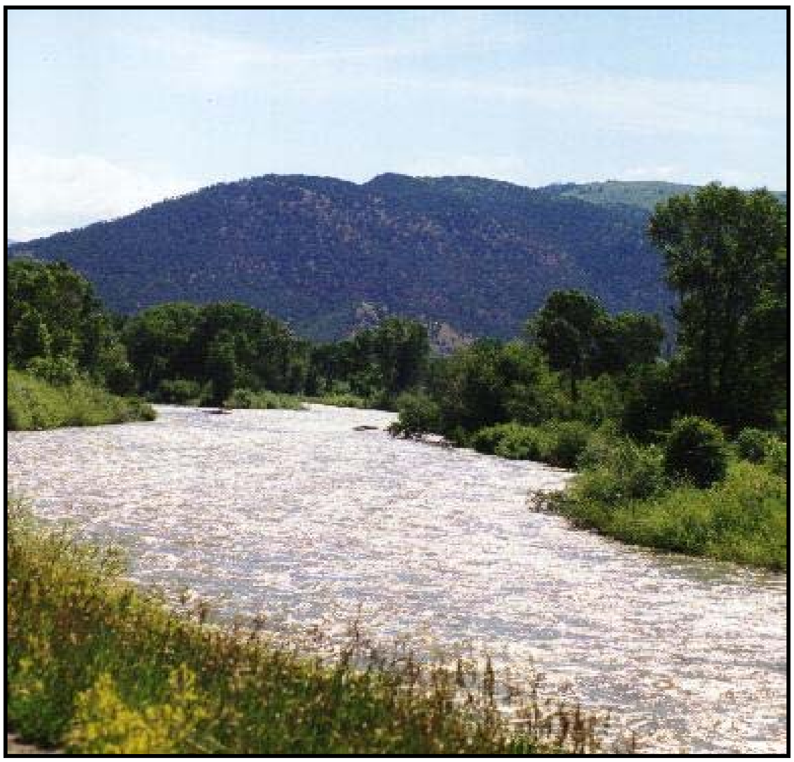
Roaring Fork Watershed
Year 2000
State of the River Report



Issued By:

Roaring Fork Conservancy

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Mission Statement:

To protect and enhance the habitat of the Roaring Fork watershed, rivers, and tributaries; to promote awareness of the importance of the watershed and to ensure the quality of our Valley for the benefit of all its inhabitants.

State of the River Report:

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1. Learning About Our Rivers

The State of the River Report is a comprehensive presentation of water quality data collected by the Roaring Fork Conservancy's water quality monitoring program for the year 2000. The data is displayed in both temporal and spatial formats, and is available to local governments, land management agencies, interested community members, and other groups. The information can be used for decision-making processes related to our rivers' water quality as well as to increase knowledge and awareness about the relationship between water quality and the health of our rivers. Water quality data is illustrated within this report relative to State-adopted stream standards and biological thresholds. Comparisons of data with State standards can help determine a desired level of overall stream health. Finally, the baseline of water quality information provided here represents an effective tool for observing trends over time and space.

2. How to Use this Report

The heart of this report can be found in Section 10, which contains water quality data by parameter, sampling location, and sampling month for the year 2000. The sections that lead to the specific data descriptions provide historic information about the watershed, availability of historic data, description of water quality sampling sites, and the methodology that the Roaring Fork Conservancy (Conservancy) has implemented within its water quality monitoring program. Finally, through interpretation of the baseline data, findings and conclusions are presented about the water quality of the Roaring Fork River.

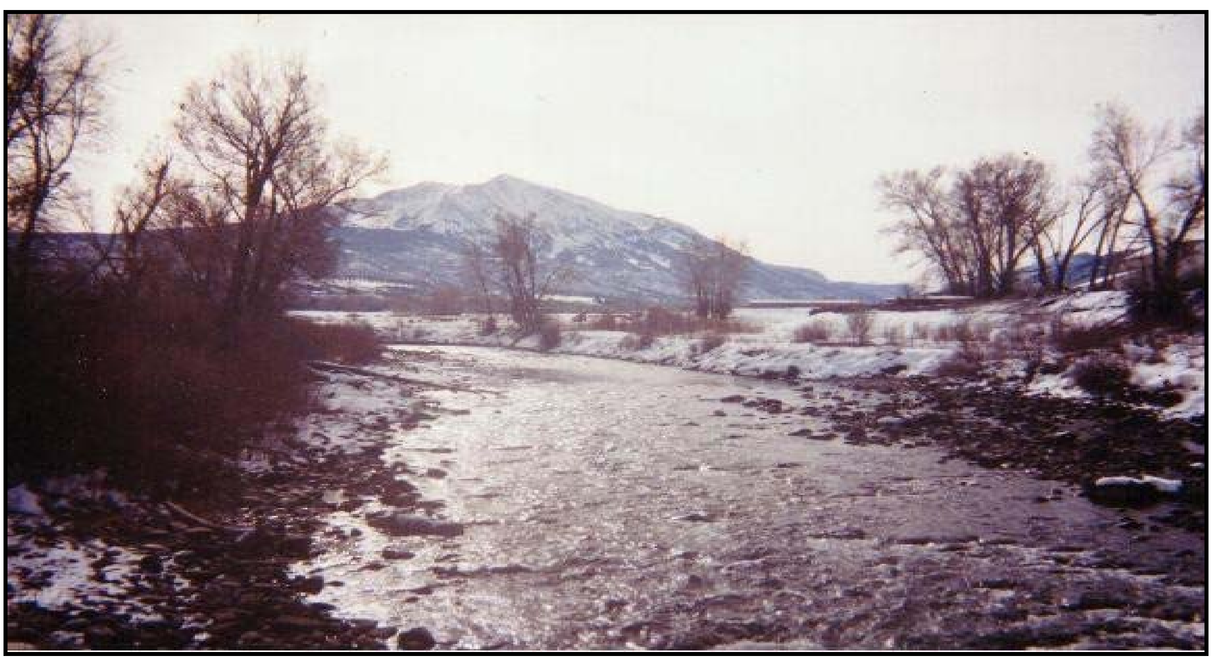
With this report, both in its written form and through public presentations of its results, the Conservancy is providing the raw data and the baseline information for future comparisons of data. Initial interpretation regarding trends and ecosystem health begins with this data set. Others are strongly encouraged to review and use this data, whether it is for site-specific analysis, for more general research, to inform public debate on water quality issues, for educational purposes, or for other reasons. The Conservancy plans to present this report at various public meetings throughout the watershed in an effort to inform a broader constituency about the Valley's water quality status and issues.

3. The Roaring Fork Watershed

The Roaring Fork watershed, shown in Figure 1, is the network of streams and rivers, including the areas they drain that ultimately feed into the Roaring Fork River. The Roaring Fork River's mainstem flows for approximately 70 river miles, starting at an elevation of over 12,000 feet at its headwaters near Independence Pass and the Continental Divide. The river drops over 6,000 feet to its confluence with the Colorado River at Glenwood Springs and during this journey transforms from a tumbling, fast-flowing mountain stream to a wider, meandering river. The Ute Indians, who seasonally occupied the Roaring Fork Valley before white settlement, fully understood the wild, raging qualities of the Roaring Fork, calling it “Thunder River.” In terms of flow, the Roaring Fork River is the second largest tributary of the Colorado River in the state, and its watershed encompasses a total of 1,460 square miles. The major tributaries of the Roaring Fork River are the Fryingpan and Crystal Rivers. All of the Valley’s major communities, including Aspen, Basalt, Carbondale, and Glenwood Springs, are located along the Roaring Fork or its main tributaries (Figure 1).

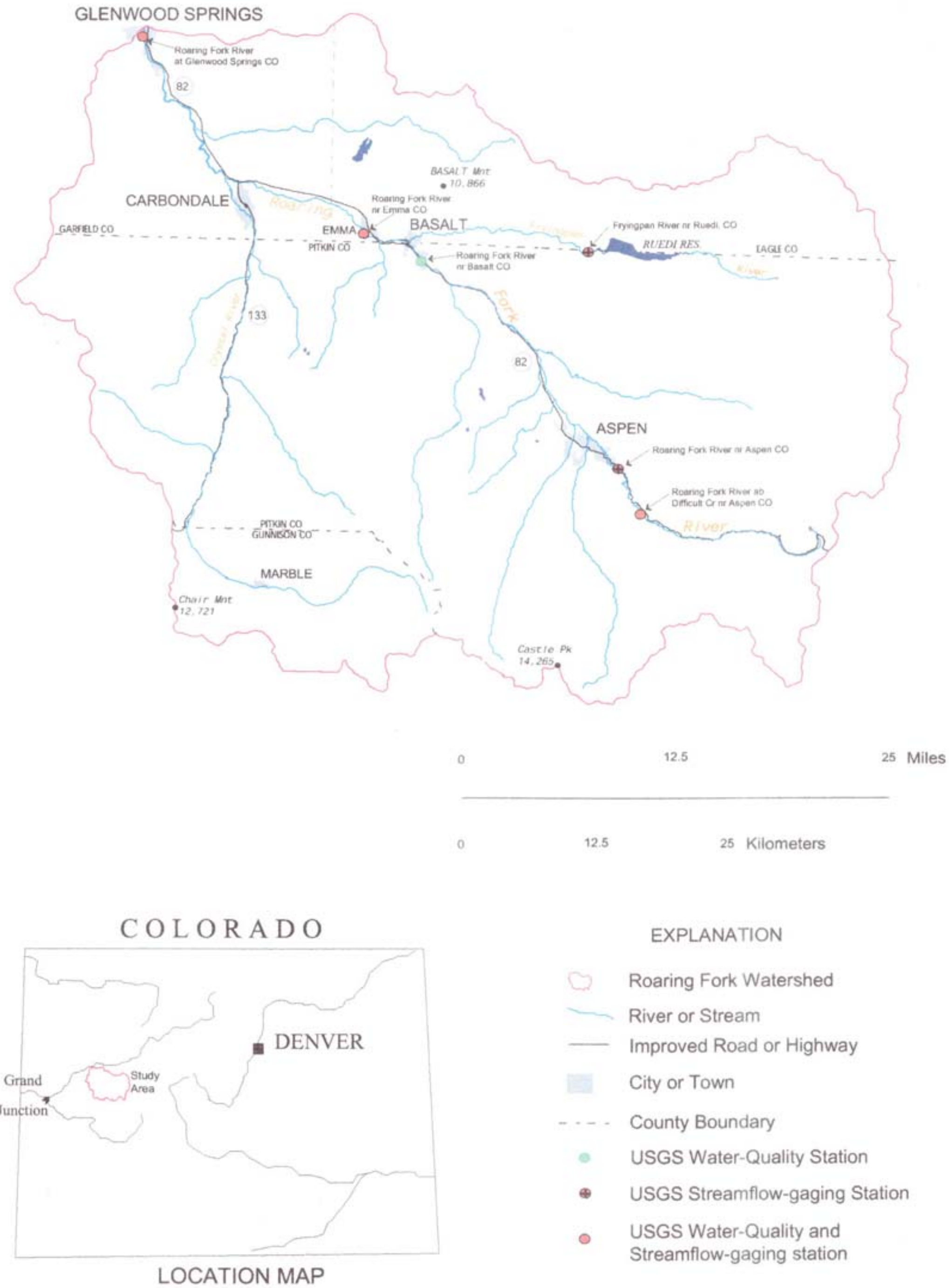
The Valley itself has witnessed a diversity of human settlement trends and associated land uses. These include habitation of the area by Ute Indians, an intense but short-lived gold and silver mining rush, agricultural activities, and the advent of what has become a major tourist industry: ski area development. The current trend in the Valley is that of increased population growth, given the area’s combination of outdoor recreational opportunities, rural lifestyle, and availability of urban and related cultural amenities.

Annual mean snowfall in the watershed is 65 to 70 inches and annual mean rainfall is 11 inches. Lava beds, the Maroon Formation, the Eagle Valley Gypsum Formation, Mancos Shale, and Mesa-Verde Sandstone occur along the lower valley. Above Aspen, granite, gneiss and schist rock formations are dominant. Plant communities along the river include canopy species of ponderosa pine, narrow leaf cottonwood, box elder, and juniper; and under story species of water birch, Gamble’s oak, wild rose, coyote willow, and scouler willow. Fish species found in the watershed include brook, brown, rainbow and Colorado River cutthroat trout, and mountain whitefish. Caddisflies, stoneflies, mayflies and midges represent common macroinvertebrates (aquatic insects) found along the Valley’s rivers (Colorado Natural Heritage Program, 1997).



The Crystal River at Carbondale, Colorado

Figure 1. Roaring Fork Watershed.



The Fryingpan River at Meredith, Colorado

4. A Taste of the Basin's Water Quality

Water quality and quantity in the watershed influence water uses, recreational pursuits (including: angling, kayaking, and rafting), and wildlife habitat dependent on flowing streams within the Valley's river corridors. As land uses have changed, so have water quality issues – with a historic focus on heavy metals from mining entering streams, and runoff from agricultural practices. Presently, attention has shifted to the influence of development pressures on our streams and rivers, through wastewater treatment discharges, storm water runoff, and increased erosion and sediment-loading.

The mainstem of the Roaring Fork River, as well as all tributaries from the source to the confluence with the Colorado River are categorized as Roaring Fork Basin, segments 1 through 10, by the State of Colorado. The State Water Quality Control Commission (WQCC) has classified the Roaring Fork River as follows: Aquatic Life Coldwater – Class 1, Recreation – Class 1, water supply, and agriculture. Section 8 provides more detailed discussion of the significance of these classifications (CDPHE, 1999).

The water quality in the Upper Colorado River Basin, which includes the Roaring Fork watershed, has been reported as some of the best in the State (CDPHE, 1998). Stretches of the Roaring Fork River and Fryingpan River are classified as "Gold Medal" waters by the Colorado Division of Wildlife (CDOW), signifying the excellent quality of the rivers' fisheries. Part of the Upper Roaring Fork River is designated “Wild Trout” water, which means this part of the river contains a self-sustaining trout population. This is one of the few such populations remaining in Colorado. However, the river system is facing strong land development pressures, the effects of which include construction and use of transportation corridors and bridges, filling of the river channel and floodplain, degradation and removal of natural vegetation, increased recreational use (rafting and angling), facility development (golf courses), and increased residential and commercial uses along the river.

As an example of the impacts of development on water quality, water quality standards were lowered for ammonia discharges on Landis Creek in Spring Valley, southeast of Glenwood Springs. Significant development was proposed and subsequently approved, but the flow in Landis Creek is small and applicable ammonia standards for the wastewater discharge were very difficult to meet under the previous standard. The State classification was changed from Cold Water Aquatic Life Class 1 to Class 2, with an associated change in un-ionized ammonia standard from 0.02 milligrams per liter (mg/L) to 0.1 mg/L. While this standard change would not be appropriate for the Roaring Fork and key tributaries where there is an established cold-water fishery, this issue demonstrates that development will affect high quality stream standards.

In addition, there is a question about the impacts to water quality of non-point source pollution introduced into the Roaring Fork River and its tributaries mainly through storm water runoff. Such pollutants may include suspended sediments, bacteria, nitrogen compounds (ammonia, nitrates, nitrites), magnesium chloride and other deicers, phosphorus, and dissolved metals. Other potential threats to the quality of the water in the watershed may come from individualized septic systems and the dewatering of streams from snowmaking practices by ski areas.

5. An Inventory of Water Quality Information

In September 1999, the Conservancy produced a Water Quality Inventory Report, which documented both ongoing and historic water quality monitoring activities in the watershed. The inventory, by charting gaps in sampling efforts and water quality information, was the first step in the design of a comprehensive, coordinated monitoring program.

The Conservancy initially sought out the monitoring groups that had water supply and/or discharge points on the Roaring Fork River. Water and sanitation plants were researched because they have legal responsibilities to monitor water quality. Additional groups and agencies were contacted for information about parameters sampled, sample frequency and site locations, type of analysis used, and flow gage information. The inventory covers the following sampling groups:

- Roaring Fork Conservancy test sites
- Wastewater treatment facilities
- Colorado Division of Wildlife (CDOW) River Watch sites (area schools)
- Colorado Department of Public Health and Environment (CDPHE) synoptic sampling and other historic studies
- United States Geologic Survey (USGS) stream gages
- Testing by golf course facilities

- Testing by municipalities, and
- Monitoring of high mountain lakes.

The Inventory Report found a number of opportunities to build upon the water quality monitoring efforts that existed as of 1999 in the Roaring Fork Valley. The fact that so many different entities were testing water quality highlighted the excellent chance of building a strong community initiative for a more comprehensive and consistent monitoring program (Crandall and Gillette, 1999).

In the year 2000, the Conservancy, in collaboration with various community interests, initiated a comprehensive water quality monitoring program in order to better understand and define the overall chemical, biological, and physical health of the Roaring Fork River and its tributaries.

6. The Conservancy's Water Quality Monitoring Program

The Conservancy's overall water quality monitoring program is based on the following goals and objectives:

GOAL #1: To design and implement a Water Quality Monitoring Program in the Roaring Fork watershed.

Objective 1: Produce an Inventory Report that summarizes water quality monitoring activities in the Roaring Fork watershed.
Objective 2: Identify new sites for monitoring.
Objective 3: Develop a water quality monitoring sample plan.
Objective 4: Establish a data management program.
Objective 5: Partner with existing River Watch monitoring activities and expand River Watch sites.
Objective 6: Establish citizen stream teams.
Objective 7: Establish water quality monitoring at the Roaring Fork Club.
Objective 8: Investigate and evaluate areas of special concern.
Objective 9: Evaluate the program.
Objective 10: Sustain the program over the long term.

GOAL #2: To provide meaningful water quality information to the citizens and decision-makers of the Roaring Fork watershed.

