Colorado's Water
Supply Future

Nonconsumptive Needs Assessment and Watershed Flow Evaluation Tool Pilot Study Workshop

Colorado Springs, Colorado – June 24, 2009

Glenwood Springs, Colorado – June 25, 2009

Agenda

- Welcome and Introductions
- Nonconsumptive Needs Assessment Overview
- Basin Roundtable Priorities Mapping
- Nonconsumptive Needs Assessment Next Steps
- Lunch Break
- Overview of Watershed Flow Evaluation Tool and Site-Specific Quantification Objectives and Watershed Flow Evaluation Tool Findings, Recommendations and Methodology
- Fountain Creek Watershed Flow Evaluation Tool Results
- Roaring Fork Watershed Flow Evaluation Tool Results
- Watershed Flow Evaluation Tool Findings and Recommendations

Welcome and Introductions

Technical Team

- Priorities Mapping
  - Amy Ackerman, Water Resources Specialist & GIS contractor
- Watershed Flow Evaluation Tool (WFET) Pilot Study
  - Brian Bledsoe, Ph.D, P.E., Colorado State University
  - Tim Cox, Ph.D., P.E., CDM
  - Bill Miller, Ph.D., Miller Ecological Consultants
  - LeRoy Poff, Ph.D., Colorado State University
  - John Sanderson, Ph.D., The Nature Conservancy
  - Thomas Wilding, Ph.D., Colorado State University

Nonconsumptive Needs Assessment Overview

HB05-1177 Water for the 21st Century Act

- Consumptive Needs
- Nonconsumptive Needs
- Water Supply Availability
- Projects and Methods to Meet Needs

37-75-104 (2)(c). Using data and information from the Statewide Water Supply Initiative and other appropriate sources and in cooperation with the on-going Statewide Water Supply Initiative, develop a **basin-wide** consumptive and **nonconsumptive water supply needs assessment**, conduct an analysis of available unappropriated waters within the basin, and **propose projects or methods**, both structural and nonstructural, **for meeting those needs** and utilizing those unappropriated waters where appropriate. Basin Roundtables shall **actively seek the input and advice of affected local governments, water providers, and other interested stakeholders** and persons in establishing its needs assessment, and shall propose projects or methods for meeting those needs. Recommendations from this assessment shall be forwarded to the Interbasin Compact Committee and other basin roundtables for analysis and consideration after the General Assembly has approved the Interbasin Compact Charter.

37-75-102. Water rights - protections. (1) It is the policy of the General Assembly that the current system of allocating water within Colorado shall not be superseded, abrogated, or otherwise impaired by this article. Nothing in this article shall be interpreted to repeal or in any manner amend the existing water rights adjudication system. The General Assembly affirms the **state constitution's recognition of water rights as a private usufructuary property right**, and this article is not intended to restrict the ability of the holder of a water right to use or to dispose of that water right in any manner permitted under Colorado law.

(2) The General Assembly affirms the **protections for contractual and property rights** recognized by the contract and takings protections under the state constitution and related statutes. This article shall not be implemented in any way that would diminish, impair, or cause injury to any property or contractual right created by intergovernmental agreements, contracts, stipulations among parties to water cases, terms and conditions in water decrees, or any other similar document related to the allocation or use of water. This article shall not be construed to supersede, abrogate, or cause injury to vested water rights or decreed conditional water rights. The General Assembly affirms that this article does not impair, limit, or otherwise affect the rights of persons or entities to enter into agreements, contracts, or memoranda of understanding with other persons or entities relating to the appropriation, movement, or use of water under other provisions of law.

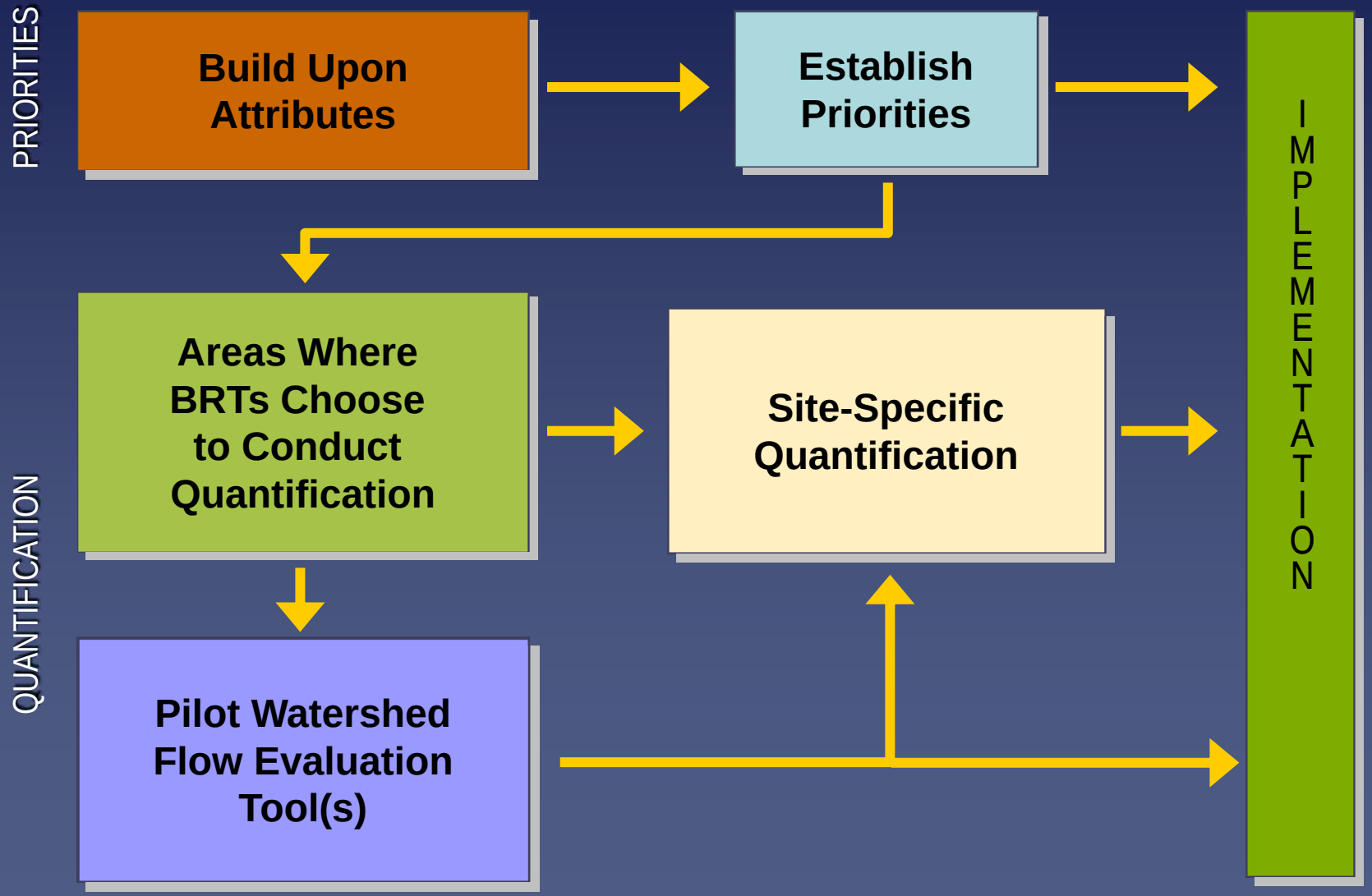
Why are we here?

- PLAN Upfront
  - Avoid long National Environmental Policy Act (NEPA) and litigation processes (be a useful guide for water supply planning up front),
  - Help plan to prevent species of special concern from becoming federally listed),
  - Point to win/win opportunities for future multi-objective projects, and
  - Help identify where future conflicts may occur
- Cultural, Ethical, and Aesthetic Values
- Economics

What Phase I of the NCNA is…

- Objective, science-based set of maps representing Colorado's important environmental and recreational attributes
- Map of stream reaches with concentrations of environmental and recreational qualities
- Results of pilot flow evaluation tools and site-specific instream flow quantifications
- This is strictly an informational stage, not reflecting future actions

Nonconsumptive Needs Assessment Methodology



What the NCNA isn't…

- The NCNA will not identify all streams as important;
  - It will identify a small subset of streams.
- The NCNA will not dictate management actions;
  - The BRTs and other stakeholders will use the NCNA to set goals and determine effective strategies and multi-purpose projects.
- The NCNA will not create a water right for the environment.
  - It will provide tools and data to allow BRTs to integrate environmental protection into water supply planning.
- The NCNA shall not be interpreted to diminish, impair, or cause injury to existing absolute or conditional water rights.

Status of Nonconsumptive Needs Assessments

- **Arkansas Basin:** Approved, WSRA quant. grant
- **Colorado Basin:** Approved, WSRA quant. grant
- **Gunnison Basin:** Approved
- **Metro Basin:** Approved, WSRA project grant
- **North Platte Basin:** Approved
- **Rio Grande Basin:** Approved, WSRA project grants
- **South Platte:** Expect July vote, WSRA project grants
- **Southwest Basin:** Expect July vote
- **Yampa/White Basin:** Expect July vote

Basin Roundtable Priorities Mapping

Priorities Mapping Methodology –

ESTABLISH PRIORITIES

Review SWSI 2 Attributes

+

Include Additional Attributes with Basin-Specific Importance

PRIORITY MAPPING

Attribute Count by 12-digit HUC

- ARKANSAS
- RIO GRANDE

Attribute Count by Segment

- NORTH PLATTE
- SOUTHWEST

Major Streams/ Focus Areas

- SOUTH PLATTE/METRO
- YAMPA/WHITE/GREEN
- COLORADO
- GUNNISON

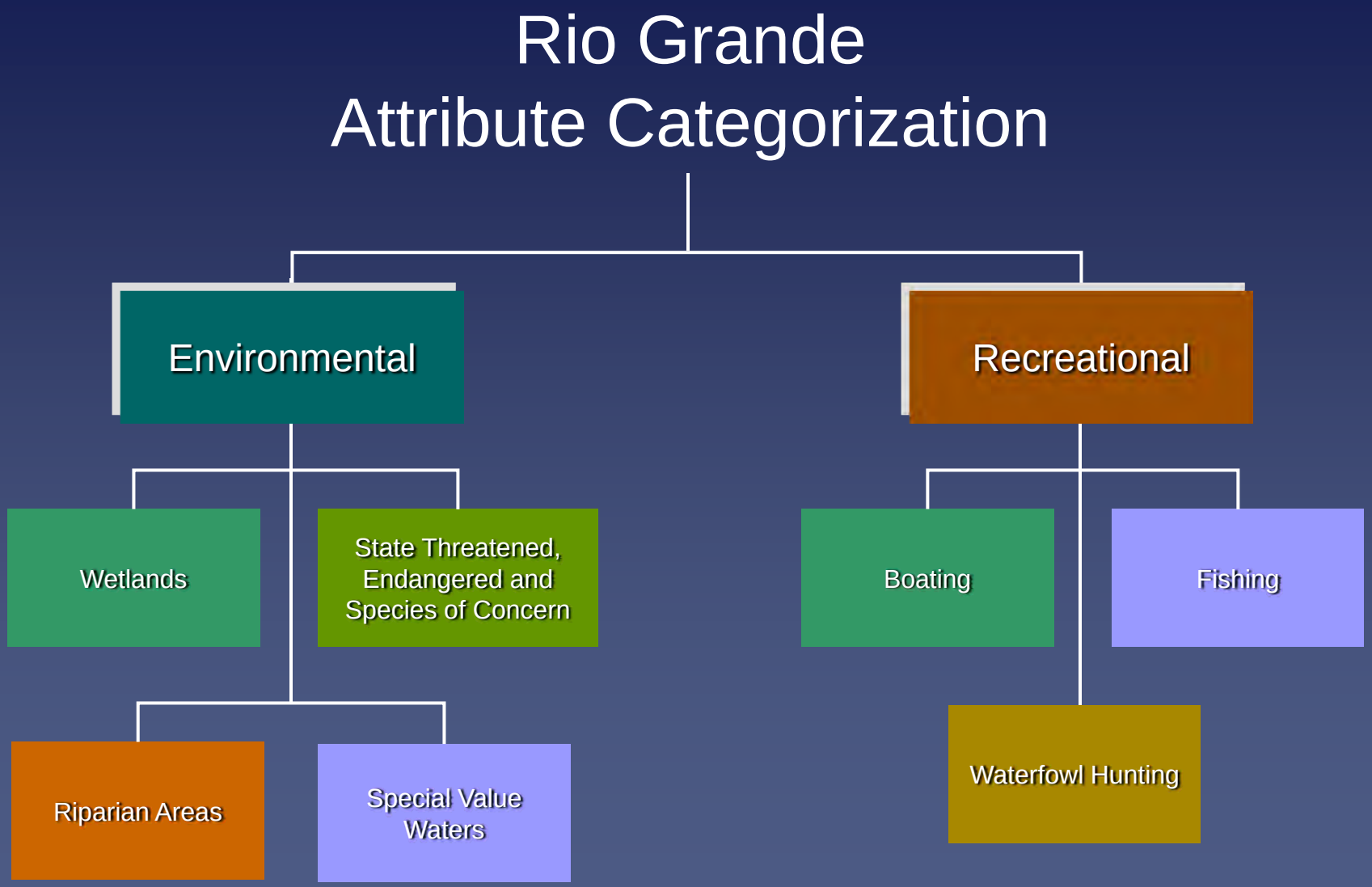
SWSI 2 Attributes

- CWCB Instream Flow Rights
- CWCB Natural Lake Levels
- CWCB water rights where water availability had a role in appropriation
- Audubon important bird areas
- CDPHE WQCD 303(d) listed segments
- Rare Riparian Wetland Vascular Plants
- Significant Riparian/Wetland Communities
- Boreal Toad Critical Habitat
- Arkansas Darter
- Greenback Cutthroat Trout
- Colorado Pikeminnow
- Bonytail Chub
- Flannelmouth Sucker
- Colorado River Cutthroat Trout
- Razorback Sucker
- Humpback Chub
- Greenback Cutthroat Trout
- Bluehead Sucker
- Rio Grande Cutthroat Trout
- Rio Grande Sucker
- Roundtail Chub
- Gold Medal Trout Streams
- Gold Medal Trout Lakes
- Recreational In-Channel Diversions
- Rafting and Kayak reaches

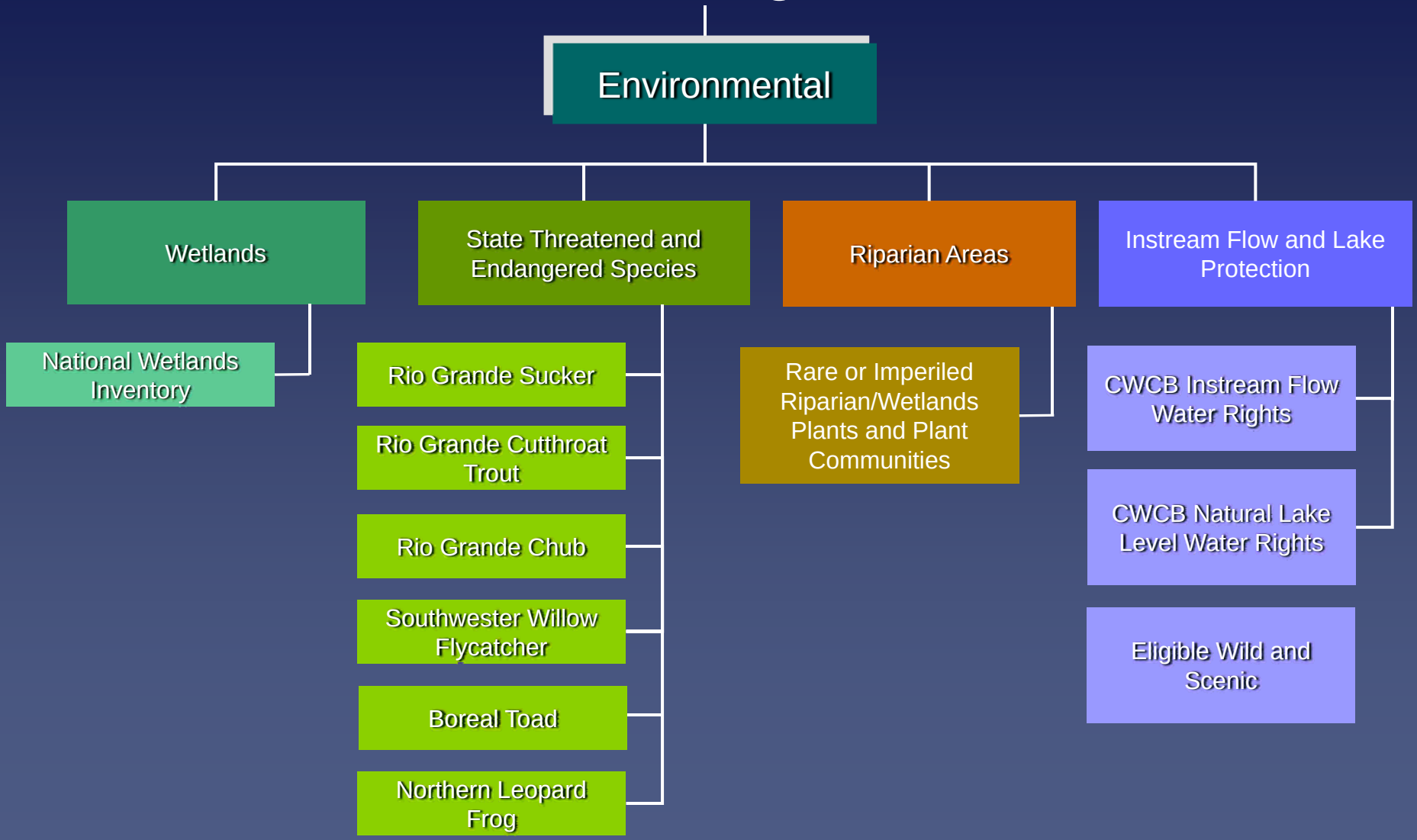
Other Basin Specific Attributes

- Bald Eagle Active Nestsites
- Bald Eagle Winter Forage
- Bald Eagle Summer Forage
- Bald Each Winter Concentration
- River Otter Confirmed Sightings
- River Otter Overall Range
- Northern Leopard Frog Locations
- Southwestern Willow Flycatcher
- Additional Fishing
- Wild and Scenic Study Rivers
- Additional Paddling/Rafting/Kayaking
- Colorado Outstanding Waters
- Wildlife Viewing
- Educational Segments
- Osprey Nest sites and Foraging Areas
- Ducks Unlimited Project Areas
- Sandhill Crane Staging Areas
- Colorado Birding Trails
- National Wetlands Inventory
- Eligible/Suitable Wild and Scenic
- GMUG Wilderness Waters/Areas
- High Recreation Areas
- Rocky Mountain Biological Laboratory (scientific and educational reaches)
- Waterfowl Hunting Areas
- Brassy Minnow
- Common Shiner
- Northern Redbelly Dace
- Plains Orangethroat Darter
- Plains Minnow
- Stonecat
- Additional Greenback Cutthroat Trout Waters
- Preble's Meadow Jumping Mouse
- Yellow Mud Turtle
- Common Garter Snake
- Piping Plover
- Least Tern
- Additional Rio Grande Sucker and Chub Streams

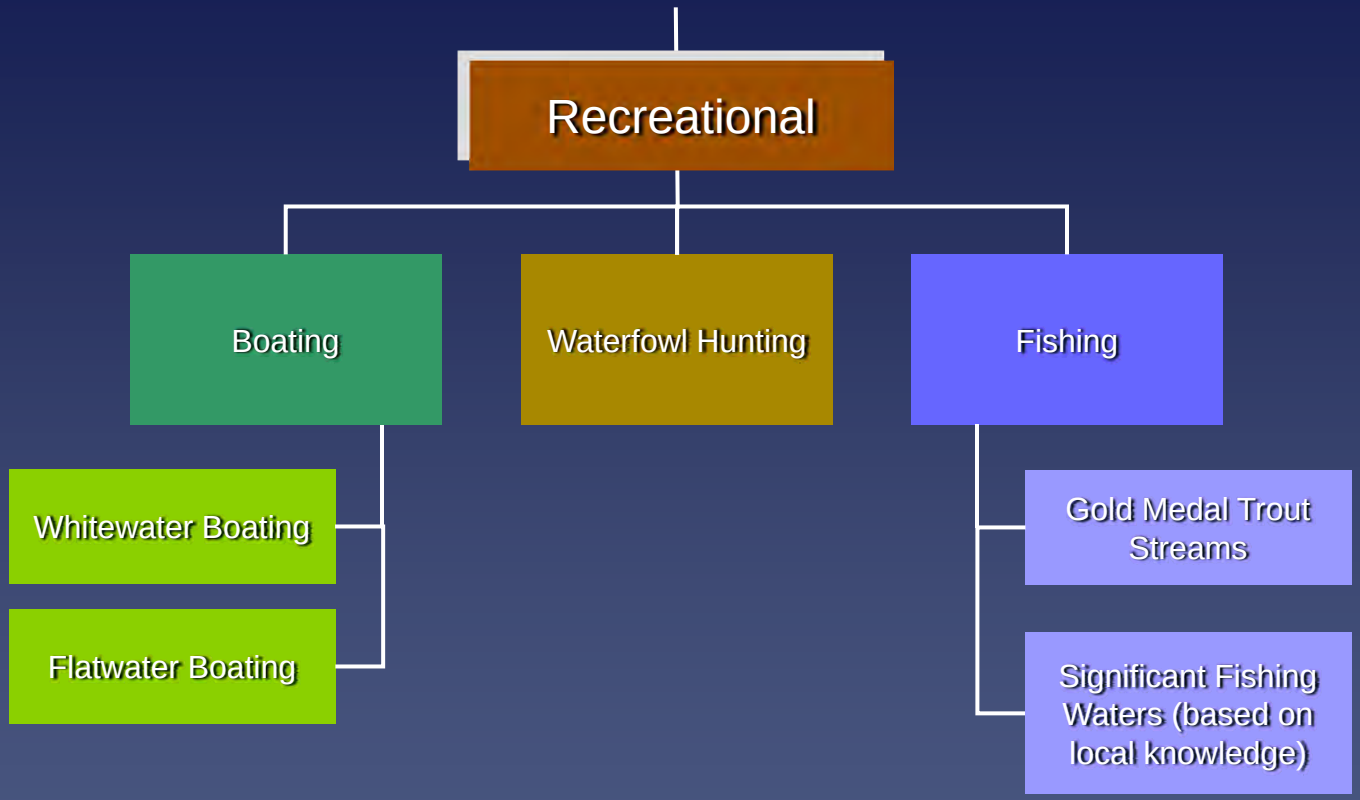
Example Attribute Selection:



Rio Grande Attribute Categorization



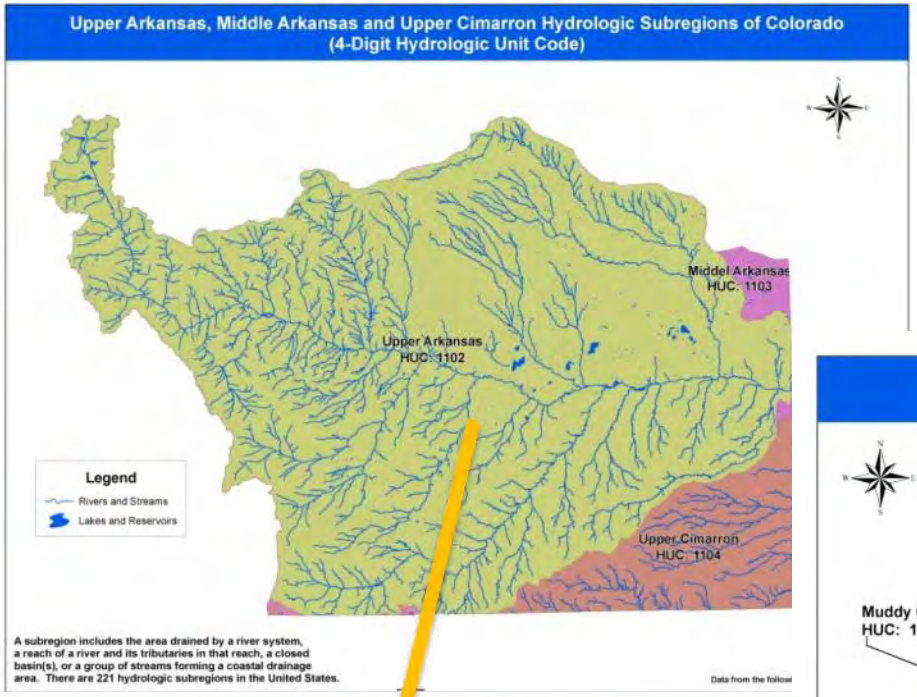
Rio Grande
Attribute Categorization

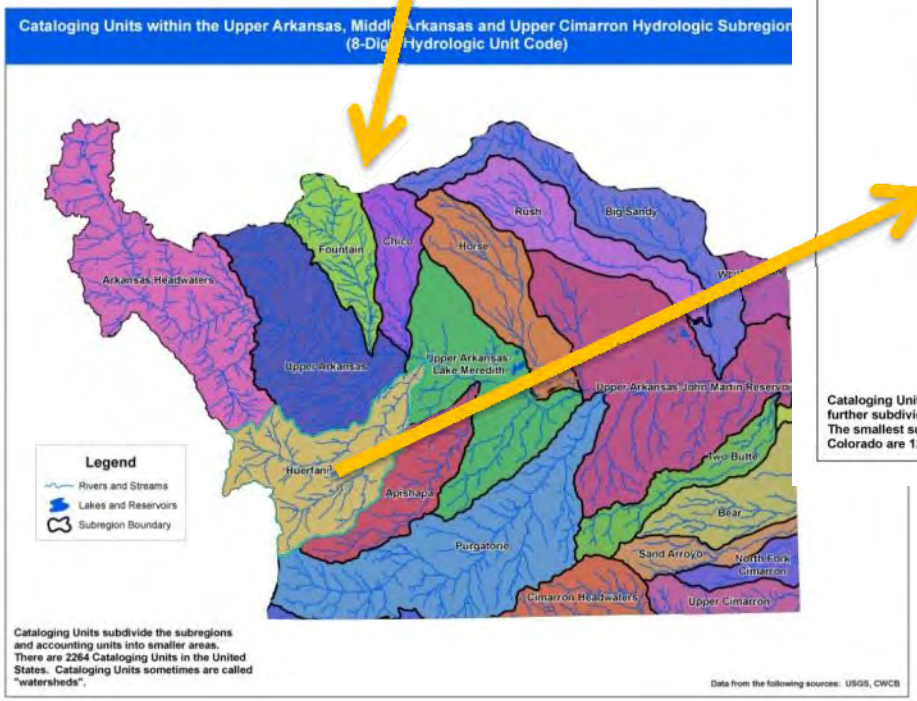


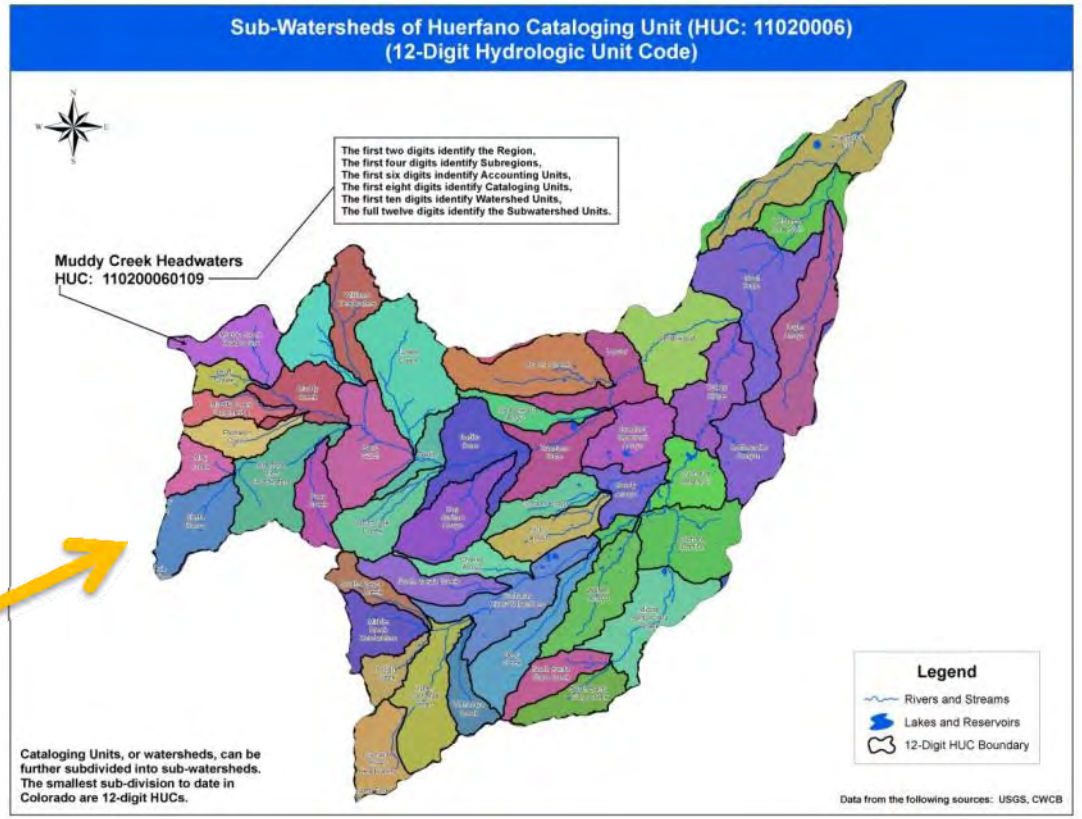
Priorities Mapping Methodology – Environmental and Recreational Attribute Count by HUC

- Develop environmental and recreational attribute maps
- Map environmental and recreational attributes by HUC (USGS drainage area coverage)
  - All attributes were counted as 1 except wetlands in the Rio Grande basin which where counted as 2 to weight the importance
- Overlay HUCs to show where there is concentration of recreational and environmental attributes

Overview of USGS HUCs



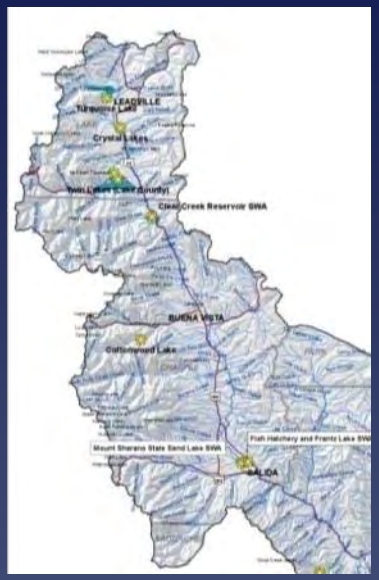




Examples of Attribute and HUC Intersection: Arkansas Basin Recreational Attributes

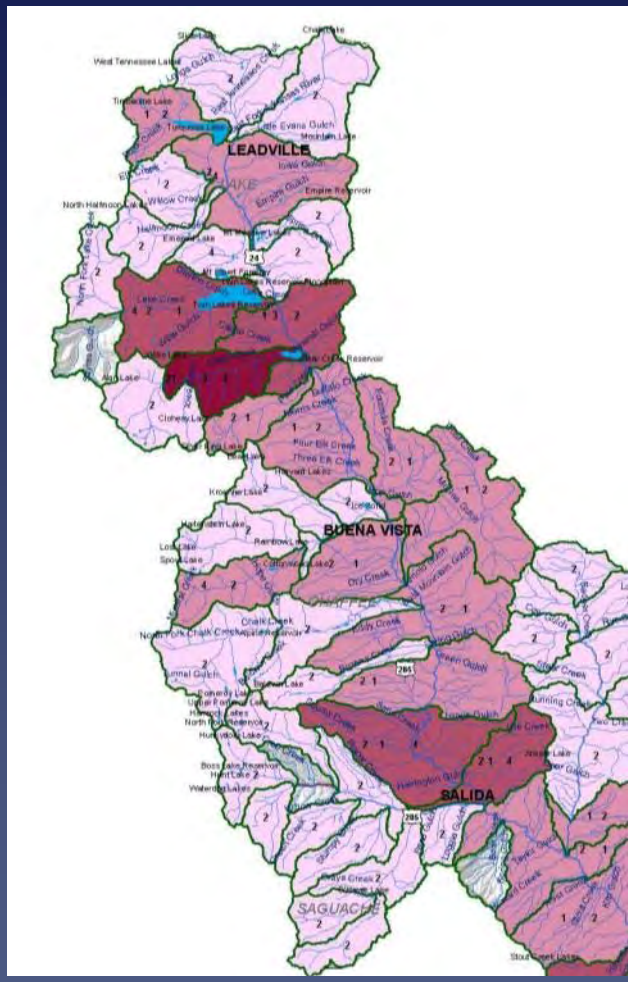
Birding Trails

Waterfowl Hunting



Whitewater/ Flatwater Boating

Significant Fishing Areas



Recreational Attribute HUC Count

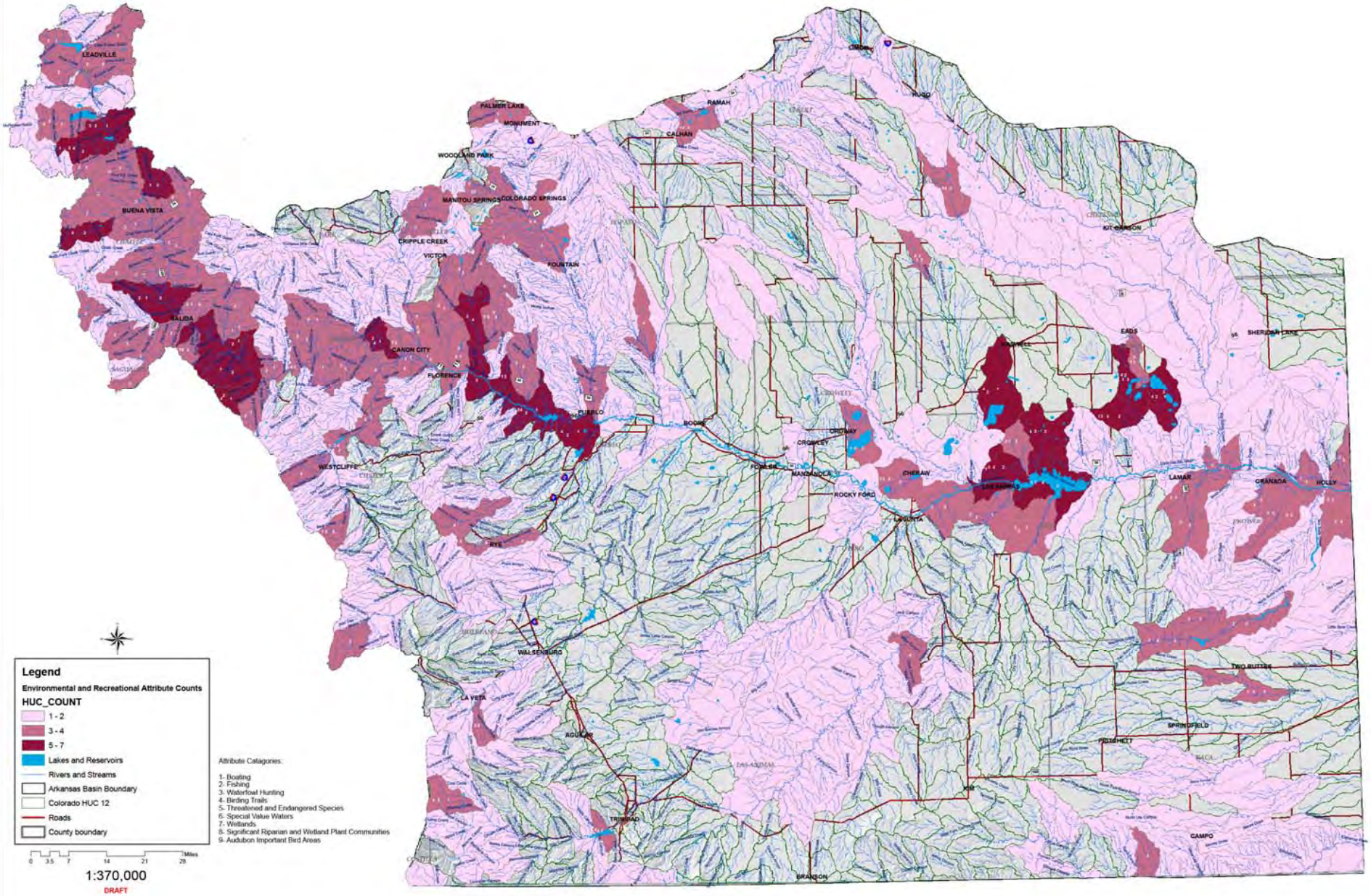
1

2

3

4

Arkansas Basin Nonconsumptive Needs Assessments
Environmental and Recreational Priorities
HUC 12 Watershed Based Environmental and Recreational Attributes Prioritization



Legend

Environmental and Recreational Attribute Counts

HUC_COUNT

- 1 - 2
- 3 - 4
- 5 - 7
- Lakes and Reservoirs
- Rivers and Streams
- Arkansas Basin Boundary
- Colorado HUC 12
- Roads
- County boundary

