



# Comprehensive Watershed Assessment: Data Analysis Results

Part 1

Photo courtesy of LBD

# Presentation Topics

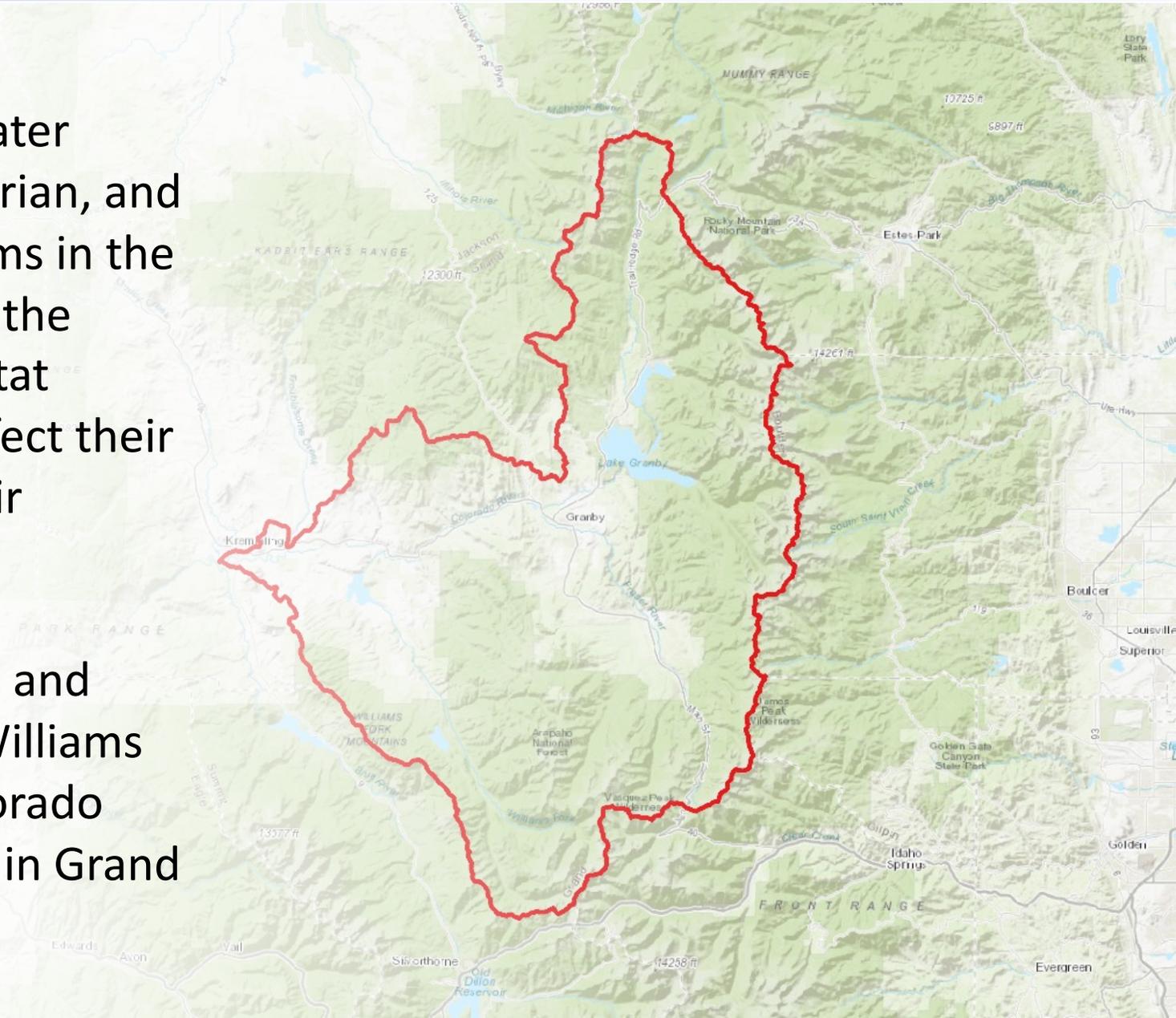
- Watershed Assessment Goals & Approach
- Geographic Orientation to Stream Groups and Reaches
- Key Aquatic Resource Concerns Identified in the 2010 GC SMP
- Watershed Assessment
  - Hydrology
  - Water Quality
  - Stream Temperature

*Question to keep in mind: How well do these quantitative assessment results align with your perspectives on watershed conditions?*

# Watershed Assessment Goal

**Watershed Assessment Goal:** Assess hydrological regime characteristics, water rights, water quality, geomorphic, riparian, and biological data relevant to focus streams in the CEA for the purpose of understanding the condition of streams and aquatic habitat within the CEA and the factors that affect their preservation and, where possible, their improvement.

**Geographic Scale:** >100 miles of rivers and streams in the Colorado, Fraser, and Williams Fork River Basins upstream of the Colorado River's confluence with the Blue River in Grand County

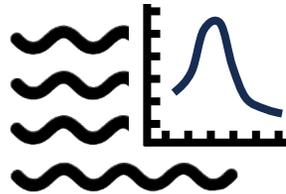


# Scoped Tasks

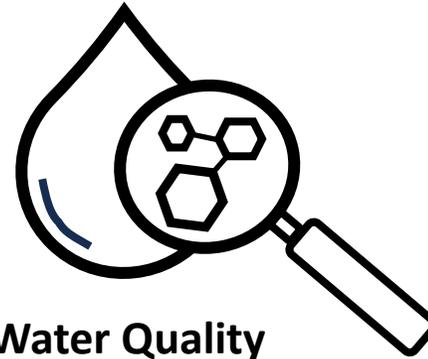
Task 1	Task 2	Task 3	Task 4
<b>Background Chapter</b>	<b>Data Analysis and Interpretation</b>	<b>Report Generation</b>	<b>Maps and Data Visualizations</b>
Conduct Literature Review Inventory Streamflow Data and Summarize Hydrological Change Summarize Past Water Development and Current Water Use and Management. Inventory Notable Landscape Events Characterize Demographic and Land Use/Cover Change Inventory Existing Environmental Data	Analyze Hydrology Characteristics & Trends Analyze Water Temperature Trends Assess Geomorphic Function Assess Aquatic Ecosystem Conditions & Trends Characterize Water Quality Conditions & Trends Perform Integrative Assessment Provide Recommendations for Monitoring & Studies	Draft Report Finalize Report Provide LBD Presentation Provide Stakeholder Presentation	Create Interactive Mapping Layers Generate Interactive Data Visualizations Develop Decision Support Tools

# Watershed Assessment Topic Areas

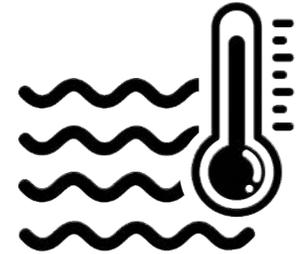
- Assessment activities arranged into 6 topic areas
- Topic areas align with the 2010 Grand County SMP



Hydrology



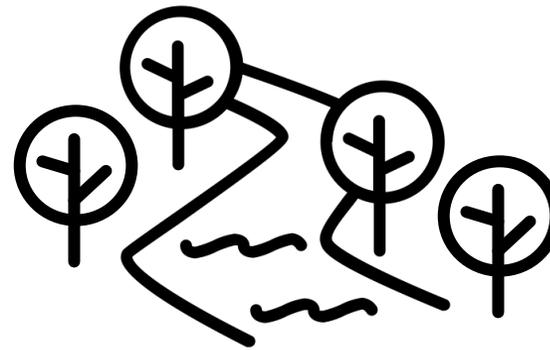
Water Quality



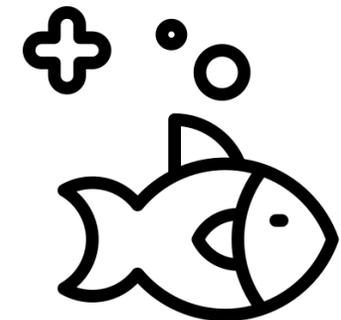
Water Temperature



Geomorphic Conditions



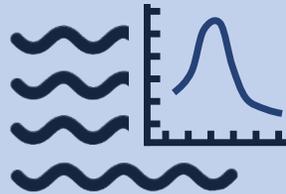
Riparian Areas



Aquatic Biota

# Watershed Assessment Topic Areas

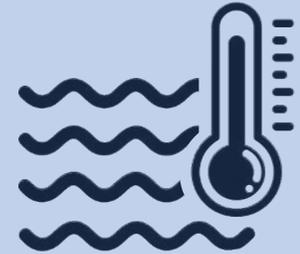
- Assessment activities arranged into 6 topic areas
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Hydrology



Water Quality



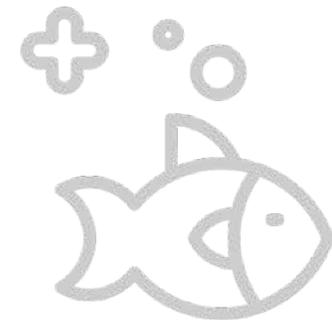
Water  
Temperature



Geomorphic  
Conditions



Riparian Areas



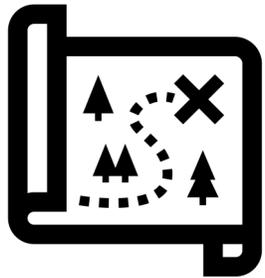
Aquatic Biota



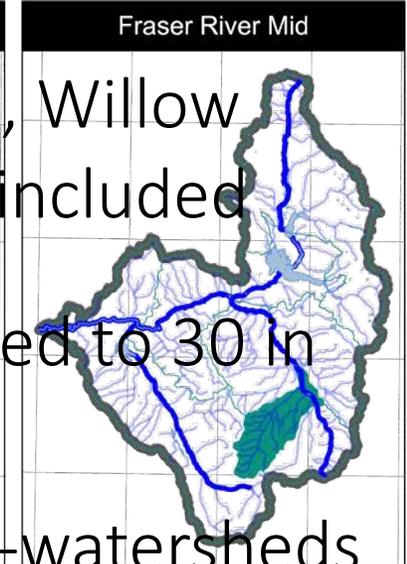
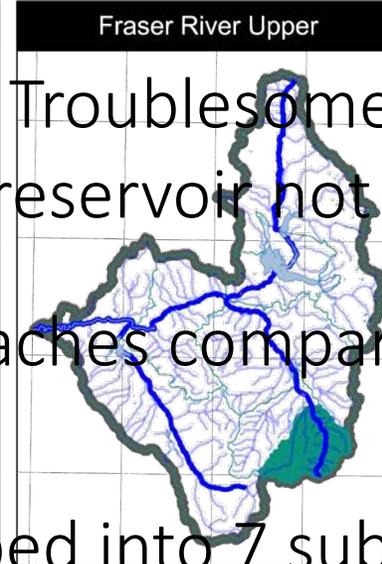
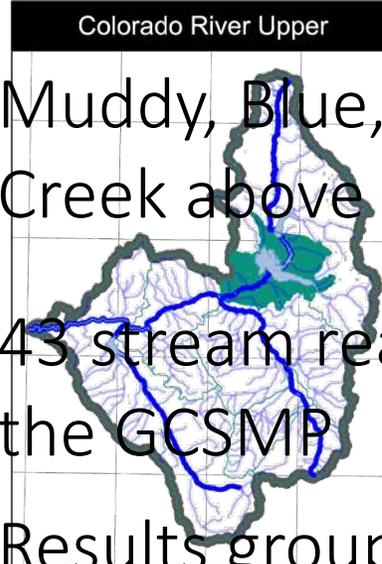
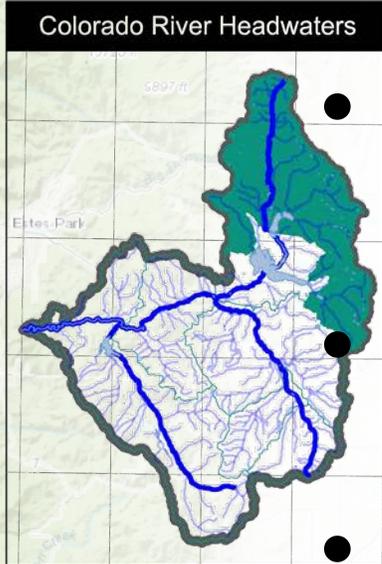
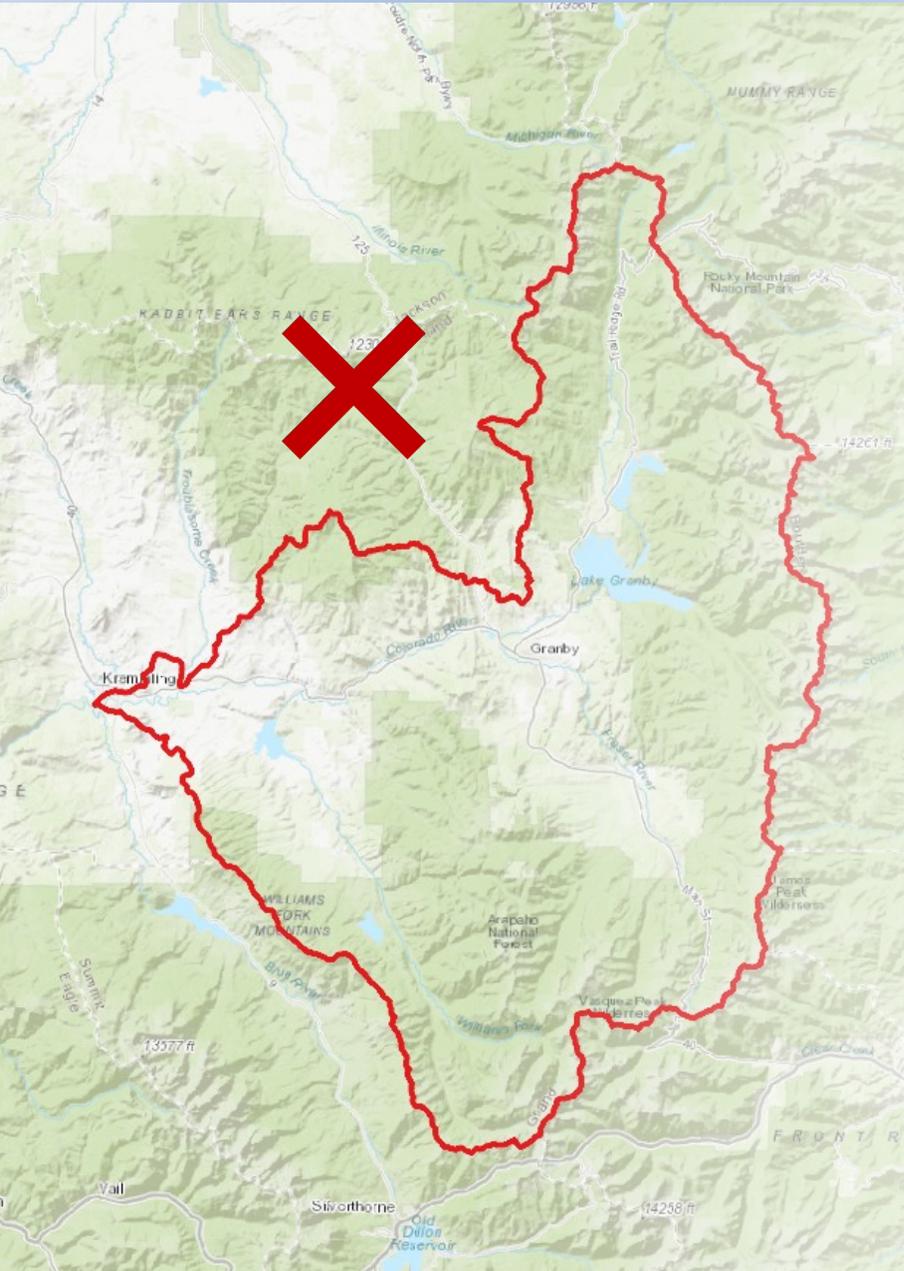
# Geographic Orientation

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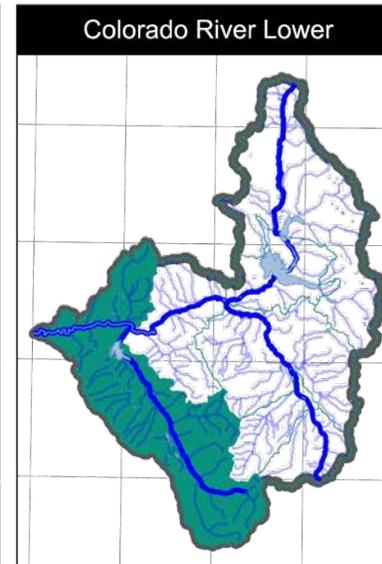
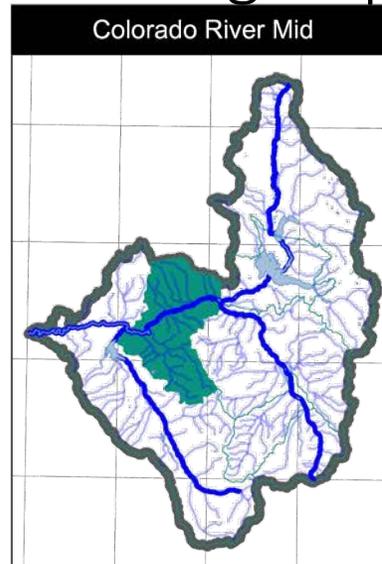
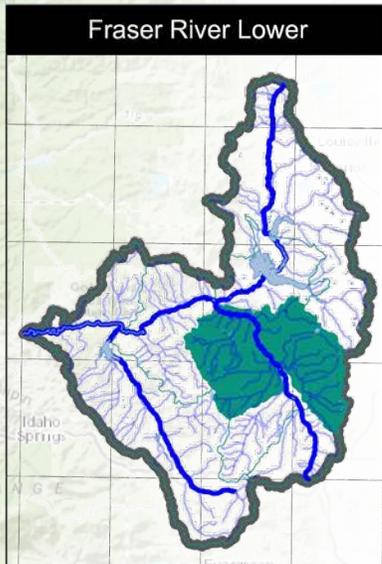
Introduction to the organizational strategy for results presentation



# CEA and Stream Group Sub-Watersheds



- Muddy, Blue, Troublesome, Willow Creek above reservoir not included
- 43 stream reaches compared to 30 in the GCSMP
- Results grouped into 7 sub-watersheds