Objective 1: Form partnerships with other organizations and agencies.
Objective 2: Conduct public presentations to gather feedback and disseminate information.
Objective 3: Publish a State of the River Report.

The main purpose of designing, implementing, and carrying out a water quality monitoring program for the Roaring Fork watershed is to gather baseline data of various chemical parameters over time. In the year 2000, the Conservancy accomplished its first "snapshot" of this effort. The findings, based on the results of the data, are included in this report. The direction the Water Quality Monitoring Program takes in the future is largely based on these findings. How this monitoring program evolves over time has been and will continue to be evaluated, and a discussion of the future of the monitoring program is provided in Section 11.

Volunteer Training and Certification

The Conservancy's Water Quality Monitoring Program has been modeled after an existing monitoring program created by CDOW, called River Watch. River Watch trains high school and middle school teachers and students to conduct water quality monitoring. River Watch participants are required to attend a comprehensive one-week training overseen by CDOW staff. A minimum of one person per school must attend, but three are encouraged. Participants are instructed on how to calibrate equipment and conduct in-stream sampling for water chemistry constituents using specified protocols. Each participant must complete every analysis at least three times and pass a test to become certified.

Conservancy staff train Valley teachers on how to conduct water quality monitoring.

The instruction covers Quality Assurance and Quality Control (QA/QC) methods as well as data entry and the shipping of samples. Also included in these training sessions are proper protocols for the collection and basic identification of macroinvertebrates, and analysis of in-stream and riparian zone physical habitat characteristics.

Citizen Stream Team Volunteers are trained by Conservancy staff during a one-day training session. Training includes instruction on the following:

- Calibration of equipment,
- Conducting instream sampling for water chemistry constituents,
- Collection techniques for conductivity, chlorides, and nutrients,
- Analysis of various parameters using lab equipment,
- Analysis of stream physical habitat characteristics, and
- Collection of macroinvertebrates.

After the initial training sessions have been completed, Stream Team participants are required to practice the methods on their own. Conservancy staff members then conduct a follow-up visit with each stream team to check on the quality and accuracy of the team's sampling and analysis techniques. Once the team has been certified through this process, it can conduct sampling and analysis on a regular basis.

Stream Team volunteers brave the cold during a water quality training session.

Water Sampling and Analysis

In the year 2000, water quality samples were collected monthly, at 25 sites (see Figure 2). These sites were selected through a combination of discussions with public officials, river users, and the general public. Government agencies and/or River Watch school programs have historically sampled some of the sites.

Key to the consistency of the monitoring program is a strict sampling schedule, which is followed even in inclement weather. River Watch students and teachers, Stream Team participants, and Conservancy staff take samples and run analyses all within the same two-day time period. Holding times for all parameters are strictly followed. If students and volunteers cannot conduct sampling according to the set schedule, they are instructed to contact the Conservancy's Water Quality Coordinator at least two days prior to that sampling event. Conservancy staff covers the sampling and analysis duties for the given site on the scheduled sampling date. **Safety** is a priority of this program. Volunteers are strongly encouraged to work in teams of at least two people. If this cannot be achieved, the Conservancy either collects the samples or works together with an available volunteer (ROCWWN Sample Plan, 2000).

The chemical, physical, and biological parameters sampled by Conservancy staff and volunteers are as follows:

- Metals analysis: Cadmium, copper, lead, zinc, magnesium, iron, selenium, arsenic, aluminum, calcium, and manganese (total and dissolved metals for all stations).
- Field parameters: Temperature, pH, total alkalinity as $CaCO_3$, total hardness as $CaCO_3$, dissolved oxygen, and conductivity. Field studies also include flow, riparian, and in-stream habitat assessments (e.g. bank stability, percent cover, substrate type, and size), and river/stream reach assessments. Macroinvertebrates are studied to evaluate biological conditions using a modified kick method. Nitrate, phosphate, sulfate, chloride, ammonia, and total suspended solids are evaluated for nutrient concentrations.

The metals and field parameters listed above are used by the Colorado Department of Public Health and Environment (CDPHE) and the WQCC to assess the physical, biological, and chemical integrity of Colorado's waters (CDPHE, 2000). A composite sample (mixed sample from a minimum of three locations) along the width of a stream can be collected because most rivers in Colorado have a uniform cross-section vertical and horizontal throughout the water column (top to bottom). A uniform cross-section is defined by similar pH, dissolved oxygen, temperature, and conductivity profiles. Generally speaking, for water chemistry, a walking composite is preferred if stream conditions allow. A bucket composite is collected from the upstream side of a bridge if a walking composite is not possible. The final option is a grab sample from a representative flowing area of the stream.

For a walking composite, all sample containers are filled individually by taking water from at least three different parts of a stream width. When taking a bucket composite, all samples are collected from the composite bucket in a prescribed order (dissolved oxygen, metals, pH, alkalinity, and hardness). If macroinvertebrates are collected, water chemistry is sampled above the area or before the macroinvertebrate sample is taken.

Physical habitat measurements are conducted utilizing a modified version of the techniques described in the EPA publication "Rapid Bioassessment Protocols for Use in Rivers and Wadeable Streams: Periphyton, Macroinvertebrates and Fish" (EPA 841-B-

99-002; sec. 5). These measurements are also focused on the specific microhabitat of each macroinvertebrate collection area and within a 200-foot reach, which encompasses the collection area.

Quality Assurance/Quality Control

An important aspect of any volunteer monitoring program is the formulation of data quality objectives for QA/QC. Since many of the protocols for water quality monitoring have been adapted from the CDOW's River Watch Program, the same data quality objectives have been implemented for this monitoring program. *The primary data quality objective behind the Conservancy's collection of chemical, biological, and physical data is to collect precise objective and consistent data on Roaring Fork watershed streams.* This is done at a frequency and geographic continuum not accomplished by other entities, and the result is data that will be of value to all levels of decision-makers. This means producing data that equates to or is comparable to the data collected or needed by decision-makers. It means data of the appropriate frequency, duration, location, and protocols to make the data valuable.

The quality, integrity, and thus usability of the data are determined by a number of factors, including precision, accuracy, representativeness, comparability, and completeness.

<u>Precision</u> of the data refers to the level of agreement among repeated measurements of the same parameter, and gives information about the consistency of the methods used. To address precision in the Conservancy's water quality monitoring program, duplicate samples are taken for pH, alkalinity, and hardness two times per year by Stream Team volunteers. River Watch schools perform a duplicate sample for pH, alkalinity, and hardness during site visits by CDOW staff. In addition, a duplicate river sample analyzed with student and Stream Team equipment and Conservancy equipment for alkalinity and hardness is completed at each site visit.

Blanks and duplicates for total and dissolved metals are taken at five sampling locations every sampling period. Conservancy staff and citizen Stream Teams are required to take blank and duplicate samples for metals two times per year. River Watch schools are required to take blank and duplicate samples for metals every fifth sampling trip. Conservancy staff takes blank and duplicate metals samples at the desired frequency when volunteers are not scheduled to fulfill that requirement.

Volunteers and Conservancy staff run a duplicate sample utilizing the Winkler Method for dissolved oxygen two times per year. When possible, a dissolved oxygen meter will be used to verify volunteer and Conservancy measurements. Meters measuring pH are calibrated by all sampling entities before each sampling event.

Immediate investigation and corrective action is taken if any of the above results fall out of their respective ranges. Corrective action may include changing equipment or chemicals and the retraining of volunteers.

Accuracy is a measure of confidence that describes how close a measurement is to its true value. To address accuracy in our program, unknown samples are delivered to River Watch Schools and citizen Stream Teams for analysis. Parameters including pH, alkalinity, and hardness are measured by River Watch students, Stream Team volunteers, and Conservancy staff twice per year. Dissolved oxygen is measured for accuracy by comparing the Winkler Titration Method used by the students, volunteers, and Conservancy staff with a calibrated dissolved oxygen reading of the same sample. All laboratory analyses utilize standards and controls in the analytical process.

Representativeness is the extent to which measurements actually represent the true environmental condition. To address representativeness in our program, participants conduct stream sampling in stream reaches that are well mixed and uniform. Samples are taken using either a composite sampling method or by taking a grab sample in the thalwag (main channel) of the stretch of stream to be monitored. By conducting sampling at a high frequency, anomalies stand out, changes are easily observed, and subtle trends are noticeable for most parameters.

Comparability is the degree to which data measurements can be compared directly to similar studies and to one another. In order to address comparability in our program, agencies such as the Environmental Protection Agency (EPA) and CDPHE have historically monitored some of the sampling sites that were selected for the program's monitoring activities. Other sites are being monitored or have been monitored by municipalities and/or wastewater treatment plants. Protocols approved by the EPA and used within the River Watch program were used for field sampling and lab analysis for temperature, pH, alkalinity, hardness, dissolved oxygen, and total and dissolved metals. A best-case scenario has all entities conducting sampling and analysis utilizing similar collection techniques and analytical methods. Optimal situations for comparing historical data with results of this study would be where sample collection methods and analytical procedures are exactly the same (as with River Watch data).

Completeness is the comparison between the amounts of data planned for collection versus the amount of usable data actually collected, expressed as a percentage. The Conservancy monitored 25 locations on a monthly basis, for various parameters. Students, volunteers, and Conservancy staff performed this work. Field and lab work is scrutinized carefully by Conservancy staff and the CDOW to ensure that the work being accomplished is credible. We sampled at all 25 sites within a day or two of each other unless unanticipated weather conditions prevented sampling. A minimum acceptable number of sites sampled during each monthly sampling month are 19 (ROCWWN QAPP, 2000).

Data Storage and Validation

The Conservancy has partnered with the CDOW River Watch Program in data management and validation. This process involves the following steps:

The first step of data validation and management occurs with the volunteers and Conservancy staff. The team leader of each Stream Team validates each piece of information that is collected or analyzed – checking for relevance, precision, accuracy, and completeness. He/she copies and signs each data sheet and sends the originals to the Conservancy. The Conservancy processes the data and the samples, and data sheets are "graded." This is where sample identification is checked. This validation is looking for obvious recording errors, erroneous numbers, math errors, and other notes provided by the volunteer.

The River Watch schools or the Conservancy enter the data they have analyzed via the River Watch web page (http://wildlife.state.co.us/riverwatch). Data entry and CDOW validation is described in the CDOW document titled IMAP (Information Management Plan, 2000). Electronic data is validated as part of the process, with data from the original data sheets being compared to entered data.

The metals samples are bar-coded for laboratory identification purposes and are delivered to CDOW's Fort Collins laboratory for analysis along with a chain of custody. The data are validated against laboratory QA/QC results and delivered electronically to CDOW's River Watch Program Leader. CDOW validates the metals samples against field QA/QC measurements and checks for completeness. The agency also runs a merge program that combines the metals data with validated volunteer data, and performs final checks for completeness, precision, and accuracy. After this step, the new batch of data is appended to the CDOW River Watch web page database and to STORET, a national water quality database administered by the EPA (ROCWWN QAPP, 2000). The final review occurs during writing of watershed reports. Potential anomalies are left in the database to be compared with the historic data from that location. Once the CDOW River Watch watershed report is written, final anomalies are recorded, and removed from the database if deemed invalid. Primary databases are in dBase software. Intermediate files are in Quattro Pro or Excel spreadsheet formats.

Sampling Station # 68: Slaughterhouse Bridge in Aspen, Colorado.

7. Sampling Locations with Station Names

Station #	
769	**1) R. Fork: Difficult (gage) (RFC)**
770	**2) R. Fork: Mill Street Bridge (AST)**
68	**3) R. Fork: Slaughterhouse Bridge (AHS)**
771	**4) Brush Creek: Brush Creek (RFC/SCST)**
71	**5) R. Fork: Gerbaz Bridge (RFC)**
773	**6) Capitol Creek: Capitol Creek (RFC/SST)**
774	**7) Snowmass Creek: Snowmass Creek (RFC/SST)**
775	**8) R. Fork: Below RF Club (RFC)**
72	**9) R. Fork: 7-11 Bridge (BHS)**
776	**10) Fryingpan: Meredith (RFC)**
733	**11) Fryingpan: Baetis Bridge (gage) (RFC)**
732	**12) Fryingpan: Below 7 Castles (RFC/BST)**
73	**13) Fryingpan: Upper Basalt Bridge (BHS)**
777	**14) R. Fork: Midland (RFC)**
778	**15) Sopris Creek: Sopris Creek (RFC)**
779	**16) R. Fork: Emma (gage) (ACA)**
780	**17) R. Fork: Ranch @ Roaring Fork (RFC/CST)**
735	**18) Crystal River: Genter Mine Br. (MCS)**
736	**19) Crystal River: Redstone (RFC/RST)**
782	**20) Coal Creek: @ Coal Creek/Rec. (RFC)**
783	**21) Crystal River: Coryell Ranch (RFC)**
784	**22) R. Fork: @ Sanders Ranch (RFC)**
785	**23) 4 Mile Creek: 4 Mile Creek (CMC)**
786	**24) R. Fork: Park East (RFC/GSST)**
45	**25) R. Fork: 7th Street Bridge (gage) (GSHS)**

Entity Conducting Sampling

RFC = Roaring Fork Conservancy
AST = Aspen Stream Team
AHS = Aspen High School
SCST = Ski Co Stream Team
SST = Snowmass Stream Team
BHS = Basalt High School
BST = Basalt Stream Team
ACA = Alpine Christian Academy
CST = Carbondale Stream Team
MCS = Marble Charter School
RST = Redstone Stream Team
CMC = Colorado Mtn. College
GSST = Glen. Sp. Stream Team
GSHS = Glen. Sp. High School

8. The Rivers' Signals: What we Measure and Why

This section provides background on what is measured for the Conservancy's water quality monitoring program, what influences these parameters, how and why they fluctuate over time, and why we care about them. By understanding these specific physical, chemical, and biological variables, we can ask deeper questions about our results. The "River Continuum Concept" provides a predictive model to hypothesize what we would expect to find from the headwaters to the mouth of each river. The River Continuum Concept proposes that natural stream ecosystems may be characterized as extending continuously from their headwater beginnings to their mouth or estuary. Furthermore, this continuous stream system provides a gradient of changing physical, chemical, and biological conditions (Vannote, 1983).

pH

One of the most basic concepts associated with water and life on earth is pH. Four billion years ago, the entire surface of the earth was covered entirely with water, and today 71% of its surface is still under water. Life evolved in water, and living cells require a water medium in which to carry out the reactions that sustain life. Whether on the earth's surface or in living cells, water contains two ions: hydrogen (H^+), which is acidic, and hydroxyl (OH^-), which is basic. These two ions strongly associate with each other, and are used to measure the acidity of water on a scale of 0 (acidic) to 14 (alkaline) pH units. The pH determines the rate of many biochemical reactions in streams and rivers. Also, pH affects the availability of certain constituents in the water (e.g. zinc toxicity generally has a larger effect on aquatic organisms at a low pH while ammonia is more toxic at a higher pH). Aquatic organisms each have an optimal pH range for functioning, and extremes on either end of the pH scale can be toxic.

Normal cellular functions take place in the pH range of 7.2 to 7.5. Organisms living in water can tolerate a wider pH range than can the interior of cells. This is because cell membranes maintain the internal pH at a constant value while natural aquatic habitats tend to fluctuate. Brown trout adults can tolerate pH values from 5.0 to 9.5, but prefer the narrower range of 6.8 to 7.0. Aquatic insect survival is optimal in the narrower range of 6.5 to 8.5. There isn't much change in pH from upstream to downstream outside of the neutral range. However, pH will change daily depending on biological activity and sun exposure. *The state standard for pH in the watershed is 6.5 to 9.0.*

Sources of acidic discharges into streams, such as mine drainage or acid rain produced by fuel combustion, can lower the pH (increase the H^+ ion concentrations) to a point at which aquatic life either becomes stressed or can no longer survive. Additionally, waste water treatment plants may introduce ammonia to stream ecosystems. Ammonia in its unionized form is toxic to aquatic life at high concentrations. Both temperature and pH affect the levels of ammonia and are important factors in determining the ability of the stream to assimilate ammonia up to the instream standard.

Hardness

Hardness measures the ability of water to precipitate soap. Metals' toxicity is also a function of water hardness. Chemically, hardness is defined as the sum of calcium and magnesium ions present in the water, converted to milligrams per liter (mg/L) of calcium carbonate (CaCO3).

Running water with high relative hardness (>200 mg/L) is most often associated with high primary productivity – the process through which plants convert light energy into sugar. Plant material supports life cycle functions by becoming food for invertebrates, which in turn support fish species. More species of fresh water insects and fish are therefore associated with hard water streams than with soft water streams. The presence of dissolved calcium and magnesium can also protect aquatic life in streams that contain high concentrations of metals. Calcium and magnesium ions out-compete metal ions for uptake sites on fish gills.

Hard water has some disadvantages as well. It can create coatings in pipes, faucet heads, and household implements such as teakettles. Hardness also can affect the taste of water although it does not introduce toxic components into our drinking water supply.

The level of hardness usually increases from upstream to downstream because of increased exposure of water to minerals in rocks and soils. The hardness of rivers and streams generally ranges from 1-500 mg/L, from 500-1000 mg/L in lakes, and from thousands to tens of thousands of mg/L in groundwater. Hardness values do not tend to change daily, although values may decrease due to dilution by snowmelt and large rainstorms. There is no state standard for hardness but hardness values are used to calculate many metals standards.

Alkalinity

Alkalinity measures the ability of water to resist changes in the H+ ion concentration (or pH) when either acid (H+) or base (OH-) is added to the water. The ability to resist changes in pH mainly depends on the amount of dissolved carbon dioxide (CO_2) in the water. A measurement of alkalinity represents the total amount of bicarbonate and carbonate in the river. Like hardness, alkalinity is measured in mg/L of calcium carbonate.

