Appendices

Appendix A: Acronyms

BOR	Bureau of Reclamation
CAP	Conservation Action Plan
CDSS StateMod	Colorado Decision Support System Stream Simulation Model
CDWR	Colorado Division of Water Resources
cfs	Cubic feet per second
Collaborative	Roaring Fork Watershed Collaborative Water Group
Conservancy	Roaring Fork Conservancy
CWCB	Colorado Water Conservation Board
CWT	Colorado Water Trust
HB 1177	Colorado Water for the 21st Century Act
IHA	Indicators of Hydrologic Alteration
ISF	CWCB's Instream Flow Program
NHD	National Hydrography Data
NRCS	National Resource Conservation Service
River District	Colorado River Water Conservation District
SHI	Stream Health Initiative
SWSI	Statewide Water Supply Initiative
TNC	The Nature Conservancy
Twin Lakes Co	Twin Lakes Reservoir and Canal Company
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

Appendix B: Options for Flow Protection or Restoration

Chrissy Sloan, 2004 Roaring Fork Conservancy Research Fellow and Sharon Clarke, Water Resource Specialist

The Roaring Fork Conservancy has identified several potential flow protection or restoration options to improve stream flows. These include: drafting emergency loan agreements to be used in dry months; obtaining senior water rights to be left instream; buying unused contract water; altering dam operations; identifying detrimental land use practices and pursuing options through land use planning and education to minimize or mitigate their harmful effects; and education and outreach to schools, public, planners, and elected officials about the relationship between water quantity and timing and ecological function. As a mechanism to prioritize and implement these options the Conservancy is committed to working with the Collaborative on developing a watershed plan that will address water quantity issues holistically and involve stakeholders in the planning and implementation process.

Watershed Plan

The process began in October 2005 when the Collaborative formed three committees—technical, development/implementation, and education/outreach—to look into what should be in a watershed plan, what it would take to produce a plan, how it would be developed and implemented, and how to educate and involve stakeholders. These committees met and reported back to the Collaborative in late January 2006. The technical committee identified the following preliminary benefits of a watershed plan:

Improved community understanding, interest, and leadership in watershed issues;

Articulation of a local collaborative approach for protecting and improving water quality, water quantity, wetland and riparian habitat, and recreational opportunities;

Provide information and guidance to promote compatible land and river use practices;

A document to set priorities and planning projects;

Encourage partnerships to identify and fund mutually beneficial projects;

Open up avenues for funding projects addressing watershed health;

Identification of creative and acceptable ways to protect watershed health;

Efficient use of financial resources and effective use of agency and organizational personnel.

Water quantity was identified as one of the five main topics and many of the issues associated with other topics are related to water quantity issues. The following watershed topics and issues of concern were identified during the 12/2/2005 technical specialists meeting:

Water Quality

runoff associated with current and past land use

State-identified impaired waters

groundwater quality impacts from individual septic systems

point and non-point sources

Source Water Assessment and Protection Program

reduced dilution effects from significant diverted flows

climate systems

Water Quantity

water supply thresholds (surface and groundwater)

transbasin diversions (amount and timing)

water conservation and re-use

water uses

water enforcement
water storage needs
instream flow management (minimum, maximum and optimum)
potential impacts of climate change
out of basin impacts (downstream calls, endangered fish, Colorado River Compact Agreement)
Aquatic, Wetland, and Riparian Resources
native fish protection
wildlife habitat
invasive species
heritage-endangered species
indicator species
expected conditions
Recreation
flat and white water boating
fish stocking
gold medal waters
public access
trails
recreation impacts on other water resources and uses
Land Use
conservation easements/open space
cultural heritage
energy development
urban runoff
impacts of decisions from different jurisdictions
land use changes
channel stability and flood control
cumulative effects
sustainable future growth
diversion points for municipal use
road de-icing and dust suppression methods
road locations
xericscaping
viewshed

Emergency Loan Agreements
The Conservancy worked with Representative Kathleen Curry to draft legislation to improve the ability to temporarily loan water for instream flow (HB 1039). This bill brought by Representative Kathleen Curry and Senator Jim Isgar allows a water right owner to loan water to the Colorado Water Conservation Board for use as instream flow for a period not to exceed 120 days and no more than 3 years in a ten year period. This bill removed the previous requirement for a Governor declared drought emergency that added substantial delays to the process.
Water Rights Acquisitions
In Colorado, the intention of the grantor determines whether water rights pass with the deed to land. Rights may be granted separately from the land or by reservation of the water right by the grantor upon conveyance of the land.

Under Colorado's Instream Flow statute, C.R.S. § 37-92-102(3), the Colorado Water Conservation Board (CWCB) may purchase instream flow rights:

The Board also may acquire, by grant, purchase, donation, bequest, devise, lease, exchange, or other contractual agreement, from or with any person, including any governmental entity, such water, water rights, or interests in water in such amount as the Board determines is appropriate for stream flows or for natural surface water levels or volumes for natural lakes *to preserve or improve the natural environment to a reasonable degree* (emphasis added).

The Board may use any funds available to it . . . for acquisition of water rights and their conversion to instream flow rights.

See www.cwcb.state.co.us/isf/Rules/Adopted_Rules.pdf for explanation of rules governing the acquisition of instream flow rights.

To this end, the Conservancy hopes to partner with the Colorado Water Trust (CWT), a non-profit water conservation organization, and The Nature Conservancy (TNC) to acquire, through donation or purchase, or assist others in acquiring, senior water rights or interests in water rights along critical reaches such as on the Crystal and Roaring Fork rivers and Hunter Creek, using voluntary approaches from willing owners for conservation benefits.

Unused Contract Water

Ruedi was constructed by the United States Bureau of Reclamation (the Bureau) and made operational in May 1968. Ruedi's 102,373 acre-feet of storage provides replacement water for out-of-priority depletions from the Fryingpan-Arkansas Project to the Colorado River as well as replacement water for junior users in the Roaring Fork Watershed for West Slope agricultural, municipal, and industrial uses on a contractual basis.

Of Ruedi's capacity, 28,000 acre-feet of Ruedi's capacity is reserved for downstream calls, the Bureau considers 63 acre-feet to be the "dead-pool," too deep in the reservoir to be used, and another 1,032 acre-feet to be "inactive storage." The agency reserves 21,778 acre-feet to "enhance recreation" and another 10,865 acre-feet for the U.S. FWS for its endangered fish program. As of January 2003, the Bureau had marketing contracts in place for 12,319 acre-feet. That leaves approximately 21,650 acre-feet of "uncommitted" water for sale.

Dam Operations

The Bureau generally maintains Ruedi winter releases between 60 and 70 cfs, depending on snowpack. However, in dry years, such as 2002, winter releases dropped to 43 cfs, approximately one-third of the mean flow for winter releases. Low flows are problematic because 1) shelf ice is more likely to form on the edges and creeps toward the center, creating a channel too narrow and fast-moving for trout; and 2) anchor ice is more likely to form on the bottom of the river, scouring the river bottom and wiping out invertebrates that trout depend on year-round for food. Flows could go as low as 39 cfs, Ruedi's inflow.

The Bureau has indicated it would be willing to work with county governments, elected officials, and organizations in the Roaring Fork Valley to better manage Ruedi for the fishery and aquatic habitat in the lower Fryingpan River, as well as for angling access in the river. The Conservancy will continue to be a party to these discussions to help encourage management for these in-basin needs.

Land Use Planning and Practices

Implementation of water conservation practices to increase water quantity throughout the watershed will require altering land use planning and practices, including agriculture practices and urban/residential use**.**

To do so, the Conservancy must identify and target potentially harmful land use practices and work with the watershed's counties and municipalities. The Conservancy has already begun to take this approach with its storm water drainage program. Another focus is riparian areas. With the help of local governments, the Conservancy is working to protect critical riparian lands. A healthy riparian corridor plays a critical role in maintaining stream flows. The Conservancy is researching potential funding sources that can be used to lease or purchase riparian areas and their associated water rights where possible. Local government set-back regulations will be reviewed and possible adaptations may be suggested.

The Conservancy must also pursue and foster relationships with local farmers and ranchers to identify and encourage implementation of sustainable agricultural systems geared toward our high altitude, semi-arid climate. This may include coordination of regional discussions about sustainable practices (rotational grazing, nutrient cycling) providing funding to implement water efficient irrigation systems (lining of ditches construction or protection of wetlands, implementation of aquaculture systems), and identifying programs geared towards leasing agricultural lands.

Continued education and outreach can help influence individual practices of water use.

Education/Outreach

Education and outreach is central to reaching the Conservancy's long-term goal of restoring healthy stream flows to the Watersheds waterways. It is also recognized as one of the most powerful ways to effect positive change. Since 1997, the Conservancy has conducted education programs with students of all ages throughout the Roaring Fork Valley. Educators teach students about the ecological, chemical, physical, and cultural significance of local riparian areas. The Conservancy works with over 25 school and civic groups from Aspen to Glenwood Springs and is committed to a watershed-wide approach to education.

The Conservancy hopes to expand its adult education program to increase awareness about the importance of xeriscaping, installing water and energy efficient resources, and generally using water in a sustainable way. To do so, the Conservancy may partner with, and/or support, other groups, such as the Colorado River Water Conservation District and American Leadership Forum, to host adult-oriented forums on various water conservation and policy issues to inspire interested public to take action and become involved in water quantity issues.

The Watershed Collaborative provides an ideal forum to reach a number of knowledgeable, interested, and influential entities in the Watershed.

Basin of Origin Mitigation

The Conservancy will look into future basin of origin mitigation bills and how they could help with water issues in the basin. The last bill was narrowly defeated in the house 2004 Colorado Legislative Session. In a decree for a water right that transfers water from one water division to another, John Salazar's bill would have required a water judge to include conditions to ensure that the present appropriation of water and prospective beneficial uses of water within the water division from which the water is exported will not be impaired or increased in cost at the expense of the water users in that division. The applicant for the decree must show that such exportation is needed after the preparation of an integrated water supply and demand plan and after an analysis of reasonable alternatives to such export.

Statewide Water Supply Initiative (SWSI) and House Bill 1177

The Conservancy is closely following two statewide projects and will make information from the Stream Flow Survey project available to decision makers.

The Statewide Water Supply Initiative was authorized by the Colorado Legislature in May 2003. The goal of SWSI is to help Colorado maintain adequate water supply for it citizens and the environment today and into the future. A final report was produced in November of 2004. The next phase of SWSI involves four groups consisting of state-wide participants to address the following specific issues:

1. Water efficiency
2. Non-permanent agricultural transfers
3. Quantifying recreational & environmental needs
4. Addressing the 20 percent "gap" between projected future water demands and availability, including development of alternatives.

House Bill 1177 passed in May 2005 will create a 25-member inter-basin compact committee to negotiate the equitable use of Colorado's waters. Under House Bill 1177 the nine roundtables from diverse parts of the state will analyze water management issues within their area and actively seek the input and advice of local stakeholders, local governments, water providers, and others interested in water management. Results will be forwarded to the Inter-basin Compact Committee and to other roundtables for consideration.

Appendix C: Summary of IHA Parameters and their Ecosystem Influences

IHA PARAMETER GROUP	**HYDROLOGIC PARAMETERS**	**ECOSYTEM INFLUENCES**
1. Magnitude of monthly water conditions	Mean or median value for each calendar month *Subtotal 12 parameters*	➢ Habitat availability for aquatic organisms ➢ Soil moisture availability for plants ➢ Availability of water for terrestrial animals ➢ Availability of food/cover for furbearing mammals ➢ Reliability of water supplies for terrestrial animals ➢ Access by predators to nesting sites ➢ Influences water temperature, oxygen levels, photosynthesis in water column
2. Magnitude and duration of annual extreme water conditions	Annual minima, 1-day mean Annual minima, 3-day means Annual minima, 7-day means Annual minima, 30-day means Annual minima, 90-day means Annual maxima, 1-day mean Annual maxima, 3-day means Annual maxima, 7-day means Annual maxima, 30-day means Annual maxima, 90-day means Number of zero-flow days Base flow: 7-day minimum flow/mean flow for year *Subtotal 12 parameters*	➢ Balance of competitive, ruderal,and stress-tolerant organisms ➢ Creation of sites for plant colonization ➢ Structuring of aquatic ecosystems by abiotic vs. biotic factor ➢ Structuring of river channel morphology and physical habitat conditions ➢ Soil moisture stress in plants ➢ Dehydration in animals ➢ Anaerobic stress in plants ➢ Volume of nutrient exchanges between rivers and floodplains ➢ Duration of stressful conditions such as low oxygen and concentrated chemicals in aquatic environments ➢ Distribution of plant communities in lakes, ponds, floodplains ➢ Duration of high flows for waste disposal, aeration of spawning beds in channel sediments
3. Timing of annual extreme water conditions	Julian date of each annual 1-day maximum Julian date of each annual 1-day minimum *Subtotal 2 parameters*	➢ Compatibility with life cycles of organisms ➢ Predictability/avoidability of stress for organisms ➢ Access to special habitats during reproduction or to avoid predation ➢ Spawning cues for migratory fish ➢ Evolution of life history

		strategies, behavioral mechanisms
4. Frequency and duration of high and low pulses	Number of low pulses within each water year Mean or median duration of low pulses (days) Number of high pulses within each water year Mean or median duration of high pulses (days) *Subtotal 4 parameters*	➢ Frequency and magnitude of soil moisture stress for plants ➢ Frequency and duration of anaerobic stress for plants ➢ Availability of floodplain habitats for aquatic organisms ➢ Nutrient and organic matter exchanges between river and floodplain ➢ Soil mineral availability ➢ Access for waterbirds to feeding, resting, reproduction sites ➢ Influences bedload transport, channel sediment textures, and duration of substrate disturbance (high pulses)
5. Rate and frequency of water condition changes	Rise rates: Mean or median of all positive differences between consecutive daily values Fall rates: Mean or median of all negative differences between consecutive daily values Number of hydrologic reversals *Subtotal 3 parameters*	➢ Drought stress on plants (falling levels) ➢ Entrapment of organisms on islands, floodplains (rising levels) ➢ Desiccation stress on low-mobility streamedge (varial zone) organisms

The Nature Conservancy with Smythe Scientific Software and Totten Software Design, April, 2005. Indicators of Hydrologic Alteration Version 7 User's Manual.

Appendix C. (cont.) Summary of Environmental Flow Component (EFC) Parameters and their Ecosystem Influences

EFC TYPE	HYDROLOGIC PARAMETERS	ECOSYTEM INFLUENCES
1. Monthly low flows	Mean or median values of low flows during each calendar month *Subtotal 12 parameters*	· Provide adequate habitat for aquatic organisms · Maintain suitable water temperatures, dissolved oxygen, and water chemistry · Maintain water table levels in floodplain, soil moisture for plants · Provide drinking water for terrestrial animals · Keep fish and amphibian eggs suspended · Enable fish to move to

		feeding and spawning areas · Support hyporheic organisms (living in saturated sediments)
2. Extreme low flows	Frequency of extreme low flows during each water year or season Mean or median values of extreme low flow event: · Duration (days) · Peak flow (minimum flow during event) · Timing (Julian date of peak flow) *Subtotal 4 parameters*	· Enable recruitment of certain floodplain plant species · Purge invasive, introduced species from aquatic and riparian communities · Concentrate prey into limited areas to benefit predators
3. High flow pulses	Frequency of high flow pulses during each water year or season Mean or median values of high flow pulse event: · Duration (days) · Peak flow (maximum flow during event) · Timing (Julian date of peak flow) · Rise and fall rates *Subtotal 6 parameters*	· Shape physical character of river channel, including pools, riffles · Determine size of streambed substrates (sand, gravel, cobble) · Prevent riparian vegetation from encroaching into channel · Restore normal water quality conditions after prolonged low flows, flushing away waste products and pollutants · Aerate eggs in spawning gravels, prevent siltation · Maintain suitable salinity conditions in estuaries
4. Small floods	Frequency of small floods during each water year or season Mean or median values of small flood event: · Duration (days) · Peak flow (maximum flow during event) · Timing (Julian date of peak	Applies to small and large floods: · Provide migration and spawning cues for fish · Trigger new phase in life cycle (i.e. insects) · Enable fish to spawn in floodplain, provide

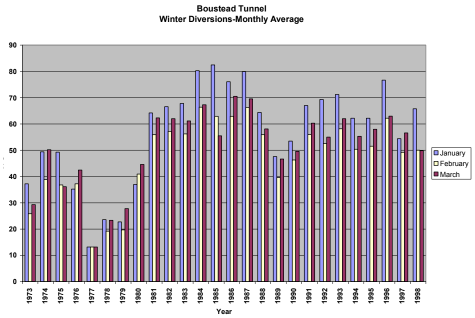
	flow) · Rise and fall rates ______________________ *Subtotal 6 parameters*	nursery area for juvenile fish · Provide new feeding opportunities for fish, waterfowl · Recharge floodplain water table · Maintain diversity in floodplain forest types through prolonged inundation (i.e. different plant species have different tolerances) · Control distribution and abundance of plants on floodplain · Deposit nutrients on floodplain
5. Large floods	Frequency of large floods during each water year or season Mean or median values of large flood event: · Duration (days) · Peak flow (maximum flow during event) · Timing (Julian date of peak flow) · Rise and fall rates ______________________ *Subtotal 6 parameters*	Applies to small and large floods: · Maintain balance of species in aquatic and riparian communities · Create sites for recruitment of colonizing plants · Shape physical habitats of floodplain · Deposit gravel and cobbles in spawning areas · Flush organic materials (food) and woody debris (habitat structures) into channel · Purge invasive, introduced species from aquatic and riparian communities · Disburse seeds and fruits of riparian plants · Drive lateral movement of river channel, forming new habitats (secondary channels, oxbow lakes) · Provide plant seedlings with

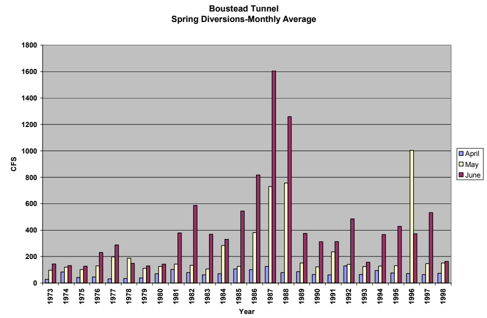
		prolonged access to soil moisture

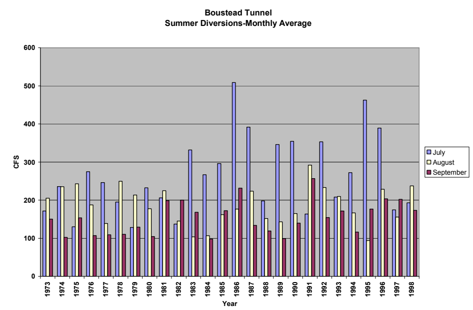
The Nature Conservancy with Smythe Scientific Software and Totten Software Design, April, 2005. Indicators of Hydrologic Alteration Version 7 User's Manual.

