Utilizing Instream Flow to Predict and Protect Aquatic Habitat

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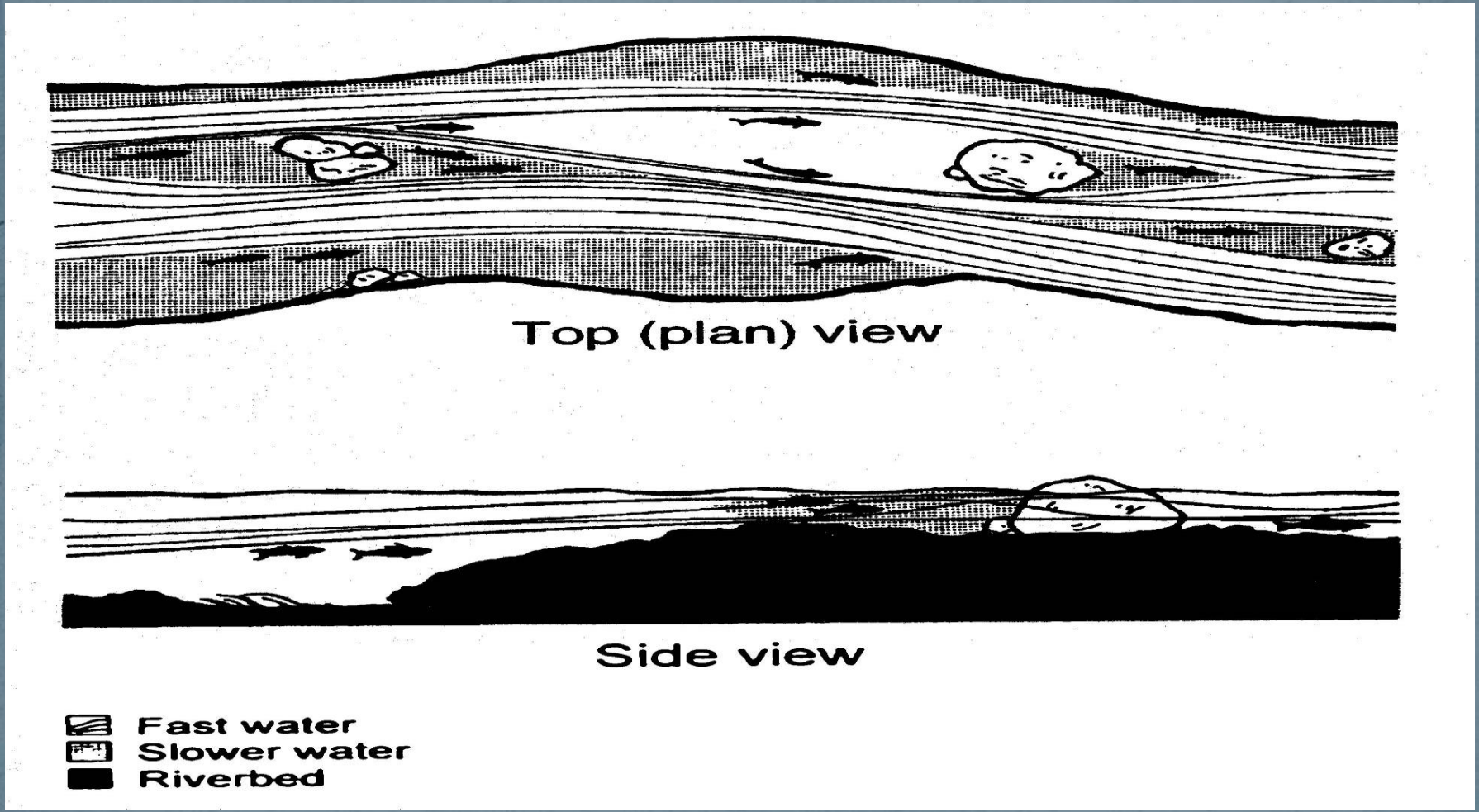
Colorado Parks and Wildlife

Objective: Simulate the Natural Stream Environment



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Methodologies

- Historic Flow Methods (Hydrology)
- Hydraulic Methods
- Hydraulic /Habitat Methods

- Standard Setting Techniques
  - Hydrology Based (Historic flow methods)
    - Tennant
      - Uses percent of mean annual flow for decision
      - Data developed from a wide variety of stream types
    - Hoppe
    - Great Plains

    - Little if any field data involved, utilizes recorded or estimated flow regime of the river

- Mid-Range Techniques
  - Modified Tennant – Repeats all of Tennant's steps to develop site specific approach
  - Hydraulic simulation
    - R2Cross
    - Wetted Perimeter

- HABITAT (INCREMENTAL) TECHNIQUE
  - High controversy project
  - Project specific
  - Many decision variables
  - Expensive
  - Designed for negotiations

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Incrementalism: Development of instream flow policy that incorporates multiple or variable rules to establish flow requirements to meet the needs of aquatic ecosystem.

Methodology components include:

- Water quality
- Water supply
- Channel Hydraulics
- Aquatic biota components
- Habitat Suitability for target species

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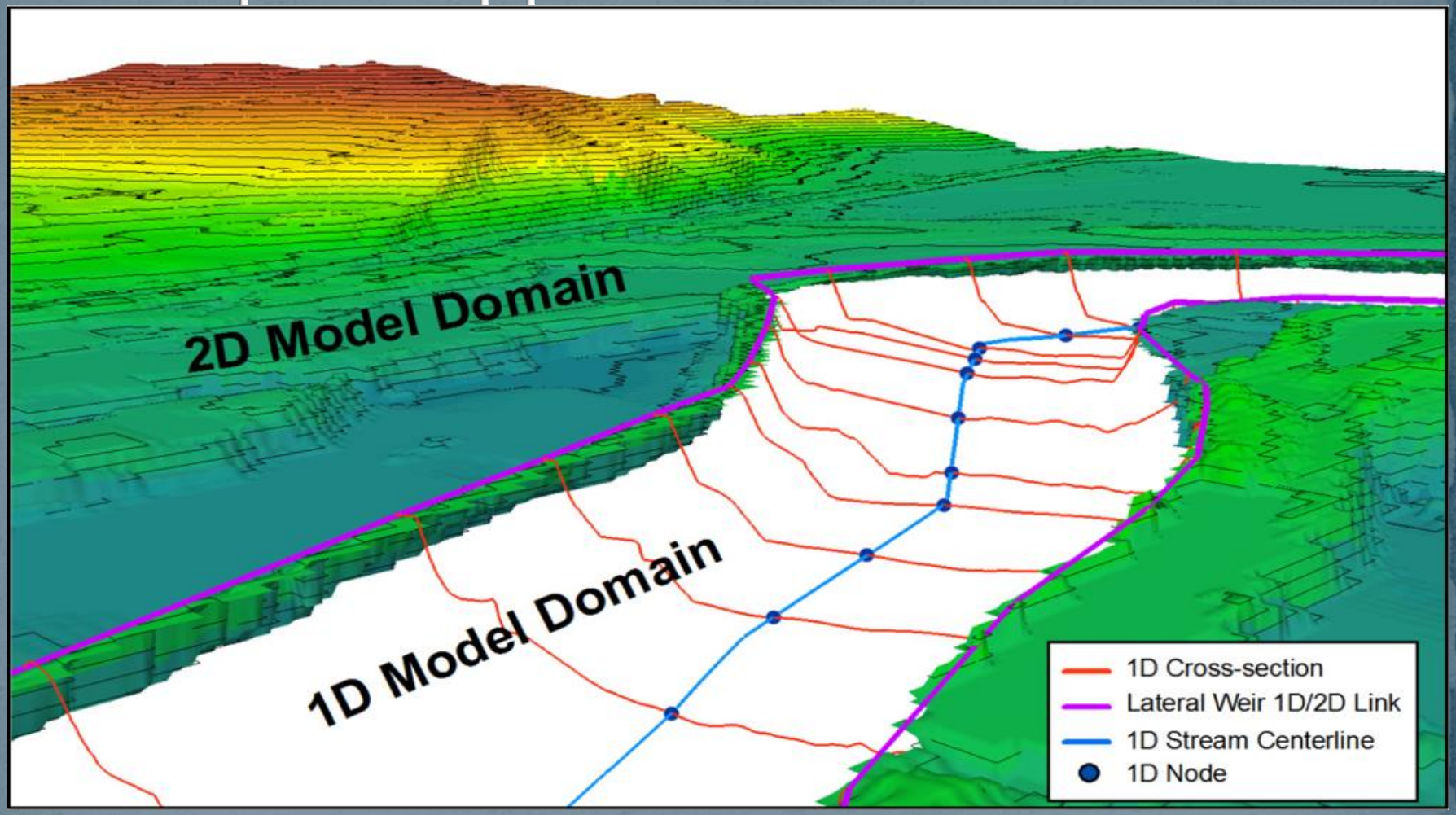
Conceptual approach



Channel Hydraulics

Physical descriptors of channel

Width, Depth, Velocity, Discharge and Substrate

= Physical space for aquatic biota

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Hydraulic Models

- 1-D models
  - R2Cross
  - PHABSIM
    - IFG4
    - WSP
    - MANSQ
- 2-D Models
  - FESWMS
  - RMA-2
  - River2D

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Hydraulic Models

- One Dimensional
  - Simulates velocity in one dimension only
  - Example Models
    - HEC
    - PHABSIM
    - RHABSIM
- Applications
  - Traditional method since the 1980s
  - Simple channels or habitat features

- Two Dimensional Models
  - Simulates velocity in 2 dimensions
    - Example Models
      - RMA-2
      - FESWMS
      - River2D
- Applications
  - The new “standard” for IFIM
  - Complex channel hydraulics
  - Investigation of local channel change

Hydraulic Model Data

- One Dimensional
  - Channel cross section data
  - Water Surface elevation
  - Water velocity
  - Water Depth
  - Substrate
  - Does not require geo reference between cross sections
- Two Dimensional
  - Channel topography data
  - Water Surface elevation
  - Water velocity
  - Water Depth
  - Substrate
  - Does require spatial reference
  - Can be geo-referenced data

HABITAT USE CRITERIA

- Describes the habitat life history requisites for the species under study
- Can be life stage or activity specific
- May include adjustments or weighting for habitat availability
- Link between behavior and hydraulics

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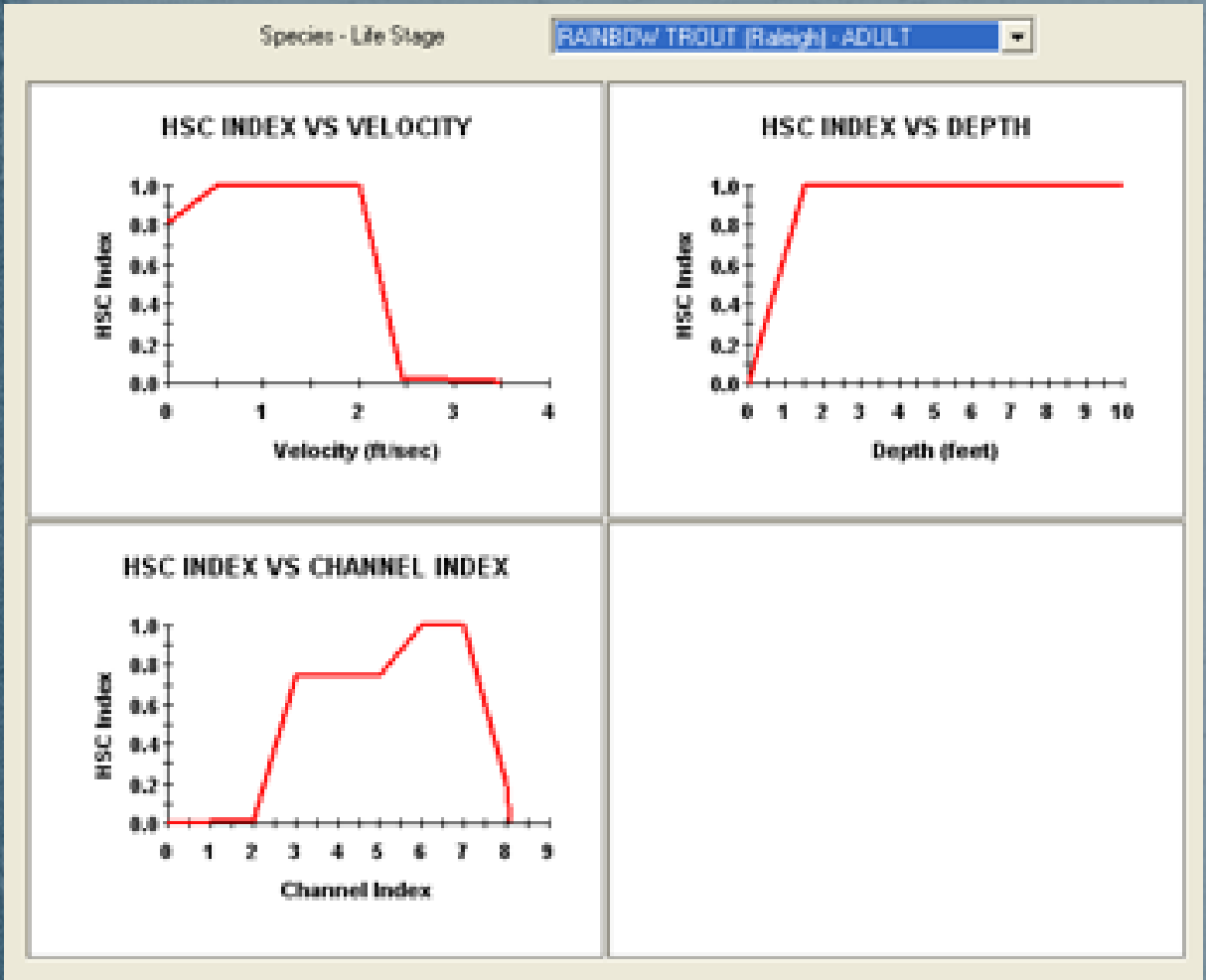
Example Category II Univariate Criteria