If H^+ ions (acid) are added to a system, carbonate ions will associate with them so they are not left free in solution. If OH- ions (base) are added to the system, H+ ions dissociate, or split apart, from the carbonate ion and combine with the OH- ions to form water. By this constant adjustment in the concentrations of carbonate and bicarbonate ions, the concentration of free H+ ions is kept relatively constant – that is the pH will change very little. A system that can resist changes in pH is a "buffered" system, referring to its ability to absorb acidic ions without major changes in pH. Such a system is highly alkaline.

Living cells utilize this buffering system to maintain a uniform internal environment where the biochemical reactions necessary to sustain life can proceed. High alkalinity also protects fish in streams that contain high concentrations of dissolved metals.

The same minerals in soils and rocks that influence hardness also affect alkalinity. Surface water or groundwater that has contact with limestone or dolomite will have high values for alkalinity. Large amounts of acid from mine drainage will lower the alkalinity because carbonate and bicarbonate ions will be removed from solution as they associate with the H^+ ions. Alkalinity fluctuates daily and seasonally but to a lesser degree than hardness. Also, alkalinity values are always less than hardness values except in the presence of certain geologic influences. There is no state standard for alkalinity.

Temperature

Temperature is recorded in degrees (°) Celsius (C). Temperature determines which kind of organisms can survive in water. Some bacteria can live in water that is almost boiling, at 98° C (208° F). Most plants, insects, and fish, however, require temperatures below 20° C (68° F). Temperature affects the amount of oxygen that can dissolve in the water and is therefore available to organisms for respiration. Fish and insects prefer lower temperatures because cold water holds greater levels of dissolved oxygen than warm water. The optimal temperature range for Brown Trout egg survival is between 2-13° C. Brown trout adults thrive at water temperatures between 12-19° C. The same holds true for macroinvertebrate stone, caddis, and mayfly nymphs. Most plants and other types of fish (such as bass, carp, and catfish) prefer warmer waters.

Water temperature in stream environments varies by season. Water is warmer in the summer than in the winter. Altitude also affects temperature with warmer water usually occurring at lower altitudes. Water uses, such as power plant cooling and manufacturing, influence temperature, causing water to warm up. Activities such as logging, ski area development, and agricultural practices can also raise water temperatures by contributing runoff to streams from land with little vegetative cover, and by reducing the shading effects of riparian habitat. Cold-water releases from dams like that at Ruedi Reservoir can stress fish because of a drastic change in water temperature. Temperature affects pH and respiration. Temperature will increase when moving further downstream, eventually leading to a change in species composition to those that thrive in warm water environments. *The state standard for temperature in the cold-water Roaring Fork watershed is a maximum of 20° C.*

Dissolved Oxygen

Oxygen is critical for fueling cellular respiration, which in turn enables cells to carry out functions like growth and repair. Similar to carbon dioxide, atmospheric pressure causes molecular oxygen to dissolve in water. This dissolved oxygen is measured in mg/L.

The amount of dissolved oxygen in water determines which organisms can survive in a particular environment. Foul-smelling bacteria that use nitrate or sulfate to accept electrons and provide fuel can survive in environments with very little oxygen. A higher content of dissolved oxygen in water relates to purer water quality and the ability for more diverse life forms to survive. Brown trout adults and their eggs thrive in water that contains 9-12 mg/L of dissolved oxygen.

Water temperature, stream velocity, altitude, and level of organic matter content all affect the amount of dissolved oxygen that water can hold. As mentioned above, cold water contains more dissolved oxygen than warm water. Standing water often contains less dissolved oxygen than rapidly flowing water, and water at high elevations contains less dissolved oxygen than water at low elevations due to decreased air pressure. Bacteria consume dissolved oxygen during decomposition of organic matter and therefore lower the oxygen content of water. As temperatures increase downstream, dissolved oxygen values will decrease because warmer water holds less oxygen. *The state standard for dissolved oxygen is a minimum of 6 mg/L, with a 7 mg/L minimum during fish spawning periods.*

Metals

Metals are most commonly considered to be those elements in the middle of the periodic table that can exist in several charged states (protons vs. electrons). Surface water normally contains trace amounts of metals that are either dissolved in the water or associated with minute solid mineral material that is suspended. Metal concentrations in solution are expressed in micrograms per liter (ug/L) or parts per billion (ppb). These are very small concentrations.

Metals are transported within river systems in different forms. Two specific forms, total (not filtered) and dissolved (filtered) metals are sampled by the Conservancy's monitoring program. Total metals include forms that are bound up and not available to aquatic life in a potentially harmful way. For example, in the case of copper sulfate, $CuSO_4$, Cu^{2+}, and SO_4^{2-} are paired. When the two molecules break up, Cu^{2+} is floating free and would be considered dissolved. Dissolved metals in water are determined using a filtered sample. Only single metals (dissolved) pass through the 0.45 micron filter. It is this form of the metal that is the most harmful to aquatic life if present in excessive amounts.

All life forms require trace amounts of metals to carry out normal cellular functions. Iron carries oxygen from air to the cells in our bodies. Copper performs the same function for invertebrates such as in shrimp and snails. Zinc is essential for cell differentiation and growth. However, excess amounts of some dissolved or suspended metals can impair the ability of aquatic life to live and reproduce by interfering with oxygen uptake. Other metals like lead and cadmium are toxic to aquatic organisms.

As with alkalinity, hardness, and pH, exposure to minerals in soils and rocks increases the concentration of dissolved metals in water. High concentrations of dissolved metals are often found in low pH (<5) waters that drain certain types of rocks, mined areas, and urban areas. Rapid runoff raises the concentration of suspended mineral material in water. Metals will always be present in some natural background state. Concentrations of metals may increase due to human-caused land and water use practices, such as mining and dumping.

Metals can affect aquatic life in several ways. A sudden, high concentration can cause death and is called the "acute" exposure limit. A lower exposure over a longer period of time can cause a wide variety of behavioral and physical impacts and is called the "chronic" exposure limit. Many metals have a maximum standard classified by the WQCC. Yet a metal concentration that is found to exceed a standard does not necessarily imply that organisms are experiencing harm, as it is also important to consider the duration and frequency of the exposure. If a metal concentration were to exceed a maximum state standard for all sampling events over a three-year period, it can be concluded with a greater degree of certainty that organisms are experiencing the effects of toxicity. If one or two data points in three years exceed a threshold, it is less likely that significant toxic impacts are felt by organisms, although such information would be extremely valuable in investigating and addressing possible sources of metals' contamination. The State has standards for the more common metals, based on their potential to impact human or aquatic life (ROCWWN 2000 Watershed Report Series - #11, 2000).

Flow

Flow in cubic feet per second (cfs) is an important factor in determining the concentration of a certain constituent. Spatial and temporal variations of a parameter can be affected by the amount of steam-flow at any particular moment. Data between sites and between time periods can be better understood when flow values are incorporated into parameter values. The USGS is responsible for monitoring established stream discharge gaging stations at key locations on watersheds throughout the country. A plot of the discharge rate or flow as a function of time is called a hydrograph. In the Roaring Fork Valley, there are five stream gages, which coincide with four of the Conservancy's sampling locations. These are at Difficult Campground, Emma, and the 7th Street Bridge on the Roaring Fork River, and at Baetis Bridge on the Fryingpan River.

Flow patterns in the Roaring fork watershed are fairly typical of natural mountain streams. Peak flows are evident during spring snowmelt months and low flows during fall and winter. Flow levels and patterns also play an important role in sustaining aquatic ecosystem functions. For example, adequate year-round in-stream flows are needed to protect aquatic habitat and organisms. Spring flushing flows replenish subsurface water sources, support riparian and floodplain vegetation, and establish various types of fish habitat. Water diversions and impoundments such as Ruedi Reservoir tend to temper this pattern in certain reaches.

Marble Charter School River Watchers return to school after a day of sampling.

9. The Clean Water Act and Water Quality Standards

The Clean Water Act is a federal law that sets forth how the United States will restore and maintain the chemical, physical, and biological integrity of its waters (oceans, lakes, streams and rivers, ground water, and wetlands). The law provides protection of the nation's surface waters from both point and non-point pollution sources. The EPA has delegated the administration of certain portions of the Clean Water Act program to many of the 50 states, including Colorado.

The Clean Water Act

The Clean Water Act directs public agencies and pollutant discharge permit-holders to track water quality, ranging from comprehensive national reports to monitoring data from single dischargers. The following are a few of the most important types of information available through the state water quality agencies and the EPA:

- The National Water Quality Inventory: Report to Congress
- List of Impaired Waters
- List of Permitted Discharges
- Basin-Wide Water Quality Plans
- Allocating resources for a Non-point Source Program
- Intended Use Plans
- Wasteload Allocation Studies
- National Estuary Program

Under the Clean Water Act, states establish water quality standards that define the goals and limits for all waters within their jurisdictions. Water quality standards provide the means for enforcement that support the Act's goals. In establishing water quality standards, states must undertake three major interrelated actions as specified under the Clean Water Act. They must: 1) designate uses, 2) establish water quality criteria, and 3) develop and implement anti-degradation policies and procedures. It is these standards that can be used for comparison and interpretation of the data collected for this State of the River Report.

Colorado's Water Quality Standards

Specific to Colorado, in 1973 the State legislature passed the Colorado Water Quality Control Act, which established a procedure to protect surface waters in the State of Colorado based on their "beneficial uses." The State Act provides for a nine-member board appointed by the Governor to determine standards and other rules for water quality protection. This is the Colorado Water Quality Control Commission. Commission members are appointed from geographical areas of the state and serve three-year terms. The Commission has authority to establish regulations for water quality standards, control regulations, permit regulations for wastewater discharge, and 401 certification for Army Corps of Engineers 404 permits. These regulations are reviewed every three years as to the need for changes, as required by the Clean Water Act. The Commission sets policies and guidelines for water quality programs that are carried out by the CDPHE Water Quality Control Division (CDPHE, 2000).

All surface waters are subdivided into "segments" that are determined by the uses of the specific stretch of water and the level of protection required to maintain those uses. Standards represent assigned values to protect the uses in each segment. A new segment is assigned when the water use or quality of water changes from the segment upstream. WQCC decisions are made by the Board based on testimony and data supplied by interested entities along those segments. This was the process through which Landis Creek's ammonia standards and aquatic life classification were lowered, as described earlier in the report.

Standards establish the maximum amount of degradation of a particular water quality parameter to which a stream segment may be exposed to from point sources (e.g. discharges from a pipe). Standards are mainly focused on regulating the **maximum** levels of pollution that may be discharged to a stream (e.g. metals) but they can also set forth **minimum** standards (e.g. dissolved oxygen). Other standards may establish a minimum *and* maximum, or range (e.g. pH).

Water Use Classifications or "Beneficial Uses"

Standards are set to protect the so-called "beneficial use" of a stream segment. In Colorado, these uses are broken down into one of five categories:

1) Aquatic life,
2) Water supply,
3) Agriculture,
4) Recreation, and
5) Outstanding Waters.

A stream may have any or all of these classifications. Criteria are developed to protect the specified beneficial use of a stream segment. Specific standards, numeric or narrative, can be established to protect the different criteria in the standards. Aquatic life protection is broken down into Class 1 and Class 2. Class 1 water has a higher level of protection (lower limits for pollution) than Class 2 water. Each of these classes is further divided into cold and warm water. Class 1 water, either cold or warm, can support a wide variety and number of individual sensitive species, while Class 2 water is unable to support such species diversity.

Standards also are applied to domestic water supplies. Water used for agriculture must be suitable for irrigation and as drinking water for livestock. Water designated for recreation is also separated into 2 classes. Class 1 has the higher level of protection and is suitable for primary contact – activities where some water might be ingested such as swimming or water skiing. Class 2 recreation waters are assumed to have less potential for swimming and boating and are used for activities such as fishing or wading.

Types of Stream Standards

Stream standards are either "narrative" or "numeric".
Narrative standards apply to all surface waters of the State, providing protection from human-caused or non-point sources of the following types:

- Material that can settle out to form deposits that are detrimental to use (sedimentation),
- Floating debris,
- Material that produces color, odor or taste (sludge),
- Material that is harmful to humans, plants, animals, or aquatic life,
- Material that will cause the proliferation of undesirable aquatic life (excess nutrients),
- Material that will cause a film or deposit (oil and grease).

Numeric standards fall into four categories: 1) site specific, 2) Table Value Standards, 3) Ambient quality-based, and 4) wetlands.

Site-specific standards are set for stream segments where studies have been done that show indicator species present in a stream reach. Data are presented to the WQCC and standards set to protect the species and water uses from degradation. Table Value Standards (TVS) are provided for physical and biological parameters, inorganic parameters, and metals (see Appendix A). The numeric levels are based on available information and generally protect the beneficial use of the water where site-specific standards do not appear to be needed.

The standards for inorganic and metals may also be "acute" or "chronic." An acute standard represents one-half the concentration that will kill five percent of a test population in 96 hours. The maximum standard may not be exceeded more than once in a three-year period. A chronic standard is lower, and represents the maximum concentration that still protects 95 percent of the population from growth or reproductive abnormalities. A chronic standard also may not be exceeded more than once in a three-year period. A stream standard incorporates multiple species thresholds established by compiling species-specific biological thresholds. The acute and chronic standards cover a wide range of plant and animal species. The standards for protecting the most sensitive species are those that are enforced. Also, when there is more than one use classified, the most sensitive standards will be applied. Please see Appendix B for a list of standards adopted for the Roaring Fork watershed. If a parameter is not listed in these tables, then no standards exist for it.

Sometimes standards might be a function of another parameter as in the case of some metals and water hardness. For most metals the standard is set for the dissolved fraction. In other examples, dissolved oxygen has a low standard and pH has both a high and a low standard.

Ambient quality-based standards are set for stream segments where natural or human-caused concentrations of harmful substances are higher than the TVS and cannot be reasonably lowered. Wetlands may have their own set of site-specific standards, or are covered by standards that protect the stream segment with which they are most directly connected.

10. Data Display and Results

Once the CDOW and Conservancy have determined that the data stored in dBase is accurate and reproducible, the next step is to display the data for evaluation. Data can be evaluated in many ways, but should be driven by the questions that were behind the monitoring design – questions that relate to the needs of the data users. Data analysis may entail use of simple summary statistics, such as calculation of averages, geometric means, high and low values, or variance around a mean. Another analytical tool is to display the data as a graph. Parameters can be graphed at one location through time or at many locations during the same sampling month. A parameter also can be graphed alone or with another parameter geographically from upstream to downstream. These types of displays help evaluate collected data against natural or predicted patterns for each parameter as hypothesized in the River Continuum Concept.

Another perspective is offered by comparing the data to some available threshold or standard. An example of a biological threshold might be the limit for the life cycle stage of a species present within the aquatic environment. An example of a standard might be the legal discharge limit for a parameter set on a particular discharge permit. We can also compare the collected data to the WQCC stream standard for each parameter if it exists.

These types of comparisons and displays help evaluate the health of our rivers in the context of defined criteria that are designed to protect various levels of water uses.

In this report, parameters are graphed spatially (upstream to downstream) and temporally (through time). Data is compared to existing segment specific stream standards and to expected trends in and relationships between specific parameters (via the River Continuum Concept). Where appropriate, biological thresholds for common species in Colorado Rivers are also included.

Once the data is displayed, the next step within this section is to interpret the data's significance. What were the high and low values for a particular year? What are the high and low values for a given station? What might we predict? Do any trends emerge from upstream to downstream? What might cause these trends? Do any parameters have similar patterns or do any of these parameters relate to each other? How are they related? Why might they be related? How do results from today compare to historic data? These are the questions to pose as water quality sampling data is evaluated.

Data displayed in this report summarizes the year 2000. In general, graphs of different parameters are displayed for each station (line graphs), and stations are arranged on the graphs in an upstream-to-downstream order, with values corresponding to the station listing in Section 7. If a station is located in a stream segment for which the WQCC has established stream standards, the standards appear as a line of either maximum or minimum permissible values. For reference, WQCC Table Value Stream standards are provided in Appendix A, and those that are segment-specific to the Roaring Fork watershed are contained within Appendix B. In the case of biological thresholds, it should be noted that unless they match with WQCC stream standards, they are not regulated or otherwise enforceable. WQCC stream standards, Table Value or segment-specific, are derived from species-specific biological thresholds, which may or may not be for the dominant species in the Roaring Fork watershed.

The first two graphs, Figures 3 and 4, use the Difficult Campground (site #769) and Roaring Fork Club (site #775) sites to show parameter values throughout the year. The relationships between dissolved oxygen and temperature, and total alkalinity and hardness, are highlighted. Dissolved oxygen and temperature have a chemical relationship. Alkalinity and hardness tend to fluctuate seasonally in the same pattern.

Figures 5 and 6 focus on monthly averages along the Roaring Fork River mainstem for temperature and dissolved oxygen, and monthly averages for total alkalinity and hardness for the sites along the tributaries. Seasonal shifts in total alkalinity and hardness are displayed in Figures 7 and 8, for all sampling sites. May and November provide the two comparative months, and the data indicate the influence of flow levels on the concentrations of these parameters.

The WQCC stream standard for dissolved oxygen is 6.0 mg/L, and ranges between 6.5 and 9.0 for pH. Figures 9 and 10 present the finding that average dissolved oxygen and pH values on all of the Roaring Fork mainstem sites are within these standards.

Hardness values demonstrate a seasonal pattern on the mainstem of the Roaring Fork, which is shown in Figure 11. The tributary sites tended toward the higher end of the pH standard range, as presented in Figure 12.