0 3.5 7 14 21 28 Miles

1:370,000

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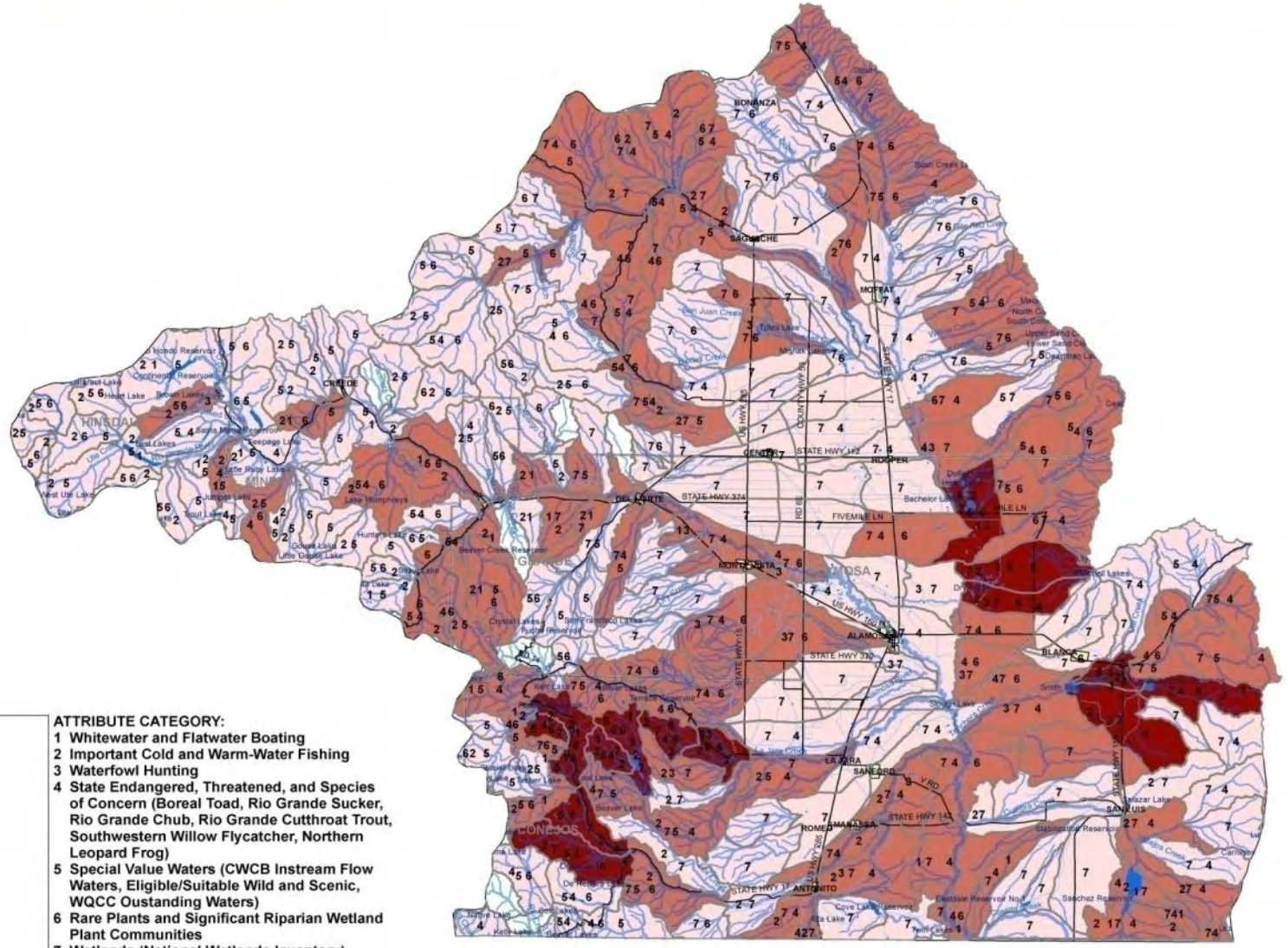
Attribute Catagories:

1- Boating
2- Fishing
3- Waterfowl Hunting
4- Birding Trails
5- Threatened and Endangered Species
6- Special Value Waters
7- Wetlands
8- Significant Riparian and Wetland Plant Communities
9- Audubon Important Bird Areas

Rio Grande Basin Non-Consumptive Needs Assessment
Sample 12-Digit HUC Prioritization Based on Environmental and Recreational Attributes



Legend

- Roads
- WaterBodies

Rivers and Streams

stream order

- artificial structure
- 1
- 2 - 3
- 4 - 5
- 6 - 7
- Cities and Towns
- County Boundary
- huc12_boundary

RG_rec_env_huc12_Merge

WEIGHTED_VALUE

- 1 - 3
- 4 - 5
- 6 - 8

ATTRIBUTE CATEGORY:

1. Whitewater and Flatwater Boating
2. Important Cold and Warm-Water Fishing
3. Waterfowl Hunting
4. State Endangered, Threatened, and Species of Concern (Boreal Toad, Rio Grande Sucker, Rio Grande Chub, Rio Grande Cutthroat Trout, Southwestern Willow Flycatcher, Northern Leopard Frog)
5. Special Value Waters (CWCB Instream Flow Waters, Eligible/Suitable Wild and Scenic, WQCC Oustanding Waters)
6. Rare Plants and Significant Riparian Wetland Plant Communities
7. Wetlands (National Wetlands Inventory)

0 3.757.5 15 22.5 30 Miles

Scale 1:500,000

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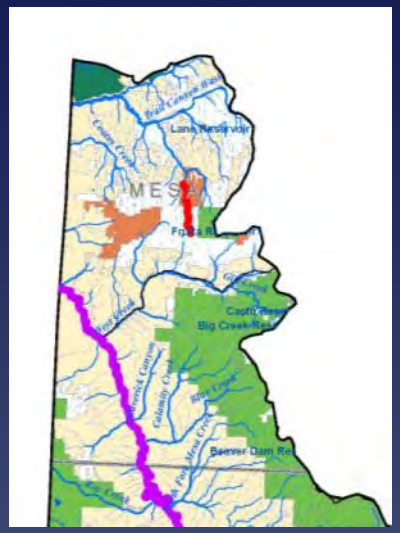
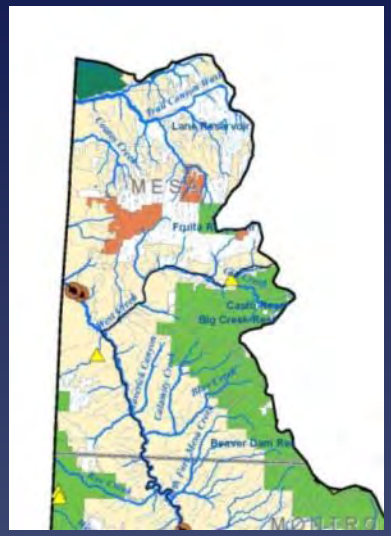
Data from the following sources: See individual environmental and recreational maps. CWCB, USGS

Priorities Mapping Methodology – Environmental and Recreational Attribute Count by Segment

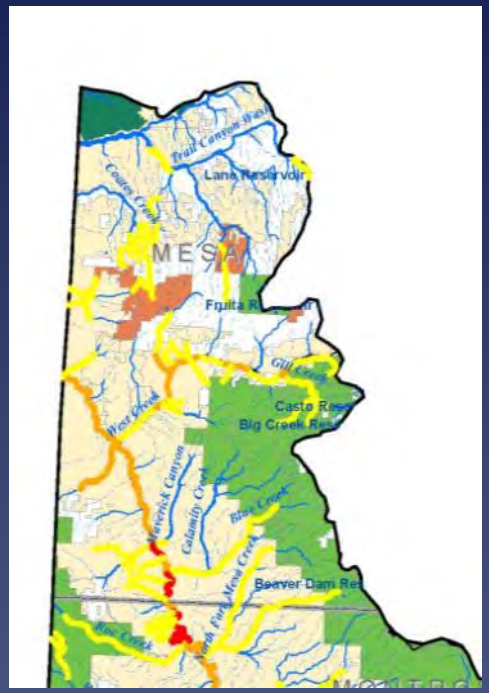
- Develop environmental and recreational attribute maps
- Use ¼ mile buffer to include attributes within that distance
- Map environmental and recreational attributes by Stream/Lake Segment (NHD line coverage)
- Overlay Stream/Lake Segments to show where there is concentration of recreational and environmental attributes

Examples of Attribute and Segment Intersection: Southwest Basin Environmental Attributes



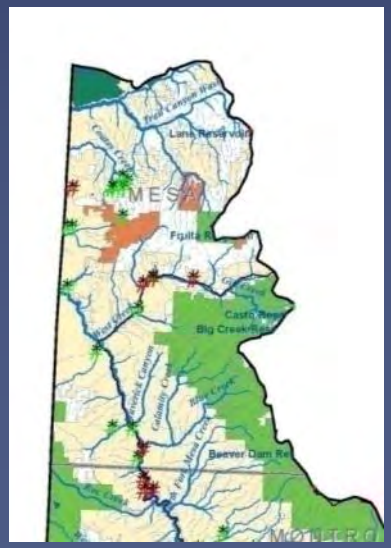


STATE ENDANGERED, THREATENED, AND SPECIES OF CONCERN



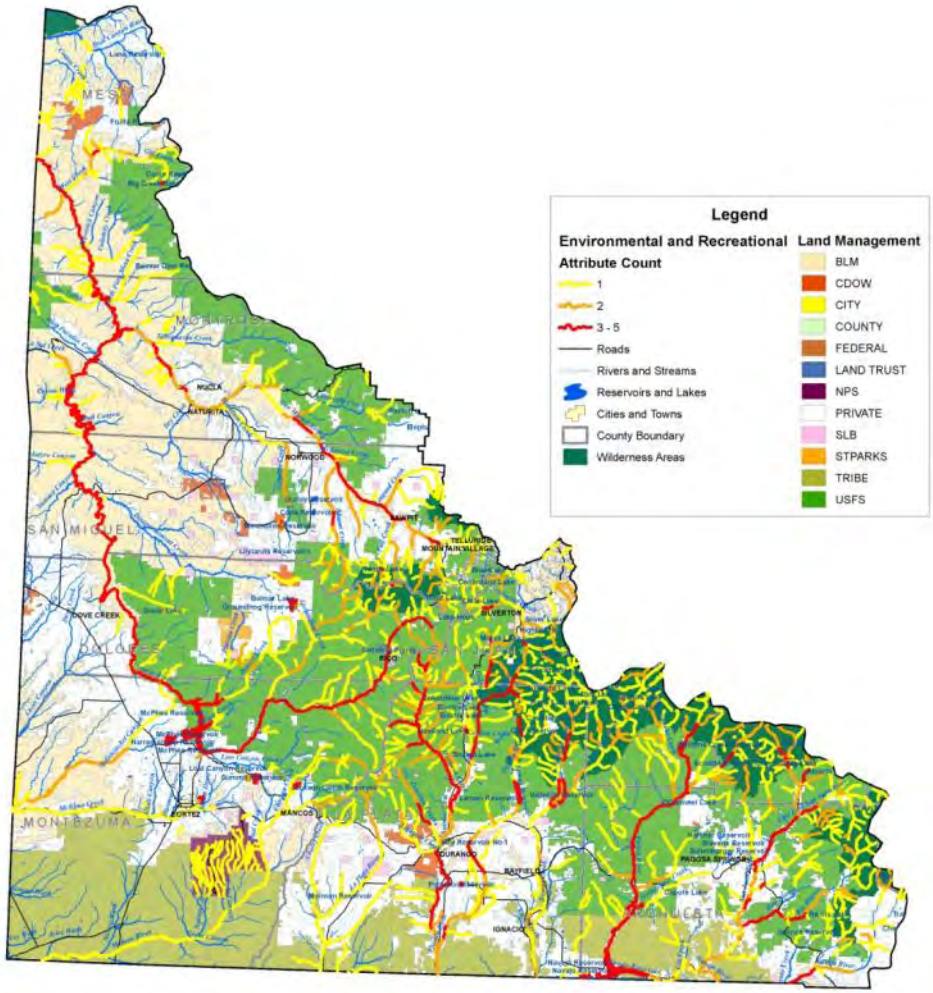
WILD & SCENIC

ISFS



PLANTS

Southwest Basin Non-Consumptive Needs Assessment
Environmental and Recreational Attribute Count per Stream Segment



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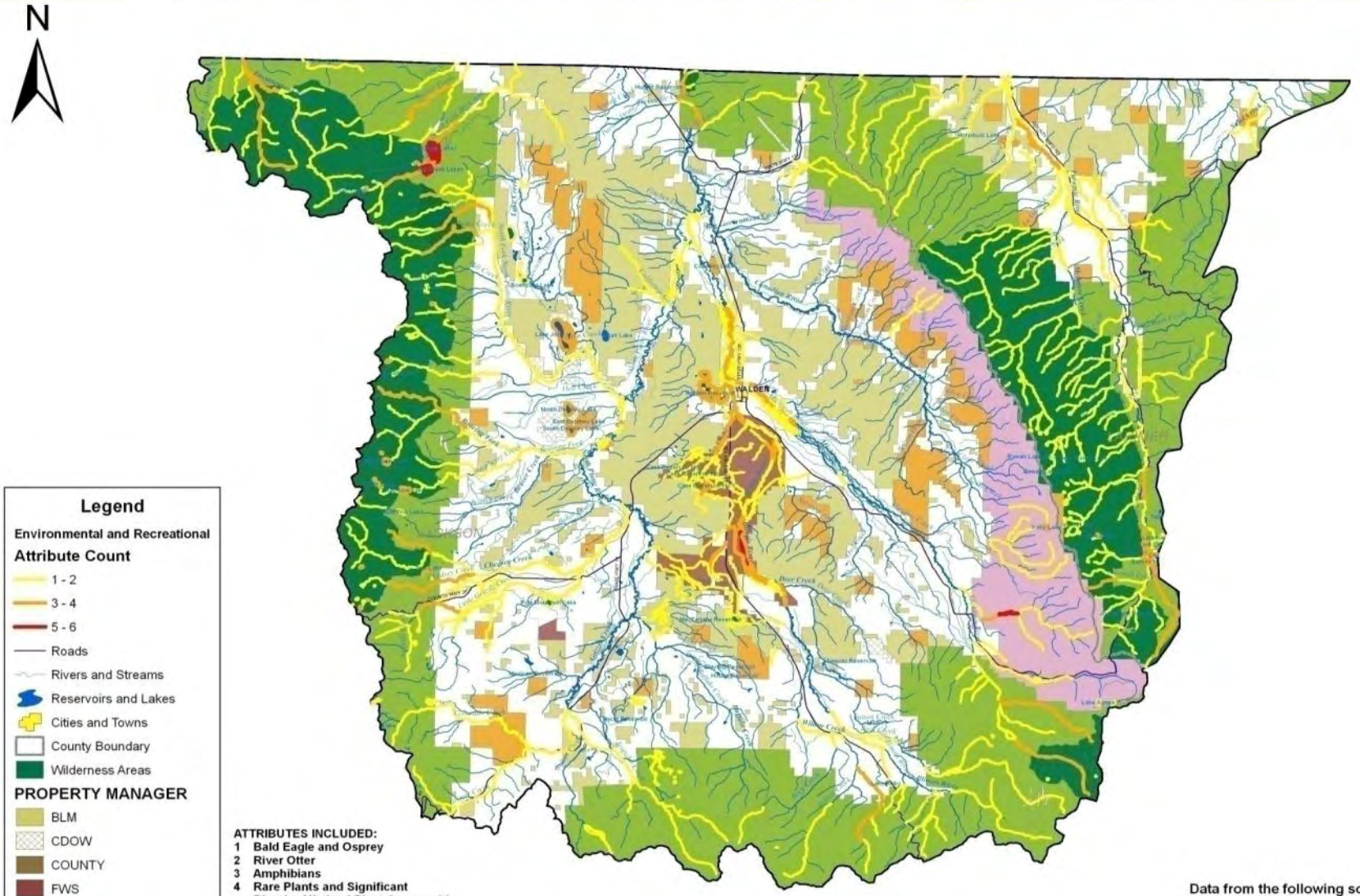
Data from the following sources:
See Individual Attribute Maps,
NREL, CWCB

0 5 10 20 30 40 Miles

Scale: 1:625,000

Attribute Categories Included:
- Aquatic-Dependent State Endangered, Threatened and Species of Concern (Including Conservation Agreement Species)
- Rare Plants and Significant Riparian/ Wetland Plant Communities
- Special Value Waters (CWCB Instream Flow Waters, CO Outstanding Waters, Eligible and/ or Suitable Wild and Scenic River Reaches)
- Whitewater and Flatwater Boating
- Cold and Warm-Water Fishing
- Waterfowl Hunting/Viewing

North Platte Non-Consumptive Needs Assessment
Environmental and Recreational Attribute Count per Stream Segment



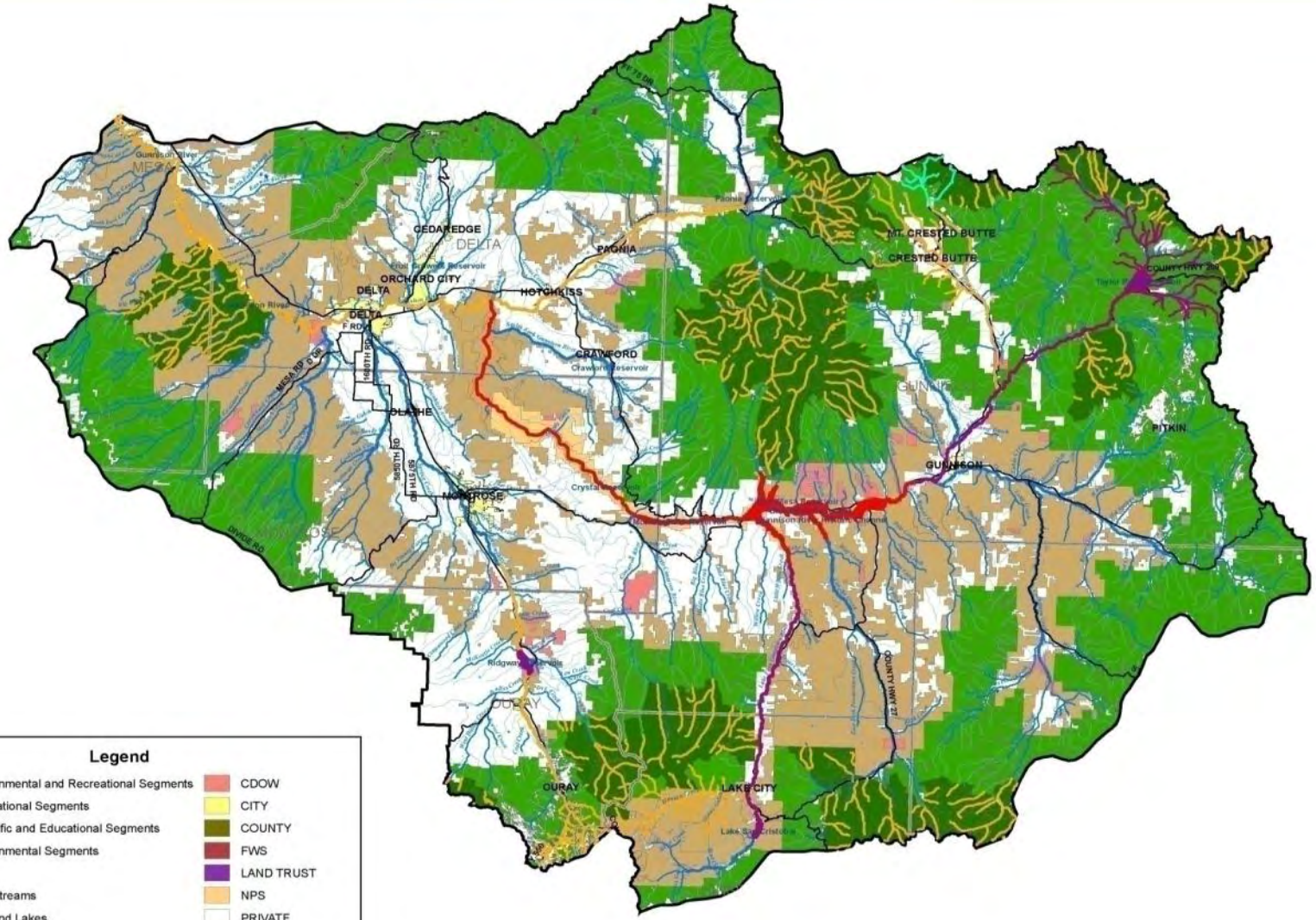
Data from the following sources: See individual attribute maps, CWCB

Disclaimer: Data used for this effort is gathered from public information sources. Many lands are in private property ownership. Always respect private property rights.

Priorities Mapping Methodology – Major Segments/Focus Areas

- Develop matrix that identifies reaches with significant/important environmental and recreational attributes
  - More input from BRTs
  - Gunnison basin included scientific and educational areas
  - Colorado basin's matrix identified segments with attributes at risk
- Map segments with color scale to identify environmental, recreational, environmental and recreational, educational and scientific
- Colorado Basin used a single color to identify segments

Gunnison Basin Non-Consumptive Needs Assessment
Major Stream and Lake Segments



Legend

- Major Environmental and Recreational Segments
- Major Recreational Segments
- Major Scientific and Educational Segments
- Major Environmental Segments
- Roads
- Rivers and Streams
- Reservoirs and Lakes
- Cities and Towns
- County Boundary
- Wilderness Areas

Land Management

- BLM
- BOR
- CDOW
- CITY
- COUNTY
- FWS
- LAND TRUST
- NPS
- PRIVATE
- SCHOOL DISTRICT
- SLB
- STATE
- STPARKS
- USFS

0 3 6 12 18 24 Miles

Scale 1:500,000

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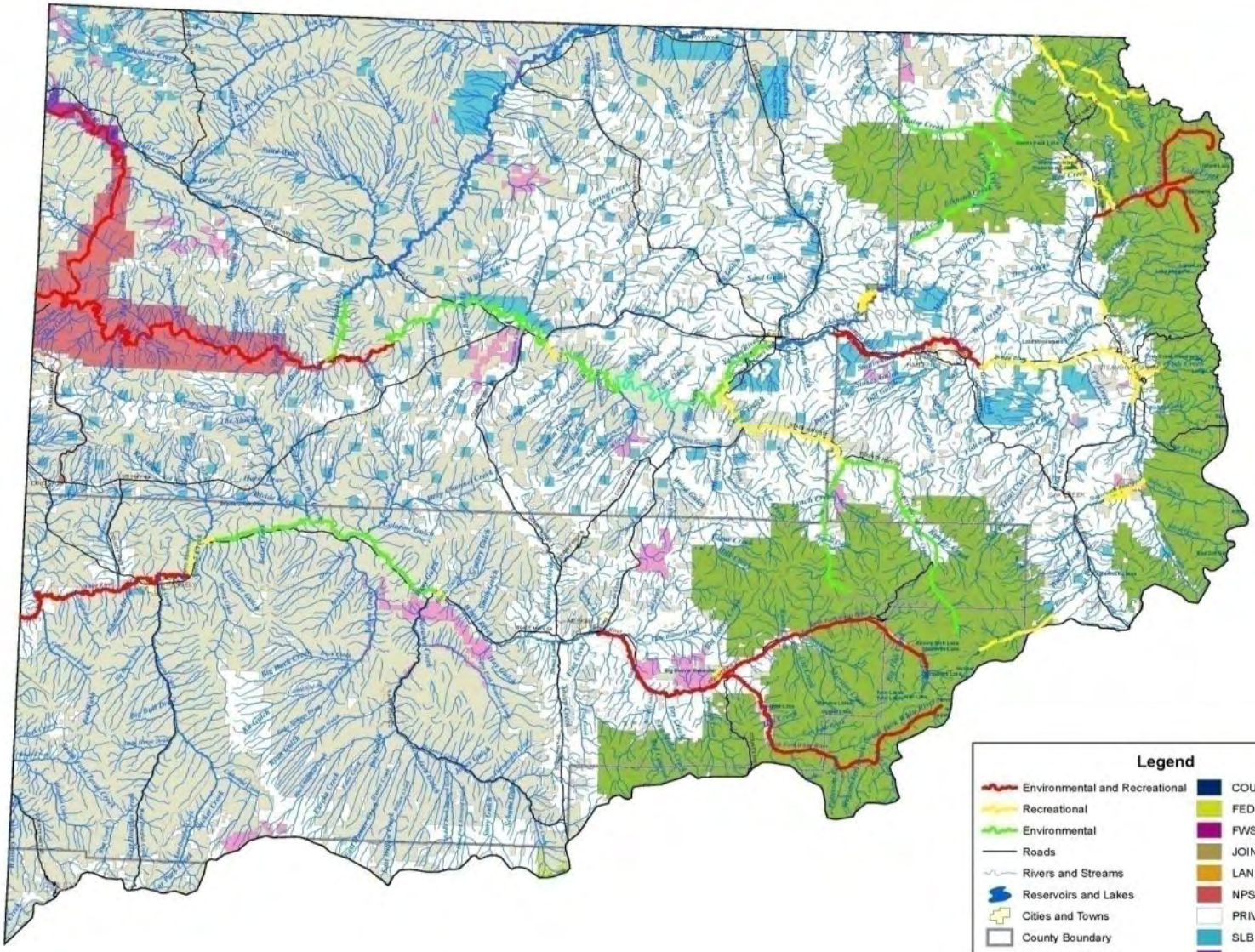
Data from the following sources:
NCNA Committee/RT Members,
NREL (CSU), CWCB

Yampa/White/Green River Basin Non-Consumptive Needs Assessment
Major Environmental and Recreational Segments



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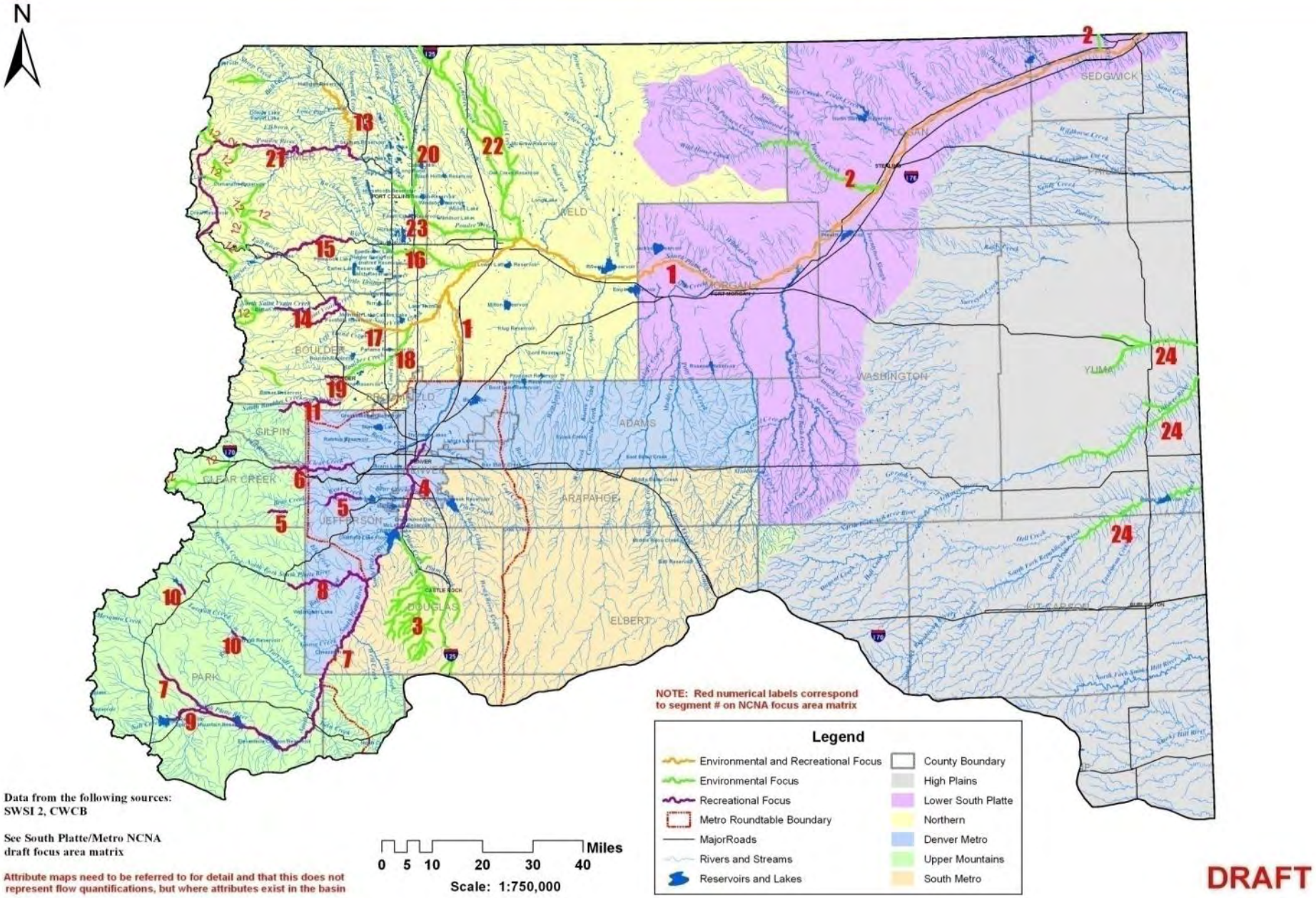
Data from the following sources:
See Major Segments Matrix

Scale: 1:500,000

Phase I South Platte/Metro Basin Non-Consumptive Needs Assessment: Candidate Environmental and Recreational Focus Areas



Data from the following sources:
SWSI 2, CWCB

See South Platte/Metro NCNA draft focus area matrix

Attribute maps need to be referred to for detail and that this does not represent flow quantifications, but where attributes exist in the basin

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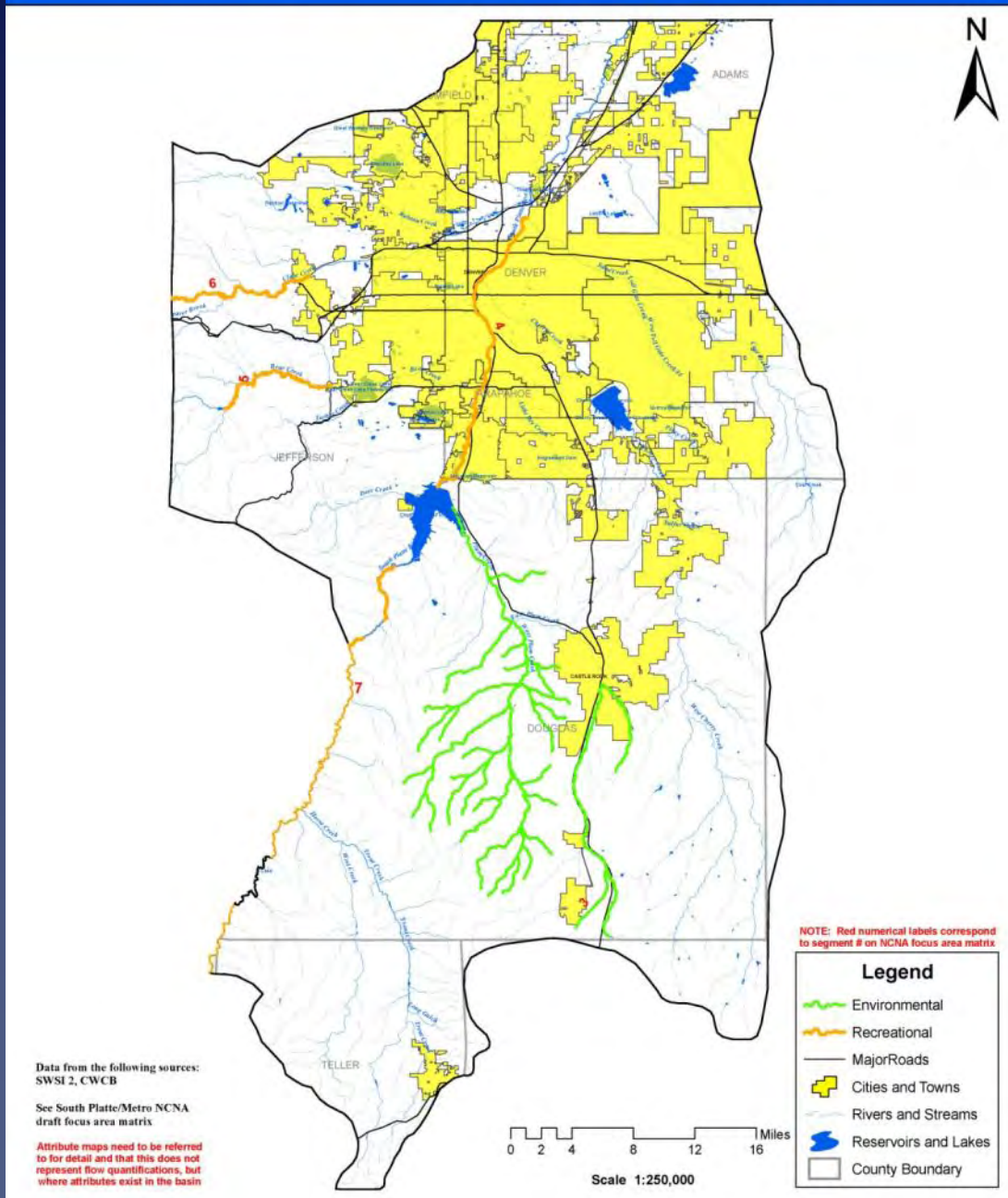
Phase I South Platte/Metro Basin Non-Consumptive Needs Assessment: Candidate Environmental and Recreational Focus Areas



Colorado Basin Nonconsumptive Needs Assessment
Priority Streams and Lakes

Document: K:\SWSI 2\GIS\NCNA Basin Maps\Colorado\Map MXDs\Colorado_Attribute_Streams_34x44_090127.mxd

Statewide Nonconsumptive Needs Assessment Priorities Map

Colorado Basins

North Platte Basin

Environmental and Recreational Attribute Count by Stream Segment
- 1 - 2
- 3 - 4
- 5 - 6

Yampa/White/Green Basin

Major Environmental and Recreational Segments
- Environmental Segments
- Environmental and Recreational Segments
- Recreational Segments

Colorado Basin
- Colorado Streams with Attributes at Risk

Gunnison Basin

Major Environmental, Recreational and Scientific/Educational Segments
- Environmental and Recreational Segments
- Recreational Segments
- Scientific and Educational Segments
- Environmental Segments

South Platte/Metro Basin

Candidate Environmental and Recreational Focus Areas
- Environmental Focus Area
- Environmental and Recreational Focus Area
- Recreational Focus Area

Arkansas Basin

Environmental and Recreational Attribute Count by HUC
- 1 - 2
- 3 - 4
- 5 - 7

Southwest Basin

Environmental and Recreational Attribute Count by Stream Segment
- 1
- 2 - 3
- 4 - 6

Rio Grande Basin

Weighted Environmental and Recreational Attribute Count by HUC
- 1 - 3
- 4 - 5
- 6 - 8

Basemap Legend
- Rivers and Streams
- Lakes and Reservoirs
- Cities and Towns
- Highways
- Counties
- Basins

0 25 50 100 150

Miles
1 inch = 12 miles

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** Note: See individual basin maps for detailed Needs Assessment information. **

Document: G:\SWS\NONCONSUMPTIVE\STATEWIDE-BASEMAPPING\MXD\FigureX_Statewide_Basins_Location_36x48.mxd

Results/Conclusions

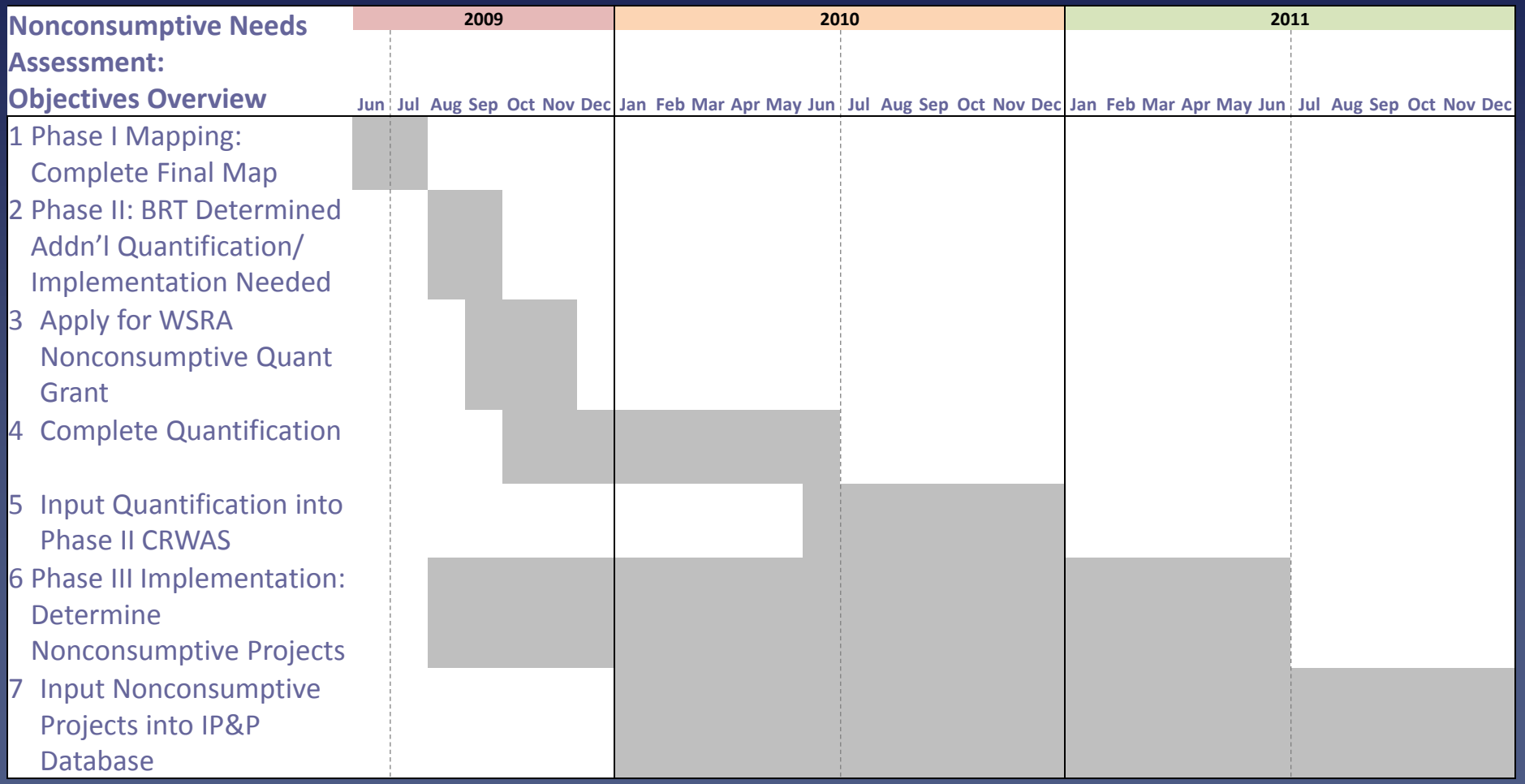
- Methodologies differed based on basin-specific needs
- Mapping provides framework for prioritization of recreational and environmental needs
- BRTs now have a tool to assist in determining focus areas where quantifications may be developed
- Mapping also may be used to support future implementation actions for protecting water for nonconsumptive needs

Nonconsumptive Needs Assessment Next Steps

Where do we go from here?

- Final map deliverable June 30th, 2009
  - Some maps may still be in draft form or will be approved in July
- Completed flow evaluation tool pilots June 30th , 2009
- Basin directed “status” of focus areas
- Basin directed flow evaluations
- Basin determined identification of nonconsumptive needs strategies (structural & nonstructural projects or processes)

Draft Schedule



Phase II- Status Determination Questions:

- How do these attributes interface with consumptive needs?
- Are there existing efforts/protections for priority areas?
- Are there areas without protections that need further study?
- What strategies are needed to support nonconsumptive priority areas?
- Are there areas where new flow or water level quantification is appropriate?
- Are there areas where a project, whether structural (e.g. river restoration) or nonstructural (e.g. instream flow or voluntary flow management) can be identified and implemented; and
- Are their areas no action is needed at this time?