- Combined SI = Depth SI * Velocity SI * Channel Index SI
- SI can be a paired suitability value or exponential equation

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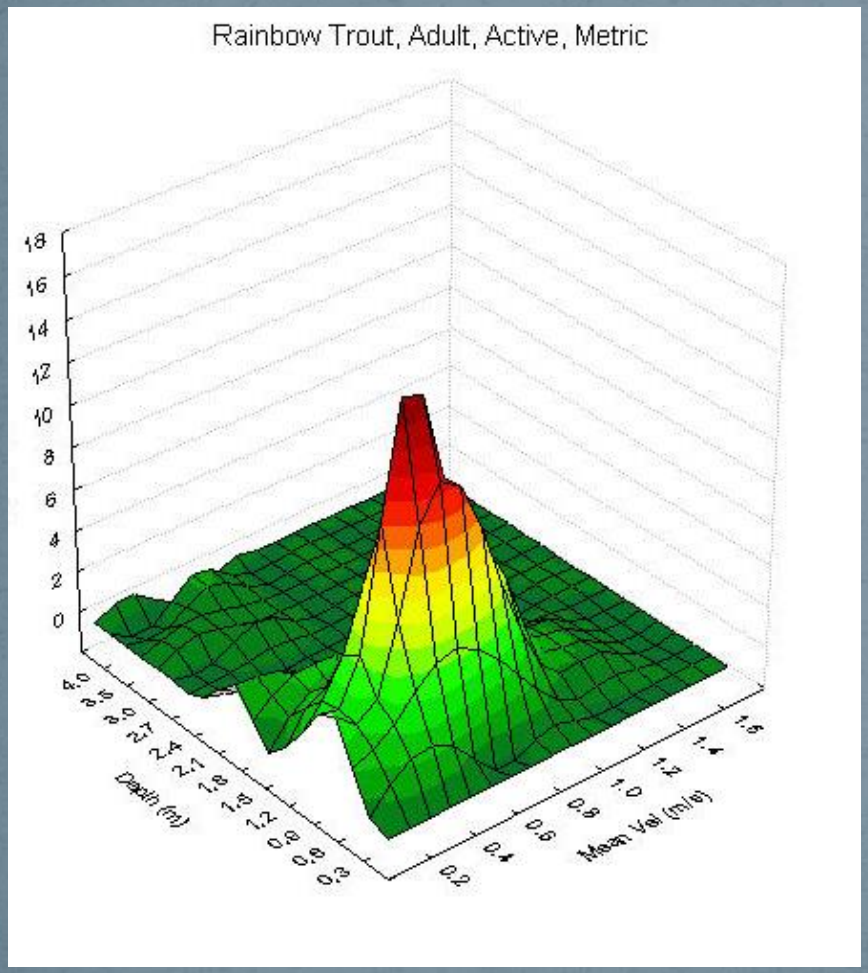
Example Category IV bivariate criteria



- **Rainbow Trout-Adult**
- $Z=(1/11.08667378)*(\exp(-((0.087184)+(11.36193*Dep)+(56.9357*Vel)+(3.539872*Dep*Vel)+(-51.7545*Dep^2)+(-309.223*Vel^2)+(55.63995*Dep^3)+(626.7088*Vel^3)+(-23.3391*Dep^4)+(-559.162*Vel^4)+(3.403427*Dep^5)+(184.4437*Vel^5))$

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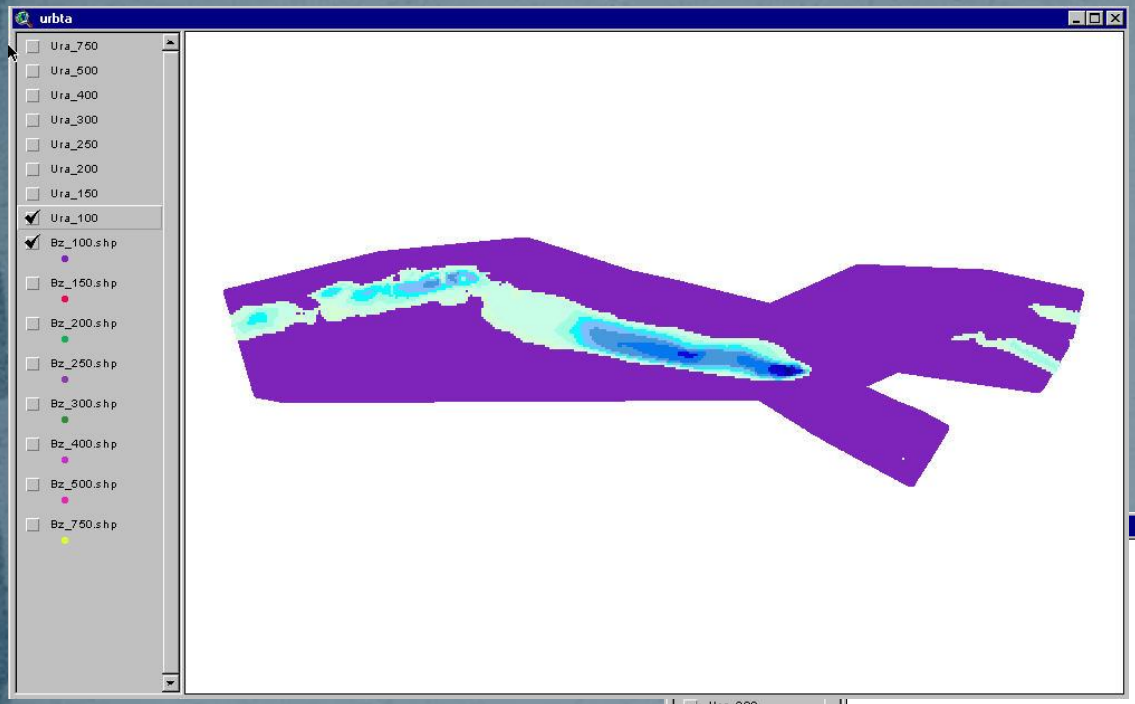
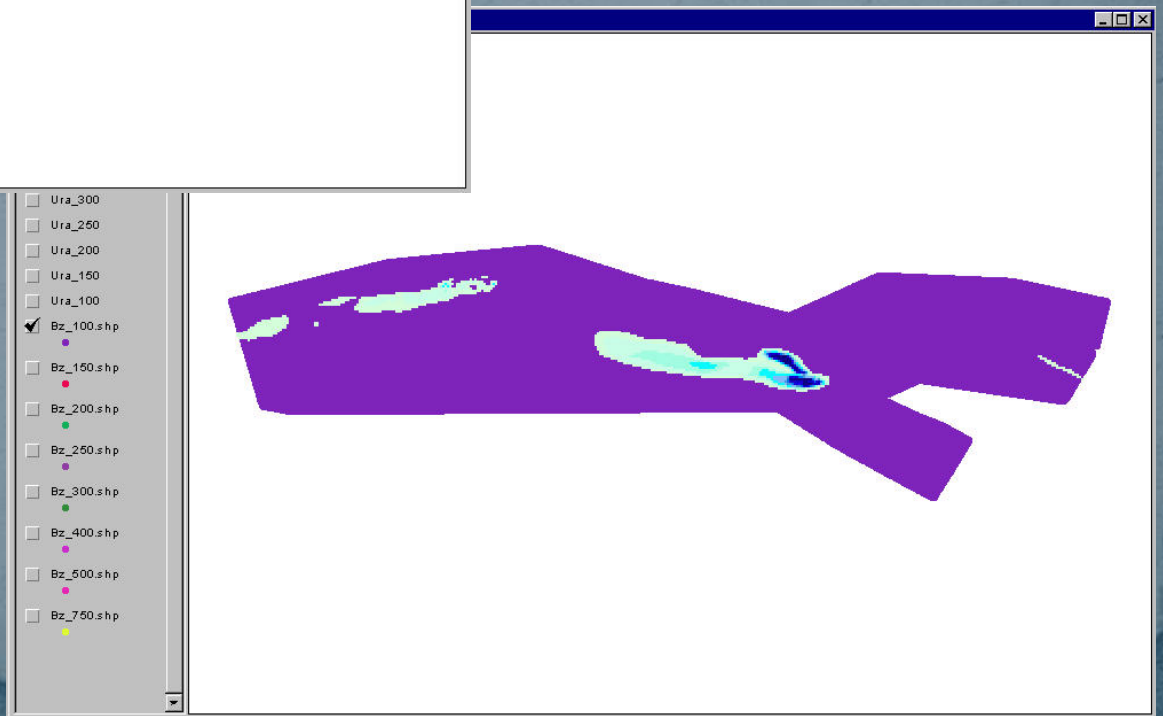
Example univariate and bivariate habitat





Habitat - Flow Relationships

- Physical Habitat Simulation System (PHABSIM)
- Habitat Criteria and Hydraulic Data must contain similar descriptions of channel variables (depth, velocity, cover, substrate)
- Hydraulic Model Calibrated and Simulations
- Habitat Use Criteria Generated
- Model linkage between hydraulic and habitat components

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HABITAT MODELING

- Combines hydraulic simulations with habitat criteria
- Result shows the area of usable habitat at each particular flow modeled