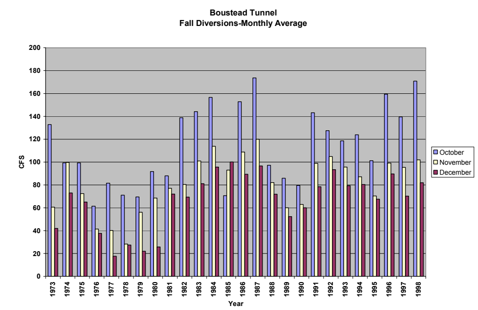
Appendix D: Seasonal Tunnel Diversions

Boustead Tunnel 1973-1998



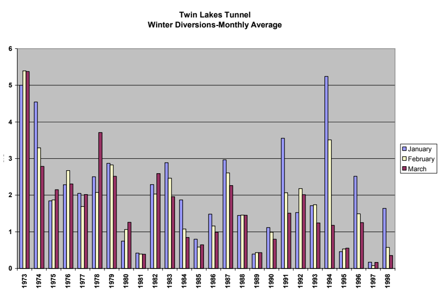


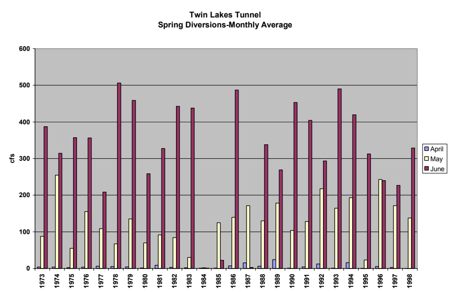


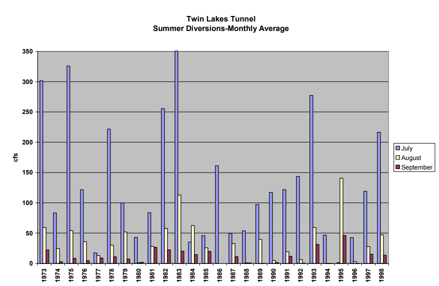


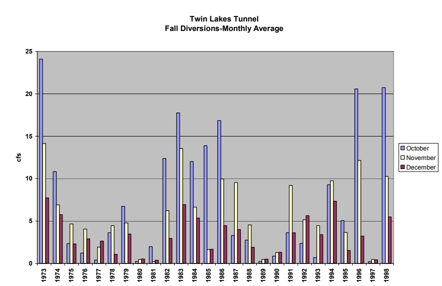
Date source: Hydrobase (Average calculated from daily mean cfs)
Note: Y-axis is different for each season

Twin Lakes Tunnel 1973-1998



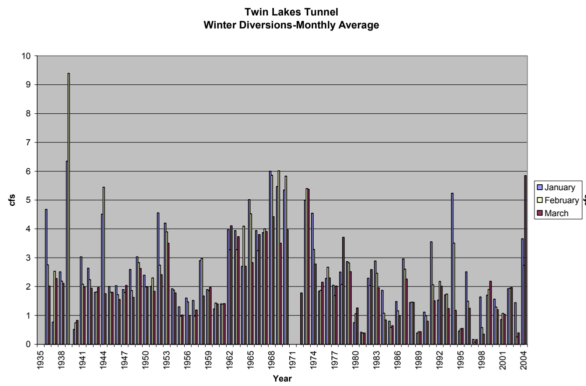


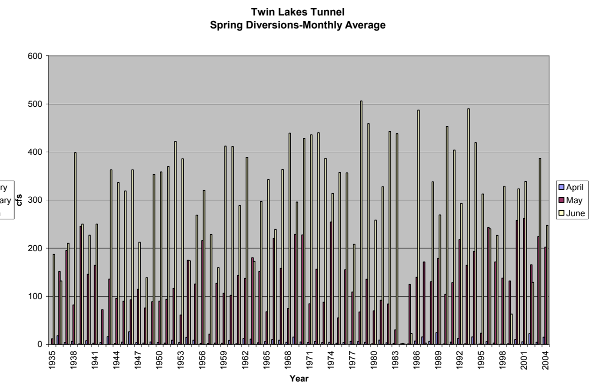


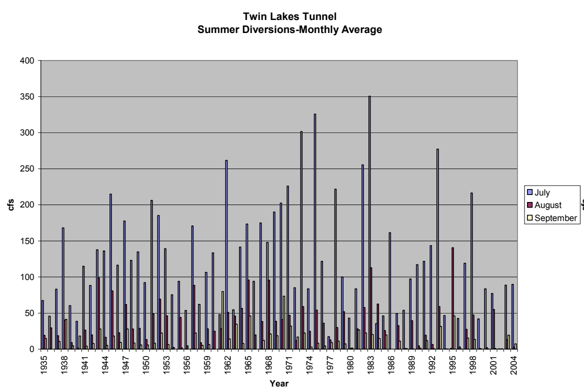


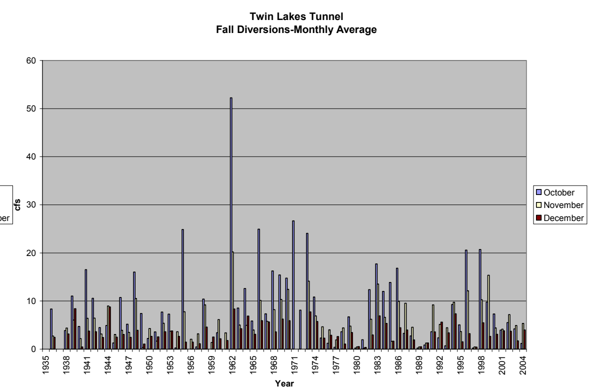
Date source: http://cdss.state.co.us/DNN/ (Monthly acre feet totals converted to cfs)
Note: Y-axis is different for each season

Twin Lakes Tunnel 1935-2004









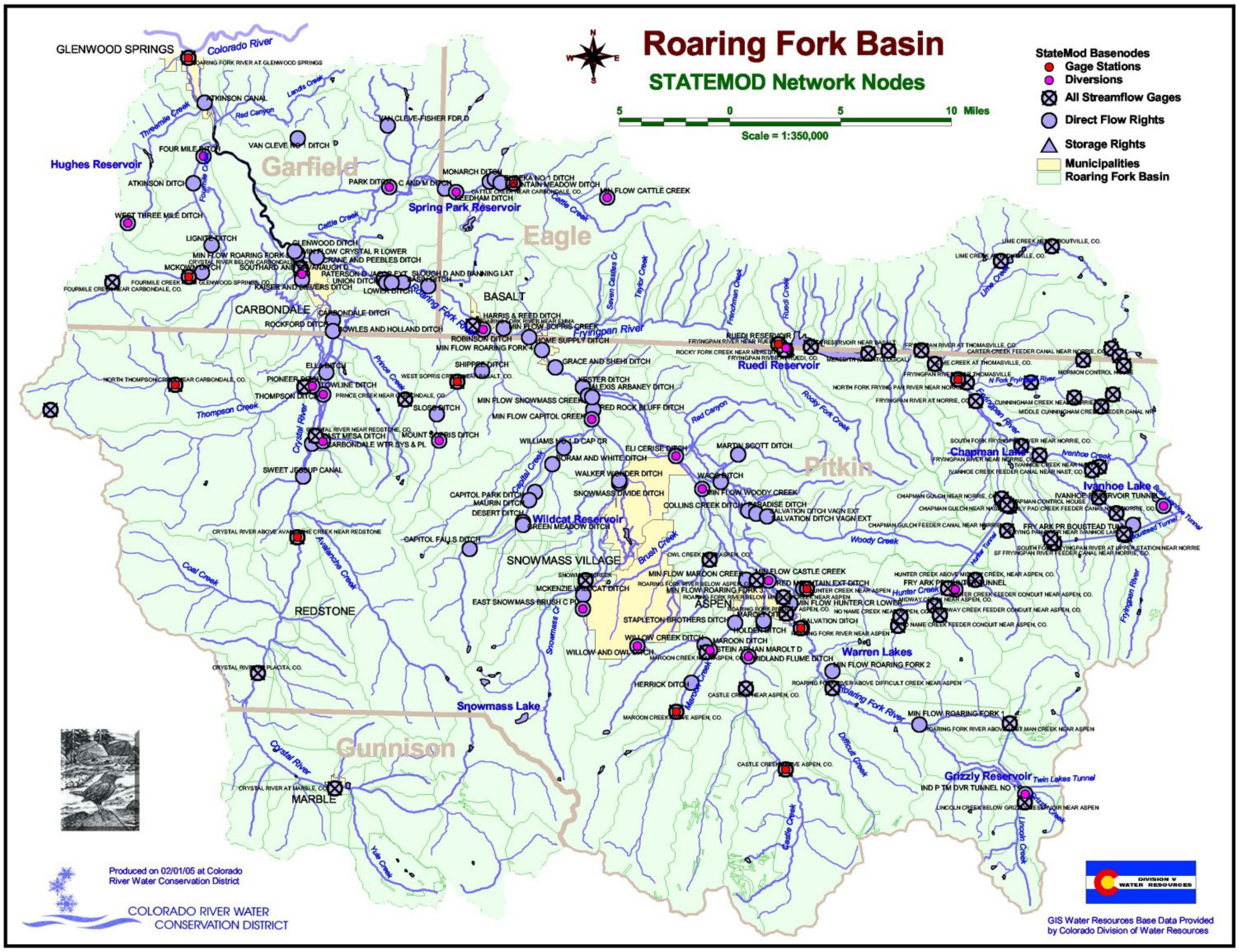
Note: Y-axis is different for each season

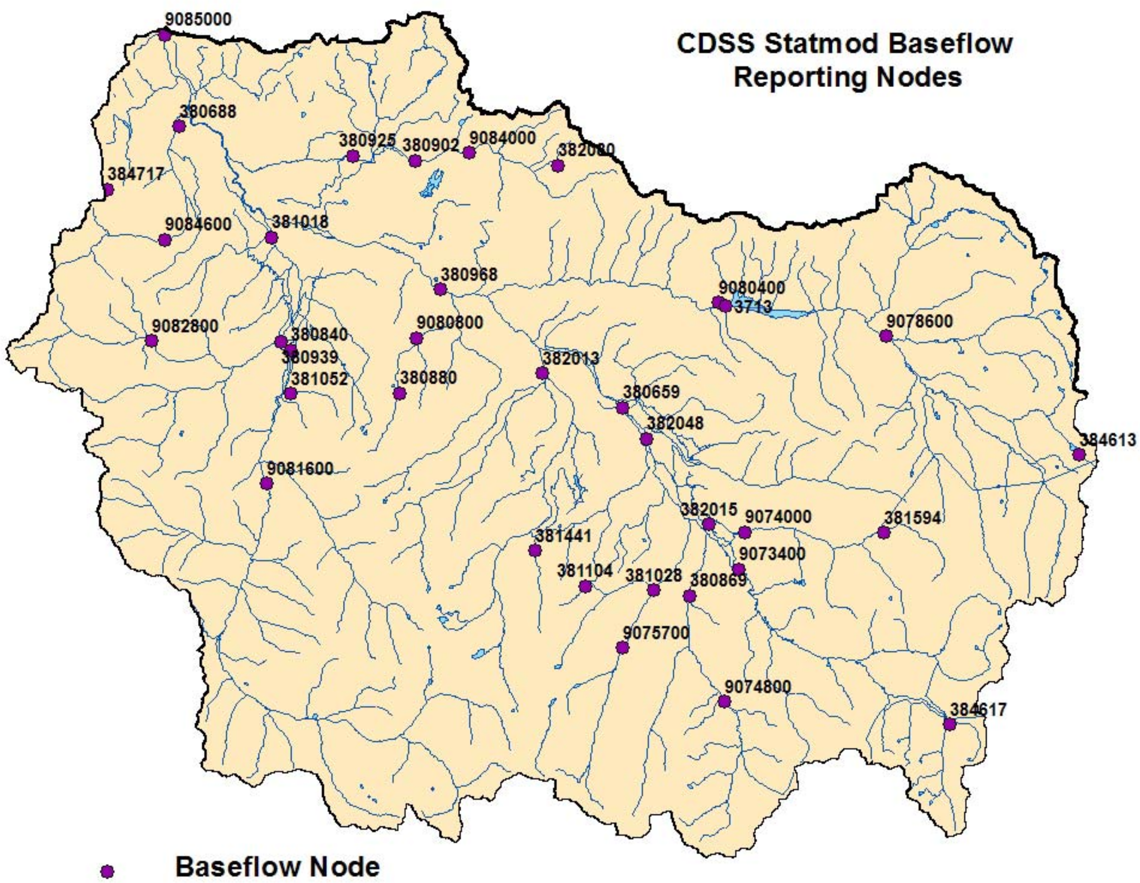
Appendix E: Real Time Stream Flow Gages

SITE NUMBER	STATION NAME	ABBRE-VIATION	CURRENT OPERATOR	DRAIN-AGE AREA (SQ.MI)	BEGIN DATE*
9072550	ROARING FORK RIVER ABOVE LOST MAN CREEK NEAR ASPEN	ROALMCCO	BOR	9.1	10/1/1980
9073005	LINCOLN CREEK BELOW GRIZZLY RESERVOIR NEAR ASPEN	LINGRRCO	BOR	15.2	10/1/1980
9073300	ROARING FORK RIVER ABOVE DIFFICULT CREEK NEAR ASPEN	ROADIFCO	USGS	75.8	10/1/1979
9073400	ROARING FORK RIVER NEAR ASPEN	ROAASPCO	USGS	108	10/1/1964
9074000	HUNTER CREEK NEAR ASPEN	HUNTASCO	USGS	41.1	6/1/1950
9077000	SNOWMASS CREEK	SNOCRECO	CDWR		
9077200	FRYING PAN RIVER NEAR IVANHOE LAKE	FRYIVLCO	CDWR	18.7	10/1/1963
9077610	IVANHOE CREEK NEAR NAST	IVCRNACO	CDWR	9.43	10/1/1975
9077800	SOUTH FORK FRYINGPAN RIVER AT UPPER STATION NEAR NORRIE	FRYSFUCO	CDWR	11.5	10/1/1963
9077945	CHAPMAN GULCH NEAR NAST	CHAGULCO	CDWR	6	10/1/1972
9078500	NORTH FORK FRYING PAN RIVER NEAR NORRIE	FRYNFNCO	CDWR	42	10/1/1910
9078600	FRYINGPAN RIVER NEAR THOMASVILLE	FRYTHOCO	CDWR	134	10/1/1975
9080100	FRYING PAN RIVER AT MEREDITH	FRYMERCO	CDWR	191	10/1/1910
9080300	ROCKY FORK CREEK NEAR MEREDITH, CO.	RFCMERCO	CDWR	12.3	10/1/1968
9080400	FRYINGPAN RIVER NEAR RUEDI	FRYRUDCO	USGS	238	10/1/1964
9081000	ROARING FORK RIVER NEAR EMMA	ROAEMMCO	USGS	853	3/12/1998
9081600	CRYSTAL RIVER ABOVE AVALANCHE CREEK NEAR REDSTONE	CRYAVACO	USGS	167	10/1/1955
9083800	CRYSTAL RIVER BELOW CARBONDALE, CO.	CRYBECARB	USGS	350	5/18/2000
9085000	ROARING FORK RIVER AT GLENWOOD SPRINGS	ROAGLECO	USGS	1451	4/1/1906
	ROARING FORK RIVER BELOW MAROON CREEK NEAR ASPEN	ROABMCCO	CDWR		11/4/1988
	BUSK-IVANHOE TUNNEL	BUSTONCO	CDWR		
	CHARLES H. BOUSTEAD TUNNEL	BOUTONCO	CCWR		
	RUEDI RESERVOIR NEAR BASALT	RUERESCO	CDWR		

*** Not always continuous**

Appendix F: CDSS StateMod nodes




CDSS Statmod Baseflow
Reporting Nodes
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380925
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9084000
382080
9084600
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3713
9078600
9082800
380840
380939
9080800
381052
380880
382013
380659
382048
384613
9081600
382015
9074000
381594
381441
9073400
381104
381028
380869
9075700
9074800
384617
Baseflow Node

Appendix G: Gages used in instream flow analysis and CWCB Instream Flow Tabulation