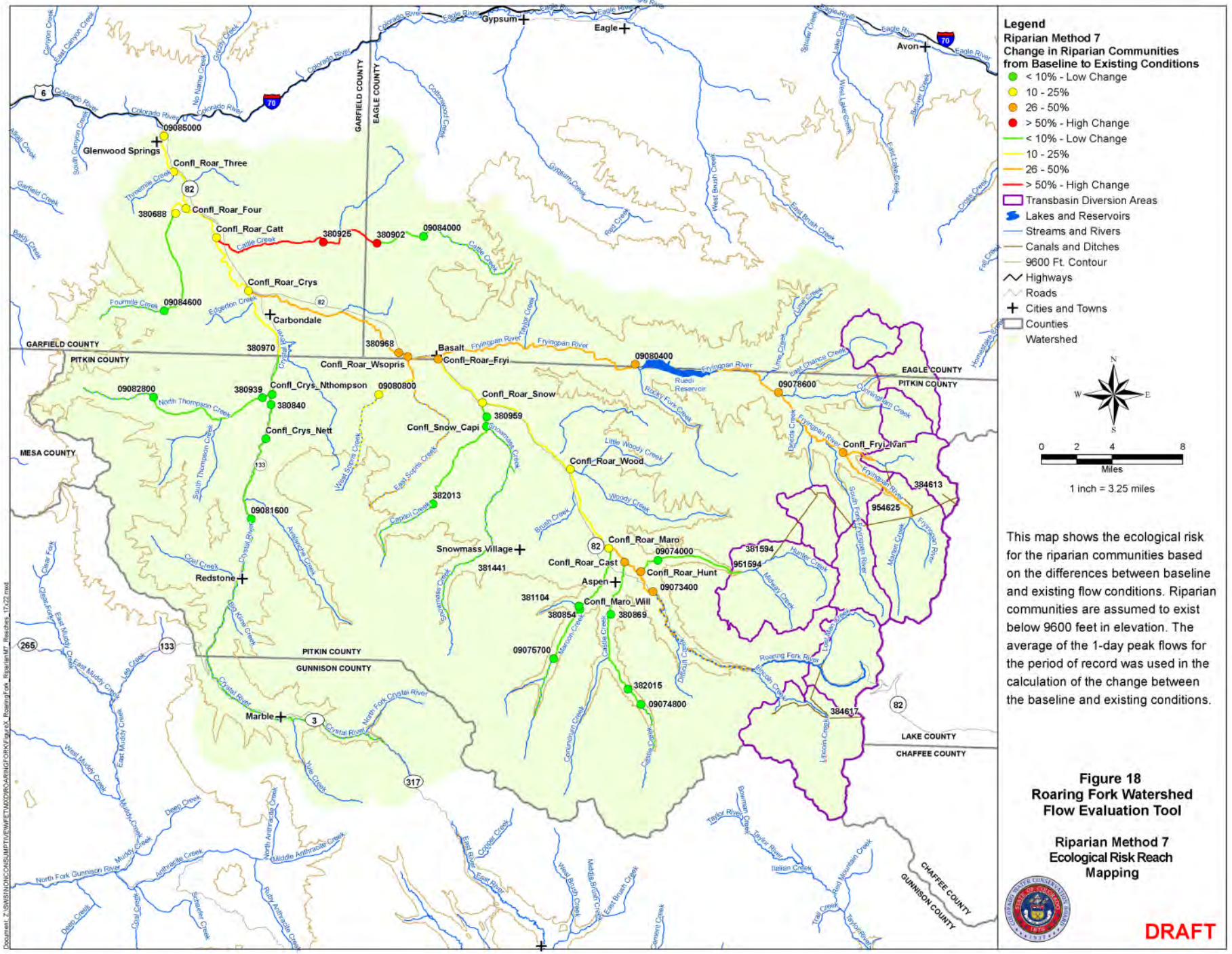
Overview of Watershed Flow Evaluation Tool (WFET) and Site-Specific Quantification Objectives and WFET Findings, Recommendations and Methodology

Overview

- Watershed Flow Evaluation Tool Capabilities and Limitations
- Site-Specific Quantification Capabilities and Limitations
- How the two methods can work together
- Pilot study findings
- Watershed Flow Evaluation Tool Methodology

Watershed Flow Evaluation Tool (WFET) Capabilities and Limitations

- Provides regional assessment of ecological risk conditions related to flow
- WFET will identify areas based on flow conditions that are at ecological risk
- WFET can provide a range of seasonal flow conditions that are associated with ecological risk levels
- WFET will not provide results as detailed or accurate a site-specific analysis
- WFET is not meant to set flow prescriptions
- WFET can be used to target areas in need of further site-specific study



This map shows the ecological risk for the riparian communities based on the differences between baseline and existing flow conditions. Riparian communities are assumed to exist below 9600 feet in elevation. The average of the 1-day peak flows for the period of record was used in the calculation of the change between the baseline and existing conditions.

Figure 18
Roaring Fork Watershed
Flow Evaluation Tool

Riparian Method 7
Ecological Risk Reach Mapping

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Site-Specific Quantification Capabilities and Limitations

- Site-specific quantification can tell you a lot of things about a smaller geographic extent such as a river reach
- Requires field data measured at the site
- Higher cost than office methods
- Provided greater detail on multiple parameters than non-field methods
- Directly relates channel characteristics to hydraulics, hydrology, and habitat
- Site-specific studies can help validate WFET results

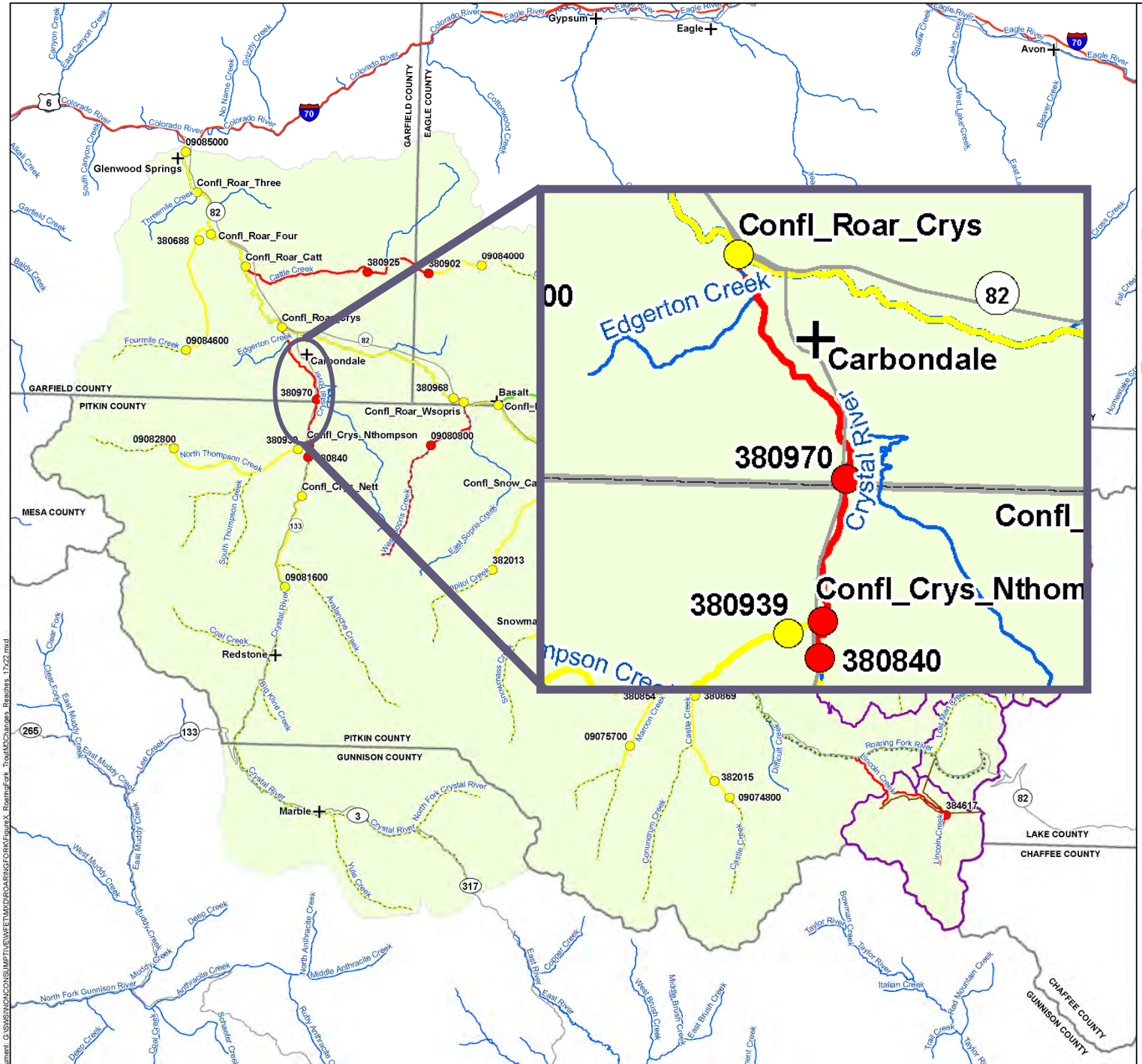

Figure
Roaring Fork Watershed
Flow Evaluation Tool

Trout Method 3
Changes in Class Risk Mapping

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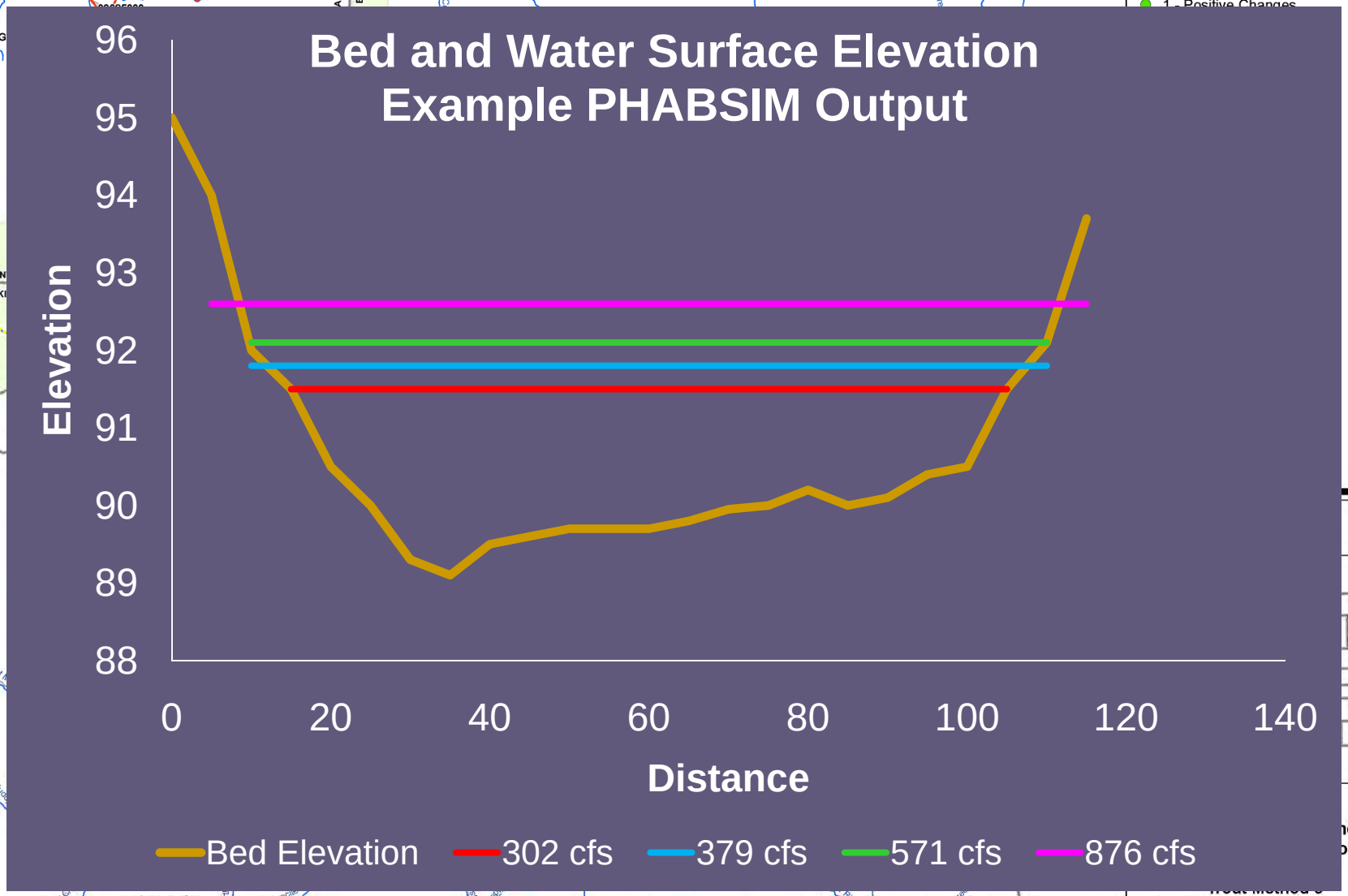

Legend

Trout Method 3 Changes Between Baseline and Existing Conditions

Habitat Suitability

- ≤ -1 - Negative Changes
- 0
- 1 - Positive Changes

Changes in Class Risk Mapping

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How the two methods can work together

- WFET results could identify areas that need further site-specific studies
- Site-specific studies can help validate WFET results
- Site-specific studies can help calibrate WFET Flow Ecology relationships

WFET Pilot Findings – Technical

- Flow-ecology relationships derived for several key environmental and recreational attributes across the state
- Ecological risk mapping developed for key attributes
- For Roaring Fork, preliminary validation shows that WFET results are comparable with site-specific data
- For Roaring Fork, results build upon and support previous watershed efforts

WFET Pilot Findings – Tool Application

- WFET is best utilized in areas with detailed hydrologic data or models for pre and post water management conditions
- WFET could be used in a predictive capacity to examine potential future water management using conditions today as a baseline
- WFET can be used to generate a range of seasonal flow conditions based on ecological risk
- WFET could be used to target Instream Flow acquisitions as well as restoration efforts

WFET Pilot Recommendations

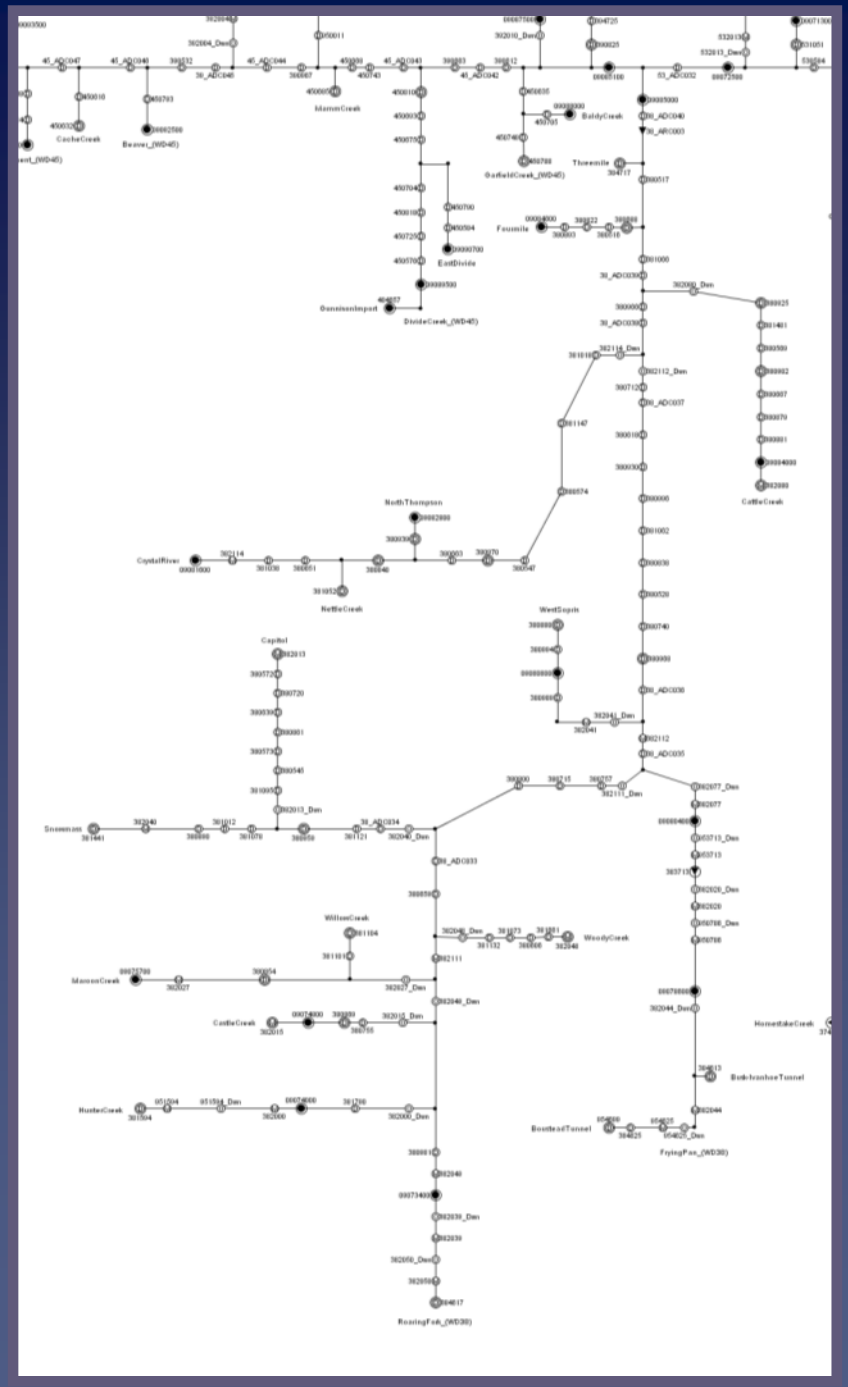
- Further validation should be completed with other site-specific studies and CWCB Instream Flow R2CROSS data
- Calibration of ecological risk levels with site-specific data
- Further refinement of ecological risk between and above nodes
- Further refinement of hydrograph development to consider intra-year and year to year variability

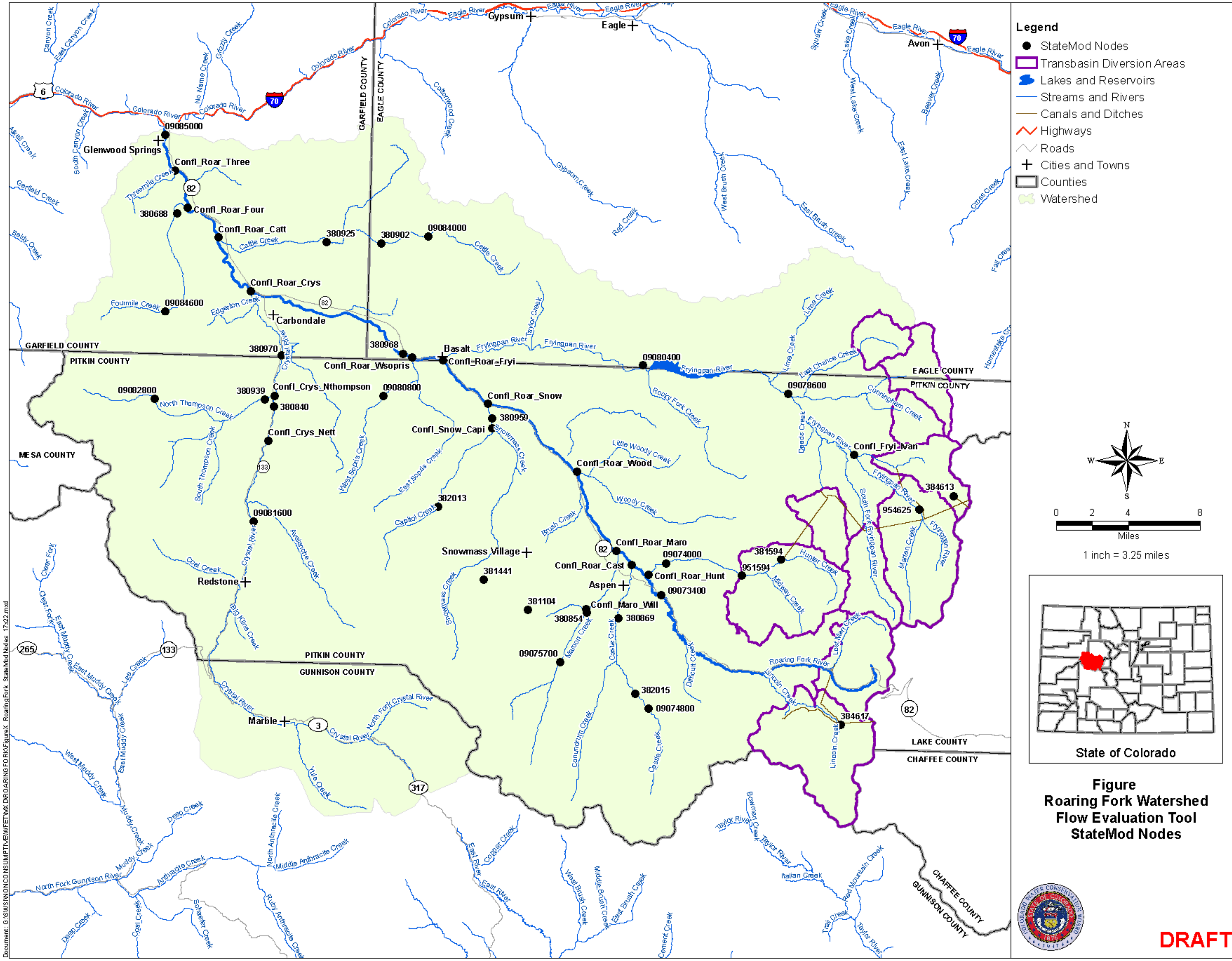
Steps Utilized for WFET Pilot Studies

- Hydrologic foundation – used Colorado Decision Support System (CDSS) Model and USGS Gages
- Utilized the Nature Conservancy's Indicators of Hydrologic Alteration (IHA) software to analyze hydrologic data
- Developed Flow Ecology relationships for key flow metrics generated by IHA
- Developed mapping showing areas that may be at risk due to changes in flow regime

Hydrologic Foundation Roaring Fork

- Used CDSS to generate
  - Baseline (unaltered) daily hydrology for 1975-2005
  - Current (altered) daily hydrology for 1975-2005
- Baseline and current hydrology data developed for 47 nodes in the Roaring Fork Basin
- Assume based on CDSS documentation that model is calibrated
- Assume model output is sufficient for relative comparisons




Legend
StateMod Nodes
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Streams and Rivers
Canals and Ditches
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Miles
1 inch = 3.25 miles
State of Colorado
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Carbondale
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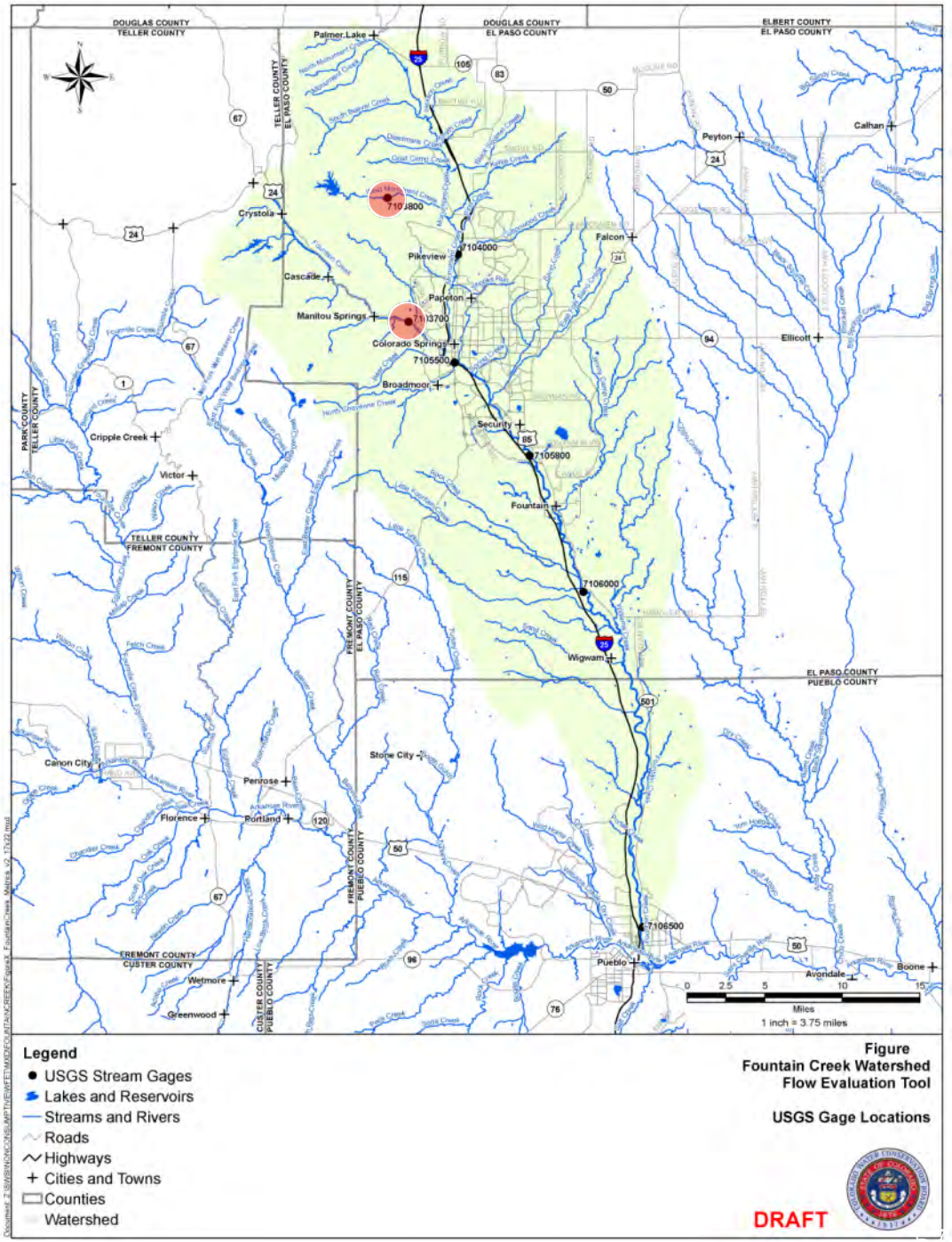
384617

Figure
Roaring Fork Watershed
Flow Evaluation Tool
StateMod Nodes

Hydrologic Foundation – Fountain Creek

- Used long-term USGS flow gage records
- No DSS available
- Seven (7) gages
- Spatially distributed throughout watershed:
  - monsoonal
  - high elevation snowpack
- Primarily interested in monthly data

- Review of available data, past studies, past modeling
- Results indicate a change in hydrologic regime that corresponds to major trans-basin projects downstream of Colorado Springs and groundwater development



IHA Analysis

- IHA analysis completed for baseline and current hydrology for following flow statistics:
  - August and September mean flow (cfs)
  - January mean flow (cfs)
  - Average annual peak daily flow (cfs)
  - Mean annual flow (cfs)
  - 2-Year Flood Frequency flow (cfs)

Flow Ecology Relationships – Literature Search

	Interior Western	Rocky Mountains	Great Plains	Total
Fish	19	18	15	52
Riparian Vegetation	20	1	8	29
Invertebrates	9	9		18
Vertebrates	4			4
Terrestrial Invertebrates	2		1	3
Algae	2			2
Total	56	28	24	108

Flow Ecology Relationships

- Fountain Creek
  - Trout
  - Warm Water fish (Arkansas Darter)
  - Erosion Potential
- Roaring Fork
  - Trout
  - Riparian
  - Warm Water Fish (Flannelmouth and Bluehead Sucker)
  - Recreation

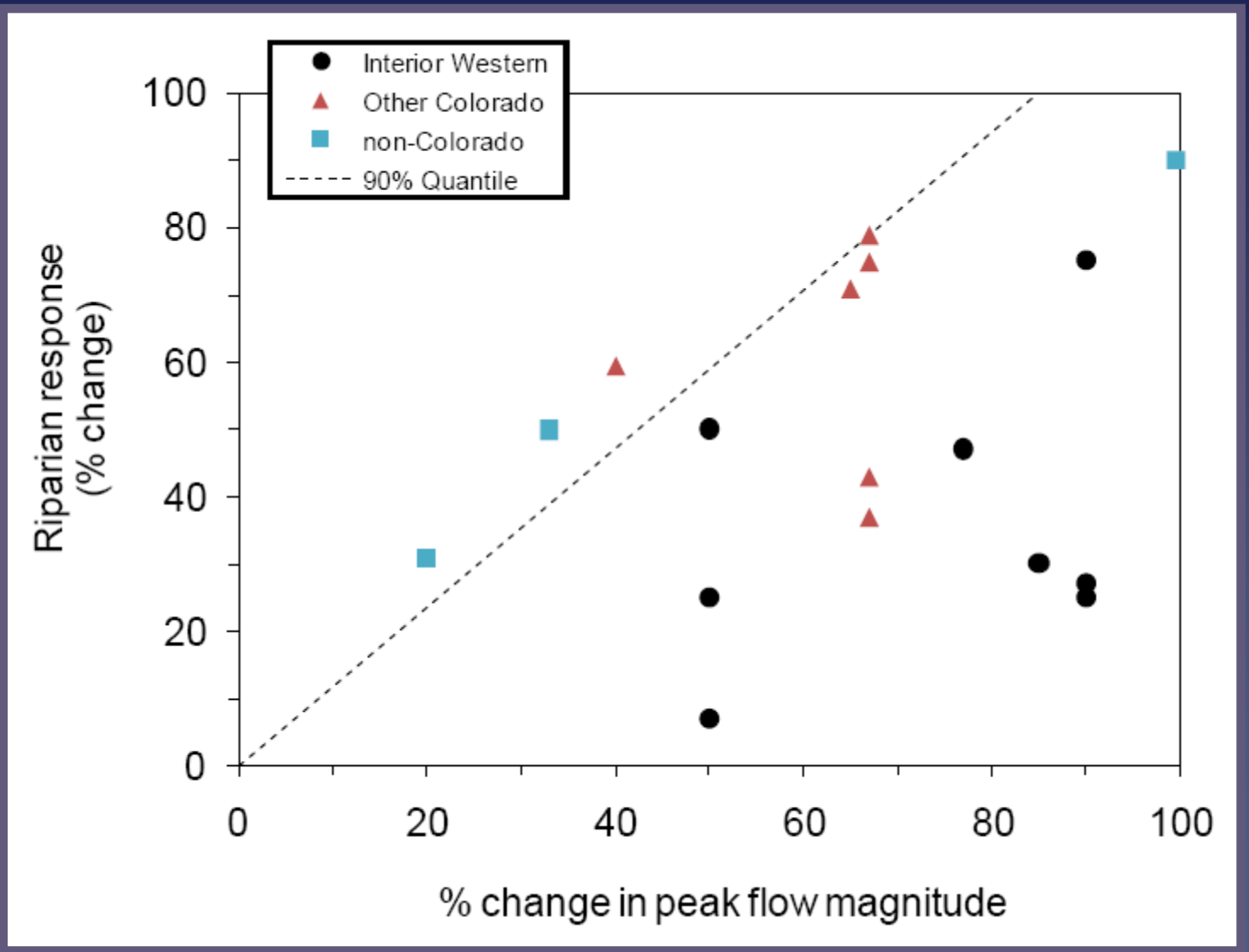
Flow Ecology Relationship – Trout (Fountain Creek and Roaring Fork)

Rating	Summer Low Flow (% of mean annual flow)	Description
0 (worst)	<10%	Inadequate to support trout
1	10-15%	Potential for trout support is sporadic
2	16-25%	May severely limit trout stock every few years
3	26-55%	Low flow may occasionally limit trout numbers
4 (best)	>55%	Low flow may very seldom limit trout

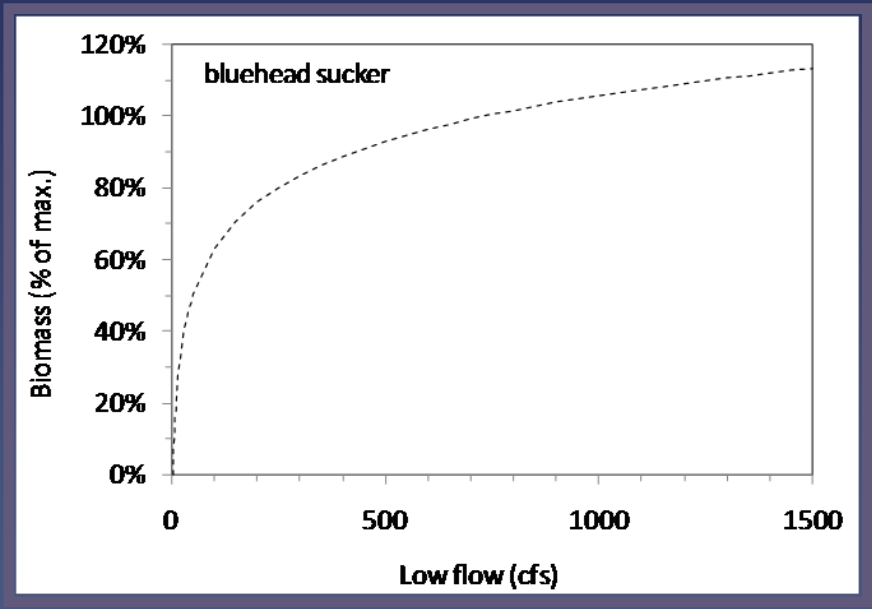
Flow Ecology Relationship – Warm Water Fish (Fountain Creek)

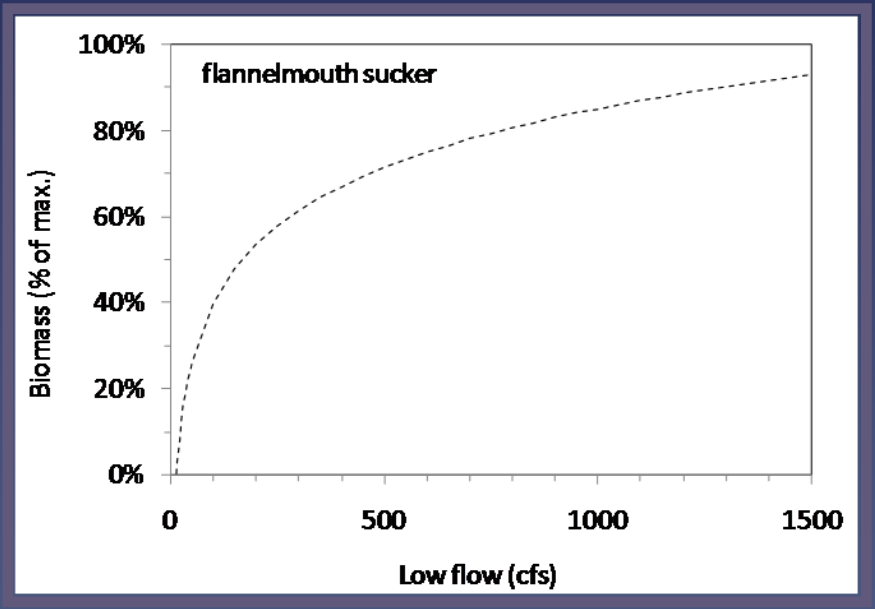
Low Flow (% of mean annual flow)	Description
<10%	Severe degradation
10-30%	Poor or minimum habitat
30-40%	Fair or degrading habitat
>40%	Good habitat

Flow-Ecology Relationship – Riparian Conditions (Roaring Fork)

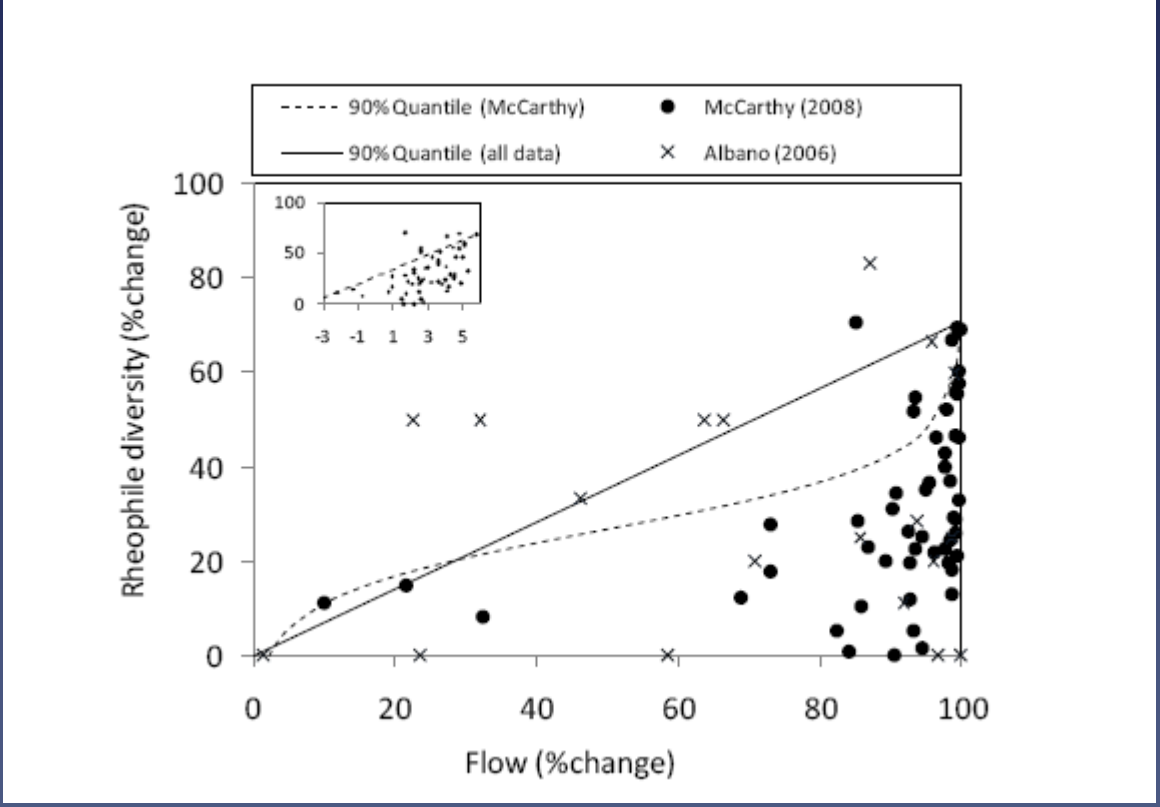


Flow Ecology Relationships – Warm Water Fish (Roaring Fork)