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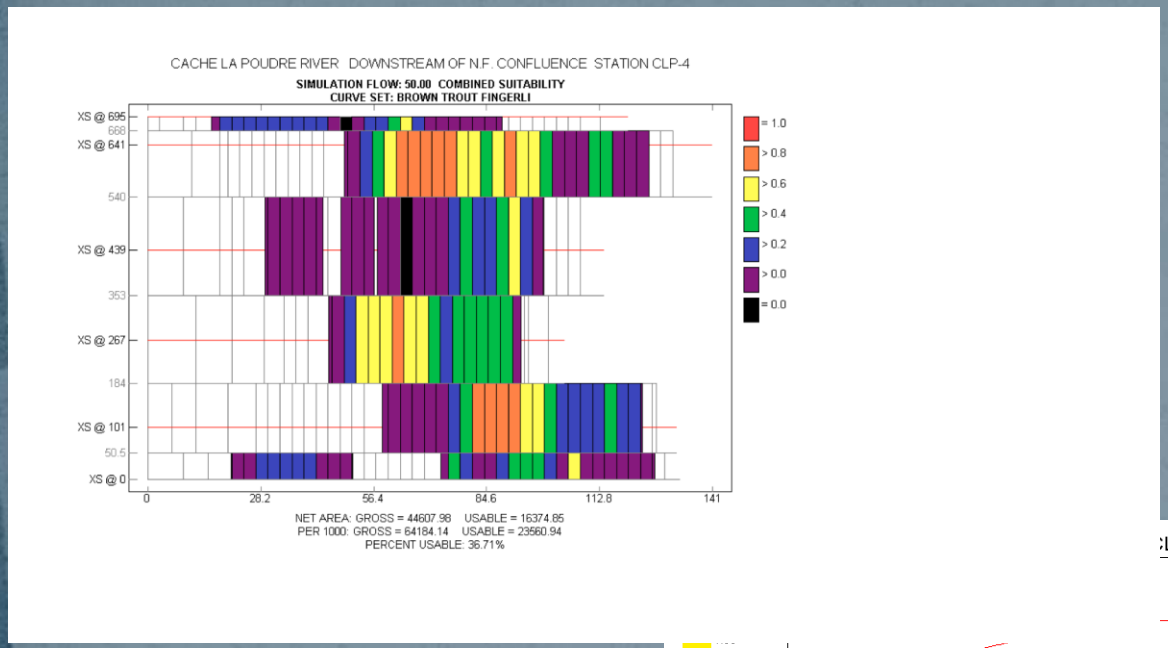
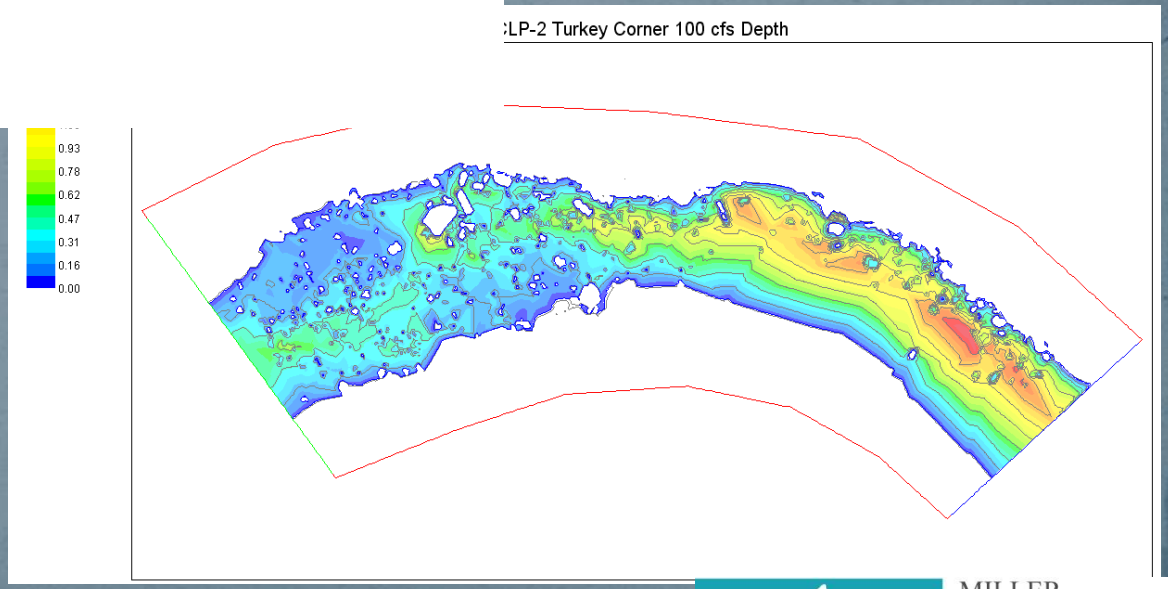
Comparison of 1-D and 2-D habitat representation





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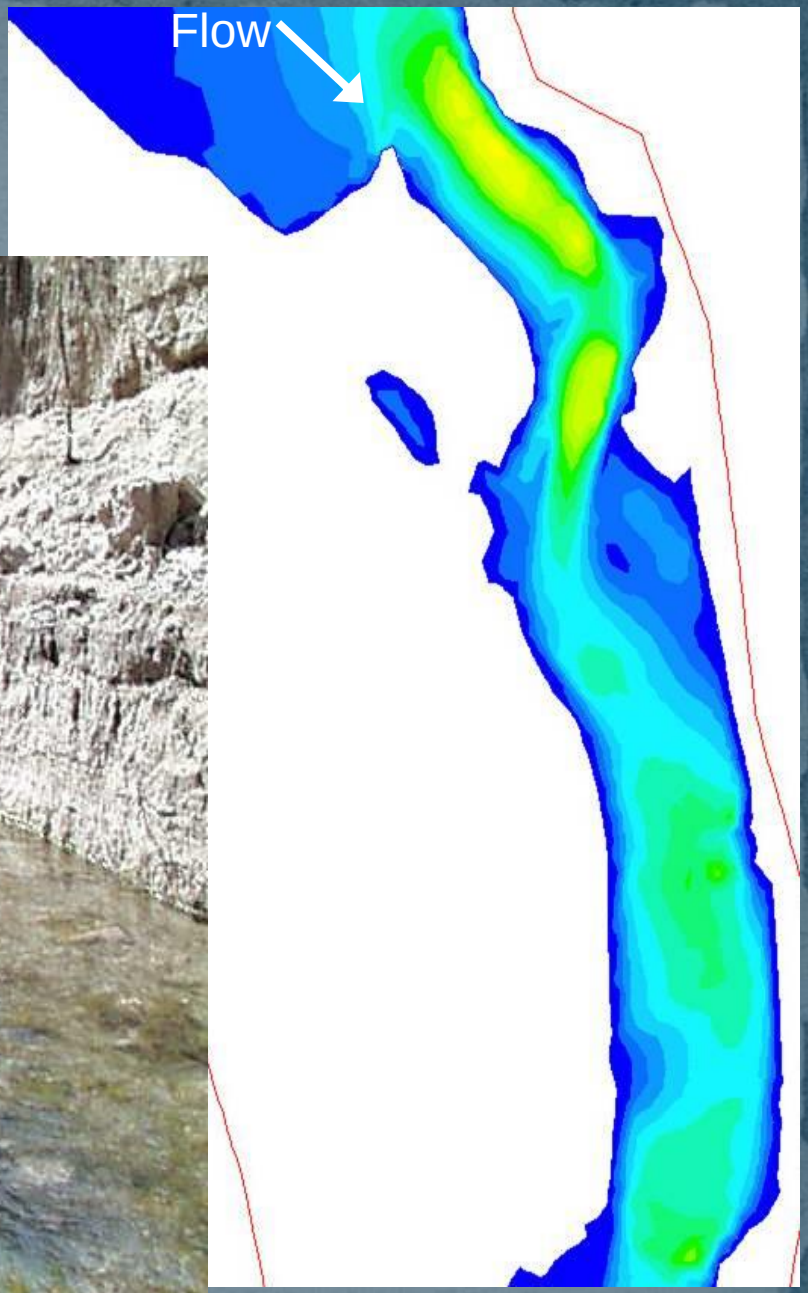
Natural system vs. Model

Photo: 15 cfs

Model: 14 cfs



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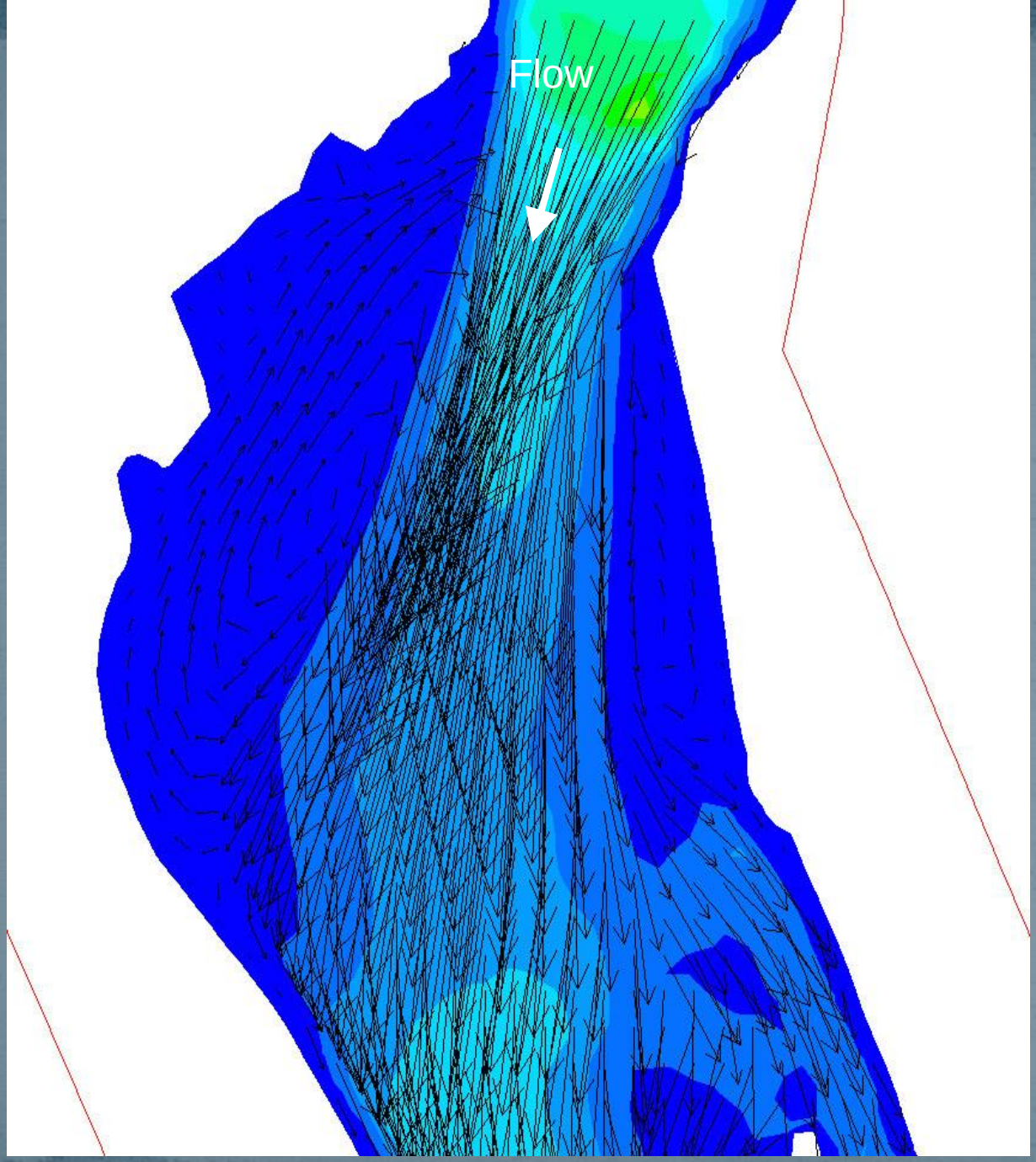

