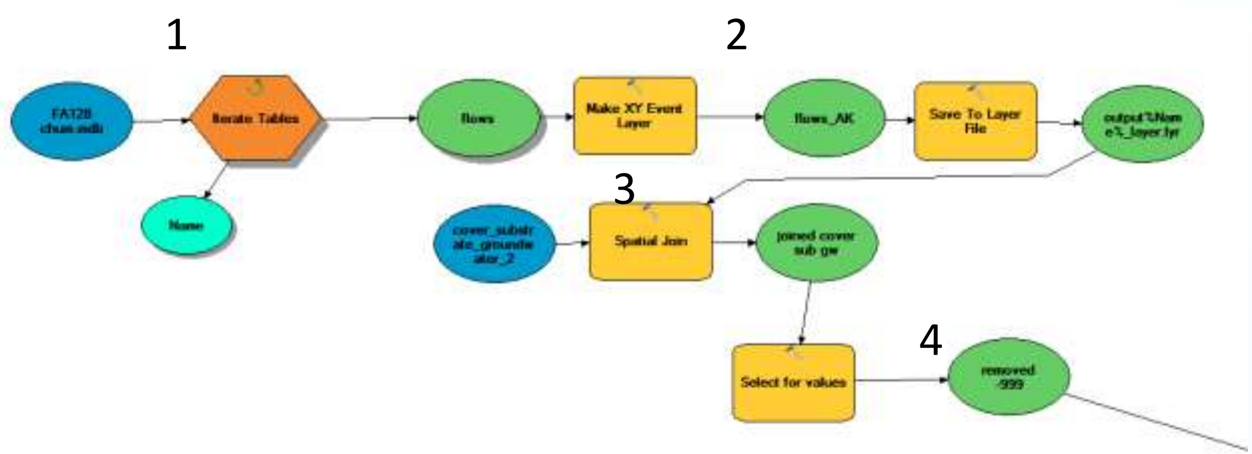
GIS Model Flow Chart

1. Import hydraulic data
2. Convert to spatial setting and project to AK State Plane
3. Join input data with substrate, cover and ground water data and clips data
4. Remove illogical values



Blue= input
Yellow= tool
Orange=repeat
Green=output

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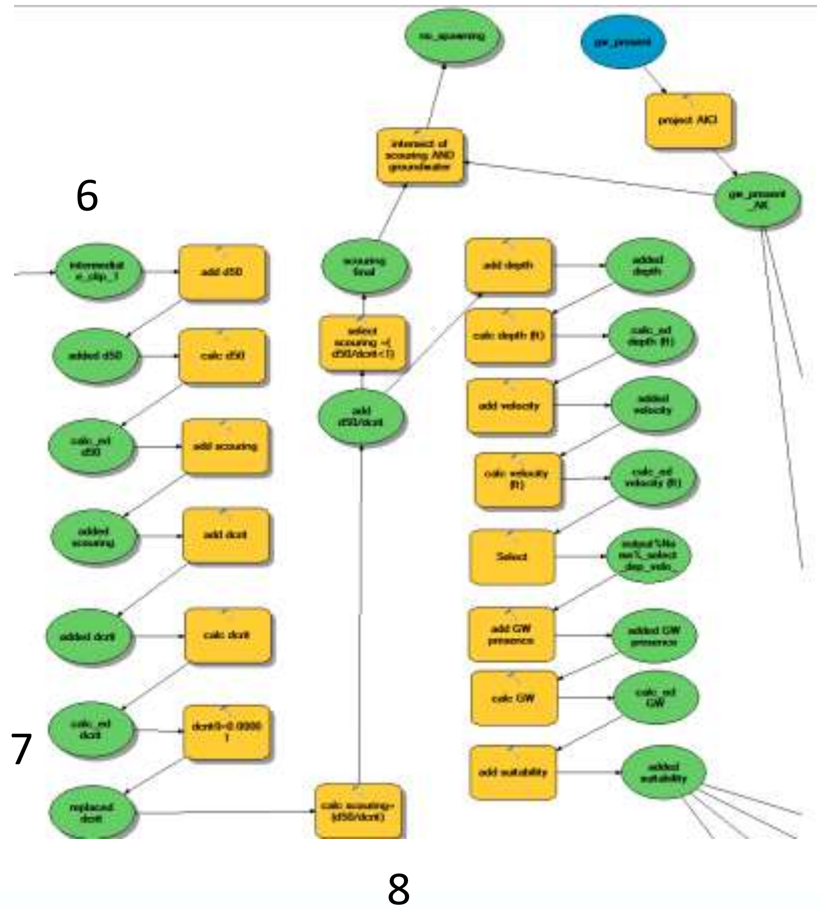
GIS Model Flow Chart

6 . Add fields and populate fields in float data format: D50, Scouring

7. Eliminate 0 values, needed for step 8

8. Compare D50/D critical as a ratio for scouring



Blue= input
Yellow= tool
Orange=repeat
Green=output

Example of Scoured Areas 16,000 cfs simulation

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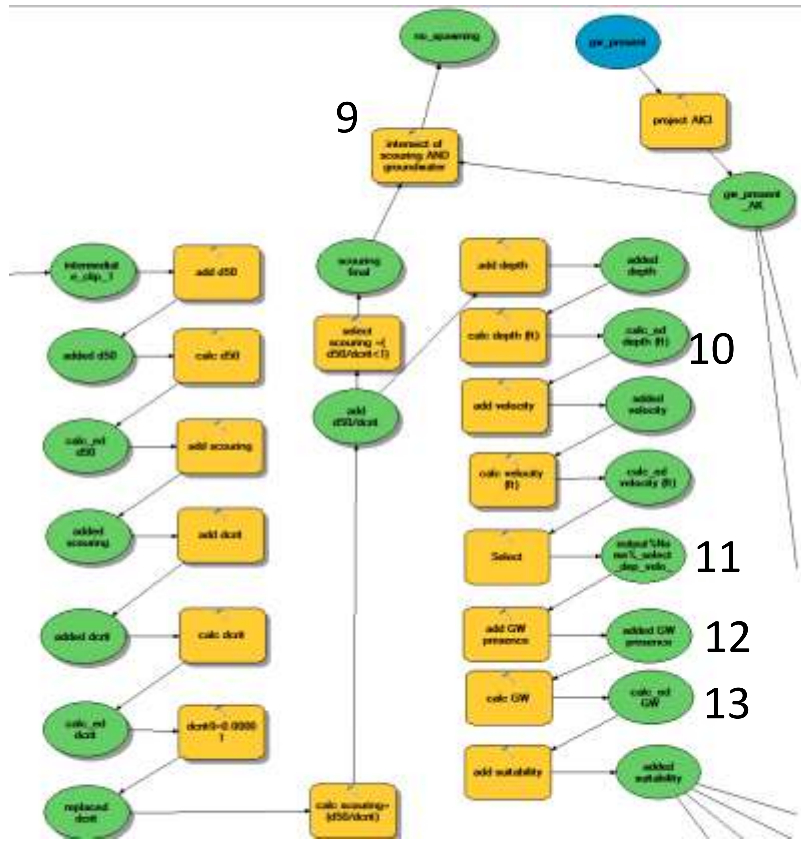
GIS Model Flow Chart

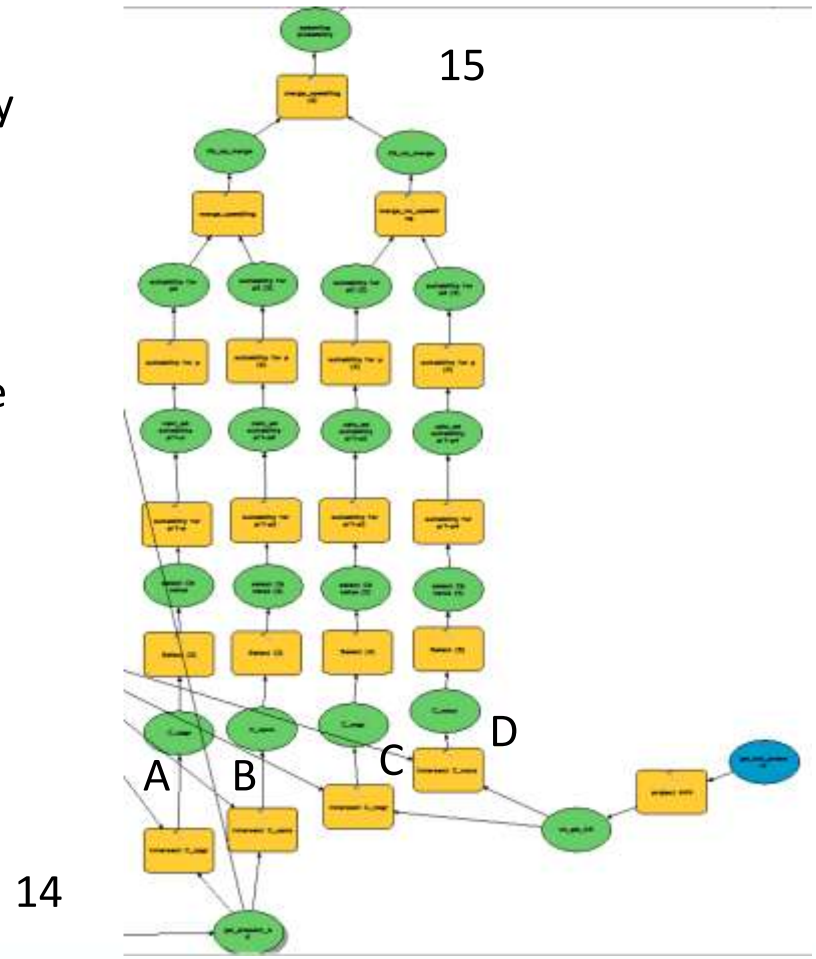
9. Selecting for D50/Scouring <1 and intersecting with groundwater
10. Add field and populate field in float data format: depth, velocity
11. Select for habitat requirements for depth, velocity
12. Add field and populate field in presence absence format: groundwater
13. Add field for suitability calculation



Blue= input
Yellow= tool
Orange=repeat
Green=output

GIS Model Flow Chart

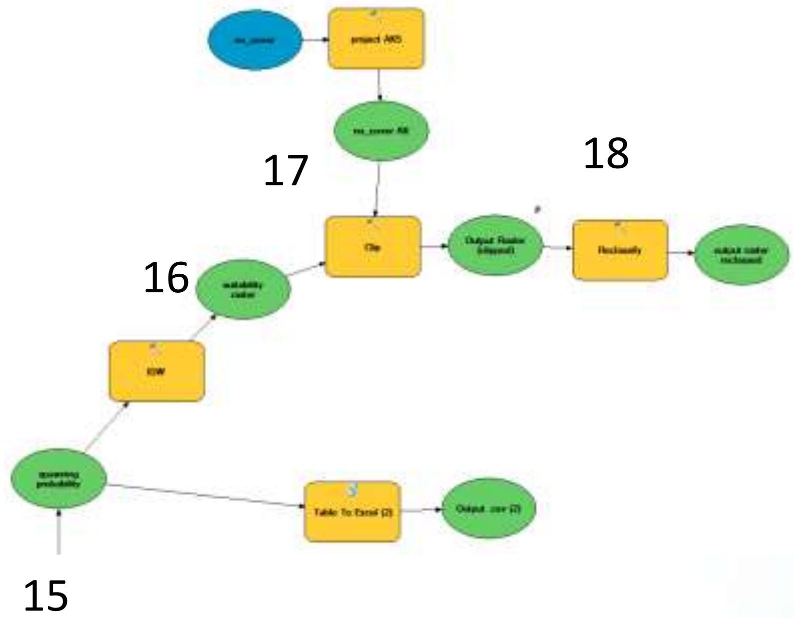
14. Calculate Habitat Suitability for 4 different criteria
    A. Upwelling + gravel
    B. Upwelling + cobble
    C. No upwelling + gravel
    D. No upwelling + cobble
15. Merge the data back together into one Habitat Suitability field