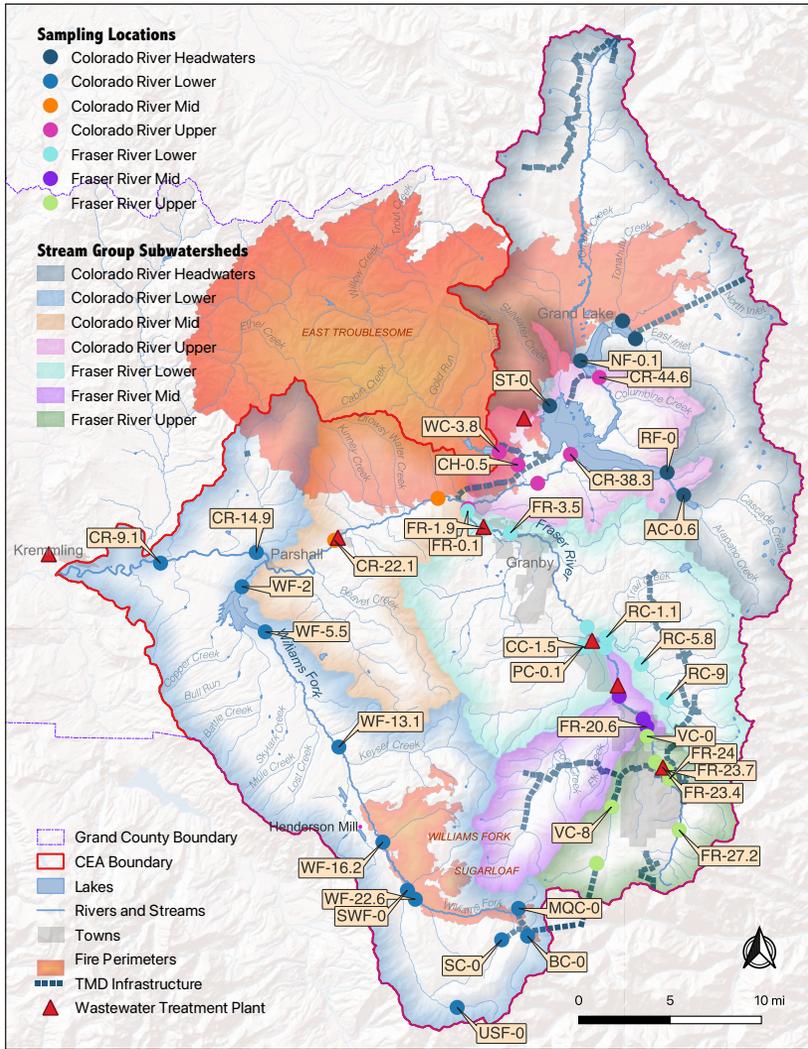


 Stream Group Sub-watershed

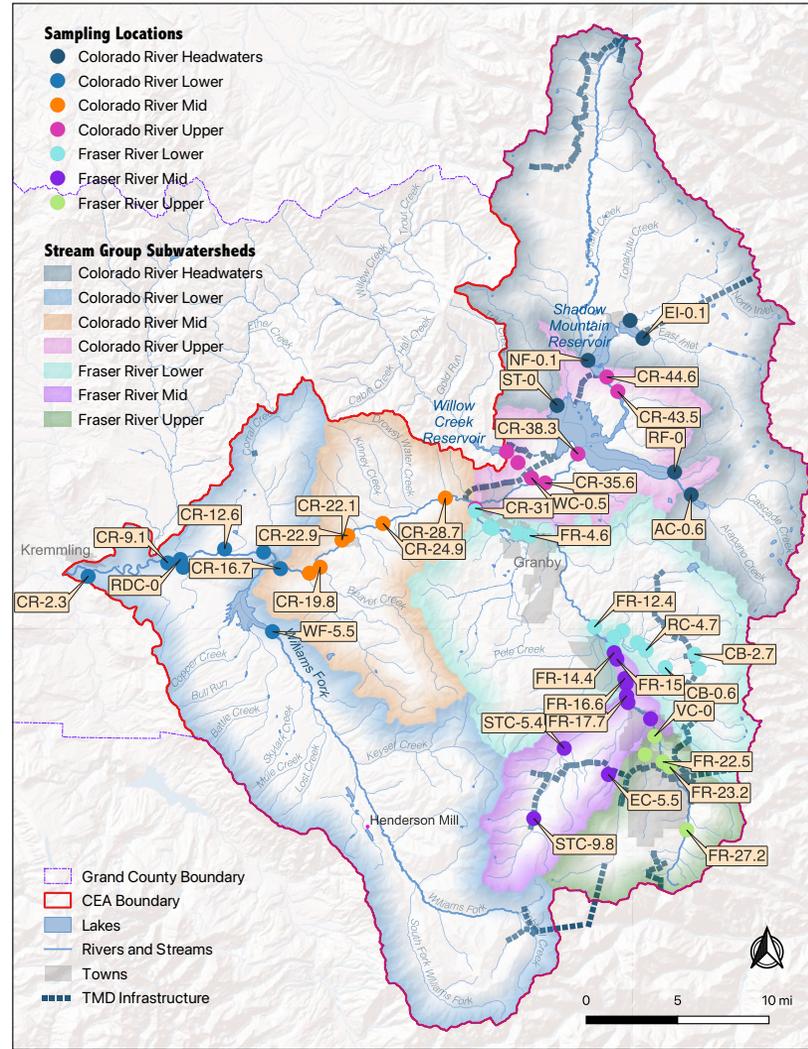


# Handouts and Wall Maps

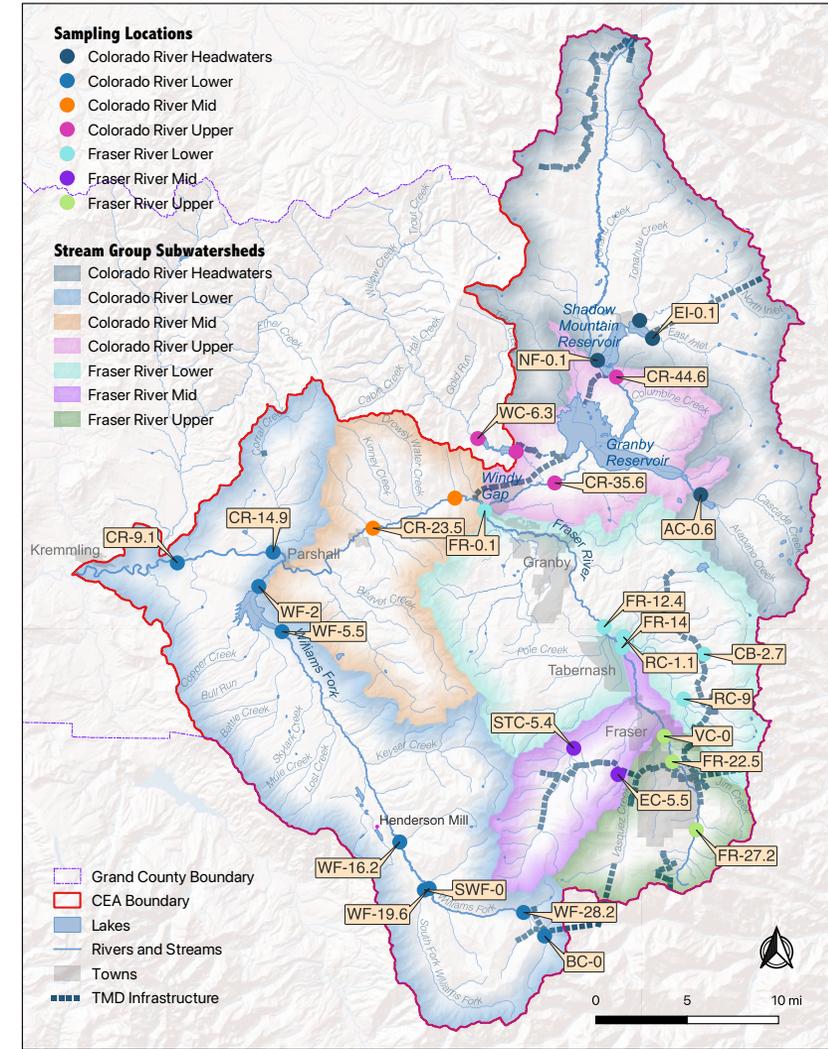
## Water Quality



## Streamflow



## Stream Temperature

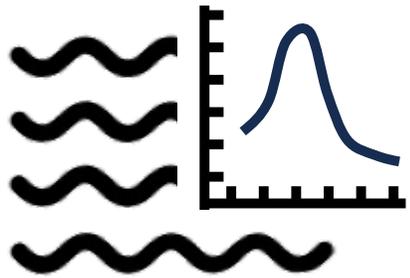




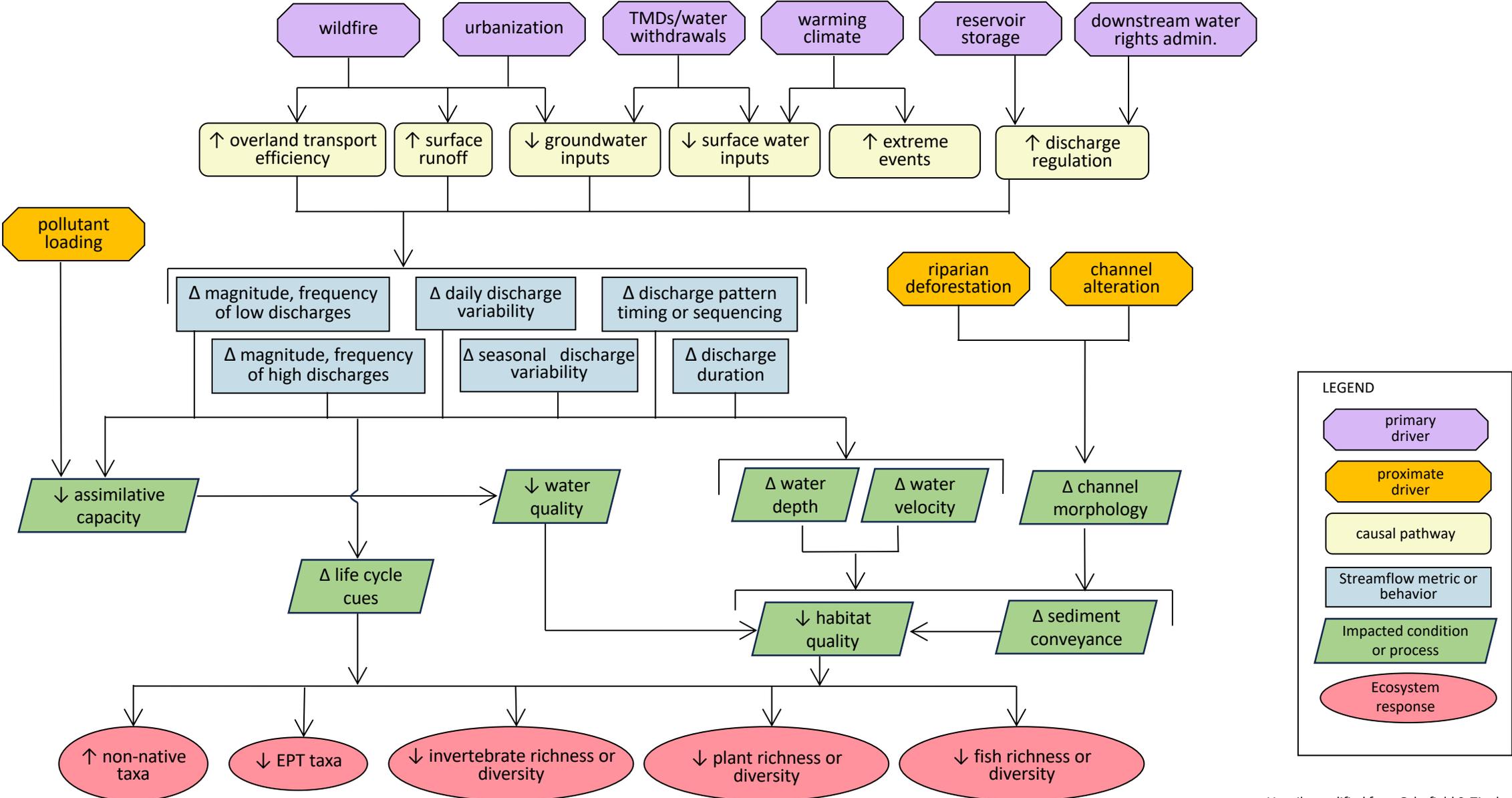
# Streamflow Behavior Assessment

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Summary of Findings

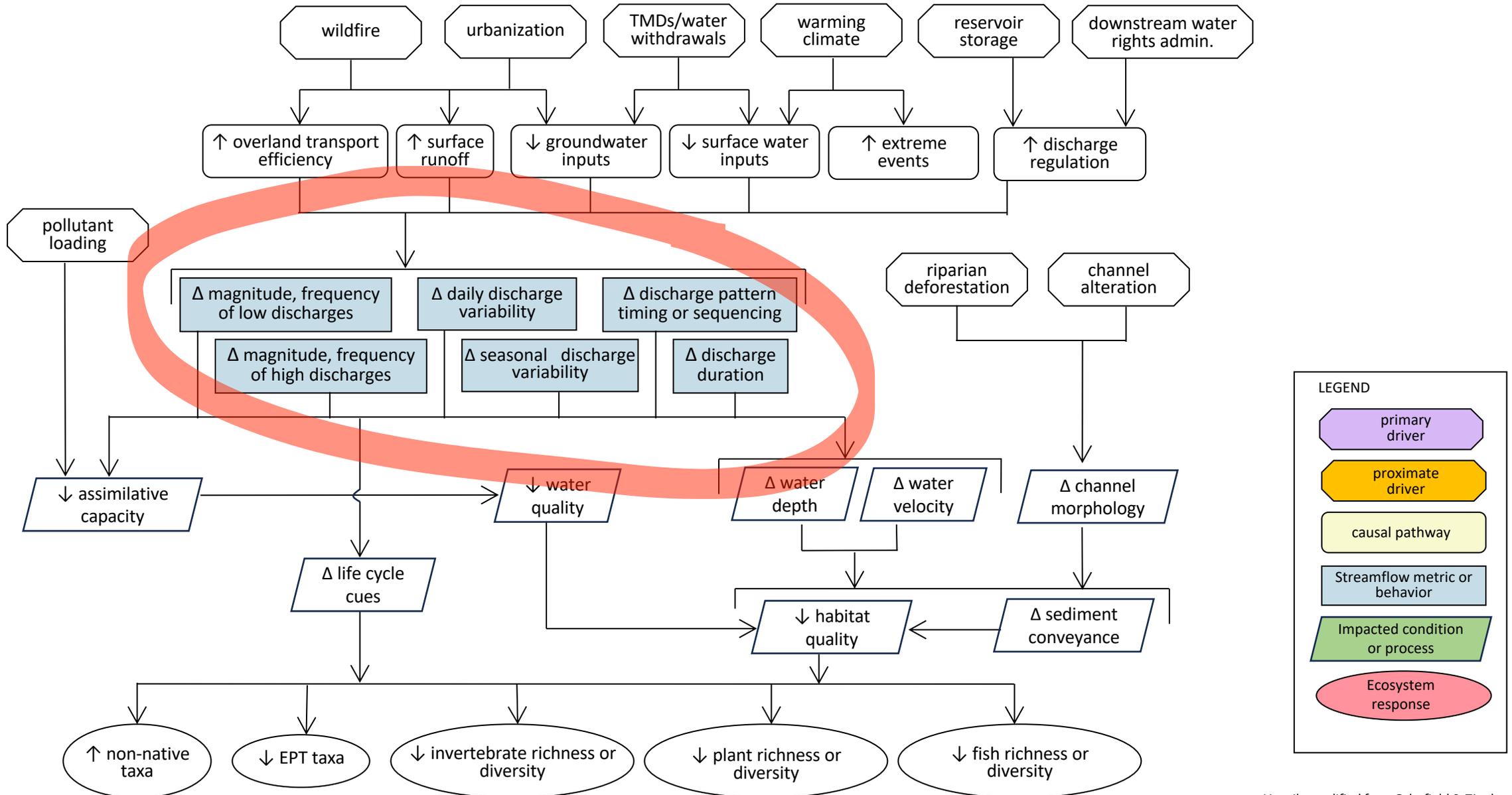


# Streamflow Behavior: Causal Pathway Conceptual Model

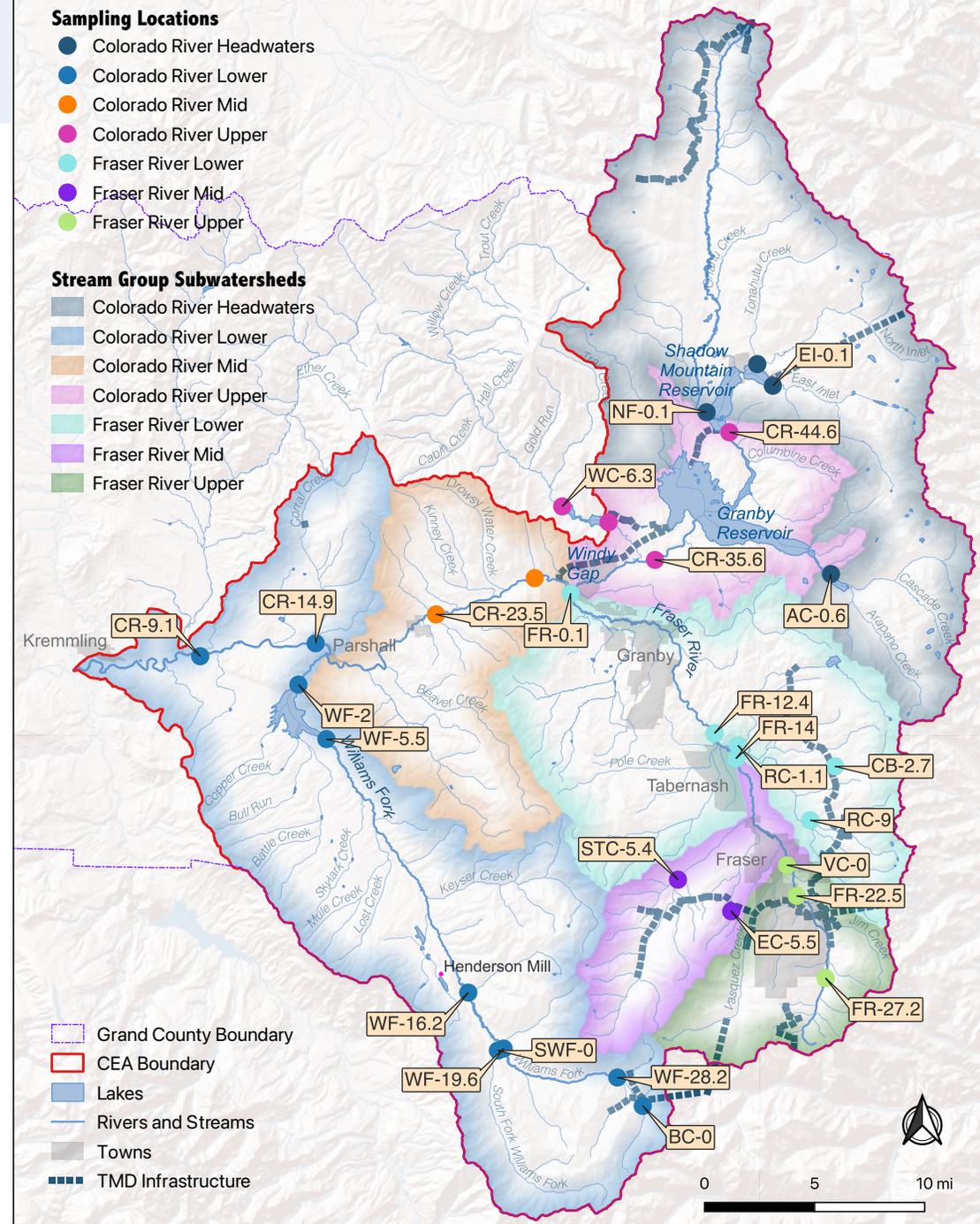
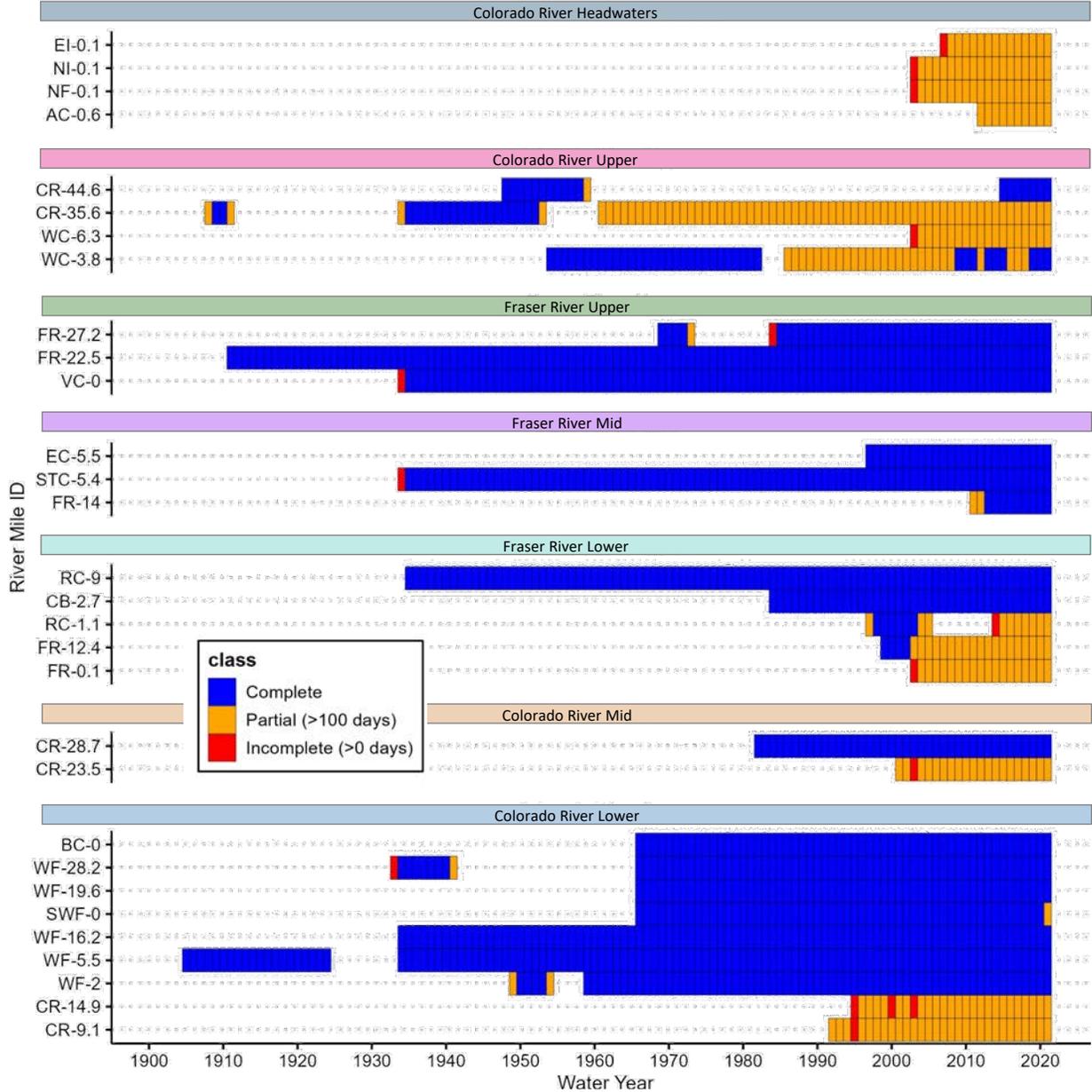


Heavily modified from Schofield & Ziegler; 2010

# Streamflow Behavior: Causal Pathway Conceptual Model



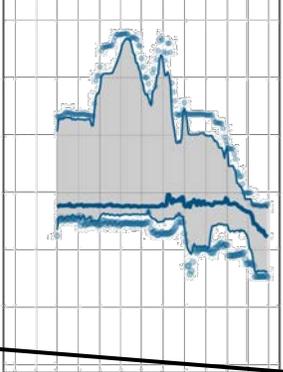
# Streamflow – Data Inventory



# Streamflow – Data Inventory

## Colorado River Upper

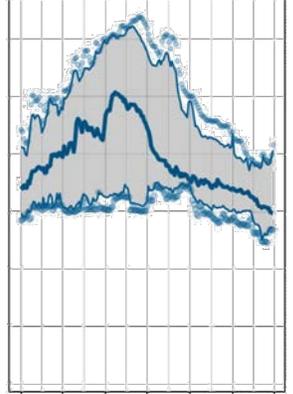
CR-35.6: Colorado River downstream Granby Reservoir at Y-Gage



Apr May Jun Jul Aug Sep Oct

## Colorado River Mid

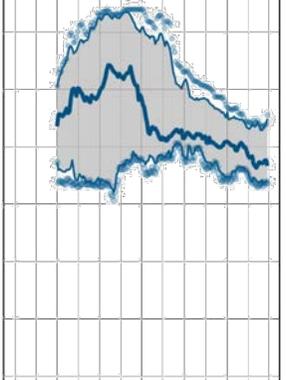
CR-28.7: Colorado River downstream of Windy Gap Reservoir



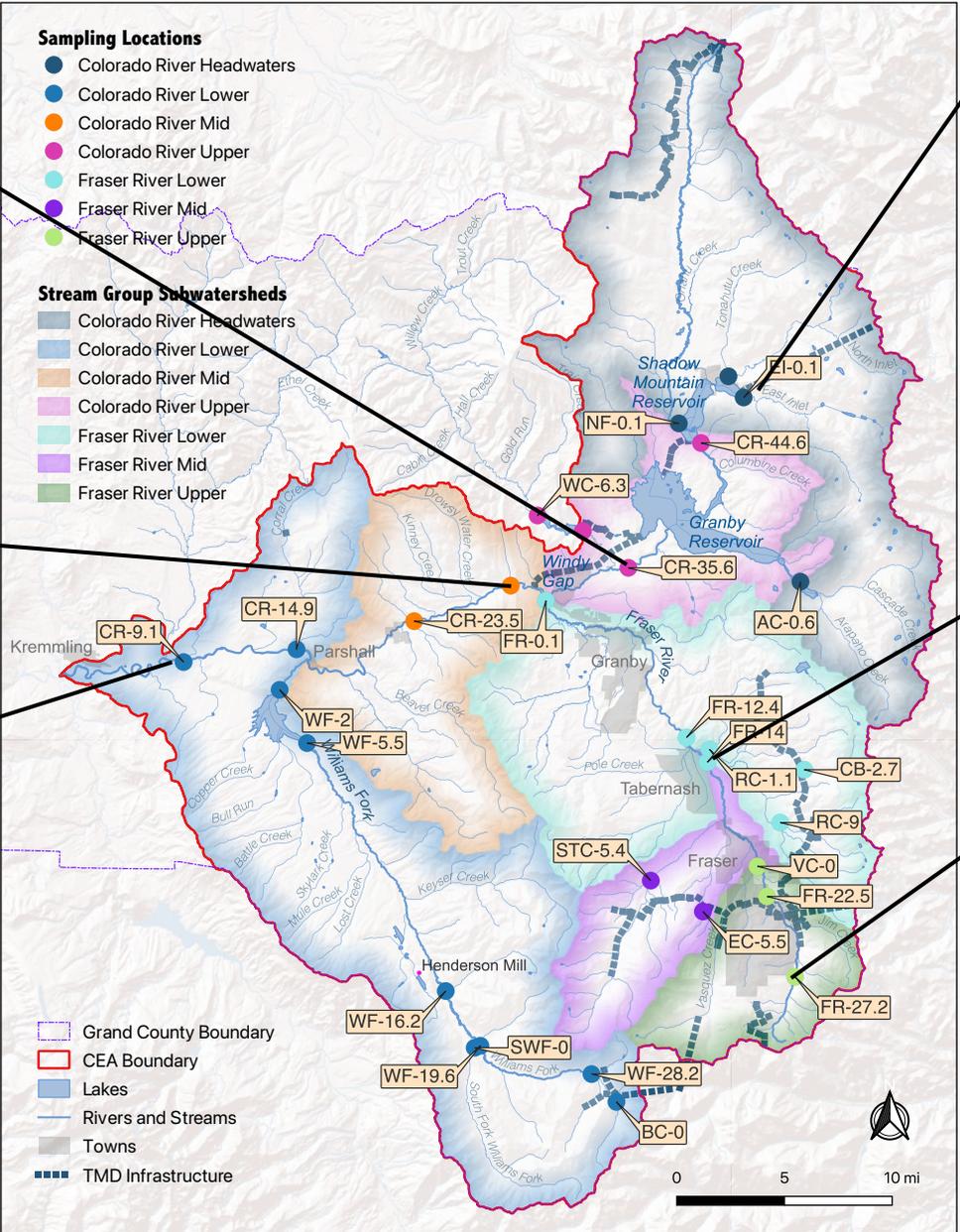
Apr May Jun Jul Aug Sep Oct

## Colorado River Lower

CR-9.1: Colorado River downstream of KB Ditch

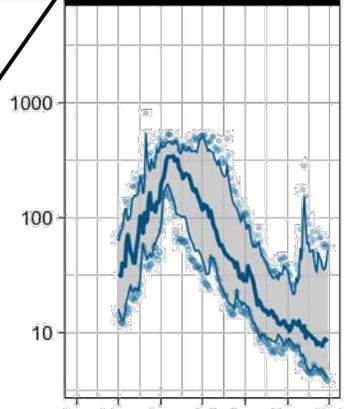


Apr May Jun Jul Aug Sep Oct



## Colorado River Headwaters

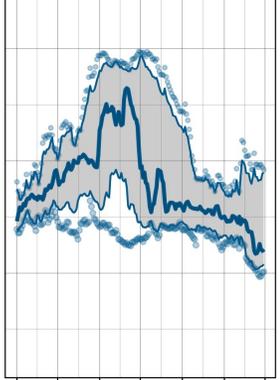
EI-0.1: East Inlet upstream of Grand Lake



Apr May Jun Jul Aug Sep Oct

## Fraser River Lower

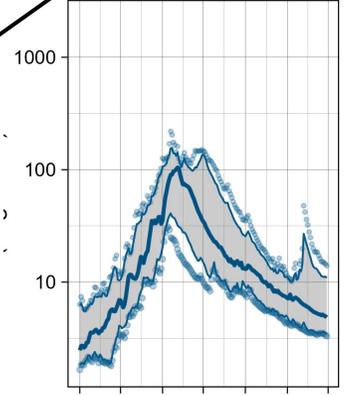
FR-14: Fraser River upstream of Tabernash



Apr May Jun Jul Aug Sep Oct

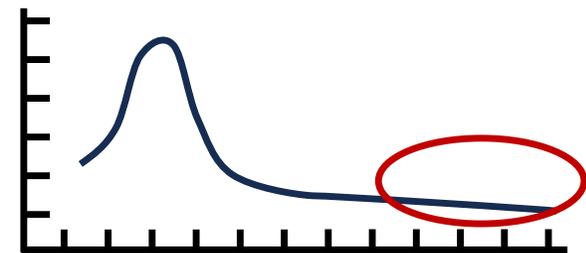
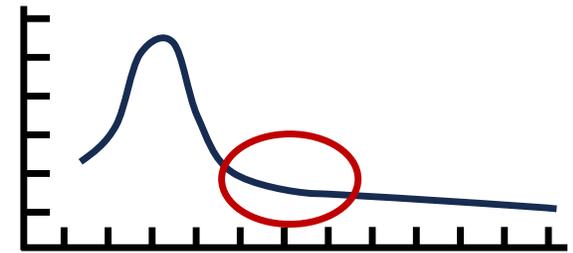
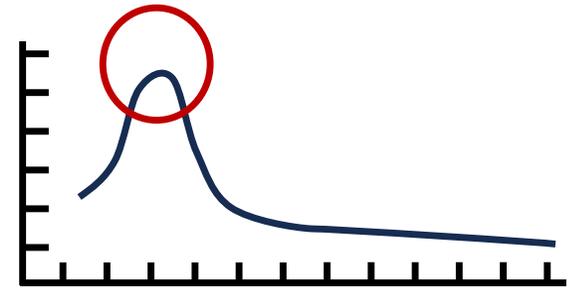
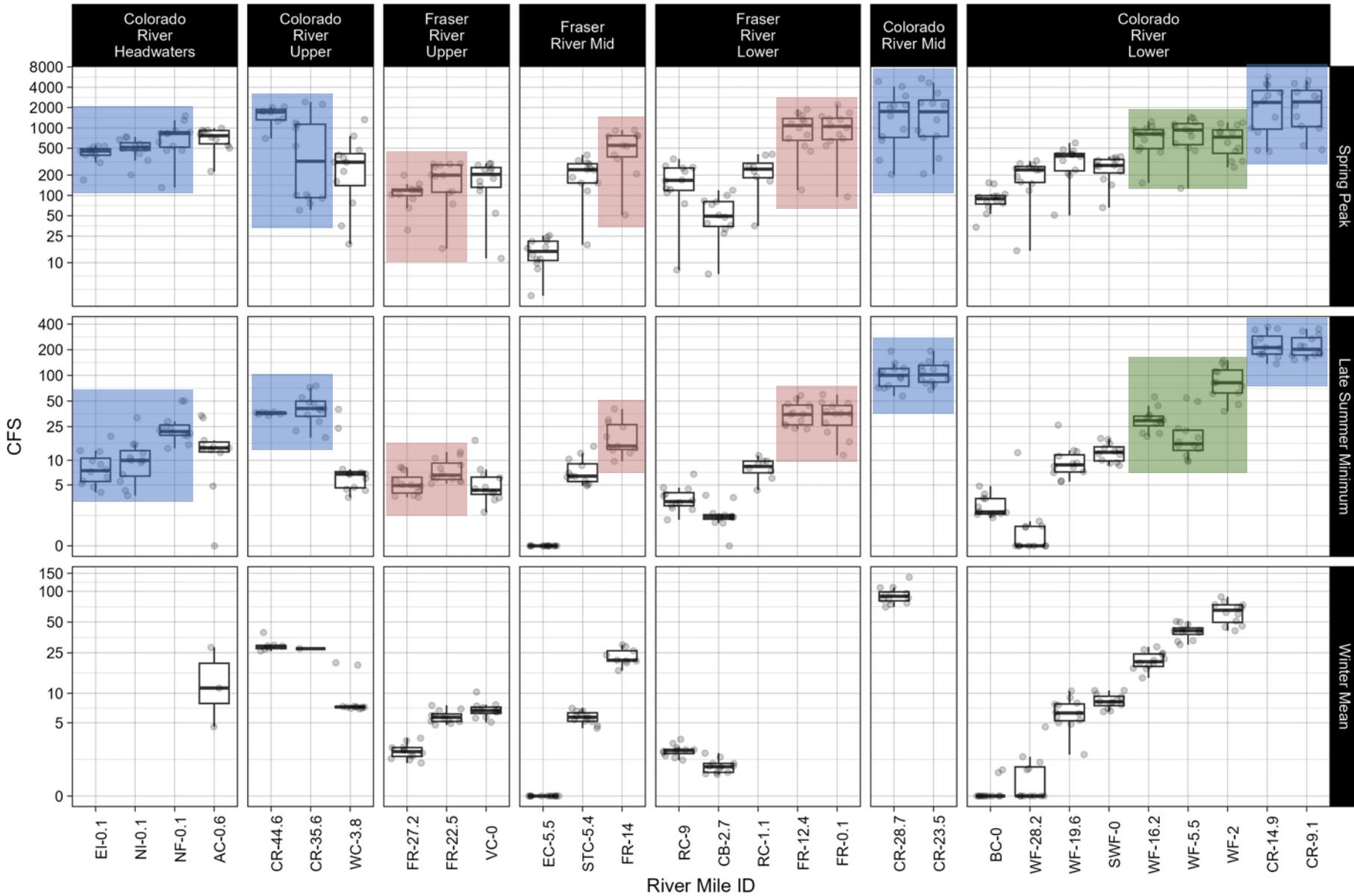
## Fraser River Upper

FR-27.2: Fraser River At Upper Sta. Near Winter Park, Co.