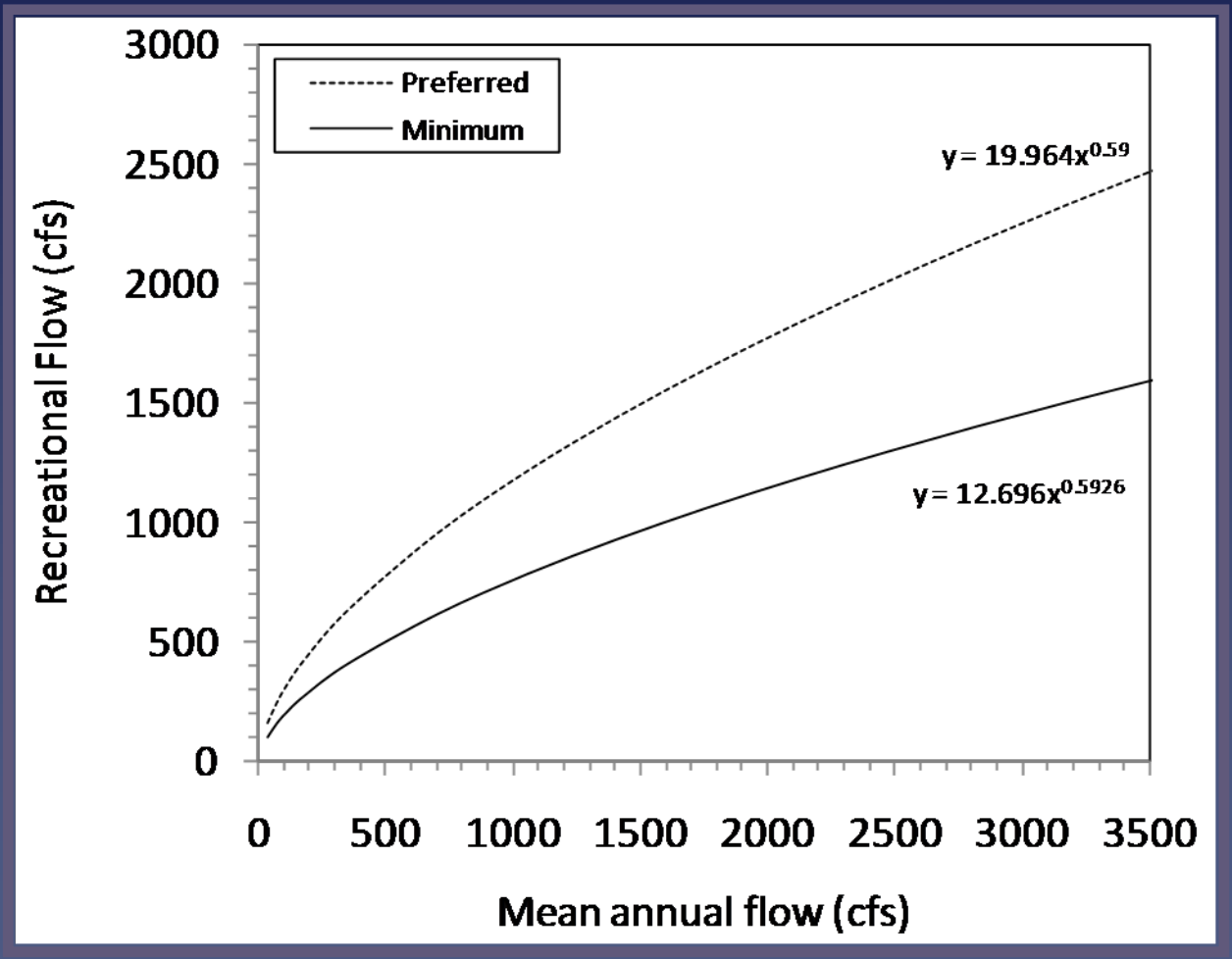




Flow Ecology Relationships – Invertebrates (Not applied in this pilot study)



Flow Ecology Relationships – Recreation (Roaring Fork)



Erosion Potential (Fountain Creek)

- Estimated sediment transport effectiveness for range of flow conditions
- Metric calculate for gages on lower portion of Fountain Creek

Ecological Risk Mapping

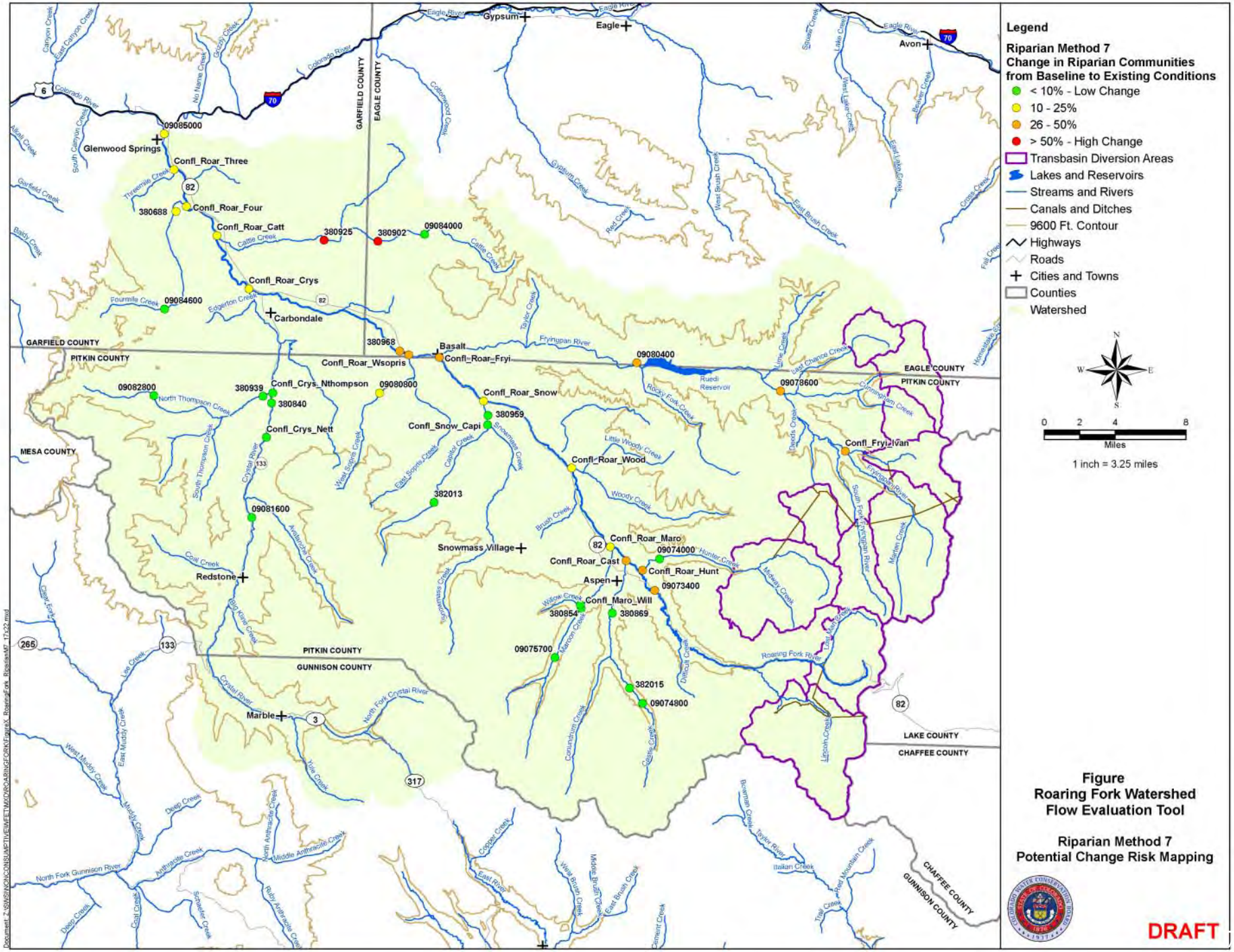
- Calculated flow metrics from Flow-Ecology curves at StateMod Nodes and USGS gages
- Assigned risk levels to nodes and gages based on ecological metrics
- Assigned risk level between nodes and gages
- Generated mapping
  - Produce one ecological risk map for each attribute
  - Maps are metric dependent
  - Some maps are based on differences between baseline and existing hydrology (one-step process for final map)
  - Some maps are based on understanding baseline and existing conditions but final map is based on existing conditions and associated ecological risk

Types of Ecological Risk Maps

Map	Baseline Conditions	Existing Conditions	Change
IHA Metrics			x
Trout	x	x	
Warm Water Fish (Fountain Creek)	x	x	
Warm Water Fish (Roaring Fork)			x
Riparian			x
Recreation	x	x	
Erosion Potential	x	x	

Riparian Metric Calculations

$$\frac{\textbf{Annual Peak Daily Flow}_{\textbf{existing}} - \textbf{Annual Peak Daily Flow}_{\textbf{baseline}}}{\textbf{Annual Peak Daily Flow}_{\textbf{baseline}}} \textbf{x1.18}$$


Legend
Riparian Method 7
Change in Riparian Communities
from Baseline to Existing Conditions
< 10% - Low Change
10 - 25%
26 - 50%
> 50% - High Change
Transbasin Diversion Areas
Lakes and Reservoirs
Streams and Rivers
Canals and Ditches
9600 Ft. Contour
Highways
Roads
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Counties
Watershed
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1 inch = 3.25 miles
Figure
Roaring Fork Watershed
Flow Evaluation Tool
Riparian Method 7
Potential Change Risk Mapping
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Gypsum
Eagle
Avon
Glenwood Springs
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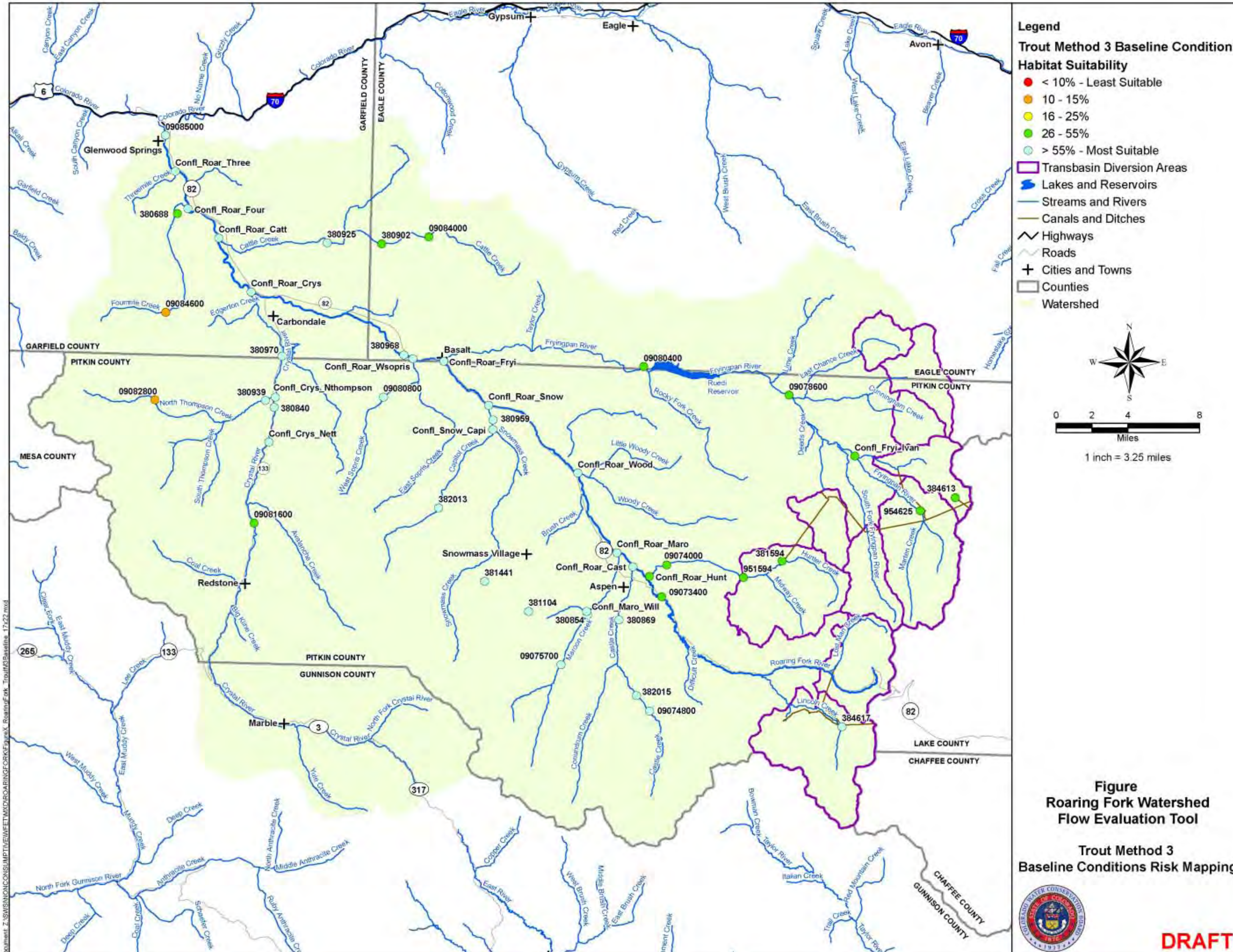
MESA COUNTY
GUNNISON COUNTY
LAKE COUNTY
CHAFFEE COUNTY
Ruedi Reservoir

Trout Metric Calculations

$$\frac{(\textbf{August Average } Q_{\textbf{existing}} + \textbf{September Average } Q_{\textbf{existing}})/2}{\textbf{Mean Annual Flow}_{\textbf{baseline}}}$$

$$\frac{(\textbf{August Average } Q_{\textbf{baseline}} + \textbf{September Average } Q_{\textbf{baseline}})/2}{\textbf{Mean Annaul Flow}_{\textbf{baseline}}}$$


Legend
Trout Method 3 Baseline Conditions
Habitat Suitability
< 10% - Least Suitable
10 - 15%
16 - 25%
26 - 55%
> 55% - Most Suitable
Transbasin Diversion Areas
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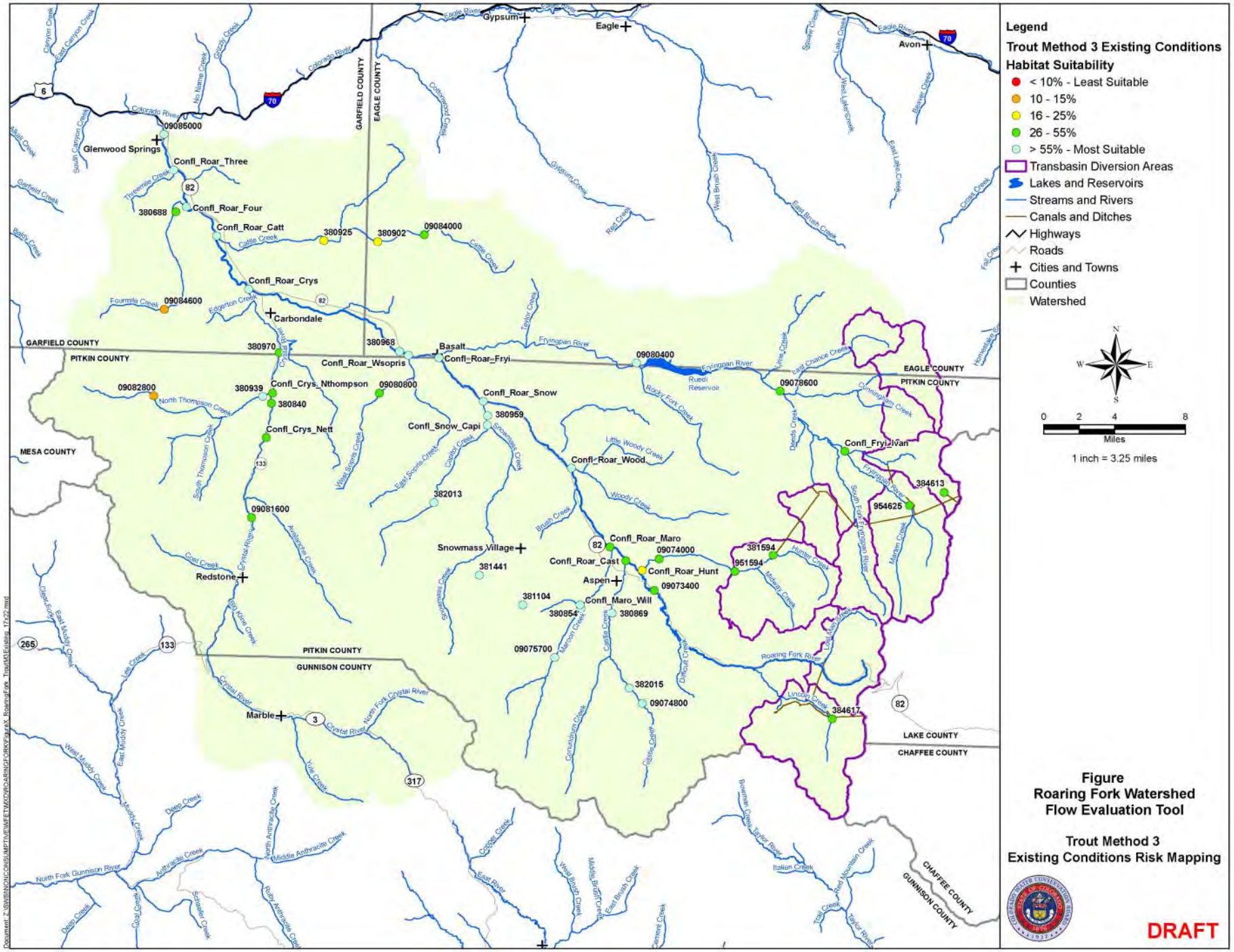
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Roaring Fork Watershed
Flow Evaluation Tool
Trout Method 3
Existing Conditions Risk Mapping
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Assigning Risk Levels Between Nodes and Gages

Assigning Risk Levels Between Nodes and Gages (con't)

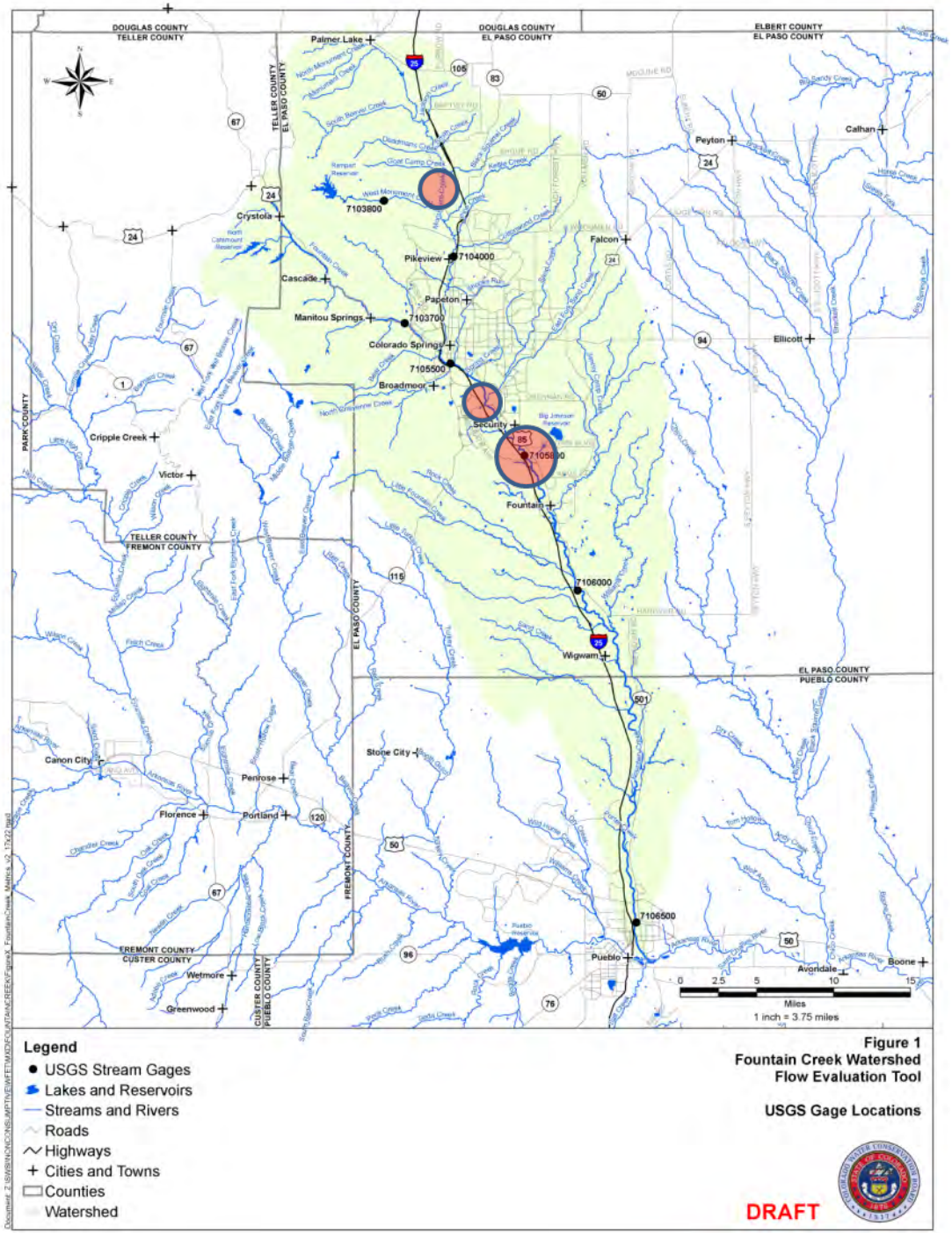
Questions?

Fountain Creek Watershed Flow Evaluation Tool Results

Fountain Creek WFET Results

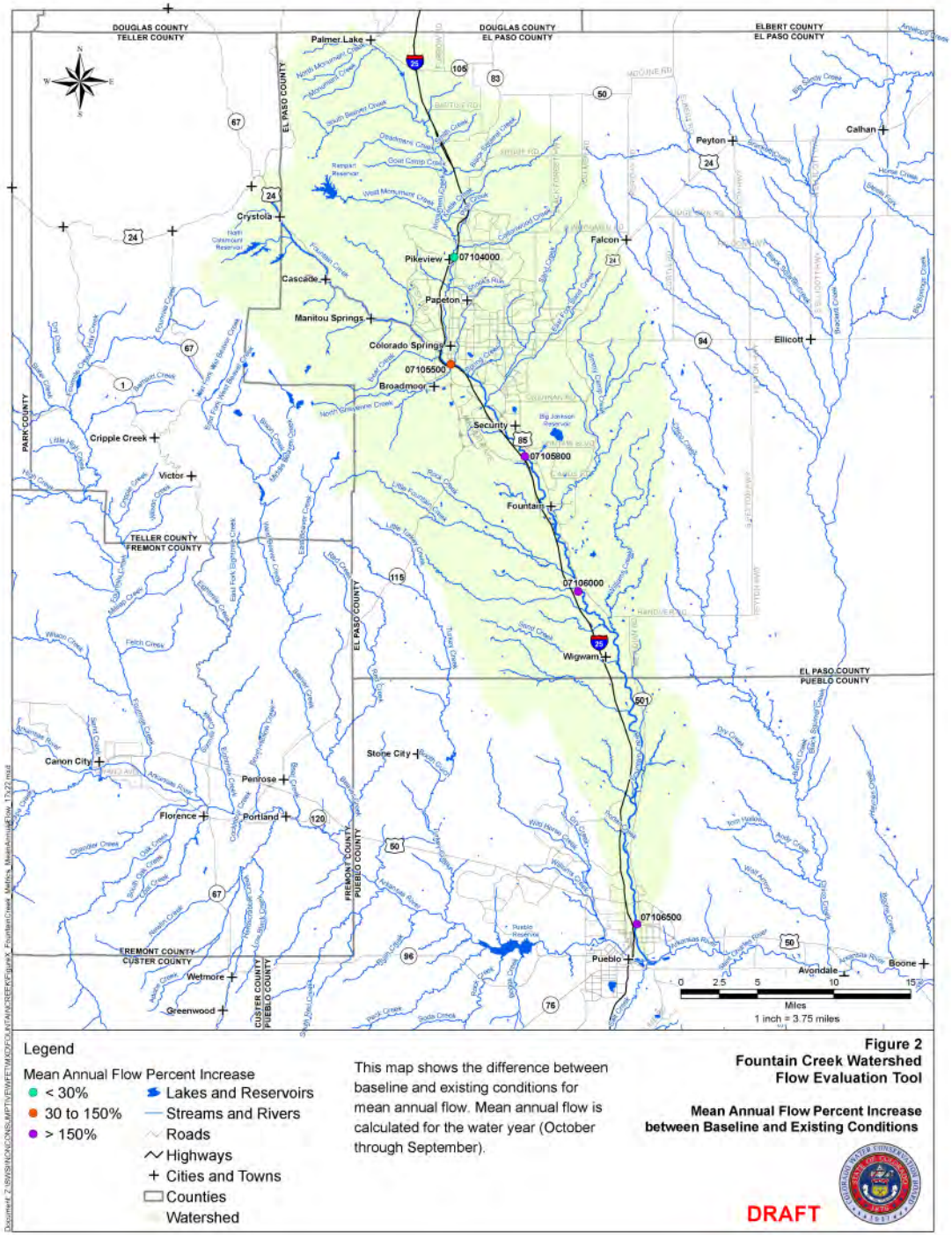
- IHA Results
  - Mean annual flow
  - Mean January flow
  - Mean August flow
  - 1-Day peak flow
  - 2-Year flood flow
- Risk Mapping
  - Trout
  - Warm Water Fish
  - Erosion Potential
- Fountain Creek WFET Pilot Conclusions

How have flows changed?



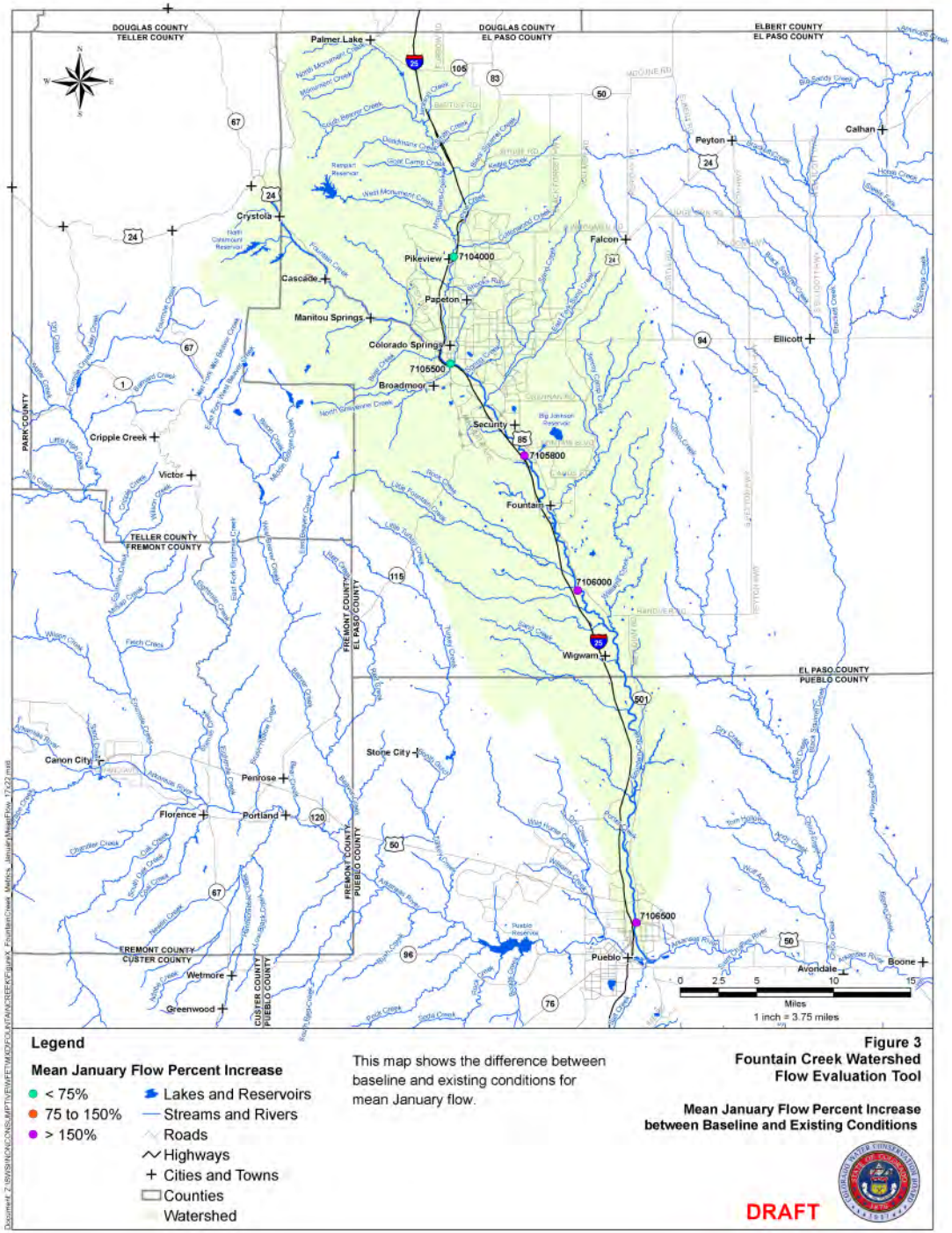
USGS Gage Locations

Return flows from transbasin diversions and groundwater are noticed downstream of Security gage (07105800)



Mean Annual Flow Percent Increase between Baseline and Existing Conditions

- All locations showed increases in mean annual from baseline to existing conditions
- Downstream reaches have higher increases



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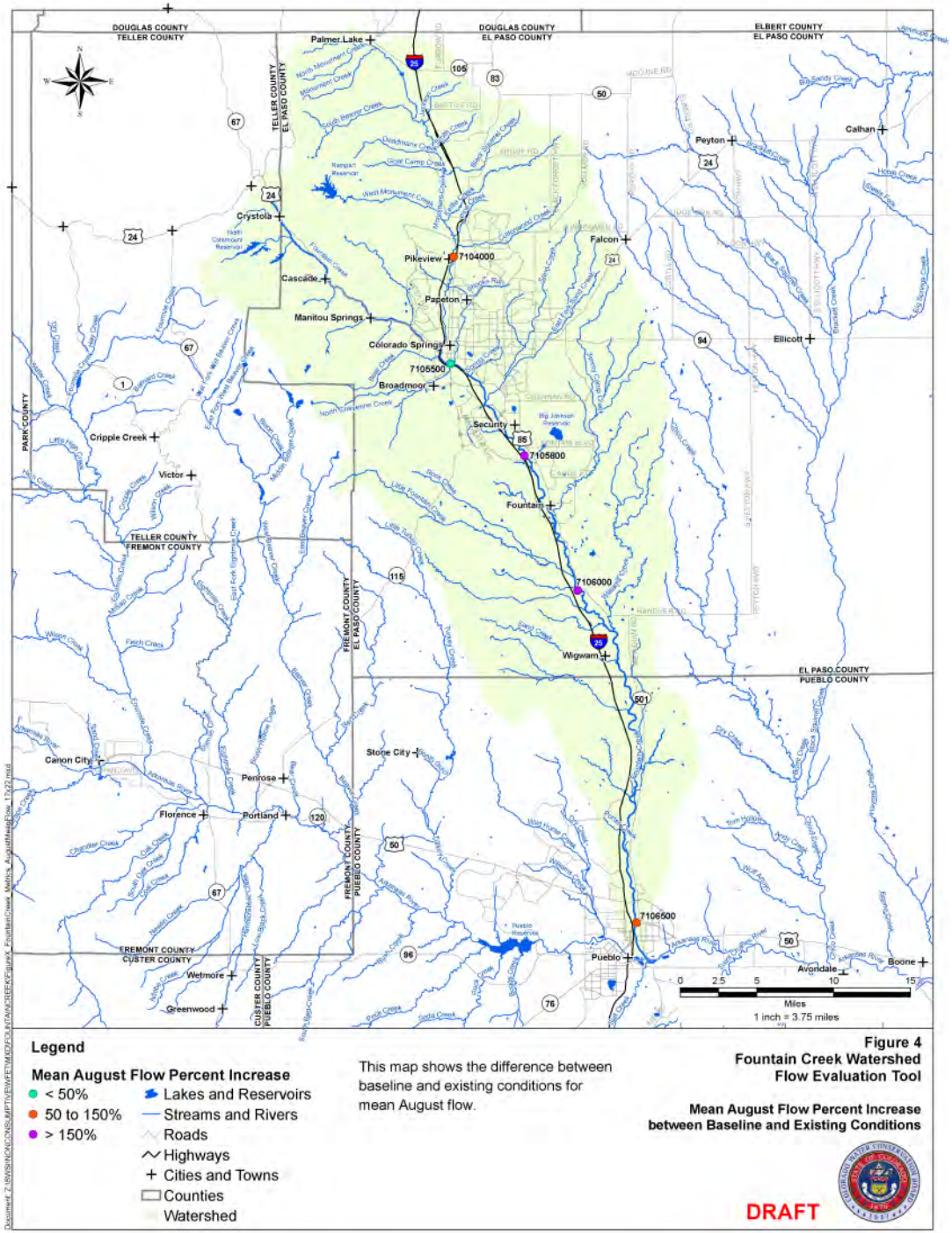
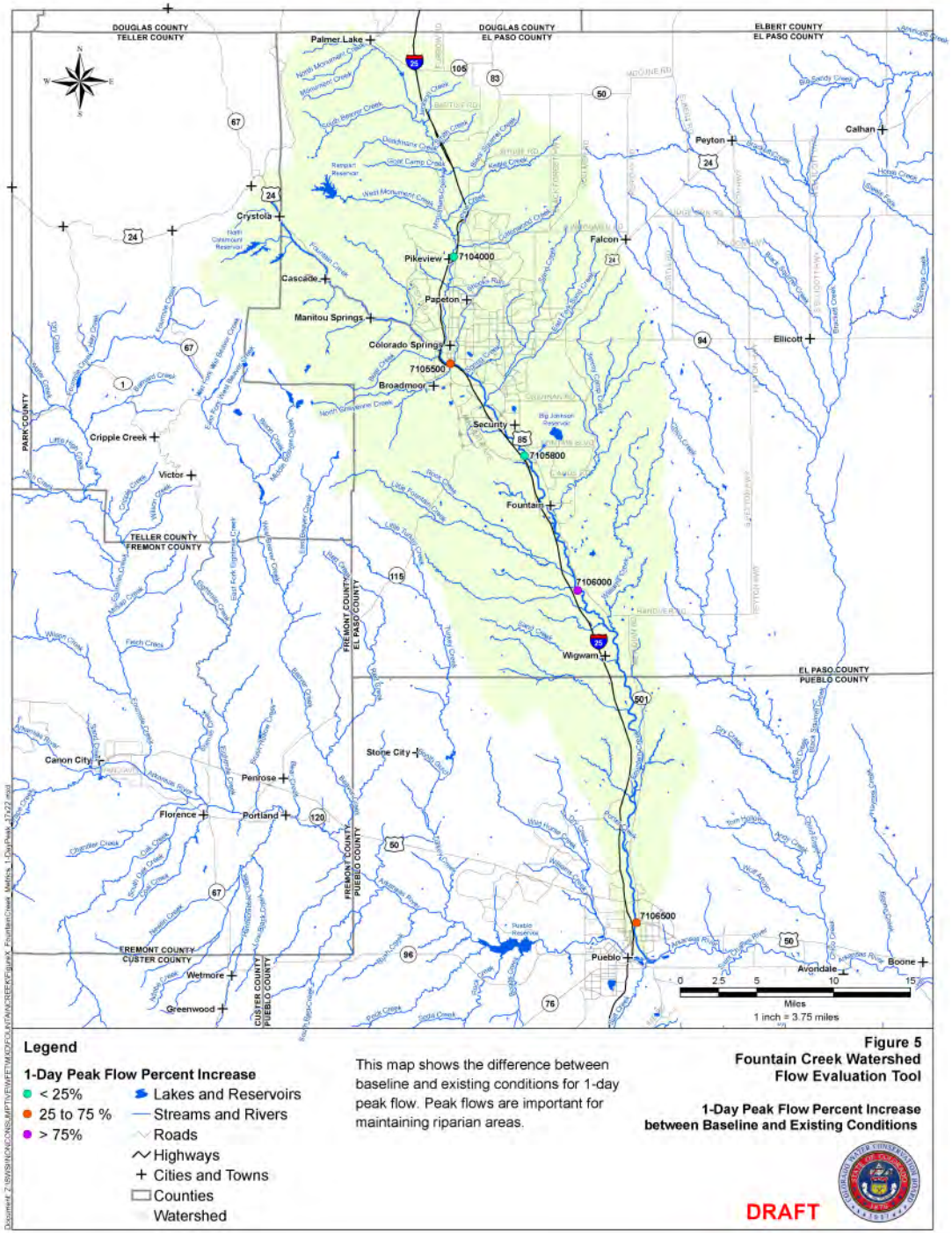