Blue= input
Yellow= tool
Orange=repeat
Green=output

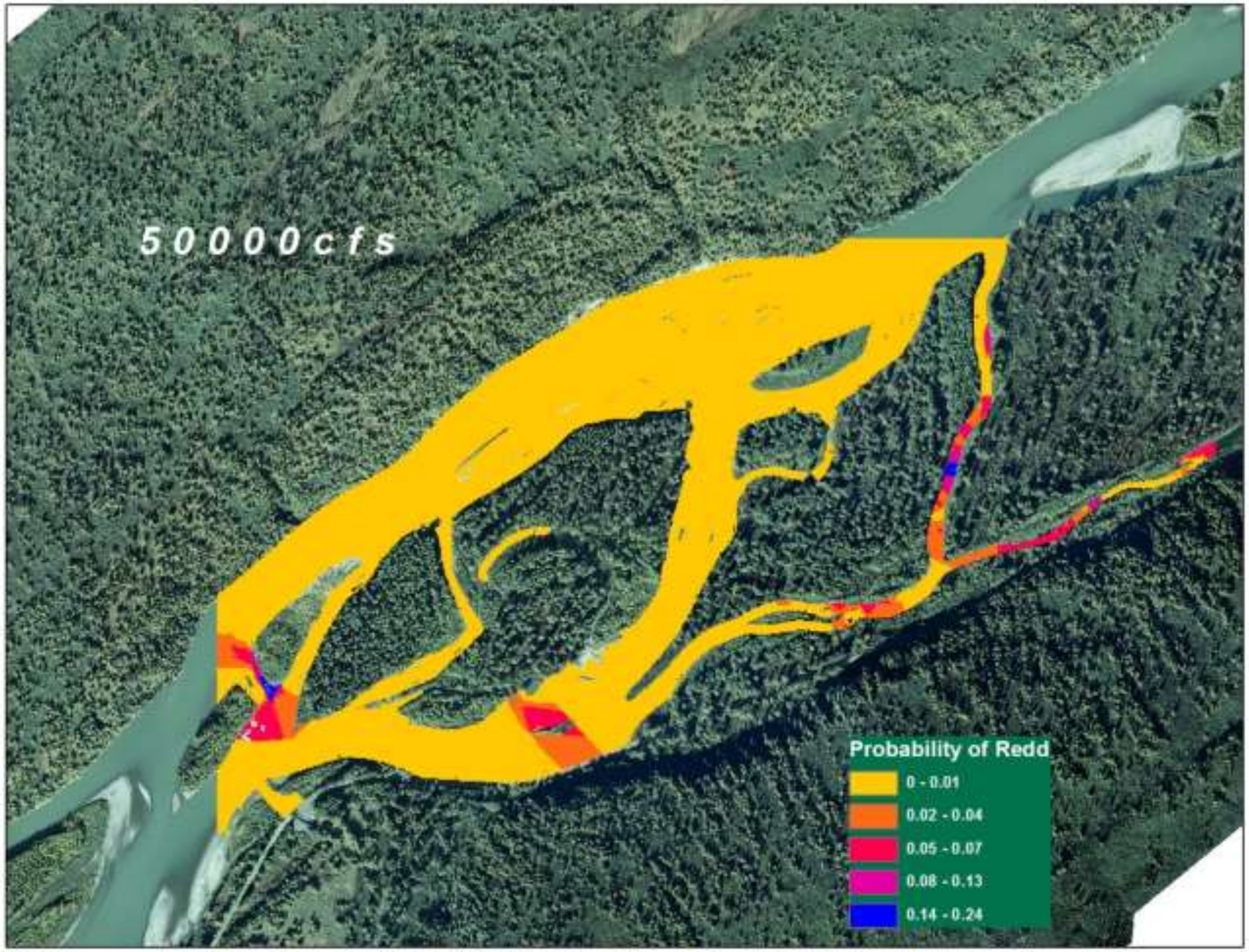
GIS Model Flow Chart

15. From previous slide
16. Convert Suitability output to raster data type using Inverse Distance Weighting method
17. Clip the boundaries to rivers edge
18. Reclassify to count pixels (area) representing each habitat suitability

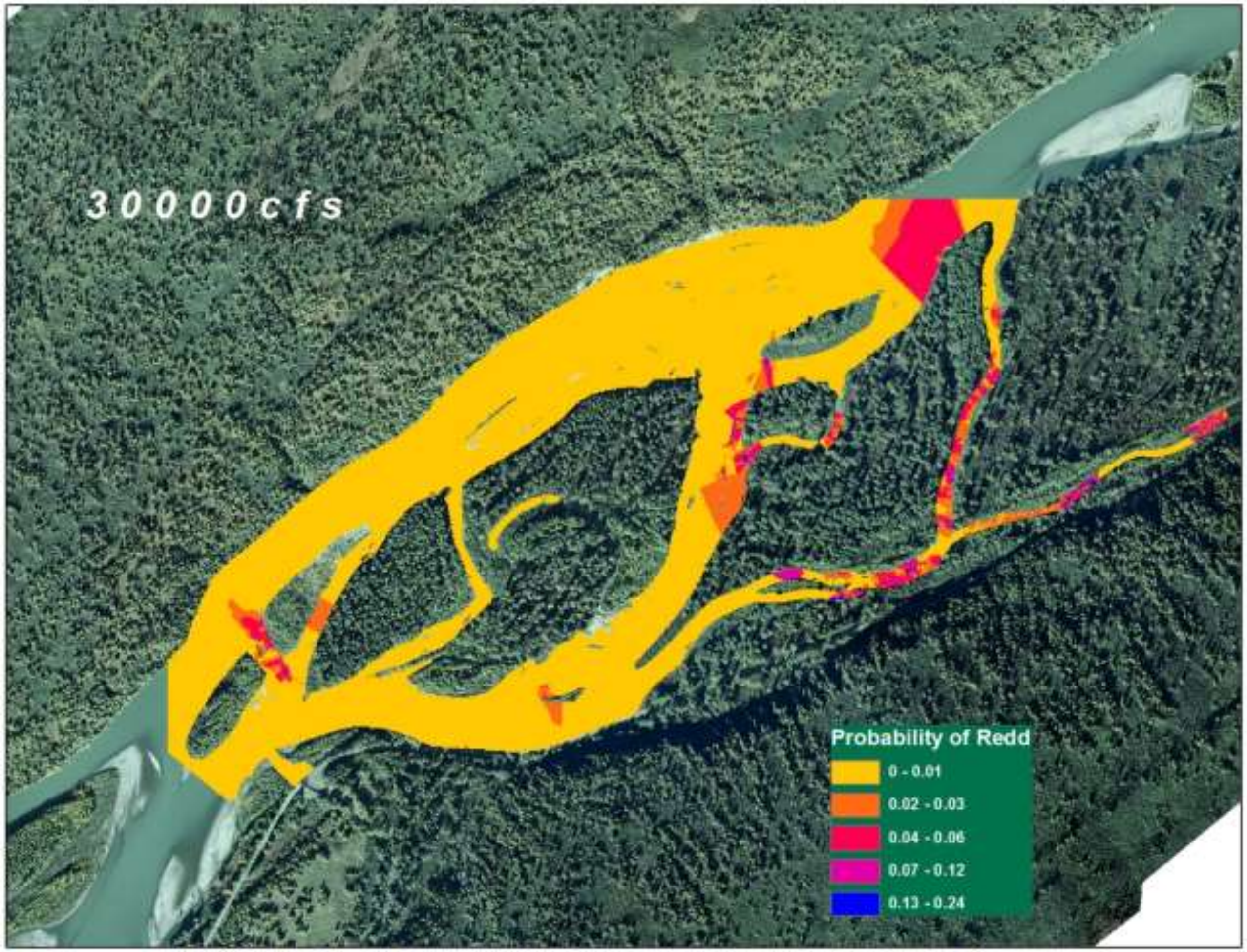


Blue= input
Yellow= tool
Orange=repeat
Green=output

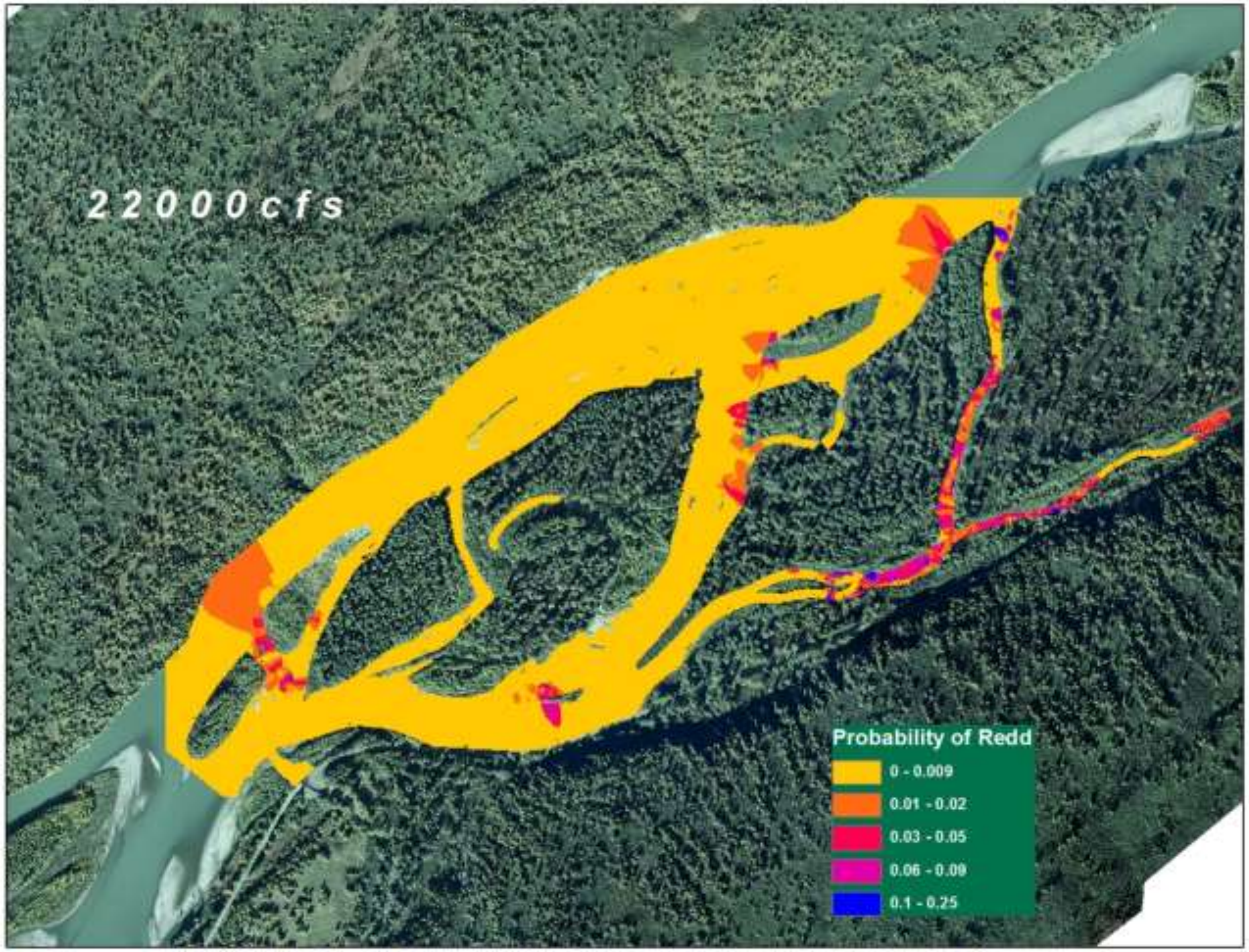
FA-128 (Slough 8A) Chum Spawning 50,000 cfs simulation