Example
Velocity Vectors

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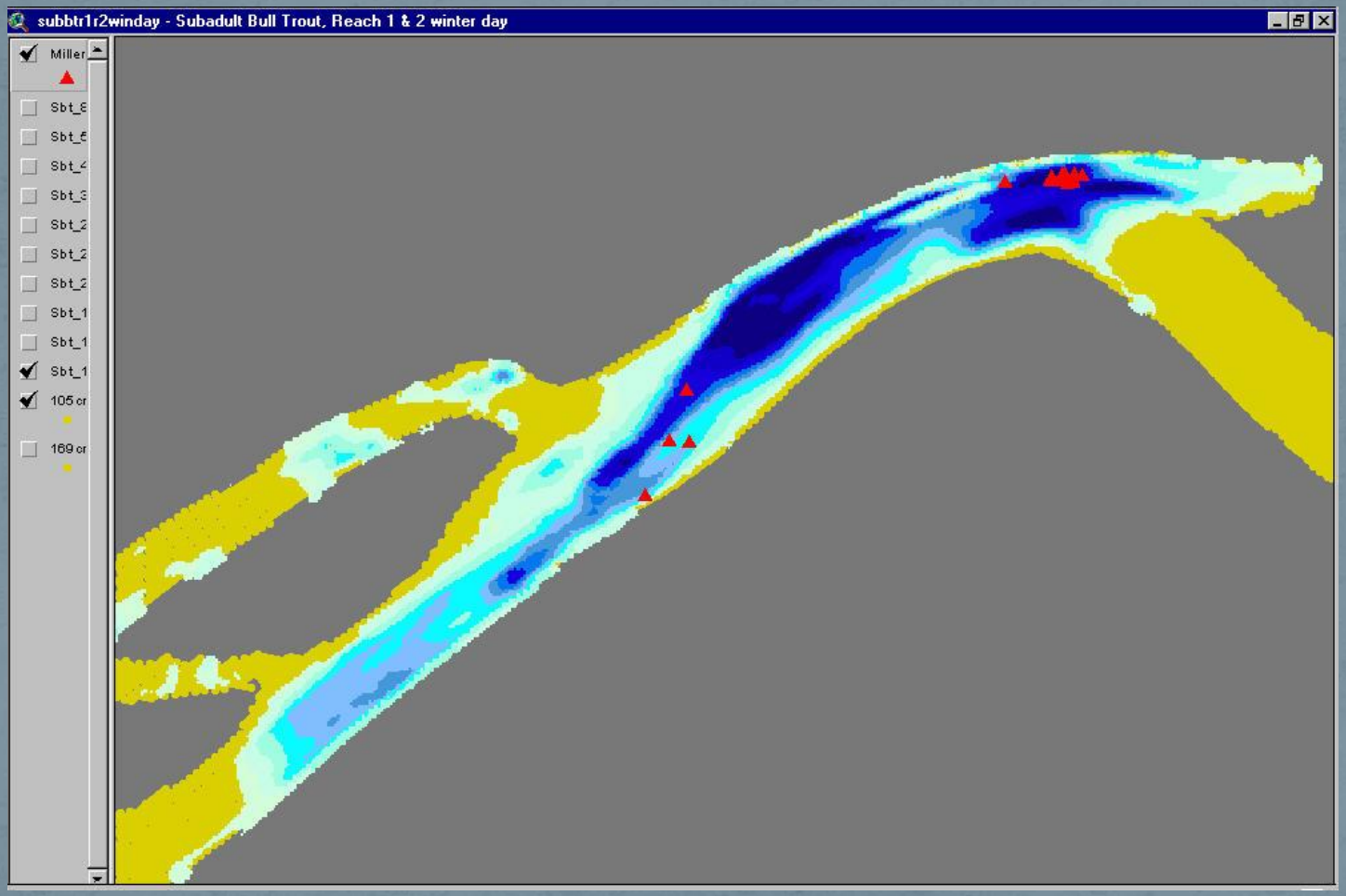
Graphic results



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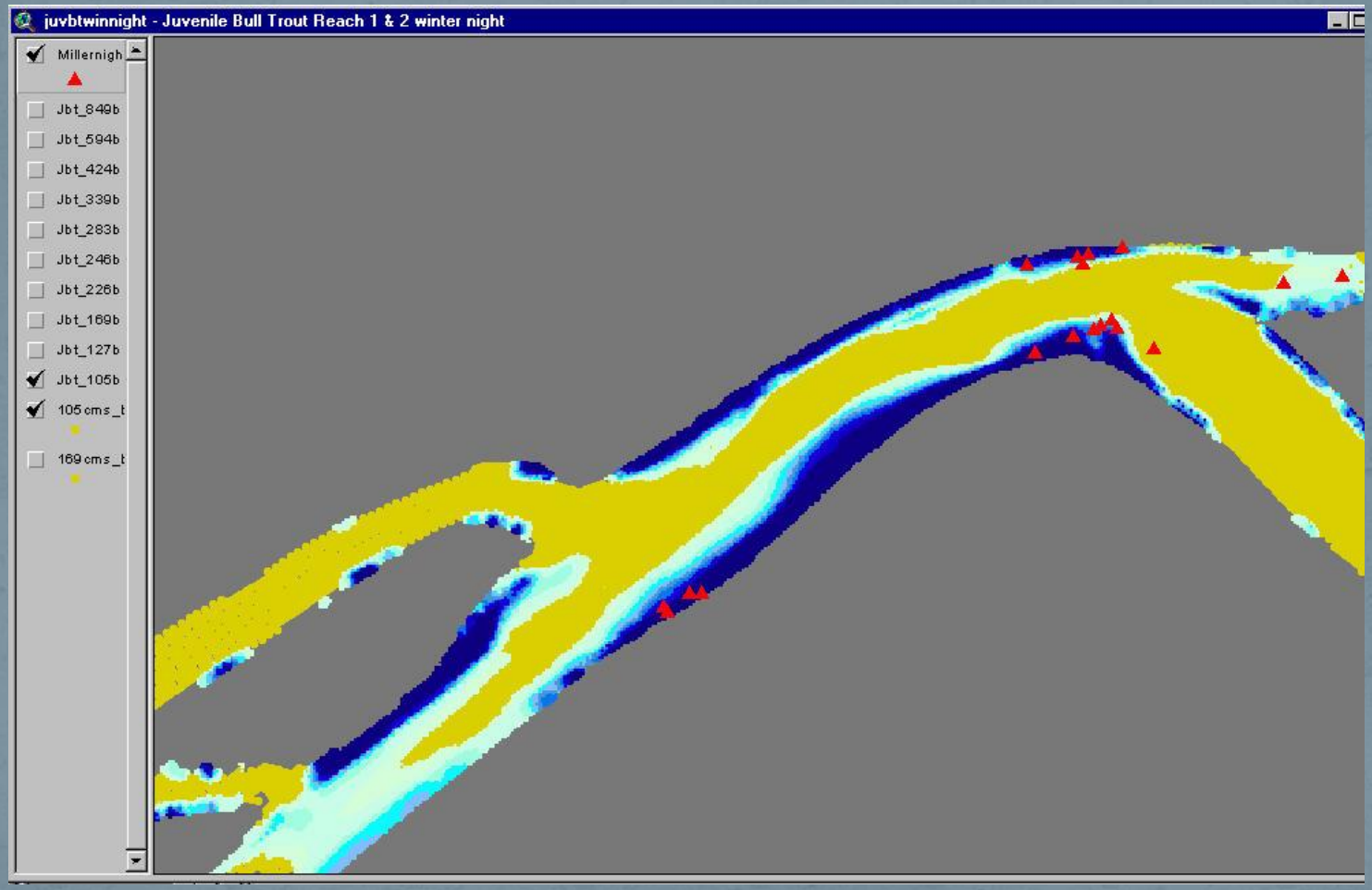
Graphic results



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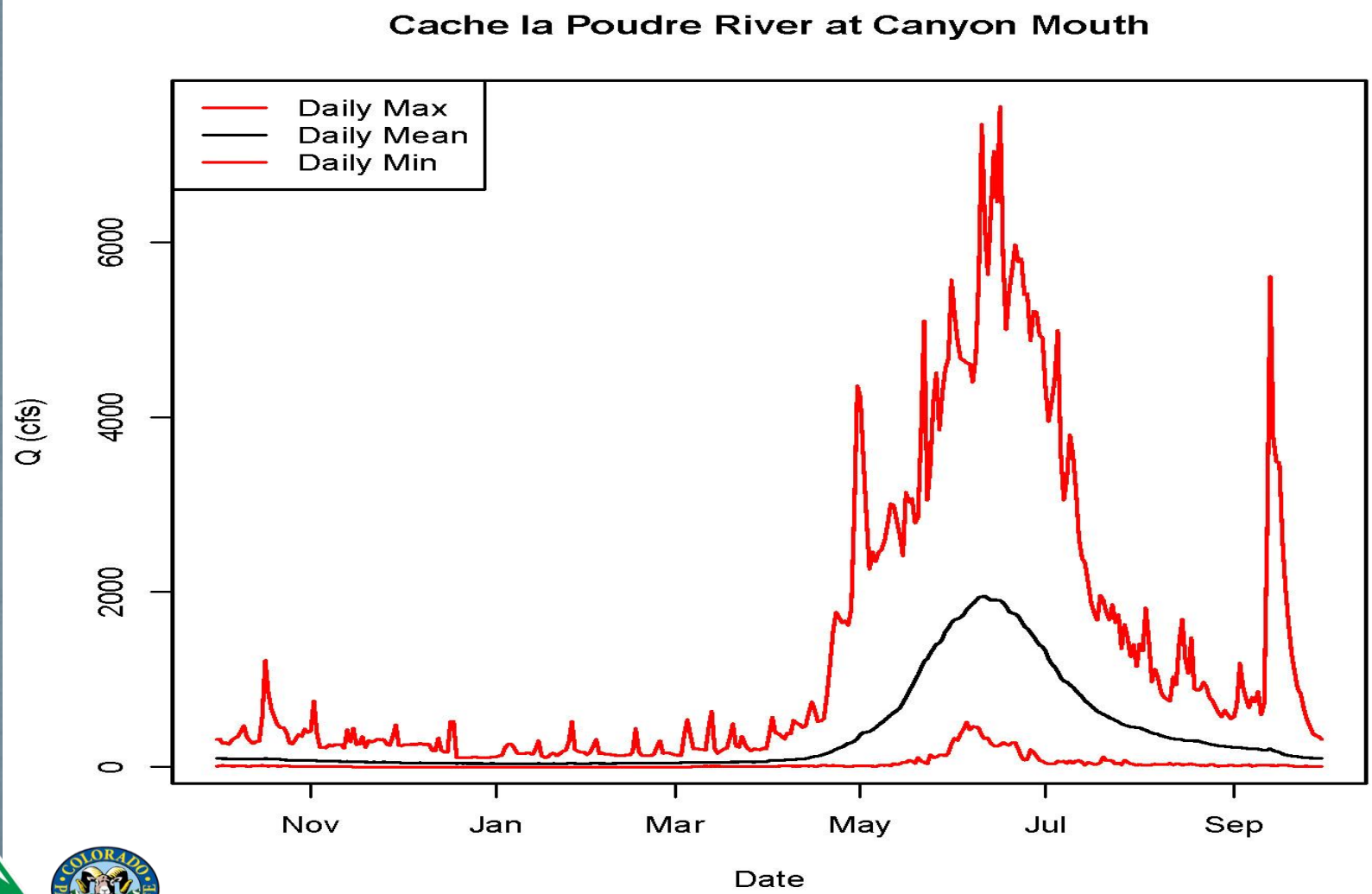
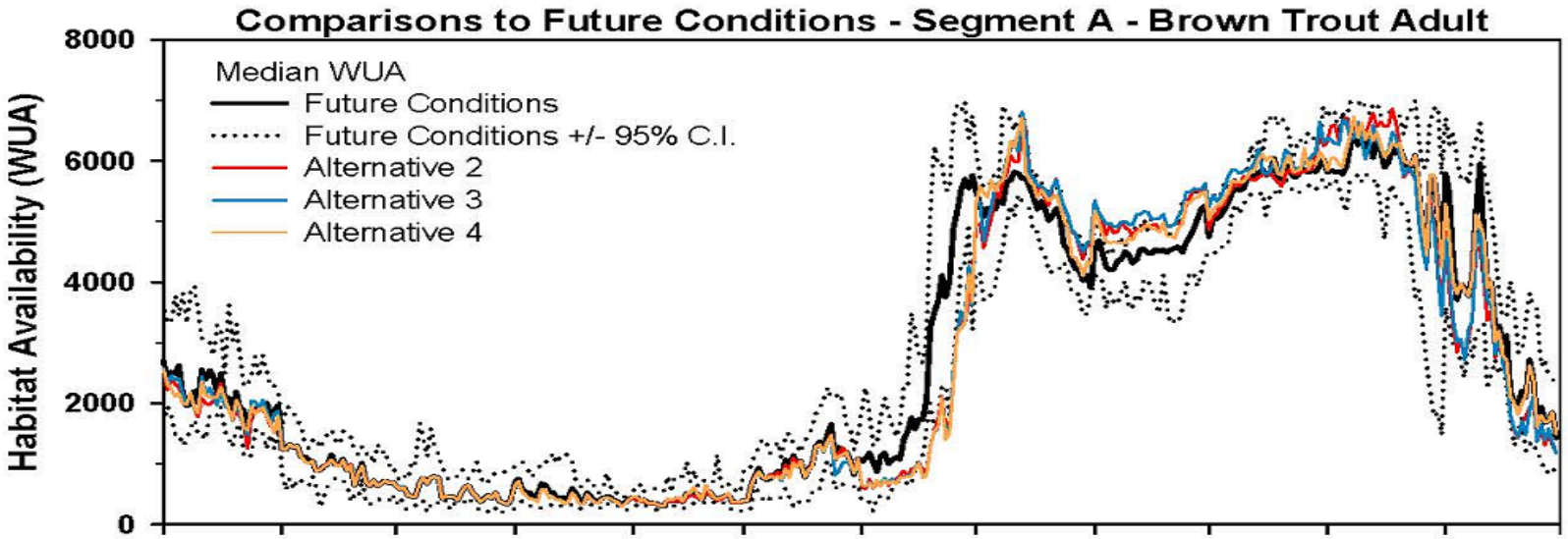
Habitat Time Series