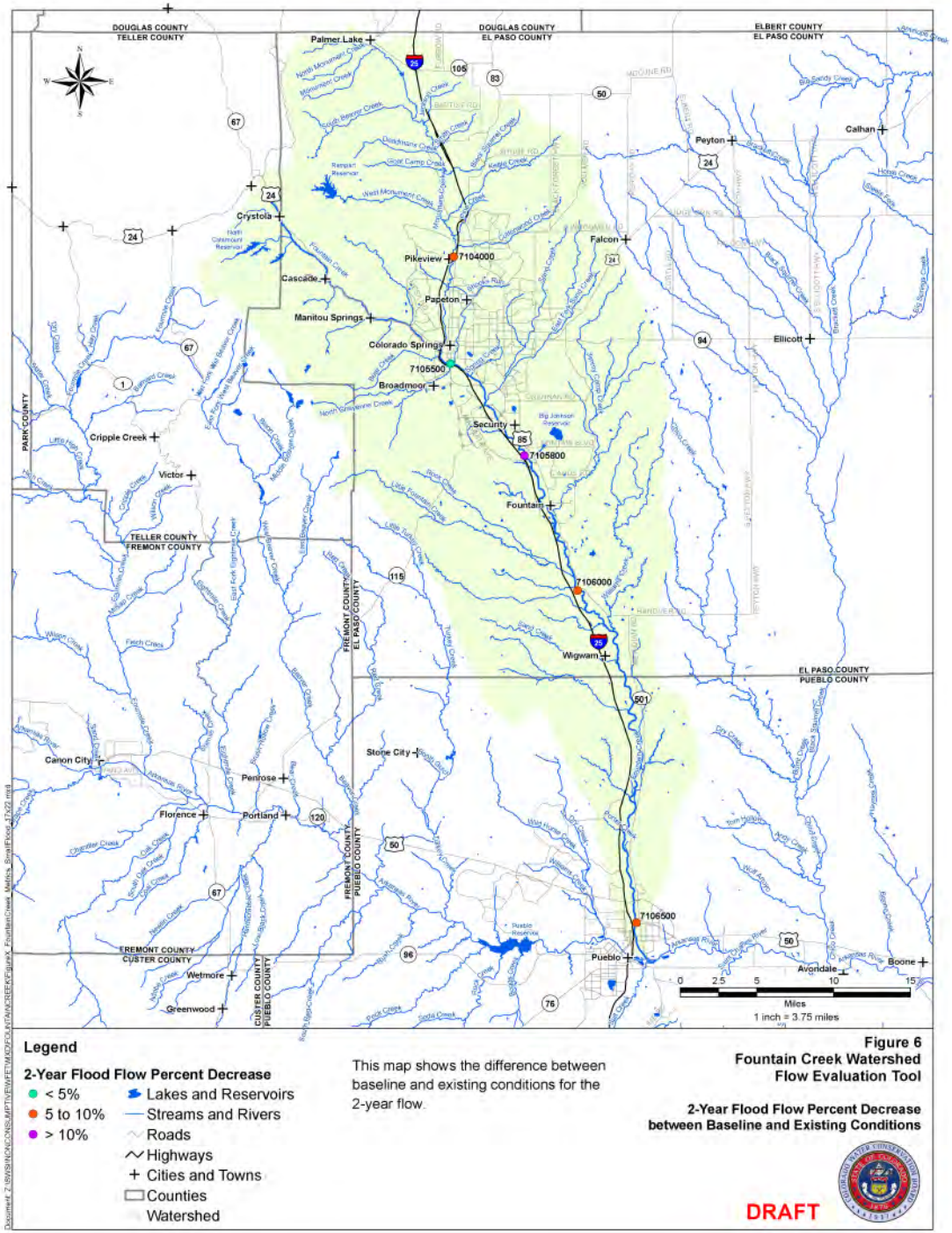
Mean August Flow Percent Increase between Baseline and Existing Conditions

- All locations showed increases in mean August from baseline to existing conditions
- Increases vary throughout basin



1-Day Peak Flow Percent Increase between Baseline and Existing Conditions

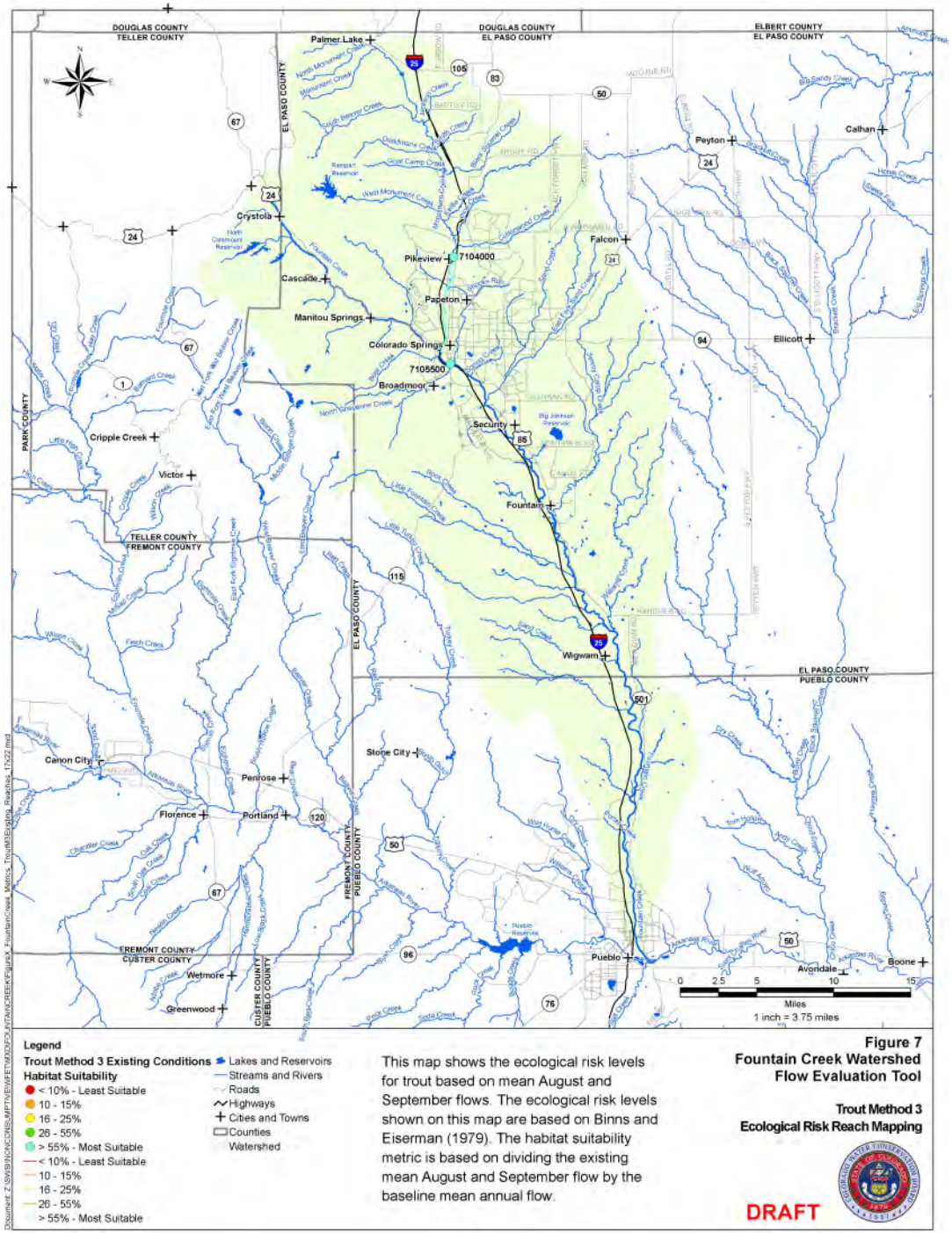
- All locations showed increases in 1-day peak flow from baseline to existing conditions
- Increases vary throughout basin



2-Year Flood Flow Percent Decrease between Baseline and Existing Conditions

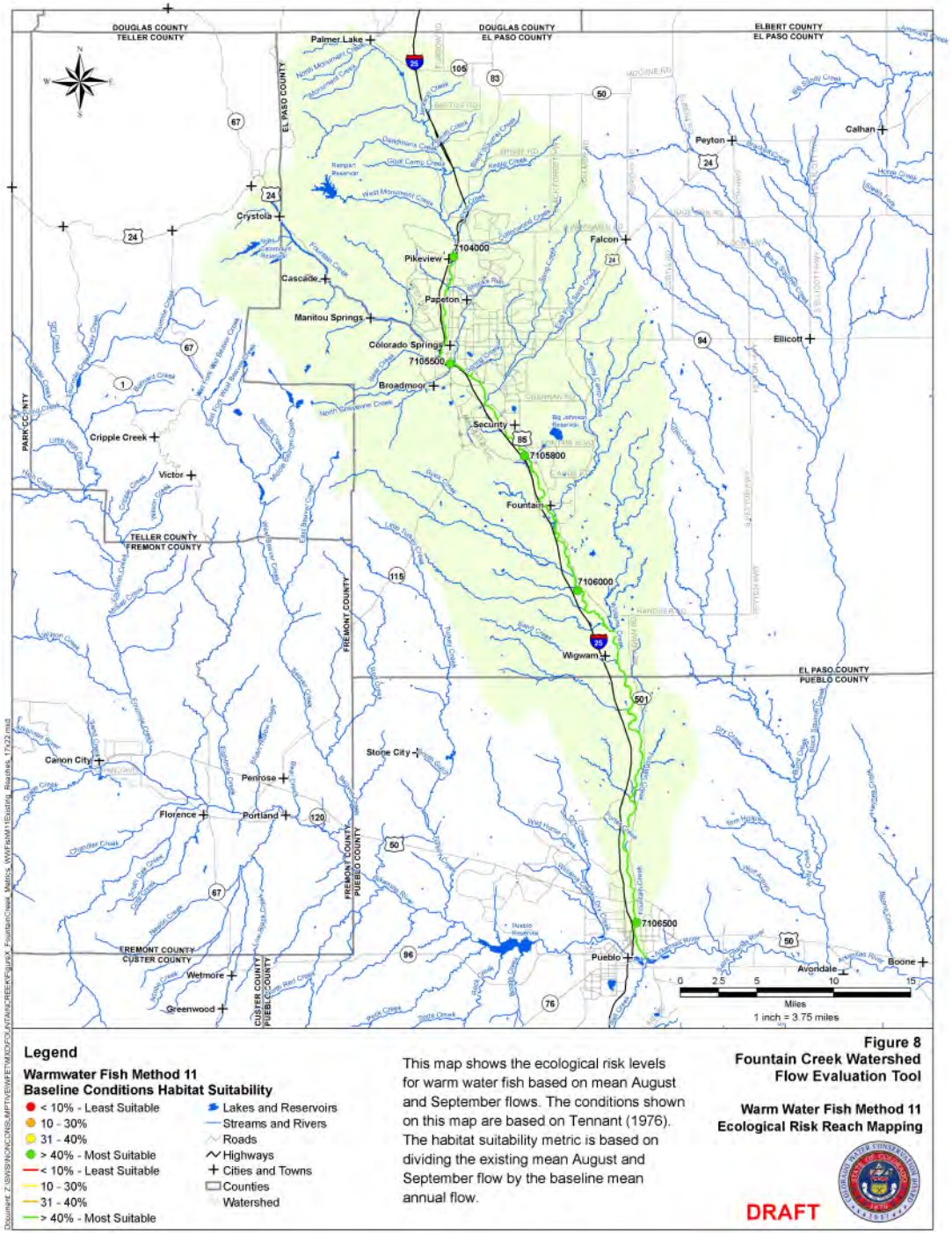
- All locations showed decreases in 2-year flood flow from baseline to existing conditions
- Decreases vary throughout basin

How do these changes in flow relate to ecological changes?



Trout Method 3 Conditions Risk Mapping

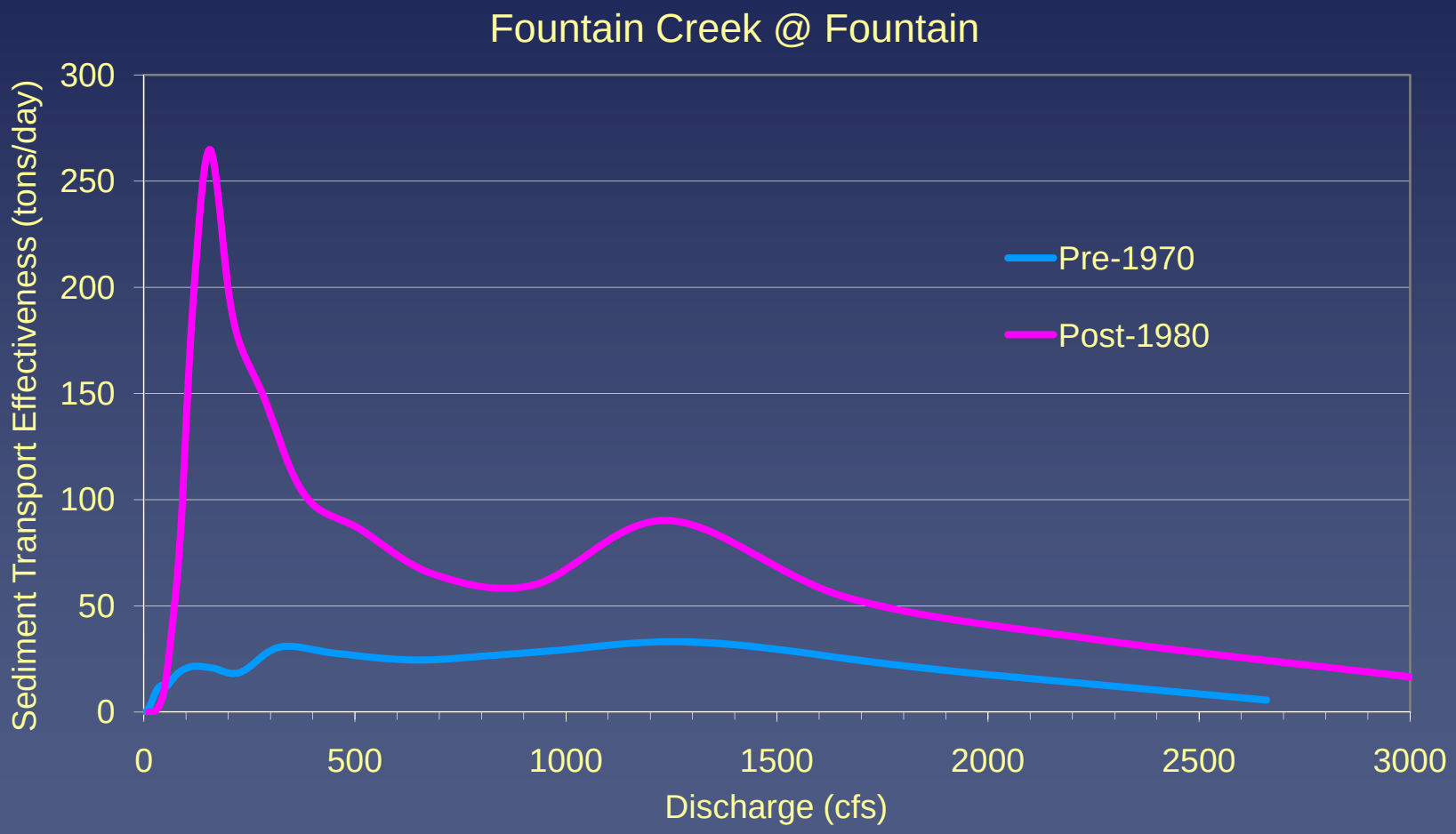
- Metric based on August and September mean flows
- Baseline and existing conditions have high habitat suitability conditions
- Existing conditions metrics nearly double that of baseline conditions metrics



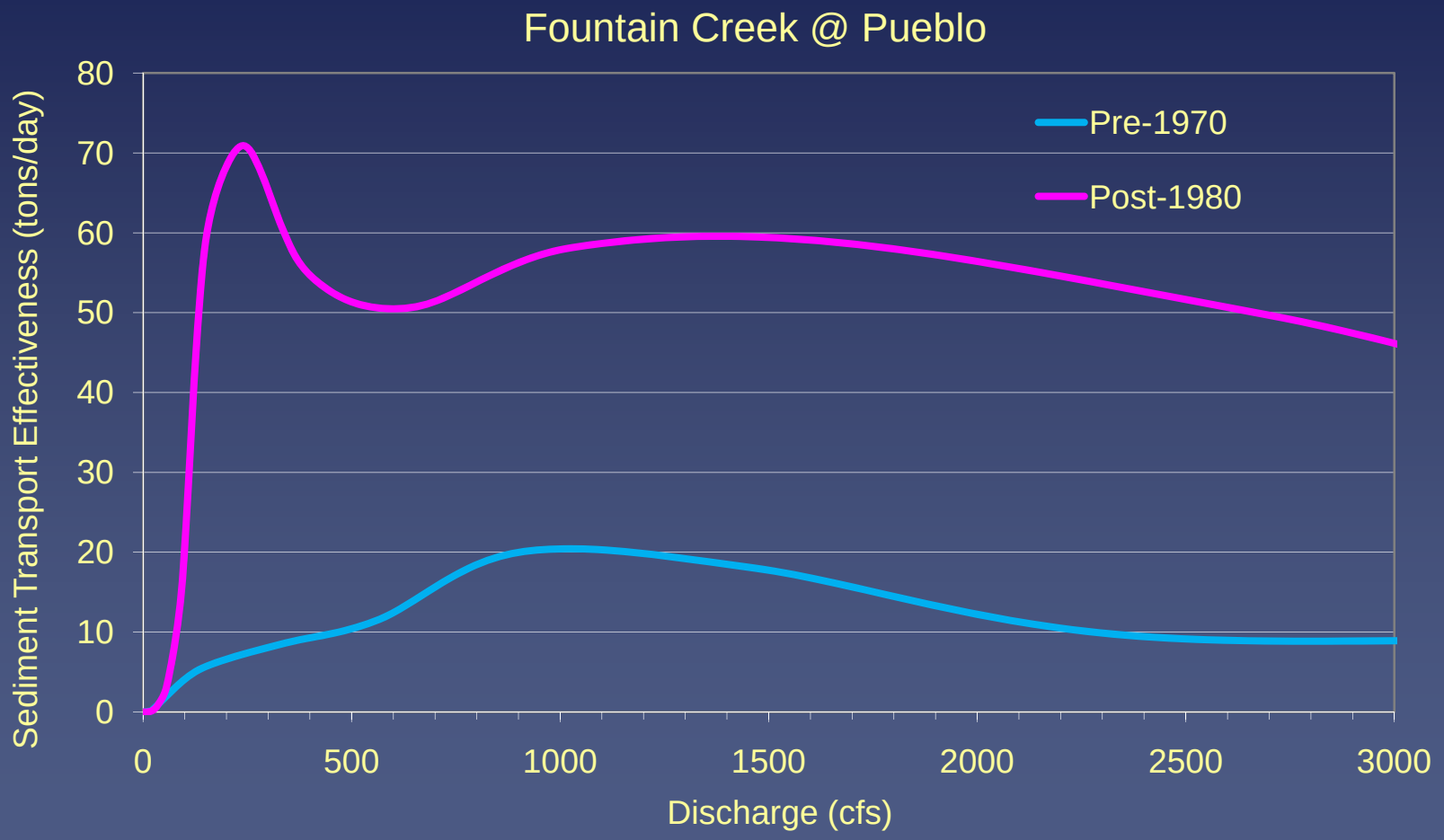
Warm Water Fish Method 11 Conditions Risk Mapping

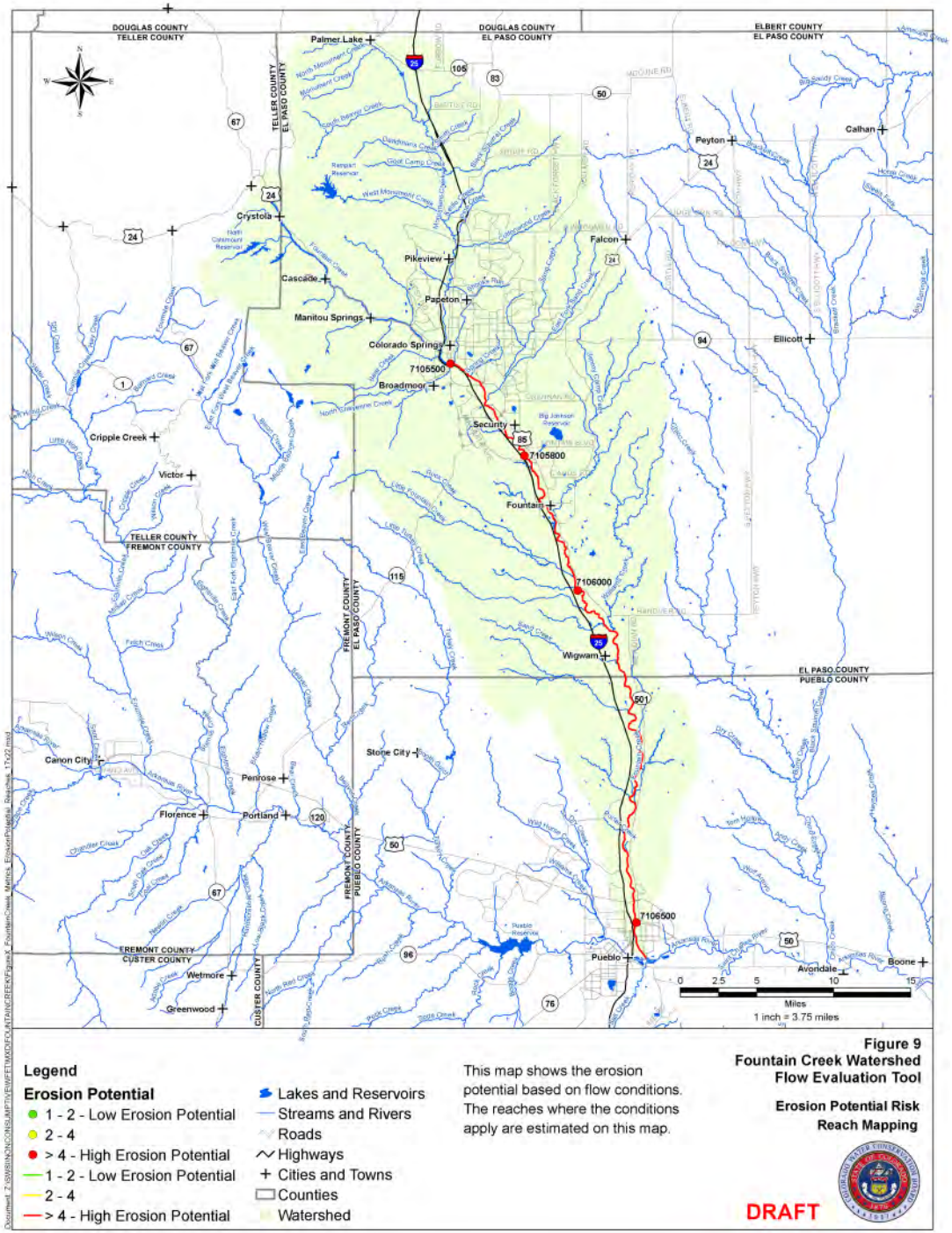
- Metric based on August and September mean flows
- Baseline and existing conditions have high habitat suitability conditions
- Existing conditions metrics nearly triple that of baseline conditions metrics

Erosion Potential



Erosion Potential (con't)





Erosion Potential Risk Mapping

- Figures show high erosion potential downstream of Colorado Springs

Fountain Creek WFET Pilot Conclusions

- Fountain Creek is a complex system with many contributing factors to stream flow and channel change
- Flows have increased downstream of Monument and the Las Vegas WWTP
- Ecological changes based on flow for trout and warm water fish are inconclusive
- Erosion potential is high at lower flows
- More detailed analysis could be completed upon completion of surface water DSS

Questions?

Roaring Fork Watershed Flow Evaluation Tool Results

Roaring Fork WFET Results

- IHA Results
  - Mean annual flow
  - Mean January flow
  - Mean August flow
  - 1-Day peak flow
  - 2-Year flood flow
- Risk Mapping
  - Trout
  - Warm Water Fish
  - Riparian
  - Recreation
- WFET Validation
  - Trout current flow conditions
  - Trout conditions based on higher risk levels
- Methodology for range of flow conditions based on ecological risk levels
- Roaring Fork WFET Pilot Conclusions

How have flows changed?

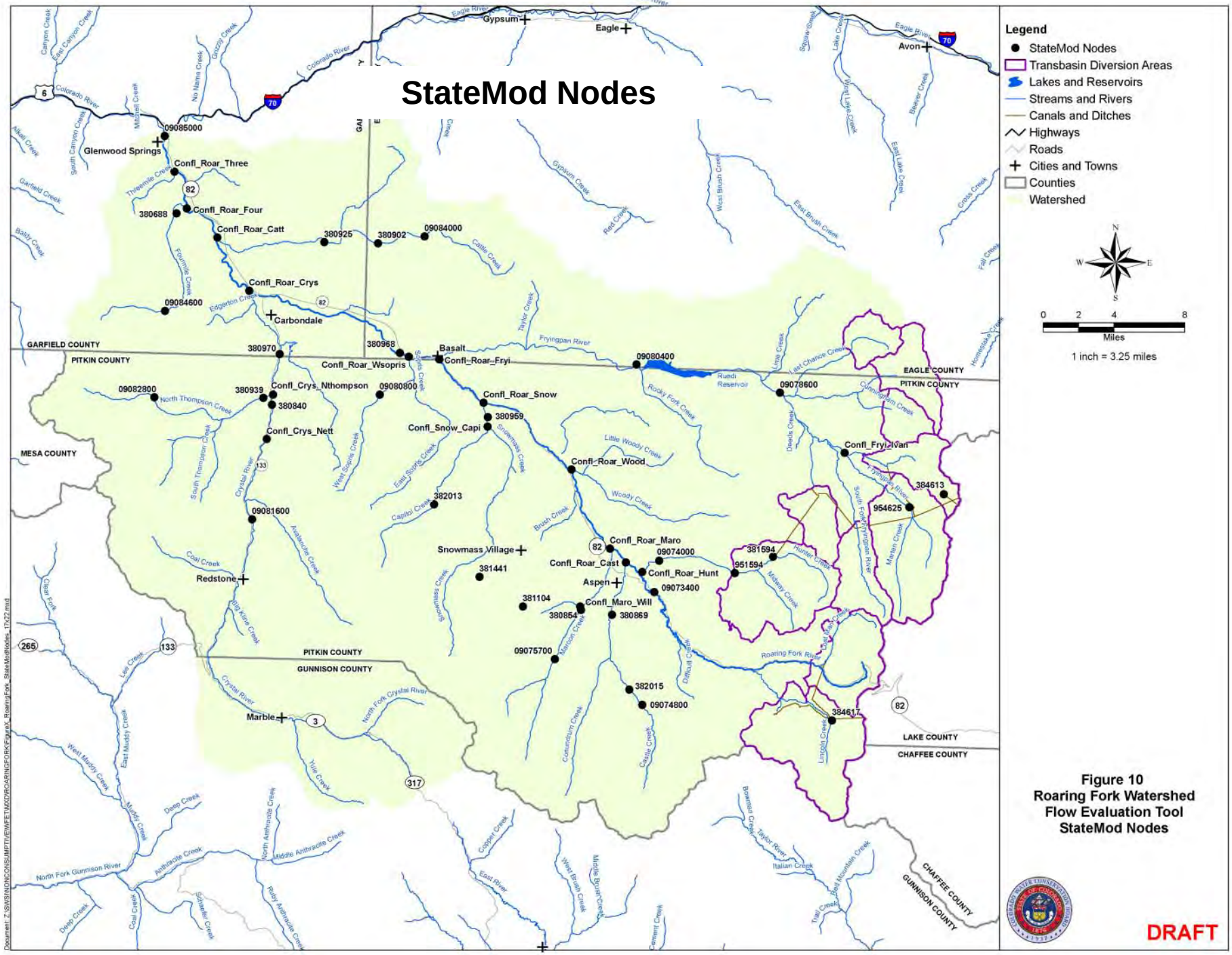


Figure 10
Roaring Fork Watershed
Flow Evaluation Tool
StateMod Nodes

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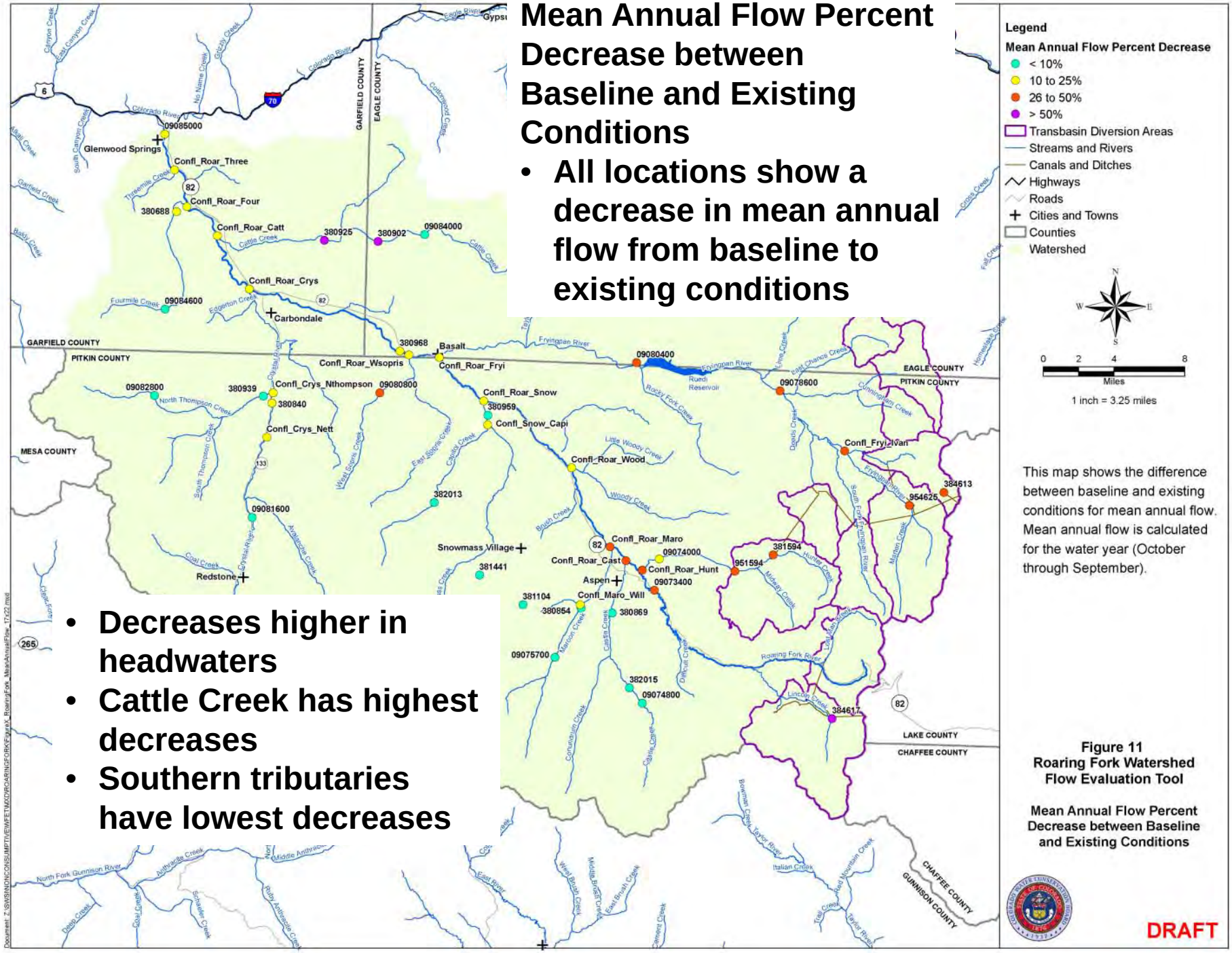
Mean Annual Flow Percent Decrease between Baseline and Existing Conditions
• All locations show a decrease in mean annual flow from baseline to existing conditions
• Decreases higher in headwaters
• Cattle Creek has highest decreases
• Southern tributaries have lowest decreases
Legend
Mean Annual Flow Percent Decrease
< 10%
10 to 25%
26 to 50%
> 50%
Transbasin Diversion Areas
Streams and Rivers
Canals and Ditches
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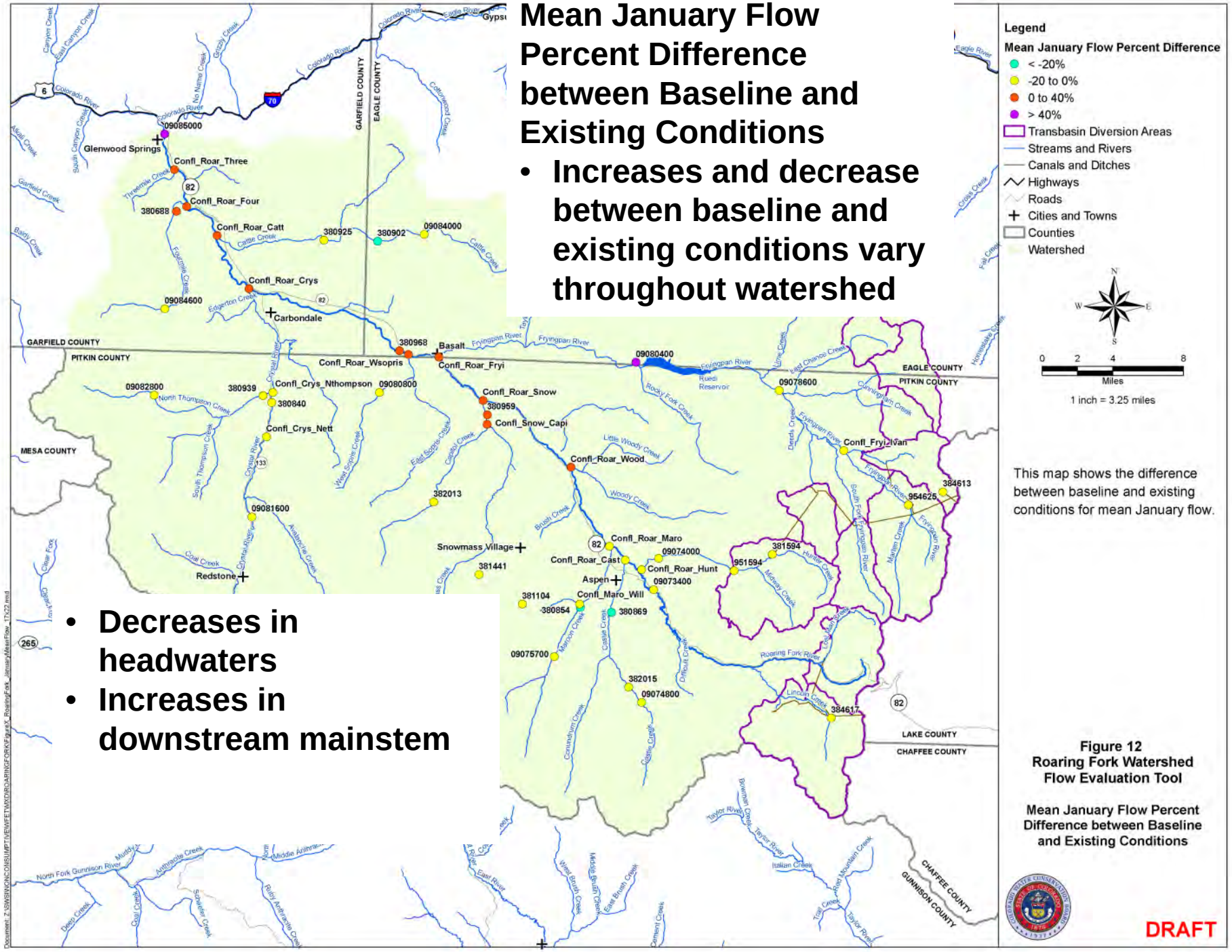
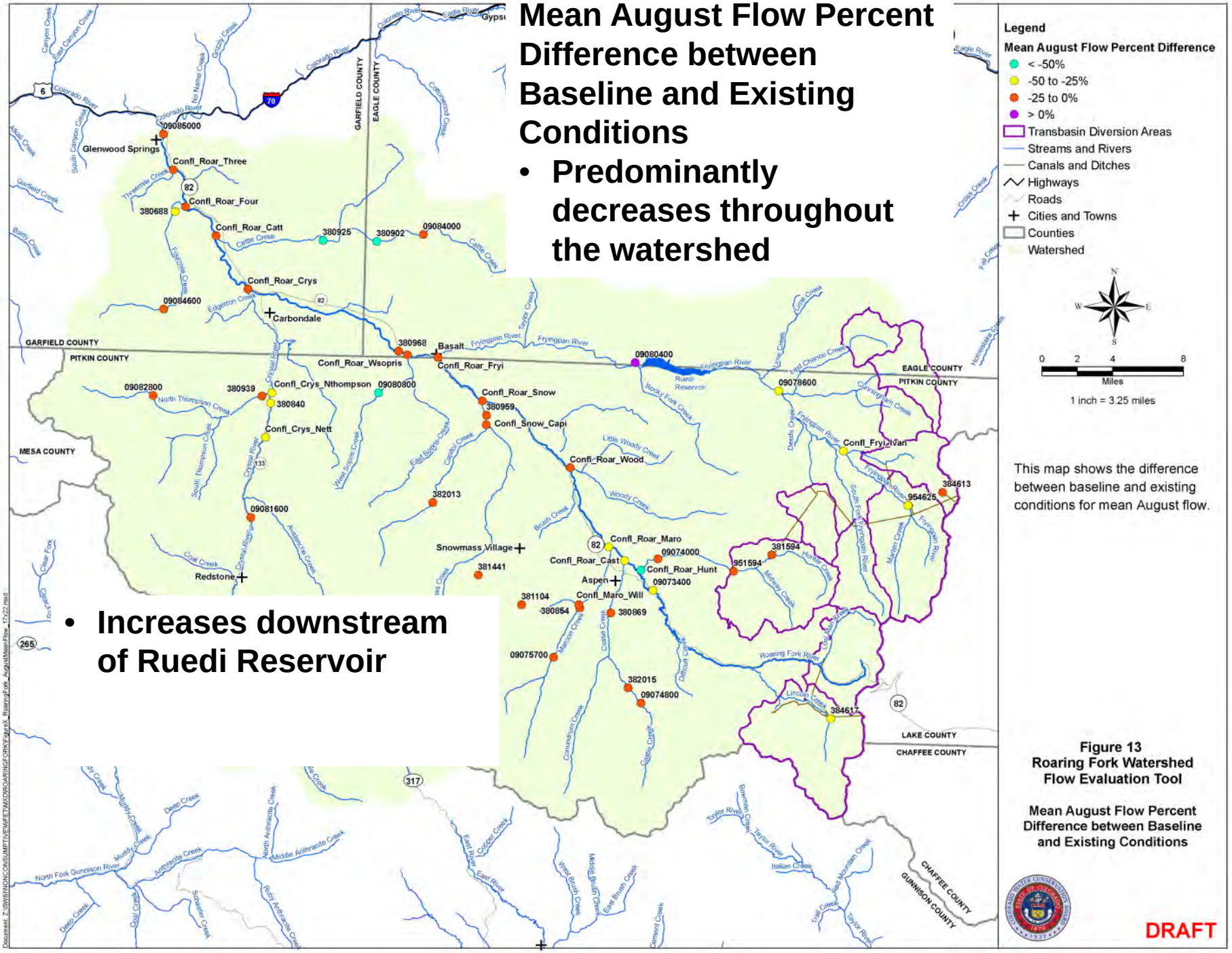
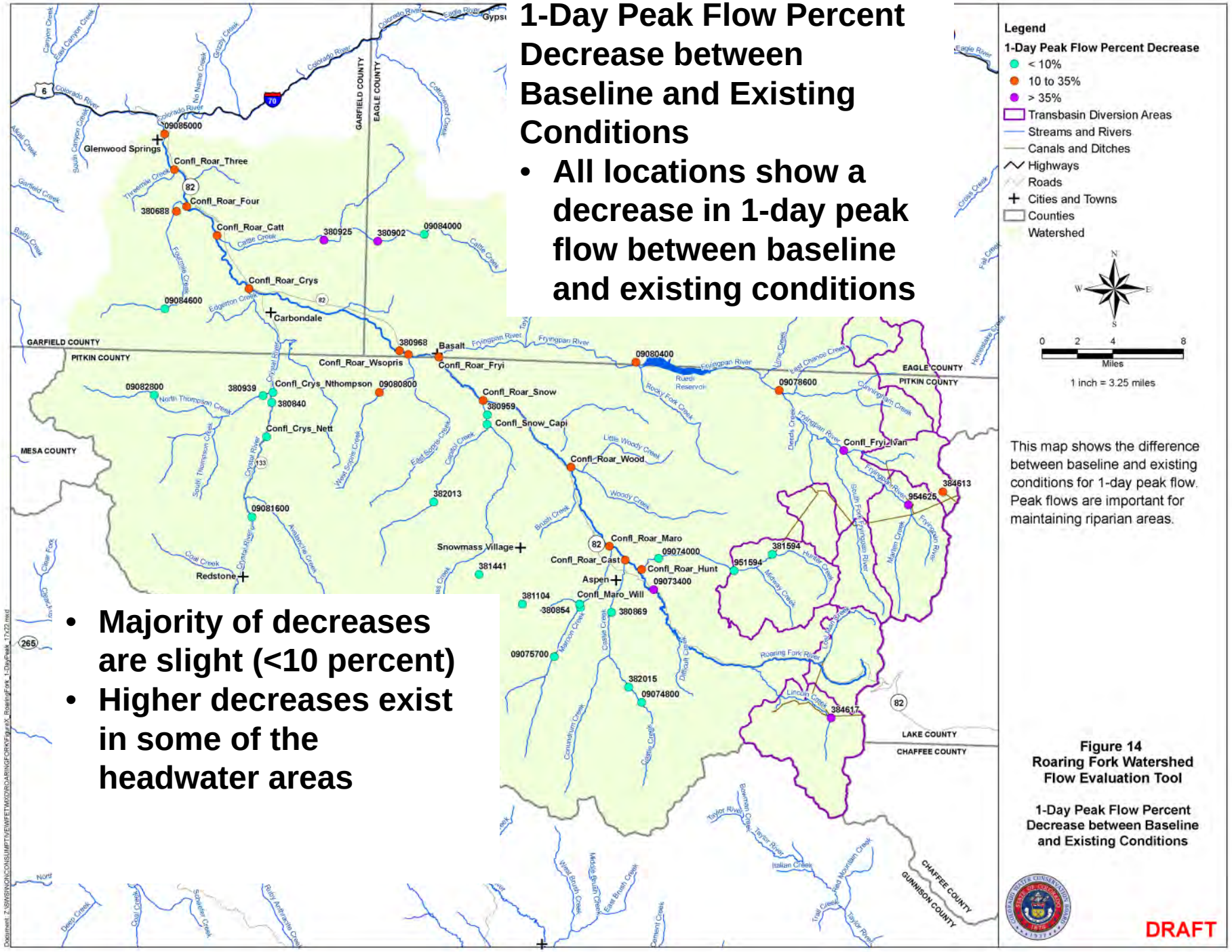
Roads
Cities and Towns
Counties
Watershed
0 2 4 8
Miles
1 inch = 3.25 miles
This map shows the difference between baseline and existing conditions for mean annual flow. Mean annual flow is calculated for the water year (October through September).
Figure 11
Roaring Fork Watershed
Flow Evaluation Tool
Mean Annual Flow Percent Decrease between Baseline and Existing Conditions
DRAFT
Glenwood Springs
Carbondale
Basalt
Snowmass Village
Aspen
Redstone
Ruedi Reservoir
GARFIELD COUNTY
EAGLE COUNTY
PITKIN COUNTY
MESA COUNTY
LAKE COUNTY
CHAFFEE COUNTY
GUNNISON COUNTY
09085000
Confl_Roar_Three
Confl_Roar_Four
380688
Confl_Roar_Catt
380925
380902
09084000
Confl_Roar_Crys
09084600
380968
Confl_Roar_Wsopris
Confl_Roar_Fryi
09080400
09078600
09082800
380939
Confl_Crys_Nthompson
09080800
380840
Confl_Crys_Nett
Confl_Roar_Snow
380959
Confl_Snow_Capi
Confl_Roar_Wood
Confl_Fryi_Ivan
384613
954625
382013
09081600
Confl_Roar_Maro
09074000
Confl_Roar_Cast
Confl_Roar_Hunt
09073400
381594
951594
381441
381104
Confl_Maro_Will
380854
380869
09075700
382015
09074800
384617