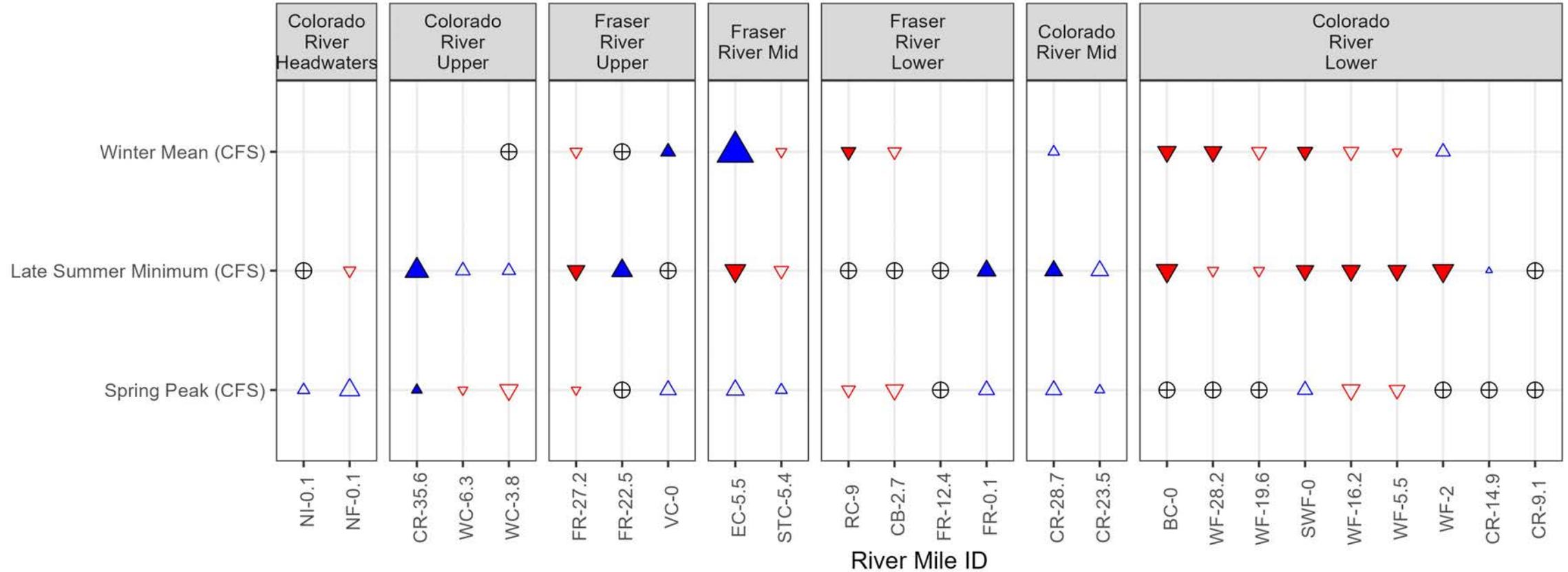
Apr May Jun Jul Aug Sep Oct

# Streamflow Behavior: Major Flow Components



# Streamflow Behavior: Trends

Trends in Hydrologic Metric (Magnitudes)  
(2003-2021)



Trend Direction

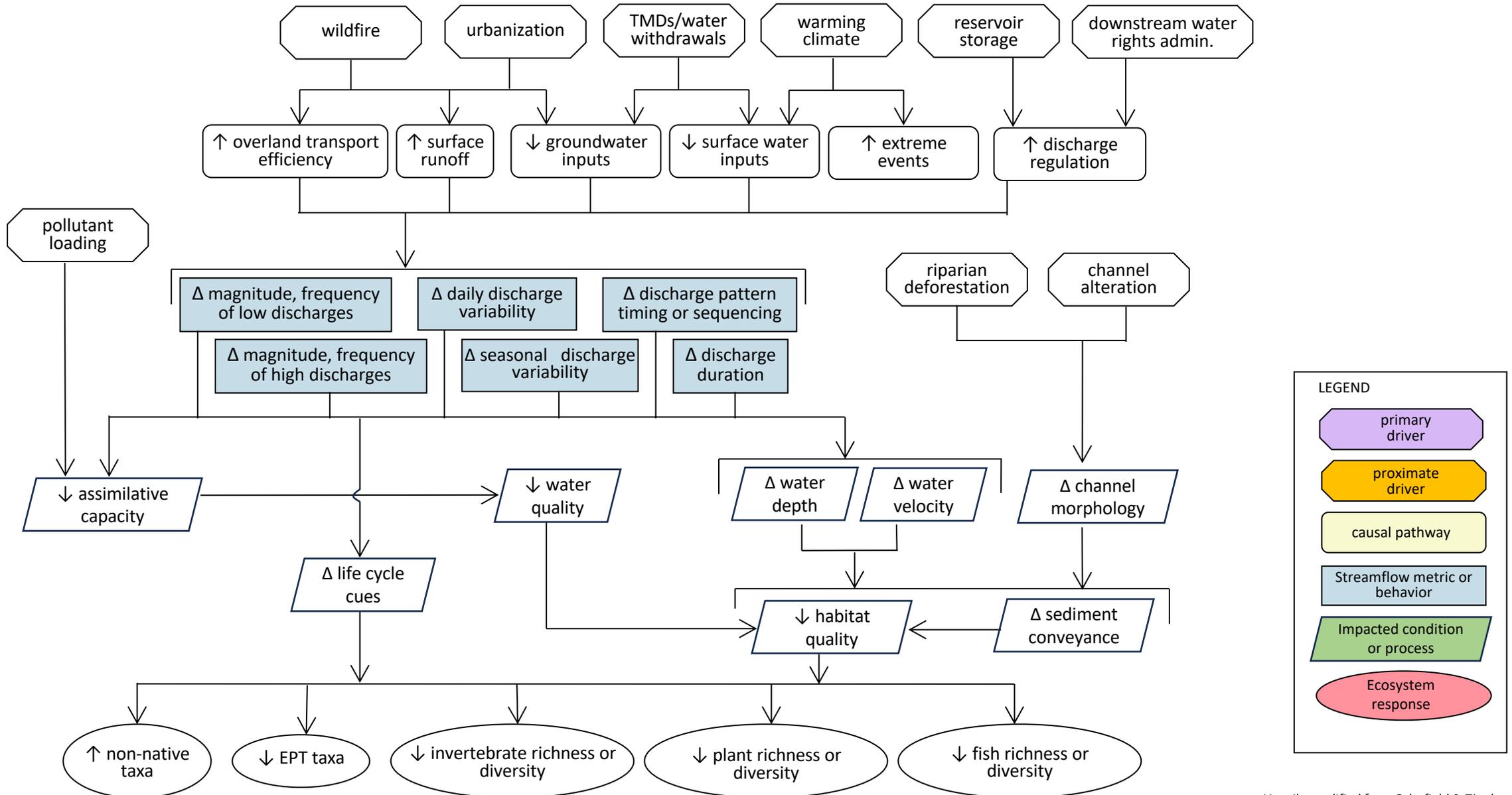
- ▲ Likely Positive
- △ Somewhat Likely Positive
- ⊕ As Likely Positive as Negative
- ▽ Somewhat Likely Negative
- ▼ Likely Negative

Change Per Year (%)

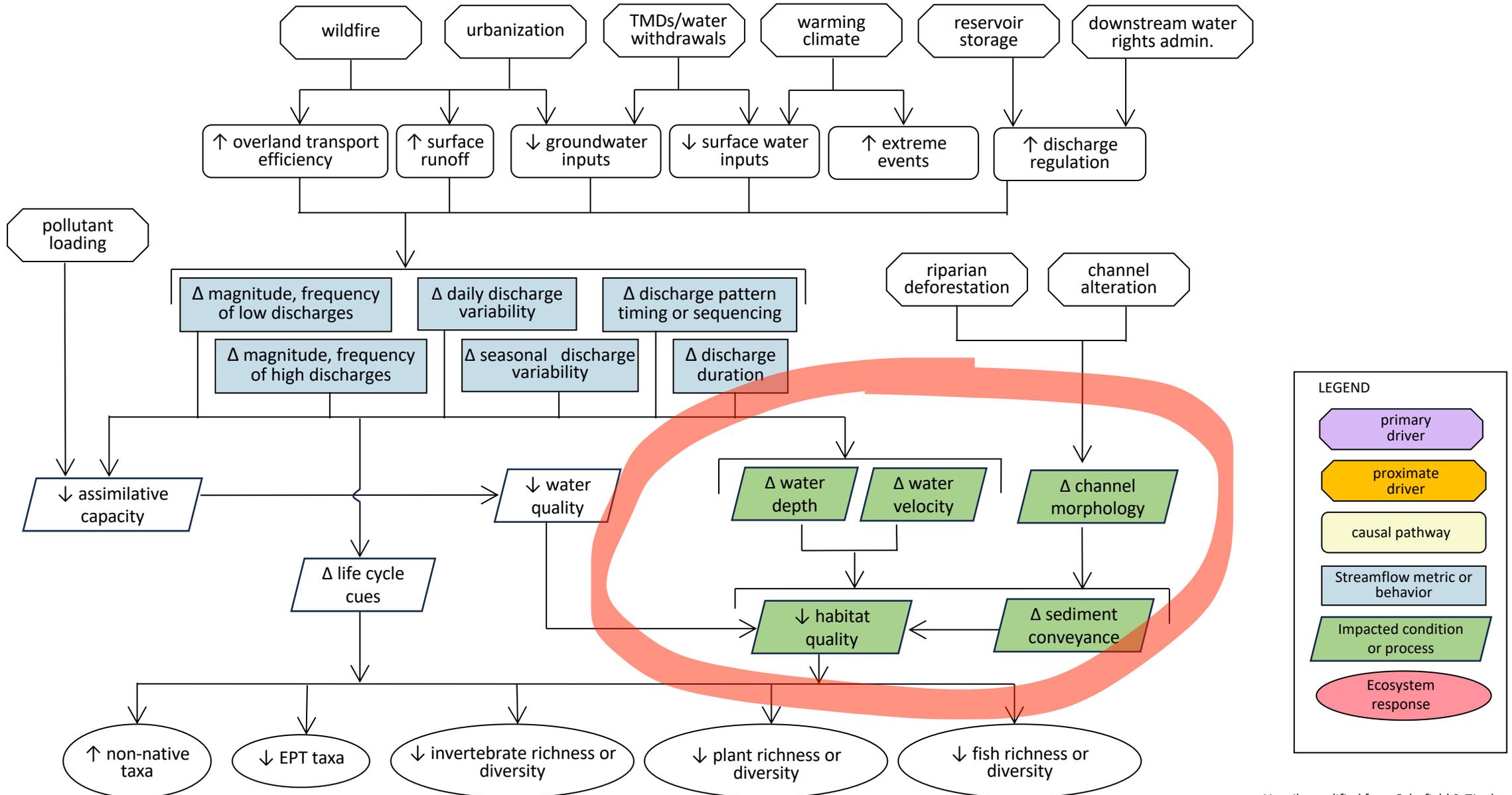
- △ 1.0
- △ 2.5
- △ 5.0
- △ 10.0



# Streamflow Behavior: Causal Pathway Conceptual Model



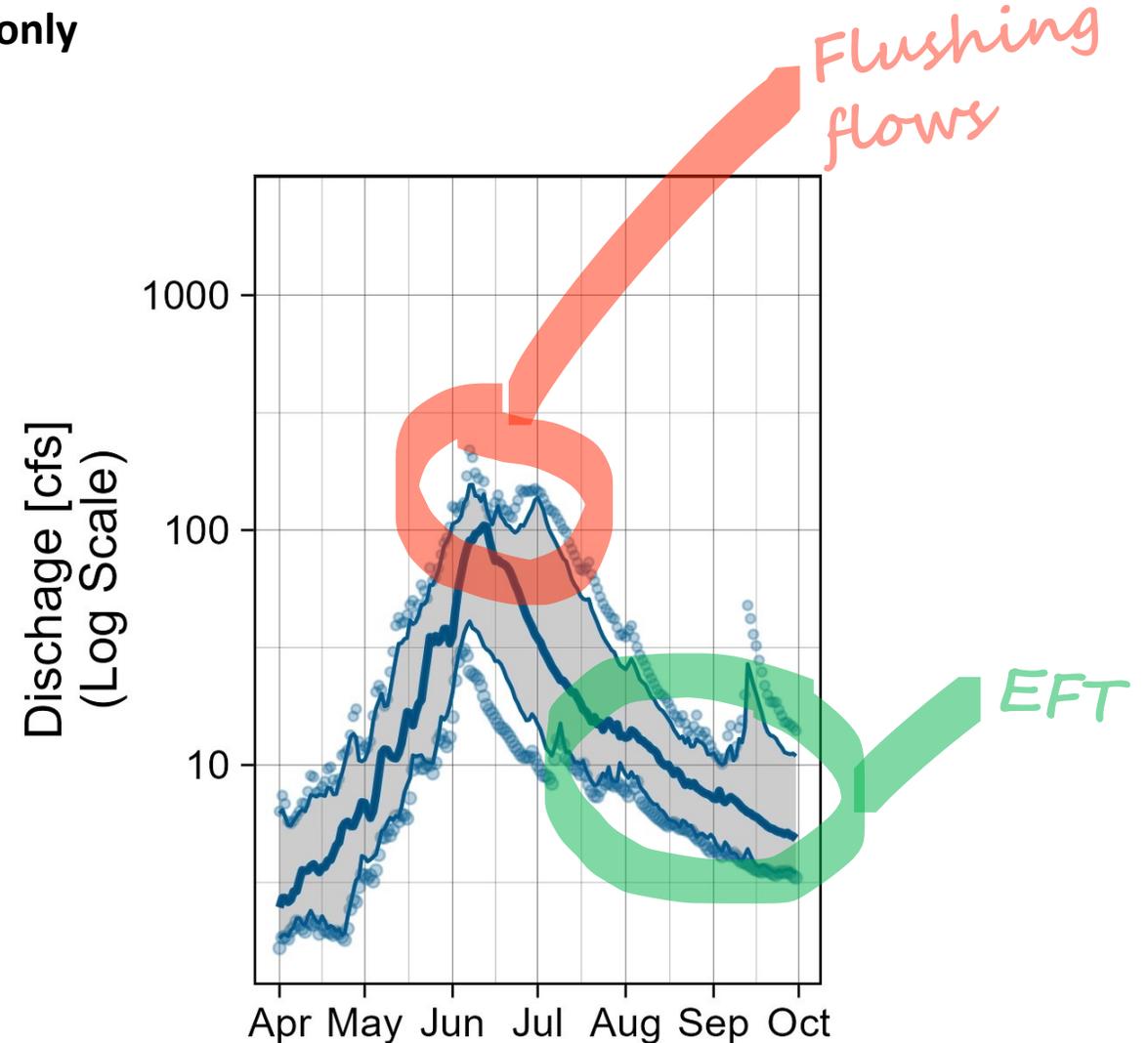
# Streamflow Behavior: Causal Pathway Conceptual Model



# Streamflow Behavior: 2010 GC SMP Flow Recommendations

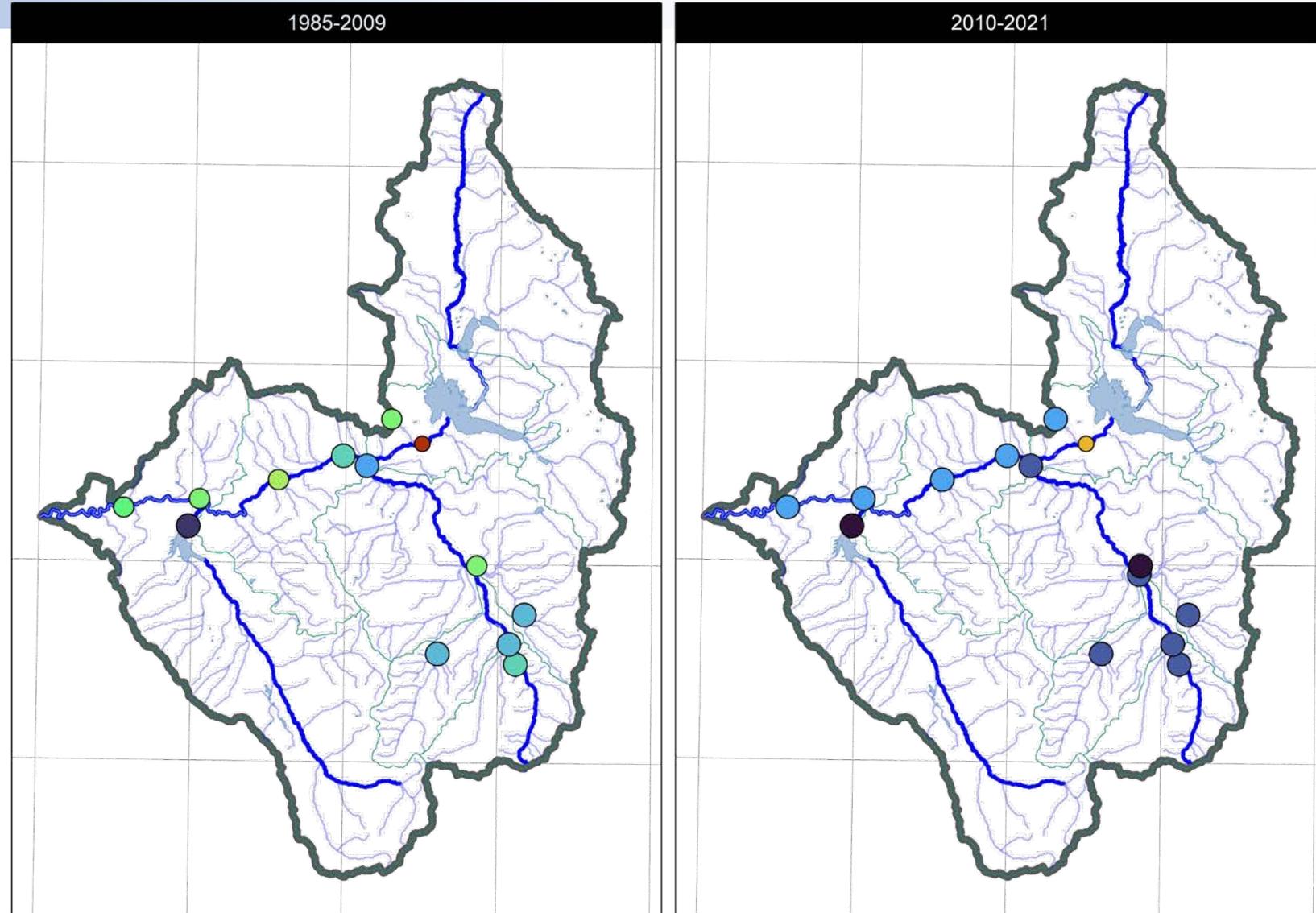
Recommendations used as benchmarks for assessment, but only completed where stream gauges exist (shaded yellow boxes)

2010 GC SMP ID	Corresponding River Mile IDs	Environmental Flow Target (cfs)		Flushing Flow Target (cfs)
		Winter	Summer	
F1	FR-27.2			
F2	FR-23.2 to FR-25.6			
F3	FR-21 to FR-23.4	4-10	4-10	80
F4	FR-20 to FR-21	10-30	20-30	
F5	FR-16.9 to FR-18.1			
F6	FR-14 to FR-16.9	40-50	40-60	200
F7	FR-12.4			
F8	FR-6.7	40-100	75-100	
F9	FR-4.5 to FR-6.7	40-100	80-120	400
F10	FR-0.1 to FR-3.5	40-100	80-120	400
F-VC	VC-0 to VC-8	5-8	5-8	50
FRC-1	RC-5.8 to RC-9	6-10	6-10	40
FRC-2	RC1.1 to RC-4.7	20-30	30-50	150
FSTL	STC-0	5-10	5-10	70
CR1	NF-0.1			
CR2	CR-43.5 to CR-44.6			
CR3	CR-31 to CR-38.3	40-100	90-160	200
CR4	CR-16.7 to CR-30.8	125-250	200-400	600
CR5	CR-9.1 to CR-14.9	150-250	250-500	800
CR6	CR-1.7 to CR-9.1	150-250	250-500	850
WR	WF-0.5 to WF-2	40-100	40-140	200
RE	RDS-0 to RDC-0.7	1.2	2.1	12
WC	WC-2.3 to WC-3.8	7-10	7-10	50



# Streamflow Behavior: Peak Flows

- Recommended flushing flows: meet target peak flows for 3 consecutive days, once every two years
- Higher achievement in current period compared to historical period (1985-2009) across all reaches.



Years (%) Achieving Flushing Flow ● 25 ● 50 ● 75 ● 100

# Streamflow Behavior: Peak Flows

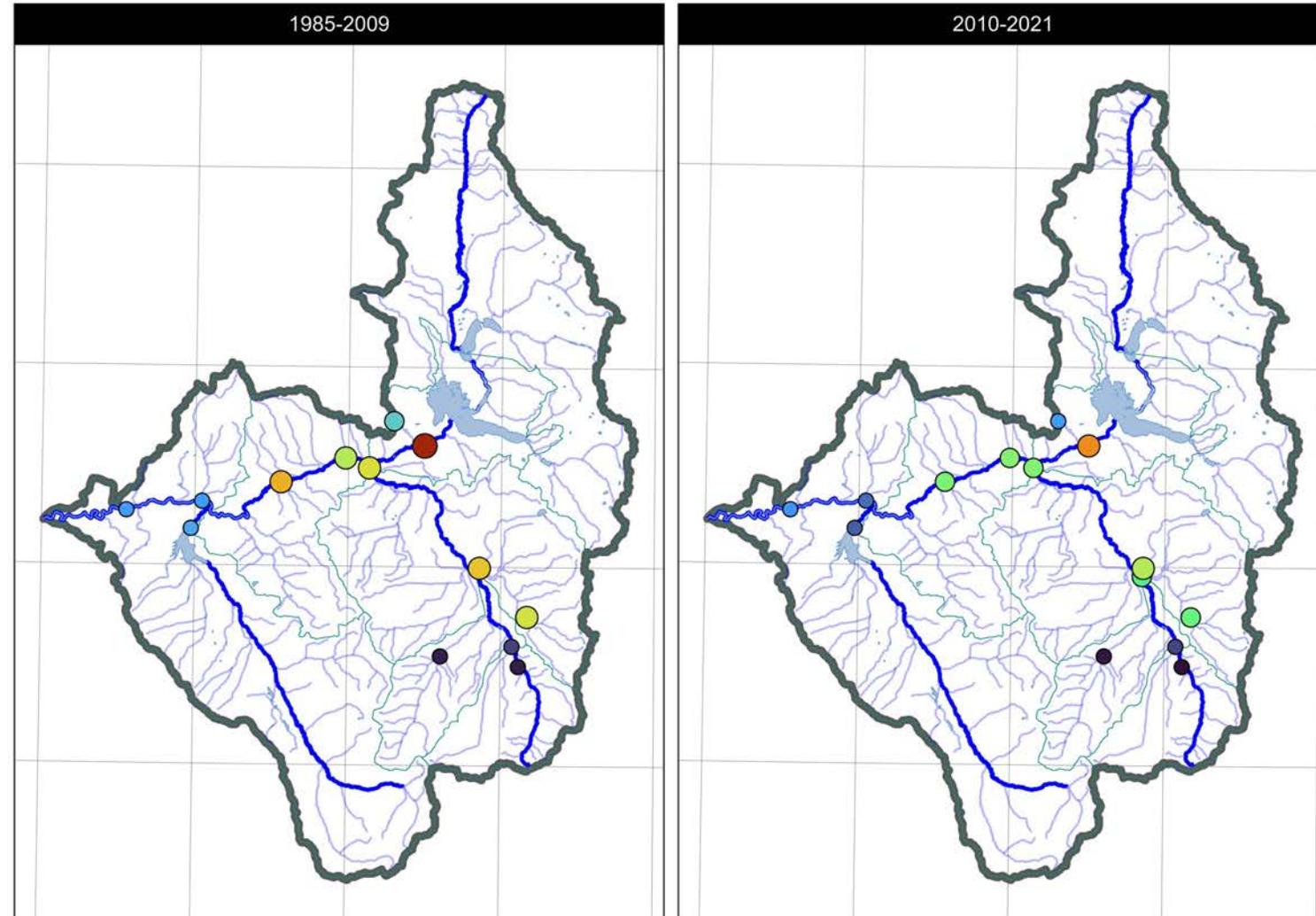
- Recommended flushing flows: meet target peak flows for 3 consecutive days, once every two years
- Higher achievement in current period compared to historical period (1985-2009) across all reaches.

<i>Stream Group</i>	<i>Reach ID</i>	<i>River Mile ID</i>	<b>Historical (1985 – 2009)</b>		<b>Current (2010 – 2021)</b>	
			<i>Years in Record</i>	<i>Flushing Flow Target Met (% Years)</i>	<i>Years in Record</i>	<i>Flushing Flow Target Met (% Years)</i>
Colorado River Upper	CR3	CR-35.6	25	32	12	50
	WC-2	WC-3.8	24	67	12	83
Fraser River Upper	F3	FR-22.5	25	76	12	92
	F-VC	VC-0	25	80	12	92
Fraser River Mid	F-STL1	STC-5.4	25	80	12	92
	F6	FR-14	-	-	11	91
Fraser River Lower	F-RC1	RC-9	25	80	12	92
	F-RC2	RC-1.1	9	67	7	100
	F10	FR-0.1	6	83	12	92
Colorado River Mid	CR4	CR-28.7	25	76	12	83
	CR4	CR-23.5	8	63	12	83
Colorado River Lower	WF-3	WF-2	25	96	12	100
	CR5	CR-14.9	12	67	12	83
	CR6	CR-9.1	16	69	12	83



# Streamflow Behavior: Summer Flows

- Summer environmental flow targets (EFTs) protect availability of adult habitat
- Summer EFT met 26-100% of days across CEA reaches
- Lowest achievement on Colorado R. below Granby, Windy Gap to Williams Fork, Ranch Creek, and Mid/Lower Fraser River
- Small to moderate improvements compared to historical period.
- Years with lowest target achievement include 2012, 2013, 2018, 2021



Percent Days Below Lower EFT ● 0 ● 25 ● 50 ● 75 ● 100

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<i>Stream Group</i>	<i>Reach ID</i>	<i>River Mile ID</i>	<b>Historical (1985 – 2009)</b>	<b>Current (2010 – 2021)</b>
			<b>Summer EFT (lower) (% of days met)</b>	<b>Summer EFT (lower) (% of days met)</b>
Colorado	CR3	CR-35.6	7	26
River Upper	WC-2	WC-3.8	70	80
Fraser River	F3	FR-22.5	98	100
Upper	F-VC	VC-0	92	92
Fraser River	F-STL2	STC-5.4	98	99
Mid	F6	FR-14	-	61
Fraser River	F-RC1	RC-9	43	58
Lower	F-RC2	RC-1.1	36	48
	F10	FR-0.1	41	55
Colorado	CR4	CR-28.7	48	55
River Mid	CR4	CR-23.5	32	56
	WF-3	WF-2	78	88
Colorado	CR5	CR-14.9	80	86
River Lower	CR6	CR-9.1	80	81

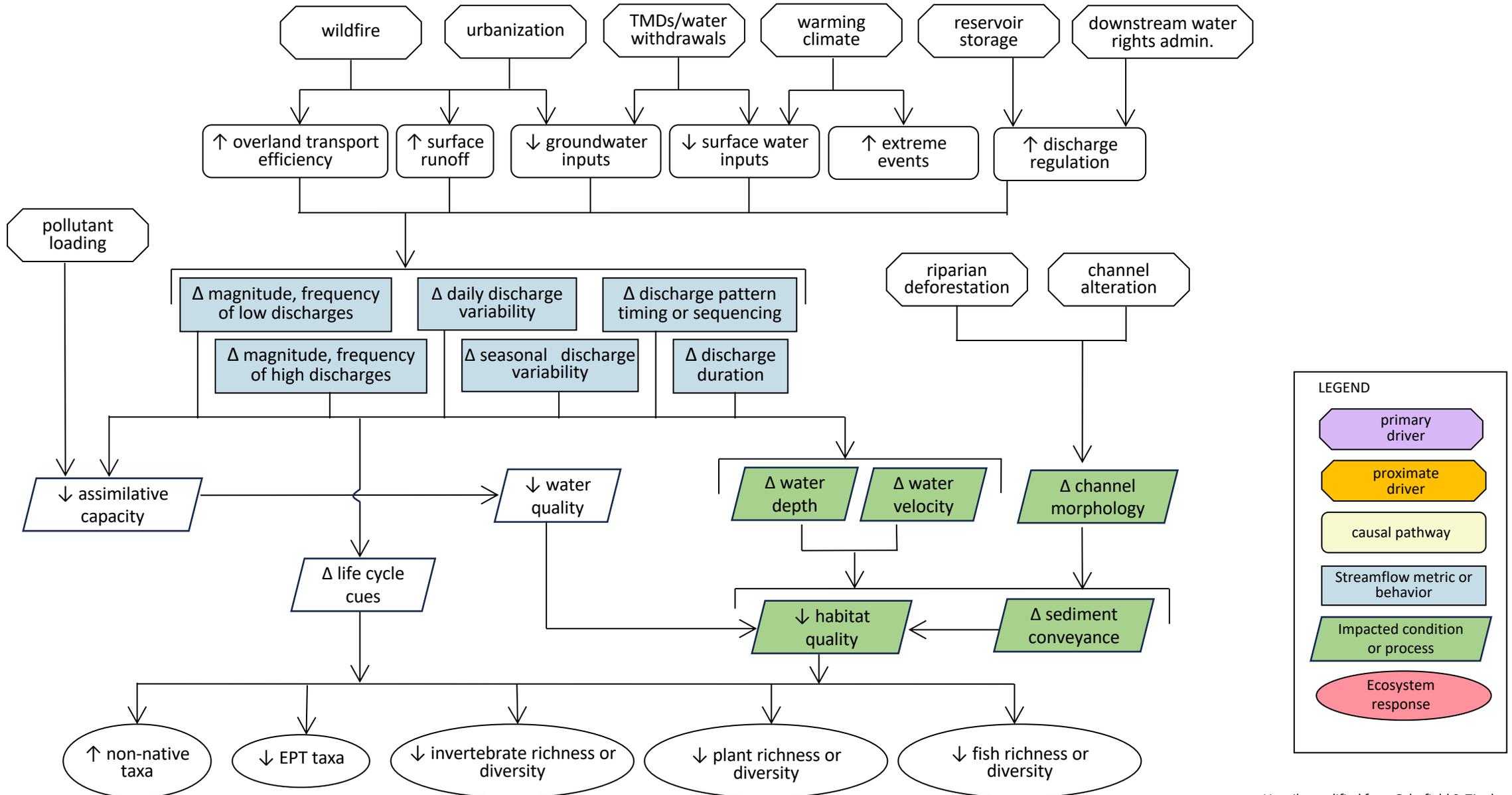


# Streamflow Behavior: Winter Flows

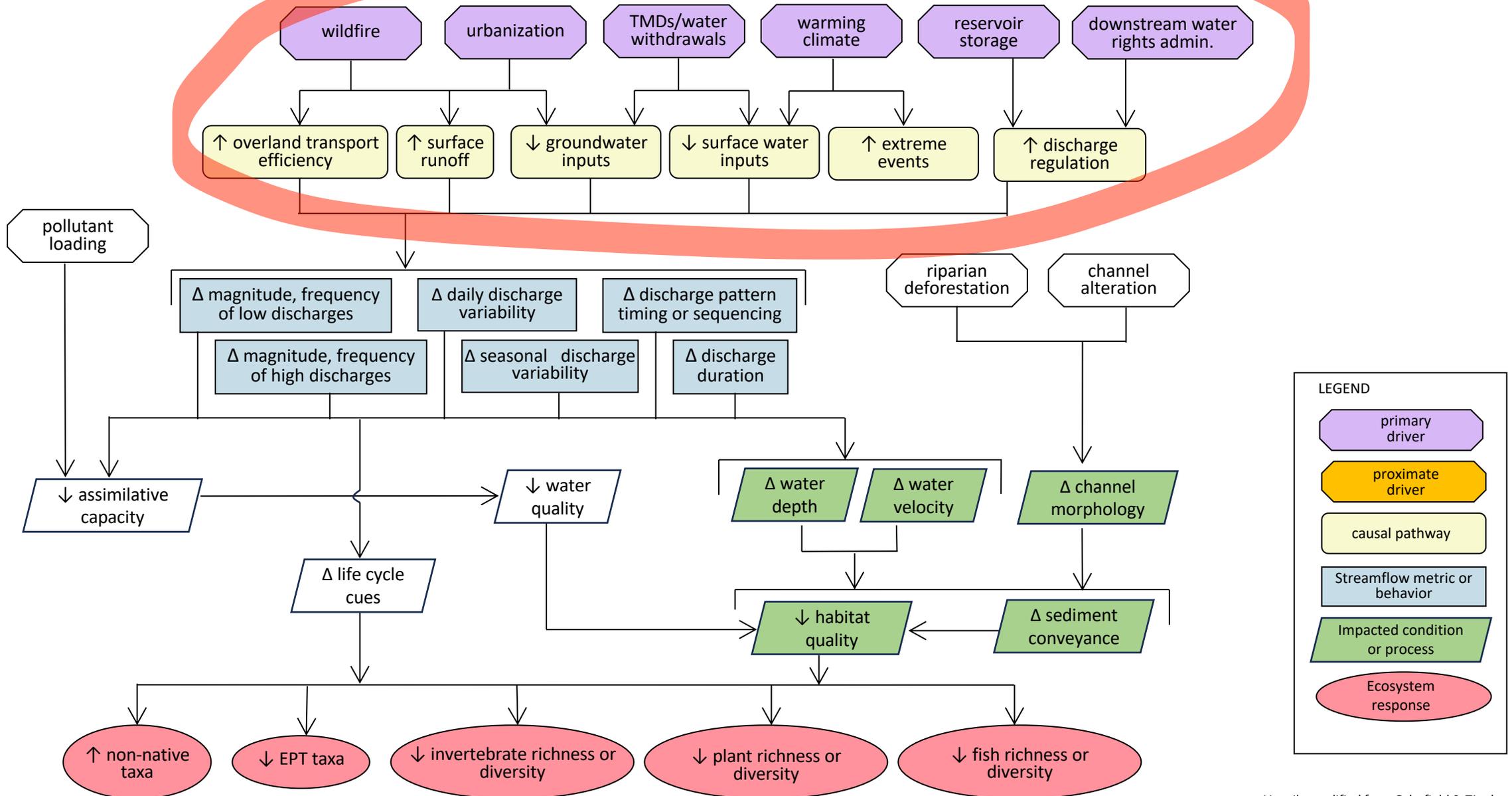
- Winter environmental flow target protects spawning/incubation habitat
- Analysis is limited by a lack of winter flow data on many reaches
- Winter EFT met 3-99% of observed days across CEA reaches.
- Lowest achievement on Colorado River Mid, Fraser River Mid and Ranch Creek