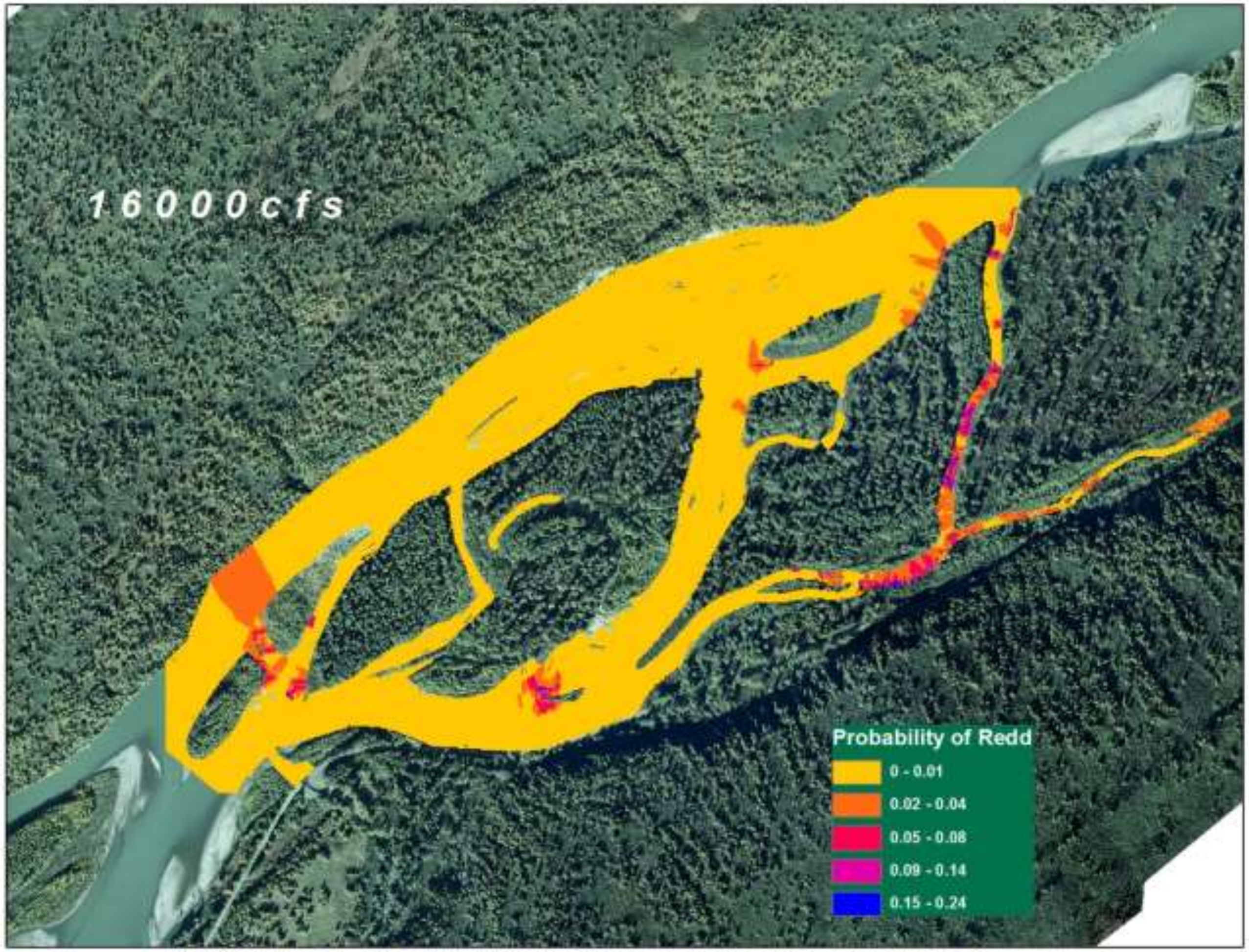
FA-128 (Slough 8A) chum spawning 30,000 cfs simulation



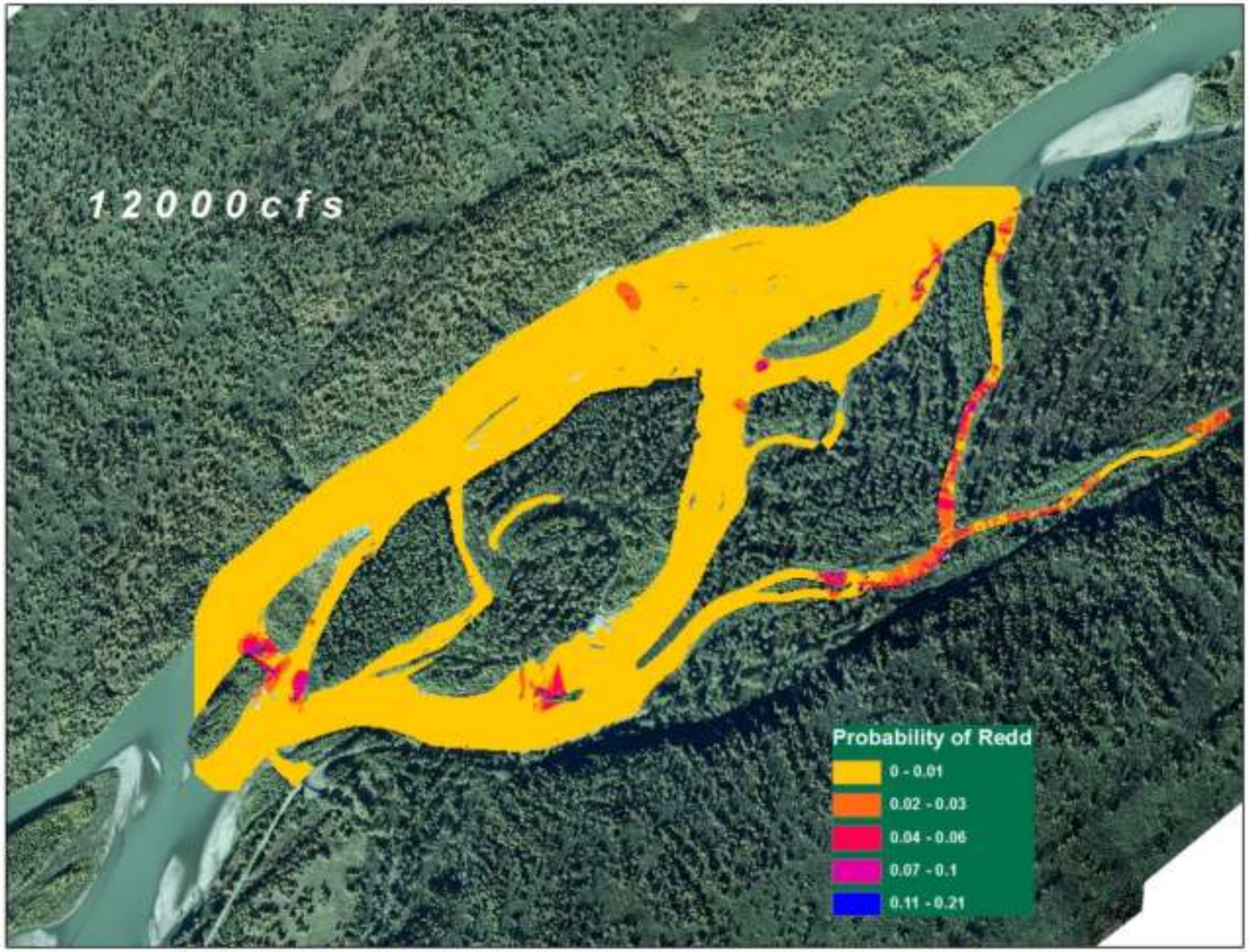
FA-128 (Slough 8A) chum spawning 22,000 cfs simulation



FA-128 (Slough 8A) chum spawning 16,000 cfs simulation



FA-128 (Slough 8A) chum spawning 12,000 cfs simulation



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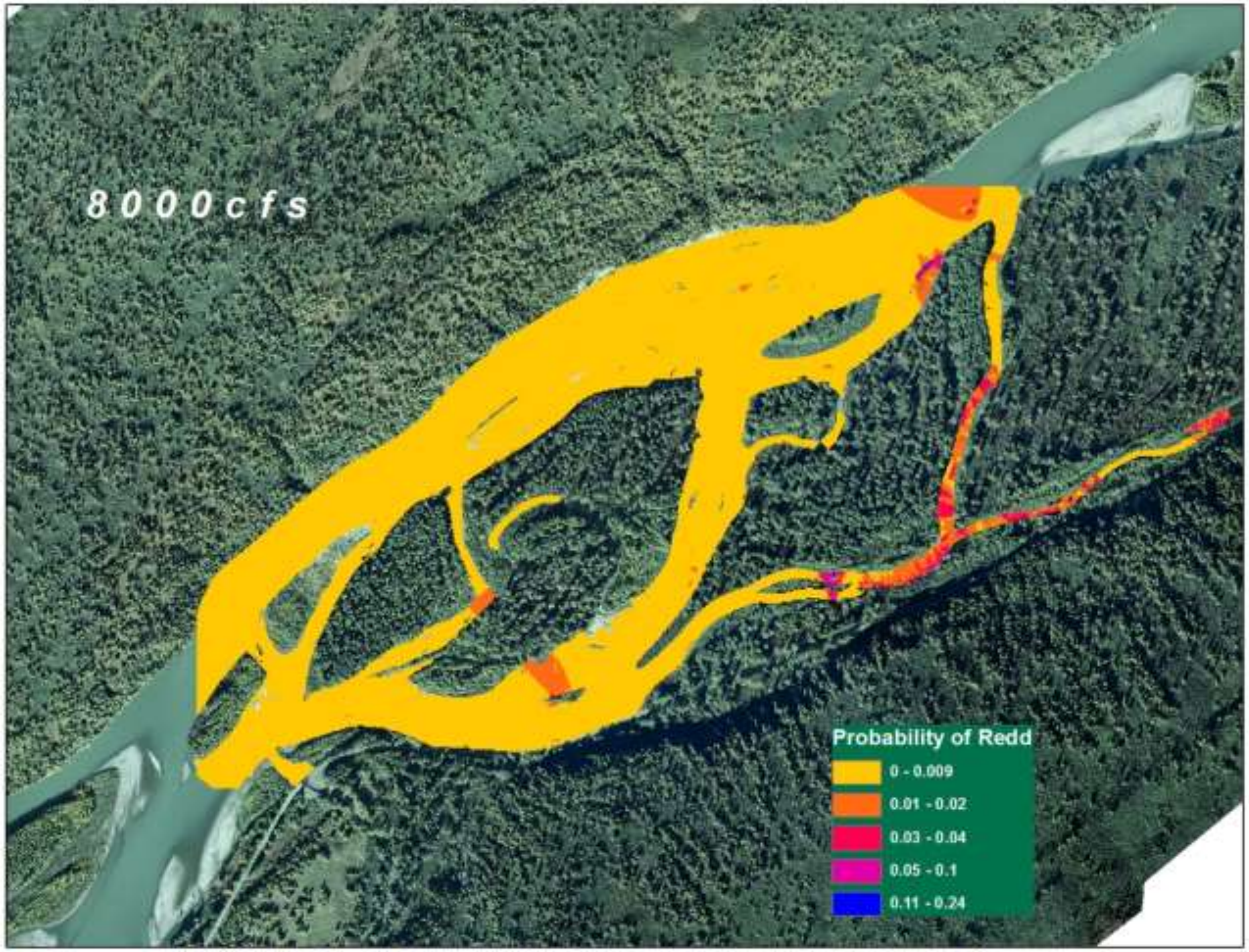
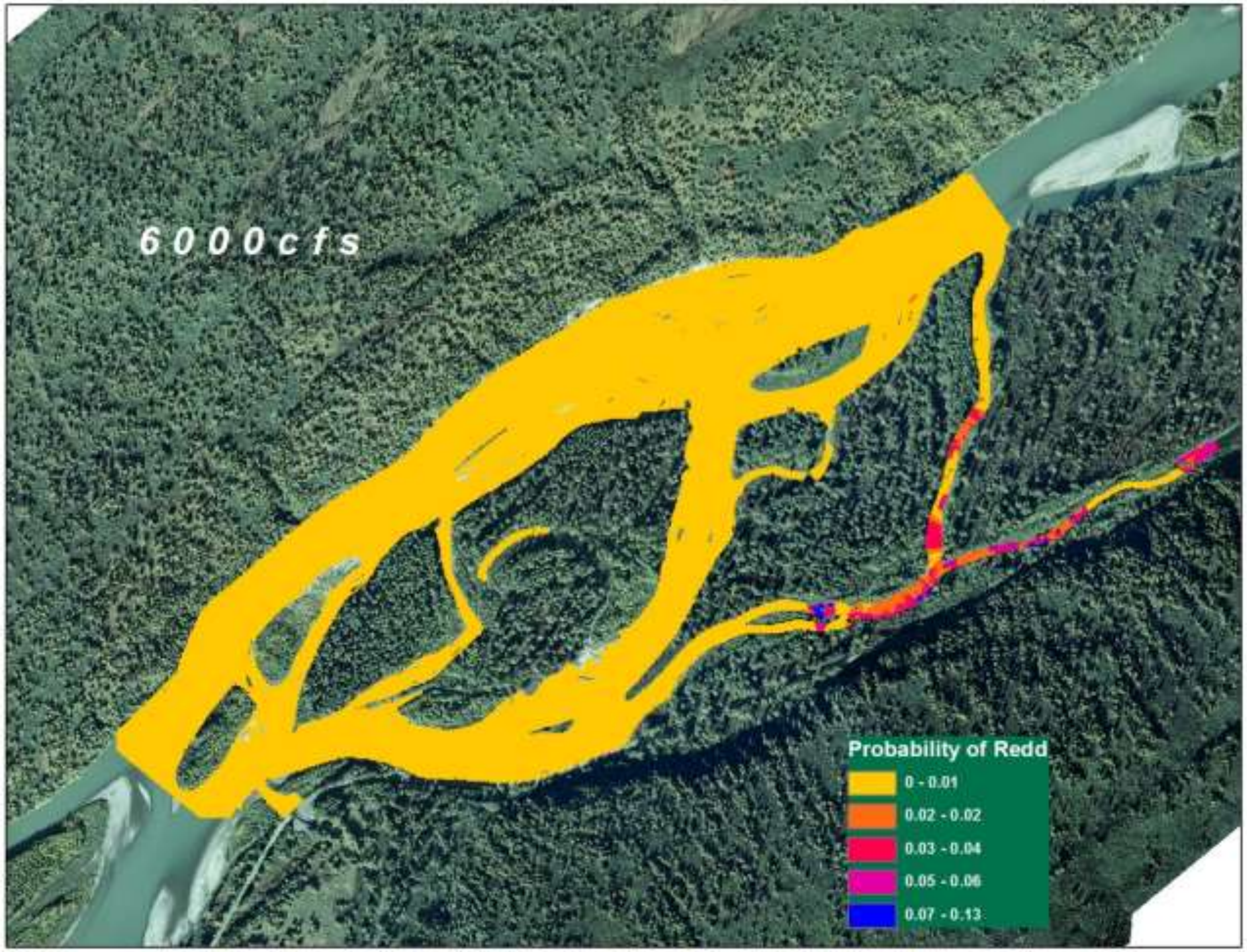
Preliminary Draft Subject to Revision Study 8.5 38