STATION NAME	ISF	CASE NUMBER	CFS	DATES	CFS	DATES	APPROP. DATE
CRYSTAL RIVER BELOW CARBONDALE,CO	Yes	5-75W2720	100	5/1-9/30	60	10/1-4/30	5/1/1975
ROARING FORK RIVER NEAR EMMA	Yes	5-85CW639	145	4/1-9/30	75	10/1-3/31	11/8/1985
CHAPMAN GULCH NEAR NAST	Yes	5-73W1950	3	4/1-9/30	1.5	10/1-3/31	7/12/1973
ROARING FORK RIVER ABOVE LOST MAN CREEK NEAR ASPEN	Yes	5-76W2950	10	1/1-12/31			1/14/1976
FRYINGPAN RIVER AT MEREDITH	Yes	5-73W1955	**				
NORTH FORK FRYINGPAN NEAR NORRIE	N/A	NONE					
CRYSTAL RIVER ABOVE AVALANCHE CREEK NEAR REDSTONE	Yes	5-75W2721	80	5/1-9/30	40	10/1-4/30	5/1/1975
HUNTER CREEK NEAR ASPEN	Yes	5-79CW190	16	1/1-12/31			1/31/1979
ROARING FORK RIVER ABOVE DIFFICULT CREEK NEAR ASPEN	Yes	5-76W2949	15	1/1-12/31			1/14/1976
ROARING FORK RIVER BELOW MAROON CREEK NEAR ASPEN	Yes	5-85CW646	55	4/1-9/30	30	10/1-3/31	11/8/1985
FRYINGPAN RIVER NEAR THOMASVILLE	Yes	5-73W1955	**				
FRYINGAN RIVER NEAR RUEDI	Yes	5-73W1945	110	5/1-10/31	39	11/1-4/30	7/12/1973
ROARING FORK RIVER NEAR ASPEN	Yes	5-76W2948	32	1/1-12/31			1/14/1976
ROARING FORK RIVER AT GLENWOOD SPRINGS	N/A	NONE					
SNOWMASS CREEK	TBD	5-76W2943A	***				
LINCOLN CREEK BELOW GRIZZLY RESERVOIR	Yes	5-76W2936	8	1/1-12/31			1/14/1976
FRYINGPAN RIVER NEAR IVANHOE LAKE	*	5-73W1948	12	4/1-9/30	6	10/1-3/31	7/12/1973
IVANHOE CREEK NEAR NAST	*	5-73W1952	2	4/1-9/30	1	10/1-3/31	7/12/1973
ROCKY FORK CREEK NEAR MEREDITH	N/A	NONE					
SOUTH FORK FRYINGPAN RIVER AT UPPER STATION NEAR NORRIE	*	5-73W1947	6	4/1-9/30	3	10/1-3/31	7/12/1973

***Data unavailable past 1997**

** ISF Amounts on the Fryingpan River Case Number: 5-73W1955

CFS	DATES	CFS	DATES	CFS	DATES	CFS	DATES	CFS	DATES	CFS	DATES	CFS	DATES	APPROP DATE
100	4/1-4/30	150	5/1-5/31	200	6/1-6/30	100	7/1-7/31	75	8/1-8/31	65	9/1-9/30	30	10/1-3/31	7/12/1973

***** ISF on Snowmass Creek Case Number 5-76W2943A**

Instream Flow Recommendation:

12 cfs (04/1 - 10/15)

Multi-stage winter instream flows on the reach of Snowmass Creek between West Snowmass Creek and Capitol Creek.

Percentile Water Year	Predicted Recurrence Interval	Average daily stream flow from October 11 through October 15	Multi-stage Instream Flows
50% or Greater	1:2	Greater than or equal to 29.0 cfs	12 cfs (10/16 - 11/30) 10 cfs (12/1 - 03/31)
25th% to 50th%	1:4 to 1:2	Less than 29.0 cfs and greater than or equal to 27.0 cfs	12 cfs (10/16 - 10/31) 10 cfs (11/1 - 12/14) 9 cfs (12/15 - 12/31) 10 cfs (01/1 - 03/31)
10th% to 25th%	1:10 to 1:4	Less than 27.0 cfs and greater than or equal to 19.0 cfs	12 cfs (10/16 - 10/31) 10 cfs (11/1 - 11/14) 9 cfs (11/15 - 12/21) 8.5 cfs (12/22 - 12/28) 8 cfs (12/29 - 12/31) 9 cfs (01/1 - 03/31)
Less than 10th%	1:10	Less than 19.0 cfs	9 cfs (10/16 - 10/21) 8 cfs (10/22 - 10/31)

			7 cfs (11/1 - 12/31) 8 cfs (01/1 - 03/31)

Appendix H: Conservation Action Planning

The Nature Conservancy's mission is to conserve a set of places that will conserve biodiversity globally. TNC does this by defining and developing action plans for **conservation areas.** Conservation areas are geographically defined regions:

- where conservation action can be effectively taken and
- that are, or have the potential to be, ecologically functional systems (e.g., relatively intact hydrologic cycles or fire regimes) supporting species and biological systems representative of the ecoregion (large areas defined by their distinct climate, geology and native species) in which they lie.

Working with partners, The Nature Conservancy uses an adaptive management process to develop and implement Conservation Action Plans. Through collaboration and a science-based approach, Conservation Action Plans:

- select key features of biodiversity (i.e., conservation targets) within each conservation area and assess conservation strategies for those key features;
- identify the conditions or activities that are threatening or may threaten the species and systems of concern;
- develop strategies with partners for reducing threats in the conservation areas and restoring viability and integrity to degraded species and systems of concern; and
- develop the measures of success that will be used to (1) understand if the conservation strategies are driving toward effective conservation and (2) to revise, improve, and share information on the efficacy of the different strategies.

The Conservation Action Plans that result from this process are considered to be adaptable over time and use the measures of progress and success to stimulate continued thinking and changing approaches to conservation.

The Nature Conservancy formally calls the adaptive management program behind the Conservation Action Plans the "Five-S Framework," which is shorthand for Systems, Stresses, Sources, Strategies, and (measures of) Success. The 5-S Framework is widely used both within and outside The Nature Conservancy to design conservation strategies and develop measures of both strategy effectiveness and conservation status. The table below gives examples for each of these S's.

Steps in TNC's "Five S" Process for Conservation Action Planning

"S" Step	Purpose & Notes	Example
1. Systems	To identify and select representative "targets" of the ecological systems, communities, and species in the area. This selection considers the viability (size, condition, and landscape context) of each target and the overall biodiversity health of the area.	System: Montane Riparian Forests Community: Narrowleaf Cottonwood/red osier dogwood riparian forest Species: Colorado River cutthroat Trout
2. Stresses	To identify and rank the major impairments to the viability of each target that are currently occurring or that are expected to occur within the next 10 years.	Decreased flow and increased water temperature
3. Sources	To identify and rank the factors that are directly causing the stresses now, or that are expected to cause stress in the next 10 years.	Water diversions
4. Strategies	To identify and rank opportunities to reduce or eliminate the key stresses that are lowering or may lower the viability of the targets.	Decrease the amount of diversions in key stretches during critical periods
5. Success	To identify measures and monitoring strategies for evaluating whether conservation efforts are maintaining or enhancing the viability of the targets.	Measure water temperatures Monitor trout population size

Through broad application, The Nature Conservancy has found that using the 5-S Framework for conservation action planning yields objective information on species status, degree of threats, and progress toward conservation success. Such objective information, when available, empowers a range of stakeholders to constructively discuss, interact, and consider alternative ways of acting to conserve natural systems.

Within this framework, the importance of # 5, the **Success Step** should not be underestimated. It is critical to understand if conservation strategies are having their intended impact. If they are not, the conservation targets may be at increasing risk. As a result, the efficiency and effectiveness of the strategies would then be low. Conversely, if a strategy is succeeding brilliantly, then its lessons should be exported to other applications in order to advance conservation success as a whole.

These issues are of critical interest to practitioners implementing the strategies, their managers, their organizations, and the stakeholders and donors that support and rely on them.

Additional Online Information:

An overview of the 5S Framework for planning can be downloaded at:
http://conserveonline.org/docs/2005/08/TNC_CAP_Basic_Practices_v_17_Jun_05.pdf
The latest version of the CAP/5S Workbook, used to document the process can be downloaded at: http://conserveonline.org/docs/2005/08/CAP_v4b.xls

The User Manual for the CAP/5S Workbook can be downloaded at:
http://conserveonline.org/docs/2005/03/CPM%20User%20Manual%20v4b_022805_pdf6.pdf

Appendix I: Non-Parametric IHA Scorecards

Non-parametric IHA Scorecard for the gage at the Roaring Fork River at Glenwood Springs. The pre-impact period (1906-1967) had 61 years of data and a mean annual flow of 1370 cfs compared to the post-impact period (1968-2004) with 37 years of data and a mean annual flow of 1167 cfs. Bolded significance values are statistically significant at P<.05.

	MEDIAN PRE (cfs)	**MEDIAN POST (cfs)**	**SIGNIFICANCE**
Parameter Group #1			
October	624	639	0.764
November	523	635	**0.000**
December	435	532	**0.000**
January	380	464	**0.000**
February	362.5	452	**0.000**
March	382	506	**0.000**
April	715.5	729.5	0.898
May	2620	1830	**0.008**
June	4935	3930	**0.030**
July	2210	1740	0.239
August	869	804	0.628
September	650	673	0.767
Parameter Group #2			
1-day minimum	292	390	**0.000**
3-day minimum	305	404	**0.000**
7-day minimum	327.7	418.4	**0.000**
30-day minimum	358.4	436.7	**0.000**
90-day minimum	376.8	464.8	**0.000**
1-day maximum	8040	5720	**0.000**
3-day maximum	7473	5573	**0.002**
7-day maximum	6980	5339	**0.005**
30-day maximum	5503	4272	**0.003**
90-day maximum	3608	2878	**0.030**
Number of zero days	0	0	**0.000**
Base flow	0.2544	0.3751	**0.000**
Parameter Group #3			
Date of minimum	37	43	0.347
Date of maximum	164	161	0.277
Parameter Group #4			
Low pulse count	8	3	**0.000**
Low pulse duration	3.5	2.5	0.152
High pulse count	2	2	**0.043**
High pulse duration	46.5	31	0.517
Low Pulse Threshold	420		
High Pulse Level	1380		

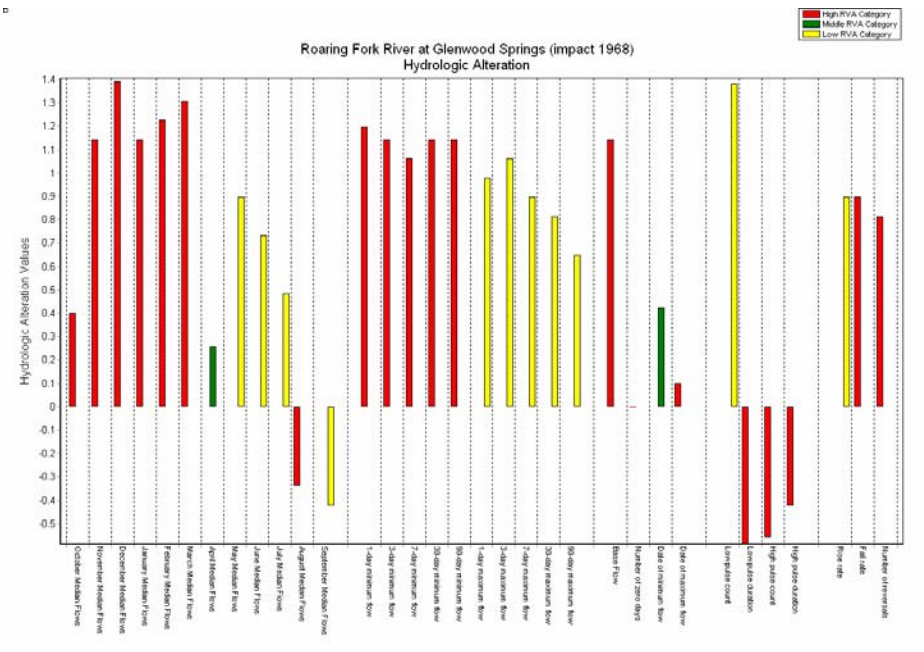
Parameter Group #5			
Rise rate	38	29	**0.021**
Fall rate	-33	-27	**0.011**
Number of reversals	121	132	**0.001**
EFC Low flows			
October Low Flow	599	626	0.497
November Low Flow	523	634	**0.000**
December Low Flow	435	532	**0.000**
January Low Flow	397.5	464	**0.000**
February Low Flow	369.5	456.5	**0.000**
March Low Flow	395	506	**0.000**
April Low Flow	593	669	**0.041**
May Low Flow	1088	1043	0.610
June Low Flow	1210	1036	0.783
July Low Flow	1010	1003	0.829
August Low Flow	780	788	0.931
September Low Flow	619.5	673	0.353
EFC Parameters			
Extreme low peak	310	315	0.558
Extreme low duration	2	2.5	**0.017**
Extreme low timing	40.5	45	0.616
Extreme low freq.	6	0	0.210
High flow peak	1528	2100	**0.000**
High flow duration	7.75	14	**0.017**
High flow timing	172	163	0.640
High flow frequency	3	3	0.339
High flow rise rate	177.3	164	0.434
High flow fall rate	-115.8	-122.2	0.300
Small Flood peak	9660	9600	0.958
Small Flood duration	92	104	0.089
Small Flood timing	166	180	**0.000**
Small Flood freq.	0	0	**0.000**
Small Flood rise rate	226.8	149.5	**0.012**
Small Flood fall rate	-154.4	-155.5	0.979
Large flood peak	14700	11800	0.317
Large flood duration	111.5	116	0.660
Large flood timing	166	194	**0.000**
Large flood freq.	0	0	**0.000**
Large flood rise	288.1	173.1	0.501
Large flood fall	-247.9	-189.8	0.608

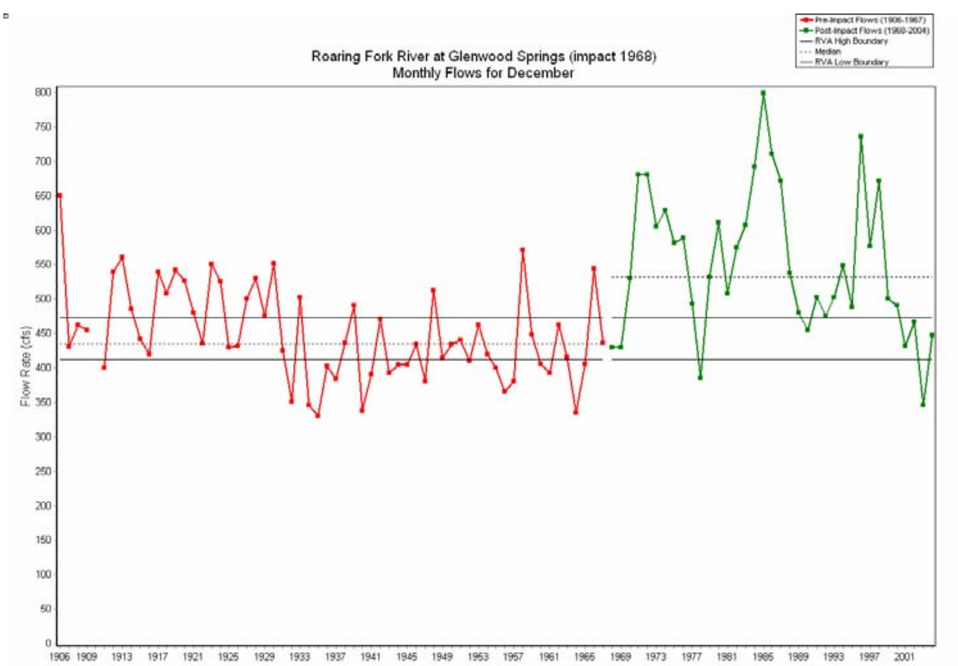
To provide a long term record of stream flows above Aspen two gages-the Roaring Fork River at Aspen (09073500) and the Roaring Fork near Aspen (09073400) were combined. The former gage operated from 1910-1964 with no data from 1922-1932 and the latter from 1964-present. Below is the resulting non-parametric IHA Scorecard. The pre-impact period (1911-1934) had only 13 years of data and a mean annual flow of 169.2 cfs compared to the post-impact period (1935-2004) with 70 years of data and a mean annual flow of 92.64 cfs. Bolded significance values are statistically significant at P<.05.