There were two questionable data points that resulted from this yearlong monitoring effort. One of these data points, a below-standard dissolved oxygen reading at the Ranch at Roaring Fork (site #780), is displayed and interpreted in Figure 13. Another interesting data point was that of high pH levels at Brush Creek (site #771) seen in Figure 14. Finally, a dramatic twist in the expected relationship between total alkalinity and hardness was found at Coal Creek Rec (site #782), with high alkalinity levels (Figure 15).

Figures 16 and 17 show the relationship between flow and hardness at the Roaring Fork River's most upstream sampling location (Difficult) and at its mouth (7th Street Bridge in Glenwood Springs). These two graphs provide good examples of the River Continuum Concept in terms of both temporal and spatial values.

Figure 18 shows total iron levels at several downstream sampling locations along the Roaring Fork and Crystal Rivers for April. Increased iron levels might be attributed to an accumulation and subsequent flush from snow pack of this metal into the river system. The CDPHE or WQCD uses 50th percentile of iron concentrations to assess impairment based upon exceedances. A violation would occur if this standard is exceeded again within a three year period.

Examples of data from selected sampling locations can be found in Appendices C and D. Summary statistics for all stations can be found in Appendix E. All data is available from the Conservancy's Water Quality Coordinator upon request in either hard or electronic formats.

Figure 2. Sampling Location Map.

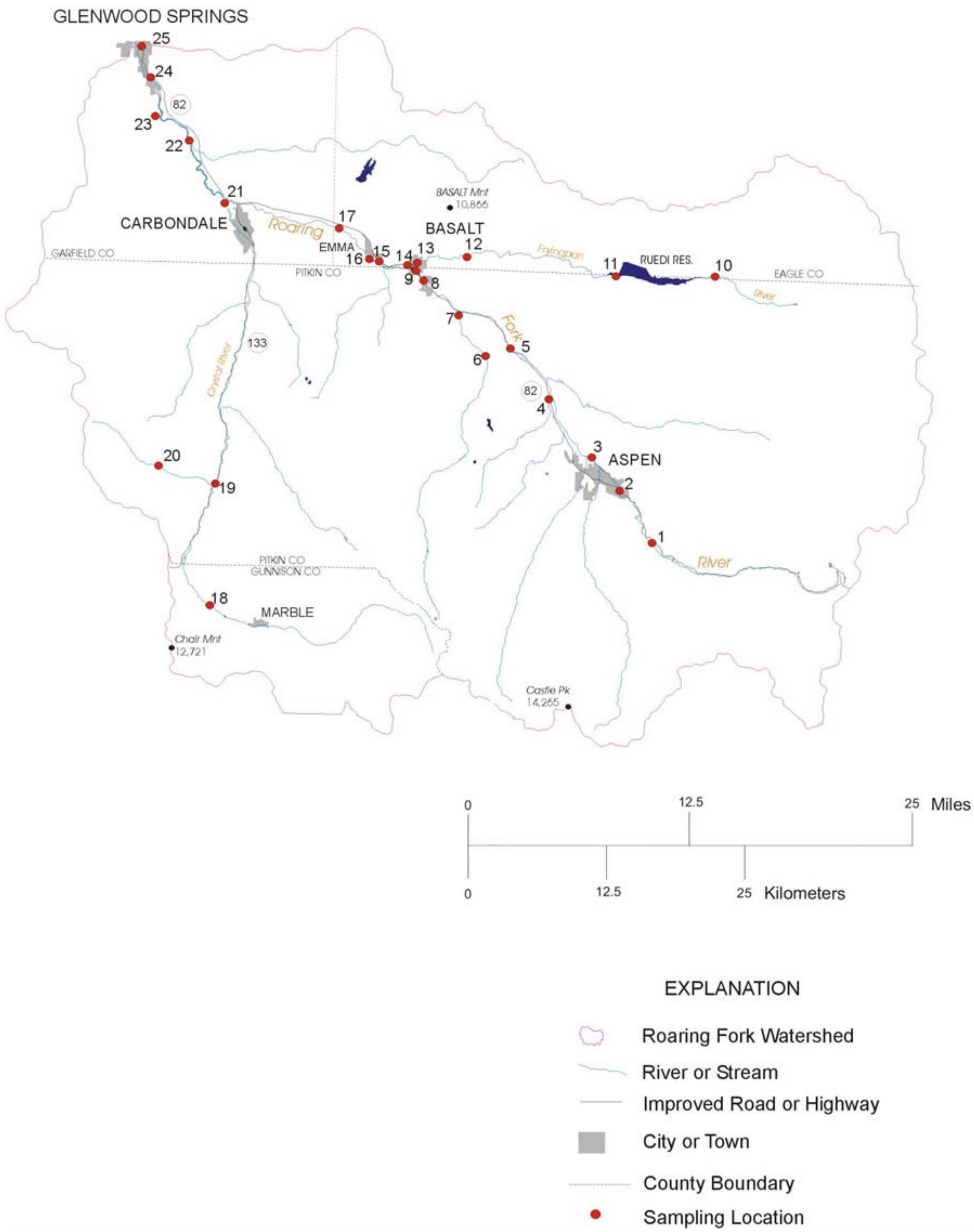
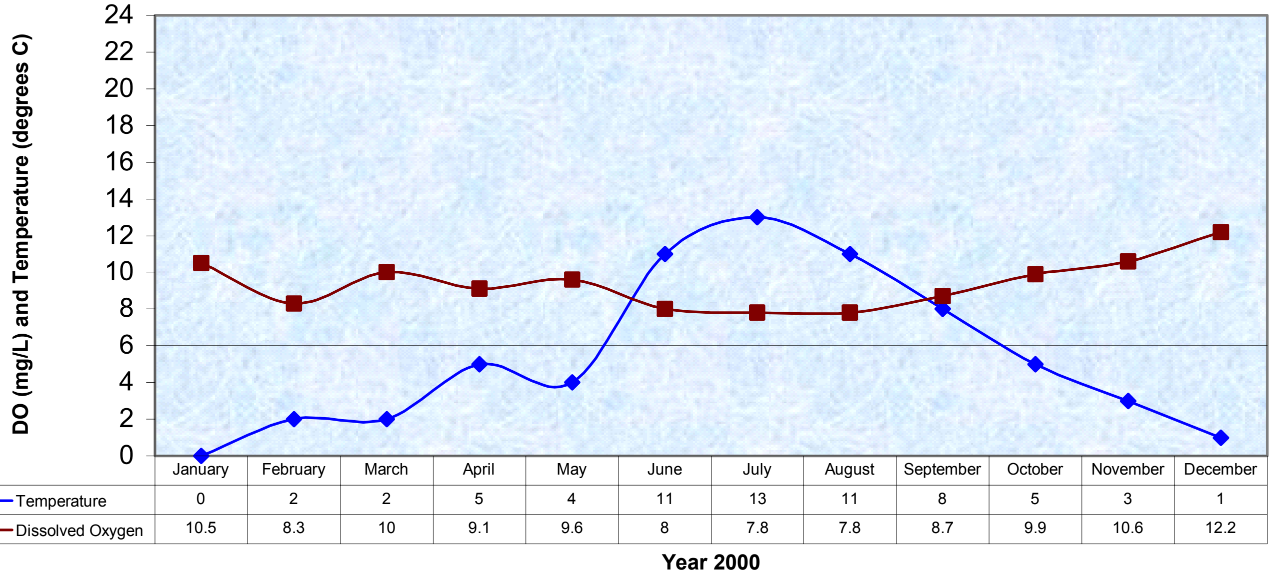
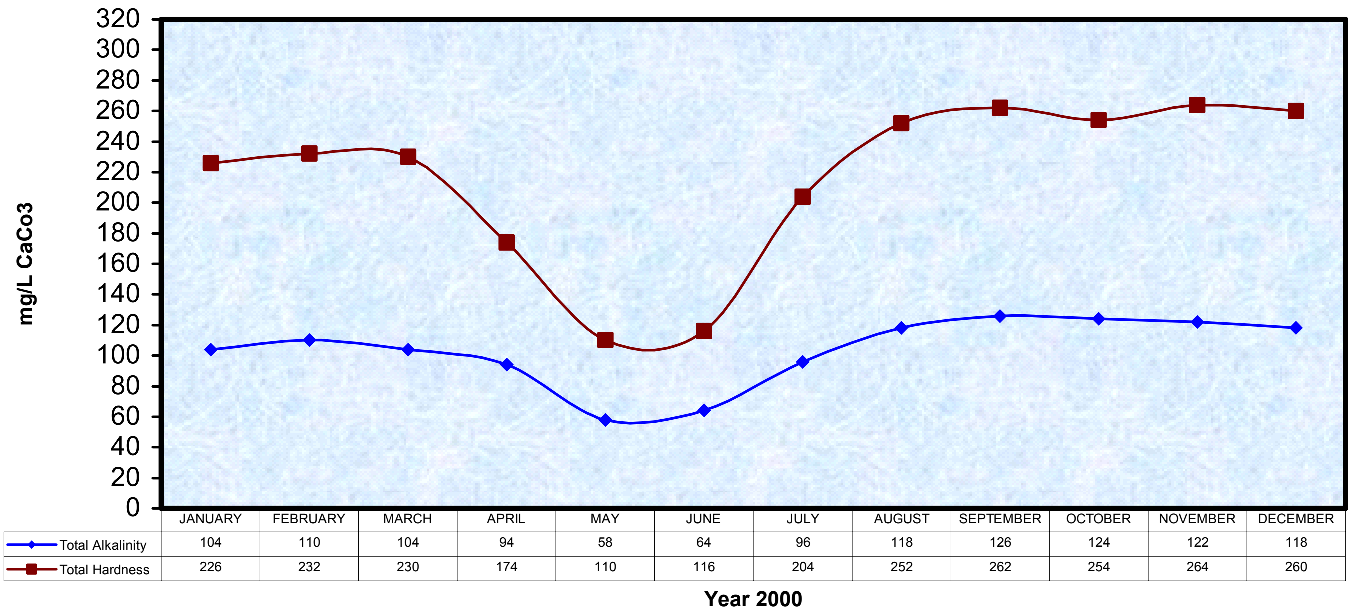


Figure 3: Difficult Campground Dissolved Oxygen and Temperature for Year 2000



	January	February	March	April	May	June	July	August	September	October	November	December
Temperature	0	2	2	5	4	11	13	11	8	5	3	1
Dissolved Oxygen	10.5	8.3	10	9.1	9.6	8	7.8	7.8	8.7	9.9	10.6	12.2

Figure 4: Below Roaring Fork Club Total Alkalinity and Total Hardness for Year 2000

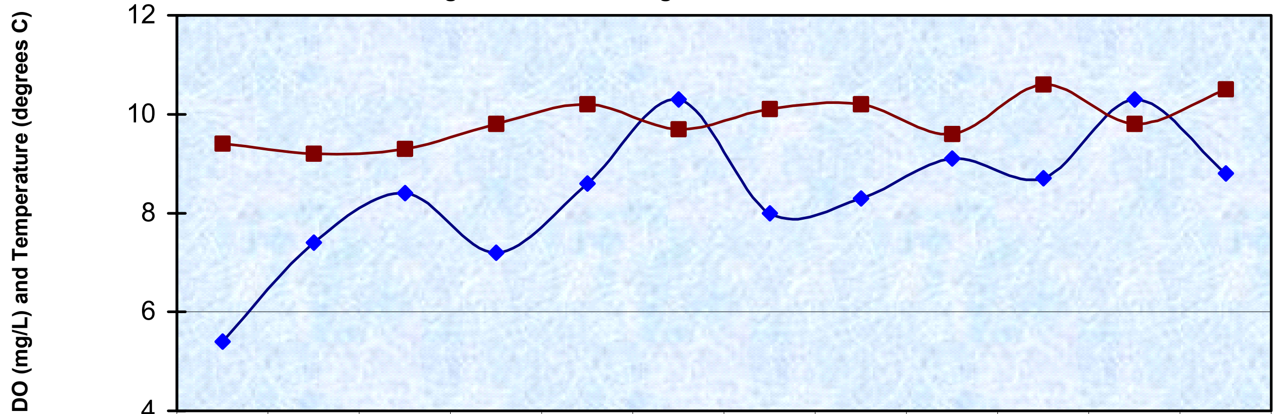


	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Total Alkalinity	104	110	104	94	58	64	96	118	126	124	122	118
Total Hardness	226	232	230	174	110	116	204	252	262	254	264	260

This graph shows how both alkalinity and hardness values decrease during high flow in May and June due to dilution.

Values will be higher during low flow when less water is in the river.

Figure 5: Dissolved Oxygen and Temperature Monthly Average Values at each sampling location along mainstem Roaring Fork for the Year 2000

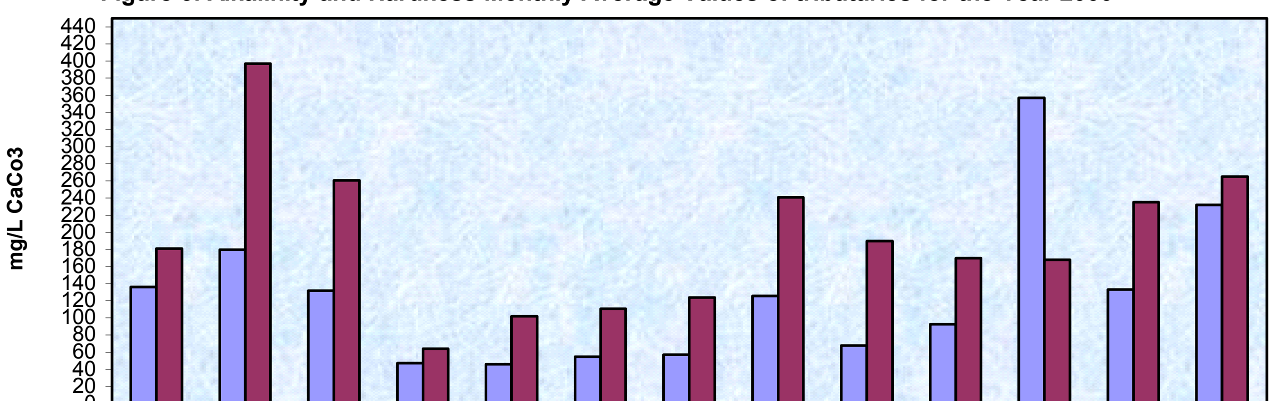


	Difficult	MillSt	Slaughter house	Gerbaz Br	Below RF Club	7-11 Br	Midland	Emma	Ranch @ RF	Sanders Ranch	Park East	7th St Br
Temperature	5.4	7.4	8.4	7.2	8.6	10.3	8	8.3	9.1	8.7	10.3	8.8
Dissolved Oxygen	9.4	9.2	9.3	9.8	10.2	9.7	10.1	10.2	9.6	10.6	9.8	10.5

Sample Site

State standard for dissolved oxygen is a minimum of 6 mg/L. This graph shows average values for dissolved oxygen (influenced by temperature) along the mainstem of the Roaring Fork River.

Figure 6: Alkalinity and Hardness Monthly Average Values of tributaries for the Year 2000

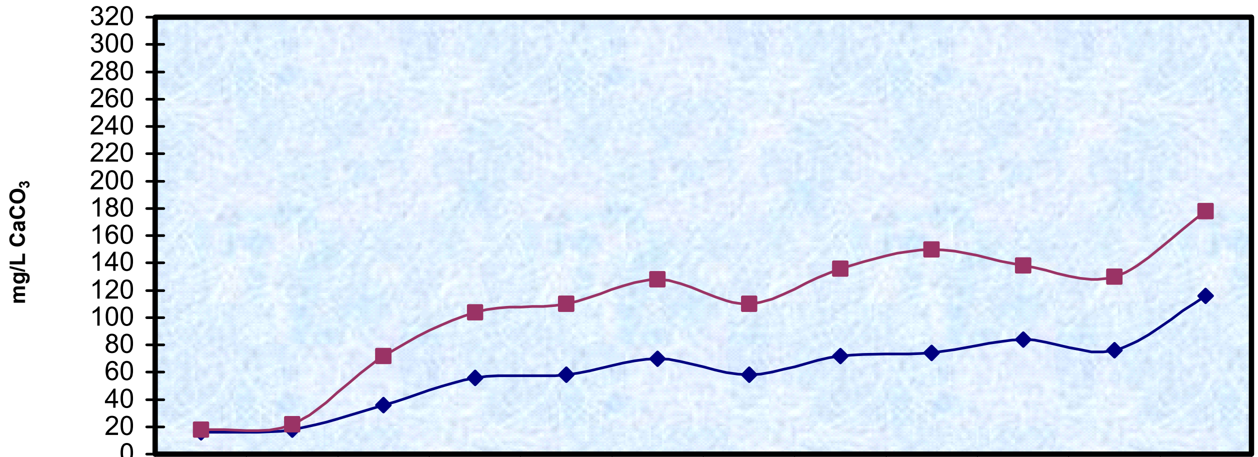


	Brush Cr	Capitol Cr	Snowmass Cr	Meredith	Baetis Br	Below 7 Castles	Upper Basalt Br	Sopris Cr	Genter Mine Br	Redstone	Coal Cr/Rec	Coryell Ranch	4 Mile Cr
Alkalinity	136	180	132	47	46	55	57	126	68	93	357	133	232
Hardness	181	397	261	64	102	111	124	241	190	170	168	235	265

Sample Site

This graph shows how alkalinity and hardness average values are lower on the Fryingpan River (Meredith to Uppser Basalt Bridge). This is due to the granite bedrock in the Fryingpan's headwaters.