			1985 - 2009	2010 - 2021
<i>Stream Group</i>	<i>Reach ID</i>	<i>River Mile ID</i>	Lower EFT (% of days)	Lower EFT (% of days)
Colorado River	CR3	CR-35.6	-	-
Upper	WC-2	WC-3.8	43	74
Fraser River	F3	FR-22.5	87	99
Upper	F-VC	VC-0	55	83
Fraser River	F-STL2	STC-5.4	85	79
Mid	F6	FR-14	-	4
Fraser River	F-RC1	RC-9	3	3
Lower	F-RC2	RC-1.1	1	-
	F10	FR-0.1	-	-
Colorado River	CR4	CR-28.7	9	13
Mid	CR4	CR-23.5	-	-
Colorado River	WF-3	WF-2	89	93
Lower	CR5	CR-14.9	-	-
	CR6	CR-9.1	-	-

# Streamflow Behavior: Causal Pathway Conceptual Model



# Streamflow Behavior: Causal Pathway Conceptual Model

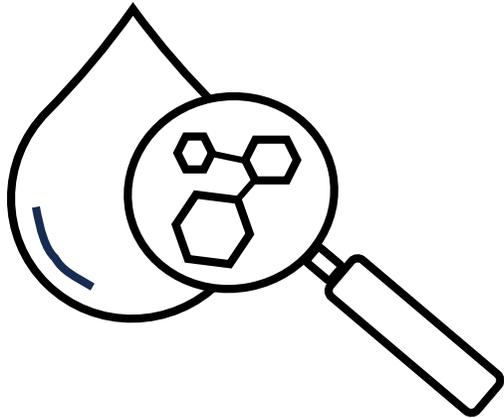




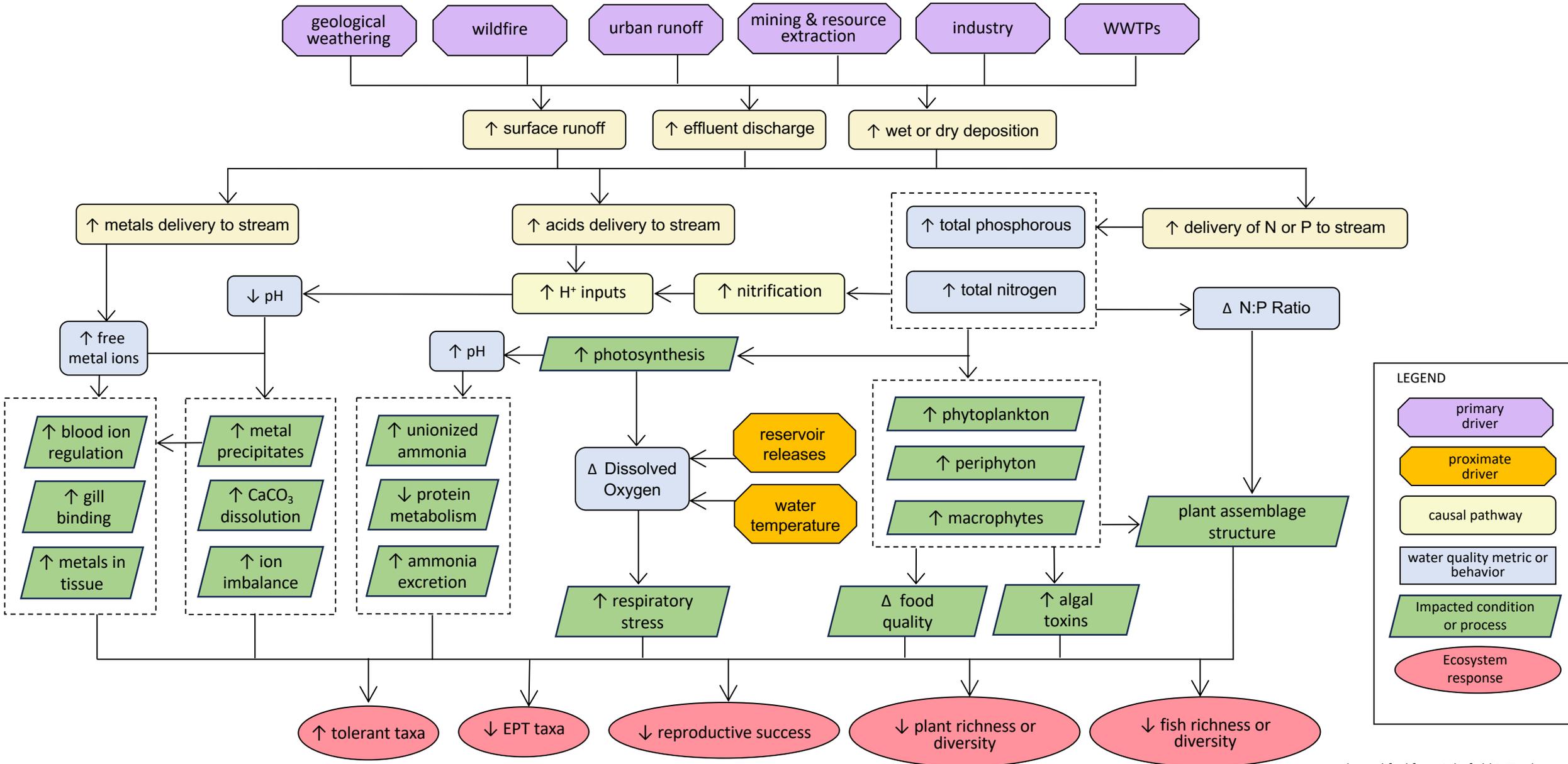
# Water Quality Assessment

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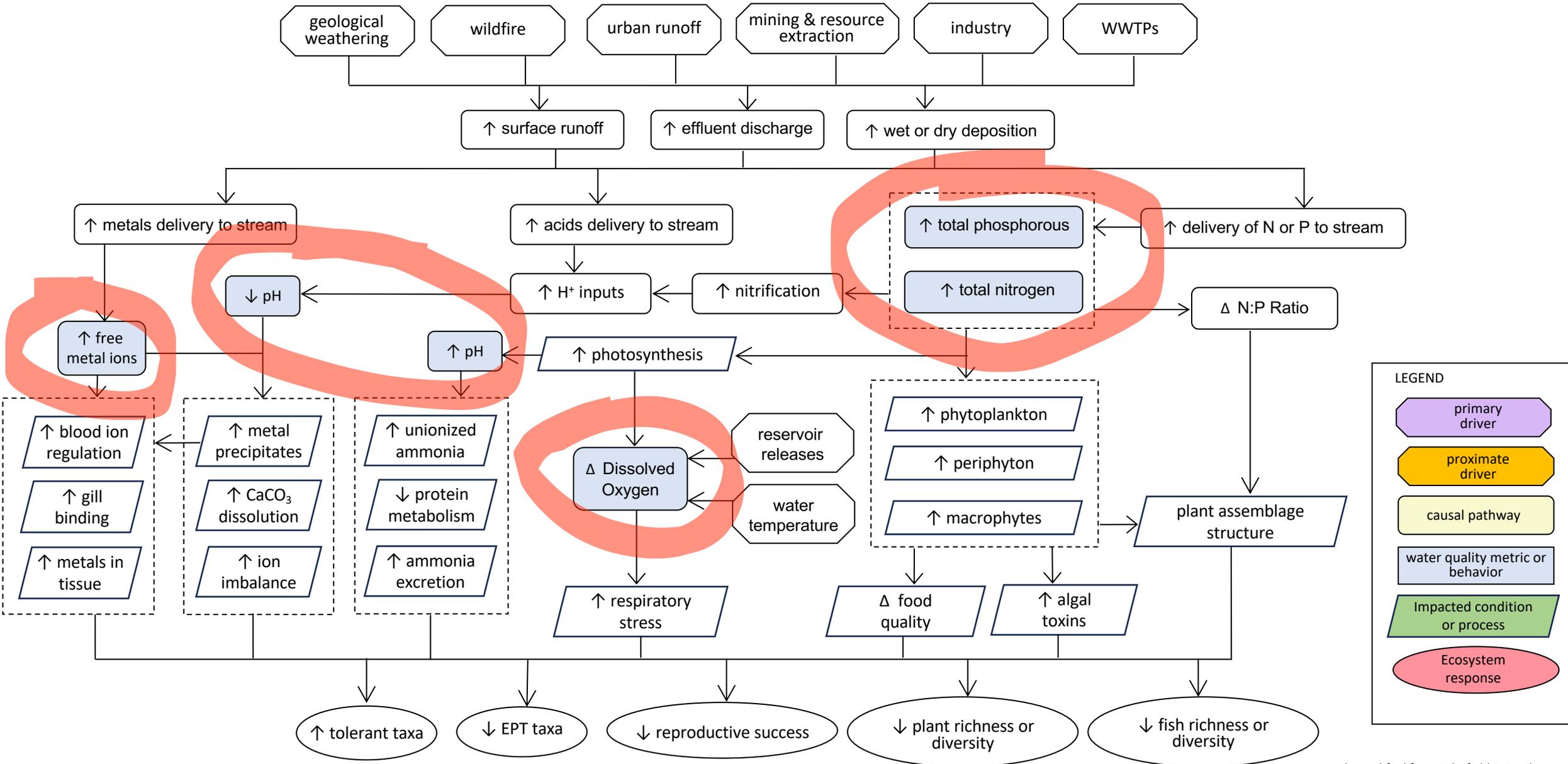
## Summary of Findings



# Water Quality: Causal Pathway Conceptual Model



# Water Quality: Causal Pathway Conceptual Model

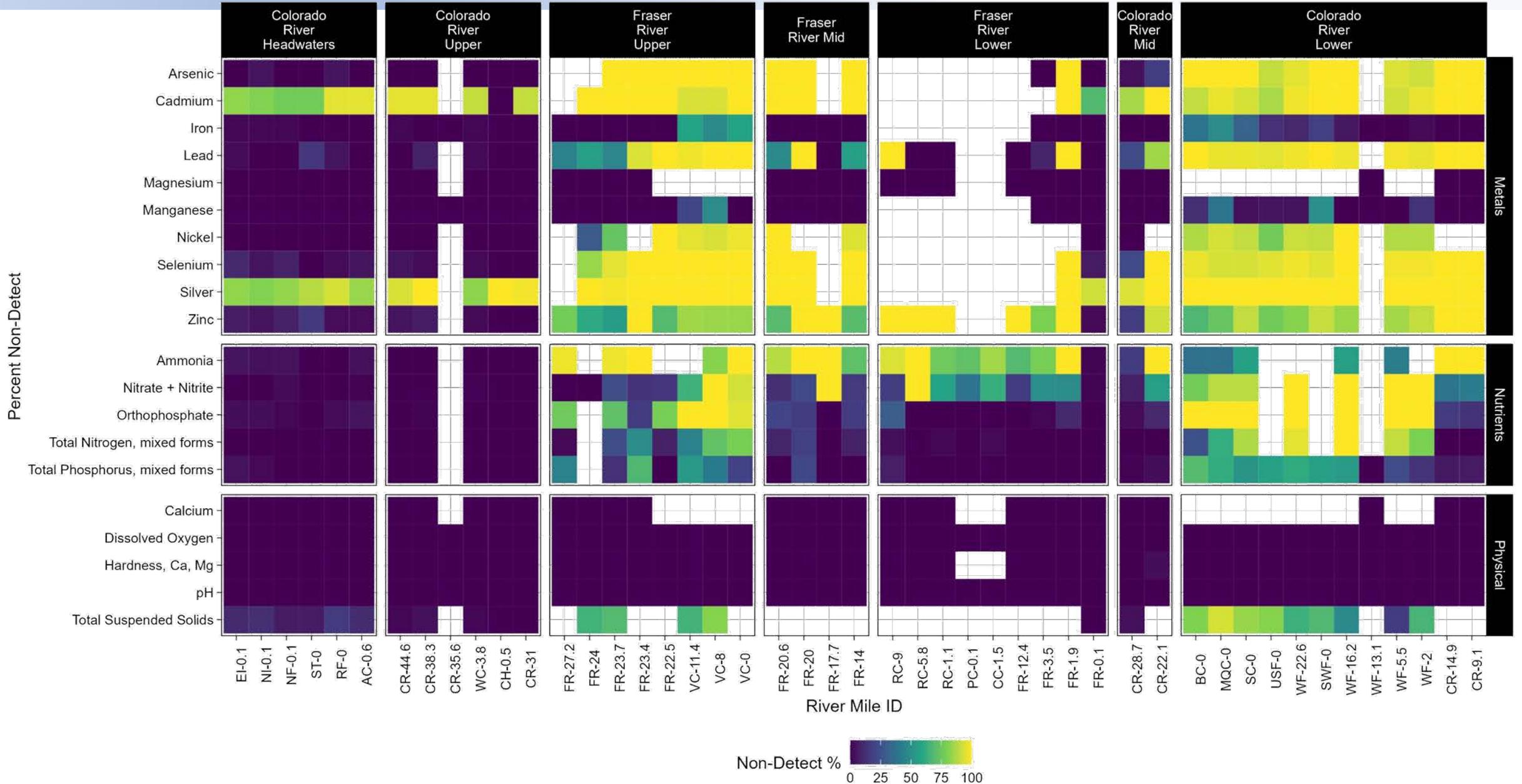




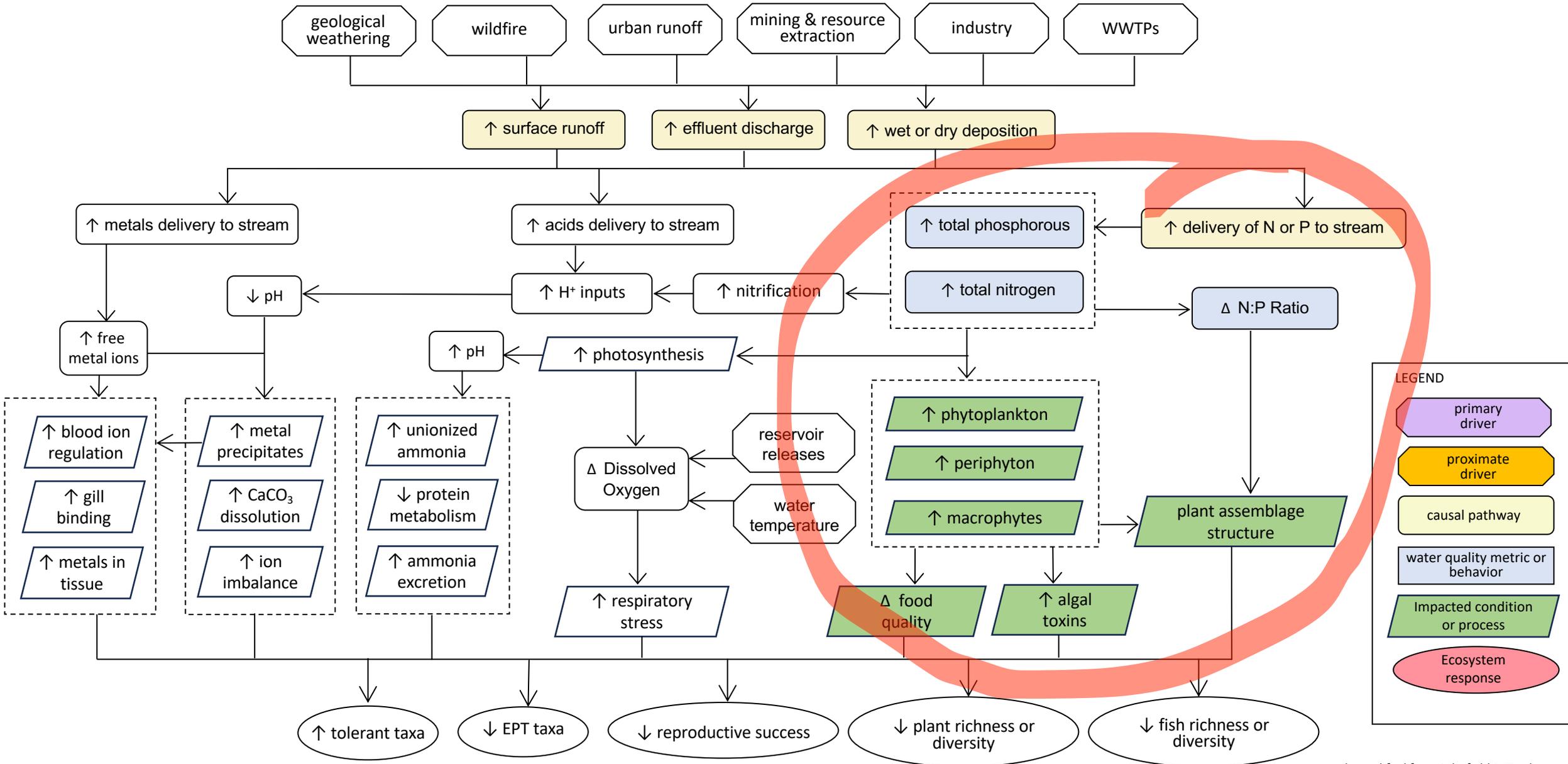




# Water Quality: Non-Detects



# Water Quality: Causal Pathway Conceptual Model



# Water Quality: Nutrients

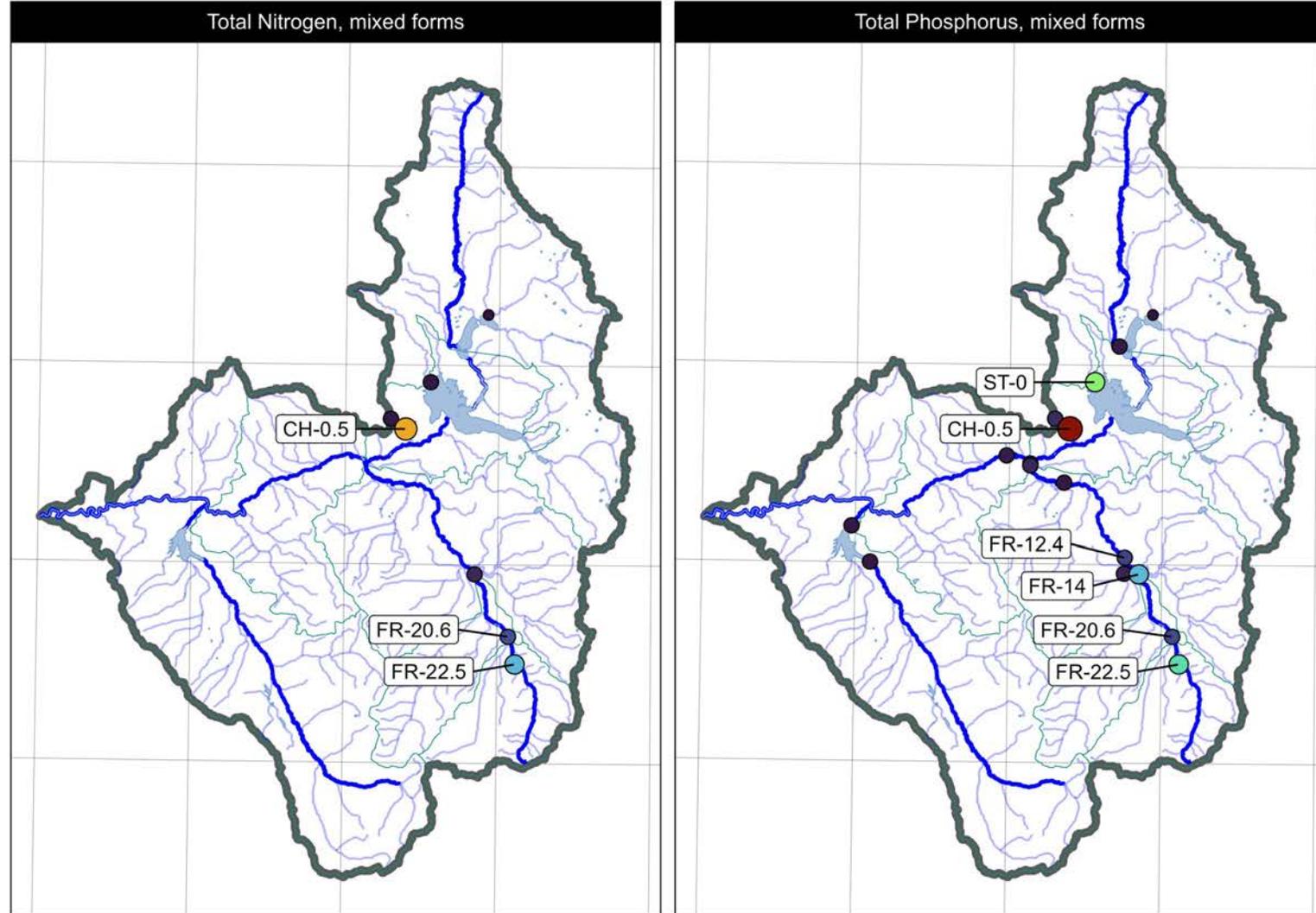
**TP is the most commonly elevated nutrient:**

- Colorado River Headwaters
- Colorado River Upper Tributaries
- Colorado River Upper and Mid mainstem reaches
- Fraser River mainstem reaches
- Williams Fork mainstem.

**Elevated TN observed in:**

- Colorado River Headwaters
- Colorado River Upper Tributaries
- Fraser River Upper and Mid mainstem reaches

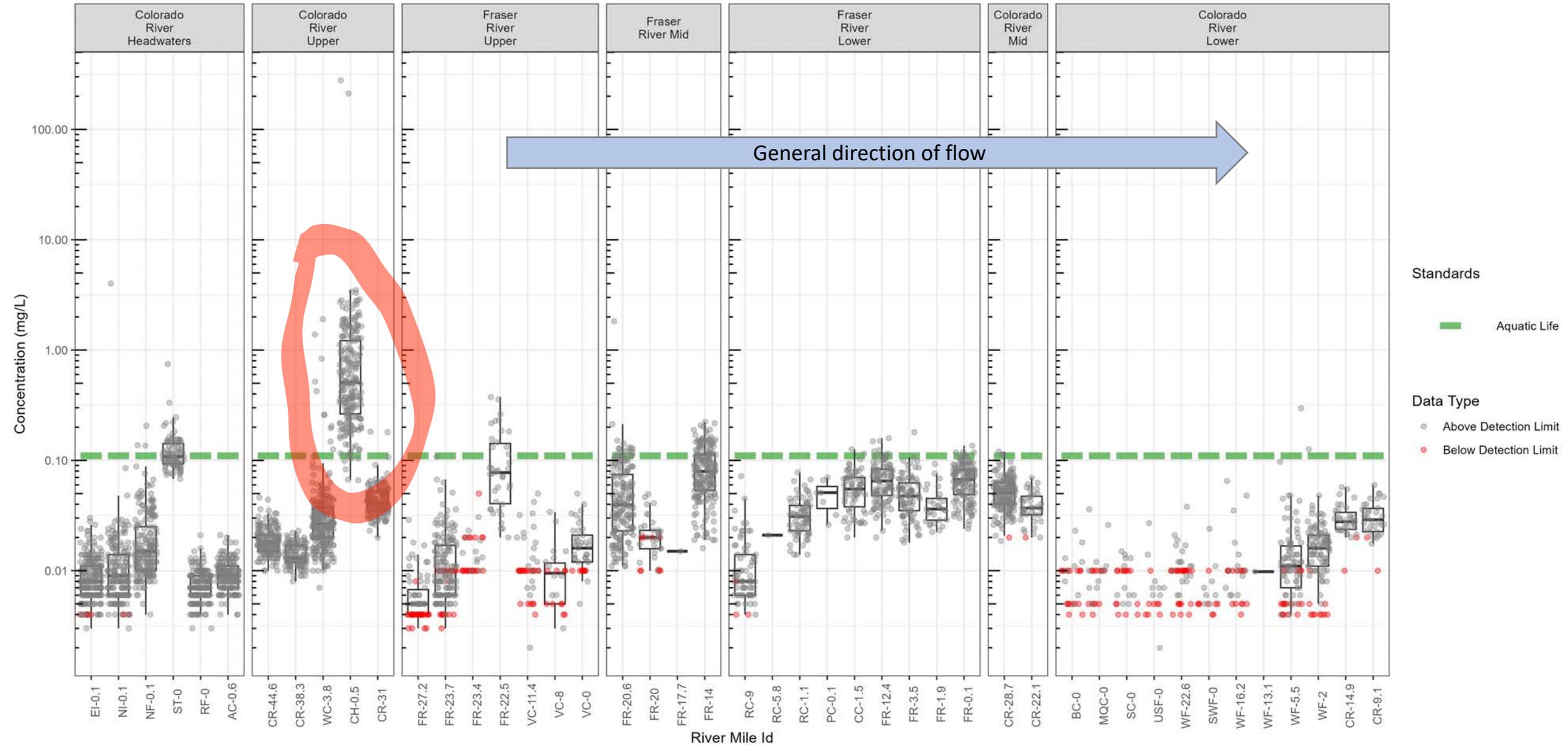
\*Note: this is not an assessment of regulatory exceedances