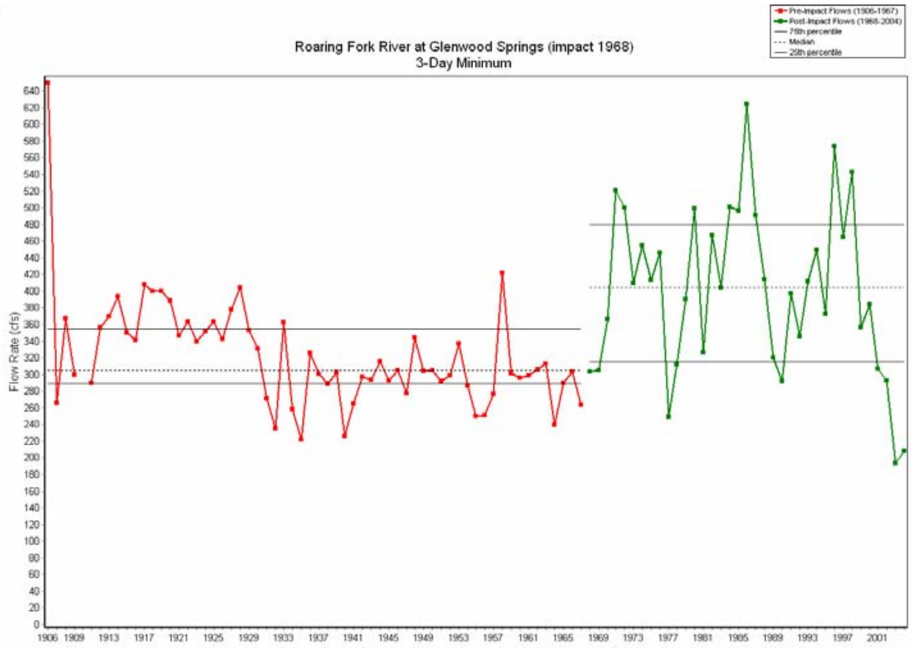
	MEDIANS PRE (cfs)	MEDIANS POST(cfs)	SIGNIFICANCE
Parameter Group #1			
October	59	37	**0.002**
November	53.5	29	**0.000**
December	40	26	**0.000**
January	30	24	**0.004**
February	33	23	**0.000**
March	33	22	**0.000**
April	60	39.75	**0.008**
May	272	175.5	**0.010**
June	902.5	364.3	**0.008**
July	362	94.5	**0.007**
August	117	50	**0.018**
September	65.5	39.75	**0.010**
Parameter Group #2			
1-day minimum	25	16.5	**0.029**
3-day minimum	25	18	**0.034**
7-day minimum	25	18.57	**0.039**
30-day minimum	30	20.08	**0.010**
90-day minimum	30.88	22.02	**0.002**
1-day maximum	1430	681.5	**0.025**
3-day maximum	1317	623.3	**0.019**
7-day maximum	1199	553.8	**0.004**
30-day maximum	972.2	398.7	**0.001**
90-day maximum	557.6	244.7	**0.000**
Number of zero days	0	0	**0.000**
Base flow	0.1591	0.2031	0.142
Parameter Group #3			
Date of minimum	32	51.5	0.227
Date of maximum	161	161	0.955
Parameter Group #4			
Low pulse count	5	5	0.777
Low pulse duration	5	5	0.809
High pulse count	3	2	0.055
High pulse duration	14	28.75	0.073
Low Pulse Threshold	36		
High Pulse Level	134		
Parameter Group #5			
Rise rate	7	3	**0.000**

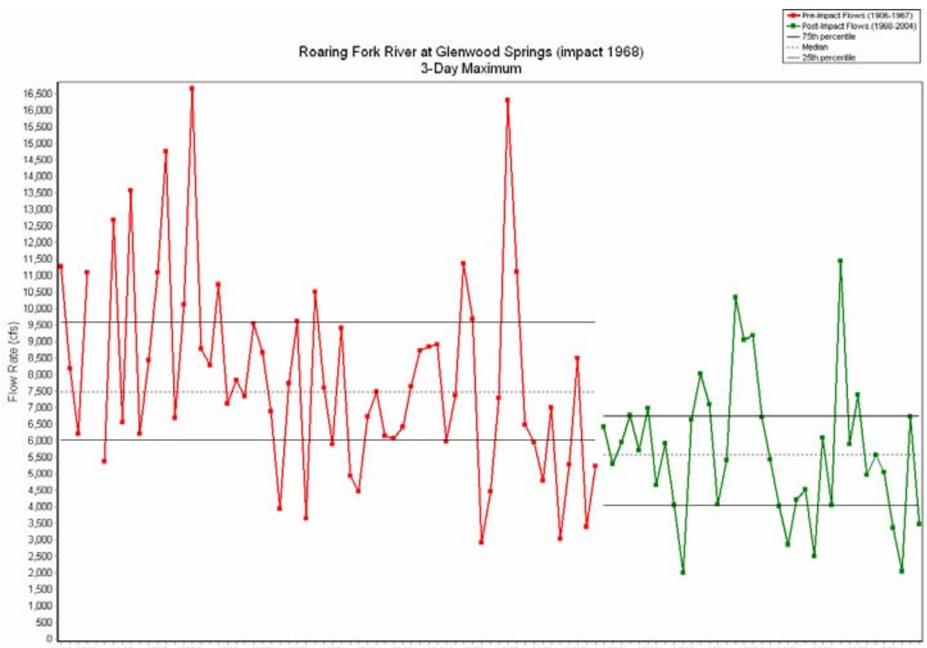
Fall rate	-6	-3	**0.000**
Number of reversals	84	117	**0.000**
EFC Low flows			
October Low Flow	57	38	**0.002**
November Low Flow	53.5	32	**0.000**
December Low Flow	40	31	**0.003**
January Low Flow	31.5	29	0.112
February Low Flow	34	29	**0.039**
March Low Flow	33	30	**0.041**
April Low Flow	44.25	42	0.518
May Low Flow	96.5	75	0.179
June Low Flow	93.5	111	0.093
July Low Flow	87.75	76.25	0.362
August Low Flow	78	49	**0.027**
September Low Flow	63	41	**0.000**
EFC Parameters			
Extreme low peak	24	24	0.562
Extreme low duration	4.25	3.5	0.643
Extreme low timing	60	343	**0.030**
Extreme low freq.	1	7	**0.001**
High flow peak	140	124	0.426
High flow duration	6	5	0.499
High flow timing	213.5	172	**0.015**
High flow frequency	3	4	**0.014**
High flow rise rate	24.5	18.39	**0.021**
High flow fall rate	-10.53	-12.06	0.182
Small Flood peak	1595	1695	0.630
Small Flood duration	93.5	82	0.429
Small Flood timing	162.5	176.5	0.221
Small Flood freq.	0	0	**0.000**
Small Flood rise rate	56.74	42.17	**0.404**
Small Flood fall rate	-25.69	-37.07	**0.049**
Large flood peak	2230		**0.000**
Large flood duration	90		**0.000**
Large flood timing	166		**0.000**
Large flood freq.	0	0	**0.000**
Large flood rise	59.42		**0.000**
Large flood fall	-38.51		**0.000**
Flow level to begin a high flow event is 134.750			
Flow level to end a high flow event is 55.000			
Flow level to begin an extreme low flow is 26.000			

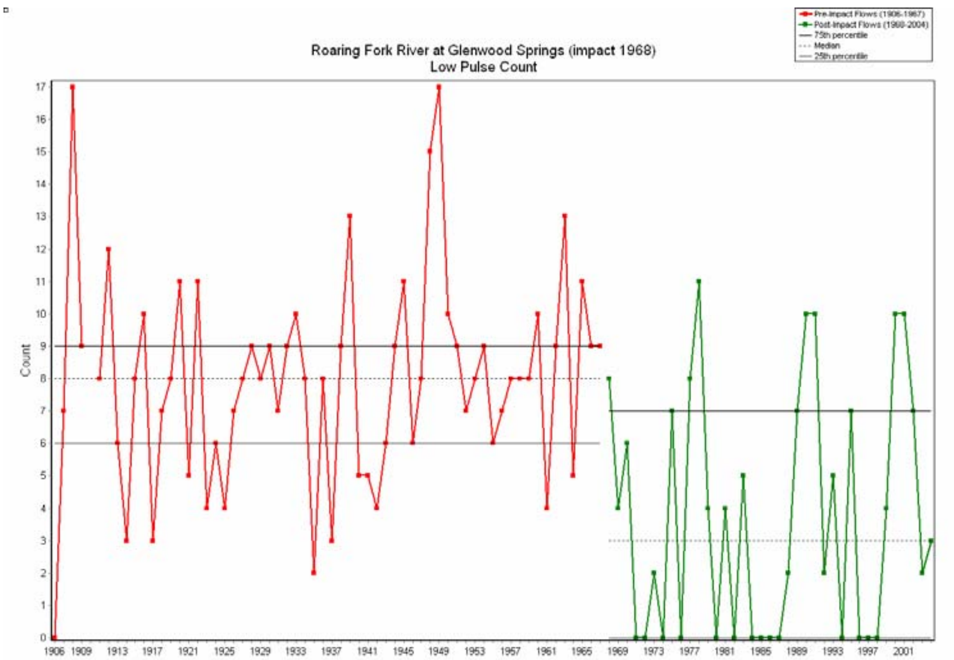
Appendix J: IHA results for two gages

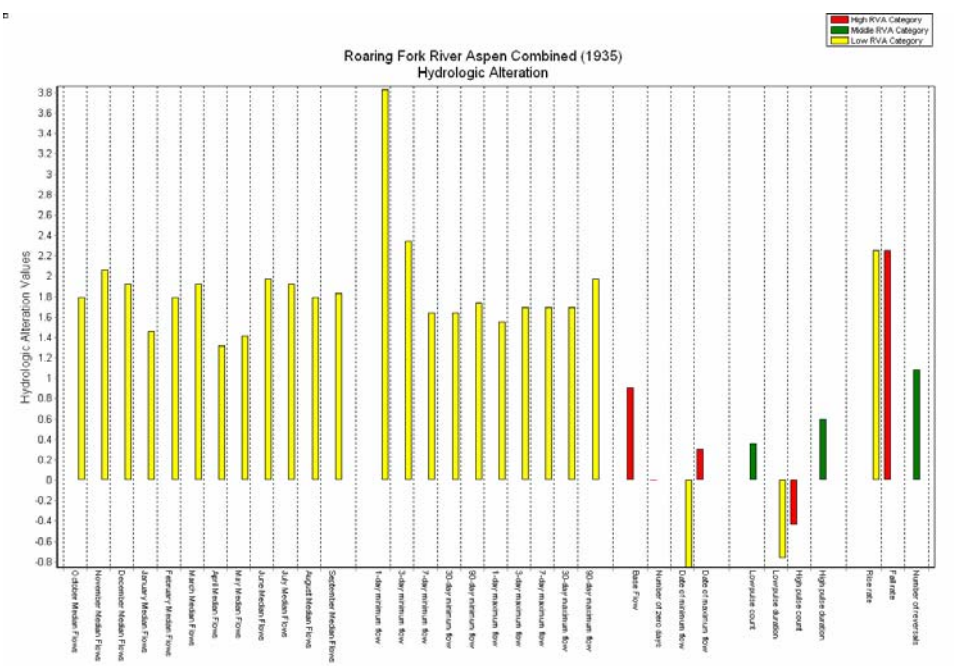


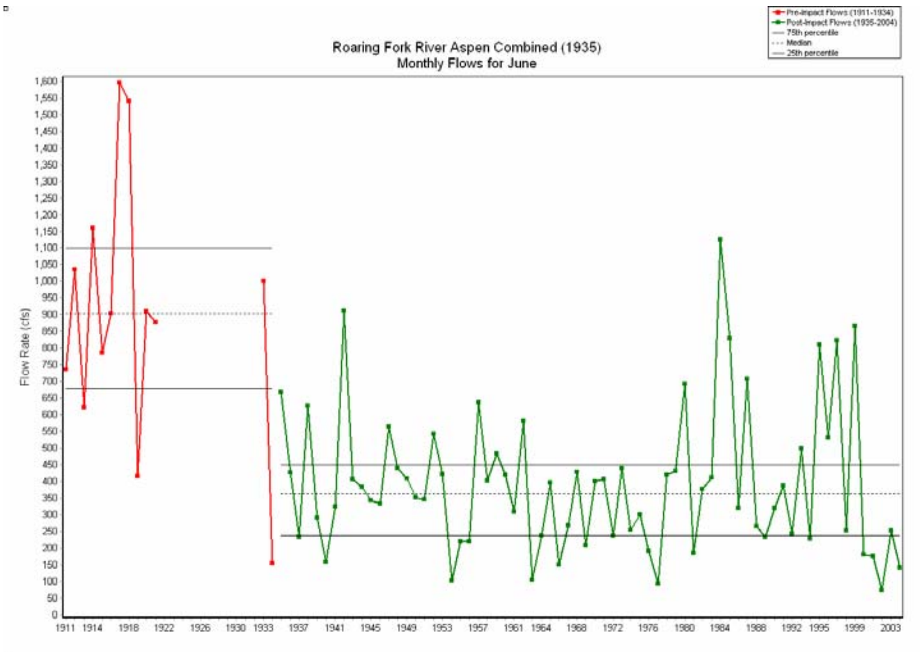


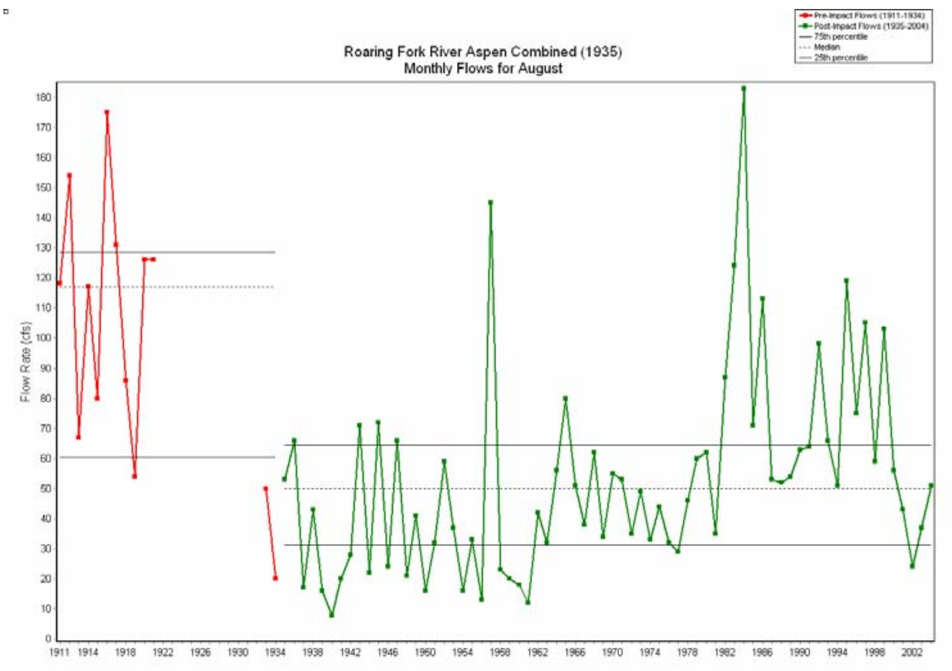

Roaring Fork River at Glenwood Springs (impact 1968)
3-Day Minimum
Pre-Impact Flows (1906-1967)
Post-Impact Flows (1968-2004)
75th percentile
Median
25th percentile
Flow Rate (cfs)

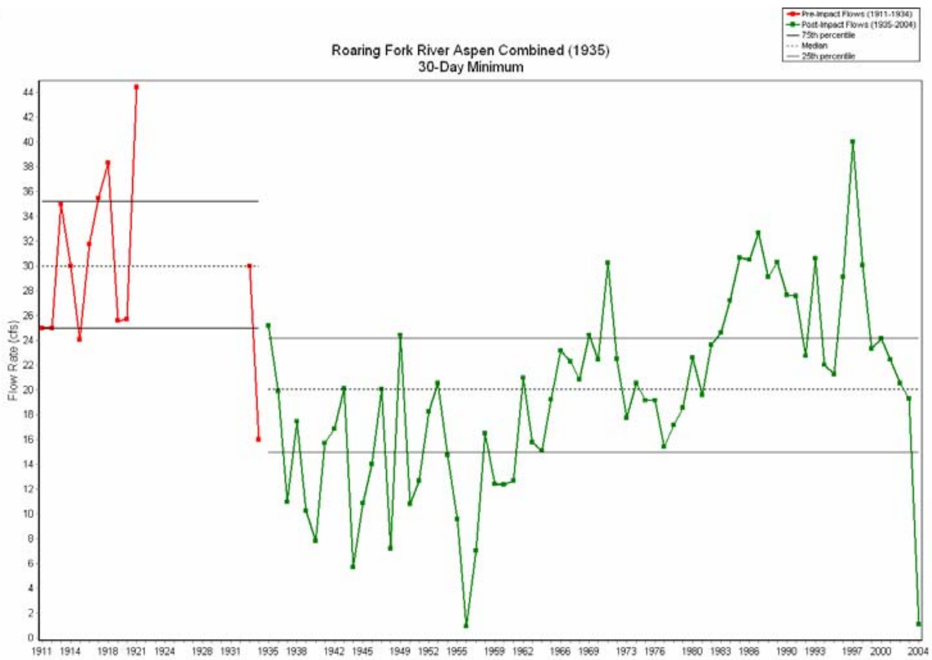

Roaring Fork River at Glenwood Springs (impact 1968)
3-Day Maximum
Pre-Impact Flows (1906-1967)
Post-Impact Flows (1968-2004)
75th percentile
Median
25th percentile
Flow Rate (cfs)

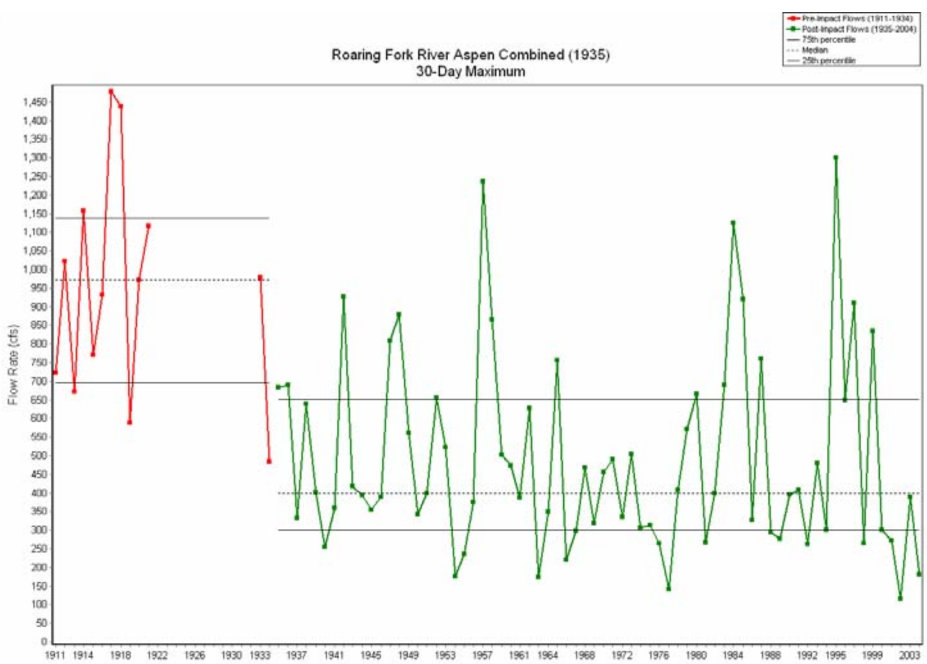

Roaring Fork River at Glenwood Springs (impact 1968)
Low Pulse Count
Pre-Impact Flows (1906-1967)
Post-Impact Flows (1968-2004)
75th percentile
Median
25th percentile
Count