Figure 7: Roaring Fork River Total Alkalinity and Hardness for May 2000

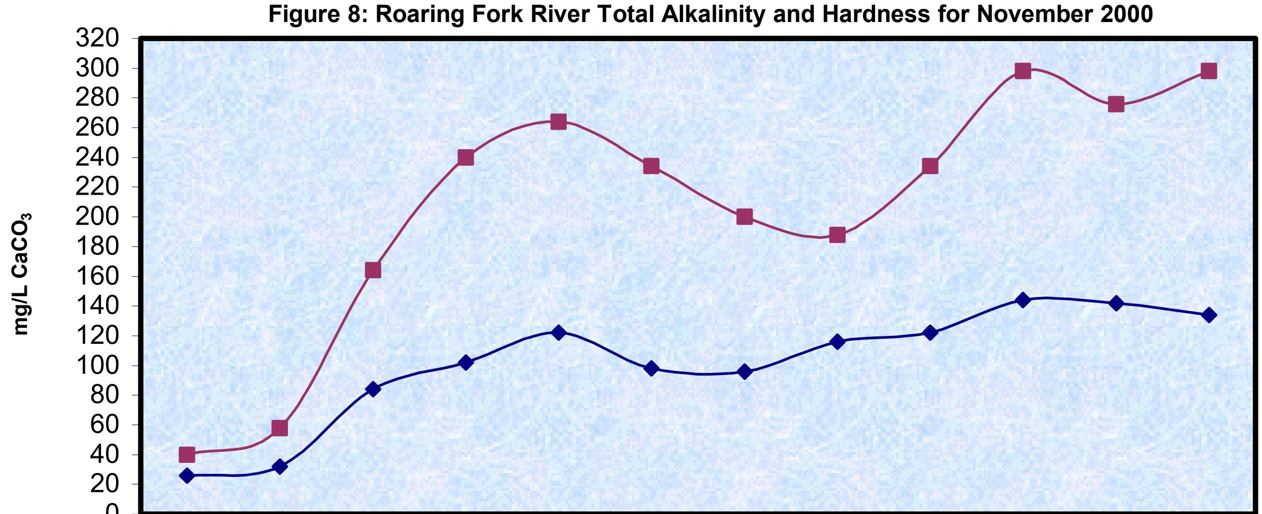


	Difficult	Mill St Br	Slaughterhouse	Gerbaz Br	Below RF Club	7-11 Br	Midland	Emma	Ranch @ RF	Sanders Ranch	Park East	7th St Br
Total Alkalinity	16	18	36	56	58	70	58	72	74	84	76	116
Total Hardness	18	22	72	104	110	128	110	136	150	138	130	178

Sample Site

This graph shows alkalinity and hardness values during high flow along the Roaring Fork mainstem. See next graph (Figure 8) for changes during low flow.

Figure 8: Roaring Fork River Total Alkalinity and Hardness for November 2000

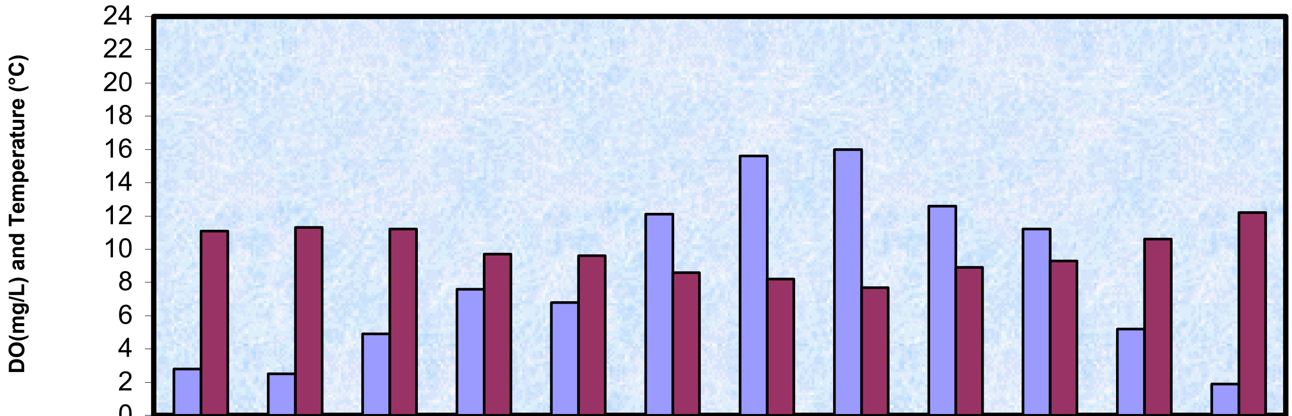


	Difficult	Mill St Br	Slaughterhouse	Gerbaz Br	Below RF Club	7-11 Br	Midland	Emma	Ranch @ RF	Sanders Ranch	Park East	7th St Br
Total Alkalinity	26	32	84	102	122	98	96	116	122	144	142	134
Total Hardness	40	58	164	240	264	234	200	188	234	298	276	298

Sample Site

Compared to the previous graph, these values are higher. This is because there is less dilution during low flow months. Also notice how values increase downstream as bedrock types change from granite to sedimentary.

Figure 9: Dissolved Oxygen and Temperature Monthly Averages from all stations on the Roaring Fork River mainstem

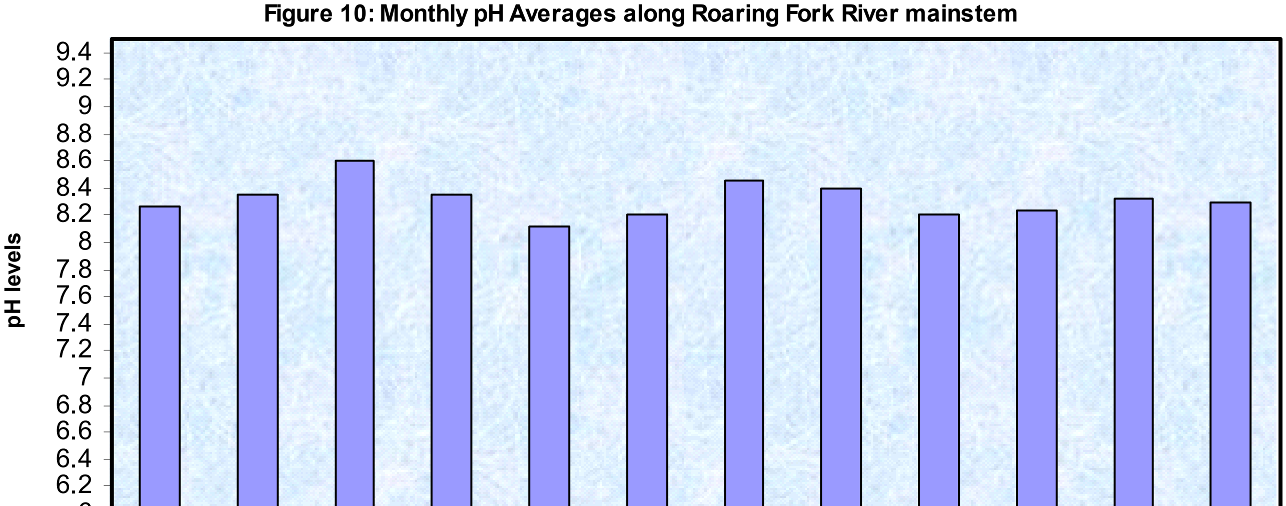


	January	February	March	April	May	June	July	August	September	October	November	December
Temperature	2.8	2.5	4.9	7.6	6.8	12.1	15.6	16	12.6	11.2	5.2	1.9
Dissoved Oxygen	11.1	11.3	11.2	9.7	9.6	8.6	8.2	7.7	8.9	9.3	10.6	12.2

Year 2000

State standard for dissolved oxygen is a minimum of 6.0 mg/L. This graph shows that temperature increases during summer months, corresponding to decreases in dissolved oxygen. Warmer water holds less oxygen.

Figure 10: Monthly pH Averages along Roaring Fork River mainstem

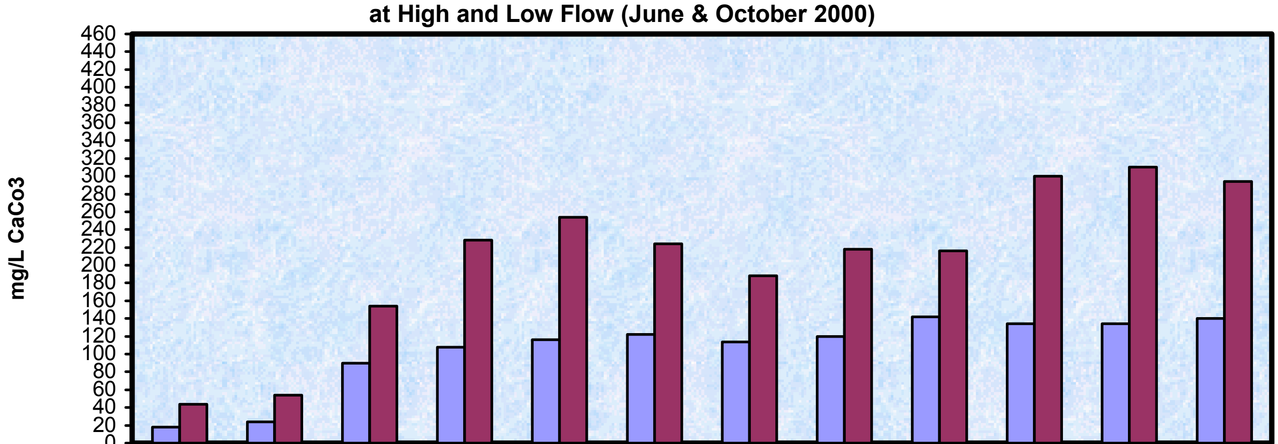


	January	February	March	April	May	June	July	August	September	October	November	December
pH	8.27	8.35	8.6	8.36	8.12	8.21	8.45	8.4	8.21	8.23	8.33	8.3

Year 2000

State standard for pH is between 6.5 and 9.0. This graph shows how average pH levels along the mainstem of the Roaring Fork met state standards.

Figure 11: Hardness Values along mainstem Roaring Fork at High and Low Flow (June & October 2000)

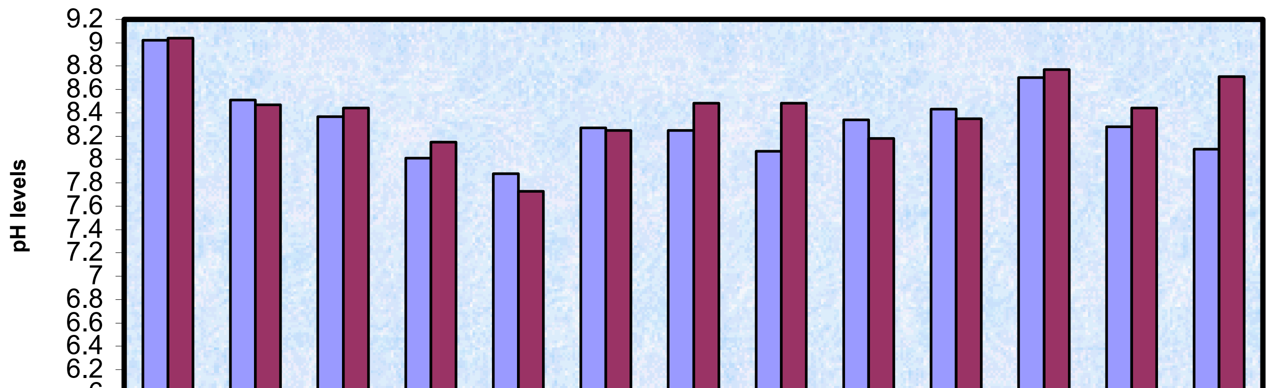


	Difficult	Mill St Br	Slaughterhouse	Gerbaz	Below RF Club	7-11 Br	Midland	Emma	Ranch @ RF	Sanders Ranch	Park East	7th St Br
High flow	18	24	90	108	116	122	114	120	142	134	134	140
Low flow	44	54	154	228	254	224	188	218	216	300	310	294

Sample site

This graph shows how hardness values increase downstream for both low and high flow. The low values upstream at difficult, Mill Street and Slaughterhouse reflect granite bedrock while values downriver reflect sedimentary rock.

Figure 12: pH Values of tributaries at High and Low Flow (June & October 2000)

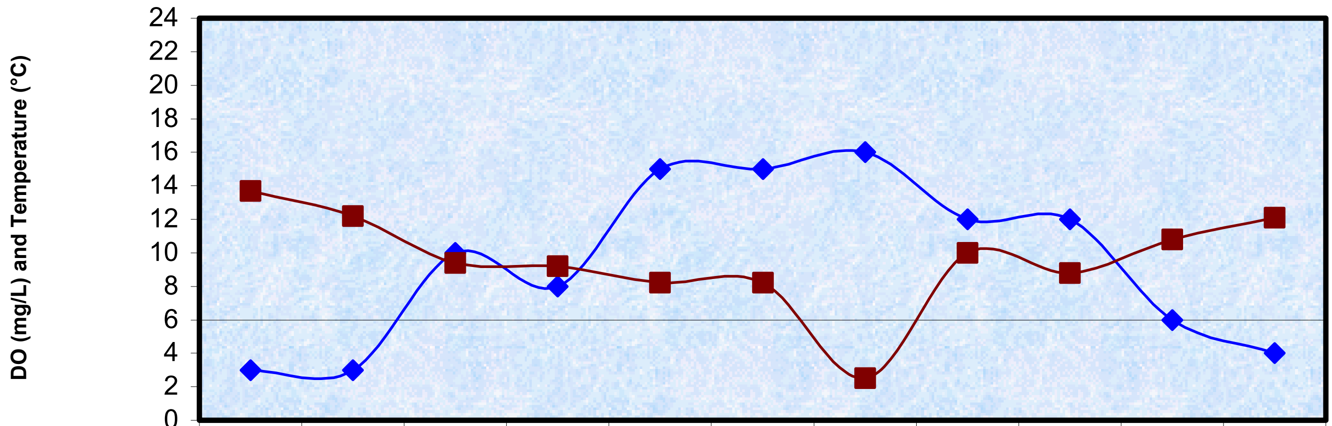


	Brush Cr	Capitol Cr	Snowmass Cr	Meredith	Baetis Br	Below 7 Cast	Upper Bas Br	Sopris Cr	Genter Mine Br	Redstone	Coal Cr Rec	Coryell Ranch	4 Mile Cr
pH high	9.02	8.51	8.37	8.01	7.88	8.27	8.25	8.07	8.34	8.43	8.7	8.28	8.09
pH low	9.04	8.47	8.44	8.15	7.73	8.25	8.48	8.48	8.18	8.35	8.77	8.44	8.71

Sample Site

State standard for pH is between 6.5 and 9.0. This graph shows pH values at high and low flow for all tributary sampling locations. These higher values are indicative of pH vales valley-wide.

Figure 13: Ranch at Roaring Fork Dissolved Oxygen and Temperature for Year 2000

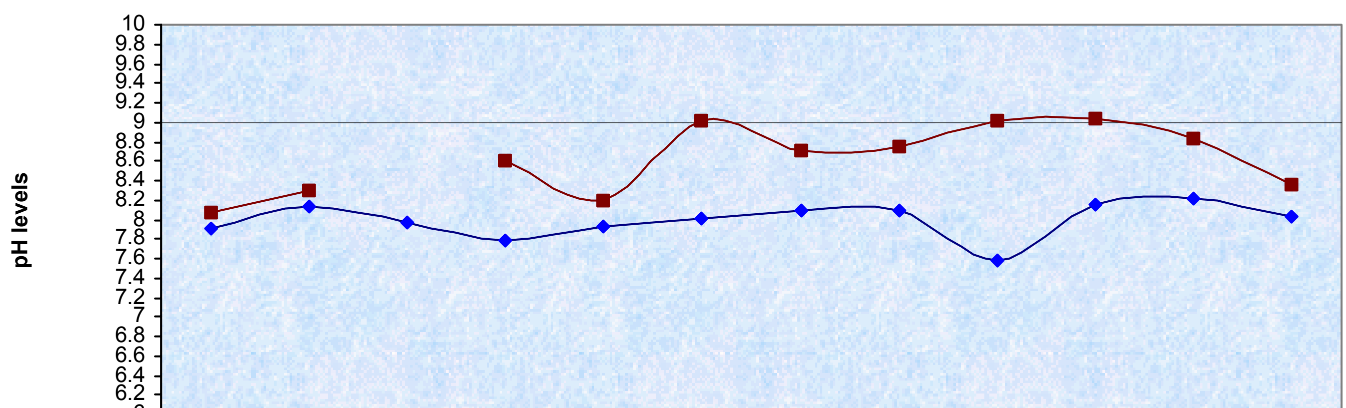


	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Temperature	3	3	10	8	15	15	16	12	12	6	4
Dissolved Oxygen	13.7	12.2	9.4	9.2	8.2	8.2	2.5	10	8.8	10.8	12.1

Year 2000

State standard for dissolved oxygen is 6.0 mg/L. This graph shows a dissolved oxygen reading in August that fell below state standards. Low flow, high water temperatures, and decomposition of organic matter by bacteria can cause this condition.