Samples (%) Above Regulatory Standard ● 1 ● 25 ● 50 ● 75 ● 100

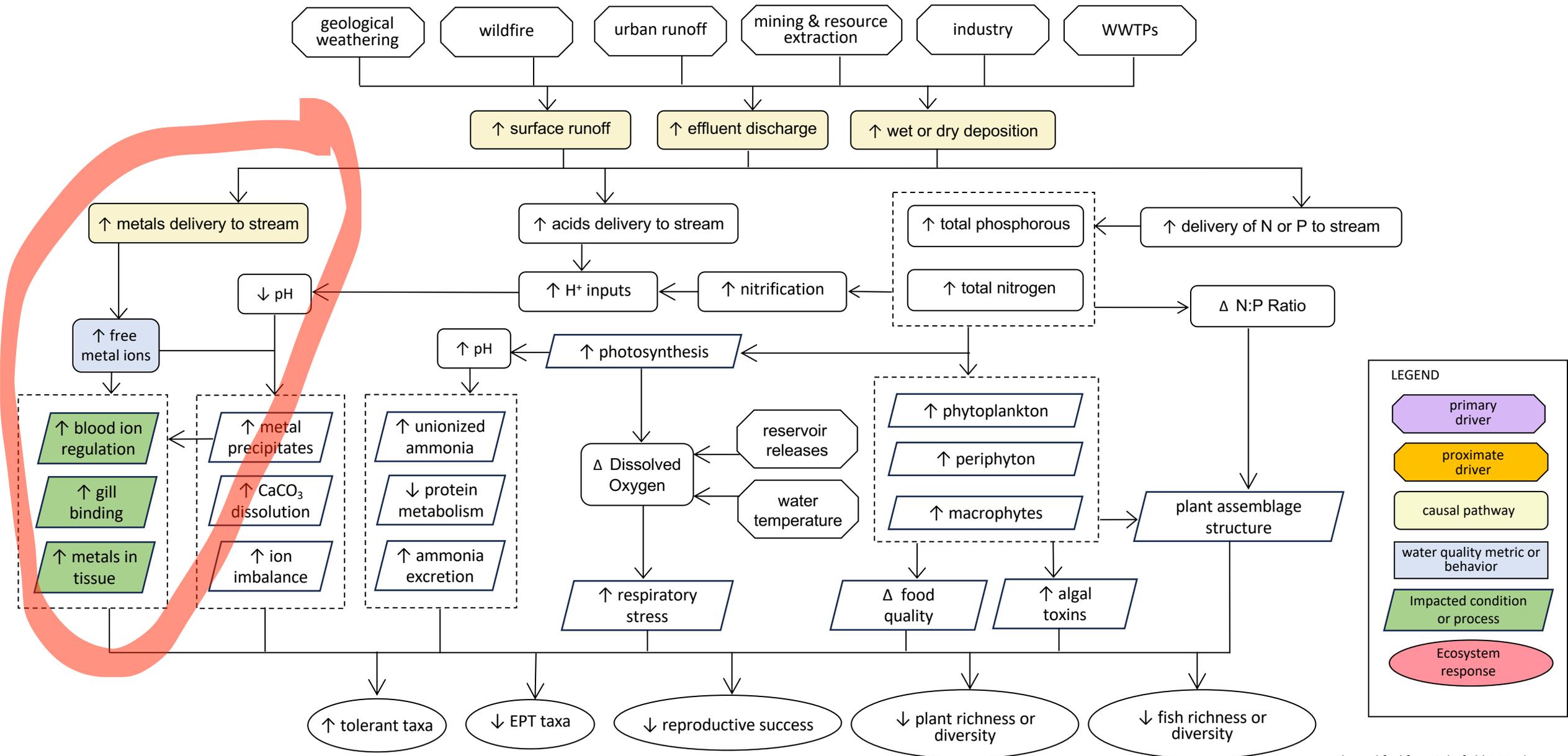
# Water Quality: Nutrients + Introduction to Boxplots

All Sites: Total Phosphorus, mixed forms (Total)





# Water Quality: Causal Pathway Conceptual Model



# Water Quality: Metals

## Iron is the most common elevated metal:

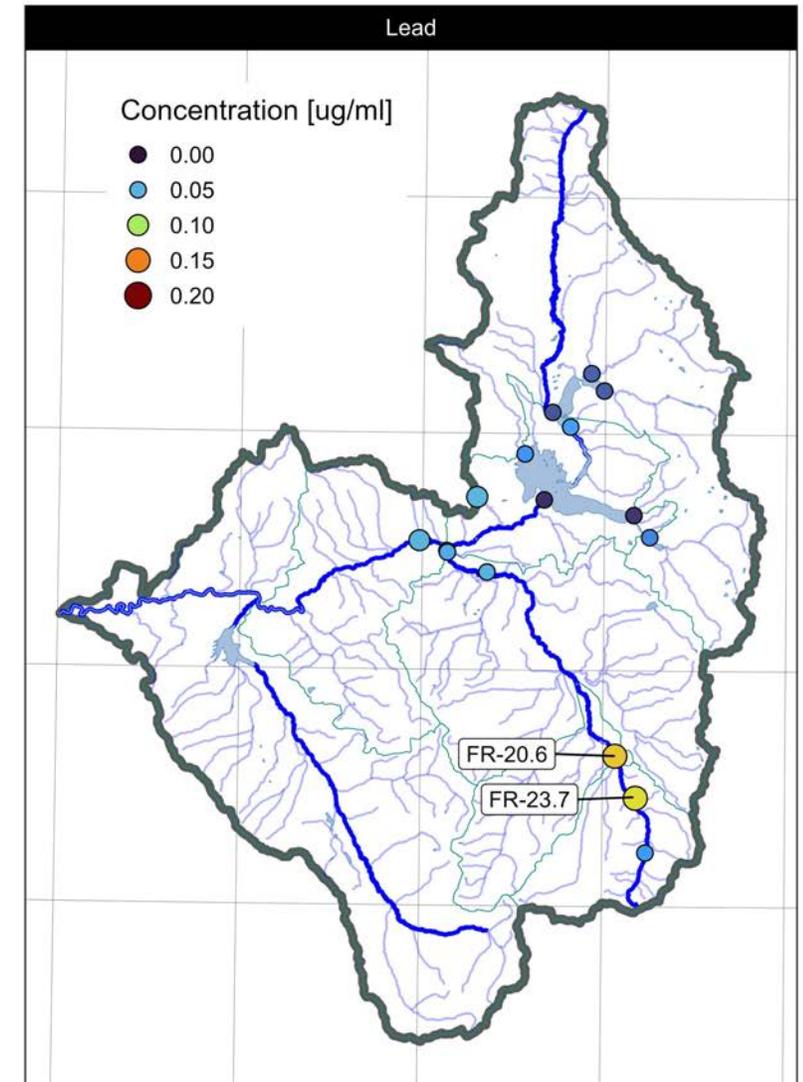
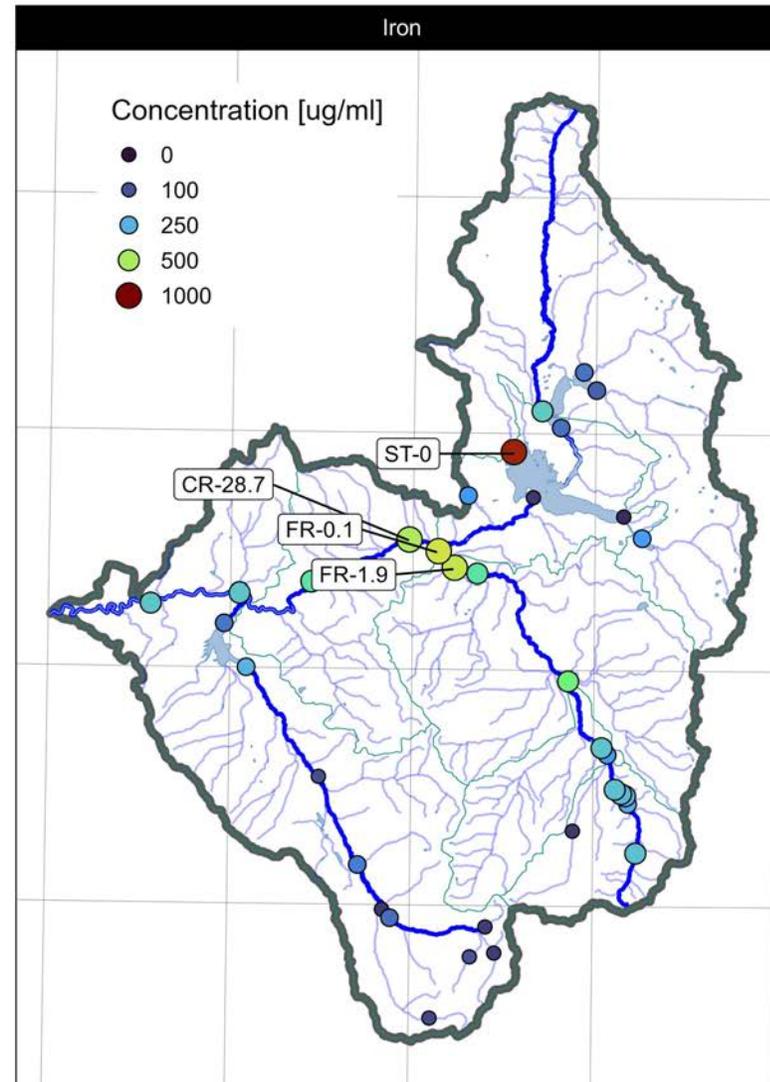
- Colorado River Headwaters/Upper Tributaries
- Colorado River Upper and Mid mainstem
- Fraser River mainstem
- Williams Fork mainstem.

## Elevated lead observed:

- North Inlet (post-fire)
- Upper and Mid Fraser River mainstem

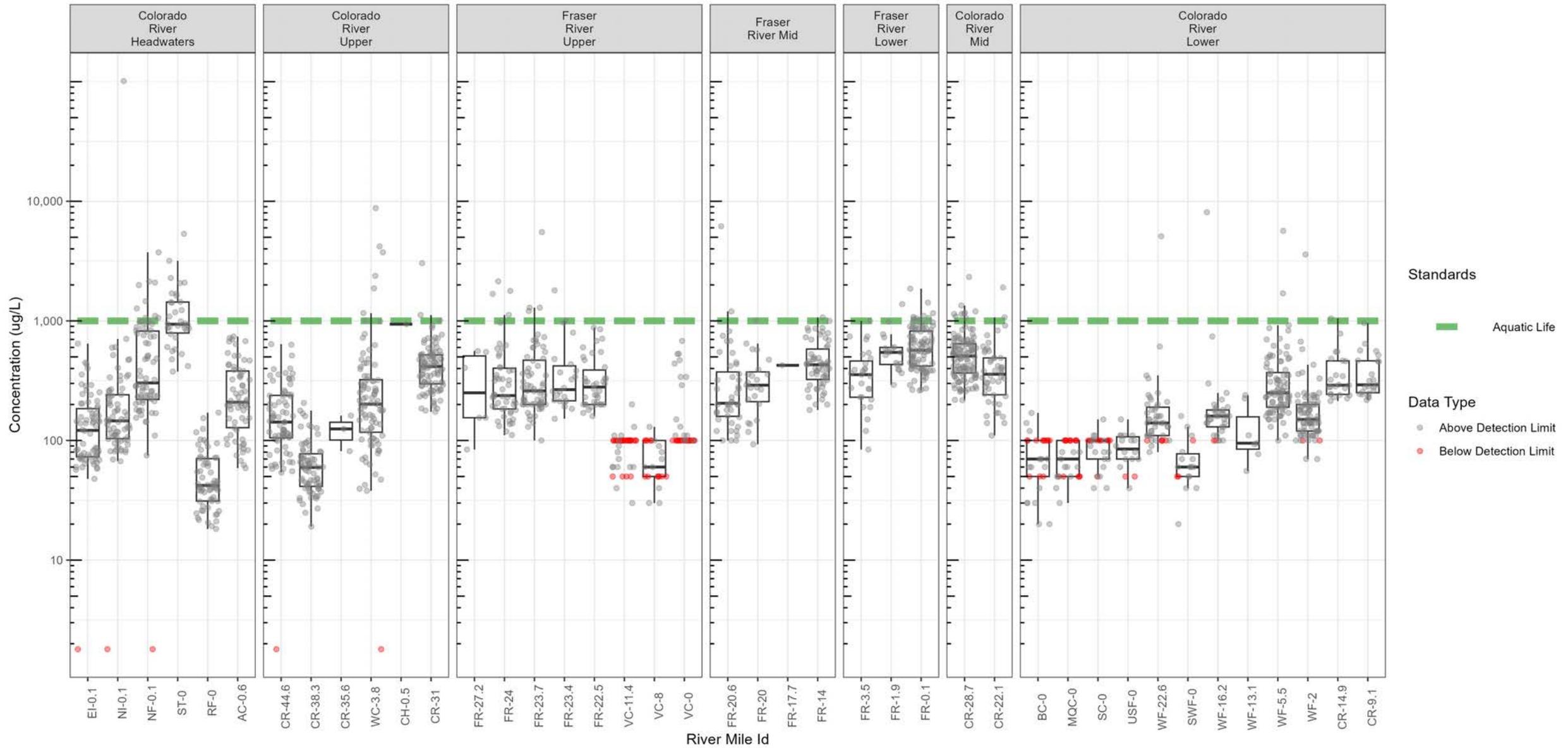
## Elevated silver observed:

- Colorado River Headwaters
- Colorado River Upper and Mid mainstem
- Fraser River Upper mainstem



# Water Quality: Metals

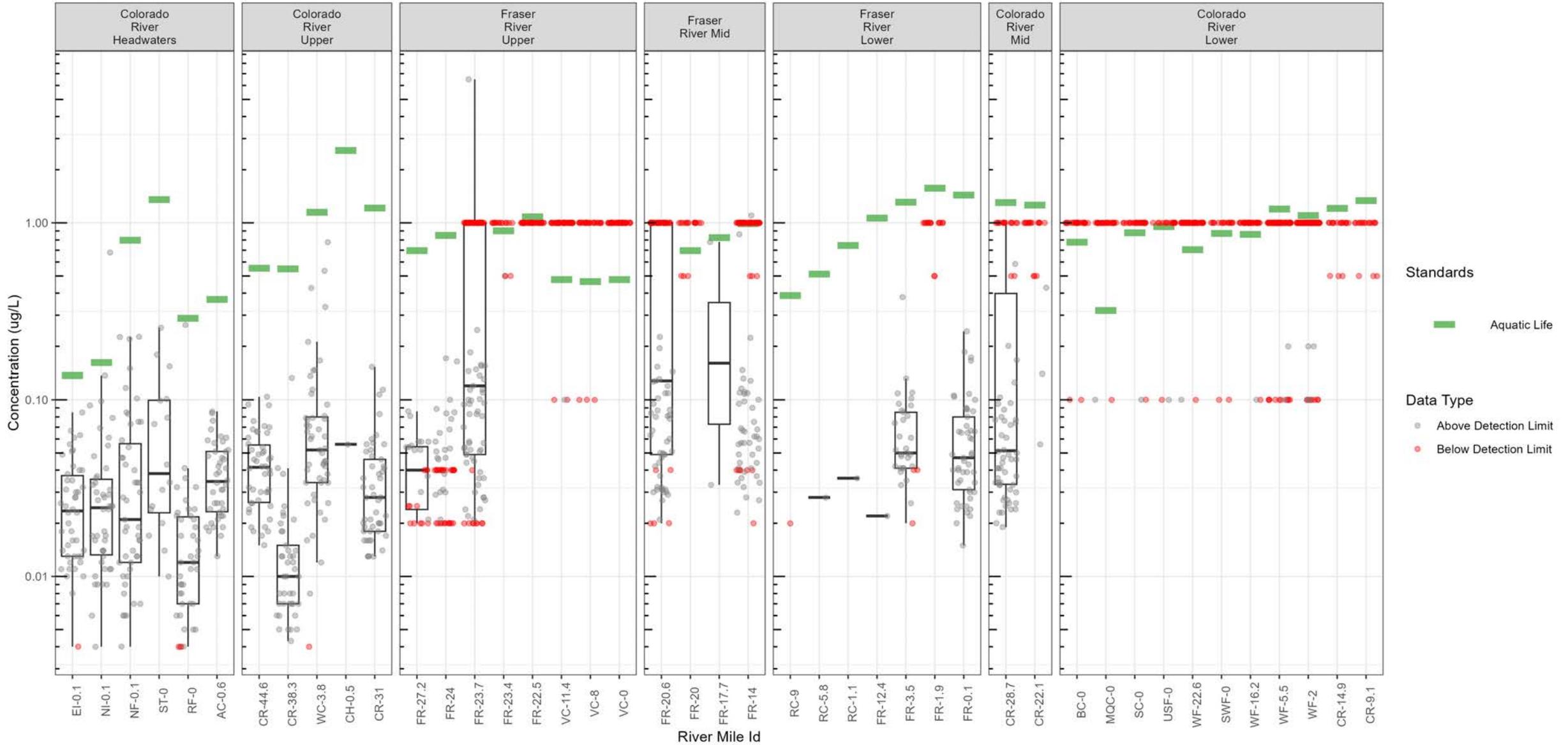
All Sites: Iron (Total)





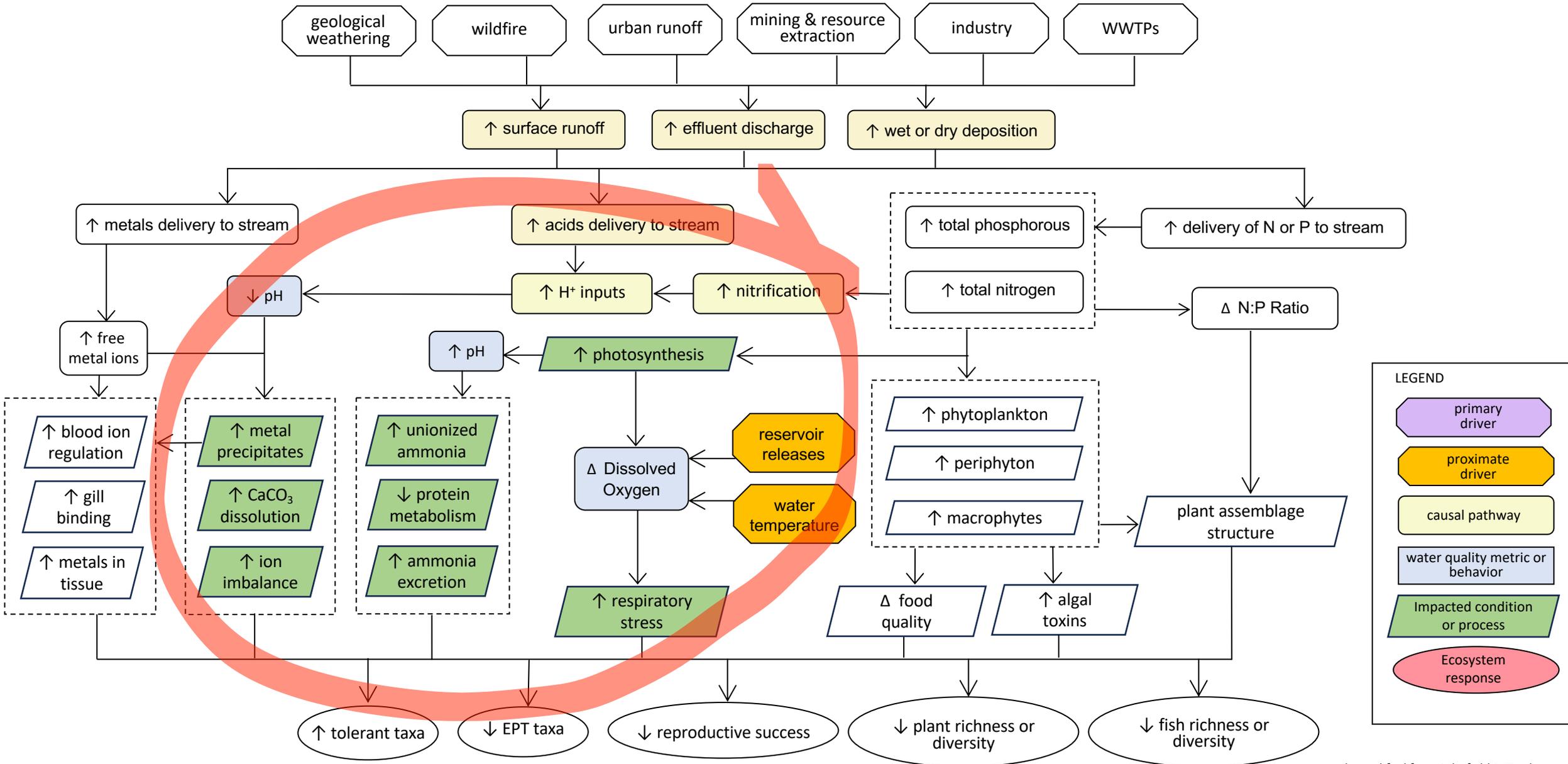
# Water Quality: Metals

All Sites: Lead (Dissolved)





# Water Quality: Causal Pathway Conceptual Model



# Water Quality: Physical Parameters

## Low DO observed:

- Colorado River Headwaters
- Colorado River Upper mainstem
- Fraser River tributaries
- Williams Fork Headwater Tributaries
- Williams Fork mainstem

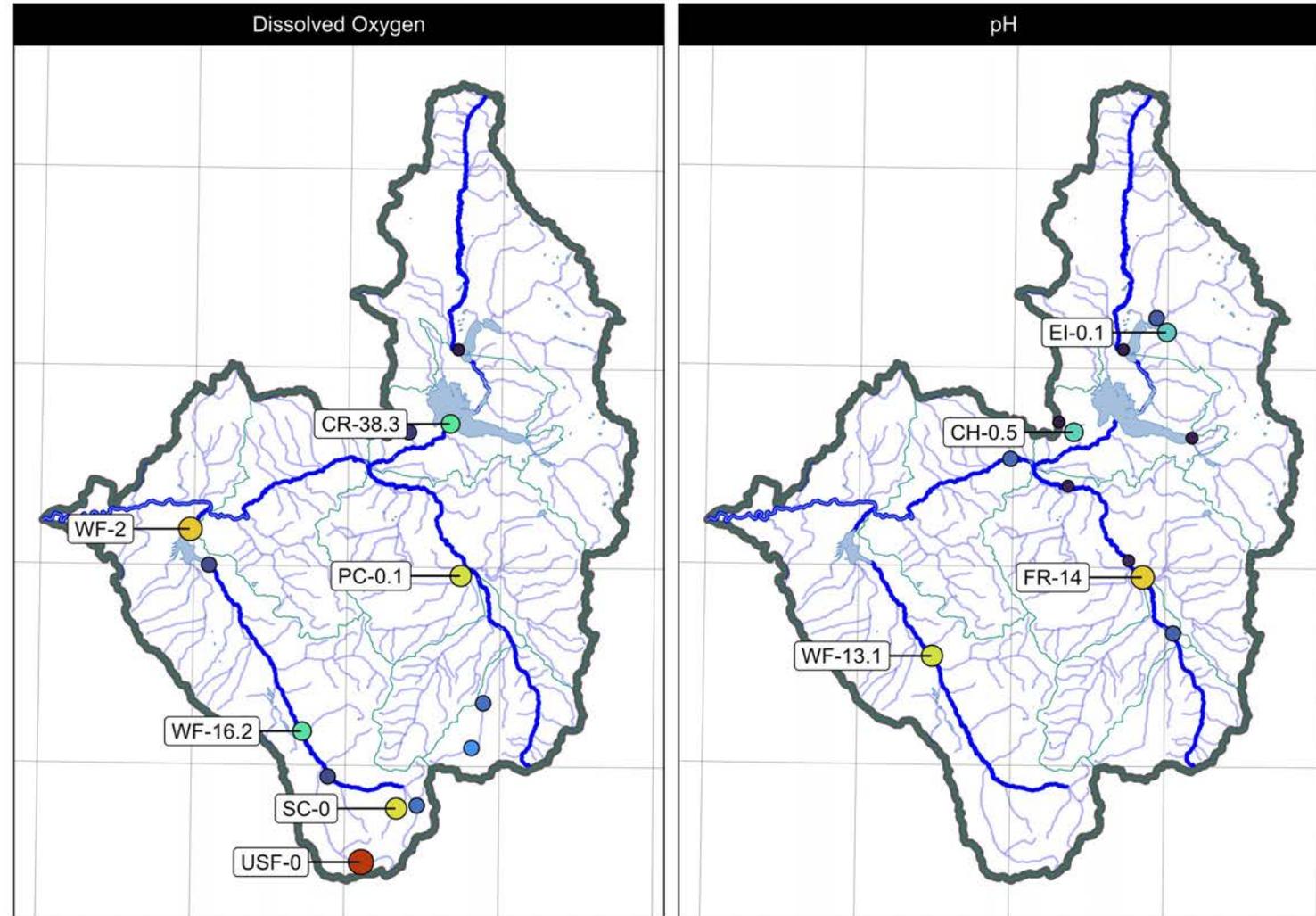
## Low pH observed:

- Colorado River Headwaters

## High pH observed:

- Colorado River Headwaters
- Colorado River Upper (Tributaries)
- Fraser River Mid and Lower mainstem
- Colorado River Mid mainstem
- Williams Fork River

\*Note: this is not an assessment of regulatory exceedances

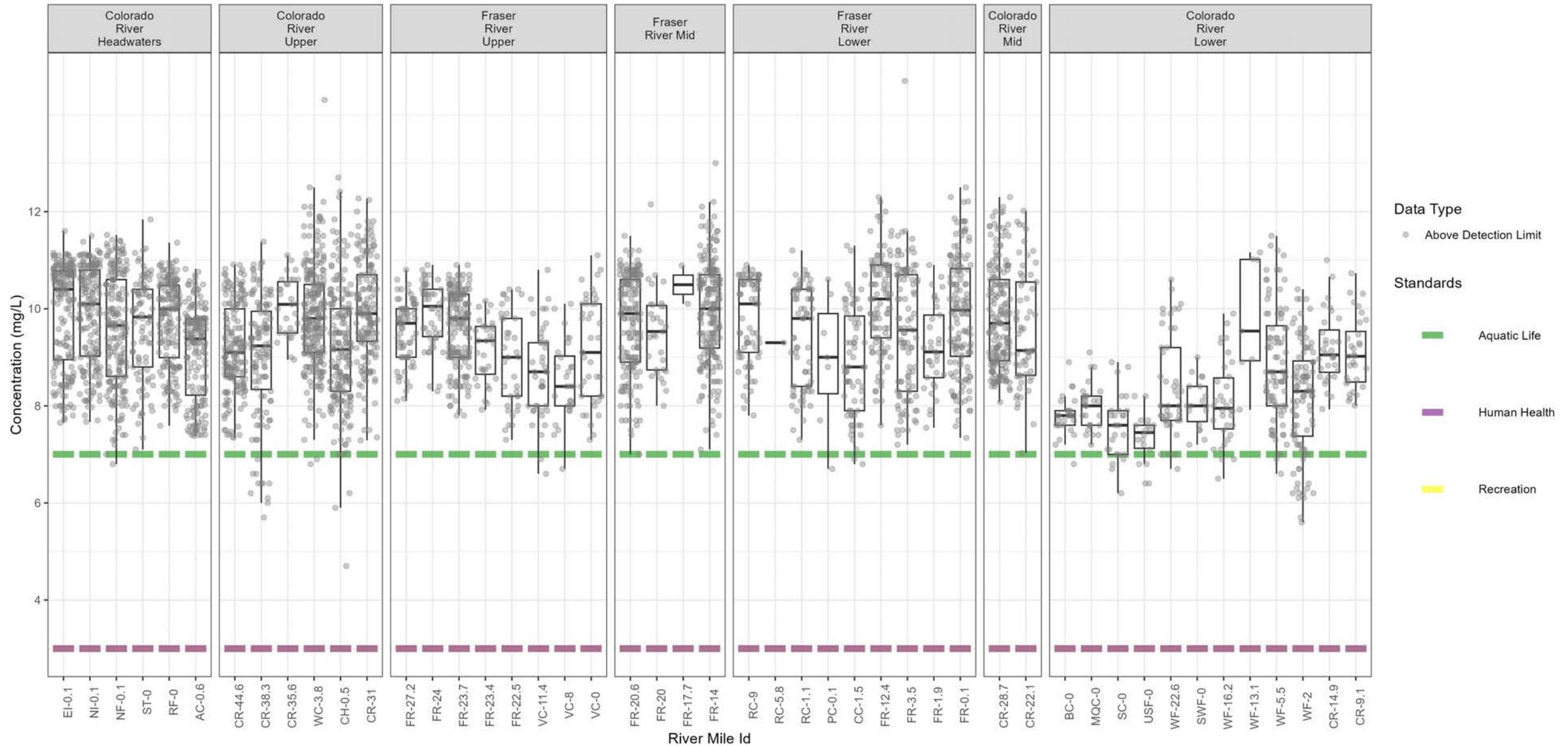


Samples (%) Outside Regulatory Standard

● 1	● 10	● 20
● 5	● 15	● 25

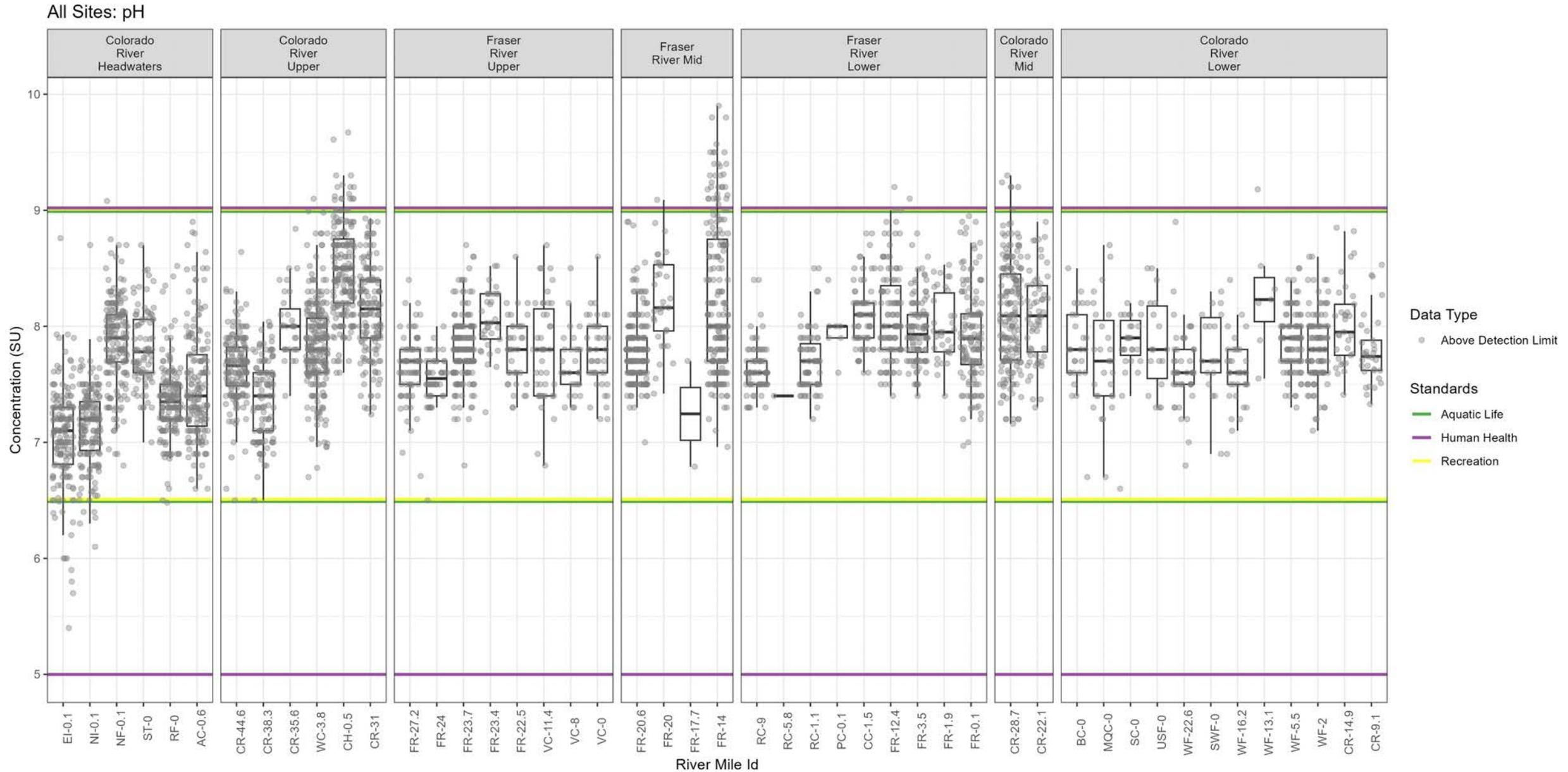
# Water Quality: Physical Parameters

All Sites: Dissolved Oxygen (Total)