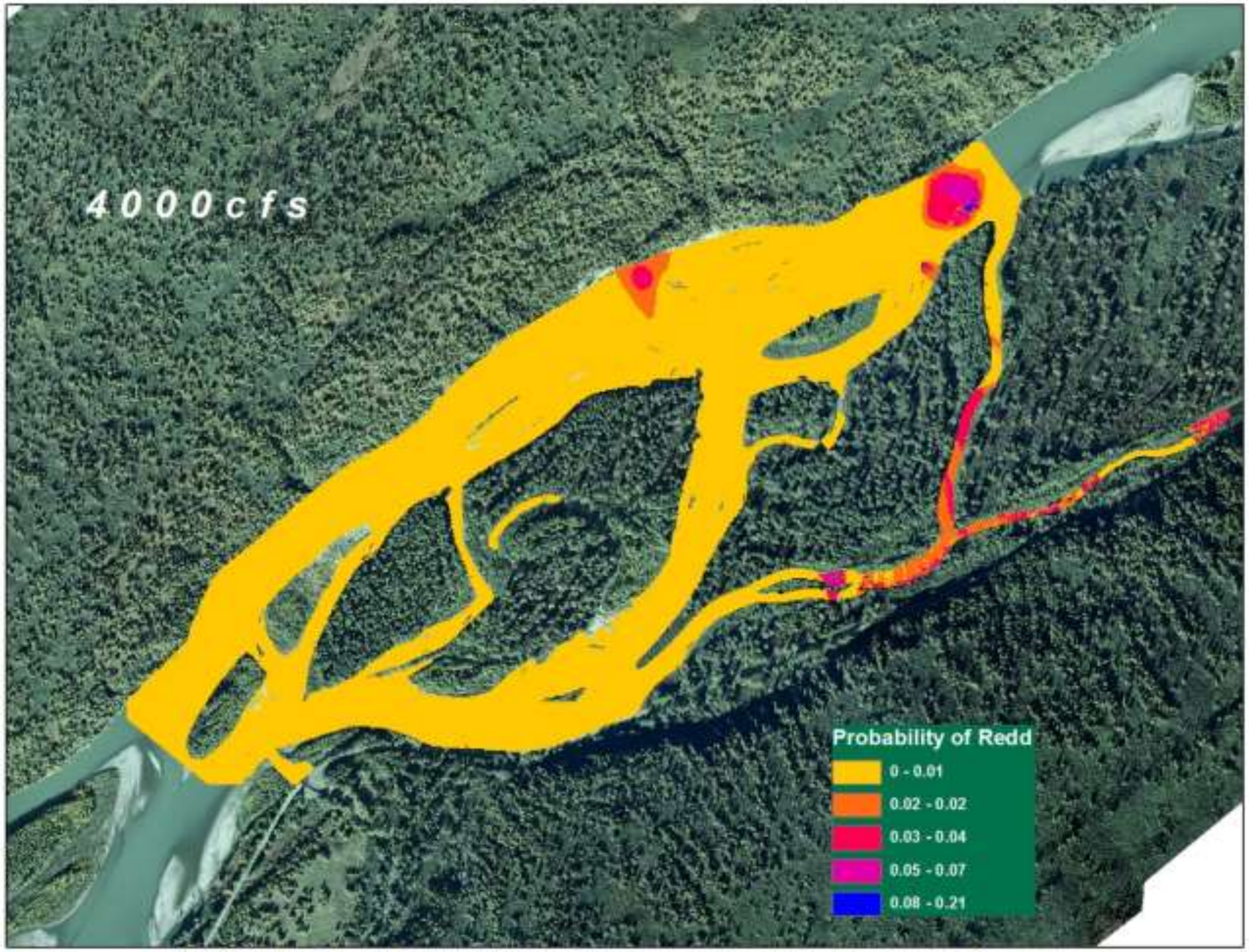
FA-128 (Slough 8A) chum spawning 8,000 cfs simulation



FA-128 (Slough 8A) chum spawning 6,000 cfs simulation



FA-128 (Slough 8A) chum spawning 4,000 cfs simulation



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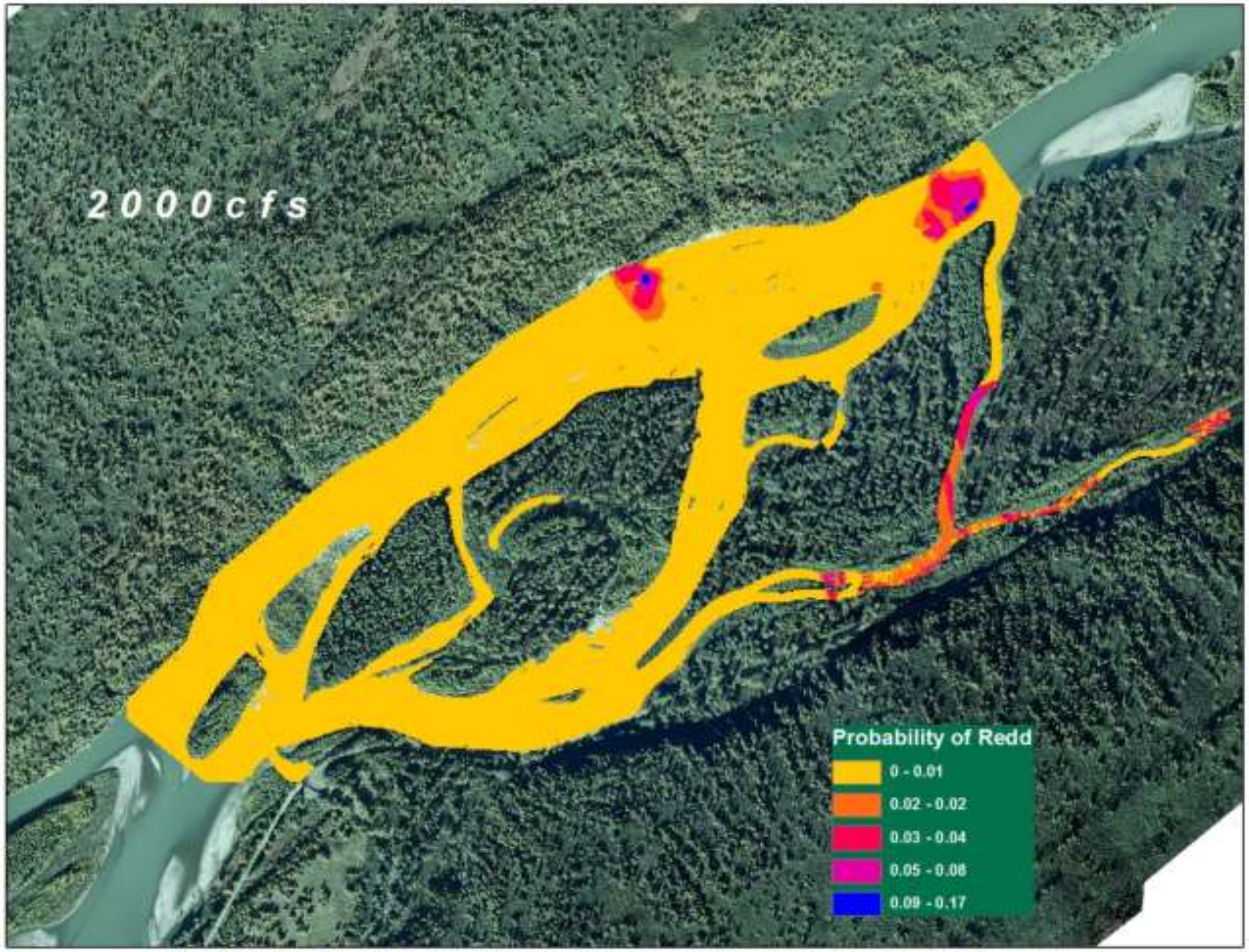
FA-128 (Slough 8A) chum spawning 2,000 cfs simulation