Figure 14: Brush Creek and Meredith pH levels for Year 2000

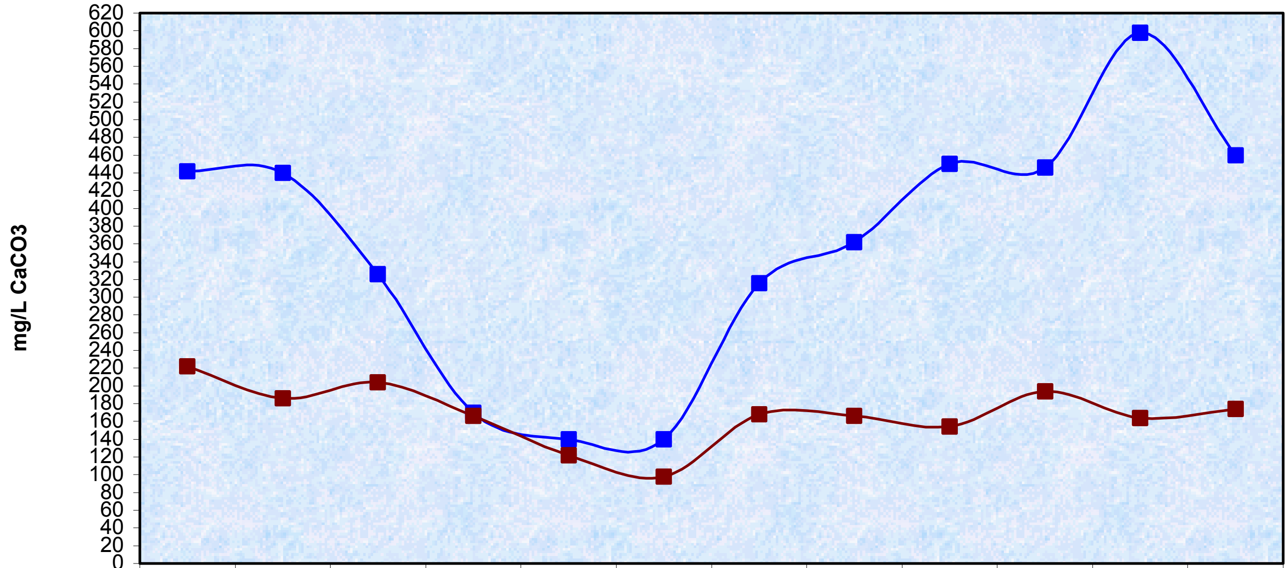


	January	February	March	April	May	June	July	August	September	October	November	December
Meredith	7.9	8.13	7.96	7.79	7.93	8.01	8.1	8.09	7.58	8.15	8.21	8.03
Brush Creek	8.07	8.3		8.61	8.2	9.02	8.7	8.75	9.02	9.04	8.83	8.35

Year 2000

State standard for pH is between 6.5 and 9.0. This graph shows how pH levels at Brush Creek exceeded State standards during June, September, and October. Notice how pH levels at Meredith were lower, yet met state standards.

Figure 15: Coal Creek Rec Total Alkalinity and Total Hardness for Year 2000

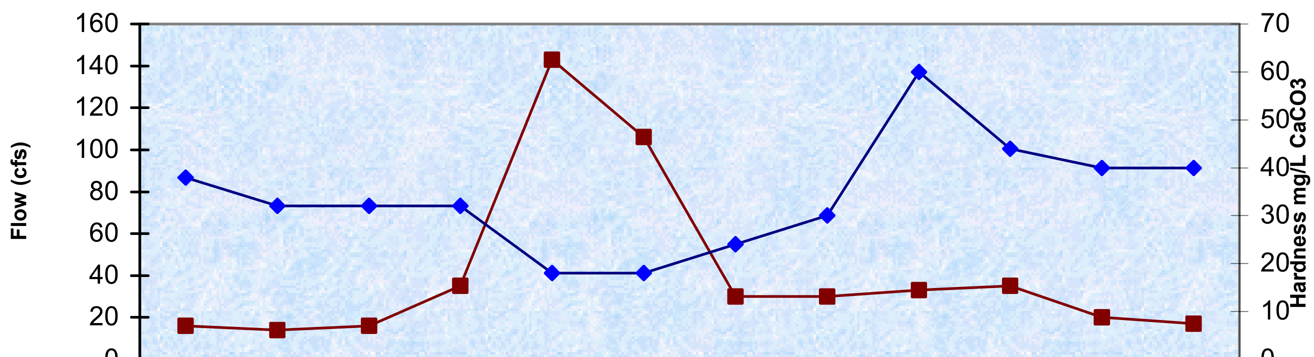


	January	February	March	April	May	June	July	August	September	October	November	December
Alkalinity	442	440	326	170	140	140	316	362	450	446	598	460
Hardness	222	186	204	166	122	98	168	166	154	194	164	174

Year 2000

This graph shows the high alkalinity levels at this site. This is due to the Mancos shale deposits found here. Normally, hardness exceeds alkalinity.

Figure 16: Flow and Total Hardness at Difficult Campground for the Year 2000

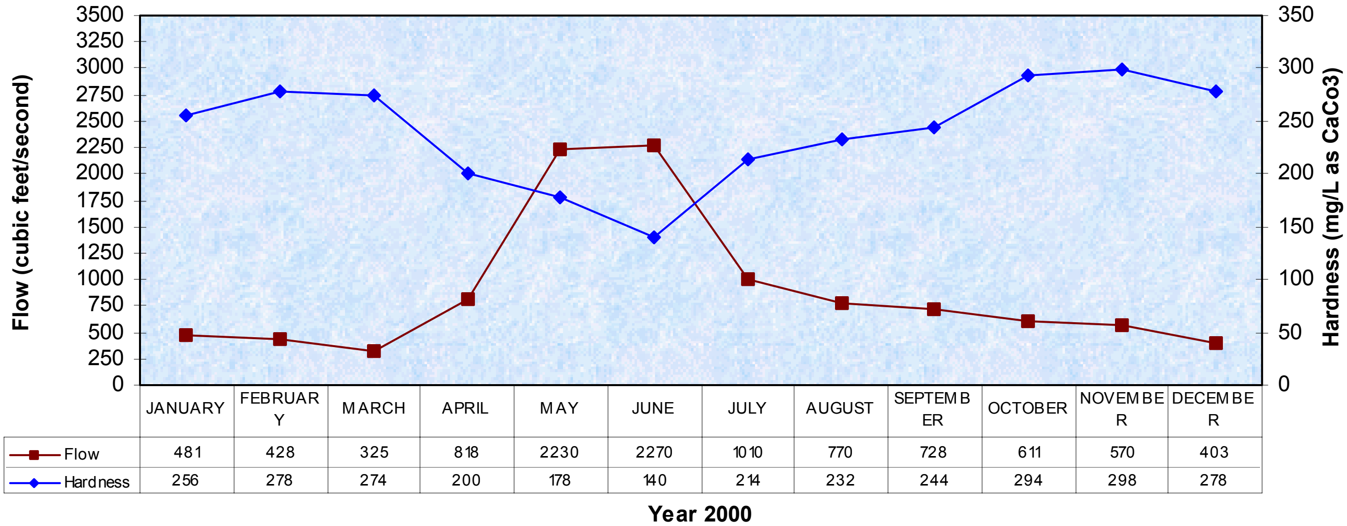


	January	February	March	April	May	June	July	August	September	October	November	December
Flow	16	14	16	35	143	106	30	30	33	35	20	17
Hardness	38	32	32	32	18	18	24	30	60	44	40	40

Year 2000

This graph shows the relationship between flow and hardness. Notice how hardness values decrease during high flow (dilution) and increase during low flow. See next graph for flow/hardness relationship downstream.

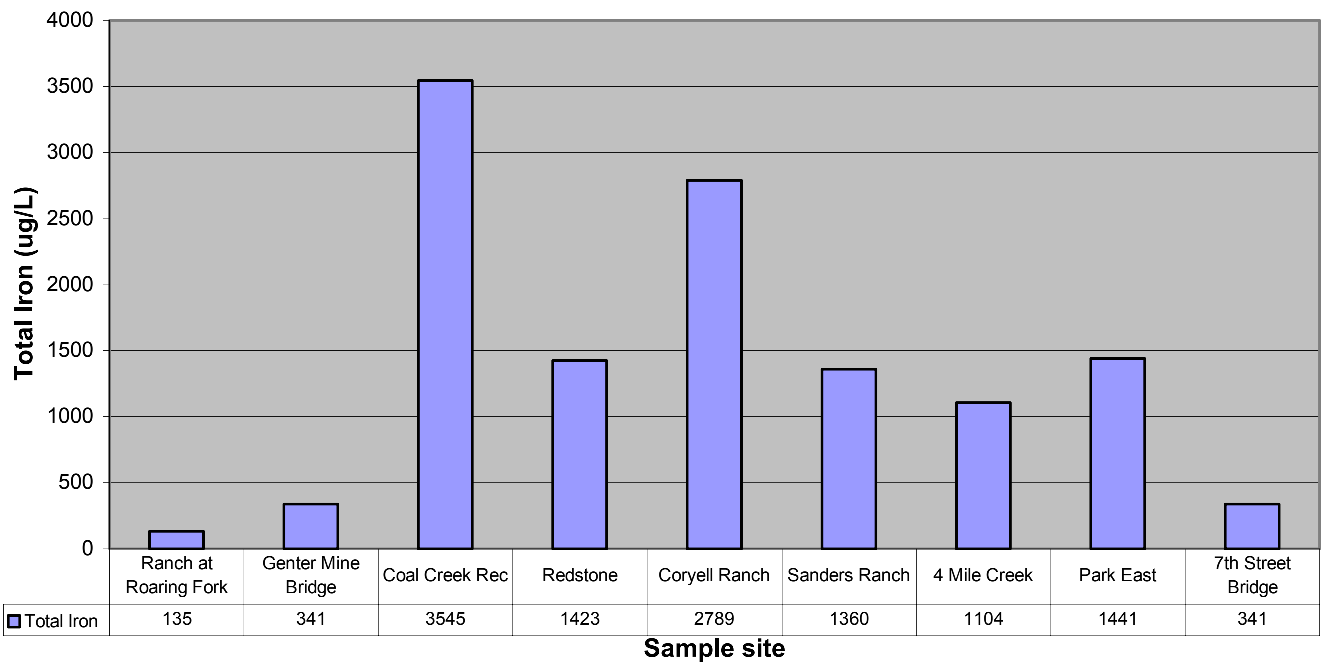
Figure 17: Flow and Total Hardness at 7th Street Bridge for the Year 2000



	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Flow	481	428	325	818	2230	2270	1010	770	728	611	570	403
Hardness	256	278	274	200	178	140	214	232	244	294	298	278

This graph shows the flow/hardness relationship at the Roaring Fork's mouth. Values for both parameters are higher than those of the previous graph. The data are similar to the previous graph in terms of values at high and low flow.

Figure 18: Total Iron values for April at downstream samplling locations on the Roaring Fork and Crystal Rivers



	Ranch at Roaring Fork	Genter Mine Bridge	Coal Creek Rec	Redstone	Coryell Ranch	Sanders Ranch	4 Mile Creek	Park East	7th Street Bridge
Total Iron	135	341	3545	1423	2789	1360	1104	1441	341

This graph shows how total iron values increased on the Crystal and Roaring Fork Rivers. An accumulation of this metal in snowpack might have subsequently flushed out during spring runoff. The state standard for iron is 1000 ug/L.

The Roaring Fork meets the Colorado River at its confluence in Glenwood Springs, Colorado

11. Findings and Future Directions

Overall, the data indicate that water quality throughout the watershed is at a high level. Beneficial uses are being supported and the water is suitable for supporting aquatic life, agriculture, and recreation in the segments where these uses are designated. Alkalinity and hardness parameters provide good references for defining baseline conditions. These parameters, measured at the various sample locations over time, appear to be consistent with the River Continuum Concept and the geology of the basin as outlined in Section 3. Values for both of these parameters increase downstream, as predicted. This is also reflected in the granite bedrock at the headwaters and sedimentary bedrock along the hillsides and Valley floor.

Dissolved oxygen and temperature readings throughout the watershed indicate that the Roaring Fork River and its tributaries are capable of sustaining a variety of aquatic species in a healthy ecosystem. With regard to pH, although the values are generally high throughout the Valley, reflecting the geology, most values remained within WQCC stream standards established to support a healthy ecosystem.

Approximately 80% of the metals samples taken in 2000 have been analyzed and forwarded to the Conservancy by CDOW. At the time of this report, high total iron readings were noted in April 2000 at five sites along the Crystal and lower Roaring Fork Rivers. Although these readings exceed the state standard of 1000 micrograms per liter (ug/L), they do not represent a violation unless they are exceeded at least one more time during a three-year period with readings above the 50th percentile of data collected. Also, high values for cadmium, lead, and selenium were found at the Redstone site. The Conservancy will notify the CDPHE of these high values and has developed a strategy to isolate the source of this problem. Sampling upstream of this site at strategic locations can help determine where high concentrations of metals may be entering the river.

Two additional potential problem areas were found during the first year of testing. These included one low data point for dissolved oxygen at the Ranch at Roaring Fork site, and high pH levels on a few occasions (exceeding WQCC stream standards) at the Brush Creek site. Additional testing for dissolved oxygen at the Ranch at Roaring Fork site in the summer of 2001 may help clarify the low reading that fell below state standards for dissolved oxygen (less than 6 mg/L). The high pH levels at the Brush Creek site (possibly due to a higher alkalinity) are consistent with historical data taken by the CDPHE (1998 and 1999).

Sampling in 2001

In the first year of data collection, the purpose of the Conservancy's Water Quality Monitoring Program was to gather baseline water chemistry information in order to evaluate the chemical health of the Roaring Fork River and its tributaries. It is now important to review what questions we asked when we first initiated the program and if the data collected has answered these questions. For instance, did the data collected meet WQCC stream standards? If not, why? Have we established a solid baseline monitoring program with which to compare future data and establish trends? Are we sampling in the proper locations, at the proper frequency, and for the appropriate constituents that we originally configured? Further, what program changes need to be made in order to address these questions and future questions about the health of the Roaring Fork River and its tributaries over the long term? Using this as a barometer, the Conservancy, will continue to adjust the monitoring design as a result of data analysis, outside input, and evolving needs throughout the basin and over time.

For the year 2001, the Conservancy decided that additional baseline data was needed in order to best evaluate existing conditions. Chemical monitoring continued into its second year, however additional parameters were added in order to address the physical and biological health of the watershed, and to provide additional baseline information to supplement water column chemistry data. By incorporating chemical data from the first and second years of monitoring with physical habitat evaluations and biological data collected in 2001 and beyond, a more comprehensive look at the health of the Roaring Fork watershed will be accomplished.

Adjustments to sampling sites have also been made. The Conservancy decided to reduce the number of sites tested from 25 to 23. Three of the original sites have been eliminated (Below RF Club, Below 7 Castles, and Midland), with the addition of a new site (Crystal Fish Hatchery). Two of the 23 sites (Coal Creek Rec and Meredith) were monitored on a quarterly basis.

After two years of sampling, the sites, parameters, and frequency of sampling will be re-evaluated to address the need for long-term trend analysis spatially and temporally. Further, by including the use of statistical models designed to quantify trends and significant changes more accurately and consistently, the Conservancy will be able to make sound scientific and managerial decisions on where to direct the program into the future.

Additions to the program include the following:

- Physical habitat evaluations: These help determine physical changes over time at a particular sampling location. Changes in the physical habitat influence water chemistry and aquatic life. These evaluations are accomplished quarterly and will be used along with chemical and biological data in order to fully assess river health.
- Monitoring for macroinvertebrates: This was conducted in the fall of 2001. The CDPHE sponsored the collection and analysis at 13 sites valley-wide. Stream Team volunteers and River Watch students have been trained on how to collect these organisms.
- Sampling for nutrients: The Conservancy implemented a plan to sample and analyze nutrients three times in 2001. Nutrients include nitrate, ammonia, phosphate, chloride, sulfate, and total suspended solids. In 2001, CDOW sponsored these collections along with the analyses for all 23 sites.
- Flow measurements: The Conservancy took flow measurements at several sites during 2001. This will complement flow measurements taken at the four USGS sampling locations. Flows are taken when chemical monitoring takes place. Flow measurements provide information on how much water is diluting a particular parameter, and how parameter levels change during different flow regimes such as high and low flow, snowmelt, or thunderstorms.

Basalt High School Students Check their Kick Nets for Macroinvertabrates.

The Conservancy hopes that the continued monitoring of the chemical, physical, and biological parameters of the Roaring Fork River and its tributaries will lead state and local governments, as well as individuals to make better-informed decisions about water quality in the watershed. Based upon our work, we strongly encourage the use of Best Management Practices (BMP's), stream restoration projects, other improvements (based upon the need), and regulatory decisions where appropriate. Such committed and comprehensive attention to the state of the Valley's rivers will help ensure the health and integrity of the Roaring Fork River system well into the future.

12. River Stewardship

The Roaring Fork Conservancy's mission is to "promote awareness of the importance of the watershed and to ensure the quality of our Valley for the benefit of all its inhabitants." Engaging the community to become stewards of the Roaring Fork watershed is an integral approach in actively realizing this mission. The Conservancy, through its water quality monitoring program, strives to foster long-term conservation and stewardship of the Roaring Fork watershed through participation of community members who are intimately involved with their rivers and streams.

Creating a stewardship ethic includes the building of partnerships. These partnerships link government agencies, schools, local businesses, foundations, and the general public, working together to achieve a common goal of river protection and preservation. It is also through these partnerships that the Conservancy can assure continuation of the water quality program, which will allow ongoing tracking of and response to changes in the water quality of the Roaring Fork River and its tributaries. Finally, working cooperatively with others improves the chances of a grassroots effort toward protection of the Valley's environmental quality for all current and future inhabitants.