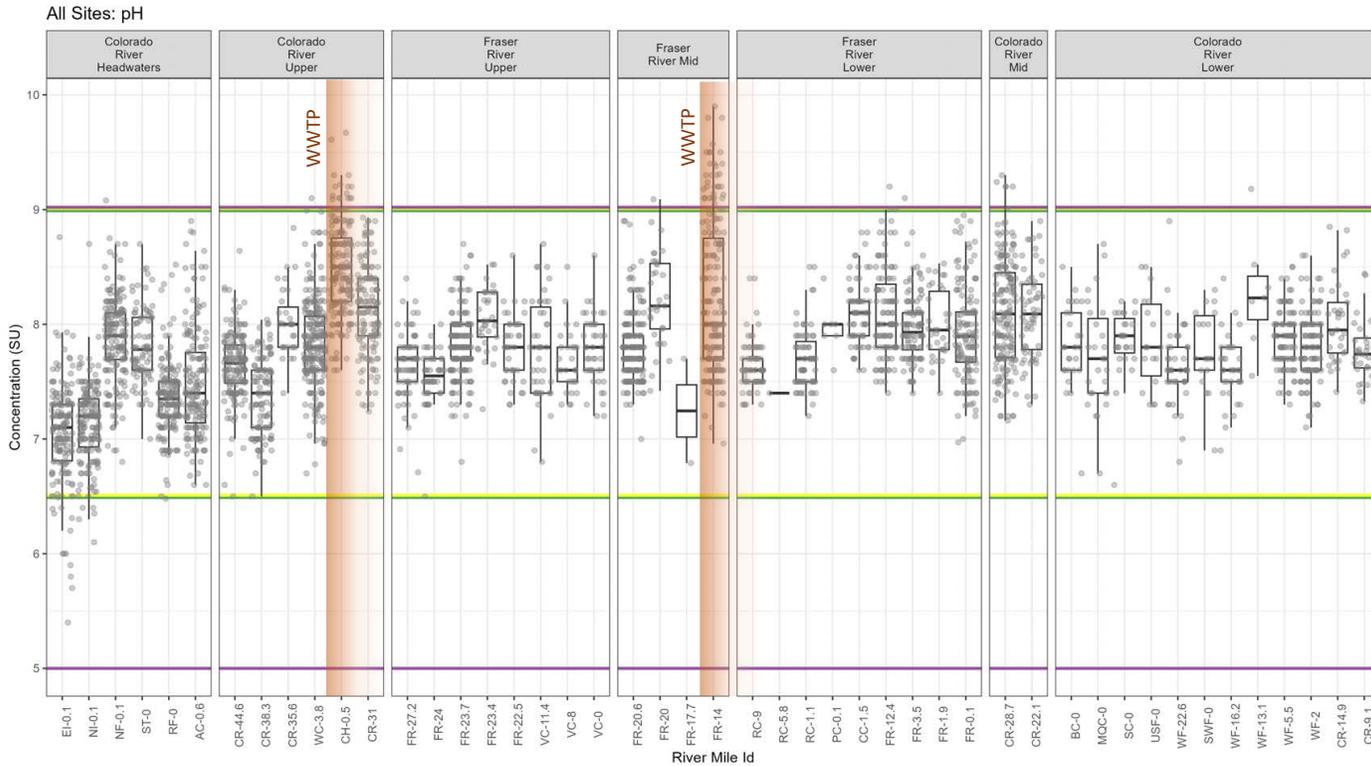




# Water Quality: Physical Parameters



# Water Quality: Physical Parameters

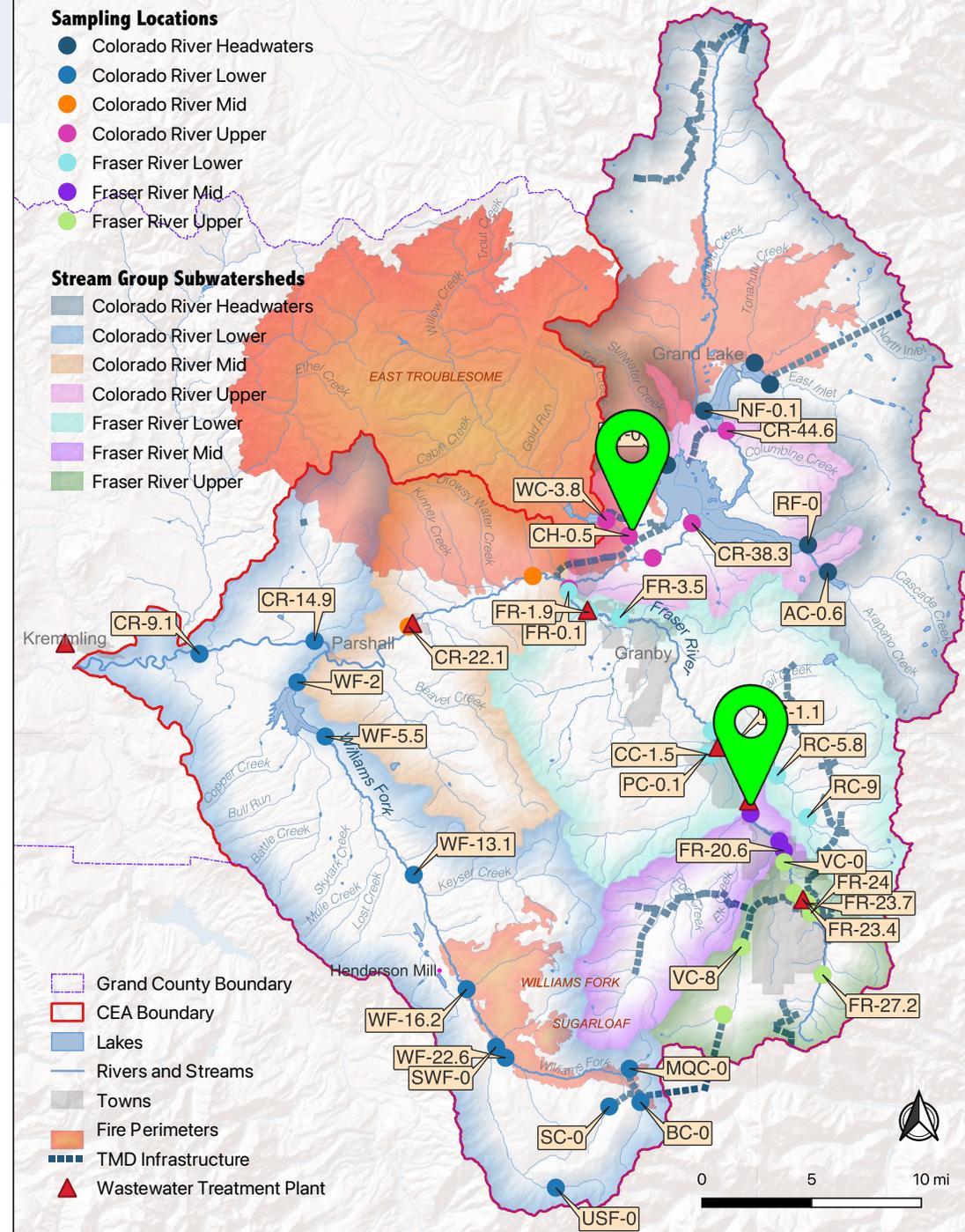


## Sampling Locations

- Colorado River Headwaters
- Colorado River Lower
- Colorado River Mid
- Colorado River Upper
- Fraser River Lower
- Fraser River Mid
- Fraser River Upper

## Stream Group Subwatersheds

- Colorado River Headwaters
- Colorado River Lower
- Colorado River Mid
- Colorado River Upper
- Fraser River Lower
- Fraser River Mid
- Fraser River Upper





# Water Quality: Trends (2008 – 2020)

## Approach:

- Modified Seasonal Mann-Kendall

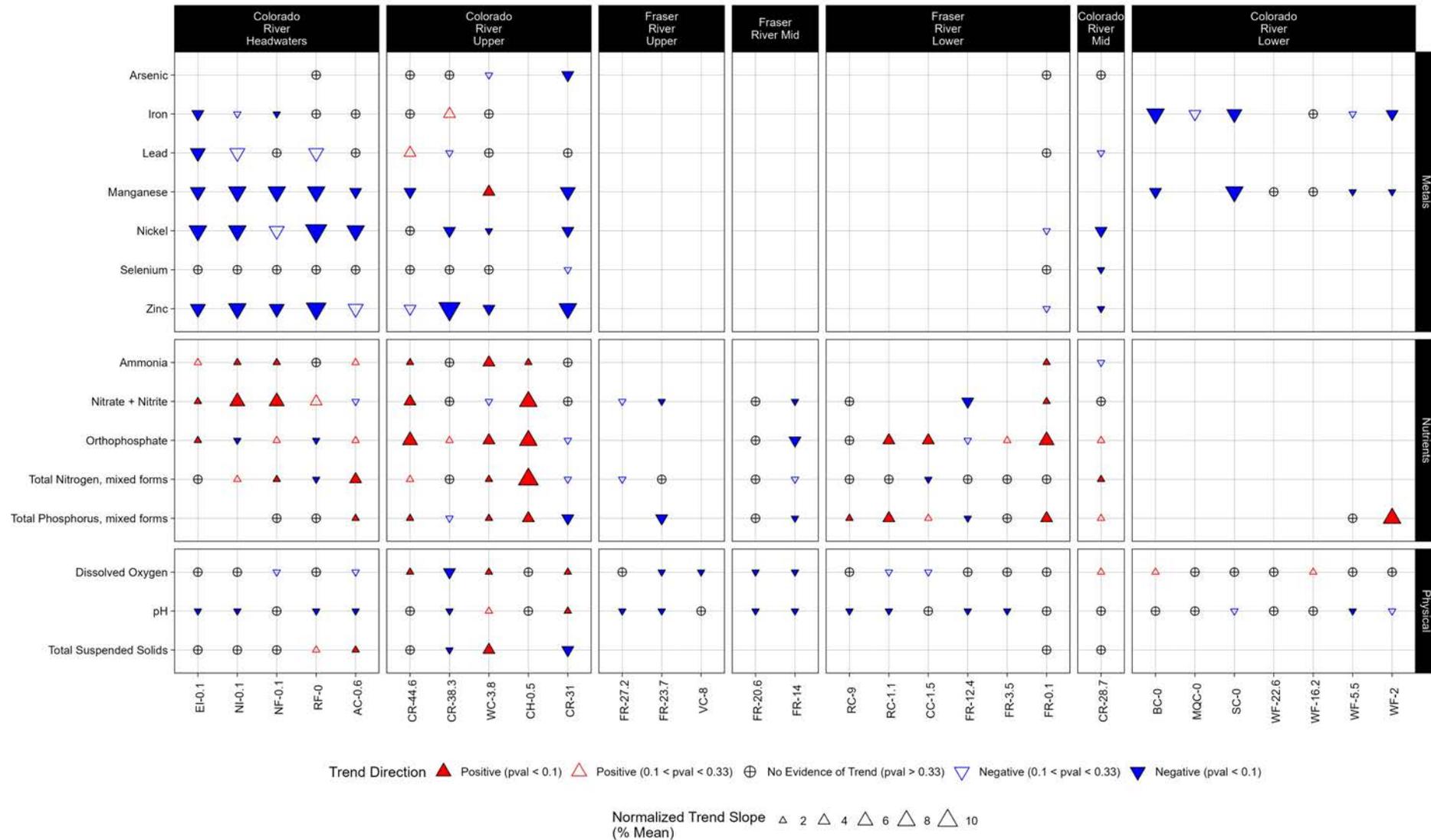
## Metals

- Likely **Negative** trends at many sites in Colorado Headwaters and Upper.

## Nutrients:

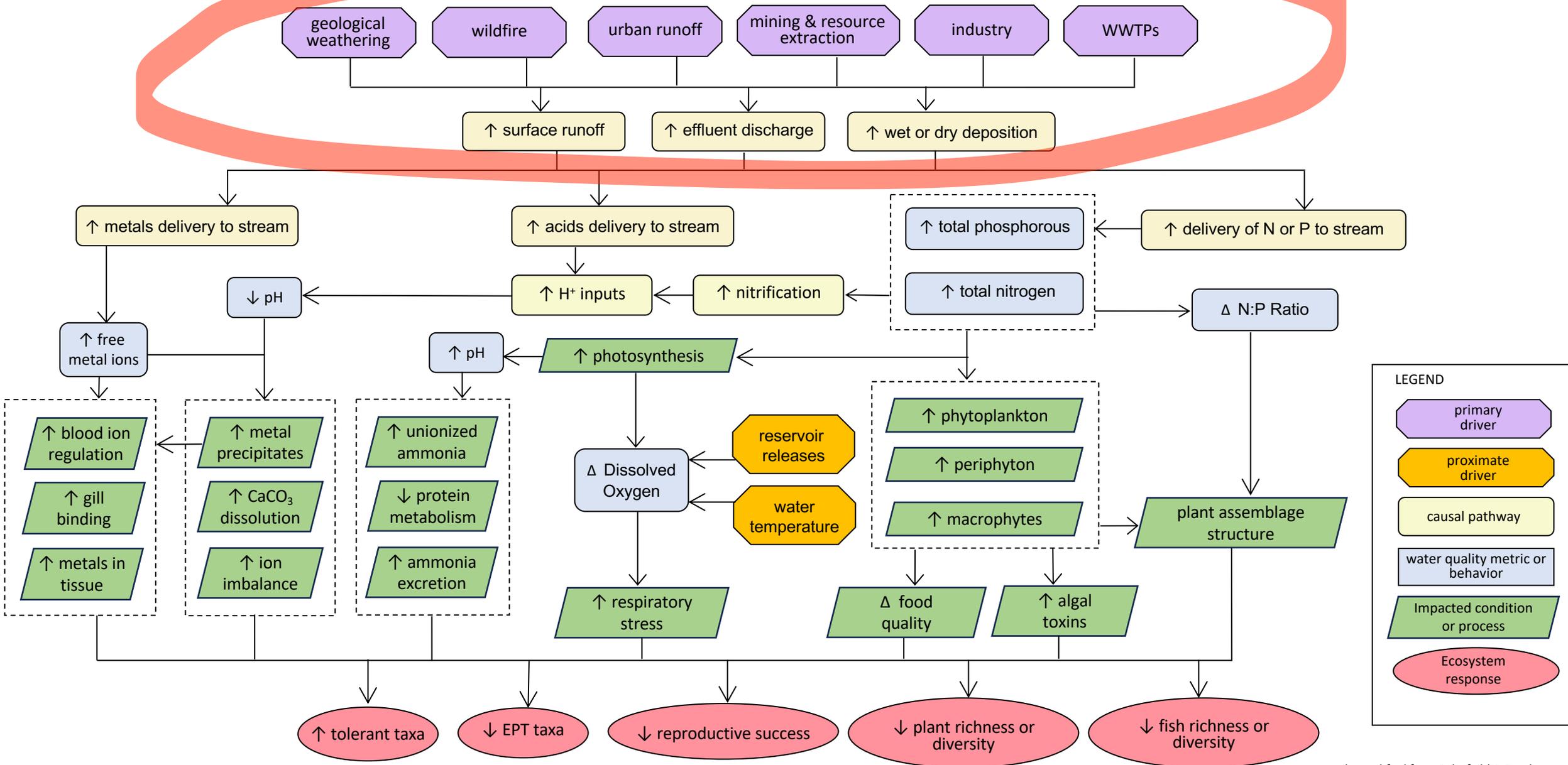
- Likely (moderate to large) **Positive** Trends in on Colorado River Headwaters and Upper, and Fraser River Lower

- Likely (small) **Negative** trends below WWTP on Fraser Upper & Mid.





# Water Quality: Causal Pathway Conceptual Model

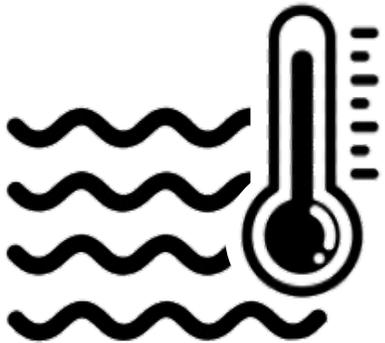




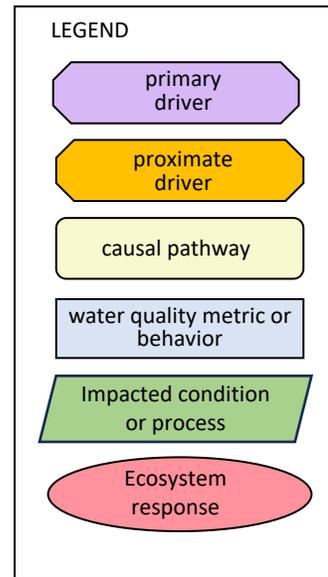
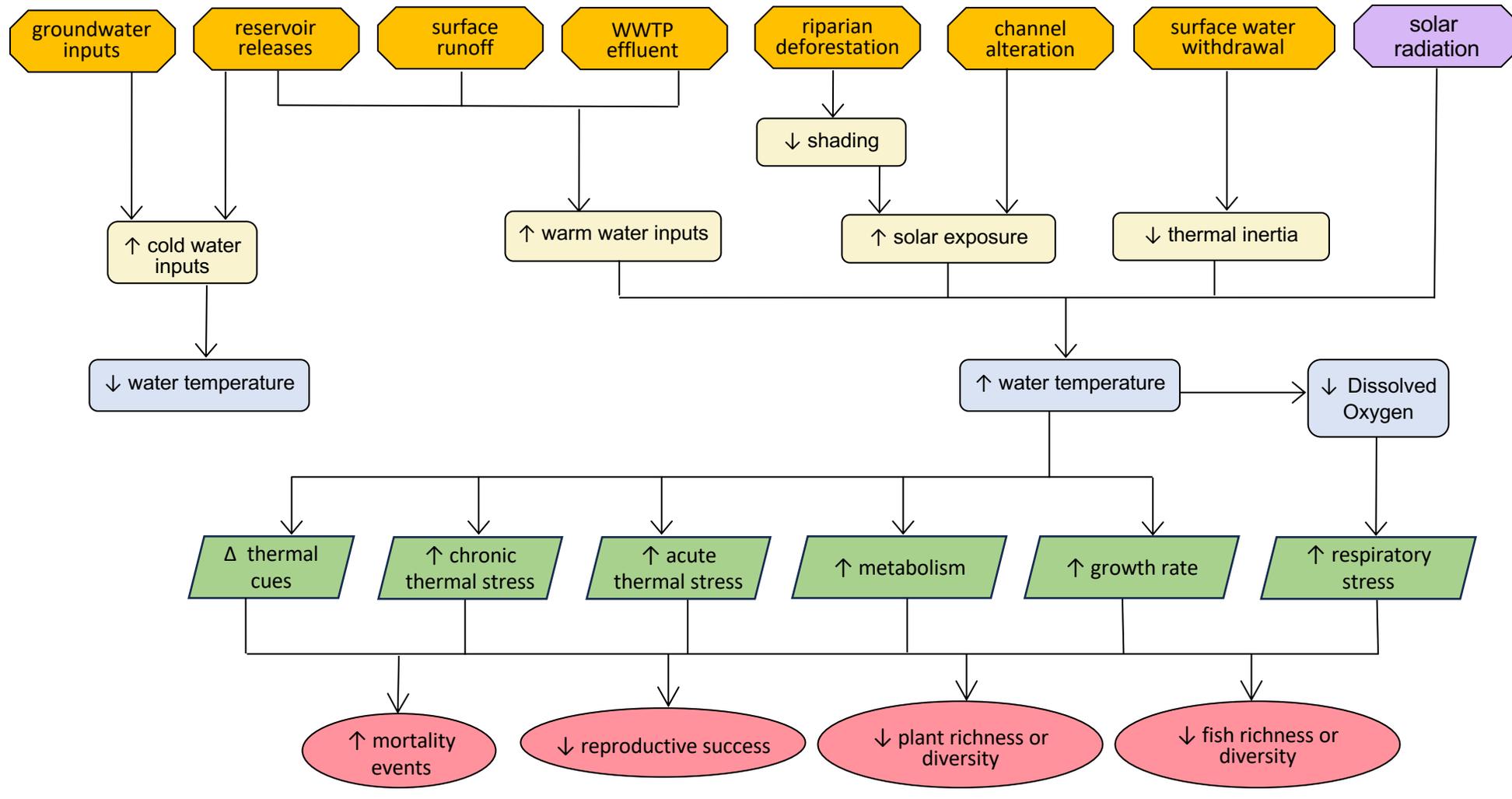
# Stream Temperature Assessment

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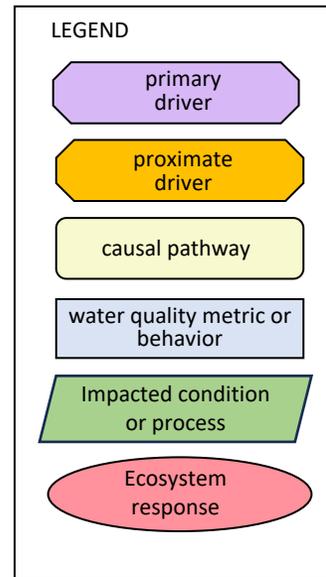
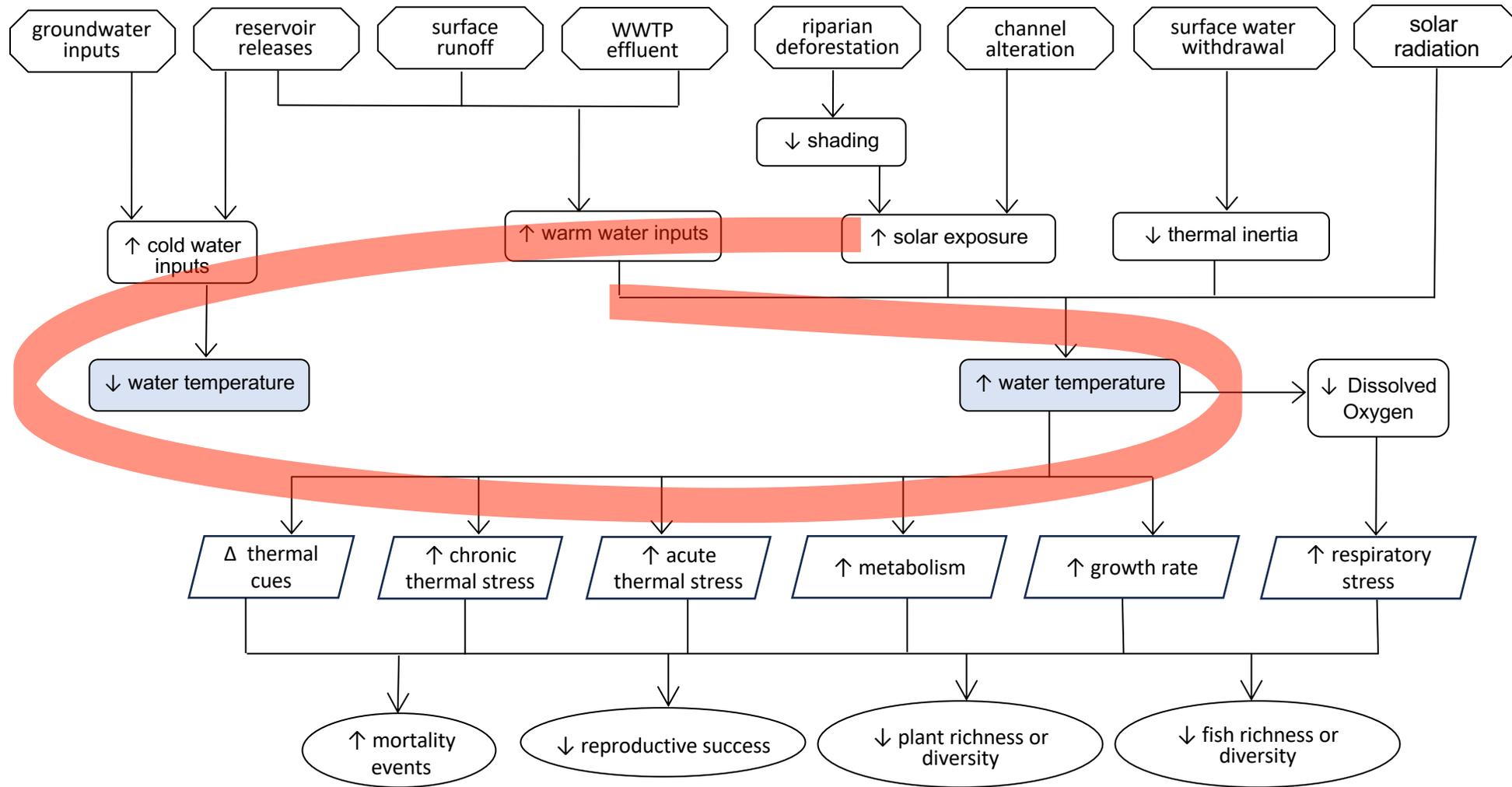
Summary of Findings