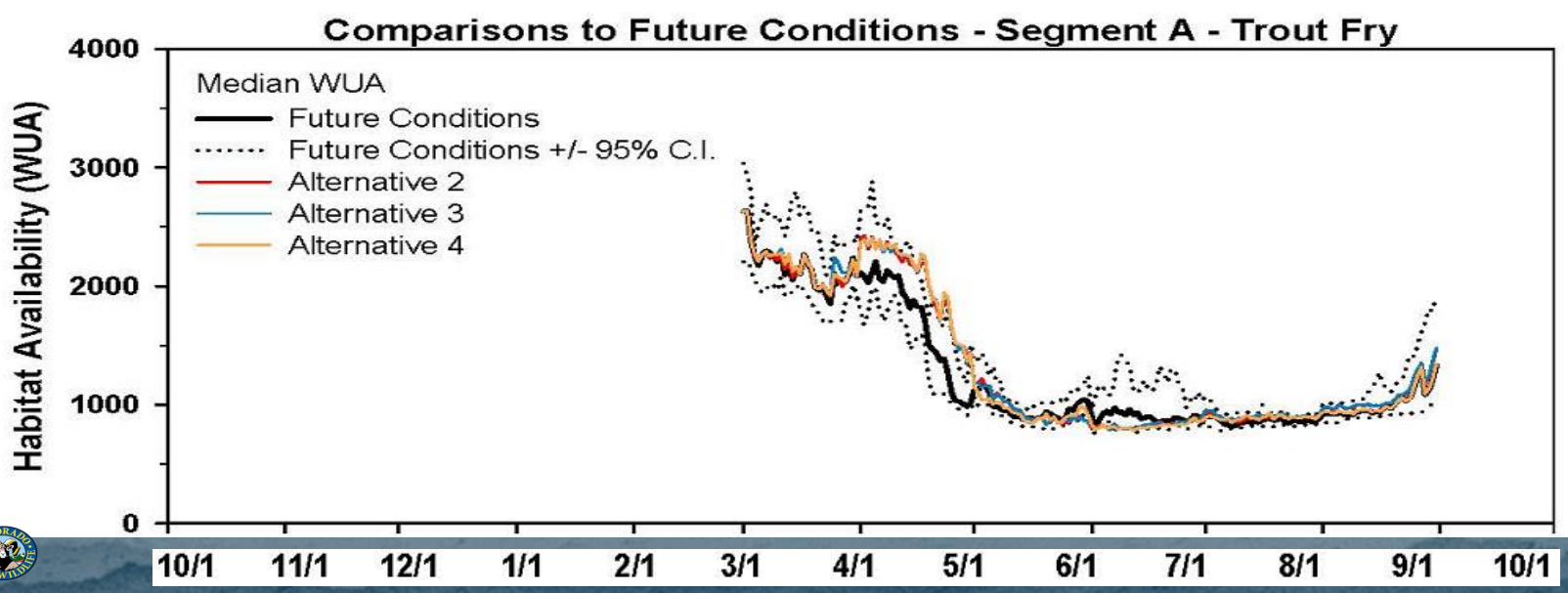
- Result of Habitat modeling is the habitat versus flow relationship
  - This is theoretical based only on channel shape
  - Actual habitat over the range of flows requires link with hydrology
- Habitat time series shows habitat over time as a function of flow
  - This is the actual habitat realized by aquatic species