Roaring Fork River Aspen Combined (1935)
Hydrologic Alteration
High RVA Category
Middle RVA Category
Low RVA Category
Hydrologic Alteration Values
October Median Flows
November Median Flows
December Median Flows
January Median Flows
February Median Flows
March Median Flows
April Median Flows
May Median Flows
June Median Flows
July Median Flows
August Median Flows
September Median Flows
1-day minimum flow
3-day minimum flow
7-day minimum flow
30-day minimum flow
90-day minimum flow
1-day maximum flow
3-day maximum flow
7-day maximum flow
30-day maximum flow
90-day maximum flow
Base Flow
Number of zero days
Date of minimum flow
Date of maximum flow
Low pulse count
Low pulse duration
High pulse count
High pulse duration
Rise rate
Fall rate
Number of reversals

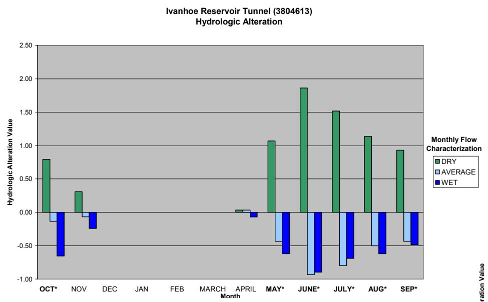

Roaring Fork River Aspen Combined (1935)
Monthly Flows for June
Pre-Impact Flows (1911-1934)
Post-Impact Flows (1935-2004)
75th percentile
Median
25th percentile
Flow Rate (cfs)


Roaring Fork River Aspen Combined (1935)
Monthly Flows for August
Pre-Impact Flows (1911-1934)
Post-Impact Flows (1935-2004)
75th percentile
Median
25th percentile
Flow Rate (cfs)

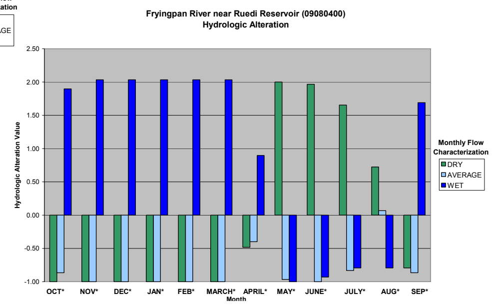

Pre-Impact Flows (1911-1934)
Post-Impact Flows (1935-2004)
75th percentile
Median
25th percentile
Roaring Fork River Aspen Combined (1935)
30-Day Minimum
Flow Rate (cfs)

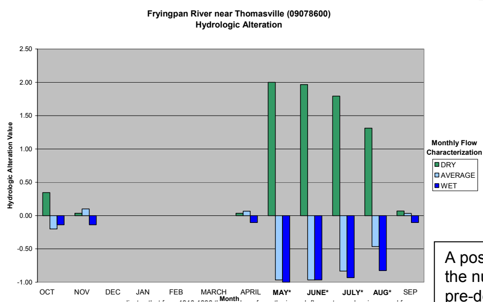

Pre-Impact Flows (1911-1934)
Post-Impact Flows (1935-2004)
75th percentile
Median
25th percentile
Roaring Fork River Aspen Combined (1935)
30-Day Maximum
Flow Rate (cfs)

Appendix K: Hydrologic alteration results for each node (upstream to downstream order by sub-watershed)



Fryingpan River Sub-Watershed
Hydrologic Alteration





A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Fryingpan River Sub-Watershed

Ivanhoe Reservoir Tunnel Node: 3804613

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	4.49	2.88	2.54	2.08	2.08	2.50	8.05	44.74	80.69	27.21	9.91	5.44
Developed	2.77	2.75	2.54	2.08	2.08	2.50	7.85	33.47	26.70	4.23	5.00	3.60
Percent	*61.78*	*95.34*	*100.00*	*100.00*	*100.00*	*100.00*	*97.49*	*74.81*	*33.08*	*15.54*	*50.45*	*66.31*
Significance	**0.000***	0.158	1	1	1	1	0.596	**0.000***	**0.000***	**0.000***	**0.000***	**0.000**
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**moderate**			**none**			**high**			**severe**	
Overall Alteration												**high**

Fryingpan River near Thomasville Node: 09078600

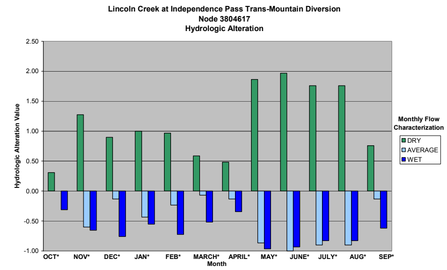
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	46.23	29.78	26.18	21.39	21.45	25.86	82.98	461.17	831.87	280.50	102.22	56.03
Developed	41.44	29.65	26.18	21.39	21.45	25.86	82.78	217.77	200.00	100.00	75.01	54.20
Percent	*89.64*	*99.55*	*100.00*	*100.00*	*100.00*	*100.00*	*99.76*	*47.22*	*24.04*	*35.65*	*73.38*	*96.73*
Significance	0.117	0.727	0.961	0.999	1	0.989	0.758	**0.000***	**0.000***	**0.000***	**0.000***	0.361
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**high**			**high**	
Overall Alteration												**moderate**

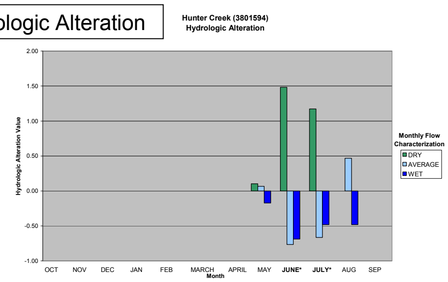
Fryingpan River near Ruedi Reservoir Node: 09080400

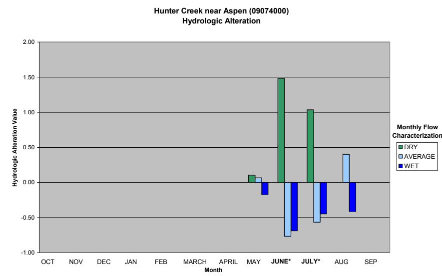
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	84.97	57.30	46.68	41.46	42.17	49.24	125.84	648.92	1141.68	379.18	152.92	92.25
Developed	171.40	153.46	136.53	130.07	138.27	137.00	172.85	110.01	122.97	181.84	121.42	177.01
Percent	*201.72*	*267.83*	*292.51*	*313.69*	*327.88*	*278.23*	*137.35*	*16.95*	*10.77*	*47.96*	*79.40*	*191.89*
Significance	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**severe**			**severe**			**severe**			**severe**	
Overall Alteration												**severe**

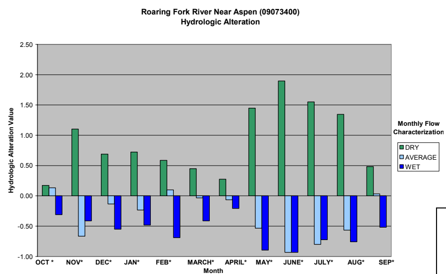
bold* significant at P< .05

Upper Roaring Fork River Sub-Watershed Hydrologic Alteration









A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Upper Roaring Fork River Sub-Watershed

Lincoln Creek at Trans-mountian Diversion Independence Pass **NODE: 3804617**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	36.47	26.33	22.07	18.22	20.72	20.78	36.78	245.03	561.76	202.54	69.96	43.54
Developed	31.27	18.91	18.13	15.56	18.36	18.57	28.80	80.39	23.81	3.94	27.19	34.56
Percent	*85.75*	*71.85*	*82.17*	*85.36*	*88.61*	*89.36*	*78.30*	*32.81*	*4.24*	*1.95*	*38.87*	*79.37*
Significance	**0.004***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**severe**			**severe**			**severe**			**severe**	
Overall Alteration												**severe**

Roaring Fork Near Aspen **NODE: 09073400**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	52.10	37.61	31.53	26.04	29.58	29.69	52.54	350.04	802.52	289.35	99.94	62.20
Developed	47.91	30.18	27.80	23.43	27.22	27.39	44.52	180.19	258.35	89.32	52.72	52.55
Percent	*91.96*	*80.25*	*88.19*	*89.98*	*92.00*	*92.25*	*84.73*	*51.48*	*32.19*	*30.87*	*52.75*	*84.49*
Significance	**0.037**	**0.000***	**0.000***	**0.000***	**0.001***	**0.003***	**0.007***	**0.000***	**0.000***	**0.000***	**0.000***	**0.006***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**severe**			**severe**			**severe**			**severe**	
Overall Alteration												**severe**

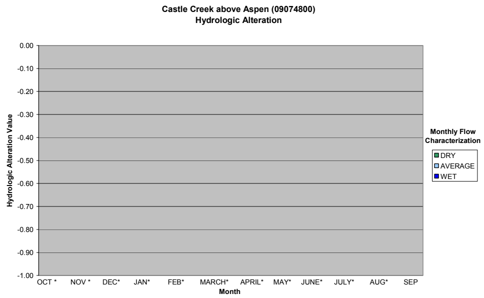
Hunter Creek **NODE: 3801594**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	11.35	8.03	5.59	5.05	4.74	5.26	16.28	131.44	225.44	60.23	20.48	12.52
Developed	11.35	8.03	5.59	5.05	4.74	5.26	16.28	122.36	59.21	21.00	20.48	12.52
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*93.09*	*26.27*	*34.86*	*100.00*	*100.00*
Significance	0.994	1	1	1	1	1	0.916	0.317	**0.000***	**0.000***	0.253	0.999
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**moderate**			**moderate**	
Overall Alteration												**moderate**

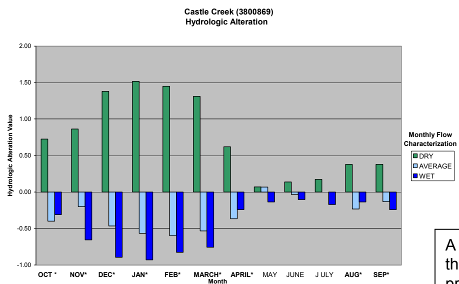
Hunter Creek **NODE: 09074000**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	14.20	10.04	6.99	6.31	5.92	6.58	20.35	164.30	281.80	75.29	25.60	15.65
Developed	14.20	10.04	6.99	6.31	5.92	6.58	20.35	154.90	118.37	36.84	25.60	15.65
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*94.28*	*42.00*	*48.93*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	0.936	0.398	**0.000***	**0.000***	0.414	0.999
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**moderate**			**moderate**	
Overall Alteration												**moderate**

bold* significant at P< .05



Maroon/**Castle** Creeks Sub-Watershed
Hydrologic Alteration



A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Maroon/Castle Creek Sub-Watershed

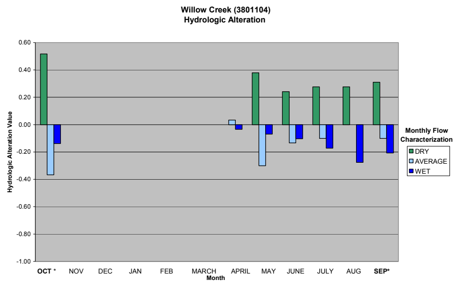
Castle Creek above Aspen **NODE: 09074800**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	16.59	15.21	12.73	9.95	9.81	9.63	14.19	69.42	175.21	97.00	43.68	28.27
Developed	16.59	15.21	12.73	9.95	9.81	9.63	14.19	69.42	175.21	97.00	43.68	28.27
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	1	1	1	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

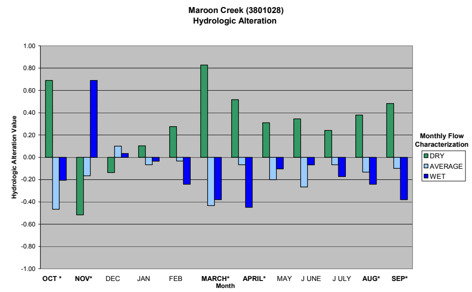
Castle Creek **NODE: 3800869**

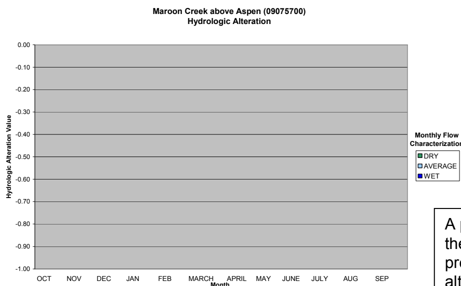
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	36.32	21.77	22.22	20.70	19.70	22.21	35.30	122.67	254.59	155.92	76.83	58.54
Developed	31.10	15.77	15.71	14.33	13.59	16.71	30.68	115.49	245.08	144.57	68.71	52.02
Percent	*85.63*	*72.44*	*70.72*	*69.21*	*69.01*	*75.25*	*86.91*	*94.15*	*96.26*	*92.72*	*89.44*	*88.86*
Significance	**0.001***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.020***	0.242	0.418	0.258	**0.045***	**0.011***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**severe**			**severe**			**moderate**			**high**	
Overall Alteration												**severe**

bold* significant at P< .05



Maroon/Castle Creeks Sub-Watershed Hydrologic Alteration





A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Maroon/Castle Creek Sub-Watershed

Willow Creek **NODE: 3801104**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	9.90	8.12	6.46	5.29	4.42	4.34	5.60	21.56	72.67	49.80	24.35	12.35
Developed	8.55	8.12	6.46	5.29	4.42	4.34	5.60	19.85	69.19	45.28	21.52	11.23
Percent	*86.36*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*99.85*	*92.08*	*95.21*	*90.92*	*88.38*	*90.95*
Significance	**0.004***	1	1	1	1	1	0.999	0.268	0.219	0.166	0.059	**0.038***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**moderate**			**none**			**none**			**none**	
Overall Alteration												**moderate**

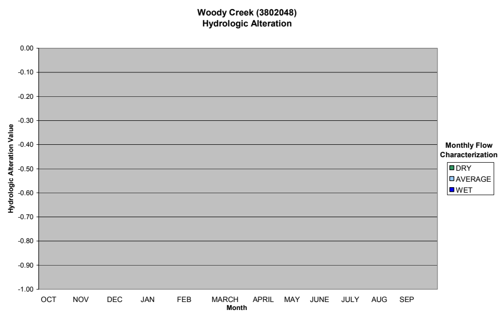
Maroon Creek above Aspen **NODE:09075700**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	33.33	27.35	21.75	17.78	14.88	14.61	18.86	72.58	244.68	167.69	82.01	41.59
Developed	33.33	27.35	21.75	17.78	14.88	14.61	18.86	72.58	244.68	167.69	82.01	41.59
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	1	1	1	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

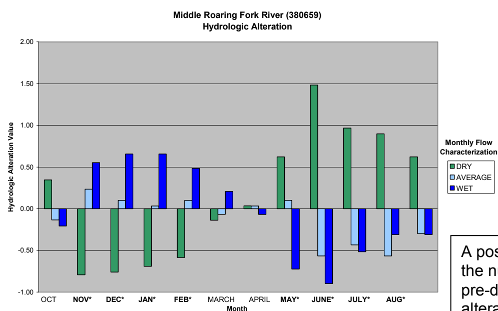
Maroon Creek **NODE: 3801028**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	36.24	28.44	23.21	19.46	16.69	17.00	22.17	79.08	260.38	178.67	87.71	46.36
Developed	31.56	30.96	23.56	19.16	16.16	15.87	19.78	73.94	247.52	165.49	74.41	38.20
Percent	*87.08*	*108.83*	*101.51*	*98.45*	*96.82*	*93.40*	*89.20*	*93.50*	*95.06*	*92.62*	*84.84*	*82.40*
Significance	**0.003***	**0.006***	0.636	0.682	0.182	**0.001***	**0.003***	0.226	0.22	0.239	**0.023***	**0.001***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**high**			**moderate**			**moderate**			**high**	
Overall Alteration												**high**

bold* significant at P< .05



Upper Middle Roaring Fork River
Sub-Watershed
Hydrologic Alteration



A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Upper Middle Roaring Fork River Sub-Watershed

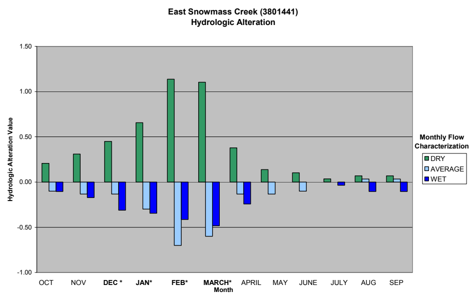
Woody Creek **NODE: 3802048**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	8.57	6.07	4.22	3.81	3.57	3.98	12.29	99.24	170.21	45.48	15.47	9.45
Developed	8.57	6.07	4.22	3.81	3.57	3.98	12.29	99.24	170.21	45.48	15.47	9.45
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	1	1	1	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

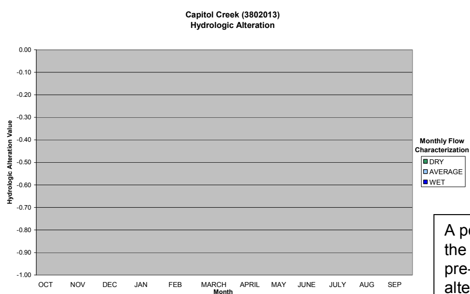
Middle Roaring Fork River **NODE:3800659**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	191.9	120.9	110.8	100.7	97.42	107.6	184.5	918	1951	877.4	392.2	244.6
Developed	178.1	138.1	124.7	108.9	103.48	110.1	176.7	703.4	1221	596.1	288.7	216.9
Percent	*92.81*	*114.20*	*112.50*	*108.13*	*102.30*	*102.30*	*95.80*	*76.63*	*62.59*	*67.94*	*73.61*	*88.66*
Significance	0.156	**0.000***	**0.000***	**0.000***	**0.000***	0.152	0.324	**0.000***	**0.000***	**0.000***	**0.000***	**0.005***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**high**			**high**			**high**			**severe**	
Overall Alteration												**severe**

bold* significant at P< .05



Snowmass Creek Sub-Watershed
Hydrologic Alteration



A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Snowmass Creek Sub-Watershed