# Water Quality: Causal Pathway Conceptual Model

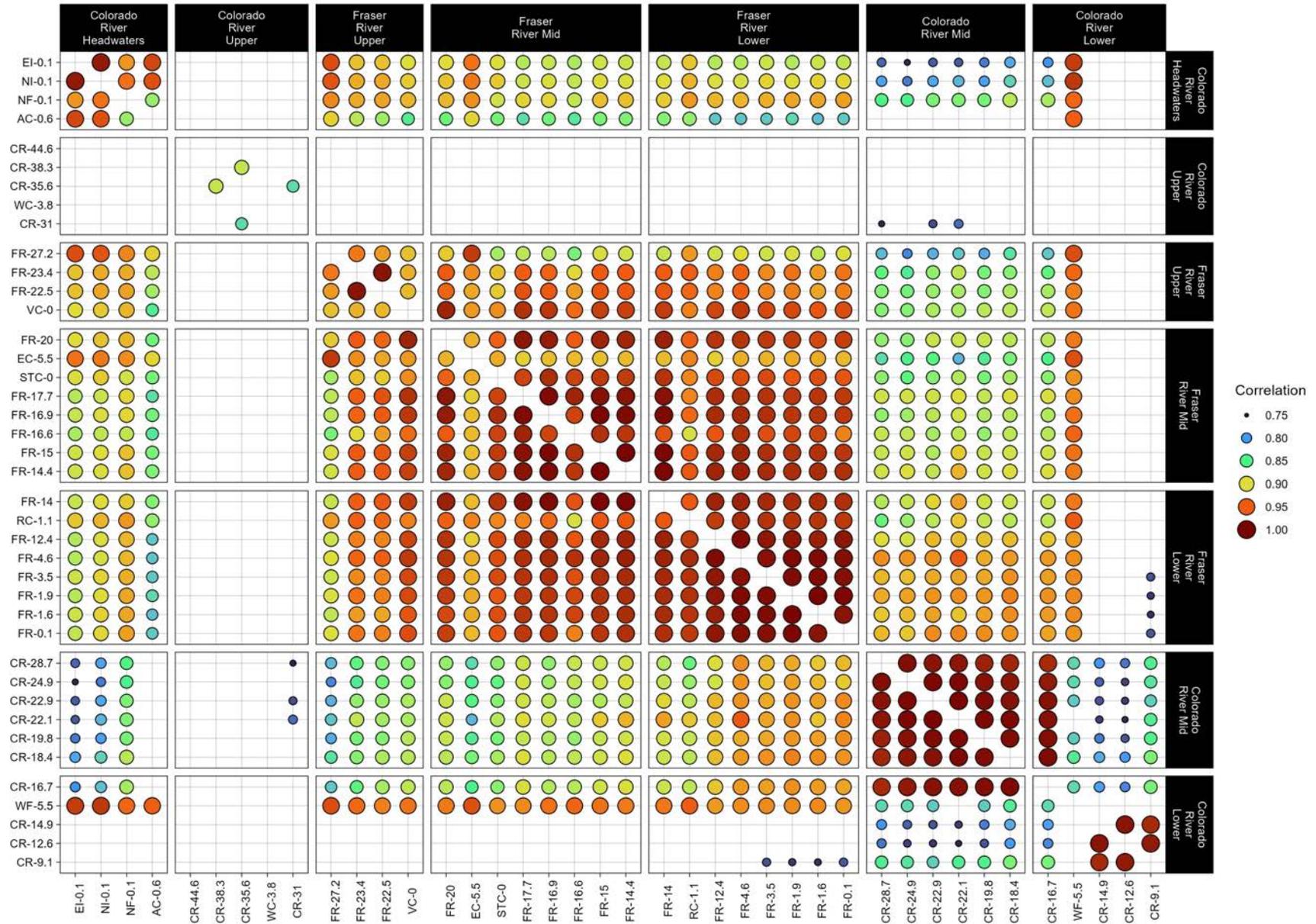


# Water Quality: Causal Pathway Conceptual Model



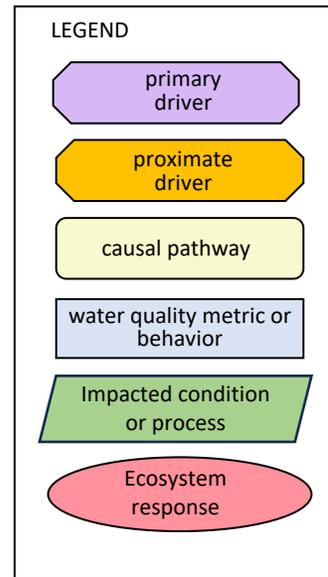
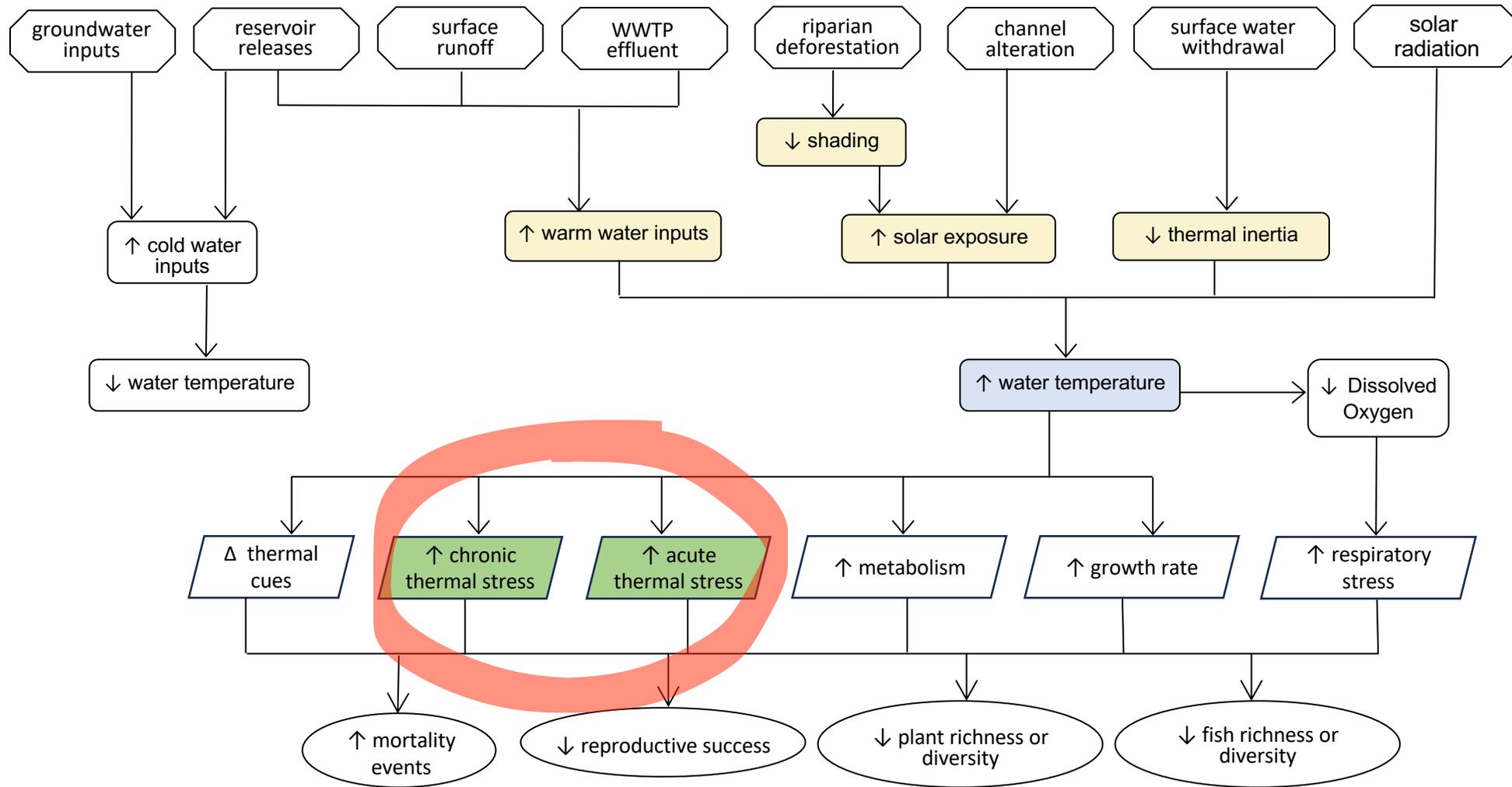


# Stream Temperature: Temporal Coherence Across Sites

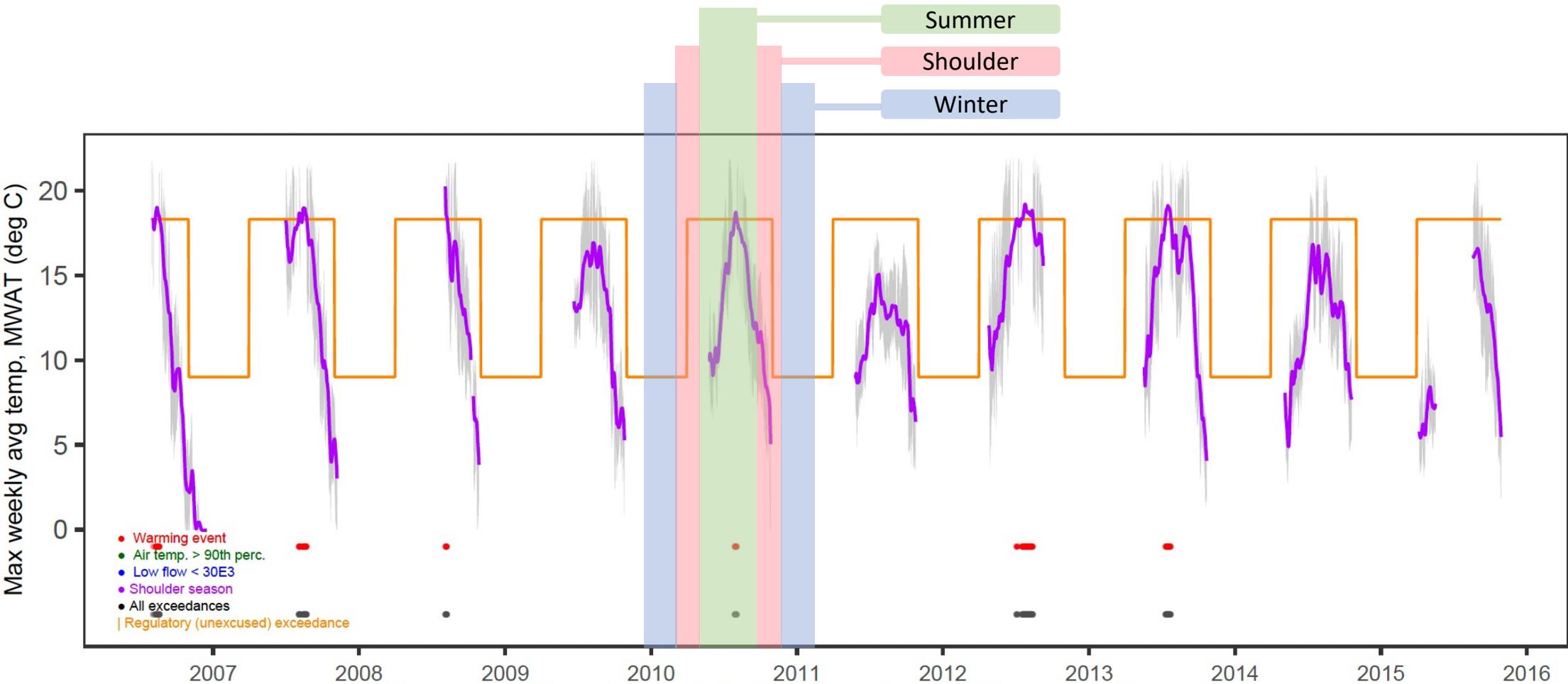




# Water Quality: Causal Pathway Conceptual Model

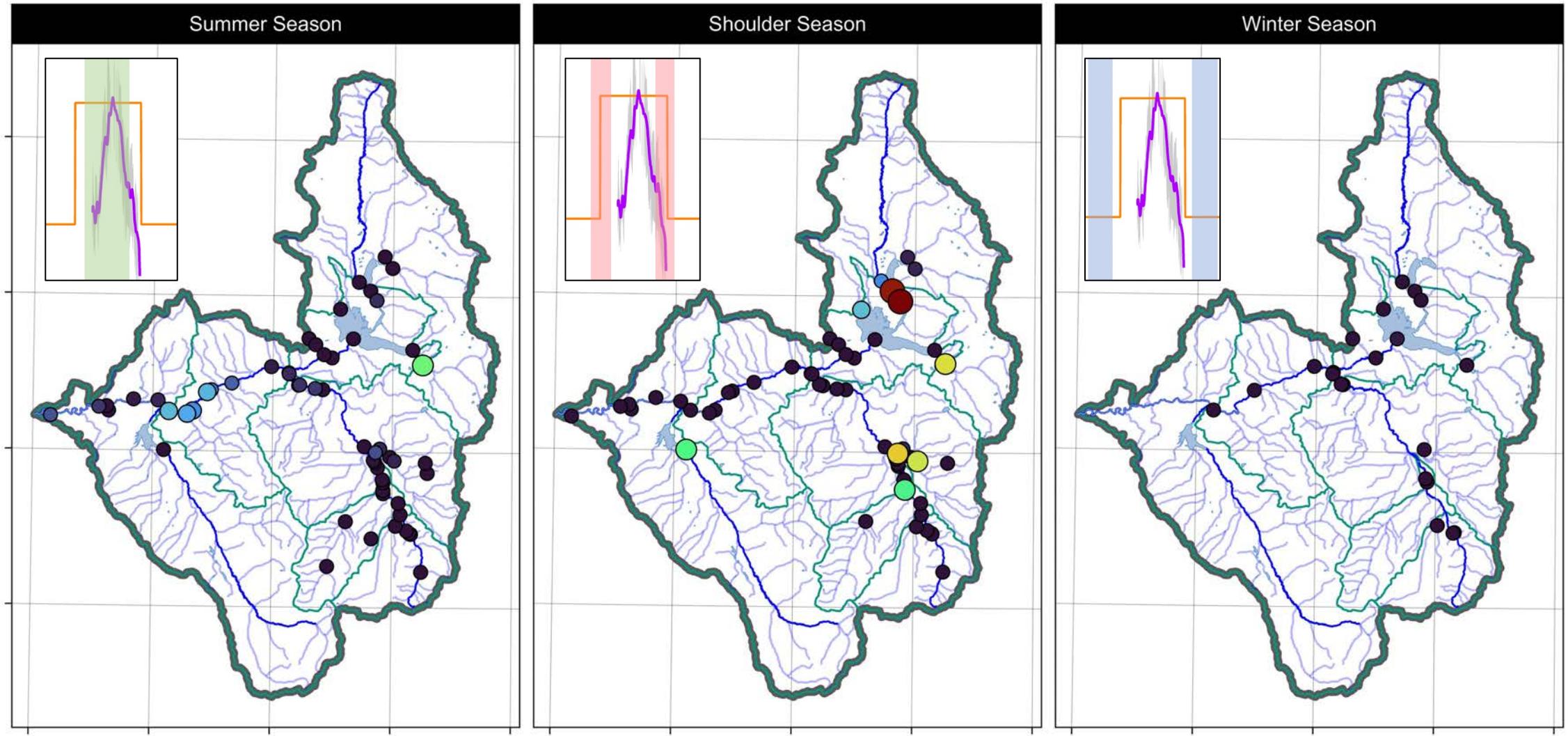


# Stream Temperature: Stream Standards Exceedances



WAT summary: Years in record: 10, total exceedances: 84, unexcused exceedances: 0

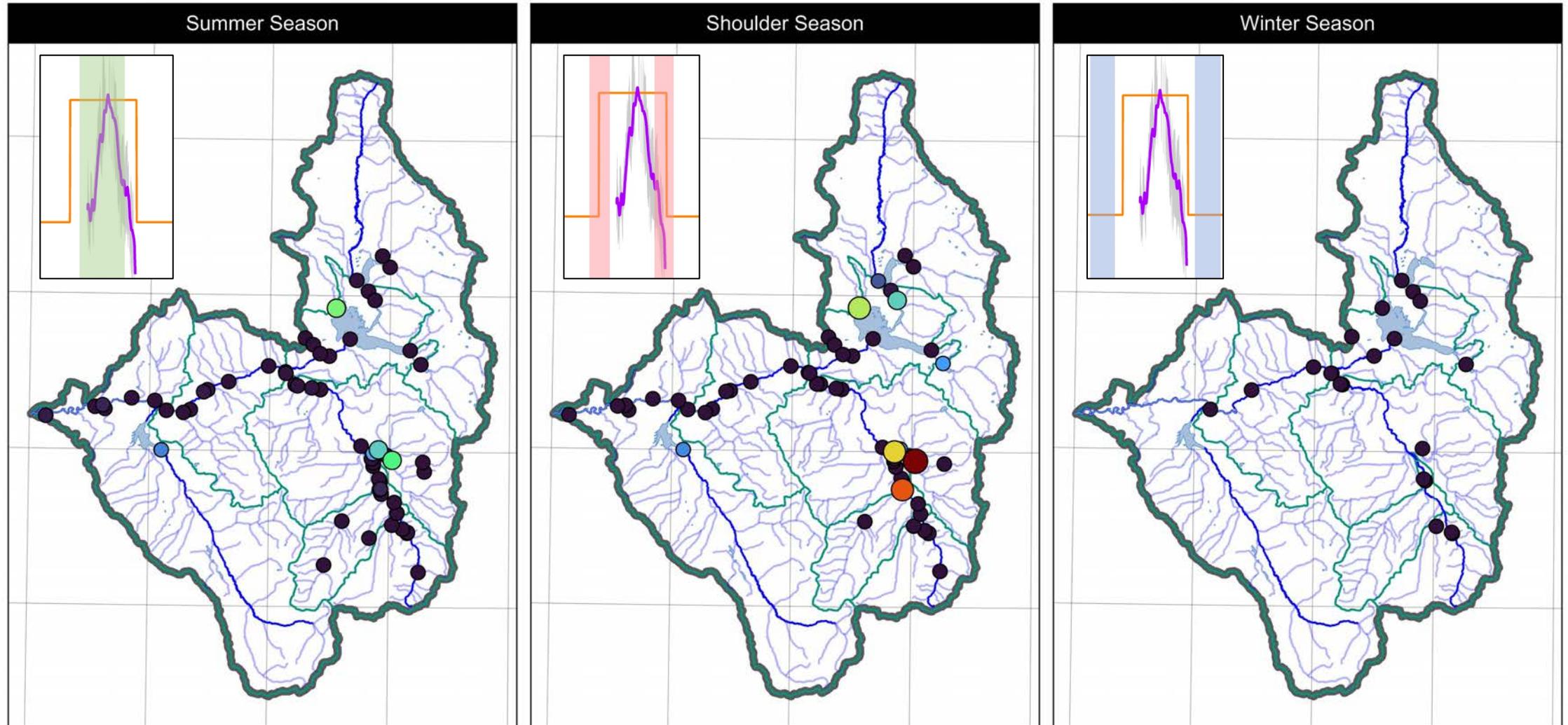
# Stream Temperature: **Chronic** Threshold Exceedances



\*Note: this is not an assessment of regulatory exceedances

Days (%) Above Chronic Standard ● 0 ● 5 ● 10 ● 20 ● 25

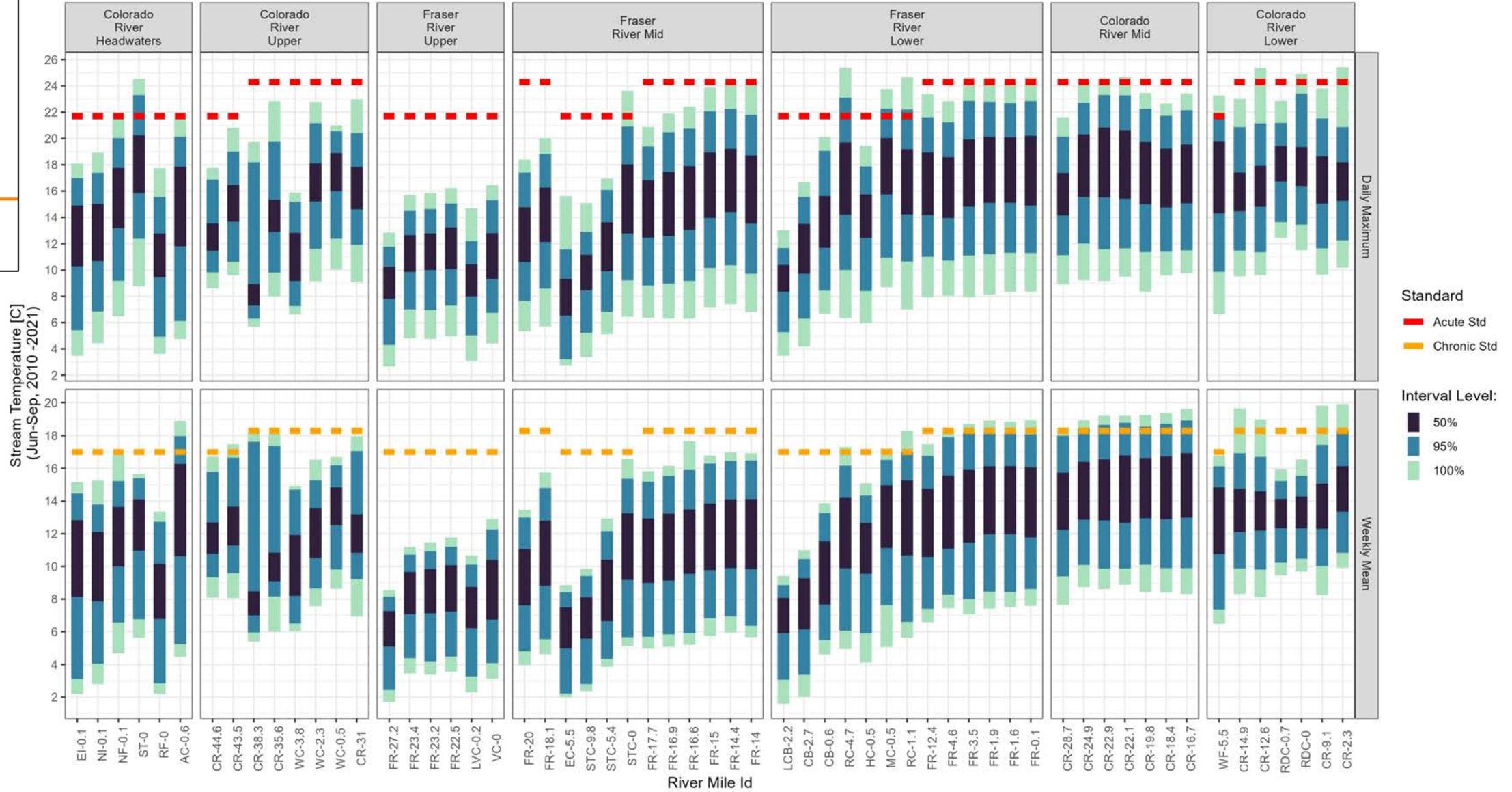
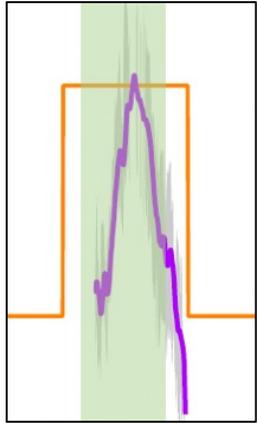
# Stream Temperature: **Acute** Threshold Exceedances



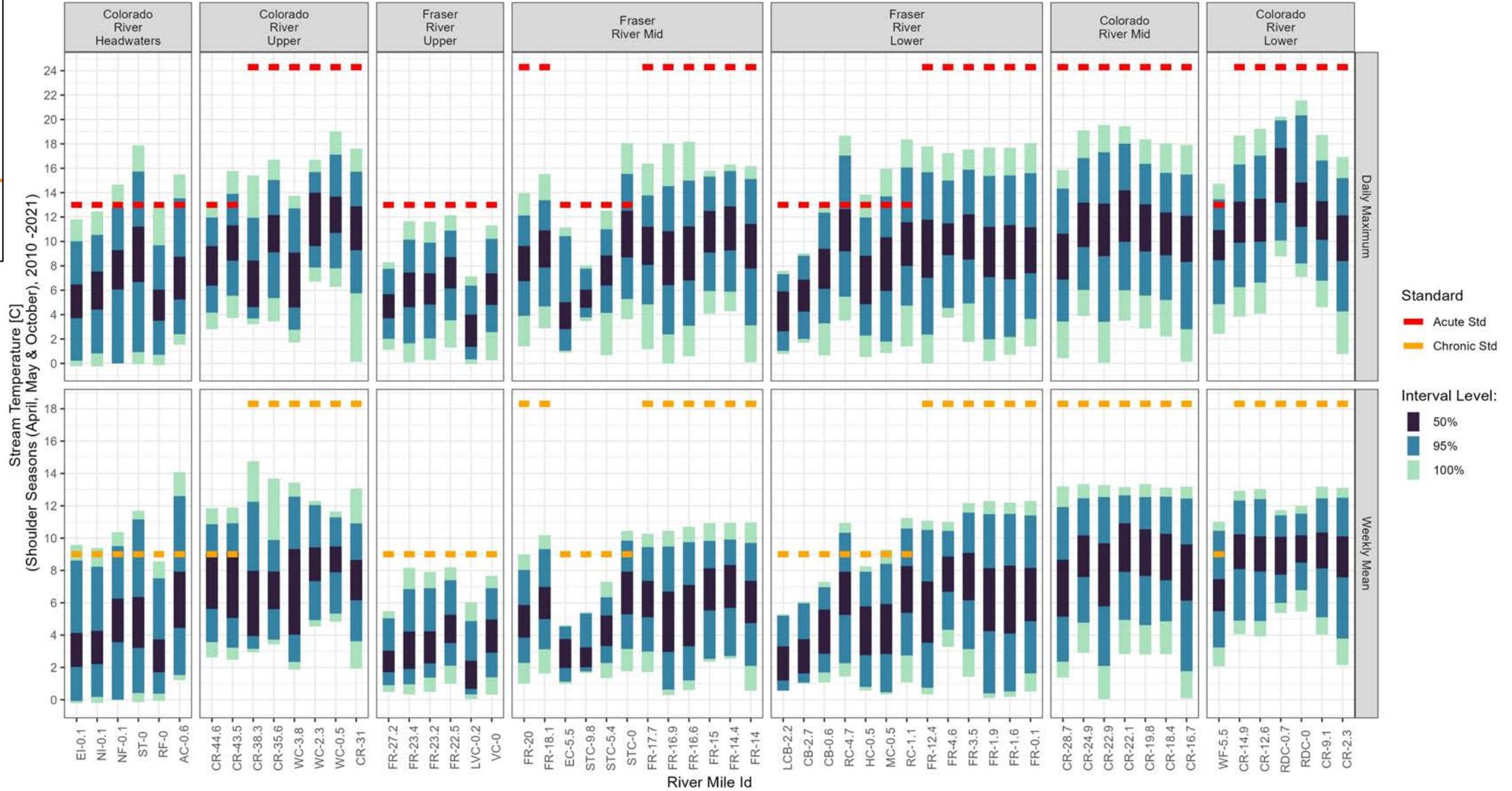
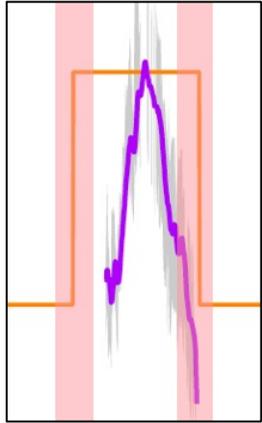
\*Note: this is not an assessment of regulatory exceedances