Mean January Flow Percent Difference between Baseline and Existing Conditions
• Increases and decrease between baseline and existing conditions vary throughout watershed
• Decreases in headwaters
• Increases in downstream mainstem
Legend
Mean January Flow Percent Difference
< -20%
-20 to 0%
0 to 40%
> 40%
Transbasin Diversion Areas
Streams and Rivers
Canals and Ditches
Highways
Roads
Cities and Towns
Counties
Watershed
0 2 4 8
Miles
1 inch = 3.25 miles
This map shows the difference between baseline and existing conditions for mean January flow.
Figure 12
Roaring Fork Watershed
Flow Evaluation Tool
Mean January Flow Percent Difference between Baseline and Existing Conditions
DRAFT
Glenwood Springs
Carbondale
Basalt
Snowmass Village
Aspen
Redstone
Confl_Roar_Three
Confl_Roar_Four
Confl_Roar_Catt
Confl_Roar_Crys
Confl_Roar_Wsopris
Confl_Roar_Fryi
Confl_Crys_Nthompson
Confl_Crys_Nett
Confl_Roar_Snow
Confl_Snow_Capi
Confl_Roar_Wood
Confl_Roar_Maro
Confl_Roar_Cast
Confl_Roar_Hunt
Confl_Maro_Will
Confl_Fryi_Ivan
09085000
380688
380925
380902
09084000
09084600
380968
09080400
09078600
09082800
380939
380840
09080800
380959
382013
09081600
381441
381104
380854
380869
09075700
382015
09074800
09074000
09073400
951594
381594
954625
384613
384617
GARFIELD COUNTY
EAGLE COUNTY
PITKIN COUNTY
MESA COUNTY
LAKE COUNTY
CHAFFEE COUNTY
GUNNISON COUNTY

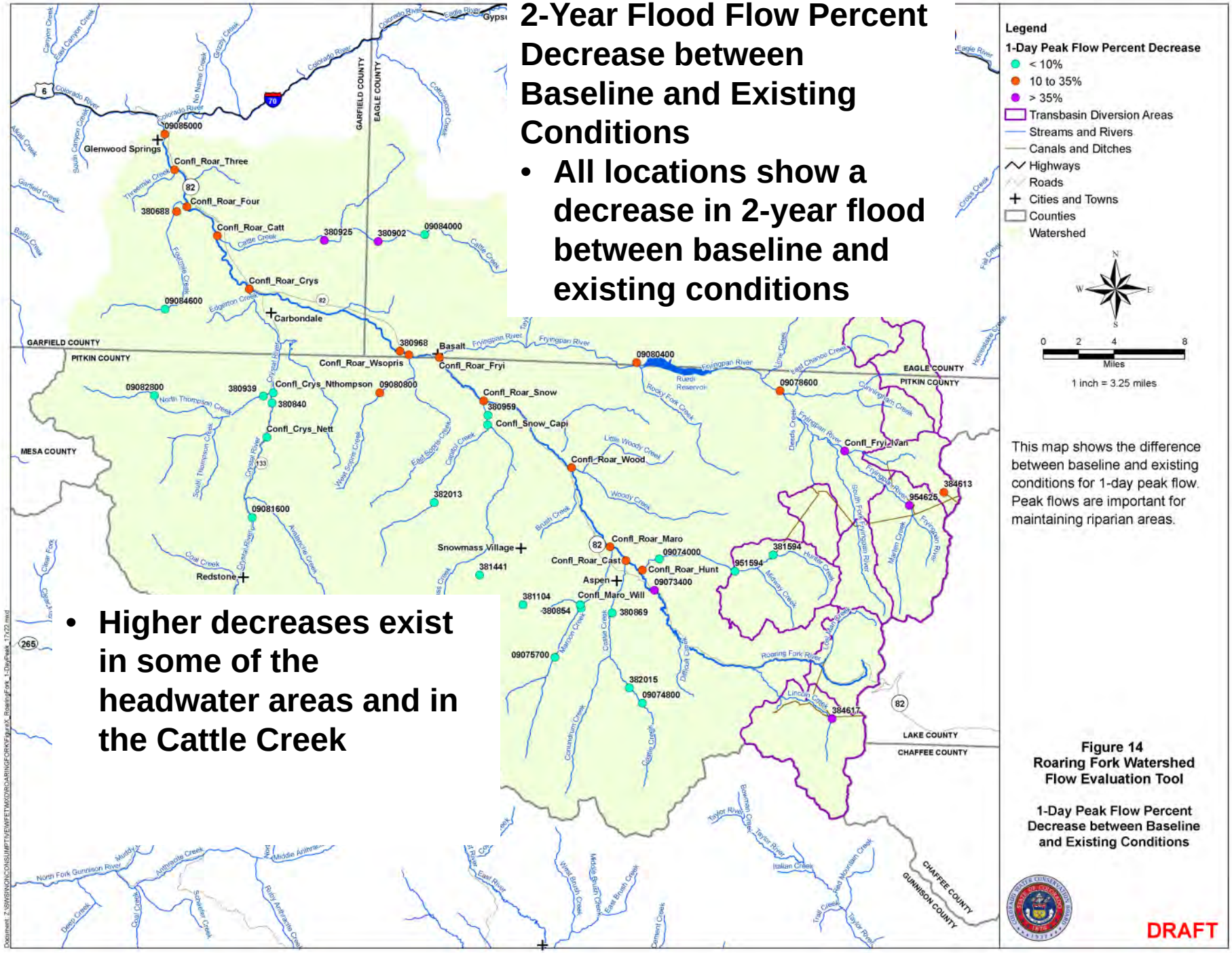

Mean August Flow Percent Difference between Baseline and Existing Conditions
• Predominantly decreases throughout the watershed
• Increases downstream of Ruedi Reservoir
Legend
Mean August Flow Percent Difference
< -50%
-50 to -25%
-25 to 0%
> 0%
Transbasin Diversion Areas
Streams and Rivers
Canals and Ditches
Highways
Roads
Cities and Towns
Counties
Watershed
0 2 4 8
Miles
1 inch = 3.25 miles
This map shows the difference between baseline and existing conditions for mean August flow.
Figure 13
Roaring Fork Watershed
Flow Evaluation Tool
Mean August Flow Percent Difference between Baseline and Existing Conditions
DRAFT
Glenwood Springs
Carbondale
Basalt
Snowmass Village
Aspen
Redstone
Ruedi Reservoir
GARFIELD COUNTY
EAGLE COUNTY
PITKIN COUNTY
MESA COUNTY
LAKE COUNTY
CHAFFEE COUNTY
GUNNISON COUNTY
09085000
Confl_Roar_Three
Confl_Roar_Four
380688
Confl_Roar_Catt
380925
380902
09084000
Confl_Roar_Crys
09084600
380968
Confl_Roar_Wsopris
Confl_Roar_Fryi
09080400
09078600
09082800
380939
Confl_Crys_Nthompson
09080800
380840
Confl_Crys_Nett
Confl_Roar_Snow
380959
Confl_Snow_Capi
Confl_Roar_Wood
Confl_Fryi_Ivan
384613
954625
382013
09081600
Confl_Roar_Maro
09074000
Confl_Roar_Cast
Confl_Roar_Hunt
09073400
381441
381104
Confl_Maro_Will
380854
380869
381594
951594
09075700
382015
09074800
384617

1-Day Peak Flow Percent Decrease between Baseline and Existing Conditions

- All locations show a decrease in 1-day peak flow between baseline and existing conditions



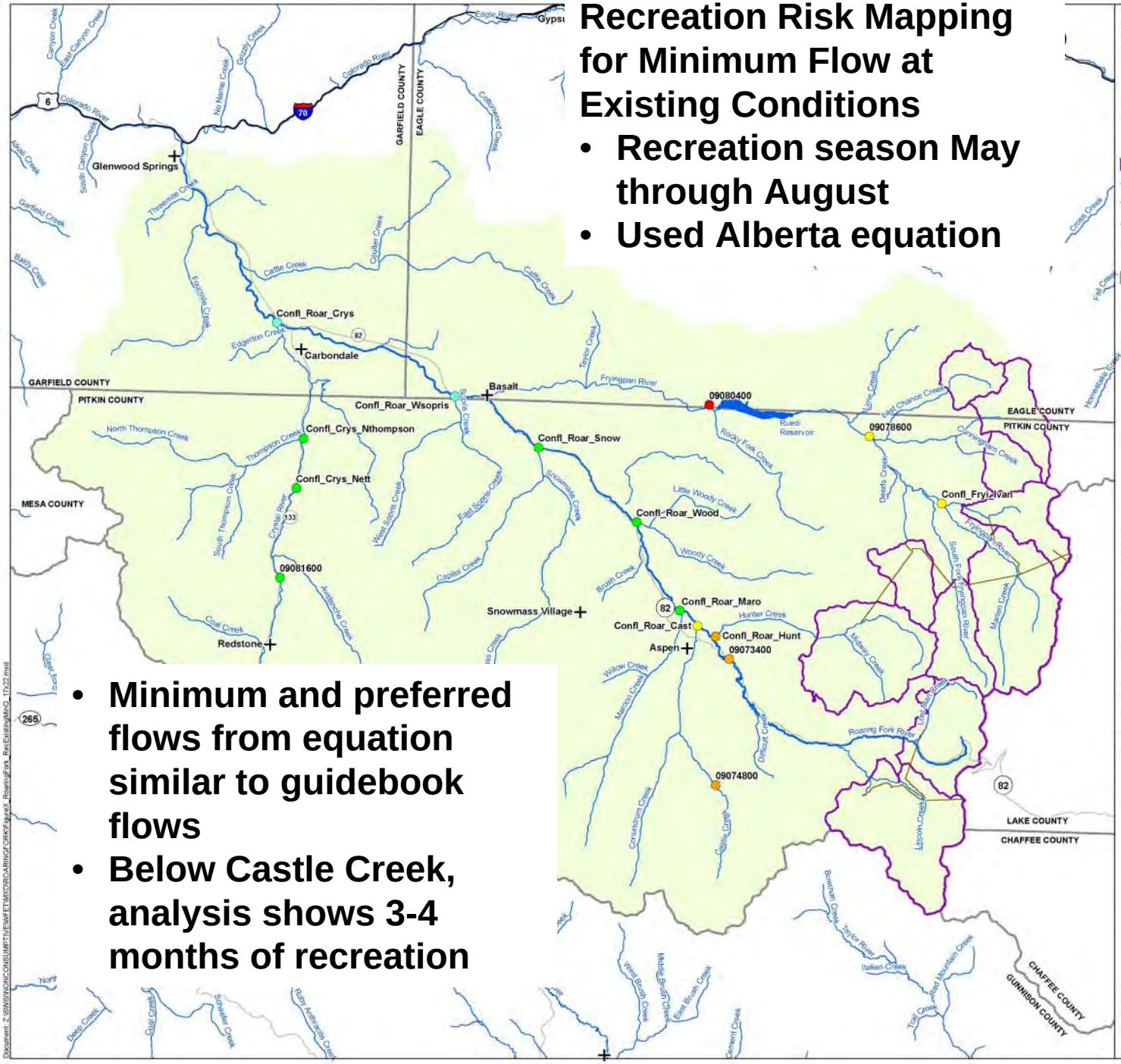
- Majority of decreases are slight (<10 percent)
- Higher decreases exist in some of the headwater areas


2-Year Flood Flow Percent Decrease between Baseline and Existing Conditions
• All locations show a decrease in 2-year flood between baseline and existing conditions
• Higher decreases exist in some of the headwater areas and in the headwater areas and in the Cattle Creek
Legend
1-Day Peak Flow Percent Decrease
< 10%
10 to 35%
> 35%
Transbasin Diversion Areas
Streams and Rivers
Canals and Ditches
Highways
Roads
Cities and Towns
Counties
Watershed
0 2 4 8
Miles
1 inch = 3.25 miles
This map shows the difference between baseline and existing conditions for 1-day peak flow. Peak flows are important for maintaining riparian areas.
Figure 14
Roaring Fork Watershed
Flow Evaluation Tool
1-Day Peak Flow Percent Decrease between Baseline and Existing Conditions
DRAFT
Glenwood Springs
Carbondale
Redstone
Snowmass Village
Aspen
Basalt
GARFIELD COUNTY
EAGLE COUNTY
PITKIN COUNTY
MESA COUNTY
LAKE COUNTY
CHAFFEE COUNTY
GUNNISON COUNTY
09085000
Confl_Roar_Three
Confl_Roar_Four
380688
Confl_Roar_Catt
380925
380902
09084000
Confl_Roar_Crys
09084600
380968
Confl_Roar_Wsopris
Confl_Roar_Fryi
09080400
09078600
09082800
380939
Confl_Crys_Nthompson
09080800
380840
Confl_Crys_Nett
Confl_Roar_Snow
380959
Confl_Snow_Capi
Confl_Roar_Wood
Confl_Fryi_Ivan
384613
954625
382013
09081600
Confl_Roar_Maro
09074000
Confl_Roar_Cast
Confl_Roar_Hunt
09073400
381441
381104
Confl_Maro_Will
380854
380869
381594
951594
09075700
382015
09074800
384617

How do these changes in flow relate to ecological changes?

Recreation Risk Mapping for Minimum Flow at Existing Conditions

- Recreation season May through August
- Used Alberta equation



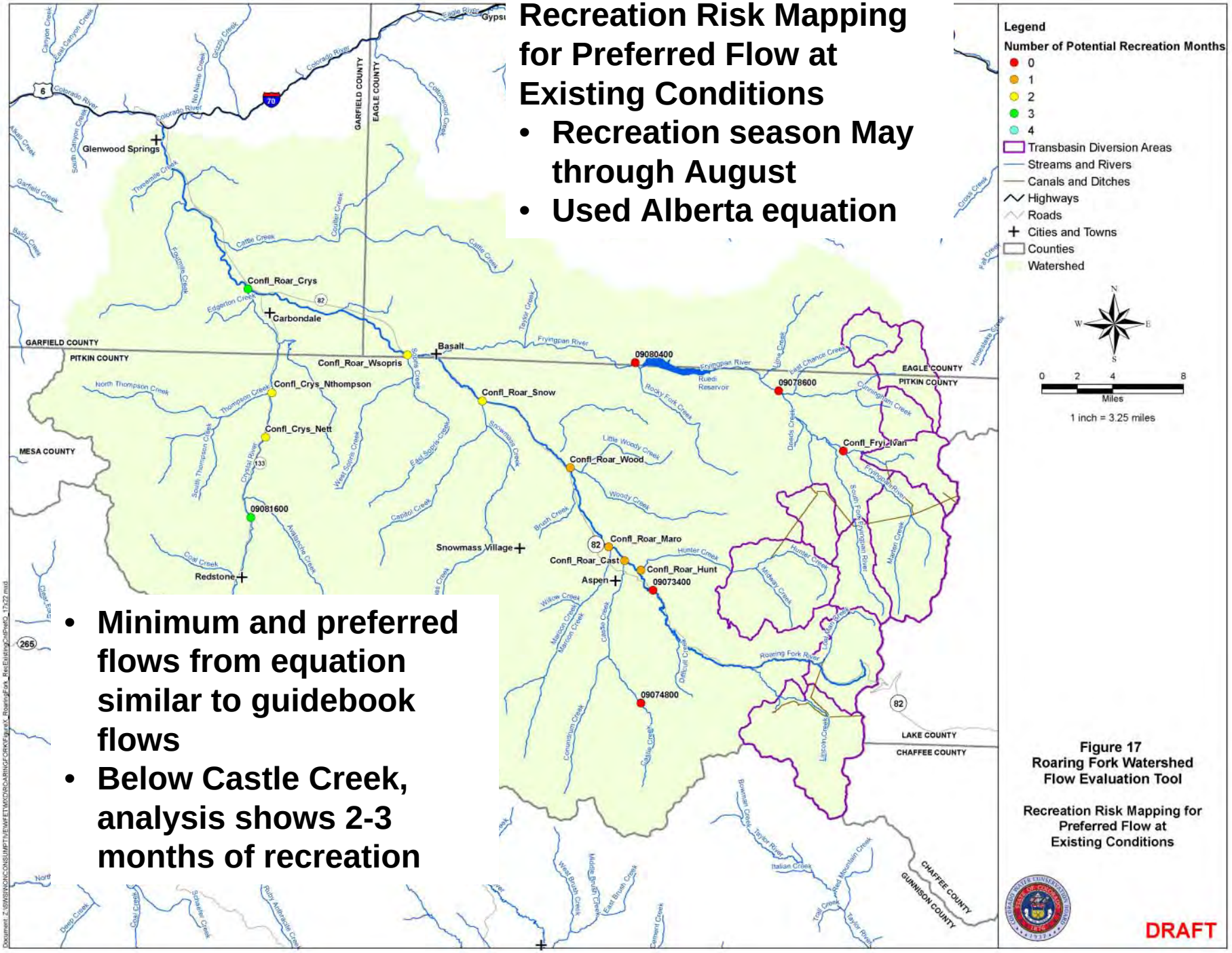
- Minimum and preferred flows from equation similar to guidebook flows
- Below Castle Creek, analysis shows 3-4 months of recreation

This map shows the number of potential months that recreation would be supported based on preferred flows calculated using the Alberta equation (Rood et al. 2006) for existing conditions. The number of potential recreation months is 4 months (May through August). The mean flow of the May through August flows were compared to the minimum calculated flows and if they exceed the minimum flow they were counted as suitable.

Figure 16
Roaring Fork Watershed Flow Evaluation Tool

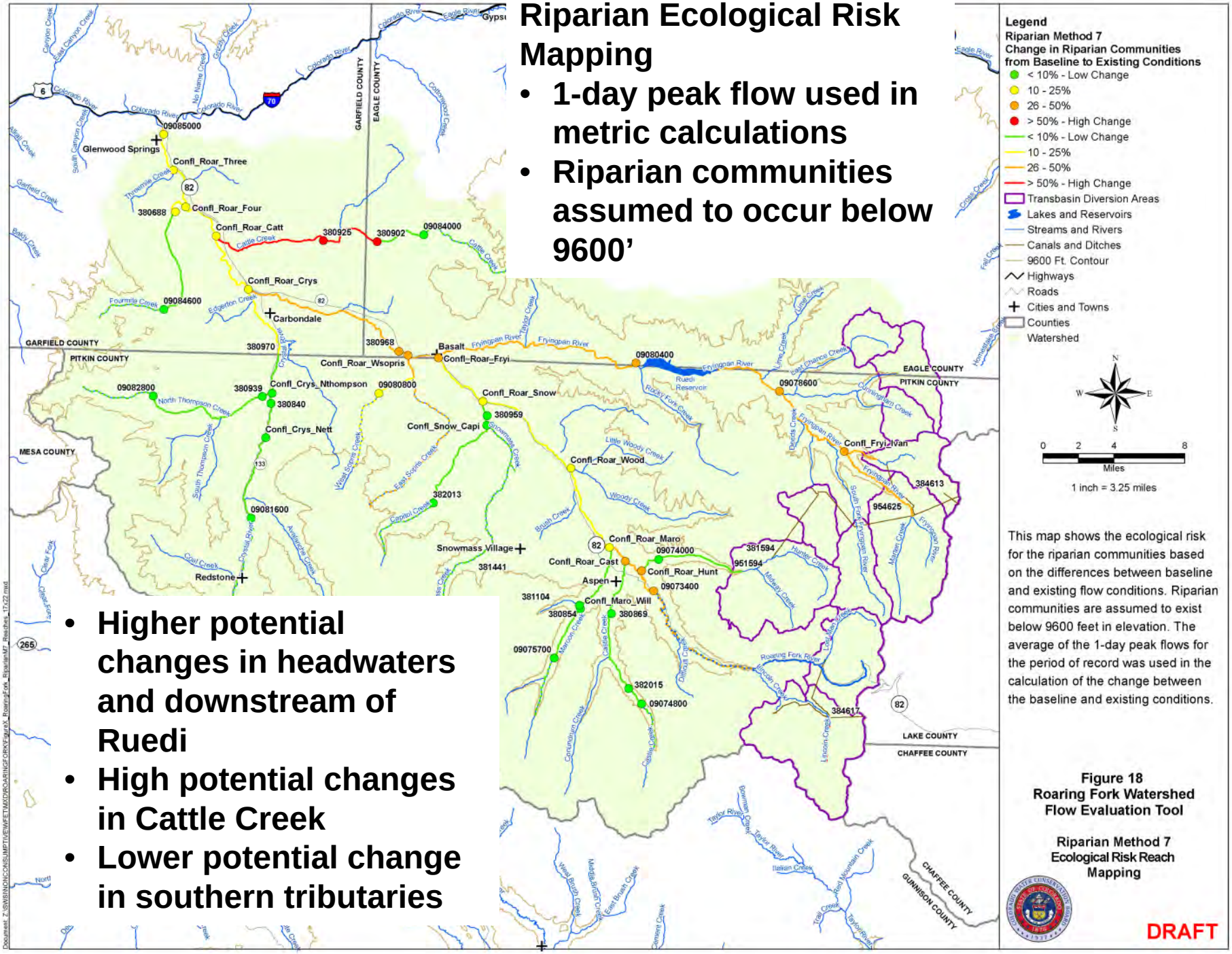
Recreation Risk Mapping for Minimum Flow at Existing Conditions

DRAFT


Recreation Risk Mapping for Preferred Flow at Existing Conditions
• Recreation season May through August
• Used Alberta equation
• Minimum and preferred flows from equation similar to guidebook flows
• Below Castle Creek, analysis shows 2-3 months of recreation
Legend
Number of Potential Recreation Months
0
1
2
3
4
Transbasin Diversion Areas
Streams and Rivers
Canals and Ditches
Highways
Roads
Cities and Towns
Counties
Watershed
0 2 4 8
Miles
1 inch = 3.25 miles
Figure 17
Roaring Fork Watershed
Flow Evaluation Tool
Recreation Risk Mapping for Preferred Flow at Existing Conditions
DRAFT
Glenwood Springs
Carbondale
Basalt
Snowmass Village
Aspen
Redstone
Confl_Roar_Crys
Confl_Roar_Wsopris
Confl_Crys_Nthompson
Confl_Crys_Nett
Confl_Roar_Snow
Confl_Roar_Wood
Confl_Roar_Maro
Confl_Roar_Cast
Confl_Roar_Hunt
Confl_Fryi_Ivan
09081600
09080400
09078600
09073400
09074800
GARFIELD COUNTY
PITKIN COUNTY
EAGLE COUNTY
MESA COUNTY
LAKE COUNTY
CHAFFEE COUNTY
GUNNISON COUNTY

Riparian Ecological Risk Mapping

- 1-day peak flow used in metric calculations
- Riparian communities assumed to occur below 9600’

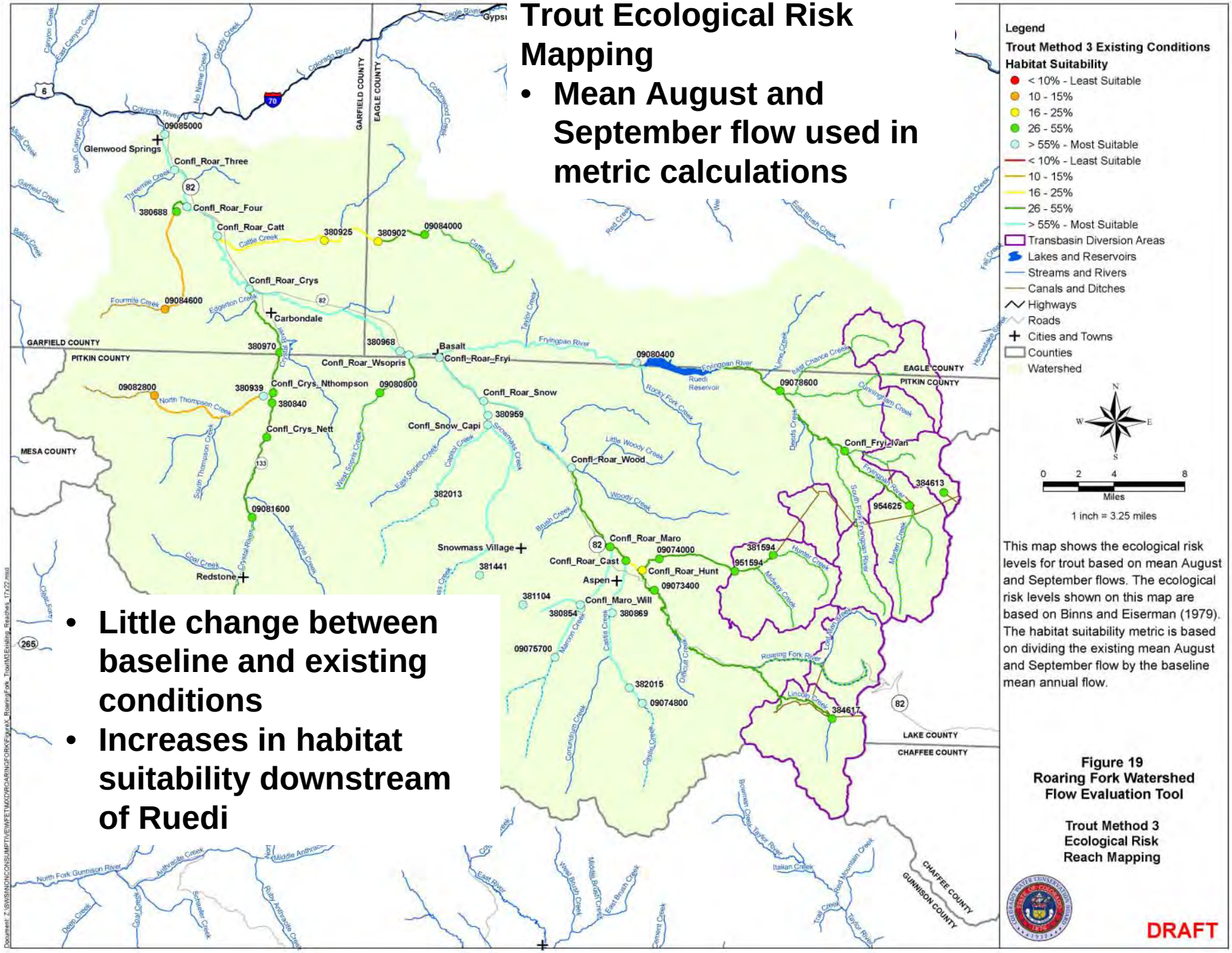


- Higher potential changes in headwaters and downstream of Ruedi
- High potential changes in Cattle Creek
- Lower potential change in southern tributaries

Trout Ecological Risk Mapping

- **Mean August and September flow used in metric calculations**

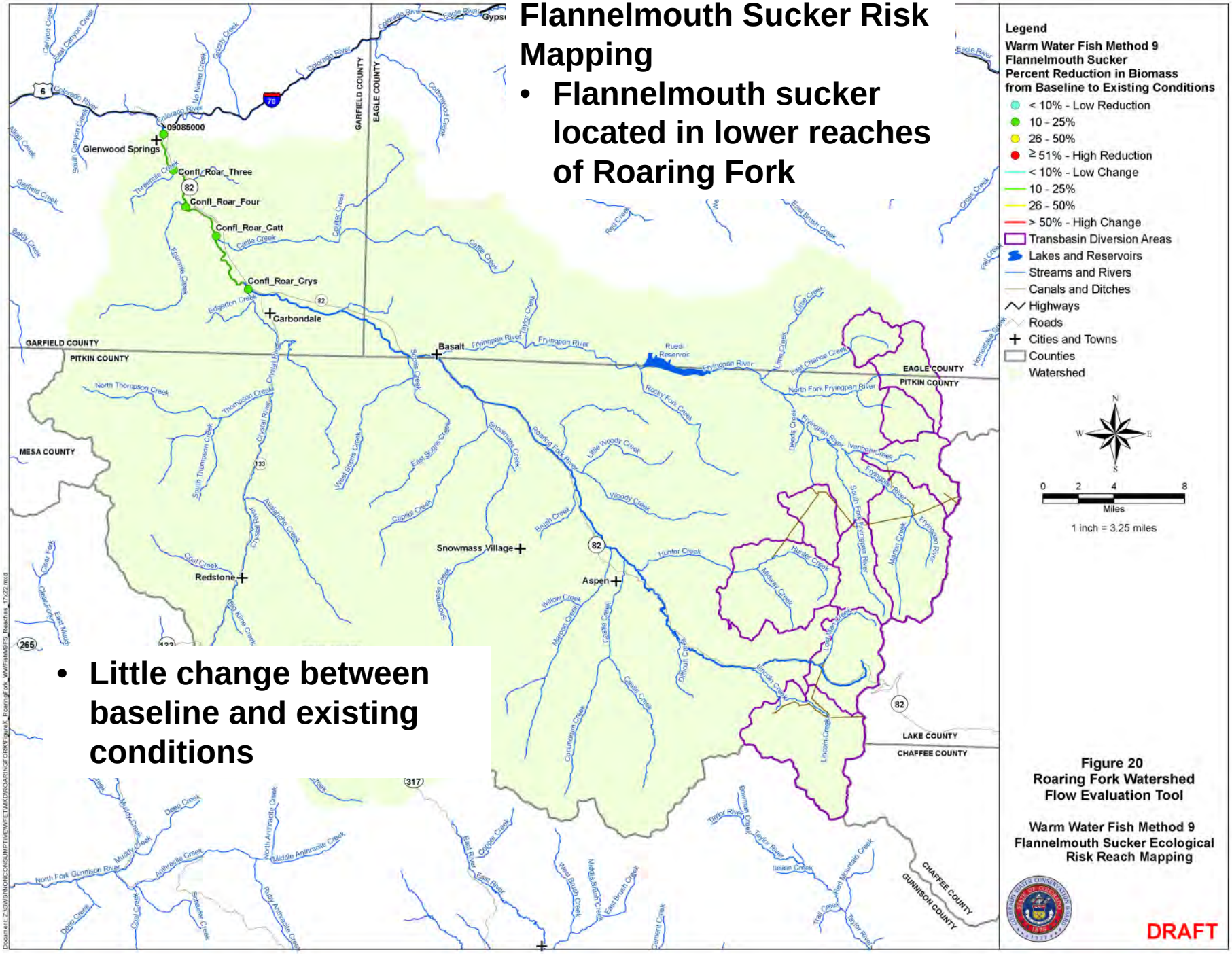
- **Little change between baseline and existing conditions**
- **Increases in habitat suitability downstream of Ruedi**



Flannelmouth Sucker Risk Mapping

- Flannelmouth sucker located in lower reaches of Roaring Fork

- Little change between baseline and existing conditions



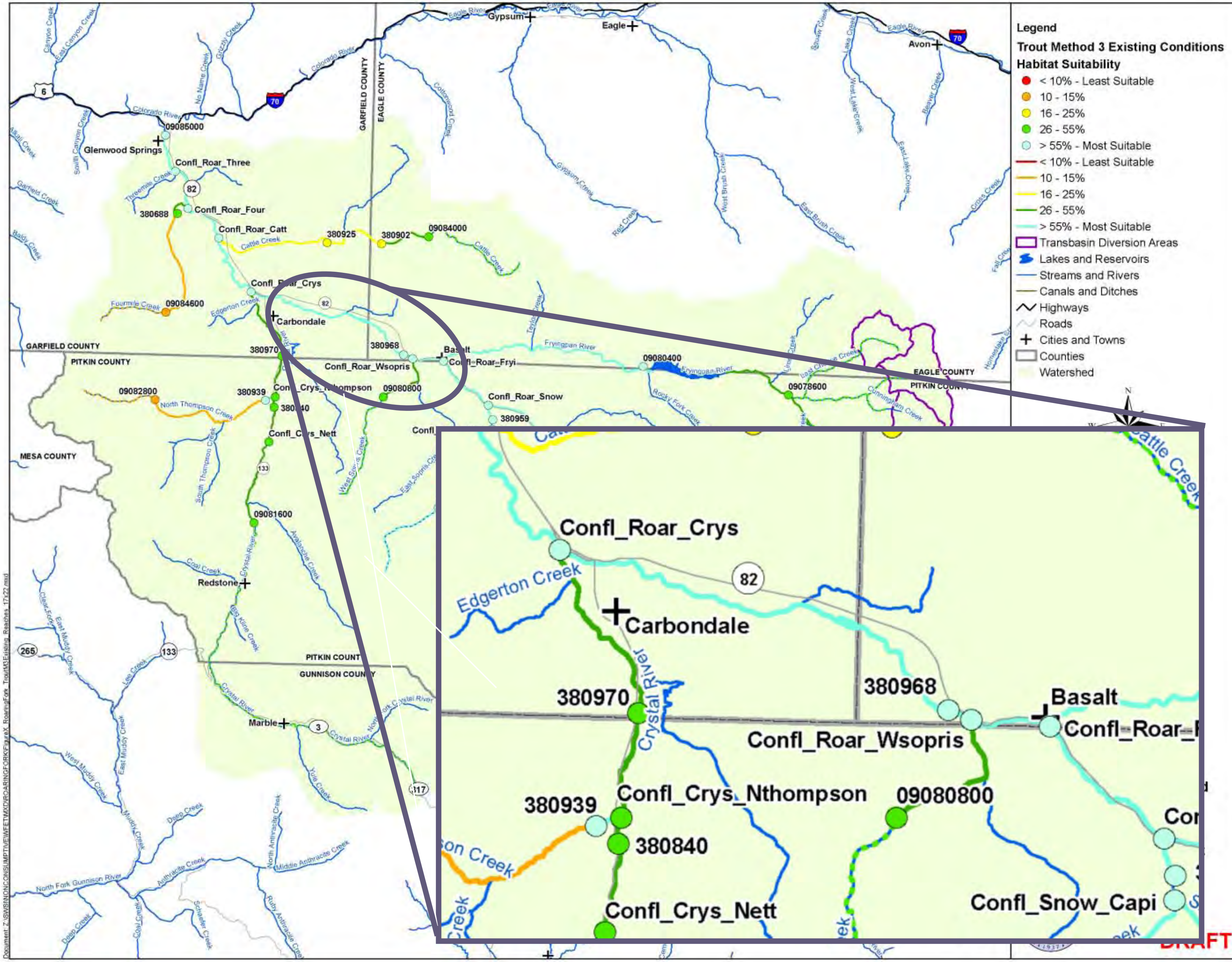
Questions?

WFET Validation

- Used results from site-specific pilot
  - Are results from site-specific pilot for existing conditions similar to WFET results?
  - What conditions are present for site-specific reach using high risk flow conditions predicted from WFET?