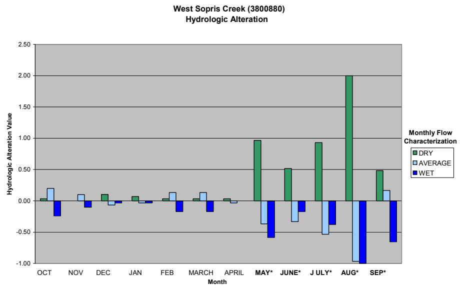
East Snowmass Creek — **NODE: 3801441**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	34.03	27.92	22.21	18.16	15.19	14.92	19.25	74.11	249.82	171.21	83.72	42.47
Developed	32.93	26.70	20.47	16.40	13.46	13.33	18.19	72.99	247.81	168.74	81.53	40.75
Percent	*96.75*	*95.61*	*92.16*	*90.33*	*88.62*	*89.32*	*94.50*	*98.49*	*99.19*	*98.56*	*97.38*	*95.96*
Significance	0.332	0.096	**0.004***	**0.001***	**0.000***	**0.000***	0.081	0.709	0.752	0.75	0.609	0.378
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**moderate**			**severe**			**none**			**none**	
Overall Alteration												**moderate**

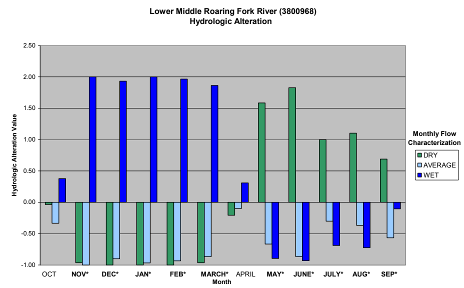
Capitol Creek — **NODE: 3802013**

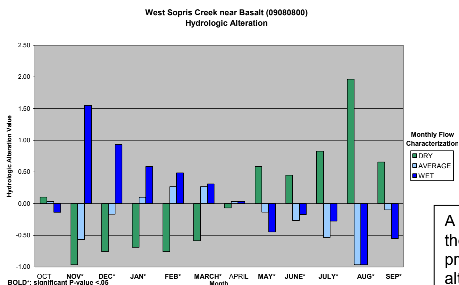
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	13.04	10.70	8.51	6.96	5.82	5.72	7.38	28.39	95.67	65.57	32.06	16.27
Developed	13.04	10.70	8.51	6.96	5.82	5.72	7.38	28.39	95.67	65.57	32.06	16.27
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	1	1	1	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

bold* significant at P< .05



Lower Middle Roaring Fork River Sub-Watershed Hydrologic Alteration





BOLD*: significant P-value <.05
A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.

A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Lower Middle Roaring Fork River Sub-Watershed

West Sopris Creek **NODE: 3800880**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	1.56	0.61	0.55	0.55	0.59	0.70	2.60	8.62	15.82	11.19	5.69	2.53
Developed	1.37	0.61	0.55	0.55	0.59	0.70	2.58	4.42	10.29	5.64	2.50	2.09
Percent	*87.50*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*99.35*	*51.23*	*65.06*	*50.36*	*44.00*	*82.72*
Significance	0.121	1	1	1	1	1	0.929	**0.000***	**0.000***	**0.000***	**0.000***	**0.003***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**high**			**severe**	
Overall Alteration												**high**

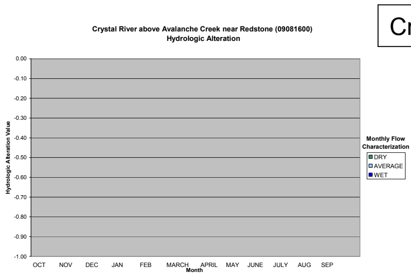
West Sopris Creek near Basalt **NODE:09080800**

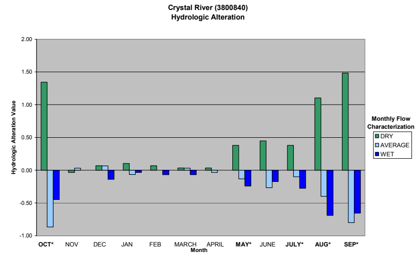
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	3.01	1.16	1.07	1.06	1.15	1.35	5.02	16.67	30.59	21.63	11.01	4.91
Developed	2.77	1.60	1.40	1.29	1.35	1.48	5.09	11.38	22.85	13.87	6.76	3.88
Percent	*92.16*	*137.68*	*131.30*	*122.31*	*117.19*	*109.64*	*101.51*	*68.24*	*74.68*	*64.14*	*61.37*	*79.11*
Significance	0.569	**0.000***	**0.000***	**0.000***	**0.000***	**0.003***	0.738	**0.002***	**0.006***	**0.000***	**0.000***	**0.002***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**high**			**severe**			**high**			**severe**	
Overall Alteration												**severe**

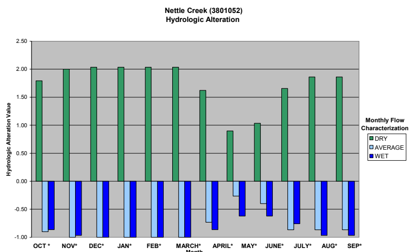
Lower Middle Roaring Fork River **NODE: 3800968**

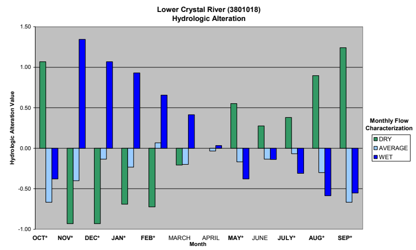
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	390.68	237.60	218.84	202.16	191.84	220.40	413.27	1884.99	3746.60	1728.47	783.29	493.89
Developed	429.09	390.99	341.75	312.05	306.22	314.65	447.97	1036.79	1779.93	1050.30	508.35	434.58
Percent	*109.83*	*164.56*	*156.16*	*154.35*	*159.62*	*142.76*	*108.40*	*55.00*	*47.51*	*60.76*	*64.90*	*87.99*
Significance	0.247	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	0.376	**0.000***	**0.000***	**0.000***	**0.000***	**0.023***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**high**			**severe**			**high**			**severe**	
Overall Alteration												**severe**

Crystal River Sub-Watershed Hydrologic Alteration









A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Crystal River Sub-Watershed

Crystal River above Avalanche Creek near Redstone **Node: 09081600**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	93.12	63.68	48.14	48.29	47.08	59.84	205.68	766.85	1262.97	532.57	177.53	115.36
Developed	93.12	63.68	48.14	48.29	47.08	59.84	205.68	766.85	1262.97	532.57	177.53	115.36
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	1	1	1	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

Nettle Creek **NODE: 3801052**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	1.67	0.50	0.86	0.89	0.82	1.05	1.82	3.92	6.34	5.32	2.86	2.50
Developed	0.33	0.00	0.00	0.00	0.00	0.00	0.12	1.63	3.11	1.59	0.33	0.51
Percent	*20.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*6.48*	*41.49*	*49.07*	*29.97*	*11.36*	*20.54*
Significance	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**severe**			**severe**			**severe**			**severe**	
Overall Alteration												**severe**

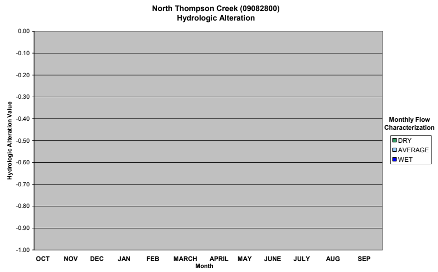
Middle Crystal River **Node: 3800840**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	123.07	70.05	64.13	63.96	61.33	77.87	236.69	835.00	1371.76	626.70	225.12	161.43
Developed	53.36	70.27	63.49	63.42	60.78	76.69	235.92	732.88	1296.04	512.49	119.87	66.05
Percent	*43.36*	*100.31*	*99.00*	*99.15*	*99.10*	*98.49*	*99.68*	*87.77*	*94.48*	*81.77*	*53.25*	*40.91*
Significance	**0.000***	0.983	0.754	0.64	0.643	0.657	0.832	**0.014***	0.112	**0.025***	**0.000***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**moderate**			**none**			**moderate**			**severe**	
Overall Alteration												**high**

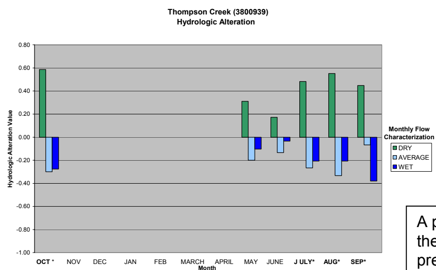
Lower Crystal River **Node 3801018**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	164.8	82.3	85.59	85.33	82.93	105.6	305.7	988.8	1682	746.6	289.3	219.2
Developed	120.1	120.63	105.88	97.98	92.76	111.2	306.5	875.1	1553	621.3	192.6	134.9
Percent	*72.89*	*146.58*	*123.71*	*114.82*	*108.98*	*105.28*	*100.26*	*88.50*	*92.36*	*83.22*	*66.57*	*61.55*
Significance	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	0.075	0.817	**0.022***	0.135	**0.037***	**0.000***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**severe**			**high**			**moderate**			**severe**	
Overall Alteration												**severe**

bold* significant at P< .05



Thompson Creek Sub-Watershed
Hydrologic Alteration



A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Thompson Creek Sub-Watershed

North Thompson Creek **Node: 09082800**

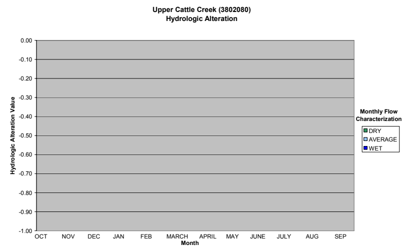
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	2.42	2.08	1.85	1.78	1.66	3.33	22.36	102.78	69.32	7.53	2.99	1.87
Developed	2.42	2.08	1.85	1.78	1.66	3.33	22.36	102.78	69.32	7.53	2.99	1.87
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	1	1	1	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

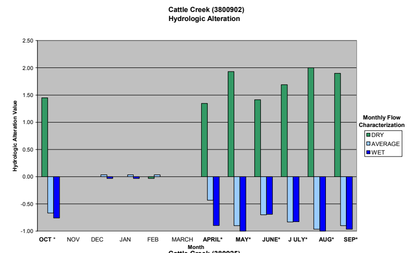
Thompson Creek **NODE: 3800939**

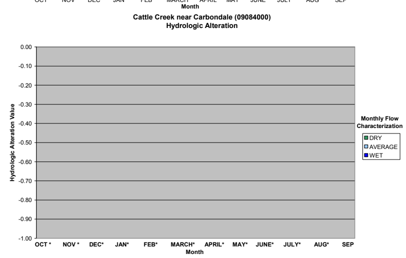
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	23.58	8.09	12.39	12.89	11.83	16.55	44.51	146.88	150.48	72.56	39.17	33.15
Developed	19.09	8.09	12.39	12.89	11.83	16.55	44.51	136.31	138.51	61.95	31.97	27.45
Percent	*80.93*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*92.81*	*92.05*	*85.37*	*81.63*	*82.81*
Significance	**0.001***	1	1	1	1	1	1	0.368	0.341	**0.028***	**0.002***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**moderate**			**none**			**none**			**severe**	
Overall Alteration												**moderate**

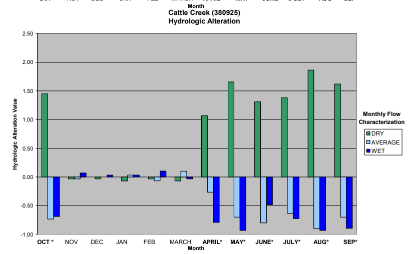
bold* significant at P< .05

Cattle Creek Sub-Watershed
Hydrologic Alteration









A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models
Cattle Creek Sub-Watershed

Upper Cattle Creek **Node: 3802080**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	4.63	4.56	3.60	3.64	3.59	4.08	19.35	66.76	62.14	11.75	5.20	4.49
Developed	4.63	4.56	3.60	3.64	3.59	4.08	19.35	66.76	62.14	11.75	5.20	4.49
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	1	1	1	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

Cattle Creek near Carbondale **NODE: 09084000**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	4.63	4.56	3.60	3.64	3.59	4.08	19.35	66.76	62.14	11.75	5.20	4.49
Developed	4.63	4.56	3.60	3.64	3.59	4.08	19.35	66.76	62.14	11.75	5.20	4.49
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

Middle Cattle Creek **Node: 3800902**

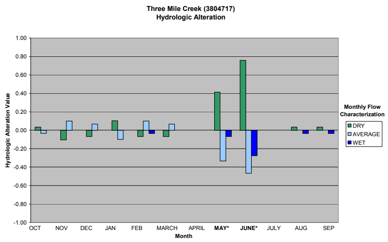
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	7.29	5.50	4.85	4.98	4.78	5.47	21.80	73.25	73.26	19.09	9.11	7.94
Developed	3.80	5.50	4.85	4.98	4.78	5.47	7.71	16.94	15.18	6.89	5.87	3.31
Percent	*52.12*	*100.15*	*100.00*	*100.00*	*100.00*	*100.00*	*35.35*	*23.12*	*20.72*	*36.09*	*64.46*	*41.69*
Significance	**0.000***	0.901	0.979	1	1	1	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**moderate**			**none**			**severe**			**severe**	
Overall Alteration												**high**

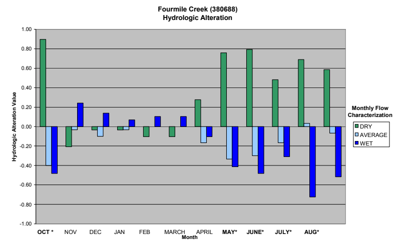
Middle Cattle Creek **Node 3800925**

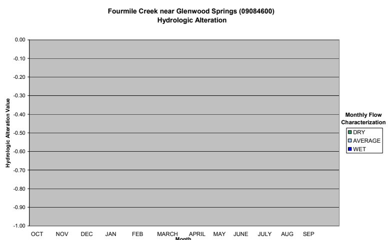
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	21.05	10.09	11.86	12.31	11.53	14.48	37.38	106.23	126.93	63.22	33.8	29.1
Developed	7.85	10.3	12.03	12.42	11.68	14.32	21.51	31.88	49.22	35.18	14.8	12.38
Percent	*37.31*	*102.08*	*101.44*	*100.93*	*101.25*	*98.93*	*57.55*	*30.01*	*38.78*	*55.65*	*43.79*	*42.54*
Significance	**0.000***	0.655	0.67	0.696	0.706	0.854	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**moderate**			**none**			**severe**			**severe**	
Overall Alteration												**high**

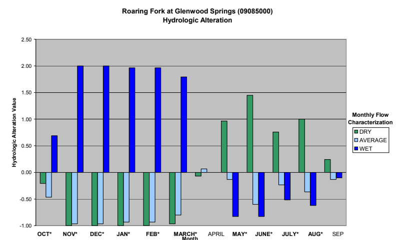
bold* significant at P< .05

Lower Roaring Fork
River Sub-Watershed
Hydrologic Alteration









A positive hydrologic alteration value indicates that from 1910-1996 the number of months in each flow category has increased from pre-developed to developed conditions, while a negative hydrologic alteration value indicates a decrease in the number of months.
* Significant P-value< .05

Comparison of pre-developed and developed flows derived from Colorado River Decision Support System Stream Simulation Models

Lower Roaring Fork River Sub-Watershed

Upper Three Mile Creek **Node: 3804717**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	0.96	0.28	0.49	0.50	0.47	0.60	1.03	2.24	3.62	3.04	1.63	1.43
Developed	0.96	0.28	0.49	0.50	0.47	0.60	1.03	1.69	2.40	3.03	1.63	1.43
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*75.64*	*66.36*	*99.73*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	**0.031***	**0.000***	0.941	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**high**			**none**	
Overall Alteration												**moderate**

Four Mile Creek near Glenwood Springs **NODE: 09084600**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	0.72	0.75	0.64	0.60	0.61	1.00	12.05	61.47	23.13	1.98	0.99	0.54
Developed	0.72	0.75	0.64	0.60	0.61	1.00	12.05	61.47	23.13	1.98	0.99	0.54
Percent	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Significance	1	1	1	1	1	1	1	1	1	1	1	1
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**none**			**none**			**none**			**none**	
Overall Alteration												**none**

Four Mile Creek **Node: 3800688**

Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	7.58	2.84	4.015	4.14	3.9	5.43	19.62	77.85	49.8	23.15	12.41	10.65
Developed	5.34	3.06	4.155	4.23	3.98	5.47	17.14	56.23	31.96	19.91	9.77	8.53
Percent	*70.49*	*107.69*	*103.44*	*102.16*	*102.08*	*100.75*	*87.37*	*72.23*	*64.17*	*86.02*	*78.77*	*80.19*
Significance	**0.000***	0.443	0.573	0.552	0.54	0.73	0.076	**0.000***	**0.000***	**0.022***	**0.000***	**0.000***
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**moderate**			**none**			**high**			**severe**	
Overall Alteration												**high**