Hydrology Time Series

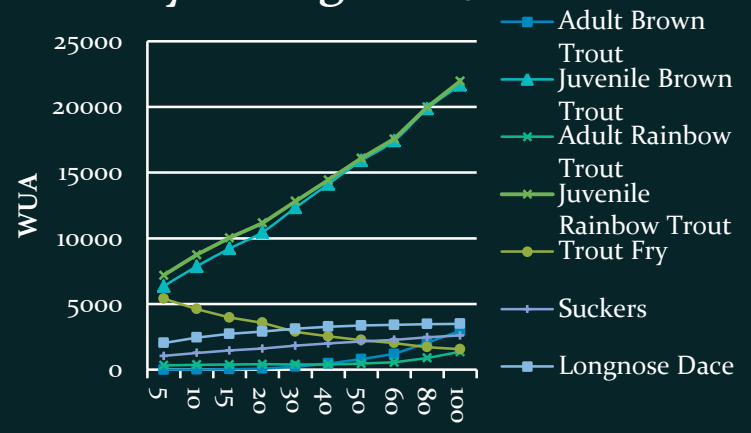


Habitat Time Series

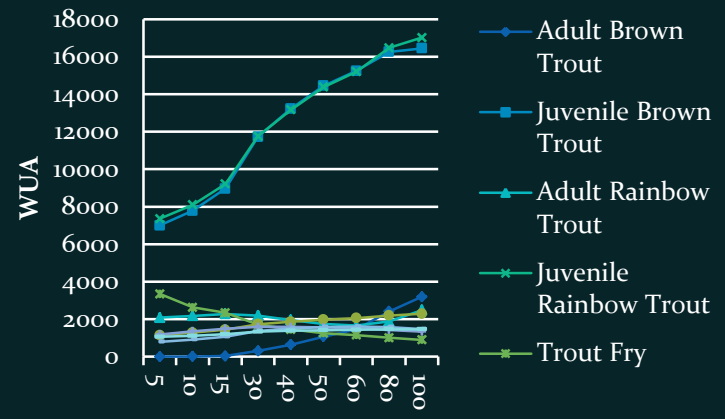




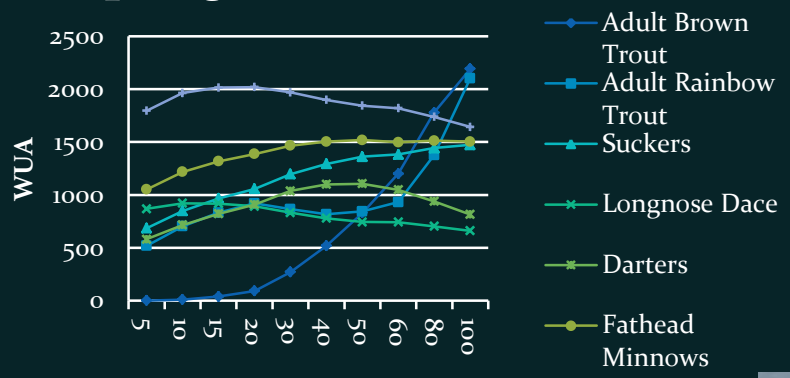
Canyon Gage to L/W Canal



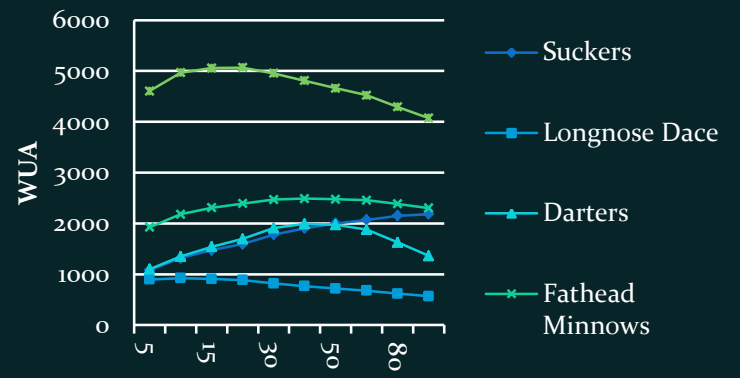
L/W Canal to Spring Ck



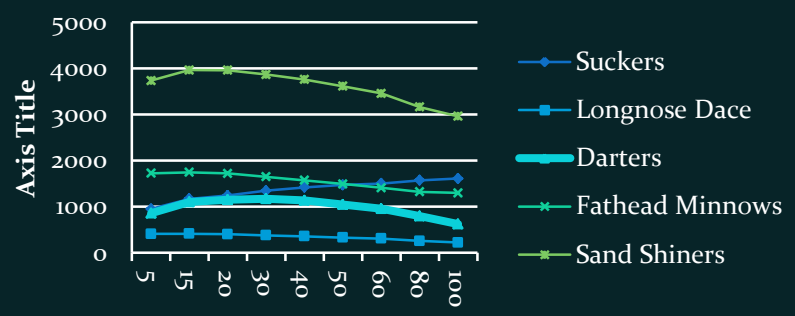
Spring Creek to New Cache



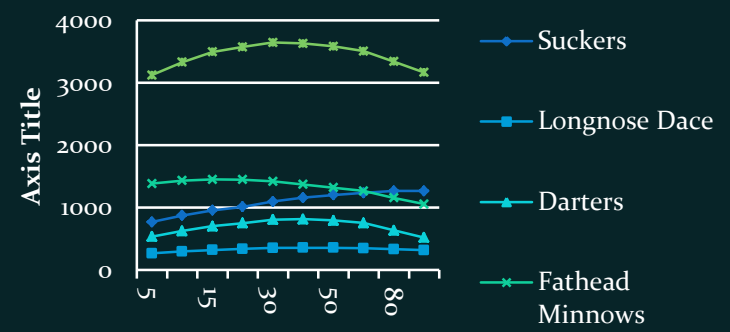
New Cache to WC 17



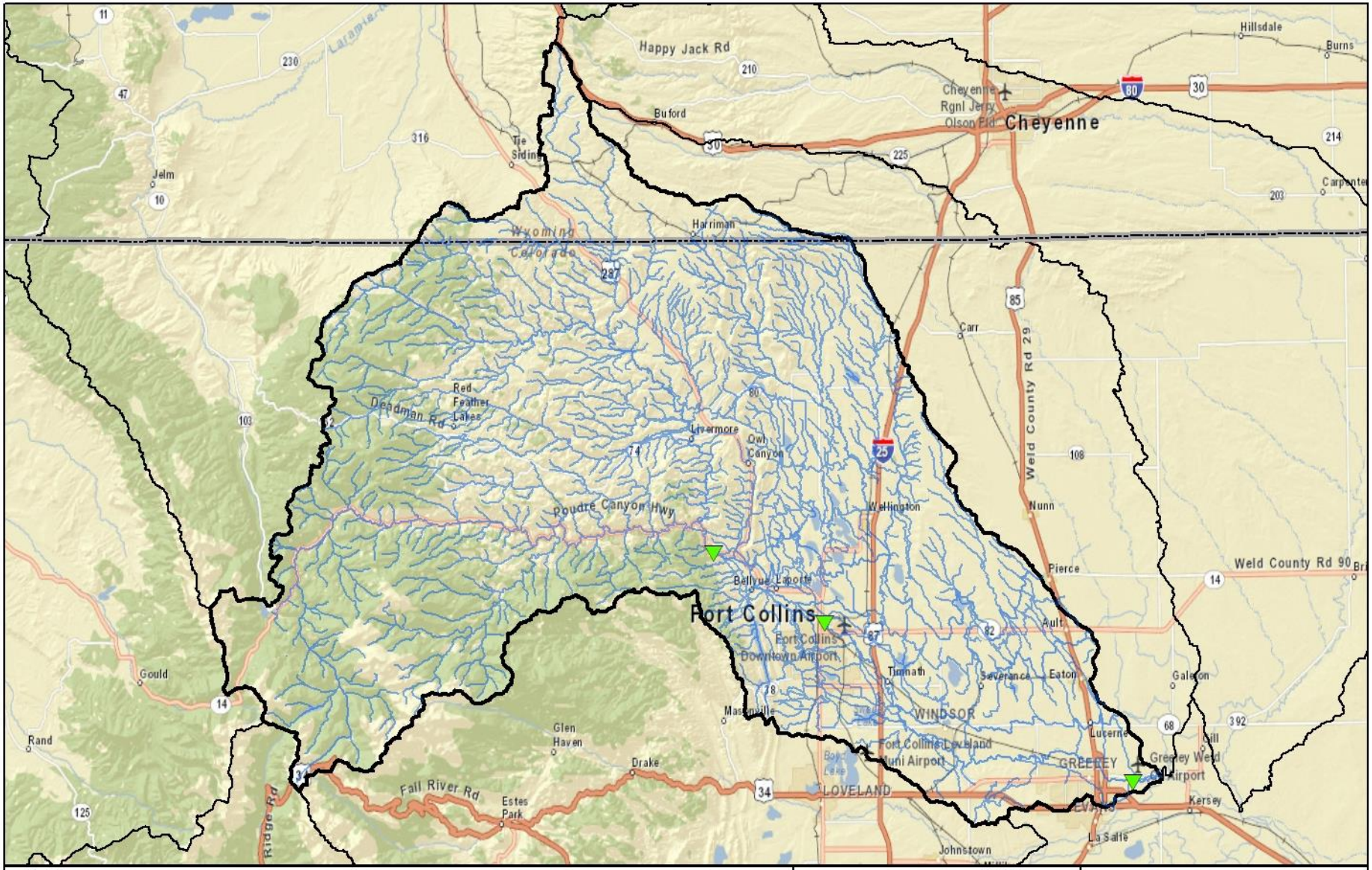
WC 17 to 59th Ave



59th Ave to S. Platte



WORKING RIVER HEALTHY RIVER



Legend

- Cache la Poudre
- Colorado Boundary
- Streams
- Stream Gage

0 1 2 4 6 8 Miles

N

DRAINAGE NETWORK	
DRAWN: ERICHER	2/12/2013
CHECKED:	
APPROVED:	
SHEET: 1 OF 1	

STATE OF COLORADO
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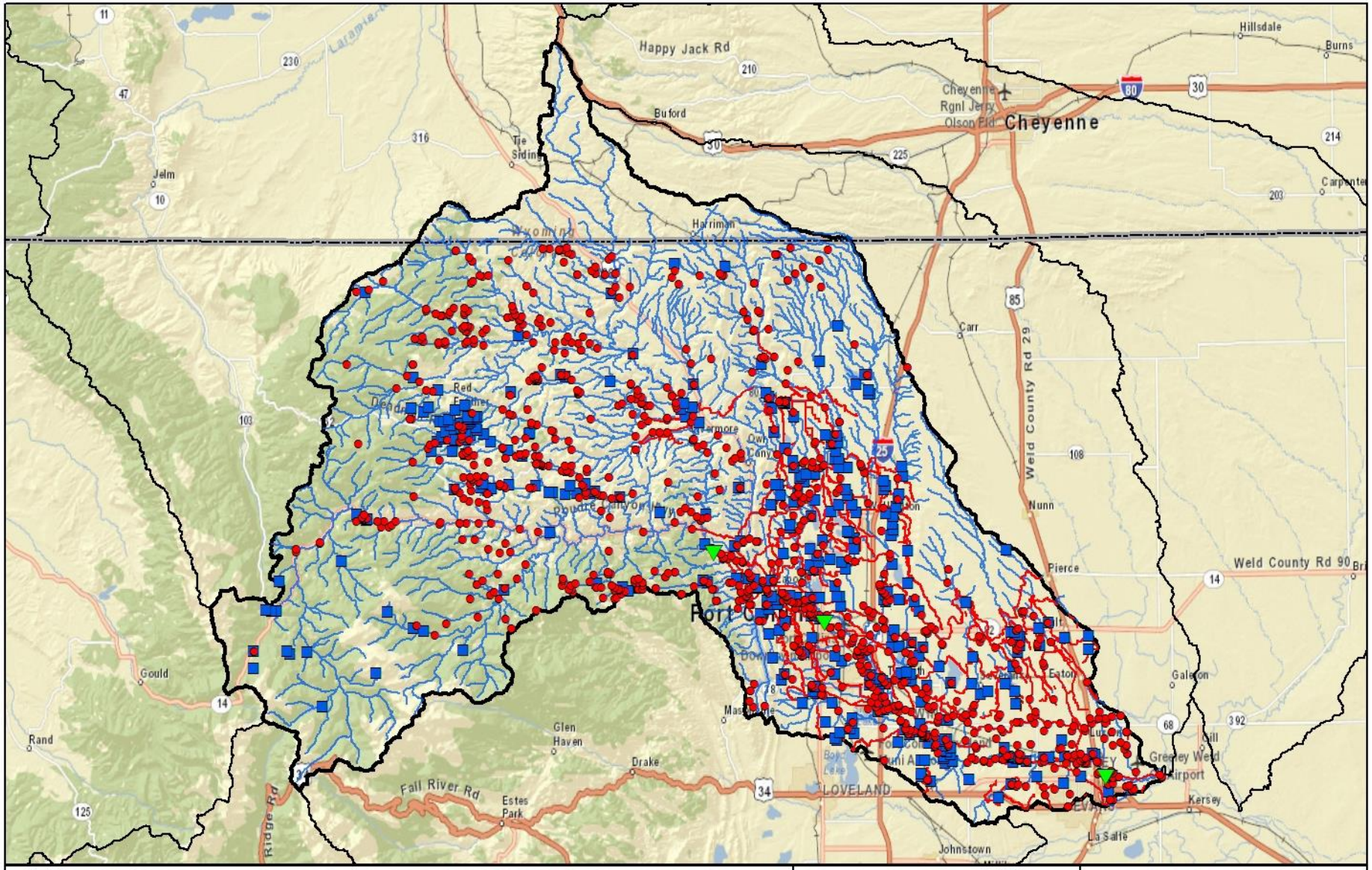
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

CACHE LA POUDRE WATERSHED



Legend

- Cache la Poudre
- Colorado Boundary
- Streams
- Canals
- Stream Gage
- Diversions
- Reservoirs

0 1 2 4 6 8 Miles

N

DIVERSION NETWORK	
DRAWN: ERICHER	2/18/2013
CHECKED:	
APPROVED:	
SHEET: 1 OF 1	

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DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
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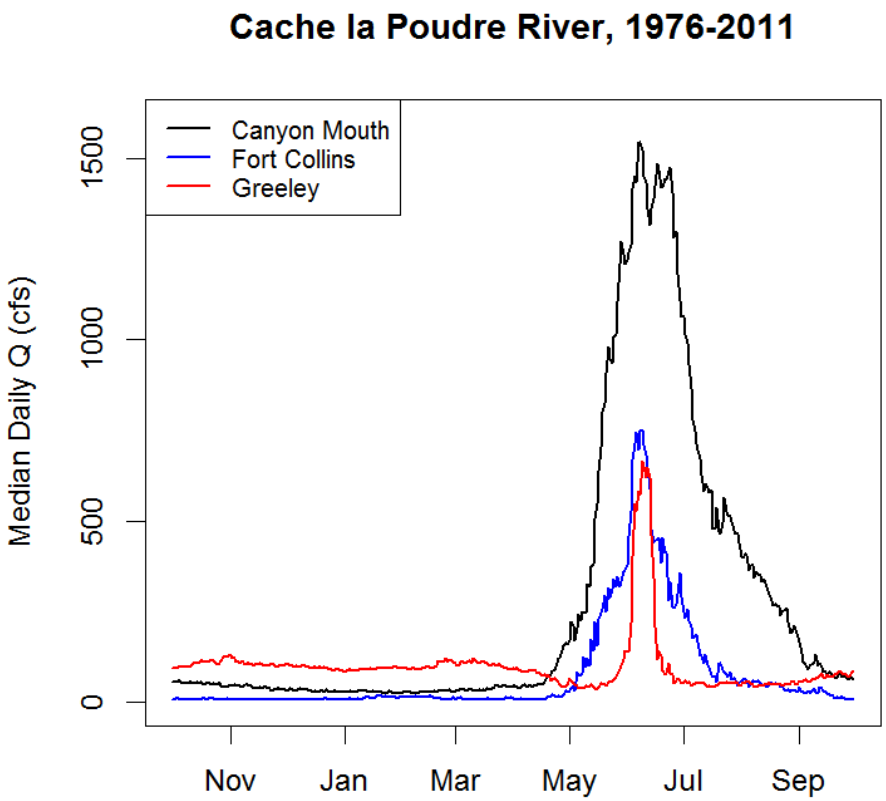
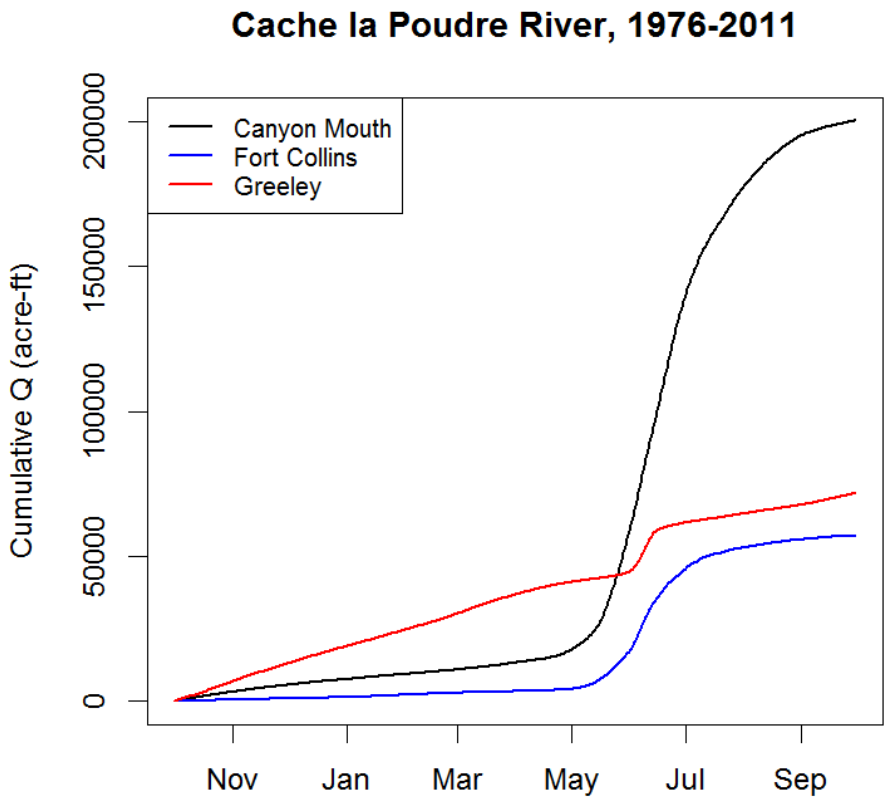
CACHE LA POUDRE WATERSHED