Site-Specific Approach

- Used existing PHABSIM data for the Roaring Fork at the Tree Farm, near Emma, Colorado
- Site established as part of the Fryingpan Fishery study
- Representative of the Roaring Fork from Fryingpan River downstream to the Crystal River
- Objective: Demonstrate use of site specific data to evaluate NCNA flows



Legend
Trout Method 3 Existing Conditions
Habitat Suitability
< 10% - Least Suitable
10 - 15%
16 - 25%
26 - 55%
> 55% - Most Suitable
< 10% - Least Suitable
10 - 15%
16 - 25%
26 - 55%
> 55% - Most Suitable
Transbasin Diversion Areas
Lakes and Reservoirs
Streams and Rivers
Canals and Ditches
Highways
Roads
Cities and Towns
Counties
Watershed
Glenwood Springs
Carbondale
Basalt
Redstone
Marble
Gypsum
Eagle
Avon
GARFIELD COUNTY
PITKIN COUNTY
EAGLE COUNTY
MESA COUNTY
GUNNISON COUNTY
09085000
Confl_Roar_Three
Confl_Roar_Four
380688
Confl_Roar_Catt
380925
380902
09084000
Confl_Roar_Crys
09084600
380970
380968
Confl_Roar_Wsopris
Confl_Roar_Fryi
09080400
09078600
09082800
380939
Confl_Crys_Nthompson
380840
09080800
Confl_Roar_Snow
380959
Confl_Crys_Nett
09081600
Confl_Snow_Capi
DRAFT

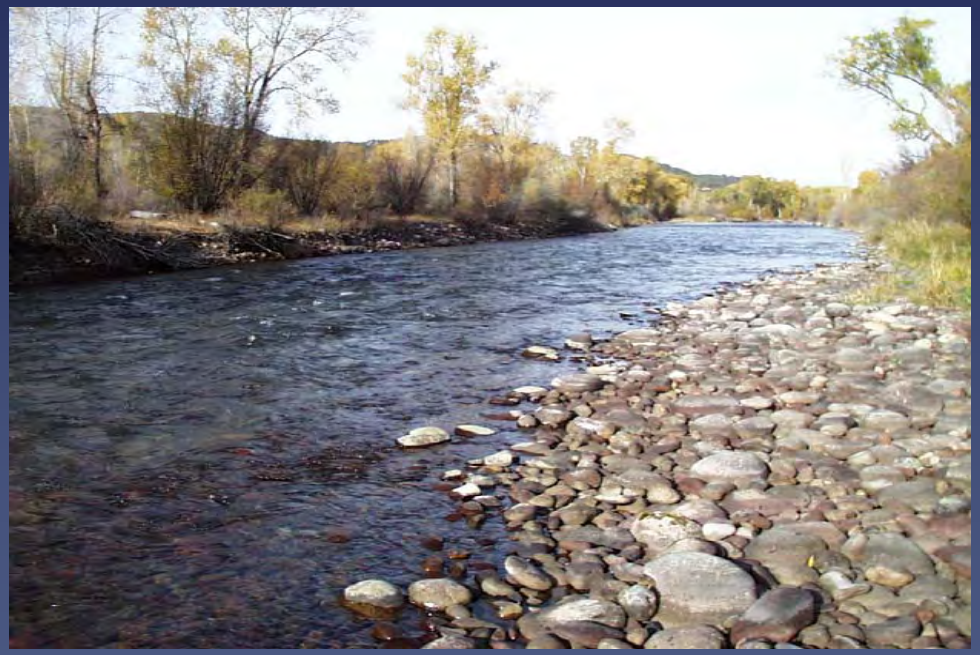
Methods

- PHABSIM data set
  - Five cross sections
  - Riffle and Run habitat
  - Four different flows measured
- Analysis
  - Graphed water surface at a range of conditions to determine channel width changes with flow
  - Simulated habitat for rainbow and brown trout over a range of flows conditions
  - Compared habitat for baseline and existing condition hydrology (StateMod)

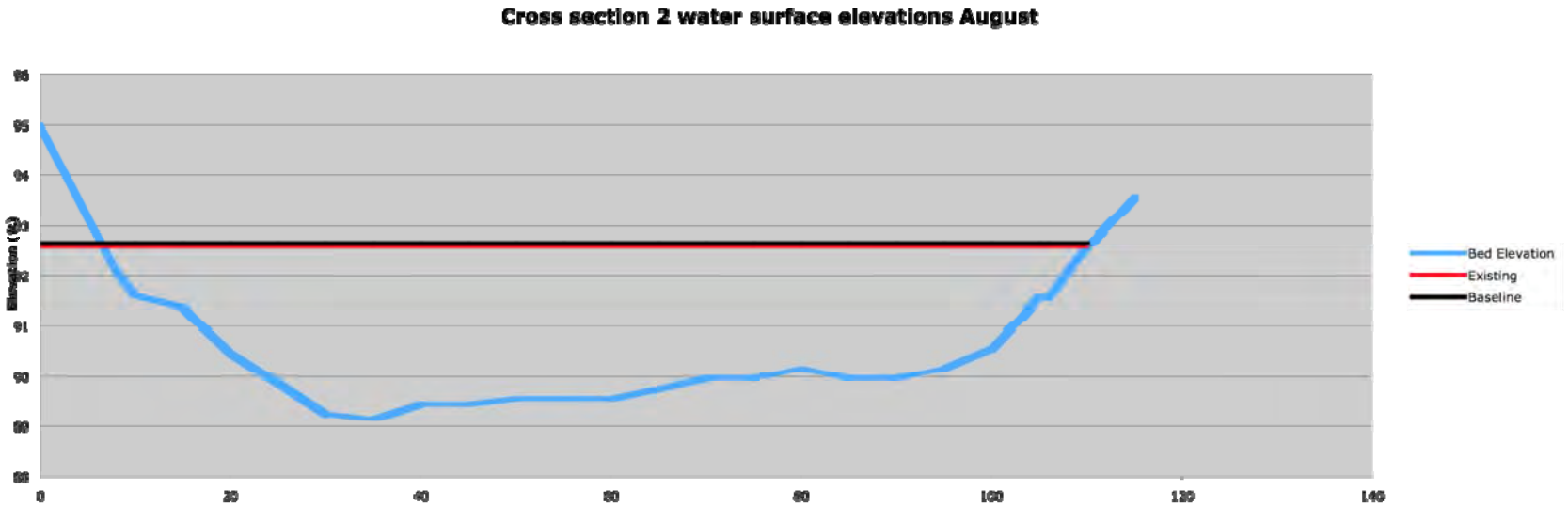
Are results from site-specific pilot for existing conditions similar to WFET results?

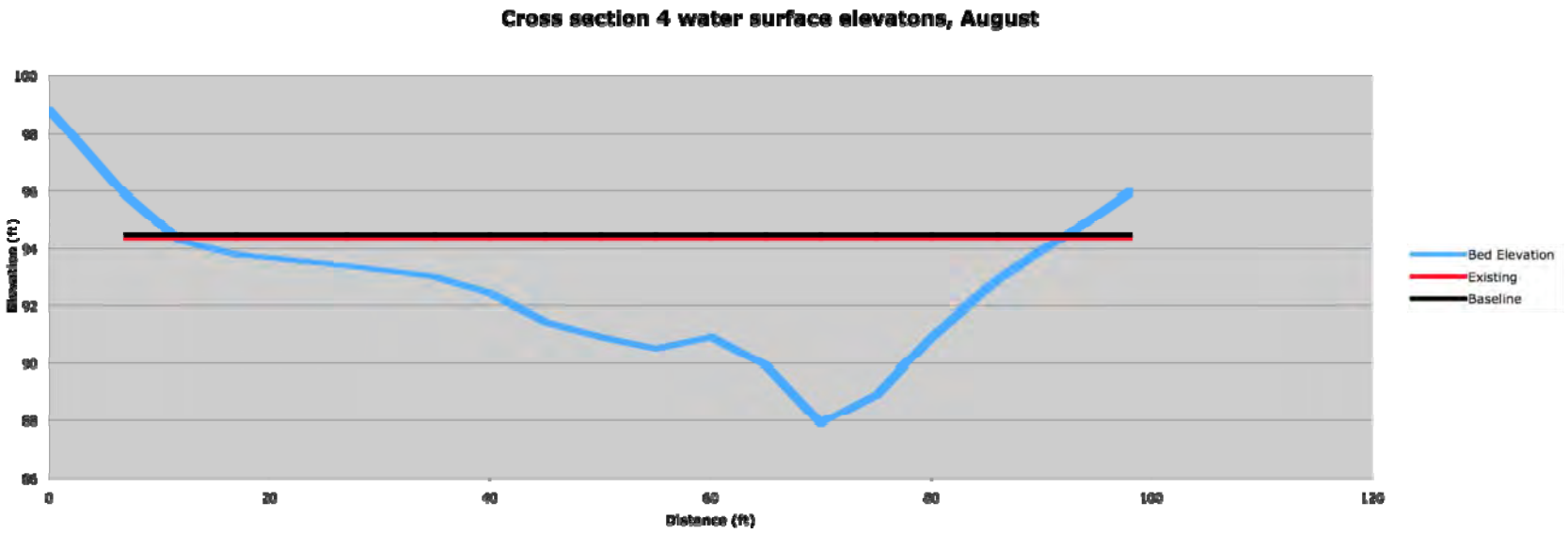
High flow (875 cfs)

Low Flow (300 cfs)

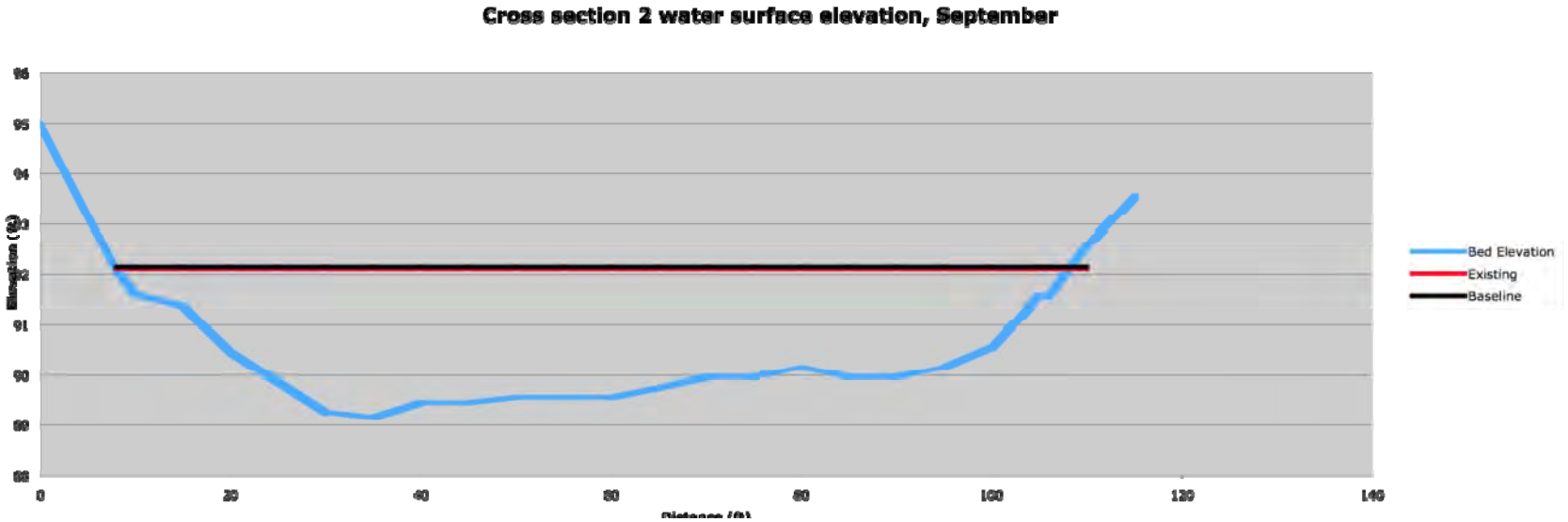


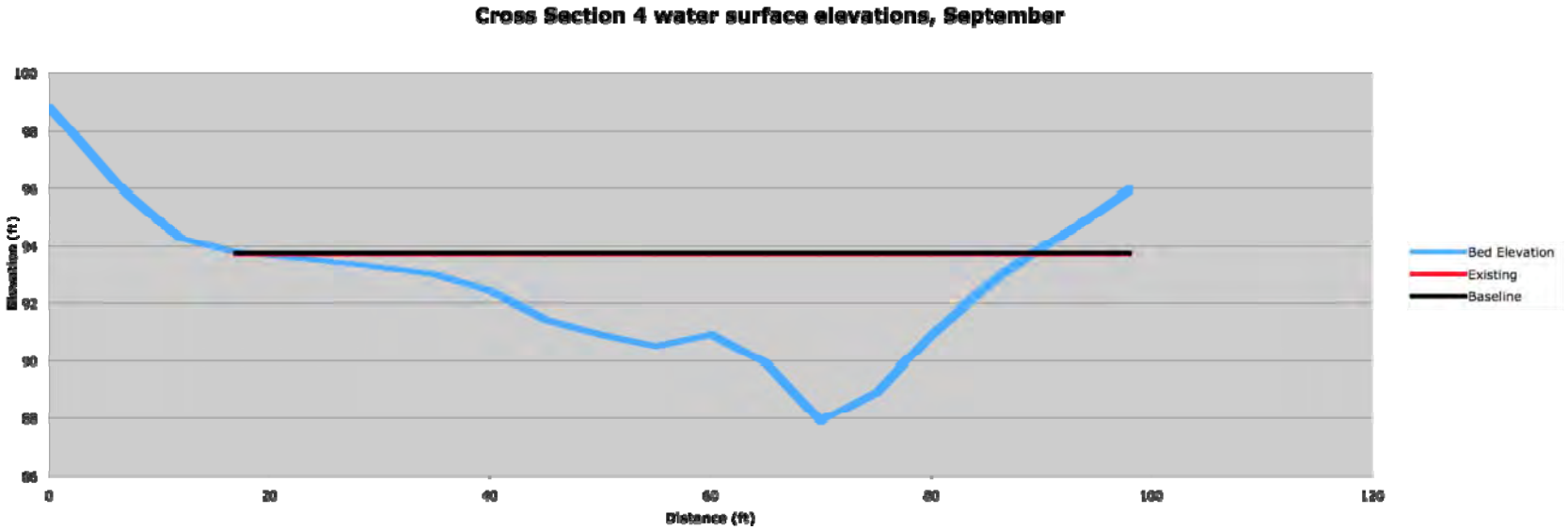
August water surface



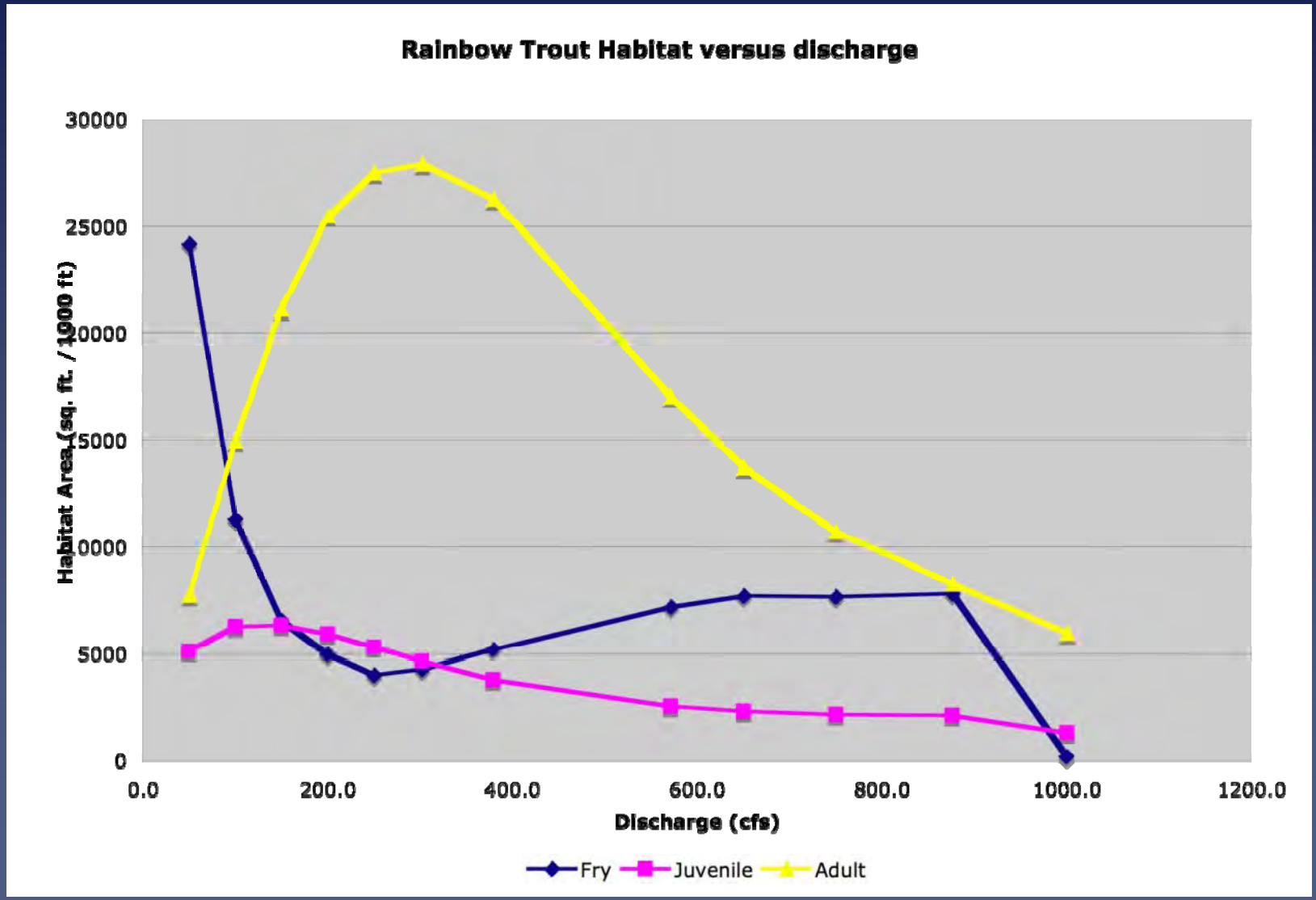


September Water Surface

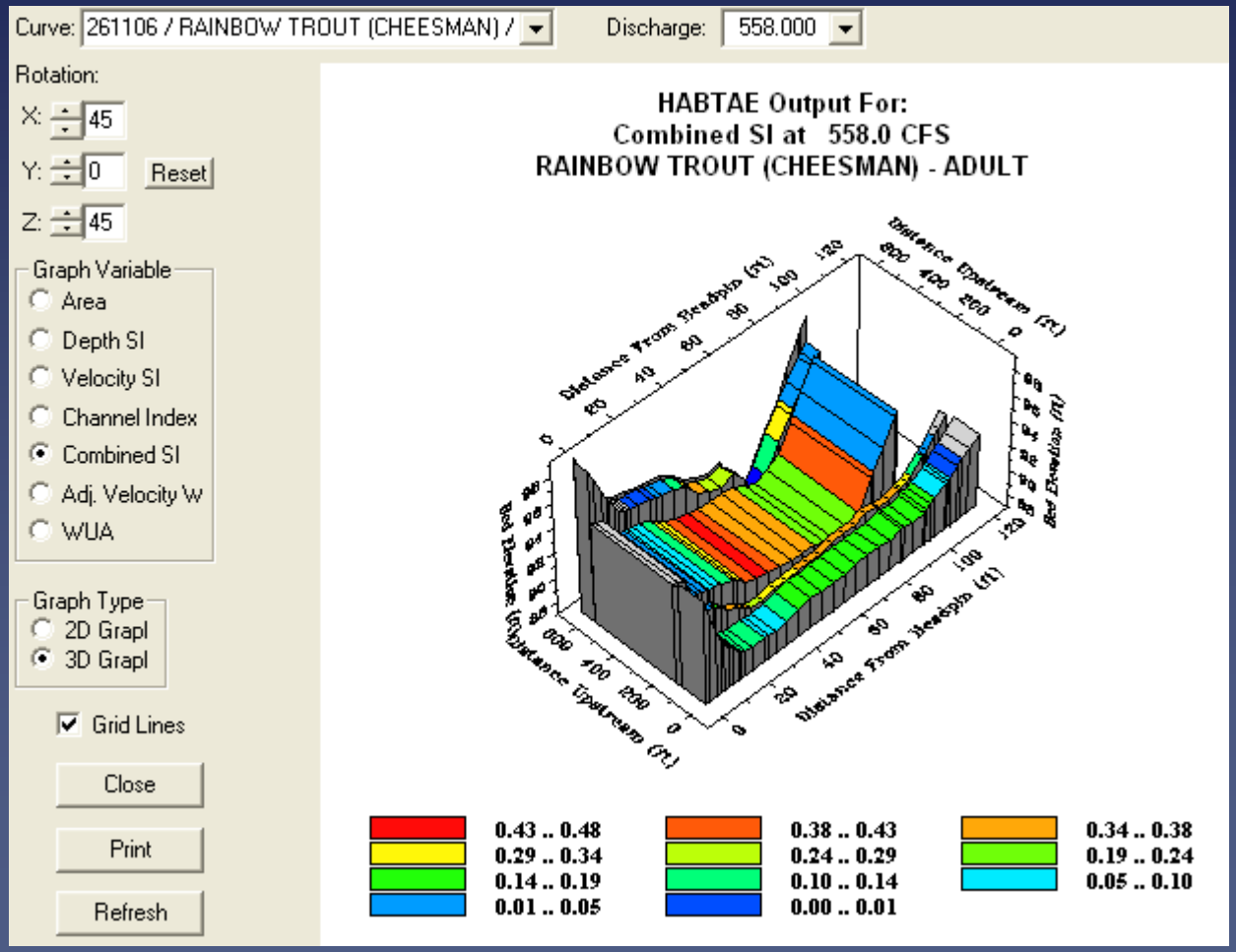




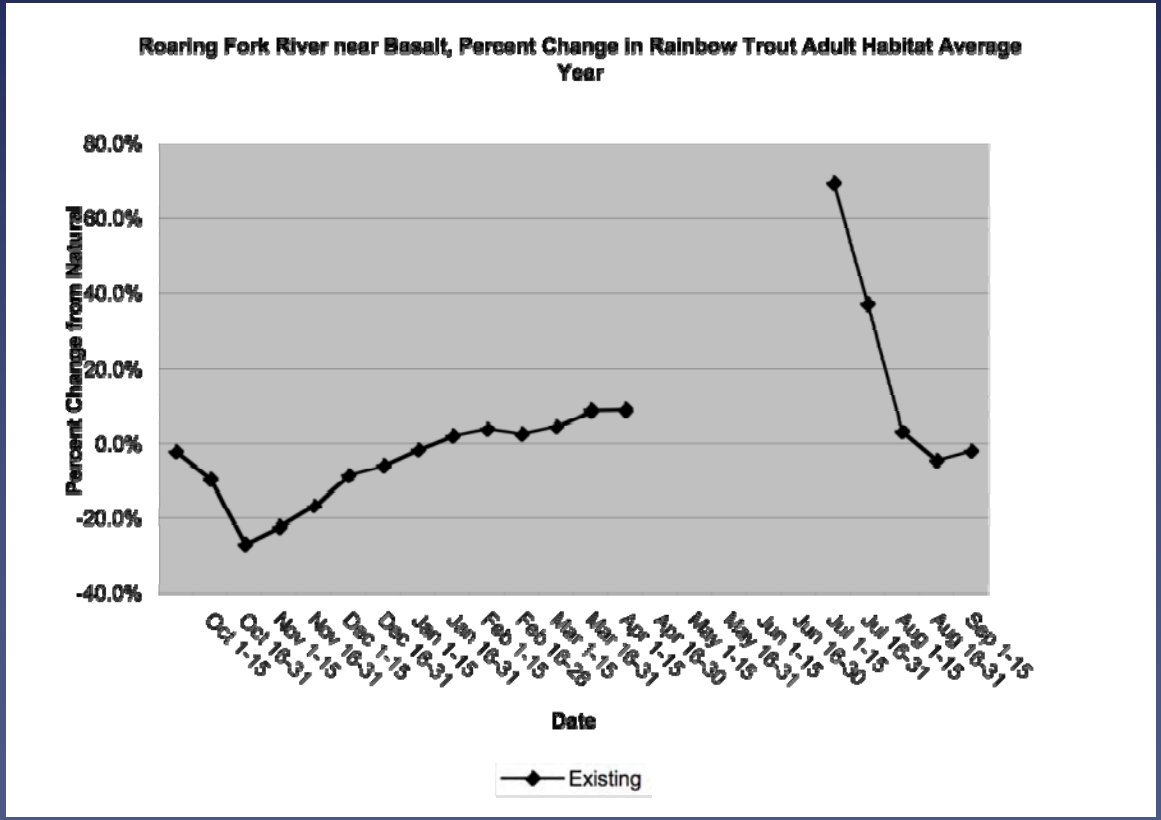
Weighted Usable Area



Rainbow September Existing Habitat (3D)



Percent change in habitat for Adult rainbow trout

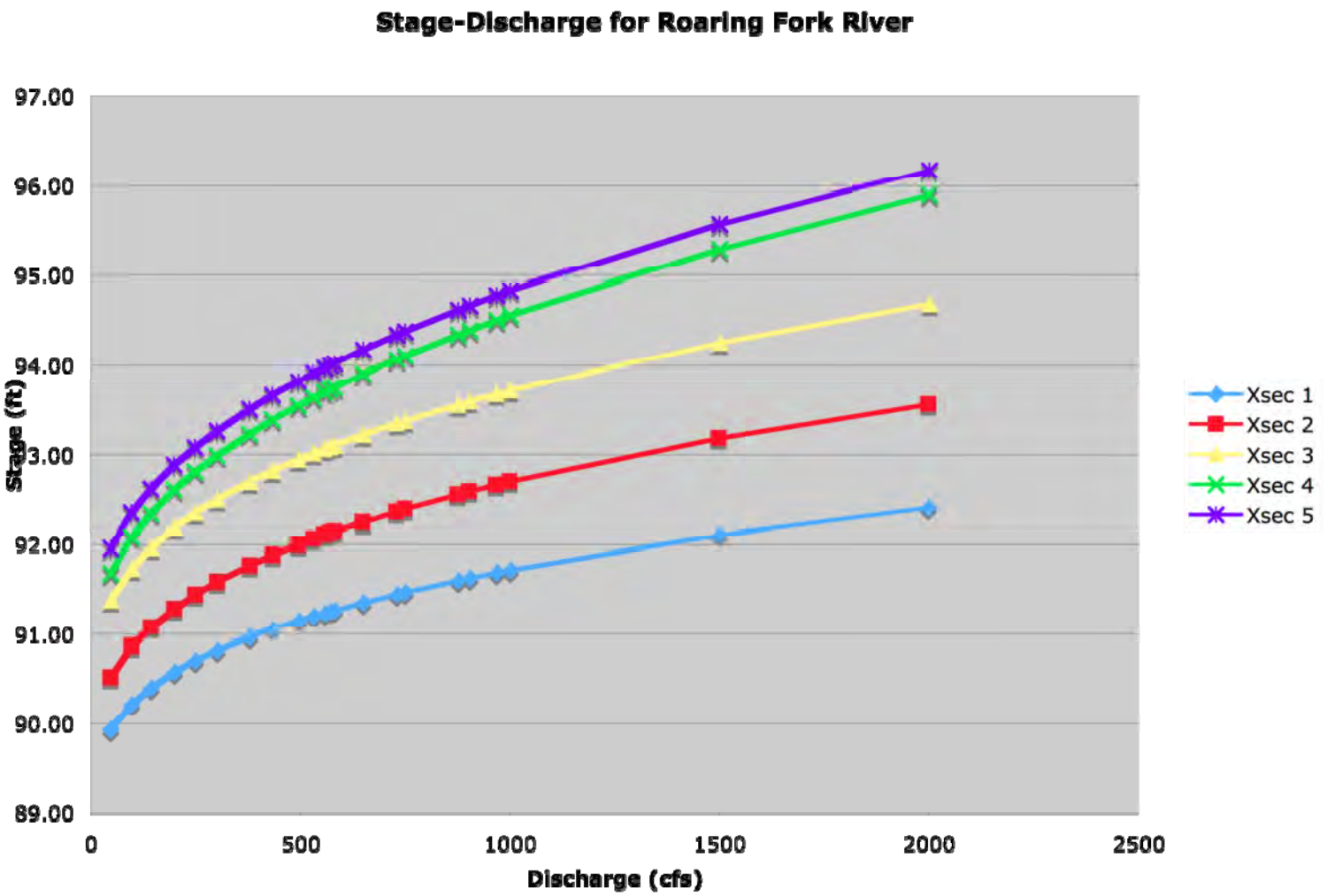


What conditions are present for site-specific reach using high risk flow conditions predicted from WFET?

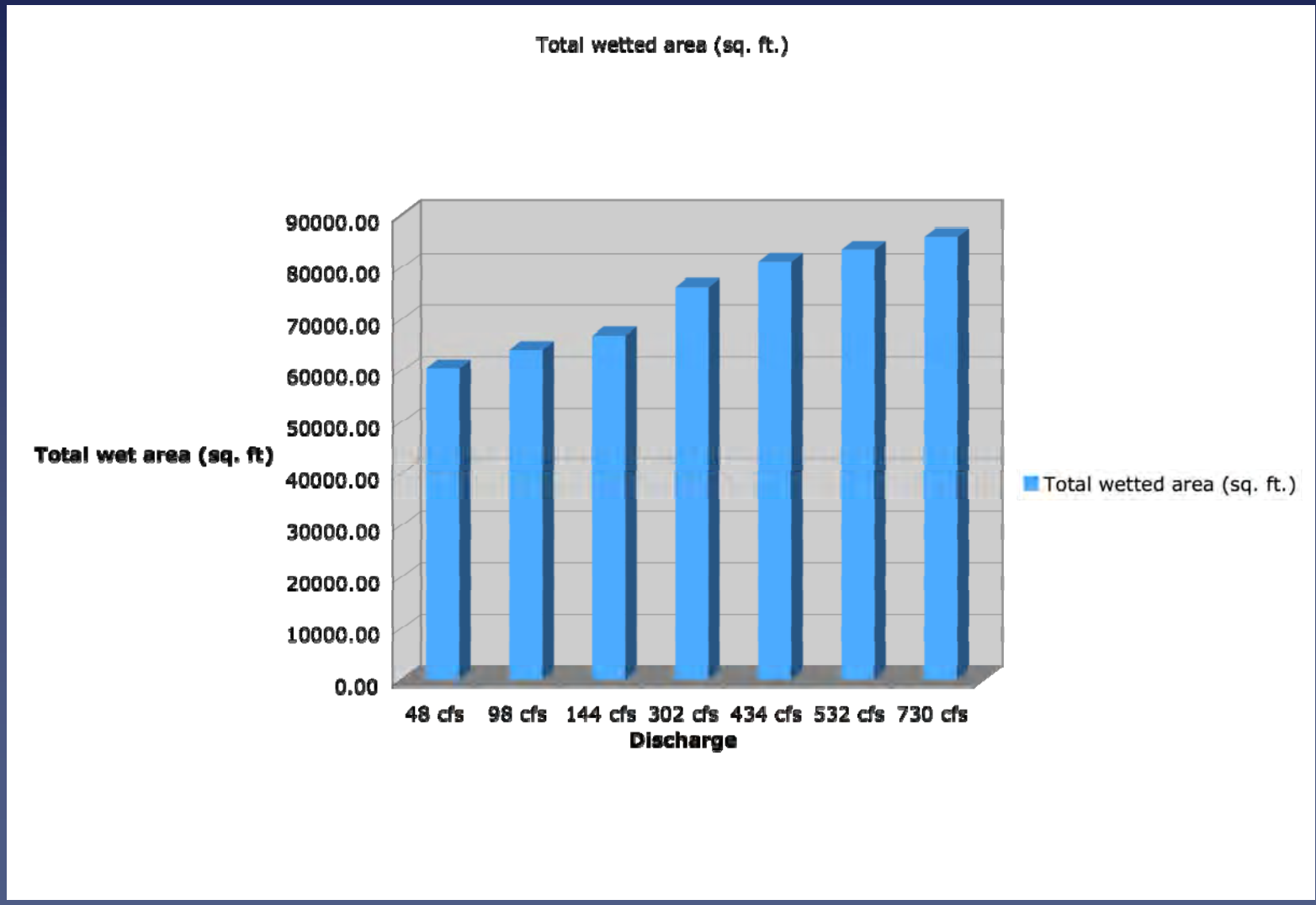
High Risk Flows used for Validation

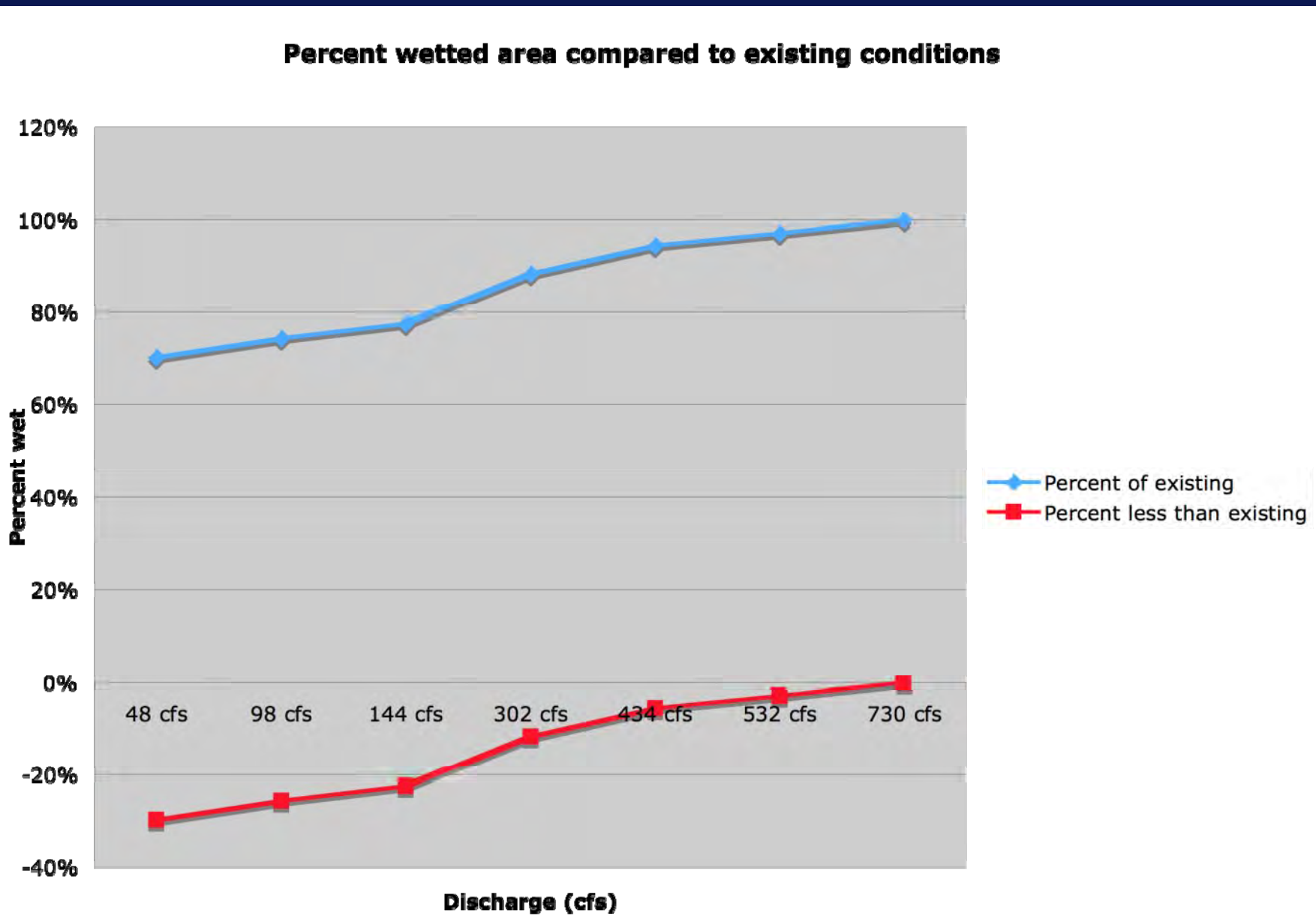
- 48 – 144 cfs
- Represent “red and orange” risk levels from mapping
- Flows used in PHABSIM to predict habitat conditions for site-specific reach