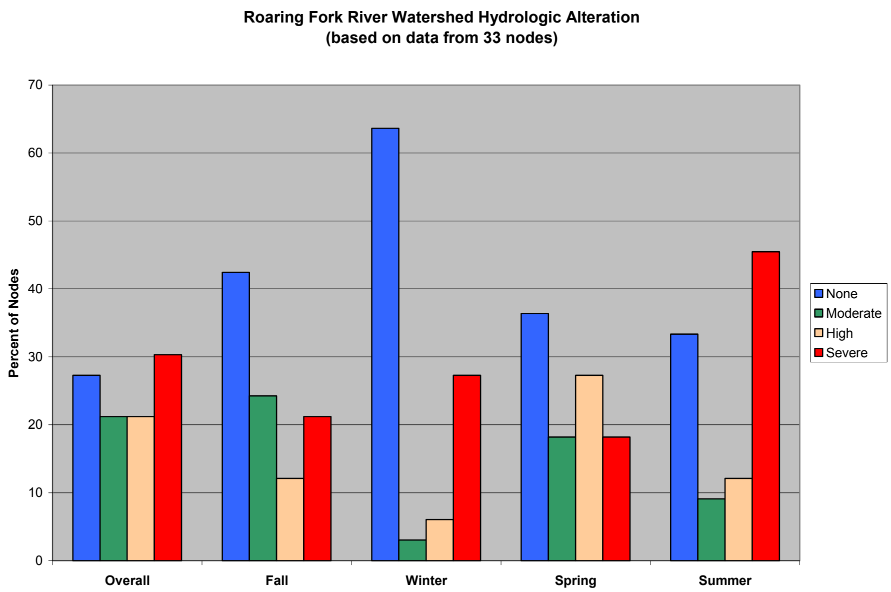
Roaring Fork at Glenwood Springs **Node 09085000**

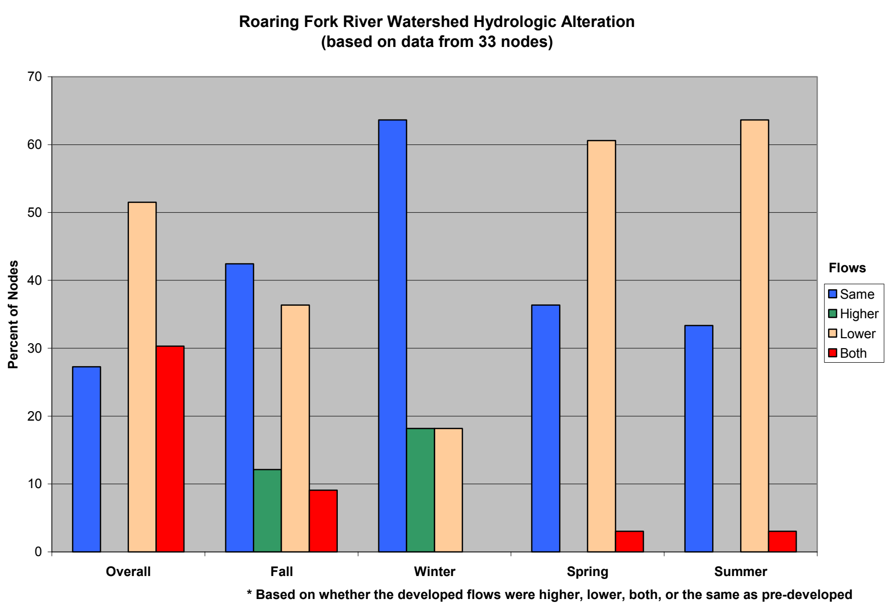
Medians	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**
Pre-developed	613.90	346.44	328.49	317.76	306.66	366.17	805.63	3099.97	5884.65	2635.99	1150.24	796.09
Developed	721.08	641.13	538.13	482.06	461.20	490.08	838.53	2042.66	3807.09	1884.14	836.63	730.90
Percent	*117.46*	*185.06*	*163.82*	*151.71*	*150.40*	*133.84*	*104.08*	*65.89*	*64.70*	*71.48*	*72.74*	*91.81*
Significance	**0.009***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	0.668	**0.000***	**0.000***	**0.000***	**0.000***	0.178
		FALL			**WINTER**			**SPRING**			**SUMMER**	
Alteration		**severe**			**severe**			**high**			**high**	
Overall Alteration												**severe**

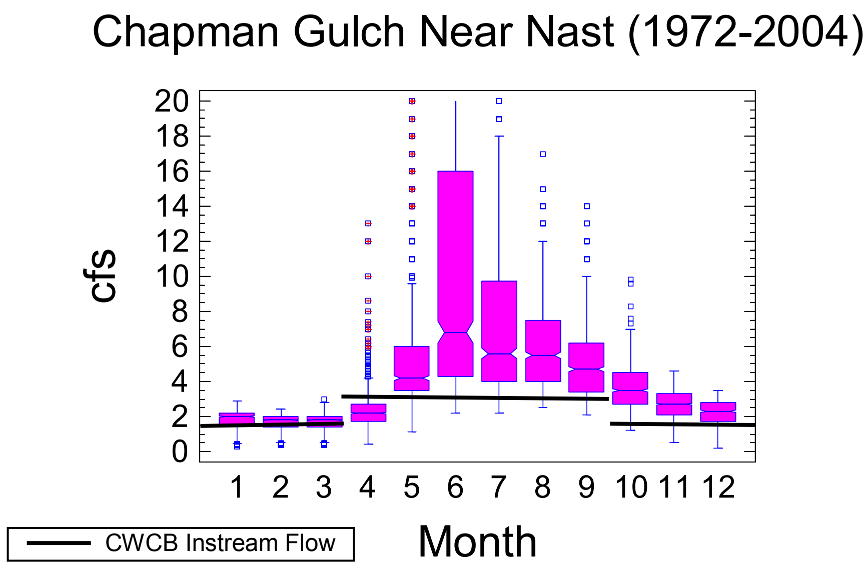
bold* significant at P< .05

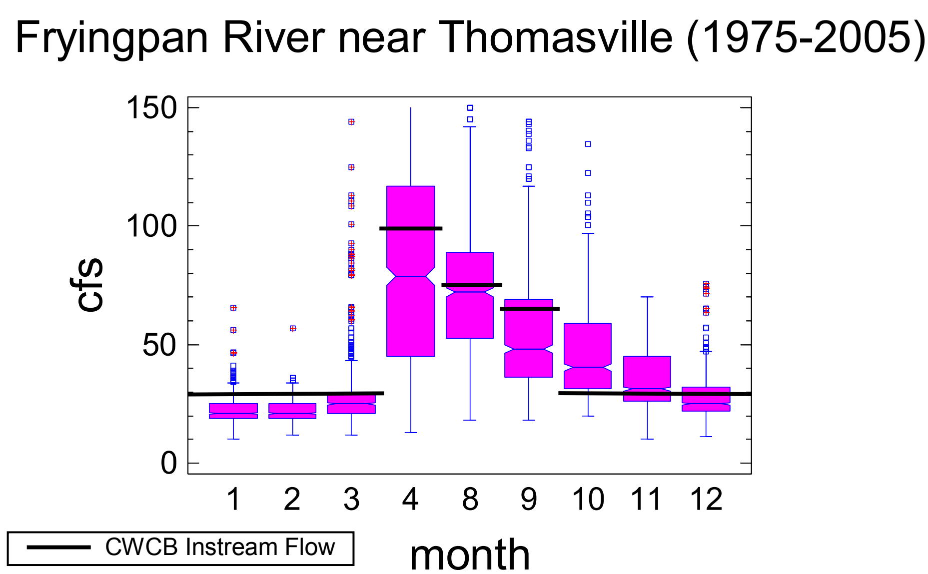
Appendix L: Histograms of Hydrologic Alteration Results

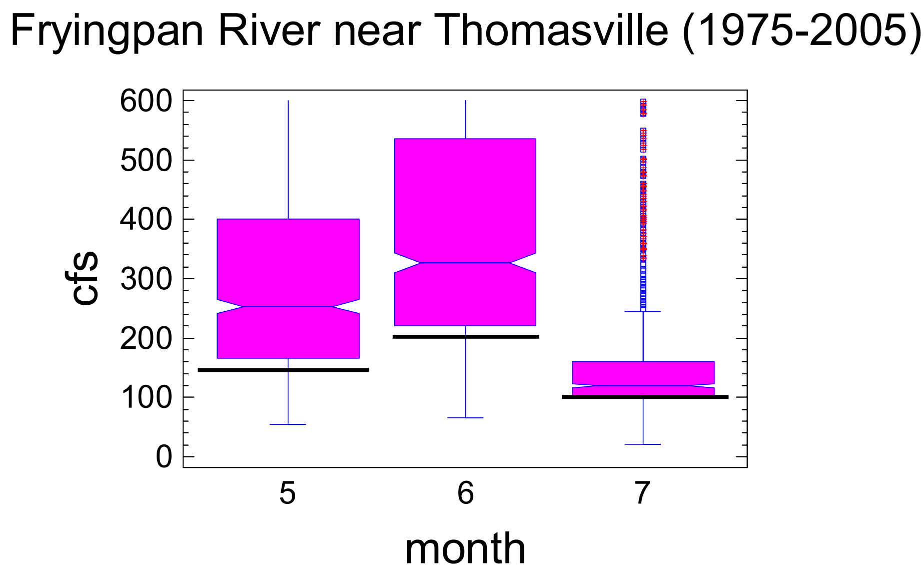
Percent of modeled nodes in each class and percent that had higher, lower, both, or the same flows comparing developed flows to pre-developed flows

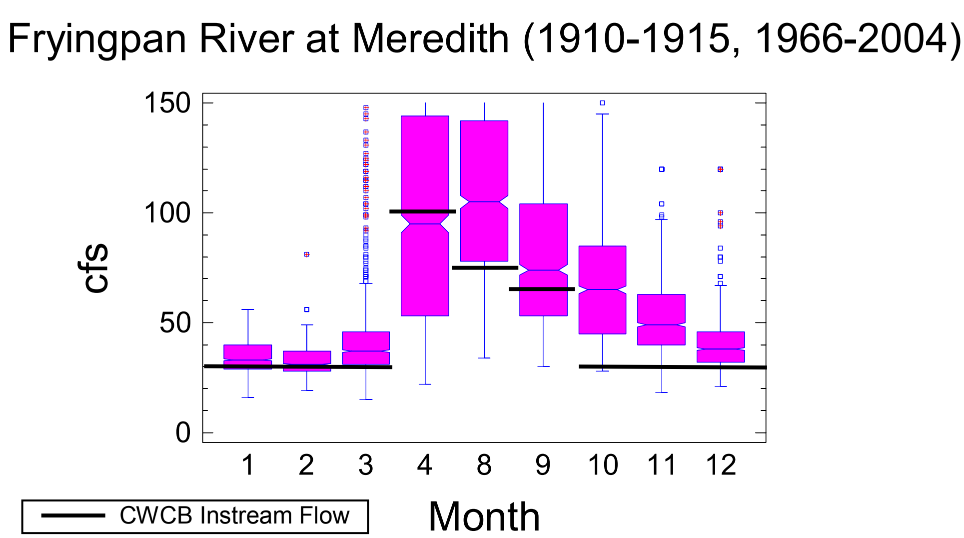




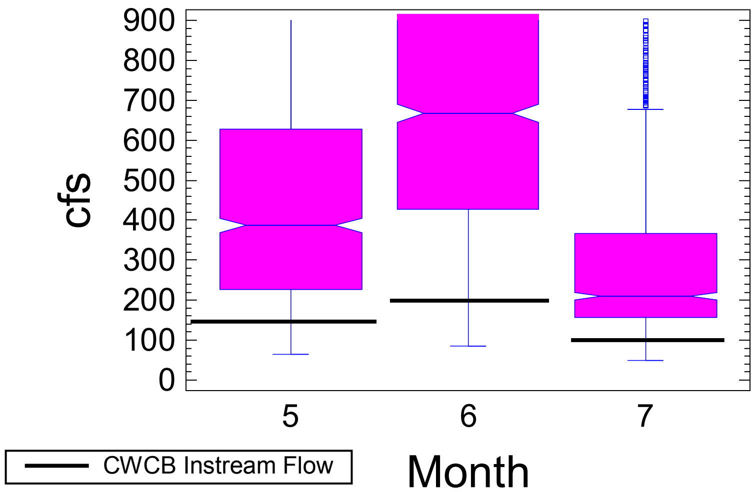

Chapman Gulch Near Nast (1972-2004)
cfs
Month
CWCB Instream Flow


Fryingpan River near Thomasville (1975-2005)
cfs
month
CWCB Instream Flow

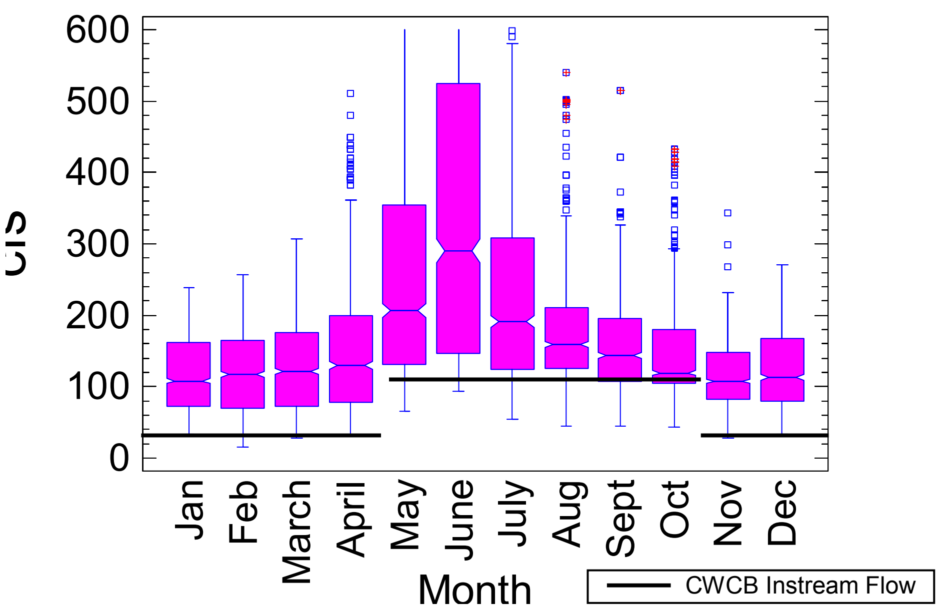

Fryingpan River near Thomasville (1975-2005)
600
500
400
300
200
100
0
cfs
5
6
7
month

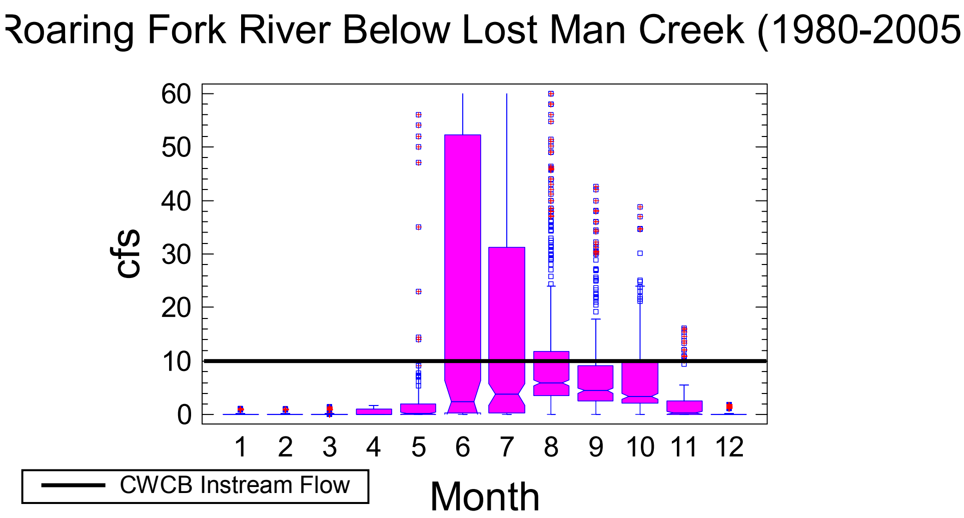

Fryingpan River at Meredith (1910-1915, 1966-2004)
150
100
50
0
cfs
1
2
3
4
8
9
10
11
12
CWCB Instream Flow
Month

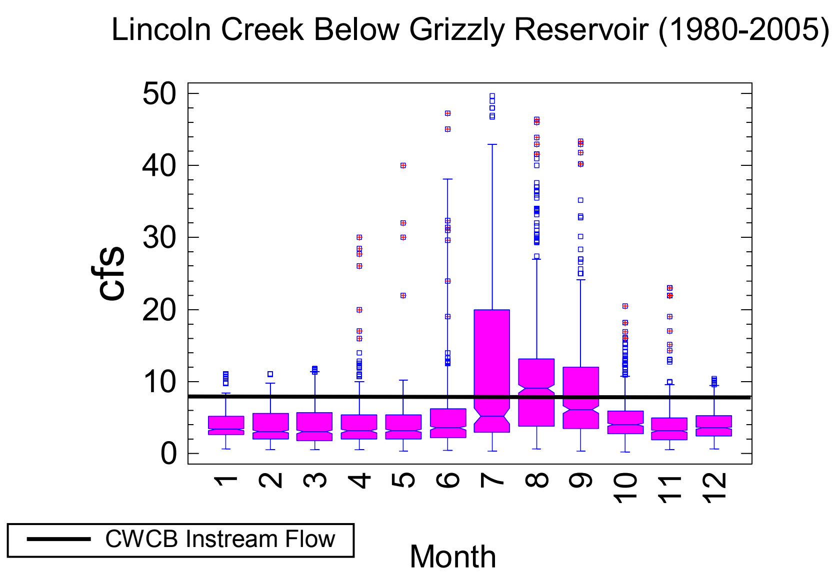
Fryingpan at Meredith (1910-1915, 1966-2004)