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FA-128 (Slough 8A) Scouring

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FA-128 (Slough 8A) Scouring

FA-128 (Slough 8A) Scouring

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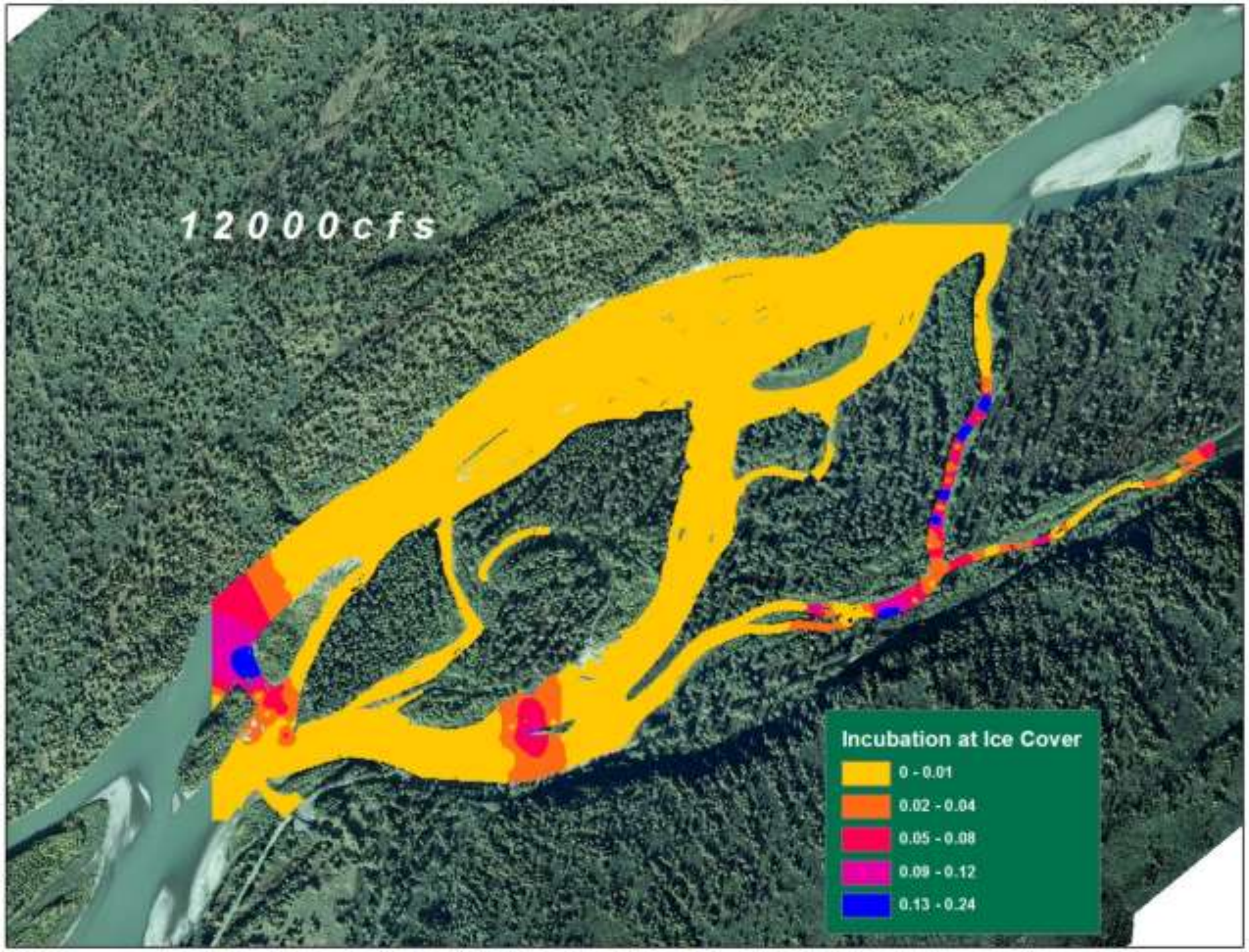
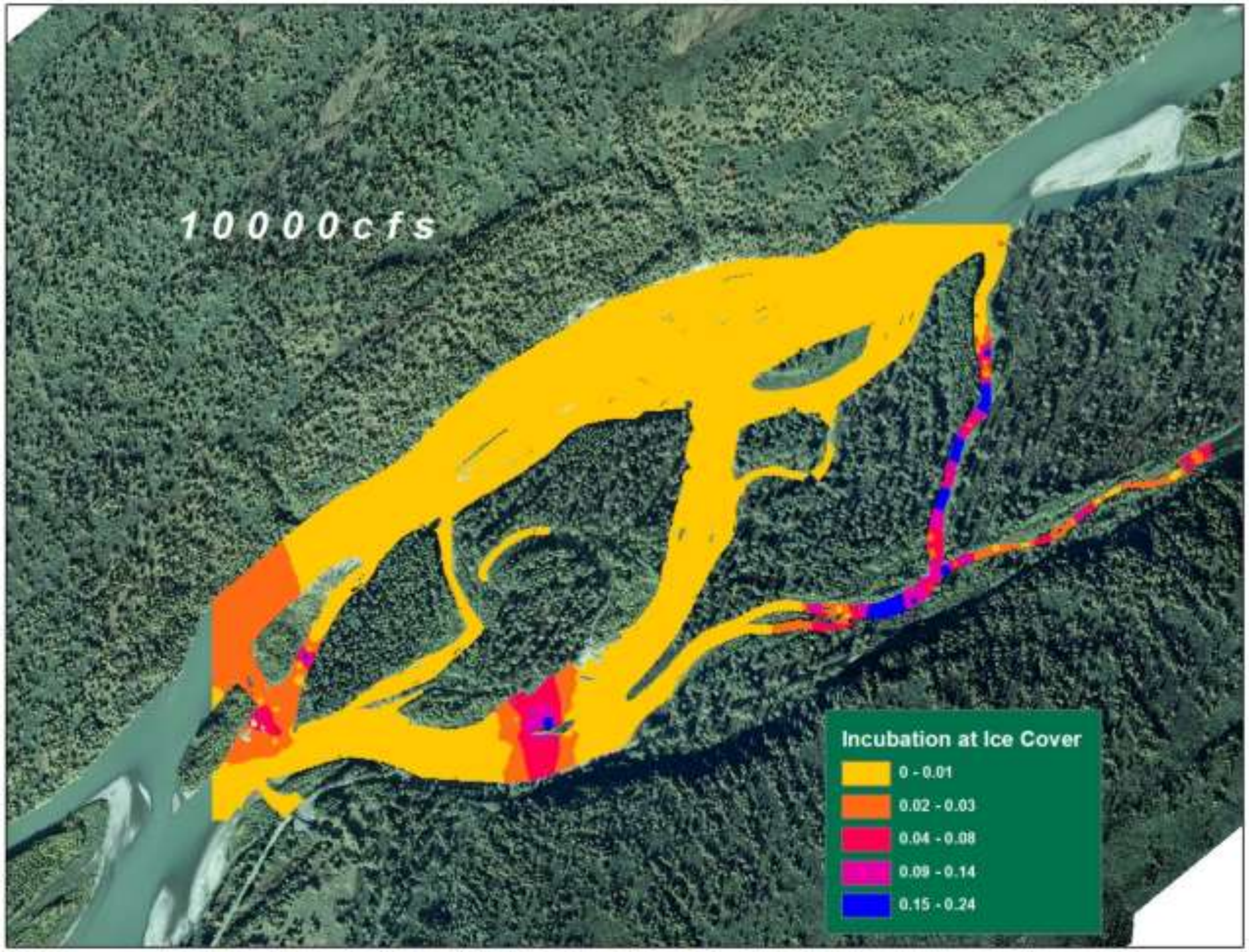
FA-128 (Slough 8A) Chum Winter Incubation 12,000 cfs simulation



FA-128 (Slough 8A) Chum Winter Incubation 10,000 cfs simulation



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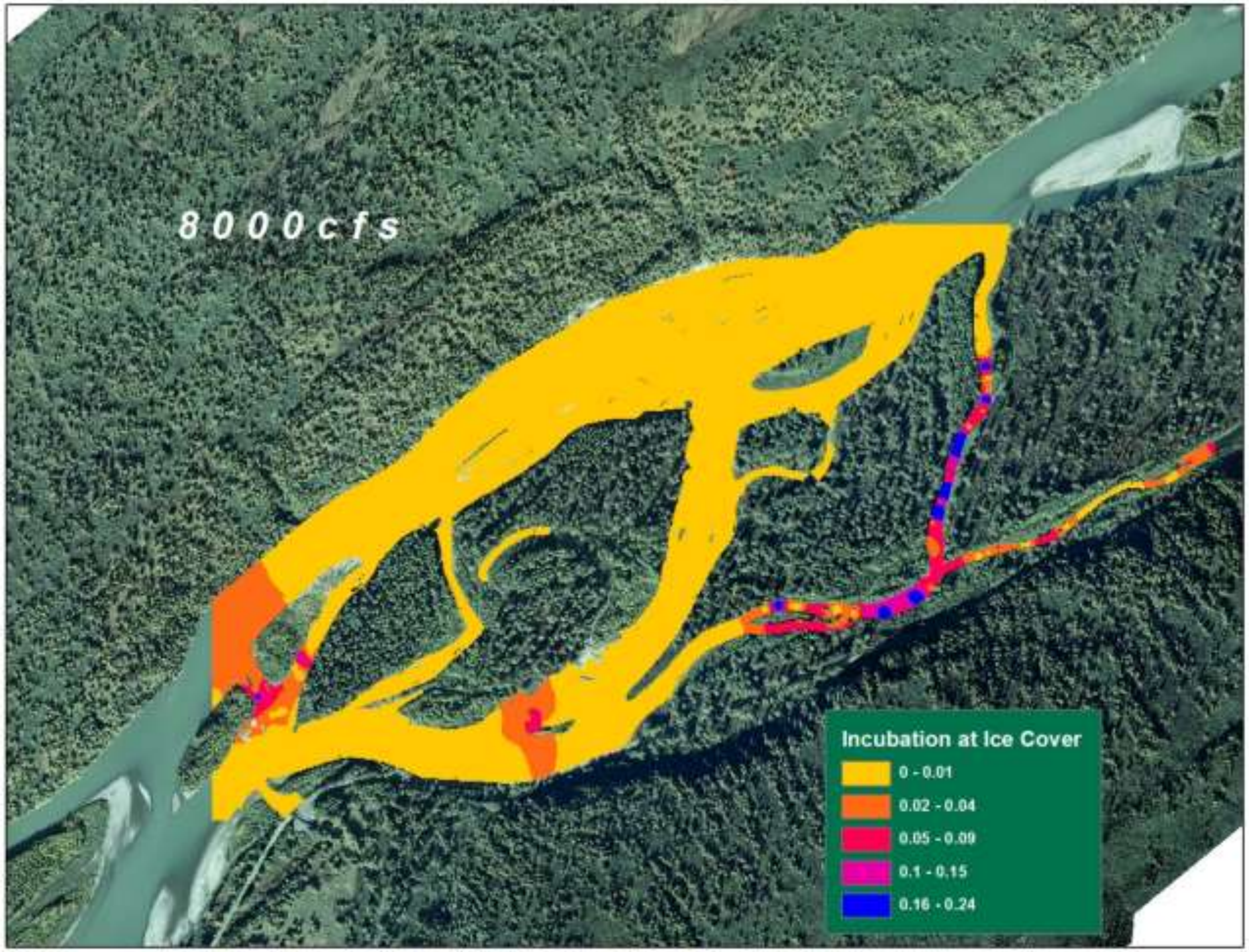
FA-128 (Slough 8A) Chum Winter Incubation 8,000 cfs simulation



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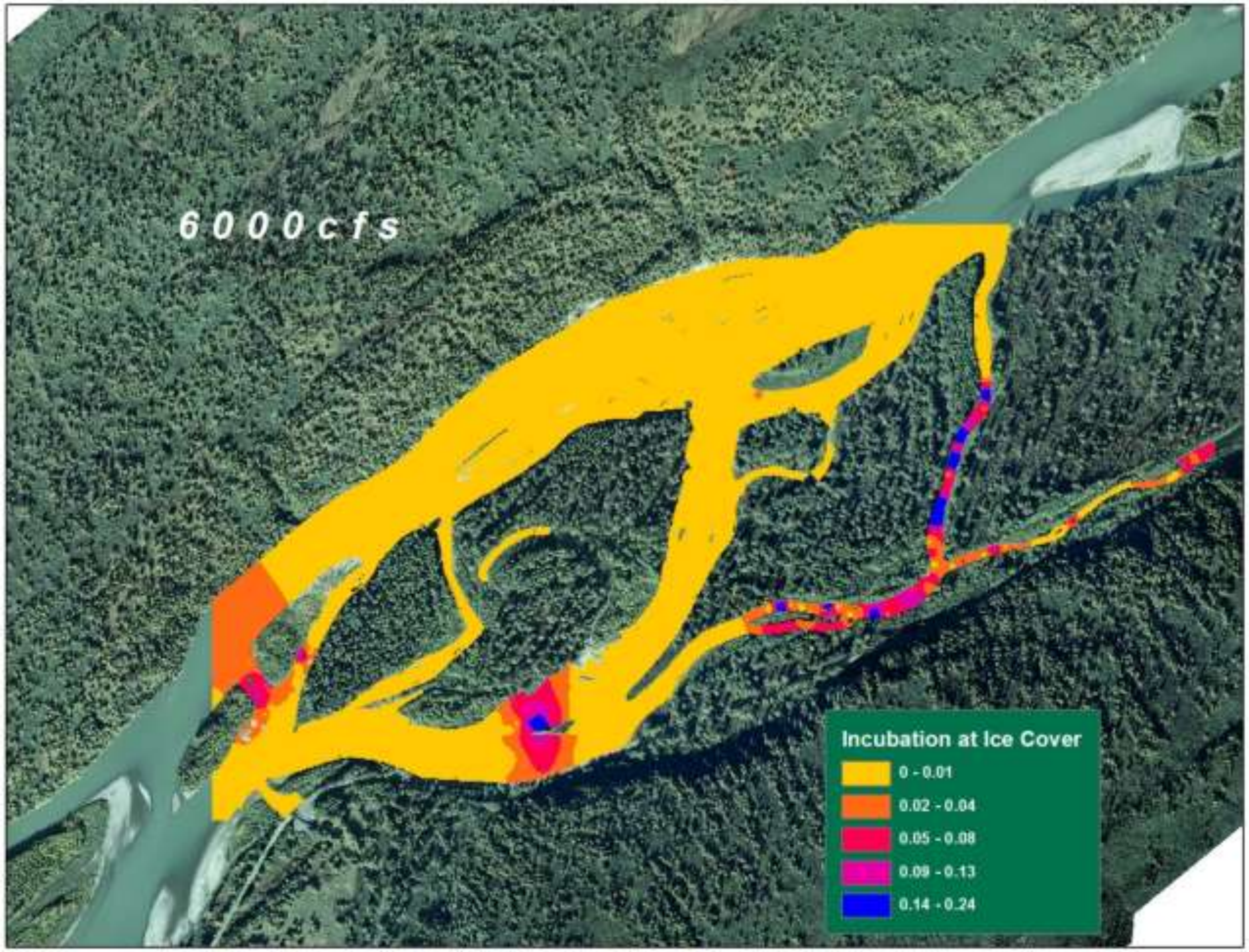
FA-128 (Slough 8A) Chum Winter Incubation 6,000 cfs simulation