Observed Hydrology

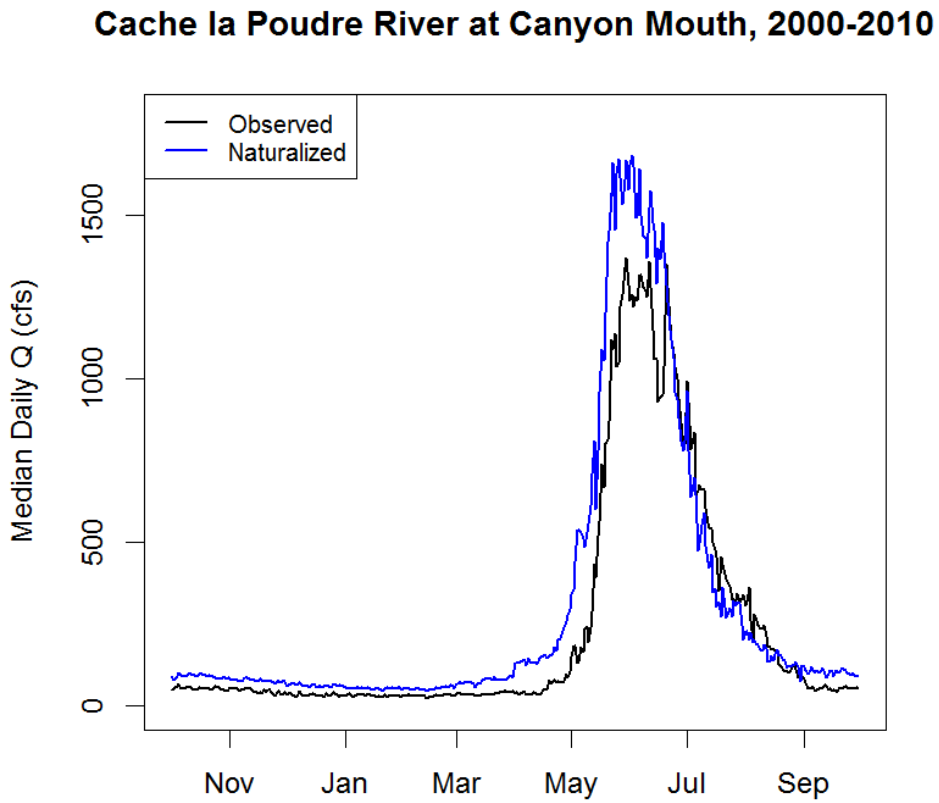


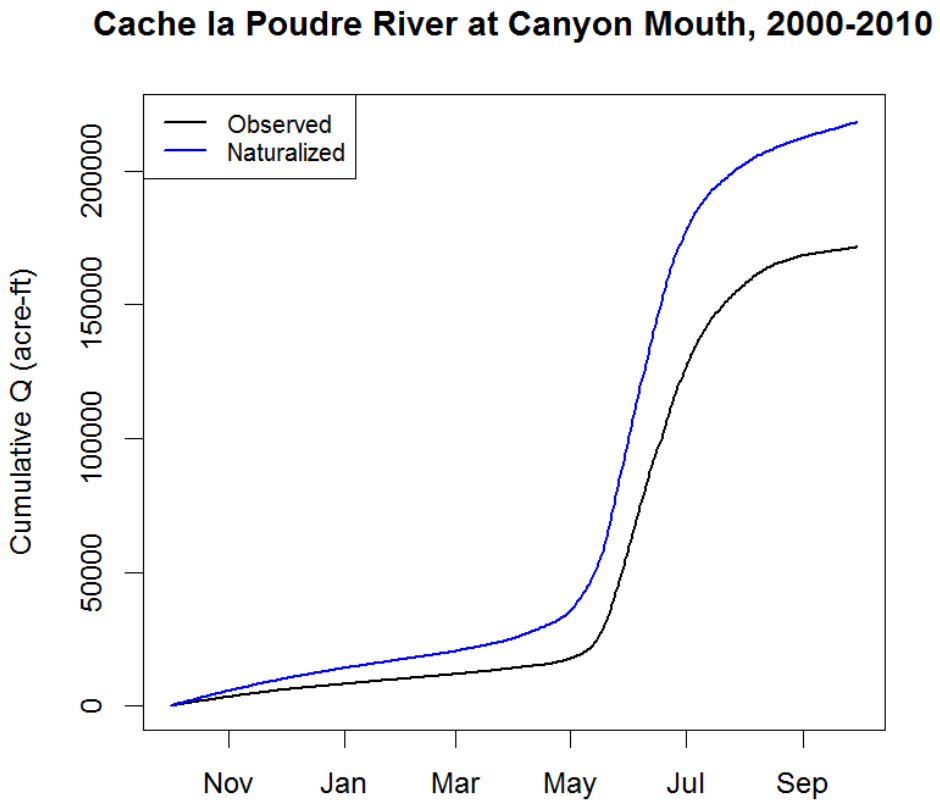


	Median Qpeak (cfs)
Canyon Mouth	1550
Fort Collins	750
Greely	670

	Annual Yield (acre-ft)
Canyon Mouth	200,440
Fort Collins	57,890 (-71%)
Greely	71,940 (-64%)

Observed vs. Naturalized

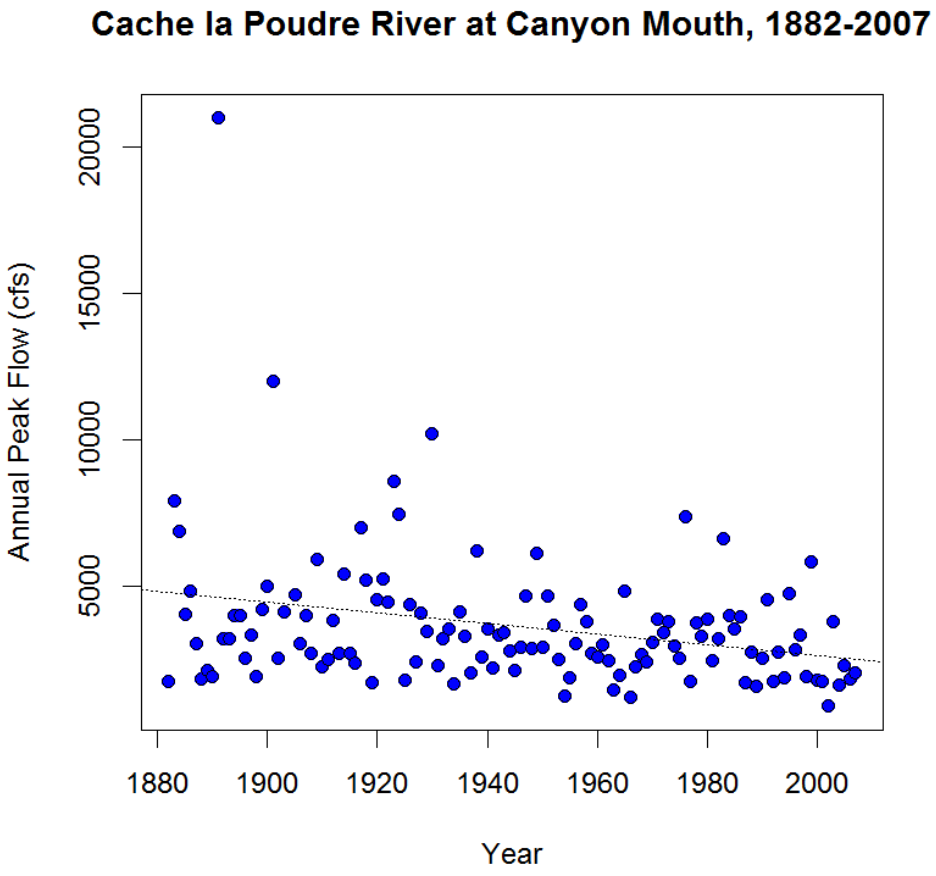


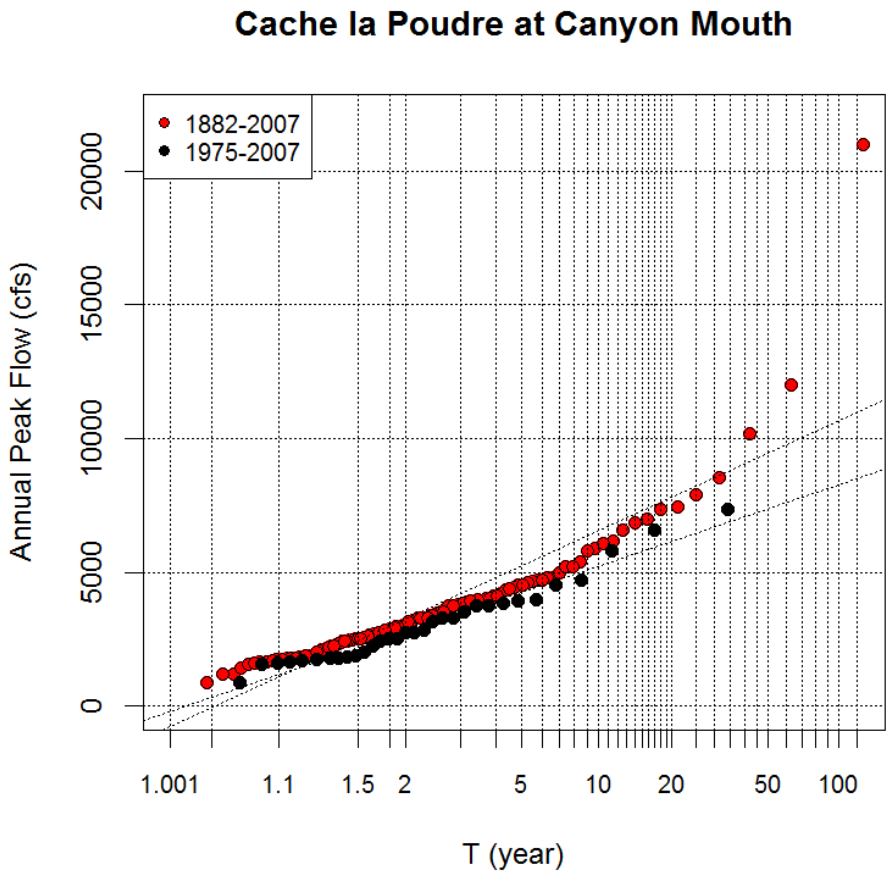


	Median Qpeak (cfs)
Observed	1370 (-18%)
Naturalized	1680

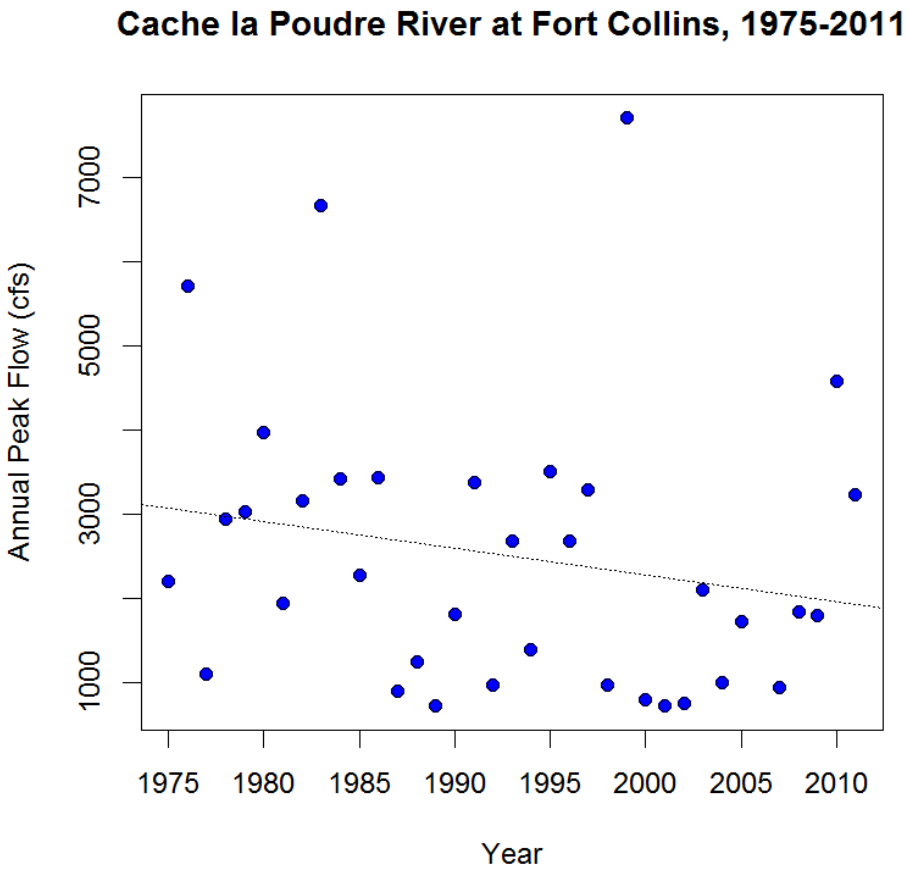
	Annual Yield (acre-ft)
Observed	171,480 (-21%)
Naturalized	218,250