Comparison of 48, 98, 144 and 730 cfs using site specific methods

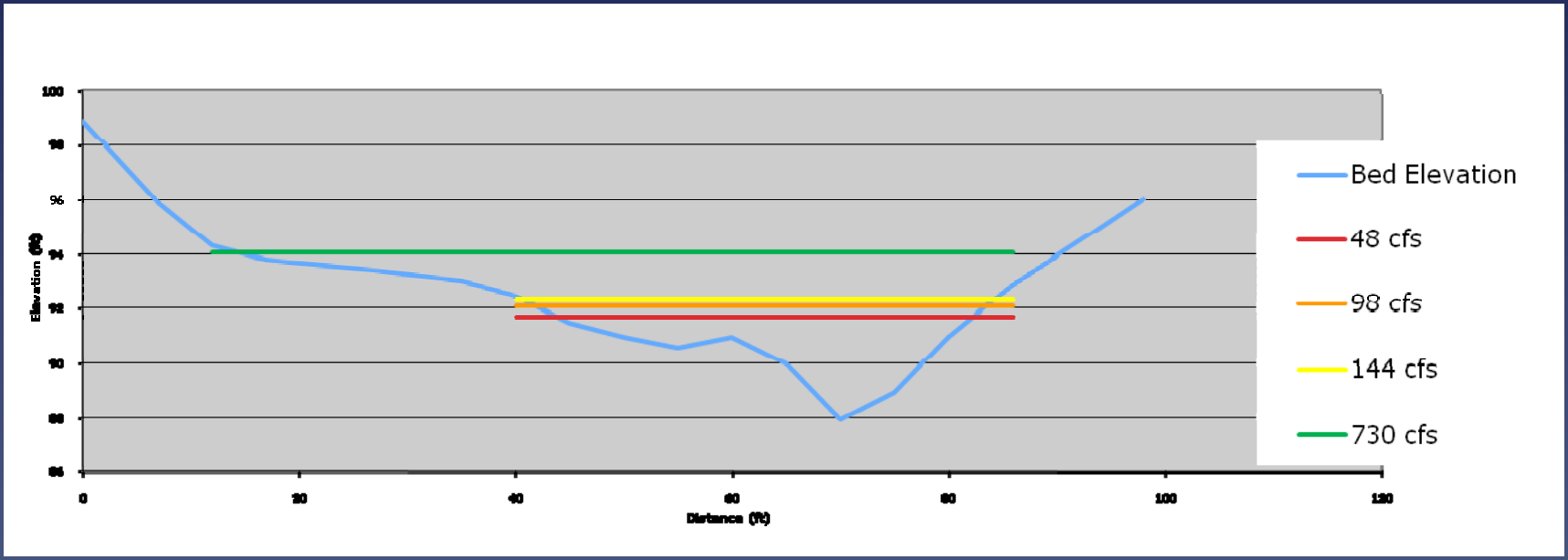


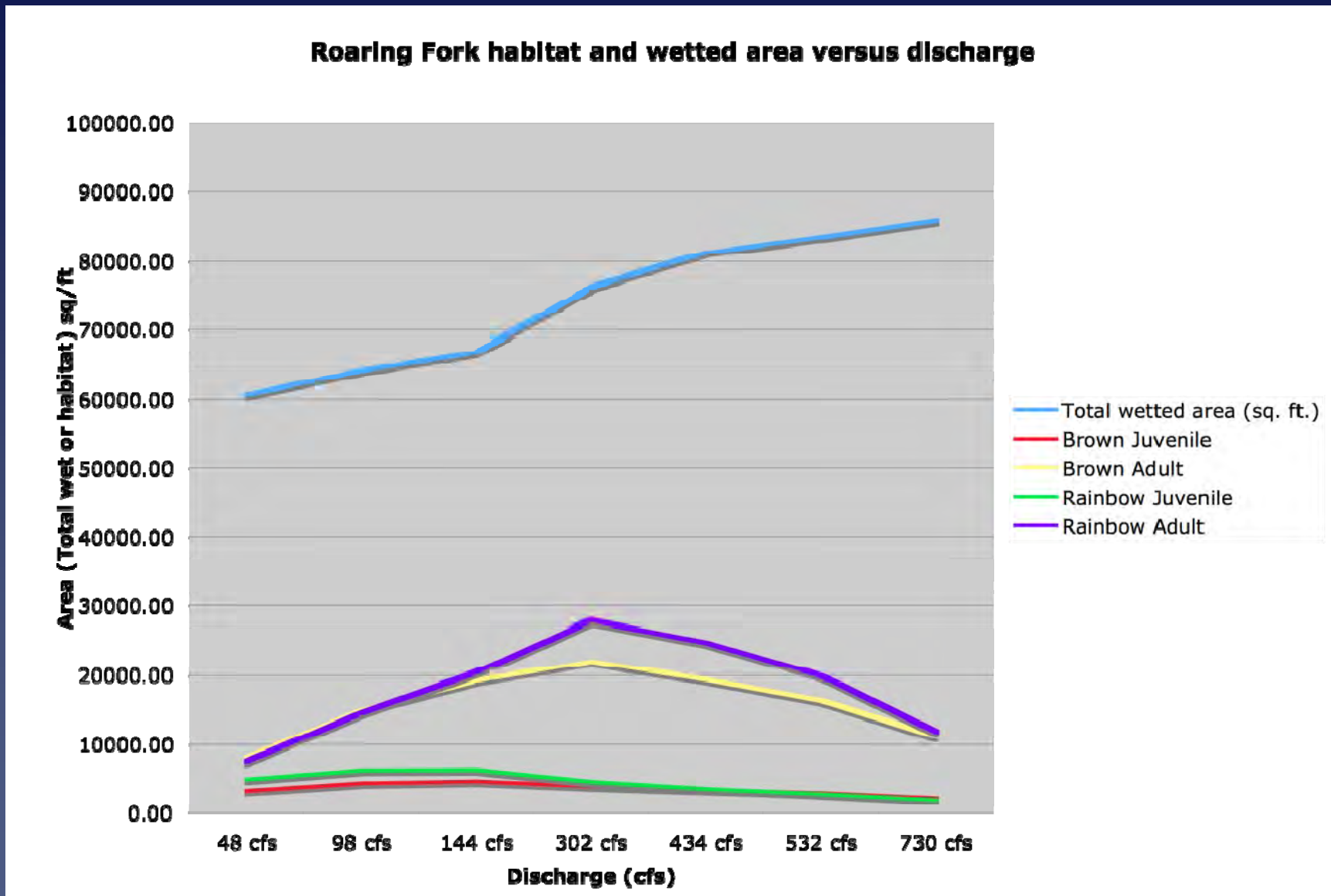
Comparison of 48, 98, 144 and 730 cfs using site specific methods




Percent wetted area compared to existing conditions
120%
100%
80%
60%
40%
20%
0%
-20%
-40%
Percent wet
48 cfs
98 cfs
144 cfs
302 cfs
434 cfs
532 cfs
730 cfs
Discharge (cfs)
Percent of existing
Percent less than existing

Water Surface elevation versus discharge, Roaring Fork Cross Section 4




Roaring Fork habitat and wetted area versus discharge
100000.00
90000.00
80000.00
70000.00
60000.00
50000.00
40000.00
30000.00
20000.00
10000.00
0.00
Area (Total wet or habitat) sq/ft
48 cfs
98 cfs
144 cfs
302 cfs
434 cfs
532 cfs
730 cfs
Discharge (cfs)
Total wetted area (sq. ft.)
Brown Juvenile
Brown Adult
Rainbow Juvenile
Rainbow Adult

Conclusion for Roaring Fork Site specific pilot study

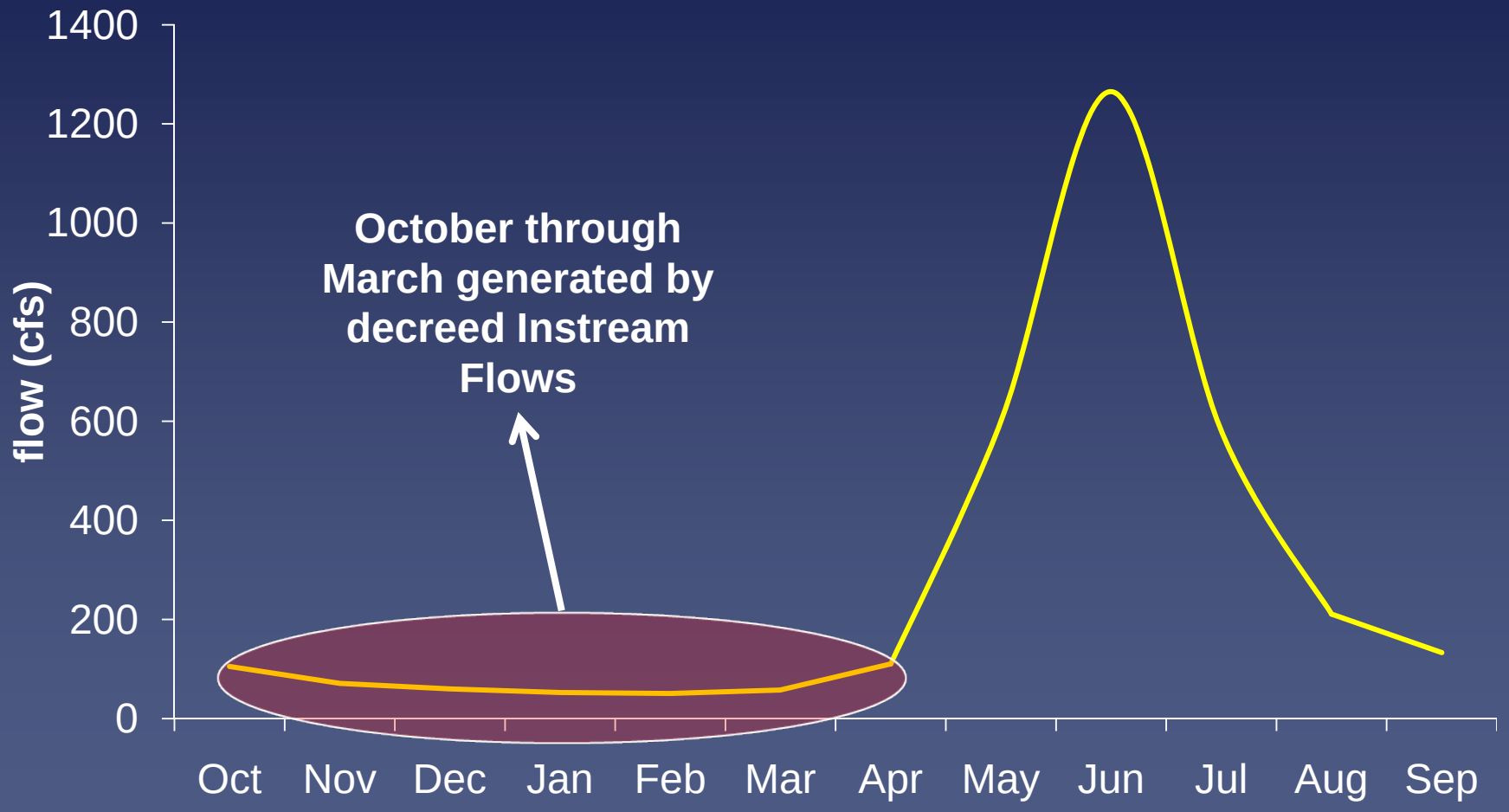
- Site Specific approach quantifies changes for specific river reaches, species and river discharges
- Application requires existing data or collection of new data
- Hydraulic model permits calculation of multiple metrics (e.g. water surface changes, habitat quantity changes, habitat quality changes)
- Analysis of habitat data allows comparison of multiple flow regimes and evaluation of alternative flow management scenarios
- In general, site specific results validate the WFET results
- Comparison of channel metrics (e.g. water depth, water width) shows little change between baseline and existing conditions for August and September flows
- WFET level of risk can help in choosing the appropriate site-specific tool

Questions?

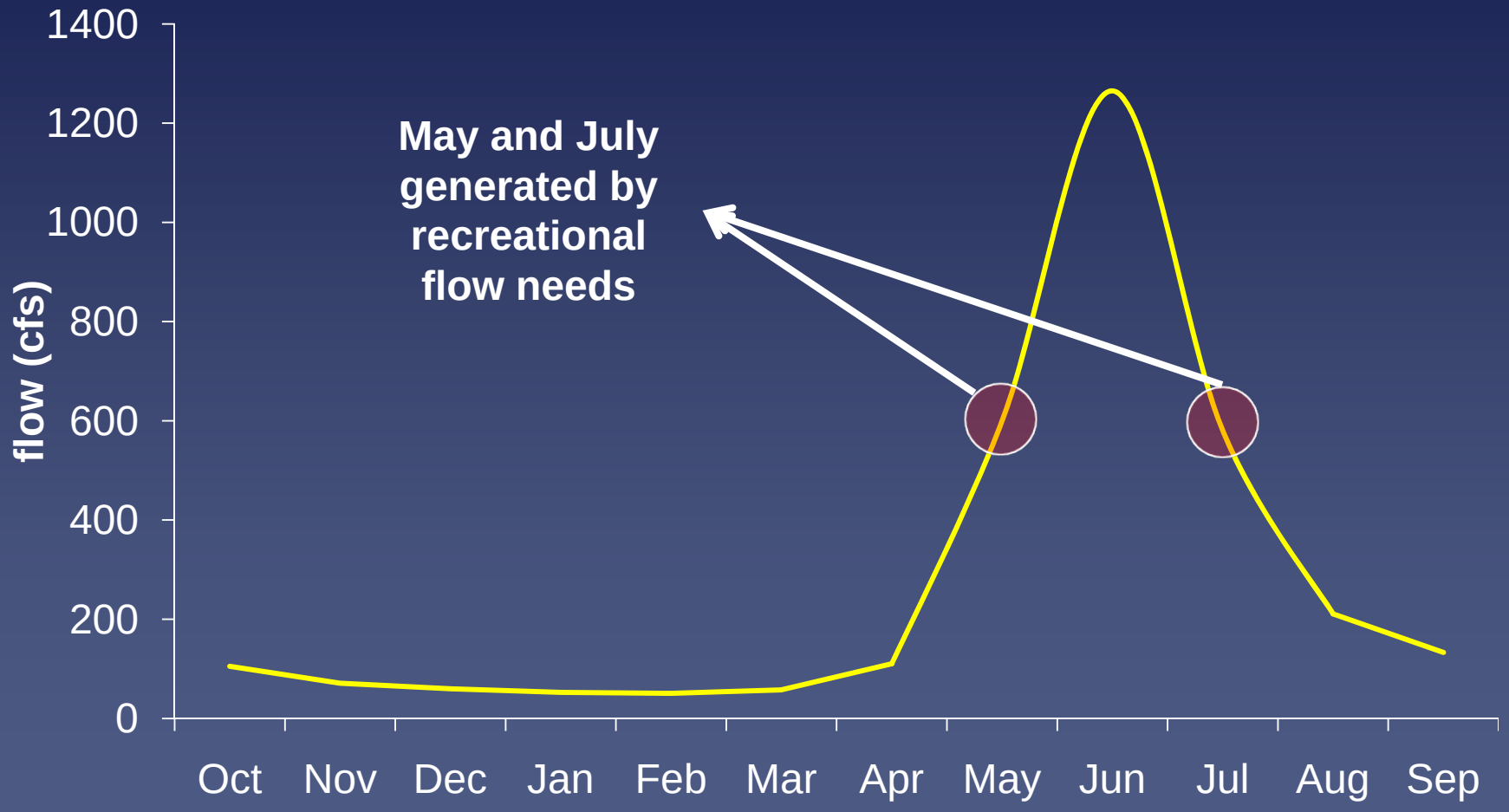
Methodology for Range of Flow Conditions based on Ecological Risk Levels

- Flows are not prescriptive
- Developed range of annual hydrographs based on ecological risk levels
- Monthly mean flows estimated based on entire period of record
- No year to year variability considered at this time
- No intra-year variability considered at this time
- Hydrographs could be modeled in StateMod or water supply availability tools

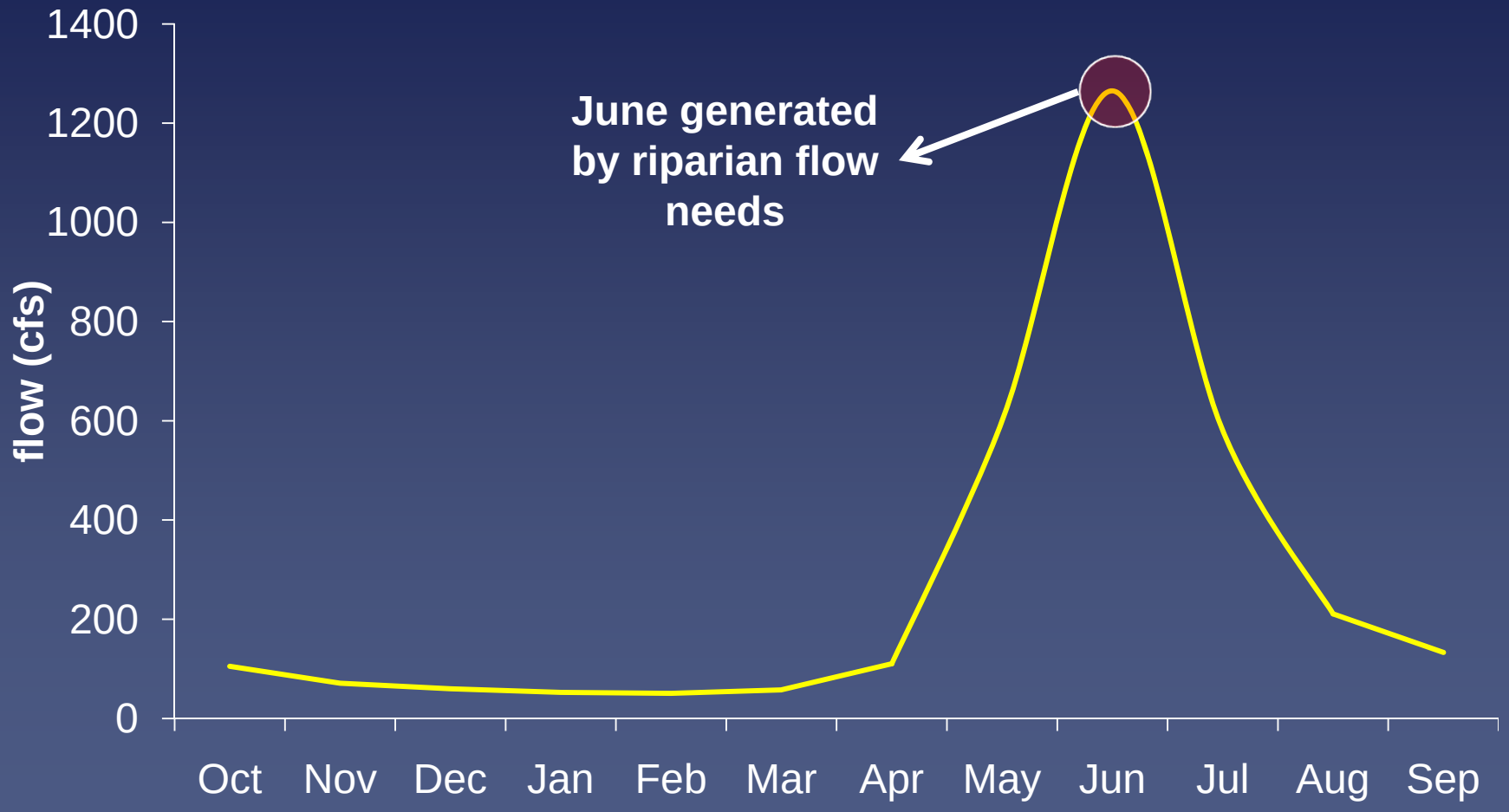
Monthly Hydrograph Development



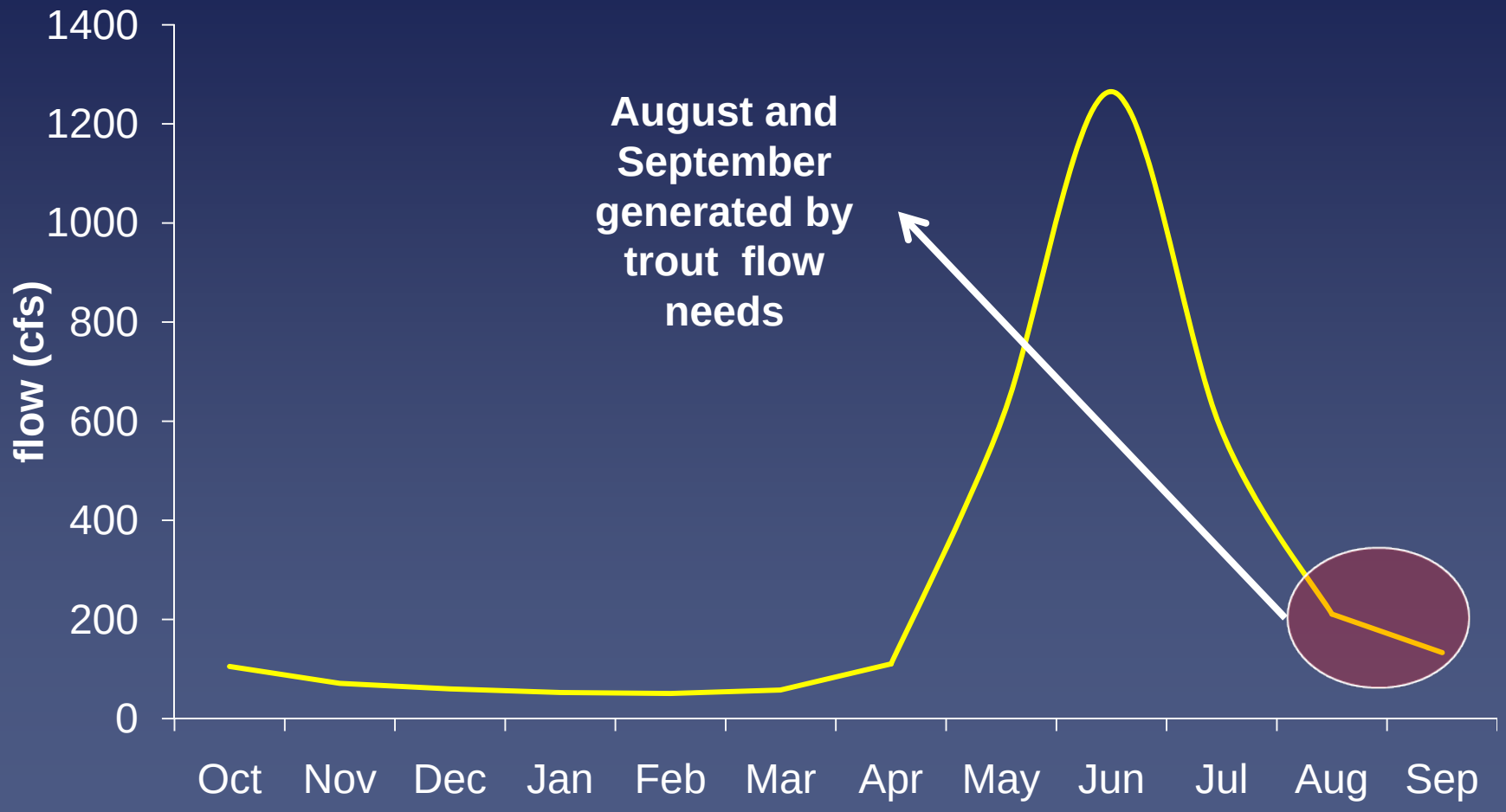
Monthly Hydrograph Development



Monthly Hydrograph Development



Monthly Hydrograph Development



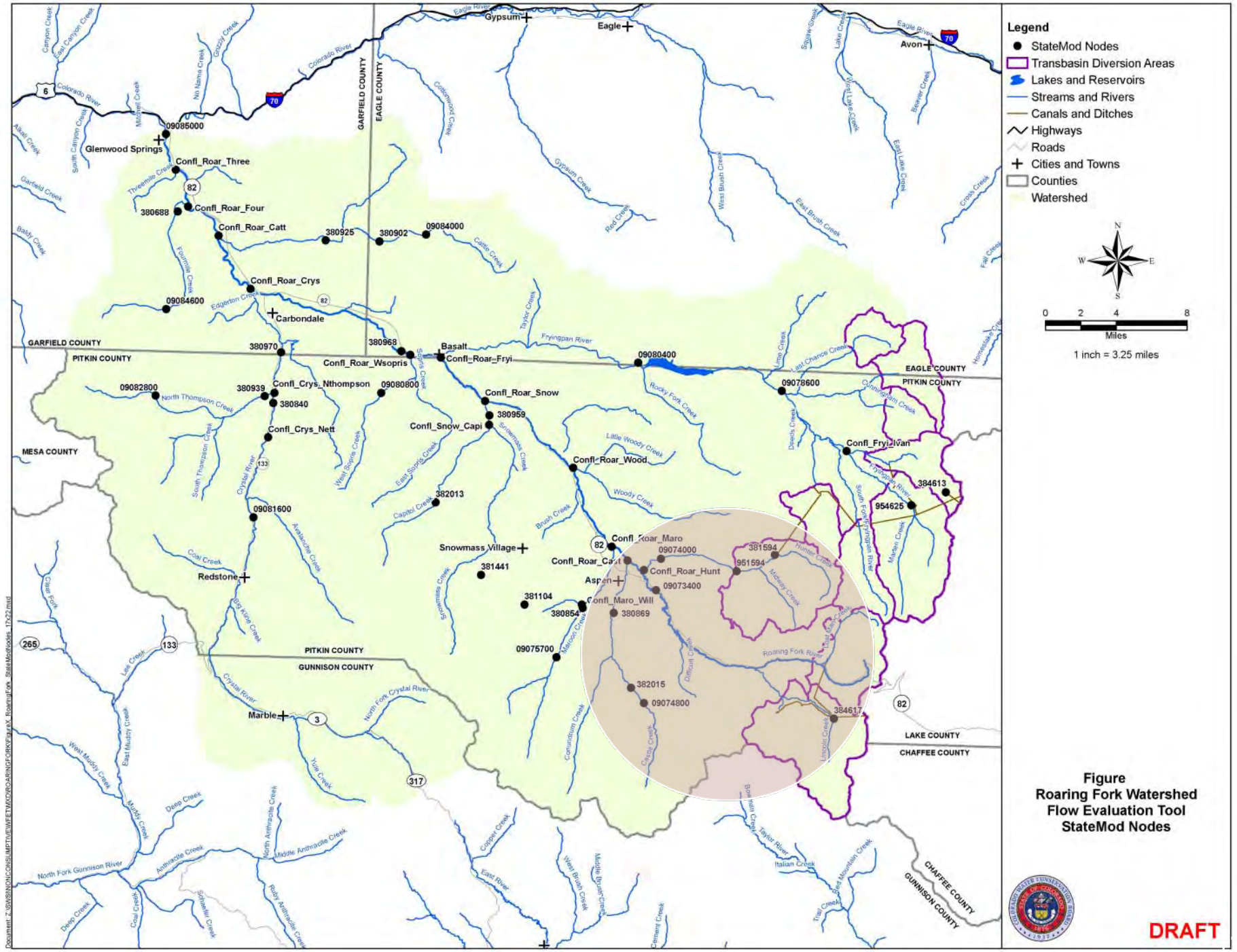
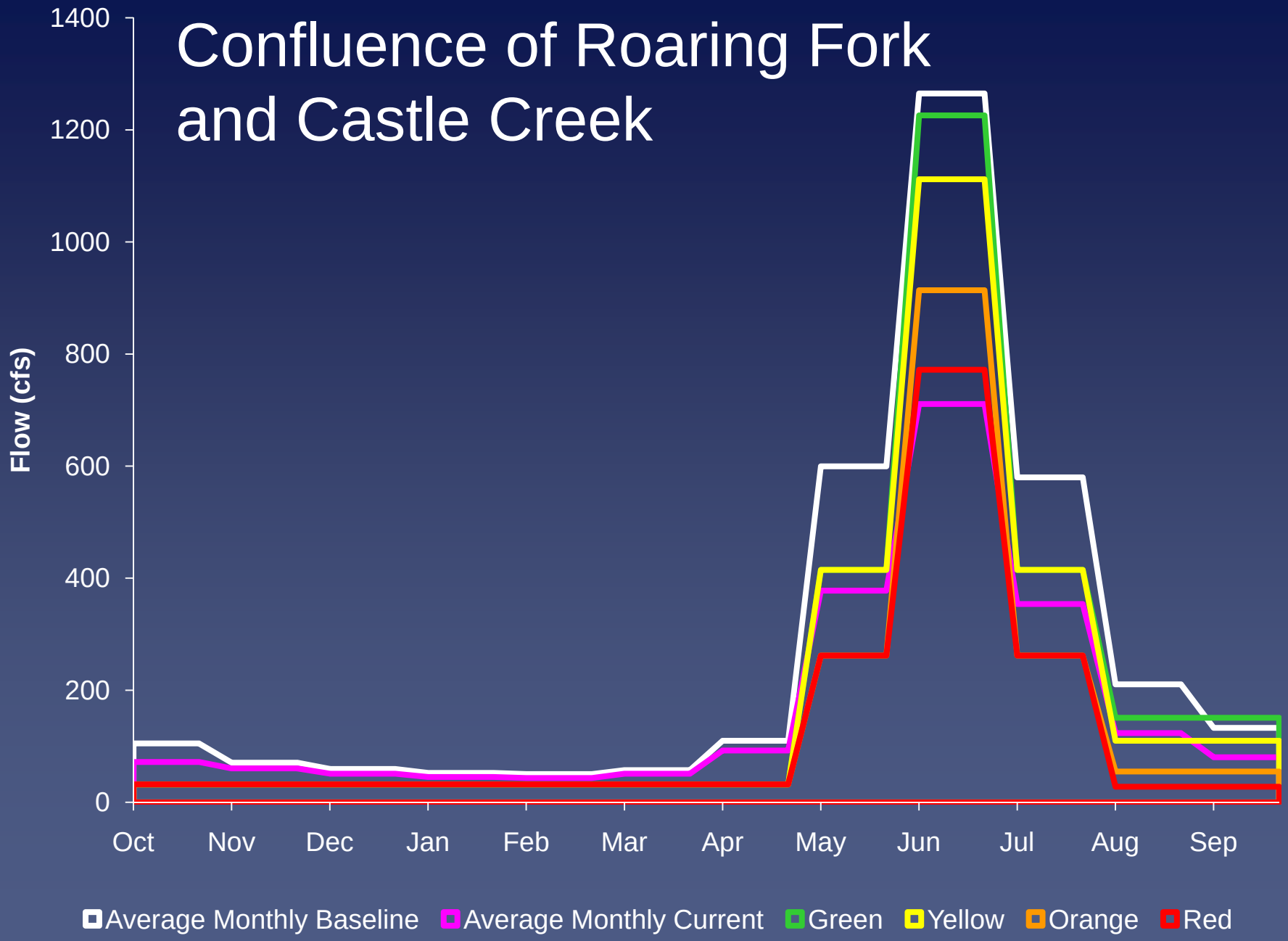
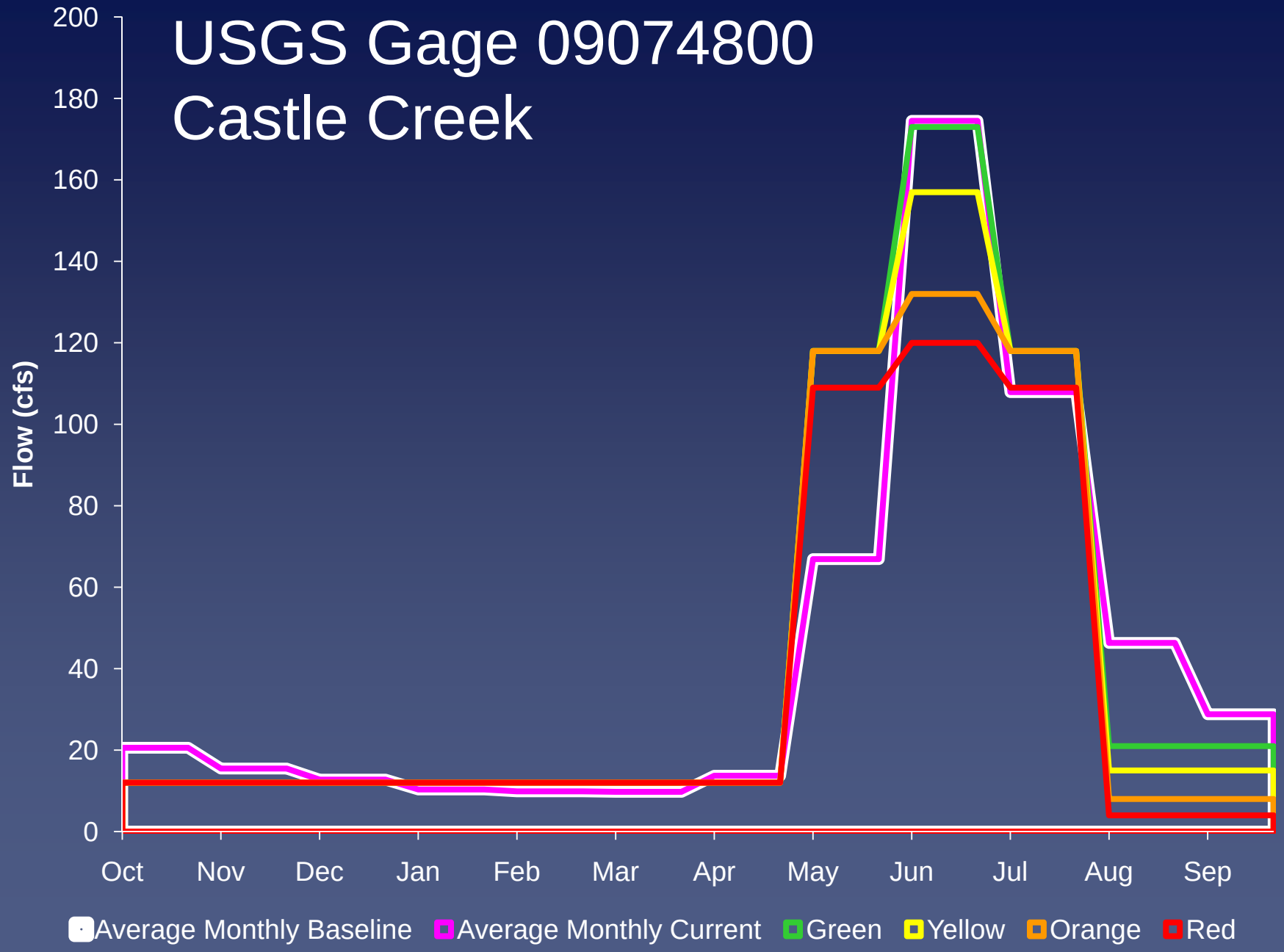
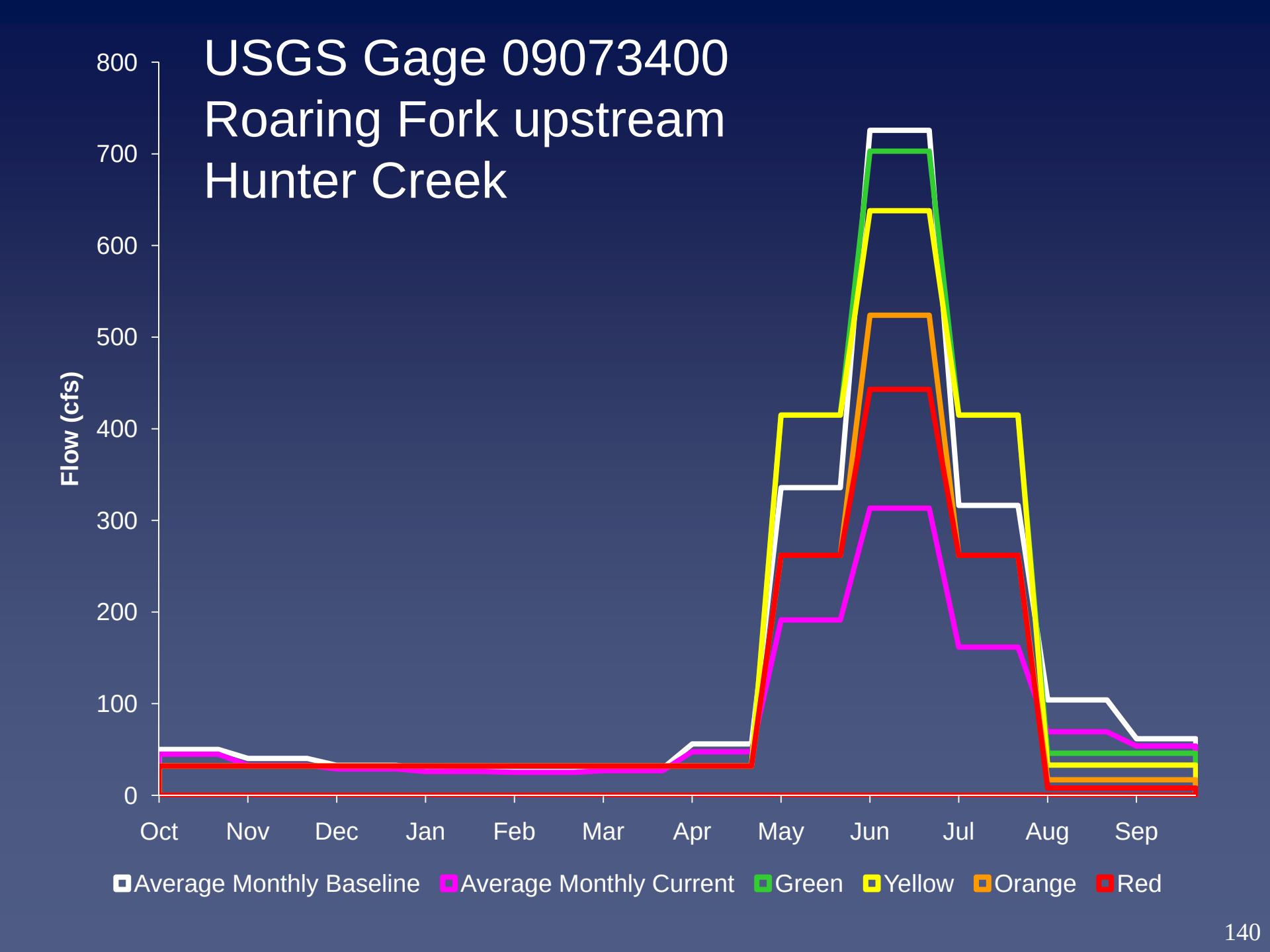


Figure
Roaring Fork Watershed
Flow Evaluation Tool
StateMod Nodes

Confluence of Roaring Fork and Castle Creek




USGS Gage 09074800
Castle Creek
Flow (cfs)
200
180
160
140
120
100
80
60
40
20
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Average Monthly Baseline
Average Monthly Current
Green
Yellow
Orange
Red


USGS Gage 09073400
Roaring Fork upstream
Hunter Creek
Flow (cfs)
800
700
600
500
400
300
200
100
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Average Monthly Baseline
Average Monthly Current
Green
Yellow
Orange
Red

Questions?

Roaring Fork WFET Pilot Conclusions

- Colorado DSS model provides higher resolution of hydrologic data
- WFET indicates at risk areas for riparian and recreation
- WFET existing conditions for trout show ecological risk is minimal
- PHABSIM results for trout show existing conditions are comparable to baseline conditions
- PHABSIM results show stressed conditions for trout for high risk flows level indicated by WFET

Roaring Fork WFET Pilot Conclusions

- Results indicate that calibration of WFET risk levels are possible with site-specific data
- Further validation efforts are needed for existing trout fisheries with site-specific data
- Further validation could be completed with other Colorado Basin site-specific studies and CWCB Instream Flow R2CROSS data
- WFET can be used to generate a range of seasonal flow conditions based on ecological risk

Questions?

WFET Findings and Recommendations

WFET Pilot Findings – Technical

- Flow-ecology relationships derived for several key environmental and recreational attributes across the state
- Ecological risk mapping developed for key attributes
- For Roaring Fork, preliminary validation shows that WFET results are comparable with site-specific data
- For Roaring Fork, results build upon and support previous watershed efforts

WFET Pilot Findings – Tool Application

- WFET is best utilized in areas with detailed hydrologic data or models for pre and post water management conditions
- WFET could be used in a predictive capacity to examine potential future water management using conditions today as a baseline
- WFET can be used to generate a range of seasonal flow conditions based on ecological risk
- WFET could be used to target Instream Flow acquisitions as well as restoration efforts

WFET Pilot Recommendations

- Further validation should be completed with other site-specific studies and CWCB Instream Flow R2CROSS data
- Calibration of ecological risk levels with site-specific data
- Further refinement of ecological risk between and above nodes
- Further refinement of hydrograph development to consider intra-year and year to year variability

Questions?