We gratefully acknowledge the following project partners for the valuable guidance and input they have provided to the Conservancy's Water Quality Monitoring Program:

City of Aspen Environmental Health Office
Carbondale Environmental Board
Colorado Department of Public Health and Environment
Colorado Division of Wildlife
Colorado River Water Conservation District (CRWCD)
Eagle County Environmental Health Department
Northwest Colorado Council of Governments (NWCCOG)
Pitkin County Environmental Health Department
Roaring Fork Club
Town of Basalt
Town of Snowmass Village
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U.S. Forest Service
U.S. Geological Survey

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Colorado Division of Wildlife
Colorado River Water Conservation District
City of Aspen
Northwest Colorado Council Of Governments
Pitkin County
Town of Basalt

The following schools, through the River Watch curriculum, are active participants in the Program:

Aspen High School, Marc Whitley and students
Basalt High School, Andre Wille and students
Alpine Christian Academy, Susan Blue and students
Marble Charter School, Christy Welles and students
Carbondale Middle School, Pete Doherenwend and students
Glenwood Springs High School, Mike Wilde and students
Colorado Mountain College, Peter Jeshofnig and students

And last but not least, the program is sustained, in the truest sense of the word, by a dedicated and passionate group of Stream Team Volunteers that we would like to recognize:

Chuck Albin
Rob Baxter
Ernie Bradley
Mike Bradley
Jill Briggs
Ed Cervone
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14. Appendices

A. State Water Quality Standards
B. Roaring Fork Water Quality Standards
C. Monthly Data (four seasonal examples)
D. Station Data (five selected sites)
E. Summary Statistics
F. Roaring Fork Conservancy Information

Appendix A

TABLE I

PHYSICAL AND BIOLOGICAL PARAMETERS

PARAMETER	RECREATIONAL			AQUATIC LIFE			AGRICULTURE	DOMESTIC WATER SUPPLY
	CLASS 1a EXISTING PRIMARY CONTACT	CLASS 1b POTENTIAL PRIMARY CONTACT	CLASS SECONDARY CONTACT	CLASS 1 COLD WATER BIOTA	CLASS 1 WARM WATER BIOTA	CLASS 2		
PHYSICAL								
D.O. (mg/l)(1)(8)	3.0 (A)		3.0 (A)	6.0(2)(G) 7.0(spawning)	5.0 (A)		3.0 (A)	3.0 (A)
pH (Std. Units)(3)	6.5-9.0 (Bm)			6.5-9.0(A)	6.5-9.0(A)			5.0-9.0(A)
Suspended Solids(4)								
Temperature (°C)				Max 20 °C, with 3 °C Increase (5)(G)	Max 30° C, with 3 C Increase (5)(G)			
BIOLOGICAL:								
Fecal Coliforms per 100 ml (Geometric Mean)	200(6)(A)	325(6)	2000(6)(GM)					2000(E)
E. Coli per 100 ml	126(6)	205(6)	630(6)					630

Note: Capital letters in parentheses refer to references listed in section 31.16(3); Numbers in parentheses refer to Table 1 footnotes.

Appendix A (cont.)

TABLE II

INORGANIC PARAMETERS

PARAMETER	AQUATIC LIFE			AGRICULTURE	DOMESTIC WATER SUPPLY
	CLASS 1 Cold Water Biota	CLASS 1 Warm Water Biota	CLASS 2		
INORGANICS:					
Ammonia (mg/l as N) (Un-ionized unless otherwise noted)	chronic = 0.02(K) acute = 0.43/FT/FPH/2[4]	chronic = 0.06(K) acute = 0.62/FT/FPH/2[4]	acute: see (1) chronic: Cold = 0.02 Warm = 0.06-0.10[1]		0.5 total [2](K) (30-day)
Total residual Chlorine (mg/l)	0.019 (L) (1-day) 0.011 (L) (30-day)	0.019 (L) (1-day) 0.011(L) (30-day)			
Cyanide – Free (mg/l)	0.005(H) (1-day)	0.005(H) (1-day)		0.2(G) (1-day)	0.2(B,D[m]) (1-day)
Fluoride (mg/l)					2.0[5](E) (1-day)
Nitrate (mg/l as N)				100(3)(B)	10[6](K) (1-day)
Nitrite (mg/l as N)	TO BE ESTABLISHED ON (5)	A CASE BY CASE BASIS (5)		10(3)(B) (1-day)	1.0(2)[6](K) (1-day)
Sulfide as H2S(mg/l)	0.002 undissociated(A) (30-day)	0.002 undissociated(A) (30-day)			0.05(F) (30-day)
Boron (mg/l)				0.75(A,B) (30-day)	
Chloride (mg/l)					250(F) (30-day)
Sulfate (mg/l)					250(F) (30-day)
Asbestos					7,000,000 fibers/L[7]

NOTE: Capital letters in parentheses refer to references listed 31.16(3); numbers in parentheses refer to table II footnotes.

TABLE III
METAL PARAMETERS

(Concentration in ug/l)

METAL[1]	AQUATIC LIFE [1][3][4][J]		AGRI-CULTURE[2]	DRINKING WATER-SUPPLY[2]	WATER + FISH[7]	FISH INGESTION [10]
	ACUTE	CHRONIC				
Aluminum	750	87			---	---
Antimony				6.0 (30-day)	6.0	4,300
Arsenic	340	150	100[A] (30-day)	50[E] (1-day)	0.018	0.14
Barium				1,000[E](1-day) 490 (30-day)	---	---
Beryllium			100[A,B] (30-day)	4.0 (30-day)	---	---
Cadmium	$(1.13667-[\ln(hardness)*(0.04184)])*e^{(1.128[\ln(hardness)]-3.6867)}$ (Trout)=$(1.13667-[\ln(hardness)*(0.04184)])*e^{(1.128[\ln(hardness)]-3.828)}$	$(1.10167-[\ln(hardness)*(0.04184)])*e^{(0.7852[\ln(hardness)]-2.715)}$	10[B] (30-day)	5.0[E] (1-day)	---	---
Chromium III[5]	$e^{(0.819[\ln(hardness)]+2.5736)}$	$e^{(0.819[\ln(hardness)]+0.5340)}$	100[B] (30-day)	50[E] (1-day)	---	---
Chromium VI[5]	16	11	100[B] (30-day)	50[E] (1-day)	100(30-day)	---
Copper	$e^{(0.9422[\ln(hardness)]-1.7408)}$	$e^{(0.8545[\ln(hardness)]-1.7428)}$	200[B]	1,000[F] (30-day)	---	---
Iron		1,000(tot.rec.)[A,C]		300(dis)[F] (30-day)	---	—

(continued on next page)

Appendix A (cont.)

TABLE III
METAL PARAMETERS

(Concentration in ug/l)

METAL[1]	AQUATIC LIFE [1][3][4][J]		AGRI-CULTURE[2]	DRINKING WATER-SUPPLY[2]	WATER + FISH[7]	FISH INGESTION [10]
	ACUTE	CHRONIC				
Lead	$(1.46203-[\ln(\text{hardness})^*(0.145712)])^* e^{(1.273[\ln(\text{hardness})]-1.46)}$	$(1.46203-[\ln(\text{hardness})^*(0.145712)])^* e^{(1.273[\ln(\text{hardness})]-4.705)}$	100[B] (30-day)	50[E] (1-day)	—	---
Manganese	$e^{(0.3331[\ln(\text{hardness})]+6.4676)}$	$e^{(0.3331[\ln(\text{hardness})]+5.8743)}$	200[B] (30-day)	50(dis)[F] (30-day)	—	---
Mercury	1.4	0.77 FRV(fish) [6] = 0.01 (Total)		2.0[E] (1-day)	—	---
Nickel	$e^{(0.846[\ln(\text{hardness})]+2.253)}$	$e^{(0.846[\ln(\text{hardness})]+0.0554)}$	200[B] (30-day)	100[E] (30-day)	—	4,600
Selenium[9]	18.4	4.6	20[B,D] (30-day)	50[E] (30-day)	—	---
Silver	$½e^{(1.72[\ln(\text{hardness})]-6.52)}$	$e^{(1.72[\ln(\text{hardness})]-9.06)}$ (Trout) = $e^{(1.72[\ln(\text{hardness})]-10.51)}$		100[F] (1-day)	—	---
Thallium		15[C]		0.5 (30-day)	0.5	6.3
Uranium	$e^{(1.1021[\ln(\text{hardness})]+2.7088)}$	$e^{(1.1021[\ln(\text{hardness})]+2.2382)}$			---	---
Zinc	$e^{(0.8473[\ln(\text{hardness})]+0.8618)}$	$e^{(0.8473[\ln(\text{hardness})]+0.8699)}$	2000[B] (30-day)	5,000[F] (30-day)		

NOTE: Capital letters in parentheses refer to references listed in section 31.16(3);
Numbers in parentheses refer to Table III footnote

Appendix B

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 12 BASIN: Roaring Fork River Stream Segment Description		Desig	Classifications	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
1.	All tributaries to the Roaring Fork River system, including all wetlands, lakes and reservoirs, within the Maroon Bells/Snowmass, Holy Cross, Raggeds, Collegiate Peaks and the Hunter/Fryingpan Wilderness Areas.	OW	Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)=0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
2.	Mainstem of the Roaring Fork River, including all tributaries, wetlands, lakes and reservoirs, from the source to a point immediately below the confluence with Hunter Creek, except for those tributaries included in Segment 1.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)=0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
3.	Mainstem of the Roaring Fork River, including all tributaries, wetlands, lakes and reservoirs from a point immediately below the confluence with Hunter Creek, to the confluence with the Colorado River except for those tributaries included in Segment 1 and specific listings in Segments 3a through 10.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)=0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
3a.	Mainstem of Red Canyon and all tributaries, wetlands, lakes and reservoirs from the source to the confluence with the Roaring Fork River, except for Landis Creek from its source to the Hopkins Ditch Diversion.	UP	Aq Life Cold 2 Recreation 2 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.1 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)=0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
4.	Mainstem of Brush Creek from the source to the confluence with the Roaring Fork River.	UP	Aq Life Cold 1 Recreation 2 Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05	As(ch)=100(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
5.	Mainstem of the Fryingpan River from the source to the confluence with the North Fork.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)-0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
6.	Mainstem of the Fryingpan River from the confluence with the North Fork to the confluence with the Roaring Fork River, including Ruedi Reservoir.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)-0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	

Appendix B (cont.)

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

	Stream Segment Description	Desig	Classifications	Physical and Biological	Inorganic (mg/l)	Inorganic (mg/l)	Metals (ug/l)	Metals (ug/l)	Metals (ug/l)	Temporary Modifications and Qualifiers
7.	All tributaries to the Fryingpan River system, including all wetlands, lakes and reservoirs, except for those tributaries included in Segment 1.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)-0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
8.	Mainstem of the Crystal River, including all tributaries, wetlands, lakes and reservoirs, from the source to the confluence with the Roaring Fork River, except for specific listings in Segments 1, 9 and 10.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)-0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
9.	Mainstem of Coal Creek including all tributaries, wetlands, lakes and reservoirs from the source to the confluence with the Crystal River.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)-0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) U(ac/ch)=TVS Zn(ac/ch)=TVS	

REGION: 12 BASIN: Roaring Fork River Stream Segment Description		Desig	Classifications	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
10.	Mainstem of North Thompson Creek, including all tributaries, wetlands, lakes and reservoirs from the source to the confluence with the Crystal River.		Aq Life Cold 1 Recreation 2 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50 Hg(ch)=0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	

Appendix C:Monthly Data   February 2000 Data Results

Station #	Sample #	Station	Date	Time	Flow (cfs)	pH	Temp	Phen Al	Total Al	Total H	DO
769	769.002	Difficult	2/17/00	1400	14(avg)	7.97	2	0	28	32	8.30
770	770.002	Mill St Br	2/17/00	1307	-9	7.80	2	0	42	48	8.50
68	68.030	Slaughterhouse	2/17/00	1235	-9	8.25	2	0	86	166	10.0
771	771.002	Brush Cr	2/17/00	1109	-9	8.30	3	4	128	166	10.4
71	71.008	Gerbaz Br	2/17/00	1146	-9	8.40	3	8	100	226	11.2
773	773.002	Capitol Cr	2/16/00	952	-9	8.25	0	12	166	362	10.8
774	774.002	Snowmass Cr	2/16/00	1020	-9	8.28	1	8	146	276	10.0
775	775.002	Below RF Club	2/16/00	1000	-9	8.55	2	24	110	232	12.7
72	72.114	7-11 Br	2/16/00	1030	-9	8.10	2	0	76	134	12.0
776	776.002	Meredith	2/16/00	1158	-9	8.13	0	0	56	68	10.3
733	733.016	Baetis Br	2/16/00	1235	96(avg)	8.08	4	0	50	108	10.4
732	732.016	Below 7 Castles	2/16/00	1312	-9	8.12	3	0	54	116	10.4
73	73.085	Upper Basalt Br	2/16/00	1030	-9	8.64	1	24	118	232	10.9
777	777.002	Midland	2/16/00	1400	-9	8.81	4	12	78	170	11.1
778	778.002	Sopris Cr	2/10/00	1420	-9	-9	0	92	154	280	13.0
779	779.002	Emma	2/10/00	1330	259(avg)	-9	1	0	84	176	12.2
780	780.002	Ranch @ RF	2/16/00	915	-9	8.44	3	16	102	198	13.7
735	735.021	Genter Mine Br	2/10/00	1145	-9	8.42	0	0	74	272	9.4
736	736.021	Redstone	2/17/00	1350	-9	8.25	1	0	136	240	10.7
782	782.002	Coal Cr/Rec	2/17/00	1315	-9	8.44	1	64	440	186	-9
783	783.002	Coryell Ranch	2/16/00	1210	-9	8.58	5	24	140	304	11.9
784	784.002	Sanders Ranch	2/16/00	1130	-9	8.75	4	24	118	238	13.7
785	785.002	4 Mile Cr	2/17/00	1045	-9	8.27	5	16	254	266	10.0
786	786.002	Park East	2/16/00	1015	-9	8.53	3	8	136	248	12.3
45	45.149	7th St Br	2/9/00	1050	428	8.22	2	0	122	278	10.0

Station #	Sample #	Station	Date	Time	Flow (cfs)	pH	Temp	Phen Al	Total Al	Total H	DO
769	769.005	Difficult	5/17/2000	1230	143(avg)	7.55	4	0	16	18	9.6
770	770.005	Mill St Br	5/17/2000	1125	-9	7.80	4	0	18	22	9.3
68	68.033	Slaughterhouse	5/17/2000	906	-9	7.80	5	0	36	72	-9
771	771.005	Brush Cr	5/17/2000	1015	-9	8.20	5	4	86	102	9.3
71	71.011	Gerbaz Br	5/17/2000	1035	-9	8.00	5	0	56	104	9.3
773	773.005	Capitol Cr	5/17/2000	950	-9	8.52	7	32	178	356	8.9
774	774.005	Snowmass Cr	5/17/2000	940	-9	8.31	7	4	94	144	9.4
775	775.005	Below RF Club	5/17/2000	1000	-9	8.19	8	0	58	110	9.2
72	72.119	7-11 Br	5/18/2000	1530	-9	8.53	7	12	70	128	-9
776	776.005	Meredith	5/18/2000	1130	-9	7.93	5	0	34	40	9.4
733	733.019	Baetis Br	5/18/2000	1220	173(avg)	8.21	5	0	48	104	10.9
732	732.019	Below 7 Castles	5/18/2000	1300	-9	8.18	8	4	62	114	9.3
73	73.089	Upper Basalt Br	5/26/2000	1115	-9	8.80	8	0	48	112	9.1
777	777.005	Midland	5/17/2000	1030	-9	8.30	7	0	58	110	10.5
778	778.005	Sopris Cr	5/17/2000	1100	-9	-9	7	0	88	156	9.2
779	779.005	Emma	5/17/2000	1100	888(avg)	-9	7	0	72	136	9.9
780	780.005	Ranch @ RF	5/17/2000	1500	-9	-9	8	0	74	150	9.2
735	735.024	Genter Mine Br	5/18/2000	1015	-9	8.32	5	0	70	110	10.1
736	736.024	Redstone	5/18/2000	1150	-9	8.26	6	0	72	102	9.8
782	782.005	Coal Cr/Rec	5/18/2000	1215	-9	8.48	6	12	140	122	9.2
783	783.005	Coryell Ranch	5/18/2000	1115	-9	8.17	8	0	78	118	9.9
784	784.005	Sanders Ranch	5/18/2000	1015	-9	8.15	8	0	84	138	10.1
785	785.005	4 Mile Cr	5/18/2000	1600	-9	8.72	13	28	196	226	8.4
786	786.005	Park East	5/18/2000	1230	-9	8.24	9	0	76	130	10.2
45	45.152	7th St Br	5/11/2000	1230	2230(avg)	8.65	10	60	116	178	9.0

August 2000 Data Results

Station #	Sample #	Station	Date	Time	Flow (cfs)	pH	Temp	Phen Al	Total Al	Total H	DO
769	769.008	Difficult	8/10/2000	1035	30(avg)	7.90	11	0	24	30	7.8
770	770.008	Mill St Br	8/10/2000	-9	-9	7.90	15	0	40	56	7.7
68	68.036	Slaughterhouse	8/10/2000	1205	-9	8.27	15	4	84	178	8.0
771	771.008	Brush Cr	8/9/2000	1100	-9	8.75	15	24	138	206	7.6
71	71.014	Gerbaz Br	8/9/2000	1300	-9	8.38	15	12	104	198	8.0
773	773.008	Capitol Cr	8/9/2000	930	-9	8.46	12	20	206	484	8.6
774	774.008	Snowmass Cr	8/9/2000	930	-9	8.43	13	24	144	322	8.7
775	775.008	Below RF Club	8/10/2000	1035	-9	8.52	15	16	118	252	8.0
72	72.123	7-11 Br	8/10/2000	1600	-9	8.76	20	28	112	212	7.9
776	776.008	Meredith	8/9/2000	1045	-9	8.09	14	0	82	56	7.9
733	733.022	Baetis Br	8/9/2000	1115	308(avg)	7.85	8	0	44	86	9.8
732	732.022	Below 7 Castles	8/9/2000	1145	-9	8.17	12	0	50	94	8.6
73	73.092	Upper Basalt Bridge	8/10/2000	1600	-9	8.18	13	0	46	94	8.4
777	777.008	Midland	8/10/2000	1330	-9	8.56	16	4	64	136	8.3
778	778.008	Sopris Cr	8/10/2000	1115	-9	8.45	16	12	122	246	7.9
779	779.008	Emma	8/10/2000	1135	541(avg)	8.40	16	4	78	158	8.6
780	780.008	Ranch @ RF	8/10/2000	1800	-9	8.63	16	12	94	162	2.5
735	735.027	Genter Mine Br	8/9/2000	1330	-9	8.34	16	8	80	192	7.4
736	736.027	Redstone	8/9/2000	1300	-9	8.62	14	16	99	184	8.0
782	782.008	Coal Cr/Rec	8/9/2000	1300	-9	8.75	20	48	362	166	6.6
783	783.008	Coryell Ranch	8/9/2000	1140	-9	8.42	17	12	180	122	8.2
784	784.008	Sanders Ranch	8/9/2000	1025	-9	8.38	15	12	132	244	9.9
785	785.008	4 Mile Cr	8/9/2000	930	-9	7.99	13	4	278	316	7.6
786	786.008	Park East	8/10/2000	1830	-9	8.51	22	4	68	236	8.3
45	45.155	7th St Br	8/9/2000	1350	770(avg)	8.55	16	8	92	232	8.2