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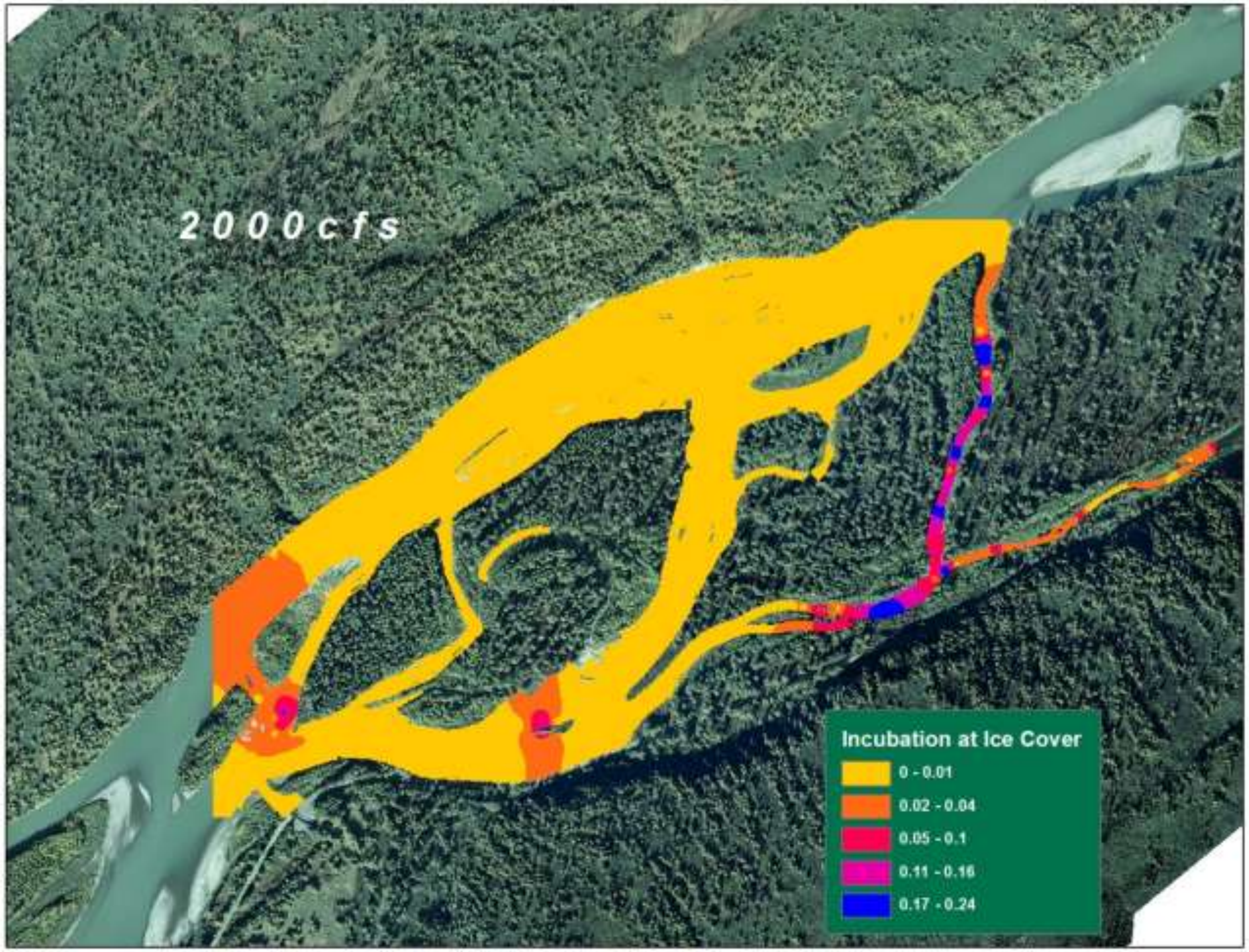
FA-128 (Slough 8A) Chum Winter Incubation 2,000 cfs simulation



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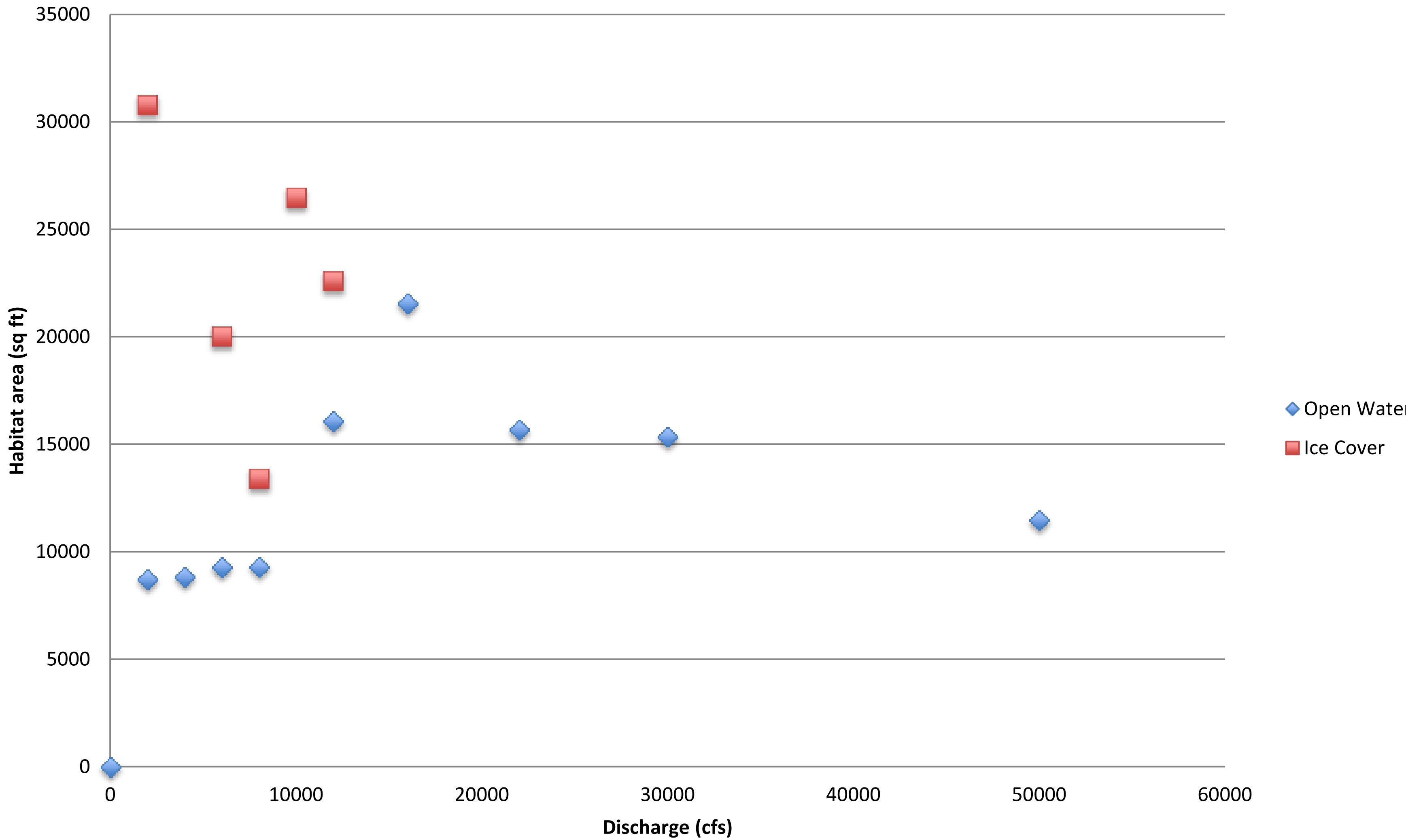
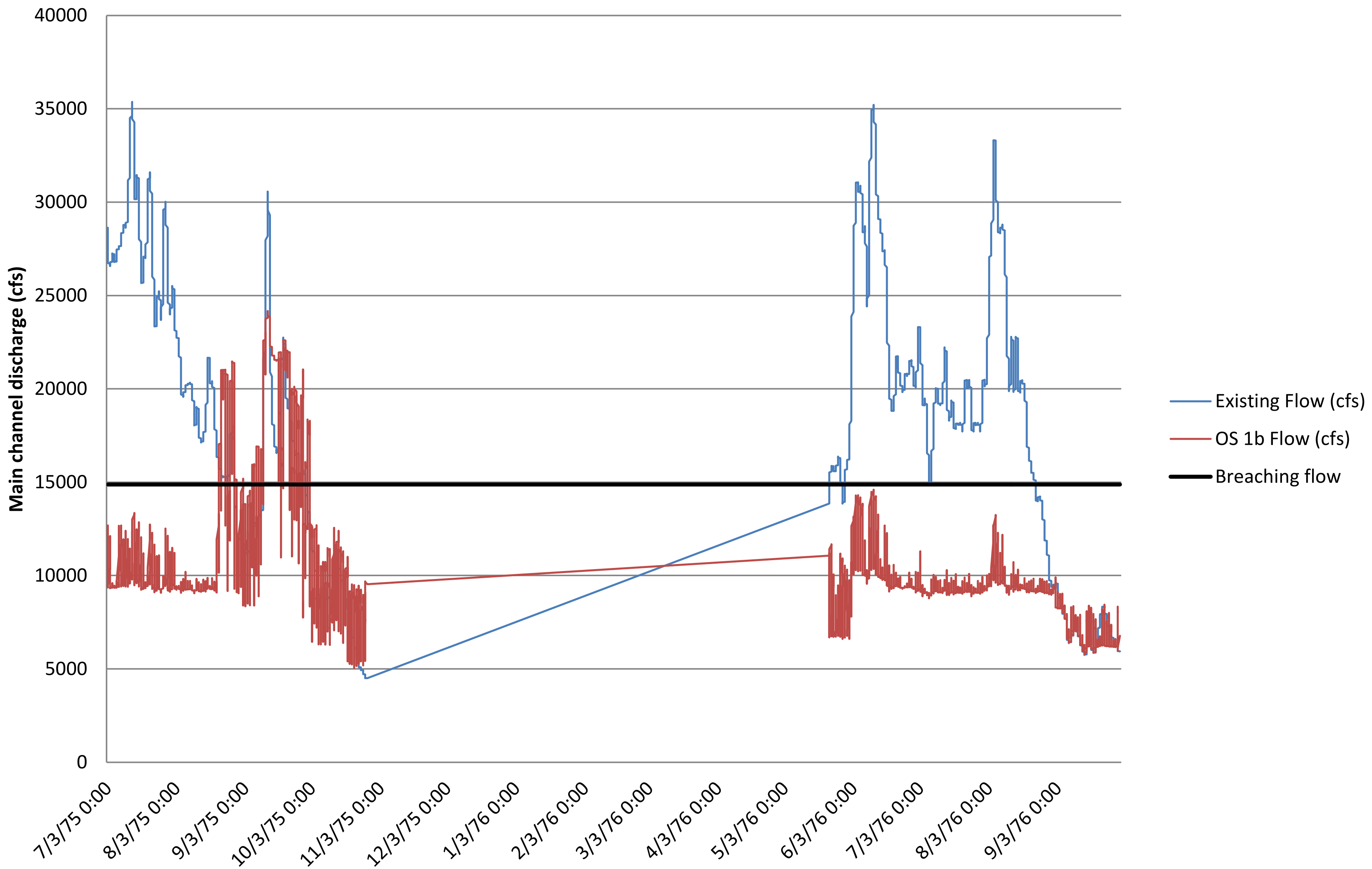
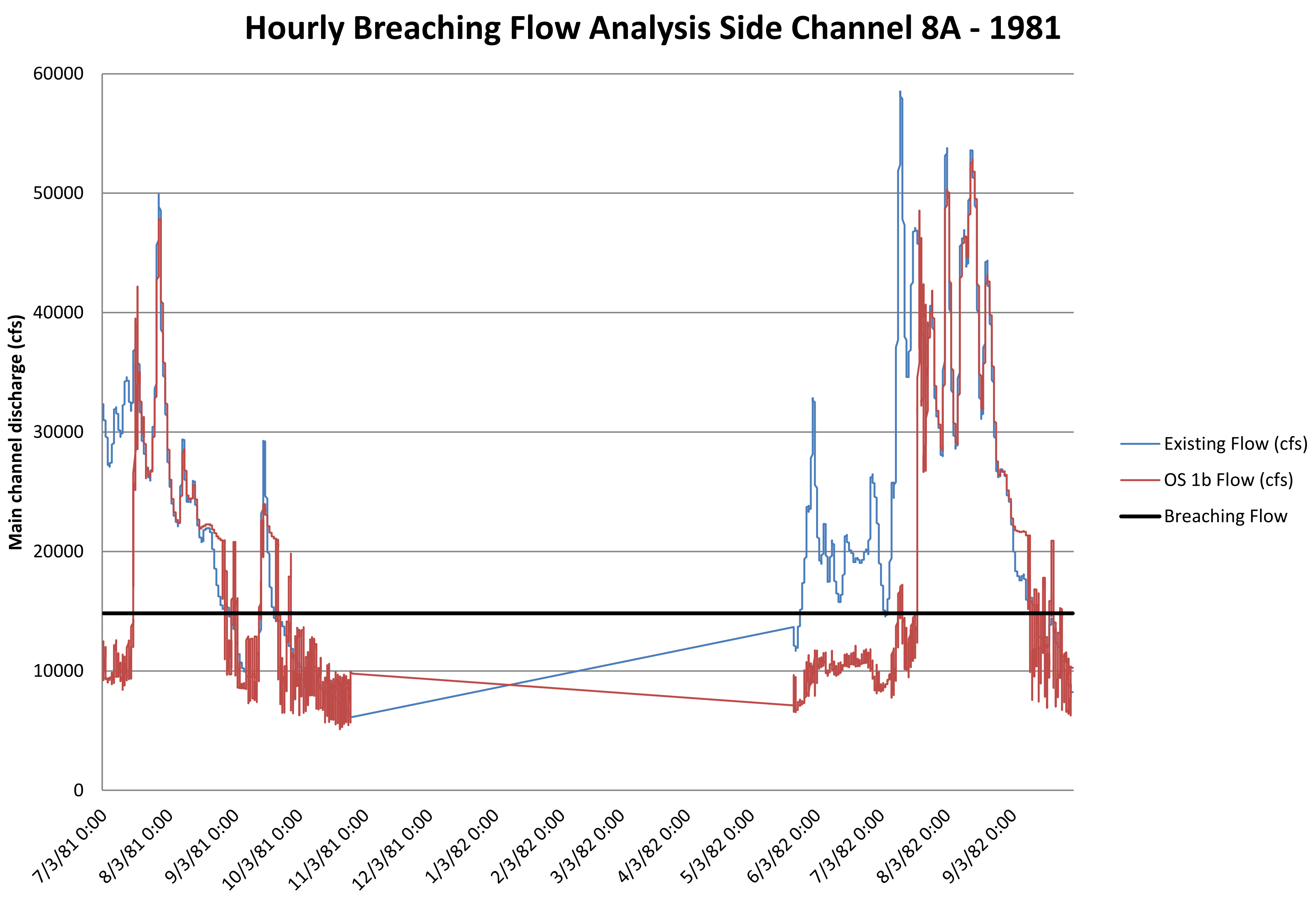
FA-128 (Slough 8A) Effective spawning/incubation habitat area versus flow, open water and ice cover