Days (%) Above Acute Standard ● 0 ● 5 ● 10 ● 20

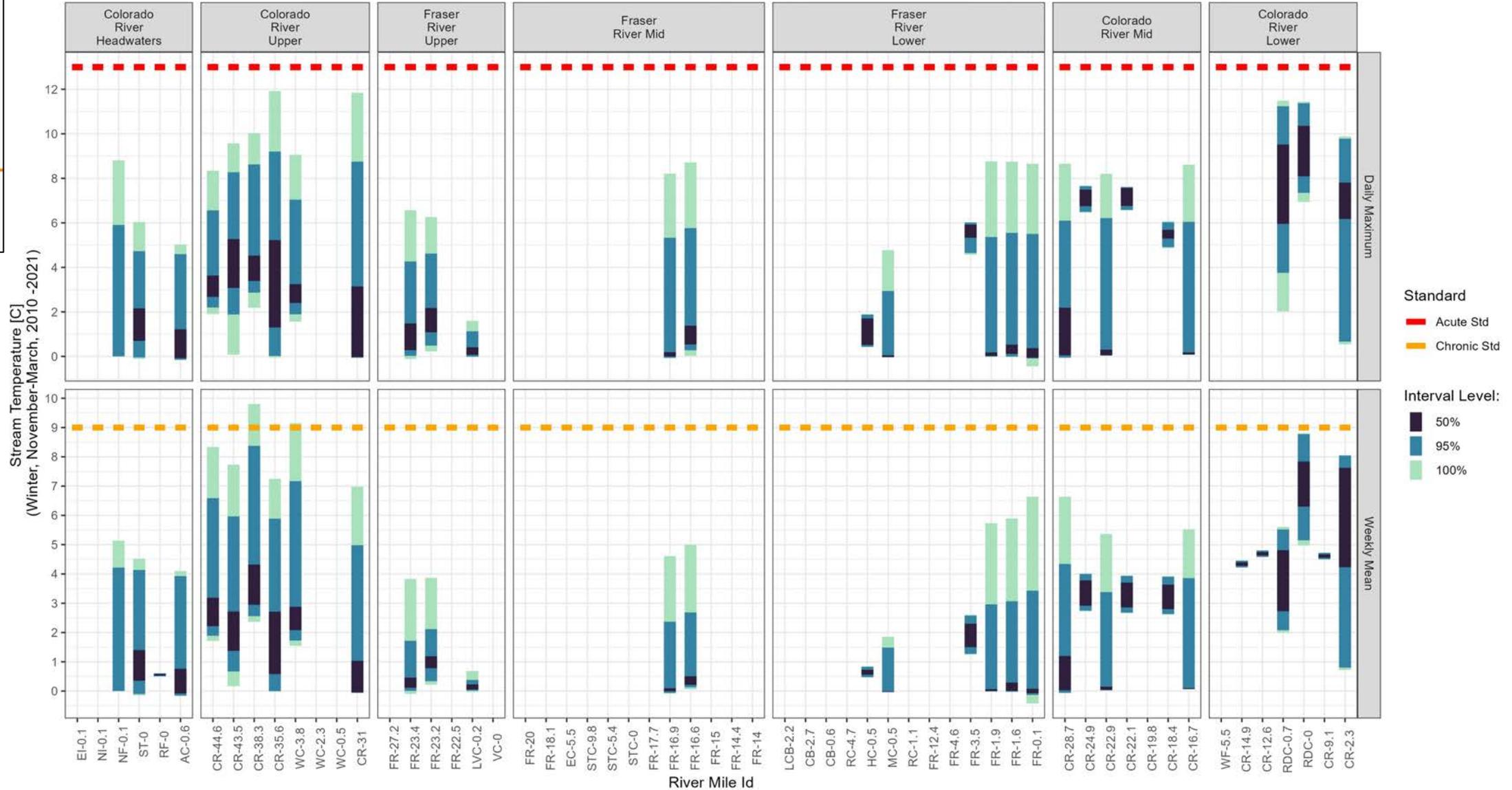
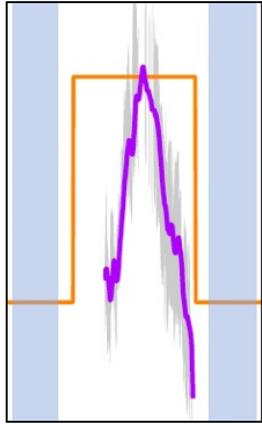
# Stream Temperature: Summer Months



# Stream Temperature: Shoulder Months

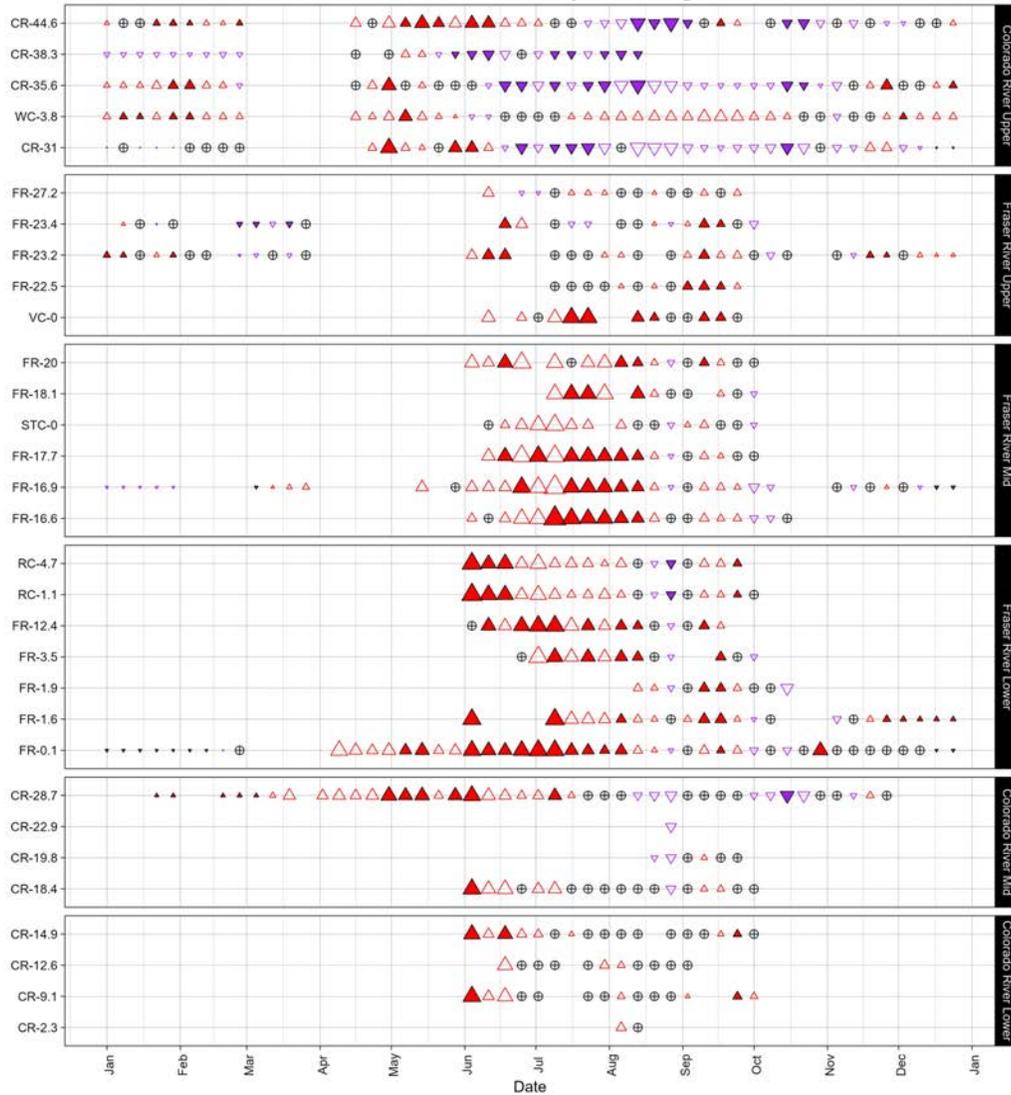


# Stream Temperature: Winter Months



# Stream Temperature: Weekly Trends (2008 -2021)

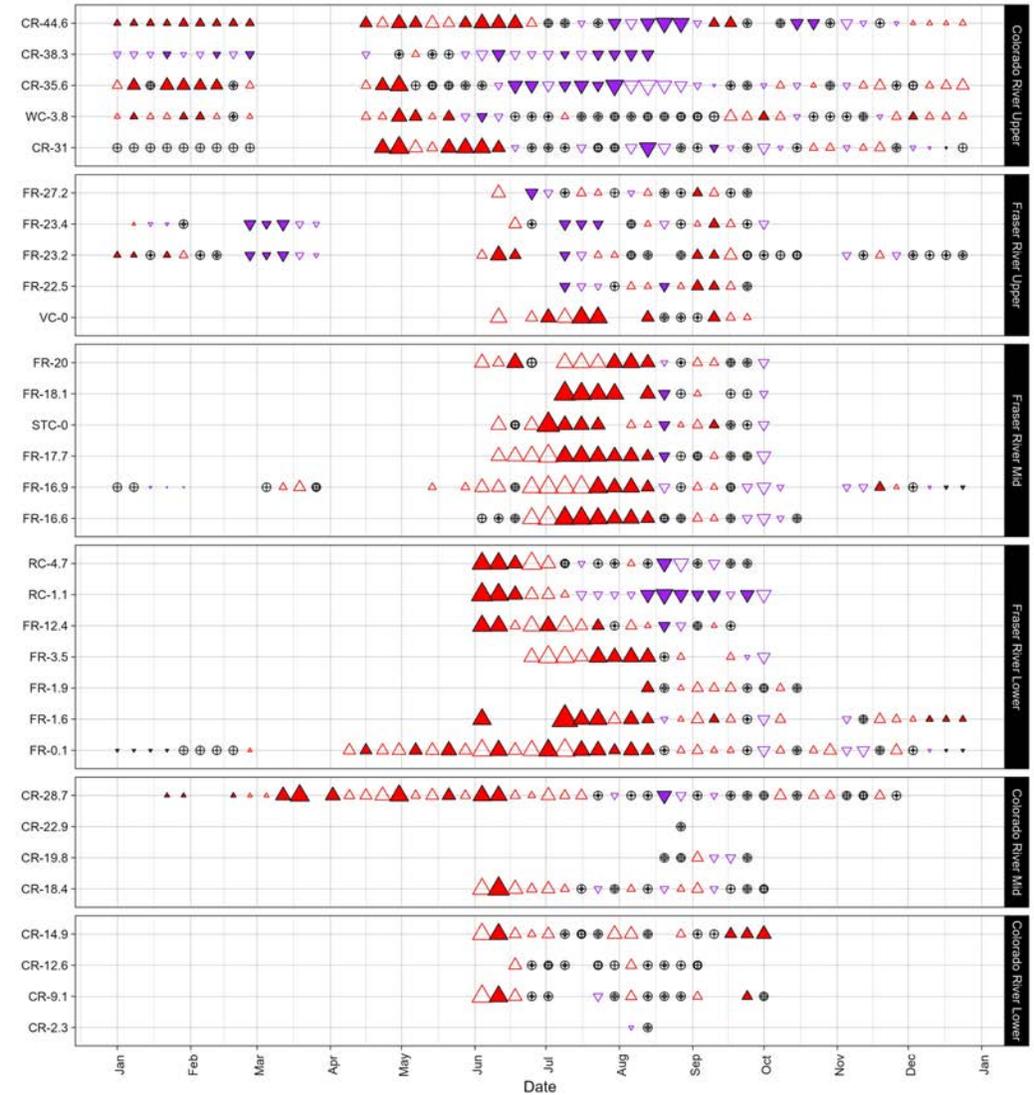
## Maximum Weekly Average



Trend Direction ▲ Likely Positive △ Somewhat Likely Positive ⊕ As Likely Positive as Negative ▼ Somewhat Likely Negative ▽ Likely Negative

MWAT Change Per Year (°C) · 0.00 △ 0.10 △ 0.25 △ 0.50

## Daily Maximum

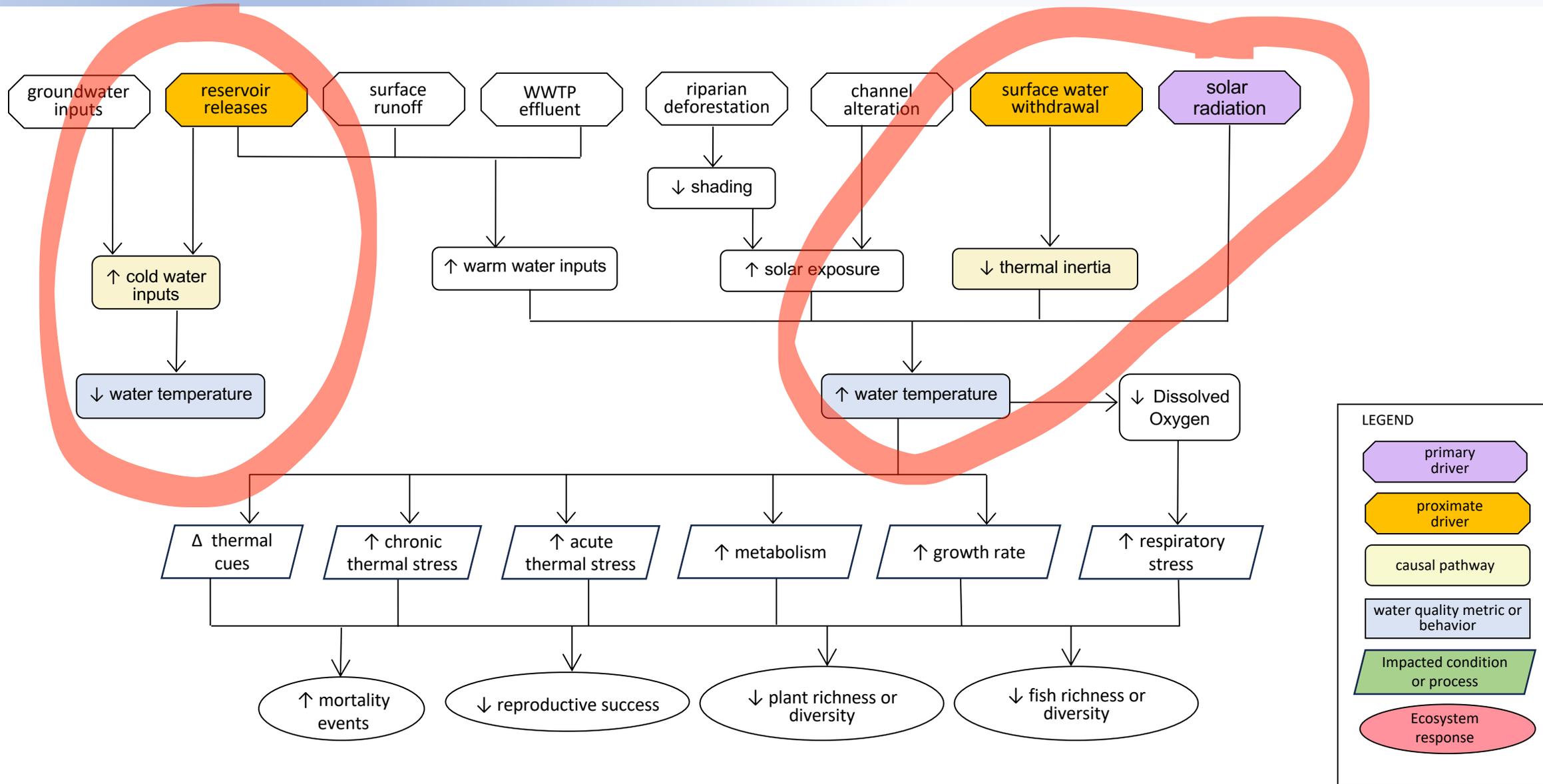


Trend Direction ▲ Likely Positive △ Somewhat Likely Positive ⊕ As Likely Positive as Negative ▼ Somewhat Likely Negative ▽ Likely Negative

DM Change Per Year (°C) · 0.00 △ 0.10 △ 0.25 △ 0.50



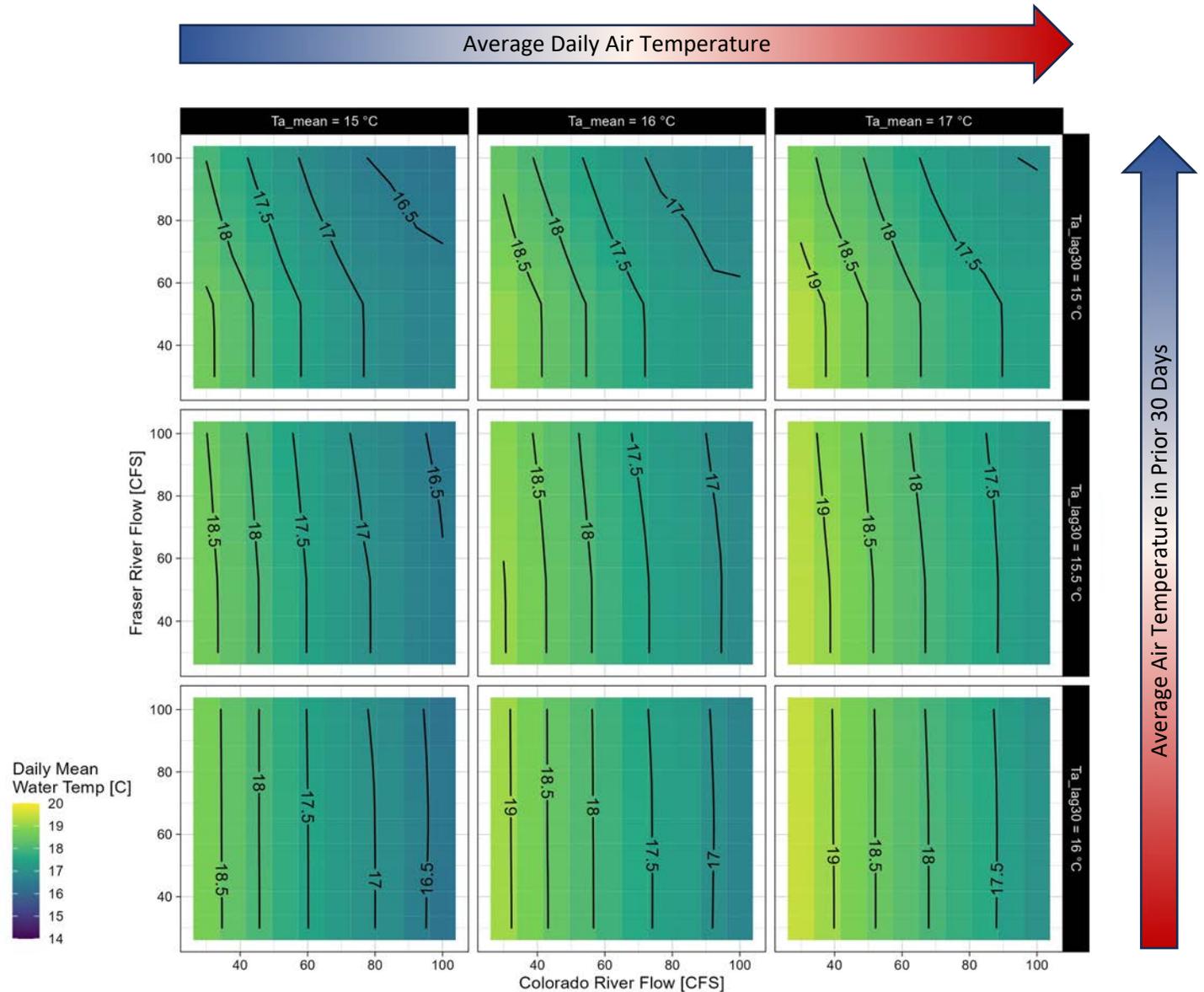
# Water Quality: Causal Pathway Conceptual Model



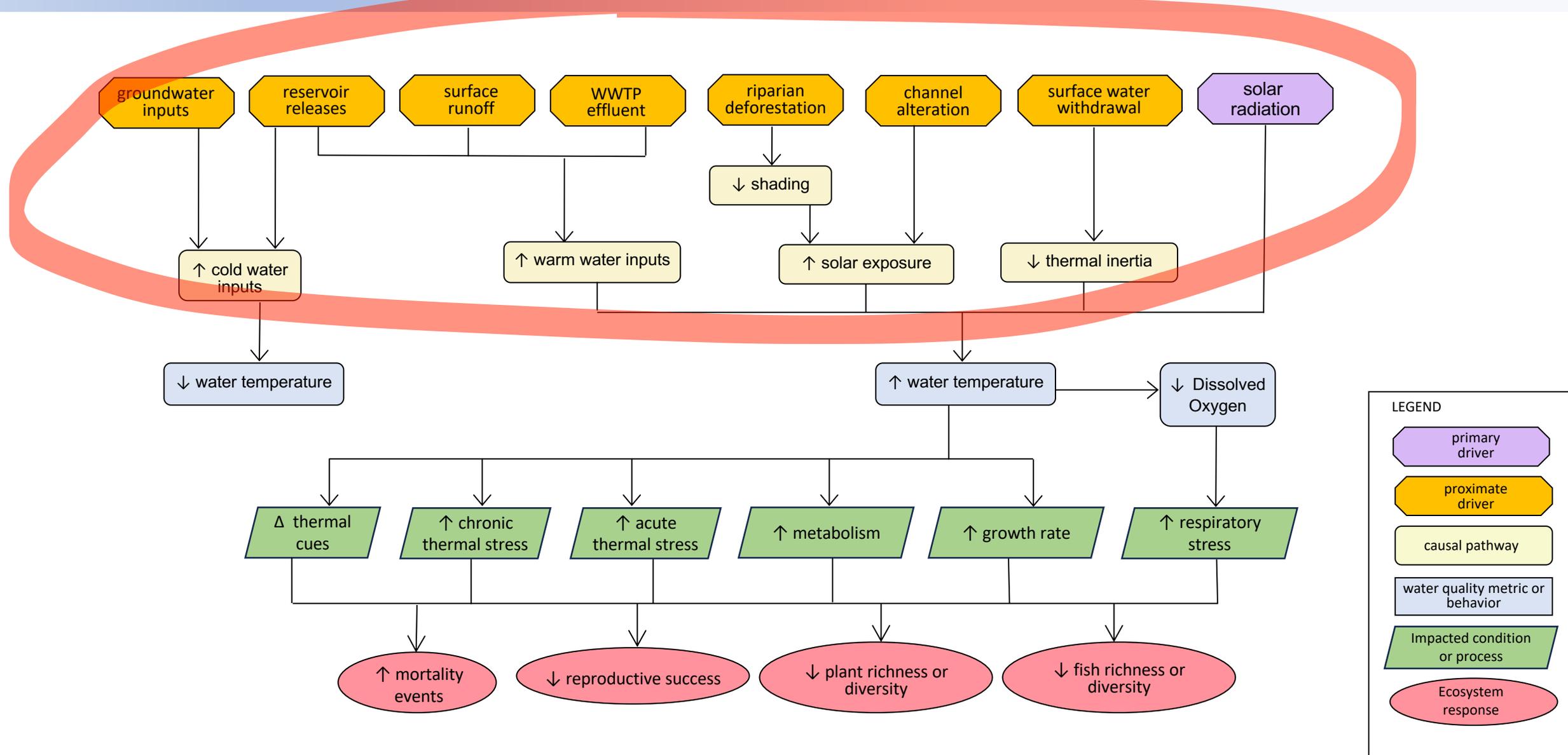
# Stream Temperature: Sensitivity to Flow & Climate

## Example Modeling Results:

- Colorado River Mid sites are sensitive to streamflow sources under varying air temperature conditions
- Sensitivity of Colorado River flow across wide range of meteorological conditions
- Greater sensitivity to Fraser River flows in early summer when air temperatures are relatively low.



# Water Quality: Causal Pathway Conceptual Model





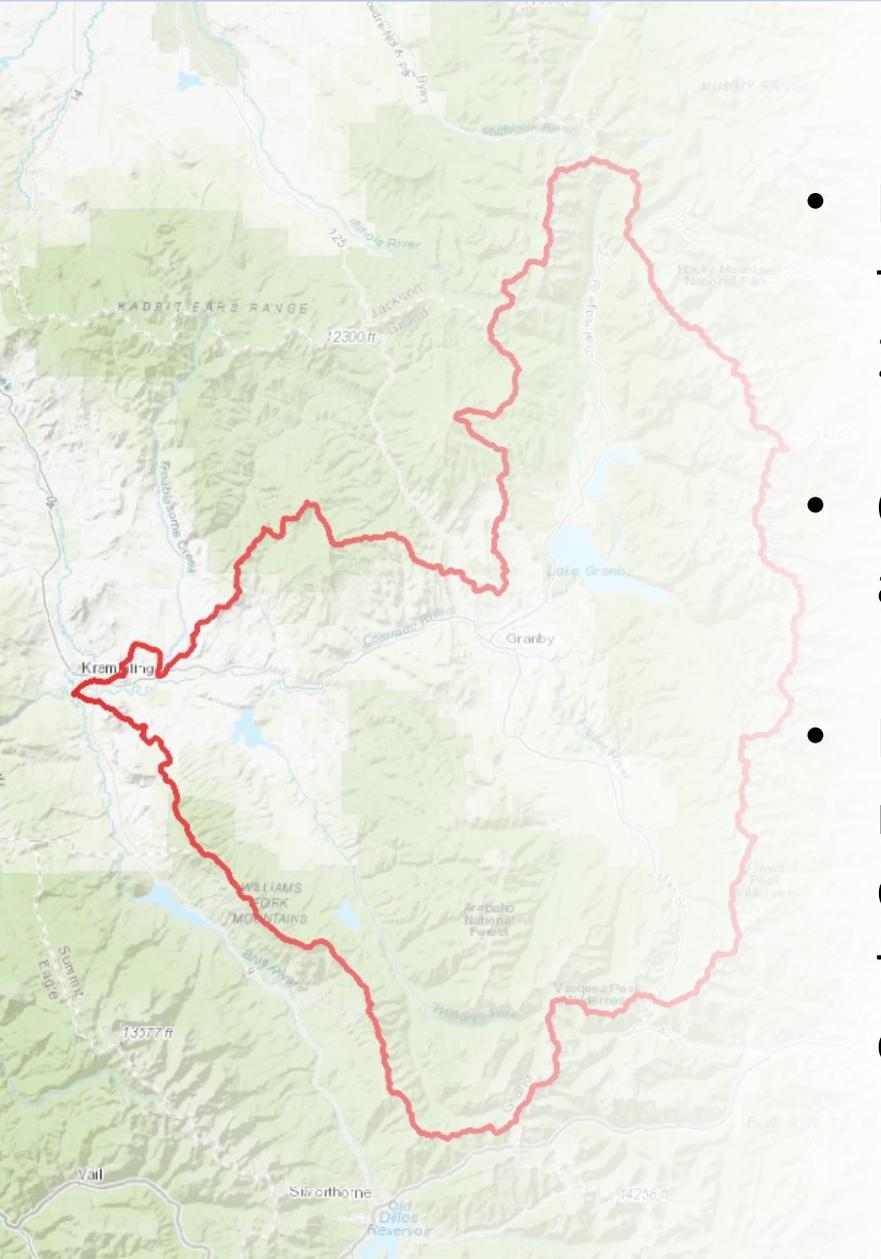
# Wrap-Up

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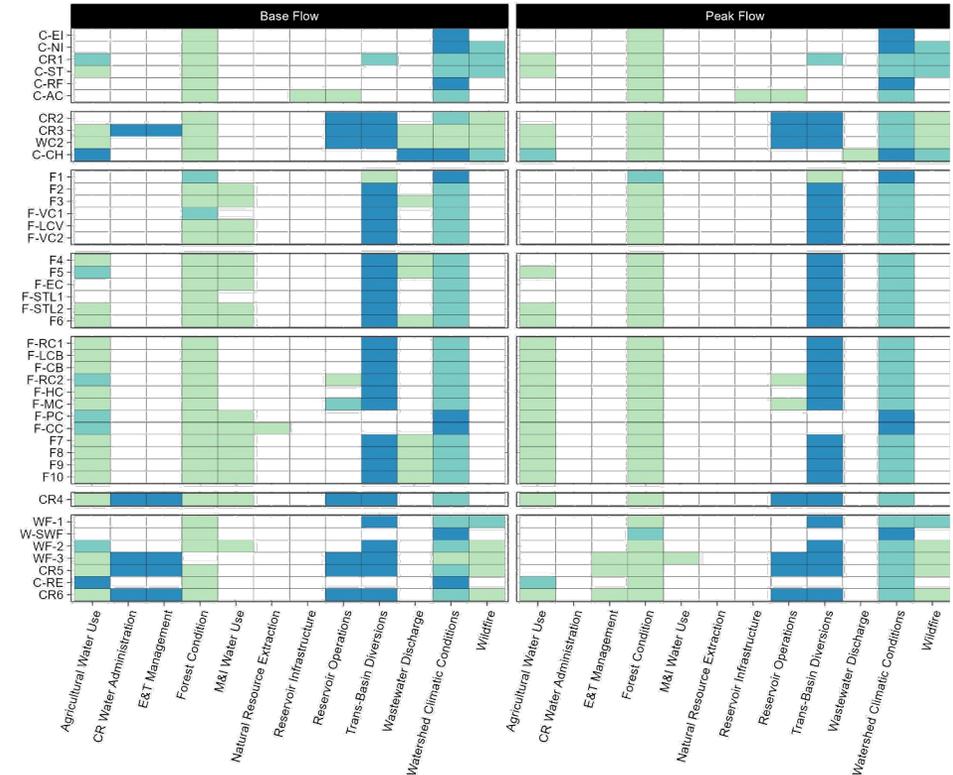
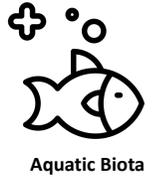
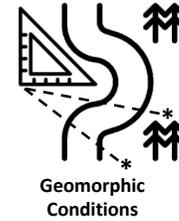
What comes Next?



# Next Steps



- Present on remaining three topic areas in early 2024
- Complete integrative assessment
- Finish composing final report and supporting deliverables and submit to LBD for review and comment





Questions?

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Seth Mason  
seth@lotichydrological.com  
970-903-7561