Station #	Sample #	Station	Date	Time	Flow (cfs)	pH	Temp	Phen Al	Total Al	Total H	DO
769	769.011	Difficult	11/1/2000	945	20 (avg)	7.79	3	0	26	40	10.6
770	770.011	Mill St Br	11/2/2000	1530	-9	7.08	9	0	32	58	9.50
68	68.039	Slaughterhouse	11/1/2000	1020	-9	8.26	3	0	84	164	10.1
771	771.011	Brush Cr	11/1/2000	1130	-9	8.83	6	2	160	210	9.9
71	71.017	Gerbaz Br	11/1/2000	1100	-9	8.14	4	0	102	240	11.2
773	773.011	Capitol Cr	11/1/2000	930	-9	8.33	3	24	162	422	9.8
774	774.011	Snowmass Cr	11/1/2000	1000	-9	8.21	4	12	134	314	10.2
775	775.011	Below RF Club	11/1/2000	1050	-9	8.34	4	24	122	264	10.8
72	72.126	7-11 Br	11/2/2000	830	-9	8.76	7	36	98	234	10.5
776	776.011	Meredith	11/1/2000	1350	-9	8.21	3	0	48	70	10.4
733	733.025	Baetis Br	11/1/2000	1425	72(avg)	8.06	9	0	42	104	10.4
732	732.025	Below 7 Castles	10/31/2000	1600	-9	-9	5	0	52	124	8.8
73	73.095	Upper Basalt Bridge	11/2/2000	830	-9	8.31	7	0	62	124	10.3
777	777.011	Midland	11/1/2000	1315	-9	8.55	4	12	96	200	10.4
778	778.011	Sopris Cr	11/1/2000	1130	-9	8.36	4	20	122	258	10.3
779	779.011	Emma	11/3/2000	1230	299(avg)	8.70	5	40	116	188	10.0
780	780.011	Ranch @ RF	11/1/2000	1313	-9	8.70	6	12	122	234	10.8
735	735.03	Genter Mine Br	11/2/2000	1030	-9	8.13	4	0	72	192	11.4
736	736.03	Redstone	11/1/2000	1300	-9	8.38	5	0	108	226	9.2
782	782.011	Coal Cr/Rec	11/1/2000	1100	-9	8.86	5	104	598	164	10.4
783	783.011	Coryell Ranch	11/1/2000	1000	-9	8.78	8	20	172	246	10.5
784	784.011	Sanders Ranch	11/1/2000	930	-9	8.34	7	24	144	298	11.2
785	785.011	4 Mile Cr	11/2/2000	1300	-9	8.61	9	20	278	292	9.5
786	786.011	Park East	11/1/2000	1150	-9	8.80	6	20	142	276	9.2
45	45.159	7th St Br	11/8/2000	1220	570(avg)	8.52	4	24	134	298	13.2

2000 Difficult Campground Data Results

Month	River	Station #	Sample #	Station	Date	Time	Flow (cfs)	pH	Temp	Phen Alk	Tot A	Tot H	DO
January	R. FORK	769	769.001	Difficult	1/20/2000	1300	16	7.70	0	0	30	38	10.5
February	R. FORK	769	769.002	Difficult	2/17/2000	1400	14	7.97	2	0	28	32	8.3
March	R. FORK	769	769.003	Difficult	3/16/2000	1515	16		2	0	30	32	10.0
April	R. FORK	769	769.004	Difficult	4/12/2000	1330	35	7.79	5	0	26	32	9.1
May	R. FORK	769	769.005	Difficult	5/17/2000	1230	143	7.55	4	0	16	18	9.6
June	R. FORK	769	769.006	Difficult	6/15/2000	1345	106	7.51	11	0	14	18	8.0
July	R. FORK	769	769.007	Difficult	7/14/2000	1100	30	7.94	13	0	24	24	7.8
August	R. FORK	769	769.008	Difficult	8/10/2000	1035	30	7.90	11	0	24	30	7.8
September	R. FORK	769	769.009	Difficult	9/14/2000	930	33	7.66	8	0	42	60	8.7
October	R. FORK	769	769.010	Difficult	10/5/2000	945	35	7.72	5	0	26	44	9.9
November	R. FORK	769	769.011	Difficult	11/1/2000	945	20	7.79	3	0	26	40	10.6
December	R. FORK	769	769.012	Difficult	12/6/2000	1030	17	7.86	1	0	28	40	12.2

Month	River	Station #	Sample #	Station	Date	Time	Flow (cfs)	pH	Temp	Phen Alk	Tot Al	Tot H	DO
JANUARY	R. FORK	779	779.001	Emma	1/20/2000	1230	260(avg)		3	52	120	192	12.3
FEBRUARY	R. FORK	779	779.002	Emma	2/10/2000	1330	259(avg)		1	0	84	176	12.2
MARCH	R. FORK	779	779.003	Emma	3/9/2000	1245	237(avg)	8.74	7	16	80	200	11.9
APRIL	R. FORK	779	779.004	Emma	4/13/2000	1245	453(avg)	8.72	8	36	80	190	10.5
MAY	R. FORK	779	779.005	Emma	5/17/2000	1100	888(avg)		7	0	72	136	9.9
JUNE	R. FORK	779	779.006	Emma	6/14/2000	1110	1380(avg)	8.27	12	0	62	120	9.4
JULY	R. FORK	779	779.007	Emma	7/14/2000	1120	486(avg)	8.34	15	12	92	172	8.1
AUGUST	R. FORK	779	779.008	Emma	8/10/2000	1135	541(avg)	8.4	16	4	78	158	8.6
SEPTEMBER	R. FORK	779	779.009	Emma	9/13/2000	1250	379(avg)	8.37	13	12	96	190	9.0
OCTOBER	R. FORK	779	779.010	Emma	10/5/2000	1335	330	8.44	12	16	110	218	9.2
NOVEMBER	R. FORK	779	779.011	Emma	11/3/2000	1230	299(avg)	8.7	5	40	116	188	10.0
DECEMBER	R. FORK	779	779.011	Emma	12/8/2000	930	267(avg)	8.37	1	0	94	192	11.2

Appendix D: Station Data (cont.) 2000 7th Street Bridge Data Results

Month	River	Station #	Sample #	Station	Date	Time	Flow (cfs)	pH	Temp	Phen Alk	Tot A	Tot H	DO
JANUARY	R. FORK	45	45.148	7th St Br	1/20/2000	1305	481	8.27	4	20	132	256	12.4
FEBRUARY	R. FORK	45	45.149	7th St Br	2/9/2000	1050	428	8.22	2	0	122	278	10.0
MARCH	R. FORK	45	45.150	7th St Br	3/16/2000	1245	325	8.37	6	24	130	274	10.4
APRIL	R. FORK	45	45.151	7th St Br	4/12/2000	1242	818	8.70	8	40	116	200	9.7
MAY	R. FORK	45	45.152	7th St Br	5/11/2000	1230	2230	8.65	10	60	116	178	9.0
JUNE	R. FORK	45	45.153	7th St Br	6/15/2000	945	2270	8.14	12	0	76	140	9.0
JULY	R. FORK	45	45.154	7th St Br	7/12/2000	1415	1010	8.95	16	16	118	214	8.8
AUGUST	R. FORK	45	45.155	7th St Br	8/9/2000	1350	770	8.55	16	8	92	232	8.2
SEPTEMBE R	R. FORK	45	45.156	7th St Br	9/14/2000	1250	728	8.67	16	20	138	244	9.5
OCTOBER	R. FORK	45	45.158	7th St Br	10/11/200 0	1235	611	8.32	10	32	138	294	11.4
NOVEMBER	R. FORK	45	45.159	7th St Br	11/8/2000	1220	570	8.52	4	24	134	298	13.2
DECEMBER	R. FORK	45	45.160	7th St Br	12/7/2000	1225	403	8.60	2	28	140	278	13.8

Appendix E: Summary Statistics (cont.) pH and Temperature

Site/**pH**	#	Maximum	Minimum	Mean		Site/**Temp**	#	Maximum	Minimum	Mean
Difficult	11	7.97	7.51	7.76		Difficult	12	13	0	5.4
Mill St Br	11	7.98	7.06	7.70		Mill St Br	12	15	0	7.4
Slaughterhs	11	8.40	7.01	8.00		Slaughterhs	12	18	1	8.4
Brush Cr	11	9.04	8.07	8.63		Brush Cr	12	16	0	8.2
Gerbaz Br	11	8.40	8.00	8.28		Gerbaz Br	12	15	1	7.2
Capitol Cr	12	8.58	7.02	8.29		Capitol Cr	12	13	0	6.8
Snowmass Cr	11	8.49	8.14	8.35		Snowmass Cr	11	13	0	6.5
Below RF Club	11	8.59	8.19	8.43		Below RF Club	12	16	1	8.6
7-11 Br	11	8.84	8.10	8.61		7-11 Br	11	20	0	10.3
Meredith	12	8.21	7.58	7.99		Meredith	12	14	-1	5.8
Baetis Br	12	8.21	7.73	7.94		Baetis Br	12	9	3	6.2
Below 7 Cast	11	8.27	7.83	8.11		Below 7 Cast	12	12	0	6.8
Upp Bas Br	12	8.80	7.95	8.37		Upp Bas Br	12	14	1	7.7
Midland	11	8.81	8.22	8.41		Midland	12	16	1	8.0
Sopris Cr	10	8.48	8.07	8.35		Sopris Cr	12	16	0	7.4
Emma	9	8.74	8.27	8.48		Emma	12	16	1	8.3
Ranch @ RF	9	8.97	8.41	8.61		Ranch @ RF	12	16	3	9.1
Genter Mine Br	12	8.42	7.82	8.26		Genter Mine Br	12	16	0	6.8
Redstone	12	8.62	8.25	8.40		Redstone	12	15	0	7.6
Coal Cr Rec	12	8.86	8.44	8.64		Coal Cr Rec	12	20	-1	8.9
Coryell	11	8.78	8.17	8.42		Coryell	11	17	1	9.7
Sanders	12	8.75	8.15	8.43		Sanders	12	15	1	8.7
4 Mile Cr	12	8.86	7.99	8.50		4 Mile Cr	11	17	2	10.8
Park East	12	8.94	8.18	8.52		Park East	12	22	0	10.3
7th St Br	12	8.95	8.14	8.50		7th St Br	12	16	2	8.8

Appendix E: Summary Statistics (cont.) Alkalinity and Hardness

Site/**Alkalinity**	#	Maximum	Minimum	Mean		Site/**Hardness**	#	Maximum	Minimum	Mean
Difficult	12	42	14	26		Difficult	12	60	18	34
Mill St Br	12	46	18	35		Mill St Br	12	58	22	46
Slaughterhs	12	92	36	71		Slaughterhs	12	204	72	155
Brush Cr	12	176	84	136		Brush Cr	12	234	102	181
Gerbaz Br	12	114	56	96		Gerbaz Br	12	240	104	199
Capitol Cr	11	250	126	180		Capitol Cr	12	506	346	397
Snowmass Cr	11	154	84	132		Snowmass Cr	11	322	140	261
Below RF Club	12	126	58	103		Below RF Club	12	264	110	215
7-11 Br	11	122	58	96		7-11 Br	11	234	122	188
Meredith	12	82	26	47		Meredith	12	124	30	64
Baetis Br	12	50	42	46		Baetis Br	12	124	82	102
Below 7 Cast	12	62	50	55		Below 7 Cast	12	124	90	111
Upp Bas Br	12	118	42	57		Upp Bas Br	12	232	90	124
Midland	12	96	50	75		Midland	12	200	110	154
Sopris Cr	12	186	66	126		Sopris Cr	12	316	124	241
Emma	12	120	62	90		Emma	12	218	120	178
Ranch @ RF	12	138	72	110		Ranch @ RF	12	234	142	185
Genter Mine Br	12	80	36	68		Genter Mine Br	12	310	66	190
Redstone	12	136	60	93		Redstone	12	248	52	170
Coal Cr Rec	12	598	140	357		Coal Cr Rec	12	222	98	168
Coryell	12	180	70	133		Coryell	12	336	114	235
Sanders	12	156	68	118		Sanders	12	300	134	235
4 Mile Cr	12	286	110	232		4 Mile Cr	12	316	132	265
Park East	12	142	18	103		Park East	12	310	130	220
7th St Br	12	140	76	121		7th St Br	12	298	140	241

Site/**Diss.Oxy.**	#	Maximum	Minimum	Mean
Difficult	12	12.2	7.8	9.4
Mill St Br	12	11.0	7.5	9.2
Slaughterhs	11	10.7	7.5	9.3
Brush Cr	12	10.7	7.1	9.2
Gerbaz Br	12	12.1	7.9	9.8
Capitol Cr	12	13.2	6.5	9.2
Snowmass Cr	12	12.5	8.2	9.5
Below RF Club	12	13.0	8.0	10.2
7-11 Br	10	12.0	7.9	9.7
Meredith	12	11.7	7.5	9.5
Baetis Br	12	11.3	8.3	10.2
Below 7 Cast	12	10.4	8.4	9.3
Upp Bas Br	10	10.9	8.2	9.5
Midland	12	13.8	8.3	10.1
Sopris Cr	12	13.0	7.4	9.8
Emma	12	12.3	8.1	10.2
Ranch @ RF	11	13.7	2.5	9.6
Genter Mine Br	12	18.3	7.4	9.1
Redstone	12	14.1	7.9	9.6
Coal Cr Rec	11	11.5	6.6	8.8
Coryell	11	12.2	8.2	9.9
Sanders	12	13.7	9.3	10.6
4 Mile Cr	12	10.8	7.1	9.0
Park East	11	13.4	8.0	9.8
7th St Br	12	13.8	8.2	10.5

Appendix F: <u>Roaring Fork Conservancy Information</u>

The Roaring Fork Conservancy (Conservancy) is a 501(c)(3) nonprofit organization located in Basalt, Colorado. The Conservancy's mission is to protect and enhance the habitat of the Roaring Fork watershed, rivers, and tributaries; to promote awareness of the importance of the watershed, and to ensure the quality of our Valley for the benefit of all its inhabitants. The watershed area encompasses three counties and five municipalities. Since the Conservancy was founded, we have established working relationships with several federal and state entities working in the watershed area such as the Colorado Division of Wildlife (CDOW), Colorado Department of Public Health and Environment (CDPHE), the United States Environmental Protection Agency (EPA), the United States Geological Survey (USGS), as well as other federal, state, and local agencies. The Conservancy is involved in numerous projects and initiatives in support of its mission to protect and preserve the rivers of the Roaring Fork Valley. These include:

- **Water Quality:** The Conservancy is performing Valley-wide water quality testing and analysis on a monthly basis. With this information, coordinated management practices are implemented and specific water quality issues addressed.
- **Conservation Easements:** Through holding conservation easements, we seek to maintain and manage river access as well as to preserve wetlands, riparian areas, and wildlife corridors.
- **Education:** School programs reach hundreds of students throughout the Valley every year. Students study all facets of the riparian ecosystem through hands-on biology, chemistry, and geology field courses. They learn about the aquatic web of life and the effects of human activity on riparian areas. Additionally, students contribute research to the statewide River Watch Program. We also provide an educational booth at Basalt River Days.
- **Field Programs:** The Fryingpan Cleanup takes place annually, involving community members in cleaning up the Fryingpan Road and River. The Conservancy has presented campfire programs throughout the Valley during summer months, and a winter slide program entitled *Discover Series*. One of the direct connections the Conservancy has to the rivers is through area outfitters and guides. Nine outfitters, to-date, are participating in the For Our Rivers Program, a program that contributes donations to the Conservancy in support of promoting river access and habitat protection.
- **Community Outreach:** The Conservancy played a pivotal role in encouraging the Town of Basalt to establish an ordinance increasing river setbacks for development and protecting sensitive riparian habitat along the Town's river corridors. With a Section 319 Non-point Source Pollution grant in-hand, the Conservancy, together with the Town of Basalt, is evaluating storm water runoff and storm water management practices for the Town. In addition, the Conservancy has advised on issues including the potential effects of magnesium chloride to river health and the review of the White River National Forest Plan. The Conservancy is presently partnering with the Colorado River Water Conservation District and Ruedi Water and

Power Authority to evaluate the economic and environmental effects of Ruedi Reservoir operations. The economic study began in August 2000, with an assessment of the impact of recreation activities in the Fryingpan Valley on the local and regional economy.

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