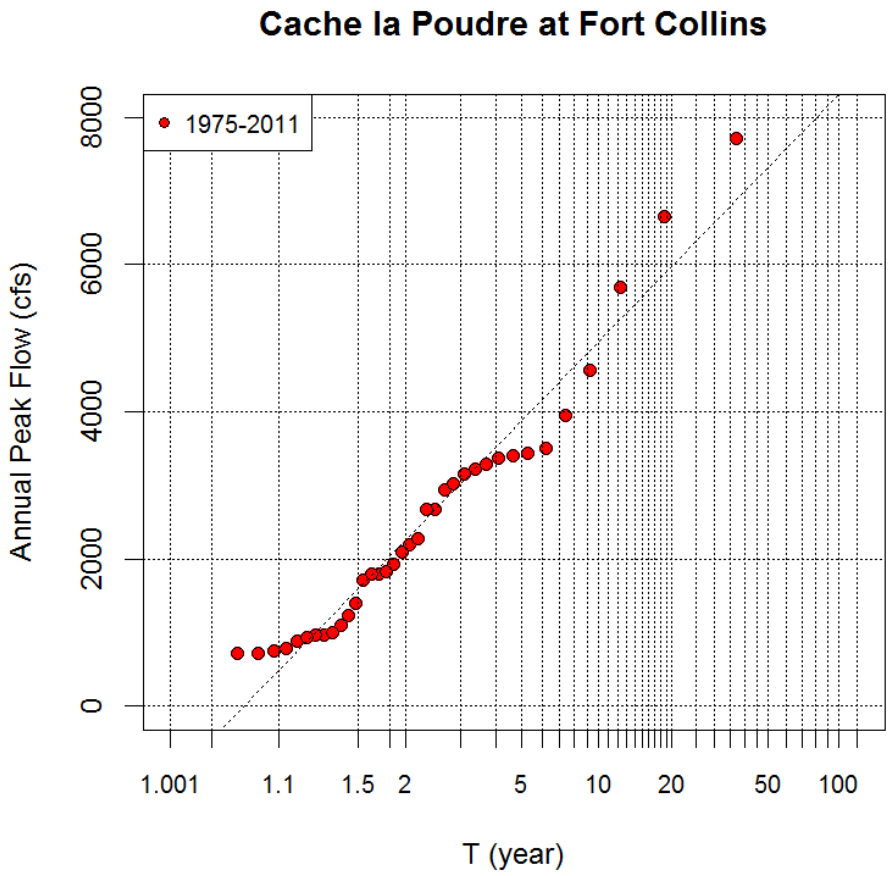
Flood Frequency Analysis: Canyon Mouth



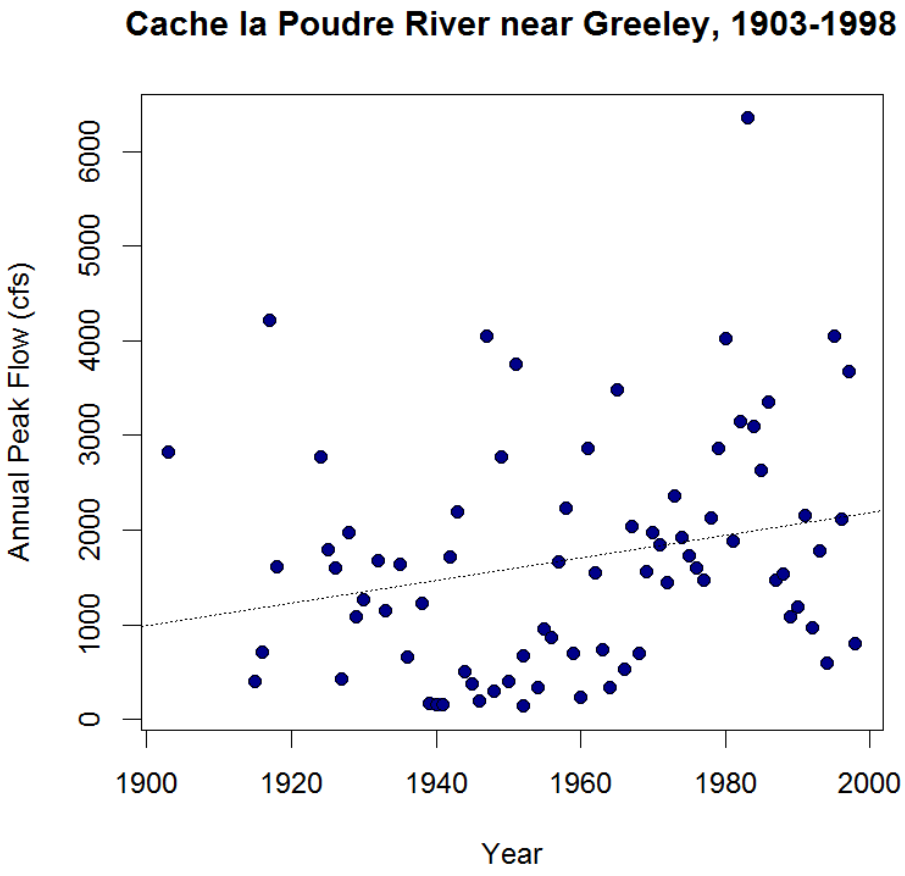


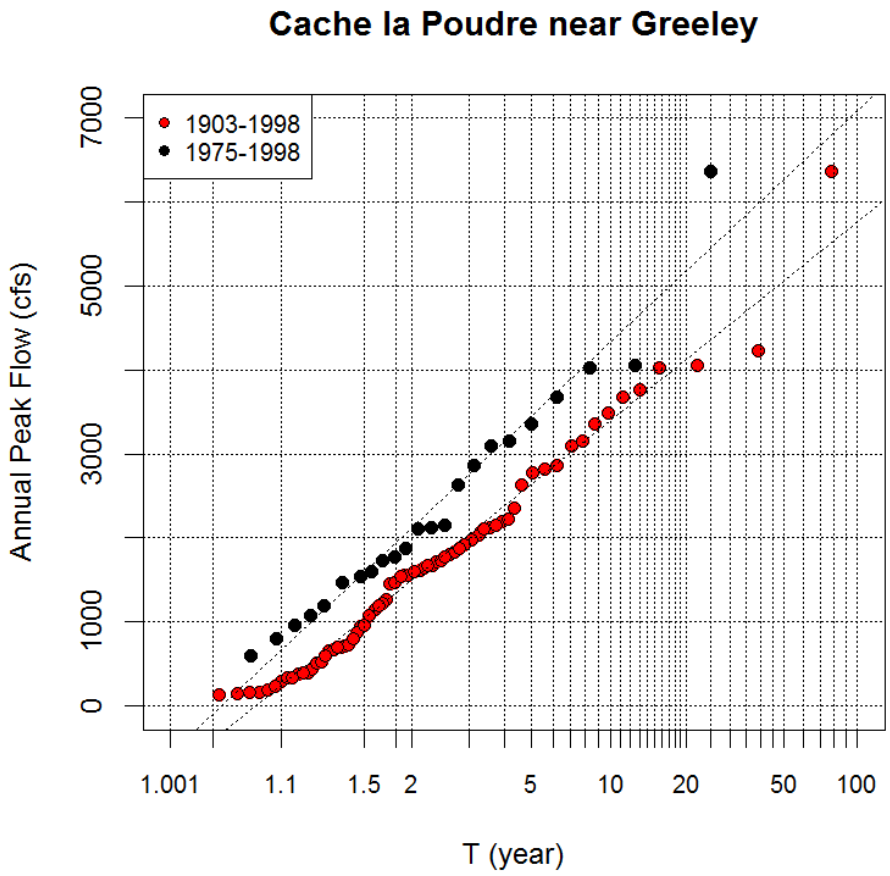
Flood Frequency Analysis: Fort Collins





Flood Frequency Analysis: Greeley



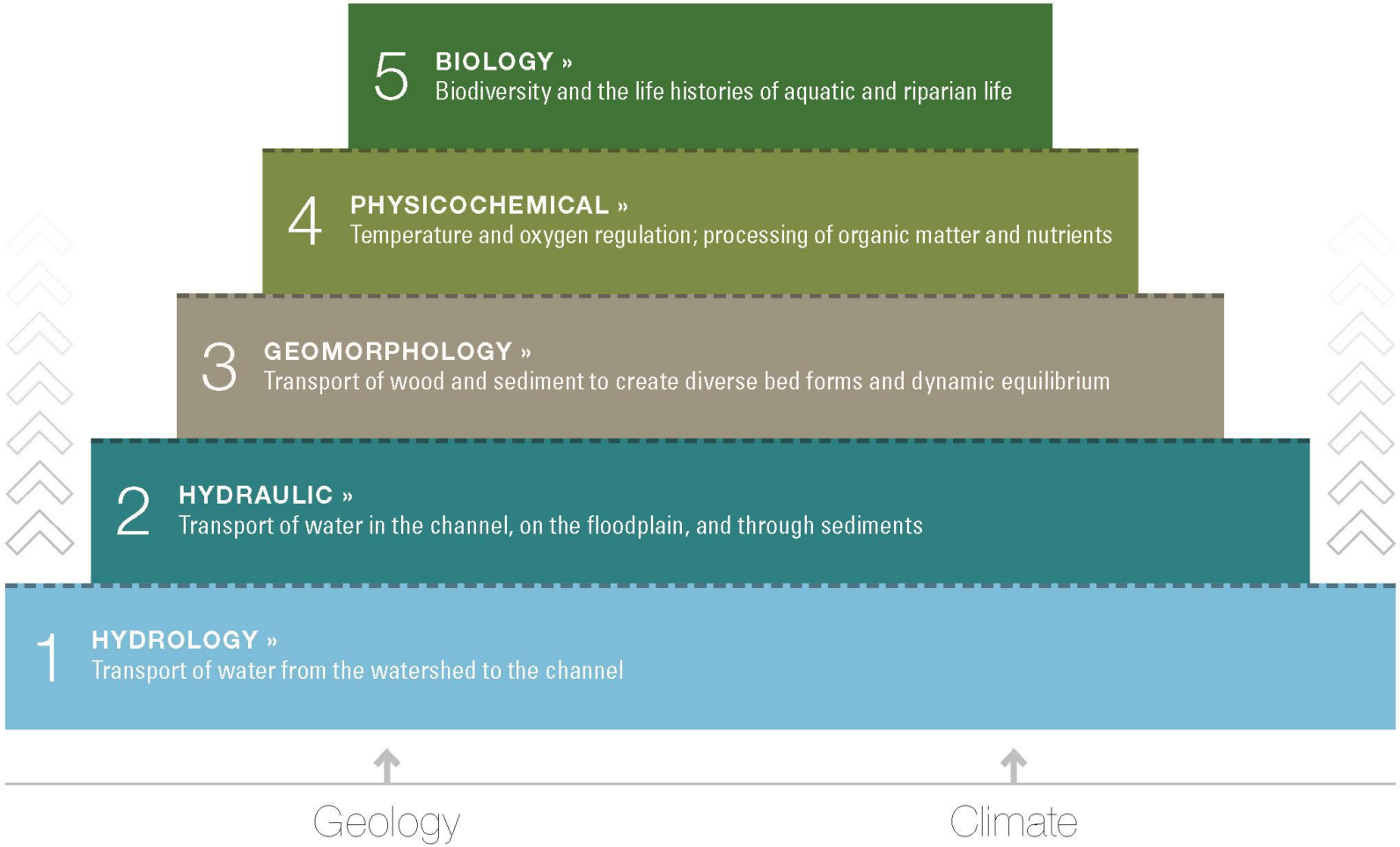


Channel Maintenance Flows

- **Flushing**
  - Remove superficial fine sediment deposits from riffles
- **Channel Maintenance**
  - Remove interstitial fine sediment from gravels
  - Maintain of pool-riffle morphology
  - Maintain active channel width
- **Riparian Maintenance**
  - Lateral connect the active channel with the riparian zone to facilitate exchange of sediment and nutrients
  - Maintain hyporheic zone through groundwater recharge, which affects water chemistry, temperature, and baseflow
- **Floodplain/Valley Maintenance**
  - Induce channel migration
  - Cause vertical accretion on floodplain

Stream Functions Pyramid

A Guide for Assessing & Restoring Stream Functions » OVERVIEW



StreamMechanics

How do we accomplish the Cooperation and Collaboration with flushing flows, that we have seen working on the minimum flow issue?