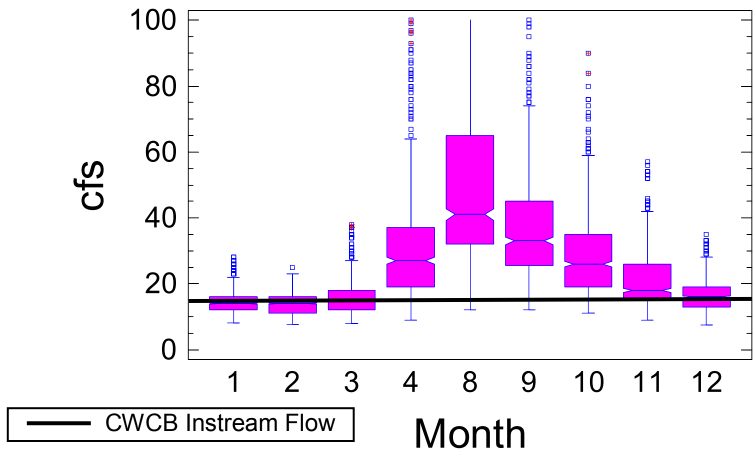
Fryingpan River Near Ruedi (1964-2005)



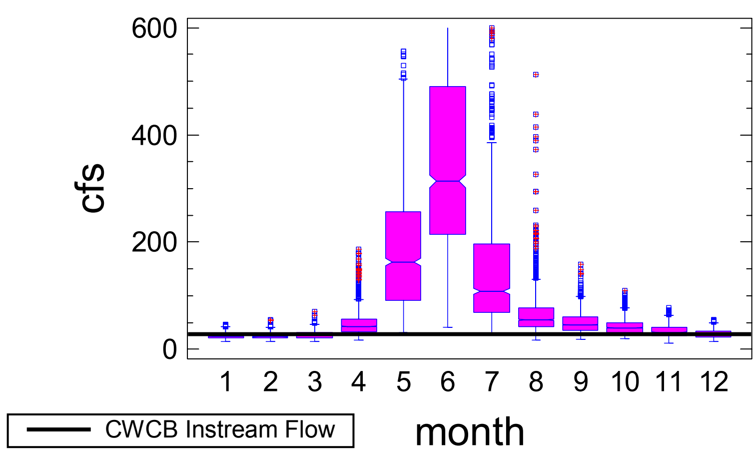

Roaring Fork River Below Lost Man Creek (1980-2005
cfs
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12
CWCB Instream Flow
Month


Lincoln Creek Below Grizzly Reservoir (1980-2005)
cfs
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12
CWCB Instream Flow
Month

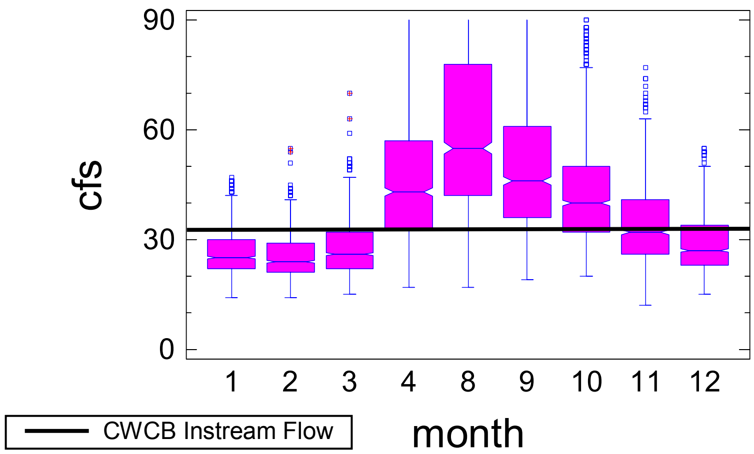
Roaring Fork River above Difficult Creek (1979-2005)



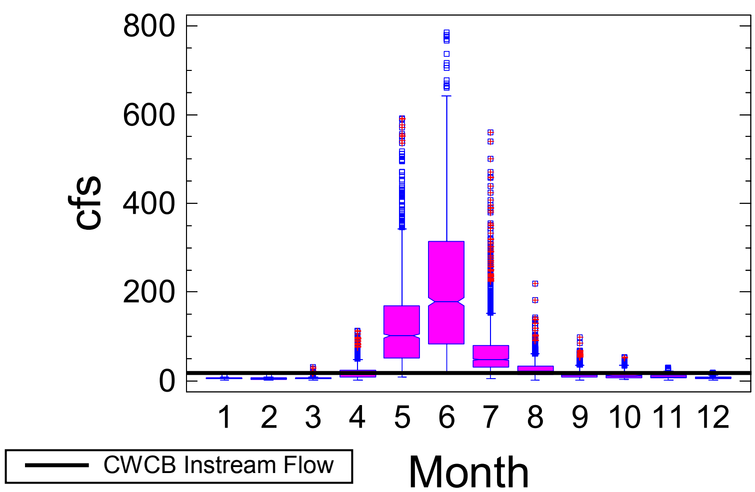
Roaring Fork River near Aspen (1964-2005)



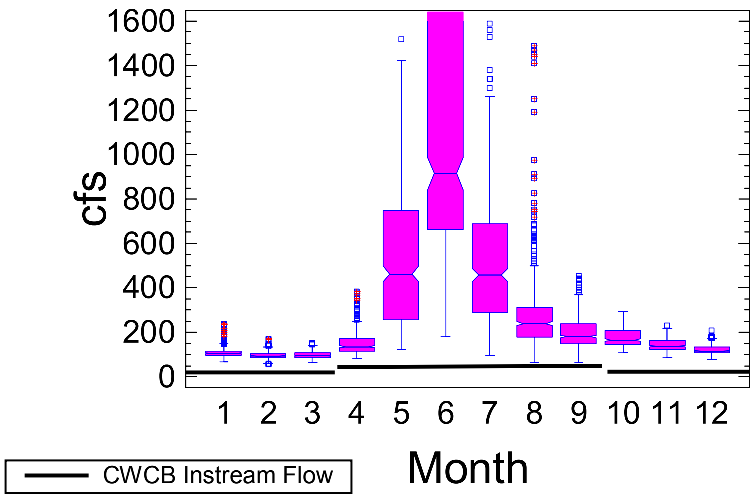
Roaring Fork River near Aspen (1964-2005)



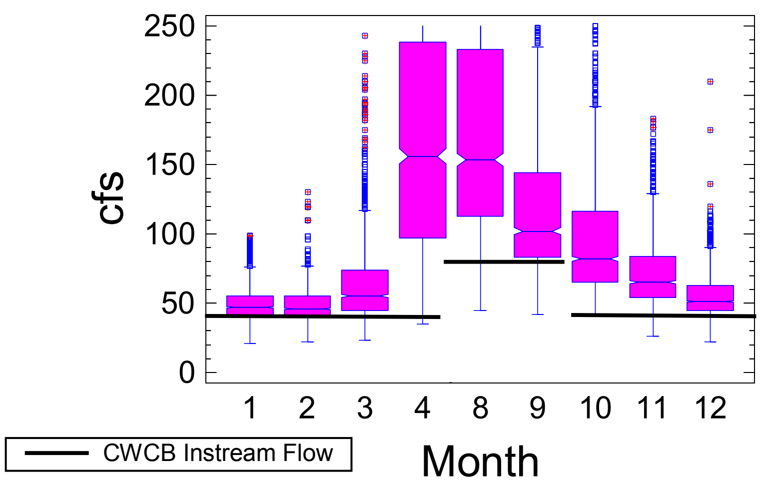
Hunter Creek near Aspen (1950-2005)



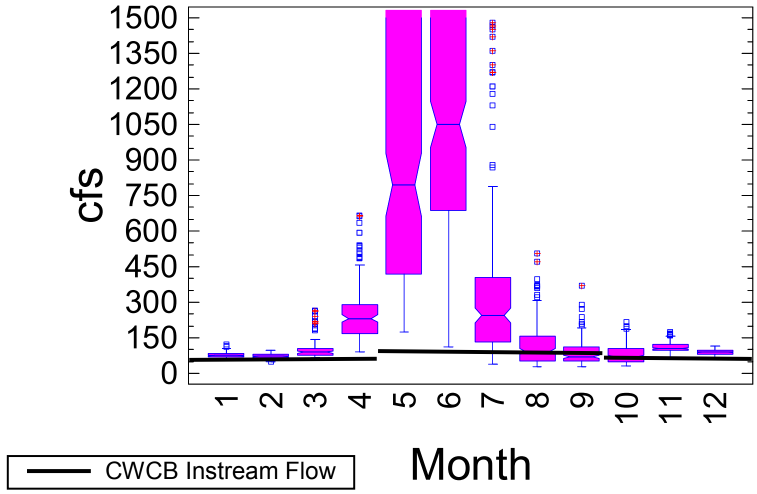
Roaring Fork below Maroon Creek



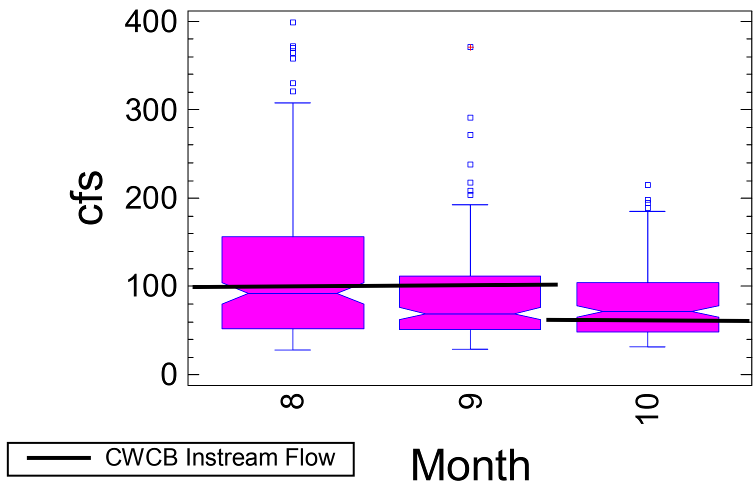
Crystal River above Avalanche Creek (1955-2005



Crystal River Below Carbondale, C0 (2000-2005)



Crystal River Below Carbondale, C0 (2000-2005)



Appendix N: Excerpt from Fryingpan-Arkansas Project Operating Principles referencing the Twin Lakes Exchange (March 15, 1961)

The construction and operation of the project involve the diversion of water from the headwaters of the Fryingpan River and other tributaries of the Roaring Fork River to the Arkansas River Basin. The project contemplates—

(a) The maximum conservation and use of water;

(b) The protection of western Colorado water uses, both existing and potential, in accordance with the declared policy of the State of Colorado; and

(c) The preservation of recreational values.

In order to accomplish such purposes, the project shall be operated by the United States in compliance with the Federal reclamation laws, the laws of the State of Colorado relating to the appropriation, use, or distribution of water, and the following operating principles:

...

11. An appropriate written contract may be made whereby Twin Lakes Reservoir and Canal Company shall refrain from diverting water whenever the natural flow of the Roaring Fork River and its tributaries shall be only sufficient to maintain a flow equal to or less than that required to maintain the recommended average flows in the Roaring Fork River immediately above its confluence with Difficult Creek in a quantity proportionate to the respective natural flow of the Roaring Fork River. The recommended average flows above mentioned are flows in quantities equal to those recommended as a minimum immediately above its confluence with Difficult Creek according to the following schedule submitted by the United States Fish and Wildlife Service and the Colorado Game and Fish Commission:

Month	Average Second-feet	Acre-feet (thousands)	Month	Average Second-feet	Acre-feet (thousands)
October	44	2.7	May	100	6.2
November	35	2.1	June	120	7.1
December	29	1.8	July	100	6.2
February	25	1.4	September	44	2.6
March	24	1.5			
April	64	3.8			

Total acre feet: 40.9

In maintaining the above averages, at no time shall the flow be reduced below 15 cfs during the months of August to April, inclusive, or below 60 cfs during the months of May to July, inclusive, providing the natural flow during said period is not less than these amounts. The obligation to supply the minimum streamflow as set forth in the above table on the Roaring Fork River shall, to the extent of 3,000 acre-feet annually, be a project obligation to be supplied from any waters diverted from the south tributaries of Hunter Creek, Lime Creek, Last Chance Creek, or any of them.

The Twin Lakes Reservoir and Canal Company shall not be required to refrain from diverting water under its existing decrees from the Roaring Fork River except to the extent that a like quantity of replacement water is furnished to said company without charge therefore through and by means of project diversions and storage.

If by reason of storage capacity in the Ruedi Reservoir, or any reservoir constructed in addition thereto, the Twin Lakes Reservoir and Canal Company derives additional water or other benefits or advantages it would not have realized had this project not been constructed, then nothing herein contained shall prevent the project from making appropriate charges for such water or other benefits or advantages. All revenues derived from the use of water stored in Ashcroft Reservoir shall be used to assist in the repayment of the construction, operation, and maintenance costs of that reservoir, or any reservoir constructed in lieu thereof, as may be determined by the Secretary of the Interior.

Appendix O: Roaring Fork and Crystal Rivers Strategic Plan

Organization of overall project

Colorado Water Trust (lead)
Roaring Fork Conservancy
The Nature Conservancy (Colorado Headwaters Project)
Colorado Water Conservation Board

Mission Statement

The Upper Roaring Fork River and the Crystal River contain important biodiversity (fish and wildlife resources), some of which are globally rare or endangered. Historic water management practices in these reaches have adversely impacted fish and wildlife populations and the riparian habitats that they need to survive and reproduce. Creative, voluntary approaches to rebalance water use will be used such that stream flows will be able to sustain important fish and wildlife resources. The approaches include market-based transactions and water rights management strategies that will establish ecologically sustainable flow levels and restore degraded riparian habitat where needed. The Partnership will work with willing landowners and water rights holders in the Upper Roaring Fork and Crystal Rivers as well as local, state, and federal agencies to accomplish its goals.

Immediate goals

1. Develop public awareness of streamflow issues.
2. Complete ditch study of Town of Carbondale.
3. Obtain donation of one water right for Roaring Fork River instream flows from a local government.
4. Hold initial meeting(s) with private water rights interests on Roaring Fork River.
5. Obtain donation of one water right for Crystal River instream flow support from one local government.
6. Begin private, confidential fundraising to purchase additional water rights (do not want to dampen donations, heat up market).
7. Draft legal brief on transfer of water rights lost to stream as a result of Trans-mountain diversions.

Near-term goals

1. Elevate public awareness of streamflow issues.
2. Reconnaissance-level investigation of piped irrigation system for Town of Carbondale.
3. Obtain donation of additional water rights for Crystal River instream flow from another local government.
4. Hold initial meeting(s) with private water rights interests on Crystal River.
5. Obtain additional donations of water rights for Roaring Fork instream flows from local governments.
6. Obtain additional water rights for Roaring Fork instream flows from private parties through donation and/or purchase.
7. Draft legal brief on right of diversion as one of the bundle of sticks that comprise a water right.

Mid-term goals

1. Secure public support for streamflow issues.
2. Obtain additional water rights for Roaring Fork instream flows from private parties through donation and/or purchase.
3. Obtain additional water rights for Crystal instream flows from private parties through donation and/or purchase.
4. Define instream flow and habitat needs for Roaring Fork River.
5. Define instream flow and habitat needs for Crystal River.
6. Exchange Roaring Fork water rights up the Crystal River.
7. Donate initial package of instream flow rights/interests for basin to CWCB ISF Program.
8. Begin adjudication of initial donation to CWCB.

Long-term goals

1. Maintain public support for streamflow issues.
2. Complete adjudication of initial donation to CWCB ISF Program.
3. Meet flow goals for Roaring Fork River with permanent acquisitions.
4. Meet flow goals for Crystal River with permanent acquisitions.
5. Donate second package of instream flow rights/interests for basin to CWCB.
6. Adjudicate second package of donations to CWCB.

Appendix P: National Hydrography Data (NHD) Application

How local, state and federal organizations store and utilize their linear referenced data varies not only between the organizations themselves but also between the departments within the organizations. Because of this variance, there is a need for flexible tools to create, display, query, analyze, and distribute linear referenced data. NHD data and tools (http://nhd.usgs.gov/) can provide the foundation for the Project. A tool developed by the Forest Service translates linear data to events. The source data for NHDinGeo (geodatabase version of NHD) is the 1:24,000-scale USGS topographic maps. The blue lines on these maps are scanned to produce Digital Line Graph (DLG) hydrography. At this point the data are not suitable for linear referencing and hydrologic navigation (determining upstream and downstream linkages) because they contain waterbodies and wide streams are portrayed with a right and left bank (double-banked). These two types of features make it very difficult to determine connectivity. The NHDinGeo undergoes a process called centerlining to make a direct connection through waterbodies and double-banked streams.

The NHD provides a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. Within the NHD, surface water features are combined to form “reaches,” which provide the framework for linking water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data and any associated information about them in upstream and downstream order. These data are developed nationally with the intention of identifying a local steward to verify and update the hydrology. We are working with the River District and USGS to accomplish this and eagerly anticipated the completion of the NHD editing tool (November, 2005). To aid this process, we obtained stream layers from the four counties (Garfield, Gunnison, Eagle, and Pitkin counties) in our watershed as well as USFS data. These will be compared to the NHD layer to identify and correct potential errors or omissions. All of Pitkin County and parts of Eagle County’s stream layers were developed using aerial photography which may represent different positions of the channel especially in meandering and braided systems. The other counties were developed using 1:24,000 USGS DLG hydrography data, which is the basis for the NHD. The USFS hydrology network contains all “blue line” streams from topographic maps and channels determined from following contour crenulations, most likely ephemeral channels. Our editing objective is to ensure that all perennial streams, trans-mountain diversions, reservoirs and major ditches are represented, connected, and flow direction is correct. We will retain intermittent channels that are represented in NHD and will not add ephemeral channels or move the channel to reflect the aerial photographs. Though this process we can correct obvious errors and flag areas of concern. Initially, CDWR, counties, and USFS will be contacted to determine what is correct in these areas. A few cases may require a site visit to determine what is happening. This may be the case in trying to determine if a ditch flows over a stream or is connected to a stream. All edits will be made to the NHDinGeo personal geodatabase and returned to the USGS to redo the hydrologic connectivity and incorporate into the national database. A workshop was held in November, 2005 with USGS to outline this process and make sure that the changes can be made in a timely manner.