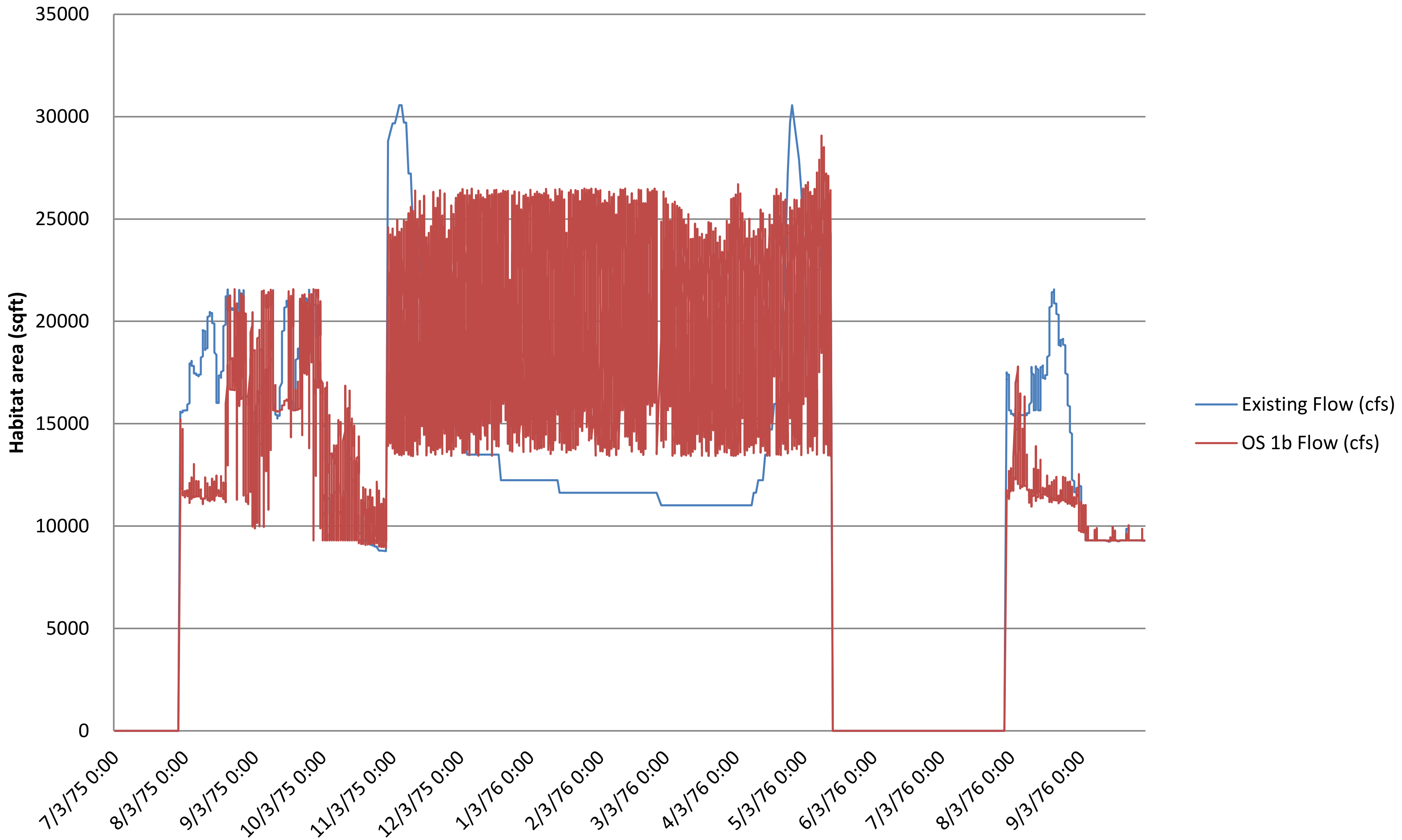


Hourly Breaching Flow Analysis Side Channel 8A - 1976

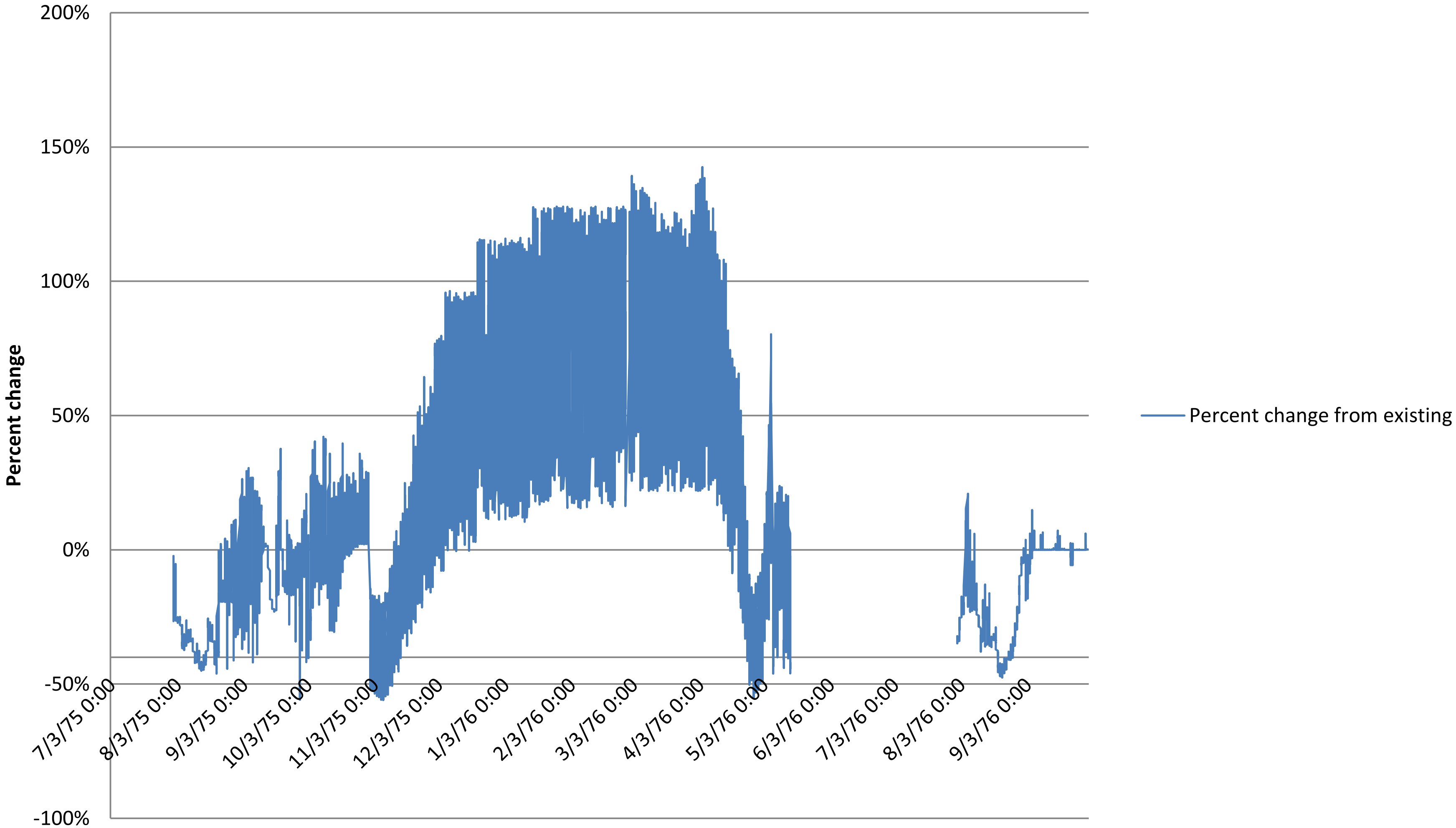


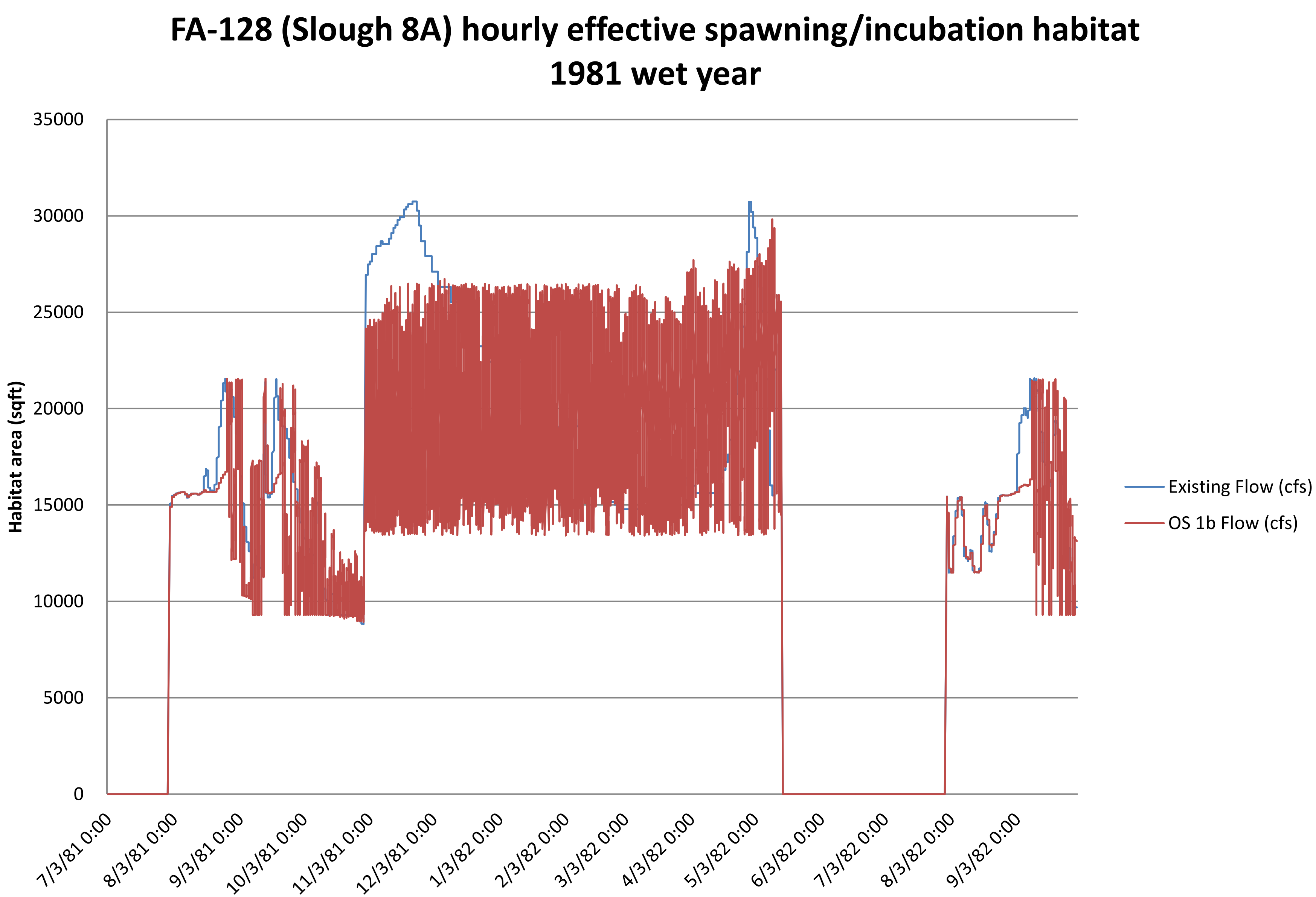

Hourly Breaching Flow Analysis Side Channel 8A - 1981
Main channel discharge (cfs)
60000
50000
40000
30000
20000
10000
0
7/3/81 0:00
8/3/81 0:00
9/3/81 0:00
10/3/81 0:00
11/3/81 0:00
12/3/81 0:00
1/3/82 0:00
2/3/82 0:00
3/3/82 0:00
4/3/82 0:00
5/3/82 0:00
6/3/82 0:00
7/3/82 0:00
8/3/82 0:00
9/3/82 0:00
Existing Flow (cfs)
OS 1b Flow (cfs)
Breaching Flow

FA-128 (Slough 8A) hourly effective spawning/incubation habitat 1976 dry year



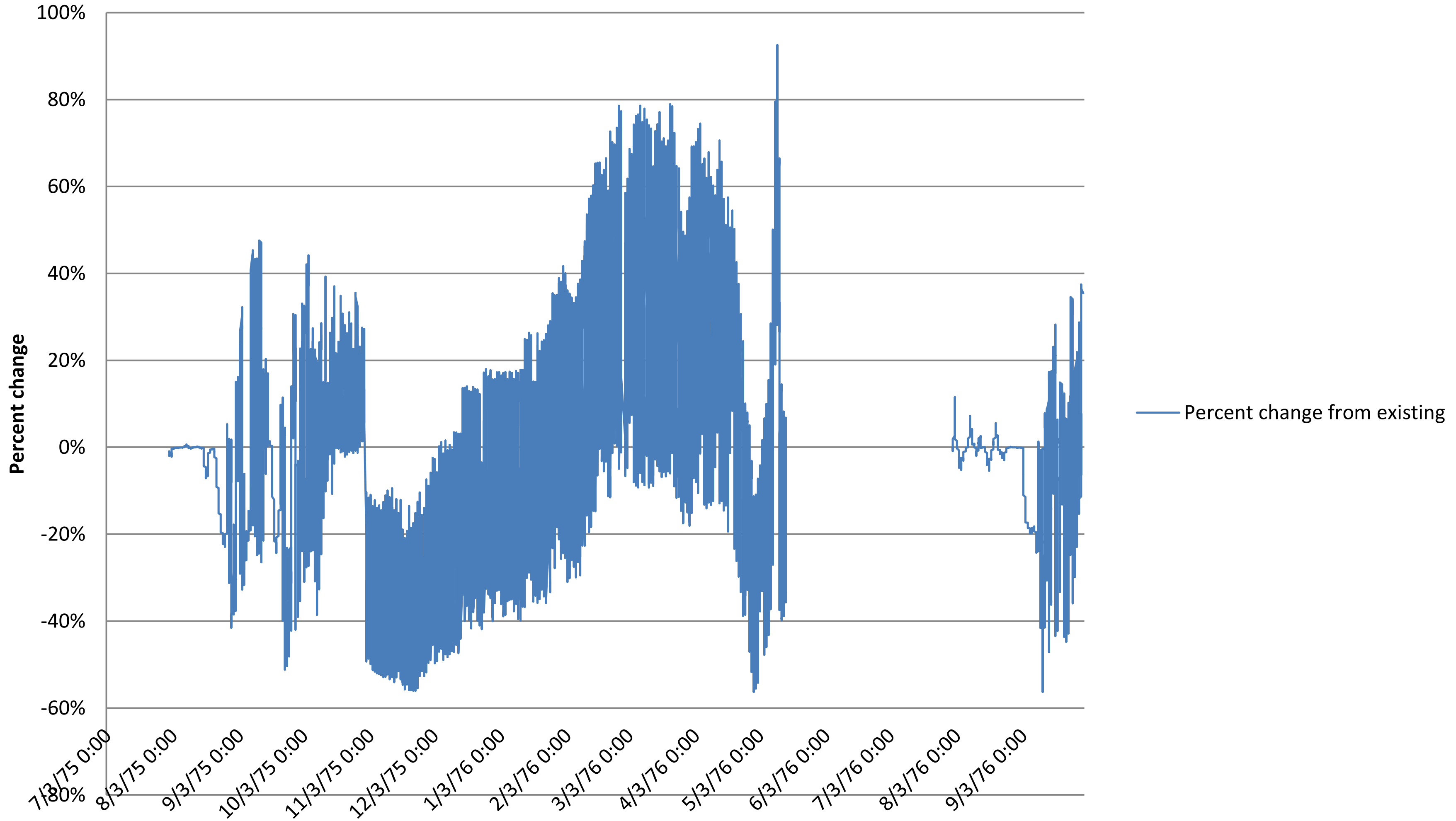
FA-128 (Slough 8A) Hourly effective spawning/incubation habitat percent change from existing conditions 1976 dry year





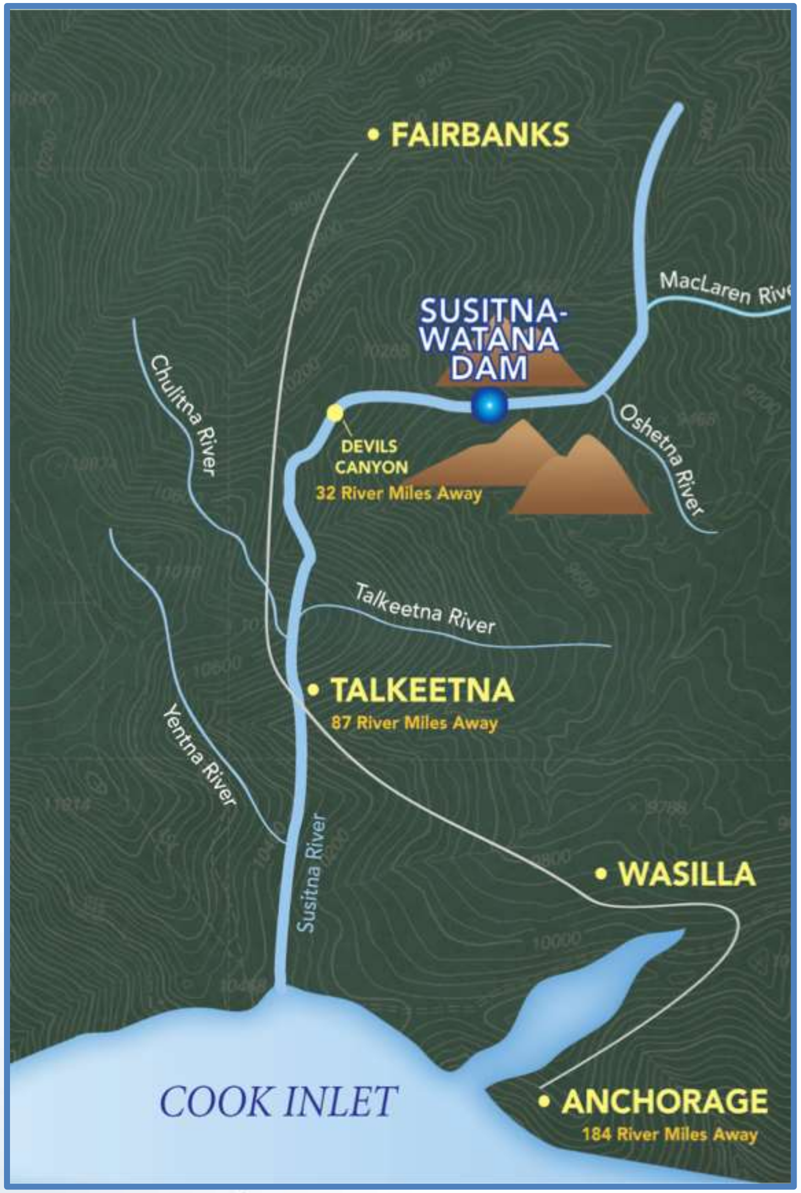
FA-128 (Slough 8A) hourly effective spawning/incubation habitat
1981 wet year
Habitat area (sqft)
35000
30000
25000
20000
15000
10000
5000
0
7/3/81 0:00
8/3/81 0:00
9/3/81 0:00
10/3/81 0:00
11/3/81 0:00
12/3/81 0:00
1/3/82 0:00
2/3/82 0:00
3/3/82 0:00
4/3/82 0:00
5/3/82 0:00
6/3/82 0:00
7/3/82 0:00
8/3/82 0:00
9/3/82 0:00
Existing Flow (cfs)
OS 1b Flow (cfs)

FA-128 (Slough 8A) hourly effective spawning/incubation habitat percent change from existing conditions 1981 wet year



Summary

- Approach provides tabular and graphical data outputs for input to DSS or other decision processes.
- The analysis sequence is similar to other 2-D habitat analysis with the addition of explicit inclusion of ground water conditions, breaching in lateral habitats, and water quality.
- A similar approach will be used on other species and life stages of interest.



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2-D Fish Habitat Middle River Focus Areas

Questions